specialty paper merchants), or to use silk parachutes they have prepared themselves. Silk parachutes made for military signal flares are occasionally available as military surplus. These parachutes, which are made in several sizes and come with shrouds attached, already folded and packed, are also used by pyrotechnists.

The variants of parachute shells may be almost as numerous as those of other shells; many types of objects, or several objects together, may be suspended from a parachute, or several parachutes may be put in a single shell. The same principle applies in all cases. For purposes of this discussion, a 4″ shell containing color and one flare, suspended from a silk parachute about two feet in diameter, will be described.

If the parachute is to be home-made, the lightest silk lining fabric, or what is sometimes called "model airplane silk" is appropriate. Trace a circle 24″ in diameter onto a piece of tissue paper; laying the tracing flat atop a piece of silk, secure it to the silk with straight pins. Now cut the tissue paper and the silk together, following the traced line on the tissue, using pinking shears (to prevent the edges from unravelling). When complete, remove the pins and discard the tissue pattern.

On the completed silk circle, using a ruler and marker, divide the circumference into eight segments, marking the divisions at the edge. The shrouds of the parachute are made 16-18″ long from strong, braided cotton cord; a bit of silk is twisted into a knot at each of the eight divisions, and one end of each shroud tied above each of these knots, so it will not slip off. Finally, the shrouds are gathered, held over the center of the parachute as it lays flat on the work surface, and tied together with an overhand knot. Grasping the center of the parachute with the fingers of one hand, and holding the knotted shrouds in the other, pull taut until the parachute assumes the form of a folded umbrella. Then lay it flat on the work surface again and neatly fold it into a small bundle, finally wrapping the shrouds around this (being careful not to tangle them). Attach about 18″ of braided picture wire to the knot at the end of the shrouds; the flare will in due course be attached to this wire. If using a military surplus parachute, all that requires to be done at this point is to attach the picture wire to the shrouds as indicated.

The flare suspended from the parachute is a case rolled on a ¾″ diameter former, 4″ long. It consists of three turns of 70-lb. kraft and two turns of 30-lb. Cut 70-lb. kraft to strips 4″ x 7½″, with the grain running the 4″ way; and 30-lb. kraft to strips 4¾″ x 5″, grain the 5″ way. Using a smooth metal rod (because of the paste) roll up the 70-lb., pasting along the long way on the edge toward the hand holding the form (after the first turn), as illustrated in Figure 73. Interleave the 30-lb. with the 70-lb., flush with this pasted edge and overlapping the other by ¾″. Paste the last inch of the 30-lb.; bringing the 70-lb. flush with the end of the former (so that the 30-lb. overlaps), fold the 30-lb. over in the triangle fold (as with a saettine) and knock it on the worktable to consolidate the fold. The case, removed from the former, will dry stiff along the mouth (because of the pasted edge of 70-lb.) and will thus stand funnel-and-rod filling.

To fill the case, first ram about 1″ of sawdust firmly in the bottom of the case (against the fold). Then, any colored lance formula, wheel color pot formula, or similar mixture to produce color or illumination may be rammed by funnel and rod into the case until it is full; the surface should be slurry-primed and dipped into 4F grain powder, then allowed to dry.

Pierce the sawdusted end of the flare with an awl approximately ½″ from the end and slide a piece of annealed (soft) iron wire through the hole. This wire should be about 8″ long and should be bent up double, then twisted over the end of the flare, leaving a pair of wires that may be formed into a ring on the end of the flare, as illustrated in Figure 74.

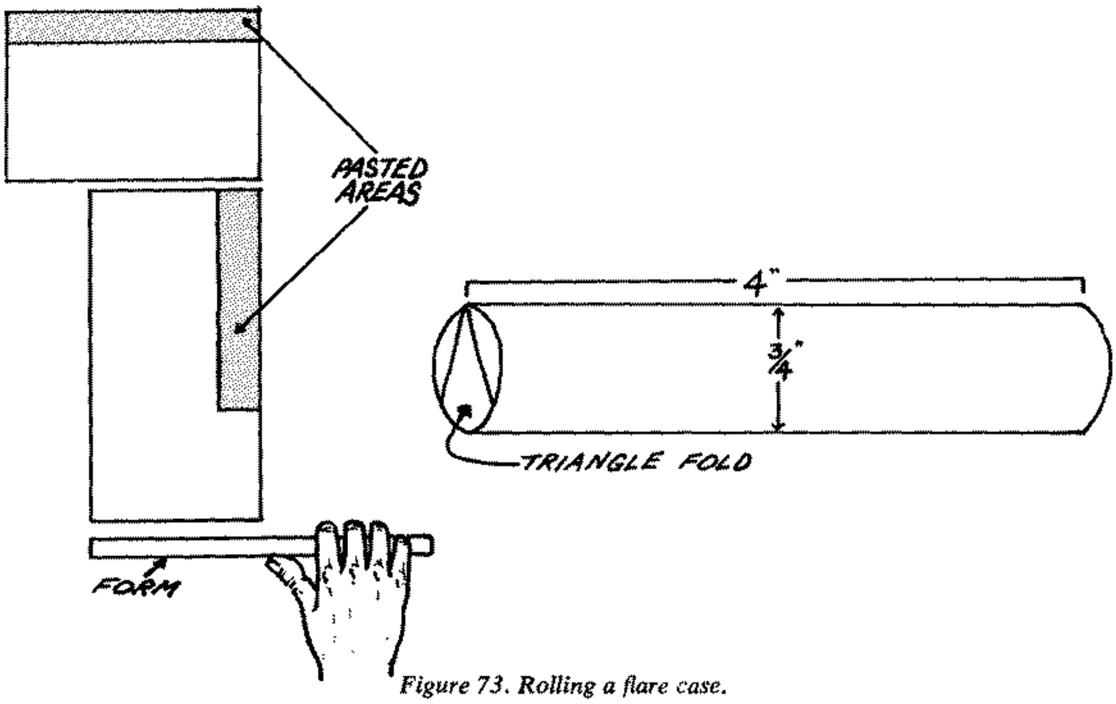

Figure 73. Rolling a flare case.

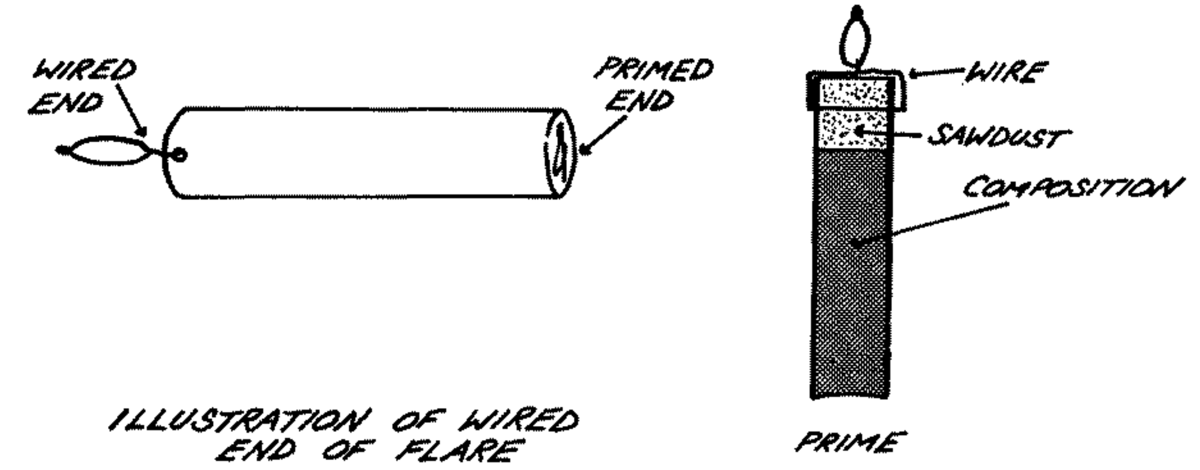

Figure 74. Wired end of flare.

The picture wire attached to the shrouds of the parachute may now be tied to the wire ring on the flare, and the assembly of flare and folded parachute set aside.

The case for the parachute shell must be rolled on a former with a recess in one end to accommodate the match of a spolette or other shell fuse. Cut a piece of .018″ chipboard 12″ wide by 22½″ long, grain running the 12″ way. Cut a piece of 70-lb. kraft paper 48″ long by 15″ wide, grain running the 15″ way. Lay the chipboard on the kraft, centered on its width and parallel with one end. Roll the two pieces together on the 3½″ former (like a saettine) until all is rolled up together; paste the edge, then slip the tube on the former until the chipboard is parallel with one end. Insert the fused disc having a spolette charged with 1″ of powder, and pleat the overhanging kraft down; place another disc over the folds as usual.

This case is now to be set, fused end down, over a hole in the work surface or some other support. Fill mixed FFA powder, colored stars, and a bed of rough powder over both, to a depth of about 2-2½″. It is not necessary, nor even desirable, to core the FFA in the center. Now prepare the flare for insertion into the color break by punching a ¾″ hole in the center of a 3½″ chipboard disc. The flare's primed end is pushed just through the hole, and this disc is now pushed (together with the flare) down onto the stars and powder. Both must be firmly seated against the firmly-compacted color break.

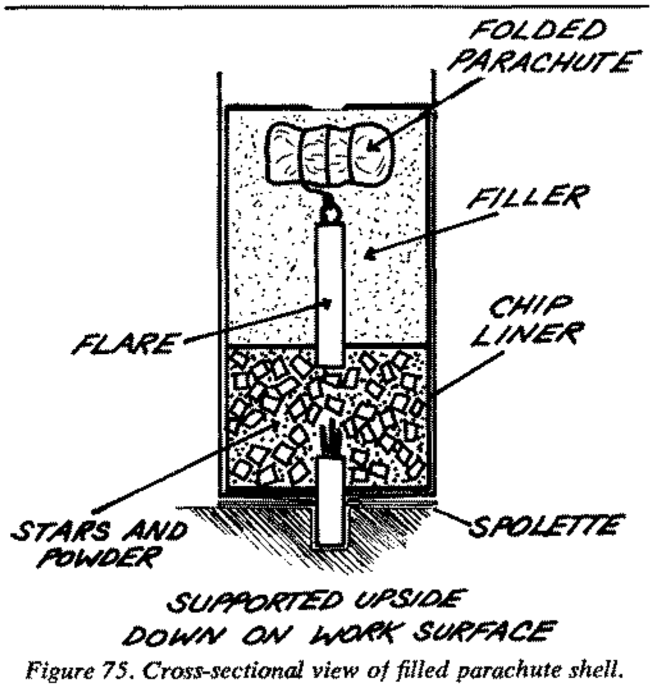

Figure 75. Cross-sectional view of filled parachute shell.

The area between the case wall and the flare should be well filled with bran, rice hulls, or cotton hulls until the top end of the flare and its ring are well covered; then the picture wire, loosely coiled, and finally the parachute and its shrouds are set gently into the case, and filled all around and on top with more of the filler. When the filler is level with the chipboard liner, a chipboard disc is set in place, the overhanging kraft pleated down, and the shell made ready for spiking.

The shell should be spiked with only 12 side strings of doubled 8-ply cotton (in other words, the pattern for a 3″ shell is used on a 4″ parachute shell, for wider spacing). Upon completion of the vertical spiking, the string is spiralled down to the bottom and one turn only taken to pinion the vertical strings, then spiralled quickly back to the location of the bottom of the color section of the shell. This color section is spiked very closely, until finally a half-hitch of twine may be thrown over at the top in the usual fashion. Figure 76 illustrates this spiking pattern.

When the paste has dried on the string, *every other* of the vertical strings may be slit with a razor blade; thus, the string is stuck to the sides of the shell, but does not hold the bottom tightly. This further weakens the parachute end of the shell. Finally, the pastewrap is applied as usual, but with only four turns of 40-lb. kraft, instead of 60- or 70-lb. Lift and leader of the shell is done as usual, with lift powder sufficient for a 4″ color-and-report.

The intended performance of this shell is to act almost as a small mortar. Rather than blowing out the sides, as does a conventional color break, the combination of chipboard liner, close circumferential spiking around the color segment of the shell, and the slitting of the string on the bottom of the shell, help to make the shell burst out that end (the shell bottom), pushing the flare (ignited by the burst) and parachute well

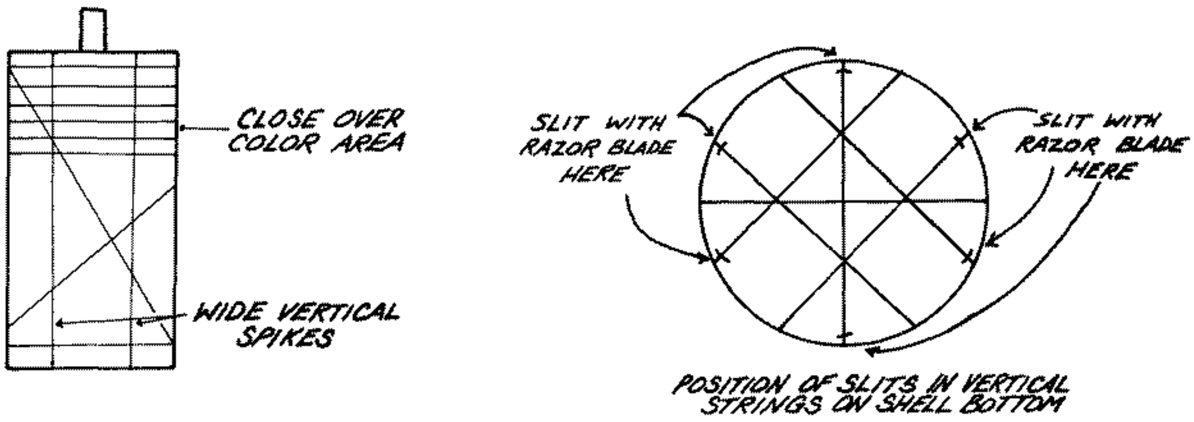

Figure 76. Spiking pattern of a parachute shell.

clear of the break, where they will open and descend slowly, with the flare burning out well before touching earth. It will be seen that the method of rolling the chipboard liner into the shell case (rather than inserting it later) is necessary, since the disc which is pierced to receive the flare must fit down inside the liner (which it would not do in the event the liner were inserted after rolling up the kraft on a 3½″ form). The disc pierced to receive the flare, together with the bulky filler, act as a wad to help propel the parachute and flare clear of the burst, while protecting the cloth of the parachute and shrouds from being burnt by the break.

FINALE AND FLIGHT CHAINING

It is traditional that at the end of a fireworks display, a large number of shells be fired in quick succession as a "finale". Also it may be desired from time to time during the body of a display to fire a group of shells in specific order from pre-loaded mortars, either in quick succession, or in regulated time with precise delays between shells or groups of shells. It is even possible (although very seldom done) by a combination of techniques to fire an entire display in one continuous chain, using match and delay fuses without the use of electricity. The advent of electrical firing has diminished the need for these most elaborate chaining techniques, but it is wise to know all of them even when using them with electrical firing.

The simplest and most often used technique is that of chaining a single series of shells to fire in quick succession, using quickmatch only. This technique relies on constricting the match pipe around the match, using a knot to delay the normal rapid passage of fire. Needed to chain in this manner are piped match, *buckets* (thin paper tubes, rolled dry of three turns of 30-lb. kraft on a ¾″ diameter form, about 3″ long), and string.

To make a *bucket chain,* cut the piped match into 12-18″ lengths, with about one inch of black match bared on each end. Begin by taking two such lengths, bared ends together, and insert them into one end of a bucket tube. Using a strong twine (8- to 10-ply cotton, or 3-ply flax twine), choke the bucket firmly down onto the match and tie with a clove hitch. Taking another length of match, thrust its end with one of the free bared match ends of the already-tied length into another bucket, again tying the bucket on with a snug clove hitch. Figure 77 depicts this procedure. This may be repeated to form a chain of any length desired, although generallly these chains are made with a dozen buckets per chain, corresponding with a dozen mortars per 3″ finale rack.

As many buckets are chained together as shells needed to be fired in succession, breaking this number up into dozens, or other convenient quantities, depending upon the number of mortars per rack. For example, if a 72-shell finale is needed, one might make up six chains of a dozen buckets (assuming the shells to be fired from 6-12 mortar racks).

Next the shells are assorted in the succession in which they are to fire, and chained into the buckets beginning with the first and continuing through the last in the desired order. Shells to be chained need only be fitted with a short leader having about an inch of bare match, the leader cap being unnecessary. The bared end of the match and part of the pipe are simply thrust into the open end of the bucket and firmly tied

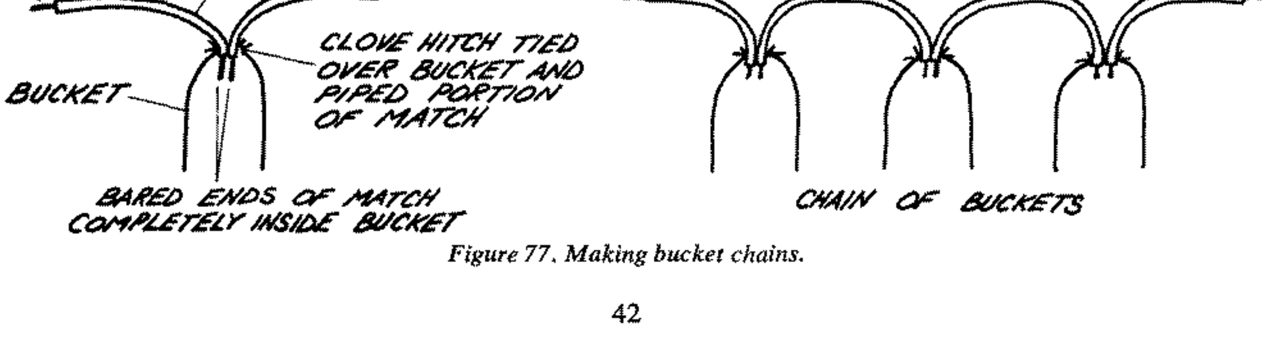

Figure 77. Making bucket chains.

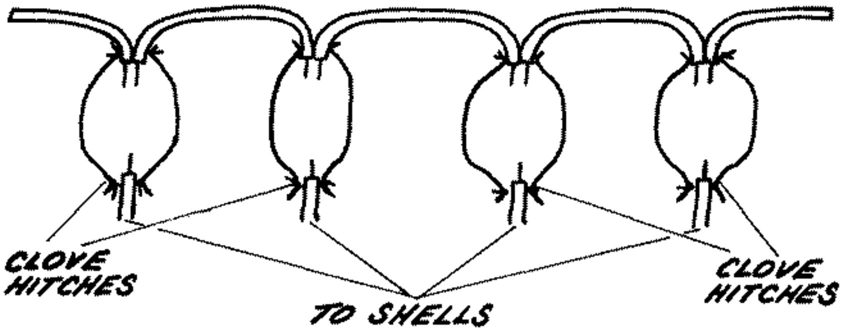

Figure 78. Completed chain of shells.

with a clove hitch. Figure 78 below shows the appearance of the completed chain.

Usually the chained shells are brought to the display site in this state of preparation, and are loaded there into the waiting racks in the desired order. A connection is made at that time between chains. This may be made either by the use of a *terminal bucket* on one end of the chain, or simply by splicing the match. The terminal buckets, used for non-branching connections, as illustrated in Figure 79 below, may be the same size (i.e., ¾″ diameter x 3″ long) as the buckets used for shell chaining, or may be somewhat smaller (i.e., ½″ diameter), depending upon the operator's preference.

In making these shell chains, it is of course possible to tie the buckets onto the shell leaders first, then tie the connecting match in afterward, instead of tying the connecting links first as previously described, then tying the chained buckets onto the shell leaders.

A spiking horse to hold the twine may be useful, as it permits the use of one hand to hold and manipulate match lengths, buckets, shell leaders, etc., while the other hand makes the knot. It is typical to use the string dry for this purpose, although a few workers prefer to rub the string with a block of tar while putting it on the horse, others even preferring to use pasted string.

In operation, one end of the chain is lighted. The fire proceeds down the chain at the normal speed of piped match until it reaches the tie. There is then a slight delay as it burns through the tie, igniting both the shell leader and the link of match connecting to

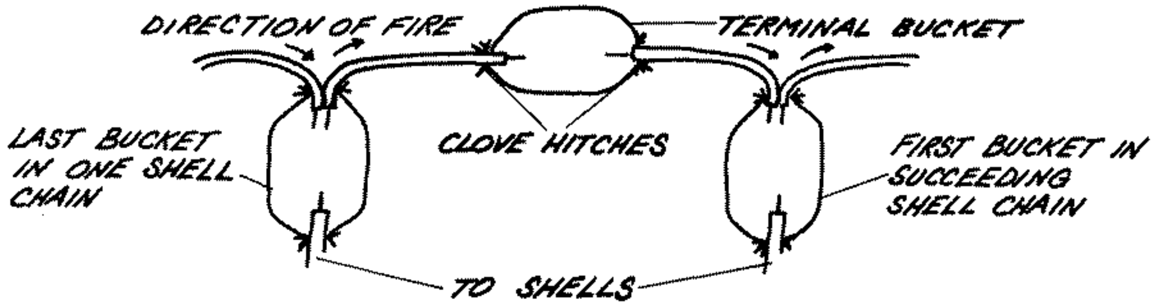

Figure 79. Connection between two chains of shells.

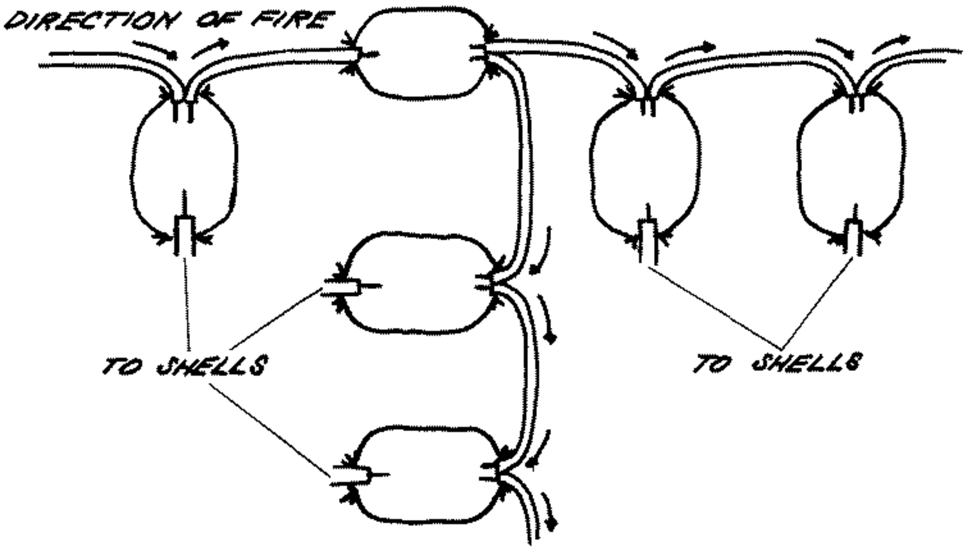

Figure 80. Branching chains.

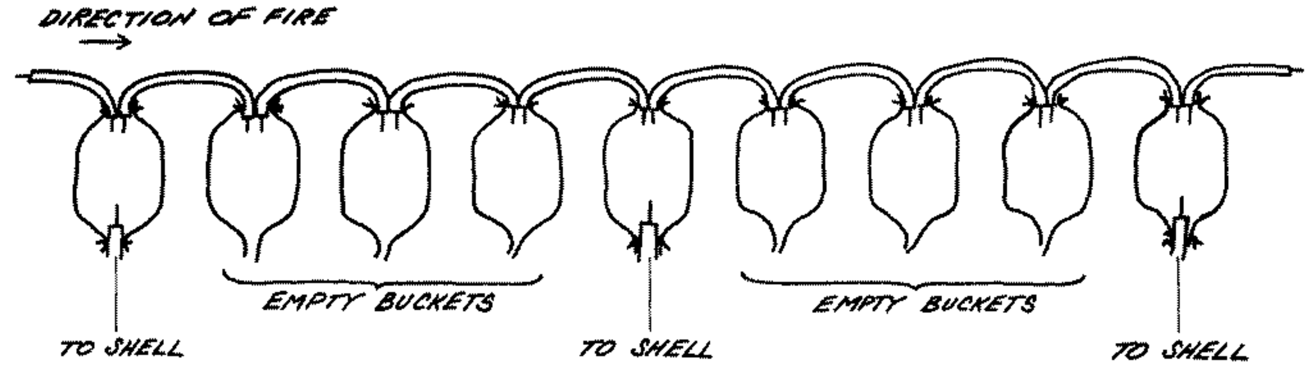

Figure 81. Chain with empty buckets for delay between chained shells.

the next bucket. These delays are really very short, taken individually, but the cumulative effect over the complete chain of several dozen shells is to establish a rapid, successive fire, rather than firing all the shells at once as would be the case if they were all simply spliced into one long piece of continuous quickmatch using only a pasted paper splice at each junction. It is impossible to give an exact delay factor, but it will be found that perhaps four to six shells will be in the air at any given instant during such a finale.

A simple successive chain, using match and buckets only, will suffice for most finales. Very large and ambitious displays, or displays where much material must be fired within a very short time, involve multiple branching connections between chains, and often different sizes of shell are chained in this manner, giving a "layered" or "tiered" effect, owing to the greater heights at which larger diameter shells burst. Such branching connections are not difficult to make. Figure 80 illustrates a branching connection whereby one chain ignites two other chains.

By use of such branching connections, one chain in succession may branch to two, and each of these to two more, thus increasing the number of shells being fired as the finale progresses, building to a climax. Alternatively, a short branching chain may be chained in periodically, perhaps shells of a complementary color, to provide "crescendi"; or short branching chains of the same color may be chained in at intervals as the continuing chain changes, providing "refrains." The variety of effects procurable is limited only by the taste and imagination of the pyrotechnist.

The presence of any constriction on match pipe is sufficient, as is evident from the performance of an ordinary finale chain, to create some delay; anywhere from just a momentary delay, as in a well- and consistently-chained finale, to an almost complete stop where match is tied so tightly as to prevent passage of fire. It is sometimes desired, however, to incorporate a greater and predictable amount of delay between shells or segments of a finale chain than may be accomplished by means of ordinary chaining as previously described. Such delay may be achieved by several means.

The simplest method, one often used in "field expedient" situations where portions of a display are assembled on the display site rather than in the workshop, is to chain in a certain number of "empty buckets" between shells. In other words, beginning with a normal bucket chain, instead of tying in a shell at every bucket, one ties in a shell at every other one, or every third, or fourth, or sixth one, depending upon the amount of delay one wishes to have between the firing of each shell — the more empty buckets, the greater the delay. The empty buckets are loosely twisted or folded shut on the end into which a shell would normally be tied. Such chains burn at the normal rate that they would were they completely chained with shells; however, as is obvious, they ignite only the shell actually tied in. Because of variations in match and in the tightness and consistency of tying by various operators, it is impossible to state precisely what the delay in seconds per empty bucket tied in will be, but this can be approximated with repeatable accuracy by testing the match to be used.

A more precise delay may be accomplished with timed delay fuses, either pieces of Bickford-style fuse cross-matched on either end, or spolettes. Using spolettes, the desired delay is determined by the length of the powder charge rammed into the tube. The powder surfaces should be roughened on either end to ensure easier ignition, and the hollow end of the tube filled with match as usual. A nosing is then pasted on either end into which match may be tied. Figure 82 indicates

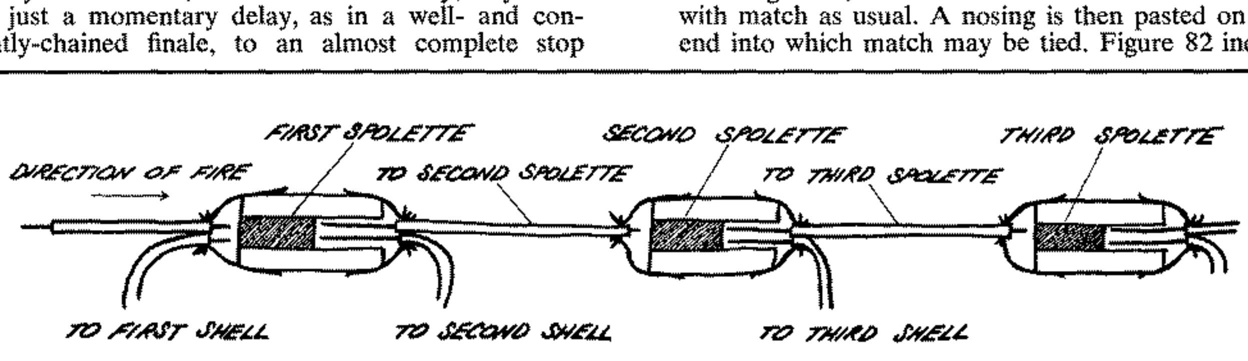

Figure 82. Chain with spolette delays.

a method of chaining with spolettes. Match from the first shell to be fired is tied into the front nosing of the first spolette in the chain together with a leader to light the chain. Into the rear nosing is tied the leader of the next shell, together with a short length of match to connect to the second spolette in the series. This short length is tied into the front nosing of the second spolette. Into the rear nosing of the second spolette is tied the leader of the third shell to be fired, together with a short length of match to connect to the third spolette of the series, and so forth.

When the leader to the chain is ignited, it communicates fire to the leader of the first shell and to the first spolette. This burns through, igniting the leader of the second shell and the short piece of match to the second spolette. The second spolette then takes fire, burns through, communicating fire to the third shell and the third spolette and so on until the end of the chain.

The timings of the various spolettes can, of course, be whatever is desired. A common plan is to make the spolettes the same length of powder as the spolettes on the shells; e.g., suppose a chain of 5″ shells each with spolettes charged with 1¼″ of powder. If spolettes between the shells are charged with 1¼″ of powder, the effect is that as the first shell bursts, the second shell is fired; the second shell bursts, and the third shell is fired, and so on. Such chains, if assembled with well-made spolettes and excellent match, can fire lengthy sequences of shells with clockwork precision.

Figure 83. Cross-matched time fuse with buckets tied over ends.

An easier variant of the technique described with spolettes employs cross-matched pieces of time fuse. The length of delay desired is measured on the fuse, which is cut just a bit longer so that the fuse may be punched for cross-matching on both ends. The cross-matching is inserted, crimped in place if necessary, and an ordinary bucket is tied over each cross-matched end, as shown in Figure 83.

These pieces of cross-matched fuse with buckets tied on the ends may be used in a manner comparable to that of the spolette chains. The identical chaining depicted previously in Figure 82 using spolettes, is depicted in Figure 84 using time fuse.

While time fuse cannot be used to make short delays as spolettes can, it is quite simple to make a very long delay (e.g., 15-20 seconds) using time fuse, which would require several spolettes chained in succession.

The temptation must be resisted to make one long tube and simply to tie it in the middle of the time fuse. Each cross-matched end must be tied with its own separate bucket, as shown. The fire often flashes through if a long tube tied once in the middle is employed.

No matter how the chains are constructed, they must be firmly anchored so that the chain is not broken or torn as the shells are fired. If the mortars are in racks, it is easy to tie the chain with a length of strong twine to the side rail of the rack. Some operators prefer to tie chains to thin strips of wood. These strips are then nailed to the side of the finale racks. If individual buried mortars are used, then a wire or rope should be stretched between two pegs, the length of the mortar battery, and the chain tied to this wire or rope. Figure 85 illustrates this.

Some operators, when using buried mortars, will make the chains with longer than normal leaders on the shells. A long piece of light lumber (e.g., 1″ x 2″ stock) is then used, and the shell leaders are woven through the wood.

The principles of ordinary chaining, branching connections, and time delays can be combined to produce an infinite variety of effects, at the taste and

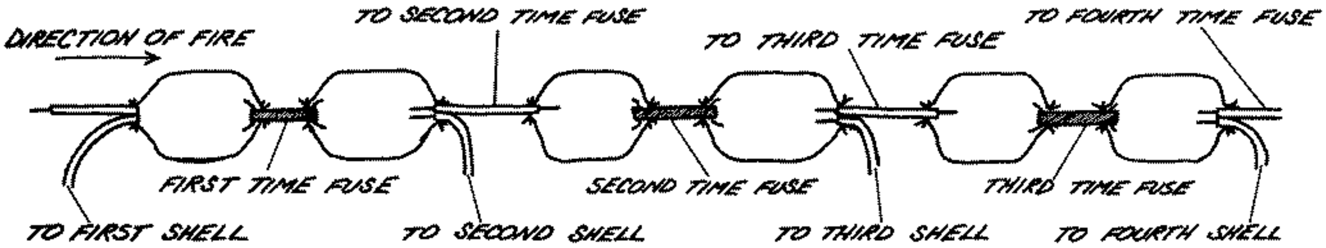

Figure 84. Chain with time fuse delays.

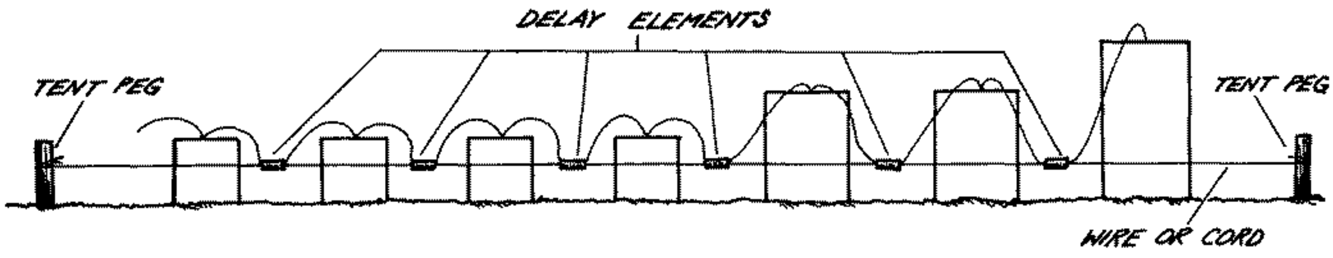

Figure 85. Delay fuses tied to wire or cord along mortar line.

discretion of the pyrotechnist. One might, for example, include time delays between segments of finale chained to fire in ordinary quick succession, as: two dozen red shells, six second delay; two dozen white shells, six second delay; two dozen blue shells, six second delay; two dozen salutes. One might arrange to fire first one shell, then delay; then two shells, then delay; then four shells, etc.

Necessary safety precautions for all chained shells are as follows:

(1) Anchor ordinary chains by tying to the rack at least every three or four shells.

(2) Anchor each and every delay by tying.

(3) Finales should be upwind from the rest of the show and should be covered with a tarp so that a stray spark does not ignite the match unexpectedly, ruining the show and possibly injuring someone close to the finale at a time when its firing is unexpected. This is particularly a problem when very lightly piped, machine-made match is used to chain shells, as a cinder could conceivably burn right through such light piping.

(4) Finales should be far away from any spectators, racks firmly staked or otherwise anchored in place, and preferably barricaded with sandbags. The safest procedure is to dig a trench and set the racks in it. If a trench is used, great effort must be made to ensure that its bottom is flat, so that the bottom of the rack is uniformly supported. Otherwise (especially with larger shells), the recoil from firing may break the rack bottom. If this occurs, it is possible that some of the mortars, being secured by their sides instead of bottom, may lose the bottom plugs when fired and thus cause shells to explode too low.

(5) If mortars are used above ground, *no matter what method is used to support them,* the operator should always plan for the possibility that one or more mortars may fall or be blown over before they are fired. Many serious and fatal injuries have occurred from mortars being used above ground. This method should never be used if there is any other alternative. If the mortars must be used above ground, they should be far enough from people and property so that in the worst case, the shells will not endanger either.

(6) If the finale is a long one, it is desirable to chain in a leader every two or three dozen shells for purposes of relighting, should the chain go out. An operator should follow the finale chain with a portfire or fusee to relight it promptly in such an event. At the same time, such a person should be prepared to get away quickly, or, failing that, throw himself to the ground at once should a rack tip over, a salute detonate in the gun, or some other mishap occur that might result in grave injury.

(7) Some operators prefer to use several short chains instead of a single long chain for a long finale. Although this requires the operator to light the finale several times, it reduces the risk of losing the entire finale should it somehow be ignited prematurely. This technique is also used frequently in conjunction with electrical firing. It is claimed that the overall speed and effect of the finale can then be regulated by firing several short segments.

(8) Finales, or any other rapid-fire chained shells, represent perhaps the most serious hazard to people and property, since *there is no way to stop firing the shells in case of an accident.* Therefore great care must always be used in planning and executing these parts of a display; they should never be "thrown togethe at the last moment.

RINFASCIATURE

Although it is conventional practice to finish the filled and spiked shell casings with several turns of pasted paper, as has been previously described, such a finish is not necessary to produce a successful shell. In conditions where the use of wet, pasted paper is undesirable (for example, in making a test shell for immediate firing, or in humid conditions where the time needed for a pasted wrap to dry is intolerable), there is a traditional method by means of which shells may be made with a dry paper wrap in lieu of a pasted wrap. This is known as *rinfasciature* (from the Italian *rinfasciare,* to re-wrap or re-bandage), and is sometimes also called "dry-pasting," "pasteless method," or "double-case, double-strung method." The spiked shell is wrapped up in dry paper, this dry wrap is folded down over the ends of the shell, and is held in place by a second spiking.

Procedures employed for making shells by this method are the same as for a conventional shell through the process of case-filling. The first spiking, over the filled case, may be done with somewhat fewer strings, given the size of the shell, than would be used if the shell were to be completed with a pastewrap. Table 22 suggests typical spiking patterns.

Table 22. Typical spiking patterns for rinfasciature.

Shell size	No. side strings first spiking	No. side strings second spiking
3″	8	8
4″	12	12
5″	16	16
6″	24	24
8″	32 or 36	32 or 36

Thin, strong string is necessary. Two strands of 8- or 10-ply cotton may be used, as is typical with shells to be pasted in conventionally, but because this method of construction makes a shell somewhat larger in finished diameter, bulkier string may lead to too tight a fit in the mortar. Belgian, Danish, or Italian flax twines are often favored, but are more difficult to obtain than cotton. Polyester-cotton blends may provide strength with less bulk than plain cotton string. However, single-break shells may be made successfully with cotton string.

It is essential that the string be pasted heavily, because it is such pasted string that in effect holds the shell together. The pasted string "bites" into the paper and cannot come loose; the string is rendered resistant to fire, and is thus protected during firing, and burning fallout is held to a minimum.

After the shell casings are spiked, they are to be wrapped in *dry* 40- or 50-lb. kraft paper, one turn per nominal inch of shell diameter. Appropriate lengths may be found in Part I of this article (Table 11, p. 21, PYROTECHNICA • IX). This paper should have the grain parallel to the axis of the shell, and should overhang the bottom of the shell by almost a full diameter, and the top by half a diameter. The pyrotechnist should make an effort to wrap the paper onto the shell as tightly as possible, keeping the edges parallel.

Fold over the paper on the bottom of the shell, using the *tongue fold* previously described. If the tongue should protrude beyond the edge of the shell when it is folded down, it is folded back under itself, as depicted in Figure 86. Such a fold is said to be especially "fireproof." Consolidate these bottom folds by tapping with a block of wood, or by jolting the shell, bottom down, on the work surface. The top may now be folded in. Begin by folding one side of the overhanging paper in toward the shell fuse. If the calculation has been correct, it will lap up against the fuse (somewhat). Carefully tear the paper at this point to accommodate the fuse, so the paper will lie flat. Now begin to pleat the paper in toward the center. It will be obvious that the paper is too long to lie neatly up against the shell fuse, so the pleats must be made to lie just alongside it. Pay careful attention to pleating close to the fuse, as this is the weak point at which gas may be admitted, causing a malfunction. White glue, hide glue, or wax is often applied here. Consolidate these folds into place, again tapping with a block of wood. Any corners that may protrude, top or bottom, should also be tapped with the wood block to crush them in toward the shell body.

Now that the outer dry wrap has been put in place, the shell may *again* be spiked, using the same pattern of string as employed in the first spiking. The strings of the first spiking may be felt through the layers of dry paper, and effort should be made to place the strings of the second spiking so that they lie between those of the first spiking. The purpose of this is two-fold; to distribute the reinforcement afforded by the string, and also to avoid building unnecessary bulk.

When this second spiking is in place, a third, finishing, wrap of 30-lb. paper is added over it, solely as a protection of the strings during firing. This consists of two turns, closed on the bottom by means of a tongue fold, and gathered around the spolette as one would gather a paper sack around the neck of a bottle. The gatherings around the spolette are held in place by windings of pasted string, and the whole wrap is spiked on with four or six vertical side strings only. Once this final wrap is complete, the shell may be prepared with lift and leader as for any shell.

It must again be stressed that the weak point of any shell is around its fuse. The sealing effect of many turns of pasted paper is absent in rinfasciature, and must be replaced with a good seal of hide glue or white glue at several steps during the shell's manufacture, preferably following the first spiking and following the second spiking, as well as initially gluing the spolette in the top inside end disc.

The suggested spiking guidelines given are *minimums,* and may be augmented for special breaks. In effect, one is putting only *half* of the string on the shell with each spiking. One may, without harm, use more string, keeping in mind that the shell must still fit in the proposed mortar. The main concern is to avoid adding unnecessary bulk and to save time in spiking. The present writer has made 5″ shells by this method using 24 side strings on each spiking for such shells as crossettes, where a wide burst is desirable.

The integrity of the shell contents is of greater importance in this method than with a pasted shell, although the importance of this factor in *any* shell cannot be too strongly emphasized. The stars must be well consolidated, and large comets or tube garnitures must be well packed with dry sawdust or rough powder as may be required, so that the shell case is tight and solid after the first spiking.

The virtues of rinfasciature as a method are variable with the type of shell to be made and the use to which it is to be put. It is doubtful whether there is any advantage to it in terms of time saved in manufacture with small 3″ or 4″ single-break shells, which can be pasted-in in one installment. It is, however, most useful when one wishes to make a few 3″ or 4″ test shells for immediate firing. The real virtue of

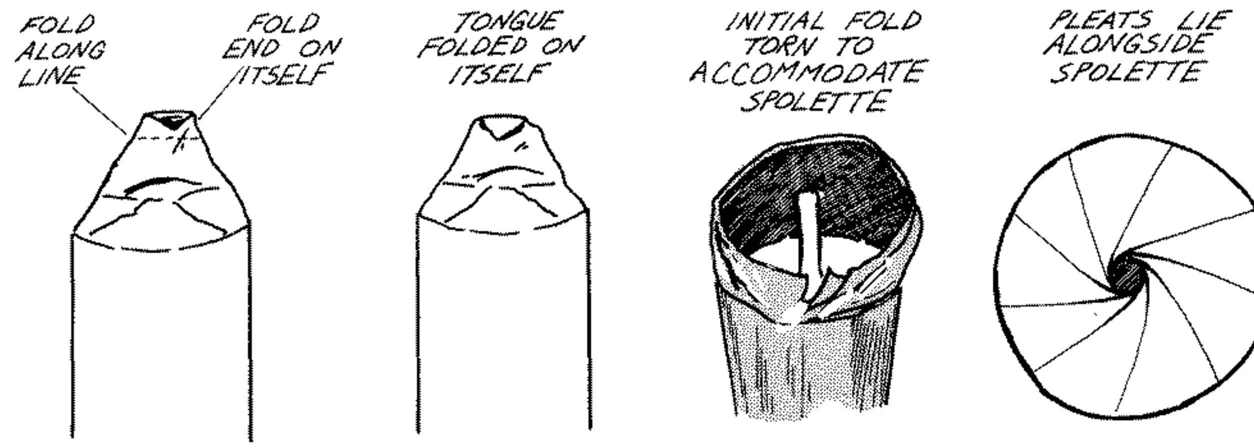

Figure 86. Folding down paper on ends of shell.

rinfasciature seems to lie in the genuine expedition of the process in making large 5″, 6″, and 8″ shells. Normally such shells require that they be pasted-in in two or three installments, using heavy paper that takes many days to dry. Using rinfasciature, such shells can be completely finished in one sitting and even fired the same day. The actual time spent in manufacture (as opposed to waiting for the shells to dry) is indeed less.

Multiple break shells may be made by this method, but the complex intermediate dry-wrappings of the individual breaks and of the shell at various stages of assembly, and extra time spent in spiking, makes the resultant product more a tour-de-force of pyrotechnic skill, to be appreciated by those familiar with the manufacturing process, than a commercially feasible alternative method, or a method offering better effect.

CONCLUSION

The methods outlined in these pages are maintained in fewer firework manufacturers' plants every year, for reasons which become evident upon an examination of the business. Imported fireworks, chiefly from Oriental countries in which labor is cheap, have made competitive inroads into a business once enjoyed predominantly by domestic makers. Faced by this competition, such makers have adopted methods which are modified from the traditional ones (e.g., the spiral-wound "can" shell with fiber end caps, extensive use of flashbags, and "stringless" shells), or which depart radically from them (plastic shells). The character of all such changes in methods is to reduce the amount of hand labor spent in building shells. Traditional methods also require the worker to acquire knowledge and manual dexterity, and are not learnt overnight. The methods introduced to replace them reduce or eliminate this element of skilled workmanship.

Given these disadvantages of traditional methods, which are mostly economic, it is appropriate briefly to consider their benefits. One is that simple materials, available cheaply, quickly, and easily, are all that are required. The more "modern" methods have large start-up capital costs in the form of purchased materials or specialized equipment. Another advantage of traditional methods is that variation is much easier to effect; shells of any number of breaks, or containing any of a great variety of special effects, can be made virtually to order. The principal ingredients, apart from simple hand tools and basic materials such as paper, string, stars, and powder, are the time, skills, and imagination of the shellbuilder.

Pyrotechnics is undoubtedly a vigorously competitive business, but ultimately one that depends upon creating beauty and drama that can entertain an audience. Failure in this most important aspect will render the whole enterprise profitless, notwithstanding however many economies of time or labor may have been realized in production. It is in this creative dimension that the traditional methods commend themselves especially to the fireworker. Toward the broader recognition of the central place held by artistry in fireworks, these pages have been dedicated.

FROM THE EDITOR *(continued from inside front cover)*

quality controls in unsafe, clandestine factories, unsupervised by any regulatory authority) with legal "Class C" merchandise, and with legally sanctioned public displays fired by trained operators. All these are lumped together with the common heading "fireworks," or, as often as not, "firecrackers" (what display operator has not been irked by the comparison of a fancy 5-inch multibreak shell to a firecracker?).

The table reproduced here tells a different tale. In the year for which these data were collected, 1984, fireworks caused a total of six deaths (exceeding only measles, botulism, and poisoning by vitamins). In a nation of 230 million people, this is truly a disappearingly small number. It is interesting, in perusing the table, to compare this to the numbers of people killed by old-fashioned infectious diseases such as tuberculosis, syphilis, and appendicitis, for which cures were supposedly found years ago. Yet we can be sure that the sensational press, in possession of statistics showing six deaths from fireworks as opposed to two from botulism, might well produce banner headlines in a pre-Fourth of July edition:

"FIREWORKS CAUSE
3 TIMES AS MANY DEATHS
AS BOTULISM."

If the truth be told, the insurance problem faced by the firework industry (and in general by all businesses, nonprofit organizations, and units of government) is

(FROM THE EDITOR *is continued on page 83)*

ANNUAL FATALITIES IN THE U.S. FROM SELECTED CAUSES

738,000	Heart disease	677	Infectious hepatitis
328,000	Cancer	410	Syphilis
209,100	Stroke	334	Excess cold
55,350	Motor vehicle accidents	205	Floods
38,950	Diabetes	129	Nonvenomous animals
24,600	Suicide	107	Lightning
21,730	Emphysema	90	Tornados
18,860	Homicide	48	Venomous bites or stings
7,380	Drowning	17	Polio
7,380	Fire	15	Whooping cough
3,690	Tuberculosis	8	Smallpox vaccination
2,563	Poisoning	6	Fireworks
2,255	Firearm accidents	5	Measles
1,886	Asthma	2	Botulism
1,517	Motor vehicle collisions with trains	1	Poisoning by vitamins
1,025	Electrocution	0	Smallpox
902	Appendicitis		

—Science, October 1985