

TRADITIONAL CYLINDER SHELL CONSTRUCTION

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It is convenient, and prevents leakage of the report composition, to pierce, match, and insert the matched shot into the comet, then repeat the procedure in that sequence rather than to pierce all, then match all, then insert all of the shots. Naturally, it is desirable to have the unpierced shots all cut to individuals and all the match cut to proper sized pieces before beginning this procedure.

The comets with inserted shots must next be *pasted in* with three turns of 30-lb. kraft. The paper should be cut to strips $2\frac{3}{8}$ " wide by 12" long for this purpose, with the grain the $2\frac{3}{8}$ " way. The paper strips may be prepared with paste all at once by first laying down one strip, brushing it with paste, then another, and so on until several dozen are laid in a "lapped pile" as for pasting small shells (Fig. 21, p. 24, Part I, PYROTECHNICA • IX). It is not, however, necessary to break this thin paper as it is well enough saturated with paste simply by letting it stand.

The comets should be pasted by taking a strip from the pile and placing it on a clean part of the work surface, making sure it is lying flat, without wrinkles. Position the comet at one end of the strip with the overhanging paper on the cavity end of the comet, and paper covering all but about $\frac{1}{4}$ " - $\frac{1}{2}$ " of the side of the comet. Roll the comet up, folding the overhanging portion of the paper over the shot and the end of the comet while rolling. When all the paper is rolled on and folded over the cavity end of the comet, pick the comet up, supporting its solid bottom on the palm of one hand; with the palm of the other hand, work the folds of paper down smoothly, then with the fingers smooth the paper on the sides of the comet. Note that the pasted paper holds the string "ears" of the shot in place, preventing the shot from falling out of the comet after the bottom of the shot hole burns through. It is important to avoid wrinkles in the paper on the sides of the comets. Also, strive for *consistency* in the portion of the comet sides left uncovered by the paper. It is not really significant if $\frac{1}{4}$ " or $\frac{1}{2}$ " of the side be left uncovered; however, all comets going into the shell should have the *same* portion left uncovered. It is desirable that a comet with the dimensions given here have certainly no more than $\frac{1}{2}$ " of the side left uncovered. It is also important that enough be left uncovered that the comet has a chance to ignite from the sides as well as the bottom. Figure 57 illustrates the finished comet. Allow the pasted comets to dry for a week.

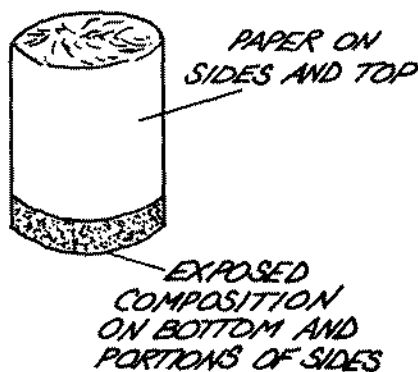


Figure 57. Finished crossette comet.



Photo courtesy of Gary L. White

Crossette shell burst.

Needless to say, these basic procedures may be modified to produce comets of almost any dimensions. In practice, it is difficult to make a comet less than 1" in diameter because the dimensions of the shot become too small to handle comfortably. Large comets 2" or more in diameter can be made for very large shells or for single fire from small mortars; the dimensions of the shot need not be enlarged proportionately to those of the comet, because a $\frac{1}{2}$ " shot is capable of cracking even a large comet. Finally, the duration of the comet before it bursts may be regulated by the distance between the solid bottom of the comet and the bottom of the shot hole. If the comets crack too soon, the solid portion may be lengthened; in the example given, keeping all other dimensions equal, the comets may be pumped $1\frac{1}{2}$ " or $1\frac{3}{4}$ " long rather than $1\frac{3}{8}$ ". Excessive length will, however, allow the pattern of the break to lose coherence, diminishing its beauty.

The finished comets are stacked in shells just as plain comets are (see Fig. 30, p. 29, Part I, PYROTECHNICA • IX). Again, as with plain comets, they should fit tightly in a ring. Adjustments to the former diameter or the reduction of the case diameter by adding a chipboard liner after rolling up the case are in order to achieve this. Some makers prefer to stack the bottom row of comets with the exposed ignition surfaces facing up, the next row with them down, and subsequent pairs of rows with ignition surfaces similarly facing. This is held to improve ignition. Others prefer to orient all rows either up or down. It is a matter of preference, dependent upon custom, taste, or experimental result. The entire center of the shell case is to be filled with FFA powder, and the shell closed, spiked, pasted, and finished as for an ordinary comet shell.

COLOR CHANGING (TIPPED) COMETS

The principle of covering one end and part of the sides of a comet to restrict burning and to achieve a transformation effect, as in crossettes, can also be applied to produce other results. An example of this is the color-changing comet.

A cavity formed in one end of a comet, like that of a crossette but larger and of different shape, is filled with a composition of a different type than that of which the comet itself is pumped. Pasted paper is used to cover the end and sides restricting burning to

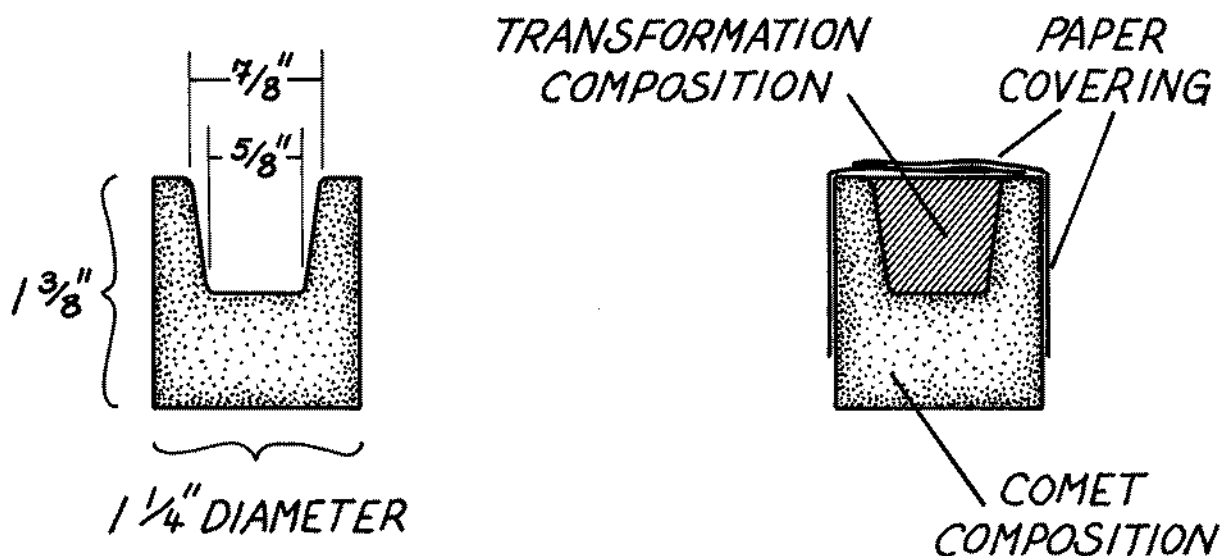


Figure 58. Color-changing (tipped) comet.

one end, and, when the composition of the comet has burned down to the level of the transformation composition, there is the appearance of a change in color.

The comets described here are of similar exterior dimensions to the crossette comets previously described — $1\frac{1}{4}$ " in diameter and $1\frac{3}{8}$ " long. The cavity, like that of the crossette comet, is $\frac{3}{4}$ " deep, but instead of being cylindrical, is tapered from $\frac{7}{8}$ " at the end of the comet to $\frac{5}{8}$ " at the bottom of the cavity. Figure 58 illustrates the shape of the comet.

In order for this effect to succeed, the choice of compositions is critical. The comet itself should be pumped of a low light intensity composition, like a charcoal streamer or gold flitter. The transformation composition is appropriately one of high light intensity, such as a brilliant white barium nitrate-aluminum mixture, or a titanium streamer. Bright colors may also be used though care should be taken that their compositions are chemically compatible with that of the comet.

The same care should be taken to pump uniform comets for this effect as for crossettes, making certain all are cut to the same length and allowed plenty of drying time. When the comets are fully dried, a quantity of the transformation composition should be dampened to approximately the consistency for cut stars. This should be pressed into the cavities of the comets with the fingers, and "battered" smoothly in place with a small knife or flexible spatula. These filled comets again should be set to dry completely.

Once dry, the comets are to be papered as with crossettes using three turns of 30-lb. kraft (12 " x $2\frac{3}{8}$ ""). The depth of the paper on the sides should be kept constant so that all the comets will undergo the color change simultaneously. The time at which this transformation takes place is adjustable both by changing the depth of solid comet between the bottom of the comet and the bottom of the cavity, and to a lesser extent by the papering.

PILLBOX STARS AND SHELLS

While the manufacture of stars as such is outside the purview of this article, a word is in order about pillbox stars and the way in which they are made and

used in traditional cylinder shells. The various books on pyrotechny all carry basic descriptions of pillbox stars, implying a rather small tube of perhaps $\frac{1}{2}$ " diameter x $\frac{3}{4}$ " long, loaded with damp composition with match protruding from both ends. These stars, when dry, are filled randomly into shells much as are cut stars. While this may have been true in the days when the northern European style of ball shell was an item of current commerce, there are a few differences in the techniques used in cylinder shells.

The two most important purposes of a pillbox star are (1) to provide a sustained duration of effect and a larger flame than is possible with a cut star, and (2) to provide either a means of more certain ignition (via the match) or of sturdier consolidation of the composition (via the case) than is possible with cut stars. In practice, pillbox stars are used in shells in much the same manner as comets (treated in Part I, pp. 28-30, PYROTECHNICA • IX). Whereas comets, however, are made typically of gunpowder-type ingredients (charcoal or flitter effects), pillbox stars usually are either colors or high-intensity aluminum stars; the pillbox technique is used because these compositions are harder to ignite or are more fluffy and difficult to consolidate, than would be compositions suitable for use in regular comets.

The casings for pillbox stars should be rolled of medium weight kraft paper (40-, 50-, or 60-lb.), of about three to four turns with only the edge or the last turn pasted. It is usual to roll long tubes, and to divide the case with ruler and pencil, then clip the individual pillboxes to size with scissors. Usual diameters for pillbox stars would be $\frac{3}{4}$ ", $\frac{7}{8}$ ", or 1 ", with the length of the case slightly longer than its diameter (say, $\frac{3}{4}$ " dia. x 1 " long; $\frac{7}{8}$ " or 1 " dia. x $1\frac{1}{4}$ " long). Some manufacturers who use many pillbox stars will purchase thin-walled, spiral wound cases rather than roll pillboxes. It is immaterial what is done as long as the case is not too heavy; its purpose is merely to contain the composition, not to direct its force (as in a gerb or serpent).

The traditional pillbox star having match running out both ends is supplemented by some pillboxes made

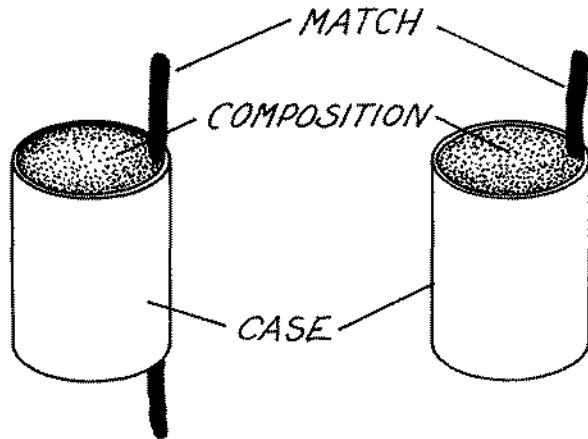


Figure 59. Two varieties of pillbox star.

with match running out only one end (see Fig. 59). These stars matched on one end only are used for stacking on the top and bottom of the shell, so that the match does not interfere with the firm placement of the top or bottom disc. The stars should be stacked in rings about the periphery of the shell case, just as comets are. The alternation or staggering of the stars, brick-fashion, lends itself well to the accommodation of the match ends. Match need not stick out the ends of the star more than $\frac{1}{2}$ "- $\frac{3}{4}$ ".

The usual method of making the stars is to thread the match through the case, dip it into the bowl of composition (dampened about the same as for cutting stars, or perhaps a little less), and to compress the composition in place using thumb and forefinger. In larger cases, a rod with a flat area made on one side (to accommodate the match) may be used with a small foot to hold the case while pressure is applied by hand or with a small mallet.

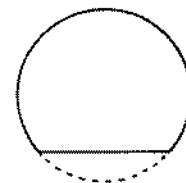
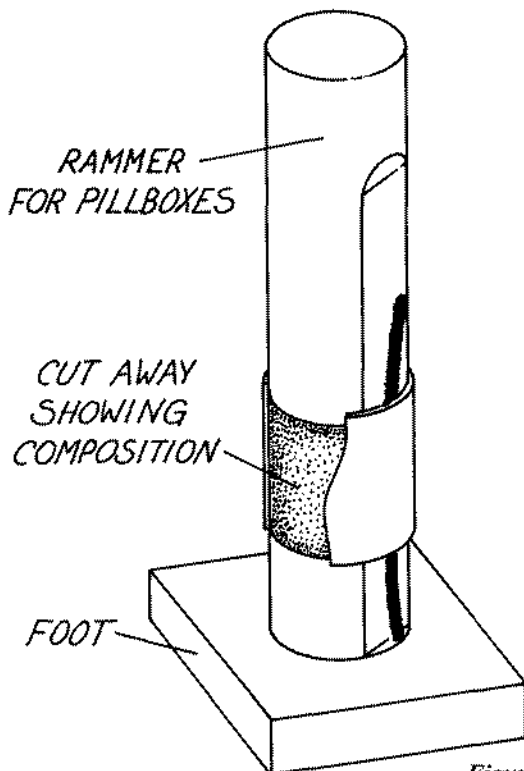
Choice of the size of stars is governed by the size of the shell and also what will fit tightly in rings. The smallest practical size in which to make pillbox shells is 5". In larger sizes, a "double ring" effect may be had by filling cut stars of contrasting color between the outer rings of pillboxes and a canulle with powder at the center. Otherwise the whole center of the shell may be filled with powder. Spiking may be normal, or extra-close (i.e., 32 strings on a 5" rather than 24; 48 strings on a 6" rather than 32; 64 strings on an 8" rather than 48) for a harder and more regular burst. Pastewrap, lift, and leader, as usual. Pillbox stars may of course be used for the breaks of a multiple break shell.

SHELL-OF-SHELLS

An attractive effect may be achieved by filling a large shell with several small shells having time fuses arranged to take fire from the break of the shell. These small shells are thrown out into a wide circular pattern and when their time fuses burn through, explode in a ring of small color bursts. The construction of the small shells is basically similar to that of an ordinary single-break color shell, with a few differences. They may be made in a variety of sizes and adapted to fit in large shells of all sizes. The possibilities for variation on the theme are innumerable. For purposes of this example, small shells made on a $1\frac{1}{4}$ " form to fit seven in a ring in a 5" shell (rolled on a $4\frac{1}{2}$ " form) are described — first the manufacture of the small shells, then the assembly of the shell-of-shells.

Insert shells

Have a former turned of hardwood, $1\frac{1}{4}$ " in diameter with a working surface about 6" long. Down the center of one end, a $5/16$ " hole should be bored about 4-5" deep. Figure 61 illustrates this former.



END VIEW OF RAMMER AND FOOT: CYLINDER WITH FLAT SIDE MILLED ON IT

Figure 60. Foot and rammer for pillboxes.

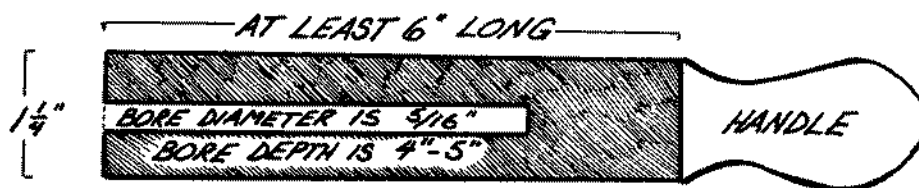


Figure 61. Former for rolling insert shell cases.

Also obtain an awl with a shank about $\frac{1}{4}$ " diameter within 3-4" of its point. This is used to pierce the hole for the time fuse in the end of the case after rolling up on the former.

Cut 125-lb. tagboard (.009") to strips $2\frac{1}{2}$ " wide x 8" long. Cut 30-lb. kraft to strips 5" wide x 13" long. The grain of the paper should be the short way in both cases. To form the cases, lay a strip of tagboard centered on a strip of the kraft. Roll them up together just as for a saettine (see Part I, Fig. 33, p. 31). Paste the edge of the kraft. Slip the case up over the end of the former so that the liner of tagboard is flush with the former end, and the kraft overhangs. Close this end with a tongue or triangle fold. It will be necessary to tuck the protruding corners of the final fold under, to make the end of the case smooth and round (see Part I, Fig. 12.2, p. 15). This final tongue fold should be stuck down with a dab of glue under it. Consolidate the folds by rapping the former and case on the work table.

While the case is still on the former, take the awl and pierce the center of the end with it — the awl will be accommodated by the hole bored in the end of the former. The hole made should be about $\frac{1}{4}$ " in diameter. Carefully withdraw the awl while holding the folded end of paper shut with the fingers, re-consolidate the case end if necessary, then remove the case from the form. Seven such cases must be rolled for one 5" shell.

The time fuse used for the small shells is the $\frac{1}{4}$ " spun fuse of Japanese manufacture (see Part I, p. 13); the $\frac{3}{8}$ " fuse is too big. Formerly a $\frac{1}{4}$ " white cloth tape fuse was available and was used. The white $\frac{3}{16}$ " dynamite fuse has also been used, but it is slower and more troublesome.

Insert the end of the $\frac{1}{4}$ " fuse, straight from the roll, through the awl hole in the folded case end, until

it is well through and a couple of inches are visible on the other end of the case, past the kraft. With a good ruler and a fine-nibbed pen, or with dividers, mark off a $\frac{3}{4}$ " interval about $\frac{1}{4}$ - $\frac{3}{8}$ " from the end of the fuse. Punch a hole with a sharp awl, or with the finest tip of a turret-style leather punch, at the mark nearest the fuse end. Insert a 1" piece of thin match through, crimp if necessary, and pull the cross-matched fuse back through the hole in the case end, until the cross-match is tight against the inside. The other mark should be clearly visible perhaps $\frac{5}{8}$ " above the folds. With a nippers or sharp scissors, cut the fuse off about $\frac{1}{2}$ " above this mark. Proceed in this manner for the other six cases. Figure 62 illustrates these procedures.

When all the cases have been thus rolled, punched, fused, and cross-matched, assemble them with fused ends down, open ends up, accommodating the fused ends between two strips of wood or some other support. Small cut stars all of the same color should be filled into the shells together with enough powder so that by jiggling and working in the case it can be filled solidly to the level of the tagboard liner. It is suggested that first stars, then powder, be put in to about half the depth, then consolidated; and the process repeated. The stars and powder are mixed together as it is impossible to core the burst powder in such a small case. Either FFFFA or the "fines" of FFA, passing through 8x8 hardware cloth, are good choices for the burst powder. Finally, level off the fill at the edge of the liner with powder, and close the end with the tongue fold. Consolidate the folds by tapping with a mallet or by jolting the filled shell on the work table. The small case should feel firm and tightly filled at this point.

The small shells are spiked with six or eight vertical passes of pasted string, and horizontally to make

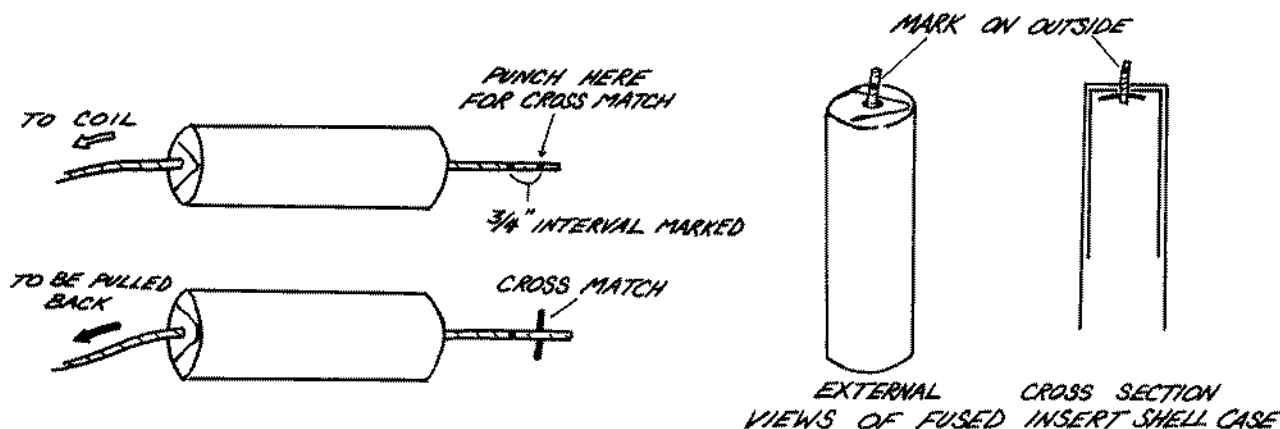


Figure 62. Fusing and cross-matching small insert shells.

little squares on the sides. One strand either of unwaxed linen shoemaker's thread or of 6-ply or 8-ply cotton is adequate. The string is tied to the fuse and the shell spiked just like a larger one.

After spiking, the little shells are pasted in just as larger ones would be. Some makers take the precaution of sealing around the fuse after spiking with a bead of white glue or liquid hide glue, especially as the end is not formed with a tight fitting disc, but only of folds of paper. This glue should be allowed to dry prior to pasting if this step is taken. Prepare strips of 30-lb. kraft paper 5" wide x 13" long, the grain running the 5" way, for pasting (as illustrated in Part I, Fig. 21, p. 24). Paste the little shells folding the overhanging paper over the bottoms and twisting it around the fuse, one turn at a time, while rolling. The pastewrap should form a good "crown" around the 1/4" fuse, but enough fuse should be left exposed so that the mark for outside cross-matching is clearly visible and some fuse is left below it. Set the little shells aside to dry.

When dry, the time fuse should be pierced with an awl (or punched with the leather punch) at the place marked, and cross-matched with thin match (crimping if necessary to hold the match in place). Alternatively, some pyrotechnists prefer to cut the fuse square across at the mark and dip in slurry priming. A short piece of thin match is then bent over the end of the fuse and tied. Finally the matched, primed fuse is dredged in fine grain powder (FFFFA or rifle powder) and set to dry. The small shells are now ready for assembly into the shell-of-shells.

Assembly of shell-of-shells

First variant. Color and shell-of-shells

Cut 70-lb. kraft 11" wide and long enough for five turns around a 4 1/2" form — normally one 48" and one 24" strip are used. The grain should be short. Roll up a shell case on the 4 1/2" form, inserting the disc and pleating the bottom shut as usual.

Place the insert shells in a ring around the periphery of the case at its bottom, fused ends up. The shells should fit snugly in a ring; if they do not, the pattern

will not be as good. If they do not fit snugly, the diameter of the insert shell case former may be adjusted by pasting several turns of paper on it to bring the diameter of the cases up; whereof the snug fit of the insert shells will necessarily follow. This process of adjustment may take several tries. Loosely fitting inserts may in the meantime be brought up to diameter by rolling several turns of dry kraft 2 1/2" wide around their sidewalls, securing with a piece of paper tape. This does not seriously affect the break of the small shell. When all shells are securely and snugly in place, fill the interstices between the shells and the shell wall with rammed sawdust or rough powder, according to practice for comets, saettines, etc. This fill should come to the height of the sidewall of the shell. Now lower the usual canulle to the bottom disc, in the center of this ring of shells. Fill around the canulle with rough powder to a height just covering the cross-matchings of the insert shell fuses. Then begin to fill cut stars around the canulle on top of this bed of rough powder. The stars, for best effect, should be those of the appropriate size for a 4" shell, or a little smaller than usual for a 5"; this is to provide that the burst of the smaller shells is not covered up by the spread of the central color. Naturally, the color chosen for the central burst should be contrasting to that of the insert shells. It is better to choose a more intense or bright color for the little shells than for the central burst also for this reason.

When the color stars of the central break are filled to an appropriate level, fill the canulle with FFA powder, remove, level off the top of the stars with rough powder, and close with a disc having the usual spolette of 1 1/4" or 1 3/8" powder charge. The spiking pattern has the usual 24 vertical strands (see Part I, Table 10, p. 20), but the horizontal spiking at the bottom of the shell is about twice as wide as usual, while the portion covering the central starburst is in little squares as always. Figure 63 illustrates these details.

Paste in the shell with three turns of 70-lb. kraft and allow to dry. Then paste again with two turns of

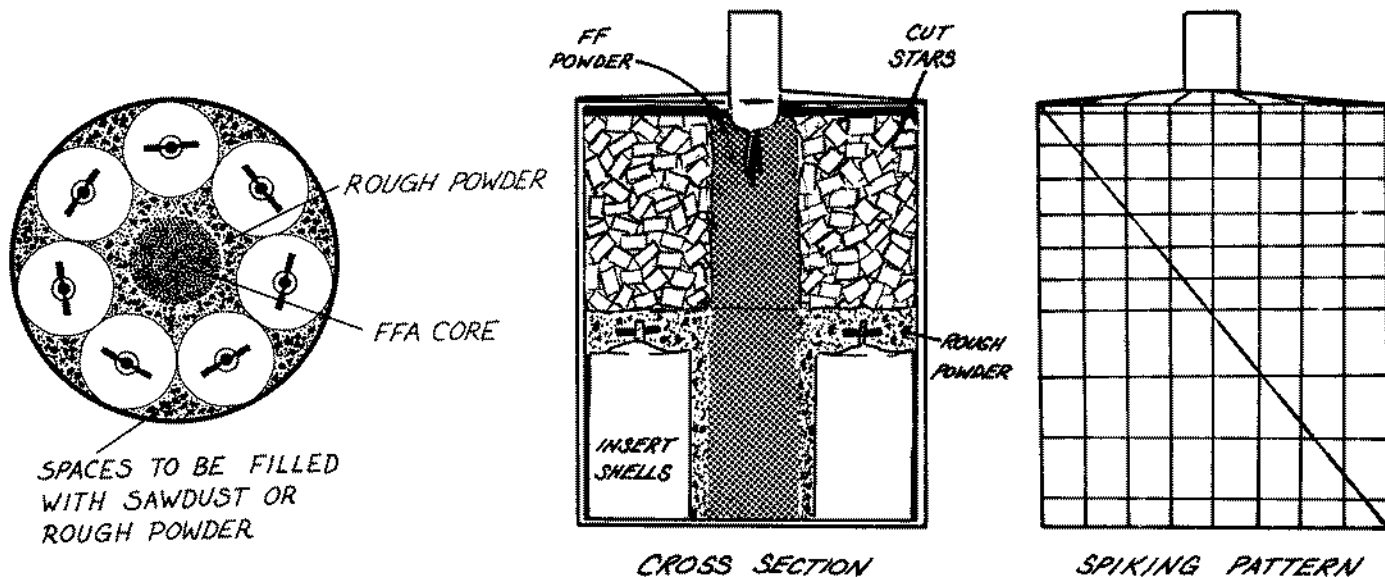


Figure 63. Shell-of-shells details

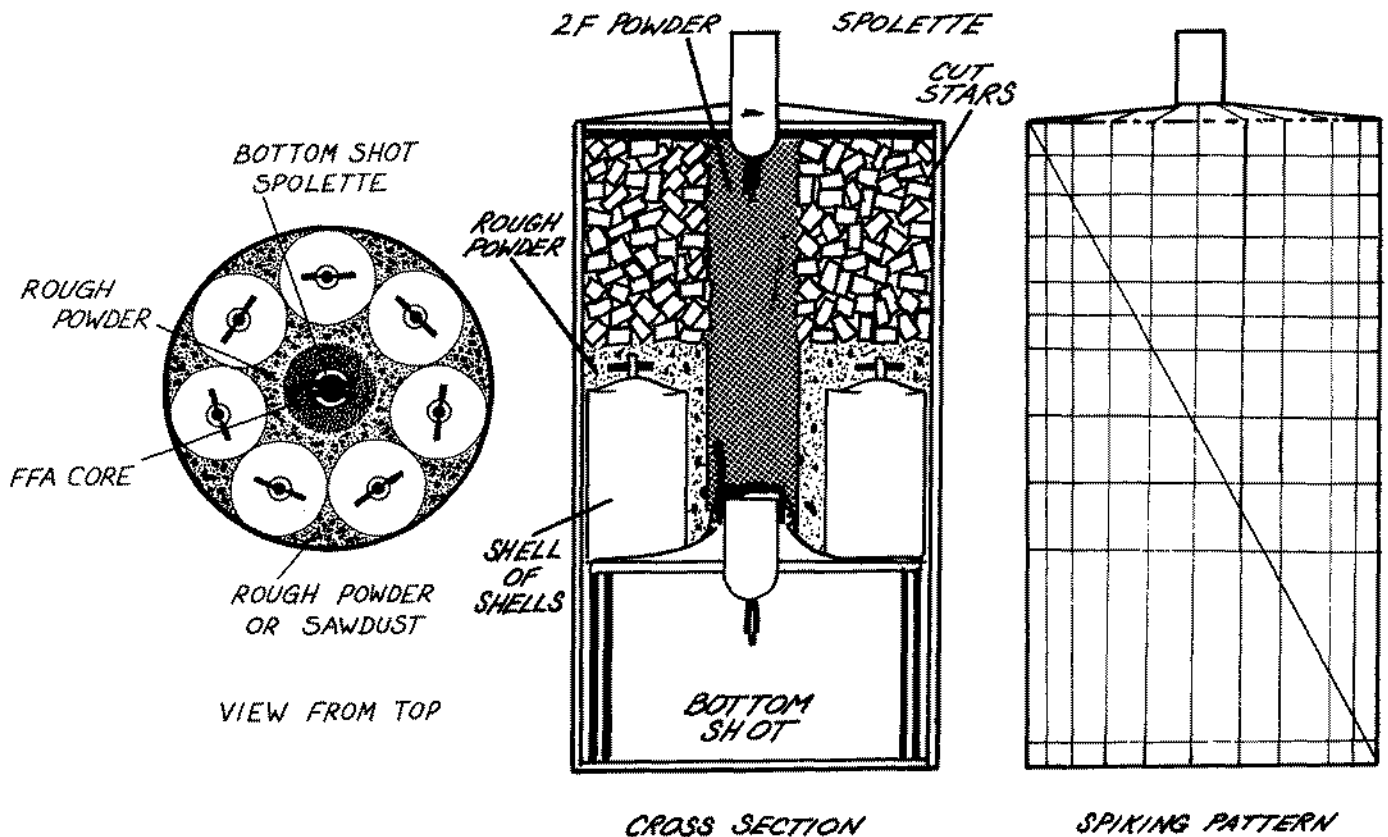


Figure 64. Details of shell-of-shells with heavy report.

70-lb. kraft and again allow to dry. The shell may then be weighed, finished with lift powder (one ounce per one pound of shell weight) and leader, all in the usual fashion described in Part I, pp. 23-28.

Second variant. Shell of shells with heavy report (with or without central color)

Prepare a "bottom shot" having a spolette charged with $1\frac{1}{4}$ " of powder. This may either be a $3\frac{1}{2}$ " machine made core, to be "sawdusted in," or more advantageously a hand-rolled case built on a $4\frac{1}{4}$ " disc. If the latter, begin with a $2\frac{1}{2}$ " form having a $\frac{3}{4}$ " hole bored about 3" into one end. Cut a strip of 30-lb kraft 16" long x $9\frac{1}{2}$ " wide. Roll this up on the form first, slipping it up a full diameter over the form and closing one end with a tongue fold, as previously described in the section on hand-rolled reports.

The newsprint strips should be folded to about $3\frac{1}{2}$ " wide. Roll them on until the outside diameter is about $4\frac{1}{4}$ ". The strips should be flush with the end of the form. Then cut a 48" and a 24" strip of 70-lb. kraft about $7\frac{1}{2}$ - 8" wide and roll these on over the newsprint, pasting the edge. With a knife, cut a hole in the folded-over 30-lb. kraft for the spolette (which will be accommodated by the hole in the former). Seat the spolette in its end disc firmly against the end of the form and the turns of newsprint surrounding it; pleat the outer kraft down over the disc, setting the folds with a mallet; and place another disc over the folds as usual for any shell. Remove the fused casing from the former.

Fill the inner "bag" of 30-lb. kraft with flash powder having suitable bulking agents. The fill level

should be about $\frac{1}{2}$ " below the top of the turns of folded newsprint. Fold the ends of the bag down onto the flash. Any remaining space, up to the edge of the newsprint core, should be filled with bran or sawdust. Finally, an end disc is placed over the core and the outer kraft folded down. The assembled report must then be spiked with 24 vertical strands of doubled 8- or 10-ply cotton and pasted with five turns of 70-lb. kraft. When dry, the report should measure about $4\frac{3}{8}$ " in diameter. Scrape the spolette end and match with two lengths of good match, tying with pasted or tarred twine.

The outside diameter of the report (somewhat smaller than $4\frac{1}{2}$ ") permits a certain adjustment of the diameter of the case which is to be rolled up on it. It may be enlarged with bands of paper or chip-board about its walls until a strip of kraft rolled up upon it will just snugly accommodate the seven insert shells.

Cut a 48" and a 24" strip of kraft to roll the shell case. The width of these will vary depending upon whether it is desired to have a central burst of color, then the shell-of-shells followed by heavy report; or just a dark opening, followed by the surprise opening of the insert shells, then the heavy report. In either event, roll the casing upon the report (or roll a long color case and "sawdust in" the smaller bottom shot) so that enough paper overhangs above the bottom shot to allow room for the shell-of-shells, color stars (if desired, about $3\frac{1}{2}$ " depth) and paper to fold over for the top.

Place the shells in a ring, with the spolette of the bottom shot in the center, around the periphery of the case on the top of the bottom shot. Ram the interstices with fill, and lower the canulle over the spolette of the bottom shot. Fill around the canulle, and above the small shells just to cover their fuses. If a dark opening is desired, at this point the canulle may be filled with FFA powder and the shell closed, spiked, and pasted. If color is desired in the center, it is added, and the procedure from there is the same as in the first variant. Figure 64 illustrates spiking patterns and other details for this style of shell.

The top spolette of the shell should be charged with just 1" of powder. This will open the shell on the way up and allow plenty of time for the functioning of the contents.

Pastewrap should be one strip of 70-lb. kraft 48" long, to cover the shell bottom and to come in just to touch the spolette; let dry and paste again with 48", overhanging a full diameter on both top and bottom, to be torn into six strips, each to be torn in turn and "forked" around the spolette. This extra pastewrap gives the long shell extra strength. Lift with one ounce lift per pound of shell weight.

Third variant. "Sun and planets," or two-breaks; first a dark opening of shell-of-shells, then a burst of color

This variant combines multiple break construction with the shell-of-shells effect to produce a sequence of events rather the reverse of the shell described in the first variant method. Begin by rolling a normal color case of a 24" strip and a 48" strip of 70-lb. kraft about 8" wide. Close the bottom with a solid end disc and pleat down. Fill the break with color stars and powder core as usual for the final break of a multiple break color shell without a report. Close with an end disc equipped with a spolette of 1" or 1 1/4" powder charge. Spike the shell with 24 vertical passes only of double 8-ply cotton, tying off on the spolette. Match the spolette of the break by the preferred technique (following the discussion under multiple breaks of color).

Prepare a break case for the small shells; this will be shorter than usual so the 24" and 48" kraft strips need only be 7" wide. Close the bottom with a punched disc and pleat down the overhanging paper, taking care not to obstruct the fuse hole in the disc. Place the small shells in the case and fill and ram their interstices.

Set the break case with the hole in its bottom disc over the matched spolette of the already-spiked color break in the usual manner. Lower the canulle of appropriate size over the spolette, centered in the case; fill around it, and over the tops of the matched fuses of the insert shells, with rough powder. Fill the canulle to the proper depth with FFA powder and withdraw. Close with a spolette and end disc, the spolette (which will be the main spolette of the shell) having a 1" powder charge.

Spike the break of small shells onto the color break with 24 vertical passes of double 8-ply cotton, laying these passes between those on the bottom color break. When complete, spiral down to the bottom and begin horizontal spiking of the two breaks, making little squares and laying the string close at the joining of the two breaks, then proceeding again with little squares to the top of the shell. Tie the string off using the half-

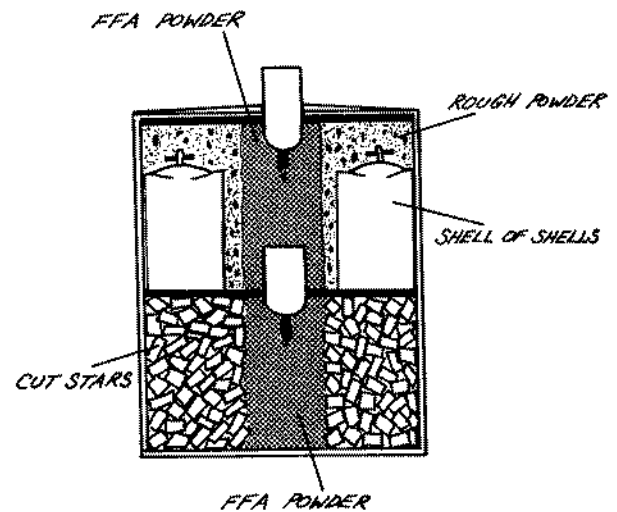


Figure 65. Cross-section of "sun and planets" shell.

hitch around the top of the shell, just below the top disc, as usual.

Pastewrap should be one 48" long strip of 70-lb. kraft to cover the shell bottom and to come in just to touch the spolette; let dry and paste again with 48" of 70-lb., overhanging a full diameter on both top and bottom, to be torn down around the spolette in the usual fashion. Finish with lift and leader after final drying. Figure 65 illustrates a cross-section of this shell.

This style of shell may be further elaborated by making the bottom break a break-and-report. In this case, the bottom shot should have a spolette with a 3/4" powder charge. The break-and-report are made as usual for any multiple break shell ending in a report.

Fourth variant. Two timed openings of shell-of-shells in one break.

Prepare seven insert shells in the usual manner, marking a distance between cross-matchings of 3/4" as usual on the time fuse for these seven. Now prepare seven more such shells, but make the marks 1 1/4" apart instead of 3/4". The insert shells should be filled with colors making an agreeable contrast; for example, the first seven with blue, the second seven with red, according to the taste of the pyrotechnist. The shells are spiked and pasted in the usual fashion. Punch and cross-match at the marks, keeping the two timings separate.

Roll up a case long enough to accommodate two layers of insert shells; the usual 24" and 48" strips of 70-lb., perhaps 12" wide, should suffice. Close the bottom with a solid disc and set the first ring (the shells with 3/4" of time fuse) in the case with fuses pointing up. Ram the interstices in the usual fashion with rough powder or sawdust. Now lower the canulle to the bottom of the case. The space around the canulle may be filled with small cut stars (the usual size for 3" or 4" shells), or it may be filled with rough powder if a dark break is desired. When the level of the fuses of this first ring of insert shells is reached (whether stars or rough powder are being used for the central fill), a bed of rough powder should be made to cover the fuses of the first ring of shells. The sec-

ond ring of shells (with 1¼" of time fuse) should then be placed, with fuses pointing *down*, so that those fuses lie between the upward-pointing fuses of the first ring. Carefully fill more rough powder so that these fuses and their cross-matchings are submerged. The central area between the shells and the canulle may then continue to be filled either with stars or rough powder right to the level of the upturned bottoms of the second ring of insert shells.

The interstices between the second ring of shells and the case wall may be filled either with rough powder or *carefully* with sawdust, and rammed. If sawdust is chosen, care must be taken to avoid getting any in the central area between the canulle and shells. Finally, fill the canulle with FFA powder and withdraw it. Level off the fill with coarse rough powder and close the shell with a spolette having a charge of 1¼" of powder and its disc. Pleat down overhanging paper; put the second disc in place, and spike with the usual 24 vertical strings and horizontal strings to make little squares on the sidewalls of the case. Paste with three turns of 70-lb. kraft, dry, and paste again with two more turns. After drying, lift and leader in the usual fashion. Figure 66 shows a cut-away view of this shell.

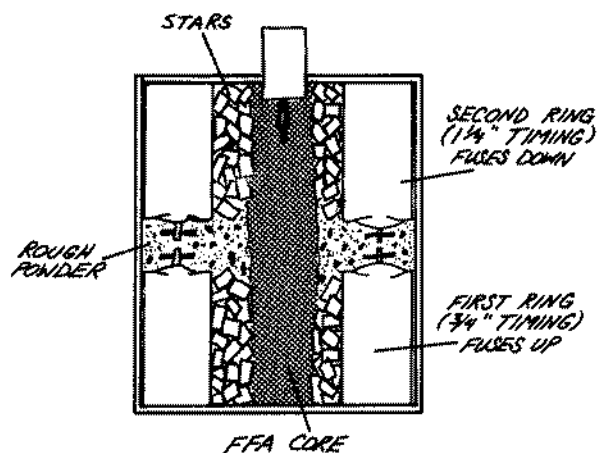


Figure 66. Two timed openings of shell-of-shells in one break.

This style of shell may also be made with a bottom shot, and if this is to be done, the spolette of the bottom shot may be rammed with 1¾" or even 2" of powder. The top spolette of the shell should then have only 1" of powder in it, and the pastewrap should consist of six turns — two, 48" sheets in the fashion described for the second and third variants.

General observations

The possibilities for variation on the shell-of-shells are numerous, by no means confined to those outlined here. These general principles should always be borne in mind, however: (1) The insert shells must fit *snugly* in the case of the large shell. This may be accomplished either by adjusting the size of the insert, or the size of the shell case; but if the latter, never so as to enlarge the case to a point where the finished shell will not fit its mortar easily. (2) If color stars are to be in the same opening as insert shells, they should be smaller than the normal size for the shell in question; in other words, use stars of the normal

size for 4" shells in 5" and 6" shell-of-shells; stars of the normal size for 5" and 6" shells in 8" shell-of-shells. (3) When multiple rings of shells having different timings are used, the *shortest* timing is placed on the *bottom* (or on top of the bottom shot); followed by the next shortest; and so on, with the *longest* timing closest to the *top*, next to the spolette. Those components placed at the top of the break are projected farthest from the break; those on the bottom tend to remain closer to its center. Since it is desired that the rings form themselves concentrically, it is logical to have the shortest timing closest to the center, etc. (4) As opposed to multiple break shells (in which, when many breaks are involved, the shell must be opened on the way up), when a single break of several timed openings of shell-of-shells is fired, it is desirable to have the shell as nearly stationary (at its apex) as possible. Then the insert shells will have only outward momentum from the break and gravity working on them, and will be most likely to form a symmetrical pattern. Thus a spolette of the full length should be used, and a generous lift charge to obtain the greatest possible altitude.

Insert shells for larger shells may of course be made larger than those described here. It is desirable to have at least six, and possible to have many more, in each ring. Small shells may be made as described here; larger ones may be made with end discs just as full-sized single-break shells, and in very large shells (such as 8" and larger) the inserts may even be fused with spolettes for extra precision. Shell-of-shells effects can of course be combined with other effects in multiple break shells when extremely elaborate shells are made. In such circumstances, it is generally wise to place them in the first break, since, as discussed under multiple break shells, the first break often seems to break harder than the subsequent ones, giving a better spread and a more symmetrical pattern, especially to be desired with shell-of-shells.

ROSETTES

As a change from the usual type of insert shell made with colored stars and powder, *rosettes* made with exactly the same style of case, spiking, and pasting, but containing instead a special granulated flash powder are occasionally made. The effect resembles to some extent that of a titanium report, but is not so loud, and the silver splatter is more of a streamer or spiderweb in its appearance than is the titanium, which is particulate in appearance.

The flash powder is mixed of the following formula:

	Parts	%
Potassium chlorate	5	58.82
Bright aluminum	2½	29.41
Antimony sulfide	1	11.76

Great care must be taken in mixing these ingredients, and the sieves used to mix them should be reserved particularly for this use, and washed between uses. After the mixed ingredients have been sieved three times through 20-mesh, they are ready for granulation. Fresh wheat paste must be mixed, rather thin (1 lb. of paste to 10 pints of water or so). Do *not* use paste which may have undergone, or may be undergoing, a souring reaction! If the above mixture is made in pounds, somewhere between four and five pints of such paste will be needed to reduce it to a granula-

table condition. The resultant dampened mixture should have a consistency like dough and be able to be consolidated into a ball.

The granulation should be done through 3x3 hardware cloth, pushing the composition a couple of times through the sieve just to make sure it is well mixed. Finally, granulate onto paper-lined drying trays, as if making rough powder. After the results of this granulation have had an opportunity to dry for an hour or so, gently re-granulate through 3x3, using a sweeping motion. This repeated granulation tends to round the grains and to eliminate the dust.

After drying for several days in the shade, the dried rosette composition should be gently broken up and again sieved through the 3x3 cloth. The loose granules should then be shaken on 8x8 hardware cloth to remove those granules that are too fine. The desired result is a dust-free, coarse granular material, passing 3x3 and retained by the 8x8.

The insert shell cases are filled full of this material without other additions. They are then spiked, pasted, and prepared for insertion in shell-of-shells just as any insert shells would be. The most effective use of rosettes is made in shell-of-shells that open dark and contain one or more timed openings of rosettes, followed by a heavy report.

TIMED INSERT EFFECTS USING SPOLETTES

As experience in making multiple break shells amply will demonstrate, the variation in length of powder charged into a spolette is a versatile technique for timing a sequence of effects in a shell. This technique is exploited to the fullest, however, not in multiple break shells (where one spolette takes fire successively after another), but in shells containing, in one break or opening, several inserts each equipped with its own spolette. Each spolette is charged with a different length of powder. When the shell opens, all spolettes take fire simultaneously; each burns through at a different time, resulting in a succession of effects timed (if the work has been done correctly) with clockwork precision.

In order to simplify further discussion, a word is in order about the spolettes used for these timed effects. The tubes used are those appropriate for 3" shells (see Part I, Table 5, p. 12) — 5/16" inside diameter, .550" outside diameter, and 2" long, or for longer timings, the same inside and outside diameters by 3" long. The spolettes are charged in increments of 1/4" of powder, and are denoted by the number of quarters of an inch of powder charged in them, as in Table 21 below.

Table 21. Spolette charges for timed effects.

Description	Tube dimensions	Length of charge
No. 1	5/16" x .550" x 2"	1/4"
No. 2	5/16" x .550" x 2"	1/2"
No. 3	5/16" x .550" x 2"	3/4"
No. 4	5/16" x .550" x 2"	1"
No. 5	5/16" x .550" x 2"	1 1/4"
No. 6	5/16" x .550" x 2"	1 1/2"
No. 7	5/16" x .550" x 3"	1 3/4"
No. 8	5/16" x .550" x 3"	2"
No. 9	5/16" x .550" x 3"	2 1/4"
No. 10	5/16" x .550" x 3"	2 1/2"

The spolettes are to be matched, nosed, tied, and pierced through the nosing as described in Part I, pp.

11-13. It may be noted that while the small tubes described above are used for inserts in a break, it may be desired to ram the indicated number of increments for one of the above timings in a large tube, as for a bottom shot, between breaks, etc., and in this case, in further discussion, this will be indicated, e.g., "No. 7 (large spolette) for bottom shot."

Timed report inserts

A convenient size for timed report inserts is "nominal 2"," in other words, the size that would be shot from a mortar of 2" actual diameter were they to be used as single fire reports. These actually finish at a diameter slightly in excess of 1 3/4", and fit four per layer in 5" shells (made on a 4 1/2" form), or six per layer in 6" shells (made on a 5 1/2" form). They are made like small hand-rolled salutes, with the exception that no end discs are used; the ends are formed of folded paper.

To roll such a salute, have a former made 1 3/8" in diameter, approximately 6" long on its working surface (exclusive of handle), with a hole approximately 5/8" in diameter bored about 4" down its length, centered on the flat end. This form is thus very much like that used for small shells for shell-of-shells, except for the diameter of the hole. The larger hole is necessary because of the larger diameter opening that must be pierced in the folds forming the case end, to accommodate the spolette.

Also have a pointed piercer turned from a 1/2" steel rod. This need not be equipped with a handle, since hand pressure will not be sufficient to force it through the folds, and it will be necessary to drive it through with a mallet. Figure 67 illustrates this piercer.

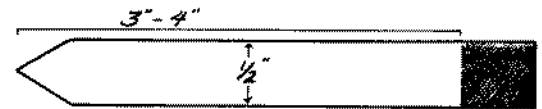


Figure 67. Piercer for report ends.

Cut strips of 30-lb. kraft 5" wide x 8" long, grain 5"; these are to form the inner bags of the small reports. Roll up the kraft on the form and slip it up over the end about one diameter, folding the ends shut with the tongue fold. Take the form, with folded over kraft still on it, and roll up, over the kraft, and flush with the end of the former, a strip of chipboard 2 1/2" wide and long enough to bring the exterior diameter to 1 3/4". The length of this strip will vary with the thickness of the available chipboard; naturally, a thicker chipboard will build up to diameter with fewer turns and thus a shorter piece will be needed than would be with a thinner chipboard. Try a 22 1/2" or 23" strip of .030" to start with, and adjust as necessary, using an outside calipers set at 1 3/4" as a gauge. If one strip of chipboard will not build up to the proper diameter, try adjusting the inside diameter of the case (i.e., the former diameter); the only thing critical is the outside diameter of the report. Finish the report with a strip of 40-lb. kraft 6" wide x 18" long. This is then folded down with a tongue fold to form one end of the case, secured with a dab of glue, and consolidated by rapping on the workbench.



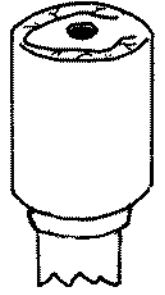
1. INNER BAG ROLLED OF 30-LB. KRAFT



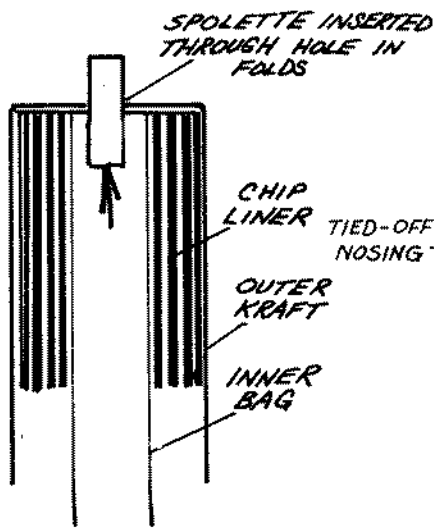
2. CHIPBOARD ROLLED OVER INNER BAG TO DIAMETER OF 1 3/4"



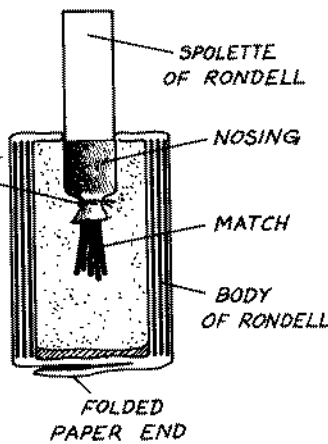
3. OUTER 40# ROLLED OVER CHIPBOARD AND CLOSED WITH TONGUE FOLD



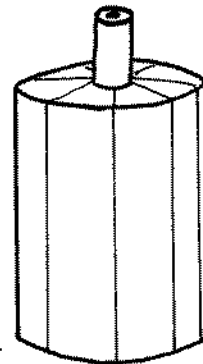
4. AFTER PIERCING WITH 1/2" HOLE ON FOLDED END



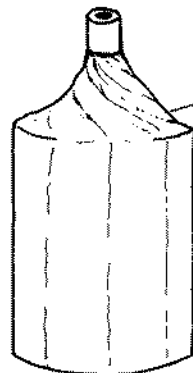
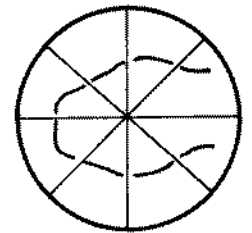
5. CROSS SECTION OF FUSED CASE



6. CROSS SECTION OF FILLED AND CLOSED CASE



7. SIDE AND BOTTOM VIEWS OF SPIKED AND FILLED CASE



HEAVY CROWN TO SEAL AROUND SPOLETTE

8. PASTED REPORT SHOWING STYLE OF TWISTED PAPER AROUND SPOLETTE TO MAKE A HEAVY CROWN

Figure 68. Details of timed report inserts.

Placing the piercer squarely on the center of the case end, drive it through the folds with the mallet, making sure it penetrates to the full 1/2" diameter portion of its shank. Holding the folds shut with two fingers (one on either side of the piercer) extract the piercer (otherwise it has a tendency to pull the folds open). The pierced case may now be removed from the form.

Insert spolettes of the required timings into the pierced holes. They should be inserted so that 1 1/4"-1 1/2" of their length protrudes from the case, regardless of whether they are 2" or 3" tubes (this is to assure that they stack uniformly in the shells they are put into). The flush rammed end of the spolette is on the outside, nosed and matched end inside the case, as in a normal single-break shell or report.

Fill the inner bag with flash powder (which need not be diluted with filling or bulking agents) to about 1/2" below the chipboard core. Fold the inner bag shut and push the folds down to the level of the chipboard or below. If space is left, this may be filled with a little sawdust. Finally, close the outer 40-lb. kraft with a tongue fold. The reports may now be spiked.

Spike with two strands of 8-ply cotton, making eight vertical passes (forming two crosses at 45° from each other on the bottom of the report). Horizontal or circumferential spiking is optional; the string may be tied off on the spolette after the vertical stringing is done. When the paste on the string has dried, it is important to seal well around the base of the spolette where it meets the string and folded paper of the case end, using white glue or liquid hide glue. When this glue is dry, the reports may be pasted with four turns

of 30-lb. kraft, or a piece of 6 1/4" x 24", grain 6 1/4". This should be folded on the bottom, and twisted around the spolette, while rolling; the paper should form a solid and heavy crown about the spolette, to seal the report against any premature ingress of fire. Figure 68 illustrates steps in the rolling, filling, spiking, and pasting of report inserts.

Construction of 5" color and 5-timed reports

Prepare four small reports with spolettes #2, #3, #4, and #5, in the manner just described. Prepare a bottom shot for a 5" shell as previously described. The spolette should be a #6 or perhaps better a #7, to allow a little extra time for the small reports. Match all of these spolettes by tying two strands of match over their scraped and roughened powder charges.

Cut a 48" and a 24" kraft strip 14 1/2"-15" long. Roll these up on the bottom shot in the usual fashion for color and report; alternatively, if the bottom shot is made with a 3 1/2" machine-wound core, roll a long case on the former, and "sawdust in" the bottom shot. This case should be exactly like a normal color and report shell except for the extra length to allow for the timed reports. Now the four small reports may be put in place around the shell wall. If the small reports do not "seat" well on the top of the bottom shot, sprinkle some sawdust or rough powder in before placing them, so as to have no hollows or air spaces at this juncture. They should fit snugly, with the spolette of the bottom shot sticking up in the central area amongst them. The interstices between the shell case wall and the small reports should be rammed with sawdust or rough powder, in the usual fashion. The central area up to the top of the sidewalls of

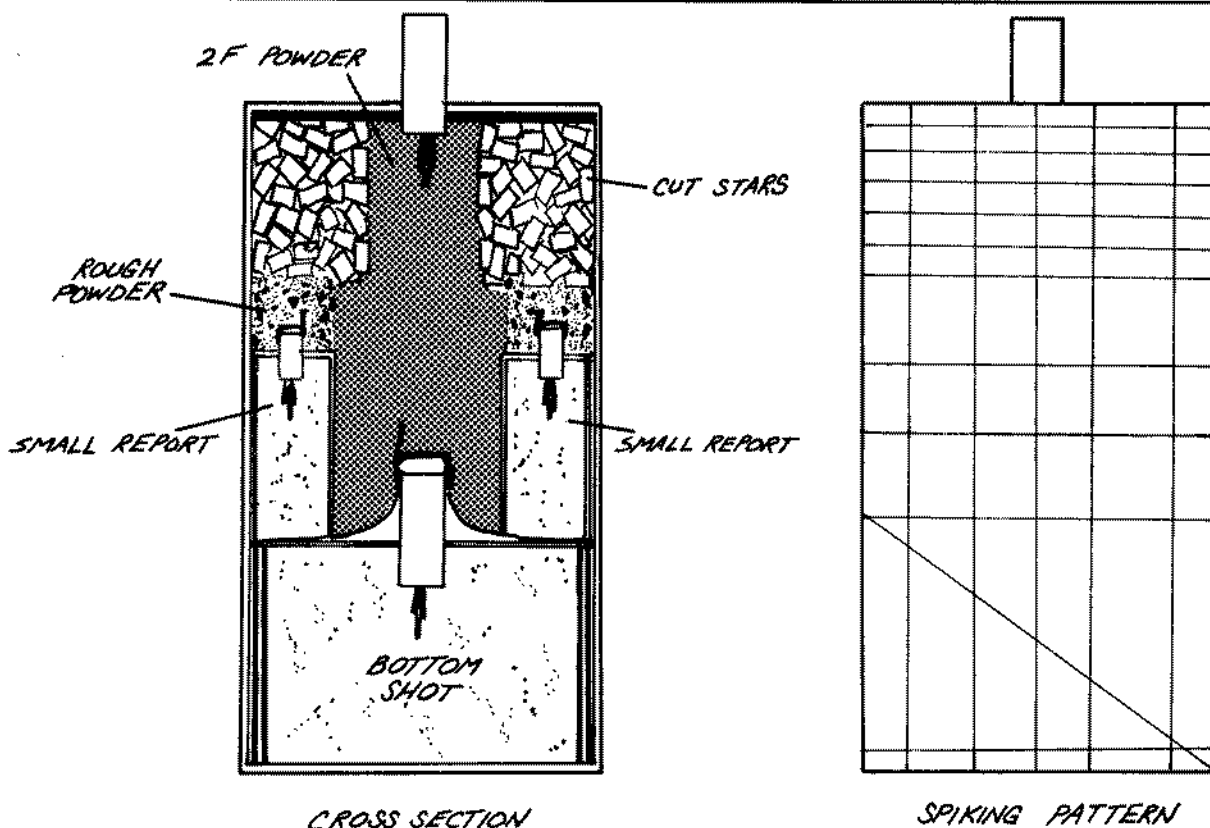


Figure 69. Color and five-timed reports.

the small reports is filled with FFA powder as a spreading charge. Now lower the canulle of appropriate size for the shell down onto the bed of FFA powder in the center. Fill around it with rough powder, to cover the spolettes of the small reports. On this bed of rough powder fill and consolidate stars of the desired color or colors, to a height of 3½"-4". Fill the canulle with FFA powder, remove it, and level the top fill off with more rough powder. Close the shell with a disc and spolette having a powder charge of 1". Spike with the normal 24 vertical strings, coming up wide over the reports and making little squares as usual with the horizontal strings over the part of the case containing the cut stars. Figure 69 illustrates cross-sectional and exterior (post-spiking) views of this shell.

Paste with one 48" sheet of 70-lb. kraft, coming in just to touch the spolette on top, and covering the bottom; let dry. Paste again with one 48" sheet of 70-lb., extending a full diameter over the top and bottom both, tearing into six strips on the top and tearing each strip halfway down to "fork" around the spolette. After this is dry, the shell may be fitted with lift (one ounce per one pound of shell weight) and leader.

The shell may be made with no colored stars, to break dark. In this case, the small reports may be made with #1, #2, #3, and #4 spolettes, and the bottom shot with a #5 or #6. The reason for starting with a #2 when color is used is to permit the color break to develop before beginning with the reports; a #1 spolette will cause the first report to break almost as the shell opens, which would spoil the effect of the color. If the shell is made with no color, the paper for the case may be cut to a shorter width accordingly.

Construction of 6" color and 7-timed reports

Prepare six small reports with spolettes of #2, #3, #4, #5, #6, and #7 lengths. The bottom shot for a 6" shell should have a #8 or even a #9 spolette in its usual size tube. Scrape and roughen, and match all spolettes as for the 5" color and five-timed report shell.

Cut two 48" strips of 70-lb. kraft 16-17" wide. Roll up the case on the bottom shot (or if it is made on a 4½" core, roll up the case on the former and "sawdust it in"). Place the small reports around the sidewall and ram as usual with sawdust or rough powder. Set the canulle down over the spolette of the bottom shot and fill around it with rough powder, up to the tops of the spolettes of the small reports. Fill with colored stars to a depth of 4" or so, consolidating in the normal fashion; fill the canulle with FFA powder, remove, level off with rough powder, and close with a disc and spolette having a powder charge of ¾". This short charge becomes necessary because of the long timing of the many inserted components.

Spike with 32 vertical strings and horizontal spiking, wide over the reports and making little squares over the color, as in the 5" five-timed report shell. Paste in with two 48" sheets of 70#, the first to come into the spolette, the second to tear down around it, just as in the previous example (allowing drying time between the two pastings). Lift and leader as usual.

This shell may also be made without color, and the timing of the small reports may then again begin with the #1 spolette and may be shortened accord-

ingly through the sequence, in the same manner and for the same reasons as the 5" five-timed report shell.

Construction of 5" 9-timed reports

Having mastered the five-timed and seven-timed report shells, the more difficult project of nine-timed reports may be tackled. This shell approaches the limits of timing of effects contained in one opening, and care must be taken that none of the reports fall too close to the ground (much less on the ground). It should be said here that it is extremely unwise to put a spolette with more than a 2½" powder charge on any bottom shot or insert. Items with more time can and will come all the way back down. Better to have too short a time on the spolette of a bottom shot than to have it drop in a crowd! Not only must the timing of the reports be impeccable, but also the shell must be constructed strongly, to withstand the heavy lift.

The bottom shot, made as usual for a 5" shell, should have a spolette of #9 or even #10 duration. The eight small reports will begin with #1 and go through the sequence to #8. Begin by rolling the case up on the bottom shot. It may consist of one 48" and one 24" strip about 15-16" wide, or, for extra strength, two 48" strips of 70#. The "sawdusted in" bottom shot is not recommended for this shell, as it is difficult to achieve firm ramming of the sawdust in such a long case, and also it is more time-consuming to manipulate; also, the usual case form is not long enough to roll such a case.

Making a bed of rough powder or sawdust so that the small reports may be seated firmly with no hollows nor air spaces on the top of the bottom shot, place reports #5, #6, #7, and #8 in the case, their matched spolettes pointing up. Ram the interstices with rough powder or sawdust. The central space, accommodating the matched end of the bottom shot, should be filled with FFA powder to the height of the small reports' sidewalls. Some makers, however, eschew any use of FFA powder in a nine-timed report, feeling that the shots will be spread adequately with pure rough powder while opening the shell during its ascent.

The space above the sidewalls of the small reports is usually filled with rough powder, until the spolettes, and their match, are well covered. The #1, #2, #3, and #4 reports are now put in place with their matched spolettes down. These spolettes should fit into the spaces between the spolettes of the first ring of small reports which have upward-pointing spolettes; in other words, the reports in the top ring are staggered. At this point, the rough powder filling between the spolettes of the bottom ring should still be somewhat loose. Push the reports in the top ring down so that they seat firmly in this bed of powder. Now a little powder is poured into the central hollow and lightly consolidated with a wooden stick. The interstices between the top ring of reports may be rammed either with rough powder or with sawdust; but if sawdust is chosen, care should be taken to get none down the central hollow.

It is desirable to communicate fire quickly to the center of the break to ignite all the spolettes of the small reports, as well as that of the bottom shot. In order to accomplish this, the spolette for the main break of the shell is often equipped with especially

long match, and often a "splint" of thin wood (such as a long matchstick) is tied in with the nosing so that the match is not broken or bent when forced down the central powder core. A better way, however, is to hold the matched spolette in place while filling the powder around it in the central hollow of the top ring of reports. When filled, the spolette will rest in its approximate final position, and this may be adjusted by slight pulling and pushing or lateral movement that will not be so likely to break the long match. Finally the punched end disc is placed down over it and firmly seated in place. The bottoms of the top ring of reports should, needless to say, be as even and

level as possible; if there are any irregularities, the top of the shell may be filled to level with rough powder as usual, before seating the end disc.

The shell should be spiked with the usual 24 vertical strings, with side stringing coming up wide over the bottom shot, and about double width all the way up to the top over the area of the small reports. Pastewrap is two 48" sheets of 70#, the first coming into the spolette and the second extending the full diameter, torn down and forked around the spolette, as previously described, drying as usual between the two pastings. Lift and leader as usual, using one ounce of lift per pound of shell weight. This shell must be fired from a sound, full-length (30" minimum) 5" mortar; observe it closely and if the bottom shot falls too low, more lift is necessary. This shell should open while it is still on the way up, and momentum carries the components further upward before they begin to fall. Also it should be noted that the two rings of reports are placed differently than in shell-of-shells. Here the shorter timings are in the top ring precisely because they will be thrown out farther from the burst. The pattern of the reports is of no concern (as compared to a shell-of-shells where symmetrical rings make the effect).

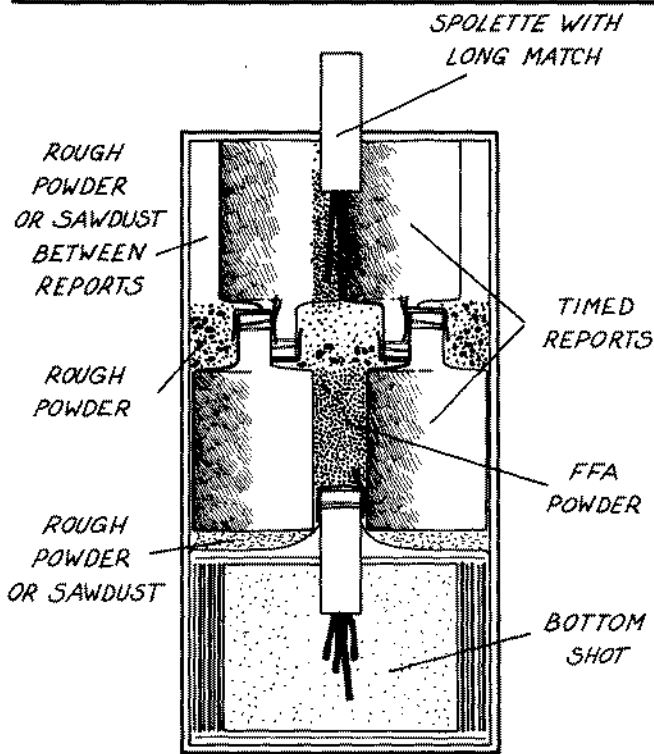
Figure 70 illustrates the cross-sectional and exterior views of a nine-timed report, as well as a top view showing the staggering of the reports.

Construction of a 5" draw-out shell

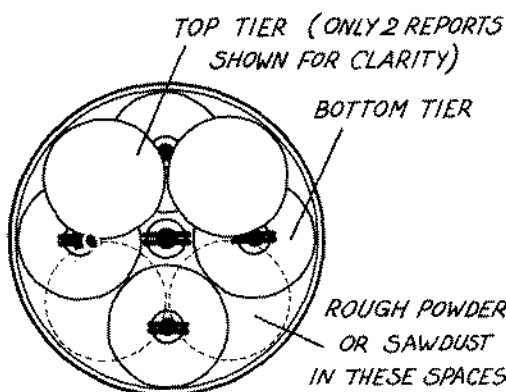
Previous discussion has centered on shells which contained a variety of timed reports all in one opening. The so-called "draw-out" shell relies on combining this timed-report construction with usual multiple-break technique. In construction, it is a normal shell of two color breaks and report; however, the first break contains four timed reports, and the second color break does not open until these timed reports have all exploded. The final heavy report follows the second color break with normal timing.

Begin by constructing a bottom shot for a 5" shell. The spolette should be charged with 3/4" of powder. Roll up, fill, and close the bottom break and report all in the usual fashion. The spolette (charged in the usual large tube for breaks on a 5" multiple break shell, viz., 2 1/2" long x 3/8" or 5/16" I.D. x 5/8" or 11/16" O.D.) should have the #5 charge, 1 1/4". Spike this break and report in the usual fashion. Match the spolette by the preferred technique (see discussion of multiple break shells).

Roll a long case for the top break and four timed reports; the paper can be one 48" and one 24" strip of 70#, each 10-10 1/2" wide. Place the four matched reports, spolettes pointing up, on the punched disc at the bottom of this case. Ram the interstices with sawdust or rough powder and set the case on top of the previously spiked break and report. Lower the canulle over the matched spolette of the break-and-report. Fill around it with rough powder, up to cover the spolettes of the small timed reports. Fill above the reports with colored stars, consolidating as usual; fill the canulle with FFA powder and withdraw. Level the fill, consolidate, and close the shell with a disc and spolette having a 3/4" powder charge. The timed reports in this shell should have #1, #2, #3, and #4 timings.



CROSS SECTION



VIEW FROM TOP
SHOWING STAGGERED
POSITION OF REPORTS

Figure 70. Nine-timed reports.

Now, spike this break on with 24 vertical strings, laid between the 24 verticals previously spiked on the bottom break and report. Having finished the verticals, spiral down to the bottom, coming up wide over the report. Spike as usual with little squares over the color break, then lay the string close over the junction of the breaks. Come up wide over the timed reports, again making squares over the color of the first break, finishing by casting the usual half-hitch over the shell at the top of the first break. Pastewrap is one 48" sheet of 70# to come into the spolette, and one 48" sheet of 70# extending the full diameter, torn down around the spolette as in previous examples, with drying between the two pastings. Lift with one ounce per pound of shell weight up to 10 lbs., ½ ounce per pound thereafter. Figure 71 shows cross-sectional and exterior views of this shell.

This style of shell is subject to further elaboration, which usually takes the form of special effects other than cut stars being put in the second break. Saettines, shell-of-shells with ¾" timing between cross-matchings, and whistles are examples of such effects. If this is done, the spolette of the bottom shot may be lengthened to 1" or 1¼" to delay its explosion until the effects are finished; the other timings (of the main spolette and timed reports) should be kept the same.

It should be noted that the two openings of a draw-out shell apply force over the full diameter of the shell. If one employs a first break of color with the four reports, this can be sufficient to halt the upward travel of the shell, if the orientation of the shell in the air is right. Therefore, if there is too much time on the second break, such downward travel could be accelerated (if orientation of the shell were again just right), and the bottom shot could hit the ground.

Construction of 5" hammer shell

The use of spolette timing of insert effects is not confined to reports. It may also be used to time bursts of color, by themselves or mixed with reports. One such effect traditionally made is the so-called "hammer" shell, which consists of four color bursts alternating with four reports, timed in sequence: color, report, color, report, color, report, color, report. If success has been achieved with the timed-report effects previously described, this shell is simple in its conception and should pose no problem.

Make spolettes with powder charges #1 through #8. Assign the *even*-numbered spolettes, #2, #4, #6, and #8, to the manufacture of timed report inserts exactly as in the previous examples. For the *odd*-numbered spolettes, provide a former 1¾" in diameter, and a supply of 1¾" end discs, some punched with ½" holes for spolettes, some solid; small cut stars as for shell-of-shells inserts; and strips of 125-lb. tagboard 2½" wide x 11" long; and strips of 60-lb. kraft paper 5" wide x 18" long. These materials are used to make the small color bursts. The 1¾" case former should have a ⅝" hole bored 3-4" down the center of one end, to accommodate the matched end of the spolette.

Roll up the 60-lb. kraft on the form and paste down the edge. Slip this tube up over the end of the former, in the fashion well known for shell cases, and insert the fused disc, matched end into the hole in the former. Pleat the overhanging paper down over the disc, setting the folds and placing another disc over them to hold them in place. The spolette, regardless of whether it is a 2" or a 3" tube, should be seated so that about 1½" protrudes from the end of the case. Remove the case from the form; roll up a strip

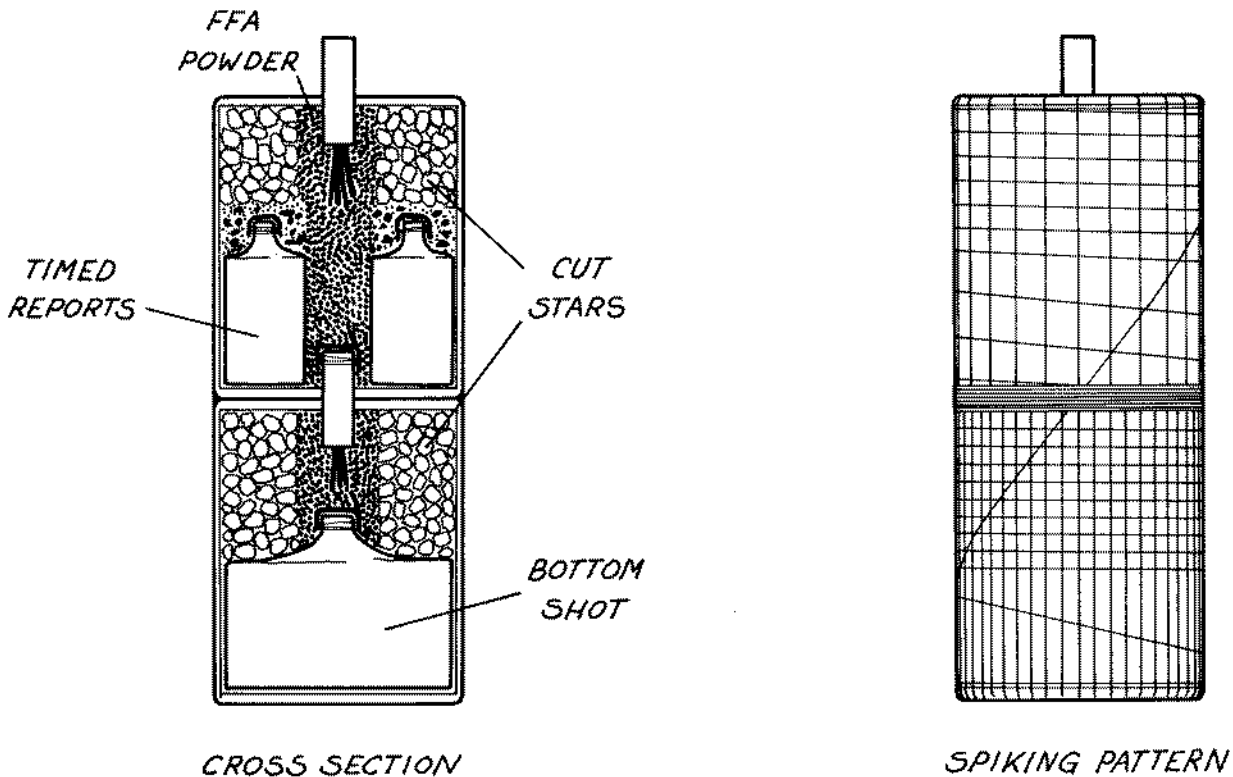


Figure 71. "Draw-out" shell.

of the tagboard and insert it into the case as a liner (some pyrotechnists prefer to roll the tag, then the kraft, on the former — it is a matter of technique and whatever is easier is acceptable). When the four timed color burst cases are finished, they are ready to be filled.

Fill them like shell-of-shells; i.e., stars and powder may be put in alternately until the level of the liner is reached. It is difficult to core the powder in the center with so small a case. Level off the fill with more powder, and push an end disc down onto the stars and powder. Close the bottom of the case with a tongue fold over the disc.

Spike the color shells like larger shells, using eight vertical strings and horizontal spiking to make little squares on the sidewalls. Seal well around the spolette with glue after spiking. When this is dry, the little shells may be pasted-in with a 6¼" x 18" strip of 30-lb. kraft, grain the 6¼" way, forming up the crown about the spolette in the same way as with the timed reports.

When all the color and the report inserts are dry and ready, scrape and match all their spolettes in the usual fashion. The case for the shell may conveniently be rolled with a 10" wide strip each 24" and 48" long, closing not with a solid disc, but with a punched one. After removing from the form, insert a spolette nosed with long match into the punched disc; place another punched disc over the folds and press the two discs and the folded paper between them together with the hands, adjusting the spolette to make sure it is straight and inserted in the case to the proper depth. This spolette should have a powder charge of ¾".

Now the first layer of effects (viz., color #1, report #2, color #3, and report #4) may be set in place with the spolettes pointing *up*, the interstices between the inserts and the shell wall rammed with sawdust or rough powder, and the central hollow around the matched and nosed spolette filled with FFA powder, or a 50:50 mixture of FFA and rough powder. Building the shell on the fused disc in this manner obviates any problems with insertion of the spolette.

Now fill to cover, with mixed FFA and rough powder, the matched ends of the spolettes of this first layer. Place the second layer of effects (viz., color #5, report #6, color #7, and report #8) with matched spolettes pointing *down*, staggered so these spolettes nest in between those of the first layer, exactly as in the nine-timed report shell. Ram the interstices with sawdust or rough powder (if with sawdust, observing as usual the precaution not to get any in the central area); fill the remaining hollow in the center with more mixed FFA and rough powder, shaking and consolidating well to ensure that the area around the spolettes and crowns of the effects is well and solidly filled. Finally, if there is any irregularity of the up-turned bottoms of the small reports and color shells, level the fill with rough powder. Insert a solid disc; pleat the overhanging paper down, and the shell is ready for spiking.

Spike with the usual 24 vertical strings, and horizontally at about double the usual width, as for the nine-timed report shell. Paste in with two 48" strips of 70#, the first to come into the spolette, the second

to be torn down around the spolette, as on the nine-timed report shell. Lift and leader as usual.

This shell may be made with a bottom shot, using the timings for the nine-timed report shell. In this case, the sequence of color and report bursts should be reversed, with the reports using the *odd* numbers, the color shells the *even* ones, and the sequence will thus be report, color, report, color, report, color, report, color, heavy report.

Construction of 5" 8-timed spider shell and 9-timed spider shell

This shell is constructed very similarly to the hammer shell, except that the effects are all constructed like the color shells for the hammer shell. The stars with which the small shells are filled are of a charcoal streamer type. In order to procure a harder burst, some pyrotechnists add a small amount — ⅛ ounce, for example — of loose flash powder to the contents of the small shells. It is almost impossible in a 1¾" shell to make a sufficiently small flash bag to tie on the end of the spolette to contain this flash powder. Others find that finely granulated gunpowder, e.g., FFFFA, will give a sufficiently hard burst to make a good spider. Once the small spiders are made, the filling, spiking, pasting-in, and finish of the shell follow the pattern of the 5" hammer shell.

Like the hammer shell, the timed spider effect may be made with a report at the bottom, using the timings for nine-timed reports. Another possibility is to construct the shell with a large spider as the second break. This may be made with the #9 or #10 timing, rammed in a large spolette, with a flash bag tied onto it, and filled as for any bottom spider on a multiple break. This is then spiked vertically with 24 vertical strings and the eight-timed spiders put in a break case on top of the bottom spider break. It is convenient to roll the break case like the case for a normal eight-timed effect, and to place the bottom row of four shells, spolettes up, in it and to ram their interstices with sawdust or rough powder. This case is then set with punched disc on its bottom, over the matched spolette of the bottom break, and the filling of the top layer (spolettes down) of four shells completed with the two breaks stacked together. The main spolette of the shell, charged with ¾" of powder, is set in place as with the nine-timed report shell, the fill leveled with rough powder, and the punched disc placed over the spolette and firmly seated. Pleat the overhanging paper down, put another disc on over the folds, and spike, as for any two-break, with the 24 verticals laid between the strings previously spiked on the bottom spider break.

Horizontal spiking proceeds down the side, and up over the spider break on the bottom making little squares; laid close over the junction of the two cases; and up at about double width over the timed spiders, just as for the nine-timed report shell. Figure 72 illustrates cross-sectional and exterior views of this shell.

Some pyrotechnists believe that making a nine-timed spider shell is dangerous when using real spider shells. In modern practice some makers call a shell "nine-timed spiders" while actually using all *sferas* instead. True spiders as bottom shots are not advisable; and with *sfera* shells, small flash bags could conceivably be used.

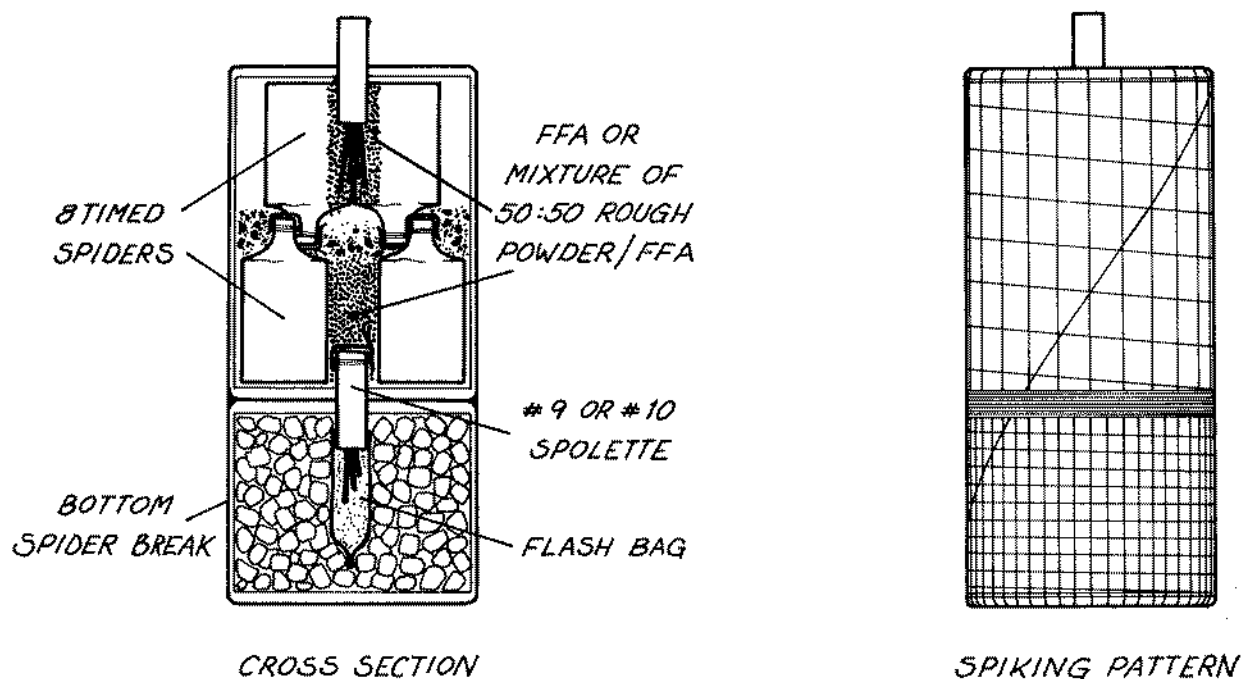


Figure 72. Nine-timed spiders.

General observations

As with shell-of-shells effects, it will be evident that there are many possible variations and combinations of spolette-timed effects. With experience, the pyrotechnist may adapt the techniques described here to vary the sequence of events to his taste. They may also be combined with other effects or types of construction; for example, one might have a dark opening of shell-of-shells as a first break, followed by a second break of color with four timed reports, then a heavy report.

While 5" is a typical size for these effects, and smaller sizes would be ineffective, larger sizes of 6", 7", and 8" are good for timed effects — particularly the hammer and timed spider type, where timed color bursts are used. These larger sizes are more seldom seen, because of the additional expense in making what are already laborious shells in the smaller 5" size. However, the use of larger inserts is made possible and the effect is still better. In 6", the insert effects to fit four per layer should finish at about 2¼" in diameter. Color bursts for hammer and timed spider shells are typically made on either a 2" or 2½" form, and reports may be rolled on a 1½" or 1¾" form with the chipboard core diameter at 2" to 2⅞" before rolling on the outer kraft. In 7", full sized 3" color shells and reports, rolled on 2½" forms (or cores of 2½" outside diameter) fit very conveniently in a case rolled up on a 6¼" former. Eight-inch, timed-effect shells are generally made with five shells per layer, using full-sized 3" shells. If a double layer is used, this permits 11 timings, so care should be taken to assure all of them burst well above the ground. One inch is a good starting charge to use in the spolette

of a 7" or 8" timed effect shell, allowing plenty of lift charge.

The uniformly successful achievement of timed-effect shells in these larger sizes represents one of the most demanding challenges in pyrotechny. Such shells should not be attempted until the simpler timed effects in smaller sizes have been mastered. Also they should not be used in public exhibition until the pyrotechnist has made adequate trials with the timing on all spolettes to ensure that no inserts or bottom shots come back down before exploding. The order in which the various shells described in this section have been presented approximates, in ascending order, their difficulty.

PARACHUTE SHELLS

The successful deployment of a flare or other pyrotechnic device from a parachute that has been ejected from a shell is one of the more difficult achievements of the shell-builder. In recent years, importation of adequate parachute shells from the Orient (made in the traditional Oriental ball-shell form), coupled with the increasingly close quarters in which firework displays must be shot (making any parachute effect of doubtful safety) have conspired virtually to eliminate the traditional cylinder-style parachute shell from current manufacture. Its construction is now an element of knowledge missing from the experience even of many otherwise accomplished shell builders.

The construction of paper parachutes, their shrouds, and their folding and preparation have been well described in several published works on pyrotechny. American makers have tended either to purchase prepared paper parachutes from the Orient (these were once, and may still be, an article of commerce among