GENERAL ELECTRIC

ELECTRONIC COMPONENTS DIVISION

CRT-705-85 (8-57)

TECHNICAL INFORMATION SERIES

Title Page

AUTHOR	SUBJECT CATEGORY	NO.
P. P. Coppola	Cathodes, sprayed oxide	R58ETC-2
		DATE 4/1/58

TITLE
The Application of a Limiting Aperture to Cathode Spraying

ABSTRACT A method for preparing smooth sprayed cathodes by the application of a limiting aperture shield is described. The aperture provides a means of control and orientation of the area of an emission coating spray directed to a moving cathode target and thus precludes the deposition of large powder agglomerates usually found in the peripheral region of any spray cone emanating from a spray gun nozzle, regardless of the nozzle size.

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CONCLUSIONS
Smooth cathodes prepared by the spray aperture method have improved the quality of electron beam spot size and performance in cathode ray tubes. With a minimum of effort and change in equipment, the spray method is easily adaptable to manufacturing.

By cutting out this rectangle and folding on the center line, the above information can be fitted into a standard card file.

For list of contents—drawings, photos, etc., and for distribution see page attached.

FOR GENERAL TIS INSTRUCTIONS SEE EDI 1.3

GE ACCOUNTING REFERENCE ____________

COLLABORATORS P. P. Coppola

COUNTERSIGNED P E Sullivan DEPT. Cathode Ray Tube LOCATION Electronics Park, Syracuse, N.Y.

General Electric Company
Electronic Components Division
Technical Information Series
Contents Page

Contents of Report
No. Pages Text 7
No. Charts
Drawing Nos. 7

Photo Nos. 1

References

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The Application of a Limiting Aperture to Cathode Spraying

Introduction

Since the advent of the "oxide" cathode more than fifty years ago, the techniques for fabricating it are still more of an art than a science. A large number of papers have been written on the general subject of fabrication, namely on how to prepare the alkaline earth carbonate powders, how to prepare desirable liquid suspensions of these powders, how to apply the suspension to the base metal, and so forth. The main objective in every instance has been and still is to provide a cathode coating which is physically and chemically adaptable for some particular application so as to provide a desired emission level, stability, and life. These last three properties encompass a wide variety of specific characteristics which are most desirable and, in many cases, critical. To mention a few, assuming no problems exist with the base metal, there would be included such items as a smooth cathode surface, a uniform emission current from the coating, and a good adherence to the base metal.

In an electron beam device such as a cathode ray tube, the cathode is one of the top priority components to keep under control and attempt to improve. The electron gun structure is of equal importance, but, no matter how well designed it may be it cannot function properly if the emitter characteristics are mediocre. However, the reverse is true also, namely, that an excellent emitter cannot show its potentialities if the gun itself is not properly designed. In short, the source of the electrons and the gun lens system have to be considered as one package. Thus, for the design and development of a better product, constant attention must be focused on the fact that the cathode and gun are intimately related.

Consideration of the Cathode Surface

In a cathode ray tube, it is desirable not only to have an electron beam of high intensity, but also one which when projected onto a phosphor target screen produces a spot which is small in diameter, well defined, and well focused. The electron emission level of a cathode is a strongly contributing factor for the attainment of these spot characteristics, but if it is assumed that sufficient electrons are evolved, then the next consideration is the quality of the emission, that is, the uniformity of the velocities of the electrons and their respective directions as they emanate from the cathode. It is known that a distribution of electron velocities inherently exist in an oxide cathode and that they are Maxwellian in character. However, the physical state of a cathode surface, that is, the degree of irregularities such as projections and valleys contribute strongly to increasing the range of velocities of the electrons which ultimately find themselves in an electron beam. The Maxwellian distribution curve may be in a sense narrowed through increase in cathode emission density. Thus, at all times processes to affect maximum activity are necessary. Also, at the same time in order to preclude the effect of coating irregularities on the electrons evolved, major emphasis must also be placed on the fabrication techniques which will produce cathode coatings as smooth as possible.

Cathode surface irregularities aggravate problems introduced by the relatively high resistance of an oxide coating. The voltage drop across the cathode coating resistance and the preferentially high currents produced by the strong fields at each protrusion promote heat gradients in these localized spots which in turn provide higher current densities to heat the spots up still more, thus creating a self feeding mechanism. The end result may be either a cathode surface with point sources of very high emission current or the actual physical loss of these points due to removal by electrostatic forces.[1] The electric field at the surface of an irregular cathode can be extremely non-homogeneous and the equipotential levels in close proximity to the cathode will follow the hills and valleys of the surface.[2,3] Moreover, such a non uniformity of the field causes a series of cathode lenses which converge and diverge and deflect electrons escaping from the cathode.

From the foregoing arguments it can be seen therefore that effects created by surface irregularities may produce a beam, the velocity distribution of which in any plane is in excess of the Maxwellian irregularities. These in turn are related directly to the quality of an excited spot of phosphor on a cathode ray tube screen.

Preparation of a Smooth Cathode Surface

Since it appeared that a major contribution could be made for the improvement of the electron optics in a cathode ray tube through the introduction of a smooth surfaced electron source, a program was begun in the laboratory to investigate techniques known in the art for applying alkaline earth carbonates to a nickel base metal. A number of these techniques such as spraying, cataphoretic coating, dipping, electrolysis, and brushing were applicable and with sufficient time and effort it was quite probable that any one or all of the methods would provide a cathode of the desired smoothness. Each of the techniques mentioned, however, have certain peculiarities which would create some problems if they were to be set up on a large scale manufacturing basis. Thus, each method had to be quickly weighed qualitatively from past experience, and from information in the literature. It was felt that the quickest returns could be obtained by first concentrating on the spraying technique since this method could be most easily transferred to manufacturing.

In the factory, cathodes are prepared by spraying the emission coating from a stationary spray gun mounted in front of spray bars containing disc cathode assemblies. The bars are positioned on an oval track and move across the line of sight of the spray gun. The gun is triggered a few seconds before the bar reaches the gun and left on until the bar has completely passed. The spray cone shape is circular. The type of emission coating suspension, the degree of air pressure applied to the suspension, the distance of the gun to the cathode target, the gun nozzle size, the speed of the moving target, the drying time and number of passes are some of the parameters which govern the texture, density, and thickness of a coating on the base nickel. Densities ranging from 0.9 g/cc to 1.2 g/cc and thicknesses ranging from .0025" to .0030" have been maintained for some time. The densities usually referred to in respect to oxide cathodes include the binder material. Thus, the actual powder densities are somewhat lower than the figures quoted above. Considerable experience by many workers in the field has shown that the limits of density and thickness must be held rather close to insure a combination of desired emission level and good adherence to the base metal. There has been much work reported in the literature on the influence of pore volume, particle shape, particle size of alkaline earth carbonate powders, types of binders, and vehicles and so forth as affecting emission quality, but this is beyond the scope of this report and shall not be touched upon. However, in the work carried out in the laboratory to prepare a smooth cathode coating, the probable influence of these factors was not lost sight of.

Examination of numerous cathodes prepared in the factory indicated rather excellent control of thickness and density. A close microscope examination disclosed a surface which was quite fluffy in appearance with many irregularities. It should be borne in mind and it is well known that an inherent characteristic of spray coatings (if deliberately not made wet) is a fluffy surface. Nevertheless, it was felt that the surface of the cathodes could stand improvement.

In the preparation of spray suspensions for the fabrication of fine textured coated cathodes, a good deal of effort has been directed to procedures for breaking up of agglomerates. Constant rolling procedures are followed in the hope that single particles of alkaline earth carbonates would remain as such when eventually carried through a spraying schedule for the application of a coating to a base metal. Unfortunately, in many cases the results have been poor. In our work a number of cathode spray suspensions were examined under the microscope immediately after rolling. The examinations were made quickly to preclude the agglomeration or union of particles due to solvent evaporation. Relating this examination to that of a standard sprayed cathode surface indicated that the size of the irregularities on the cathode exceeded the size of the largest particle in the suspension. Apparently, then, the majority of the irregularities were agglomerated particles which may have been produced in any one or a combination of the following places: In the bottle attached to the spray gun, in the nozzle of the spray gun where atomization is supposed to occur, or during the flight of the suspension droplets to the cathode base metal. Microscope examination of a thin spray deposit formed on a stationary target which had been positioned in front of the gun showed a distribution of texture progressing from a smooth fine grain surface in the center to a rather coarse surface in the peripheral region of the deposit. Also, regardless of the size and shape of a deposit produced, the deposit always showed a similar distribution of texture starting from the center and progressing outward. Thus, it was seen that only when a relatively small target cathode was stationary and well centered in respect to the spray cone emanating from the gun, could it pick up the fine textured inner layer of coating. Movement of either the gun or the cathode would produce an integrated distribution of the cross section of the spray cone on the cathode surface. From these observations it was reasoned that the use of an adjustable slit or limiting aperture shield interposed between the gun and the moving cathode target would mask off any desired amount of the outer portion of a spray cone which normally a cathode target would see. Accordingly, parts for laboratory spray equipment which incorporated an adjustable limiting aperture were made and assembled. The size of an aperture was determined by the diameter of the spray cone which would arrive at the locale of a cathode face. When the aperture is made sufficiently small so that only the center or fine portion of the spray cone can pass through, then a very smooth cathode surface should be produced. Figure 1 shows the shape and relative size of that portion of a spray cone which a cathode would see without a limiting aperture. Also shown in Figure 1 is the relative size of aperture which should produce good results. Incidentally, it should be mentioned that if a cathode target moves laterally across the aperture and is considerably smaller in diameter than the spray cone, then no masking is needed at the top or bottom of the aperture.

Figure 2 shows the mechanical details of the limiting aperture shield and the drying oven. Figure 3 shows the mechanical details of the cathode turntable. Figure 4 shows the complete spray equipment enclosed in a laboratory hood, and Figure 5 shows the orientation of the spray gun, shield, and turntable. The specially designed spray bar used is shown in Figure 6. In the spray bar the cathodes are positioned slightly below the top aperture which masks off the outer cathode periphery from the spray material. Each cathode row on the bar has the same radius of curvature as that of the turntable such that when the spray bar is attached to the turntable, the rows are positioned exactly opposite the limiting aperture of the spray shield. To keep contamination to a minimum all metal parts for the spray equipment were made from stainless steel or aluminum. The spray shield and gun can be independently adjusted for distance to the cathode target. The turntable is driven by a variable speed motor. Airco, pre-purified nitrogen gas, is passed from a reducing valve through an intermediate filter, thence through a DeVilbiss transformer and filter to a solenoid valve, into the side of the hood and to the gun. The gun is a DeVilbiss type EGA, series 502, with an E nozzle, an E needle and number 395 cap. The gun and parts are shown in Figure 7.

During the spray operation the hood door is kept closed and the hood fan is turned on to draw air only through a special filter at the side of hood. The gun trigger is kept closed and nitrogen is passed to the gun via the solenoid valve. The specific details of the laboratory spraying procedure used were as follows: A jar of freshly rolled cathode spray suspension was attached to the gun. Gun adjustments were made similar to those used in the factory, namely, the spreader valve adjustment nut was closed. The needle valve adjustment nut was closed and then opened to 70 percent of one turn for a slightly "wet" spray and below 50 percent for a slightly "dry" spray. With the gun trigger closed, nitrogen pressure was adjusted to 50 pounds per square inch. A magnetic stirrer kept the spray suspension agitated constantly. The speed of the turntable was adjusted to perform one revolution in 3.2 seconds. The maximum oven temperature used was 80°C. This temperature is well below that of 225°C used in the factory. Before a spray operation was started, the oven was turned on and allowed to reach equilibrium temperature with the hood fan on and the turntable operating. When the proper conditions were achieved, the turntable was stopped temporarily and spray bars (loaded with cathode assemblies) were attached to the slots. The turntable was turned on and operated for 5 minutes before spraying was commenced. Details for best results in respect to gun to shield and shield to spray bar distances, the number of spray passes and drying passes were determined empirically for the RCA 33C-131 and Sylvania CR-1 spray suspensions used to date, the objectives in each case being smooth cathodes of .0025" to .0030" thick .

Results

(a) Surface Texture

Photomicrographs of the surfaces of a number of cathodes prepared are shown in Figure 8. (a) is a normal factory sprayed Sylvania mix cathode, (b) is a normal factory sprayed RCA mix cathode shaved, (c) is a laboratory sprayed RCA mix cathode (slightly "wet") using the limiting aperture, (d) is a laboratory sprayed Sylvania mix cathode (slightly "wet") using the limiting aperture, (e) is a laboratory sprayed Sylvania mix cathode (slightly "dry") using the limiting aperture, and (f) is a factory sprayed cathode received from Sylvania Electronics. The flattened portion of the photomicrograph of the purchased Sylvania cathode may be due to gauging. A considerable improvement in surface texture is evident for cathodes sprayed **with the limiting** aperture as compared to cathodes sprayed in a normal manner.

Height variation measurements of the cathode surfaces shown in Figure 8 were made by E. F. Schilling[4] using a microscope with vertical fine focus adjustment. The results are given in Table 1.

Table 1

Method of Spraying	Height Variation
Laboratory (with aperture) RCA Mix	.00048"
Laboratory (with aperture) RCA Mix	.00052"
Factory Shaved (without aperture) RCA Mix	.00088"
Factory Shaved (without aperture) RCA Mix	.00092"
Normal Factory (without aperture) RCA Mix	.0014"
Normal Factory (without aperture) RCA Mix	.0019"
Purchased Sylvania Factory Cathodes	.00072"
Purchased Sylvania Factory Cathodes	.0008"
Laboratory (with aperture) Sylvania Mix	.0008"
Laboratory (with aperture) Sylvania Mix	.0005"
Factory Shaved (without aperture) Sylvania Mix	.0009"
Factory Shaved (without aperture) Sylvania Mix	.0010"
Normal Factory (without aperture) Sylvania Mix	.0016"
Normal Factory (without aperture) Sylvania Mix	.0018"

The figures of Table 1 show that the cathodes sprayed with a limiting aperture have the least height variation, thus substantiating the evidence presented in the photomicrographs of Figure 8.

(b) Density and Thickness Measurements

The cathode coatings produced in the laboratory and the factory with and without the use of a limiting aperture were measured for their density and thickness to determine any change produced. For the density measurements a direct method was used. The direct method involves the measurement of density of the coating actually on the cathodes* The cathode cap with coating is cut on a lathe with a clean, dry razor. The coated cap is weighed carefully on a Sartorius semi-micro balance. The coating thickness is measured either with a Kodak Contour Projector Comparator Model 2A or with a Federal Dial Gauge D21-C. The coating is removed from the cap, the cap weighed and the density is determined. It should be pointed out that a certain amount of sample compression occurs when a coating thickness is measured with a dial gauge as compared to figures obtained for thickness when using the comparator. From a number of thickness measurements made, the amount of compression was found to be about 15 percent of the total uncompressed coating thickness. This figure is the same as that arrived at by B. Wolk of Sylvania[5]. Density calculations using the dial gauge thickness measurements are listed in Table 2.

*Cathode coatings are 0.117" in diameter.

Table 2

Method of Spraying	Average Density g/cc
Laboratory (with aperture) Sylvania Mix Needle valve 70% open	1.29
Laboratory (with aperture) Sylvania Mix Needle valve 50% open	1.33
Normal factory (without aperture) Sylvania Mix	1.25
Purchased Sylvania Factory cathodes	1.22

As shown in Table 2, the use of a limiting aperture for cathode spraying results in some increase of the coating density which is to be expected if large voids created by a random distribution of large agglomerates are avoided. In industry and in our own immediate area, workers concerned with the art of cathode fabrication are often wary of any coating process which increases coating density, no matter how small it is, beyond that accustomed to, since the conditions of coating adherence to the base metal, carbonate decomposition temperature during exhaust, and the emission density may be affected adversely. Thus, to make certain that the cathodes prepared with a limiting aperture were not adversely affected as to conditions noted above, and also to determine if they provided a focus quality better than heretofore obtained, a number of tests were performed by E. F. Schilling: Tubes containing cathodes prepared with a limiting aperture and control tubes containing standard factory cathodes were exhausted, activated and aged in the factory using standard procedures. Several tubes containing cathodes prepared with a limiting aperture were opened after processing and cathode coatings were examined for radial cracks and any other signs of poor adherence. The coatings were good. Initial emission characteristics were found to be normal. Examination of the cathode images projected on the phosphor screen not only showed no indication of cracks, but also showed a spot size improvement as high as 25 percent. Details of the spot size measurements, depth of focus ratings and results of arcing may be found in a report by E. F. Schilling, reference 4.

A number of tubes were placed on standard cathode ray tube life test and after several hundred hours life thus far have shown emission results which are good.

Conclusion

The main objective of the work described in this report was to improve the quality of a cathode so as to help obtain an improved electron beam spot size and performance in a cathode ray tube. As a first approach, cathode fabrication techniques were considered which with a minimum of effort and change in equipment were easily adaptable to existing factory facilities. The specific choice of the spray technique described in the report was a fortunate one as shown by the successful results obtained.

It should be realized, however, that as the art of fabrication of electron beam devices progresses, especially with the introduction of electron guns capable of being driven in whole or in part by transistorized sets, an increase in mutual conductance will be the next step. Thus, a better, more uniform, and flatter cathode surface capable of being mounted with closer inter-electrode distances than in present day tubes is necessary. This means that newer and better methods for obtaining desired quality cathodes must be actively pursued.

Acknowledgement

The author wishes to thank S. Sofia for his valuable assistance in determining the proper cathode spray conditions which helped toward the successful completion of this work. Thanks are due also to W. Egy who was responsible for the unique design of the cathode spray bar.

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[2] G. W. Preston, Effect of Roughness on the Maximum Current Density in an Electron Beam, J. App. Phys., 27, 627 (1956).

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[5] B. Wolk, The Relationship between Thermal Decomposition in Vacuum and the Microstructure of Alkaline Earth Carbonates, J. Electrochem. Soc., No. 5, 89 (1958).

PPC:jfe

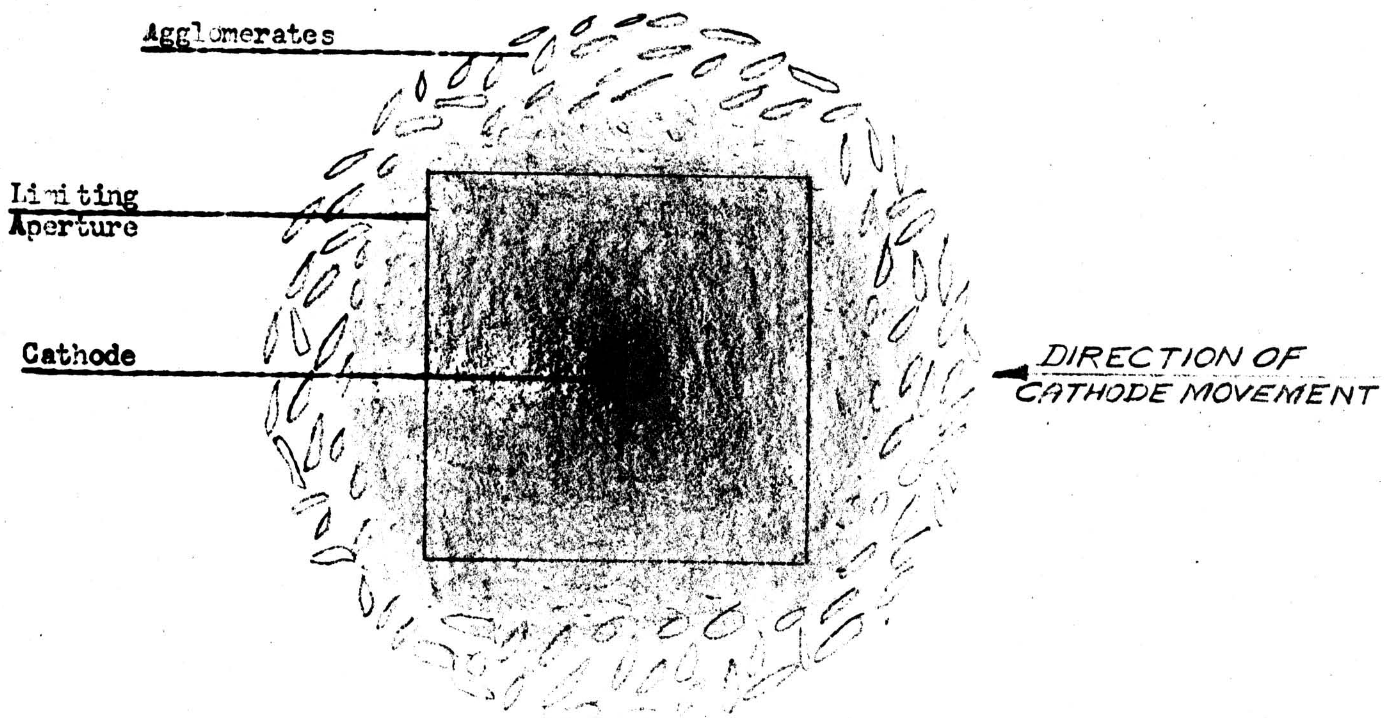
Agglomerates
Limiting
Aperture
Cathode
DIRECTION OF
CATHODE MOVEMENT

FIGURE 1

GENERAL ELECTRIC

P69982-51A119 — SH NO. 3

TITLE: DRYING ASSEMBLY & SPRAY SHIELD - ROTARY SPRAY FIXTURE

FIRST MADE FOR: N1G000 DG CATHODE

REQD	No	MATERIAL	
1	1	16 GA (.059) BLACK IRON - 18½ x 20	
2	2	2x2x⅛ ANGLE IRON - 5" LG.	
1	3	16 GA (.059) BLACK IRON - 5x10	
2	4	16 GA (.059) BLACK IRON - 2" x 7"	
4	5	#10-32 x ½ RD. HD. C'SCW.	ST.
4	6	#10 LOCK WASHER	ST.
4	7	#10-32 HEX. NUT	ST.
1	8	16 GA - (.059) BLACK IRON - 19x20"	
5	9	SIGN BOARD SOCKET 600W - 250V - GE	
5	10	250 WATT - 110V INFRA RED BULBS	
AS REQD	11	ELECTRIC WIRE - 14 GA. S.C. - R.C.	
1	12	SEE DET. 12	
1	13	SEE DET. 13	

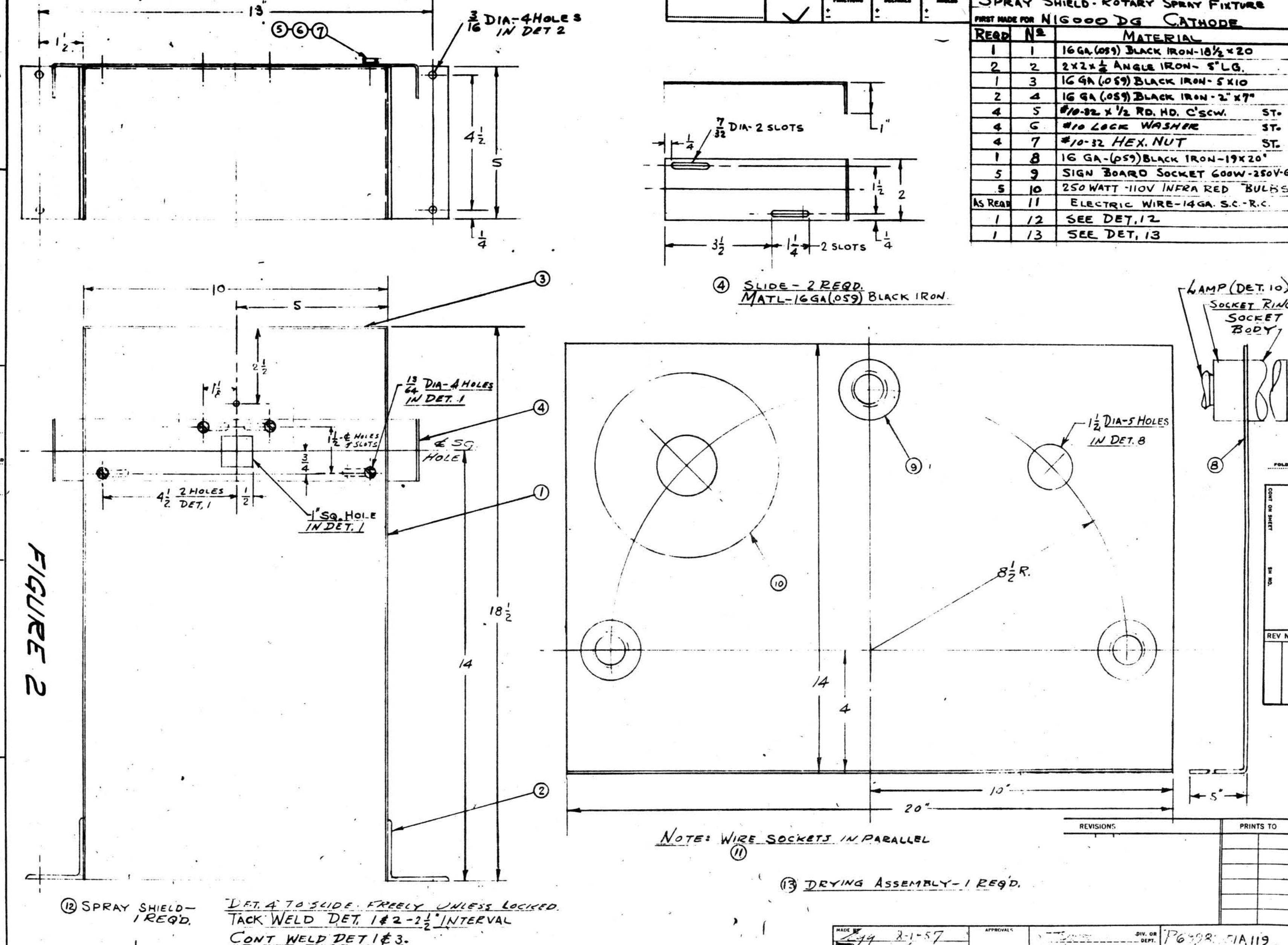

FIGURE 2

UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING— APPLIED PRACTICES / SURFACES / TOLERANCES ON MACHINED DIMENSIONS: FRACTIONS ± DECIMALS ± ANGLES ±

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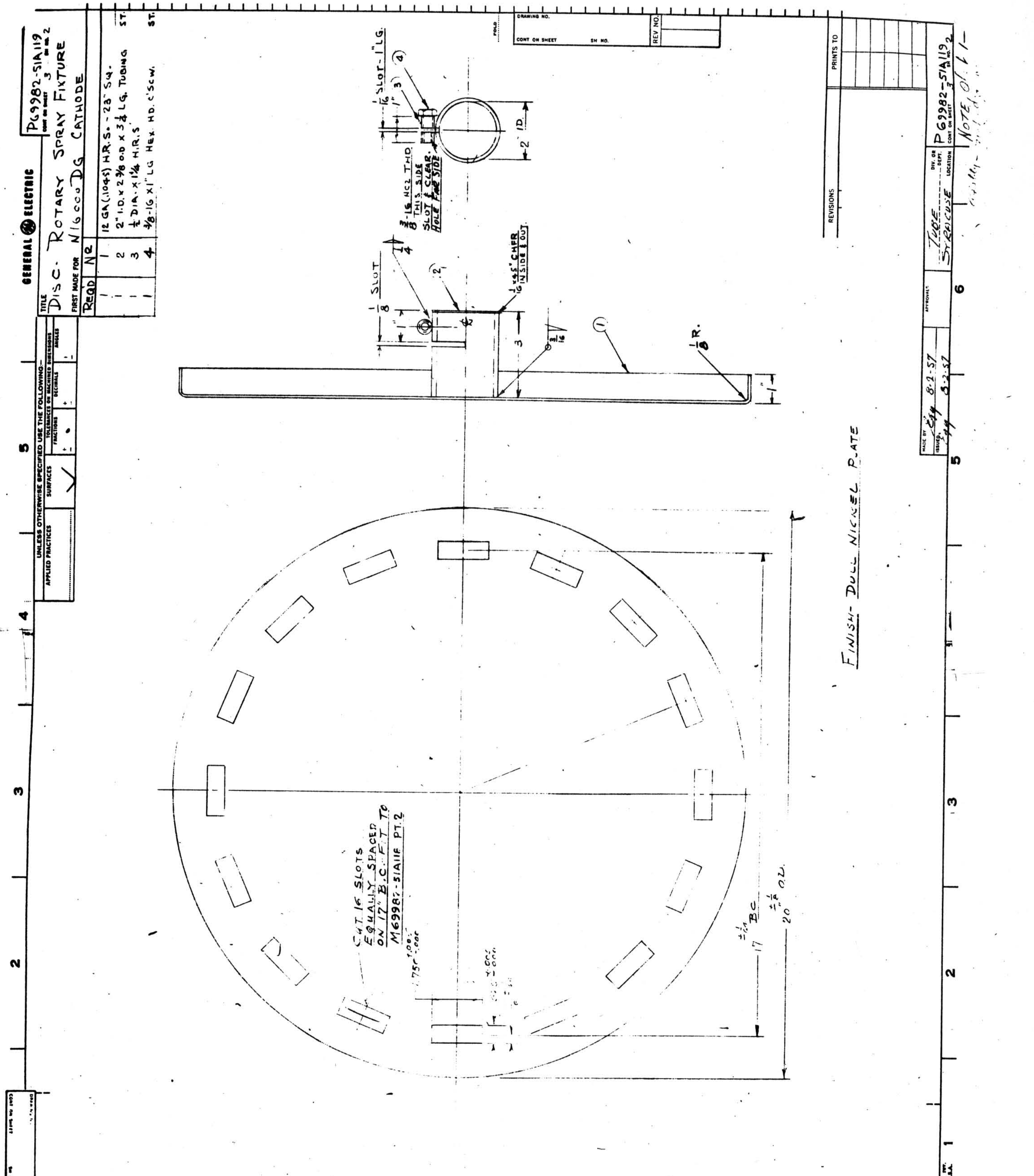
GENERAL ELECTRIC
P69982-51A119
CONT ON SHEET 3 SH NO. 2
TITLE DISC - ROTARY SPRAY FIXTURE
FIRST MADE FOR N16000 DG CATHODE
REQD NO
1 1 12 GA (.1045) H.R.S. - 23" SQ.
1 2 2" I.D. x 2 3/8 O.D. x 3 1/4 LG. TUBING
1 3 1/4 DIA. x 1 1/4 H.R.S.
1 4 3/8-16 x 1" LG. HEX. HD. C'SCW.
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING—
APPLIED PRACTICES
SURFACES
TOLERANCES ON MACHINED DIMENSIONS
FRACTIONS
DECIMALS
ANGLES
1/16 SLOT - 1" LG.
3/8-16 NC2 THD THIS SIDE SLOT & CLEAR. HOLE FAR SIDE
2" I.D.
1/8 SLOT
1/16 x 45° CHFR INSIDE & OUT
1/8 R.
FINISH - DULL NICKEL PLATE
CUT 16 SLOTS EQUALLY SPACED ON 17" B.C. F.T. TO M69982-51A11F PT.2
17 B.C.
20" O.D.
DRAWING NO.
CONT ON SHEET
SH NO.
REV NO.
PRINTS TO
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MADE BY 8-2-57
ISSUED 8-2-57
APPROVALS
TUBE
SYRACUSE
DIV. OR DEPT.
LOCATION
P69982-51A119
CONT ON SHEET 3 SH NO. 2

FIGURE 3

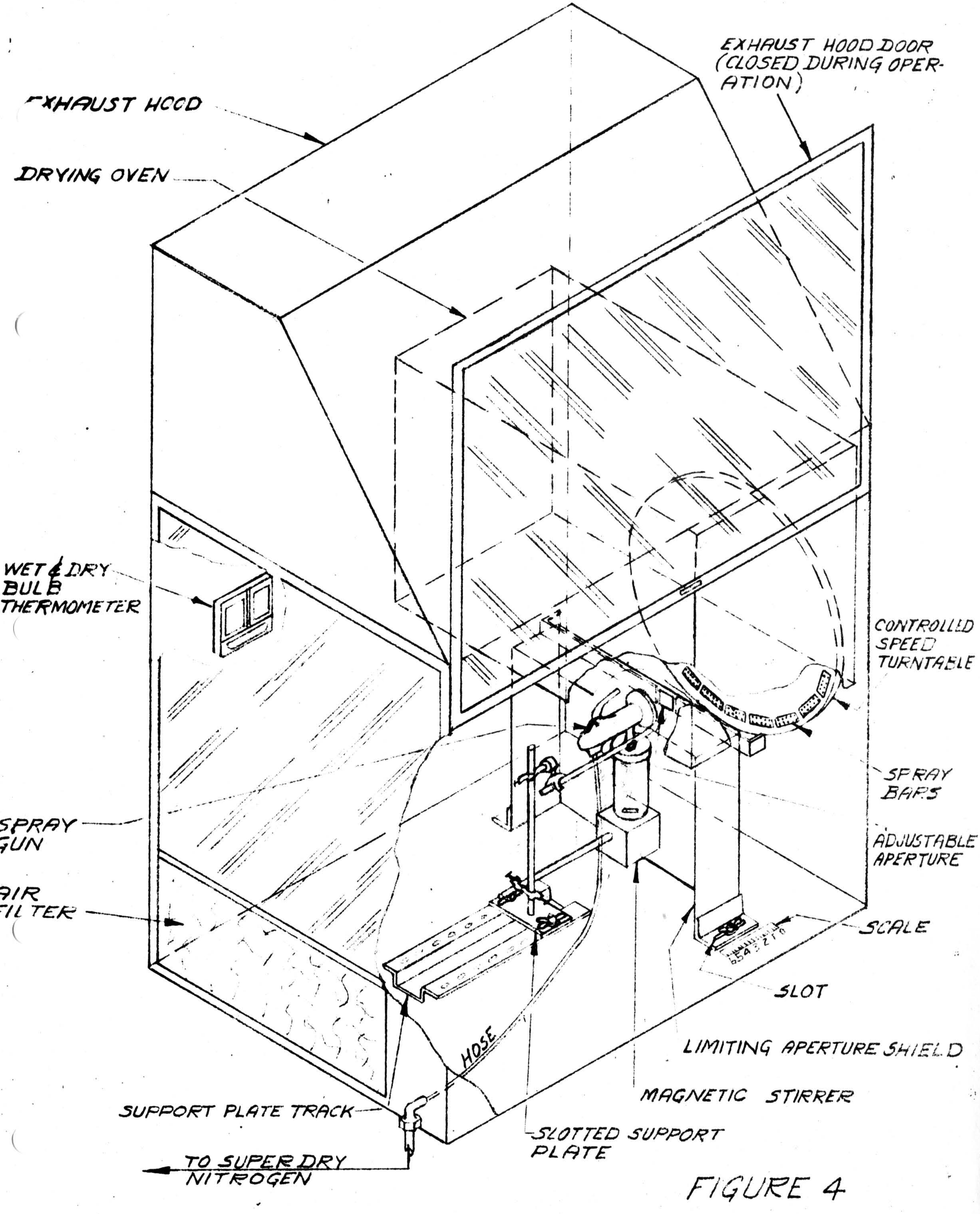
EXHAUST HOOD DOOR (CLOSED DURING OPERATION)
EXHAUST HOOD
DRYING OVEN
WET & DRY BULB THERMOMETER
CONTROLLED SPEED TURNTABLE
SPRAY BARS
SPRAY GUN
ADJUSTABLE APERTURE
AIR FILTER
SCALE
SLOT
HOSE
LIMITING APERTURE SHIELD
MAGNETIC STIRRER
SUPPORT PLATE TRACK
SLOTTED SUPPORT PLATE
TO SUPER DRY NITROGEN

FIGURE 4

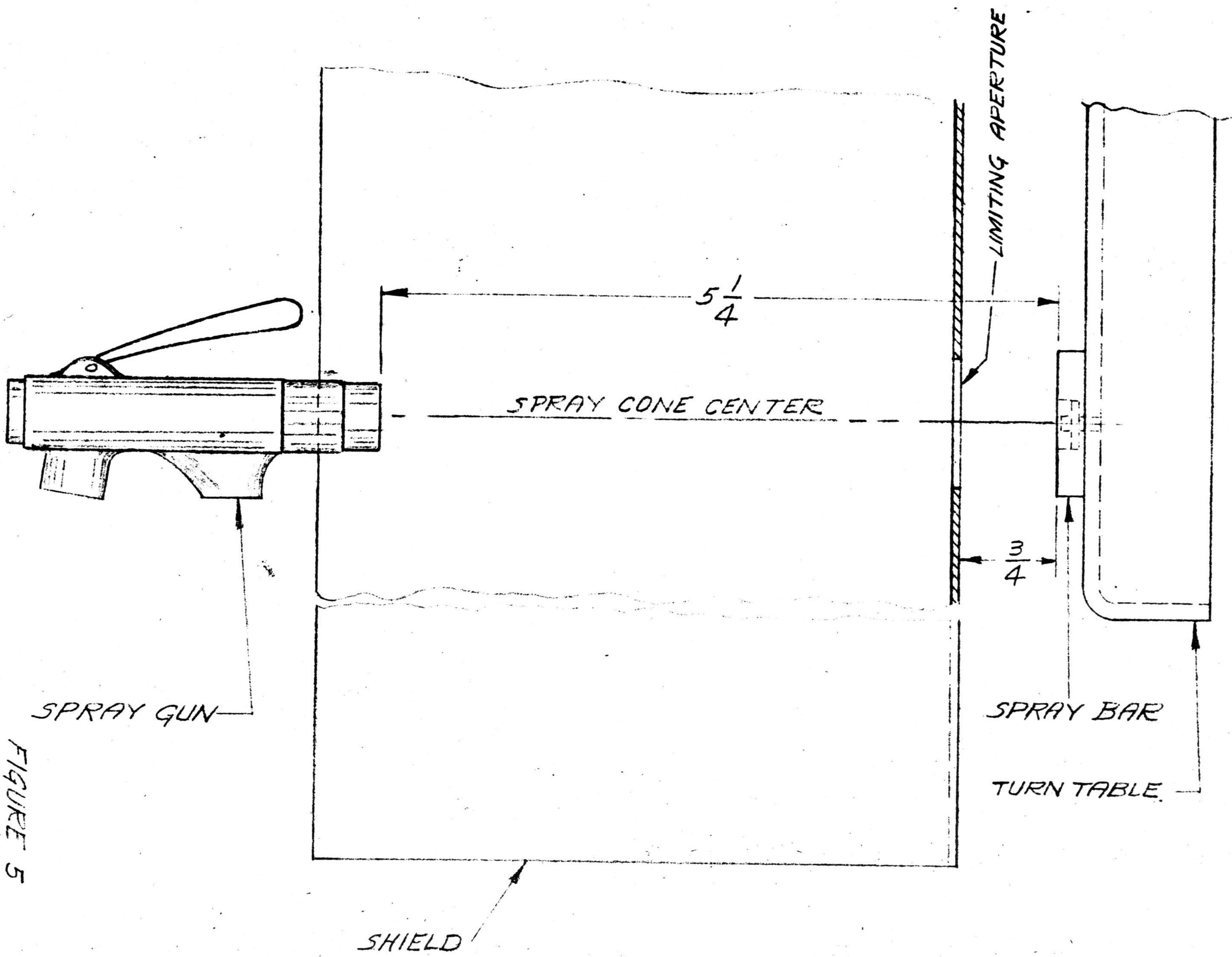
LIMITING APERTURE
5 1/4
SPRAY CONE CENTER
3/4
SPRAY GUN
SPRAY BAR
TURN TABLE
SHIELD

FIGURE 5

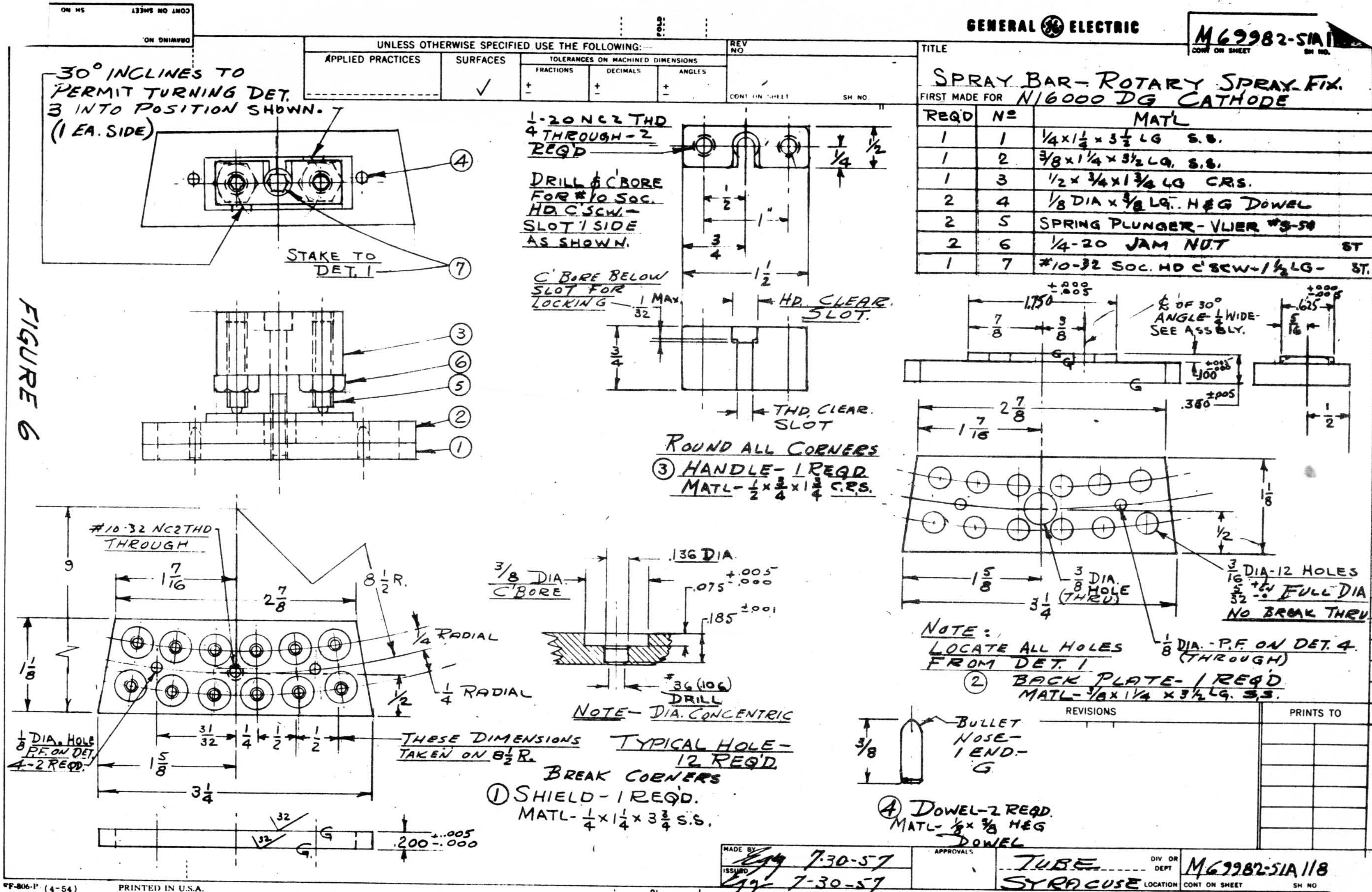
GENERAL ELECTRIC
M69982-51A 1
TITLE
SPRAY BAR - ROTARY SPRAY FIX.
FIRST MADE FOR N16000 DG CATHODE
REQ'D | NO | MAT'L
1 | 1 | 1/4 x 1 1/4 x 3 1/2 LG S.S.
1 | 2 | 3/8 x 1 1/4 x 3 1/2 LG. S.S.
1 | 3 | 1/2 x 3/4 x 1 3/4 LG CRS.
2 | 4 | 1/8 DIA x 3/8 LG. H&G DOWEL
2 | 5 | SPRING PLUNGER - VLIER #S-50
2 | 6 | 1/4-20 JAM NUT ST
1 | 7 | #10-32 SOC. HD C'SCW - 1 1/2 LG - ST.
UNLESS OTHERWISE SPECIFIED USE THE FOLLOWING:
APPLIED PRACTICES
SURFACES
TOLERANCES ON MACHINED DIMENSIONS
FRACTIONS
DECIMALS
ANGLES
REV NO
30° INCLINES TO PERMIT TURNING DET. 3 INTO POSITION SHOWN. (1 EA. SIDE)
STAKE TO DET. 1
1/4-20 NC2 THD THROUGH - 2 REQ'D
DRILL & C'BORE FOR #10 SOC. HD C'SCW. - SLOT 1 SIDE AS SHOWN.
C'BORE BELOW SLOT FOR LOCKING - 1/32 MAX.
HD. CLEAR. SLOT.
THD CLEAR. SLOT
ROUND ALL CORNERS
3 HANDLE - 1 REQ'D
MATL - 1/2 x 3/4 x 1 3/4 C.R.S.
C OF 30° ANGLE - 1/4 WIDE - SEE ASS'BLY.
3/16 DIA - 12 HOLES
5/32 FULL DIA
NO BREAK THRU
3/8 DIA. HOLE (THRU)
1/8 DIA. - P.F. ON DET. 4 (THROUGH)
NOTE: LOCATE ALL HOLES FROM DET. 1
2 BACK PLATE - 1 REQ'D
MATL - 3/8 x 1 1/4 x 3 1/2 LG. S.S.
#10-32 NC2 THD THROUGH
8 1/2 R.
1/4 RADIAL
1/4 RADIAL
1/8 DIA. HOLE P.F. ON DET. 4 - 2 REQ'D.
THESE DIMENSIONS TAKEN ON 8 1/2 R.
BREAK CORNERS
1 SHIELD - 1 REQ'D.
MATL - 1/4 x 1 1/4 x 3 3/4 S.S.
3/8 DIA. C'BORE
.136 DIA.
#36 (.106) DRILL
NOTE - DIA. CONCENTRIC
TYPICAL HOLE - 12 REQ'D
BULLET NOSE - 1 END - G
4 DOWEL - 2 REQ'D.
MATL - 1/8 x 3/8 H&G DOWEL
REVISIONS
PRINTS TO
MADE BY 7-30-57
ISSUED 7-30-57
APPROVALS
TUBE DIV OR DEPT
SYRACUSE LOCATION
M69982-51A 1/8
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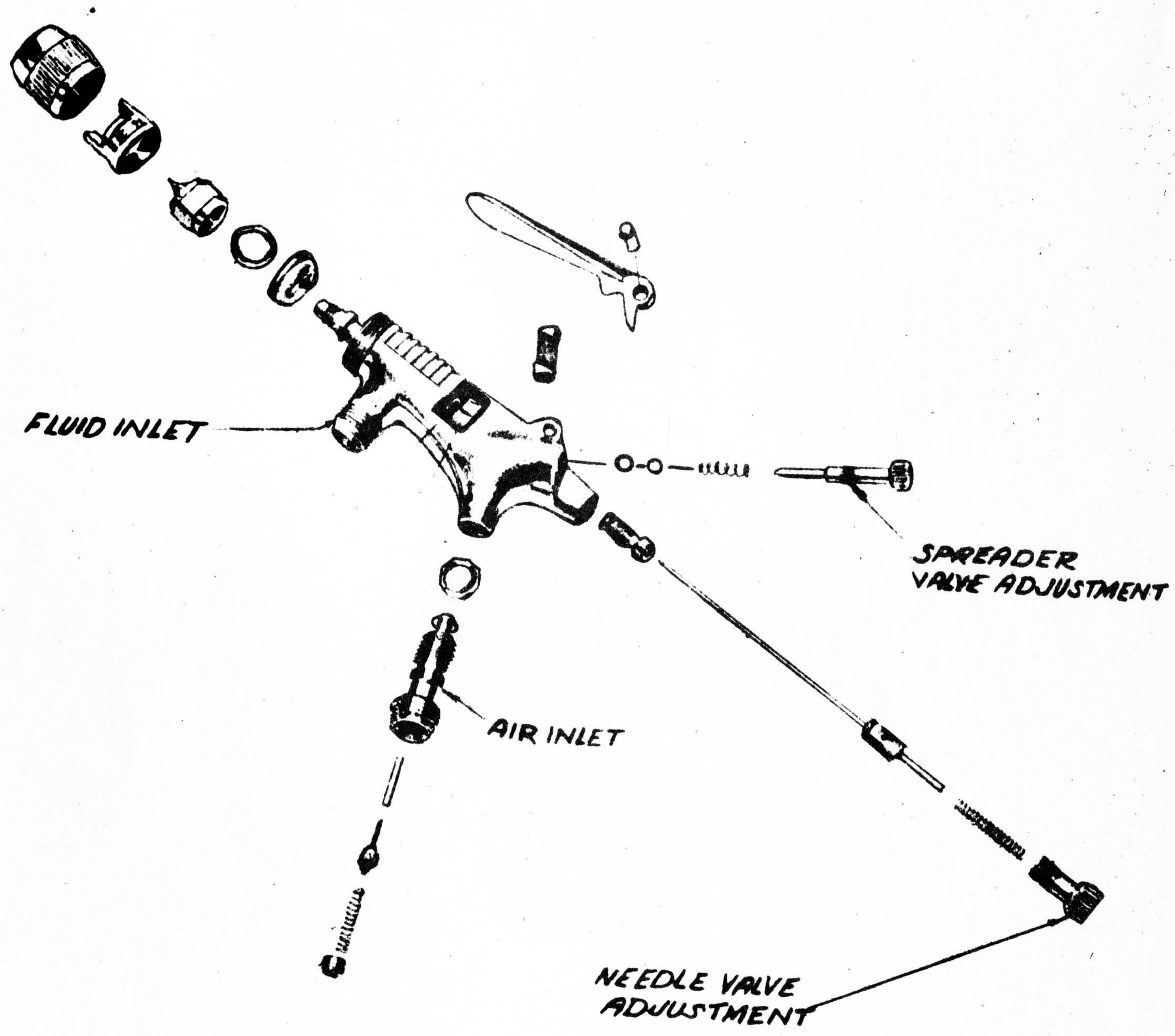
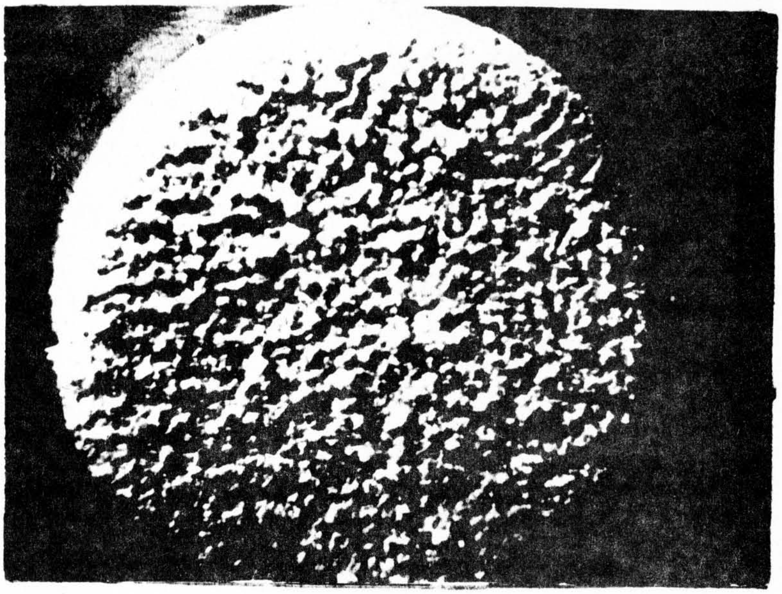
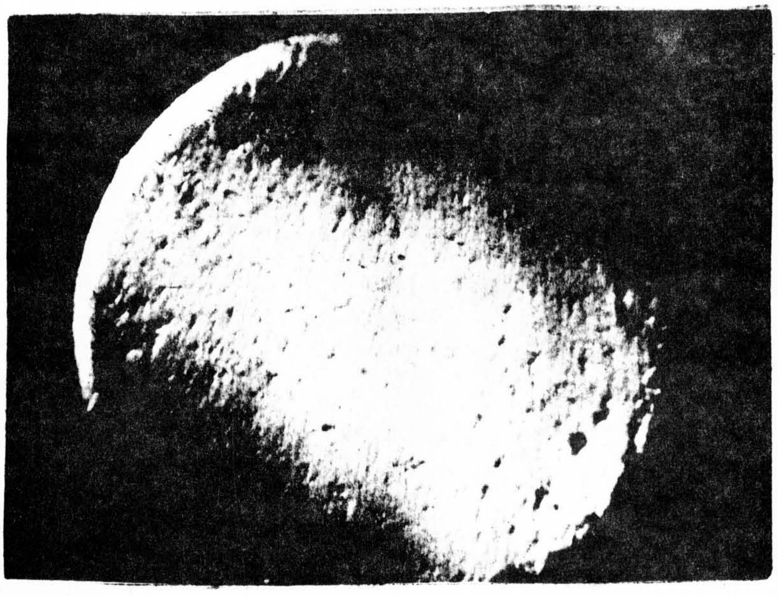
FIGURE 6



DEVILBISS SPRAY GUN FIGURE 7

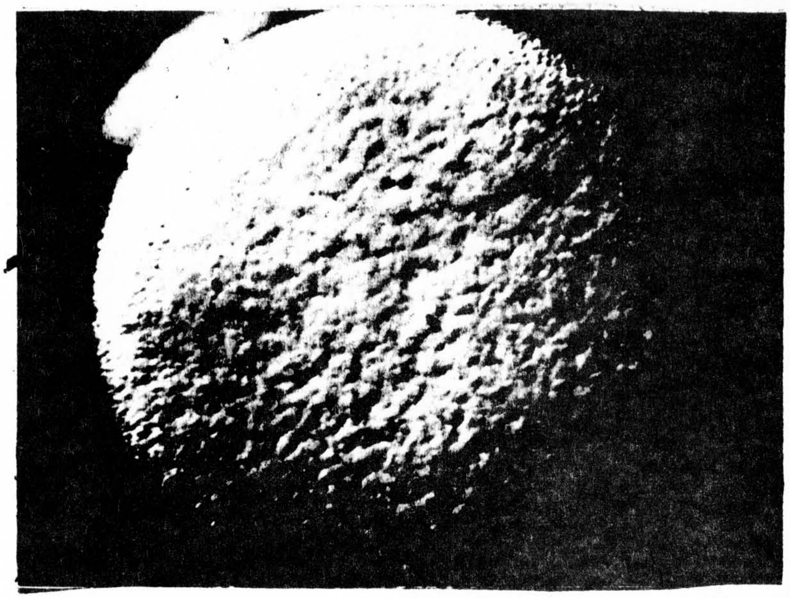


(a)

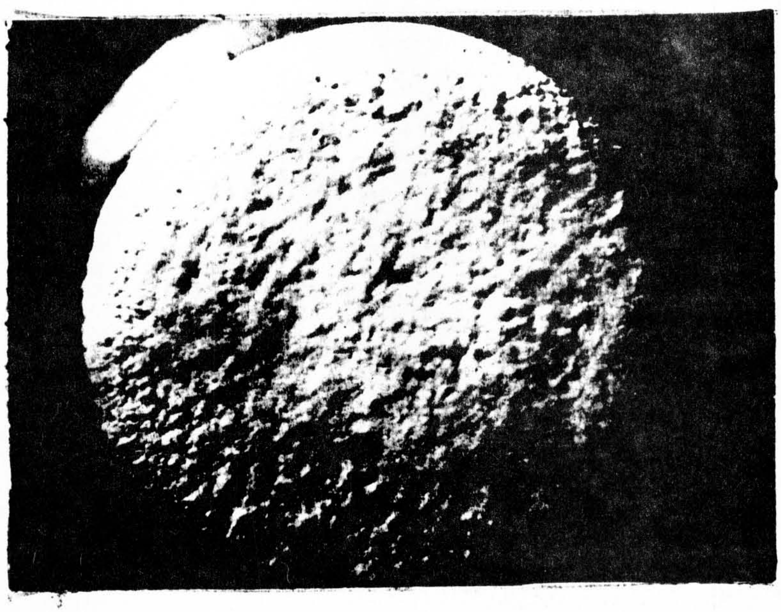


(b)

FIGURE 8 (a) & (b)

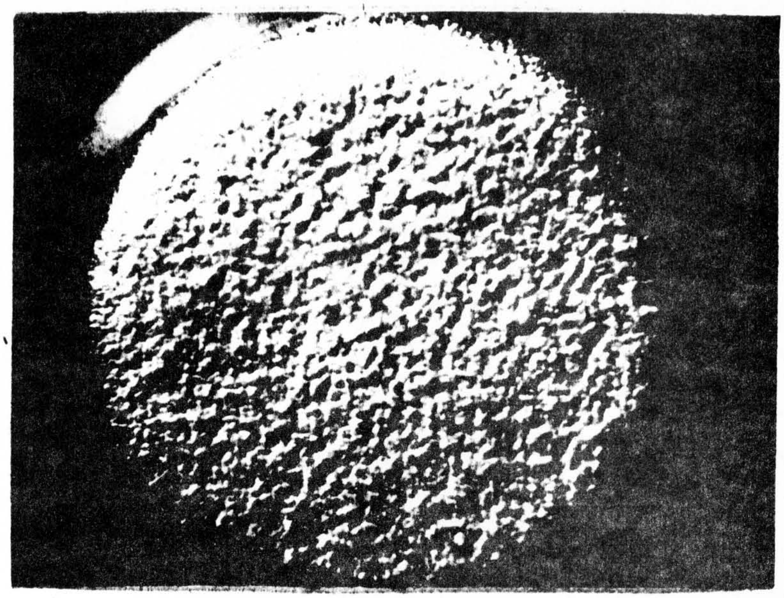


(c)

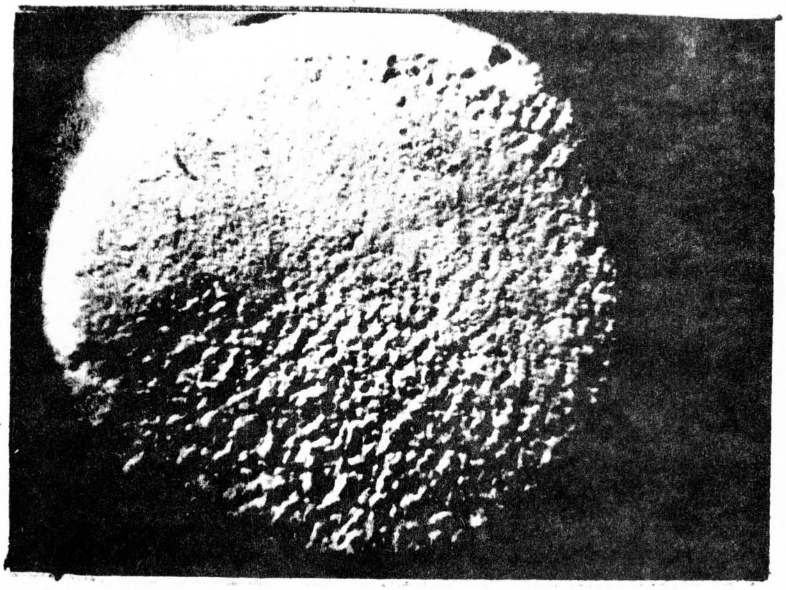


(d)

FIGURE 8 (c) & (d)



(e)



(f)

FIGURE 8 - (e) & (f)