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Stars Blown Blind

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When an aerial shell bursts, stars that fail to burn are often said to be "blind stars", or more descriptively as having been "blown blind". This detracts from the beauty of the shell and contributes to debris fallout. The problem can be caused by any of a combination of factors; the most important of these are the degree of violence of the shell burst and the burn characteristics of the stars.

In simplest terms, a star will ignite when its surface has been raised to its ignition temperature. The star will continue to burn only so long as the burning surface feeds sufficient energy to the next deeper layer of the star, to raise that unignited composition to its ignition temperature. (See Figure 1.) (For a more complete discussion of pyrotechnic ignition and propagation, see reference 1.)

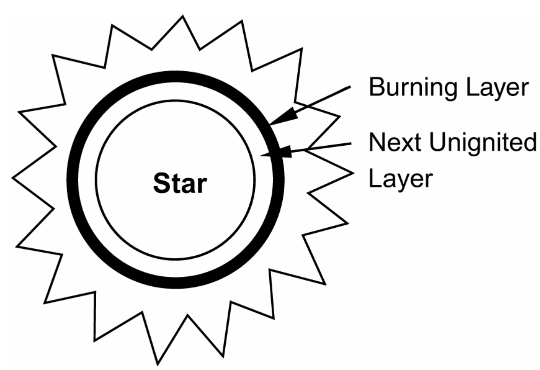

Figure 1. Illustration of a burning fireworks star.

One way in which thermal energy is fed to the next (unignited) layer is for radiant energy from the flame to be absorbed by the surface of the star and then conducted more deeply into the star. When a burning star is moving through the air, the flame will be deflected down wind. (See Figure 2.) Thus, in this case, the feedback of thermal energy to unignited composition is impeded. Also, the up wind side of the star will be

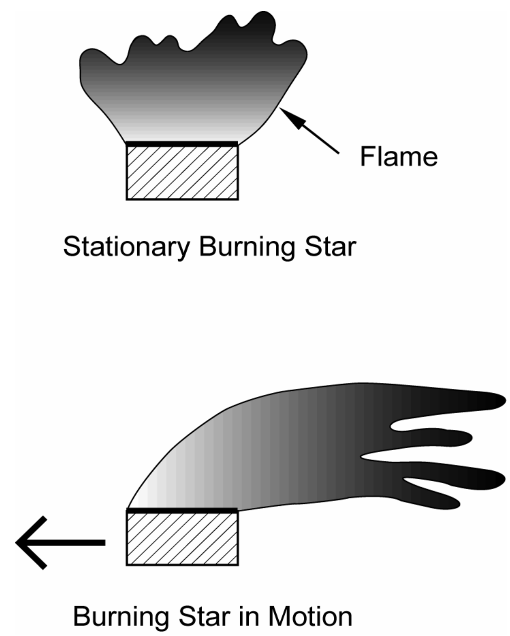

Figure 2. Illustration of the effect of air movement past a burning star.

exposed to relatively cold air. This acts to further cool the burning surface.

During some recent tests, this effect was captured on film. Figure 3 shows the explosion of an 8-inch aerial shell that had been suspended in a test stand. (The purpose of this test was to determine its time to explosion and the blast pressure produced.) Figure 4 is an enlargement of a portion of Figure 3, showing stars (dark spots) with their flames (light areas) trailing behind.

If the amount of energy being fed back is no longer sufficient to raise the next layer of the star to its ignition temperature, the burning star will be extinguished. Among those factors of importance in determining whether this will happen is the speed of the star as it moves through the air. The faster the star is moving, the more its flame trails behind it, thus feeding

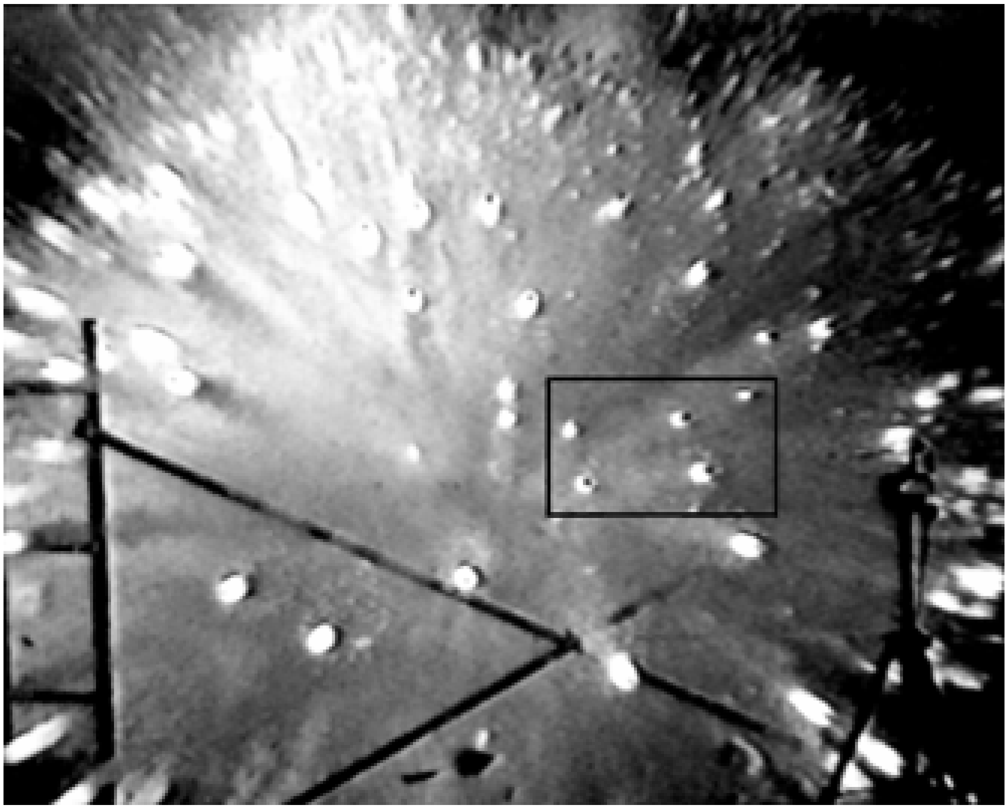

Figure 3. Explosion of an aerial shell in a test stand.

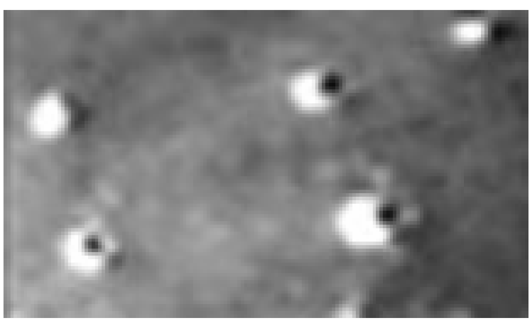

Figure 4. Enlargement of Figure 3 showing the flames trailing the burning stars.

back less radiant energy. Also there is a greater cooling of the star's surface from the air impinging on it. For a given star size and mass, its initial speed is determined by the violence of the shell burst. Thereafter the star slows due to aerodynamic drag forces. Thus, if a star manages to stay ignited during the first brief moments after the shell bursts, it will generally burn completely.

Other important factors determining whether a star will be extinguished upon shell burst are associated with the chemical nature of the star. For example, one factor is the amount of heat being produced by the burning composition; another is the amount of energy needed to raise a composition to its ignition temperature.

Often star priming is only thought of in terms of aiding star ignition. However, it is also an important aid in the continuation of burning during and just after shell burst. (For a more complete discussion of this phenomenon, see reference 2.) When the authors manufactured spherical stars commercially, they concluded that the optimal amount of rough meal prime was to use as much as possible without noticeably delaying the visual appearance of the star after the shell burst. Generally this was 10–15% of prime (by weight) for stars larger than 3/8 inch, and 15–25% for stars smaller than 3/8 inch. This was felt to be optimum for two reasons. First, with this amount of prime, perchlorate color stars and even strobe stars would stay ignited even after emerging from hard-breaking shells.

Second, rough meal prime (75% potassium nitrate, 15% charcoal, 10% sulfur and +5% dextrin) is the least expensive composition used in making stars. The more of it that could be used without detracting from the star's performance, the less expensive the stars could be made.

Blind stars are often thought of as failing to ignite before the shell bursts. However, as discussed above, the stars may have ignited, only to be blown blind by the violence of the explosion of the shell. Two easy solutions to the problem are to break the shells more softly or to prime the stars more heavily.

References

1) K. L. and B. J. Kosanke, "Pyrotechnic Ignition and Propagation: A Review", *Journal of Pyrotechnics*, Issue 6 (1997). Also appeared in *Selected Pyrotechnic Publications of K. L. and B. J. Kosanke, Part 4 (1995 through 1997)*, Journal of Pyrotechnics, Inc., Whitewater, CO (1999).

2) K. L. and B. J. Kosanke, "Pyrotechnic Primes and Priming", *Proc. 4th International Symposium on Fireworks* (1998).