Originally Displayed on P-80 Systems

From "The Chemistry of Powder & Explosives by Tenney L. Davis" 1943.

The principle of the rocket and the details of its design were worked out at an early date. Improvements have been in the methods of manufacture and in the development of more brilliant and more spectacular devices to load in the rocket head for display purposes. When rockets are made by hand, the paper casing is mounted on a spindle shaped to form the long conical cavity on the surface of which the propelling charge will start to burn. The composition is rammed into the space surrounding the spindle by means of perforated ram rods or drifts pounded by a mallet. The base of the rocket is no longer choked by crimping, but is choked by a perforated plug of clay. The clay, dried from water and moistened lightly with crankcase oil, is pounded or pressed into place, and forms a hard and stable mass. The tubular paper cases of rockets, gerbs, etc., are now often made by machinery, and the compositions are loaded into them automatically or semi-automatically and pressed by hydraulic presses.

John Bate and Hanzelet understood that the heavier rockets require compositions which burn more slowly.

"It is necessary to have compositions according to the greatness or the littleness of the rockets, for that which is proper for the little ones is too violent for the large--because the fire, being lighted in a large tube, lights a composition of great amplitude, and burns a great quantity of material, and no geometric proportionality applies."

Present practice is illustrated by the specifications tabulated below for 1-ounce, 3-ounce, and 6-pound rockets as now manufactured by an American fireworks company.

		Ounce	Ounce	Pound
Size..................................		1	3	6
	Saltpeter.......	36	35	30
	Sulfur..........	6	5	5
(Composition of charge)	No. 3 charcoal..	..	5	5
	No. 5 charcoal..	12	..	..
	Charcoal dust...	7	17	12

	Inch	Inch	Inch
Length of case.......................	3	4 1/4	13
Outside diameter.....................	1/2	11/16	2 3/8
Inside diameter......................	5/16	7/16	1 1/2
Overall length of spindle............	2 3/4	4	12 3/4
Length of taper......................	2 1/2	3 23/32	12
Choke diameter.......................	5/32	1/4	3/4

The diameter of the base of the spindle is, of course, the same as the inside diameter of the case. That of the hemispherical tip of the spindle is half the diameter of the choke, that is, half the diameter of the hole in the clay plug at the base of the rocket. The clay rings and plugs, formed into position by high pressure, actually make grooves in the inner walls of the cases, and these grooves hold them in place against the pressures which arise when the rockets are used. The propelling charge is loaded in several successive small portions by successive pressings with hydraulic presses which handle a gross of the 1-ounce or 3-ounce rockets at a time but only three of the 6-pound size. The presses exert a total pressure of 9 tons on the three spindles when the 6-pound rockets are being loaded.

Rockets of the smaller sizes, for use as toys, are closed at the top with plugs of clay and are supplied with conical paper caps. They produce the spectacle only of a trail of sparks streaking skyward. Rockets are generally equipped with sticks to give them balance and direct their flight and are then fired from a trough or frame, but other rockets have recently come on the market which are equipped with vanes and are fired from a level surface while standing in a vertical position.

Large exhibition rockets are equipped with heads which contain stars of various kinds, parachutes, crackers, serpents, and so on. In these, the clay plug which stands at the top of the rocket case is perforated, and directly below it there is a heading of composition which burns more slowly than the propelling charge. In a typical example this is made from a mixture of saltpeter 24 parts, sulfur 6, fine charcoal 4, willow charcoal dust 1 1/2, and dextrin 2; it is loaded while slightly moist, pressed and allowed to dry before the head of the rocket is loaded. When the rocket reaches the top of its flight, the heading burns through, and its fire, by means of several strands of black match which have been inserted in the perforation in the clay plug, passes into the head. The head is filled with a mixtur, say, of gunpowder, Roman candle composition (see below), and stars. When the fire reaches this mixture, the head blows open with a shower of sparks, and the stars, which have become ignited, fall through the air, producing their own specialized effects.

In another example, the head may contain a charge of gunpowder and a silk or paper parachute carrying a flare or a festoon of lights or colored twinklers, the arrangement being such that the powder blows the wooden head from the rocket, ejects the parachute, and sets fire to the display material which it carries. In order that the fire may not touch the parachute, the materials which are to recieve the fire (by match from the bursting charge) are packed softly in cotton wool and the remaining space is rammed with bran.

The very beautiful liquid fire effect is produced by equipment which is fully assembled only at the moment when it is to be used. The perforation in the clay plug at the top of the rocket is filled with gunpowder, and this is covered with a layer of waterproof cloth well sealed, separating it from the space in the empty head. When the piece is to be fired, the pyrotechnist, having at hand a can containing sticks of yellow phosphorus preserved under water, removes the wooden head from the rocket, empties the water from the can of phosphorus, and dumps the phosphorus, still wet, into the head case, replaces the wooden head, and fires. The explosion of the gunpowder at the top of the rocket's flight tears through the layer of waterproof cloth, ignites the phosphorus, blows off the wooden head, and throws out the liquid fire. A similar effect, with yellow light is obtained with metallic sodium.

Roman Candle Composition

	Parts	
Saltpeter......................	34	(200 mesh)
Sulfur.........................	7	(200 mesh)
No. 4 charcoal (hardwood).......	15	(about 24 mesh)
No. 3 charcoal (hardwood).......	3	(about 16 mesh)
No. 2 charcoal (hardwood).......	3	(about 12 mesh)
Dextrin........................	1	

Sky Rockets

From "Pyrotechnics" by George W. Weingart 1947.

Next to Roman candles these are perhaps the most popular articles of the pyrotechnical craft and, on good authority, apparently antedate the candle. So much has been written about sky rockets that any detailed description would be superfluous. The French, partucularly, have left a most complete history, sometimes amusing, in view of the present status of rocket manufacture. The rocket consists of a tube of paper rammed with suitable composition, its lower end choked to about one third of the diameter of its bore and having a hollow center extending upward through the composition to about 3/4 inch of the top. A stick attached to the tube serves to balance it while ascending. Roughly, the composition of a rocket, that is, the portion of it that is burning while it is ascending, should be seven times its diameter in length. Six-sevenths is pierced through the center while one-seventh is solid and acts as a fuse to communicate the fire to the heading when the rocket reaches the highest point of its flight.

The tube is made of strong paper, preferably 3 turns of hardware paper on the inside with 4 or more turns of straw board or Kraft paper on the outside. A good rocket case can also be made of heavy rag or building paper, if it is properly rolled with good paste. The process of choking the case and ramming in a mold has been practically discontinued.

Good rockets should be uniform, all those of one caliber ascending to the same height and bursting at about the same time. This is particularly desirable in bouquets of 100 or more, fired simultaneously, or a straggling effect is produced.

Most rockets larger than 3 ounce rockets are rammed singly or by gang rammers. Hydraulic rammers are also in use.

One to three ounce rockets are rammed solid on the candle machine or by hand and the hollow center is made by driving a steel spindle into them afterwards. These must have their lower ends choked as explained previously. An efficient way of making the hollow center is to use a mortising machine and replace the chisel with a spindle as mentioned above. A V-shaped block is set on the table of the machine in such a position that when a rocket is placed against it, it will be in just the right place for the spindle to enter it. A step on the pedal to the mortising machine will force the spindle into rhe rocket, forming the hollow center.

To ram rockets from 4 to 8 ounces singly, the case is slipped on the spindle illustrated under sky rockets. A scoop of clay is shaken in and rammed with eight good blows of the mallet on the longest rammer. Then a scoopful of composition is rammed with about eight lighter blows. This is repeated until the case is filled to about 1 inch from the top. Shift rammers as it becomes necessary to use shorter ones. There should be 1 inch of solid composition above the top end of the spindle. Now the final charge of clay is put in and the hollow pin rammer used. This sets the clay while leaving an opening for the fire to reach the heading. Care must be used to see that the hollow tube just pierces the clay. If it does not go through, the heading will fail to fire; if it goes too far, the heading will fire prematurely or the rocket may blow through before rising.

The following are good compositions for rockets of the different sizes given:

	1 to 3 Ounces	4 to 8 Ounces	1 to 3 Pounds	4 to 8 Pounds
Saltpeter	18	16	16	18
Mixed coal	10	9	12	12
Sulfur	3	4	3	3

If rockets burst before ascending add more coal; if they ascend too slowly add more saltpeter. For the smaller sizes use fine coal; for larger ones use coarser coal in proportion to the diameter. In 4 to 8 pound rockets use partly granulated saltpeter.

All rockets larger than 3 ounces are provided with a cone containing the heading.

Heading Rockets

Prepare a board with holes through it about 1 1/4 inches in diameter and raised from the table about 3 inches. Place cones in these holes with the point downward. Fill them about half full of stars, gold rain, etc., a little meal powder and charcoal or candle composition. Apply gum to the upper edge of a rocket and stick it into one of the cones. Raise carefully out of the hole and press the cone evenly into place. Set aside to dry. The rocket may now be wired to the stick and is then ready for use. In the case of shelf goods, the rockets are, of course, papered and matched before attaching cones.

Short Stick Rockets

These are the same as long stick rockets except that a stick only one third the regular length is used. This makes a less cumbersome rocket which ascends higher. However, a wing tab must be attached to the stick. Cut a piece of cardboard about 3 inches long, 1 1/2 inches wide at one end and 1/2 inch at the other. Smear a little dextrin on one end of the stick; place the tab on it, wide end down, and drive a 2 ounce tack through it in the middle.

When dry it is ready for use. These rockets are much easier to carry about but require more care in firing to get them started straight.

Notes on rockets from "A History of Fireworks" by Alan St H. Brock 1949.

A rocket of 2 lb. calibre--that is to say, approximately 2 1/16 in. in diameter--has a charge of 12.5 oz. of composition, and rises to a height of approximately two thousand feet in six seconds. The power developed is not continuous, however. In the first second of flight a maximum impulse of 62 lb. is developed; thereafter the power diminishes rapidly. For a time it serves to retard deceleration, but towards the end of the flight the burning composition does little more than to provide the visual effect of the tail. Anything approaching sustained flight, over even a limited distance, is out of the question.

In order that the maximum internal pressure may be developed as quickly as possible, a conical cavity is formed in the composition with which the body is filled, thus exposing a greatly increased surface to ignition. The pressure is increased, and to some extent conserved, by reducing the size of the outlet by which the resulting gases escape. This is achieved by constricting the case, while still wet, by pressure with a cord. The waist, so formed, is known as the 'choke.' Small rockets, as well as other kinds of fireworks, are choked by means of a diaphragm of compressed dry, ground clay in which a hole of suitable size is formed. The process of charging, or filling the case, is as follows: the case is placed on a spindle--a strong gun-metel base with a nipple of a size to fit the choke exactly and having above a tapering metal extension conforming to the dimensions of the cavity. The composition is poured in in small quantities measured in a scoop, each scoopful being consolidated by blows with a wooden mallet on a wooden 'drift' bored to receive the spindle. Before the first scoop of composition is introduced the rocket is 'set down'--that is, several blows are given on a suitably shaped drift to consolidate the paper at the choke and give it accurate shape. Next a scoop of ground dry clay is poured in and charged firm as a protection to the paper of the choke. The charging is then proceeded with. Varying drifts are used in order that the hole may correspond approximately with the diameter of the tapering spindle as the composition rises in the case.

A short portion of the case above the spindle is charged solid; this is referred to as the 'heading', and is usually about one and a half times the bore in depth. A diaphragm of clay is formed above the heading, in which is a central hole.

The proportions (in parts by weight) of the three ingredients today vary considerably with the calibre, as in the following table:

Calibre	Saltpetre	Sulphur	Charcoal

6 lb.	13	2	8
2 lb.	13	2	7 1/2
1 lb.	13	2	7 1/4
1/2 lb.	13	2	7
4 oz.	13	2	6 1/2
2 oz.	13	2	6
1 oz.	13	2	5

In display rockets the charcoal content is made up of approximately equal parts of fine and coarsely ground charcoal in order to enhance the effect of the tail.

I should make clear that the classification of the various sizes of rockets by a system of pounds and ounces does not refer to their actual weights, but to the weight of a ball of lead of a size to fit the mould in which the rocket case is contained while in process of charging, to prevent its being split by the force of the blows. Today only rockets of the larger sizes are charged in moulds, but the classification remains despite sporadic attempts on the part of writers to introduce what, not altogether without justification, they considered a more rational system.

The dimensions of the various calibres of rockets today are as follows:

Calibre	External Diameter	Internal Diameter	Length of Body
6 lb.	2 5/8 in.	1 13/16 in.	20 in.
2 lb.	2 1/16 in.	1 1/2 in.	13 in.
1 lb.	1 5/8 in.	1 1/8 in.	10 1/2 in.
8 oz.	1 3/8 in.	15/16 in.	8 5/8 in.
4 oz.	1 1/8 in.	3/4 in.	6 3/8 in.
2 oz.	15/16 in.	5/8 in.	5 1/4 in.
1 oz.	3/4 in.	1/2 in.	4 1/2 in.

When a rocket reaches the top of its trajectory the fire of the burning 'heading' passes throught the hole in the clay diaphragm above it into the cap, igniting the garniture and a small 'blowing charge' which bursts the cap and throws out its contents.

Some earlier pyrotechnists, as an alternative to the clay diaphragm, turned over and malleted down the top of the case to form the partition, through which one or more holes were pierced by means of an awl. Others, including the writer of an article which appeared in the "Gallery of Nature and Art" as late as 1817, advocated the use of chewed paper, a method which, one would think, must have depended for success on the dental equipment of the charger.

Formerly the clay diaphragm was charged in solid and the hole was bored afterwards. In modern practice the hole is formed during consolidation by using a drift provided with a projecting dowel.

From "Fireworks and Explosives" published by Pyro-Tech (date unknown).

Basic Fuel Mixtures - all parts by weight

Material	2 or 4 oz.	8 oz.	1 lb and larger
Potassium nitrate	8	8	8
Sulfur flour	2	2	2
Charcoal	4	4 1/2	5 to 5 1/2

The potassium nitrate should be ground to the superfine consistancy of powdered sugar or better. This is a must! If not done so, your completed rocket WILL NOT FUNCTION PROPERLY! Charcoal being used should be of willow dust on the smaller rockets and a mixture of willow dust and coarse mesh sizes (40-100m) combined, (The latter being lessor), for larger ones. The ratio of charcoal is approximately 50% dust - 50% coarse on 8 oz. size, and 30% dust to 70% coarse on 1 lb and larger sizes (again this must be adjusted properly to suit your needs). The coarse mesh charcoal also adds a spark "tail" to the rocket upon ascending. If your rocket explodes before or during ascending, add more charcoal to the fuel. If it ascends too slowly, add less charcoal. Thus you can pinpoint a particular mixture just right for your particular requirements.