Explosive Flashlight: A New Development in an Explosive Light Source

By JACK GERSHON and R. H. STRESAU

An explosive flashlight has been developed at Armour Research Foundation for use as an ultra-high-speed photographic light source. The flashlight consists of a long Plexiglas cylinder $2\frac{1}{4}$ in. ID by $2\frac{1}{2}$ in. OD; the inside wall is partially lined with Du Pont EL 506A-8 sheet explosive and the interior is filled with argon gas. The duration of illumination is controlled by the length of the cylinder; the light reaches the required intensity in 10 μsec and has no effective tail. The light intensity is sufficient for microsecond color photography.

The light source also has the advantages of being (1) easily handled (because of its light weight and the safety of Du Pont sheet explosive); (2) easily preassembled and stored; and (3) waterproof. Since the duration of illumination can be varied, the flashlight is an appropriate light source for photographic applications where the light duration must match varying event times. This flashlight has been used as a light source for the Beckman & Whitley Model 189 Framing Camera.

In the past, explosive-argon flashbombs have been widely used where illumination sufficient for photography with microsecond exposure times and relatively small apertures was needed. The advent of Du Pont sheet explosive has opened new possibilities in the design of more easily constructed, rugged and convenient light sources of this general description.

The present paper is a description of one such type of explosive flashlight which has been developed at the Armour Research Foundation. The flashlight is specifically designed to be used with the Beckman & Whitley Model 189 Framing Camera, where the duration of illumination must be tailored to fit varying event times.

The explosive flashlight consists of a long acrylic plastic tube that is partially lined with Du Pont EL 506A8 sheet explosive. The tube is sealed with a 4 by 4 by $\frac{1}{4}$-in. acrylic plastic window on one end and a $2\frac{1}{4}$-in. diameter sheet explosive disc on the other end.

Presented on October 17, 1960, at the Fifth International Congress on High-Speed Photography in Washington, D.C., by Jack Gershon (who read the paper), Armour Research Foundation of Illinois Institute of Technology, 10 West 35 St., Chicago 16, and R. H. Stresau, Consultant, 7 Summit Rd., Lake Zurich, Ill.

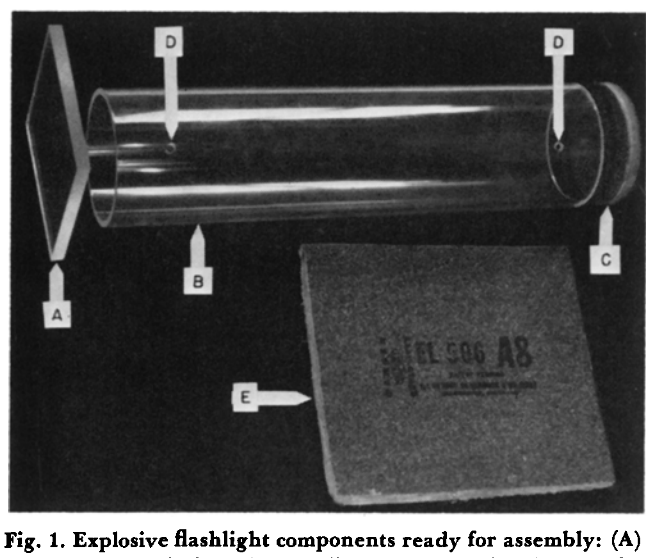

Fig. 1. Explosive flashlight components ready for assembly: (A) acrylic plastic window; (B) acrylic plastic tube; (C) sheet explosive disc; (D) argon filler holes in the tube wall; and (E) unrolled sheet explosive liner.

The tube is $2\frac{1}{2}$ in. in outside diameter and $2\frac{1}{4}$ in. in inside diameter. The tube length varies according to the duration of illumination desired. Two $\frac{1}{8}$-in. holes are drilled in a line along the tube 1 in. from each end. These holes allow the tube to be purged of air and filled with argon gas prior to a test firing.

The sheet explosive is cut in such a manner as to allow a $\frac{1}{4}$-in. to $\frac{1}{2}$-in. gap in the circumference when it is rolled to fit inside of the tube. This cylinder of explosive is then slid into the tube with the circumferential gap lying below the $\frac{1}{8}$-in. holes in the tube. This allows the flashlight to be easily filled with argon gas.

Pyroxylin base cement* is placed on the rear edge of the sheet explosive liner, and the $2\frac{1}{4}$-in. diameter sheet explosive disc is slid into the tube until it touches the liner. The disc acts as a seal for the rear of the acrylic plastic tube and as a means of detonating the explosive liner.

The front of the tube is sealed with a 4 by 4 by $\frac{1}{4}$-in. acrylic plastic window. The window is also affixed to the tube with pyroxylin base cement.

The window end of the flashlight is pointed at the subject under observation from a distance of approximately 4 ft. This provides an even concentrated field of illumination about 15-in. in diameter. If a greater field of illumination is desired, a double concave lens can be affixed to the acrylic plastic window to increase the area of illumination to about 3 ft in diameter.

Figure 1 shows the explosive flashlight components ready for assembly: A, the acrylic plastic window; B, the acrylic plastic tube; C, the sheet explosive disc; D, the argon filler holes in the tube wall; E, the unrolled sheet explosive liner. Figure 2 shows the flashlight assembled and ready for storage or use.

Since the shock through the argon atmosphere retains nearly its full strength beyond the end of the sheet

* Duco household cement, e.g.

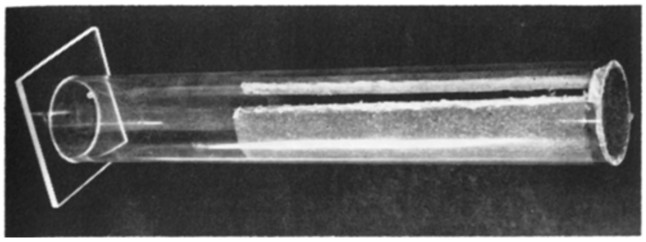

Fig. 2. Explosive flashlight assembled and ready for storage or use.

explosive, it is necessary to line only about three-fifths of the tube with an explosive liner. It might be mentioned that this construction results in a more uniform luminosity throughout the length of the tube.

Figure 3 shows a cross section of the flashlight. An electric detonator initiates a tetryl pellet which in turn detonates the sheet explosive disc. The reaction of the disc sends an expanding spherical shock wave down the tube. The convergent output of the explosive liner reinforces the shock wave and maintains its velocity, temperature and luminosity at levels well above those of the sheet explosive liner. For this reason a smaller amount of explosive can be used for a given duration of light. As an example, in a 100-μsec duration flashlight, the weight of the explosive disc and explosive liner is approximately 2 lb.

Simple estimates of light intensity were made by comparison of photographs made using flashlights of this type with others made by direct sunlight. The same film and objects were used in both sets of photographs. The Beckman & Whitley framing camera was used with the explosive flashlights, while the pictures taken by sunlight were photographed with a still camera at the same aperture (*f*/16) as the Beckman & Whitley camera, but at varying shutter speeds. By this means it was estimated that the illumination, by the flashlight, of the 15-in. field mentioned previously is about 10,000 times that of direct sunlight or close to 100,000 lm/sq cm.

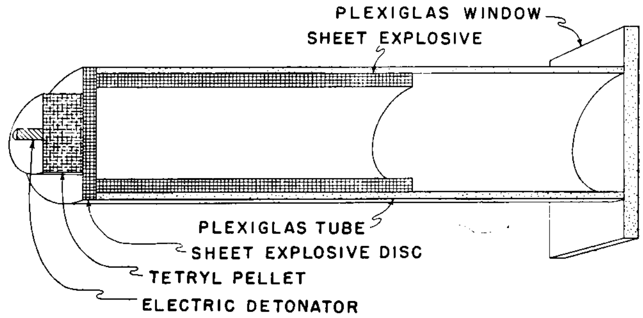

Fig. 3. Cross-sectional view of explosive flashlight.

This illumination is adequate for microsecond color photography.

The duration of the light at maximum intensity may be varied by varying the length of the flashlight. It is very nearly 4 μsec for each inch of the acrylic plastic tube. (As previously mentioned, the explosive liner is roughly three-fifths of the tube length.) It is estimated from streak camera photographs that the maximum intensity is gained within 10 μsec after the firing of the detonator, and that after the uniform output it decays from maximum to negligible intensity in 10 μsec.

The experimental program for which this flashlight was developed is described in a separate paper presented at the Fifth Congress, entitled "Microsecond Observations of the Dynamic Response of Explosives to Very High Rates of Loading," by H. S. Napadensky, R. H. Stresau and J. Savitt. That paper includes several sequences of events photographed using explosive flashlights as herein described.

Some of the advantages of this explosive flashlight are: (1) it is easy to handle due to the light weight and safety of Du Pont Sheet Explosive; (2) it is waterproof; (3) a number of flashlights can be assembled and stored; and (4) by varying the tube length and explosive liner length the duration can be tailored to fit various event times.