BASIC PYROTECHNICAL MANIPULATIONS

(L-101)

INTRODUCTION

Pyrotechnics can be a very artistically satisfying and rewarding profession or hobby. But in order for pyrotechnics to be enjoyed in this manner, responsibility, knowledge, and imagination need to be exercised by the pyrotechnist.

Pyrotechnics can also be extremely hazardous. Many tragic accidents are reported each year. However, in all cases, each one of these mishaps could have been avoided if simple safety precautions had been followed. Fireworks accidents happen to two classes: (1) to beginners who have insufficient skill or no knowledge of what they are doing; and (2) to the experienced, who after so many years of working with pyrotechnics, have become lax in following the safety precautions they already know. They knew better, yet they didn't.

There is nothing easier than to make pyrotechnics dangerous, but, at the same time, it is not only possible, but very easy, to manufacture fireworks without danger. Therefore, ALL SAFETY PRECAUTIONS GIVEN MUST BE FOLLOWED TO THE LETTER.

The staff of Westech has spared no pains in preparing this manual. All of the formulas, processes, and procedures are proven and have been used with success. Many have never been available before to the great majority of pyrotechnists. However, Westech will take no responsibility for any damage or injury resulting from use or misuse of this material, since the conditions of use are beyond our control. The purchaser and/or user take full responsibility for use.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

All fireworks consist of three main parts: a composition (sometimes called "compo"); a casing; and a means of ignition. The composition formulas for the various items are given under the appropriate items in other treatises. The manufacture of the various types of casings generally used in all pyrotechnical devices are given here. Specifications peculiar to individual items are given elsewhere under the particular item. The common ignition mechanisms are described here.

Pyrotechnical devices may also have other parts or factors used in their manufacture. Materials, items that neither make up part of the compositon nor the casing but are necessary for their proper function, are described here. Any special tools required are given elsewhere under the particular item. General manipulations and procedures necessary to combine all the above in order to construct the various fireworks items are explained here. Specific manipulations and procedures are explained under the appropriate items.

SAFETY PRECAUTIONS

1. If you are not 21 years of age, work with adult supervision.

2. Always wear adequate safety equipment when mixing or loading chemical mixtures. These operations are the most hazardous in pyrotechnics. Safety equipment should include: (1) a face shield or goggles; (2) fireproof gloves; (3) fireproof apron; (4) a dust respirator, when working with chemicals that are light-weight and finely powdered. These small particles gather in your lungs and stay there. They may cause serious injuries later in life. Especially dangerous are finely powdered aluminum and charcoal.

3. Make sure there are no open flames present when you are working. (Hot water heaters, furnaces, pilot lights in stove, etc.). This includes smoking.

4. Always be neat. Keep area clean with no open chemical containers or spilled chemicals. When chemicals are spilled, immediately wash clean with water.

5. Keep chemicals and supplies in a safe, cool, dry place, out of reach of small children and pets.

6. Have a good source of water readily available. (Fire extinguisher, bucket of water, hose, etc.)

7. Always keep batches of any powder as small as practically possible. In case of accidental ignitions, small quantities are not extremely hazardous. NEVER mix more than a gram or two of flash or salute powder at one time.

8. When mixing ingredients, do it gently and carefully. If dust begins to rise during mixing, STOP! NEVER RUB, POUND, HAMMER, OR GRIND TWO INGREDIENTS TOGETHER. ALWAYS GRIND CHEMICALS SEPARATELY, THEN MIX CAREFULLY TOGETHER USING MIXING SIEVES (except salute mixtures—these require special mixing.)

9. Wash hands and face well after working with chemicals. This includes ears and nose.

10. NEVER PLACE ANY FLAMMABLE MIXTURE IN A METAL OR GLASS CASING. This includes CO_2 cartridges and metal pipes. Use only paper casings such as those recommended in this manual.

11. Use a reliable variety of fuse. The 3/32" or 1/8" waterproof safety fuse available at Westech is ideal.

12. Do not set off fireworks where local laws prohibit such practice.

13. If a device fails to operate, leave it alone. After 1/2 hour examine it to discover the trouble and then bury it. Do not try to use or refire it again. NEVER CUT OPEN THE CASING OR TRY TO UNLOAD IT.

14. Do not mix chemicals indiscriminately. If you aren't absolutely sure of what you are doing or compounding, STOP!

15. Avoid use of Chlorates when at all possible. They are the chief hazard of even professionals, not to mention amateurs. Substitute a Perchlorate or Nitrate whenever possible. Chlorates form highly heat-, shock-, and friction-sensitive mixtures and a careless mistake while handling them is disastrous. NEVER, NEVER MIX A CHLORATE WITH SULFUR OR ANY SULFUR-CONTAINING COMPOUND (sulfides, sulfates, etc.).

CASINGS

The various types of paper used to make casings are: Kraft - This is the kind rom which brown paper sacks are made. It may also be purchased in rolls or sheets n different weights. Any weight will do. Chipboard - This is a rather thick type of aper. In addition to being used for rolling the longer or larger diameter casings, it s used for rolling mortar tubes. In the case of mortar tubes, mailing tubes or other trong paper tubes will give good results. Chipboard can be obtained from print shops, lthough it is quite expensive, in .015 to .022 thicknesses. It must be thoroughly oaked with paste before being wet-rolled.

All casings should be rolled so the grain of the paper goes up and down the length f the completed casing. The paper is cut against its grain and to the width of the esired length of the casing. Casings can be rolled in two different ways: wet or dry.

A wet-rolled casing is made by applying a light coat of paste to the entire sheet f paper and then rolling it quickly around a former before the paste has time to soften he paper so it tears while rolling. A layer of paste is also applied to the former be- ore the case is rolled to keep it from adhering to the former when it is withdrawn. Before withdrawing the former, the newly formed case is now firmly rolled and pressed ack and forth on a smooth table top using a "rolling board." This action serves to rive out any air pockets and further squeeze the paper layers together to give the ase a good tight construction. A quick and slight twist is now given to the former in he opposite direction to which the case was rolled around it so it may be easily with- rawn. Allow two days for a wet-rolled casing to dry. It should be dried in a warm, pt hot, dry place. Room temperature is fine. A hot place will warp the tube in drying nd thus give a weak construction.

A dry-rolled casing is made by rolling the paper around the former and then pplying paste only to the last edge of paper to keep the tube from unrolling.

Although some pyrotechnists use a "hot water" paste, a "cold water" type is referred, since it is easier to make and to apply. The best pyrotechnical quality paste an be made by adding 4 ounces of any type of flour to 3 cups of cold water, a little at a me and with constant stirring. When thoroughly mixed, add about 1½ tablespoons of odium silicate (thick, syrupy type) and mix thoroughly. The silicate allows the paste o completely penetrate into the fibers of the paper on which it is spread, thus producing ore efficient bonding than ordinary paste. A brush called a "sash tool" is best for r spreading the paste on the paper.

IGNITION DEVICES

1. Priming - In order to insure ignition of certain articles, priming is used. is made from either of the following compositions:

Meal Powder	11	Potassium Nitrate	15
Dextrine, yellow	1	Charcoal, dust	3
Water		Dextrin, yellow	1
		Sulfur	2
		Water	

The most effective and by far the least expensive way to prime a device is to at the priming on tissue paper. Add enough water to make a fairly thin priming, at the tissue thoroughly, position it where needed, and allow to dry. The more rface area of the tissue that is exposed, the better. This method greatly conserves priming and provides much more surface area for ignition, than the old way of dab- ng on the priming as a thick paste.

2. Match. - There are two varieties of match: raw and quick.

Raw Match - This is made by coating thick (about 1/8") cotton string with priming, or by coating many small strands and then joining them together. This latter method is by far the better one, since it gives a match that burns much fiercer because the priming is coated on the outside and the inside of the finished match. The quickest, cleanest and best way is to use a Black Match Machine (T-MM). Another way (though it is quite messy) is to first place the string for about five minutes in boiling water. This is to remove any of the moisture resistant coating that some varieties of string have. (The "match cotton" (S-MC) available at Westech is ideal. It is especially made for making match and does not have the moisture resistant coating. It is also the ideal diameter and makes the "multi-strand" match.) Then, while it is still wet, tie one end to a nail that is placed about waist high and run the string to another similarly placed nail about 30 feet away. Do this with as many lengths of string as needed. With the right hand take a handful of priming which has had enough water added to it to make it about the consistency of very thin mud. Only practice will tell how much water to add. It should not be so thin that it runs easily out of the hand. Nor should it be so thick that it goes on unevenly or too heavily on the string. Hold the pan of thinned priming in the left hand to catch any drippings and walk backward to the other end of the string, letting it run through the priming in the right hand. Do not be afraid of taking a good handful of priming; there is no clean way of making match rapidly. Water will have to be added from time to time to the priming to keep it thin enough, as the string soaks much of it from the priming. This is the reason for having the string as wet as possible before the priming is applied.

If the weather is dry, the match will be ready for piping in a day or two. When the match is dry and stiff, it may be cut and pipes threaded on.

Quick Match - This is made by simply enclosing raw match in a paper tube called a "pipe". Match piping serves the double purpose of protecting the match as well as making it burn faster. A piece 20 feet long will flash from one end to the other in less than a second. A match pipe is made by dry rolling 3 or 4 turns of paper (Kraft, Manila or Newspaper) around a dowel 1/4" in diameter. The longer the pipe is made, the harder it is to roll. However, try to roll about three foot lengths. It is easier if the pipe is rolled at a slight spiral. Whenever two pipes must be joined, crease or gather the end of the first pipe so the next pipe may be slipped over it for about an inch.

3. Safety Fuse-This comes in various diameters from 3/32" to 3/8". It is waterproof, inexpensive, and the best fuse for fireworks ignition.

MATERIALS

1. Adhesive - This is Professional Pyrotechnic Adhesive. Complete details, formula, and instructions for making it are available from Westech (Catalog number L-TR1).

2. Gunpowder - This is standard black rifle powder. It can be obtained at sporting goods stores in one pound cans in grain sizes from the largest of Fg to the smallest of FFFFg. The Fg is preferable as a driving charge, the FFFg for a bursting charge. The pyrotechnist cannot make normal gunpowder that has the driving ability of commercial black powder. Special presses, and heavy equipment weighing many tons are required. However, L-TR4 gives formulas and instructions for making excellent substitutes that are as good as, or better (and less expensive) than commercial black powder.

Meal Powder - This is standard black rifle powder ground with a mortar and pestle until it is in dust form. The FFFFg is preferable because it is the smallest size grain. However, Fg, FFg, of FFFg may be used. They will just require more grinding. It is used in priming, match, bursting charges, composition formulas, etc. A fairly good substitute for meal powder can be made by the pyrotechnist using the following method:

Potassium Nitrate	15	75	The Potassium Nitrate should be as pure and finely powdered as possible. The "Double, refined powder" is ideal. Charcoal should also be very fine, and made from willow or other soft wood. "Air-floated, willow" is the best.
Sulfur	2	10	
Charcoal, dust	3	15	

Make sure that each ingredient is in a very finely powdered form. This is especially necessary for the Potassium Nitrate. It should be as fine as flour or powdered sugar. Mix all together and place in a tumbler, similar to those used in lapidary for polishing gems. Those available at Westech are ideal. Add lead balls (about 1/2" diameter and weighing twice the weight of the ingredients). Tumble for at least one hour. The longer it is tumbled, the stronger the powder will be. Care must be taken to do this away from any open flames, or sparks. The engine housing of the tumbler motor must be enclosed. The entire production should be conducted away from any property or people.

TOOLS

These are the special tools that are necessary to make the fireworks described. Such things as formers, rammers, star pumps, ramming bases are included. It is understood that everyday tools such as scissors, saw, drill, drafting compass, etc. should also be on hand.

MANIPULATION AND PROCEDURE

This is the manipulation of the composition(s), casing(s), ignition devices, materials, and tools, using a given procedure for the construction of the various fireworks items. The mere possession of a formula is of little use to one not acquainted with the proper manipulation of the ingredients and materials. Thus, the manipulation of compositions, casings, materials, and tools is more important than knowing how much of each to use.

One of the basic manipulations for all fireworks that are primed is called "nosing". This is done by simply wrapping the filled and primed casing with a few turns of paper (decorative or plain). The paper should extend over each end about 1-1/2". These ends are called "nosings" and serve to protect the article from any premature ignition and also to secure the match in its place. The nosing may either be twisted or tied around the match, and tucked in the other end.

Mixing is the most important manipulation in pyrotechnics. Without careful mixing, consistent and quality work is impossible to obtain. A properly mixed composition should be homogeneous and all ingredients of a predetermined and consistent particle size. This is where most amateurs go astray, their compositions lacking one or both of these qualities. Chemicals should be reduced to the necessary powdered form with a mortar and pestle and then weighed accurately on a good balance. The ingredients should then be mixed using mising sieves because these insure not only a homogeneous mixture but help insure correct particle size and the whole process of mixing is greatly expedited and facilitated.

For general mixing operations, 24 meah sieves should be used. All oxidizers should first be sifted through 40 mesh sieves. Then they are mixed with the ingredients, using the 24 mesh sieves. Separate sieves must be used for mixing chlorate-containing compositions and those that do not contain any chlorates. The mixing sieve should be placed over a large sheet of paper and then all the ingredients pushed through, one at a time. When all the mixture has passed through, mix again as before, sifting onto the first sheet of paper and giving a last thorough mixing. Never mix any salute composition using a mixing sieve. These ingredients should merely be lightly but thoroughly mixed on a piece of paper, using a plastic spoon.

When using metal filings, titanium, aluminum flitters, coarse charcoal, etc., these are saved until everything is sifted and mixed completely and then added and mixed into the composition.

NOTE: Iron and steel filings should always be coated with paraffin or linseed oil to protect them from premature oxidation (usually by the saltpeter) if the device is to be stored for more than a day or two. If this is not done, the effect will be completely ruined, and the device useless.

Always add the saltpeter in the composition to the sulfur when sifting these two for the first time. Sometimes the sulfur is charged with static electricity so that it is very difficult to sift unless the saltpeter is added.

Never throw a chlorate onto the sieve with dextrin or other hydrocarbons. Sift the chlorate first and then add the other ingredients one by one.

Great care should be taken never to let the fingernails strike the sieve while working, as it is very easy to "strike fire" in this way, with disastrous effects.

A very important manipulation in pyrotechnics, and one which many newcomers have difficulty in doing properly is charging the various casings with composition. There are numerous ways to charge (fill) a case. The simplest is to merely pour the composition into the casing, as is done when filling salutes. Perhaps the most common is to drive (ram) composition into a casing. This is done by pouring small portions of composition into the case, inserting a rammer that securely fits into the opening, and then striking the rammer several blows with a mallet (preferably rawhide) so it firmly consolidates the composition. Rockets, fountains, wheel drivers and others are charged this way. The composition for these devices should only rise about 1/2 to 1 I.D. (after consolidation) for each charge composition. The use of measuring scoops,

made especially for this purpose and available from Westech, is highly recommended. Instead of using a mallet, the compo can also be consolidated using an arbor press. All ramming and pressing operations should be carried out on a very solid foundation. A "ramming block," made in the following way, is ideal. Place a 2' length of solid timber (a 5 x 5" piece or thicker) in a 5-gallon pail. Now pour sand and/or small gravel around the timber. Rap the sides of the pail frequently so the filling is well consolidated. A cavity of some sort should be made in the middle and on the top of the timber to receive the ramming bases of the various tools. If these bases are all made the same size, then can be interchanged in the block. A 2" diameter x 1" deep cavity works well. (All tools at Westech are interchangeable in this size cavity.) Pressing is done by inserting the rammer and then pressing the composition with hand pressure inside the case. This type of charging is used for filling whistles, box stars and other items. Another way of charging a case by ramming (driving) is with a funnel and rod instead of hammer and mallet. This is used to fill lances, bottle rockets, and other small items. These operations are explained in more detail under the appropriate items.

In describing some of the manipulations and procedures on various items, exact dimensions and other specific details are not always given, but rather a general outline or idea. This is because these items are so dependent upon the experience and skill of the artificer and so dependent upon the particular raw materials, working conditions, etc., that what would prove satisfactory for one pyrotechnist would fail for ten others. All formulas, manipulations, procedures, etc., should always be considered good advice, and not the irrevocable truth. Even the same formula will vary from time to time for the same individual. This is why pyrotechnics is an art requiring considerable experience and imagination and is, therefore, very rewarding only to those whose desire is sufficient to acquire them.

EXPLODING FIREWORKS (PART I)

(L-102A)

I. INTRODUCTION

Explosive sound has a legitimate place in fireworks but only if used with responsibility. Fireworks that explode with a snap, tremendous report, or anywhere in between are very exciting. However, they are also very dangerous to shoot and even moreso to make. Many individuals have been seriously injured trying to make or use these items. All of these accidents could have been avoided if the individuals involved had had an adequate knowledge of the principles, theory, and safety precautions pertaining to these items.

Thus, all safety precautions given in this treatise must be followed to the letter.

Certain principles of pyrotechnical theory are given so the pyrotechnist can better understand the processes that are involved in making exploding fireworks. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks items consist of three main parts, viz., a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanism(s) necessary for proper performance are described. Fourth, any special materials (items that neither make up part of the composition, casing, nor ignition mechanism, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulations and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

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FIRECRACKERS/ FLASHCRACKERS

A. Lady Fingers

Both the black powder and flash types of Lady Fingers are made the same way. The only difference is in the type of exploding composition.

Composition: Formula #1 or Meal Powder.

Casings: All casings can be made from regular newspaper, which is the type of paper used in almost all firecrackers nowadays. They are 3/4" long x 1/8" O.D. x as small as possible I.D.

Ignition Device: Chinese-type fuse (see L-TR5 for complete details for making this item).

Tools: The only tool necessary is a very small nail.

Manipulation and Procedure: Cut the paper into 3/4"x2" pieces. Fold 1/2" from one end. Sprinkle some composition along this fold and place a length of fuse so it protrudes from one end but enters into the powder train. Now fold the smaller end of the paper over the powder and fuse and roll up tightly, pasting the last roll. Crimp the ends closed with the nail.

These may also be made by the mass production process described below. Allowances should be made in the tool dimensions.

B. Common-sized

These are crackers 1-3/4" in length or smaller and not exceeding 5/16" in O.D. Firecrackers not exceeding these dimensions formerly carried an import duty of only a few cents a pound. For larger crackers the duty was such that it prohibited their importation. Thus, their size designation became known as "common-sized."

Composition: Formula #1.

Casings: The common-sized firecrackers are usually in the following sizes:

Length	I.D.	O.D.	Remarks
1"	1/8"	3/16"	2' long tubes with an I.D. of 1/8" and either 3/16" or 5/16" O.D. are dry-rolled. The desired firecracker lengths and quantity are then cut from these long tubes.
1-1/2"	1/8"	3/16"	
1-5/8"	1/8"	3/16"	
1-11/16"	1/8"	5/16"	
1-3/4"	1/8"	5/16"	

Ignition Device: Chinese-type fuse, or 3/32" safety fuse.

Tools: A nail for crimping the ends of the casings closed; a 1/8" x 3' case-former (wooden dowel or metal rod) and a special firecracker tray made as follows: Cut a piece of metal, approximately .025" thick, 3" x 9". Divide it into 3 equal squares, each 3" on a side. Now bend the two outside pieces up and toward each other, so the configuration shown in Figure 1 is obtained.

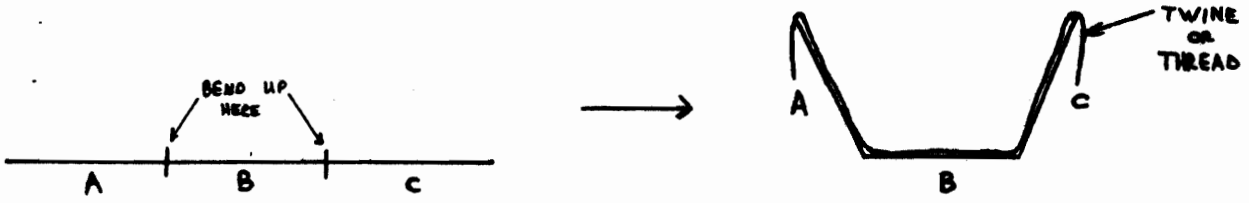

Figure 1

Manipulation and Procedure: Dry-roll a piece of newspaper around the former. The newspaper should be 2' wide and whatever length will give a casing 3/16" (or 5/16") O.D. The desired length and number of casings are now cut from this long piece. A piece of strong twine, or thread (depending on the size of the casings), is draped over the cracker tray, so it lies as flush as possible against the sides and bottom of the tray. Now stack the cracker casings so the twine goes under the exact center of the bottom row of casings. Pull and tie the loose ends of the twine together so the casings are formed into a tight bundle. Remove the bundle from the tray, stand it on end on a firm surface, and crimp the ends of the casings closed with the nail by striking it a sharp blow against the inner rolls of paper at the ends of the tubes. Turn the bundle over and paste a sheet of Gampi tissue over the open side of the bundle, closing the ends which will later carry the fuses. When this is dry, holes corresponding to the tubes are punched in the paper. This is done by using one to four nails held in the hand while holding the bundle of tubes steady with the other. The edges of the paper are then bent slightly upward, giving it the form of a shallow saucer with many small holes in its bottom. The powder for charging the crackers is then introduced into this saucer, and the whole is shaken gently until all the tubes are full. Then, with a quick movement, flip the bundle in a complete revolution, so that the excess powder in the saucer, and a portion of the powder in each of the tubes, is emptied out, each of the tubes being left partly full of powder with enough space at the top for the fuse and the crimp. The paper is now torn off from the bundle, and the fuses, cut to length, are put in place. After all fuses are in place, the final crimp is made as before.

C. Salute-sized

These are firecrackers 2" and 3" in length. There are two types: Chinese and American. The difference is in the type of fuse used and type of casing. The Chinese type use the Chinese-type fuse and the newspaper casing just as in the smaller sizes of crackers. The American type use safety fuse and a wet-rolled casing of better quality paper such as Kraft or Manila.

Composition: Formula #1

Casings: (a) Chinese—Same as common-sized except the dimensions are:

2" (or 3") x 3/16" I.D. x 7/16" O.D.

(b) American - Kraft, Manila or other good quality paper cut to the same lengths. Both kinds of casings are cut from 2' or 3' long tubes.

Ignition Device: Chinese-type fuse (doubled) for the Chinese variety; 3/32" safety fuse for the American type.

Tools: A nail, a case former 3' long and 3/16" diameter.

Manipulation and Procedure: These may be either made by the mass production process described above, or they may be made singly as was described for Lady Fingers. If this is the case, the paper should be folded 2 or 3 inches from one end to make the fold.

C. Cannon Crackers

Composition: Formula #1.

Casings: These are made from the same paper as the American salutes mentioned above and wet-rolled in the following sizes:

Length (Inches)	I.D. (Inches)	O.D. (Inches)
4	7/16	9/16
5	1/2	3/4
6-1/2	5/8	7/8
8	3/4	1
9-1/2	7/8	1-1/4
10-1/2	1	1-1/2
13	1-1/4	1-3/4

Ignition Device: 1/8" diameter safety fuse.

Materials: Professional Pyrotechnic Adhesive.

Tools: A nail, case formers in the above I.D. dimensions and 1-2" longer.

Manipulation and Procedure: After the cases have been rolled, and before they dry, crimp one end completely closed, and the other with an opening of about 1/4". Allow at least 2-3 days to dry. Fill about 4/5 full with composition (a fuller load will give a decreased report), and insert a length of safety fuse. Now plug both ends with a thick mixture of Pro. Pyro Adhesive and let dry.

SALUTES

A. Silver Tube Salutes

Composition: Formula #2

Casings: These can be bought ready-made from Westech or can be rolled by the pyrotechnist. Use a good quality paper (Kraft or Manila). Also necessary are a pair of end plugs. These cannot be easily made but can be obtained from Westech.

Ignition: 3/32" or 1/8" safety fuse.

Materials: Pro. Pyro Adhesive.

Tools: A former 1/2" in diameter and 3' long.

Manipulation and Procedure: Cut the paper into 36" x 24" pieces and wet-roll making a tube 36" long when dry. Cut in 1-1/2" sections. Punch a hole in the middle of the wall of the casing and insert a length of safety fuse. Apply some Pro. Pyro Ad. to a paper end plug with a brush and insert the plug into an end of the casing. Allow to dry for a few minutes. Fill about 3/4 full with powder and secure the other end plug with the Adhesive. Do not allow the powder to come in contact with the wet Adhesive, so allow the salute to stand on its dry end until the last plug and Adhesive are dry.

B. M-80 Salutes

These are exactly like the above except using a 9/16" diameter case former and a 36" x 28" length of paper. End plugs and casings can be obtained from Westech.

C. Cherry Bombs

Composition: Formula #2

Casings: These are two paper cups, one fits inside the other to form a complete casing. This is then dipped in a modified mixture of Pro. Pyro Adhesive. These casings can be obtained from Westech, since they cannot be made by the pyrotechnist. They are made in large factories using mechanical punches.

Ignition: 3/32" or 1/8" green safety fuse.

Materials: Pro. Pyro Adhesive modified for making Cherry Bombs.

Manipulation and Procedure: Punch a small hole in the inner cup. Insert a length of green fuse. Fill the inner cup about 3/4 full of powder. Fit the two cups together. Hold the Cherry Bomb by the fuse and dip it into the modified Adhesive.

D. Super Bull Dog Salutes

Different items go by this same name. Essentially they are all barrel-shaped salutes with a center fuse. Some manufacturers use a standard M-80 type casing without "M-80" written on it and call this a Bull Dog salute. Others merely use a red casing the size of a silver salute. But the best known variety is essentially an enlarged Cherry Bomb. This is the type discussed here.

Composition: Formula #2

Casings: These measure 5/8" I.D. x3/4"O.D. x 1" long. End caps are made

to fit flush over their ends, rather than fit inside the ends as in the case of M-80's and Silver Salutes.

Ignition: 3/32" or 1/8" safety fuse.

Materials: Modified Pro. Pyro Adhesive.

Tools: Same as for Silver Salutes except the case former should be 5/8" dia.

Manipulation and Procedure: Roll the casing as described under Silver Salutes using a piece of paper 36" x 28". Cut to length when dry and punch a small hole in the middle of the casing and insert a length of safety fuse. Apply some Adhesive around the lip of the end cap and put it over the end of the casing. Allow to dry a few minutes. Fill about 3/4 full with powder and put on the other end cap as before. The powder must not come in contact with the wet Adhesive so allow to dry by standing it on its dry end a few minutes. Hold by the fuse and dip the casing into a modified mixture of Adhesive.

NOTE: If the fuse hole is made too large in Cherry Bombs and Super Bull Dog salutes, it may be necessary to add a dab of Adhesive to keep the fuse in place during the dipping process.

IMPORTANT: The safest way to make salutes or any exploding device is to introduce the composition in two separate portions, first the required amount of oxidizer(s), and then the required amount of a mixture of the other ingredient(s). In this way, there is no large amount of explosive composition in any one place, nor is there in actuality, any explosive composition until the two portions are mixed inside the casing. The scoop sizes for introducing these two portions must be found by experimentation. One scoop is used for the oxidizer(s) and another is used for the remaining mixture. Mixing the two portions can be done by placing a number of the completed salutes or other exploding devices in a large cardboard box, closing the lid, and then gently turning the box over a few times. This is another reason exploding devices are only partially filled: it facilitates mixing of the components as well as giving increased report.

COMPOSITION FORMULAS

mula #1

Potassium Nitrate.....	5
Aluminum, dark pyro dust.	.2
Sulfur, flowers	3

Formula #2

Potassium Perchlorate.....	7
Aluminum, dark pyro dust	3

Note: All parts as by weight. the oxidizers must be very finely powdered for maximum results. Necessary tools for compounding these formulas are a good lab scale and a mortar and pestle.

The success of these formulas depend on a good dark pyro aluminum.

In the past, most of the salute and flash formulas combined Potassium Chlorate or Potassium Perchlorate with Sulfur and/or Antimony Sulfide, in addition to the Aluminum. These admixtures are EXTREMELY HAZARDOUS, and must NEVER be used. They are very heat-, shock-, and friction-sensitive. Thus, they may ignite by the mere process of mixing their ingredients, or by pouring the mixture into a case.

Besides this danger, some acid is always present in the sulfur or antimony sulfide. This acid attacks the chlorate, breaking it down into chloric acid which can cause the mixture to detonate without warning! Flowers of sulfur has much more acid content thatn sulfur flour, and must never be used with any oxidizer except the nitrates. The hazards of acid formation with the nitrates is not significant. However, the use of flowers of sulfur with perchlorates or chlorates is disasterous.

Thus, avoid the use of all chlorates whenever possible. NEVER, NEVER GRIND OR RUB A CHLORATE WITH ANY OTHER CHEMICAL. THIS MIXTURE CAN DETONATE WITHOUT WARNING! Nearly 100% of accidents and mishaps attributable to fireworks-making can be traced to the use of chlorate/sulfur or perchlorate/sulfur mixtures.

The use of these hazardous mixtures started many years ago when there was not available a good grade of dark pyro aluminum. To overcome this defect, and in order to obtain a good report, it was necessary to resort to chlorate/sulfur (and/or sulfide) or perchlorate/sulfur admixtures. These hazardous and old-fashioned formulas are perpetuated even today by those who aren't aware of the improved, modern dark pyro aluminum now available. This variety makes completely unnecessary the need for sulfur and sulfides in salute formulas.

There are many varieties of aluminum powder, and there are many varieties of "dark pyro" aluminum. However, of all these types, only a few varieties of the "dark pyro" can be used. The majority give unsatisfactory performance. Therefore, if your results are not up to par, the fault is most likely with the type of aluminum used. The best advice is to be wary of the many varieties of aluminum and so-called "dark pyro" aluminums that are available today.

Generally, the darker the aluminum, the more reactive it is. Even more depends upon its particle size and shape, and amount of grease, stearates, or other contaminents that decrease its reactivity. Unfortunately, most "dark" aluminums encountered are various shades of a greyish silver, instead of being really dark. They also are not of ideal particle size, and shape, and have too much grease content.

After conducting hundreds of experiments on all the existant "dark pyro" aluminums available, Westech selected the best available. Its use is encouraged for quality results.

EXPLODING FIREWORKS (PART II)

(L-102B)

COMPOSITION FORMULAS

Formula #1
- Potassium Perchlorate..... 7
- Aluminum, dark pyro dust... 3

Formula #2
- Potassium Perchlorate..... 1-3/4
- Sodium Salicylate, USP, fine powder 1

Formula #3
- Potassium Perchlorate..... 40
- Magnesium, 100 mesh..... 34
- Aluminum, dark pyro dust.. 26

Formula #4
- Potassium Chlorate..... 3
- Antimony Trisulfide..... 1
- Lampblack..... 1
- Aluminum, dark pyro dust... 1
- Barium Carbonate ..... $\frac{1}{10}$

Formula #5
- Potassium Perchlorate 3
- Barium Nitrate..... 3
- Aluminum, dark pyro dust... 4

Note: All parts as by weight. the oxidizers must be very finely powdered for maximum results. Necessary tools for compounding these formulas are a good lab scale and a mortar and pestle.

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After conducting hundreds of experiments on all the existant "dark pyro" aluminums available, Westech selected the best available. Its use is encouraged for quality results.

EXPLODING CONES

All of these unusual items use paper cones similar to the ones on which thread or twine is wrapped. They look like the standard display cones but are actually the loudest of all ground noisemakers, along with the larger sizes of Cannon Crackers.

A. Black Volcanos

Composition: Formula #1.

Casings: A paper cone described above. They can also be obtained from Westech.

Ignition: 3/32" or 1/8" safety fuse.

Materials: Pro. Pyro Adhesive; 1/8" chipboard.

Manipulation and Procedure. Cut a disc from the chipboard with a diameter equal to the diameter of the cone at about 1/2 its height. Insert a fuse in the top of the cone and secure it with a dab of Adhesive. Allow to dry a few minutes, then fill about 3/4 full with powder. Insert the chipboard disc and secure and reinforce with plenty of Adhesive. Leave in the inverted position until dry.

B. Whistling Devils

These are the same as above except they begin with a long shrill whistle and then explode.

Compositions: Formula #2 (whistle); Formula #1.

Casings: Same as above except with a slight modification. The nose of the cone must be clipped off to allow for the insertion of the whistle tube. The whistle casing itself should be 3" long x 5/16" I.D. x 1/2" O.D. It must be rolled from a smooth type of paper such as the type used in post cards. A rough paper will affect the whistle tone adversely. Kraft and Manila papers may be used with almost as good results.

Ignition: 3/32" or 1/8" safety fuse, priming.

Materials: Same as above.

Tools: Wooden dowel or aluminum rod 5/16" diameter x 8" long, a ramming base for making the whistle. This is made as follows: Drill a hole 5/16" diameter and 1/2" deep in the center of a block of wood at least 2" square and 1/2" thick. Insert and glue in place a piece of wooden dowel (or aluminum rod) 5/16" diameter and 1-1/4" long (cut from the 8" piece). The remaining 6-3/4" piece will be used to press the whistle compo into the case.

Manipulation and Procedure: Wet-roll the whistle casing and allow to dry at least two days. When dry, place over the ramming base nipple and press Formula #2 into it, using small quantities until the composition is 1/4" from the top of the casing. Remove from the base and prime both ends well. Insert a fuse in the end which has the 1" vacancy. This space is necessary for the proper production of the sound. When the priming is dry, insert the whistle into the nose of the cone and secure from the inside with Adhesive. Fill 3/4 full with Formula #1 and secure with the chipboard disc as before.

C. Block Busters

These are the same as Black Volcanos except Formula #3 is used. These are extremely powerful and loud so the greatest of caution must be exercised. As with the Volcanos, the powder charge must not be confined, so cut the chipboard disc accordingly.

TORPEDOS

These are small spheres that explode when thrown against a hard surface. Their composition is one that is very sensitive to friction or shock. Use of extreme caution must be taken at all times when making or using them.

Composition: Formula #4. This is the one exception where chlorate/sulfur (or sulfide) are together. Thus, this formula is extremely hazardous. Under no circumstances should more than a gram or two of this composition be made at one time.

Casings: These are small cups of paper about 3/4" in diameter and 3/4" deep. These fit together to form a capsule similar to a Cherry Bomb casing. These too are such that they must be punched out by a machine and cannot be made by the pyrotechnist. They may be purchased from Westech.

Materials: Fine gravel that is clean and coarse; Sodium Silicate (water glass); tissue paper (any type of thin paper will do).

Tools: 22 cal. long rifle shells (to be used as measuring scoops); safety goggles, or face shield; safety gloves.

Manipulation and Procedure: Pour three scoops of Potassium Chlorate in the inner cup of the casing. Place on top of this, without mixing, two scoops of the mixture of the other ingredients, then one pinch of gravel. Close the capsule with the outer cup. Fill a small bowl with the Sodium Silicate and dip the completed capsule in it. It does not matter if their contents mix now. Take the greatest of caution once these chemicals begin to mix as they are very friction sensitive. Remove the capsule from the bowl (it need only be immersed a few seconds) and cover with small pieces of tissue paper until the capsule is completely covered with them and assumes a spherical shape. Allow to dry in a safe place. An alternate outside covering is a thick mixture of fine sawdust and Sodium Silicate. Keep dipping until the capsule assumes a

spherical shape. Use heavy safety gloves and goggles for this operation. The gloves also make it possible to apply the outer coating easier.

IMPORTANT: Use the utmost of caution when using and do not throw near any people because the gravel is impelled with considerable force with the explosion.

The manufacture of these items is only recommended to pyrotechnists who have plenty of experience in making other fireworks items, and are cognizent of the precautions and dangers incident to Potassium Chlorate usage.

MUSICAL SALUTES

These ever-polular items have gone by a variety of names such as "chasers," "whistling whizzers," "whistling tornados," etc. They scoot along the ground while whistling and smoking, finally ending with a loud report.

Compositions: Formula #2 (whistle); Formula #1.

Casings: These are wet-rolled from Kraft or Manila paper. Their dimensions are 5/16" I.D. x 1/2" O.D. x 4-3/4" long.

Ignition: Safety fuse, Priming.

Materials: Wrapping tissue.

Tools: Same as for "Whistling Devil" cones.

Manipulation and Procedure: Place the casing over the nipple on the ramming base and press in Formula #2 in small portions until it has the height of about 1-1/2" inside the tube. Pour in a small quantity of Formula #1 DO NOT RAM THIS. Remove from the ramming base and wrap the tissue paper cut in 2" x 6" around it, tucking in the overlapped portion that extends over the end with the salute composition. To further secure this end, apply a dab of paste. Then insert some priming in the other end so it covers the whistle composition surface and insert a length of safety or other type of fuse. Twist the overlapping portion of tissue paper around the fuse to secure it and allow to dry.

AERIAL FLASH BOMBS

All types of aerial flash bombs consist of a paper tube secured to a wooden base. Just above the base is a piece of safety fuse that protrudes through a hole punched in the tube. Inside the tube is a small quantity of Fg powder and a large salute with a time fuse. The black powder, upon ignition from the safety fuse, shoots the salute high into the air at the same time igniting its time fuse. When the salute reaches its zenith, the time fuse ignites the salute composition with a tremendous flash-report. Aerial flash bombs are in a variety of sizes. Their sizes are listed below:

Paper Mortar Tubes:

#	I.D.	O.D.	Length (inches)
0	3/4	7/8	3-3/4
1	1	1-3/16	5
2	1-1/4	1-1/2	6-1/2
3	1-1/2	1-13/16	7-1/2
4	1-3/4	2-1/8	8-3/4
5	2	2-7/16	10
100	2-1/4	2-3/4	11-1/4

Salutes Casings:

0	5/8	3/4	3/4
1	13/16	1	1
2	1	1-1/4	1-1/4
3	1-3/16	1-1/2	1-1/2
4	1-3/8	1-3/4	1-3/4
5	1-3/4	2	2
100		2-1/4	2-1/4

Wooden Bases:

0	1-1/2 x 1-1/2 x 3/8	3-shot	2-1/2 x 2-1/2 x 3/4
1	1-3/4 x 1-3/4 x 3/8	5-shot	3-1/2 x 3-1/2 x 3/4
2	2 x 2 x 1/2	9-shot	4-3/4 x 4-3/4 x 3/4
3	2-1/4 x 2-1/4 x 5/8		
4	2-1/2 x 2-1/2 x 3/4		
5	3-1/2 x 3-1/2 x 3/4		
100	3-1/2 x 3-1/2 x 3/4		

A. Single Report

Composition: Formula #5, Fg. black rifle powder (for the mortar lifting charge).

Casings: Both the mortar and salute should be wet-rolled from Kraft or Manila or Chipboard to the above dimensions. Be sure and apply plenty of force when rolling the mortar as it has to withstand the immense pressure of the lifting charge of black powder. Mailing tubes or other strong tubes may be used for the mortar with equal results.

Ignition: Mortar - 3/32" safety fuse; Salute—special fireworks time fuse, 1/4" or 3/8" diameter; Priming.

Materials: Pro. Pyro Adhesive; chipboard about 1/8" thick.

Tools: Wooden dowel or a metal pipe with an O.D. equal to the I.D. of the mortar (if the mortar is rolled by the pyrotechnist), another former (dowel or pipe) to roll the salute casing. (Westech has formers that are ideal for this purpose.)

Manipulation and Procedure: Punch a hole in the mortar about 1/4" from one end, cement it to the wooden base with the Adhesive and let dry. Plug one of the ends of the salute casing with Adhesive and an end plug made from chipboard cut in a disc shape with a diameter equal to the I.D. of the salute. While this is drying, drill a hole in another chipboard disc equal to the diameter of the time fuse. Time fuse comes in various diameters the most common being 1/4" and 3/8". Cut the time fuse to the proper length. (This must be ascertained by experimentation, depending on the effect desired and amount of lifting charge.) Secure it well with Adhesive and prime both ends well. The fuse should extend half its length inside the salute and half outside. When the Adhesive is dry, pour in enough salute powder to fill its casing about 3/4 full. Secure the remaining end plug with Adhesive, making sure the salute comp does not come in contact with the wet Adhesive. Pour in a quantity of Fg black powder. (This quantity must also be determined by experimentation, depending on the size of the salute. Generally, the various amounts will be somewhere between 1/4 teaspoon to 2 teaspoonfuls.) Drop the salute, fuse end down, on top of the powder. Cut a circle with a diameter equal to the I.D. of the mortar from thin cardboard and push it down on top of the salute to secure it and the driving charge in the mortar. Insert a length of safety fuse through the hole at the bottom of the mortar.

B. Repeaters

These are 3-, 5-, or 9-shot #0 aerial bombs arranged on one wooden base. They are matched with connecting lengths of safety fuse so that they go off in sequence one after another. The last shot in the 5- and 9-shot repeaters can be a larger sized bomb if desired.

MISCELLANEOUS AERIAL SHELLS

A. Whistling Aerial Bombs:

These are made in the same sizes as the Aerial Flash Bombs, except there is no #0 size. They have the added effect of a screaming whistle as they ascend before the report.

Compositions: Formula #2 (whistle) and Formula #1.

Casings: Same as for Aerial Flash Bombs with the addition of a whistle casing with the following dimensions: 2" x 5/16" I.D. x 1/2" O.D.

Ignition: Same as above, also some black match.

Materials: Same as above.

Tools: Same as for Musical Salutes and Aerial Flash Bombs.

Manipulation and Procedure: Make the whistle according to the directions given under Musical Salutes, except only make a column of whistle comp. about 3/4" high. Make sure the comp. is pressed very tightly since it has to withstand the

pressure of the lifting charge without blowing through. Use adequate precaution when pressing. Prime both ends heavily and insert two or three 1-1/2" lengths of bare match in the end with the 1" vacancy. These not only assure the ignition of the whistle but take off some of the pressure of the lifting charge. The matched and primed whistle takes the place of the time fuse. Secure it well in the hole of the end plug with Adhesive. Proceed as in Aerial Flash Bombs.

B. Thunder Shells:

These are also made in sizes from #1 on up. Instead of a single large report, they explode in many smaller reports. They are made the same way as Aerial Flash Bombs, except as many flashcrackers that will fit inside the salute casing are used instead of the salute compo. In addition, a small quantity of meal powder is also placed in with the crackers as well as some FFFg black powder. This bursting charge assures the ignition of all the crackers as well as scattering them over a wide area in the sky. In the larger sizes, salutes may be used in addition to crackers. It is not necessary to use thick-walled casings as used in Aerial Flash Salutes. Wet-roll all the aerial casings used in Thunder Shells with only a 1/16" wall. These shells are also known by other names such as "Battle-in-the-clouds," "Sky Rocket Shells," etc.

C. Rocket Shells:

Various manufacturers use this name to designate different shells. One type is merely another name for a Whistling Aerial Bomb. However, the type discussed here is a combination of a Thunder Shell with a whistle as it ascends. Follow the directions in parts A. and B. above to make this shell.

D. Siren Bombs:

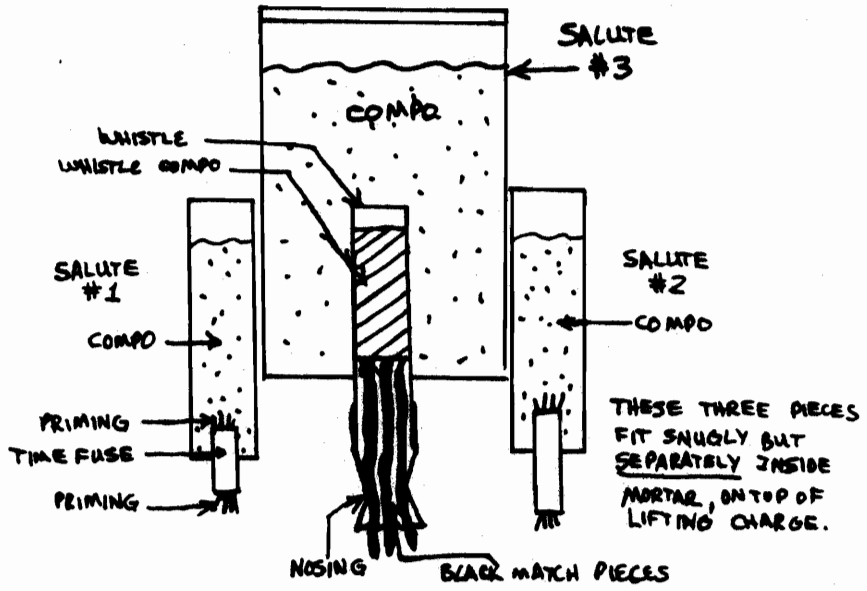
Again, various manufacturers use this name for different shells. One type is a Whistling Aerial Bomb. Another type is the same as a Whistling Bomb except it has two or three whistles burning at once as it ascends. This is a very effective piece of fireworks, and is the type discussed here. Only #3 sizes and larger should be made. Proceed the same as for Whistling Aerial Bombs except drill two or three holes in the end plug instead of one.

E. Thunderbolt Shells:

These are the same as Aerial Flash Bombs except Formula #3 is used instead of #5.

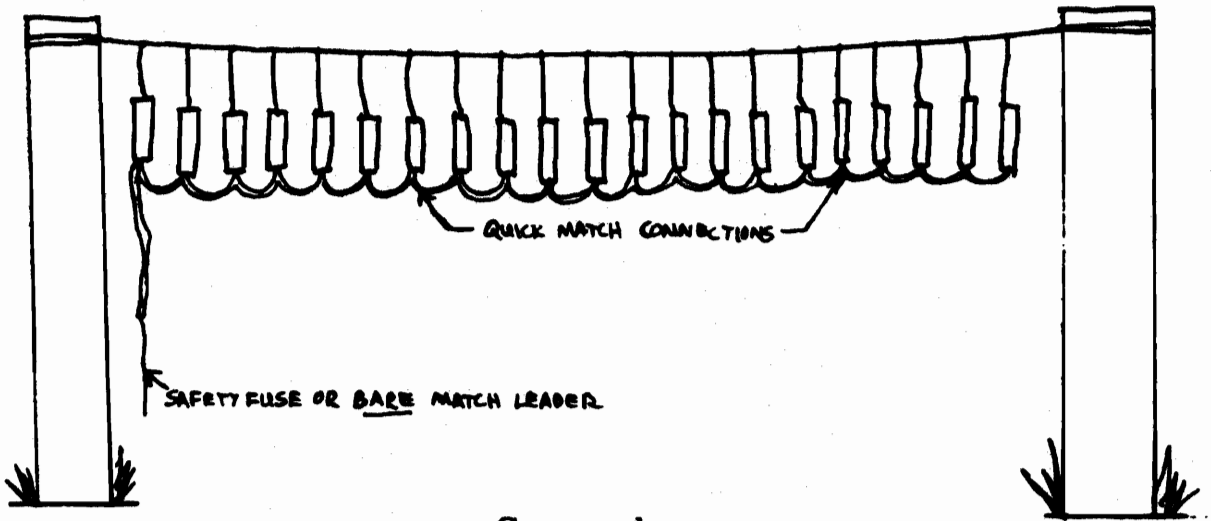
F. Sky Devil Shells: This is a timed-reports aerial shell with a whistle as it ascends. Generally, these are made in only #5 and #100 sizes, but occasionally #3 and #4 are made. The mortar shoots a shell that whistles as it ascends. First one report is heard, then about one second later another report is heard, then 1-1/2 seconds later the whistle ends with an ear-splitting explosion. The first report is heard about 1-1/2 seconds after the mortar fires the shell. The total whistle time is 3-1/2 seconds.

These shells require considerable skill to make as the time fuses, driving charge, and whistle compo. length require extremely accurate measuring and coordination. They are made like Rocket Shells except only two reports are put in the thin-walled casing instead of the many smaller ones. The last report is also put inside the casing but firmly cemented to the whistle with Adhesive. The whistle acts as its time fuse. All time fuses must be well primed. The whistle casing should be 3-1/4" long with about 2" of whistle compo. Only experimentation will tell the correct length of the time fuses and whistle comp. since all pyrotechnists work under different factors and use different materials and methods.



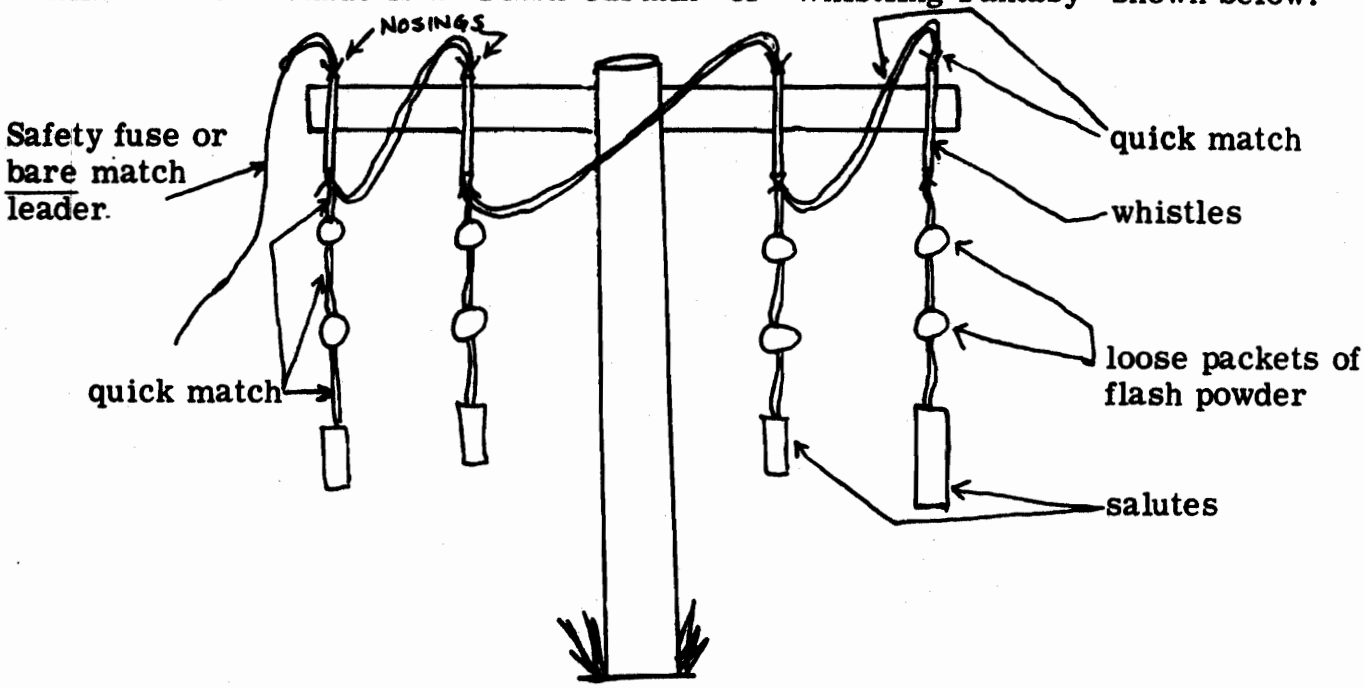
CANNONADES

These are a long string of Cannon Crackers or salutes that are connected by quick match. When ignited their effect is like an old-time cannon bombardment. Two posts (2 x 4's or larger) should be put in the ground about 20 to 50 feet apart. They should each be about 6' high. A strong wire is connected between their tops and a number of pieces of strong twine about 18 inches long are tied to it about 18" apart. The salutes are tied to these pieces of twine. Quick match is then led to each of them and secured in place with Adhesive. Make sure that there is a piece of bare match going into the salute and not all piped match. A long length of safety fuse or bare match is connected to the first end of quick match by twine. Another item



Cannonade

similar to a cannonade is a "Flash Curtain" or "Whistling Fantasy" shown below.



Flash Curtain

RAINBOW REPORTS

These are formulas for flash powder that ignite with various colored flashes. If confined in even the loosest of containers they will still explode with a good-sized report.

A. Red
- Magnesium, powder 1
- Strontium Nitrate 1

B. Green
- Magnesium, powder..... 10
- Barium Nitrate 10
- PVC..... 1

C. Yellow
- Magnesium, powder..... 1
- Sodium Oxalate 1
- Potassium Perchlorate ... 1

D. Violet
- Magnesium, powder 10
- Potassium Perchlorate 10
- Cupric Oxide 3
- Strontium Nitrate 3
- PVC..... 1

E. Blue
- Magnesium, powder 10
- Potassium Perchlorate 10
- Paris Green 3
- PVC 1/2

F. White
- Magnesium, powder..... 1
- Potassium Perchlorate..... 1

NOTE: The Magnesium powder should be at least 100 mesh or finer.

BASIC WHEELS AND REVOLVING PIECES

(L-103)

I. INTRODUCTION

Wheels and revolving pieces present to the pyrotechnist one of the best means display his imagination and artistic ability to the fullest extent. So much can be eated using so little actual physical means. Revolving pieces can be effectively ed in the smallest backyard display, in medium-sized displays for groups, parties, country clubs, to the largest stadium sized exhibitions. Many other forms of reworks depend on size for their effect. This is true of "Niagara Falls" effects, d some aerial shells.

Revolving pieces provide not only showers of sparks and fire but motion and imation as well. Thus they are able to provide a varied and interesting display themselves. Since many of the more interesting and artistic effects take much nd labor, revolving pieces in general, not to mention the more elaborate creations, ve tended to disappear from exhibition as well as commercial fireworks. The rious pyrotechnist should not let this deter him from creating his own imaginative heels, either large or small. A truly well balanced display will include a varied lection of revolving pieces.

Most wheels and revolving pieces can be constructed and displayed with comrative safety. However, there are some items that have more than uncommonly ngerous compositions. Therefore, all safety precautions given in this treatise ust be followed to the letter.

Certain principles and pyrotechnical theory are also given so the pyrotechnist n better understand the processes that are involved in making revolving pieces. hese should be read and must be understood before actually making any of the items scribed. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since all fireworks items consist of three main parts, viz., a composition, a sing, and a means of ignition, the following format is adopted to make their conruction clearer. First, the composition(s) that are required are given. Second, e casing's qualities, dimensions, etc., are listed. Third, the ignition mechanism(s) cessary for proper performance are described. Fourth, any special materials ems that neither make up part of the composition nor the casing but are necessary r their proper function) are listed. Fifth, any special tools that are required are ven. And sixth, the manipulation and procedures necessary in combining all of e above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive anual. All of the formulas, processes and procedures are proven and have been ed with success. Many have never before been available to the great majority pyrotechnists. However, Westech can take no responsibility for any damage or jury resulting from use or misuse of this material, since we have no control over e conditions of use. The purchaser and user take full responsibility. Pyrotechnics n be a fascinating and rewarding occupation. Do not compound it with tragedy nor ve it a bad name through carelessness or thoughtlessness.

II. THEORY AND GENERAL PRINCIPLES

Wheels and revolving pieces function on the same principles as the rocket. burning composition confined within a cylindrical case produces gases which xert pressure on the walls of the case. If the case were closed, en the pressure would be exerted equally on both ends and the case would remain ationary. However, there is a hole in one end. This allows the gases to escape th a corresponding decrease in pressure at this end. Since the pressure at the posite closed end is now greater as the result of the loss of gases at the open end, pushes the case in the direction away from the closed end.

A difference between the rocket and a wheel "driver" is that the rocket needs produce a tremendous amount of force within a matter of a few seconds or less. o achieve this, the rocket is charged so that there is a conical hollow inside its wder core. In this way, not only the end of the composition burns, but also the wder along the walls of the hollow. A very large amount of area of the powder is us allowed to burn at once and produce the needed force.)

On the other hand, wheel drivers are intended to produce a smaller sustained nount of force over a longer period of time. Thus they are charged without a nical hollow so only the end of the powder burns. So charged, there is less area the powder to burn at once so it produces less force but over a longer period. here is much less force required in order to spin a balanced, light weight wheel ound an axis than to overcome the force of gravity and project the same weight em upward to a great height.

Wheels are generally classified as to the number of drivers they have, i.e., ne case," "two case," "six case," etc. They can be "single action": only one iver burning at a time; "double action": two drivers burning at once; or "multiple tion": more than two drivers burning at once.

Wheels can also be endlessly varied and garnished. Thus, there are "Reversing heels": wheels that start one way and then turn the other; "Colored", "Rainbow", or osette" wheels: wheels that have small lances or colored pots attached to them so to burn along with the drivers: wheels with whistles and/or salutes; drivers with rious compositions so as to vary their effects of sparks and flame as they turn; stop-art" wheels, "delay" wheels and many, many others. Imagination is the only limit.

The various drivers and garnishments on wheels are fired with quick match safety fuse. When effects are to be delayed, safety fuse is used. For simul-neous firing, quick match is employed.

The actual wheels or other types of frameworks to which the drivers are tached should be as light in weight as possible but also quite strong. Ready-made heels should be used if at all possible, since it is sometimes quite difficult to combine e above qualities in homemade wheels. Pine is an excellent material for the con-ruction of frameworks, etc. Wheels and all lightly colored structures should be ained or painted a flat black so they are invisible and not interfere with the patterns sparks and fire.

III. COMPOSITION FORMULAS

The more meal powder a composition has the more force it produces. Thus r small or light-weight wheels, drivers may be used with smaller proportions of eal powder, or only one driver need burn at once. For heavier and more elabore wheels, more drivers need to be fired at one time, or more meal powder be lded to the composition. Only experimentation will tell how much meal powder add to or delete from a composition, each type of wheel being different.

The size of a wheel will generally determine how rapidly it should revolve, id this, in turn, will dictate the amount of meal powder in the composition and/or e number of drivers burning at one time. In general, small wheels and saxons ıould revolve with great speed. Larger wheels should revolve quite slowly, but ey should not be so slow as to cumbrously lumber around their axis. If any reolving piece or wheel revolves too slowly add meal powder; if it revolves too fast ecrease the amount of meal powder. (All parts are by weight.)

1 (Saxons)		#2 (Fierce Gold)		#3 (Chinese Gold)	
Ieal Powder	4	Potassium Nitrate	18	Potassium Nitrate	18
otassium Nitrate	2	Sulfur	5	Sulfur	5
ılfur	2	FFFg Black Powder	12	Iron, filings or borings	12
harcoal, dust	1	Charcoal, dust	3	Charcoal, dust	3
harcoal, mixed*	1	Charcoal, mixed*	2	Charcoal, mixed*	2

4 (Brilliant Gold)		#5 (Silver)		#6 (Silver)	
otassium Nitrate	18	Potassium Perchlorate	8	Potassium Nitrate	6
ılfur	5	Aluminum Metal, bright	2	Sulfur	1
teel, needle filings	12	Aluminum, flitters	1	Charcoal, dust	1
harcoal, dust	3	Red Gum Yacca	2	Titanium, coarse	3
harcoal, mixed*	2				

NOTE: Charcoal, mixed, is a combination of various mesh sizes of charcoal. he more varied, the better. This will give a shower of sparks that will have nmediate through prolonged burning durations. A general rule is that the larger ıameter the driver, the coarser should be the charcoal.

IV. PRODUCTS OF MANUFACTURE

. Single Case

Saxons. These consist of a single case made to revolve in a plane of its axis y jets of fire projected through holes, one at either end, and at right angles to the xis. Saxons revolve about a nail driven through the center of the case into a post r other support. They may be double action: both holes fire simultaneously, reforcing each other; single action: only one end fires at a time, the other end tarting just as the first finishes; or reversing: the second end fires after the first ut reverses the direction of spin. Each of these varieties may also have one or vo small cases charged with color compositions attached to the side of the case, roducing a ring of color inside the fire of the saxon.

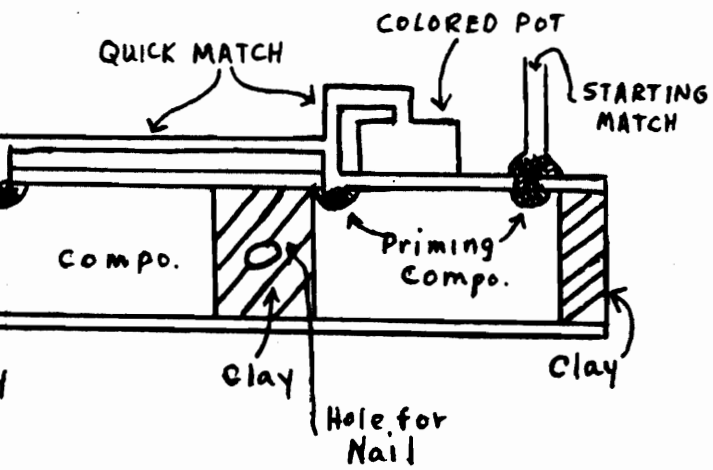
Composition: Formulas #1, #5, or #6

Casing: These should be wet-rolled of Kraft or Manila paper. They may be ny size but those between 1/2" to 3/4" I.D. are generally used. The following roportions work well. Taking the inside diameter (I.D.) as 1, the outside diameter).D.) should be 1-1/2 x the I.D., and the length x 10 the I.D. The ends are closed ith rammed, dry clay.

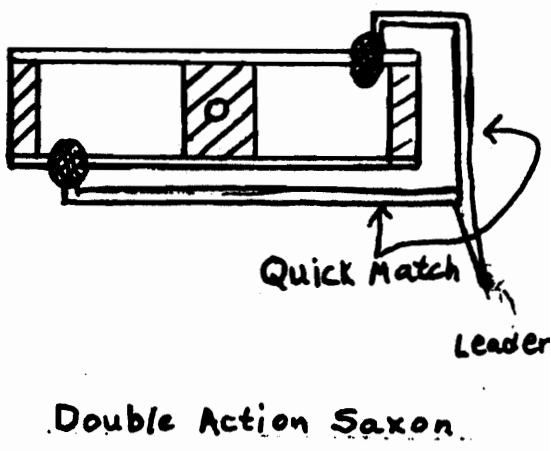
Ignition: Quick match, and black match (or safety fuse).

Tools: A rammer one inch longer than the length of the case and of the ame I.D. It may be cut from a wooden dowel or aluminum rod. A mallet, referably of rawhide, a drill (about 3/16" dia.), and a scoop to measure the correct mount of clay and composition.

Manipulation and Procedure: Stand the casing on one end on a firm surface, our in some clay, and then ram solid with about ten blows from the mallet and ammer. Enough clay should be used so as to make a plug the same thickness s 1/2 I.D. of the case. The whole quantity of clay should be introduced at once, ot in many small portions. Now drive in small portions, Formula #1. Introduce ist enough each time so when it is driven with ten blows it rises about one I.D. nside the case. When the composition reaches about 1/4" from the center of the ase, clay is driven for 1/2". Then composition is again rammed so it comes to ithin one I.D. from the end of the case. Clay is then driven in to the top. A hole s bored about 3/16" in diameter and just through the case as near to each of the layed ends as possible. If the saxon is to be "reversing", then drill holes on the ame side; otherwise they are bored on opposite sides. Bore a hole all the way rough the center of the case (where the 1/2" clay plug is located) at right angles o the other two holes. Now bore one more hole just through the case as near to the enter clay portion as possible and on the same side to one of the end holes. Insert piece of quick match in this hole, lead it over the center clayed portion and insert the hole on the opposite end. Insert a piece of blackmatch or safety fuse in the ole at the other end. Before the match is inserted, all three fuse holes should be ell primed. After the priming is dry, the whole saxon should be rolled up in a ew turns of paper to secure the quick match and protect the holes from any premature ignition from sparks.



Reversing, Colored Saxon



Double Action Saxon

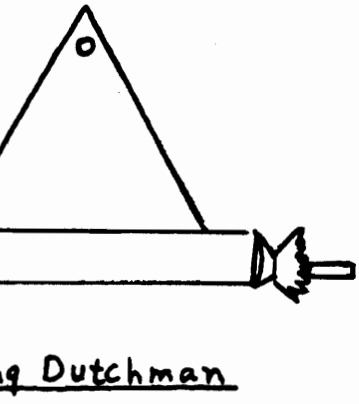
. Flying Dutchmen.

These also go by other names, sometimes being classified as Triangles, or s Saxons, or in a class by themselves. They have the same composition, casing, nd ignition as the Saxon.

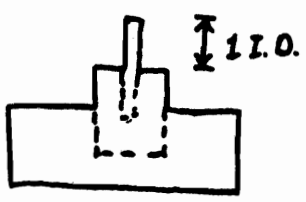
Materials: Professional Pyrotechnic Adhesive, a triangular piece of wood pine is good) or 1/8" chipboard. It should be cut in an equilateral triangle, each ide having the length of the casing minus two I.D. A hole should be bored through ne of the angles as shown.

Tools: A special ramming base described as follows: drill a hole the same iameter as the I.D. of the case and 3/8" deep in a block of wood. Insert and glue n place a piece of wooden dowel 1/2" long. When the glue is well dried, drill a ole in the center of this dowel 3/8" deep x 1/3 the I.D. Insert in this hole a dowel ut so that it protrudes above the surface of the larger dowel the length of 1/2 I.D. f the casing. Two rammers both 1" longer than the casing and of the same I.D. ne should have a hole drilled in one end such that the rammer can fit over the maller of the two dowels of the ramming board. A mallet, preferably of rawhide, nd a scoop for measuring composition and clay are also needed. Of course, luminum will make better tools than wood.

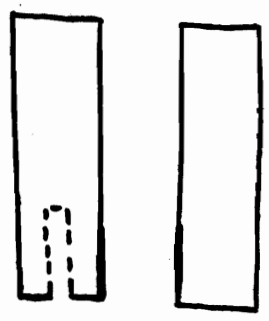
Manipulation and Procedure: Slip the casing over the ramming base and sing the rammer with the hole, ram in with ten good blows enough clay to form a hickness of 1/2 I.D. As always, the clay should be poured in all at once. Now rive a scoopful of composition with ten good blows. The scoop should hold just nough composition so that when it is driven it rises about 1/2" within the casing. Continue driving composition until it has come to within 1 I.D. of the asing. Now drive in just a small amount of clay to cover the composition. Prime he fuse hole and cavity well and insert a fuse. When the priming is dry, roll a ew turns of paper around the casing. The paper should be long enough so it ex- ends about 1-1/2" past each end. These loose ends are called "nosings." They hould be twisted and tucked into each end of the casing and around the fuse to ecure and protect it from premature ignition. The completed casing should now e attached with dabs of Professional Pyro Adhesive to the triangular piece of wood.



g Dutchman



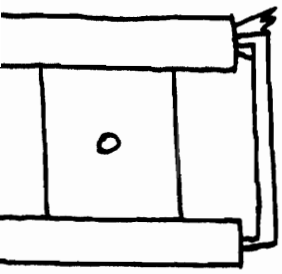
Driving Board



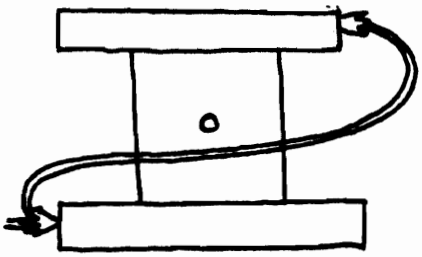
Rammers

Two Case

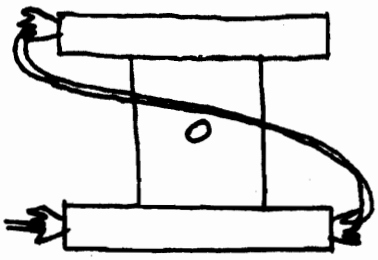
These items are sometimes classified as Triangles but are most often known "Comet Wheels." They may be single or double action. They are made exactly e the above but attached to a swuare piece of light wood instead of a triangular ce. Each side of the piece of wood has the length of the casings minus two I.D. so, if it is to be single action, the first driver is not closed with clay at its butt l. Instead it is primed and a length of quick match inserted. This is then lead to the nozzle end of the other driver. In the case of double action wheels, both t ends of the drivers are closed, the nozzle on the second driver being connected ne nozzle of the first by a length of quick match. Any of the composition formulas t do not have much meal powder may be used for double action wheels. Single ion wheels will require compositions with more meal powder.



Single Action



Double Action



Single Action, Reversing

Three Case (Triangle Wheels)

These also are in various forms, some having six-sided blocks, others with ee. Since the six-sided are the most common, its construction is given here.

Composition: Formula #2.

Casing: Same as the Saxon. Triangle casings generally are not larger than " I.D.

Ignition: Quick match or safety fuse, priming.

Materials: Prof. Pyro. Adhesive, a six-sided piece of 1/8" chipboard structed as follows: With a compass, draw a circle with a radius equal to the gth of the casing to be used on 1/8" thick chipboard, marking the center. Using same radius, divide the circumference into six equal segments and draw lines necting alternate intersections, 1, 2, 3, forming an equilateral triangle (see ure 1). Now draw three lines from the center to each of these points (shown hed). Draw lines at right angles to these dashed lines a length of 2/3 the length he casing to be used from the center. The area shown as shaded can then be out and a hole drilled in the center, slightly larger than the nail on which it will n. This wooden base can be used as a template to outline additional ones, or a rdboard or metal pattern can be made for the same purpose.

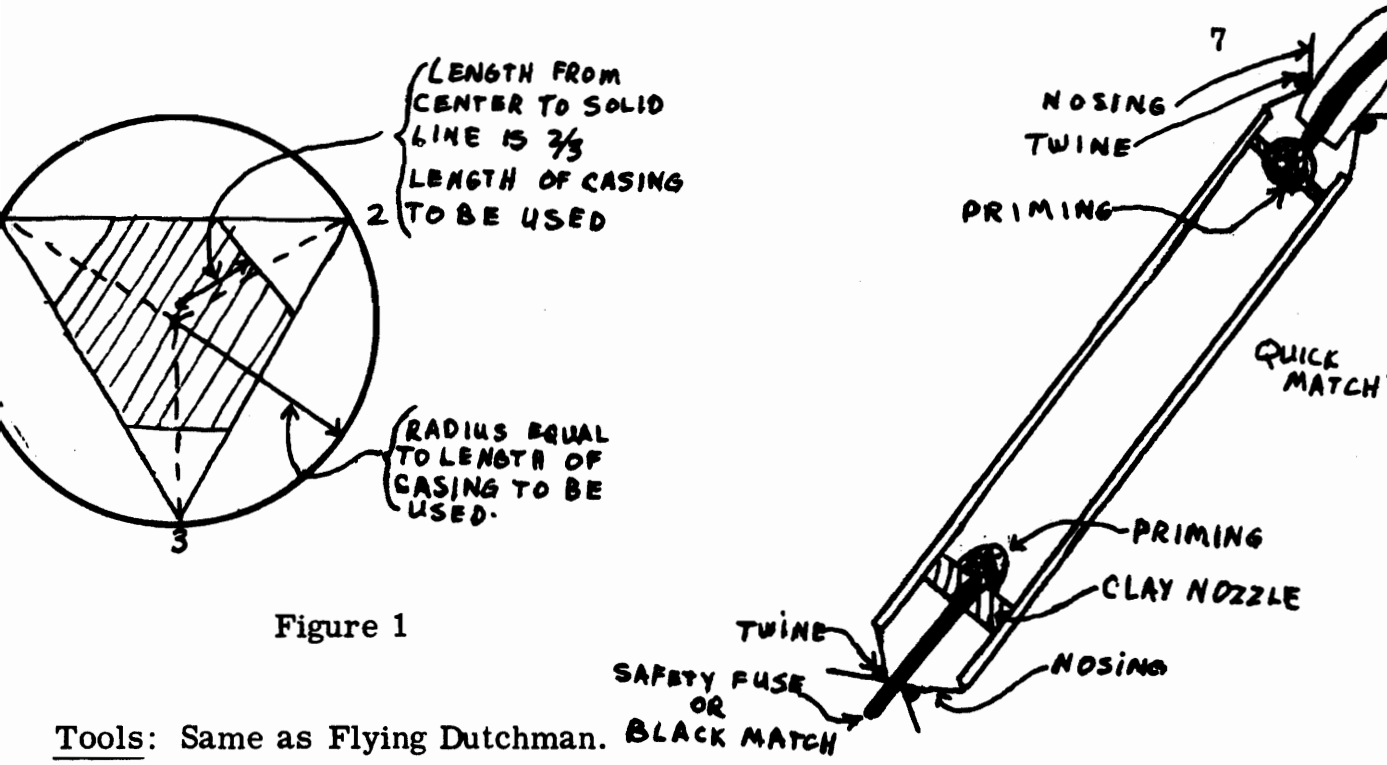


Figure 1

Tools: Same as Flying Dutchman.

Manipulation and Procedure: All drivers are rammed as described under ying Dutchmen, except the first two drivers are not closed with clay at their butt ds. Roll a few turns of decorative or other paper around each casing as described making a nosing. With dabs of Prof. Pyro. Ad., attach a driver to each of the aller sides of the block of wood. Prime all nozzle holes and open ends well. sert a length of safety fuse into the nozzle hole of the first driver and connect the tt end of the first driver to the nozzle end of the second with a length of quick- tch. Connect the second driver to the third in the same way with quick match. en the priming is dry (allow a day or two), twist the ends of the outside wrapping paper around all match and fuse connections, further securing these by tying with ine.

Multiple Case (Vertical Wheels)

These are constructed by fastening four to eight drivers to a wooden wheel de for this purpose. The wheels are usually 18" in diameter, or less. On good rtical wheels, the composition of the various drivers, or sets of drivers, should varied and increase in effect as the burning proceeds. For example, the first se is charged with plain driving composition, the second with steel filings, the rd with pieces of cut stars, etc. Also, the larger wheels may be garnished with rious colored pots, whistles, salutes, reverse their direction of spin, etc.

Compositions: Any.

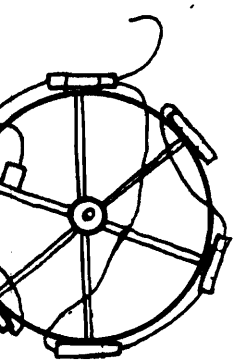
Ignition: Quick Match, priming, safety fuse.

Casings: Same as for Triangles, using 3/4" I.D. or less.

Materials: Same as for Triangles except wooden wheels are used instead
f a wooden block.

Tools: Same as for Triangles.

Manipulation and Procedure: Same as for Triangles. The cases and garnish-
ents should be attached to the wheels with small dabs of Prof. Pyro. Ad., and
ed with twine or #18 guage annealed iron wire. Colored pots should be placed on
e inside of the spokes, (not facing toward you) and so that the direction of the spin
away from the burning end. This is to keep the pot burning evenly (see diagram
). Care should be taken to be sure and use strong burning color compositions for
ots and lances. In order to be strong burning, the compositions must be well mixed.
se mixing sieves. If they are not well mixed, they will not burn evenly and with
nough force to keep from being blown out by the revolving wheel. This is especially
ue of those placed nearer the outside. Colored pots and lances must burn the same
ngth as the drivers, all stopping at the same time. If colored pots are not well
ecured to the wheel, they are easily thrown off. Use small wire nails and a dab of
rof. Pyro Ad. to secure them in the same manner as lance work (see diagram 2).
arnishments should be placed so they balance the wheel as nearly as possible. Make
ure all quick match connections are tight. They should be tied with twine when-
ver they cross a spoke or touch the wheel rim.



ACTION, REVERSING,
LORED WHEEL

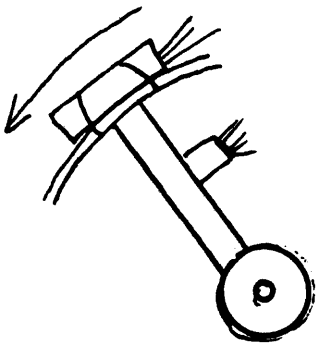


DIAGRAM 1

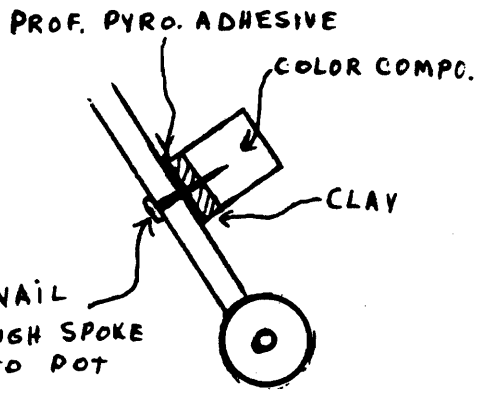


DIAGRAM 2

EXHIBITION WHEELS AND REVOLVING PIECES

PART I (VERTICAL)

(L-103A)

I. INTRODUCTION

The single wheels and revolving pieces that make up this class are generally
in diameter or larger. Where multiple wheels are used, smaller sizes are em-
yed. However, smaller scale versions can be made and be very effective even
small backyard displays.

All of the general principles, theory, formulas, safety precautions, etc., that
re discussed in L-103 should be observed and applied. All wheels, frameworks,
other structures should be well constructed and as light in weight as possible.

The turning cases on large revolving pieces should be of various diameters.
e largest sizes should start the wheel spinning and then the drivers should become
gressively smaller. This is because when the wheel is first fired, all the cases
still charged and the wheel is quite heavy. As the cases progressively burn, the
eel becomes lighter and less force is needed to make it revolve. Whenever a wheel
o reverse, the same size driver(s) as the previous one(s) should be used, as addi-
nal force is needed to stop the spin and start it in the new direction.

When creating your own effects, care should be taken not to have too many dif-
ent effects happening at the same time. Otherwise the display is mere confusion.
agination should be tempered with good taste. For example, do not have a revolving
with an outside set of gold drivers, then a small wheel with silver drivers in the
ter spinning the opposite way, and colored pots between these two. Generally, only
different kinds of visual effects (direction of wheel spin, turning case composition,
or pots, etc.) may be happening at one time. Audio effects such as whistles may
added whenever desired without bringing confusion. Such pointed audio effects as
utes require more discrimination and are usually saved for a finale.

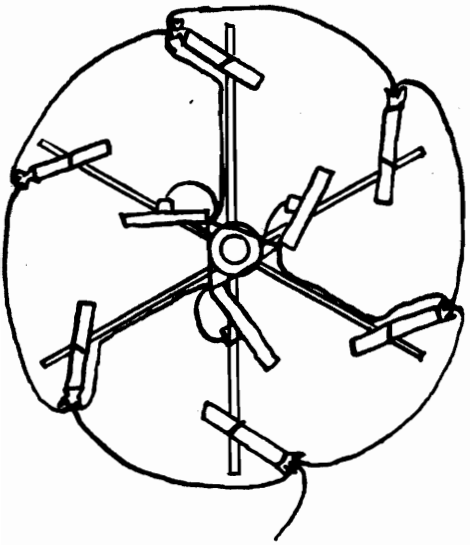
When matching small wheels or saxons to larger revolving pieces, care should
taken to not allow the quick match pipe to be secured inside the small driver's nosing
saxon's outer wrapping of paper). If this happens, the smaller piece may be
ined to the larger piece with the match pipe and not revolve. A good way to avert
s is to allow the piping to enter and leave the nosing as usual but tie the nosing around
bare match instead of the pipe. Also, use a quick match made with good quality
wder (either commercial meal powder, or the type described in L-TR4). If inferior
wder is used, it will not have enough force to blow the pipe and match connection free.

In general, all exhibition wheels should be placed on wooden posts six to twelve
t above the ground.

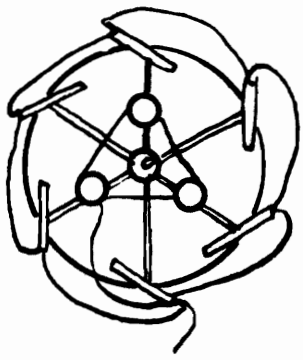
II. PRODUCTS OF MANUFACTURE

Revolving Suns

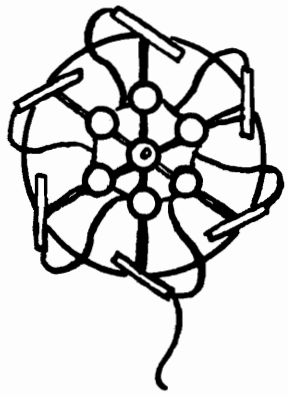
These are light wooden frames made in the shape of the spokes of a wheel. They erally have six spokes but may have more. They may be colored, or garnished in y ways. Sometimes they have two rims to which are attached the gerbes. Revolv- suns differ from regular vertical wheels in that they have gerbes rather than ers to propel them. Gerbes have less meal powder than wheel drivers. Gerbes meant to provide more of a shower effect instead of motive force. Thus, revolving s usually have six or more gerbes firing at once to provide enough force to turn n. It is for this reason that revolving suns are usually not made to reverse. The ond set of drivers would be hard pressed to stop the spin and start the device re- ing again in the opposite direction. Revolving suns should start to turn very slowly then continue to turn with a regular movement. Revolving suns also differ from els in that the turning cases are placed obliquely around the circumference, rather tangentially. The correct angle is about 45 degrees. This is best done by attach- each driver to the rim and to a spoke. If the number of drivers (gerbes) is greater the number of spokes, then a smaller inner rim is used and the gerbes attached to two rims.



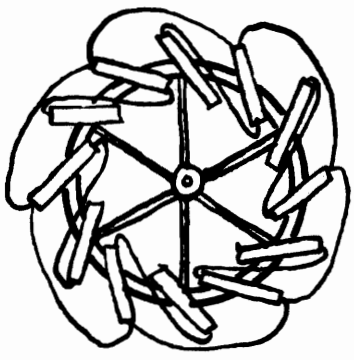
REVOLVING SUN W/ COLORED SAXONS



REVOLVING SUN W/ 3 POTS



REVOLVING SUN W/ 6 POTS

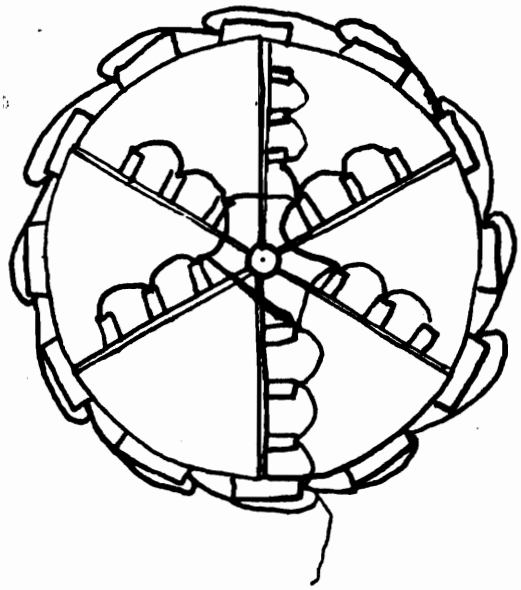


REVOLVING SUN- DOUBLE VOLLY

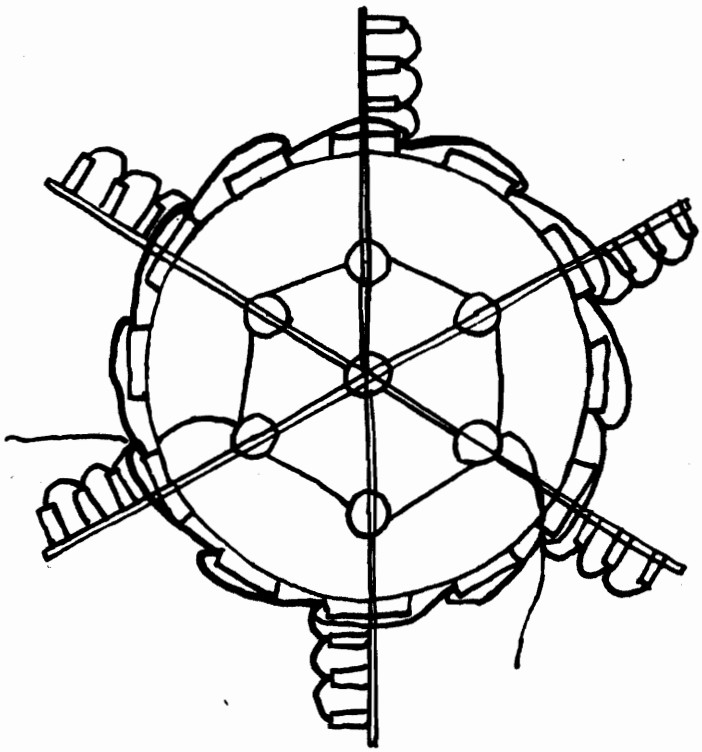
REVOLVING SUN - COLORED, DOUBLE VOLLY

Compound Exhibition Wheels

These are essentially large, multiple action vertical wheels that are heavily nished.



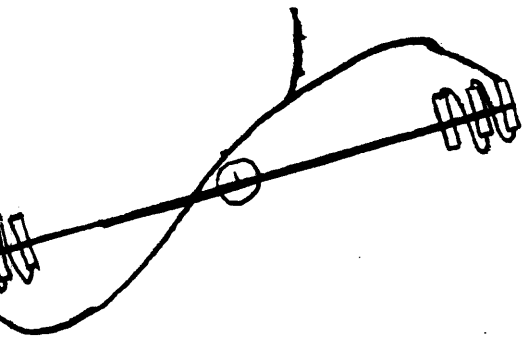
ES IN CENTER AND ALL
ERS AROUND WHEEL FIRE AT ONCE



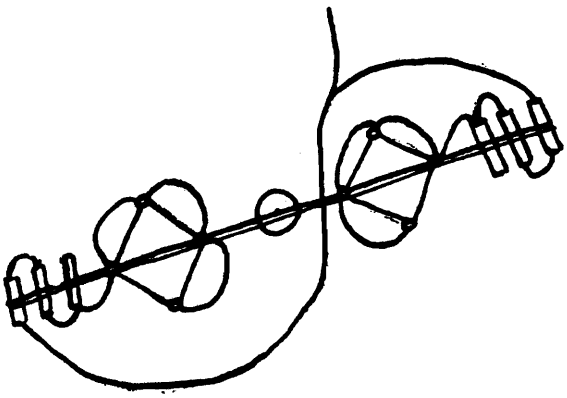
LANCES ON OUTSIDE, COLORED POTS IN CENTER, AND DRIVERS ON WHEEL ALL FIRE AT ONCE. SAXONS MAY BE SUBSTITUTED FOR THE COLORED POTS.

Windmills

These are made of long, thin, light pieces of wood with an axle hub in the center. heir extremities are drivers placed at right angles that fire in pairs (one at each end) e amount of meal powder in the turning cases will vary greatly depending upon the size he piece and type of garnishments. They may be reversing or one-way.



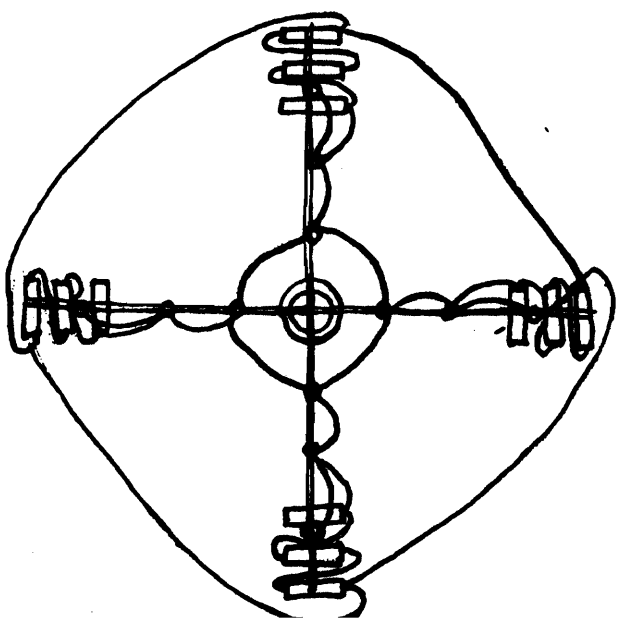
WINDMILL - TRIPLE VOLLEY



WINDMILL - DOUBLE REVERSING, WITH LANCES

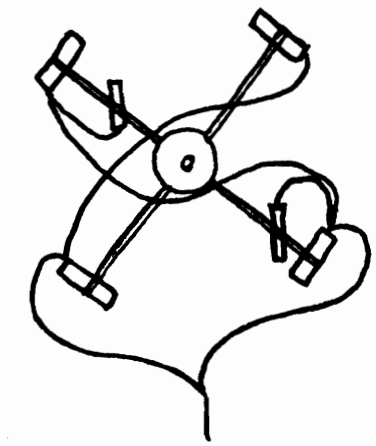
The following piece is very effective. The colored pots are charged with very ght color compositions and the drivers only with meal powder and charcoal dust. The portions must be determined with experimentation, depending upon the size of the ce. Start with about 84 parts meal powder to 16 of charcoal. This driver composi- n will give very few sparks and if the colored pots are bright enough, they should hide sparks with their brightness. All that will be seen is a circle of revolving flares hout any visible motive force, the roar and hiss of the invisible drivers adding to effect.

Also very effective is to start a similarly-constructed piece with regular gerbes no colored pots. Have the last drivers be of the meal powder/charcoal composition fire the bright flares at the same time. What results is a very effective "Trans- mation Wheel," transforming itself from a regular type wheel display of golden wers to one of bright revolving colors.

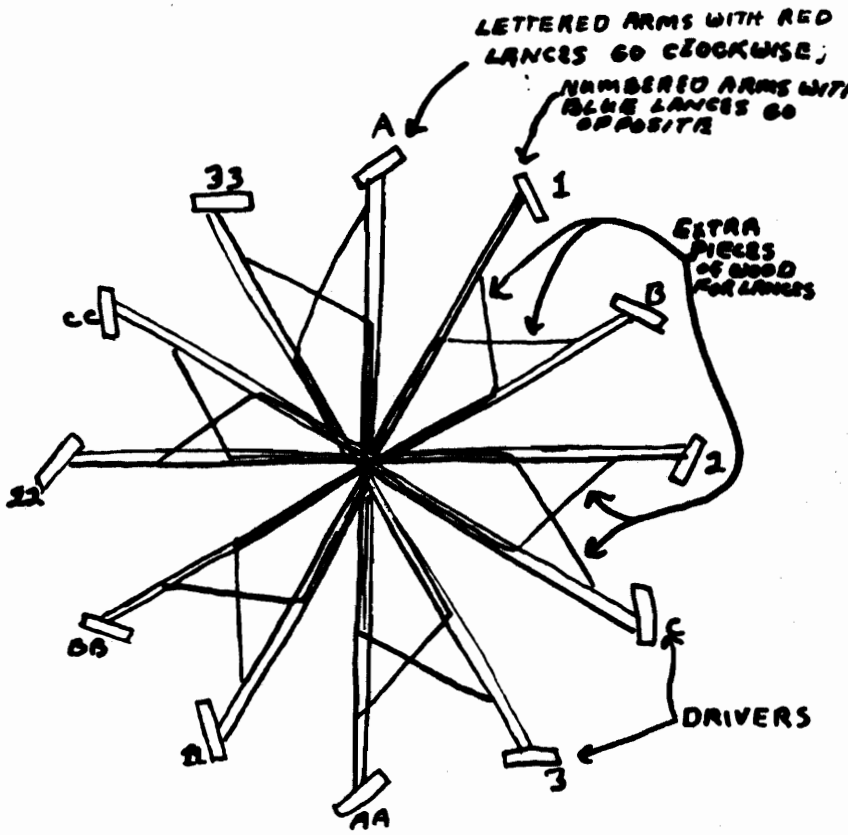


Chromatropes

These make an extremely effective display. They are flat bars of wood pivoted e center with drivers placed at an angle of 45 degrees on their ends. At this angle form an extraordinary fine effect by the intersections of the various streams of Two, four, or six pairs of arms are used, each pair revolving in the opposite ction. Two sets of drivers may be used, the second set either reversing the whole e or continuing the same direction. The front pair of arms may carry two saxons, vertical wheel may be placed in the center. Most effective of all is to place lance- of geometric form on the arms. The intersection of these, forming ever-changing ietrical designs, adds greatly to the intersection of the fire.



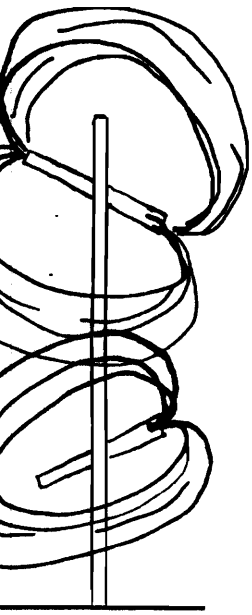
MATROPE WITH TWO PAIRS
MS AND TWO SAXONS



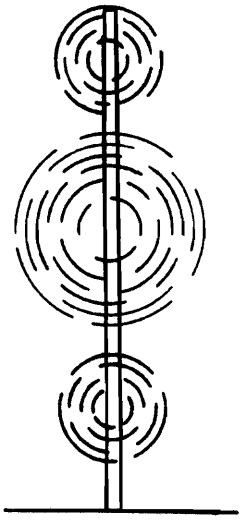
6 PAIRS OF ARMS, WITH EXTRA PIECES OF WOOD ATTACHED FOR GEOMETRIC LANCEWORK

Multiple Exhibition Vertical Wheels

These are many vertical wheels placed in some type of a pattern. They are very ctive if they are reversing—the whole pattern changing direction one or two times. very effective is to vary the driving composition so all wheels fire with one type then change to another. Of the utmost importance is that all corresponding drivers he various wheels burn the same length. This is effected by charging them with the e weight and same type of composition and ramming them the same amount.

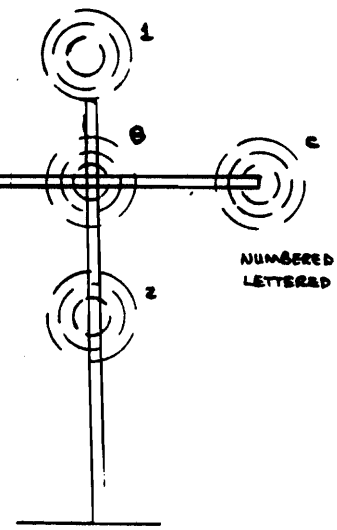


MYSTIC CIRCLES



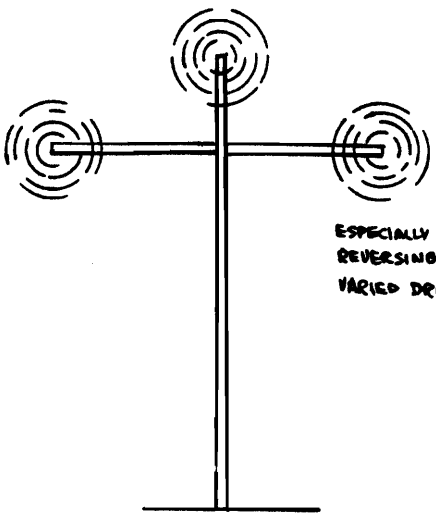
MIDDLE GOLD WHEEL GOES ONE DIRECTION; OUTSIDE WHEELS (SILVER) TURN THE OPPOSITE WAY.

DIAMOND BROACH



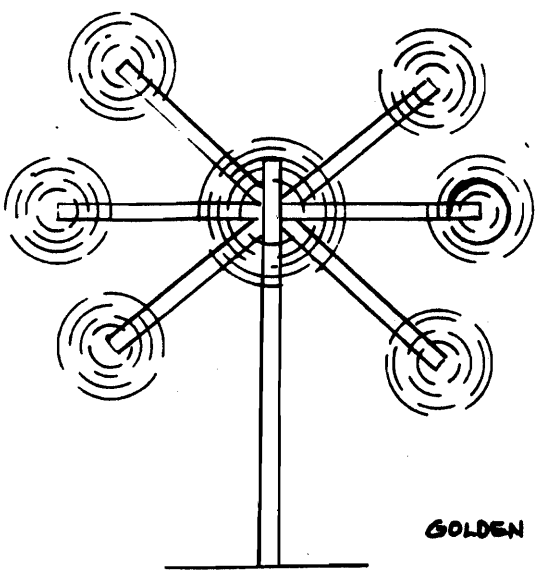
NUMBERED WHEELS ARE GOLD. LETTERED WHEELS ARE SILVER.

FLITTER SET



ESPECIALLY EFFECTIVE WITH REVERSING WHEELS AND VARIED DRIVER COMPOS.

THREE MUSKETEERS

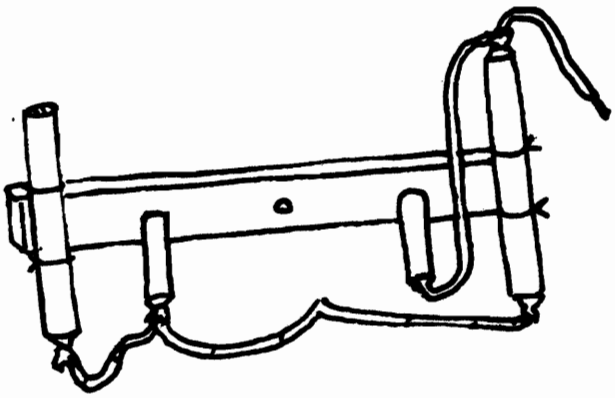


GOLD OUTSIDE WHEELS GO LEFT, THEN CHANGE TO RIGHT. SILVER INSIDE WHEEL DOES THE OPPOSITE.

GOLDEN CLUSTER

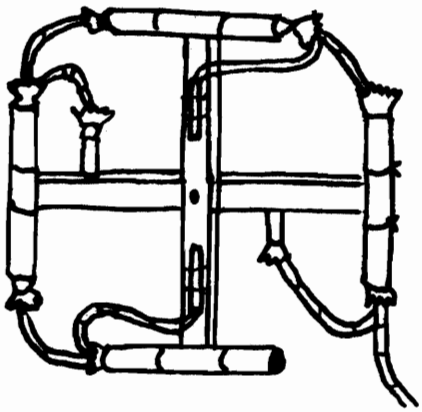
ancy Wheels

Airplane Spin - This is constructed as shown. The first driver is silver and burns with a red pot. The second driver is gold and burns along with the green pot. This ery effective piece as it transforms itself from a red and silver wheel to a gold and one.



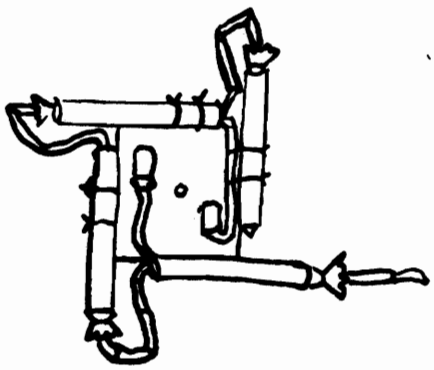
Airplane Spin

Flash Wheel - This is constructed as shown, with whistles and colored pots.



Flash Wheel

Colored Rosette Wheel - A very beautiful piece. The two pots are red and all s are charged with formula #7. They are placed around a square piece of wood.



Colored Rosette Wheel

EXHIBITION WHEELS AND REVOLVING PIECES

PART II (HORIZONTAL)

(L-103B)

I. INTRODUCTION

The single wheels and revolving pieces that make up this class are generally !" in diameter or larger. Where multiple wheels are used, smaller sizes are nployed. However, smaller scale versions can be made and be very effective ·en for small backyard displays.

All of the general principles, theory, formulas, safety precautions, etc., at were discussed in L-103 should be observed and applied. All wheels, frame-)rks, and other structures should be well constructed and as light in weight as)ssible.

The turning cases on large revolving pieces should be of various diameters. ıe largest sizes should start the wheel spinning and then the drivers should be-)me progressively smaller. This is because when the wheel is first fired, all e cases are still charged and the wheel is quite heavy. As the cases progressive- burn, the wheel becomes lighter and less force is needed to make it revolve. henever a wheel is to reverse, the same size driver(s) as the previous one(s) ıould be used, as additional force is needed to stop the spin and start it in the ew direction.

When creating your own effects care should be taken not to have too many fferent effects happening at the same time, otherwise the display is mere con-sion. Imagination should be tempered with good taste. For example, do not have revolving sun with an outside set of gold drivers, then a small wheel with silver ·ivers in the center spinning the opposite way, and colored pots between these two. enerally, only two different kinds of visual effects (direction of wheel spin, turn-g case composition, color pots, etc.) may be happening at one time. Audio effects ıch as whistles may be added whenever desired without bringing confusion. Such)inted audio effects as salutes require more discrimination and are usually saved r a finale.

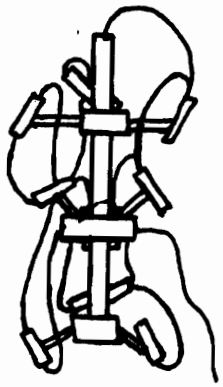
When matching small wheels or saxons to larger revolving pieces, care should taken to not allow the quick match pipe to be secured inside the small driver's)sing (or saxon's outer wrapping of paper). If this happens, the smaller piece may chained to the larger piece with the match pipe and not revolve. A good way to ·ert this is to allow the piping to enter and leave the nosing as usual but tie the)sing around the bare match instead of the pipe.

In general, all exhibition wheels should be placed on wooden posts six to twelve et above the ground.

PRODUCTS OF MANUFACTURE

Caprice

For a compact piece this is one of the most effective made. It consists of a eel with three tiers of three cases each. Each tier is similar in appearance to three single triangle wheels superimposed at distances about equal to their diameter. Each case at the end of each spoke is so fixed that it varies the direction of the fire. The cases are led up in the following order: First, one case fires horizontally; then another fires upward; then another fires downward; then another fires horizontally; two cases now fire together (one up and the other down); finally the four remaining cases fire, one in each direction (one up, one down, one horizontal and one vertical).



Caprice

Furiloni Wheel

This is similar to the Caprice. It has, however, two tiers of three cases each l one vertical fountain. Use formula #4.

Revolving Fountain

This is a very effective piece. It consists of a wooden hub bored to turn on a rtical spindle. It has two spokes fitted with gerbes for turning, and has playing rtically a large gerb and Roman candles. The turning gerbes play tangentially l slightly upwards.

Fiesta Display Wheel

This is also very effective. It consists of a hub like the above but with six kes. The spokes are fitted with gerbes so that they fire in pairs, opposite each er. The center has a fountain matched to fire with the second set of gerbes. If se are gold, then the fountain should be silver. A battery of Roman candles es with the third pair of drivers. A star, or spangle mine fires just as the last r of drivers finish. A few whistles should also be added with the stars in the mine.

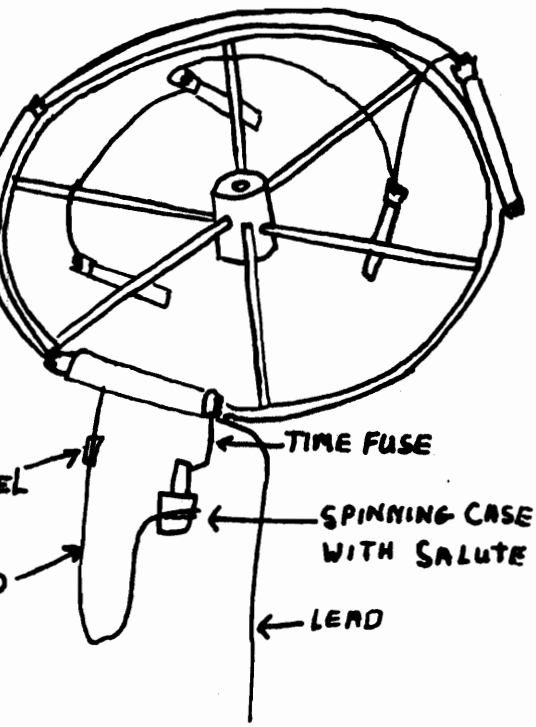
Devil Wheel

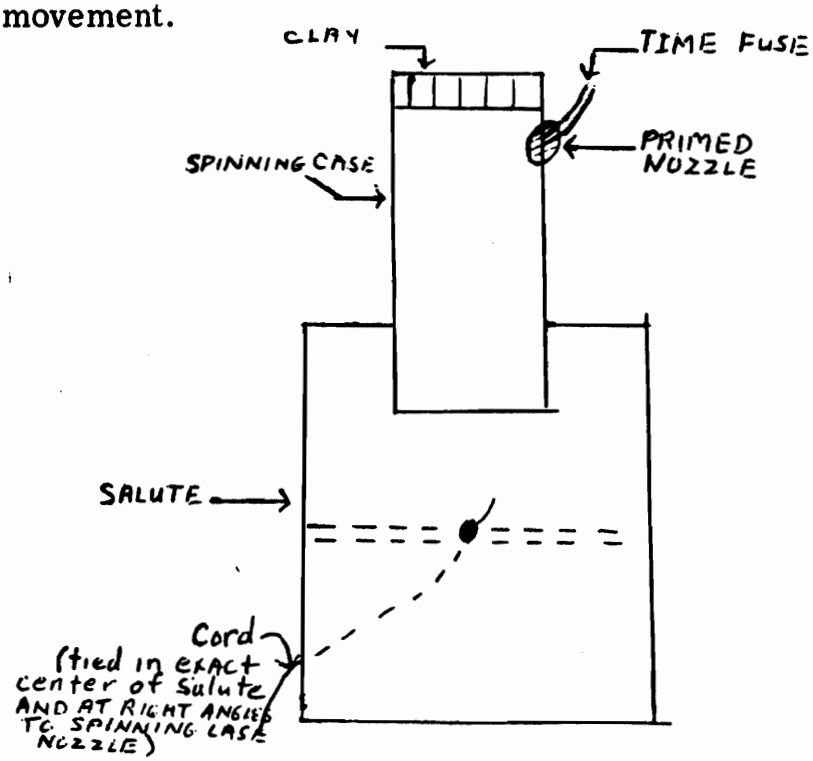
This is one of the most popular of all display wheels. It must be seen (and rd) to really be appreciated. It never fails to elicit applause and laughter and ms to be possessed with a "devilish personality," hence the name. Briefly, its ect is as follows. A circle of sparks and flame develops, revolving in a hori- tal plane. Presently a smaller circle appears on its perimeter, spinning in a tical plane but gyrating wildly up and down as it follows the revolution of the

izontal circle. As it burns out, there is a tremendous blast, which never fails licit a gasp and laughter from the spectators. This series of events is repeated ee times, ending with a revolving fountain spray.

A wooden wheel about two feet in diameter is needed. To its perimeter are ched three equally-spaced drivers. At the center of each driver a strong cord, ut two feet long, is attached to the rim of the wheel by means of a swivel, similar hose used in fishing. Each of the three cords so attached is tightly fastened to center of a large salute casing. From one end of the salute casing protrudes a all "spinning" case loaded with saxon composition so as to make it spin about the nt to which the cord is attached. Three gerbes are wired to the spokes, about fway between the rim and the hub and inclined upward at an angle of 30° above horizontal.

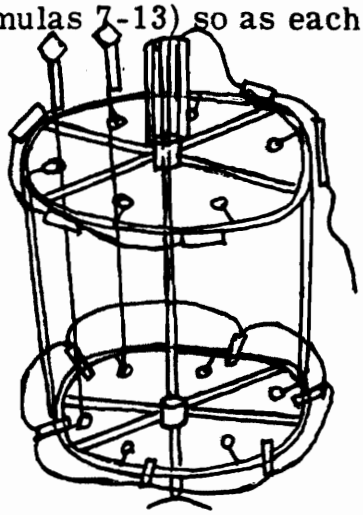
The wheel is matched as follows: Quickmatch is run from the butt end of the t driver to the nozzle of the second, and likewise from the second to the third, hat each will be ignited as the preceding one burns out. A piece of quickmatch un from the nozzles of all three central gerbes to that of the third driver, so that will be lit at once as the latter begins to burn. Now a short time-fuse (1/8" ety fuse is good) of each spinning case is inserted into the nozzle end of the driver ow which it hangs, and the "lead up" inserted in the first driver nozzle. The lead ires both the first driver and its accompanying spinning case. As the wheel begins urn, the time fuse supporting the latter burns through, and it drops to the end of cord tied around its center. The combination of centrifugal force from the olution of the wheel, which throws the spinning case outward, and the more rapid olution of the latter about the point where it is tied, provides a combination of ations that give the effect of a pinwheel attached to one of the horses on a merry-round—including the up-and-down movement.



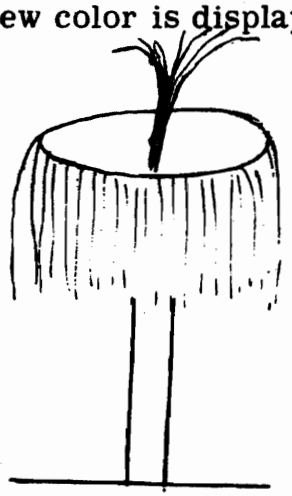


Butterfly Wheel

This consists of a large horizontal wheel with three drivers around the peri-ery matched to fire one after the other. There are also three vertical small wheels saxons nailed to the rim and matched to fire along with the large drivers. A very ective combination is to have colored driver compositions in the small wheels or ons (formulas 7-13) so as each of them fires, a new color is displayed.



Rocket Wheel



Snowstorm Wheel

Rocket Wheel

This is a very attractive piece. It consists of two wheels attached together by ht wooden supports that are tacked to each wheel's rim. The top wheel's axle is gged in its top third so the two wheels rest on a vertical rod and revolve hori-ntally. Around each rim are six screw eyes. Through these pass rockets that are tched to fire at intervals as the wheel revolves by being connected to successive vers. On top is a battery of Roman candles, matched to fire with the second set ot vers. The top wheel is fitted with six "brilliant gold" drivers that are matched to n two at a time, one each on opposite sides. The lower wheel is fitted with three six gerbes wired to the spokes and rim and inclined upward at an angle of 30 degrees give a wider spread of fire. These burn simultaneously with the last pair of drivers.

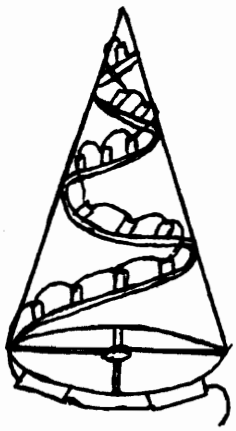
Snowstorm Wheel

This consists of a large horizontal wheel with three drivers charged with a ite flitter" composition, three gerbes fixed evenly around the periphery and point ghtly upward, charged with "Niagara Falls" composition, and a vertical gerbe fixed he center, charged with titanium. The "Niagara Falls" gerbes should not be choked h clay but left open. Mean powder may be added to the drivers if necessary to make wheel revolve at a medium speed. All seven cases are matched to fire at the same e. The piece produces a most striking display.

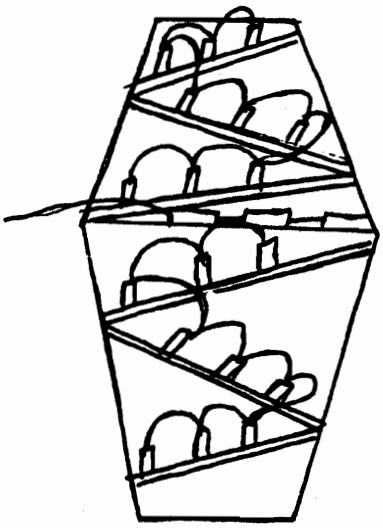
White Flitter		Niagara Falls		Gerbe	
assium Nitrate	17	Potassium Perchlorate	4	Potassium Nitrate	6
fur, flour	3	Aluminum, medium fine	1	Sulfur, flour	1
arcoal, dust	3	Aluminum, medium	1/2	Charcoal, dust	1
imony, Chinese needle	11	Aluminum, flitters	1/2	Titanium, coarse	3
minum, medium fine	10	Red Gum	1		
minum, flitters	3				

Spiral, Helix and Tornado Wheels

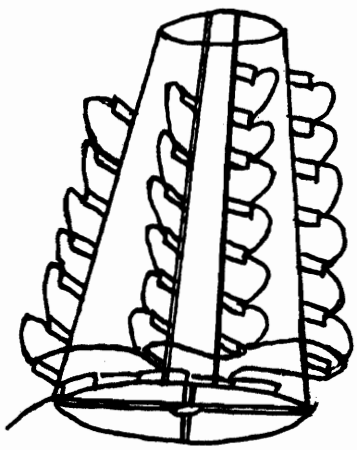
These consist of wheels which have four light supports attached so the form a . Around these supports are wound thin strips of wood bamboo or rattan to form ral. To these strips are attached lances which burn along with the drivers form- very beautiful effect. For "tornado wheels", spiral rattan is not used and the :s attached directly to the supports.



Helix



Spiral



Tornado

Carousel Wheel

These are constructed similarly to the Butterfly wheel, except all three ers burn at once. They are loaded with less meal powder and more metal filings. three small vertical wheels (or saxons) have a colored pot, each of a different r, and all of these burn along with the drivers, making a very spectacular effect.

EXHIBITION WHEELS AND REVOLVING PIECES

PART III (AERIAL)

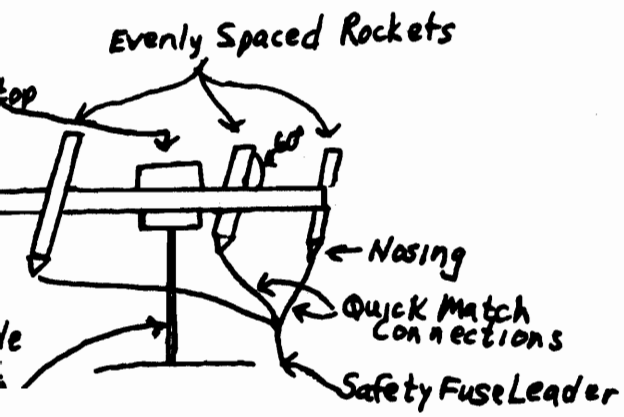
(L-103C)

The wheels that comprise this series are, without a doubt, the most spectacular olving pieces that can be made. Perhaps they are the most spectacular of any type ireworks. They are not often seen nowadays simply because they take much time, e, and patience to construct, and must also have a large area from which to fire them

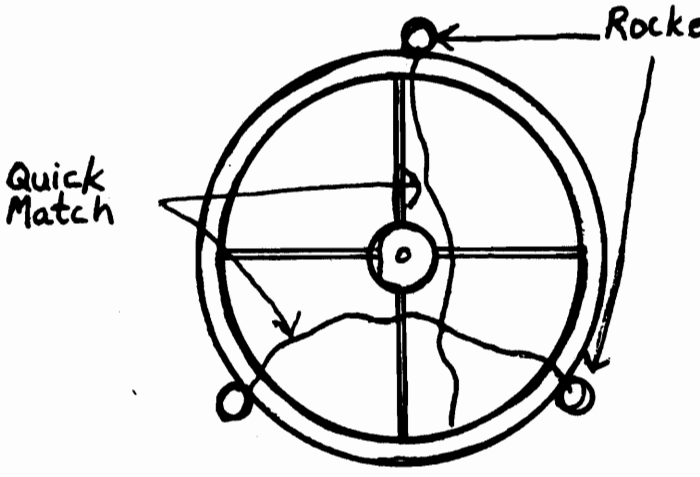
The utmost care must be exercised to have these wheels evenly balanced. If they just slightly off, they will fly off at an angle and not straight up. Needless to say, d-- can be very hazardous. All types of aerial wheels must fly straight up. To achieve , all driver casings must be the same size and each driver have the same weighed unt of clay and composition. All rocket casings must be the same size and have the e weighed amount of clay and composition in each. All quick match connections must ven and as nearly symmetrical and balanced as possible. All garnishments should nce evenly. When everything is in place, the wheel should spin evenly and without "heavy spots", when it is placed on a horizontal axis and lightly turned.

Strong, light weight wooden wheels should be used. It is very desirable to have els for aerial effects ready-made or constructed by a professional cabinet maker.

Gyro Wheels - These are aerial wheels that have rockets to give them both lift and . They are generally 6" in diameter and use three 4 oz. rockets. They are usually ungarnished or end with a salute placed on top of the partially plugged hub. They are e simple to make, as shown in the diagram. The rockets should be tied or wired nly around the outside of the rim. They should be placed so they are slanted at about 0 angle to the wheel rim. The axle should fit well inside the hub so the wheel does wobble before it ascends. But it should not fit too close so as to impede the spin of wheel.

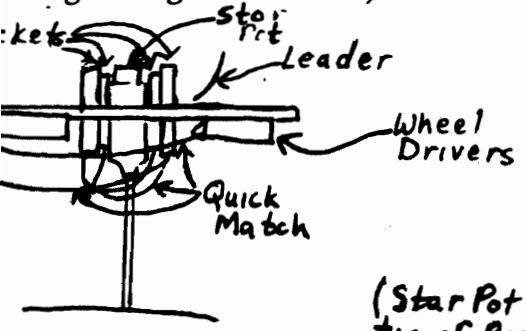


Side



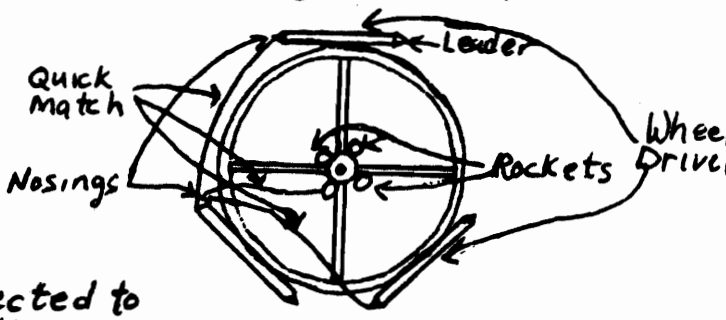
Top

Girandola Wheels - These are larger wheels (about 16" in diameter) that have el drivers to give spin and rockets to give lift. Their construction is given in the grams. For a 16" wheel use three 1/2" I.D. (4 oz. size) drivers if all three are ig to fire at once. Use four 3/4" I.D. (1 lb. size) rockets. The number and/or e of rockets and drivers may be varied, depending on the size of the wheel, type weight of garnishment, number of rockets or drivers firing at one time, etc.



dola (Side)

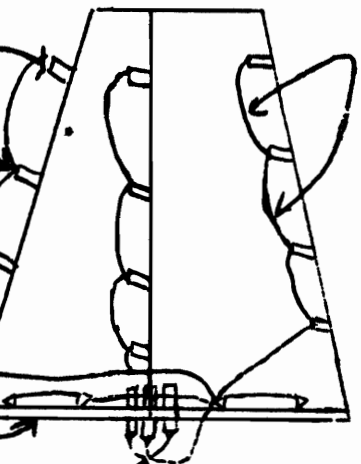
(Star Pot is connected to top of Rocket with Quick Match. It breaks with a Shower of stars at the Apex)



Girandola (Top View)

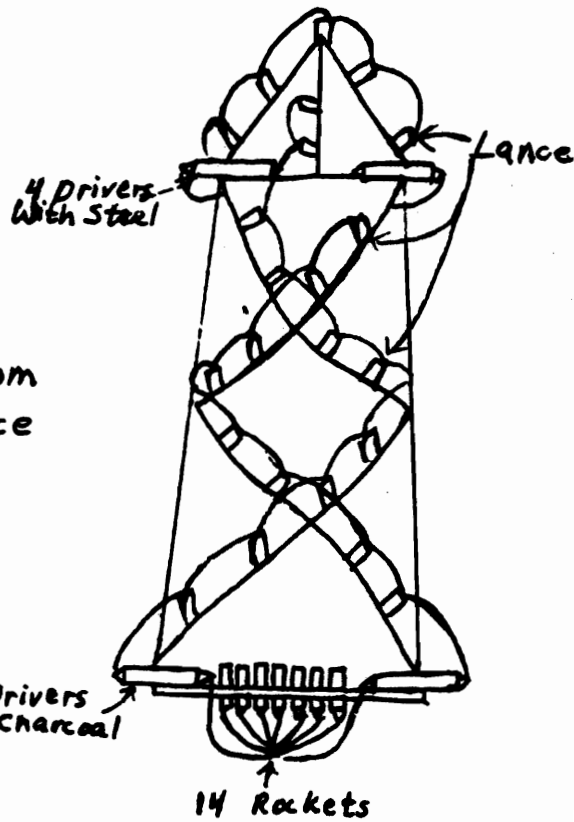
Girandola Wheels

Circus Wheels -- These are constructed in the same manner as the Girandola eels except with larger rockets and turning cases. A light framework is made con- ing of four uprights tacked and wired to the rim of the larger bottom wheel and to rim of a smaller top wheel.



alone, no 2 ckets) 6 Rockets (Fire with last Pair of Drivers)

3 radii of Bottom Wheel Distance



First only lances light, then 4 Drivers, Then last 4 Drivers Plus 14 Rockets, (2 top Drivers light with 2 Bottom Drivers.)

Circus Wheels

BASIC GROUND DISPLAYS

(L-104)

I. INTRODUCTION

Most of these items may be constructed and displayed with comparative safety. However, there are some items that have more than uncommonly dangerous compositions. Therefore, all safety precautions given must be followed to the letter.

Certain principles and pyrotechnical theory are also included so the pyrotechnist can better understand the processes that are involved in making these fireworks. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks items consist of three main parts, a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanism(s) necessary for proper performance are described. Fourth, any special materials (items that neither make up part of the composition nor the casing, nor the ignition mechanism, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material because the conditions of use are beyond our control. The purchaser and user take full responsibility.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II. COMPOSITION FORMULAS +

#1 and #2 (White Fire)	#1	#2
Saltpeter	7	8
Sulfur, flour	1	1
Antimony Sulfide, black		1
Arsenic Sulfide, red	2	

#3 (Blue Fire)	#3
Potassium Chlorate	8
Barium Nitrate	7
Paris Green	6
Shellac, orange	1
Stearic Acid	1
PVC	1/2

#4 (Red Fire)	
Potassium Chlorate	2
Strontium Nitrate	4
Shellac, orange	1

#5 (Pink Fire	
Potassium Perchlorate	4
Plaster of Paris	1
Shellac, orange	1

#6 (Yellow Fire)	
Potassium Perchlorate	2
Barium Nitrate	6
Sodium Oxalate	1
Sulfur, flour	1/2
Red Gum Yacca	1

#7 (Green Fire)	
Barium Chlorate	9
Shellac, orange	2

#8 (Orange Fire)	
Potassium Perchlorate	1
Strontium Nitrate	6
Sodium Oxalate	1-1/2
Shellac	1
Sulfur, flour	1/2

#9 (Purple Fire)	
Potassium Perchlorate	9
Strontium Nitrate	7
Copper Oxide, black	7
Sulfur, flour	5
PVC	1/2

#10 (Gerbe/Fountain/Volcano, Gold)	
Saltpeter	6
Sulfur	1
Charcoal, dust	1
Charcoal, coarse	1/2
*Steel Filings	2

*Coated with Paraffin

#11 & #12 (Gerbe/Fountain/Volcano, Silver	#11	#12
Potassium Perchlorate		3
Potassium Nitrate	6	
Sulfur, flour	1	
Charcoal, dust	1	
Aluminum, bright		1-1/2
Aluminum, flitters		1/2
Titanium, coarse	3	
Red Gum Yacca		1/2

#13 (Flower Pot)	
Saltpeter	12
Sulfur, flour	5
Lampblack	3
Arsenic Sulfide, red	2

#14 (Candle Composition)	
Saltpeter	5
Sulfur	1
Charcoal, 100 mesh	2
Charcoal, 40 mesh	1/2
Charcoal, 12-20 mesh	1/2

#15 (Green Stars)	
Barium Chlorate	9
Shellac	1
Dextrine	1/4

#16 and #17 (Red Stars	#16	#17
Potassium Chlorate	6	6
Strontium Nitrate	6	
Strontium Carbonate		1
Shellac, orange	1	1
Charcoal	2	1
Dextrin	1/2	1/2

+ NOTE: All parts are by weight.

#18 (White Stars)	
Saltpeter	10
Sulfur	3
Arsenic Sulfide, red	3
Dextrin	1/2

#19 and #20 (Blue Stars)	#19	#20
Potassium Chlorate	18	12
Paris Green	4	5
Stearic Acid	2	
PVC	1/2	1/2
Barium Nitrate		4
Shellac, orange		2-1/2
Dextrin	1	1/2

#21 (Yellow Stars)	
Potassium Chlorate	4
Shellac	1
Charcoal, dust	1
Barium Nitrate	1-1/2
Sodium Oxalate	1/4
Dextrin	1/4

#22 (Purple Stars)	
Potassium Chlorate	6
Copper Oxide, black	1
Strontium Nitrate	1
PVC	1/4
Shellac	1

#23 (Silver Stars)	
Saltpeter	10
Sulfur	3
Arsenic Sulfide, red	3
Aluminum, bright	1
Red Gum Yacca	1

#24 (Italian Streamers)	
Saltpeter	8
Sulfur	2
Lampblack	1/2
Sodium Oxalate	4
Dextrine	1/2

#25 (Gold Comet)	
Saltpeter	6
Sulfur	1
Charcoal, dust	3
Antimony, Chinese needle	3
Meal Powder	6
Dextrin	1/2

#26 (Silver Comet)	
Potassium Perchlorate	10
Barium Nitrate	2
Aluminum, bright	7
Shellac	1

#27 (Red Meteor)	
Potassium Perchlorate	24
Strontium Nitrate	12
Aluminum, bright	8
Charcoal, dust	1
Shellac, orange	2
Dextrin, yellow	2

#28 (Green Meteor	
Potassium Perchlorate	4
Barium Chlorate	8
Barium Nitrate	8
Aluminum, bright	6
Charcoal, dust	1-1/2
Red Gum Yacca	2
Dextrine, yellow	1

#29 (Blue Meteor)	
Potassium Perchlorate	14
Aluminum, bright	6
Barium Carbonate	1
Paris Green	10
PVC	1
Dextrin, yellow	1
Shellac, orange	2

#30 (Golden Butterfly	
Potassium Perchlorate	6
Barium Chlorate	4
Aluminum, bright	4
Sodium Oxalate	2
Barium Carbonate	1
Shellac, orange	2
Dextrin, yellow	1/2

#31 (Pearl Streamer)	
Potassium Nitrate	2
Charcoal, dust	1
Zinc, dust	4
Meal powder	1
Dextrine, yellow	1/4

All compositions should be mixed well with 24 mesh mixing sieves and then moistened with a 50:50 mixture of water:alcohol. Only practice will tell how much to dampen, but the mixture should have the consistency of bread dough. If the stars are dampened too much, they will not perform properly. If they are dampened too little, they will crumble. Form into pumped or cut stars, dust with meal powder, and dry at least five days in a warm place.

III. PRODUCTS OF MANUFACTURE

A. Colored Flames

1. Tableau Fire - This is one of the simplest types of fireworks. It consists of merely pouring the composition into a paper can and igniting it with a fuse.

Composition: Any of the composition formulas Numbers 1 through 9.

Casing: A small paper can.

Ignition: Safety fuse.

Manipulation and Procedure: A good tableau fire should burn brightly without sputtering or giving off excessive smoke. To achieve this all ingredients should be especially well mixed, using mixing sieves. Pour the composition in the can and insert a piece of safety fuse.

2. Torches

Composition: Same as above.

Casing: These are merely made by wet-rolling four complete turns of heavy Kraft paper around a former. They may be made any length and diameter.

Ignition: Safety fuse, priming.

Materials: A wooden handle (if the torch is to be held), or a wooden spike.

Tools: A former with which to roll the case, a funnel whose spout will fit inside the case, a wooden dowel that is about 1/4" smaller in diameter than the funnel spout and about 12" longer than the case.

Manipulation and Procedure: Stand the case upright on a solid support (floor, table) and insert the spout of the funnel. Now drop the dowel through the spout and case until it also rests on the support. Fill the funnel with composition, and, steadying the funnel with one hand, grasp the rod firmly with the other, raising it about 6". Drive it with a firm stroke up and down as the composition runs into the case. Continue until the case is filled up to the bottom of the funnel spout. When this is withdrawn, the space remaining is for the wooden spike or handle to be inserted, using a little glue. Wrap the outside with a few turns of paper, leaving enough for a nosing. Prime, insert the fuse and twist the nosing around the fuse.

B. Sprays and Showers.

These are all variations of the same principle which is a casing rammed solid with a composition that gives a shower or spray of sparks and fire.

1. Fountains. There are different forms of fountains. The first type is a hand fountain which has a wooden handle glued in one end of the casing. The second is the

spike fountain which has a wooden spike in place of the handle, and is stuck in the ground. The last type is the base fountain. This consists of a wooden block to which the casing is cemented, generally in a vertical position. The hand fountains are the smallest, the base next, and the spike, the largest.

Compositions: Numbers 10, 11, or 12. Meal powder may be added to give extra high sprays.

Casings: Almost any size casing will do but the nozzle diameter must be 1/3 the I.D. or less. They should be wet-rolled.

Ignition: Match, priming.

Materials: Wooden handle, spike, or base, Professional Pyro. Adhesive.

Tools: A ramming base described as follows: Drill a hole the same diameter as the I.D. of the case and 3/8" deep in a block of wood at least 1-1/2" square and 1/2" thick. Insert and glue in place a piece of wooden dowel 1/2" long. When the glue is well dried, drill a hole in the center of this dowel 3/8" deep x 1/3 the I.D. of the casing. Insert in this hole a dowel cut so that it protrudes above the surface of the larger dowel the length of 1/2 I.D. of the casing. Two rammers both 1" longer than the casing and of the same I.D. One should have a hole drilled in one end such that the rammer can fit over the smaller of the two dowels of the ramming base. Tools made from aluminum can also be constructed and are greatly preferable. A mallet, preferably of rawhide, and a scoop for measuring composition and clay are also needed.

Manipulations and Procedure: Slip the casing over the ramming base and, using the rammer with the hole, drive a scoopful of clay in it with ten good blows to form a plug 1/2 I.D. thick. As always, the clay should be poured in all at once. Now drive a scoopful of composition with ten good blows. The scoop should hold just enough composition so that when it is driven it rises 1/2" within the casing. Continue driving composition until it has come to within 1 I.D. of the top of the casing. This space is for the wooden handle or spike. (The composition may be driven all the way to the top for a base fountain.) Prime the fuse hole cavity well, and insert a fuse. When the priming is dry, the article may be nosed and the spike, etc., attached with Prof. Pyro. Adhesive. If desired, the base or spike, but not hand foundains may be made so they finish with a "bounce" or report. This is done by putting a 1/4 oz. of black powder after the last charge of composition and before the clay. The larger (3/4" I.D. or more) base and spike fountains may also be greatly enhanced by adding a few 1/4" cut stars that do not contain any Chlorate to the charges of composition when ramming. These are called "jeweled", "Prismatic", or "floral" fountains.

Compositions that contain steel or iron filings are more difficult to ignite. Therefore, be sure and fill the nozzle hole full of priming. The filings are also quickly oxidized by the saltpeter, causing the fountains to become quite hot and destroying the usefulness of the filings. To prevent this, the filings must be coated with paraffin so the saltpeter cannot reach them. The easiest way to do this is to melt some paraffin in a shallow pan as hot as possible without permitting it to smoke. To this add as many of the filings as the paraffin will completely coat. There should be no excess paraffin, but just enough to completely cover each filing. Shake the pan and stir frequently while cooling to prevent the filings from caking. Titanium does not need to be treated.

2. Volcanos - These have the same effect as fountains but they are made using stout cones instead of tubes.

Composition: Same as above. No meal powder is added.

Casing: A paper cone similar to the ones on which thread or twine is wrapped. It should have an opening at its tip of about 1/8". Cones made especially for volcanos may be obtained from Westech.

Ignition: Safety fuse, priming.

Materials: Prof. Pyro. Ad., 1/8" chipboard, Sodium Silicate (syrupy).

Tools: A pair of rammers made of wood but preferably of aluminum. One is 1/2" diameter and the other is 1-1/4" diameter. Both are about 3" longer than the height of the cone. A ramming mold to hold the cone while it is being rammed. This is made from a block of wood, into which a tapering hole, of the same taper as the cone, is worked. It should be deep enough to accomodate the cone for about one-half of its height.

Manipulation and Procedure: Dip the nose of the cone into a hot Sodium Silicate solution to a depth of about 1" for about one minute and allow to dry. This is to fireproof and reinforce the vent. Place the cone in its mold, prime from the inside so the vent is covered, then ram in small amounts of the composition, moistened slightly with alcohol. This is to allow better consolidation of the composition. Alcohol is used since it will evaporate faster than water. The 1/2" rammer is used till the cone is about one-half full. Punch a disc from the chipboard with a diameter equal to the diameter of the cone at the height of the composition. Coat the inside of the cone at this height with Prof. Pyro. Ad. and push in the disc. The disc must be very tight and secure, otherwise it will blow out the bottom. (For this same reason the composition must be moistened and rammed very solidly.) Finally insert a piece of safety fuse and wrap with bright paper.

A very amusing variation of the volcano is a "Piping Pyramid" or "Musical Cone." These are made as above except the nose of the cone must be clipped off to allow for the insertions of the whistle tube. The whistle casing itself should be 3" long x 5/16" I.D. x 1/2" O.D. It must be rolled from a smooth type of paper such as the type used in postcards. A rough paper will affect the whistle tone adversely. Kraft and Manila papers may be used with almost as good results. The clipped cone should have been previously dipped in the Silicate, as before. The ramming mold must have a hole in its bottom to allow for the whistle. Fill as before. (Instructions for making a whistle will be found under "Callipe Comets.")

3. Flower Pots - These provide remarkable and unusual coruscations, very different from other types of showers. They are made exactly like hand fountains. The composition #13 requires very careful mixing, otherwise no effect is produced. Use a 24 mesh mixing sieve.

4. Gerbes - These are merely fountains that are wired to a set piece rather than stuck in the ground. They are made exactly like fountains except no wooden spike, etc. is attached.

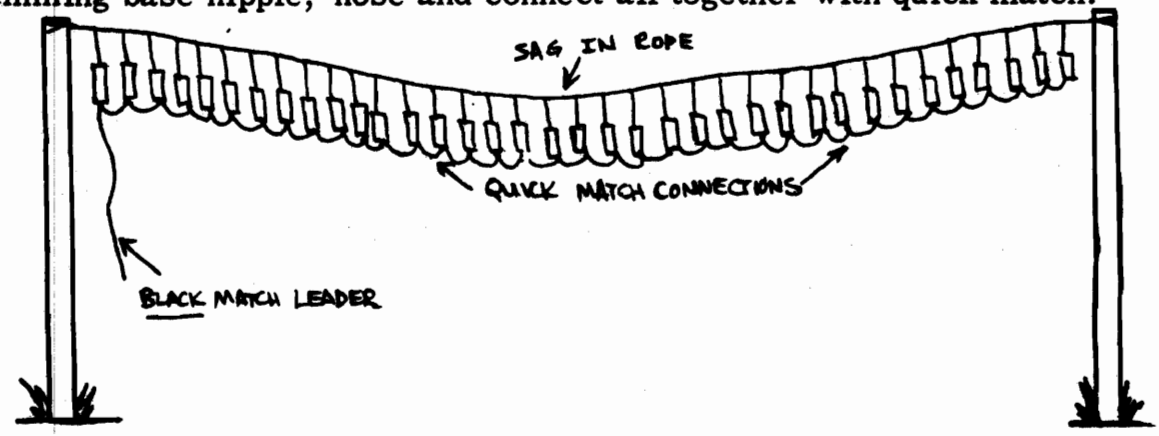
5. Cascades (Niagara Falls) - These are similar to fountains except unchoked cases are used and they are suspended from a wire so the fire falls downward rather than being shot upward from the ground.

Composition: #12 is most often used. #10 or #11 may also be used.

Casings: Any size may be used. The more there are and the larger they are, the better the effect. They are tied to a rope from 6" to 15" apart, depending upon the size used. The larger they are, the further apart they are placed. The rope should be tied just high enough above the ground so the cascade is just able to reach it. Only experimentation will indicate how close together the cases should be tied and how high above the ground they should be placed. A set of 1-1/4" I.D. casings is used for exhibition work and is tied about 50' above the ground, the arc of the suspended rope giving just the right perspective.

Tools: Same as for fountains.

Manipulation and Procedure: Same as for fountains except no clay is used. The casings should only have composition in them. Prime all cavities made by the ramming base nipple, nose and connect all together with quick match.



C. Roman Candles

Roman candles are very popular. Contrary to general opinion, skill and experience are required to make really good candles. The principle on which the Roman candle is constructed is as follows. At the bottom of the case is a plug of clay. On top of this is a small amount of grain powder (FFFFg rifle powder). On top of this powder is a pierced, cylindrical star, which just comfortably slides down the tube. Surrounding and on top of the star is a slow-burning powder called "candle comp." The grain powder, star, and candle comp sequence is repeated until the tube is filled, and functions thus–the comp burns like a fountain with luminous sparks, and upon reaching the star, ignites it and flashes around it and through its cavity to fire the blowing (propelling) charge of grain powder. The blowing charge also ignites the

the next layer of candle comp. and the effect is repeated. The fit of the stars in the tube must be just right. If they are too loose, they will merely pop out of the top and land on the ground burning; if they are too tight, they will be shot out with such force that they will blow themselves out. The candle comp. must fit snugly around the stars and also be firmly rammed down on top of them, otherwise the stars will come out like machine gun bullets. The amount of grain powder varies with the position of the star, smaller amounts being used at the lower portion of the case. This is done so the stars may rise to approximately the same height; the charge at the bottom acting through a greater distance and on a firmer surface, naturally acts more effectively and less is required.

1. Regular.

Compositions: #14, and any, or all, of the star formulas #15-#23.

Casings: These should be wet-rolled from a good quality paper (Kraft, Manila, or chipboard). The I.D. may vary from 5/16" to 1/2", but 3/8" is most often used. The O.D. should be at least 1-1/2 times the I.D., preferably more. The ideal size is 3/8" I.D. x 3/4" O.D. x 15" long. This will hold 8 to 10 balls (stars).

Ignition: Black Match, priming.

Materials: FFFFg black rifle powder; dry, powdered clay.

Tools: A rammer which is a rod 1" longer than the casing and slightly less in diameter than the I.D. so it can pass easily up and down in the candle case. An adjustable powder scoop, it is made just as a 1/4" diam. regular scoop, except the handle is not fastened but allowed to slide within the shovel part of the scoop. Thus, each powder charge can be easily adjusted using only one scoop. A star pump that is especially adapted for making Roman candle stars. The plunger has in its exact center a rod that is 1/6 the diam. and equal in length to the star it makes. Thus, it forms a central cavity down the center of the star. A regular scoop for measuring the charges of candle comp and clay.

Manipulation and Procedure: Place the case on a firm foundation, pour in a scoopful of clay and ram very hard, using a rawhide mallet. Remove the rammer and pour in a scoop of gunpowder. (NOTE: the exact amount must be ascertained by experimentation. Adjust the powder scoop so it increases the powder charge for each star. All stars would be blown to the same height—the higher the better. However, if too much powder is used the stars will be shot out with so much force that the flame will be extinguished and they will be "blown blind." Start with about 2-3 grains for the first charge.) On top of the powder charge, drop in a star, and then a scoopful of candle comp. Ram with about six light blows of the mallet. Remove rammer and pour in another scoop of gunpowder, another star, and another scoop of candle comp. Ram as before and repeat until the case has the desired number of stars. Prime, match, and nose and the candle is finished.

2. Exhibition: These are made like the regular candles except cases with a 3/4" I.D. are used. Stars that contain Aluminum (#27-#29) are generally used instead of the plainer mixings. Casing O.D.'s have the same relation to I.D. The most common length is 15".

3. Italian Streamers: These are made exactly like the exhibition candles except they are loaded with stars made from #24. They leave a beautiful golden tail as they ascend and are one of the most beautiful pieces made.

D. Mines

These are paper mortars (strong paper tubes standing vertically on a wooden base into which it is countersunk and cemented with Prof. Pyro. Ad.) that shoot into the air a display of stars, serpents, etc. They are often equipped with fountains, Roman candles, etc., which make a display on the ground before the mine itself fires.

1. Prismatic Mines:

Compositions: Any of the star compositions (No. 15-23).

Casings: The mortars for these items are made by wet-rolling chipboard or other heavy paper around a suitable former. Mailing tubes or other fairly strong paper tubes will give good results. The proportions of a mine do not particularly matter but the wall should be at least 1/32" thick and the height should be at least 2-1/2 times as long as the I.D. Since not much force is generated by the propelling charge of powder on the loosely packed stars, and since they should give a good spread both horizontally as well as vertically, the mortar need not be too strong or high.

Ignition: Safety fuse.

Materials: Prof. Pyro. Ad., circular piece of stiff chipboard the same I.D. as the mortar, a wooden block to act as the mortar base (it should be at least 1/2" larger on a side than the O.D. of the mortar), Fg black rifle powder.

Tools: A suitable former (if the mortar is to be hand-rolled).

Manipulation and Procedure: Cement the mortar in the circular groove in the mortar base with Prof. Pyro. Ad. Drop in a quantity of stars and Fg powder. For every ounce of stars, use two level teaspoons of blowing powder. The mortar may be filled up to one-half full. Now cut a hole in the center of the circular piece of chipboard just barely large enough so the Roman candle or fountain may be pushed through. The candle or fountain should not have the bottom plug of clay but be left open. The candle should be about 3 balls and the fountain quite short. Push the chipboard disc (with its centrally placed fountain or candle) into the mine until it is about 1" above its contents. Push another disc of chipboard over the candle (or fountain) until it is just inside the mortar and the job is done.

2. Spangle Mines: These are made exactly as above. Rather than shooting regular stars they shoot gold or silver "spangles" (stars that are 3/4" or 1-1/4" in diameter, made from formulas #23 or #24.) A mortar of at least 3" diameter should be used.

3. Meteoric Shower Shells: The ground version is made exactly like a Spangle mine but formulas #26, #27, #28, or #29 are used.

4. Serpent Mines: These are made exactly like Spangle Mines but using serpents or saucissons instead. The larger the I.D. of the mortar, the better.

5. Thunder Mines: Same as above but using firecrackers instead of serpents.

6. Battle Mines: Same except using M-80 type salutes with very short 1/4" fuses.

7. Thunder and Rainbow Mines: Combination of stars and firecrackers. The variety of effects is almost unlimited. The imagination of the artificer will suggest other combinations using whistles, grasshoppers, and other items.

E. Comets: These are essentially mines which shoot a single large star to a height of about 150 feet.

1. Plain: This is a paper mortar cemented to wooden base with Adhesive. It shoots a large (about 1-1/4" in diamter) tailed star to the height of about 150 feet. The star may be either gold or silver. In some circles "comets" are used to designate a star that burns with a charcoal or lampblack (golden) effect; "meteors" are used to designate a star that burns with an aluminum, or "electric" (silver) effect.

Compositions: #25 and #26.

Casings: A paper tube that is attached to a wooden base to act as a mortar. It has the following dimensions: I.D. 1-1/4" x 6" long x 1/16" wall; wooden base: 2" x 2" x 1/2". The tube is attached to the base with Professional Pyrotechnic Adhesive.

Ignition: Safety fuse, priming.

Materials: Professional Pyrotechnic Adhesive, Fg black rifle powder, thin chipboard.

Tools: 1-1/8" star pump, a suitable former 1-1/4" diam. and about 8" long (if the mortar is to be hand-rolled).

Manipulation and Procedure: Punch a hole in the mortar about 1/4" from one end, and cement this end securely to the wooden base using Adhesive. Allow to dry at least six hours. Pump a large star using a 1-1/8" star pump. Prime one end of the star heavily and allow to dry a couple of days. Weigh the star. The correct amount of driving charge is about 1/5 its weight of Fg black rifle powder. Drop this amount in the mortar and drop in the star on top of it, primed end down. Cut a thin chipboard disc equal to the I.D. of the mortar and push it on top of the star to secure it and the driving charge. Poke a length of safety fuse in the hole at the bottom of the mortar.

2. Fancy: There are many types of fancy comets. Some of these are:

a. Floral: This is the same as above except as the large star reaches its zenith, it bursts into a shower of multi-colored smaller stars. Also called "bursting comets."

Compositions: Same as the above with the addition of some colored stars.

Casings: In order to achieve the floral break, the star itself must be enclosed in a casing. This should be 3-1/4" long x 1/16" wall and made from Kraft or Manila paper. It should be wet-rolled around the star, the star itself acting as the former. One end of the star must be flush with an end of its casing. The mortar tube is the same as for plain comets.

Ignition, Materials, and Tools, same as for Plain Comets

Manipulation and Procedure: Prepare mortar tube as above and roll the star casing as explained above. (Since the star has a casing around it, it is really a very large "box star." Being such, it has less area exposed to burn and thus burns slower. It is, therefore, necessary to pump it shorter.) Prime the end of the star that is flush with its casing well. When dry, drop in various colored stars and bursting charge on top of the star to within 1/2" of the top. The bursting charge is 1/8 oz. of FFFg black rifle powder. Cut a circle of chipboard with a diameter equal to the I.D. of the star casing and push it in on top of the stars and bursting charge. Secure well with Adhesive and allow to dry. When it is dry, weigh it. The correct amount of driving charge of Fg black powder is about 1/4 to 1/5 the weight of the star. Drop the required amount of driving charge in the mortar and the star on top of this, primed end down. Secure both in the mortar with a circle of thin cardboard, as is the case of plain comets.

b. Thunderbolts: Same as above except the large star explodes with a tremendous flash and/or report. They are made exactly like Floral Comets except instead of a load of stars, they have a charge of salute powder. Before the salute powder can be added, a cardboard disc with a diameter equal to the I.D. of the star casing and a 1/4" hole cut in center is pushed in on top of the star and secured with Adhesive. The hole is well primed and the whole is set aside to dry. When dry, fill 3/4 full with salute powder (a fuller load will give a decreased report) and secure the top with another cardboard disc and Adhesive. Do not press this disc down. Salute comp. must be loose in order to give a good report. Weigh to determine amount of driving charge.

c. Calliope: These emit a shrill whistle as they ascend.

Compositions: Same as for Plain Comets. Also, whistle compo.

Casings: Mortar is the same as for Floral. The whistle is made with the following dimensions: 5/16" I.D. x 1/2" O.D. x 2" long. Use Kraft or Manila paper and wet-roll. The star is enclosed in a casing 1-1/8" I.D. x 1-3/4" long x 1/16" wall, also wet-rolled.

Ignition and Materials: Same as for Plain Comets.

Tools: Same as for Plain Comets in addition to the following: A dowel 3/8" diameter and 2" long, a dowel 1-1/8" dia. x 2-1/2" long, a dowel 5/16" diameter x 5" long, a special whistle ramming base described as follows: Drill a hole 5/16" diameter x 1/4" deep in the center of a block of wood at least 2" square and 1/2" thick; insert and glue in place a wooden dowel 5/'6" diameter x 1-1/4" long (cut from 5" piece).

Manipulation and Procedure: Construct the mortar as before with the same dimensions of a Floral Comet. Wet-roll the star casing using the 1-1/8" dowel as a former. The whistle casing is charged with composition using the ramming base described above. Ram the whistle compo. into the case, using small quantities until the composition is 1/4" from the top. Ram it very tightly, as the composition has to withstand the pressure of the lifting charge without blowing through. Use adequate precaution when doing this. (Use the remainder of the 5/16" diameter dowel for the former

and rammer). The 1" vacancy made by the ramming board in the whistle is necessary for the proper production of the sound. Place the star casing on a piece of newspaper. While holding the whistle casing (the 1" vacancy end down) in the center of the star casing, press damp star composition around the whistle using the 3/8" dowel as a rammer. Continue until the composition is 1/4" from the top. Be sure that this composition is rammed very tightly around the whistle. Cut a piece of light chipboard with a diameter equal to the I.D. of the star casing. Cut a hole in the center of it 1/2" in diameter. Press it over the star composition, the whistle sticking through the hole, and secure it well with Adhesive. Allow to dry. Prime the end of the star well and insert two or three lengths of bare match in this end of the whistle (the 1" vacancy end). These not only insure the proper ignition of the whistle, but they take off some of the pressure of the lifting charge. Weigh to determine lifting charge.

d. Rainbow: These change color as they ascend. Great care must be used in choosing the correct order of color changes as certain colors placed with others do not have the desired visual effects.

Compositions: Any of the following formulas: #25-#29. The proper succession of colors is very important. Green should not be next to white, for there would not be sufficient contrast. And green should not burn after red, for the color of the barium flame appears to one who has been watching the flame of strontium to be a light and uninteresting blue. Some suggested color changes are: green to red to gold, blue to silver to red, green to red, blue to red, green to gold, blue to silver, gold to green to red, green to red to blue to silver, gold to green to red to silver, silver to blue to red to gold.

Casings, Ignition, and Materials: Same as for Floral.

Tools: Same as for Floral, plus a 1-1/8" diam. x 6" wooden dowel.

Manipulation and Procedure: The star casing should be from 1-1/2" to 3" long, depending on how many color changes there are. Each star composition should be rammed into the casing using the 1-1/8" dowel. Prime one end well and set aside to dry. Weigh to determine driving charge. Drop the required amount of driving charge in the mortar, followed by the star. Cut a circle of chipboard equal to the I.D. of the mortar and push it down on top of the star to secure it and the driving charge in the mortar.

e. Combination: In addition, these above effects may be combined into one single comet. For example, there can be a "whistling, bursting comet"; or a "color-changing thunderbolt", etc. Use your own ingenuity and imagination in devising your own creations using the above principles.

f. Golden Butterfly Shells: This consists of a paper mortar cemented to a wooden base. It projects a large star of intense brilliancy high into the air, leaving a beautiful shimmering, flittering trail as it ascends.

Composition: Formula #20.

Casing, Materials, Tools, Manipulation and Procedure are the same as as for "plain" Comets.

g. Pearl Streamer Shells: Same as above except a beautiful pearl blue-white streamer is left as the star ascends.

EXHIBITION GROUND DISPLAYS

PART I (TEMPLE PIECES)

(L-104A)

The pieces that make up this division are various ensembles of the basic ground displays. They provide a very entertaining and varied "displayette" by themselves and should be viewed at fairly close range. They are, therefore, highly successful for backyard, private, or country club-type displays. None of these types of displays could be complete without a large variety of these items.

Temple pieces of all types are fairly easy to assemble and the pyrotechnist should have no trouble inventing his own creations. Those given here are those that have proven to be favorites for many years, or the author's own creations. All of the safety precautions, formulas, etc., given in L-104 should be observed and applied.

Temple pieces provide the pyrotechnist an opportunity for his imagination to run wild, both in deciding the combinations of effects and in naming them. The displays may be as desired, but do not allow more than two different visual effects to be happening at once, otherwise mass confusion results. Different effects may follow each other at short intervals but allow sufficient delay between them to allow each to be appreciated and savored.

1. Candle Batteries -- The various types of batteries consist of grouping together a larger number of Roman candles that fire simultaneously. They form a very effective piece of fireworks and are always one of the highlights of a display. The more candles used, the more effective the display. Generally 10 ball candles are used in all types of batteries.

Regular Candle Battery-- This piece is made by taking a box about 2" higher than the candles to be used and filling it with as many candles as it will hold. The space above the candles in the box is filled with pieces of black match. A piece of cardboard should be placed over the top until it is ready for use. When ready to fire, remove the cardboard, drape a long piece of black match over the side of the box and into the pieces of match and light the other end.

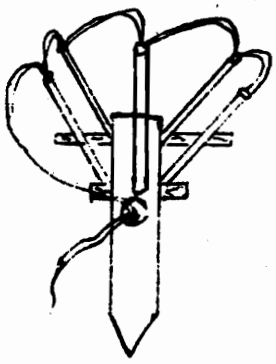
Union Battery -- This consists of three batteries of candles arranged as shown, one battery having red stars, the center white stars, and the other blue stars.

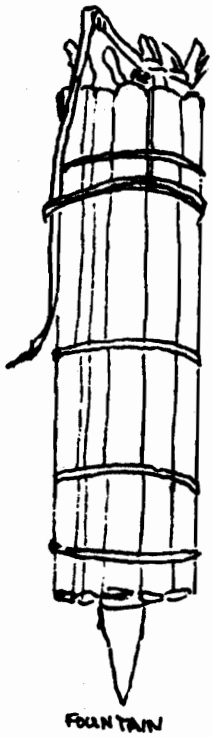
Bengola Battery -- This consists of a short colored torch backed up by a fan of candles. When a row of these is fired simultaneously, a very effective display is produced.

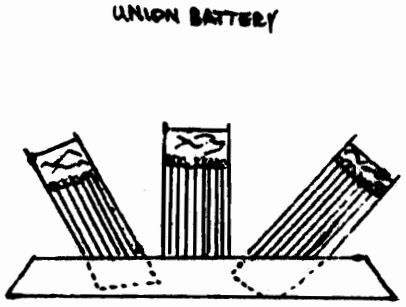
Bombette Battery -- This is an effective combination of candles and floral shells (see L-105) packed in a box as shown. All candles are lighted by pieces of match in the top, but the floral shells are matched as shown, so they fire one at a time during the burning of the candles.

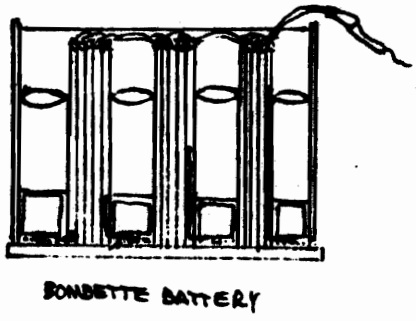
Comet Battery -- This is the same as above except comet shells are substituted for the floral shells.

Fountain Battery -- This is made by wrapping 8 to 10 candles around a central spiked fountain or flower pot. All are matched together so there is a continuous fusillade of stars together with the shower of the fountain. A row of 3 or 4 firing simultaneously is very effective.

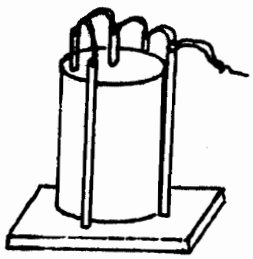








2. Devil-Among-the-Tailors -- These are made by taking a mine casing about four inches in diameter and loading it about half full with serpents and grasshoppers. Besides the central candle for firing it, there are four candles tied around the outside of the mortar, and matched to burn at the same time. The candles should hold about three balls each.



3. Jack-in-the-Box -- This is the same type and size mine as above but instead of the candles, a central golden shower fountain is used. Neither the candles or the fountain should have the lower plug of clay.

4. Aerolites -- These are made by placing a gold comet star at the bottom of a mortar with a blowing charge. Over the star is placed about 2" of candle comp and over this 1" of a colored fire, preferably blue.

5. Meteors -- These are essentially large Roman candles cemented to a wooden base. They shoot four to ten 1-1/8" diameter stars high into the air. "Splitter" stars are most often used, however, "electric, "spreader, " and "flitter" stars are occasionally employed. They may be either rapid or slow firing. They are loaded in the same manner as Roman candles except a special device is used to insure the ignition of the stars. This is by far one of the most spectacular ground display items that can be exhibited.

Composition:

Spreaders		Splitters	
Saltpeter	15	Saltpeter	8
Sulfur	2-1/2	Sulfur	2
Charcoal, dust	4	Charcoal, dust	2
Charcoal, gran.	3	Barium Nitrate	4
Zinc, dust	40	Antimony, Chinese needle	2
Dextrin	1	Aluminum, bright	1
		Dextrin	2

Also needed is candle comp.

Casings: A long, strong paper tube is needed for the mortar. It varies in length, depending on the number of stars used. It should be 1-1/4" I.D. and at least 1-3/4" O.D. It is cemented to a wooden base with Adhesive. The size of the base depends on the length of the tube. It should be large enough to give the mortar tube an ample foundation.

Ignition: Safety fuse.

Materials: Professional Pyrotechnic Adhesive, Fg black powder, black match.

Tools: 1-1/8" star pump, former to roll a mortar tube (if it is to be rolled at home), a 1-1/4" candle rammer.

Manipulations and Procedure: Secure the mortar to its base with Adhesive. When dry, drop in these items in the following order: 1/2 teaspoon Fg powder, star, candle comp. 1/2 teaspoon Fg powder, star, candle comp; continue this order until all stars are used. On top of the last star, put a double quantity of candle comp. and insert a length of safety fuse in this, having the other end of the fuse protruding out of the top of the mortar. Insert a wad of paper to secure the fuse and top layer of candle comp. After each portion of candle comp., ram firmly to make sure all the contents are seated properly. To insure the ignition of the stars, the following device is used. Two pieces of bare match at right angles to each other are placed under the bottom of the star; the four ends are turned up along the sides of the star and cut off even with the top of it. The match being held in this position, the star is inserted into the top of the mortar and pushed down with the rammer onto the driving charge of gunpowder that has already been introduced. The match at the sides of the star keeps a space open between the star and the walls of the mortar, which space is only partly or loosely filled with candle comp. The bare match acts as quick match, insuring the early ignition of the driving charge as well as the sure ignition of the stars. For a rapid firing effect, use less candle comp; its amount varies with individual taste, but at least 2 or 3 tablespoonfuls are required for a rapid fire effect and more for regular firing.

6. Band of Pipers -- This is a very effective piece made by attaching three whistling colored meteors around a mortar base and one whistling bursting comet in the center. The three should use three different formulas such as #27, #28, and #29, and the center one use #25. All four should be matched so as soon as the previous meteor finishes, the next fires immediately.

7. Carousel Ground Display -- This consists of a horizontal double action saxon and three different-sized whistles matched to burn one after the other. The last whistle and saxon must stop at the same time. Wuick match runs from the bottom of the last whistle to a mine loaded with mini-copters or flying discs.

8. Screaming Meemie -- Many manufacturers use this same name to describe different items. The type described here starts with a high-pitched whistle, followed by a spangle mine and then finishing with a prismatic mine which may also have a few whistles added.

9. Zeus' Thunderbolts -- This piece has three reporting comets (thunderbolts) that fire one after the other. These are placed around a large mortar base. In the center of these is a silver meteor that terminates with an extra heavy report.

10. Carnival Ground Display -- This is a very effective and varied ground display. It has three mortars side-by-side on a base. The first is a medium-sized serpent mine. Next is a whistling, bursting comet. And last, a silver spangle and thunder mine. A very interesting variation is to substitute the serpents in the serpent mine with mini-copters or flying discs.

11. Three Musketeers -- Some manufacturers call this piece a Screaming Meemie. It starts with a loud screaming whistle, then a silver shower fountain, and last a bounced, jeweled spray. Quick match runs from the bottom of one effect to the top of another, so each starts just as the last finishes.

12. Fiddler's Fountain -- This consists of two cases mounted on a mortar base. The first is a whistle and the second a "variegated fountain" (a fountain that burns first gold and then silver). The two cases should be connected by quick match so they burn simultaneously.

13. Tuneful Tower.--This piece has three cases on a base. The first is a bounced, gold shower fountain, the middle, a whistle, and the third a bounced silver spray. The three are connected by quick match so all burn at the same time.

14. Fiesta Ground Display -- This piece has three different mines side-by-side on a wooden base. Around the outside of the first mine are tied four 3-ball Roman candles matched to burn at the same time as a 3-ball candle that fits in the center of the mine, just like the set-up for a Devil-Among-the-Tailors. The mine is filled with small (1/2" or less) stars made from formula #25. The candles should each have different colored stars. The next mine is a thunder mine, and the last is a regular prismatic mine. Each successive mine should be matched, using a combination of safety fuse and/or quick match, so it fires just after the previous mine has finished its part. There should not be a long pause, nor should the mines overlap into each others' effects.

15. Battle-in-the-Clouds -- This is made exactly like a Devil-Among-the-Tailors. But instead of using regular stars, the candles are charged with stars using formulas #26-#29, each candle having a different color. The mine is a Battle Mine instead of containing grasshoppers and serpents.

16. Pandean Pipe Display -- This piece is very amusing. It consists of six to eight whistles, ranging in I.D. from 1/4" to 3/4", set side-by-side on a wooden base. They are matched to burn simultaneously. Each whistle is charged with about 2" whistle compo. In back of these whistles is a jeweled fountain.

17. Jubilee Ground Display -- This consists of three fountains mounted in a row on a mortar base. The middle is a silver shower and the two outside ones are gold. These should point slightly outward at an angle. All three burn simultaneously and end with a bounce. Care should be taken that all three burn the same length so that all

18. Golden Blossom Display - Consists of 3 fountains (the larger the better) mounted on a wooden frame. This is then nailed to a post that is 2-6 feet high, depending on the size of the fountains (shorter fountains being placed closer to the ground). All 3 burn at once and are loaded with formula #10. The two outside ones are pointed slightly towards each side.

19. Peacock Plume Fan -- Also consists of 3 fountains mounted the same way as 18. The center is a large golden, heavily jeweled fountain, the two outside silver fountains are somewhat smaller.

20. Fiesta Cascade -- Consists of 5 fountains mounted on a wooden frame. The center points straight up; the two on each side point towards the side. All burn at once. Any composition may be used, and they may be bounced or not.

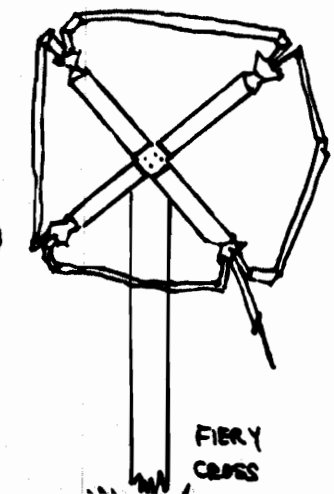
21. Fiery Cross -- Consists of 4 gerbes, mounted as shown. All burn at once. The piece should be placed 6-12 feet above the ground. It makes a very spectacular item.

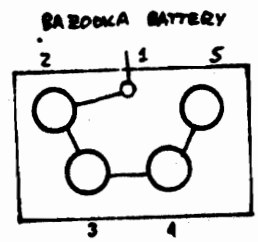
22. Fiery Echo -- Consists of 3 fountains and one whistle mounted in a row on a mortar base. All burn at once. Any composition may be used in any fountain.

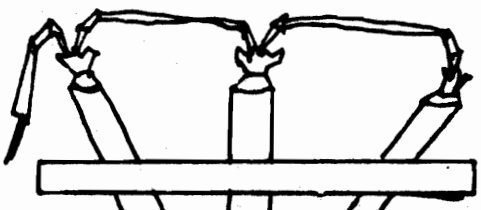
23. Mount Melody - Consists of two fountains loaded with formula #13 (Flower Pot) and one whistle in a row on a mortar base. All burn at once.

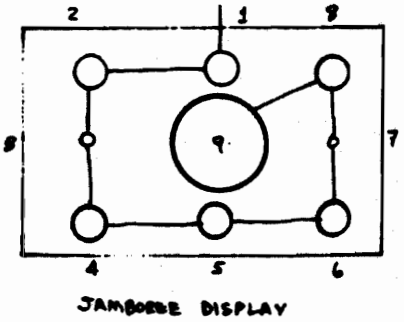
24. Bazooka Battery -- Consists of a battery of various types of comets, plus a whistle. First, the whistle fires. This is connected by a short piece of safety fuse to a golden comet; this, in turn, is connected by another short piece of safety fuse to a silver comet; then a floral comet; and last, a thunderbolt. All comets should fire just as the previous one finishes its effect. The whistle may burn as long as desired. Precise cutting of the short time delay safety fuse pieces will make this a very effective display. The arrangement of the mortars on their base is shown as they appear from above.

25. Jamboree Display -- Consists of whistles, fountains, comets, and mines, nine tubes in all. First, a golden fountain fires; after a few seconds, a golden comet fires, immediately followed by a whistle and then immediately by a silver comet. After a few seconds delay, a silver fountain fires; a few more seconds and a colored meteor followed immediately by another whistle. When the whistle concludes a small spangle mine fires. As soon as the spangles burn out, a large prismatic and thunder mine finishes the display. A combination of quick match and safety fuse is needed for a correct firing sequence. The arrangement of the mortars is shown below









EXHIBITION GROUND DISPLAYS

PART II (LANCE WORK)

(L-104B)

This part of pyrotechnics consists of using "lances" to reproduce various designs, letters, portraits, etc. "Lances" are thin paper tubes from 1/4" to 3/8" in diameter and from 2" to 4" long, filled with colored fire composition.

Compositions:

Materials	Red	Red	Green	Blue	White	Yellow	Purple
Potassium Chlorate	6	6		16		16	18
Strontium Nitrate	6						3
Strontium Carbonate		1					
Shellac	2	2	1			3	2
Lampblack	1	1	1/2			1/2	
Barium Chlorate			9				
Potassium Nitrate				8			
Sulfur, flour				2			
Arsenic Sulfide, red				1			
Paris Green				5			
Stearic Acid				2			
PVC				1/2			1
Sodium Oxalate						2	
Copper Oxide, black							3

Compositions for lances should burn clearly for about 1 minute, without flaring or clogging. All colors should burn the same length of time, so some of the slower burning compositions (for example, blue) must be not as firmly consolidated. Time each composition in the same size case to determine burning time. If a lance burns to one side, it is because the composition is not well mixed. Mix carefully and thoroughly, using 24 mesh mixing sieves. If a composition chokes and burns down the side it is because it contains too little carbonaceous materials. A little lampblack or charcoal dust will help. In very damp climates, use the red composition with strontium carbonate.

Casings: Generally, the greater the diameter of a lance, the shorter the length may be. Usually, a lance case of 5/16" in diameter, x 4" long, is used. They are made from dry-rolling a good quality paper (Kraft or Manila) three complete turns around a suitable former.

Ignition: Quick match, priming.

Materials: Prof. Pyro. Ad., and as many frames as necessary. The frames are made in any convenient size from light lumber with outer stips 1/2 x 2" and center strips 1/2 x 1", spaced 1 foot apart each way (Figure 1). Bamboo or rattan for the curves and light strips of wood for the straight lines are then tacked on in the outline of the design, letters, etc. (Figure 2). Drive 1" "double pointed" nails to a depth of 1/2" (Figure 3) at intervals of 2-1/2" in the curves and 4" on the straight lines all over the design.

Tools: A former of any convenient length and diameter to roll the lance cases. A funnel and rod to charge the cases with composition. The funnel may be made from a piece of thin aluminum. It is about 2-1/2" on top, 2-1/2" high, with a 3/4" shoulder on the bottom and a 1/4" O.D. spout projecting from the bottom for 1/4". This, when removed from the lance, leaves just the proper space in the case empty for priming. (This shoulder is not a necessity, but allows for faster work.) The rod should fit easily through the spout,

ıd be about 12" long. In use, a case is held upright on a firm table. The small end of e funnel, which is half full of composition, is inserted in the top of the case. With the ɔd moving up and down, striking the bottom firmly each time, the composition becomes ımmed with sufficient solidarity.

Manipulation and Procedure: When it has been decided what colors are to be used ɔr the various parts of the design, take a handful of lances of the desired color and dip ıeir bottoms into Prof. Pyro. Ad. to a depth of about 1/8" and press one onto each of the ıils until they are attached firmly to the rattan or stick forming the design (Figure 4). hen the Adhesive has hardened, the frame is ready for matching. Take a length of quick ıatch and, beginning at the upper left corner of the frame, staple it from one lance to ıother until the entire frame is covered, following the outline of the design as much as ɔssible (Figure 5). The special staple guns available at Westech are ideal for this oper-ıion. In the past, it was necessary to pin the match to the lance and then pierce it with an wl. These staple guns, specially made for lance work, do both these operations at once ıd at a much faster rate. When the end of a length of match is reached, splice another to , baring about 2" of the new length and slipping this bare end into the pipe of the preced-ıg. It may be necessary to slit the pipe to accomodate the spliced piece. Secure it by ring and pasting the joint or using masking tape. Now paste a strip about an inch wide ɔr use masking tape) over the top of the lance (Figures 6 and 7). When the design is ırge enough that it requires more than one frame, leave about 2' of match projecting ·om the lower right corner of each frame so that each can be connected to the one next ɔ it in the final assembly. Also, on one of the bottom frames, leave a leader of match ng enough to light the device.

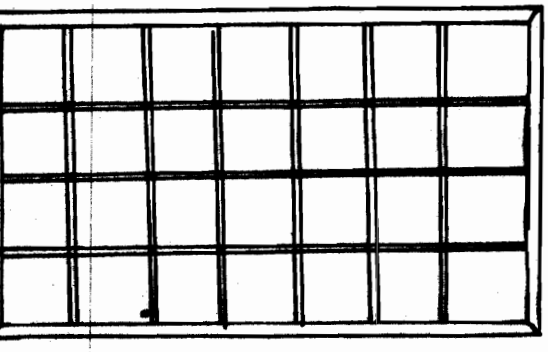


FIGURE 1

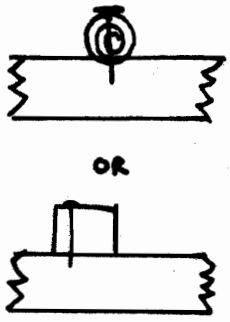


FIGURE 2

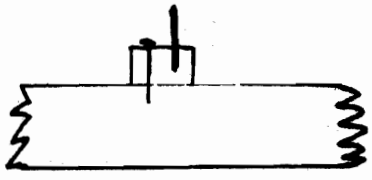


FIGURE 3

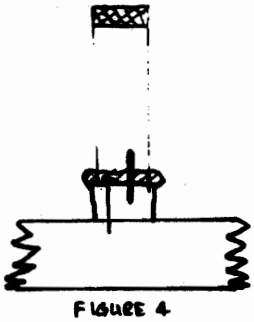


FIGURE 4

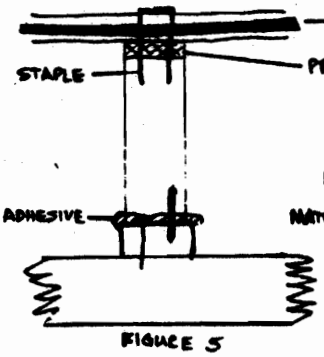


FIGURE 5

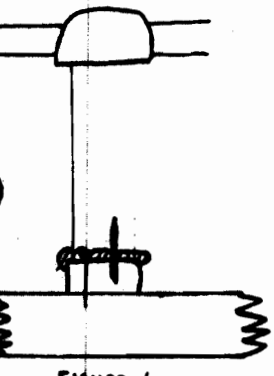


FIGURE 6

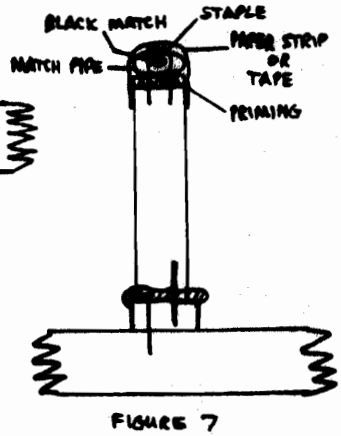
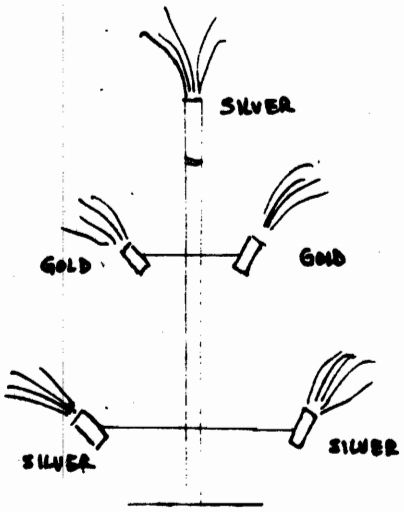


FIGURE 7

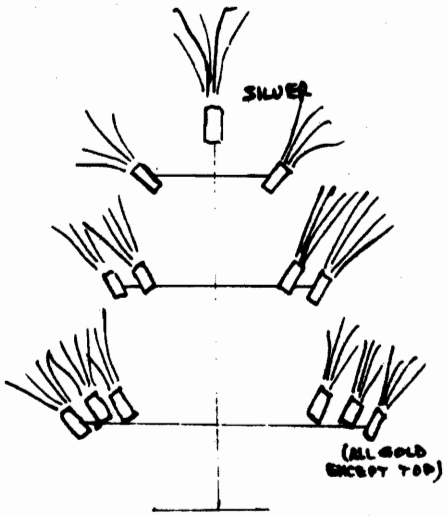
EXHIBITION GROUND DISPLAYS

PART III (SET PIECES)

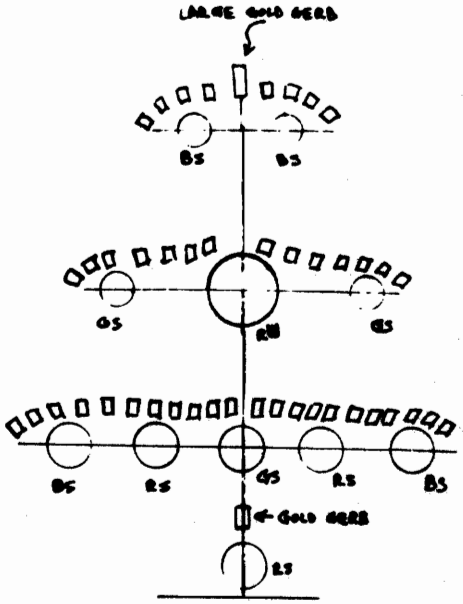
(L-104C)



PINE TREE



TREE OF LIBERTY



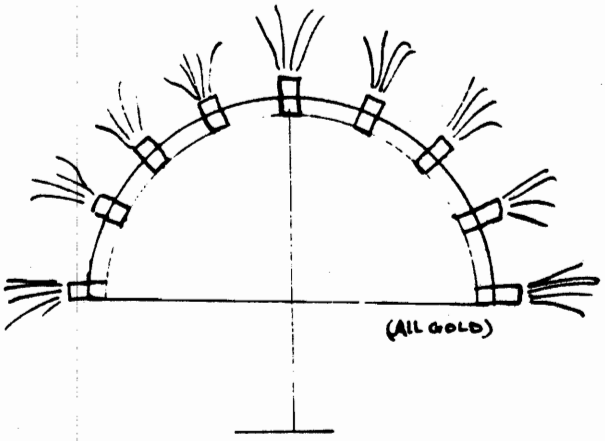
TREE OF PARADISE

BS = SAXON W/ BLUE POT
GS = " GREEN "
RS = " RED "
RW = LARGE WHEEL W/ RED "

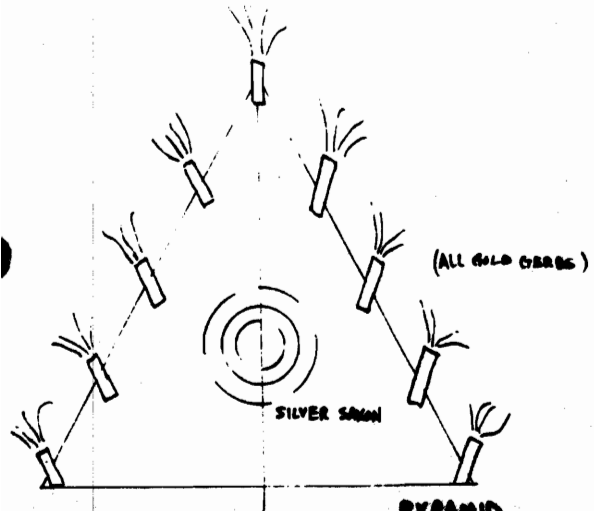
ALL BEHIND SAXONS ON WOODEN FRAME
- TOP ROW - 8 GOLD GERBS
- MIDDLE ROW - 14 "
- BOTTOM ROW - 22 "

ALL GERBS ARE CHARGED W/ STEEL.

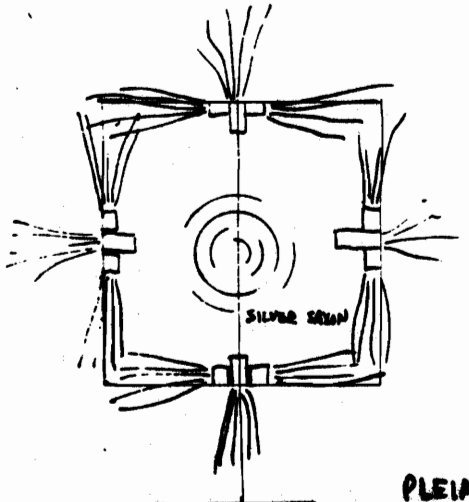
MAY ALSO HAVE A BATTERY OF ROMAN CANDLES BEHIND TOP ROW OF GERBS.



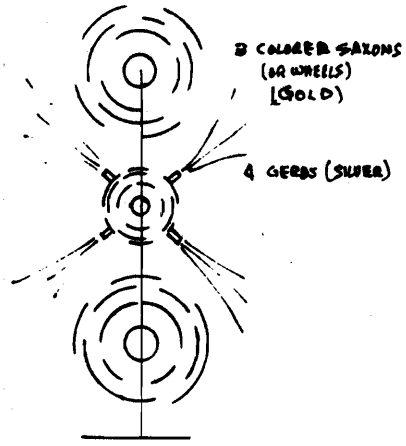
RISING SUN



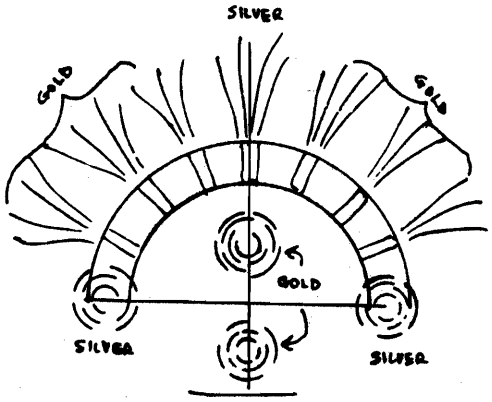
PYRAMID



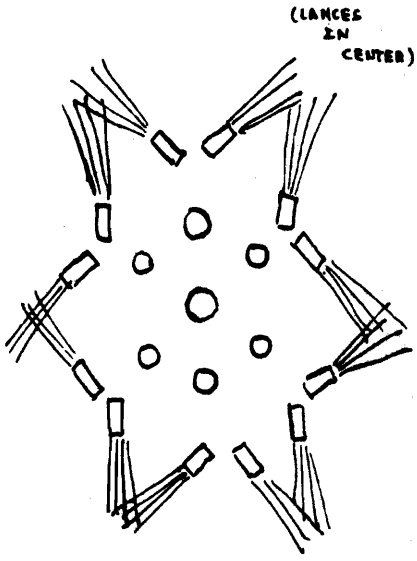
PLEIADES



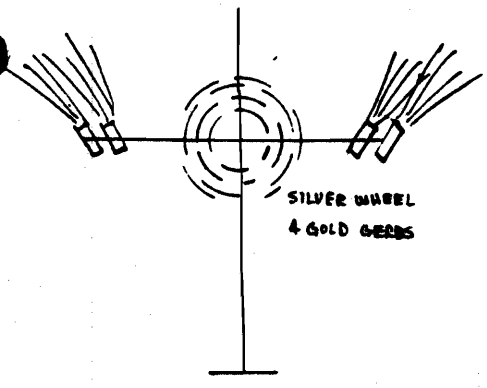
TURKISH CROSS



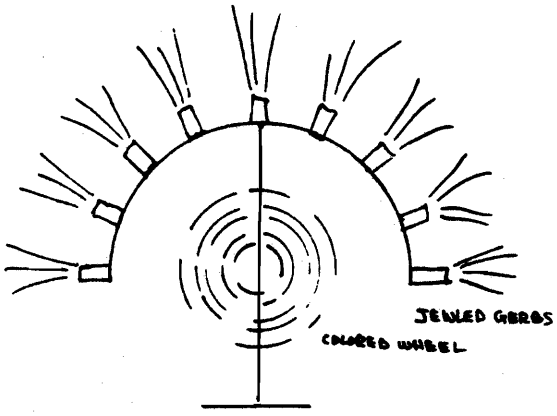
PEACOCK TAIL



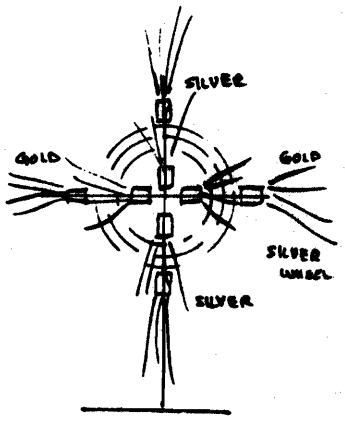
POLAR STAR



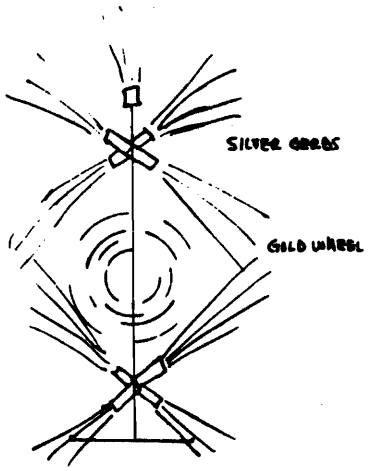
RAINBOW GARDENS



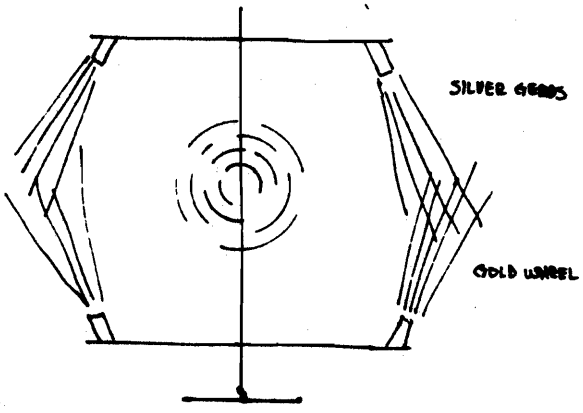
RAINBOW FANFARE



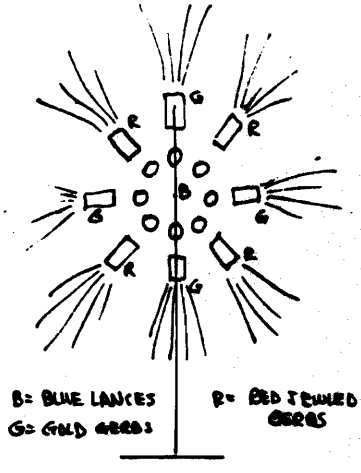
EVENING SUNSET



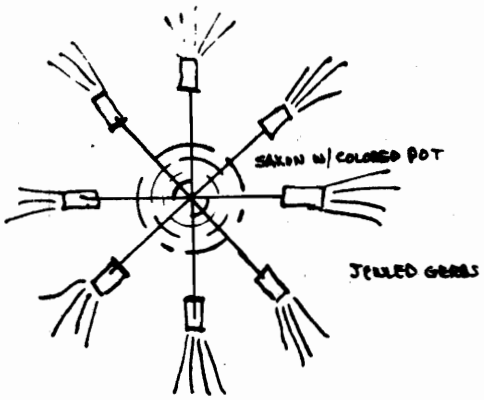
FOUNTAIN OF BEAUTY



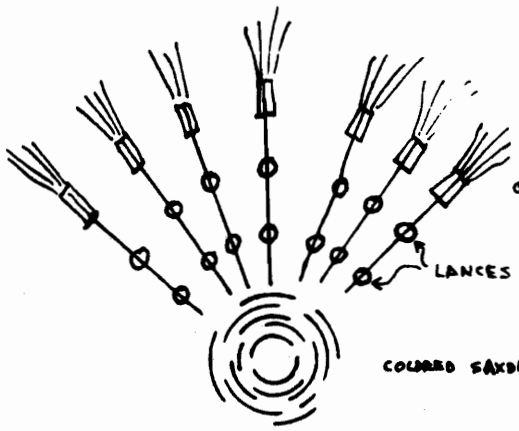
GOLDEN SENTINEL



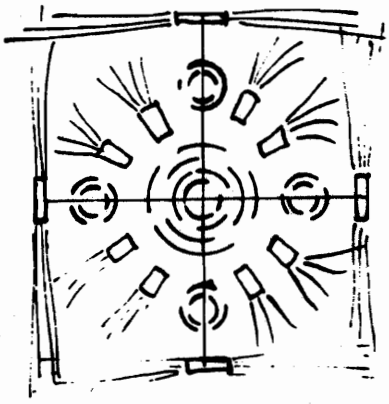
BLAZING SUN



CLUSTER OF JEWELS

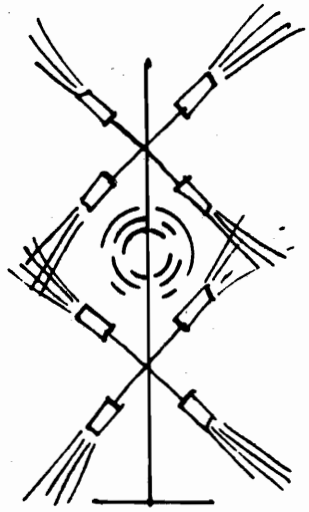


CHINESE FAN

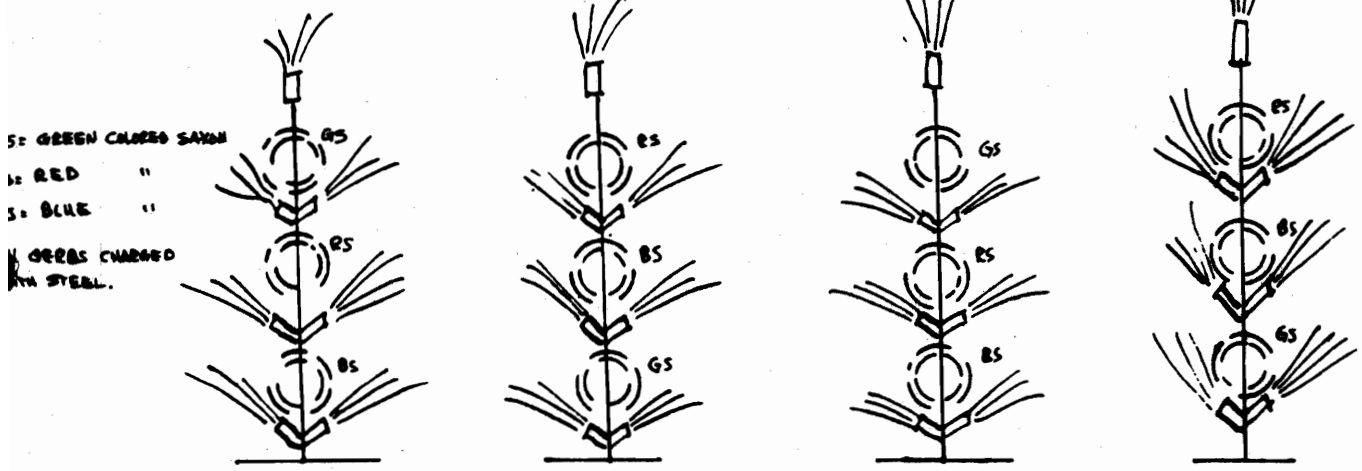


4 SAXONS
1 LARGE CENTRAL WHEEL w/ COLORED POT
16 GERBS

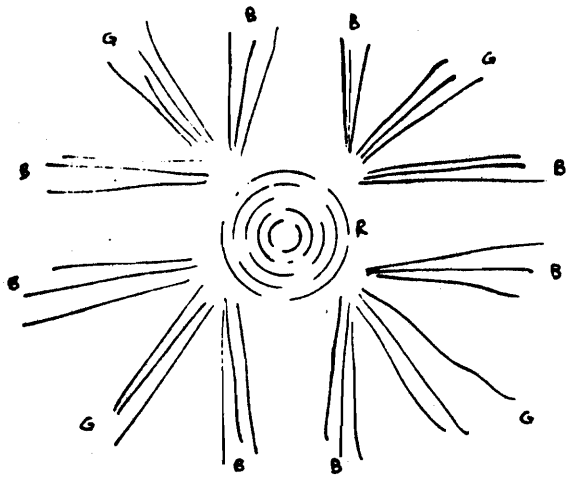
PERUVIAN GLORY



CRIS-CROSS FIRE

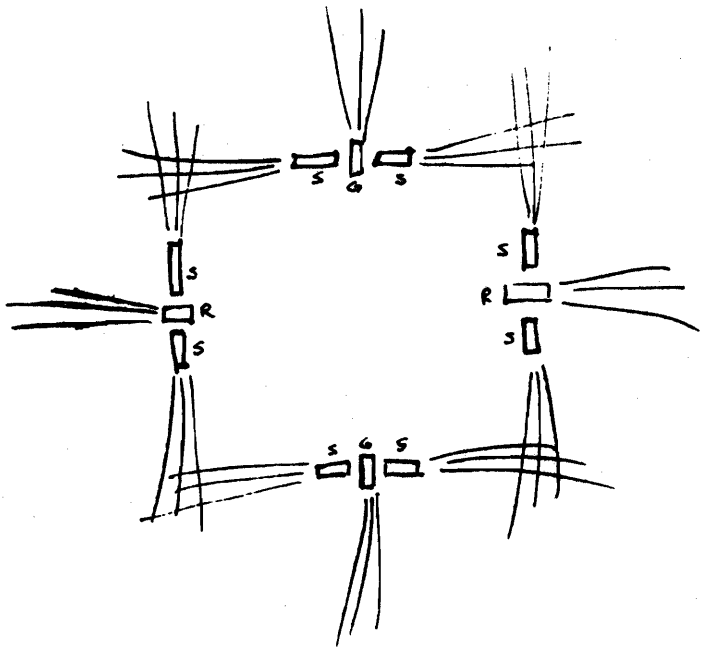


LATTICE POLES



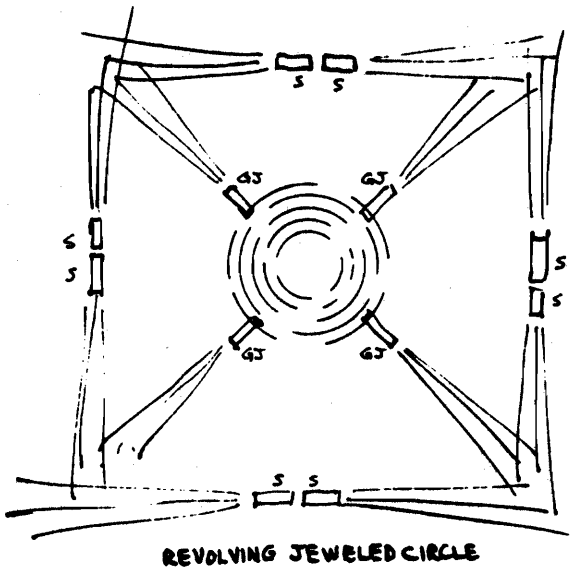
DIAMOND CIRCLET

B: BLUE JEWELED GERBS
G: GREEN "
R: RED COLORED WHEEL



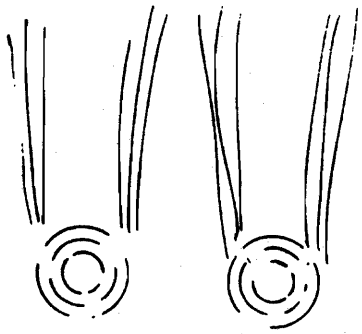
MOSAIC ROSETTE

S: SILVER GERBS
G: GOLD "
R: RED JEWELED GERBS



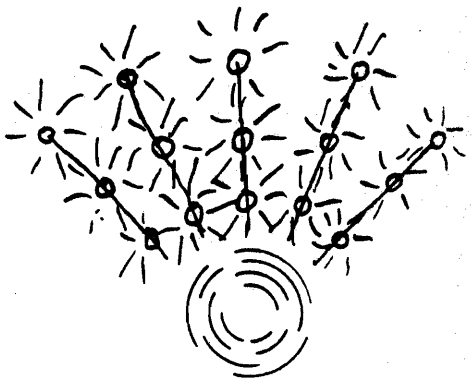
REVOLVING JEWELED CIRCLE

S: SILVER GERBS
GJ: GOLD & JEWELED GERBS



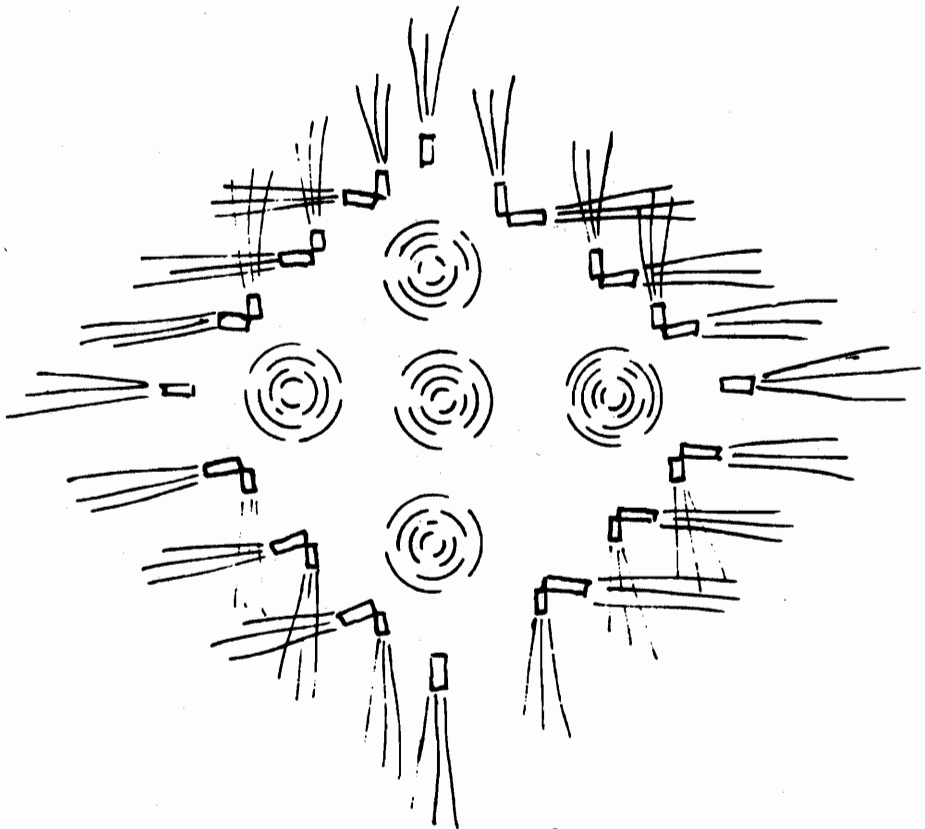
GOLDEN GLORY

GOLD GERBS
SILVER WHEELS

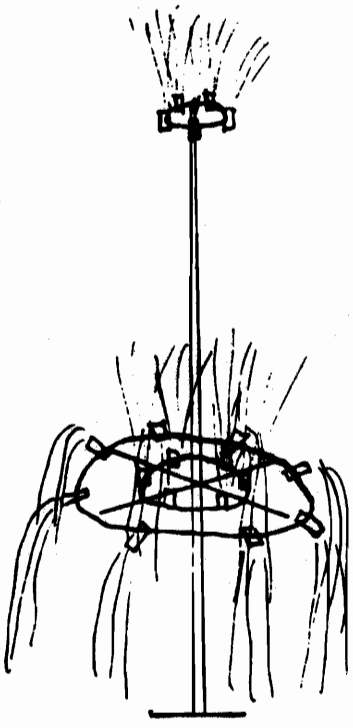


JEWELED FAN

GOLD WHEEL
ROMAN CANDLES

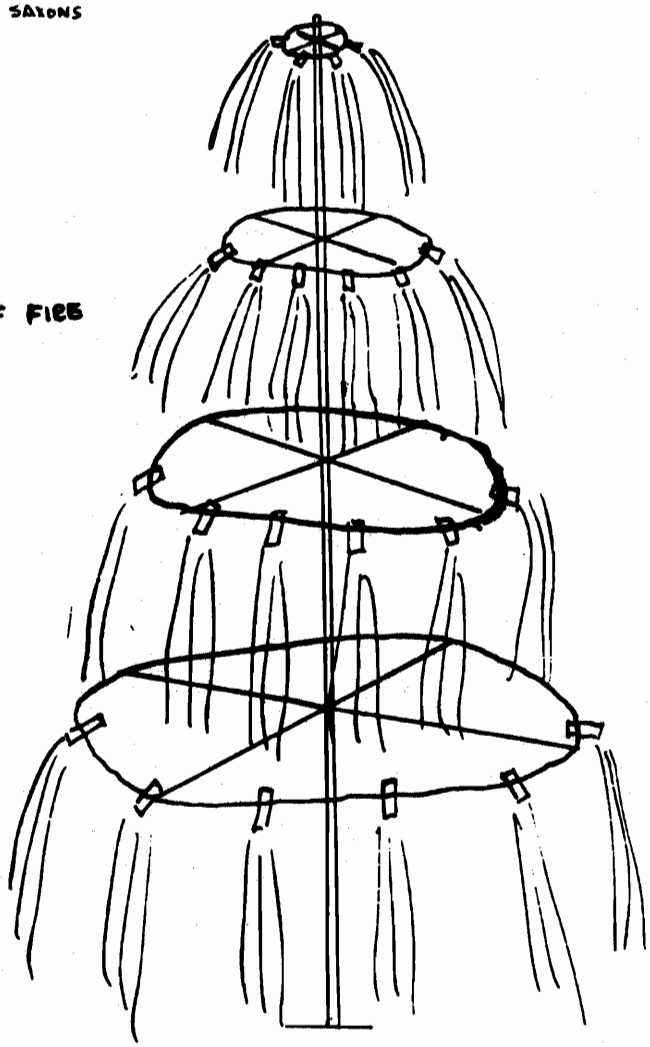


SAXON DIAMOND
BOUNCED GEMS W/ STEEL
FIVE COLORED SAXONS



MANY OTHER VARIATIONS OF THESE CAN BE IMAGINED USING TIERS, ROWS, AND OTHER ARRANGEMENTS OF ROMAN CANDLES, GEMS, MINES, COMETS, SALUTES, GRASSHOPPERS, ROCKETS, WHEELS, LANCES, ETC., ETC.

FOUNTAINS OF FIRE



BASIC AERIAL SHELLS

(L-105)

I. INTRODUCTION

Aerial shells represent the highest development of the pyrotechnical art and require great skill and patience for their successful production. They provide the basis for all pyrotechnical displays. Aerial shells are shot from mortars by means of a charge of black powder and burst high in the air with the production of showers, stars, reports, and other spectacular effects. The smaller shells are shot from paper mortars, the larger ones (3" and more), from commercial steel or iron pipe.

In order to make the construction of these items as enjoyable and as safe as possible, two sets of safety precautions are given. One is a general set to be followed at all times, no matter what type of fireworks are being constructed or fired. The other is a set to be observed especially when firing and displaying aerial shells. All safety precautions must be followed to the letter.

Certain principles and pyrotechnical theory are also given so that the pyrotechnist can better understand the processes that are involved in making aerial shells. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks consist of three main parts, viz., a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimentions, etc., are listed. Third, the ignition mechanisms necessary for proper performance are given. Fourth, any special materials (items that neither make up part of the composition nor the casing, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All of the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material, since we have no control over the conditions of use. The purchaser and user take full responsibility.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II. SAFETY RULES FOR AERIAL SHELLS

1. Always bury the mortars almost completely. Only about 2 or 3 inches should be above ground.

2. NEVER place your hand, arm, or ANY part of your body over a mortar when a shell is in it (even if it is not lit).

3. Keep all shells in boxes or cans (plastic garbage cans with tight lids are best) and assort the various sizes, one size to a container, such as 3" in one, 4" in another, etc.

4. Keep these containers up-wind and at least 15 feet away from the mortars.

5. Mortars should be placed about 4 feet apart with no overhead obstructions of any kind (wires, tree limbs, etc.).

6. Mortars should be loaded by tipping the shells into them with the leader and then letting the shell drop to the bottom. This can be done by not placing the hand directly over the mortar. Make sure the shells go all the way to the bottom. If a shell has not, bounce it gently by pulling and releasing the leader.

7. Mortars should be tilted slightly away from all people (this includes the operator).

8. To prevent mortars from sinking into the ground place a board under them. This should be about 6" wider than each mortar.

9. After firing a few shells, paper may accumulate in the mortars. A stick with a nail in the end can be used to clean them out.

10. Always check mortars for glowing particles before putting in the next shell.

11. If a shell fails to leave the mortar, never reach in to pull it out (you may lose an arm). Leave it for about five minutes and they if you have to use this pipe, douse it with a pail of water and use your long stick to fish it out. If you have another mortar, leave the shell alone until the display is finished. Bury this shell where it cannot be gotten hold of.

12. Always remember to put the right size shell in the right size mortar. A smaller shell put into a larger mortar will cause the shell to arch out of the mortar and explode on the ground.

13. After the display is over, check the grounds for possible pieces of fireworks that failed to ignite. If a shell failed to explode in the air, find this dud shell at all cost, as another person or child may find it and be severely injured by it. The best way to dispose of this material is to soak it in water and bury it where no one can get it.

III. THEORY AND GENERAL PRINCIPLES

Aerial shells are fired from mortars with a black powder charge, the coarser the etter (Fg black rifle powder works well). The amount of this lifting (or driving) charge aries, depending upon the weight, type and size of the shell. This must be determined y experimentation. But a general rule is for every ounce the shell weighs, use 1/5 oz. lack rifle powder. Some shells may require more, some less. Only experimentation will ive the correct amount for each shell. If other varieties of black powder are used, this iantity may have to be varied. Never use smokless powder or any other types of powder xcept black powder to drive shells.

The mortar length should be about five times its I.D. for shells 3" and larger. naller shell mortars need not be quite as long, and mortars used for firing multiple reak shells should be somewhat longer. Shells are named by the I.D. of mortar that fires iem. Thus, shells fired from a mortar with 3" I.D. are called 3" shells. Sometimes hells are named for their circumference, rather than their diameter. A 3" shell would ien be called a 9" shell. Even though a shell may be called a 3" shell, it is actually omewhat smaller in diameter (about 2-3/4"). This is so that it may fit easily in the mor-ar and also allow space for its "leader" of fuse.

There are various types of bursting charges. Each shell has its own type and amount, epending upon its effect. Generally there are three types.

Type I	Meal Powder..... 1	Type II -	FFFg black rifle powder
	FFFg black rifle powder. 1		
	Saltpeter 3	Type III -	Meal powder
	Sulfur..... 1-1/2		
	Charcoal, dust..... 1		

The bursting charge is ignited by a time fuse. This is a short length of specially ade safety fuse from 1/4" to 3/8" in diameter. The time fuse is ignited either by the iving charge or by the leader. Its length varies with the type of shell. The burning time or all special fireworks time fuse is about 2.5 sec/inch. The time fuse should be thickly rimed on both ends. This of the utmost importance. The use of regular blasting fuse is ot recommended. It does not burn with a trail of sparks so the trajectory of the shell annot be determined and a misfire or a potential low burst cannot be spotted.

There are many types of shell casings that hold the garnishments and various effects, ach type depends upon the particular effect the shell is to produce. There are two shapes f casings: Spherical and cylindrical. In the past, shell casings were often made in a pherical shape, but now in this country they are made almost exclusively in the form of ylinders. For the same diameter, cylindrical shells hold more display material than pherical ones; they are faster and easier to construct; and it is much easier to contrive iem in a manner to procure multiple bursts. For specialized effects, spherical shells re used. The Japanese use spherical shells almost exclusively and achieve an almost erfect symmetrical break. The chief advantage in using a spherical shell is being able achieve a symmetrical break much easier. This is especially so if ready-made spheri-al casings are used. These are available from Westech.

IV. BASIC DESCRIPTIONS

A. Composition Formulas (all parts by weight)

Formulas 1-7 are for regular stars (cut, pumped, or box—any size).

(Red)	#1	#2
Potassium Chlorate	6	6
Strontium Nitrate	6	
Strontium Carbonate		1
Charcoal, dust	2	1
Shellac	1	1
Dextrin	1/2	1/2

#3 (Green)	
Barium Chlorate	9
Shellac	1
Dextrin	1/4

#4 (White)	
Potassium Nitrate	10
Sulfur	3
Arsenic Sulfide	3
Dextrin	1/2

#5 (Yellow)	
Potassium Chlorate	4
Sodium Oxalate	1
Charcoal, dust	1/4
Shellac	1
Dextrin	1/4

#6 (Blue)	
Potassium Chlorate	9
Paris Green	3
Lactose	1
PVC	1/2
Dextrin	1/2

#7 (Purple)	
Potassium Chlorate	6
Copper Oxide	1
Strontium Nitrate	1
Shellac	1
PVC	1/4

Formulas 8-22 are for special stars (cut or pumped only—any size, except as noted).

#8 (Gold)	
Potassium Nitrate	8
Sodium Oxalate	4
Sulfur	2
Charcoal, dust	1/2
Dextrin	1/2

#9 (Silver)	
Potassium Nitrate	10
Aluminum, bright	1
Arsenic Sulfide	3
Sulfur	3
Red Gum	1

(Twinklers)	#10	#11
Meal Powder	24	25
Aluminum, bright	3	3
Antimony, Chinese needle	3	3
Sodium Oxalate	4	
Dextrin	1	1

Cut or pump 3/4" x 3/4"

#12 (Gold Flitter)	
Potassium Nitrate	4
Sulfur	1
Charcoal, dust	1/2
Sodium Oxalate	1
Aluminum, bright	4
Aluminum Flitters	1/4
Dextrin	1

#13 (White Flitter)	
Potassium Nitrate	17
Sulfur	3
Charcoal, dust	3
Antimony, Chinese needle	11
Aluminum, bright	10
Aluminum, flitters	3
Dextrin	4

#14 (Sinter)	
Potassium Perchlorate	16
Barium Nitrate	1
Aluminum, bright	6
Red Gum	1-1/2
Charcoal, dust	1
Dextrin	1-1/2

Cut 1/2" x 1/2"

#15 (Spreader)	
Potassium Nitrate	7
Sulfur	1-1/2
Charcoal, dust	2
Charcoal, coarse	1-1/2
Dextrin	1/2
Zinc, dust	20

#16 (Splitter)	
Potassium Nitrate	8
Barium Nitrate	4
Sulfur	2
Charcoal, dust	2
Antimony, Chinese needle.	2
Aluminum, bright	1
Dextrin	2

#17 (Red Electric)	
Potassium Perchlorate	24
Strontium Nitrate	12
Aluminum, bright	8
Charcoal, dust	1
Shellac, orange	2
Dextrin, yellow	2

#18 (Green Electric)	
Potassium Perchlorate	4
Barium Chlorate	8
Barium Nitrate	8
Aluminum, bright	6
Charcoal, dust	1-1/2
Red Gum Yacca	2
Dextrin, yellow	1

#19 (Blue Electric)	
Potassium Perchlorate	14
Aluminum, bright	6
Barium Carbonate	1
Paris Green	10
PVC	2
Dextrin, yellow	1
Shellac, orange	2

#20 (Snowflake)	
Potassium Chlorate	2
Lampblack	3
Aluminum, bright	1/2
Dextrin	1/2

#21 (Willow Stars)	
Lampblack	12
Potassium Chlorate	8
Potassium Nitrate	1
Dextrin	1

#22 (Steel Stars)	
Saltpeter	16
Meal Powder	2
Charcoal	2
Steel filings	5
Shellac	1/2

Formulas #23-#28 are for special Magnesium stars (cut, pumped, box—any size). They burn with a very brilliant light, much like stars containing aluminum. The Magnesium should be about 100 mesh.

(Magnesium Stars) Material	#23 (Bright)	#24 (Amber)	#25 (Red)	#26 (Green)	#27 (Blue)	#28 (Crimson)
Magnesium	1	1	4	1	2	3
Shellac	1	1	1	1	1	1
Saltpeter	5					
Potassium Perchlorate		4	7		8	
Sodium Oxalate		2				
Strontium Nitrate			4			1
Barium Chlorate				3		
Paris Green					4	
Stearic Acid					1	
PVC					1/2	

Formulas #23-#28 should be dampened with alcohol only to dissolve the shellac. The shellac gives the metal a protective coating to keep it from being oxidized.

Except for formulas #23-#28, all star formulas should be mixed well with 24 mesh mixing sieves and then moistened with a 50:50 mixture of water:alcohol. Only practice will tell how much to dampen, but the mixture should have the consistency of bread dough. If the stars are dampened too much, they will not perform properly; if they are dampened too little, they will crumble. Form into pumped or cut stars, and while still damp, dust with meal powder/barium carbonate. Then allow to dry at least five days in a warm place. The meal powder should have added to it 1/10 part Barium Carbonate to act as a neutralizer to any acid that may be present in the sulfur of the meal powder. It is especially important to have this neutralizer present in the meal powder when using it to prime chlorate-containing stars. If not, spontaneous combusion may result from some free acid reacting with the Chlorate.

Formula #15 is a very effective star. They throw two kinds of sparks when they burn, masses of brightly burning zinc and particles of glowing charcoal. Because of the zinc which they contain, spreader stars are much heavier than other stars. Aerial shells cannot carry as many or a larger driving charge must be used.

Formula #16 also makes very surprising stars. They split into bright fragments while burning and burst as they finish, producing a fine palm-tree effect. #14 also produces a beautiful effect.

A small quantity of stars using formula #21 give an unusual fulness to any shell. The ingredients must be mixed thoroughly in order to obtain the desired effect. This is somewhat difficult because of the difference in weight between the bulky lampblack and compact potassium chlorate. Dampen the lampblack first with the water/alcohol mixture and then add the other ingredients.

B. Casings

Cylindrical casings are made by wet-rolling any type of paper around a suitable former. This may be a wooden dowel or metal pipe about 8" long and with an O.D. equal to the desired casing I.D. The formers available at Westech are ideal. The former should be coated with paraffin and then before each rolling given a good layer of paste so the casing will not stick to it and can be easily removed. The table below gives the various dimensions for cylindrical shell casings (shown in inches).

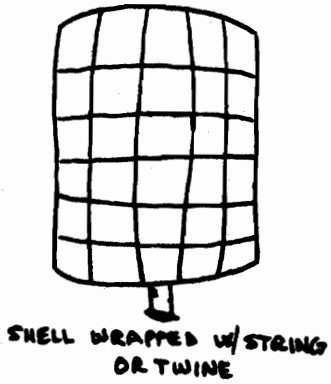
Mortar I.D.	Shell O.D.	Shell I.D.	Shell Wall Thickness	Shell Length
1-1/4	1-3/16	1	3/32	2-1/2
2	1-15/16	1-11/16	1/32**	*
3	2-3/4	2-9/16	1/32**	*
4	3-3/4	3-1/2	1/32 **	*

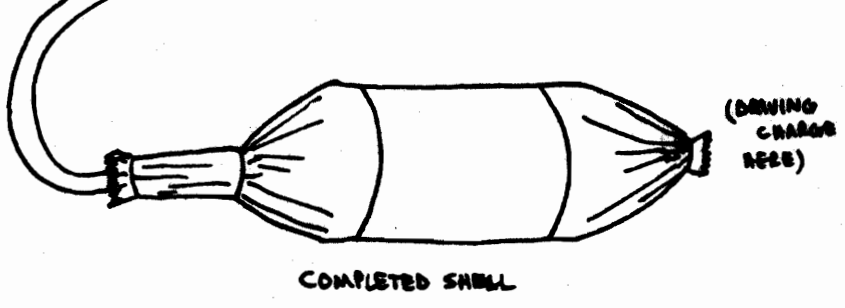
*The length of a display shell varies, depending upon the contents and the number of breaks. For example, a 3" single break star shell has a length of 3"; a 2-break 3" star shell has 2 casings, each 2-1/2" long; a 3-break 3" shell has three casings, each 2" long; a special effects 3" shell (such as whistles, fish, and stars) may be 5-1/2" long.

**In addition to the shell wall, the casing is wrapped with twine and then more paper. The twine gives the shell more strength and is responsible for the symmetrical break. The outside layer of paper gives the shell a smooth surface (for decreased wind resistance), additional strength, and a closer fit in the mortar. In addition, this paper secures the quick match leader and driving charge for exhibition shells.

End closures are made from 1/8" chipboard, and secured in the casings using Prof. Pyro Ad. In the past wooden discs were used for end plugs but chipboard plugs have less "fall-out", are lighter, easier to make, and less expensive.

There is an endless variety of garnishments that the bursting charge distributes in the sky. The many types listed in our publications cover most of the best known varieties. But the ingenuity and imagination of the pyrotechnist will suggest others as he progresses and applies and expands the principles given.





V. PRODUCTS OF MANUFACTURE

B. Commercial Single-Break Shells - These shells are classified "Class C" fireworks, and are sold "over-the-counter" in some areas. They are 2" or less and come complete with a lifting charge and paper mortar.

1. Star Shells:

Compositions: Any type of star(s), Fg black rifle powder for the lifting charge, Type II bursting charge.

Casings: A shell casing made as explained in Part IV, a paper mortar secured to a wooden base with Prof. Pyro. Ad. The following table shows the usual dimensions for commercial shells (sizes shown in inches).

	Mortar Size (Paper)			Shell Size		
Size	Length	I.D.	Wall	I.D.	O.D.	Length
#0	3	3/4	.040	5/8	11/16	2-1/8
#1	5	1	.048	3/4	15/16	2-1/2
#2	6	1-1/4	.048	1	1-3/16	2-1/2
#3	7	1-1/2	.055	1-1/4	1-7/16	2-1/2
#4	8	1-3/4	.125	1-1/2	1-11/16	2-1/2
#5	9	2	.125	1-11/16	1-3/4*	2-1/2

*Should be wrapped with string (parcel post, 6-8 ply) and finished with more paper to give a full burst. This will give a total O.D. of about 1-15/16".

If the paper mortar is to be rolled by hand, great care must be used to achieve a very strong tube. Use a good quality paper (Kraft or Manila), apply plenty of force when wet-rolling, and apply plenty of paste. Mailing tubes or other strong paper tubes give good results.

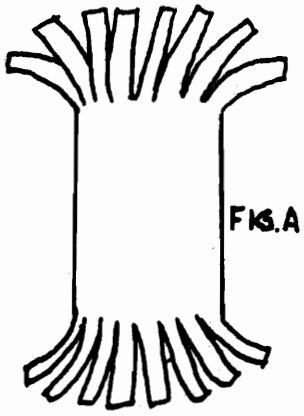
Ignition: 1/4" special fireworks time-fuse, priming, safety fuse.

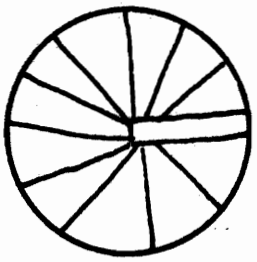
Materials: Prof. Pyro. Ad., circular piece of thin chipboard.

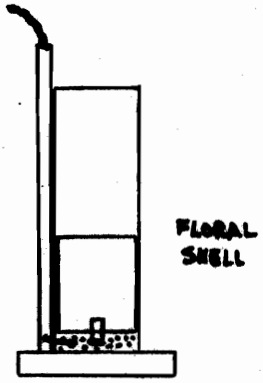
Tools: Former for rolling the casing (if hand rolled).

Manipulation and Procedure: Bore a 1/4" hole in the center of a chipboard disc. Secure well with Prof. Pyro. Ad. a length of time fuse about 1" long. (The exact length will have to be ascertained by experimentation. Each shell varies, depending upon its weight, size, etc., and these factors determine how far up the driving charge sends it. The break should occur just as the shell starts its downward flight.) About 1/4" of the fuse should extend on one side of the disc (the side that is to be outside); the rest should extend on the other side. Prime well both ends of the fuse and allow to dry. When both priming and Adhesive are dry, use Adhesive to secure the fused end closure in a casing, making sure that it fits flush with the ends and the 1/4" section of time fuse is on the outside. When the Adhesive is dry, fill nearly to the top with stars, leaving a 1/8" space to secure the other end closure. Place the filled shell on a balance to determine

the amount of bursting charge. Pour in Type II bursting charge and secure the end closure with Adhesive. The exact amount of bursting charge varies with the size of the shell and its contents. Generally, about 3/4 oz. is used for every 1 oz. of stars. At this point the shell is considered complete for commercial over-the-counter sale. However, unless it is wound with string and further finished, it will not give a full break, but one very similar to a rocket, by merely blowing out the end. First, wind it lengthwise. Wrap the string as tightly and as firmly against the fuse as possible. Each time that the string passes the time fuse, turn the shell so that about 15-16 turns are wrapped evenly around the shell. Now wrap about 10-12 turns around the sides of the shell and at right angles to the first winding. Cut the twine and secure the loose end with Adhesive. Now cut some Kraft paper one diameter longer than the shell, or a little more, and soak it thoroughly with thin paste. Roll about two layers around the shell, leaving an equal amount projecting at each end. With scissors, snip the projections into 1/2" strips longitudinally (Fig. A) and work over top and bottom as neatly as possible so that they lie evenly and tightly around the fuse and there are no openings in the bottom (Fig.B).







Punch a small hole in the mortar about 1/4" above where it is secured to the base, insert a length of safety fuse, pour in the required amount of lifting charge, drop in the completed shell (fuse end down) and push in the circular piece of thin chipboard, cut to fit snugly the inside of the mortar so it secures the shell and lifting charge.

2. Floral Shells -- These are made exactly as above. Take a Roman candle a little longer than the mortar and punch a hole in its side near the bottom star. Fit in a piece of quick match, bare the other end and slip it into the mortar through a hole punched in its side. Fasten the candle to the side of the mortar with wire and the floral shell is completed.

B. Single Break Exhibition Shells - These shells are 3" or longer and fired from commercial iron or steel pipe. They are classified as "Class A" fireworks.

Compositions: Any variety of star, Fg black rifle powder for a lifting charge, Type I bursting charge.

Casings: A shell casing made as explained in Part IV. For all around use, a 3" shell can produce breaks that equal most of the larger diameter shells.

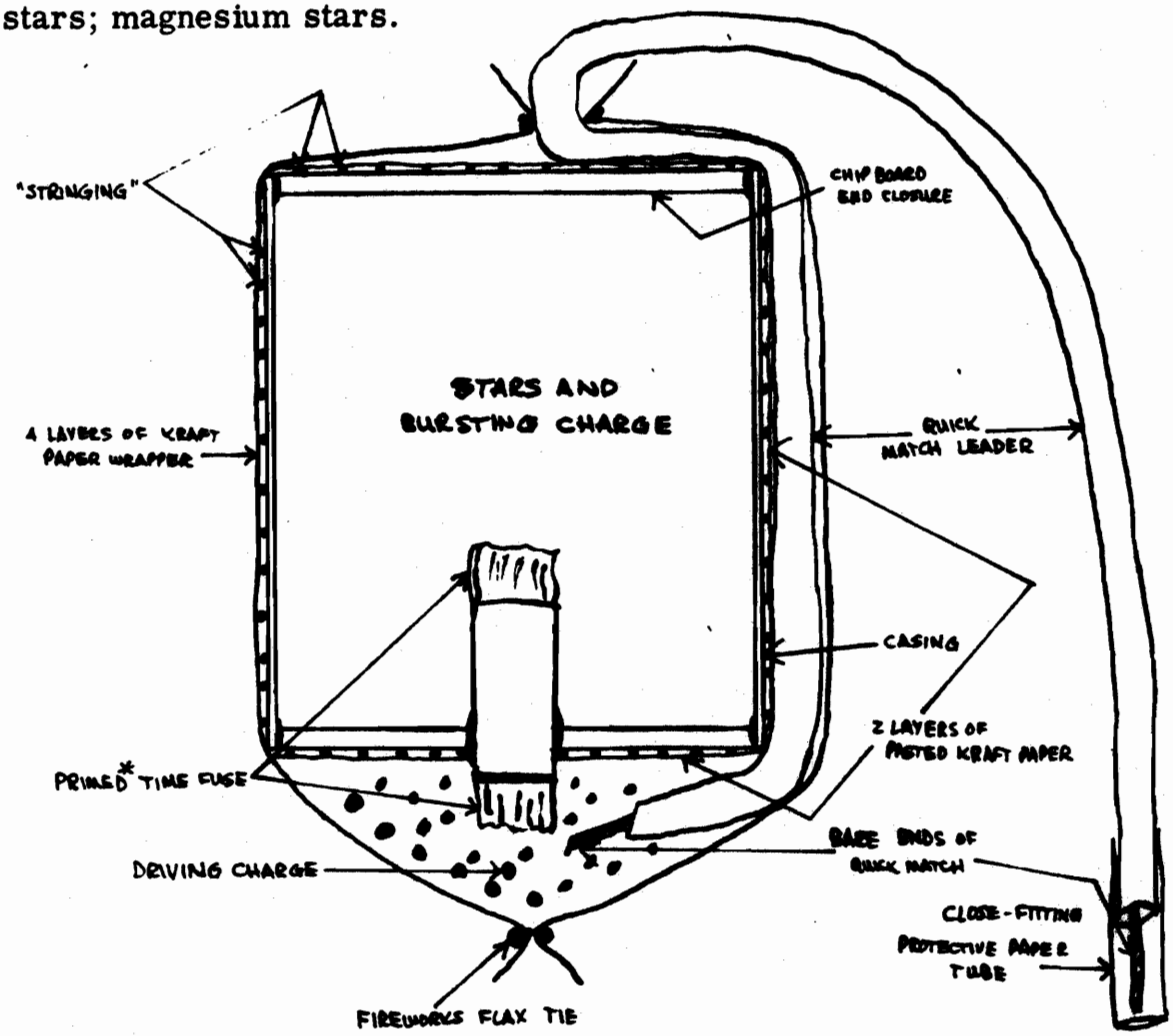
Ignition: 3/8" Special fireworks time fuse, priming.

Materials: Prof. Pyro. Ad.

Tools: A former for rolling the casing (if hand-rolled).

Manipulation and Procedure: The shells are made exactly as explained above under "star shells." However, use strong twine instead of string, 3/8" fuse instead of the 1/4" variety, Type I bursting charge instead of Type II. When the shell is completely dry, take a 2' piece of quick match and lay it along the side of the shell. The quick match should extend about 3" beyond the end with the time fuse. Both the quick match and shell are dry rolled up as tightly as possible in four thicknesses of Kraft paper, wide enough to extend one diameter beyond each end of the shell. The shell is now turned bottom end up. About 2" of the paper pipe of the quick match is removed to expose the black match. Make sure that the time fuse is well primed and has no paste, Adhesive, etc., on the priming. The driving charge is introduced and the paper wrapping is tied securely and trimmed close to the string. The other end of the wrapping is tied securely around the quick match and a few inches of black match bared at the end. This piece of black match, for safety's sake, is now covered with a close fitting paper tube, closed at one end, which is to be removed after the shell has been placed in the mortar and is ready for firing.

There are many beautiful effects using a single break of stars. Some especially good ones are: Blue and gold flitter; blue and white flitter; gold and white flitter; twinklers; spreaders, spitters; weeping willow; gold and silver, red and silver; red and green; red and blue; blue and silver; purple, red and gold; red, green and silver; red and yellow; red and gold; blue and yellow; purple and green; gold, red and green; "electric" stars; magnesium stars.



PAPER METHOD

EXHIBITION AERIAL SHELLS

PART I (FANCY BREAKS)

(L-105A)

The aerial shells that make up the "Exhibition" series are all 3 ' or larger. All of the theory, general principles, safety precautions, etc., discussed in Parts I through IV in L-105 must be thoroughly learned and applied before attempting any manufacture or display of these exhibition shells. Unless otherwise stated, the bursting charge is Type I.

PRODUCTS OF MANUFACTURE

Meteoric Shower Shells-- These are shells loaded with large (3/4" or 1-1/4") stars, generally red, green, and gold (formulas #17, #18 and #8). Of course, any other large stars may do also. Make the same as for regular shells described under "Single Break Exhibition Shells" in L-105.

Spangle (Streamer) Shells -- These are shells that break into large (3/4" or 1-1/4") tailed stars (formulas #8, #9, #12, #13, #14, #15, #16, #20, #21).

Thunderbolt Shells -- This shell produces a very surprising effect, especially if fired immediately after a regular spangle shell using formula #20. The shell breaks as a regular spangle shell, but after all of the rest have burned out, four spangles keep on burning and falling. All of a sudden they explode just before they hit the ground. This always elicits laughter and surprise from the spectators, as they think some mistake was made when the four spangles appear to burn too long.

The four reporting spangles may be made from 1/2" I.D. x 1-1/2" long casings. Insert an end cap and secure with Prof. Pyro. Ad. Fill about 1/3 full with flash powder. Punch a 1/8" hole in the other end cap and prime it well on both sides. When dry, push it into the casing until it almost reaches the powder. Secure with Adhesive. Push in some damp comp #20 until it fills the remainder of the casing and overflows on top. Prime this end well, and allow to dry for at least a week. Fill a shell with regular spangles plus the four "thunderbolts" and finish as for regular shells.

Rain or Shower Shells -- These shells are made and "strung" like single layer serpent shells (see below), but they are filled with rain cases instead of serpents. Rain cases are about 2" long x 1/2" I.D. and made by wet-rolling four turns of paper around a suitable former. They are filled with #8 (but substituting Red Gum Yacca for the Dextrin) for gold rain, and #9 for silver rain. About 1/8" in each end of the case is filled with priming.

Peacock Plumes -- These are cases made as above. One end is filled with a star composition, the other with a rain composition. The shell is made as for single layered serpent shells (see below) and produces a very effective display.

Palm Boughs -- These are made like Peacock Plumes except 6 to 10 small (1/4") stars are substituted for the rain. These are especially effective if small green stars are used which produce the effect of a blooming flower, complete with green stem and colored blossoms at the end.

"Granatine" -- Take a 1/2" I.D. x 1-1/2" long casing; plug one end with an end cap and secure with Prof. Pyro. Ad.; when dry, pour in some flash powder. Punch a 1/8" hole in another end cap, stick a 1/2" piece of black match through and prime well on both sides. When dry, insert and secure with Adhesive. When dry, wet-roll four turns

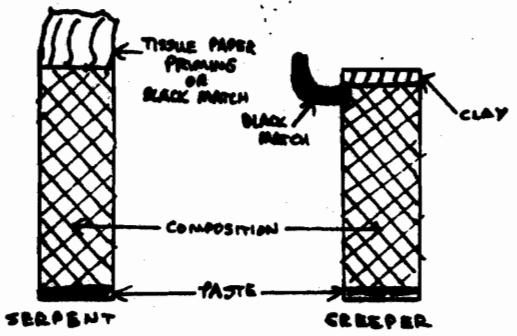
of paper around the case so there is about a 1-1/2" projection on the end that has the match. Fill with small (1/4") stars and then match and nose. Fill and "string" the shell like single or double layered serpent shells.

Serpents:

A. Regular-- These are cases 1/4" I.D. x 2-1/2" long made by wet-rolling four turns of strong paper. When dry they are driven full with the composition given below. One end is primed well and has a short piece of black match stuck in the priming; the other is thoroughly covered over with paste or dipped in Sodium Silicate.

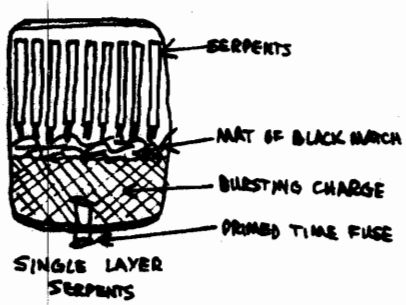
B. Creepers -- One end of the case is filled with about 1/4" driven clay. It is then filled with composition and the other end is covered with paste, etc., as above. A hole is then punched in the side, just above the clay. The hole is primed well and a piece of black match inserted.

Material	Serpents	Saucissons
Meal Powder	7	4
Saltpeter	2	2
Sulfur	1	1
Charcoal, dust	1	1
Iron filings, 40 mesh	3	3



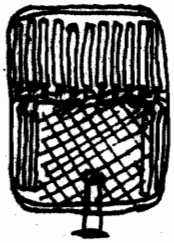
Serpent shells are made differently than regular shells. Instead of a symmetrical break, the shell should blow one end out. This is accomplished by filling the bottom of a shell casing with serpents, primed ends up. Then a thick mat, made from pieces of black match, is placed on top. The bursting charge is poured on top of the mat as shown in the drawing. The part of the shell containing the bursting charge is wrapped with triple the amount of twine; see drawing.

Double Layer Serpent Shells -- The shell casings are made a bit longer and then filled as above. But the bursting charge only occupies the center of the upper half of the casing; around the walls are placed serpents; about one or two layers thick with primed ends down, see drawing. Only a band around the center of the casing is wrapped with extra twine (see drawing) so both ends can blow out.



SINGLE LAYER SERPENTS


SINGLE LAYER "STRINGING"


DOUBLE LAYER SERPENTS


DOUBLE LAYER "STRINGING"

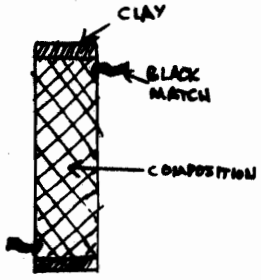
Serpents and Stars -- Stars may be placed with the bursting charge for single-layered serpent shells to give a pleasing effect.

Saucissons -- These are made like bounced fountains using a case 3/8" I.D. x 3-1/2" long x 3/32" wall. Fill and construct the shell as for single-layered serpents. Saucissons without the bounce are sometimes called "fish." Very effective shells can be made by combining saucissons and/or fish with whistles and/or stars.

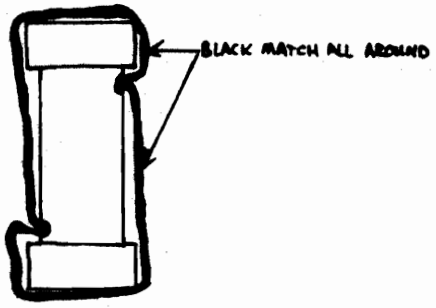
Whirlwinds -- These can be made any size but generally are 5/8-3/4" I.D. x 3" long. They are constructed as shown and use saucisson comp.

Fireflies -- These have a box star glued to each end of a whirlwind. A shell filled with these is a very effective item.

Fill and "string" the case as for single-layered serpent shells for both whirlwinds and firefly shells.



Whirlwinds

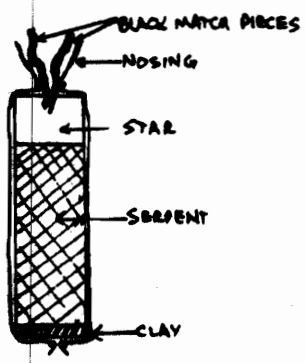


Fireflies

Stars to Serpents -- These are constructed as shown. These make a very effective surprise shell. Fill and string as for either single or double-layered serpent shells.

Stars to Whistles -- Same as above but use whistle compo. instead of the serpent formula. These shells are sometimes called "Musical Shells."

Stars to Thunder -- A very effective shell, especially if the report compositions are colored, the stars disappearing in a rainbow of colored flashes and reports.



For the above three, the damp star composition should be rammed in the case first. When it is dry (allow at least three days), the other compositions are added dry—the serpent and whistle compositions being rammed into the case. The thunder composition is merely poured into the case. (If a damp star composition containing a chlorate came into contact with another composition containing sulfur or one of its compounds, upon drying, the article could ignite from only a slight jolt.

Rainbow Reports	Red	Green	Yellow	Blue	Violet
Magnesium, 100 mesh	1	1	1	1	2
Strontium Nitrate	1				1
Barium Nitrate		1			
Sodium Oxalate			1/2		
Paris Green				1	1
PVC		1/8		1/8	1/8
Potassium Perchlorate			1	1	

Color Changing Stars -- A shell filled with these is extremely effective. All that necessary to do is to press a dampened mixture of the desired color around an unimed 1/4" cut or pumped star of another color. This is done with the fingers until ie star is a rough sphere, about 1/2" in diameter. The first star should be dry; the econd mixture may need to be dampened a bit more than usual. The finished stars hould be primed as usual. Fill and string as for a regular shell. (For complete instructions on making color-changing stars by an easy, quick, and inexpensive mass roduction process, see L-TR3.)

The proper succession of colors is very important. Green should not be next to hite, for there would not be sufficient contrast. And green should not burn after red, or the color of the barium flame appears to one who has been watching the flame of trontium to be a light and uninteresting blue. Some suggested color changes are: reen to red, blue to red, green to gold, blue to silver, green to red to gold, blue to ilver to red, gold to green to red.

Grasshoppers and Stars -- Fill the shell with mostly grasshoppers and a very ew stars. Make and string as for a regular shell. This makes a very amusing shell.

Devil-Among-The-Tailors -- This shell is filled with grasshoppers and 1 whisting saucisson. The saucisson is made as usual but with a whistle case attached to its ide. Make and string as for a regular shell. The whistle should be 2-1/2" long x 5-16" I.D. x 9/16" (about) O.D. Plug one end with about 1/8" clay and then ram to within 1" of the top with whistle comp. The 1" vacancy is necessary for the production of the whistle sound. Prime, match, and nose. Glue and tie to the primed, matched, and losed saucisson.

Conch Shells -- This consists of placing specially made 3-ball Roman candles in the bottom of a shell, like single-layered serpents. The candle casings are made of very strong paper so they can be thin and no empty portion is left on top or bottom. In addition, not as much candle comp. is used so the candles fire more rapidly. Some stars are added to the bursting charge and the shell is filled and strung like a single layered serpent shell. The candles should be well-primed and have several strands of black match protruding from the nosing.

Military Shells -- These are shells filled with M-80-type salutes. The fuses should be about 1/4" long and secured firmly in their holes with Prof. Pyro. Ad. They should be heavily primed on the outside and a short piece of black match stuck in the priming to insure ignition. The effect is quite startling as upon bursting in the air, this shell remains dark for a few moments to enable the salutes to form a full circle, then all ignite at the same time.

Thunder Shells -- These shells are filled with flash crackers and then strung like regular shells.

Thunder and Rainbow Shells -- These are made like regular shells but use half stars and half flash crackers. Especially effective are colored magnesium flash formulas.

Thunder and Whistles, Rainbow and Whistles -- are also effective shells. Whistles should be well primed, nosed and matched.

EXHIBITION AERIAL SHELLS

PART II (PATTERNED BREAKS)

(L-105B)

The aerial shells that make up the "Exhibition" series are all 3" or larger. All of the theory, general principles, safety precautions, etc., discussed in Parts I through IV in L-105 must be thoroughly learned and applied before attempting any manufacture or display of these exhibition shells.

Patterned break shells take much time, patience, skill, and experimentation to achieve successful and symmetrical patterns.

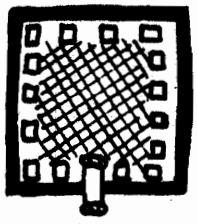
PRODUCTS OF MANUFACTURE

Spider Web Shell -- This shell produces several long, evenly spaced tentacles that reach for tremendous heights and almost to the ground. This produces a very surprising change from other regular break shells.

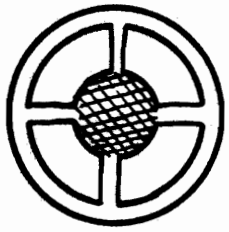
The stars are pumped approx. 3/4" x 3/4" from the following composition: (By wt.)

Meal Powder . . 33	Charcoal, dust . . 6	Mix well and dampen with a 50/50 mixture of water/alcohol.
Saltpeter 4	Lampblack 1	
Sulfur, flour . . . 8	Dextrin 1	

The casing is rolled as normal, height should be equal to O.D., but it is filled and strung in a special way. Place a single layer of stars in the casing so it covers the bottom as completely as possible. Then stack stars on top of each other around the walls so they form a single layer thick from top to bottom (see diagram). Fill the center vacancy full with Type III bursting charge, leaving just enough space at the top to place a layer of stars. In wrapping the shell with twine, it should be completely covered so the casing cannot be seen. Wrap the twine very tightly and finish as for a regular shell. Type III bursting charge.



Spider Web



Southern Cross

Southern Cross Shell -- This shell produces a dark center (where the shell breaks) and then four equally spaced arms, making a spectacular cross of fire in the sky. The stars are made from the following:

Meal Powder . . . 12	Sulfur, flour 10	Mix well, dampen with a 50/50 water/ alcohol mixture, form into the special shape as shown above.
Saltpeter 36	Dextrin. 2	
Antimony, Chinese Needle. 12		

The stars are molded into a special shape. They cannot be cylindrical or any other shape because the bursting charge (Type III) will not have sufficient force to throw such huge stars into the proper pattern.

The casing is rolled and strung like the above; height equals O.D.; twine covers entire casing. The four stars are placed around the outside and the bursting charge in the center, see diagram. Magnesium or electric stars, shaped as above, also make a very striking display, especially if different colors are used. Type III burst.

Octopus Shell -- This is the same as the above except the stars are exactly half as large but twice as many, and use the formula for Splitter stars instead of the above. Type III burst.

Weeping Willow -- This shell produces one of the most beautiful effects available in pyrotechnics. The stars are made from the following:

Meal Powder	8	Mix well. The effect of this star is entirely dependent on how well the ingredients are incorporated. Dampen with alcohol only, press and cut into 3/4" cubes.
Lampblack	6	
Antimony Sulfide	1	
Shellac	1/4	

The stars and bursting charge are all placed in the bottom half of the casing, the top half being filled with rice hulls or other nonflammable material. (see Figure 1). To achieve the hemispherical, drooping effect, a very light bursting charge is used (only about 5 grams for a 3" shell) and the shell is especially strung. The half that contains the bursting charge is given a triple amount so only one end is blown out (see Figure 2). The shell is then finished as normal. Type I burst.

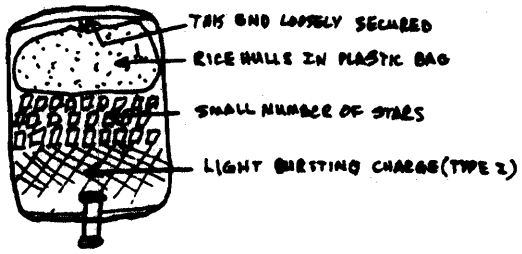


Figure 1

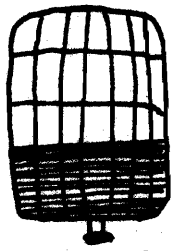
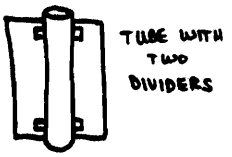


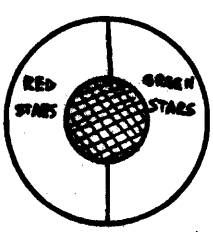
Figure 2

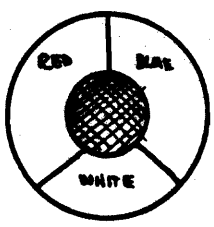
Double Ring Shells -- These produce a circle of stars with the center stars being one color and the outer ring of stars of another color. The shell casing is made as normal but it is filled in a special way. A piece of stout paper is rolled into a tube a few inches longer than the shell and with a diameter equal to 1/2 the I.D. of the shell, see Figure. Place this in the exact center of the casing and then fill the space between it and the shell wall with stars; one color is placed against the tube, and the other between these stars and the shell wall. Pour bursting charge into the tube until full. Make sure the stars and bursting charge are well seated. Now withdraw the tube, leaving a center core of bursting charge with stars around the outside. String and finish as for a regular shell. A very effective shell is using color changing stars for both the center and outer ring. Type II burst.

Compartment Shells -- These produce a circle of stars. The colors are not mixed but distributed by color, each sector of the circle has a distinct color.

Make a tube of paper as shown, and attach 2 or 3 paper dividers to it, see figure below. The center is filled with bursting powder and each compartment with different colored stars. Type II burst.







EXHIBITION AERIAL SHELLS

PART III (MULTIPLE BREAKS)

(L-105C)

The aerial shells that make up the "Exhibition" series are all 3" or larger. All of the theory, general principles, safety precautions, etc., discussed in Parts I through IV in L-105 must be thoroughly learned and applied before attempting any manufacture or display of these exhibition shells. Unless otherwise stated, the bursting charge is Type I.

PRODUCTS OF MANUFACTURE

Regular Multiple Break Shells-- The usual number of breaks is two, three, or four. Any type of shell may be used for any break. If salutes are used, they are usually used for the last break. The length of each casing of a 9" two-break shell is 2-1/2"; a three-break shell has three shell casings, each 2" long; a four-break has four casings, each 1-1/2" long. In general, the total length of all the smaller shells put together should not exceed 6" (for 3" shells). Each shell is made, filled, strung, etc., as when making any type of single break shell, except the casings are shorter, and each end closure has a 3/8" diameter hole in its center (if a 3/8" diameter time fuse is used). One end closure has the time fuse secured as normal; the other end closure has the time fuse of the next shell protruding through the hole, see Figure 1.

Each shell is joined to the next by three or four turns of Kraft paper, about 3" wide-1-1/2" on each shell, see Figure 1. Make sure to use plenty of force when rolling the two shells together in this band of paper. Smear an entire side with thin Prof. Pyro. Ad. instead of paste, and then roll up tightly.

All time fuses should be heavily primed, and have short pieces of black match stuck in the priming, see Figure 2.

Only experimentation will tell how long to cut the time fuses. The first time fuse should be about 1" long for a two-break shell, somewhat shorter for a three-break and a bit shorter still for a four-break. Thus, some of the breaks will ignite just before the shell reaches the top of its trajectory, and some on their way back down.

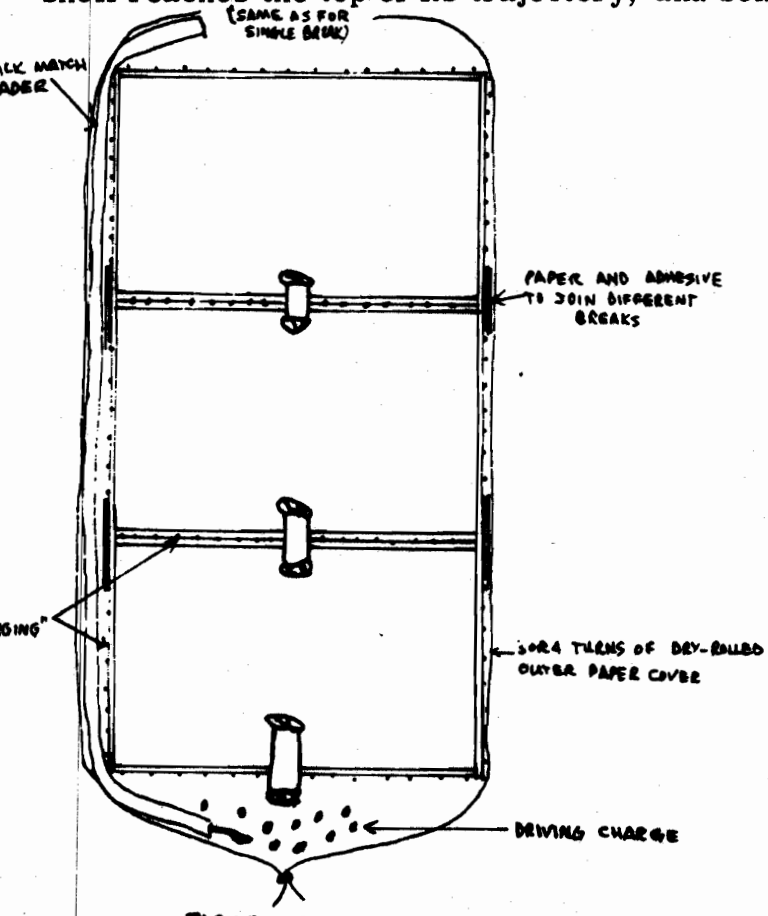
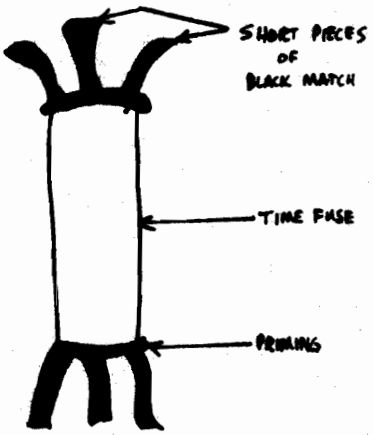
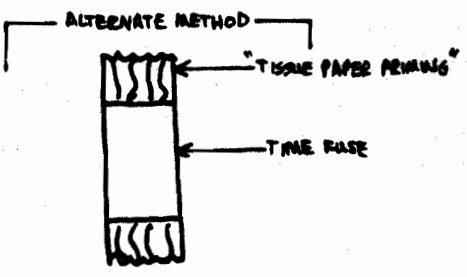


FIGURE 1





Military Shells -- This is a two-break shell; the first is a break of thunder, the second a heavy salute. A variation of this is to make a three-break shell; the first of thunder, the second of M-80-type salutes, and the last a heavy report.

Report Releasing Spangles of Stars-- The effect of this shell is quite surprising after watching several regular single break shells. The shell breaks with a huge report, but the stars do not scatter any faster than for a regular shell.

This is really a two-break shell, both breaks igniting simultaneously. Construct as for a regular two-break shell except the second break, which always must be the salute, does not have a time fuse; the time fuse hole is plugged with priming and pieces of black match that barely stick into the primed hole of the first break.

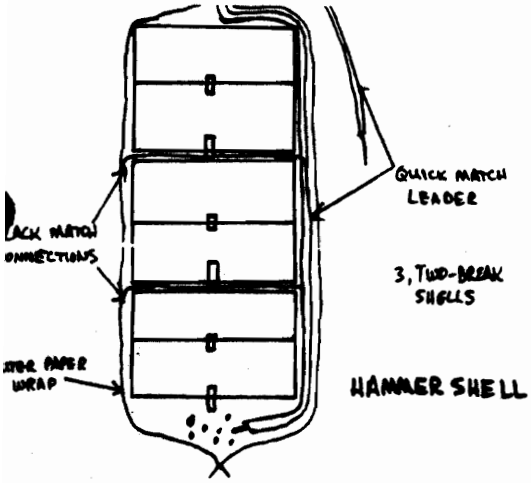
Hammer Shells--This is a timed report and star break shell. Generally there are three star breaks and three salutes. First comes the star break, and then one second later, a heavy report. This sequence is repeated two more times. Each report and each star break follow each other by exactly one second. This shell is really three 2-break shells, each shell consisting of a star break and a salute. The three shells are loosely connected by an outside wrapping of a couple of turns of paper. The time fuses for the second and third star breaks are ignited by quick match connections that are securely tied to each time fuse and are ignited by the flame from the lifting charge. Time fuse and quick match connections should be so heavily primed that they stick together.

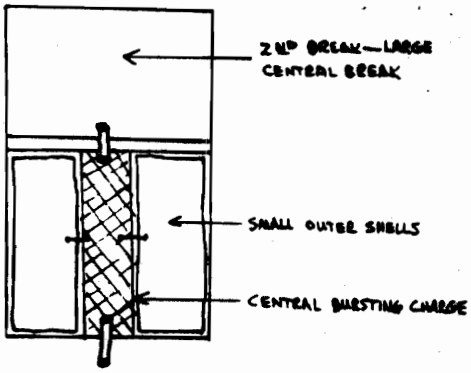
Great care and experimentation must be exercised in order to cut all time fuses the correct length, as the effect is entirely dependent upon the evenly spaced timing. An extra amount of driving charge should be used so all three shells are propelled to the necessary height.

This same method of igniting the second and third 2-break shells by quick match is an alternative way of achieving multiple break shells.

Shell of Shells -- Upon bursting in the air this shell remains dark for a few seconds, to enable the smaller shells to form a circle around the center break, then all ignite at once, the smaller shells breaking in one color around a huge break in the center of another color. This is really a two-break shell. The second break is made, filled, strung, etc., as normal, and makes the large central break. The first break is specially made and contains the smaller outside breaks. Roll three or four turns of paper into a tube the same length as the shell casing of the first break and a diameter equal to about 1/3 its I.D. Place this tube in the exact center of the shell casing. Between this tube and the shell casing are placed several (at least six) small shells all around the outside. Each has a heavily primed time fuse of 1/8" fireworks fuse in its side that sticks into the central paper tube through a hole poked in its side when each of these small shells is placed around it. When the smaller shells are all in place, fill the tube with Type III bursting powder. Secure the top end closure and finish as for a regular two-break shell. All time fuses must be exactly cut so all shells break at the same time. The smaller shells are made, filled, strung, etc., as for regular single break shells, except for the time fuses, as noted above. A suggested color combination is for the smaller shells to break in red and silver; the central break in blue.

This shell takes considerable skill to make but produces a magnificent effect and is well worth the time it takes to construct. The larger they are, the easier they are to make and the better the effect. Generally, a 4" shell is the smallest size.

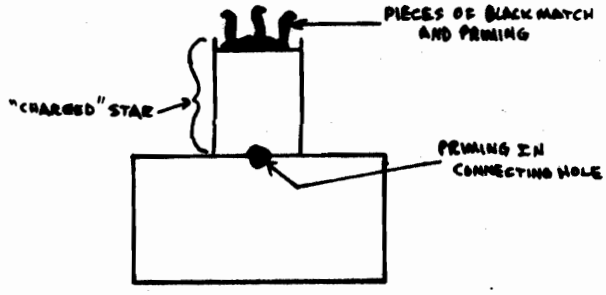




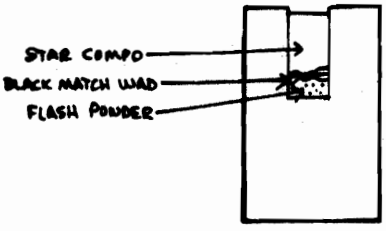
Three-in-One-Shell -- This shell has almost the opposite effect as the above. Upon reaching its height, it bursts forth with a large spread of comets. While these outside stars are spreading, three smaller shells break in the center.

This is constructed similar to a two-break shell. The first break consists of the comets placed around a central Type III bursting charge. The shell is then strung as for a normal single break shell. The second break casing is filled with three smaller shells with central 1/8" time fuses as for the Shell of Shells. These fuses should be well primed and cut very short, since the shells should break almost immediately after the bursting charge ignites them. The main time fuse to the second break should also be quite short.

Spectral Shell -- This shell breaks into colored stars. As they fall, they, in turn, break into showers of different colored stars. Though very surprising, this shell is very simply constructed. It consists of a shell filled with items similar to bursting comets. The initial stars should be "charged" stars (box stars open on one end only), about 1/2" dia. x 1/2" long or larger. These are attached to larger casings filled with 1/4" or 3/8" stars and Type I bursting charge.



Crossette Shell -- This shell has an effect similar to the Spectral Shell, except the initial stars break with a sharp pop into smaller stars of the same color. The effect is achieved by filling the shell with 1-1/8" diam. pumped stars that have a cavity part way through their centers. A specially made star pump is used to make them. When dry, about 1/4 teaspoon of flash powder is poured into the cavity. A piece of black match is now rolled into a small ball and pressed into the hole so it forms a plug slightly above the powder. The remainder of the cavity is filled with damp star compo.

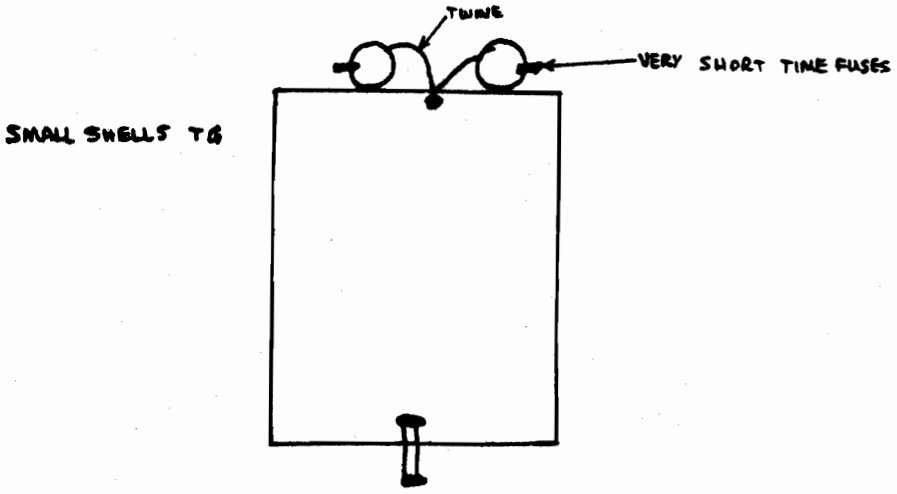


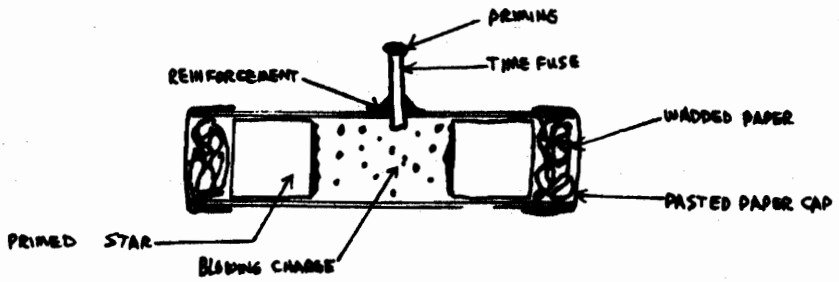
CROSSETTE STAR

Surprise Halley's Comet Shell -- This shell has a delayed comet. It ignites a short time after the shell is fired and burns out just before the shell breaks. The comet appears to be the only effect, and when the shell breaks, its effect is magnified by the surprise of the spectators who thought everything was over.

This shell is constructed as a normal single break shell except a very short (1/2" or less) time fuse is used and placed in the top end closure of the shell. A short tube (about 1/2" or less) whose diameter is just a bit smaller than the shell's is firmly secured to the top of the shell with Prof. Pyro. Ad. The inside is then packed solid with a silver comet composition; the top is well primed and nosed. Firmly tied into this nosing is a short piece of primed safety fuse. The driving charge ignites the piece of safety fuse which should be just long enough so as to delay the ignition of the comet until the shell is almost to its apex. The comet then burns with a spectacular silver trail for the remainder of the shell's upward flight and until it just turns downward. When it burns out, all is dark for the time fuse's golden sparks are not noticed after the brilliant silver comet. Then the fuse burns through and the shell breaks with a surprise.

Trajectory Garnishments -- These are small fireworks items which are connected to the shell. They ignite on its upward trajectory. Some good suggestions are: small shells jetting out of trajectory (two or three cherry bomb casings filled with small stars work fine); two or three small comets jetting out of trajectory; silver or golden comet tails that trace the shell's upward trajectory; whistles, reports, crackles (grasshoppers). All of these effects should be fastened to the top of the shell with twine. They are ignited by the flame from the lifting charge.





SHOOTING COMETS TO

ROCKETS

(L-106)

I. INTRODUCTION

Rockets in all their various forms are very popular. To make really good rockets requires skill and a constant observance of small details. Rockets can be very dangerous if contructed or fired without due precaution. Thus, all safety precautions given in this treatise must be followed to the letter.

Certain principles of pyrotechnical theory are given so the pyrotechnist can better understand the processes that are involved in making rockets. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since all fireworks items consist of three main parts, viz., a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanism(s) necessary for proper performance are described. Fourth, any special materials (items that neither make up part of the composition nor the casing but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All of the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material because the conditions of use are beyond our control. The purchaser and user take full responsibility for use.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II. THEORY AND GENERAL PRINCIPLES

Rockets function on the principle that a burning composition confined within a cylindrical case produces gases which exert pressure on the walls of the case. If the case were closed, then the pressure would be exerted equally on both ends and the case would remain stationary. However, there is a hole in one end. This allows the gases to escape with a corresponding decrease in pressure at this end. Since the pressure at the opposite closed end is now greater as the result of the loss of gases at the open end, it pushes the case in the direction away from the closed end.

One of the most common mistakes in making rockets is to use Saltpeter that has not been sufficiently pulverized. Unless it is just like powdered sugar or flour, rockets will not perform properly.

Another mistake is not loading rockets in small enough portions. Unless the composition rises in the casing about 1/2" only with each scoopful (after being driven), the composition will not be consolidated enough for maximum performance. Do not be impatient when making rockets. Good ones take time to make.

III. COMPOSITION FORMULAS

Skyrockets

Various sizes of skyrockets use different formulas. Compositions that work for small rockets are too violent for large ones. This is because the burning area in a large tube is much greater and a tremendous amount of composition is ignited at once than in a smaller tube. No geometric proportionality applies to the surface area of compo ignited and the size of the tube. Thus, large rockets need slower burning compositions (accomplished by increasing the proportion of charcoal) than smaller rockets. The following are good compositions: (All parts by weight.)

Material	2 oz.	4 and 8 oz.	1 and 2 lb.	4 lb.
Saltpeter	18	18	18	18
Sulfur, flour	4	4	4	4
Charcoal, dust	4	3	2	1
Charcoal (100 mesh)	3	3	2	2
Charcoal (40 mesh)	2	2	2	2
Charcoal (12-20 mesh)	-	2	2	3

The saltpeter should be like powdered sugar. If rockets burst before or while ascending, add more charcoal dust; if they ascent too slowly, add more saltpeter.

Material	Serpents	Saucissons	Buzz Bombs
Meal powder	6	4	7
Saltpeter	2	2	8
Sulfur, flour	1	1	2
Charcoal, dust	1	1	1
Charcoal (100 mesh)	1/2	1/2	1
Dextrin	1/4	1/4	1/4
*Iron filings (40 mesh)	ad. lib.	ad. lib.	0

*Coated with paraffin

Hummers

Material	Parts	Instructions
Meal powder	15	(The Buzz Bomb and Hummer compos
Aluminum, dark pyro	1	should be dampened very slightly with
Dextrin, yellow	1/4	a 50:50 water: alcohol mixture before loading.)

IV. PRODUCTS OF MANUFACTURE

A. Skyrockets.

A skyrocket functions as previously explained but in order to provide enough force to propel itself high into the air, the skyrocket is charged so that there is a conical hollow inside the powder core. This way, not only the end of the composition burns but the powder along the walls of the hollow. A very large amount of area of the powder is thus allowed to burn at once and produce the needed force. The hollow should extend about 6/7 of the way through the powder core. The last 1/7 is charged solid.

Compositions: Any of the formulas listed under skyrockets. Be sure to use the appropriate formula with the correct skyrocket size. Iron or steel filings may also be added to enhance the tail for display rockets.

Casings: These consist of two parts, the "engine" which contains the powder core, and the head which contains the garniture of stars, salutes, etc., that ignite when the rocket reaches its apex.

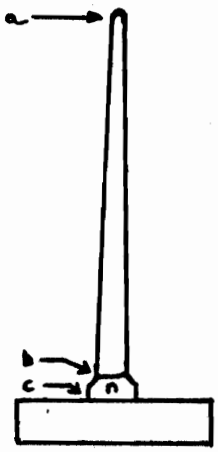
Engine: These should be wet-rolled, parallel wound from Kraft, Manila or chipboard to the following dimensions: taking the I.D. as 1, then the O.D. should be 1-1/2 times the I.D.; the length should be 10 times the I.D.

Head: There are two types of skyrocket heads. One consists of merely one or two turns of dry-rolled paper in the shape of a cone. Its height should be 4 times the rocket's I.D. It is best made by cutting some paper into a semi-circle with a radius equal to the cone's desired height. The semi-circle is then rolled up into the cone. This type is very simple and used by commercial manufacturers. The other type is more elaborate and can contain much more garniture. This type should be used when the best effects are desired. It consists of two parts: a head and a tip. The head is two turns of dry-rolled paper in the shape of a truncated cone (a cone with its tip cut off). This part has the same diameter as the O.D. of the skyrocket body, for it is this part of the head that is glued and tied to the skyrocket body. The other end of the cone has a diameter equal to 1-1/2 times the O.D. of the rocket body. The cone's height should be two times the rocket's O.D. The tip is merely a stubby cone that is glued onto the top of the truncated one. Its height should be 1-1/2 times the rocket's O.D. (see diagram on next page--page 5).

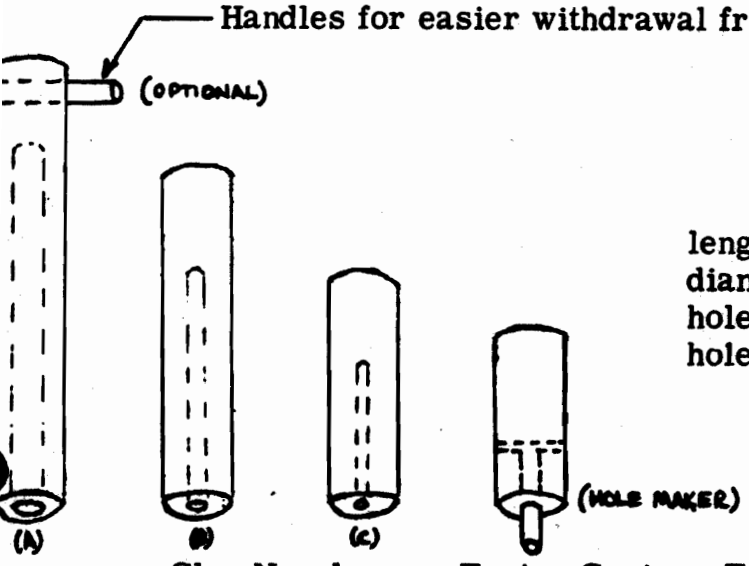
Ignition: Black match, priming.

Materials: Twine, a stick to guide the rocket in a straight course. The stick should be about three times the length of the entire rocket, including its head.

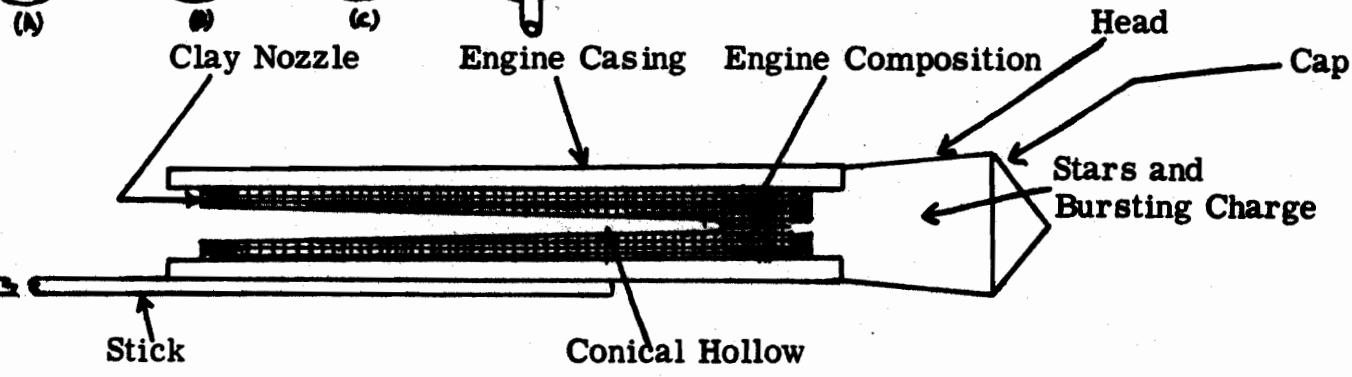
Tools: Good skyrocket tools are an absolute necessity. They may be made of hardwood but the best ones are made of a non-sparking metal such as aluminum. They consist of a spindle and a series of drifts (perforated ram rods), as shown, and with the following dimensions: Taking the I.D. of the skyrocket as 1, tools for all sizes should measure: (See diagrams, page 5).



a to b = 8 I.D.
diameter at c = I.D.
diameter at b = 1/2 I.D.
diameter at a = 1/4 I.D.
height of n = 1/2 I.D.



	(A)	(B)	(C)
length	8 O.D.	6 O.D.	4 O.D.
diameter	I.D.	I.D.	I.D.
hole length	7 I.D.	5 I.D.	3 I.D.
hole diameter	1/2 I.D.	7/16 I.D.	5/16 I.D.



Diagrams of Tools

Measuring scoops and Hole Makers are very helpful in constructing skyrockets.

Manipulation and Procedure: Slip an engine casing over the spindle, pour in a scoopful of clay, insert the longest drift, and drive with eight good blows from a mallet (preferably of rawhide). After being consolidated, the clay should be about 1/2 to 2/3 of the I.D. in thickness. The whole quantity of clay should be poured into the casing at once, not in many small portions. The clay, after being driven, actually makes small grooves in the inner walls of the case, and these grooves hold the clay plug in place against the pressure which arises from the burning composition. Now drive in small portions, the appropriate composition. Introduce just enough each time so when it is driven with about ten blows it rises about 1/2" inside the case. A measuring scoop is best so consistent measurements are made. This is repeated until the case is filled to about 1/2" from the top. Shift drifts as it becomes necessary to use

those with smaller holes. Pour in a scoopful of clay and ram solid using a Hole-Making rammer. This extremely handy tool makes a hole through the clay plug at the same time it consolidates the clay. Gently twist the engine from the spindle. Attach the desired head and fill with a garniture of stars, etc., and a bursting charge of FFFg black powder. The total weight of the heading (head + garniture + bursting charge) should not exceed 1/2 the weight of the loaded rocket engine. Wrap a turn of paper (decorative or plain) around the rocket engine so it extends past the nozzle end about 1" for a nosing. Insert a length of black match into the entire length of the conical hollow, apply some priming to the nozzle, and twist the nosing around the match. Attach the stick about 2/3 the way up on the engine case with twine and glue and the skyrocket is completed.

Almost anything can be used for the garniture of the rocket heading. All types of stars, whistles, bees, firecrackers, salutes, smoke cartridges, serpents, etc. may be used. In addition, whistles or smoke cartridges can be attached to the side of the rocket to fire during the rocket's ascension.

B. Line Rockets (Flying Pigeons)

This is a very amusing piece of fireworks. It is made by securing two rockets, with their nozzles pointing in opposite directions, to an empty tube. The head of one rocket is connected to the nozzle of the other with quick match. A piece of #18 gauge wire is stretched between two posts. One end of the wire is first slipped through the empty tube forming the middle of the pigeon. On lighting the first rocket, the pigeon will run along the line until the other rocket ignites, which returns the pigeon to its starting point.

A more effective form of a pigeon is made from a vertical wheel. Four wheel cases are fastened to the rim and the same number of rockets are secured to the hub, two pointing each way. The pigeon starts with one of the wheel cases, the rear end of which is connected to one of the rockets. This in turn is matched to the second wheel case and that to the next rocket, pointing in the opposite direction, and so on to the end. Combinations of wheel cases and rockets firing at the same time, reversing wheels and rockets, are very effective.

C. Serpents.

These are miniature rockets (without sticks) that scoot rapidly along the ground and into the air.

Casings: Wet-rolled 1/4" to 5/16" I.D. x 2" to 5" long x 1/16" to 3/32" wall.

Tools: A special "driving board" to load the composition and form the nozzle is constructed as follows: drill a hole 5/16" deep and the same diameter as the serpent O.D. in a block of wood. In the exact center, drive in a 1/8" diameter nail about half its length. With nippers, snip off the nail even with the block of wood until only the nail in the center of the hole is left. Also needed is a rammer about 2" longer than the casing and of the same I.D. It has a 1/8" diameter x 5/16" long hole bored in the exact center on one end.

Manipulation and Procedure: Insert a casing into the driving board hole. Drive in a charge of clay about 1/4" deep, then load, in small portions, the remainder of the casing with composition. The clay and composition should be loaded as for skyrockets. Insert a length of safety fuse and nose.

D. Buzz Bombs (Helicopters).

These are fireworks that begin to spin on the ground and then ascend rapidly in a spiral manner to a height of 100-125 feet, where they terminate with a loud report or a shooting star.

Casings: These are wet-rolled, parallel wound from .016" Imitation Pressboard to the following dimensions: 3/8" I.D. x 2-3/4" long x 3/32" wall. Regular pressboard is too oily. Only imitation can be used. Pressboard should be used, rather than other types of paper, such as Kraft which is not as durable. The whirling motion of the device throws and concentrates the dross of the burning compo towards the nozzle end. Unless the case is tightly wound from pressboard, the dross may burn through the casing.

Ignition: 3/32" safety fuse.

Materials: A piece of light gauge sheet aluminum (about .020") 5" long x 3/8" wide to form the wing of the Buzz Bomb; a short, strong rubber band.

Tools: Good Buzz Bomb tools are absolutely essential. They consist of two rammers and a base, as shown. One rammer must be tapered at one end. This is to form a conical cavity in the clay plug. These tools should be made of a non-sparking metal such as aluminum.

Manipulation and Procedure: Insert a casing into the ramming base. Pour in a scoop of clay, and using the straight rammer, ram very hard, using about a dozen good blows from a mallet (preferably of rawhide). The clay plug should be about .2" thick after ramming. Now pour in another scoop of clay, and using the taper rammer, ram very hard as before. The total plug thickness should be about .5" thick and should have the conical cavity as shown.

Dampen the compo, and using the straight rammer, ram very hard, using about 10 good blows for each portion. Pour in just enough compo in each portion so after the 10 blows, it has raised about 1/2" inside the case. Continue until the rammed compo is within 1/2" from the top of the case.

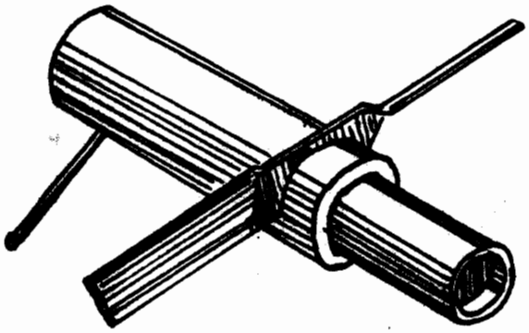
Place the loaded casing in a vice (the compo should still be damp) and drill a 3/32" diameter hole through the casing, clay plug, and into the compo. The hole should be midway between the two ends of the conical cavity as shown. The fuse hole must go through the clay plug. If it went through the paper casing, the hole would be enlarged by the escaping gases and the device would not maintain an even propulsion throughout its flight. Insert a length of fuse and secure it with glue.

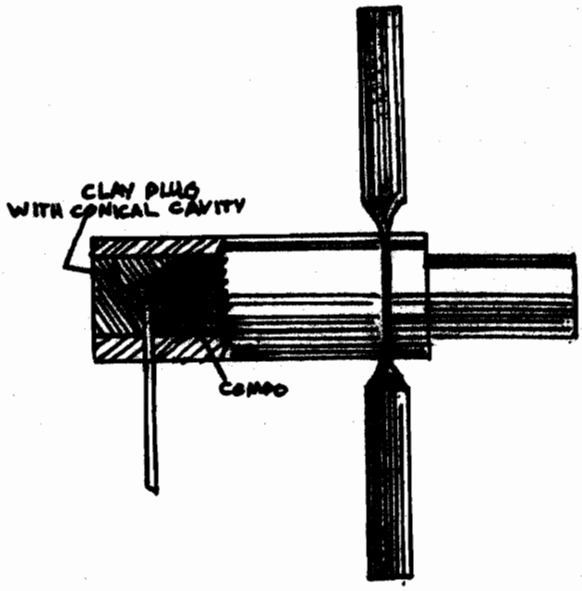
Now rotate the casing in the vice so the fuse is at the 8 o'clock position. Beginning at the 12 o'clock position and at the opposite end from the fuse, saw half-way through the casing just above the top of the compo until the saw reaches the 3-9 o'clock position. This forms a slot for the wing. Insert the wing evenly into the slot and secure with the rubber band. The upper edge of the wing, located on the same side of the case as the fuse, is twisted toward the fuse and the upper edge of the opposite wing is twisted toward the forward end of the case as shown. This provides the lifting effect.

Make a small salute (about 1" long) to fit snugly into the top of the Buzz Bomb. The end that fits into the Buzz Bomb should have a hole that is well primed. Instead of a salute, the Helicopter should have a 5/16" diam. star and a small blowing charge of meal or FFFFg powder. The star and powder are secured with a wad of paper and paste.

Allow to dry about one week before firing.

When firing, lay flat on ground, fuse pointed toward the ground (approximately in the 8 o'clock position) as shown.





E. Hummers (Z-Bombs, Hornets)

These are very amusing and unusual items. They are fired from a pipe or wire stand. Upon ignition, they shoot rapidly up into the sky, spinning like a top, and making a loud humming noise as they go. When they reach their apex, they explode with a loud report.

Casings: These are made exactly like Buzz Bomb casings.

Ignition: 1/8" safety fuse.

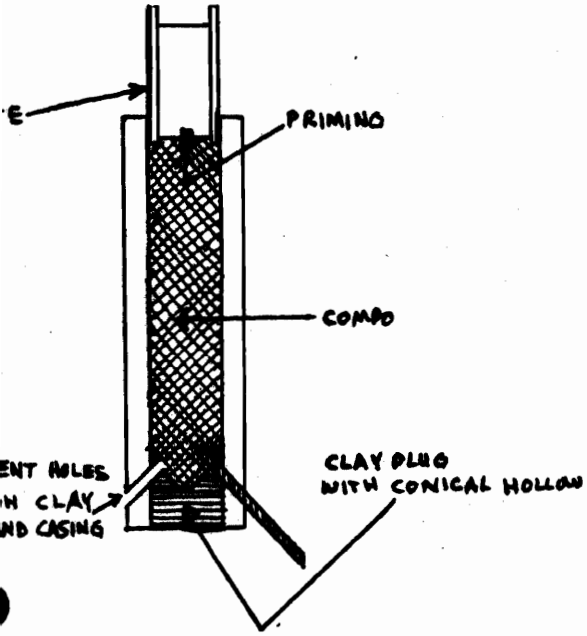
Tools: Same as for Buzz Bombs.

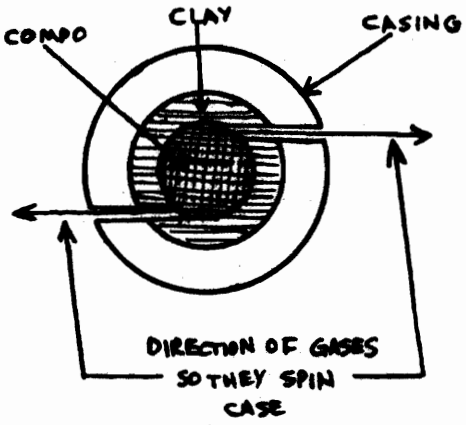
Manipulation and Procedure: Form the clay plug and fill with compo as described under "Buzz Bombs." However, two 1/8" diam. holes must be bored on either side of the casing, upward at a 60 degree angle through the casing, clay plug, and into the compo. The two holes should be midway between the two ends of the conical cavity as shown. As for the Buzz Bomb, the holes must go through the clay plug so they can't be widened by the escaping gases. The holes must be bored so the gases will spin the case (to give the humming sound) and also propel it upward.

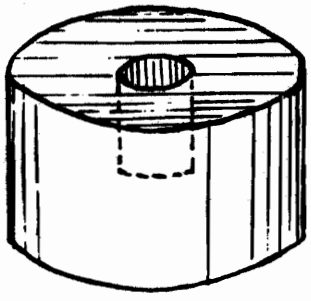
Insert a small salute, as for the Buzz Bomb. Allow to dry about one week. It must be launched from a pipe, wire frame or other launcher to start it upward on a straight course.

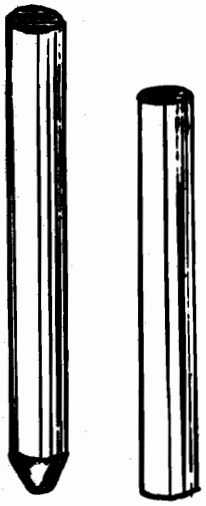
It requires considerable skill and experience to make these items since there are very many snags. The composition must burn just right. If too fierce, it may be slowed by reducing the meal powder to 12 parts and/or adding charcoal dust. The composition must be especially well consolidated. The hole must be of the right size and angle. The casing must be thick walled and hard to withstand the tremendous

pressures but yet be light weight. It must be launched correctly. Thus, it may be necessary to do some experimentation in order to adjust all of these factors to your own particular techniques.









NOVELTY FIREWORKS

(L-107)

I. INTRODUCTION

Most of these fireworks are miniatures of their larger display counterparts. Some are unique items in themselves and are only made in the small size described here. Since all of these fireworks are quite small, they have sometimes been called "children's fireworks." However, there are some items that have more than uncommonly dangerous compositions. Therefore, all safety precautions given in this treatise must be followed to the letter.

Certain principles and pyrotechnical theory are also included so the pyrotechnist can better understand the processes that are involved in making these fireworks. These should be read and must be understood before actually making any of the items described. They increase the safety as well as add to the enjoyment of pyrotechnics.

Since nearly all fireworks items consist of three main parts, a composition, a casing, and a means of ignition, the following format is adopted to make their construction clearer. First, the composition(s) that are required are given. Second, the casing's qualities, dimensions, etc., are listed. Third, the ignition mechanisms necessary for proper function are described. Fourth, any special materials (items that neither make up part of the composition nor the casing nor the ignition mechanism, but are necessary for their proper function) are listed. Fifth, any special tools that are required are given. And sixth, the manipulation and procedures necessary in combining all of the above in order to construct the various fireworks items are explained.

The staff of Westech has spared no pains in preparing this comprehensive manual. All the formulas, processes, and procedures are proven and have been used with success. Many have never before been available to the great majority of pyrotechnists. However, Westech can take no responsibility for any damage or injury resulting from use or misuse of this material because the conditions of use are beyond our control. The purchaser and user take full responsibility.

Pyrotechnics can be fascinating and rewarding. Do not compound it with tragedy nor give it a bad name through carelessness or thoughtlessness.

II. COMPOSITION FORMULAS

(All parts by weight)

Material	Pinwheels	Bottle Rockets	Sparklers	Bees
Meal powder				12
Saltpeter	17	18	20	
Sulfur, flour	3	3	4	
Charcoal, dust	2	2-6	6	
Charcoal, coarse	2			
Iron, filings (40 mesh)	6		8	
Aluminum, dark pyro		1/2	1	1

Coated with paraffin.

Fire Sticks	Emerald	Ruby
Potassium Perchlorate		2
Strontium Nitrate		6
Barium Chlorate	4	
Aluminum, bright pyro	6	6
Shellac	1	1

Smokes	Yellow	Olive	White
Meal powder		1	
Saltpeter	5	1	12
Sulfur, flour	2	1	16
Antimony Sulfide, black		1	
Arsenic Sulfide, red	3	1	
Charcoal, dust			1

III. PRODUCTS OF MANUFACTURE

A. Pinwheels

Casings: These are made from four turns of dry-rolled Kraft paper, about 1/4" I.D. x 12" to 24" long.

Ignition: Chinese fuse or safety fuse, priming.

Materials: A piece of thin chipboard cut in a 1-1/2" diameter circle with a small hole in its exact center; glue.

Tools: A circular plate of plastic or metal about 1/8" thick, cut in the same diameter as the above cardboard circle; a large board with 1/4" square strips of wood nailed to it, the same distance apart as the width of the finished pinwheel.

Manipulation and Procedure: Twist the ends closed of a number of casings, tie them loosely into a bundle and stand them upright on a large sheet of paper with the open ends up. Pour in the composition until all the tubes are full. Jolt the bundle occasionally so that none of the tubes is only partly filled. Twist the tops closed, spread them loosely on the wet towel and roll it up so each pipe will touch a part of the wet cloth. Set aside in a damp place for several hours. The tubes should be thoroughly moistened, but not too wet, before proceeding further. When this condition has been reached, press them with a rolling pin so that they will be somewhat flattened. The exact amount of flattening can only be ascertained by experiment. Fasten the circular plate of metal or plastic to the work table. Lay the circular piece of chipboard on this and, taking a filled pinwheel tube, press one end against the edge. Twisting it around the disc, continue until all the tube is rolled around the center. The circular plate should be half as thick as the finished pin-

heel so that the cardboard center will be held just in the center of the finished pinwheel, hile it is being twisted. When the wet tube is all twisted on, lift it off the circular plate nd set it between two of the 1/4" strips of wood on the board so as to keep it from un-wisting. Brush on some glue across the pipes and onto the center disc at four equi-distant oints. When dry, the pinwheels may be removed from the board and matched, ready for use

. Bottle Rockets -- There are two kinds of bottle rockets (so named because they are aunched from soda pop bottles). One ends with a report; the other does not.

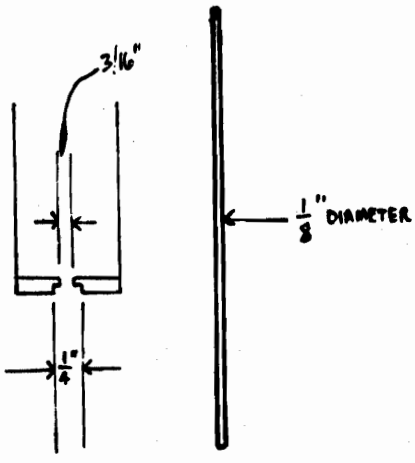
Casings: These are wet-rolled from newspaper: 3/16" I.D. x 1-1/2" long x 1/32" 'all.

Ignition: Chinese fuse or safety fuse.

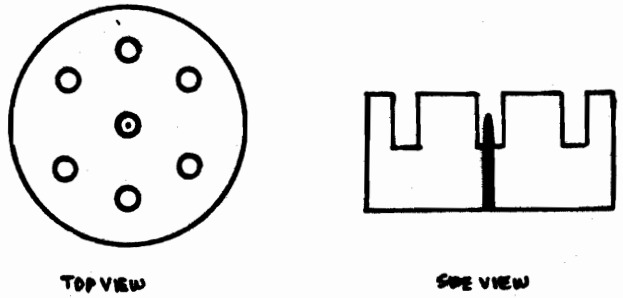
Materials: Clay, a thin stick made of balsa or bamboo to guide the rocket, with the ollowing dimensions: 6" to 10" long x 1/16" or less.

Tools: These consist of two parts: A "funnel and rod" and a "ramming/piercing ase." The funnel and rod are made from aluminum as shown. It has a shoulder that llows it to fit over the casing for easier filling. The ramming/piercer base is construc-ed from a piece of 2" diam. x 1" aluminum. Around the periphery are bored six 1/4" iam. x 1/2" holes. In the center is another hole (same dimensions) but in its exact center s a sharp, steel piercer, 3/32" diam. at its base and tapering to a point. It extends inside he hole about 1/4". (The base may be made from hardwood, if desired.)

Manipulation and Procedure: Insert casings in each of the peripheral holes in the ase. Fill the funnel half-full of clay (the rod should already be in the hole) and with a apid and hard up-and-down motion on the rod, drive in some clay in each of the cases so hey each have a hard, 3/32"-thick clay plug. Now half-fill the funnel with compo and fill ach of the casings to within 1/4" of the top of each case. Now push each filled casing all he way to the bottom of the center hole so the piercer forms the exhaust vent through the lay plug and partially into the compo. If the rocket is to finish with a report, fill the emainder of the case with flash powder and seal with a wad of tissue paper and glue. ttach the stick by rolling it and the case in a turn or two of paper. Prime the vent and nsert a fuse. The same piece of paper that holds the stick can act as a nosing if twisted round the fuse.



FUNNEL & ROD



RAMMING/PIERCING BASE

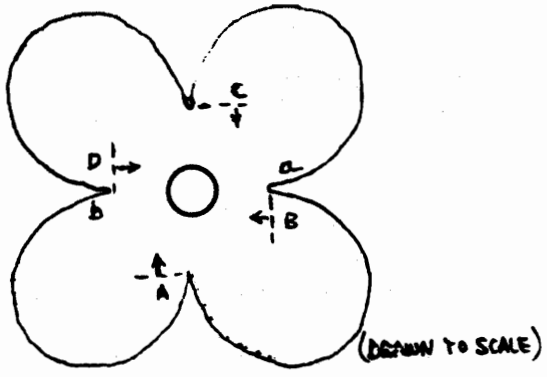
'. Flying Discs -- These are the miniature versions of the tourbillion. Upon ignition, ıese spin rapidly into the air to a height of about 50 feet throwing sparks in all directions.

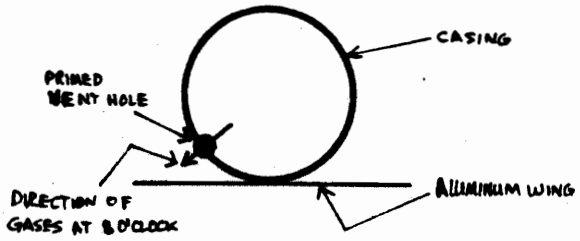
Composition: Same as for bottle rockets except add 1/2 part aluminum flitters.

Casings: Same as for bottle rockets.

Ignition: Ditto

Materials: Prof. Pyro. Ad., a piece of very thin gauge aluminum about .020" ıick, ut in the following pattern:





fter cutting out the wing from the sheet of aluminum, bend along the dotted lines at A, B, C, ıd D upward in the direction of the arrows, so each little clover leaf is at about a 30^{o} angle ith the horizontal. Now take a round nosed punch and make a small indentation downward ı the center of the wing (shown by the circle in the diagram). This forms a small pivot on hich the wing can revolve before it ascends.

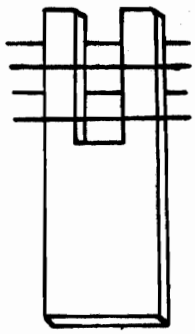
Tools: Same as for Bottle Rockets.

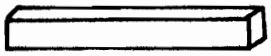
Manipulation and Procedure: Plug and fill the casings as directed under Bottle ockets. Smear a drop of glue in the 1/4" space to cover the powder. If the Disc is to nd with a report, proceed as above. Now drill a 3/32" hole through one wall and into the ompo, just above the clay plug. Prime the hole and insert a fuse. With small dabs of dhesive, attach the filled casings to the wing in a straight line between "a" and "b" (see iagram). The vent hole and fuse should point so the gases shoot downward at about 8 o'clock, ıst underneath the wing at point "D".

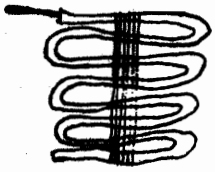
. Grasshoppers (English Crackers) -- These delightful novelties are one of the most musing pieces of fireworks that can be made. They hop, pop, crack, and jump all over ıe place, all the while shooting sparks and smoke.

Composition, Casings, Ignition: Quick match (with close-fitting pipes).

Tools: These are made from wood, as shown. The notched piece is 1" thick x 18" x 4" wide. The notch is 1-1/2" wide. The notch is 1-1/2" wide x 6" deep. The solid piece is about 1" square x 10" long. Also needed are 12 pieces of stiff wire, 4" long. These may be cut from a common wire clothes hanger.







Manipulation and Procedure: Cut the quick match into 15-inch lengths. One-half nch of the bare match is withdrawn from one end of the pipe while the other is twosted losed. A bundle of these is now wrapped in a wet towel and set aside for several hours o soften. The cloth should be dampened well and the tubes so rolled up in it that each ne touches a part of the damp cloth. The tubes should be thoroughly moistened, but ot too wet, before proceeding further. When the pipes have become so damp that they vill not tear when bent at right angles, they are folded as follows. Lay the twisted ends f a half dozen of the damp pipes across the bottom of the notched board which has been astened in an upright position to a bench. On top of these and against one side of the oard, lay a wire and bend the pipes over it until they now point in the opposite direction. ay another wire as before but on the opposite side and repeat the operation until the entire ngth of pipes has been folded up. Now take the solid piece of wood and, holding one end n each hand, press the folded pipes down as hard as possible so the turns will be well ormed. Now lift out the folded bunch, wires and all. Remove the wires, and one by one ecure the pipes in their folded condition by wrapping a half dozen turns of light string r shoemakers' linen around the bunch and a few turns between the folds. When dry, grass-oppers are ready for use.

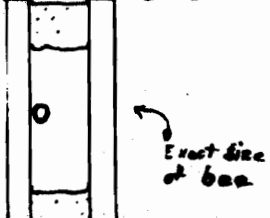
E. Bees - These items shoot around in all directions with a loud humming sound. They may also be shot from mortars, or used to fill an aerial shell.

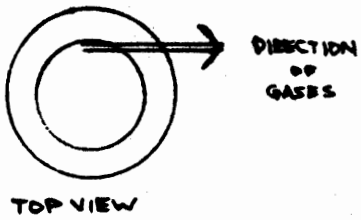
Casings: These are very important. They must be thick walled and very hard in order to function properly. They are wet-rolled from Kraft paper: 5/16" I.D. x 1-1/4" long x 9/16" O.D.

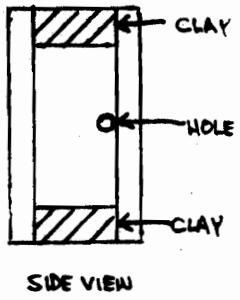
Ignition: Safety fuse and/or priming.

Tools: A rammer the same diameter as the I.D. and 2-1/4" long.

Manipulation and procedure: Place the casing on a firm surface and drive in some clay so a 1/4" thick plug is formed. Drive in the composition, in small portions, until within 1/4" from the top. Drive in another 1/4" plug of clay. Now drill a 3/32" hole in the center of the casing and barely into the composition. This hole must be driven at the angle shown in the diagram so the escaping gases will make the casing spin. Prime and insert a length of safety fuse.







BEES

F. Sparklers - - These are easily made by adding enough composition to some shellac solution to make a very thick mixture that will adhere to the wires. Stiff pieces of wire are then dipped into this mass and allowed to dry. The dipping time(s) vary; only experimentation will give good results.

G. Fire Sticks -- These are thin wooden sticks similar to the applicators used by physicians for applying iodine, etc. They are dipped for half their length into the composition given. Dissolve the shellac in alcohol and add the other ingredients, previously well mixed. Stir thoroughly to a consistency of thick glue and dip the sticks. Allow to dry.

H. Smoke Pots -- These are easily made by driving a smoke composition into any size casing with a clay plug at one end. When the casing is full of composition, prime, match, and nose.

I. Smoking Cap Sticks-- When lit, these produce a small stream of smoke for several seconds, then end with a loud bang. These are quickly made by dry-rolling a piece of newspaper 3-3/8" long into a tube with a 1/8" I.D. and 1/4" O.D. Pack damp clay into the tube to form a plug 1/4" thick. The top of this plug should be about 3/4" from the top of the tube. Now pack a very small quantity (1 grain or less) of wet picric acid into the tube. Ram the rest of the tube full with the white smoke composition. Prime, match, and nose.

J. Cracker Balls -- These are miniature torpedos, exploding when they are thrown against a hard surface. They are made by mixing 1 grain of wet picric acid with 6 grains of small, sharp edged gravel. Wrap this up in a 1" square piece of wrapping tissue paper. Add a thin layer of paste to the outside and form into a small 3/8" ball. Add more wrapping tissue and paste if necessary. Allow to dry for two weeks. DO NOT THROW NEAR ANY PERSON SINCE THE GRAVEL IS IMPELLED WITH CONSIDERABLE FORCE AND COULD CAUSE SERIOUS INJURY. THE MANUFACTURE OF THESE ITEMS IS NOT RECOMMENDED TO BEGINNERS. PICRIC ACID IS A HIGH EXPLOSIVE AND MUST ALWAYS BE HANDLED WET AND WITH EXTREME CAUTION.

JAPANESE AERIAL SHELLS

Basic Construction Techniques, Part I: Casings

(L-601 A)

When the Japanese desire a symmetrical burst pattern they use spherical casings. These consist of two parts: (1) an inner core composed of two hemispheres; and (2) an outside layer consisting of strips of pasted paper. The outside layer is really one of the main secrets to the success of a Japanese pattern break shell. While the inner core merely serves as a container for the shell contents, the outside layer is extremely strong and thick, providing a tremendous resistance to the bursting charge and thus enables it to throw the stars to a great distance. However, if the layer is not evenly pasted all around, the shell will break unevenly and spoil the symmetric effect.

A. Inner Core - As was stated before, the inner core acts only as a container for the shell contents. They can be constructed by several methods. The Japanese make them by cutting circles of a soft, porous paper and then hydraulically pressing them with a die into a mold to form a hemisphere. They can also be made by hand using paper maché, or by following the methods described by Weingart. However, the best hand method is as follows.

Cut some circles of 40 to 50 pound Kraft paper and some circles of "red rosin paper" (a variety of construction paper available at most lumber yards). The size of the circles depends upon the diameter desired of the aerial shell, as shown in the following table.

Shell Size Designation	Finished Core Size I.D.	O.D.	Outside Layer Thickness	Actual Completed Shell Size	Approx. Diam. of Circles
2"	1-1/2"	1-5/8"	1/16"	1-3/4"	3-1/2"
3"	2-3/8"	2-5/8"	1/16"	2-3/4"	4-3/4"
4"	3-3/8"	3-5/8"	1/16"	3-3/4"	6-1/2"
5"	4-1/4"	4-1/2"	1/8"	4-3/4"	8-1/4"
6"	5-1/8"	5-3/8"	3/16"	5-3/4"	9"
8"	7"	7-3/8"	5/16"	7-11/16"	12"
10"	8-3/4"	9-3/8"	5/16"	9-11/16"	14-3/4"
12"	10-3/4"	11-3/8"	5/16"	11-11/16"	17-1/2"

NOTE: The dimensions given for the cores are for Chrysanthemum/Peony-type shells. C P shells are those that burst with a very wide and rapid spread of garniture. In order to accomplish this type of burst, C/P shells have a thick outside layer which provides a tremendous resistance to the burst charge. Other types of shells -- such as Willow or Parachute Shells -- don't have a rapid and wide spread of garniture. Thus they use a thinner outside layer. In order that all shells have the same diameter, the outside layer of Willow-type shells is made thinner by increasing the C.D. of the inner core by approximately 1/16" to 3/16" and decreasing the outside layer by the same amount. The two types of casings can be summarized as follows: (1) C/P Type - Thin inner core; thick outside layer; large break. (2) Willow Type - thick inner core; thin outside layer; small break.

Paste twenty or more circles onto a board, one on top of another, with so much paste between them they become soft and pulpy rather than stick together. The two kinds of paper should be used and a separate stack of each kind prepared. This is to make it easier to see here one layer of paper begins and the other ends. Cover a ball with a layer of aluminum foil, press tightly and smooth over. The ball should have a diameter equal to the I.D. of the finished core.

Press one of the pasted circles over the top half of the ball, as shown in Figure 1. Using the same color circle, cover the bottom half of the ball so this half covers the top half about 1/4", as Figure 2 shows. Now cover the left half with the opposite color circle, and then the right half (with the same color circle used to cover the left half), as shown in Figures 3 and 4. Repeat until the desired thickness is obtained. Let dry approximately two days, cut in half, mark halves so they can be fitted together smoothly.

Although ordinary wheat or wallpaper paste or any type of paper can be used, best results are obtained if the "embrittling paste" (formula and theory described in L-TR1) and the Kraft and Red Rosin papers are used.

Since making the cores is so time-consuming, it is highly recommended that they be purchased ready-made. The "spherical shell casings" available from Westech Corporation make ideal cores since they are not only inexpensive but hydraulically pressed giving extremely uniform size and shape, something very difficult to obtain using hand methods.

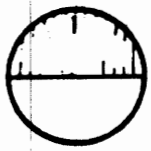


Figure 1

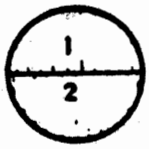


Figure 2

Figure 3

Figure 4

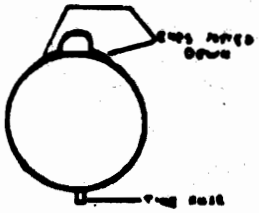


Figure 5

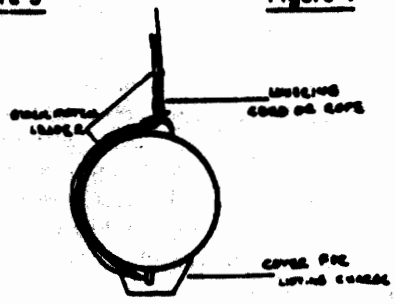


Figure 6

B. Outside Layer - This is made by evenly pasting strips of 30-pound Kraft paper and strips of Red Resin paper around the outside of the inner core after the bursting charge and garniture are inside. The two hemispheres are joined together by first alining the marks so the two halves are flush. Then they are joined together by pasting a 3/4"-wide strip of 30-pound Kraft paper around the seam two or three times, each turn slightly overlapping the other. (Masking tape can also be used instead.)

Now comes the most important operation. The shell must now be papered with strips of Kraft and red resin-type paper. The size of these strips depends upon the diameter of the shell. A good rule of thumb is to make their length about 1/2" longer than the diameter of the shell size designation and from 1" wide for 3" to 6" shells, to 2" wide for 8", 10" and 12" shells.

These strips are papered at right angles to the seam so the entire shell is evenly and smoothly covered in the following manner. Cut the strips of paper and paste fifty, or more, onto a board, one on top of another, with so much paste between them that they become soft and pulpy rather than stick together. The two kinds of paper should be used and a separate stack of each kind prepared. The object of this is to make it easier for one to see where 1 layer of paper begins and the other ends.

Now take strips of paper from one pile first and lay them on the inner core, beginning at the top and running down to the bottom (fuse end). Lay the second strip so that it will lap over the first one about 1/4" at the bottom and almost over it on top, but 1/2" lower down. The third strip should start 1/2" still further down, while the fourth strip again starts at the top. This will prevent the case from becoming egg shaped as a result of having too much paper in one place. Continue this until the entire core has been covered. Each strip must be pressed down firmly and all surplus paste squeezed out with the fingers. Now repeat the operation using the other kind of paper. The strips should be worked so they lie as evenly and tightly as possible around the time fuse.

When the desired thickness has been achieved, a loop of strong twine is placed on the top of the shell (opposite from the fuse end) and the ends of it are covered with three or four small strips of pasted paper, as shown in Figure 5. This loop serves to guide the leader from the lift charge (which will be situated under the time fuse) around the shell and eventually up and out the top of the mortar. It allows the shell to be lifted by the leader and placed in the mortar so the lift charge is exactly under the shell. Care must be taken so the shell is not situated in the mortar so the lift is off to the side somewhat. This will happen if the twine loop is not properly placed. A shell so situated may be shorn in two along the seam and "flowerpot" as it shears the inside of the mortar when fired.

A stout length of twine or rope should be attached to the loop on heavy shells to aid their placement in the mortar (see Figure 6). This cord should be grasped--and not the leader--when the shells are lowered into the mortar. Heavy shells may damage the leader if it is used to lower them in place. Generally, this extra piece of cord should be used on all shells of 6" diameter and up.

(NOTE: The preparation of the required strips of pasted paper and the operation of papering them to form the outside layer to the necessary thickness is very time-consuming and tedious. The above operation is the one used by the Orientals in constructing their shells. However, this whole operation can be greatly facilitated by using a special material available from Westech known as "Spherical Shell Wrapping." This material consists of cloth strips--which gives much more strength than paper--already impregnated with an extremely strong adhesive. All that is necessary is to simply dampen these strips with water and apply to the shell. Since these strips are constructed of thick, webbed, cloth using a thick adhesive, less of these are required to make the outer layer, thus saving a tremendous amount of time, as well as making a stronger shell and one that requires less time to dry.)

JAPANESE AERIAL SHELLS

L-601B: Basic Construction Techniques, Part II: Rice-Hull Powder

Rice-hull powder is made by coating ordinary meal powder or a meal powder substitute on whole rice hulls. (Ground-up rice hulls will not work.) The resulting product is a porous mass of powder with a considerably lower density and greatly increased surface area than that of granulated powder. Because of this, rice-hull powder is actually more effective than an equal weight of granulated powder.

The coating of powder on rice hulls serves two purposes: (1) In order to be most effective the Japanese shells that break with a certain pattern must have the stars that form this pattern expelled with considerable speed in order to overcome the force of gravity and maintain their pattern. The increased effectiveness due to the physical state of rice-hull powder helps achieve this. Also important factors are the hard, outside layer of the casing and special black powder substitutes coated on the rice hulls instead of ordinary black powder. (2) Since the contents of most Japanese-type shells are packed inside the shell extremely tight (in order to function properly), the rice hulls help maintain the porosity of the burst charge for a more effective break and use of powder.

The only way to coat the hulls is to pour them into a bowl of water. Allow them to become thoroughly saturated with water (takes about 30 minutes). Drain off the excess water, dump the soaked hulls into a box or bowl, pour in some dry meal powder over the bottom of the box or bowl so the bottom is lightly but completely covered. Then dump just enough of the soaked and drained hulls into the box so they form a single layer over the powder. Quickly sprinkle some more dry powder (about the same amount as used before) over the hulls and shake the whole lot until the powder is thinly but completely and evenly coated on each of the hulls. The hulls should be so covered with powder that they have a dull, black appearance. If they appear shiney, they are too damp and/or not enough powder was used to cover them. They should not stick together too much either. Only practice will tell exactly how much powder to use so they are neither too thinly nor thickly covered or are too damp or dry.

NOTE: For some excellent meal powder substitutes all as effective or more effective as commercial black powder, see the formulas and processes listed in L-TR4.

When the hulls are coated, spread them out evenly on a clean surface to dry.

CAUTION: When dry, rice-hull powder is HIGHLY FLAMMABLE.

JAPANESE AERIAL SHELLS

L-601C: Basic Construction Techniques, Part III: Round Stars

Stars used in Japanese-type shells are always spherical in shape. By constrast, domestic or European stars are cubical (cut stars), or cylindrical (pumped and box stars).

Round stars are based on the simple priciple of building-up successive layers around a centeral core. Al though this may seem obvious, the exact way od doing this has long remained a mystery to Western fireworks makers. The secret is to add dry material to a damp core.

There are two types of round stars. Both types are made using the above principle. The first type uses a small seed, or other very small, round object as the core. The second type uses a small, cut star as the core. This type is usually used in the manufacture of color-changing stars.

Type I - The Japanese use small, round seeds, or other small objects such as buckshot to act as the core. The small (about 1/16" diam.) candies used as cake or cookie decorations work very well. Whatever core is used, pour a quantity of them into an ordinary mixing bowl, dampen them slightly with water sprayed from an atomizer. Now sprinkle some dry starcomposition over the dampened cores and rotate the bowl rapidly, so the cores swirl around, picking-up compo evenly on their surfaces. When it appears that all the compo has been picked up, dampen the now miniature stars as before, sprinkle on more compo, and rotate the bowl again. This process is continued until the stars are the desired size.

Try not to spray the sides of the bowl with water when dampening the cores, since they will adhere to anything wet. Try to keep the sides as dry as possible at all times. If the sides become too damp, the dry compo will build-up on them due to the rolling action of the cores, instead of on the cores themselves. Th correct amount of dampening will come only with practice. The amount of dry compo to be added also can be ascertained by experience. Add enough each time so all of it is picked-up by the cores and none is left in the bowl. Of course, more will have to be added each successive time.

Type II - The same process is followed, but instead of small, round cores, cut (or pumped) stars are used. The stars may either be used immediately after they are cut--while they are still damp--or they can already dry and then sprayed damp as explained above.

To make color-changing stars, simply start with a cut star of one color, dampen, and use dry compo of another color. Or, just change compos once a layer of one color is suffieiently thick. The exact thickness must be found by experience, since it depends on the type of compo being used, size of star, placement in relation to the ouside of the star, and other factors. Each color should burn long enough so a definite color can be observed and appreciated.

JAPANESE AERIAL SHELLS

L-602: Chrysanthemum/Peony Shells

These are probably the best known Japanese aerial shells. The primary characteristic of these shells is the almost perfectly round symmetry and great size of the burst. The almost mathematical precision of the pattern produced is in direct contrast to the rather random spray pattern produced by an ordinary Euro-American shell. The effect is, indeed, like a gigantic flower blooming in the sky.

The difference between chrysanthemum and peony shells is in the stars used. Their construction methods for both are the same. A peony shell, according to a Japanese definition, "is the blossom without fire trace; and the chrysanthemum is one with fire trace." Thus, the difference is that the peony appears in full brilliance only at the full bloom, just at the stars reach their greatest spread; the chrysanthemum is just as brilliant from start to finish. This difference is achieved by using fierce burning star compos for brilliant burns, and less fierce for less brilliant burns. Since the effect of either a chrysanthemum or peony shell is so quick, the difference is difficult to notice.

A C/P shell is made in the following manner. Place a inner core hemisphere on a board that has a hole cut in it to receive part of the hemisphere. This stabilizes it and leaves both hands free. Pour into the core some round stars so they form a single layer on the bottom and part of the sides. Then stack stars up all around the sides until they come to the top (equator) of the hemisphere. The stars should fit as snugly against each other as possible. Now push into the hemisphere a circle of Gampi tissue paper so it forms a layer over the stars and then pack rice-hull powder into this cavity. The powder should be packed in quite firmly. A cross-section as the construction should now appears is shown in Figure 1.

Repeat the same operation with the other hemisphere. Now take a circle of Gampi with a diameter equal to the I.D. of the core. Place this over one of the loaded cores so it holds in the powder and stars while the whole loaded core is turned and placed over the other core so they fit together in a flush fit. Paper with a thick outer layer, finish, and lift (described in L-601A). A cross-section of the completed shell after papering but before lifting appears in Figure 2.

A double or triple petal C/P is made by placing two or three layers of stars around the core. Double petal shells are usually 6" and larger; triple are 10" and larger. So that everything can fit inside the case, smaller stars with the same amount of burst, or less burst with regular size stars is used, depending on the effect desired.

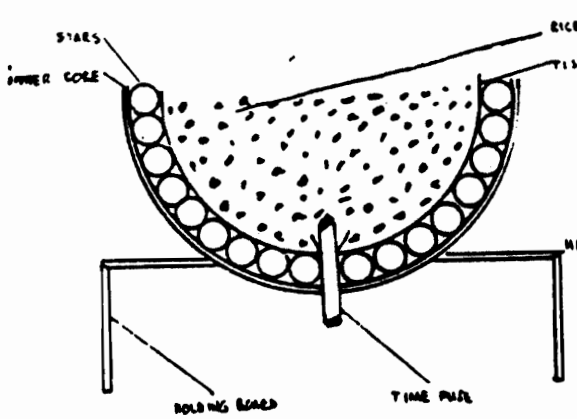


Figure 1

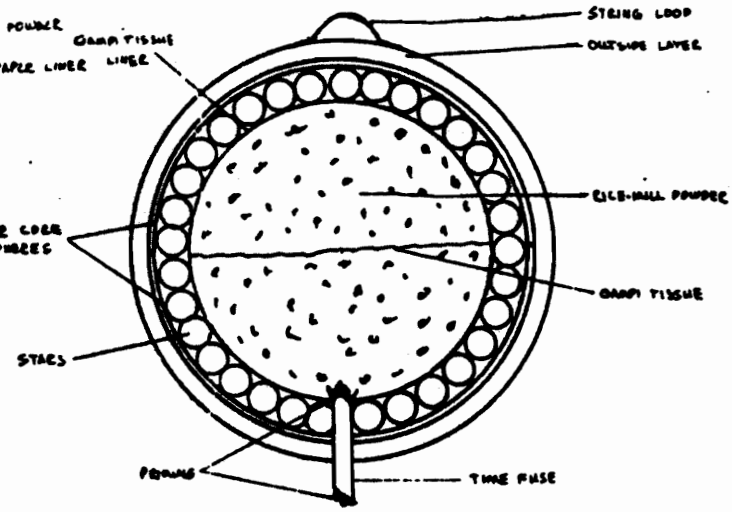


Figure 2

A type of chrysanthemum shell known as a "Diadem Chrysanthemum" shell gives a very nice effect and is easily constructed. The effect is about midway between the effect of a regular C/P shell and a Willow shell. If normal size stars are used the effect is exactly like (and indeed its construction is exactly like) the spherical shells made in the U.S. some 35 years ago. If very large stars (3/4" or larger) are used, the shell is a true Diadem shell.

The stars and rice-hull powder are thrown in randomly in each hemisphere, as much as each will hold, then the two are joined together and completed as before.

JAPANESE AERIAL SHELLS

L-603: Pistils

Pistils are a smaller cluster of stars in the center of the larger burst, forming a sphere within a sphere, not unlike the pistils of a flower surrounded by the outside petals.

A C/P with pistils shell is really two shells, one inside the other--the inside shell being the pistils, the outside shell, the petals. The shell is constructed in the following manner. (The dimensions given are for a 6" shell.) A 6" shell is the smallest size shell that can have pistils added conveniently.

The inner shell casing is merely a single layer of Gampi tissue paper wrapped diagonally around with thread. It is constructed around a "support tube" 5" long x 5/16" O.D. x 1/4" I.D. First, the support tube is cross-matched 2-1/2" from one end with two pieces of black match, each piece being 1" long. One end of the tube is closed with a wad of paste and paper, then two or three pieces of black match about 2-1/2" long are inserted in the open end of the tube, as shown in Figure 1.

Then a piece of Gampi tissue 5" wide x 9" long (trimmed size) is glued on one of the 5" ends and made into a cylinder, 5" high, shown in Figure 2. One end of the cylinder is then tied securely around the support tube, 1-3/4" from the open end, and the overlapping tissue is trimmed close to the twine, seen in Figure 3. The inner burst charge is now poured into the bag formed by the Gampi around the support tube. The bag is formed into a ball, and the top is then securely tied with twine and its ends trimmed closed to the tie, as shown in Figure 4.

Now another piece of Gampi tissue 5" wide x 10" long (trimmed size) is formed into another cylinder, 5" high, seen in Figure 5. It is secured tied just below the ball of burst powder, as shown in Figure 6. Then it is pulled over the ball, enclosing it inside, as shown in Figure 7. The inner stars (to form the pistils) are now poured in, forming a single layer all around the inner burst bag. The top end of the cylinder is securely tied to the support tube, seen in Figure 8, and then it is wrapped all around with thread so it forms a firm ball. This assembly is hereafter called the support tube assembly (sta, for short).

A strong piece of paper towel (or light cloth)--to form the outer burst bag--is formed into a cylinder. One end is tied 1" from the closed end of the sta, as shown in Figure 9. This assembly is now glued over the time fuse (time fuse extends 1" or less inside the inner core hemisphere), as seen in Figure 10. The outer burst charge is now poured into the bag and tighly packed-in to form a ball and the loose ends tied to the sta and trimmed close to the tie.

A layer of stars is now poured in between the inner core hemisphere and the outer burst charge bag, shown in Figure 11. Now, cut out a segment 2-3/4" in diameter out of the top of the other inner core hemisphere, Figure 12. Secure this cut hemisphere to the other with two or three laps of masking tape around the seam. Now a layer of stars is forced in between the bag and the casing, shown in Figure 13. The segment is glued back into place; then the whole shell is given a thick outer layer of papering.

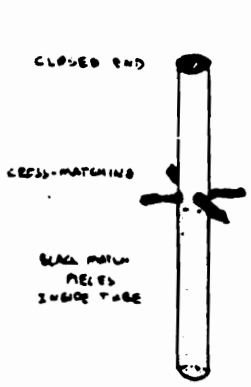


Figure 1

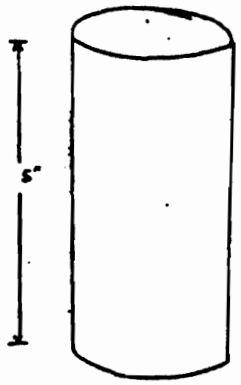


Figure 2

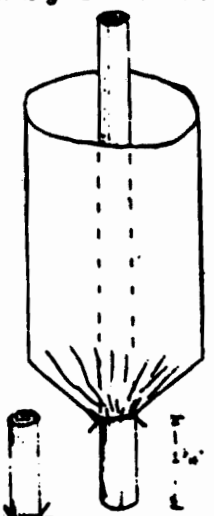


Figure 3

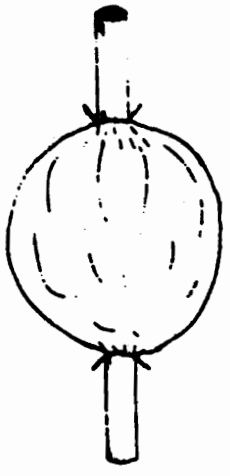


Figure 4

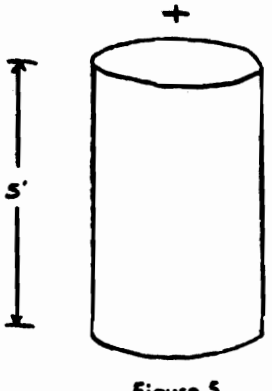


Figure 5

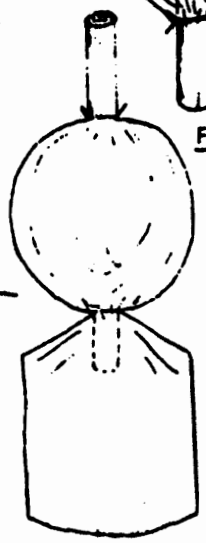


Figure 6

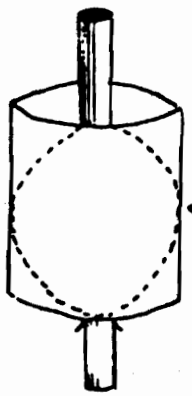
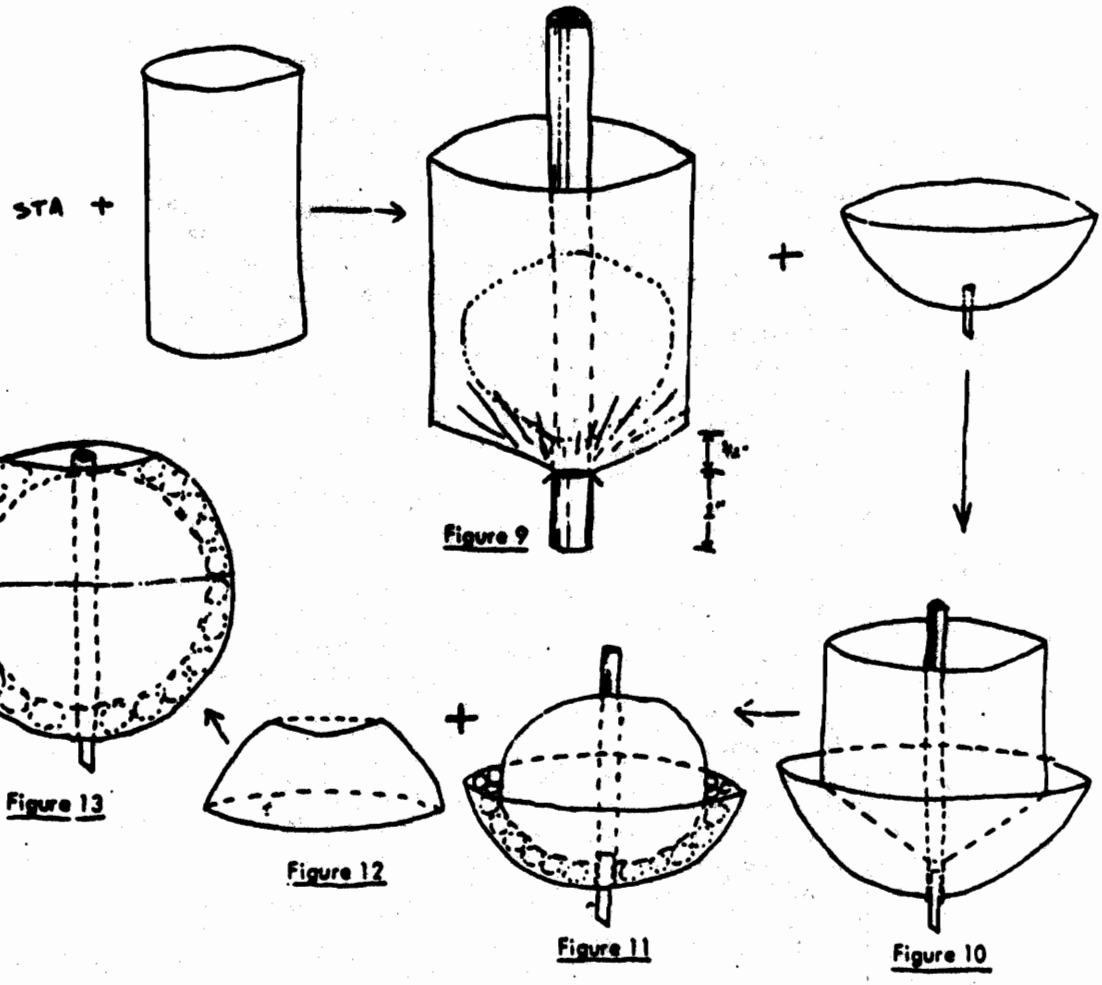
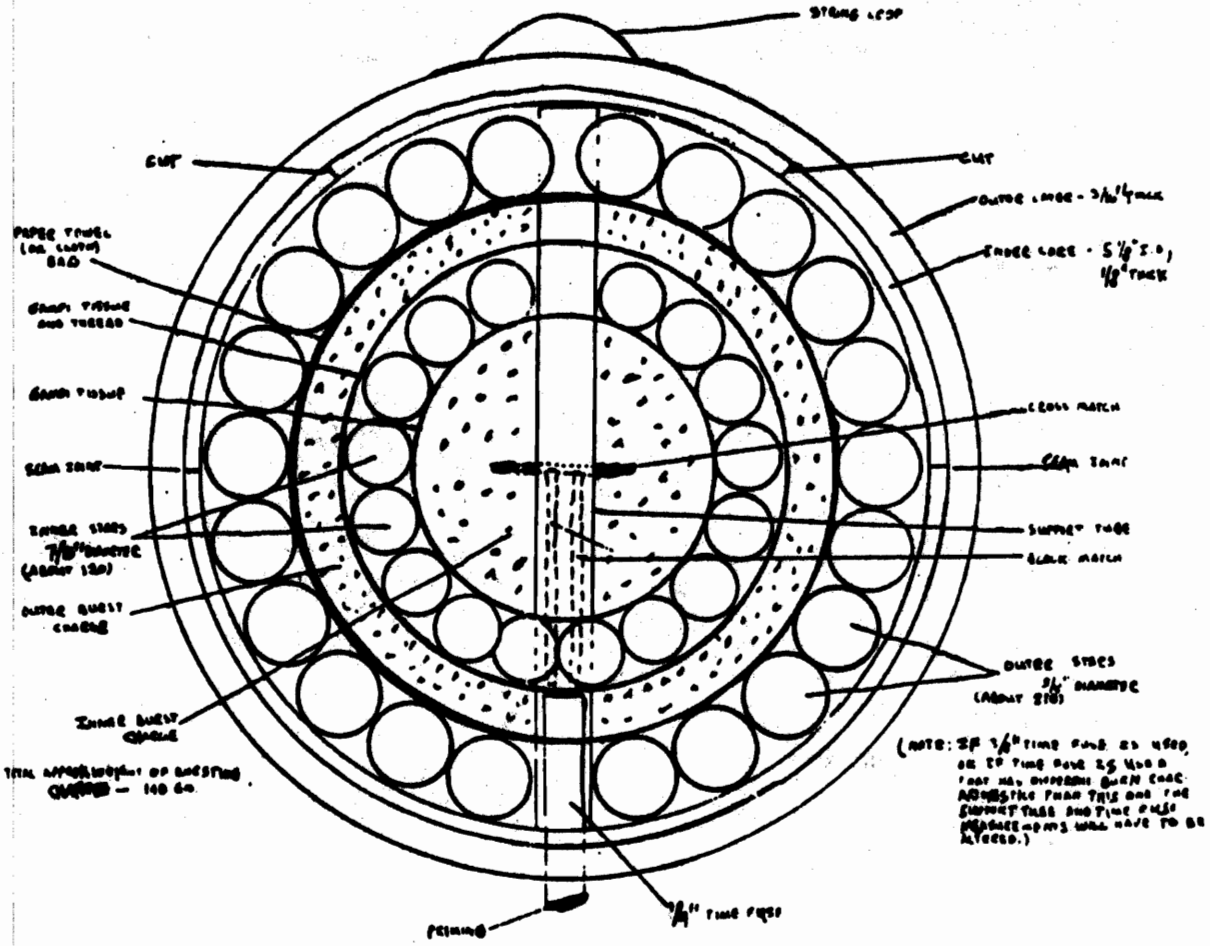


Figure 7

Figure 8





Half Scale Cross Section Drawing

JAPANESE AERIAL SHELLS

L-604: Willow Shells

A willow shell has a burst that resembles the shape of a willow tree. The burst is not anywhere as wide as the burst of a C/P shell, and the stars in the willow shell burn a much longer time than do those in the C/P shell.

To achieve the hemispherical, drooping effect, the willow shell employs the following methods: (1) Use of a very light bursting charge; (2) Use of a very thin outer layer; (3) Filling only one-half of the shell with active components.

The bursting charge is generally commercial black powder. Grain size is that of about FFg rifle powder. Black powder is used instead of rice-hull powder to give a bursting charge of less strength. The quantities to use in each size shell are given in the following table:

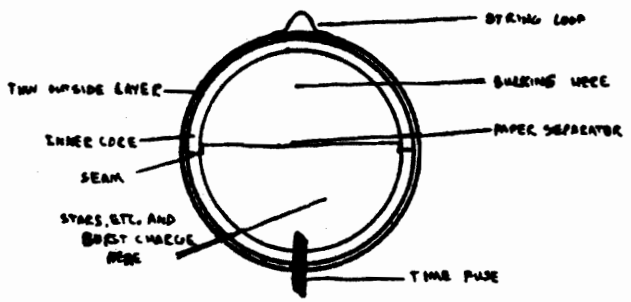
Size of Shell	Quantity of Black Powder
2"	2 grams
3"	4 grams
4"	6 "
5"	8 "
6"	11 "
8"	14 "
10"	21 "
12"	32 "

Rice-hull powder can be used in place of black powder, however less must be used.

The outer layer is papered at least half as thick as that of a C/P shell. (See L-601 A).

The burst charge and stars or other garniture are contained in only the bottom hemisphere (the fuse half). The top half is filled with rice hulls, sawdust, or other bulking and held in po sition by a circular piece of paper pressed in over them. If the upper half was not filled with inert materal, the shell would not burst with as much of a drooping effect, but more like a Diadem C/P shell. Also, with so little active material in such a large spacewith no bulking to hold it in a smaller space, the time fuse end spit may not fire the garniture if all of it had moved to the other areas of the casing.

Willows can be very effectively added to other shells that use a garniture that does not fill the entire casing. Examples are: Flag Shells, Figure Shells, Streamer Shells, Leaflet Shells, Dragon Shells, all types of Parachute Shells, Flower Shells, Criss-Cross Star Shells, Falling Leaves Shells, Report Shells.



Cross Section of Willow Shell

L.-TR1

PROFESSIONAL PYROTECHNIC ADHESIVE

This particular item is one of the most useful and versatile that the pyrotechnist at his disposal. Its composition has long been kept secret from the general public. dvantages are:

(1) an extremely strong adhesive;
(2) dries very rapidly;
(3) easy, quick, and inexpensive to prepare;
(4) can be made to any consistency desired.

Some of its main uses are:

(1) attaching the paper mortars to wooden bases in making aerial star shells, comets, mines, etc.;
(2) securing and reinforcing the paper end plugs used in the salutes;
(3) forming the outer rock-like shell of Cherry Bombs;
(4) plugging the ends of repeating aerial salutes;
(5) as the main adhesive of and for finishing aerial display shells and salutes;
(6) attaching drivers, gerbs, etc., and fortifying their junctures on wheels, revolving pieces, and other display items.

To prepare this professional adhesive the following items are needed:

(1) Calcium Carbonate (whiting, precipitated chalk).
(2) Zinc Oxide (zinc white).
(3) Sodium Silicate (water-glass).

Calcium Carbonate and Zinc Oxide can be obtained from dealers in painters' plies, hardware stores, etc. They can also be purchased from drug stores, but at ore expensive price. One pound of each is a good starting supply.

Sodium Silicate is the "water-glass" used as an egg preservative. It is sold at g stores or chemical supply houses. Make sure it is the thick, syrupy kind, not thinned-down solution used as a label adhesive. One quart is a good supply. All e of these chemicals can be obtained very inexpensively from Westech.

Mix two parts Calcium Carbonate with two parts Zinc Oxide and to this add one or o parts Sodium Silicate, depending on how thick the Adhesive has to be. Stir well l a smooth texture is obtained. This Adhesive can be made without Zinc Oxide, stituting additional parts of Calcium Carbonate instead. The advantage to this is the Adhesive is less expensive; however, it is somewhat less strong.

Make only enough Adhesive for immediate use as the unused portion cannot be ed, since it hardens within an hour or two. All utensils used in making or apply- this Adhesive should be promptly cleaned with water, since once the Adhesive dries omething it cannot readily be removed.

The Adhesive can be tinted any color by the addition of a dry pigment such as that l to color cement or water color paint powder.

To form the outer shell of Cherry Bombs, the Adhesive is modified somewhat. the Adhesive to a medium consistency. Add to this some red coloring agent and e very fine sawdust. Then, holding the Cherry Bomb by the fuse, dip it into the esive/sawdust mixture. One coating should be enough.

L-TR2

HINTS FOR PROFESSIONAL QUALITY SALUTES

Composition Formula: (parts by weight)

Aluminum, black German pyro...3

Potassium Perchlorate.....7

There are four important factors that produce extra-quality salutes: (1) type of um used; (2) particle size of Pot. Perchlorate; (3) thoroughness of the mixing of mposition; and (4) degree of compaction of the composition in the casing. There so two other factors: (1) strength of the casing; and (2) size and placement of fuse.

Major Factors. (1) The main secret to this formula is the black German pyro um. The reasons that this type works so well are: (1) it is completely free of and stearates that would, if present, slow the combustibilty; (2) the extremely esh (400 and finer) greatly increases the combustibility. Being such, it is very ive, —in fact explosive—even to static electricity, when dispersed in the air the mixing process. All other types of aluminum, including the best domestic pyro" grades, are not as free from the stearates and other imparities, and are finely powdered, being about 325 mesh. The black (sometime called "dark") an pyro aluminum looks almost exactly like black Antimony Sulfide.

(2) The Pot. Perchlorate must be finely powdered, about as fine as powdered Most material when purchased is somewhat granular. Even the types advertised owder" should be ground with a mortar and pestle (or powdered by other means) t is about like powdered sugar. Though a good report can still be obtained using ial that is not this finely powdered (and some commercial manufacturers do use nely powdered material for economical reasons), better results are obtained by the finely powdered material.

(3) The more thoroughly the components are mixed, the louder will be the report. s another factor that some commercial manufacturers, again for economical reasons observe very thoroughly. As a result of this and the previous factor, their salutes much more composition (poorly mixed, with large particle sizes, and sometimes more dangerous ingredients such as chlorates) to make the same size report as be necessary if a composition was used whose ingredients were properly mixed and all particle size.

Extreme caution must be exercised when mixing this composition. Only small ties (not more than one or two grams) should be mixed at one time. A very safe dequate method of mixing this composition is to separately introduce the ingredients he casings and then mix. First, pour the requisite amount of Pot. Perchlorate alutex—see below) into an individual casing. Then pour in the aluminum. Leave ed. Plug the remaining open end of the casing (allow to dry if necessary). When number of these may be placed in a cardboard box and tumbled by rotating the box to mix the ingredients. In this way, there is not a large quantity of explosive com- on in any one place. In fact, there is no explosive composition until the ingredients ixed inside the casing.

(4) Flash powder must be loose to give maximum results. Thus, salute casings only be partially filled, about 80%. The theory behind flash powder being loose is rease the ignitable surface area of the powder. In the past, such materials as saw- bran, barley hulls, and other "bulking agents" were used to affect this. The modern expensive and more effective) way to achieve this is to use "Salutex." See the cata-

.og for a complete description of this material. Salutex aids in increasing the surface area of the salute powder so more can be ignited at the same time. The more area that can be exposed for a given volume and time, the greater will be the report. Thus, it is possible to produce the same size report using less powder--which is more exposed--than using more powder--but which is less exposed. The salute is thereby made safer by producing an equal report but with less destructive force. And since less powder is used, salutes are also more economical than those needing more powder to produce the same report.

Other Factors. (1) The stronger the case, the louder will be the report. This is why end plugs and fuse holes should be adequately secured or reinforced. Professional Pyrotechnic Adhesive (L-TR1) is best. Under no circumstances should metal, glass, pieces of wood, cement or other un-yielding substances be used as parts of casings. Only paper sould be used, since when properly constructed, paper casings are as strong as metal but are able to be fragmented into harmless bits of paper

(2) As stated above, the more flash powder that can be ignited in a given time, the greater will be the report. Thus, a larger fuse and its placement in the middle of the composition will give an increased report. (A middle-placed fuse starts the powder burning towards the two ends; if placed at one end, the fuse would start the powder burning only at one end.) Also, if the tip of the fuse that ignites the powder is given a thick coat of priming (meal powder, dextrin and water made into a thick paste), this will further increase the report since more powder will be ignited in less time. The priming can best be added after the fuse is inserted in the empty case. Allow to dry completely before adding any flash powder. Never punch a fuse hole in a case that already is filled with composition.

These points, though simple, make the difference in producing professional quality salutes. The use of only a certain type of aluminum or other ingredients; the special particle size (usually very small) of these ingredients; and their thorough mixing constitute the great part of the "art" and most of the "secrets" of pyrotechnics.

L-TR3
ROUND STARS

Round stars are based on the simple principle of building-up successive layers nd a central core. Although this may seem obvious, the exact way of doing this long remained a mystery to Western fireworks makers. The secret is to add dry erial to a damp core.

There are two types of round stars. Both types are made using the above princi- The first type uses a small seed, or other very small, round object as the core. second type uses a small, cut star as the core. This type is usually used in the ufacture of color-changing stars.

Type I - The Japanese use small, round seeds, or other small objects such as shot to act as the core. The small (about 1/16" diam.) candies used as cake or ie decorations work very well. Whatever core is used, pour a quantity of them an ordinary mixing bowl, dampen them slightly with water sprayed from an izer. Now sprinkle some dry star composition over the dampened cores and e the bowl rapidly, so the cores swirl around, picking-up the compo evenly on surfaces. When it appears that all the compo has been picked up, dampen the now ature stars as before, sprinkle on more compo, and rotate the bowl again. This ess is continued until the stars are the desired size.

Do not spray the sides of the bowl with water when dampening the cores, since will adhere to anything wet. Try to keep the sides as dry as possible at all times. e sides become too damp, the dry compo will build up on them due to the rolling n of the cores, instead of on the cores themselves. The correct amount of pening will come only with practice. The amount of dry compo to be added also be ascertained by experience. Add enough each time so all of it is picked up by ores and none is left in the bowl. Of course, more will have to be added each essive time.

Type II - The same process is followed, but instead of small, round cores, cut s are used. The cut stars must be exactly cubical or the resulting star will not be d. The cut stars may either be used immediately after they are cut--while they are damp--or they may be already dry and then sprayed damp as explained above.

To make color-changing stars, simply start with a cut star of one color, dampen, use dry compo of another color. Or, just change compos once a layer of one color fficiently thick. The exact thickness must be found by experience, since it depends e type of compo being used, size of star, placement in relation to the outside of tar, and other factors. Each color should burn long enough so a definite color e observed.

L-TRI
PROFESSIONAL PYROTECHNIC ADHESIVE

This particular item is one of the most useful and versatile that the pyrotechnist has at his disposal. Some of its more important uses are: (1) forming the rock-like shell on Cherry Smoke Bombs and regular Cherry Bombs; (2) securing and reinforcing the end plugs of tube devices such as Smoke M-80's, Silver Tube Salutes, regular M-80's, etc.; (3) forming the end plugs using the "Acceloseal" method; (4) attaching paper mortars to wooden bases; (5) attaching drivers, gerbs, etc., and fortifying their juncture on wheels, revolving pieces, and other display items. Its advantages are: (1) is an extremely strong adhesive; (2) dries very rapidly; (3) easy, quick, and inexpensive to prepare; (4) can be made to almost any consistency desired.

To make the adhesive you'll need the following items: (1) Sodium Silicate (This must be at least 42 BE — syrupy consistency, the thicker the better. The thinned down varieties sometimes sold in drug stores as an adhesive for labels will not work.) (2) Calcium Carbonate (This material is also called whiting, precipitated chalk, powdered chalk.) Zinc Oxide added in place of some of the Calcium Carbonate will make a stonger adhesive. Powdered Fire Clay may also be used instead of the Calcium Carbonate, or at least replace a part of it.

Mix the Calcium Carbonate (and the other powders, if desired) into the Sodium Silicate until a smooth consistency is obtained. The more of the powder(s) you add, the thicker will be the adhesive. There are no set proportions; just add as much of the powder(s) to the liquid Sodium Silicate to give the desired consistency. By the way, the powdered Sodium Silicates will not work.

The adhesive may be tinted any color by simply adding any of the dry pigments available. Add as little as possible, however, since an excess will weaken the adhesive.

Mix only as much of the adhesive that you can use at one time, since once mixed, the adhesive can't be stored. Drying should be done at room temperature. Do not try to dry in direct sunlight or at elevated temptures since this will cause a skin to form on the surface, greatly retarding the drying of the underlying adhesive.

L-TR2

HINTS FOR BETTER EXPLODING FIREWORKS

Composition Formula: (parts by weight)
Aluminum, black German pyro...3
Potassium Perchlorate.....7

There are four main factors that produce better quality exploding fireworks: (1) type of aluminum used; (2) particle size of Pot. Perchlorate; (3) thoroughness of the mixing of the composition; and (4) degree of compaction of the composition in the casing. There are also two other factors: (1) strength of the casing; and (2) size and placement of fuse.

Major Factors. (1) The main secret to this formula is the black German pyro aluminum. The reasons that this type works so well are: (1) it is completely free of grease and stearates that would, if present, slow the combustibility; (2) the extremely fine mesh (400 and finer) greatly increases the combustibility. Being such, it is very sensitive, —in fact explosive—even to static electricity, when dispersed in the air during the mixing process. All other types of aluminum, including the best domestic "dark pyro" grades, are not as free from the stearates and other impurities, and are not as finely powdered, being about 325 mesh. The black (sometime called "dark") German pyro aluminum looks almost exactly like black Antimony Sulfide.

(2) The Pot. Perchlorate must be finely powdered, about as fine as powdered sugar. Most material when purchased is somewhat granular. Even the types advertised as "powder" should be ground with a mortar and pestle (or powdered by other means) until it is about like powdered sugar. Though a good report can still be obtained using material that is not this finely powdered (and some commercial manufacturers do use less finely powdered material for economical reasons), better results are obtained by using the finely powdered material.

(3) The more thoroughly the components are mixed, the louder will be the report. This is another factor that some commercial manufacturers, again for economical reasons, do not observe very thoroughly. As a result of this and the previous factor, their salutes carry much more composition (poorly mixed, with large particle sizes, and sometimes using more dangerous ingredients such as chlorates) to make the same size report as would be necessary if a composition wereused whose ingredients were properly mixed and of small particle size.

Extreme caution must be exercised when mixing this composition. Only small quantities (not more than one or two grams) should be mixed at one time. A very safe and adequate method of mixing this composition is to separately introduce the ingredients into the casings and then mix. First, pour the requisite amount of Pot. Perchlorate (and Chemite—see below) into an individual casing. Then pour in the aluminum. Leave unmixed. Plug the remaining open end of the casing (allow to dry if necessary). When dry, a number of these may be placed in a cardboard box and tumbled by rotating the box so as to mix the ingredients. In this way, there is not a large quantity of explosive composition in any one place. In fact, there is no explosive composition until the ingredients are mixed inside the casing.

(4) Flash powder must be loose to give maximum results. Thus, salute casings must only be partially filled, about 80%. The theory behind flash powder being loose is to increase the ignitable surface area of the powder. In the past, such materials as sawdust, bran, barley hulls, and other "bulking agents" were used to affect this. The modern (less expensive and more effective) way to achieve this is to use "Chemite." See the catalog for a complete description of this material. Chemite aids in increasing the surface area of the salute powder so more can be ignited at the same time. The more area that can be exposed for a given volume and time, the greater will be the report. Thus, it is possible to produce the same size report using less powder—which is more exposed—than using more powder—but which is less exposed. The salute is thereby made safer by producing an equal report but with less destructive force. And since less powder is used, salutes are also more economical than those needing more powder to produce the same report.

Other Factors. (1) The stronger the case, the louder will be the report. This is why end plugs and fuse holes should be adequately secured or reinforced. Professional Pyrotechnic Adhesive (L-TR1) is best. Under no circumstances should metal, glass, pieces of wood, cement or other un-yielding substances be used as parts of casings. Only paper could be used, since when properly constructed, paper casings are as strong as metal but are able to be fragmented into harmless bits of paper.

(2) As stated above, the more flash powder that can be ignited in a given time, the greater will be the report. Thus, a larger fuse and its placement in the middle of the composition will give an increased report. (A middle-placed fuse starts the powder burning towards the two ends; if placed at one end, the fuse would start the powder burning only at one end.) Also, if the tip of the fuse that ignites the powder is given a thick coat of priming (meal powder, dextrin and water made into a thick paste), this will further increase the report since more powder will be ignited in less time. The priming can best be added after the fuse is inserted in the empty case. Allow to dry completely before adding any flash powder. Never punch a fuse hole in a case that already is filled with composition.

These points, though simple, make the difference in producing professional quality salutes. The use of only a certain type of aluminum or other ingredients; the special particle size (usually very small) of these ingredients; and their thorough mixing constitute the great part of the "art" and most of the "secrets" of pyrotechnics.

L-TR3: PETARDS

Although simple in construction, Petards are extremely effective. The whole secret is in the nposition, which is:

Potassium Perchlorate	66	
Aluminum, dark	34	(Parts by Weight)
Chemite	1	

Most of the success depends upon the type of aluminum used. The dark pyro aluminum available m Westech is the only suitable type since it meets military specs. (The black German type can also used.) Powder the perchlorate thouroughly and then mix completely with the Chemite. Now mix in the aluminum. Chemite adds tremendously to the effectiveness of the composition. Since this compos- on contains a strong oxidizer and powdered aluminum together, it is EXTREMELY SENSITIVE TO FLAME ND STATIC ELECTRICITY! It should also not be subjected to rough handling or friction. It will, wever, withstand the shock of a bursting charge (or lifting charge) of an aerial shell. Petards are much ed in Italian-type aerial shells where multiple reports are used.

Construction of Petards is as follows. Roll 3 turns of strawboard and 4 turns of 70# Kraft around a itable former. Pull the former slightly out so the end of the paper tube can be folded and pressed down ainst the end of the former and secured with tape. Now withdraw the former completely. Insert a piece good, stiff match into the case, then pour in some compo. The match should lay along side the inside the case and extend for the whole length of the case plus as inch or so outside. Now firmly press in some wdust on top of the compo. The sawdust should be DRY, and free from as much oil and turpentine as ssible. The amount of sawdust depends on the length of delay you wish before the black match will ignite e compo. Whatever the amount decided upon, when it is pressed in there should be enough empty casing ft so it can be folded over the sawdust and match and secured in place with some masking tape. The tard is now complete. Use plenty of tape at both ends and be sure that each end is very tight.

There should be at least an inch of match protruding form the device to assure it takes fire from the burs arge of an aerial shell, rocket, etc. When made correctly, these devices never fail to take fire and plode with a tremendous report notwithstanding their very light constructian.

Of course, Petards can be made without black match and delay sawdust by first taping the first end shut before. Then poke a hole in the side of the casing and insert a length of safety fuse. Fill with compo an ld and tape the other end shut. Instead of going in the side, the fuse can also go in one of the ends.

Petards use a composition that does not have to be loose to give a good report. In fact, the compo can ghtly packed and still function very well. A well made Petard should have the compo and sawdust cked so that when the side of the device is squeezed or pressed it feels very firm and tight to the touch.

The casing should have enough turns of paper (the more turns, the louder the report) and should be very ghtly sealed at each end so they do not explode prematurely from the flash of the bursting charge, or om sparks from other sources.

L-TR4
PYRO POWDER

Composition Formulas:

	Fast	Slow	(Parts by weight.)
Potassium Chlorate	77	35	
Potassium Nitrate	-	35	
Charcoal, dust	23	30	

Much of the success of the powder depends on the physical state of the ingredients, especially the charcoal. It should be made of willow or other soft wood, and must be as finely powdered as possible. The smallest particle size available is the type known as "air-floated." This material is ideal. The oxidizer(s) should be as fine as powdered sugar or flour.

Once the ingredients have been carefully weighed, the oxidizers should be carefully sifted through a 40-mesh screen. Now add the charcoal and carefully and slowly mix using a 24-mesh screen. Be very careful doing this since this is the most hazardous part of the operation. Be careful not to rub or strike your fingernail on the screen or you may strike a spark. When the mixture is homogeneous, pour it into a large pan and add 10% water (by weight). In other words, if your total mixture weighs 100 grams, add 10 grams water. Now comes the most important step of the whole operation. Knead the powder and water together so the water is completely worked into all parts of the powder. In making the Slow Pyro Powder, you will have to add at least 15% water, sometimes a little more. 10% water should be the correct amount for the Fast Pyro Powder.

When thourghly kneaded, push the powder through an 8-mesh screen onto a clean piece of paper and allow to dry. CAUTION: When dry, either powder is HIGHLY FLAMMABLE. You can use the powder as is for a lifting charge for shells, Roman candles, etc., and as a bursting charge for 2" shells and smaller. For a bursting charge for larger shells, add 3% Dextrin to either powder and coat on rice hulls, as described in L-601B.

Fast Pyro Powder is an extremely fast mixture, and is about twice as powerful as commercially made black gunpowder. The specific volume of gaseous products of combustion of the Fast Pyro is 562 cm^3/gm; that of black powder is 280 cm^3/gm. The Slow Pyro burns about as fast as black gunpowder. The Fast Pyro can be used as a lift charge for all spherical shells 8" and smaller, and for 3" canister single and double-break. Any larger 3" or larger diameter canister shells should use the Slow Pyro for lift.

Since Pyro Powders contain a chlorate, they MUST NOT be used in formulas that contain any sulfur (or sulfides, sulfates, etc.). For example, Pyro Powder cannot be used as a substitute for "meal powder" in star, driver, or fountain formulas if these contain any sulfur. Pyro Powders can, however, be used where they will not be intimately in contact with sulfur, as is the case when Pyro Powder is used as a burst charge for shells that contain sulfur-containing stars. However, great care must be used to keep items that have this relationship between Pyro Powders and sulfur-containing items, completely dry and storage time to a minimum.

L-TR4

PYRO POWDER

Composition Formulas:

Materials	#1	#2
Potassium Chlorate	77	33
Charcoal, dust	23	10
Dextrine, yellow	2	--
Potassium Nitrate	--	33
Lactose	--	10

Much of the success of the powder depends on the physical state of the ingred-
, especially the charcoal. It should be made of willow or other soft wood, and
be as finely powdered as possible. The smallest particle size available is the
known as "air-floated." This material is ideal. The oxidizer(s) should be as
as powdered sugar or flour. The same holds true for the dextrine and lactose.
ose (common table or confectionrs sugar) is quite unstable and undependable
a chlorate. Its use is not recommended.

Formula #1 is a very quick-burning and powerful powder. Formula #2 is less
rful.

Once the ingredients have been carefully weighed, they should be thoroughly
d, using 40 mesh mixing sieves. Pour the mixture into a tough, plastic bag and
en slightly with water. Now comes probably the most important step. With the
rs, knead the powder through the bag until the water is thoroughly worked into
ixture. If necessary, add more water until the powder is just damp enough to
together like wet sand. It should not be watery, pasty, or tacky. The water
lves the oxidizer(s) so the porous charcoal is thoroughly permeated with it (them).
wetting also forms the dextrine or lactose into an adhesive which binds all the
dients into closer contact.

When thoroughly kneaded, dump the powder onto a dry, clean surface to dry.
TION: When dry, the powder is HIGHLY FLAMMABLE.

To make meal powder, break the larger pieces into a fine (100 mesh or less)
er. What actually results is a granulated powder of extremely fine particle size.

To make granulated powders (equivalent to F to FFFF grades of black rifle
er), add slightly more water to the powder while in the bag and press into a firm
Now grate the damp powder through a wire screen of the desired mesh size.
gh water should be added to the granules so they do not crumble but retain their
e when grated. However, do not add too much water, since the excess cannot be
rbed and will only upset the correct ratio and distribution of the ingredients by
ing the oxidizer(s) to crystallize out.

E: Since these meal and granulated powders contain a chlorate, they MUST NOT
be used in compo formulas that contain any sulfur (or sulfides, sulfates, etc.).
Use regular meal or granulated powders, either commercially- or self-made.

To make a coarse powder such as the type used as a lifting charge (equivalent to
grade of blasting powder), coat the powder on rice hulls. This also makes a
er equivalent to the "rice-hull powder" used as a bursting charge in Japanese

aerial shells. The only way to coat the hulls is to pour them into a bowl of water. Allow them to become thoroughly saturated with water (takes about 30 minutes). Drain off the excess water, dump the soaked hulls into a box or bowl, pour in some dry meal powder, and shake the whole lot until the powder is thinly but completely and evenly coated on each of the hulls. It is easier if 2 or 3 small portions of powder are added, rather than one large portion. The rice hulls not only serve the purpose of granulation at a fraction of the time involved, but actually increase the effectiveness of the powder. This is because the rice hulls make a powder of lower density and greater surface area than granulated powder. Few available materials have the strength, low density, and great surface area to accomplish this as effectively and at such a low cost as rice hulls.

L-TR5A
TIME FUSE

per: Ordinary writing or 30-pound Kraft paper.

wder: A good formula for fuse powder is the following: Potassium Nitrate-6; Sulfur-1; al, dust-1; Dextrin-1/4. The Potassium Nitrate must be about as fine as powdered sugar. ouble refined powder" is best. The Charcoal must also be as fine as possible and be made soft wood such as willow. The "air-floated willow dust" works best. Weigh accurately and mix 0 and 24 mesh mixing sieves are best). The resulting mixture can be used; however, a much pendable fuse powder results if the mixture is placed in a ball mill (such as T-BMS or and made into meal powder.

hen the preceding formula burns, it leaves the usual gold trail of sparks. By adding some um (bright pyro) to taste, the fuse will burn with a gold and silver tail, to one with a bright ail.

ols: A board with a very smooth surface. Also required is a "powder applicator" which tal tube, closed at one end. Just above the end closure and about 1/4" above the end is a iameter hole bored through one side. The tube can have any convenient dimensions.

anipulation: Since time fuse must be rolled to a diameter of 1/4" or larger, and since it is from paper that does not have the wet adhesion qualities of Gampi tissue, it is easiest if the is started around a hard "core" of some type. A core can be any hard object which the pyro- st finds easy for him to use. Examples of good cores are: a length of "Chinese" fuse, and a rocket stick. Use whatever is easiest for you.

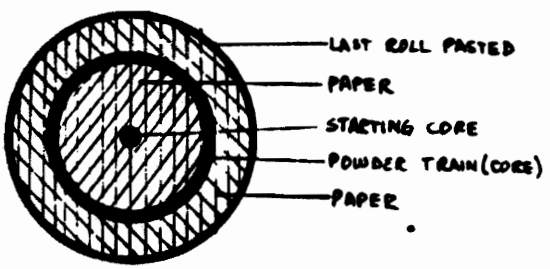
ut the paper into strips of the desired length and width. (The dimensions depend upon how thick e fuse is to be, what size is easiest for the pyrotechnist to use, type of paper, thickness of etc.

ampen the board slightly with a sponge. Lay a srip of paper on the damp board and with a sponge onto the board so it too is dampened and lays perfectly smooth and flat. Place the core on the edge of the paper and roll about 3 or 4 turns of paper around the core. Now pour an even, in of powder along the paper, parrallel to and for its entire length. The powder train width be such so when it is rolled up in the fuse it makes one complete turn or more. The thickness train depends upon the amout desired and the rolling skill of the pyrotechnist.

ter the powder core is rolled, continue rolling the paper until the desired diameter is obtained. t 4 turns of paper should be rolled around the core of powder. Apply some thin paste to t roll and then roll the completed furse back and forth on the board with as much pressure as it e so it assumes a good, tight construction. This last rolling operation is very important.

e fact that this time fuse has more of a peripheral powder train compared to the older time fuse central train gives the peripheral fuse much easier ignition properties because of the increased area of the powder train available to a flame. Thus, it gives more end spit than an equal weight der but in a central core. It also gives a larger trajectory trace.

ake sure you use as much pressure as the paper will take durning the whole rolling operation. e much be rolled as tight and firm as possible, otherwise it will not burn evenly or could even e like quickmatch. The addition of the dextrin to the powder helps give it a firmer construction.



Cross Section of Completed Time Fuse

L-TR6

CHINESE FUSE

Paper: The main secret in making "Chinese" fuse is the use of a special oriental paper called "Gampi" tissue paper. This paper combines all of the qualities of malleability, tensile, and wet strengths needed to make good fuse.

Powder: A good formula for fuse powder is the following: Potassium Nitrate, 6; Sulfur, 1; Charcoal dust, 1. The Potassium Nitrate must be about as fine as powdered sugar. The "double refined powder" is best. The Charcoal must also be as fine as possible and be made from a soft wood such as willow. The "air-floated willow dust" works best. Weigh accurately and mix well (40 and 24 mesh mixing sieves are best). The resulting mixture can be used; however, a much more dependable fuse powder results if the mixture is placed in a ball mill (such as T-TMS or T-TML) and made into meal powder.

Tools: These consist of a "fuse board" which is a piece of smooth wood about 12" (or longer) x 2" wide. Also required is a "powder applicator" which is a metal tube, closed at one end. Just above the end closure and about 1/4" above the end is a 1/16" diam. hole bored through one side. The tube can have any convenient dimensions.

Manipulation: First cut the Gampi with the grain of the paper fibers into strips about 3/4" wide for regular fuse. For fuse of smaller diameter, cut strips so thay are 1/2" wide or less; for larger fuse, cut the strips wider. Gampi tissue comes in sheets 18" x 20". The grain runs along the 20" way. The easiest way to cut it into strips is to start at one of the 18" sides and fold in half so a piece about 10" x 18" results. Fold in half the same way again. Fold in half the same way once more so a folded sheet about 2-1/2" x 18" results. Fold as carefully and press as flat as possible after each fold so all sides and corners are squared. Now with sharp scissors, cut the strips along the 2-1/2" direction to the desired width.

Dampen the board slightly with a sponge. Lay a strip of Gampi on the damp board and with the sponge, press it onto the board so it, too, is dampened and lays perfectly smooth and flat. With the powder applicator about half full, run it quickly over the damp Gampi so a thin and even stream of powder is applied down the center of the strip. Starting at the near left edge of the strip, the fingers of the left hand extended, the fingers push down and forward to start the Gampi rolling over itself. At the same time, the right hand fingers, also extended, are held against the near edge to act as a regulator to keep the Gampi from rolling over itself too rapidly, as shown in Figure 1.

The fuse is rolled starting at the tips of the left fingers and rolled in a continuous motion under the fingers until it comes almost to the base of the fingers as seen in Figure 2. Then this process is repeated, the right hand all the while acting as a regulator, until the dampened portion of the Gampi is rolled up. The rolling/twisting process is done at an angl with the fuse board, as shown in Figure 2.

When the fuse has all been rolled up, it is further twisted tight by laying it on a flat surface, placing both hands on top of it—the fingers extended, just like the position of the left hand during the rolling operation—then rolling and pressing forward with the left hand, and rolling and pressing in the opposite direction with the right hand, as shown in Figure 3. This operation is done all along the length of the fuse, starting at one end and finishing at the other.

Fuse can be mass-produced by using a wider fuse board and dampening down several Gampi strips and pouring their powder trains first, then rolling them all up, one after the other.

For fuse with heavier powder cores, cut the strips wider and use more powder. For larger diameters of fuse, roll the original fuse in more Gampi strips until the desired diameter is obtained.

The fuse can be waterproofed by dipping it quickly into some liquid shellac, nitrocellulose based lacquer, or other waterproofing agent. The fuse must be made with enough paper to keep the agent from the powder core. This is facilitated if the agent evaporates

paper to keep the agent from the powder core. This is facilitated if the agent evaporates very quickly. The waterproofing agent called "Visco" available from Westech is ideally suited, since it combines all the necessary qualities such as evaporation speed and water resistance.

Fuse can be made various colors either by using different colored Gampi, or by using a colored waterproofing agent.

Figure 1

Figure 2

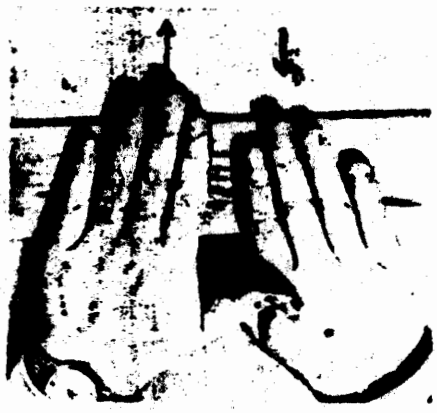


Figure 3

L-TR6

NEWEST NOVELTY DEVICES

1. Mini-Copters:

Composition: Potassium Nitrate 18; Sulfur 3; Charcoal, dust 4-6; Aluminum, dark pyro 1/2. The Potassium Nitrate must be about as fine as powdered sugar. The "double refined powder" is highly recommended. Mix thoroughly. A 40-mesh sifter and 24-mesh mixer sieves give the best results. This compostion gives very good results. However, even better results are obtained if 1/4 part Dextrin is added and the composition slightly dampened with a 50:50 water:alcohol mixture, thoroughly mixed again while damp, and still while damp, loaded into the casing.

Casings: These are wet-rolled from any type of paper stock of 40-pound or less to 3/16" I.D. x 1-1/2" long x 1/32" wall. The casings C-M by Westech are ideal. And for those who like to roll their own casings, the "Dura-Press" Kraft paper (S-KP3) by Westech gives best results.

Ignition: Chinese-type fuse is best. 3/32" safety fuse, or thin black match can also be used.

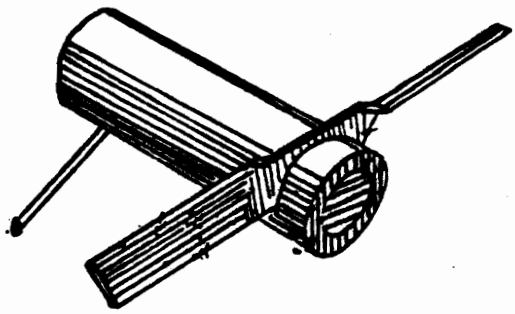
Materials: Clay, glue, a piece of thin-gauge aluminum 2-1/2" long x 3/8" wide.

Tools: A rammer 2" long x 3/16" diameter. (Better tools consist of a funnel & rod.)

Manipulation & Procedure: Place the casing on a firm surface and drive in some clay to form a plug about 3/16" thick. Puch a hole in the casing just barely above the clay and insert a length of fuse. Ram, in small portions, the composition until it comes to within 3/16" of the top of the casing. (An easier way to plug and fill the device is to use a funnel and rod.) Now, lay the casing flat on the end of a table so the fuse is hanging freely over the edge and pointing downward at about a 45 degree angle with the table top. Using a razor blade, very carefully cut a slit half-way through the casing parallel to and just above the top of the composition. With a small dab of glue, secure the little aluminum wing in its exact center into this slit. The upper edge of the wing, located on the same side as the fuse, is now twisted back toward the fuse and the edge of the wing located on the opposite side is twisted forward as illustrated. This provides the lifting force when the device is in motion. A small charge of flash powder is poured in and a small plug of glue and clay (or tissue paper) is inserted into the top. The flash powder should not be packed.

NOTE: The device will fly higher if after the fuse hole is punched, it is dipped into hot Sodium Silicate (42..2 BE) for about 10 seconds and allowed to dry. The Silicate should just cover the fuse hole. It fireproofs the hole so it doesn't increase in diameter from the hot gases.

To fire, the device is placed on a flat surface, wing side up as shown, so the fuse (which may have to be bent) is pointing at about a 45 degree angle downward.



MINI-COPTER

(L-TR6)

Composition:		
	Potassium Nitrate	18
	Sulfur	3
	Charcoal, dust	4 - 6
	Aluminum, dark pyro	1/2

(The Pot. Nitrate must be about as fine as powdered sugar. The "double refined powder" variety is highly recommended. Mix thoroughly. A 24 mesh mixing sieve is the best and easiest way.)

Casings: These are wet-rolled from any type of paper stock of 40 lb. (gauge) or , 3/16" I.D. x 1-1/2" long x 1/32" wall. The casings, C-M (Westech) are ideal.

Ignition: Chinese-type fuse, or 3/32" safety fuse.

Materials: Clay, glue, a piece of thin-gauge aluminum 2-1/2" long x 3/8" wide.

Tools: A rammer 2" long x 3/16" diameter. (Better tools consist of a funnel & rod

Manipulation and Procecedure: Place the casing on a firm surface and drive in e clay to form a plug about 3/16 thick. Punch a hole in the casing just barely above clay and insert a length of fuse. Ram, in small portions, the composition until it es to within 3/16" of the top of the casing. (An easier way to plug and fill the device use a funnel and rod, same as for filling bottle rockets.) Now, lay the casing flat on end of a table so the fuse is hanging freely over the edge and pointing downward at t a 45° angle with the table top. Using a razor blade, very carefully cut a slit half-through the casing parallel to and just above the top of the composition. With a small of glue, secure the little aluminum wing in its exact center into this slit. The upper of the wing, located on the same side as the fuse, is now twisted back towards the and the edge of the wing located on the opposite side is twisted forward as illustrated rovide the lifting effect. A small charge of flash powder is poured in and a small plug ue and clay (or tissue paper) is inserted into the top. The flash powder should not acked. NOTE: The device will fly higher if after the fuse hole is punched, it is dip- into hot Sodium Silicate for about 15 seconds and allowed to dry. The Silicate should r just above the fuse hole. It fire-proofs the hole so it doesn't increase in diameter the hot gases.

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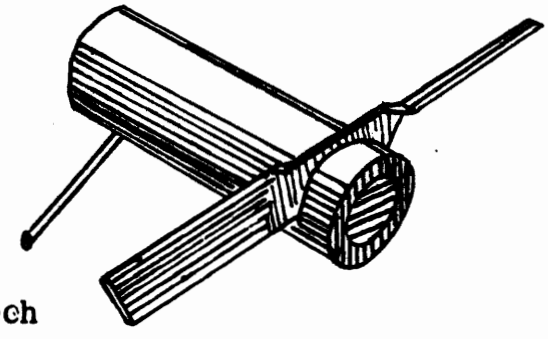


Acceloseal: Mass-Production Method of Plugging Tube Devices

For best results this method uses a tool that can be easily constructed as follows. Take a 1/4"-thick piece of wood and drill as many holes through it as possible of the same diameter as the O.D. of the tubes to be plugged.

Take the board and lay it on a firm, flat surface. Sprinkle over the board some fine sawdust so each hole is partially filled with a thin layer about 1/16" to 1/8" high. Now push into the holes the tubes to be plugged. They should be pushed all the way through the holes and be seated well on the surface and sawdust below, so they are held firmly and upright by the board. The sawdust should protrude slightly into the tubes.

Pour into each tube the required amount of Professional Pyrotechnic Adhesive (or some other sealing material equally effective). The sawdust keeps the adhesive from sticking to the surface below. When the adhesive is dry, pour in the required amount of composition (smoke, flash, etc.). (Instead of waiting for the adhesive to dry, a thin layer of sawdust can be poured on top of it and then the composition added.) Now pour in on top of the composition the necessary amount of sawdust to leave slightly less than the required space in the top of the tube. Pour in the required amount of adhesive which will slightly compress the sawdust and give a plug of the required thickness.

This method can also be use without the board for plugging small numbers of tubes. However, even small quantities are made easier if the board is used.

You'll find this method to be a very quick, easy, and inexpensive way of plugging one or both ends of any tube device (parallel or spiral) with a plug of any thickness in either end.

L-TR8

WHISTLING ROCKETS

Composition: The compo is Potassium Picrate, prepared as follows: In a non-metal container pour 1 quart boiling water; add 4 ounces Picric Acid and stir with a non-metal rod until dissolved. Now add 1 ounce Potassium Carbonate, a little at a time, stirring continuously. Allow to stand for an hour then scoop out the residue onto some paper and let dry. Carefully crush to a fine powder using a wooden dowel or rolling pin. Picric Acid and its salts are poisonous and powerful yellow dyes, so use care. 100% Picrate whistle compo burns with a sooty, black smoke. A greyish-white smoke can be obtained by using a compo of 60% Picrate and 40% powdered Saltpeter. Store Picric Acid or Picrates in non-metal containers with non-metal, tight-fitting lids.

Casings: These must be wet-rolled from a very smooth paper since the tone of the whistle is greatly influenced by the degree of smoothness of the paper. The Manila Board (S-MB) stocked by Westech is ideal, or the Roman Fuse Casings (C-RF) give excellent results. Casings should be 5/16" ID x 1/2" OD x 1-1/2" long (or longer if desired).

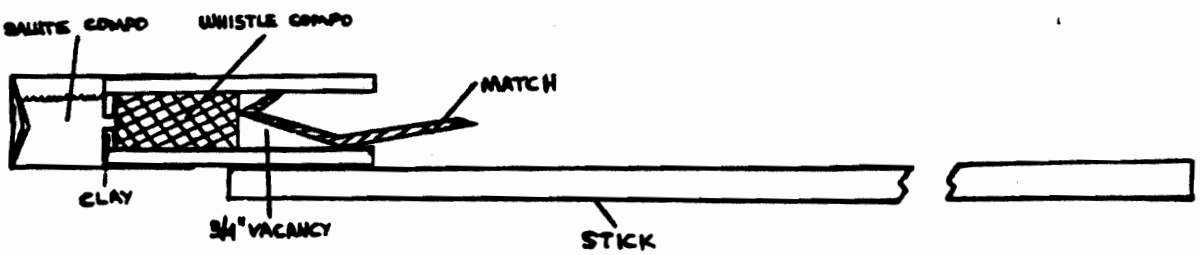
Ignition: Any type of fuse.

Materials: A stick for guiding the rocket, 3/16" x 11" long (S-311).

Tools: A rammer made of wood or plastic, 2-1/2" long x 5/16" diameter.

Manipulation & Procedure: The compo should be slightly damp when rammed or pressed into the casing. The correct amount of water to add to the compo is found by taking a pinch of compo and pressing between the thumb and index finger. If the compo feels damp, but no water runs out, then the compo is correctly dampened. Set the casing on a firm surface, put in a few pinches of compo and press firmly into place with the rammer, using as much hand pressure as you can muster. Or, you can lightly tap the compo into place using sharp, light raps from a mallet on the rammer. Continue loading until the compo fills the case about half full. There should be about 3/4" vacant space for the proper production of sound. Allow to dry in a warm (not hot) place. When dry, attach the stick and match the vacant end. Rockets can be made to termintate with a sharp report by first ramming in a plug of clay using sharp blows from a mallet. Load the compo but do not dry yet. Then take a 1/8" diameter drill bit and bore a hole through the center of the clay plug by turning the bit with your fingers. When you hit the whistle compo, stop. Roll 4 or 5 turns of paper around the top of the rocket so about 1/2" extends beyond the end. Now dry. Add some salute compo, fold (or crimp) and tape (or glue) closed. Note: The salute compo should not contain any metals (aluminum, magnesium, etc.). Do not prime Picrate whistles; they will explode if they are primed.

CAUTION: Although this whistle compo is a fairly safe mix, only small quantities should be stored and handled at one time. When dry, Picric Acid and Potassium Picrate are sensitive to friction, shock, or heat. It should be remembered that Picric Acid is a close relative to TNT. (Picric Acid is tri-nitro-phenol; TNT is tri-nitro-toluene.) Picric Acid and Potassium Picrate are also very sensitive to metals and will form extremely sensitive high order explosives by merely coming in contact with metals. Therefore, no metals should be used around Picric Acid or its salts. However, contrary to Weingart and Davis, experience of many pyrotechnists has shown that Picrate whistles are safer to make than Gallic Acid whistles.



– FULL SCALE CROSS SECTION –

L-TR9

CONTACT EXPLOSIVE

Nitrogen Tri-iodide is one of the most sensitive compounds known. Iodine and Ammonium Hydroxide in combination form Nitrogen Tri-iodide, Ammonium Iodide, and water. This substance does not burn progressively as black powder but instead detonates like nitrogylcerin. When dry, Nitrogen Tri-iodide will explode from merely a breath of air blowing on it. Small dust size particles will pop and crackle when steped on , when dry. A granual (1/8" square) will explode like a large firecracker.

To make Nitrogen Tri-iodide, two chemicals are necessary: Ammonium Hydroxide and iodine crystals. Ammonium Hydroxide should be at least 30% concentration. Ammonia water with additives, such as the types used to wash walls, can not be used. Only Iodine crystals can be used. Solutions of iodine, such as tincture of iodine used as an antiseptic, can not be used. Westech stocks the best grades of these chemicals for this use.

Place a small quantity of Iodine crystals (1-2 grams) in 1/2 cup Ammonium Hydroxide. Let stand for about 10 minutes, stirring occasionally. Now filter and wash with water. The residue is the explosive. If you do not have a funnel and filter paper, you can make one in the following way. Take a paper towel and fold it in half, then fold it in half from the other end. Put the point of the fold straight down into a small drinking glass and separate one of the folds of paper from the rest. When you pull this paper away from the rest you will have formed a cone. This is placed in the glass and the ammonia/iodine solution poured into it. The residue remaining on the cone is the explosive. Wash with water and keep WET until using.

Nitrogen Tri-iodide will not explode when wet but does so violently when dry. For storage, keep under water in an air-tight jar away from heat and light. Do not store longer than a week or two, and store only small quantities (not more than a gram or two).