### THE TYPE 300 MICROFLASH LAMP

The type 300 microflash lamp was produced at the Lamp Development Laboratory of the General Electric Company with the consultation and assistance of the University of Michigan flash lamp group, to serve as a pulsed radiation source in equipment for detecting the range and direction of certain types of targets by means of near infrared radiation (see Chapter 6). It was initially desired that the source be capable of continuous operation at the rate of 60 to 120 flashes per second for periods of several minutes at a time, that its integrated useful life be at least several hours, that the amplitude of successive radiation pulses be essentially constant, and that each pulse have a duration of only about 1 μsec and the highest possible peak intensity in the near infrared. The type 300 lamp successfully meets all these requirements and has been used in models of the equipments for which its development was undertaken.

Two preliminary lamp designs,[22a] designated types 240 and 250, were developed by the University of Michigan. In each of these designs, as in the type 10 and in the type 200 lamp designs, the arc discharge is adjacent to a solid quartz surface. Although the radiation characteristics of these lamps are quite similar to those described below for the type 300 lamps, both designs were discarded because the useful life of these lamps was too short for satisfactory service in the intended application.

The designation "type 300 microflash lamp" has been used only by NDRC. The General Electric Company has so far designated the lamp simply a "short-gap double-ended lamp." In this chapter, however, no distinction will be made between the lamps constructed by the General Electric Company and those constructed by the University of Michigan Contract NDCrc-185. Most of the variations in lamp design for the purpose of investigating the effect of various factors on the properties of the lamps, as well as the experimental investigation of these properties, were carried out by the University of Michigan group.

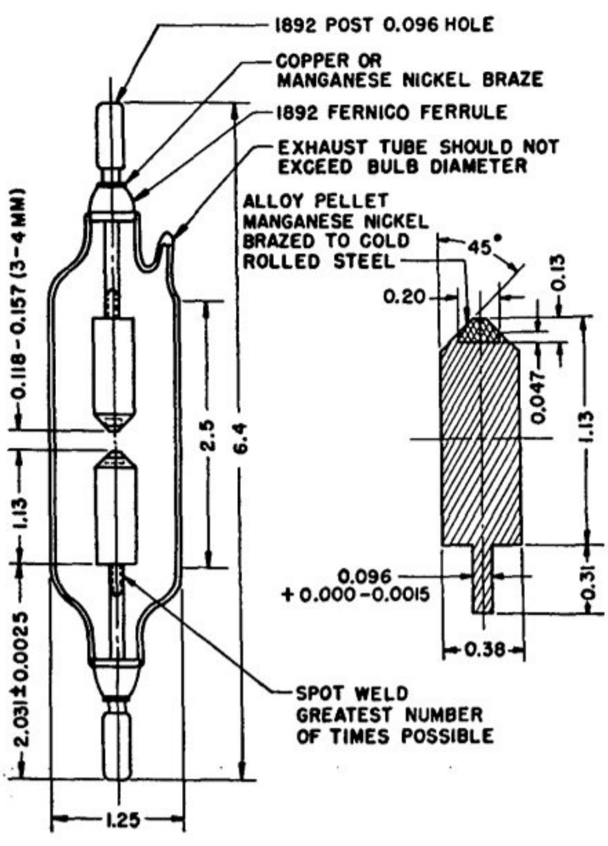


FIGURE 7. The type 300 microflash lamp.

*Design of the Lamp.* The design of the type 300 lamp and the standard dimensions used by the General Electric Company are shown in Figure 7. The design is simple and lends itself readily to large-scale production techniques. An important feature in securing long operating life is the use of the low work function alloy pellets, mentioned above in connection with the type 10 lamp, with which each electrode is tipped. After the lamp has been evacuated and outgassed it is filled with one or more of the rare gases, plus 1 to 3 centimeters of hydrogen to increase the self-breakdown potential at which the lamp will fire. The total pressure may vary from 50 to 70 centimeters of mercury. Argon is the filling gas principally used by the General Electric Company.

In the lamps constructed at the University of Michigan the main steel electrodes are supported on 100-mil tungsten leads sealed into a Nonex or Pyrex envelope, with brass electrode caps brazed to the outer ends of the tungsten seals. In order to increase the intensity of the flash by increasing the firing voltage of the lamp are gaps up to 10 mm long have been used in some lamps as compared with the 3-mm gap of the standard General Electric design. With the longer gaps, it was found to be advantageous to decrease the diameter of the steel electrodes from 3/8 inch to 5/16 inch and to round off the sharp corners of the bevels at the tip of each electrode. Argon, krypton, and xenon were used as filling gases, both singly and in mixtures. A mixture of argon and krypton in approximately equal volumes was found to produce the most desirable overall characteristics. However, the advantage of this mixture over pure argon is probably too small to make its use economically justifiable.

*Method of Firing.* In use, the lamp is connected directly across the terminals of a 0.1-μf condenser (a resistance of 0.5 ohm or less may be in series). The condenser is charged through a suitable protective resistor from a half-wave or full-wave unfiltered power supply, and the lamp is fired when the voltage across the condenser builds up to the breakdown potential of the lamp. It has been found advantageous to mount the lamp directly on one terminal of the condenser inside a coaxial cylindrical shield of brass or copper connected to the outer end of the lamp so as to serve as the second lead from the condenser. This arrangement provides good electric and magnetic shielding from the large peak discharge current (of the order of 2,000 to 4,000 amperes) and also provides a good means for dissipating the heat generated in the lamp. If the power supply is operated from a 60-cycle line, the lamp can be fired either 60 or 120 times per second without an auxiliary triggering system. The voltage at which the lamp fires is determined by the details of its construction and the characteristics of the filling gas. Most lamps have been made to fire at voltages between 3,000 and 4,000 volts. The firing of the lamp may be controlled by means of a Variac in the primary circuit of the power transformer. By adjusting the voltage applied and the constants of the lamp-firing circuit so that the condenser is not charged to the full breakdown voltage of the lamp on each half cycle, it is possible to fire the lamp at integral submultiples of 60 times per second. Type 300 lamps have been operated continuously at 120 flashes per second for many hours. The flash repetition rate could probably not be increased much beyond this value without necessitating means for forced cooling of the lamp, which has hitherto been considered undesirable. As a consequence, this rate of flashing sets an upper limit to the feasible scanning rate for systems in which the lamp is used.

*Radiation Characteristics.* The arc discharge which occurs in the type 300 lamp consists of a thin central core of very high brightness surrounded by a sheath of lower brightness about 3 mm in diameter. Tests conducted by Western Electric Company (Bell Telephone Laboratories) Contract OEMsr-1267 indicate that the brightness of the central core is 10 to 20 times greater than that of the surrounding diffuse sheath and that the ehT values of infrared filters for radiation from the core are three or more times the values found for the radiation from the entire arc. The data given in Tables 3 and 4 refer to average values for the radiation from the entire arc in a number of representative lamps.

The data on lamp characteristics were obtained at the University of Michigan with a cesium-surface vacuum phototube coupled through a wide-band amplifier to the vertical deflection plates of a cathode-ray tube. This receiver was calibrated by using the radiation from a standardized tungsten lamp chopped by means of a high-speed slotted disk. The high-speed horizontal sweep of the cathode-ray tube was triggered by means of the lamp discharge current, so that a stationary pattern of the intensity versus time characteristics of the lamp radiation was presented on the screen of the cathode-ray tube. The lamps were fired 60 times per second from a 0.1-μf condenser. For a lamp which breaks down at 4,000 volts, this corresponds to an energy input of 0.8 joule per flash or a power dissipation of 48 watts in the lamp. The peak intensity of the first few flashes may be 20 per cent higher than the equilibrium values measured after the first few seconds of operation. Some typical average characteristics are summarized in Table 3. The duration

TABLE 3. Average radiation characteristics of representative type 300 microflash lamps. Capacitance of firing condenser, 0.1 μf. Firing potential, 3,000 to 4,000 volts for 3- to 4-mm arc length, 4,000 to 8,000 volts for 7- to 10-mm arc length (depending on arc length and on pressure and composition of the filling gas).

| Arc length (mm) | Duration from beginning of flash down to 15 per cent of peak intensity (μsec) | Peak intensity relative to a cesium-surface detector (equivalent holocandles) | |
|---|---|---|---|
| | | Bare lamp | Lamp mounted in 19½-in. precision parabolic reflector |
| 3–4 | 1.6–2.4 | $(0.7\text{–}2) \times 10^5$ | $(2\text{–}4.5) \times 10^8$ |
| 7–10 | 1.7–2.7 | $(1.8\text{–}5) \times 10^5$ | $(1\text{–}2.5) \times 10^9$ |

of the flash between the points of half peak intensity is between 0.5 and 0.75 μsec for most lamps, the much longer duration values down to 15 per cent of the peak intensity, shown in the second column of the table, being due principally to the gradual decay of intensity at the "tail" of the curve. The beam candlepower values given in the last column of the table were obtained with the arc transverse to the axis and centered at the focal point of a second-surface precision glass parabolic reflector of 7⅞-inch focal length and 19$\frac{7}{16}$-inch aperture. With a lamp having a 1-centimeter arc the angular dimensions of the beam projected from this reflector are approximately 1x3 degrees. Since the bright central core may be displaced by an amount greater than its own width through the effects of thermal convection currents, electrode surface irregularities, etc., successive flashes do not follow the same path with enough exactness to permit good measurements to be obtained for the intensity distribution across the beam.

The spectral intensity distribution of the radiation from these lamps has not been measured. However, as in the case of other flash lamps, it undoubtedly consists of the characteristic line spectrum of the filling gas superposed upon a continuous spectrum. The average ehT values of certain filters for radiation from the type 300 lamps with reference to a vacuum cesium-surface detector are given in Table 4. These values are relatively independent of which of the gases indicated above is selected for filling the lamp. The highest ehT values for radiation from the entire arc were obtained with argon-filled lamps, while the highest values for radiation from only the central bright core of the arc were obtained with xenon-filled lamps. No correction has been made for the reflection and absorption of the two lantern-slide mounting plates between which the plastic membrane filters listed in Table 4 were supported.

TABLE 4. Effective holotransmission of certain filters with reference to a cesium-surface detector.

| Filter | Average ehT for radiation from type 300 flash lamp | ehT° for radiation from 2848 K tungsten source |
|---|---|---|
| Wratten 87 | 0.074 | 0.38 |
| Polaroid XR3X44 | 0.029 | 0.19 |
| Polaroid XR7X30 | 0.017 | 0.13 |
| Corning 2600 5.0 mm | 0.085 | 0.36 |
| Corning 2550 2.0 mm | 0.047 | 0.27 |
| Corning 2540 2.6 mm | 0.017 | 0.13 |

*Lamp Life and Performance.* No type 300 lamp is known to have been operated either to destruction or to the end of its useful life as a radiation source. In a life test conducted by the Western Electric Company Contract OEMsr–1267, a General Electric lamp was fired 120 times per second from a 0.1-μf condenser with a 0.2-ohm resistor in series for a total of 450 hours in continuous periods of about eight hours each. This corresponds to nearly 200,000,000 flashes. After 210 hours the peak intensity of the flash had decreased to about 70 per cent of the initial value, due partly to a decrease of the lamp firing potential and partly to clouding of the glass envelope by material sputtered from the electrodes.

In view of the long life of these lamps it might be supposed that pulses of higher peak intensity could be obtained by operating the lamp from a larger condenser or at higher firing voltages. However, the duration of the flash increases much more rapidly than its peak intensity when the capacitance of the firing condenser is increased, and the radiation characteristics of the lamp become less desirable if the construction and processing are altered so as to increase the self-breakdown firing voltage appreciably above the range of values shown in Table 3. Some increase in peak intensity might be obtained if a control tube which would withstand higher voltages (such as an ignitron) were added to the firing circuit. With the addition of such equipment it might also be possible to fire the lamps at considerably higher rates than 120 times per second. However, the problems associated with supplying adequate electric power and adequate means for dissipating the heat developed in the lamp during continuous operation at high intensity will undoubtedly continue to limit the rate of flashing which is feasible.

The operation of these lamps in the equipment (see Chapter 6) for which they were developed has been very satisfactory. It is not known whether the General Electric Company plans to produce such lamps on a commercial basis but they will presumably continue to be available from this company on special order if not otherwise.