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A MULTI-PURPOSE AND VARIABLE-PARAMETER MICROSPRAY GUN AND TWO OF ITS APPLICATIONS AT SLAC

Spray guns are commercially available in many shapes and sizes and for most any purpose. All have one thing in common: a highly limited parametric application, in other words, on or off. Some have continuous fanned spray action (e.g., artist brushes), but this limit in flexibility makes commercial spray guns inadequate for a number of applications.

Because of special spraying requirements at SLAC, a new variable-parameter spray gun has been developed. This gun has many features not found in others:

(1) Changeable fan width
(2) Changeable amount of material to be sprayed
(3) Changeable pressure
(4) Complete shoot-off from any spray material and use as dryer blower
(5) Changeable distance from gun to target, one way to establish wet or dry spraying of target.

All these features can be taken advantage of, or any combination used as needed, depending on what type of spray material and substrate are required and what technique is used. In Fig. 1, item #1 is the nozzle which can be screwed up or down to change the fan width for covering larger or smaller areas; item #2 is the rest of the spray gun which has a grooved tubulation for gases like air, oxygen, argon, nitrogen, helium or whatever combination is necessary; item #3 is a 5 cc syringe which could be replaced with a larger (50-100-500 or 1000 cc) or a smaller (5-3-1-0.1 cc) one for the best combination of highest efficiency, best utilization and most economic application.

Figure 2 is a drawing of an all-stainless steel spray gun with a 2-degree cone (item #1) to fit any standard medical glass or plastic syringe. It has an axial opening for a piece of 0.030 SS tubing which reaches through item #2 into the nozzle (item #4). This arrangement utilizes partially the Venturi effect plus plunger action for dispersion control of the spray material. Item #3 is the grooved hose connection tube which joins the side of item #2.

All parts are heliarced, except the thin SS tube which may be either finely brazed or heliarced, depending upon for what purpose and with what spray material the gun is to be used, in order to prevent contamination by electrolysis.

In spite of the compactness of the spray gun, two more parameters or features can be added: (1) By increasing the hole for the SS tubing in the nozzle (Fig. 1, item #1), and changing the tip in the nozzle (Fig. 2, item #4) to an appropriate diameter, one can achieve big spray gun performance; (2) By connecting extension hoses, one for gas and one for the spray material, the spray gun becomes useful in small and hard-to-reach places, because of its position-independency in this case.

To reduce the possibility of contamination, it is advisable to use one gun only for one and the same material, cathode material, phosphor (zinc-sulfide and the like), carbon (graphite, aquadag), etc. Even following this precaution, after use a thorough cleaning in an ultrasonic bath is mandatory for reproducible results in spraying and performance of the object sprayed.

Figure 3 shows a typical plexiglass spray box for spraying zinc-sulfide (P4) screens. Item #1 is the radiation heat reflector made out of polished aluminum. Item #2 is a 0.5-KW-to-1-KW infrared radiation lamp, G. E. type. Item #3 is the slip-on masking made of plexiglass for protecting the areas which need not be sprayed. Item #4 is a sprayed P4 screen mounted in a frame as shown in Fig. 9. Item #5 is the connecting duct for ventilation. Item #6 is a gliding door which has magnetic catches for keeping it open during spraying. Behind the gliding door is a slit through which the screens are being sprayed. Item #7 is the hinged front door for easier loading of the items to be sprayed. Item #8 is the electrical inlet, and Item #9 is an ultraviolet (black light) fluorescent lamp which acts as a production control device by showing the uniformity of the film during spraying. Figure 4 is a top view of the plexiglass spray box, and Fig. 5 is a front view. Figures 6, 7 and 8 provide a more detailed description of the spray box.

SPRAY TECHNIQUES FOR ZINC-SULFIDE

The best utilization of raw phosphor material for our purpose is to use it as made by the manufacturer, average grain size 10 microns. Most additives, no matter how little or in what form, cut down on efficiency. For the bonding purpose, plain phosphor has a poor adhesion; to overcome this, one has to add as little as possible of bonding agents. To increase the bonding effect, it becomes very helpful to heat the screen or foil to be sprayed. A firm but gentle drying action is the best approach, about 80°C to 100°C of foil temperature. If the foil temperature exceeds 100°C, an instantaneous evaporation and blister formation takes place which renders the screen useless.

Depending on the thickness of the phosphor (P4) deposition, markings for orientation purposes can be made before spraying by inscribing or etching the foil for a thinner layer; or in the case of a thicker P4 layer, by printing or writing.

Three parameters are important for fast and uniform spraying:

(1) Position of the foil: horizontal position prevents runs and allows for faster spraying than does a vertical position.

(2) Maintaining of foil temperature during spraying as close as possible to 100°C, which can be measured by a thermocouple or infrared radiation meter. Temperature measurements need only to be made once to obtain proper control settings.

(3) Distance of spray gun nozzle from the foil and the wetness of the spray solution.

In the case of vertical spraying, a very thin layer should be applied for the first spray and a drying period of 30-40 seconds allowed before the second layer is sprayed on. The thickness from layer to layer can be progressively increased until the necessary thickness is achieved. Micrometer measurements from time to time help to secure the proper thickness.

The dry zinc-sulfide (P4) film is mechanically stable and will not flake and is therefore easy to store.

In case of a decomposed P4 layer (beam burn-out), soaking in warm water and an application of a soft brush will remove the old layer. Standard rinsing and drying procedures are sufficient before respraying the foil.

Mixing of Zinc-Sulfide (P4) for Spraying

All data are by weight percent.

15% P4 zinc-sulfide (CR-402 Sylvania), Ag activated, or similar.

1% Glycerin, analytical grade.

2-3% Potassium sodium silicate (sodium meta) USP.

Balance distilled H_2O. The whole mixture should be shaken into suspension before being used.

General Considerations on Mixture

Because of possible contamination, wetting agents are not added. Also a classification in uniform grain size was not attempted, because previous experiments proved the standard grain size from the vendor was sufficient. Little change in luminescence was found in using classified grain size from 1 to 10 microns. The maximum for a low energy beam was found to be 10 microns in grain size with the layer being 0.004-inch ($\sim 100\,\mu$) thick.

Figures 9 and 10 show typical zinc-sulfide (P4) coated foils as used in the SLAC accelerator. Also see Table 1, Comparison of Beam Profile Monitor Characteristics in "Instrumentation, Computer Control and Electronic Systems for the SLAC Beam Switchyard," SLAC Report No. 68, by D.A.G. Neet, page 51. Actual lifetime data on zinc-sulfide screens will be reported later. 300 of the zinc-sulfide screens are now in use at SLAC.

CERENKOV CELL WINDOWS

The same type of spray guns were used for making Cerenkov windows. The colloidal graphite, trade name "Aquadag," has an approximate grain size of about 3000-4000 Å diameter; the actual cross section is almost leaf-shaped and is 400-600 Å thick. To secure the graphite on the surface of the aluminum foil, a reaction bond was made. Ammonium hydroxide (NH_3), even when concentrated, shows very little reaction with aluminum at room temperature, but at slightly elevated temperatures, $150^oC - 250^oC$, becomes reactive. If small enough graphite particles are suspended in the solution during spraying, the results are a graduated density cross section of reaction-bonded $C - AL_2O_3 - AL$. Also a spring-loaded masking configuration of wire or metal band could be attached for contrasting any form or shape needed before spraying. Another helpful preparation is a light etching (electrolytic or chemical) or sandblast with an SS-White machine for increasing the surface and removing excess aluminum oxide from the surface of the foil.

It also should be kept in mind that a thin film has better bonding characteristics than a heavy one. The basic particle size is 4000 Å, so anything thicker than 100,000 Å has the tendency to peel or flake off. Applied properly, the only way to remove the film is by scraping with sandpaper or steel wool to break the bond.

A wet spray for this type of carbon or graphite film is recommended. The reason for this is to give the carbon leaves a chance for an overlapping buildup before reaction and drying take place. The experimental proof shows no flaking, peeling or cracking during repeated heat cycling in air up to 350-400°C because of the gliding overlapped carbon leaves, in spite of the severe difference in coefficient of expansion of 24×10^{-6} for AL and 6×10^{-6} for C.

Figures 11 and 12 show two typical Cerenkov cell windows, while Fig. 13 shows a window under dynamic conditions at or about 10 BeV.

Mixture of Solution

All figures are given in percentage weight. The graphite is a colloidal type known as "AQUADAG" from CENCO.

The mixture consists of:

15% Colloidal graphite (AQUADAG)

10% Ammonium Hydroxide, analytical (NH_3)

75% Distilled H_2O

The solution is stirred until well suspended; then it is ready for use.

Spraying of Solution

The cleaned and masked foil is placed on a hot-plate in a hood, heated to about 150-250°C, then sprayed until a uniform thin coat is formed. Drying takes place almost instantly, and after removal of the mask from the sprayed foil, the window is ready to be installed. If a heavier coat is needed, additional coats can be applied. Still, to prevent flaking, the thickness of the sprayed layer should be kept within reason.

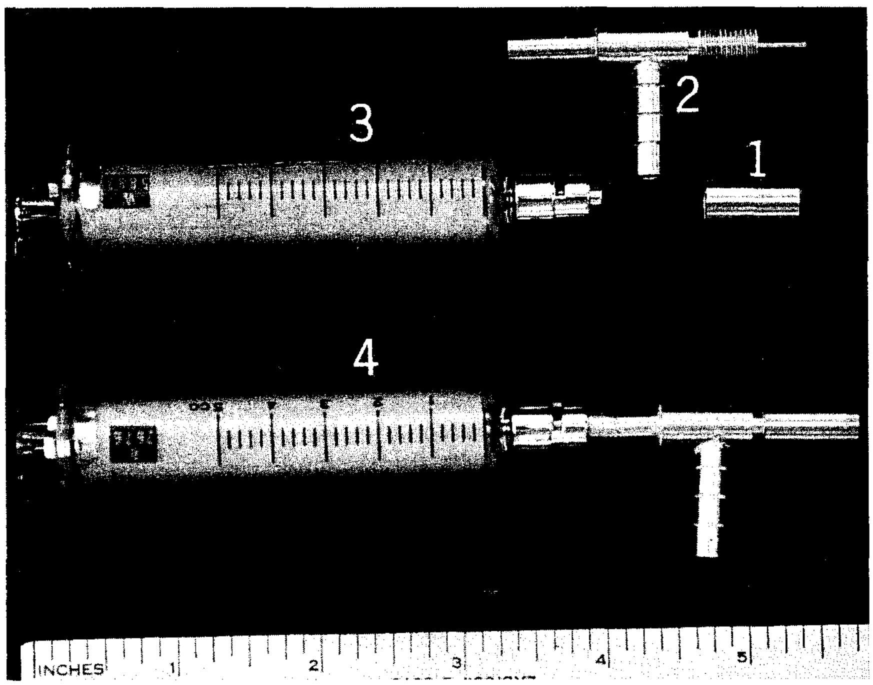
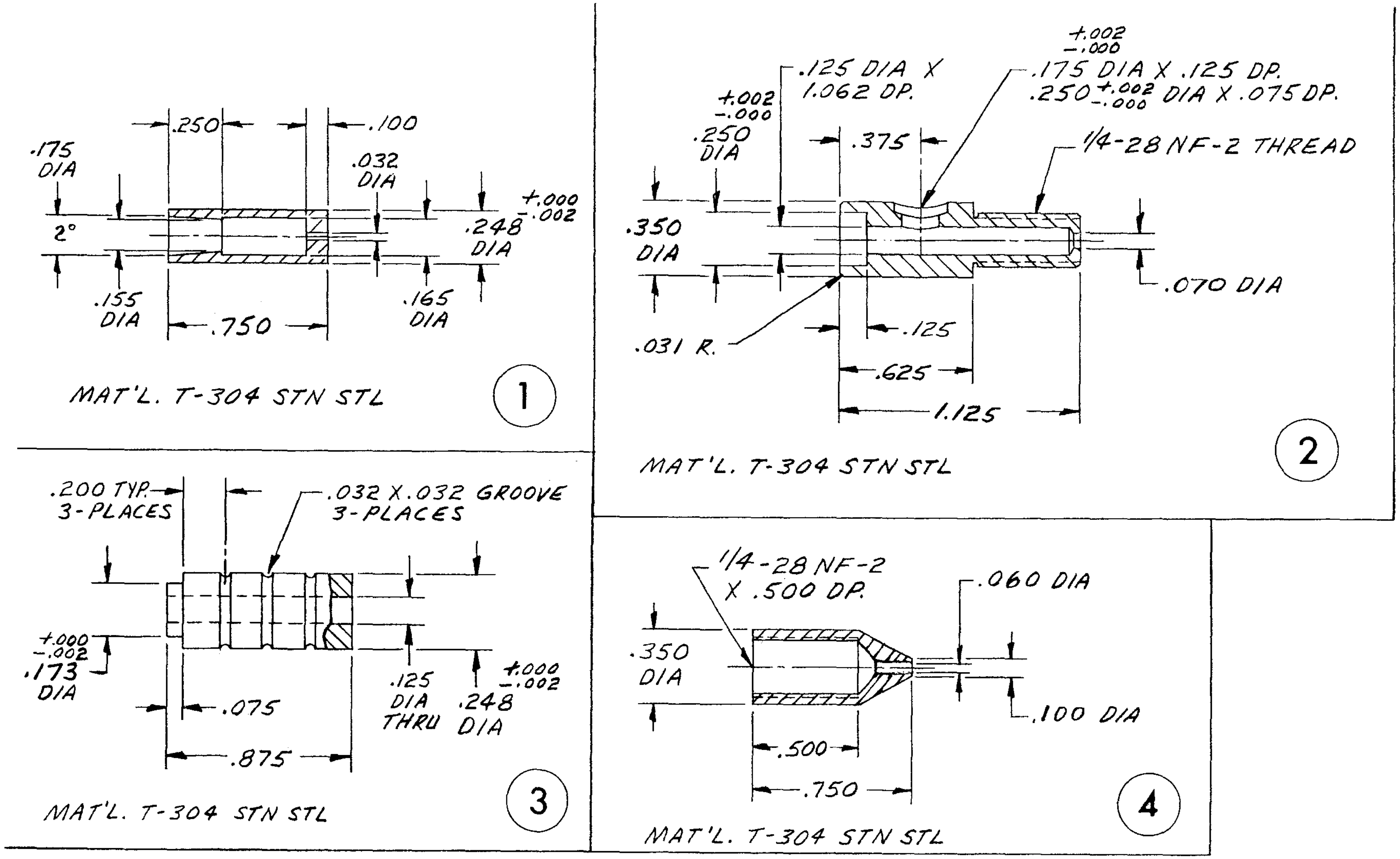


FIGURE 1



DETAILS, MULTI-PURPOSE AND PARAMETER SPRAY GUN
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Fig. 2

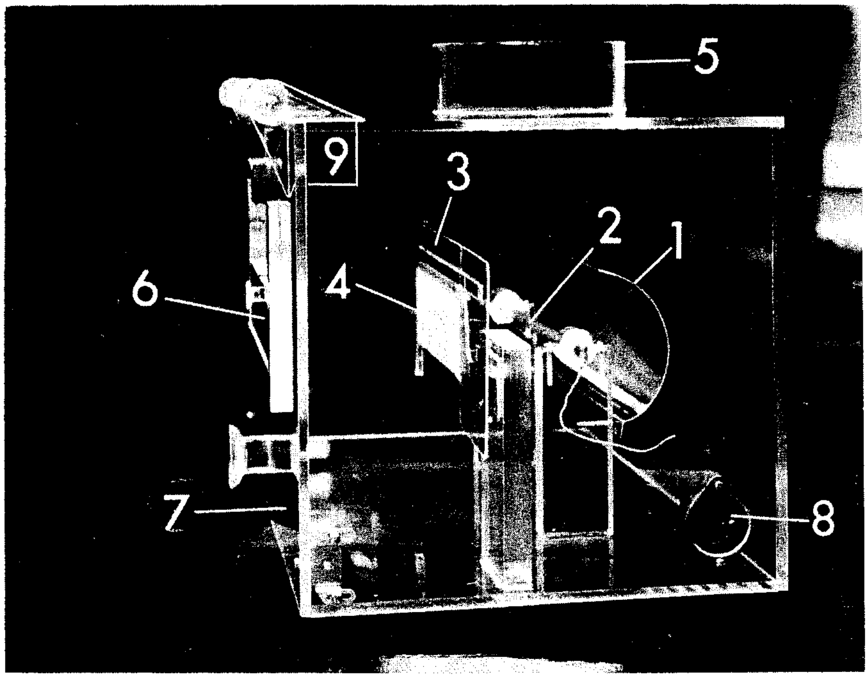

FIGURE 3

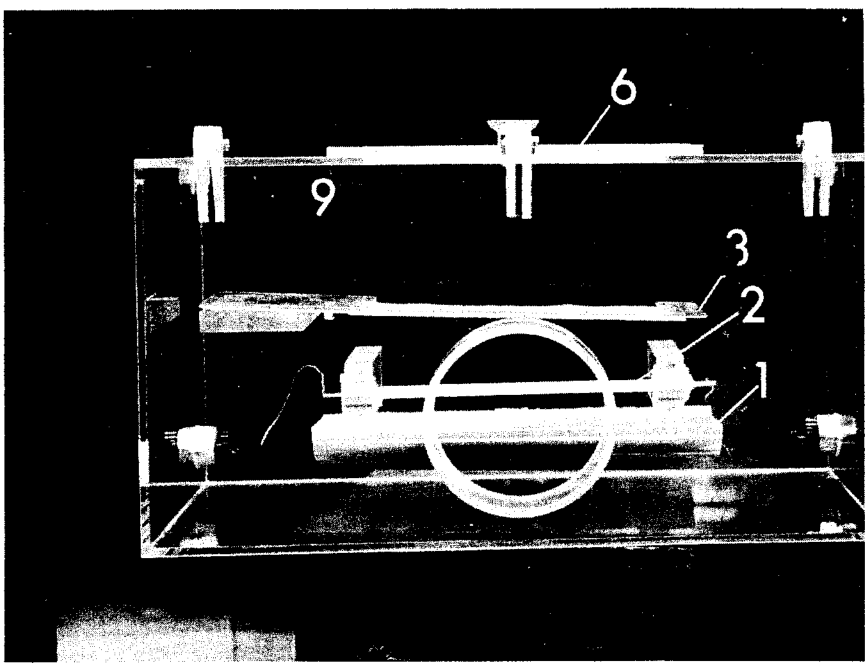

FIGURE 4

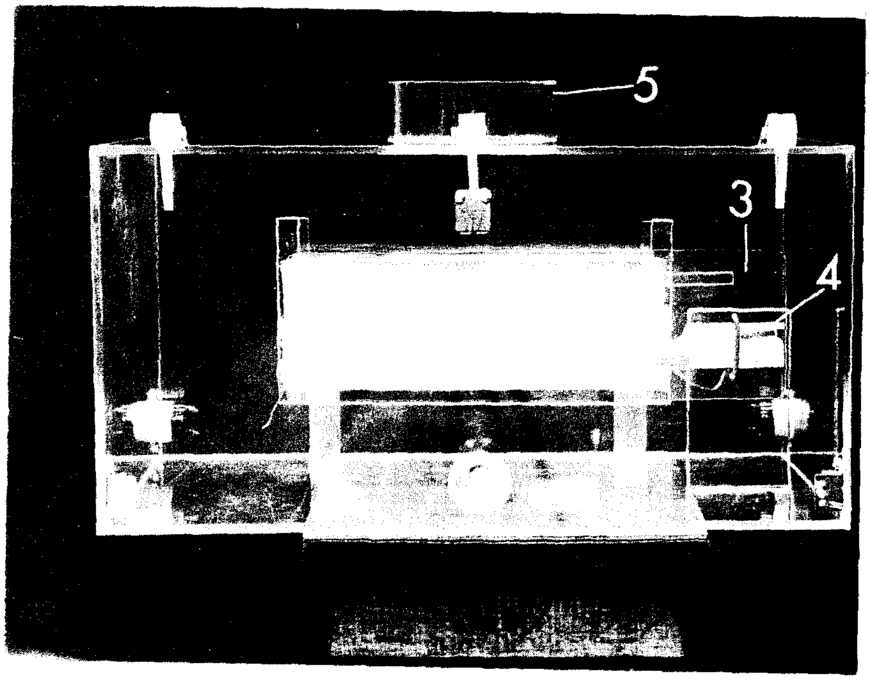

FIGURE 5

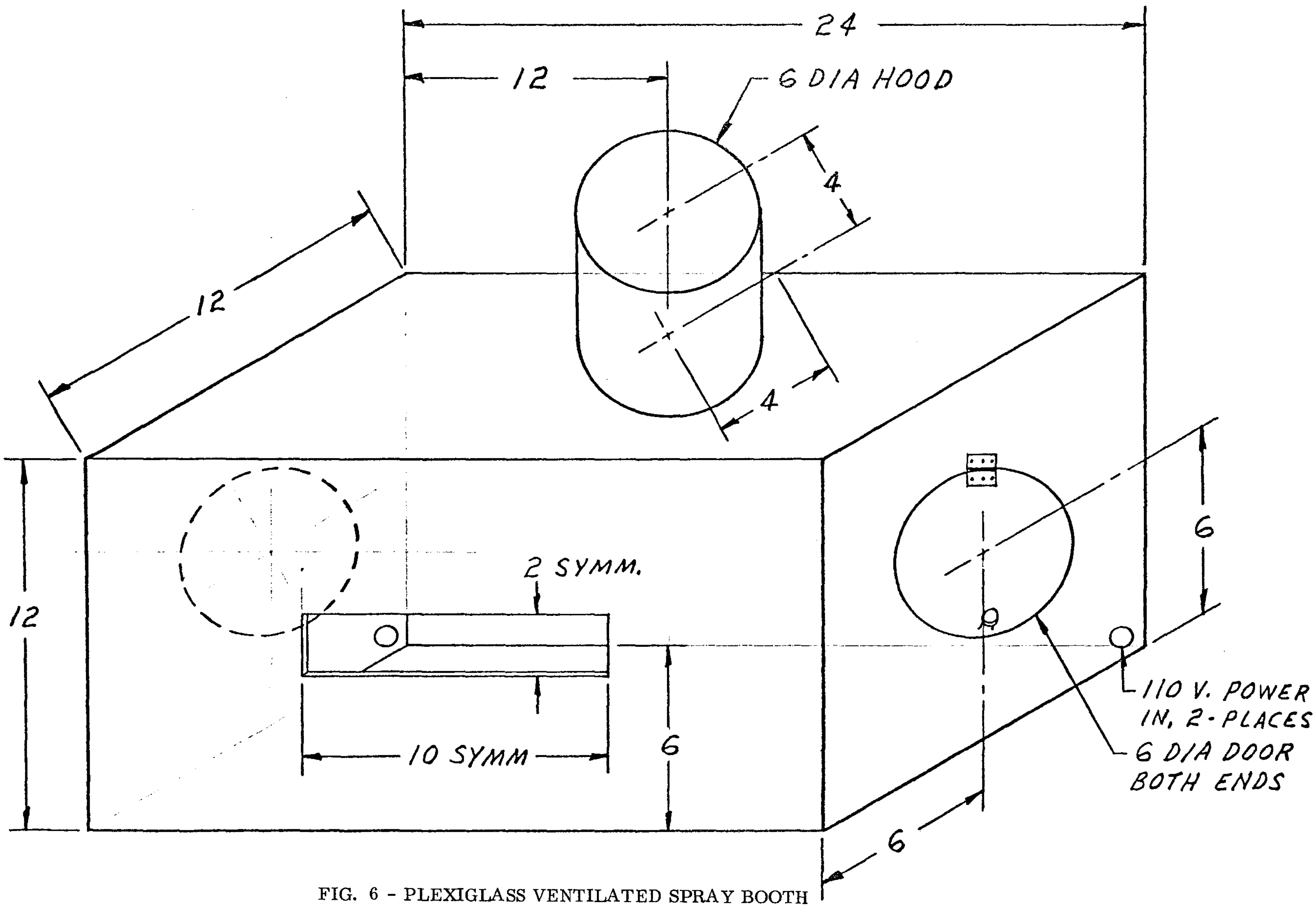

FIG. 6 - PLEXIGLASS VENTILATED SPRAY BOOTH

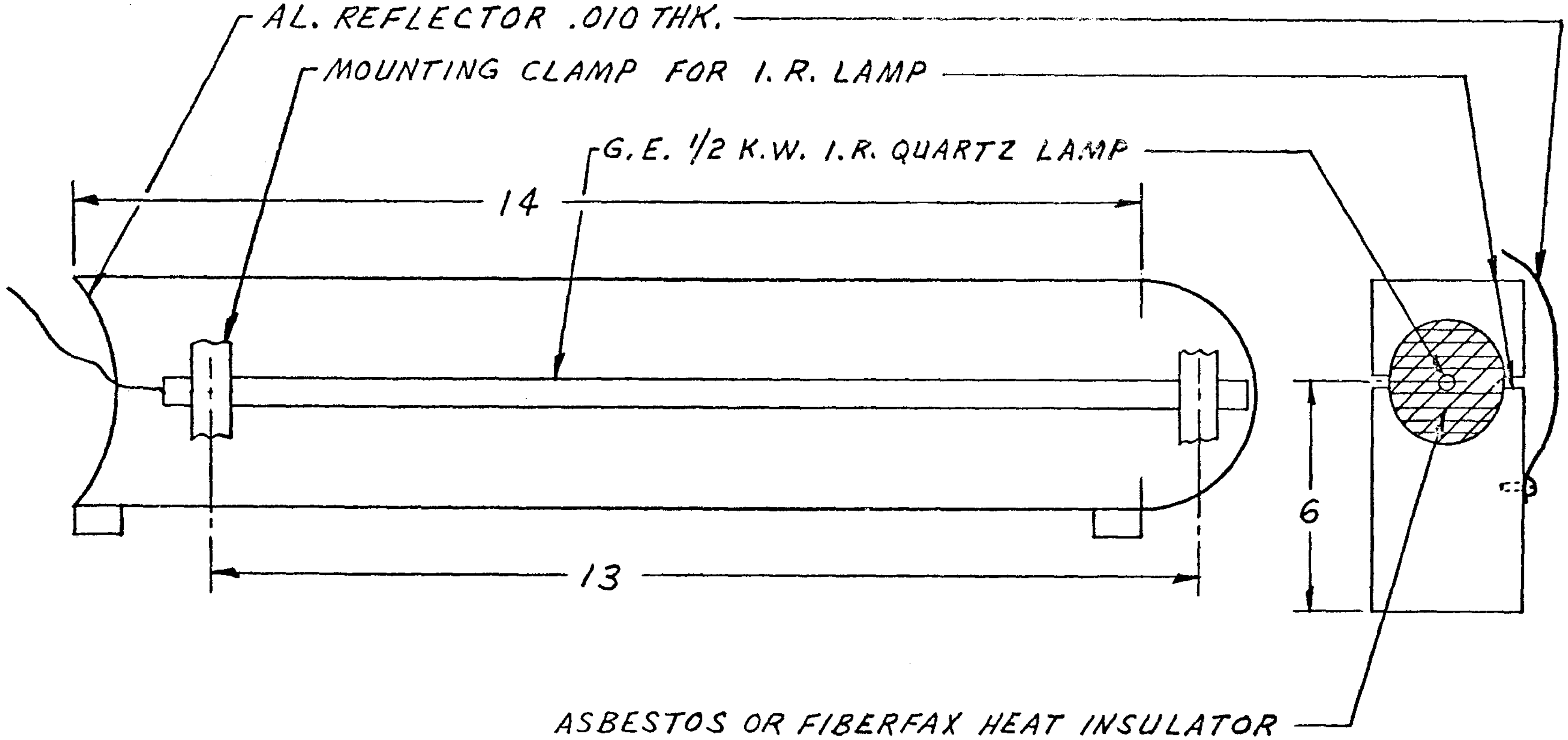

FIG. 7 - I.R. LAMP AND REFLECTOR MOUNT FOR HEATING THE AL FOIL DURING SPRAYING

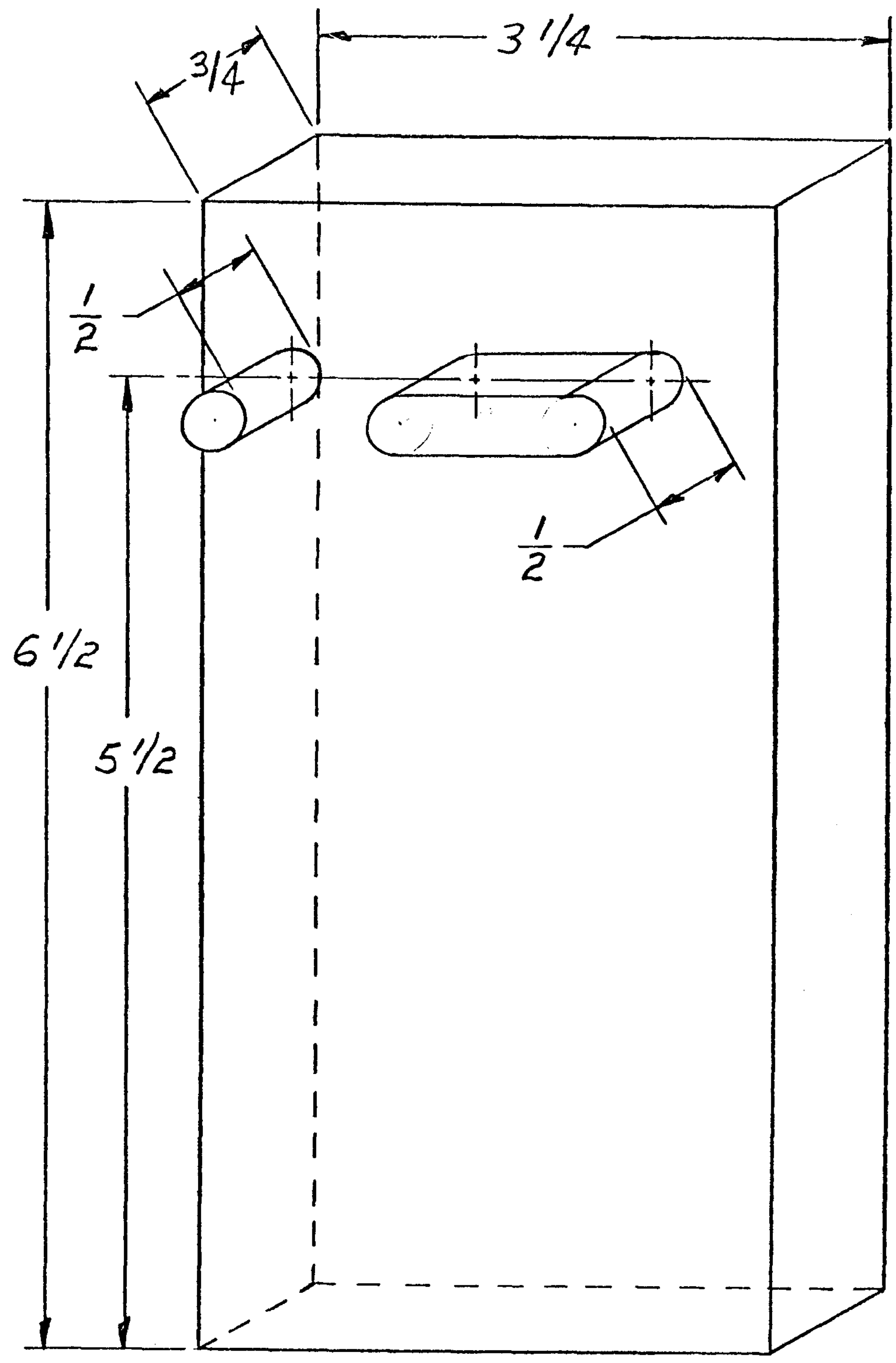

FIG. 8 - TARGET FOIL HOLDER, SEE ORIGINAL
FOR ALIGNMENT MATERIAL PLEXIGLASS

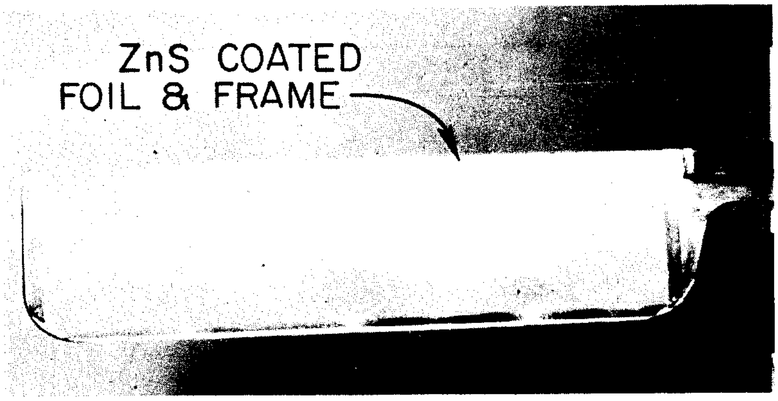

FIGURE 9

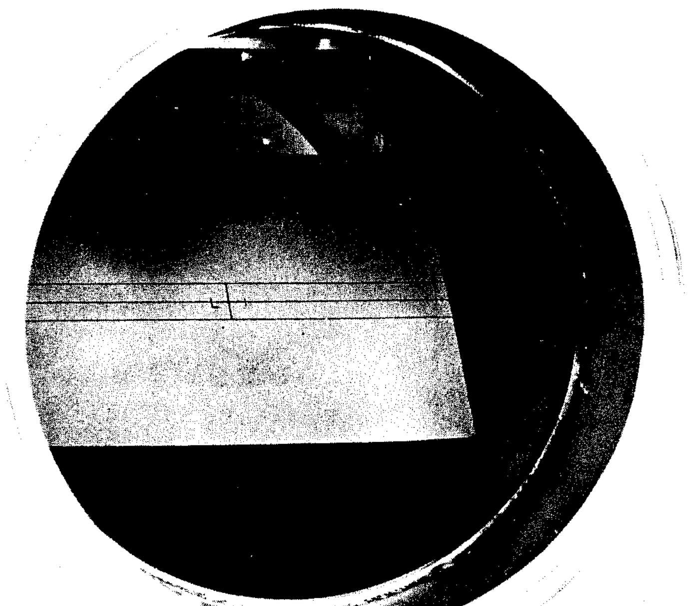

FIGURE 10

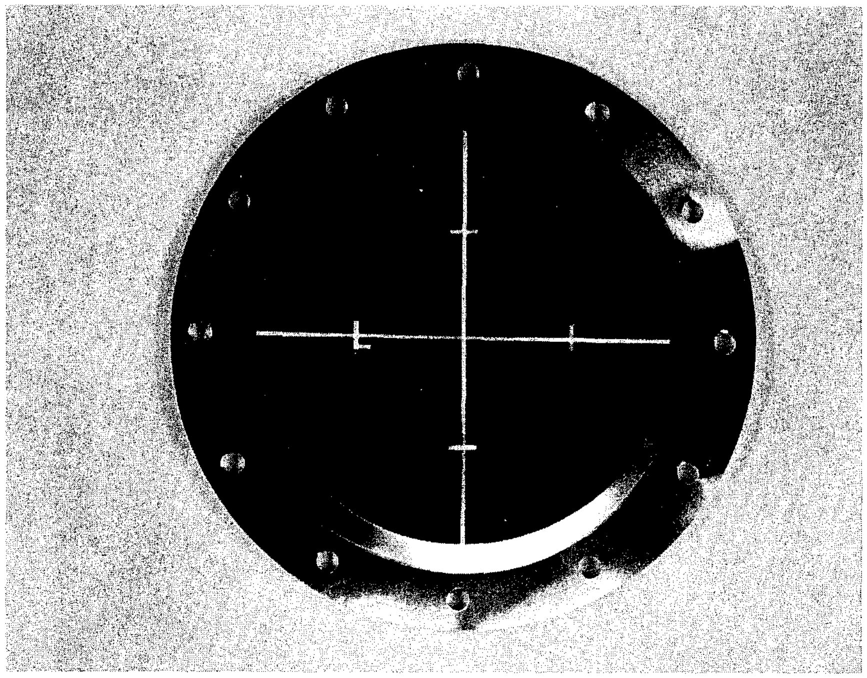

FIGURE 11

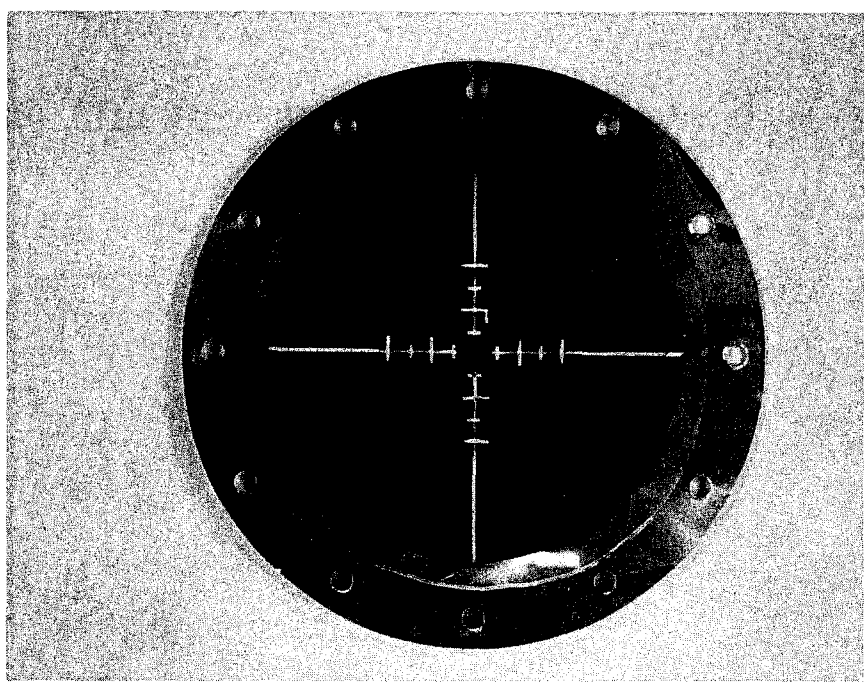

FIGURE 12

2-MILE BEAM CENTERED ON CERENKOV CELL PR2.

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FIGURE 13