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Aerial Shell Augmentation Effects

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This article provides information about a method of augmenting an aerial shell's aesthetic performance that is simple, high profit and widely appreciated by display sponsors. This method was first discussed many years ago by the authors as part of an article on electrically fired displays.[1] In that article, these effects were described as *parasitic firework effects*. They were described in that way because the "parasitic" firework effects (small shells, mine stars and other small components) derived their lift energy from other "host" aerial shells. In the present article, because it is more descriptive, these same effects will be called augmentation effects.

To draw lift energy most effectively from their host shells, the augmentation effects must be loaded on top of the host shell. Based on empirical observations, when the total weight of the augmentation effects is modest in comparison with the weight of the host shell, the altitude reached by the host shell is not noticeably reduced, and the augmentation devices reach ample height. Table 1 presents typical weights of spherical host shells and the augmentation firework effects used with them. The weight of augmentation effects range from as much as approximately 1/2 the weight of the host for a 3-inch (75-mm) shell, down to approximately 1/10 the weight of the host for a 12-inch (300-mm) shell. In part these varying relative weights correspond to the effective carrying capacity of the host shell. [Because of the relatively low ratio of shell mass to projected area, 3-inch (75-mm) shells require disproportionately larger lift charges to reach proper altitude than is required for larger shells. Accordingly, for the shell sizes listed, 3-inch (75-mm) host shells have the greatest relative carrying capacity for augmentation effects.]

Carrying capacity not withstanding, the varying relative weights for augmentation effects are the result of aesthetic considerations. When a 3-inch (75-mm) shell is properly augmented, those effects usually weigh about three ounces (85 g). For an 8-inch (200-mm) shell near optimum results can be achieved with about 16 ounces (450 g) of augmentation effects. To maximize the artistic effect, augmentation effects must be properly timed and sized with respect to the host shell. In general, the lowest altitude and smallest effects should occur first, followed by higher and larger effects leading to the break of the host shell, which should be impressively greater than the augmentation effects that preceded it. To illustrate this, consider one possible 4-inch (100-mm) *shell set* (host shell plus augmentation effects). On firing, the shell set first produces a blue-willow mine effect extending about 150 feet (50 m) in the air; this is followed shortly by a

Table 1. Augmentation Effect Weights for Spherical Host Shells.

Host Shell (Spherical)				Point Rating	Augmentation Effect Typical Total Weight	
Size		Approx. Weight				
(in.)	(mm)	(lbs)	(kg)		(oz)	(g)
3	75	0.3	0.1	1	3	85
4	100	0.8	0.4	2	5	142
5	125	1.5	0.7	3	8	227
6	150	2.5	1.1	4	10	284
8	200	5.5	2.5	8	16	454
10	250	11.	5.0	11	22	625
12	300	18.	8.2	14	28	795

flurry of four small purple (festival ball sized) breaks at about 250 feet (85 m), followed by the break of the 4-inch (100-mm) bright red chrysanthemum shell at about 500 feet (150 m). The synergistic effect of the combination of individual effects produces a result that is far more aesthetically pleasing than might be expected (particularly when the modest added cost for the augmentation effects is considered). Figure 1 is an attempt to illustrate how this 4-inch (100-mm) shell set might appear in comparison with the 4-inch (100-mm) shell alone.

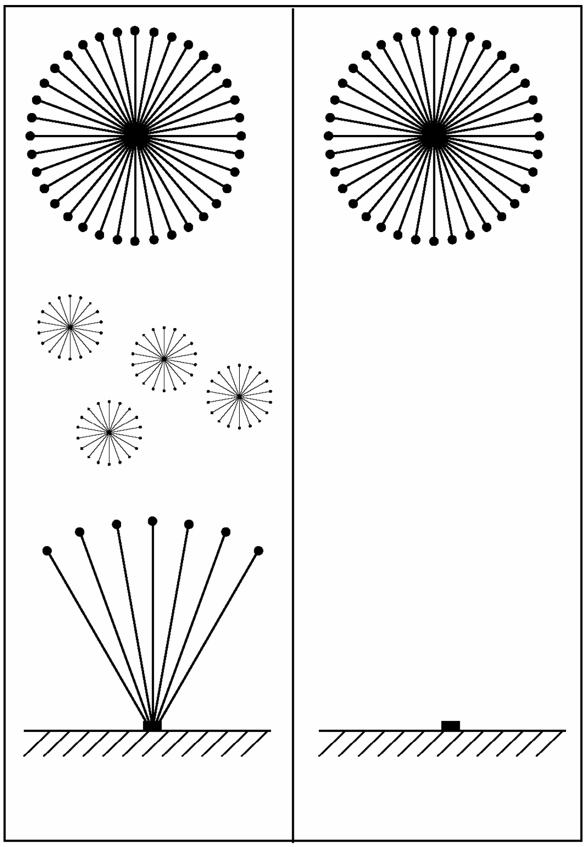

Figure 1. Illustration comparing augmented vs normal aerial shell bursts.

There are three main reasons to consider the use of augmentation effects. The first and most important reason was given above, aesthetics. Though often seriously under-utilized in displays, mines and ascending effects are attractive in their own right. They also offer variety, and they fill an otherwise unused portion of the sky. Another aesthetic payoff comes in the length of time the combined effects last; the use of a shell set such as the one described above produces a display that lasts at least twice as long as would be produced by the host shell alone. However, the most important aesthetic reason for using augmentation effects is that their use seems to significantly increase the perceived beauty of the host shell. This may be the result of helping to focus the audience's attention and build their sense of anticipation of the burst of the host shell, which then appears more beautiful than it would if seen as a single unheralded event. (Note that augmentation effects are most effective for displays using reasonably high quality star shells that are fired slowly enough for their beauty to be appreciated.)

The second reason to consider using augmentation firework effects is increased profit. Because the augmentation effects add so much to the favorable impression of the audience and yet cost relatively little, it is acceptable to increase the gross profit on their use. When the authors still performed displays, their gross profit for augmentation firework effects was approximately double that for the host shells. Yet the feedback from sponsors was universally favorable. (It's a great day when you can increase your profit and still have delighted sponsors wanting to shake your hand for the great job you did.)

The third reason for considering the use of augmentation effects is that their use allows a significant reduction in the variety of shells that must be kept in inventory. Consider the following three shell sets: (1) blue and willow mine followed by silver glitter augmentation shells followed by large red peony; (2) purple and gold glitter mine followed by green meteor shells followed by large red peony; and (3) green and silver comet mine followed by short-delay small artillery shells followed by large red peony. In each case the host shell was a red peony; however, even if these shell sets were fired one after the other, they would be perceived by the audience as presenting substantial variety. By using different combinations of only five types of mine stars (taken two types at a time), five types of augmentation shells and five types of host shells, it is possible to assemble 500 different shell sets. Obviously not all of the 500 shell sets will be artistically effective, but very many will. Thus the use of augmentation effects allows a significant reduction in the number of different types of shells needed in inventory. (This is especially useful for small scale operations.)

Augmentation effects should be prepared in advance by loading the mine stars and small shells or other small components into plastic bags and sealing them. A few of the possible assemblages of augmentation effects are suggested in Table 2. Large quantities of these pre-bagged items can be stored until needed during final loading before a show. Also given in the table is a point rating for each of the different assemblages. These can be used as an easy way of determining which and how many of each of the assemblages can be loaded on top of any given size host shell. (Note that Table 1 included a point rating for typical host shells.) Any number and combination of assemblages can be used as augmentation effects providing their cumulative point total does not exceed the point rating given for the host shell. For example, a 5-inch (125-mm) host shell has a point rating of three, thus (in addition to mine stars) six festival balls, or two festival balls plus one 2½-inch (65-mm) shell, or one 3-inch (75-mm) shell are all acceptable as augmentation effects.

Table 2. Some Possible Augmentation Effects.

Points	Description[a]
1	2 Festival Balls plus 1 oz (28 g) of mine stars
1	4 packs (approximately 70) Firecrackers or Jumping Jacks plus 1 oz (28 g) of mine stars
2	1 – 2½" (65-mm) Shell (may include 1 oz (28 g) of mine stars)
2	3–1" × l½" (25 × 38 mm) Flash Salutes
3	1 – 2½" (65-mm) Shell plus 3 oz (85 g) of mine stars
3	1 – 3" (75-mm) Shell (may include 1 oz (28 g) of mine stars)
3	1 – 2" x 2" (50 × 50 mm) Crossette Comet
3	6 oz (170 g) of 1" x 1" (25 × 25 mm) Comets
4	1 – 3" (75-mm) Shell plus 3 oz (85 g) of mine stars

Note — all items are heavily primed.

It is important that augmentation effects be well primed to insure their ignition by the escaping lift gases from the host shell. (See reference 2 for more information about primes and priming.) Probably the most reliable priming method is one that concludes with pressing the prime-coated item into granulated commercial Black Powder while the prime is still wet. This provides many angular points on the primed surface insuring easy ignition. Small shells are usually primed by dipping the whole area of their fuse into a prime mix (usually handmade meal powder in nitrocellulose lacquer), then momentarily pressing the primed area into 3 or 4 Fg commercial Black Powder. Packs of firecrackers or jumping jacks can be primed by running a bead of prime from a catsup-like squeeze bottle down the spine of each pack, then pressing the primed area into the Black Powder. Small individual components (such as small bees) are usually primed by dipping batches of several hundred at a time into the prime mix, then gently tumbling the items in handmade meal powder. Mine stars need only be primed as they would be for use in star shells. Priming is important in all cases, but especially when augmentation effects are loaded on top of canister shells, where it may be less likely than with spherical shells that each of the items will be well exposed to the burning lift gases. When augmentation items without a mine effect are used with canister shells, it is desirable to add a small charge of Black Powder to the plastic bag containing the augmentation effects. This will help to insure proper ignition of the effects by more completely filling the bag with fire when the host shell is launched.

Augmentation effects are loaded into mortars by simply dropping the filled plastic bags into the mortar after the host shell has been loaded. It is inappropriate and unnecessary to remove the augmentation effects from their bags. (Inappropriate because loose components or stars might jam between the host shell and the mortar wall; unnecessary because the plastic bag will melt away almost instantly from the flame escaping around the host shell when it is fired.)[3]

One word of caution: there is always the possibility that sparks from the firing of one shell will fall into other mortars and unintentionally ignite augmentation effects in those mortars. However, this is easily prevented by the use of individually applied protective covers placed over each mortar. Plastic sheeting and heavy aluminum foil is generally sufficient, but polyethylene pipe covers (such as those manufactured by Cap Plugs™) are probably superior. Further, it is thought that augmentation effects are only suited for electrically fired displays or preloaded manually fired displays. The use of augmentation effects in displays where mortar reloading is occurring is highly inappropriate for reasons of crew safety.

In the original version of this article, which included a discussion of augmentation (parasitic) effects, a series of reasons were given as to why there is essentially no reduction in the burst height of the host shells. However, at that time no measurements had been made to confirm and quantify that empirical observation. Recently, while studying the effect of varying mortar diameter and length on the height achieved by 3-inch (75-mm) aerial shells, some measurements were made of the degree to which the burst height of the shells was reduced when they were used as hosts for augmentation effects. In that work, it was found that under the conditions of the testing:

- 4600 feet (1400 m) above sea level
- 20-inch (500-mm) long mortars with an internal diameter of 2.93 inches (74.4 mm)
- The standard test shell was a 3-inch (75-mm) Thunderbird Color Peony-White, TAB-106, with an average diameter of 2.72 inches (69 mm) and an average mass of 4.8 ounces (36 g)

When fired alone, the aerial shell burst at an average height of 530 feet (162 m). (Further details of the test methods can be found in two articles reporting on those studies.[4,5]) When the augmentation effects with a weight totaling 3 ounces (85 g) were added on top of the test shells, the burst height of the host shell was reduced to an average of 505 feet (154 m). This corresponds to a reduction of only approximately 5 percent in burst height, which can be safely tolerated for properly performing aerial shells. While measurements were not made using larger shells, it is thought that the reduction of burst height would be proportionately no more than that found in this study. (This is because augmentation effect weights represent a smaller proportion of the weight of the larger caliber shell.)

References

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