

ADA038271

"PRODUCTION ENGINEERING MEASURE FOR HIGH RANGE GEIGER MUELLER TUBE."

"FINAL REPORT COVERING THE PERIOD FROM MAY 1974 TO SEPT. 1976"

PLACED BY PROCUREMENT AND PRODUCTION DIRECTORATE, U.S. ARMY ELECTRONICS COMMAND, FT. MONMOUTH, N.J.

LND INC.  
3230 LAWSON BLVD.  
OCEANSIDE, N.Y. 11572

APPROVED FOR PUBLIC RELEASE, DISTRIBUTION UNLIMITED.

# LND

3230 LAWSON BLVD.  
OCEANSIDE, NEW YORK 11572 • 516-878-6141

1690

"THIS REPORT HAS BEEN ACCOMPLISHED AS PART OF THE U.S. ARMY ADVANCED PRODUCTION ENGINEERING PROGRAM, WHICH HAS AS ITS OBJECTIVE THE TIMELY ESTABLISHMENT TO MANUFACTURING PROCESSES, TECHNIQUES OR EQUIPMENT TO INSURE THE EFFICIENT PRODUCTION OF CURRENT OR FUTURE DEFENSE PROGRAMS FOR HIGH RANGE GEIGER MUELLER TUBES"

"THE FINDINGS OF THIS REPORT ARE NOT TO BE CONSIDERED AS AN OFFICIAL DEPARTMENT OF THE ARMY POSITION UNLESS SO DESIGNATED BY OTHER AUTHORIZED DOCUMENTS".

"DESTROY THIS REPORT WHEN IT IS NO LONGER NEEDED. Do NOT RETURN IT TO THE ORIGINATOR".

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. DA-OB-3207	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Final Report Production Engineering Measure for High Range Geiger Mueller Tube		5. TYPE OF REPORT & PERIOD COVERED May 1974 to Sept. 76
7. AUTHOR(s) Robert W. Lehnert		6. PERFORMING ORG. REPORT NUMBER
9. PERFORMING ORGANIZATION NAME AND ADDRESS LND, Inc. 3230 Lawson blvd. Oceanside, N.Y. 11572		8. CONTRACT OR GRANT NUMBER(s) DAAB05-72-C-5869
11. CONTROLLING OFFICE NAME AND ADDRESS Dept. of the Army Headquarters US Army Electronics Command Fort Monmouth, New Jersey 07703		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2729385
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) DCAS Garden City		12. REPORT DATE Sept. 1976
		13. NUMBER OF PAGES
		15. SECURITY CLASS. (of this report) unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE N/A
16. DISTRIBUTION STATEMENT (of this Report) See attached		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Unlimited		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) See Glossary		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This program is an investigation of the proper techniques employed to provide stable, predictable performance GM tubes for use as the high range detector of the AN/VDR-1. The techniques include special cathode and anode surface treatment to prevent secondary emissions and resultant spurious counts (instability).		

CONTINUED ON NEXT PAGE

All testing has been completed during this reporting period. The tests prove the units to be completely stable and meet all the requirements of the specification.

"PRODUCTION ENGINEERING MEASURE FOR HIGH RANGE GEIGER MUELLER TUBE".

"FINAL REPORT COVERING THE PERIOD FROM MAY 1974 TO SEPT. 1976"

"THIS REPORT HAS BEEN ACCOMPLISHED AS PART OF THE U.S. ARMY ADVANCE PRODUCTION ENGINEERING PROGRAM, WHICH HAS AS ITS OBJECTIVE THE TIMELY ESTABLISHMENT TO MANUFACTURING PROCESSES, TECHNIQUES OR EQUIPMENT TO INSURE THE EFFICIENT PRODUCTION OF CURRENT OR FUTURE DEFENSE PROGRAMS FOR HIGH RANGE GEIGER MUELLER TUBES".

CONTRACT NUMBER DAAB05-72-C-5869

REPORT PREPARED BY: ROBERT W. LEHNERT

"APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED".

# TABLE OF CONTENTS

	PAGE
REPORT DOCUMENTATION PAGE - DD1473	
LIST OF FIGURES	i
LIST OF TABLES	ii
ACKNOWLEDGEMENT	iii
ABSTRACT	1
PURPOSE	2
INTRODUCTION	3
STATEMENT OF PROBLEM	3-4
DEVICE	4-25
PROCESS, EQUIPMENT AND TOOLING	26-27
PUMP AND FILL SCHEDULE	34-35
CHLORINE PROCESSING	36-38
STUDY OF VACUUM PUMPING SYSTEMS	39-40
PRINCIPLES OF OPERATION OF TURBO MOLECULAR PUMP	41-42
GENERAL CHARACTERISTICS	43-45
SPUTTER ION PUMPS	47
DIFFUSION PUMPS	49-52
PUMPING SYSTEM	53-54
FLOW CHART AND MANUFACTURING PROCESS	59-65
SPECIFICATION	68
MILITARY SPEC. SHEET SCS-415C	69-80
REQUIREMENT FOR PILOT LINE	82

TABLE OF CONTENTS (CON'T)

DESCRIPTION LND FACILITIES	83-85
ANALYSIS OF AREA OPERATIONS	86-87
CONCLUSION	88-91
GLOSSARY (APPENDIX)	92-98

## LIST OF FIGURES

<u>FIGURES</u>		<u>PAGE</u>
1	PHOTOGRAPH OF COMPONENTS AND ASSEMBLED UNITS	10
2	DRAWING OF HALOGEN QUENCHED GM TUBE TYPE 71411	11
3-10	COMPONENT DRAWINGS	12-19
11	SECONDARY ION MASS SPECTRUM	24
12	APPLICATION OF POWDERED GLASS TO CATHODE AND INSULATOR	28
13	FIRING FIXTURE	29
14	FLOW CHART OF MANUFACTURING PROCESS	30
15	<i>does not exist</i>	<i>31-Blank</i>
16	MULTIPLE LEAK CHECKING MANIFOLD	32
17	10 PLACE MANIFOLD	33
18	SCHEMATIC CROSS-SECTION OF TURBO-MOLECULAR PUMP	46
19	TYPICAL PERFORMANCE CURVES FOR OIL DIFFUSION PUMPS	51
20	PHOTOGRAPH - AUTOMATIC OVENS AND CONTROLS	55
21	PHOTOGRAPH - AUTOMATIC PUMPING SYSTEMS AND CONTROLS	56
22	PHOTOGRAPH - AUTOMATIC OVEN PUMPING SYSTEMS AND CONTROLS	57
23	GM COUNTER PUMPING AND FILLING SYSTEM	58
24	FLOW CHART OF MANUFACTURING PROCESS	60
FIGURES WITHIN MIL SEPC SCS-415C		
1	HALOGEN QUENCHED GM TUBE TYPE 71425 (DRAWING)	75
2	1 OPERATING CIRCUIT FOR 71425	76
3	PLATEAU CURVE	77
4	POSITION OF TUBE FOR PHOTSENSITIVITY TEST	78



LIST OF FIGURES (CON'T)

FIGURES WITHIN MIL SPEC SCS-415C (CON'T) PAGE

5 PULSE WAVE FORMS 79

6 RESPONSE CHARACTERISTIC OF TYPICAL 71425 80

FIGURES

25 LND FACILITIES SHOWING AREA'S USED IN MANUFACTURE  
OF HIGH RANGE GM COUNTER FOR AN/VDR-1 81

## LIST OF TABLES

<u>TABLE</u>		<u>PAGE</u>
1	PROPERTIES OF FOSTERITE CERAMIC	7
2	IONIZATION POTENTIALS FOR VARIOUS GASES	8
3	PHOTOELECTRIC WORK FUNCTIONS	9
4	VACUUM OUTGASSING AND OXYGEN FIRING SCHEDULE	20
5	SAMPLE TUBULATION OF ELEMENTS	25
6	ELECTRON CONFIGURATIONS OF HALOGENS	37
7	IONIZATIONS POTENTIALS (VOLTS)	37
8	RELEATIVE PUMPING SPEED FOR GASES IN FLAT CATHODE SPUTTER ION PUMP	48
9	EQUIPMENT AND TOOLING REQUIRED FOR MANUFACTURE OF HIGH RANGE GM COUNTERS	66-67

ACKNOWLEDGEMENT

LND WISHES TO ACKNOWLEDGE THE ASSISTANCE OF S. LEVY  
OF USAECOM, FT. MONMOUTH, FOR HIS TECHNICAL ASSISTANCE.

## ABSTRACT

THIS PROGRAM HAS BEEN AN INVESTIGATION OF THE PROPER TECHNIQUES EMPLOYED TO PROVIDE STABLE, PREDICTABLE PERFORMANCE GM TUBES FOR USE AS THE HIGH RANGE DETECTOR OF THE AN/VDR-1. THE TECHNIQUES INCLUDE SPECIAL CATHODE AND ANODE SURFACE TREATMENT TO PREVENT SECONDARY EMISSIONS AND RESULTANT SPURIOUS COUNTS (INSTABILITY); DESIGN AND BUILDING OF NEW PUMPING SYSTEMS FIXTURES ETC. TO HANDLE GREATER THAN 1000 TUBES/MONTH OF ONE TYPE.

THE TESTS PROVE THE UNITS PROVIDED TO BE COMPLETELY STABLE AND MEET THE REQUIREMENTS OF THE SPECIFICATION.

A NEW SPECIFICATION HAS BEEN PROVIDED INCORPORATING ALL THE FINDINGS OF THIS PROGRAM.

## PURPOSE

THIS IS THE FINAL REPORT UNDER CONTRACT NUMBER DAAB05-72-C-5869 PRODUCTION ENGINEERING MEASURE FOR HIGH RANGE GEIGER MUELLER TUBES. (THE PURPOSE OF THIS PROGRAM WAS TO DEVELOP A PRODUCTION OF METHOD AND ASSOCIATED DOCUMENTATION FOR THE HIGH RANGE GM DETECTOR USED IN THE AN/VDR-1 (A) RADIAC EQUIPMENTS. THIS TUBE IS A SPECIALIZED VERSION OF COMMERCIALY AVAILABLE GM DETECTORS. A MAJOR OBJECTIVE WAS TO PROVIDE LONG TERM STABILITY  $>10^{10}$  PULSES AND RELIABLE PERFORMANCE.

DURING THIS REPORTING PERIOD, EFFORT HAS BEEN EXPENDED ON THE FOLLOWING AREAS:

- A. TESTING AND SHIPMENT OF THE PILOT RUN UNITS
- B. REVIEW OF ALL TEST DATA
- C. INTERFACE WITH NUCOR AND FT. MONMOUTH GROUP CONCERNING OPERATING IN THE AN/VDR-1 EQUIPMENT
- D. FINAL REPORTS.

## INTRODUCTION

GEIGER MUELLER TUBE DEVELOPMENT WITH THE ADVENT OF HALOGEN ADMIXTURES HAS LED TO BETTER COUNTING CHARACTERISTICS AND MORE FLEXIBLE DESIGN PERMITTING GREATER ADAPTABILITY TO MORE DIVERSE APPLICATIONS. THEIR PROPERTIES AND CHARACTERISTICS ARE NOT THE SAME AS ORGANIC QUENCHED COUNTERS. THE LIFE OF ORGANIC QUENCHED COUNTERS IS LIMITED BECAUSE THE MECHANISM OF QUENCHING REQUIRES THE CHEMICAL DESTRUCTION - PREDISSOCIATION OF A DEFINITE NUMBER OF ORGANIC MOLECULES PER PULSE WHICH DO NOT NECESSARILY RECOMBINE INTO THE ORIGINAL CONSTITUENTS. THE LIFE OF THE HALOGEN QUENCHED COUNTER IS NOT LIMITED BY QUENCHING SINCE THE QUENCHING MECHANISM INVOLVES A CHANGE IN THE HALOGEN FROM MOLECULAR TO ATOMIC STATE AND BACK TO MOLECULAR STATE. FOR THIS REASON THE LIFE OF A HALOGEN COUNTER IS NOT AFFECTED BY USE.

A NEW R&D PROGRAM TO IMPROVE THE AN/VDR-1 HIRAC TUBE HAS BEEN INSTITUTED. THE MAIN OBJECTIVE IS TO SUPPLY A DETECTOR TO MEET ALL AN/VDR-1 REQUIREMENTS WITH A LIFE OF  $10^{11}$  COUNTS. THE WORK DONE IN THE INITIAL PHASE INCLUDED DEVELOPMENT AND ANALYSIS OF PASSIVE COATING FOR POTENTIAL USE ON THE CATHODE AND ANODE SURFACES. IT ALSO INCLUDED ENVIRONMENTAL TESTING OF THESE PROTOTYPE COATINGS AND INITIAL ELECTRICAL TESTING TO DETERMINE THEIR COMPATIBILITY WITH CONTRACT REQUIREMENTS.

## STATEMENT OF THE PROBLEM

THE FABRICATION OF THE HIGH RANGE DETECTOR USED IN THE AN/VDR-1 EQUIPMENT PRESENTS SEVERAL DIFFICULT AREAS OF TUB PARAMETERS TO BE MAINTAINED AND STABILIZED OVER THE TUBE LIFE. MOST CRITICAL OF THE DETECTOR OPERATING PARAMETERS AS REQUIRED BY AN/VDR-1 OPERATING CHARACTERISTICS ARE:

1. STARTING VOLTAGE
2. GAMMA SENSITIVITY
3. MINIMUM PULSE AMPLITUDE
4. REPRODUCIBILITY FROM TUBE TO TUBE
5. TUBE OPERATING LIFE

INCLUDED IN THE PREPARATION OF THE FABRICATION PROCEDURE IS CONSIDERATION AND ANALYSIS OF THE PHYSICAL PROPERTIES AND MATERIAL CHARACTERISTICS THAT CONTROL EACH OF THE CRITICAL PARAMETERS AND , IN ADDITION, THE REMAINING TUBE PARAMETERS REQUIRED BY SPECIFICATION. EFFECTIVELY, THE CONTROL OF CRITICAL PARAMETERS REDUCES TO THE TASK OF EVOLVING THE APPROPRIATE TECHNIQUES FOR:

- A. ELIMINATING THE PROBABILITY OF SECONDARY EMISSION OF ELECTRONS FROM THE CATHODE SURFACE.
- B. THE INTRODUCTION OF PROPER GAS FILL MIXTURE TO EXHIBIT THE REQUIRED "STARTING VOLTAGE AND TUBE DEAD TIME"
- C. OBTAINING A RUGGED HIGH RELIABILITY TUBE SEAL.

THE MAIN EMPHASIS OF THE WORK DONE DURING THIS REPORTING PERIOD WAS THE BUILDING AND TESTING OF THE PILOT RUN GROUP OF DETECTORS, AND ANALYSIS OF THE ENTIRE PROGRAM.

#### DEVICE

THE FINAL DESIGN OF THE HIGH RANGE GM COUNTER FOR USE IN THE AN/VDR-1 RADIAC SET IS SHOWN IN FIGURE 1 AND 2. THE DETECTOR CONSISTS OF THE FOLLOWING COMPONENTS:

1. 446 S.S. ANODE
2. GLASS BEAD
3. GROUND SPRING
4. ANODE CLIP
5. FOSTERITE INSULATORS
6. 446 S.S. CATHODE
7. GLASS TUBULATION
8. BROMINE
9. HELIUM NEON ADMIXTURE
10. POWDERED GLASS

COMPONENT DRAWINGS ARE SHOWN IN FIGURES 3 THRU 10  
THE CORRECT CHOICE OF MATERIAL IS EXTREMELY IMPORTANT IN  
FABRICATING THE MINITURE DETECTOR REQUIRED IN THE AN/VDR-1.  
ONE MUST HAVE MATERIALS THAT HAVE MATCHING COEFFICIENTS OF  
EXPANSION. THEY MUST BE ABLE TO BE NONREACTIVE TO THE HALOGENS  
GAS AND MUST BE CAPABLE OF BEING PROCESSED AT TEMPERATURES  
OF APPROXIMATELY 400°C.

THE CATHODE OF DRAWN 446 STAINLESS STEEL (72% FE, 28% CR)  
IS USED BECAUSE OF ITS NON REACTION TO THE HALOGEN GAS. THE  
DRAWN SURFACE REDUCES AREAS OF IMPERFECTIONS ONE FINDS IN  
MACHINED SURFACES. WITHOUT HONING AND POLISHING IT IS IMPOSSIBLE  
TO OBTAIN A MACHINED SURFACE WITH THE SAME FINISH AS A DRAWN  
SURFACE.

ON INCOMING INSPECTION THE CERTIFICATE OF ANALYSIS IS  
VERIFIED, THE MATERIAL IS DETERMINED IF IT IS HIGHLY MAGNETIC  
AND A SAMPLE IS FIRED WITH THE POWDERED GLASS TO INSURE PROPER  
WETTING.

THE FOSTERITE CERAMIC IS CHOSEN BECAUSE IT IS OPAQUE  
MAKING POSSIBLE THE ELIMINATION OF PHOTOSENSITIVITY. FOSTERITE  
HAS A HIGH DIELECTRIC STRENGTH AND A MATCHING COEFFICIENT OF  
EXPANSION TO THE 446 STAINLESS STEEL. TABLE 1 GIVES INFORMATION  
CONCERNING THE FOSTERITE INSULATOR.

THE POWDERED GLASS IS CHOSEN BECAUSE IT FORMS AN INERT  
HIGH TEMPERATURE SEAL BETWEEN THE CERAMIC TO METAL AND CERAMIC  
TO GLASS AND IT LENDS ITSELF TO MASS PRODUCTION.

THE MOST SERIOUS CAUSE OF DETECTOR INSTABILITY IS SPURIOUS  
COUNTS. THE MOST OBVIOUS CAUSE OF SPURIOUS COUNTS IN A COMPLETELY  
OPAQUE COUNTER IS THE SECONDARY EMISSION OF ELECTRONS AT THE CATHODE  
SURFACE BY IMPACT OF POSITIVE IONS.



THE WORK FUNCTION OF THE CATHODE AS WELL AS THE IONIZATION POTENTIALS OF THE HALOGEN ADMIXTURE DETERMINE THE PROBABILITY OF THIS PROCESS.

AN EXCELLENT WAY TO CREATE A HIGH WORK FUNCTION IS TO OXIDIZE THE CATHODE SURFACE, WHICH ALSO MAKES THE CATHODE SURFACE CHEMICALLY INERT TO HALOGENS. HALOGEN ITSELF FURTHER INCREASES THE WORK FUNCTION.

TABLE 2 AND 3 SHOW THE PHOTOELECTRIC WORK FUNCTION OF VARIOUS MATERIALS AND THE IONIZATION POTENTIALS FOR VARIOUS GASES INCLUDING THE NOBLE GASES AND HALOGENS.

THE FOSTERITE INSULATORS USED ON THE HIGH RANGE GM COUNTER (HIRAC) TUBE ARE NOT THE DESIGN ORIGINALLY CHOSEN. IT WAS DETERMINED THAT THE DISCONTINUITY IN THE ELECTRIC FIELD CAUSED BY THE ANODE TERMINATION WAS A CAUSE OF SHORTER TUBE LIFE. NEW INSULATORS WERE CONSTRUCTED AS SHOWN ON PG. 13.

TABLE 1

PROPERTIES OF FOSTERITE CERAMIC

WATER ABSORPTION	0.0 -0.02%
DENSITY	.101 LBS/IN <sup>3</sup>
SPECIFIC GRAVITY	2.8
COLOR	CREAM
THERMAL CONDUCTIVITY	$\frac{.009 \text{ GM. CAL X CM THICK}}{\text{CM}^2 \text{ X SEC X DEG C}}$
HARDNESS	7.5 MOHS
FLEXURAL STRENGTH	20000 LBS/IN <sup>2</sup>
COMPRESSIVE STRENGTH	85000 LBS/IN <sup>2</sup>
TENSILE STRENGTH	25000 LBS/IN <sup>2</sup>
COEFFICIENT OF THERMAL EXPANSION	$9.9 \times 10^{-6}/^{\circ}\text{C}$ (20°-650°C)
RESISTANCE TO IMPACT	5.1 IN LBS
SOFTENING TEMPERATURE	1350°C 2500°F 1000°C
SAFE OPERATING TEMPERATURE	1850°F
DIELECTRIC STRENGTH	250 VOLTS/MIL
TE VALUE	1020°C 1850°F
DIELECTRIC CONSTANT AT 1 MHZ	6.4
POWER FACTOR AT 1 MHZ	.0011
LOSS FACTOR @ 1MHZ	.007

TABLE 2

## IONIZATION POTENTIALS FOR VARIOUS GASES

GAS	E <sub>i</sub> eV IONIZATION
A	15-7
Ne	21-5
He	24-5
Kr	13-94
Xe	12-08
N <sup>2</sup>	16-7
O <sup>2</sup>	12-8
H <sup>2</sup>	15-9
C <sub>2</sub> H <sub>5</sub> OH	11-3
C <sub>2</sub> H <sub>4</sub>	12-1
CH <sub>4</sub>	15-2
NH <sub>4</sub>	10-1
BF <sub>3</sub>	10-25
Cl <sub>2</sub>	13-2
Br <sub>2</sub>	12-8
C <sub>2</sub> H <sub>2</sub>	11-35

TABLE 3

PHOTOELECTRIC WORK FUNCTIONS

SURFACE	WORK FUNCTION (EV)	EFFECT OF GAS ON $\phi$ , WORK FUNCTION	
		INCREASE $\phi$	DECREASE $\phi$
AG	4.7-3.85	H <sub>2</sub>	O <sub>2</sub> , N <sub>2</sub> , CN
AU	4.73	H	AIR
C	4.82	H <sub>2</sub> , CO <sub>2</sub> , AIR, NH <sub>3</sub>	
CU	4.5-4.1		
Cs	1.9		
FE	4.7-4.2	O <sub>2</sub> , H <sub>2</sub>	
PT	6.3-4.4	H <sub>2</sub> , NH <sub>3</sub>	O <sub>2</sub>
ZN	3.7-3.3		
CR	4.37		

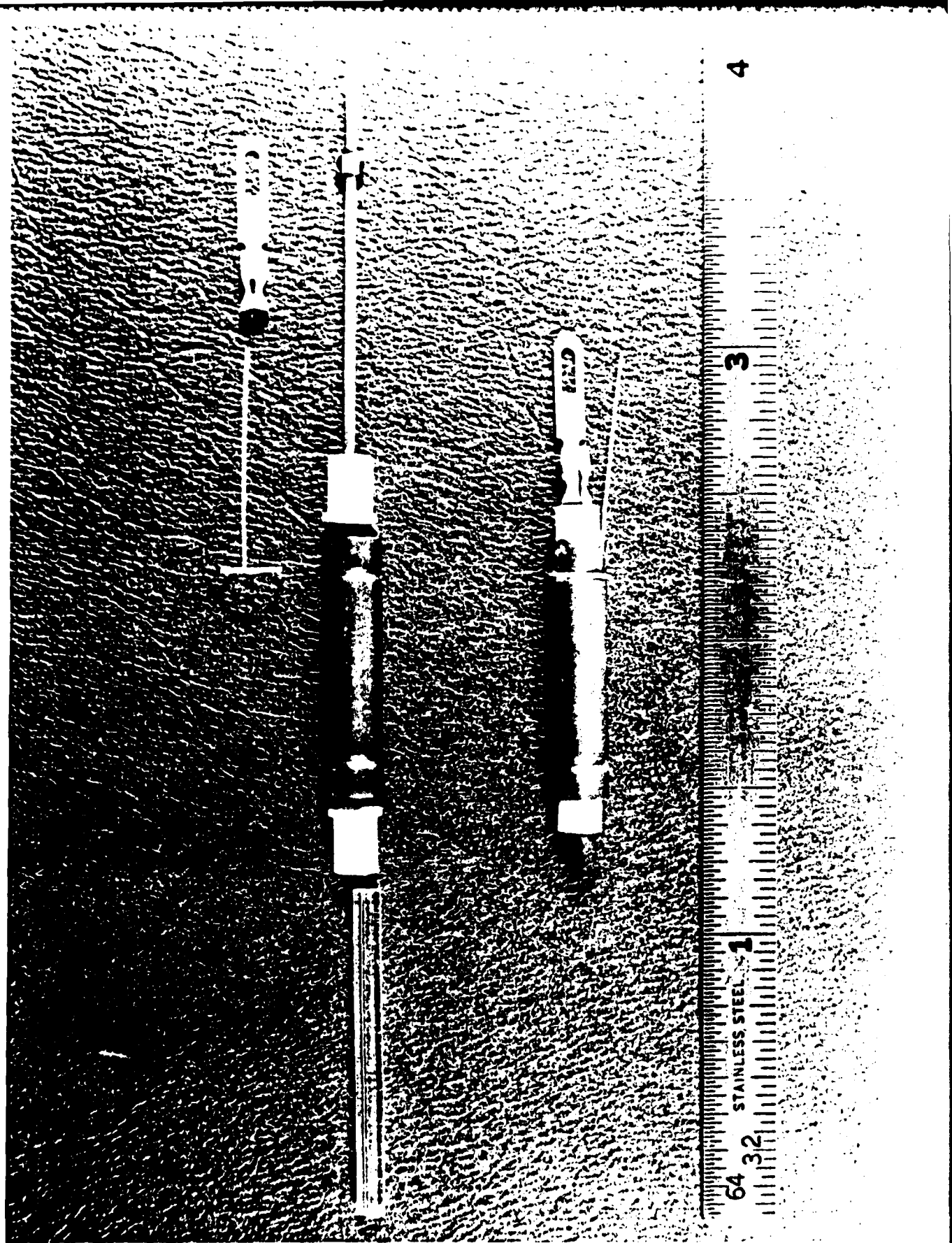
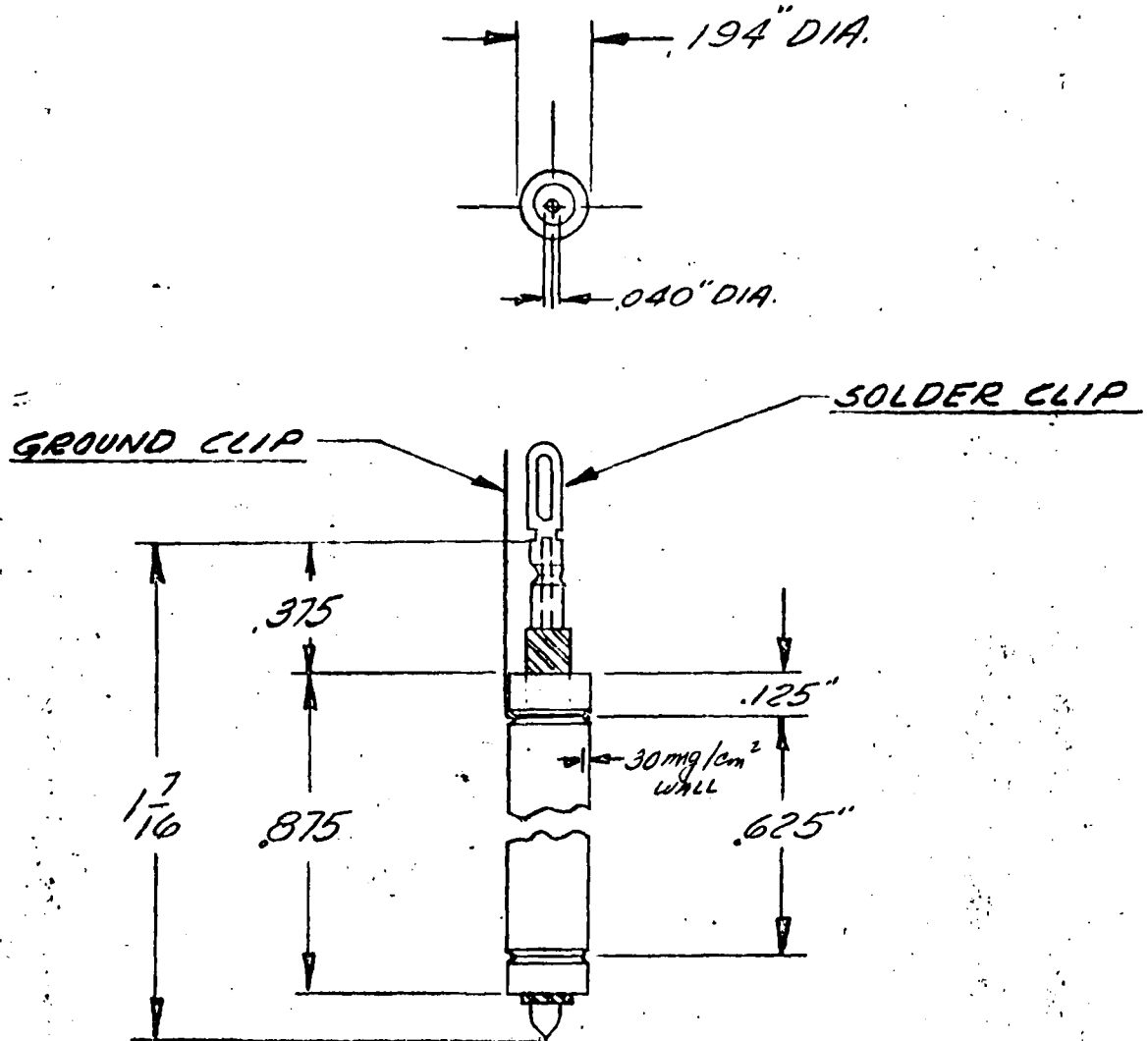
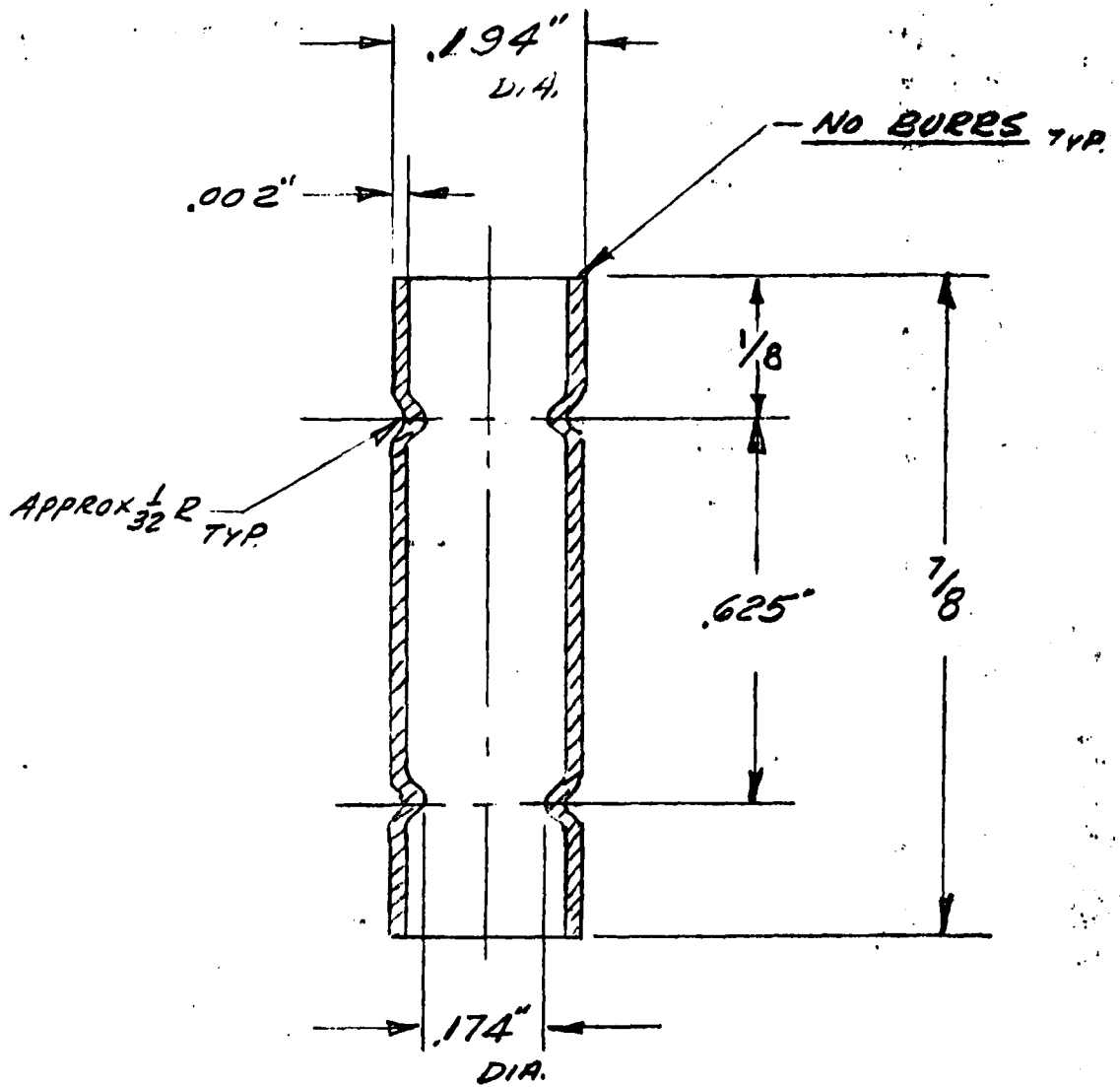


FIGURE 1 PHOTOGRAPH OF COMPONENTS AND ASSEMBLED UNIT.



MATERIAL <i>CH</i>		TOL UNLESS OTHERWISE SPECIFIED	<b>LND, INC.</b>	
BLANK SIZE <i>CH</i>		FRAC & USE DEC & OOB AND R 10	3250 LAWSON BLVD.	OCEANSIDE, N. Y.
DRAWN BY <i>Abale</i> 9/6/71		SCALE <i>1</i>	TITLE <b>HALOGEN QUENCHED G M TUBE</b>	
APP'D BY		REV	TUBE TYPE <b>71411</b>	PART NO. <b>71411</b>

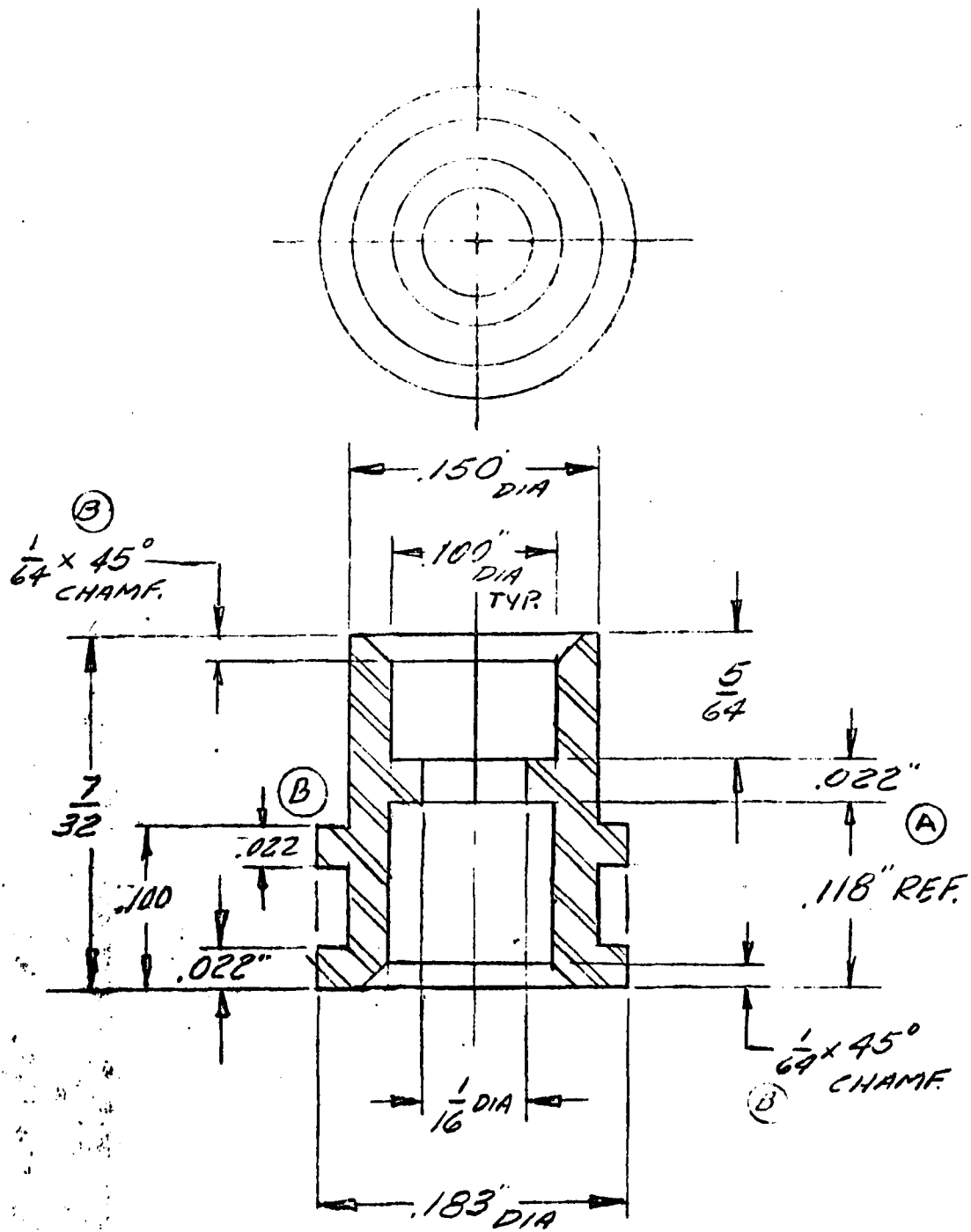
FIGURE 2



MATERIAL <b>446 ST STEEL</b>		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
BLANK SIZE PLATING DWG 039-021		FRAG & V&C DEC & .008 ANG & 1°			
DRAWN BY <i>A. Galt</i> 9/13/71		SCALE <input checked="" type="checkbox"/>		TITLE <b>CATHODE</b>	
APPROV'D BY		REF. 71410-1		TUBE TYPE 71410	PART NO. <del>71410-3</del>

FIG. 3

REV	DESCRIPTION	DATE	APPD
A	ADD .100" DIA. X .118" DP. TO FORM .022" LIP.	5/11/55	AL
B	ADDED .022" WIDE FLANGE & 1/64" X 45° CHAMF. 2 PLACES	4/17/56	AL



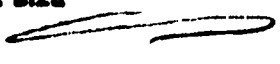
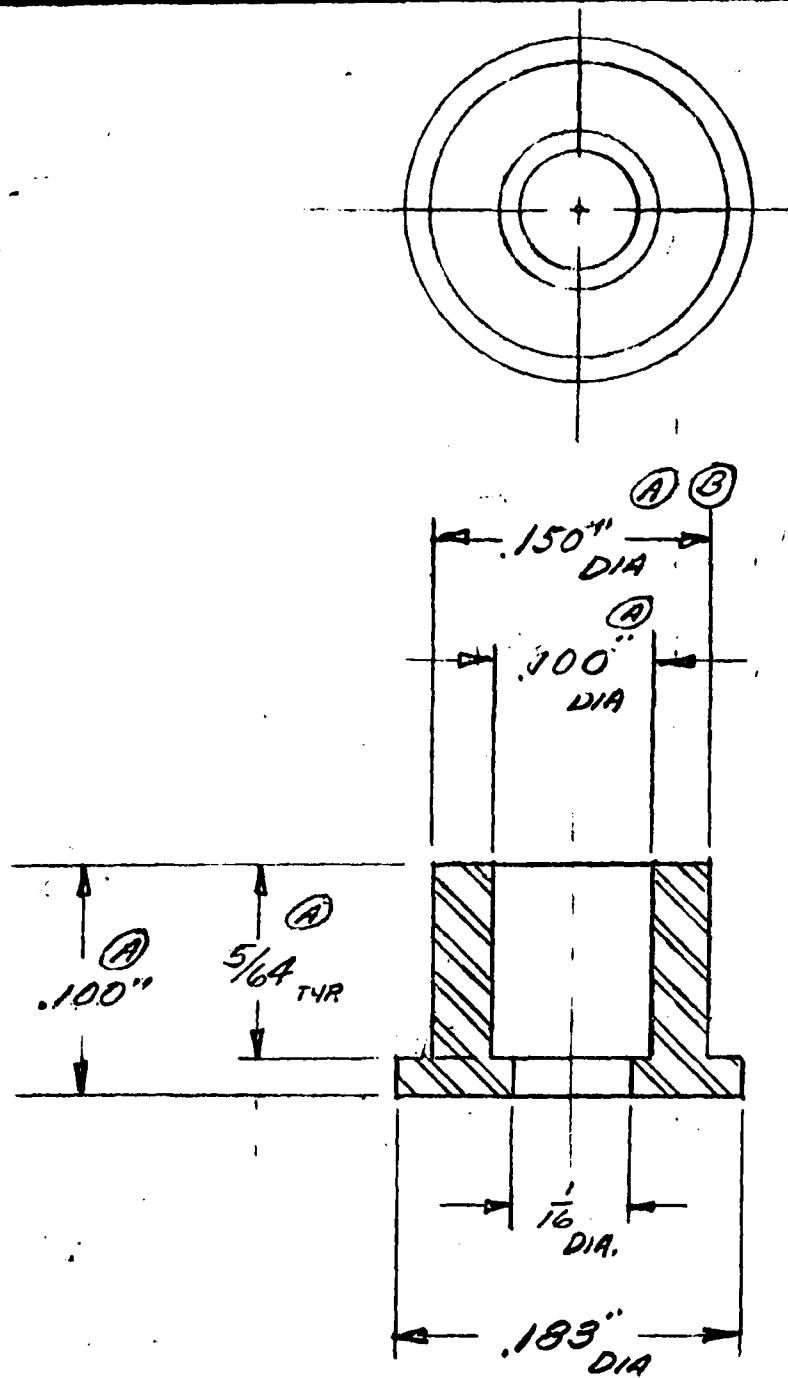
MATERIAL <b>FOSTERITE</b>		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b>	
BLANK SIZE 		FRAC 3/64 DEC 6/100 AND 1/16"		3230 LAWSON BLVD. OCEANSIDE, N. Y.	
DRAWN BY <i>W. G. ...</i>		SCALE <b>10X</b>		TITLE <b>INSULATOR</b>	
APPROVED BY	<i>W. G. ...</i> 3/3/55	REV		TUBE TYPE	PART NO. <b>010-058</b>
					REV <b>B</b>

Fig. 4





B	.150" WAS .135"	A	9/17/68
A	.195" WAS .180" - .100" WAS .085" 5/64 WAS 3/32 - .100" WAS .115"	AC	10-4-68
REV	DESCRIPTION	BY	DATE

MATERIAL <b>FOSTERITE</b>		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
BLANK SIZE		FRAC ± 1/64 DEC ± .008 ANG ± 1°			
DRAWN BY <i>A. L. L.</i> 6-3-68		SCALE 10X		TITLE <b>INSULATOR</b>	
APPV'D BY		R E F.		TUBE TYPE	PART NO. <i>1010-53</i>
					REV <b>B</b>

NO. 178

FIG. 5

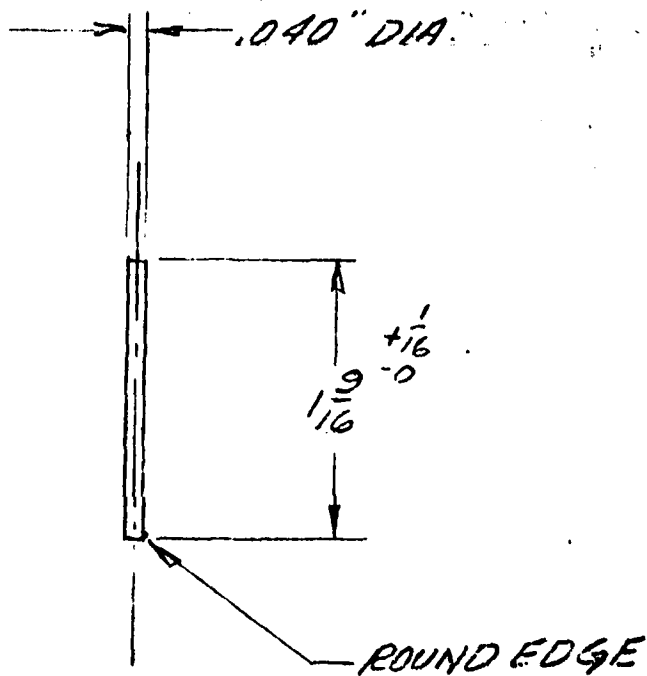
14.

010-003

REV

DESCRIPTION

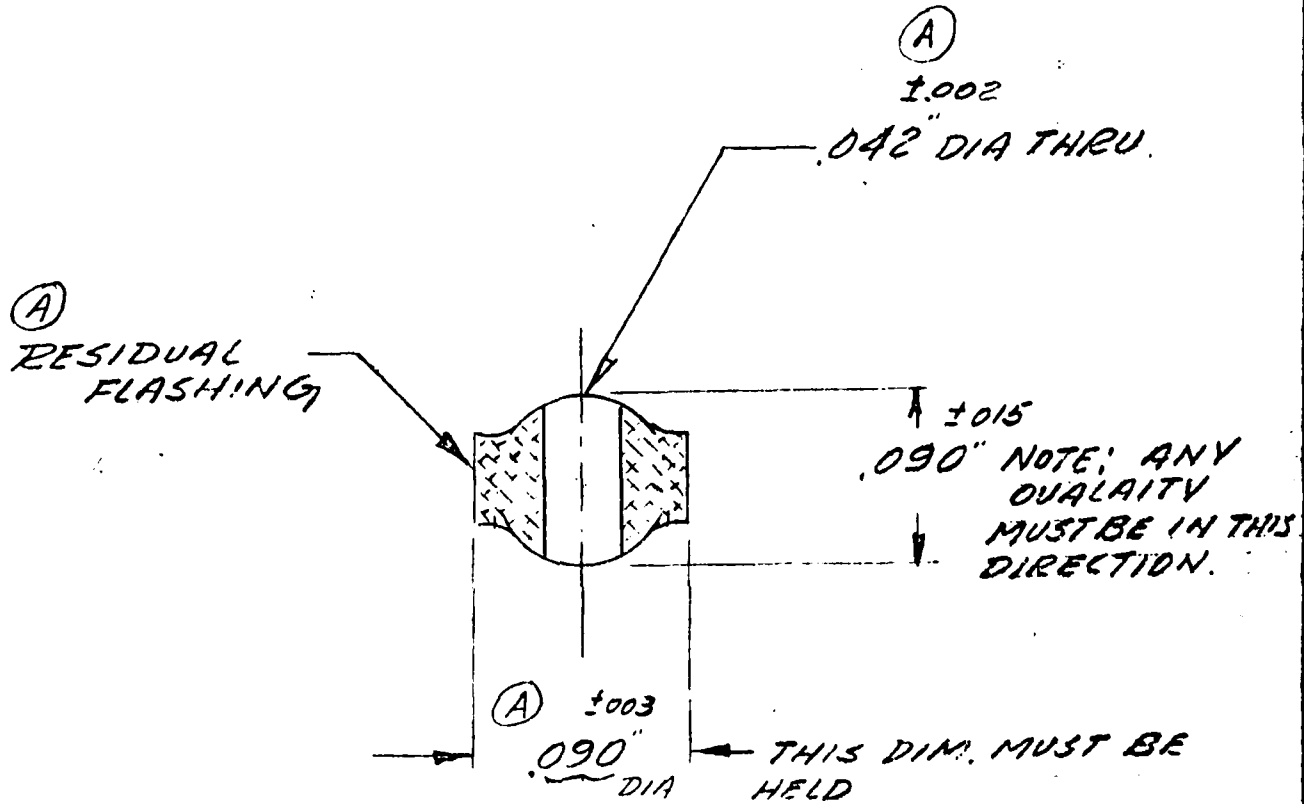
DATE APP'D



MATERIAL <b>496 ST. STEEL</b>		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
DRAWN-BASE		FRAC $\frac{1}{64}$ DEC $\frac{.005}{100}$ ANG $\frac{1}{16}$			
DRAWN BY <i>Alch</i>		SCALE <b>FULL</b>		TITLE <b>ANODE</b>	
APP'D BY	<i>Alch</i>	714	716	TUBE TYPE	PART NO. <b>058-087</b>
					REV

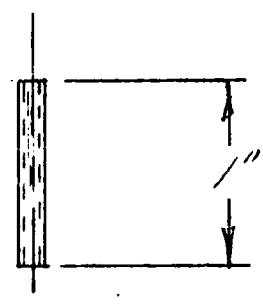
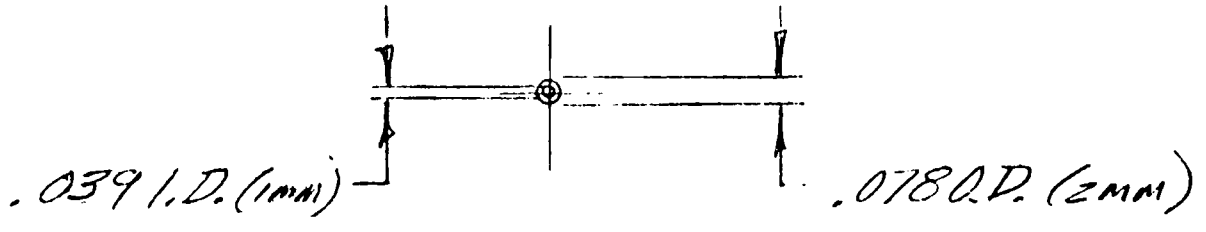
FIG. 6

REV	DESCRIPTION	DATE	APPD
A	±.002 WAS ±.001 .090 DIA. TO INCLUDE RESIDUAL FLASHING THAT IS ADDED	1/5/75	ML



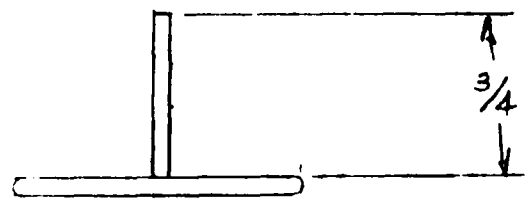
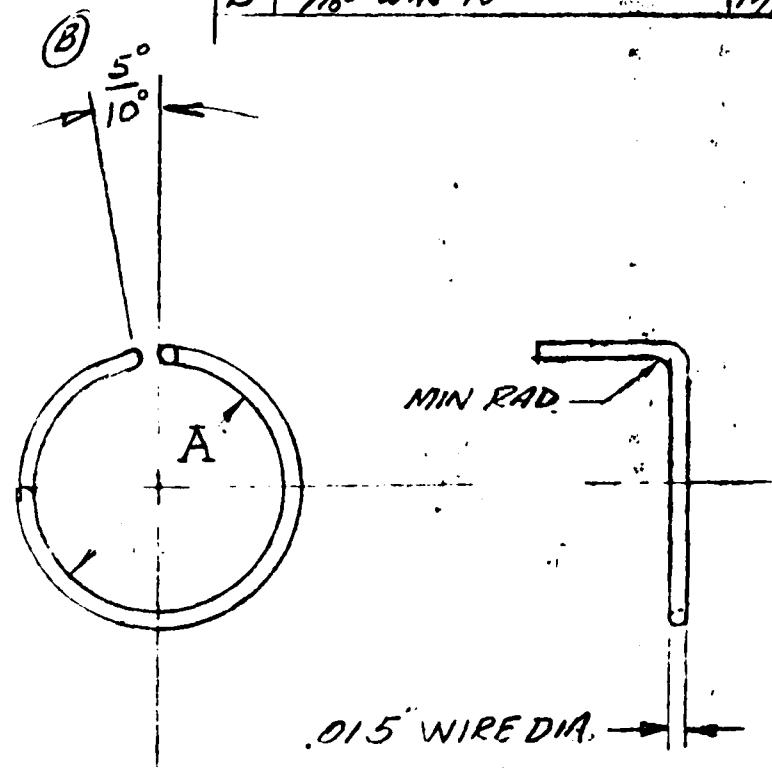
MATERIAL <i>LIME GLASS</i>		TOL UNLESS OTHERWISE SPECIFIED	<b>LND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
BLANK SIZE		PRAC & V84 DEC & .008 ANG & 1°		
		SCALE <i>10X</i>	TITLE <i>BEAD</i>	
DRAWN BY <i>Alford</i>	<i>5/6/75</i>	REV	TUBE TYPE	PART NO. <i>010-059</i>
APP'D BY				REV <i>A</i>

FIG. 7



MATERIAL <b>LIME GLASS</b>		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
BLANK SIZE		FRAC & V64 DEC & .008 ANG & 1°			
DRAWN BY		SCALE		TITLE <b>TUBING</b>	
APPROVED BY		TUBE TYPE		PART NO. <b>030-021</b>	

REV	DESCRIPTION	DATE	APPD
A	REDESIGN - DELETED DIMENSIONS	1/15	AL
B	5°/10° WAS 90°	1/15	AL

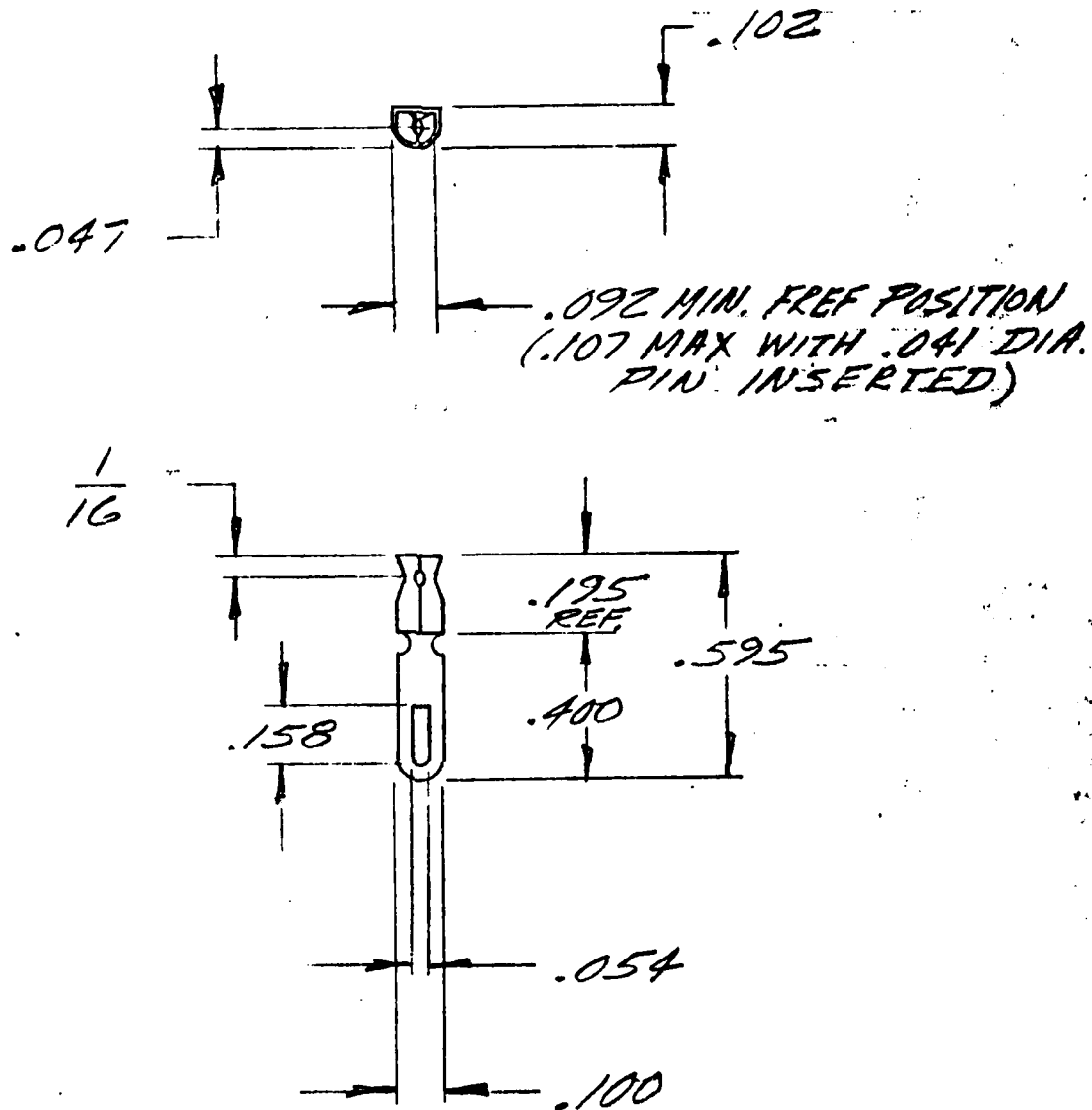


PART NO	TOL		TUBE TYP.
	A	B	
074-017	.175	1000 -005	"714, 716
074-018	.290	1005 -010	"713
074-019	.540		"712

(A)

MATERIAL <i>BERYLLIUM</i>		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
BLANK SIZE		FRAC & 1/64 DEC & .005 ANG & 10			
DRAWN BY <i>AL</i>		SCALE <input checked="" type="checkbox"/>		TITLE <i>GROUND CLIP (SPRING)</i>	
APP'D BY		REV		TUBE TYPE	PART NO. <i>017</i> <i>074-018</i> <i>019</i>
					REV <b>B</b>

FIG. 9



**NOTE**  
MFD. BY: MALCO, # 517  
ALL DIMENSIONS REF. ONLY

MATERIAL .0126 THK, Be COPPER		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
BLANK SIZE <i>~</i>		FRAC & V04 DEC & .008 ANG & 1°			
DRAWN BY <i>[Signature]</i>		SCALE 2:1		TITLE CONTACT	
APPROVED BY <i>[Signature]</i>		TUBE TYPE		PART NO. 090-021	
				REV	

FIG. 10

TABLE 4

VACUUM OUTGASSING AND OXYGEN FIRING SCHEDULE

<u>VACUUM FIRING</u> <u>TIME ON (MIN.)</u>	<u>O2 FIRING</u> <u>TIME ON (MIN.)</u>	<u>O2 FLOW</u> <u>C.F.H.</u>	<u>VAC.PRESS.</u> <u>MICRONS</u>	<u>COLOR O2</u> <u>FIRING</u>
1.0	5.0	5.5	25	DULL RED

VISUAL INSPECTION HAS SHOWN THAT SPURIOUS COUNTS OR INSTABILITIES OCCUR IN SPECIFIC SECTIONS AND NOT OVER THE ENTIRE SURFACE, DEMONSTRATING THAT INSTABILITY IS A FUNCTION OF CATHODE SURFACE.

THE CONTROL OF THE SURFACE EMPLOYES THE LND PROCESS OF PASSIVATING THE CATHODE.

AFTER MECHANICAL INSPECTION THE CATHODES AND ANODES ARE VACUUM FIRED AT A TEMPERATURE OF 800°C TO COMPLETELY CLEAN ALL COMPONENTS. THESE UNITS WERE VACUUM OUTGASSES AND OXYGEN FIRED ACCORDING TO THE SCHEDULE SHOWN IN TABLE 4 .

LND HAS USED THE SCANNING ELECTRON MICROSCOPE AND ION ANALYZER TO DETERMINE IF POSSIBLE , THE OPTIMUM CHROME OXIDE COATING, EXAMINE THE SURFACE CONDITIONS AND DETERMINE THE IMPURITIES PRESENT INCLUDING THEIR RELATIVE CONCENTRATIONS.

A SOLID SURFACE IS CHARACTERIZED IN THE SAME WAY AS ANY SOLID OR MOLECULE, WE MUST DETERMINE THE CHEMICAL IDENTITY OF THE ATOMS PRESENT. THIS CHARACTERIZATION OF THE STATIC SURFACE IS THE FIRST STEP IN UNDERSTANDING THE DYNAMICS OF THE INTERACTION OF THE SURFACE WITH EXTERNAL SYSTEMS.

SINCE ALL SURFACE MEASUREMENT TECHNIQUES RECORD THE RESPONSE OF THE SURFACE TO AN EXTERNAL PROBE, EXPERIMENTAL STUDIES REDUCE TO RELIABLY MEASURING CERTAIN RESPONSE FUNCTIONS CHARACTERISTIC OF THE SYSTEM INVOLVED AND THE OBSERVATION BEING MADE. THE PROBLEMS ENCOUNTERED IN SURFACE SCIENCE ARE SO COMPLEX THAT IT IS OFTEN EXTREMELY DIFFICULT TO INTERPRET THESE RESULTS SIMPLY. ONLY THROUGH THE CLOSE INTERPLAY OF THEORY AND EXPERIMENT CAN ONE HOPE TO GAIN A MICROSCOPIC UNDERSTANDING OF SURFACE SYSTEMS.



THE CONCERN OF LND IN SURFACE PHYSICS IS NOT PRIMARILY THE CLEAN SURFACE BUT RATHER A CLASS OF PHENOMENA THAT DEPEND ON THE INTERACTION OF A SOLID SURFACE WITH FOREIGN ATOMS OR MOLECULES. EXAMPLES ARE CHEMISORPTION, EPITAXIAL GROWTH, OXIDATION AND HETEROGENEOUS CATALYSIS. ALL OF THESE INVOLVE THE FORMATION OF OVERLAYERS, WHICH TYPICALLY DIFFER IN BOTH COMPOSITION AND STRUCTURE FROM THE INITIAL SUBSTRATE SURFACE.

THE DIRECT OBSERVATION OF SURFACE GEOMETRY BECAME FEASIBLE WITH THE DEVELOPMENT OF FIELD-ION MICROSCOPY. IN THIS TECHNIQUE THE SAMPLE IS PLACED OPPOSITE A FLUORESCENT SCREEN IN AN IMAGING GAS SUCH AS HELIUM AND A VERY LARGE ELECTRIC FIELD, ABOUT  $3-6 \text{ V/\AA}$ , IS APPLIED. HELIUM ATOMS IN THE VICINITY OF THE CRYSTAL TIP BECOME IONIZED WHEN THEY PASS THROUGH A REGION OF HIGH LOCAL FIELD ABOVE A PROTRUDING SURFACE ATOM, AND THE IONS ARE THEN REPELLED BY THE POSITIVE TIP AND PROJECTED RADIIALLY TOWARDS THE SCREEN TO PRODUCE A MICROGRAPH. BY COOLING THE TIP WITH LIQUID HELIUM, A RESOLUTION OF A FEW ANGSTROMS CAN BE ACHIEVED SO THAT INDIVIDUAL SURFACE ATOMS CAN BE IMAGED.

ABOVE CERTAIN VALUE, WHICH DEPENDS ON THE SUBSTRATE MATERIAL, THE ELECTRIC FIELD WILL CAUSE FIELD EVAPORATION, THE IONIZATION AND REMOVAL OF SURFACE ATOMS FROM THE CRYSTAL ITSELF. THIS PHENOMENON IS USED ROUTINELY TO PREPARE CLEAN SURFACES, AND IT ALLOWS THE GRADUAL EXAMINATION, LAYER BY LAYER OF THE REGIONS BELOW THE ORIGINAL SURFACE. ALTHOUGH THE OCCURENCE OF FIELD EVAPORATION THUS MAY BE PUT TO GREAT ADVANTAGE, IT ALSO LIMITS THE APPLICABILITY OF THIS TECHNIQUE, TO THOSE MATERIALS FOR WHICH THE IMAGING FIELD IS SMALLER THAN THE EVAPORATION FIELD.

A CAMECA ION ANALYZER MODEL IMS 300 WAS USED. THIS PROVIDED QUANTITATIVE INFORMATION CONCERNING THE COMPOSITION OF THE SPUTTERED MATERIAL. BY CONTINUOUSLY BOMBARDING THE SAMPLE AND SIMULTANEOUSLY MONITORING THE SECONDARY ION CURRENT OF A PRESELECTED MASS, THE COMPOSITION AS A FUNCTION OF DEPTH WAS DETERMINED AND A DEPTH PROFILE WAS OBTAINED. THE FINGERPRINT SPECTRA (CHARACTERISTIC ABUNDANCIES OF CLUSTER AND MOLECULAR IONS WERE USED FOR A COMPOUND DISTRIBUTION).

A SAMPLE OF ION ANALYZER SPECTRA OBTAINED IS SHOWN IN FIGURE 11 A TABULATION OF THE ELEMENTS FOUND IN THE ANALYSIS IS GIVEN ON THE SPECTRA. TABLE 5 IS A LIST OF MASS NUMBERS AND THEIR CORRESPONDING ELEMENTS.

A THOROUGH ANALYSIS OF THE MASS SPECTRUMS OBTAINED SHOWED THE PRESENCE OF  $CrO$ ,  $Cr_3O$ ,  $Cr_3O_2$ , AND  $Cr_3O_3$  THEREFORE THE OXYGEN FIRING PROCESS DEVELOPED BY LND IS PERFORMING ITS FUNCTION.

THE COMPONENTS IN LOTS NOT PRE-CLEANED SHOWED GREATER AMOUNTS OF IMPURITIES THAN THE GROUP IN LOTS PRE-CLEANED AT LND.

TO FURTHER REDUCE THE POSSIBILITY OF A RE-OCCURENCE OF THIS PROBLEM LND IS PRE-CLEANING ALL TUBE COMPONENTS ACCORDING TO THE SCHEDULE IN APPENDIX A-1.

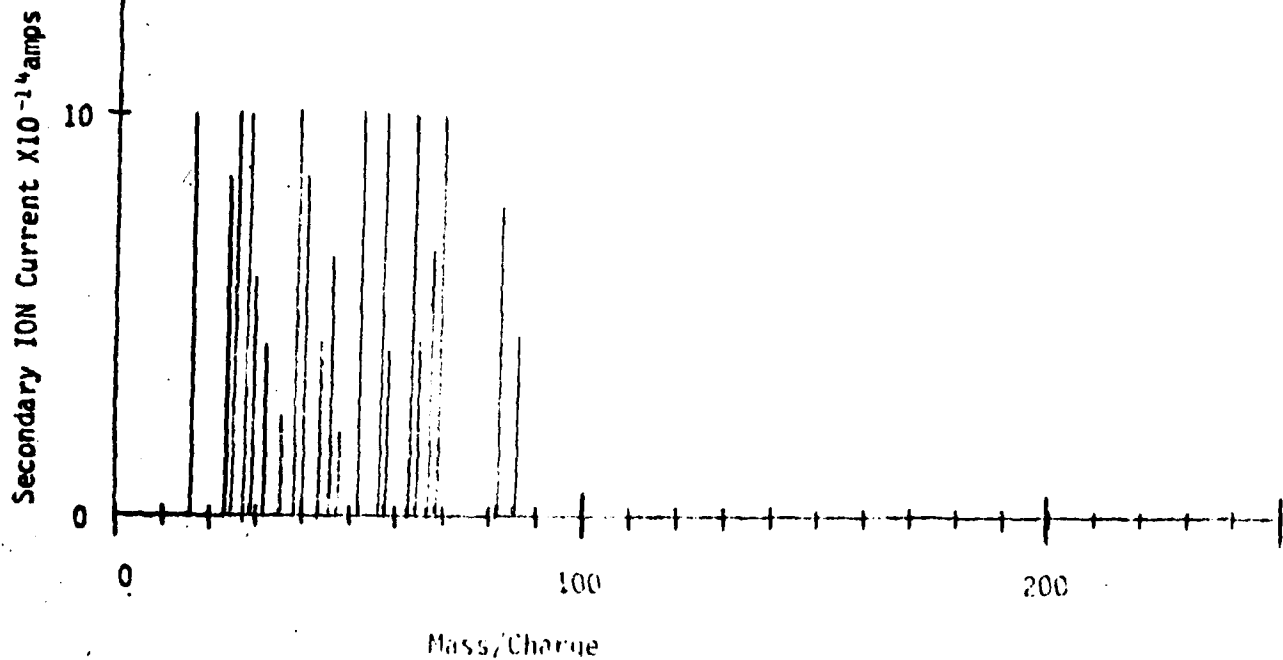
FIGURE: 11

DATE: 9/25/75

SAMPLE: Ion Spectra

SCAN NO: 10

MASS NUMBERS MONITORED: 16,23,24,25,27,28,32,35,39,  
40,44,46,47,52,56,58,62,  
66,68,81,84



MATERIAL		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b>	
BLANK SIZE		FRAC & VOL DEC & 000 ANG & 1°			
DRAWN BY		SCALE		TITLE Secondary Ion Mass Spectrum	
APP'D BY		REV		TUBE TYPE	PART NO.

TABLE 5  
SAMPLE TUBULATION OF ELEMENTS

<u>ELEMENT</u>	<u>MASS NO.</u>	<u>ELEMENT</u>	<u>MASS NO.</u>
O	16	TI	48
NA	23	NI	62
Mg	24	CU	63
AL	27	ZN	64
SI	28	CR0	68
O2	32	GA	69
CL	35	ZN	70
K	39	AS	75
CA	40	GE	76
K	41	KR	77
ALO	43	BR	81
SI0	44	CR02	84
Sc	45	CR20	120
CA	46	CR202	136
TI	47	CR203	154
CR	50	CR30	170
FE	56	CR302	188

## PROCESS, EQUIPMENT AND TOOLING

AFTER THE CATHODE AND ANODE PASSIVIATION THE DETECTORS ARE THEN ASSEMBLED USING THE FOSTERITE CERAMICS AND POWDERED GLASS. THE ASSEMBLY PROCEDURE IS AS FOLLOWS:

1. CLEAN ALL COMPONENTS PER LND SPEC.M-900260 (APPENDIX)
2. PLACE ANODE IN INSULATOR AND PLACE ASSEMBLY IN CATHODE.
3. PAINT POWDERED GLASS FRIT OVER ANODE INSULATOR JOINT AND INSULATOR CATHODE JOINT.
4. PLACE IN FIRING FIXTURE AND FIRE IN AIR OVEN AT A TEMPERATURE OF 600°C
5. AFTER FIRST FIRING PLACE REAR INSULATOR INTO TUBULATION AND PLACE ASSEMBLY INTO CATHODE.
6. REPEAT STEPS 3 AND 4

THIS PROCEEDURE IS SHOWN VISUALLY IN FIG. 14 . THE FLOW CHART OF MANUFACTURING PROCESSES.

SEVERAL PROBLEMS WERE ENCOUNTERED IN THE MANUFACTURING OF A GM COUNTER FOR THE AN/VDR-1:

1. GLASS FIRING FIXTURES
2. LEAK CHECKING FIXTURES
3. PUMPING & BAKING SYSTEMS

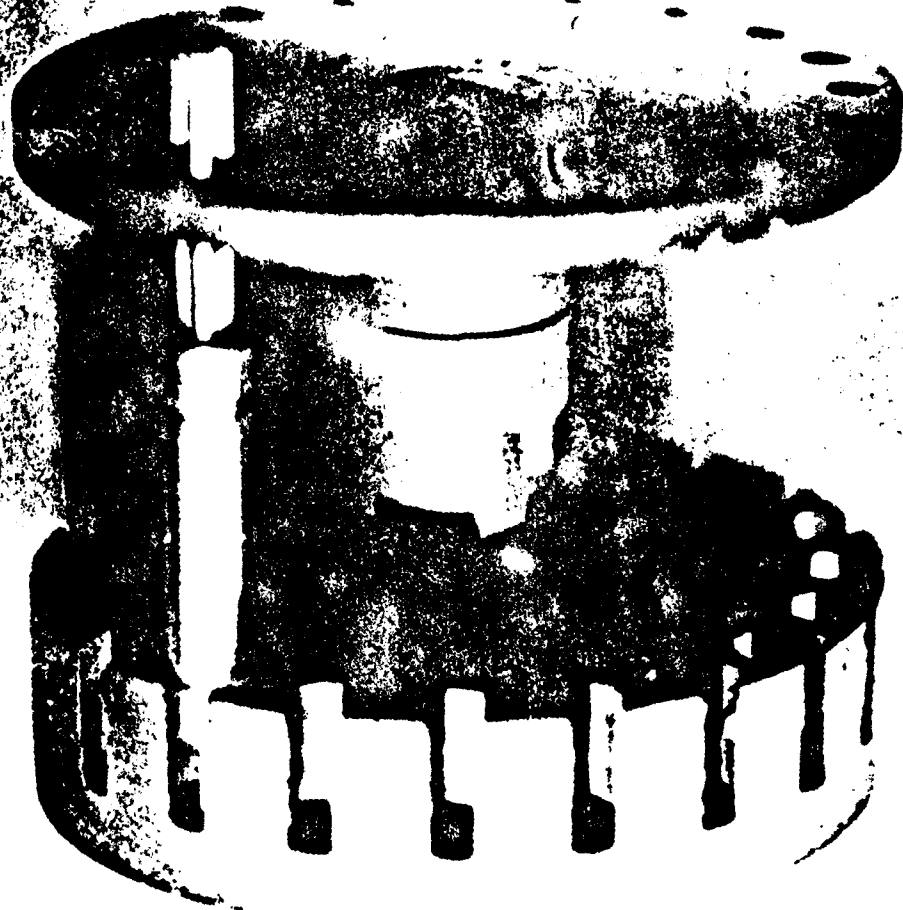
PHOTOGRAPH 12 AND 13 SHOW THE DETECTOR ASSEMBLY INCLUDING THE PAINTING OF POWDERED GLASS AND THE FIRING FIXTURE USED. IN ORDER TO FACILITATE VOLUME PRODUCTION, LND DESIGNED AND MANUFACTURED FIXTURES AS SHOWN IN PHOTOGRAPH 13 TO HOLD 50 UNITS.

THE ASSEMBLED UNITS ARE THEN LEAK CHECKED ON A HELIUM MASS SPECTROMETER ACCORDING TO LND SPECIFICATION M500140B USING A SPECIAL FIXTURE AS SHOWN IN FIGURE 16 ALLOWING MULTIPLE LEAK CHECKING OF THE DETECTORS. USING LND FIXTURE 4130 FIGURE 17 WE CAN NOW LEAK CHECK 10 UNITS IN A LITTLE MORE TIME THAN IT PREVIOUSLY TOOK TO LEAK CHECK ONE UNIT. AFTER LEAK CHECKING THE ASSEMBLED UNITS ARE THEN STORED IN A HEATED DESSICATED CABINET UNTIL INSTALLED ON THE PUMP.

WE HAVE FOUND THAT AFTER ASSEMBLY A DETECTOR MUST BE KEPT IN A DESSICATED ATMOSPHERE PRIOR TO PUMPING OTHERWISE THE INTERNAL SURFACES CHANGE CHARACTERISTICS.



PHOTOGRAPH - APPLICATION OF POWDERED GLASS TO CATHODE AND INSULATOR  
FIG. 12



PHOTOGRAPH - FIRING FIXTURE  
FIG. 13



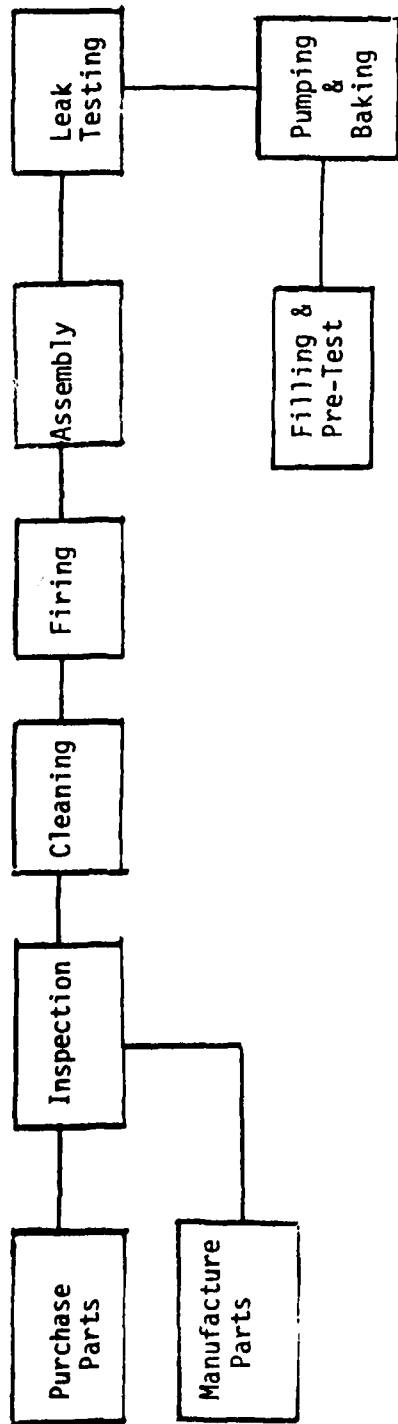


Figure 14  
FLOW CHART OF MANUFACTURING PROCESS

Page 31 blank

Typographical error when pages  
were numbered. No Figure 15.

See per the Author dated 3 June 85

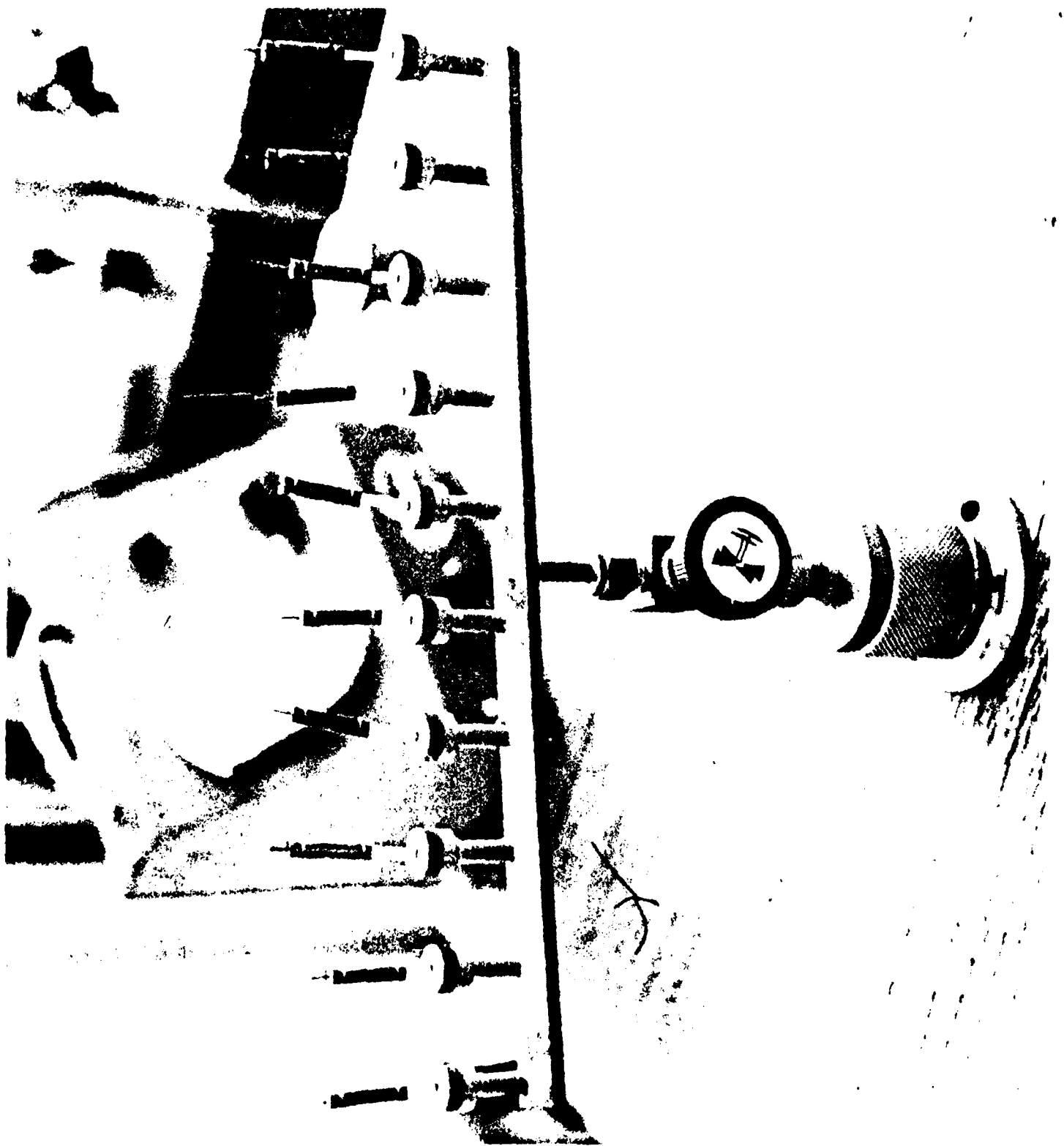
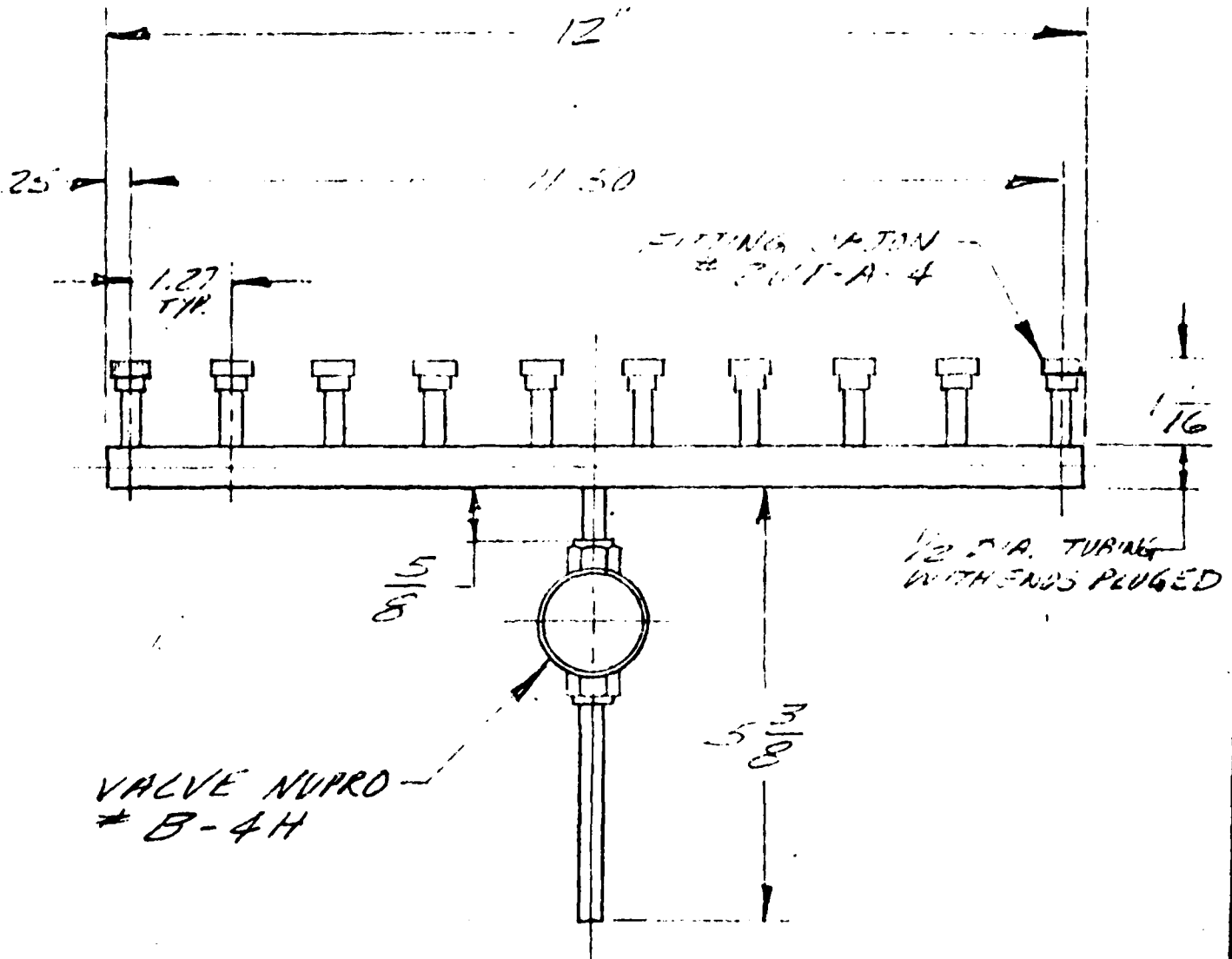


FIGURE 16  
MULTIPLE LEAK CHECKING MANIFOLD  
32



MATERIAL <b>BRASS</b>		TOL UNLESS OTHERWISE SPECIFIED		<b>LND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
BLANK SIZE <i>2</i>		FRAC & V&A DEC & .008 ANG & 10			
DRAWN BY <i>[Signature]</i>	CHKD BY <i>[Signature]</i>	REF	SCALE <b>1/2</b>	TUBE TYPE	PART NO. <b>015-012</b>
APP'D BY <i>[Signature]</i>	DATE <i>[Date]</i>				REV

FIGURE 1/

THE UNITS ARE THEN SEALED ONTO THE MANIFOLD AND PROCESSED ACCORDING TO THE SCHEDULE SHOWN BELOW:

PUMP AND FILL SCHEDULE

1. FUSE ON TUBES AND EVACUATE THE MANIFOLD WITH ROUGH PUMP. AFTER 5 MINUTES CHECK VACUUM BY SPARKING.
2. PLACE LIQUID NITROGEN AROUND COLD TRAP AND SWITCH MANIFOLD TO HIGH VACUUM PUMPING SYSTEM.
3. WHEN VACUUM IS LESS THAN  $2 \times 10^{-4}$  TORR SHIFT OVEN SHIELD OVER THE TUBES AND INCREASE THE TEMPERATURE SLOWLY (GREATER THAN 30 MINUTES) UNTIL  $400^{\circ}\text{C}$ . LEAVE AT THIS TEMPERATURE FOR 16 HOURS AND UNTIL A VACUUM OF  $5 \times 10^{-7}$  TORR ON THE MANIFOLD IS REACHED. WHEN PROPER VACUUM IS REACHED, LET OVEN COOL TO  $185^{\circ}\text{C}$  ADMIT 10 TORR  $\text{Cl}_2$  - SOAK FOR ONE HOUR AND LET OVEN COOL TO ROOM TEMPERATURE AND REMOVE OVEN COVER.
4. PUMP OUT  $\text{Cl}_2$  FOR 10 MINUTES ( $<10^{-7}$  TORR).
5. SPARK THE CATHODE OF EACH TUBE FOR A PERIOD OF ONE MINUTE.
6. PUMP OUT FOR 10 MINUTES ( $<10^{-7}$  TORR).
7. PLACE 3 TORR  $\text{Cl}_2$  IN DETECTOR,  $\text{Cl}_2$  SPARK ANODE AND CATHODE ONE MINUTE EACH.
8. PUMP OUT FOR 10 MINUTES ( $<10^{-7}$  TORR).
9. CLOSE HIGH VACUUM PUMPING SYSTEM AND OPEN VALVE TO FILLING MANIFOLD.
10. ADMIT 7 TORR BROMINE INTO MIXING BOTTLE. ADD HELIUM ADMIXTURE TO MIXING BOTTLE TO A PRESSURE OF 500 TORR. LET BROMINE AND HELIUM ADMIXTURE SATURATE FOR 5 MINUTES IN MIXING BOTTLE.
11. LET GAS MIXTURE INTO TUBE MANIFOLD UNTIL PRESSURE IN DETECTORS IS 175 TORR.

12. AFTER 5 MINUTES MONITOR STARTING VOLTAGE. ADJUST STARTING VOLTAGE TO BE 410 VOLTS
13. MONITOR AND RECORD STARTING VOLTAGE AND END OF PLATEAU POINT OF EACH TUBE.
14. AFTER 5 MINUTES MELT OFF TWO TUBES AND GIVE TO TESTING FOR EVALUATION.

## CHLORINE PROCESSING

THE ELECTRONIC CONFIGURATIONS OF THE HALOGENS ARE LISTED IN TABLE 6. EACH OF THE HALOGENS DIFFERS FROM THE INERT GAS THAT FOLLOWS IT IN THE PERIODIC SYSTEM BY HAVING ONE LESS ELECTRON IN ITS BALANCE SHELL. THESE ELEMENTS ARE ALL NONMETALS, SINCE THE ATOMS HAVE A STRONG TENDENCY TO ATTAIN THE STABLE INERT GAS CONFIGURATION (AND AN OXIDATION STATE OF -1) EITHER BY TAKING UP AN ELECTRON FROM AN ATOM OF A METALLIC ELEMENT TO FORM A SINGLY CHARGED NEGATIVE ION, OR BY SHARING ELECTRONS WITH ELEMENTS WHOSE TENDENCY TO RELEASE ELECTRONS IS NOT SUFFICIENTLY GREAT TO ALLOW ELECTRON TRANSFER.

UNDER ORDINARY CONDITIONS ALL THE HALOGENS FORM DIATOMIC MOLECULES. THIS IS A RESULT OF THE FACT THAT BY SHARING A SINGLE PAIR OF ELECTRONS BETWEEN THEM TWO HALOGEN ATOMS ATTAIN STABLE CONFIGURATIONS OF MINIMUM ENERGY.

THE HALOGENS HAVE VERY LITTLE TENDENCY TO LOSE ELECTRONS TO FORM POSITIVE IONS. THIS RELUCTANCE TO FORM POSITIVE IONS IS UNDERSTANDABLE IN TERMS OF THE HIGH IONIZATION POTENTIALS OF THESE ELEMENTS AS SHOWN IN TABLE 7. THE INTERMOLECULAR FORCES IN THE FREE HALOGENS ARE VERY WEAK AND EACH SUBSTANCE IS HIGHLY VOLATILE.

AT ROOM TEMPERATURE CHLORINE IS A GREENISH YELLOW GAS, BROMINE IS A DEEP BROWNISH LIQUID WHICH READILY VOLATILIZES TO A REDDISH BROWN VAPOR. BROMINE IS ONE OF ONLY TWO ELEMENTS WHICH ARE LIQUID AT ROOM TEMPERATURE.

ELEMENT	1	2	3	4	5	6
	<u>S</u>	<u>S P</u>	<u>S P D</u>	<u>S P D F</u>	<u>S P D</u>	<u>S P</u>
F	2	2 5				
CL	2	2 6	2 5			
BR	2	2 6	2 6 10	2 5		
I	2	2 6	2 6 10	2 6 10	2 5	

ELECTRON CONFIGURATIONS OF HALOGENS

TABLE 6

<u>ELEMENT</u>	<u>FOR 1 ELECTRON</u>	<u>FOR THE 7TH VALENCE ELECTRON</u>
F	18.6	184.26
CL	12.96	113.7
BR	11.80	- - -
I	10.6	- - -

IONIZATIONS POTENTIALS (VOLTS)

TABLE 7



CHLORINE REACTS DIRECTLY WITH ALL THE METALS FOR FORM METALS HALIDES. BROMINE WHICH HAS LESS ATTRACTION FOR ELECTRONS THAN CHLORINE IS LESS REACTIVE AND FORMS METAL HALIDES WITH ALL EXCEPT THE VERY NOBLE (UNREACTIVE) METALS.

SINCE THE ELECTRON AFFINITIES OF THE HALOGENS DECREASE IN THE ORDER  $F > Cl > Br > I$ , CHLORINE HAS LESS TENDENCY THAN BROMINE TO BE COVALENT. THE OXIDIZING STRENGTH OF THE HALOGEN DECREASES IN THE ORDER  $F_2 > Cl_2 > Br_2 > I_2$  IT IS NOT SUPRISING THAT THE REACTION OF CHLORINE WITH METAL CAPABLE OF ASSUMING MORE THAN ONE OXIDATION STATE RESULTS IN THE FORMATION OF A CHLORINE CORRESPONDING TO ONE OF THE HIGHER OXIDATION STATES.

THERE ARE THREE QUADRANTS TO THE PUMPING MANIFOLD. EACH QUADRANT HAS THE CAPABILITY OF HANDLING 12 COUNTERS.

IT HAS BEEN DETERMINED THAT THERE IS ABSOLUTELY NO CORRELATION BETWEEN POSITION ON THE MANIFOLD AND STARTING VOLTAGE OR TUBE CHARACTERISTIC.

## STUDY OF VACUUM PUMPING SYSTEMS

A MAJOR PORTION OF THE PROCESSING OF GM COUNTERS IS THE PUMPING AND OUTGASING WHICH IS ACCOMPLISHED ON A VACUUM SYSTEM.

VACUUM SYSTEMS FALL INTO TWO CATEGORIES. A STATIC SYSTEM MUST BE CONSTRUCTED SO THAT NO LEAKAGE OR OUTGASING <sup>1</sup> WILL TAKE PLACE AND SO THAT THE VACUUM CAN BE MAINTAINED WITHOUT FURTHER PUMPING, ONCE IT HAS BEEN PRODUCED. SUCH SYSTEMS MAY REMAIN CONNECTED TO THE PUMPS OR THEY MAY BE SEALED AND REMOVED FROM THE EVACUATION SYSTEM. KINETIC OR DYNAMIC SYSTEMS ON THE OTHER HAND ARE OF SUCH A NATURE THAT THE EVENTUAL VACUUM ACHIEVED REPRESENTS AN EQUILIBRIUM CONDITION BETWEEN THE PUMPING SPEED AND THE LEAKAGE AND OUTGASING RATE.

VACUUM SYSTEMS ALWAYS INVOLVE THE FLOW OF MASS INTO THEM THROUGH LEAKS OR OUT OF THEM THROUGH PUMPS. AS IN MOST FLOW SITUATIONS THE PROBLEM MAY BE REPRESENTED BY THREE FUNCTIONS: A FLOW FUNCTION (IN THIS CASE, A MASS FLOW RATE); THE POTENTIAL DRIVING THE FLOW (WHICH FOR A VCAUUM SYSTEM IS THE PRESSURE); AND THE RESISTANCE TO THE FLOW. THE RELATION BETWEEN THESE THREE FUNCTIONS CAN BE EXPRESSED AS

$$\Delta P = ZQ$$

MAKE  $\Delta P$  REPRESENT THE PRESSURE DROP CAUSING THE FLOW,  $Q$ <sup>1</sup> REPRESENT THE FLOW RATE AND  $Z$  IS CALLED THE IMPEDANCE, OR RESISTANCE OF THE VACUUM SYSTEM.

<sup>1</sup> Release of gas by materials into the system.

THE IMPEDANCE MAY DEPEND ON BOTH  $Q$  AND  $\Delta P$ . THE TERM CONDUCTANCE IS MORE OFTEN USED IN VACUUM WORK AND IS DEFINED BY

$$C=1/Z$$

THE SYSTEM USED IN THE PROCESSING OF GM COUNTERS IS A KINETIC OR DYNAMIC SYSTEM. THE THREE DIFFERENT TYPES CONSIDERED WERE:

1. TURBO MOLECULAR PUMP
2. SPUTTER ION PUMP
3. OIL DIFFUSION PUMP

## PRINCIPLES OF OPERATION OF TURBO MOLECULAR PUMP

REFER TO FIGURE 4 FOR ILLUSTRATION. THE TURBO-MOLECULAR PUMP AND ITS ATTACHED VACUUM SYSTEM, IF ANY, ARE ROUGH PUMPED TO THE LOW TORR RANGE BY A FOREPUMP WHICH MUST BE CONNECTED TO THE OUTLET. THE TURBO-MOLECULAR PUMP IS THEN STARTED AND WITHIN A FEW MINUTES THE ROTOR WITH ATTACHED BLADES, (SEE A) IS ROTATING AT 16,000 RPM. MOLECULES OR AIR, WATER VAPOR, OR OTHER GASES ENTER THE PUMP AT THE INLET, WHICH IS THE HIGH VACUUM SIDE OF THE PUMP. THESE MOLECULES COLLIDE WITH ALL THE INTERIOR SURFACES OF THE INLET PORTION OF THE PUMP, AND SOME OF THEM ARE ACCELERATED AXIALLY TOWARD THE ENDS OF THE PUMP WHEN THE FIRST DISC OF ROTOR BLADES STRIKES THEM. THE MOLECULES ARE THEN GUIDED IN A FAVORABLE DIRECTION BY IMPINGING UPON THE FIRST DISC OF STATIONARY STATOR BLADES, WHICH ARE ORIENTED IN SUCH A FASHION AS TO INCREASE THE PROBABILITY OF MOLECULES BEING STRUCK BY THE SECOND DISC OF ROTOR BLADES. THIS PROCESS IS REPEATED THROUGH NINETEEN STAGES ON EACH END OF THE PUMP, RESULTING IN WHAT IS COMMONLY REFERED TO AS A COMPRESSION RATIO. THIS ACTION DEPENDS ON THE RELATIVE MOTION OF BLADES AND MOLECULES. THE FASTER THE BLADES MOVE IN COMPARISON TO THE SPEED OF THE FREE MOLECULES, THE GREATER THE COMPRESSION RATIO OF THE PUMP BECOMES. THUS HEAVY MOLECULES, SUCH AS OIL VAPOR, HAVE COMPRESSION RATIOS SEVERAL ORDERS OF MAGNITUDE HIGHER THAN GASES SUCH AS NITROGEN OR HYDROGEN.

THE COMPRESSION OF GASES TOWARD THE ENDS OF THE PUMP RESULTS IN A FOREPRESSURE WHICH EXTENDS INTO THE FORELINE AT B AND IS PUMPED BY THE FOREPUMP CONNECTED TO THE OUTLET.

THE REFRIGERANT OR WATER COOLED, HIGH SPEED BALL BEARINGS WHICH SUPPORT THE ROTOR ARE LOCATED AT EACH END OF THE PUMP, AT C. THE OIL USED TO LUBRICATE THE BEARINGS IS THUS IN THE FOREPRESSURE. THIS OIL IS MORE VOLATILE THAN NORMAN VACUUM PUMP OIL, AND ANY SPATTERING WHICH MIGHT ACCIDENTALLY CAUSE OIL TO REACH THE BLADES CANNOT MIGRATE ANY SIGNIFICANT DISTANCE TOWARD THE HIGH VACUUM AREA AT THE CENTER OF THE PUMP BEFORE IT IS VAPORIZED AND PUMPED BACK TO THE FORELINE.

SINCE THE TURBO-MOLECULAR PUMP OPERATES ON A DEFINITE COMPRESSION RATIO PRINCIPLE, THE FOREPUMP (FREQUENTLY REFERRED TO AS A BACKING PUMP) BECOMES IMPORTANT. THE BLANK-OFF PRESSURE RATING OF THE TURBO-MOLECULAR PUMP IS BASED ON A FOREPRESSURE OF  $1 \times 10^{-4}$  TORR (MCLEOD), WHICH IS READILY ATTAINED BY WELCH DUO-SEAL TWO-STAGE VANE TYPE MECHANICAL PUMPS.

## GENERAL CHARACTERISTICS

SOME OF THE IMPORTANT CHARACTERISTICS OF THE TURBO-MOLECULAR PUMP ARE DISCUSSED IN THE FOLLOWING PARAGRAPHS TO ENABLE THE OPERATOR TO USE THE PUMP TO ITS BEST ADVANTAGE.

### THE TURBO-MOLECULAR PUMP:

1. IS FREE OF HYDROCARBON CONTAMINATION DURING OPERATION.
2. THERE IS NO BACKSTREAMING OF OIL VAPORS, AND THEREFORE NO NEED FOR LIQUID NITROGEN TRAPS. HYDROCARBONS MAY BE PUMPED THROUGH THE PUMP INDEFINITELY WITHOUT DAMAGE.
3. CAN PUMP NOBLE GASES AS EASILY AS THE COMMON GASES.  
LEAK DETECTION POSES NO PROBLEM REGARDLESS OF THE TRACER GAS USED.
4. DOES NOT STORE OR RE-EJECT PREVIOUSLY PUMP GASES. ANY GAS PUMPED BY THE PUMP IS COMPLETELY REMOVED BY THE FOREPUMP.
5. CAN PUMP INDEFINITELY AT ANY PRESSURE WITHOUT DAMAGE.
6. EVEN UNDER THE EXTREMELY UNUSUAL CONDITIONS OF OPERATING AT ATMOSPHERIC PRESSURE THE WORST THAT

COULD HAPPEN IS THAT THE DRIVE MOTOR WOULD BECOME OVERHEATED AND A THERMAL OVERLOAD WOULD TRIP.

7. HAS IMMEDIATE RECOVERY. IF THE PUMP SHOULD BE SUBJECTED TO PRESSURE IN THE UPPER LIMIT OF MOLECULAR FLOW FOR HOURS OR DAYS, AS WHEN A GAS IS BLED THROUGH A SYSTEM, THE PUMP WILL RECOVER IMMEDIATELY UPON CLOSURE OF THE BLEED. OF COURSE, WATER VAPOR OR CORROSIVE GASES WILL REQUIRE BAKE-OUT TO REMOVE COMPLETELY, AS IN ANY VACUUM SYSTEM.
8. HAS A RELIABLE PUMPING ACTION. AS LONG AS THE ROTOR IS SPINNING, THE PUMP IS PUMPING.
9. IS INSENSITIVE TO SUDDEN AIR INRUSH. ACCIDENTAL VENTING OR IMPLOSION OF SYSTEM COMPONENTS DOES NOT CAUSE PUMP DAMAGE UNLESS DEBRIS IS ALLOWED TO FALL DIRECTLY INTO THE ROTOR BLADES. A SCREEN IS PROVIDED TO PREVENT SUCH OCCURANCE. A BURST OF GAS CANNOT HARM THE PUMP, EVEN SUDDEN VENTING FROM ULTIMATE BLANK-OFF TO ATMOSPHERE.
10. HAS EASILY ATTAINED STARTING PRESSURES. THERE IS NO DELAY FROM THE TIME THE FOREPUMP NEARS ITS ULTIMATE UNTIL THE TIME THE TURBO-MOLECULAR PUMP BEGINS PUMPING EFFICIENTLY. IN FACT, THE EFFECTIVE PUMPING RANGES OF THE TWO PUMPS OVERLAP, AND THE SUDDEN DROP

11. IN PRESSURE FROM THE MILLITORR (MICRON) RANGE IS IMPRESSIVE.
12. NEED NOT BE BYPASSED BY ROUGHING LINES. IT IS SO SIMPLE TO CYCLE THAT ROUGHING CAN BE DONE DIRECTLY THRU THE PUMP BY THE FOREPUMP.
13. DOES NOT DECOMPOSE PUMP GASES. WHATEVER GOES IN, MUST COME OUT.



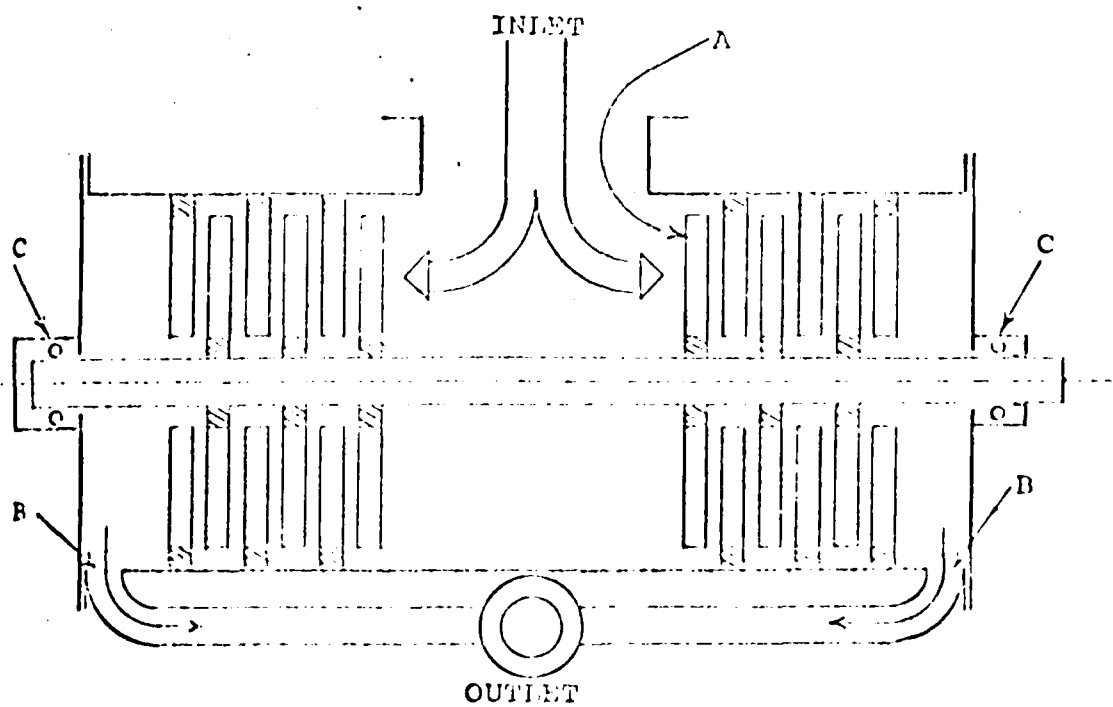


FIGURE 18  
Schematic Cross-Section of Turbo-Molecular Pump

## SPUTTER ION PUMPS

THE SPUTTER ION PUMP IS DESIGNED SUCH THAT AN ELECTRICAL DISCHARGE OCCURS BETWEEN THE ANODE AND CATHODE AT A POTENTIAL OF SEVERAL THOUSAND VOLTS IN A MAGNETIC FIELD OF A FEW THOUSAND GAUSS. SINCE THE MAGNETIC FIELD CAUSES THE ELECTRONS TO FOLLOW A FLAT HELICAL PATH, THE LENGTH OF THEIR PATH TO THE ANODE IS GREATLY INCREASED. THE GASEOUS IONS FORMED ARE ACCELERATED TO THE TITANIUM ANODE WHERE THEY MAY PERFORM IN ONE OF THREE WAYS. THEY MAY PENETRATE THE ANODE SURFACE AND THUS BE PUMPED, OR THEY MAY COMBINE CHEMICALLY WITH THE ANODE MATERIAL TO FORM A LOW-VAPOR PRESSURE COMPOUND. THE THIRD POSSIBLE OCCURANCE IS THAT THEY WILL VAPORIZE SOME OF THE ANODE MATERIAL (SPUTTERING). THE SPUTTERED ATOMS OF METAL WILL IN TURN CONDENSE ON OTHER PARTS OF THE PUMP STRUCTURE AND TRAP GAS MOLECULES.

DUE TO THE COMPLEX NATURE OF THE PUMPING ACTION OF SPUTTER-ION-TYPE PUMPS, THE PUMPING SPEED FOR VARIOUS GASES VARIES GREATLY, DEPENDING ON THE CHEMICAL ACTIVITY, EASE OF IONIZATION, AND THE MOLECULAR SIZE OF THE GAS. TABLE 8 SHOWS A SPEED VARIATION OF NEARLY 300 TO 1 FOR A SIMPLE DIODE PUMP.

IT IS FREQUENTLY STATED THAT SPUTTER ION PUMPS ARE PREFERABLE TO DIFFUSION PUMPS BECAUSE THEY DO NOT INJECT HYDRO-CARBON CONTAMINANTS INTO A SYSTEM. THIS IS TRUE WHEN A POORLY TRAPPED DIFFUSION PUMP IS USED FOR COMPARISON. HOWEVER, SPUTTER ION PUMPS CAN PRODUCE SIGNIFICANT AMOUNTS OF HYDROCARBONS WHILE A PROPERLY TRAPPED OIL DIFFUSION PUMP CAN MAINTAIN HYDROCARBONS AT LESS THAN  $10^{-12}$  TORR.

TABLE 3

RELATIVE PUMPING SPEED FOR GASES IN FLAT CATHODE SUPPTEP  
ION PUMP

<u>GAS</u>	<u>PUMPING SPEED, LITER/SEC.</u>
HYDROGEN	270
DEUTERIUM	190
LIGHT HYDROCARBONS	90 TO 160
NITROGEN	100
CARBON DIOXIDE	100
WATER VAPOR	100
OXYGEN	57
HELIUM	10
NEON	4
ARGON	1

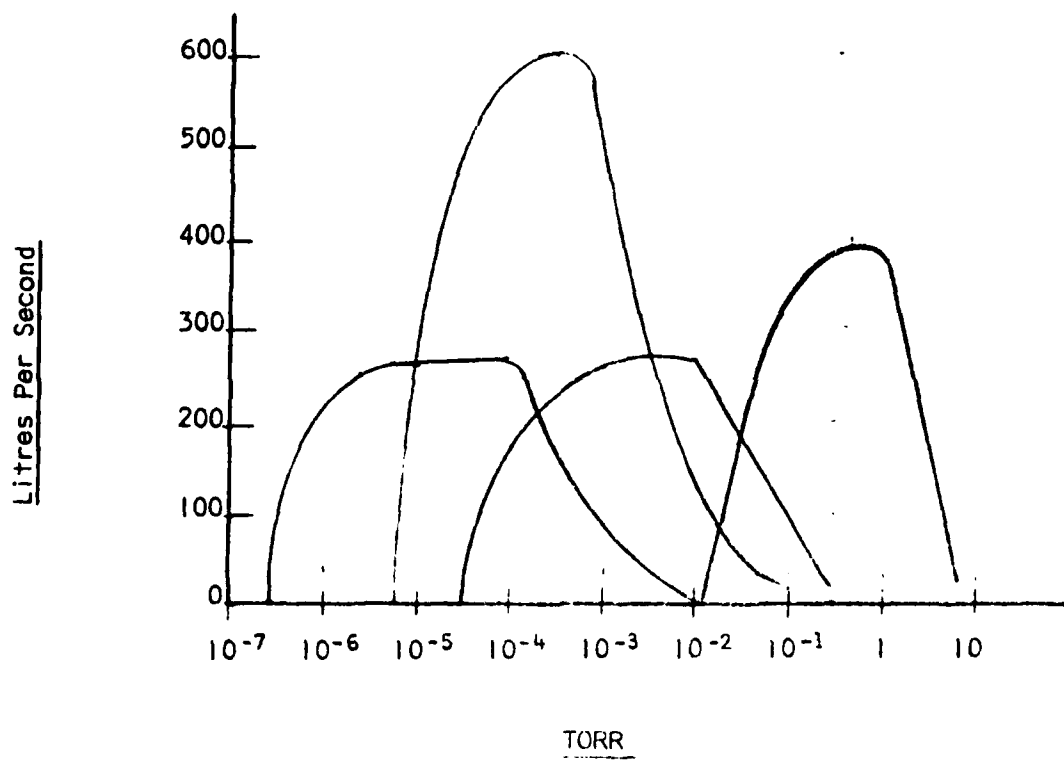
## DIFFUSION PUMPS

THE DIFFUSION PUMP IS THE MOST COMMONLY USED LOW PRESSURE PUMP. IT UTILIZES THE DYNAMICS OF A FLOWING FLUID TO PRODUCE A VACUUM, AND IT CONTAINS NO MECHANICAL OR MOVING PARTS. THE WORKING FLUID, IN ITS VAPOR PHASE, IS EJECTED AT HIGH VELOCITY BY A NOZZLE AGAINST A COLD SURFACE, WHERE IT IS CONDENSED. GAS MOLECULES IN THE REGION SURROUNDING THE JETS ARE CARRIED BY THE VAPOR JET TO THE REGION WHERE THE VAPOR IS CONDENSED AND THE PUMPING ACTION THUS PRODUCED REMOVES THE GAS FROM THE VACUUM SYSTEM. DIFFUSION PUMPS ARE USUALLY USED IN CONJUNCTION WITH A MECHANICAL FOREPUMP, THE DISCHARGE FROM THE DIFFUSION PUMP BEING LET DIRECTLY TO THE FOREPUMP.

THE PUMP ACTION DEPENDS ON THE PROBABILITY OF FINDING MOLECULES OF THE GAS IN THE VICINITY OF THE HIGH SPEED VAPOR MOLECULES. BECAUSE OF THE LOW PRESSURE EXISTING IN THE PUMP, PRACTICALLY NO COLLISIONS TAKE PLACE BETWEEN GAS MOLECULES, AND THOSE MOLECULES THAT ARRIVE AT THE JET DO SO BECAUSE THEIR LAST COLLISION WITH THE WALL DIRECTED THEM TOWARD IT. UPON COLLISION WITH THE MOLECULES IN THE JET, A MOMENTUM TRANSFER TAKES PLACE LEAVING THE GAS MOLECULES WITH SUFFICIENT MOMENTUM TO REMOVE IT TO THE REGION OF HIGHER PRESSURE. THE WORKING FLUID IMPINGES ON A COLD SURFACE, AND THE CONDENSATE FALLS INTO A HEATED CHAMBER FOR REVAPORIZATION.

DIFFUSION PUMPS HAVE BEEN CONSTRUCTED TO USE VARIOUS FLUIDS, BUT STEAM, MERCURY AND OILS ARE COMMONEST. WITH PUMPS OF THIS TYPE THERE IS NO LIMIT TO THE VACUUM ATTAINABLE (EX.  $10^{-7}$  TORR) SO LONG AS THE VACUUM SYSTEM IS PROTECTED BY A COOLING TRAP TO PREVENT THE BACKFLOW OF WORKING FLUID VAPOR.

TYPICAL PERFORMANCE CURVES FOR OIL DIFFUSION PUMPS  
FIGURE 19



LND HAS CHOSEN THE DIFFUSION PUMP SYSTEM SHOWN IN FIGURES 21 AND 22 FOR THE FOLLOWING REASONS:

1. THE PUMP WILL NOT BE DESTROYED BY THE HALOGEN GASES. IT CAN BE PERIODICALLY CLEANED WITHOUT REPLACEMENT OF MAJOR COMPONENTS.
2. ONE DOES NOT REQUIRE GREAT PUMPING SPEEDS SINCE THE LIMITING FACTOR IS THE SMALL ORIFACE OF THE DETECTOR PUMP OUT TUBULATION SHOWN IN FIGURE 8.
3. THE BASIC DIFFUSION PUMP COSTS SEVERAL HUNDRED DOLLARS WHEREAS TURBO-MOLECULAR PUMPS COST IN THE ORDER OF \$6,000.00

THE SPUTTER ION PUMP AS ALREADY DISCUSSED CANNOT BE REPAIRED, HAS DIFFERENT PUMPING SPEEDS FOR VARIOUS GASES AND WITH CONTROLLING ELECTRONICS IS QUITE EXPENSIVE THEREFORE IS NOT EVEN A SECONDARY CHOICE FOR THIS APPLICATION.

THE TURBO-MOLECULAR PUMP WOULD BE DESTROYED IF THE HALOGEN GASES ENTERED THE PUMP. ONE DOES NOT REQUIRE THE FAST PUMPING SPEED AND ITS COST WOULD PROVE PROHIBITIVE IN THIS APPLICATION.

## PUMPING SYSTEM

AS AN OFFSHOOT OF THIS PRODUCTION MEASURE LND HAS DESIGNED AND BUILT A NEW SERIES OF PUMPING STATIONS THAT INCORPORATE MANY NEW FEATURES ENABLING FASTER, MORE STABLE AND RELIABLE PRODUCTION INCLUDING;

1. HIGHER TEMPERATURE OVENS
2. AUTOMATIC TEMPERATURE CYCLING
3. STAINLESS STEEL MANIFOLD
4. AUTOMATIC GAS PROCESSING

FIGURE 20 IS A PHOTOGRAPH SHOWING THE NEW AUTOMATIC OVEN AND CONTROLS. PICTORIALLY ONE CAN SEE THE FOLLOWING:

1. OVEN
2. STAINLESS STEEL MANIFOLD
3. AUTOMATIC TIMING CONTROL
4. AUTOMATIC TEMPERATURE CONTROL

THESE CONTROLS ALLOW THE OVEN TO TEMPERATURE CYCLE OVER A SET OF PROGRAMMED TEMPERATURE RANGES FOR A PROGRAMMED TIME PERIOD.

FIGURE 21 IS A PHOTOGRAPH SHOWING THE NEW AUTOMATIC PUMPING SYSTEM AND CONTROLS. PICTORIALLY ONE CAN SEE THE FOLLOWING:

- |                         |                                    |
|-------------------------|------------------------------------|
| 1. MECHANICAL PUMP      | 7. STAINLESS STEEL FILLING VALVES  |
| 2. DIFFUSION PUMP       | 8. LIQUID N <sub>2</sub> COLD TRAP |
| 3. MIX BOTTLE           | 9. AUTOMATIC FILLING VALVES        |
| 4. CHLORINE BOTTLE      | 10. PRESSURE GAUGE                 |
| 5. BROMINE BOTTLE       | 11. AUTOMATIC TIMING MECHANISM     |
| 6. NUPRO FILLING VALVES |                                    |



FIGURE 22 IS A PHOTOGRAPH DESCRIBING PICTORIALY THE ENTIRE SYSTEM INCLUDING AUTOMATIC OVEN, PUMPING SYSTEM AND CONTROLS.

FIGURE IS A SCHEMATIC SCHEMETIC DESCRIBING THE ENTIRE SYSTEM.

AFTER THE STATION IS MANUALLY LOADED WITH DETECTORS THE PRE PROGRAMMED ELECTRONICS ASSUME CONTROL. THE OPERATOR IS NOT REQUIRED AGAIN UNTIL FINAL PROCESSING, FILLING AND TESTING.

EACH STATION ENABLES THE PUMPING OF 108 UNITS IN A 24 HOUR PERIOD. THEREFORE ONE SINGLE STATION HAS A 20 DAY WORKING MONTH CAPABILITY OF 2160 UNITS.

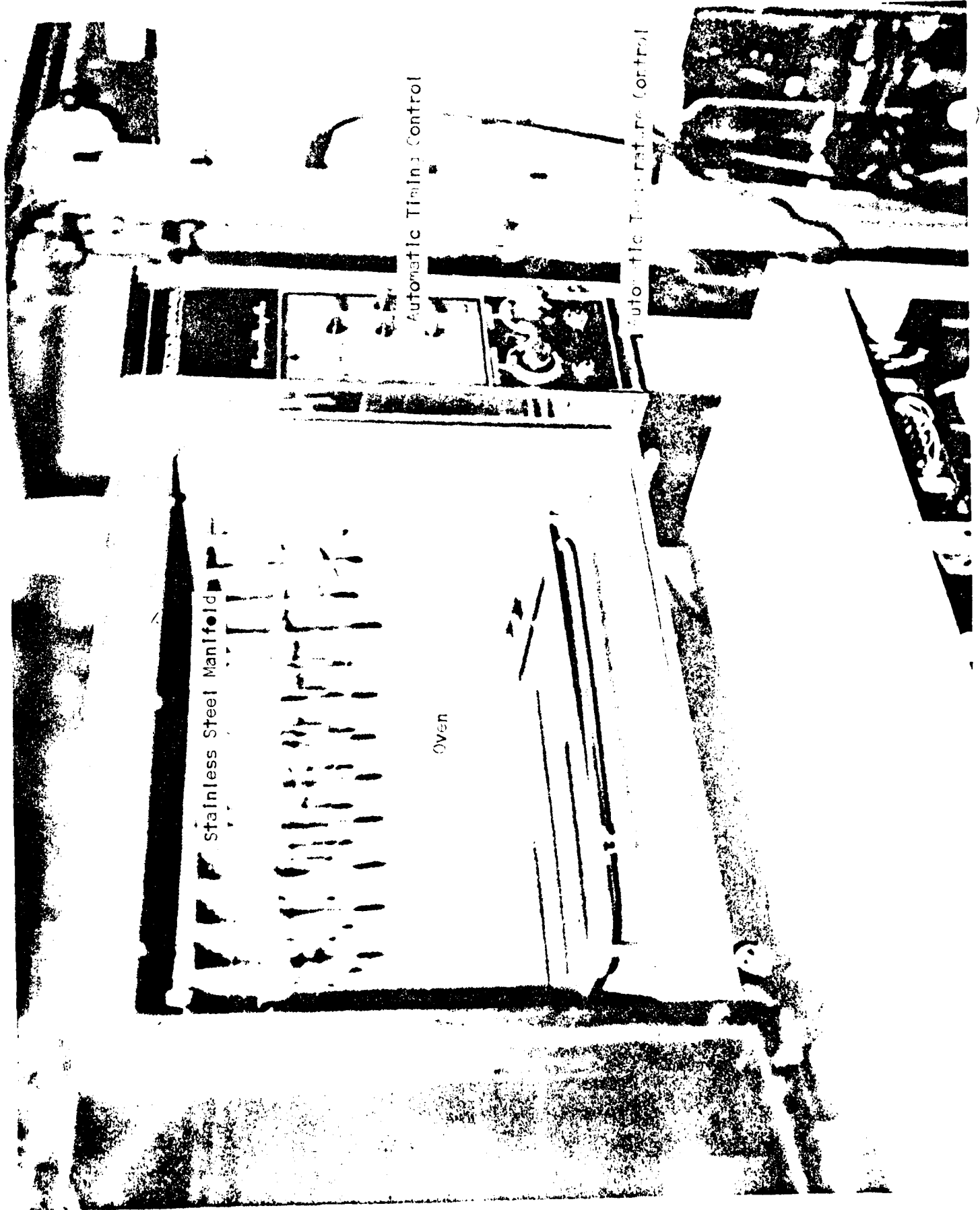


FIGURE 20

AUTOMATIC OVEN AND CONTROLS

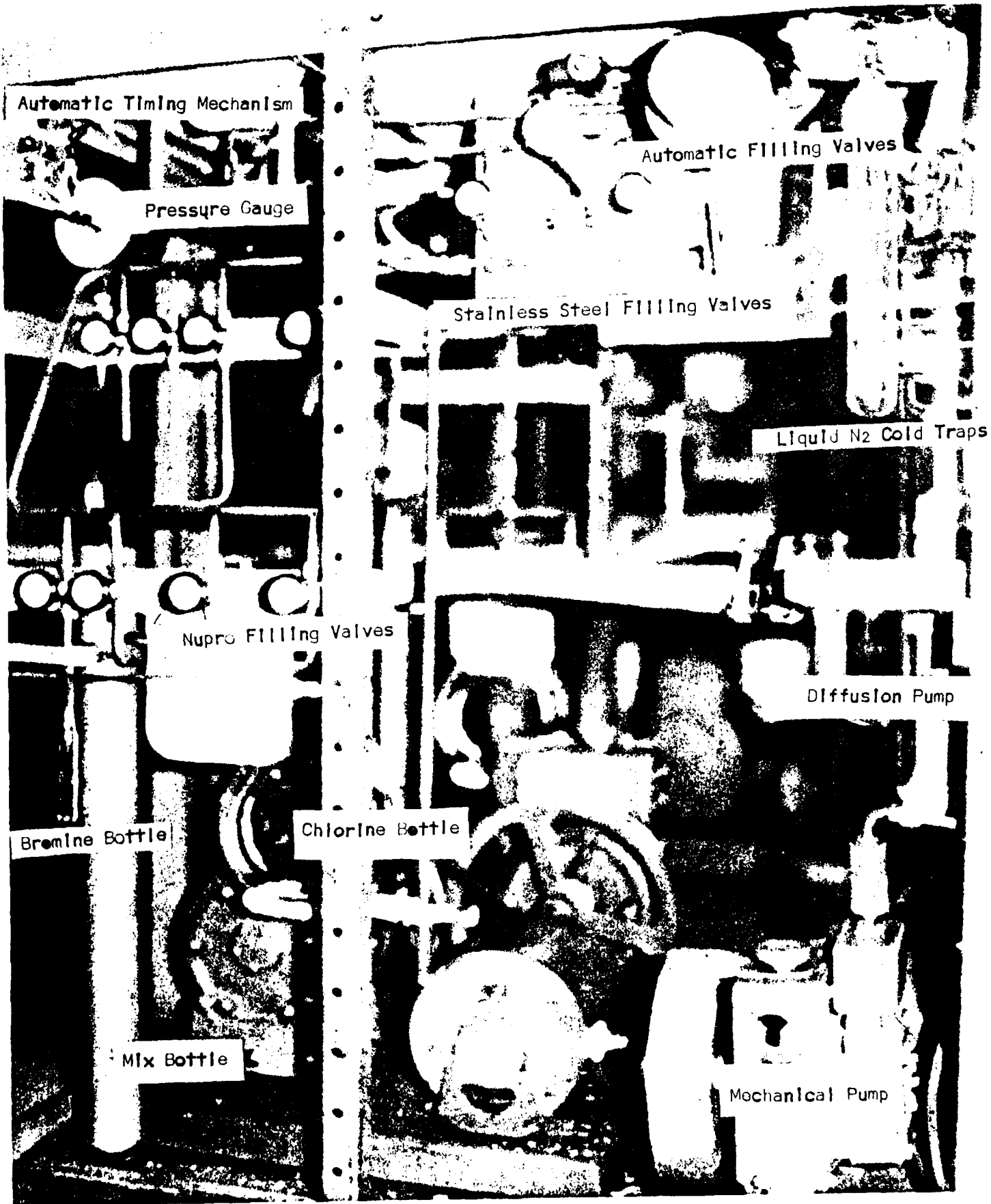


FIGURE 21 AUTOMATIC PUMPING SYSTEM AND CONTROLS

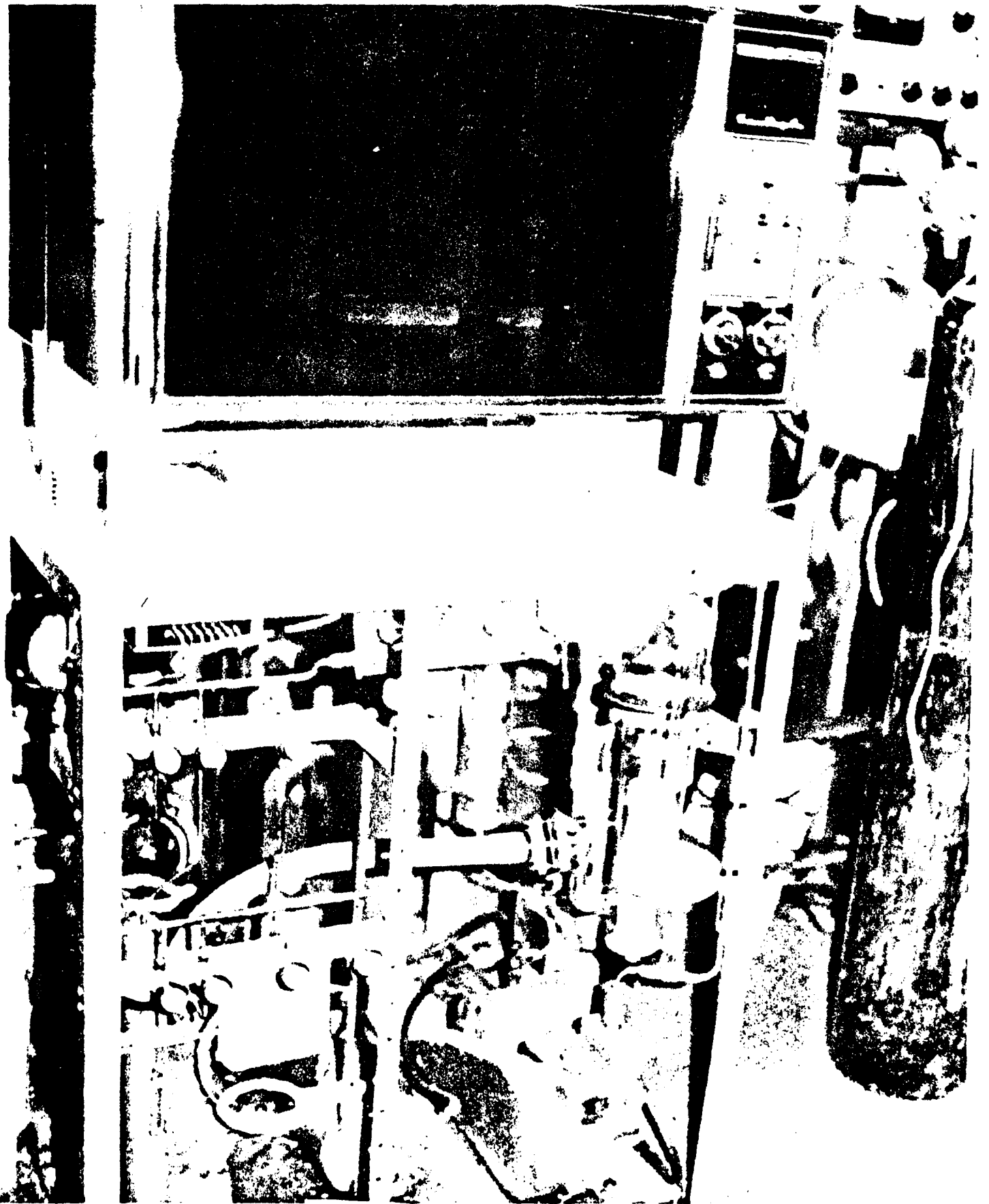
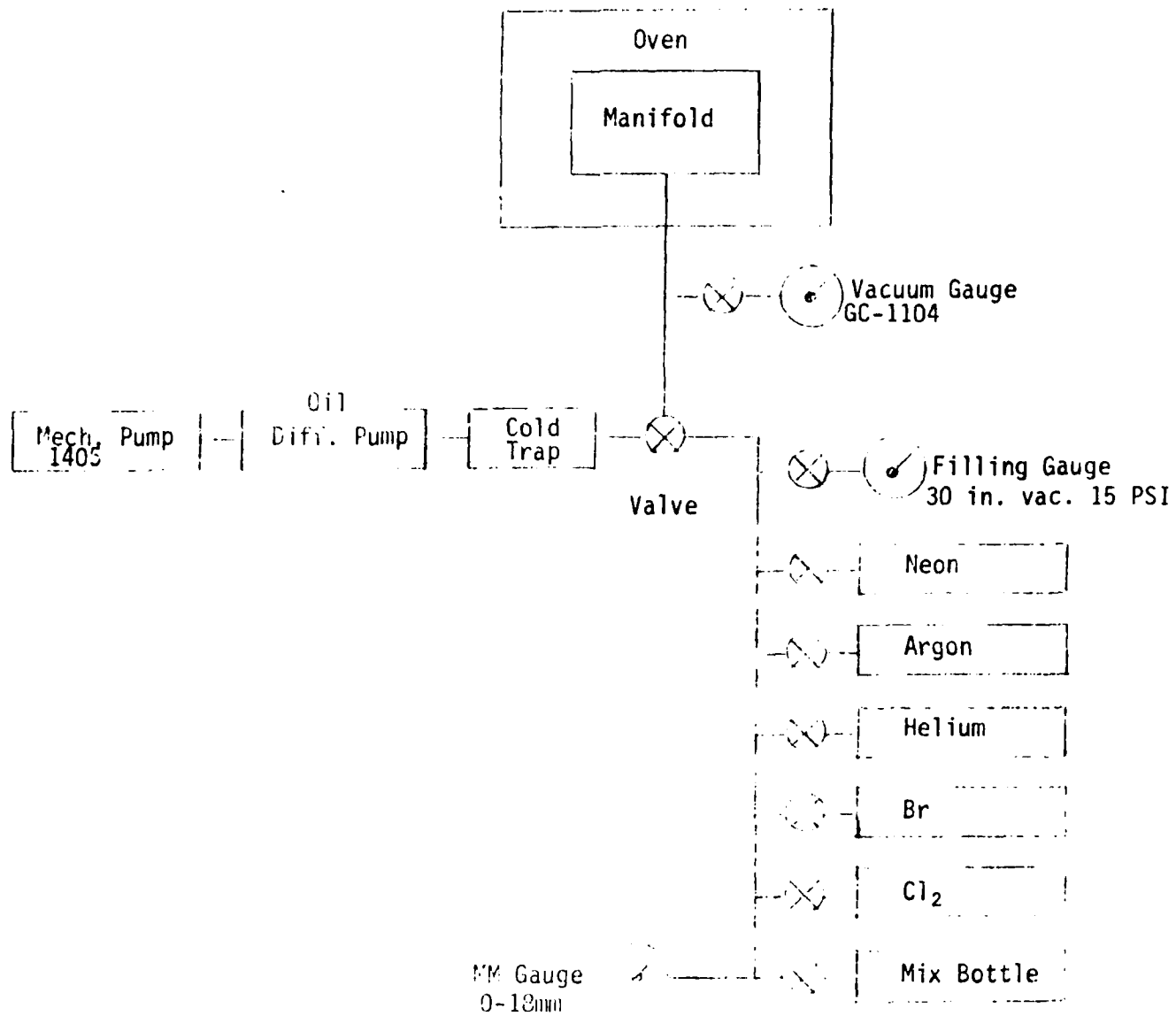


FIGURE 22

57.

AUTOMATIC OVEN PUMPING SYSTEM AND CONTROL



GAS COUNTER PUMPING AND FILLING SYSTEM

FIGURE 23

## FLOW CHART AND MANUFACTURING PROCESS

FIGURE 24 IS A FLOW CHART OF THE MANUFACTURING PROCESSES REQUIRED FOR THE HIGH RANGE GM COUNTER SHOWING THE CAPACITY FOR EACH SPECIFIC PIECE OF EQUIPMENT OR OPERATION. ALL CAPACITY FIGURES ARE GIVEN IN UNITS PER 8 HOUR DAY.

THIS IS DESCRIBED IN DETAIL.

### 1. PURCHASE PARTS

COMPONENTS OF AN ENTIRE PROGRAM CAN BE PURCHASED AT ONE TIME. COMPLETE PURCHASING PROCEDURES ARE OUTLINED IN THE LND QUALITY ASSURANCE MANUAL.

### 2. MANUFACTURE PARTS

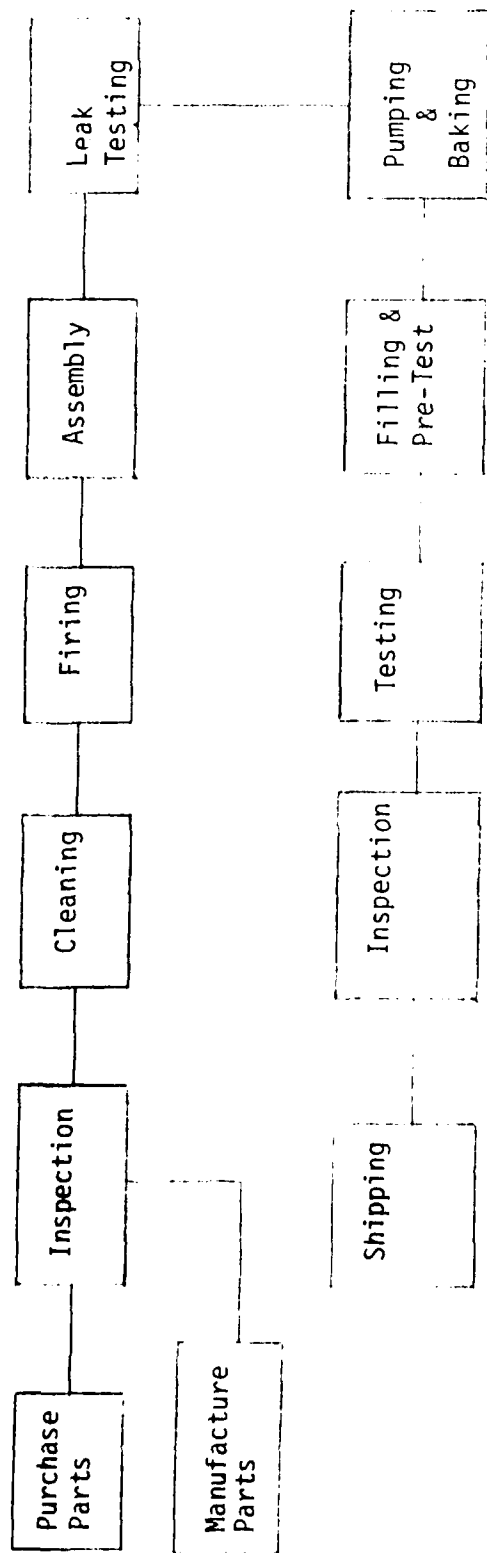
THIS INCLUDES COMPONENTS MANUFACTURED NOT ONLY IN THE LND MACHINE SHOPS BUT ALSO AT OUTSIDE VENDORS. ALL VENDORS USED BY LND MUST INSPECTED AND APPROVED BY THE LND QUALITY CONTROL DEPT. ON A PERIODIC BASIS AS DESCRIBED IN OUR Q.A. MANUAL.

### 3. INSPECTION

COMPLETE INSPECTION PROCEDURES ARE FOLLOWED INCLUDING MECHANICAL, VISUAL AND ELECTRICAL PLUS CERTIFICATES OF COMPLIANCE AND ANALYSIS ARE REQUIRED FOR ALL MATERIALS. ALL INSPECTION ACCORDING TO MIL

### 4. CLEANING

CHEMICAL CLEANING CONSISTS OF STAINLESS STEEL PROCESSING AS DESCRIBED IN LND PROCEDURE M900135 AND M800140 PLUS TRIPLE CASCADE WASHING IN BOILING DEMINERALIZED H<sub>2</sub>O OF ALL OTHER COMPONENTS. COMPONENTS FOR 800 DETECTORS CAN BE CLEANED IN A 4 HR. PERIOD.



FLOW CHART OF MANUFACTURING PROCESS

FIGURE 24

### OXYGEN FIRING PROCEEDURE

1. Take chemically cleaned and etched components and place them in vacuum firing jar.
2. Pump down to  $10^{-6}$  torr.
3. Activate RF generator and heat components to  $900^{\circ}\text{C}$ .
4. When all components have been thoroughly out-gassed admit ultra pure oxygen (760 torr) and keep heat on for 1 minute.
5. Allow to cool in oxygen atmosphere.



# LND, INC.

## PROCESS STANDARDS

PROCEDURE NO.

M-900135

TITLE

STAINLESS STEEL PROCESSING

PAGE

III - 6

ISSUED

OCT 31 1972

APPROVED

*H.R. Hardy*

1. Clean in acetone bath in ultrasonic degreaser for 3 minutes.
2. Running hot water rinse.
3. M800140 #1 - Dip in initial bath for 2 seconds.
4. Running hot water rinse.
5. M800140 #2 - Dip in depassivate for 2 seconds.
6. Hot water rinse.
7. M800140 #3 - Immerse in bright dip for 2 seconds.
8. Running hot water rinse.
9. Acetone rinse.
10. Hot air dry.

62.

REVISED

APPROVED

# LND, INC.

## PROCESS STANDARDS

PROCEDURE NO. M-800140

PAGE II-5

TITLE

STAINLESS STEEL SOLUTIONS

ISSUED Oct. 31, 1972

APPROVED

### 1. INITIAL BATH

Hydrochloric Acid (HCL 37%) A.C.S. Spec.  
Nitric Acid (HNO<sub>3</sub> 70%) A.C.S. Spec.

100 MI.  
25 MI.

Water (Distilled)

375 MI  
500 MI batch

Temperature 65° Centigrade

### 2. DEPASSIVATE

Sulfuric Acid (93% Min.)

25 MI

Water (Distilled)

475 MI  
500 MI batch

### 3. BRIGHT DIP

Nitric Acid (HNO<sub>3</sub> 70%) A.C.S. Spec.  
Hydrochloric Acid (HCl 37%) A.C.S. Spec.  
Phosphoric Acid (85%)  
Acetic Acid (Glacial) U.S.P. Spec.

200 MI.  
25 MI  
25 MI  
250 MI

Temperature 65° Centigrade

KEEP ALL SOLUTIONS UNDER FUME HOOL

63.

REVISED

APPROVED

5. FIRING

VACUUM AND OXYGEN FIRING CONSIST OF STRINGING THE CATHODES ON MOLYBDENUM RODS AND HEATING THEM IN A VACUUM TO  $900^{\circ}\text{C}$  THEN ADMITTING ULTRA PURE OXYGEN FOR A PERIOD OF 5 MINUTES THEN COOLING 100 UNITS CAN BE PROCESSED IN A 30 MINUTE PERIOD.

6. ASSEMBLY

THE ASSEMBLY OF THE HIGH RANGE GM COUNTER IS ACCOMPLISHED BY HAND. 100 UNITS CAN BE COMPLETELY ASSEMBLED IN AN 8 HOUR PERIOD.

7. LEAK TESTING

LEAK TESTING IS ACCOMPLISHED ON A HELIUM MASS SPECTROMETER USING LND FIXTURE F4130 MULTIPLE LEAK CHECKING MANIFOLD 10 UNITS CAN BE TESTED IN A 2 1/2 MINUTE PERIOD.

8. PUMPING AND BAKING

THE TUBES ARE PLACED ON A 36 POSITION MANIFOLD AND AUTOMATICALLY PUMPED, BAKED AND PREPROCESSED. THIS MANUAL PROCESS TAKES 1/2 HOUR. THE AUTOMATIC PUMPING AND BAKING CYCLE CAN BE ADJUSTED TO A 4 HOUR PERIOD.

9. FILLING & PRETEST

FINAL PROCESSING, FILLING, AND PRETESTING THE DETECTORS AND REMOVING THE DETECTORS FROM THE STATION TAKES 1 HOUR.

10. TESTING

TESTING IS ACCOMPLISHED ON THE LND AUTOMATIC PLATEAU PLOTTER. 100 TUBES ARE PLACED ON THE LND AUTOMATIC PLATEAU PLOTTER IN A 15 MINUTE PERIOD THEN THIS PREPROGRAMMED UNIT AUTOMATICALLY CYCLES A UNIT EVERY 2 MINUTES GIVING PLATEAU LENGTH, SLOPE AND SENSITIVITY.

11. INSPECTION

FINAL INSPECTION IS A VISUAL EXAMINATION INCLUDING PLACEMENT IN A GO-NO/GO FIXTURE TO INSURE PROPER ALIGNMENT OF INSULATORS. A UNIT CAN BE INSPECTED EVERY 30 SECONDS.

12. SHIPPING

THE UNITS ARE LABELED ACCORDING TO MIL-E-1 AND PACKAGED. A UNIT CAN BE LABELED AND BULK PACKED IN 30 SECONDS.

THE CAPACITY FIGURE GIVEN IS FOR THE SPECIFIC PIECE OF EQUIPMENT AND NOT THE TOTAL CAPACITY OF LND.

TABLE 9 IS A LIST OF THE EQUIPMENT AND TOOLING REQUIRED FOR THE MANUFACTURE OF HIGH RANGE GM COUNTERS.

TABLE 9

EQUIPMENT AND TOOLING REQUIRED FOR MANUFACTURE OF HIGH RANGE  
GM COUNTERS

MACHINING

LATHE  
ROLLER

INSPECTION

0-1" MICROMETER  
0-8" DEPTH GAGE  
6" VERNIER CALIPER  
CHRISTIAN BECKER SENSITIVE BALANCE  
-100°F TO +350°F TENNY ENVIRONMENTAL CHAMBER

CLEANING

ULTRA SONIC CLEANER  
VAPOR DEGREASER

FIRING

10KW LEVEL GENERATOR MODEL T-10  
LND DESIGN 4 POSITION WATER COOLED RF SWITCH  
POWER CONTROLS AND INTERLOCKS  
ECCO UNIT FOR OUTGASSING  
FOREPUMPS, DIFFUSION PUMPS, COLD TRAPS AND VALVING.

ASSEMBLY

GLASS FRIT MIXER

GRUENBERG 10,000 WATT OVEN

LEAK TESTING

VEECO MS12 HELIUM MASS SPECTROMETER

VEECO CALIBRATED LEAK STANDARD

PUMPING AND BAKING

GM STATION

FOREPUMP, DIFFUSION PUMP, COLD TRAP OVEN AND GAS MANIFOLD.

FILLING AND PRE-TEST

GAS MANIFOLD

POWER SUPPLY AND ELECTROSTATIC VOLTMETER

OSCILLOSCOPE

TESTING

POWER SUPPLY AND ELECTROSTATIC VOLTMETER

OSCILLOSCOPE

AUTOMATIC PLATEAU PLOTTER

INSPECTION

0-1" MICROMETER

6" VERNIER CALIPER

## SPECIFICATION

THE SPECIFICATION UTILIZED FOR INSPECTION AND ACCEPTANCE OF THE PILOT RUN HAS BEEN REVISED AND UPDATED REFLECTING THE FINDINGS OF THIS PROGRAM. THE FOLLOWING IS A REVISED VERSION OF THE SPECIFICATION SCS-415B. IT HAS ARBITRARILY BEEN GIVEN THE DESIGNATION SCS-415C TO AVOID CONFUSION. THE SPECIFICATION HAS BEEN PLACED INTO STANDARD MILITARY QPL FORMAT.

SCS-415C  
05 MAR 1976  
SUPERSEDING  
SC-415B  
15 OCTOBER 1974  
SUPERSEDING  
SCS-415A  
17 DECEMBER 1971

MILITARY SPECIFICATION SHEET  
ELECTRON TUBE, RADIATION COUNTER  
TYPE 71425 HIGH RANGE GIEGER TUBE

The complete requirements for procuring the electron tube described herein shall consist of this document and the latest issue of specification MIL-E-1, MIL-C-45662, MIL-1311A method 1031, IEEE Publication 309.

This specification is mandatory for use by all departments and agencies of the department of Defense.

DESCRIPTION:

Halogen-filled, low sensitivity, self-quenching for detection of gamma radiation.

Dimensions: see figure 1  
Mounting Position: Any  
Weight: 0.8 grams, nominal

ABSOLUTE RATINGS:

Parameter:	Ebb	Ta	Rp	Life
Unit:	Vdc	°F	Meg	Counts
Maximum:	650	+200°	---	----
Minimum	490	-70°	---	10 <sup>10</sup>

TEST CONDITIONS: 520      ---      3.3

---

GENERAL:

Qualification - required (see not 2)  
Marking - see note 3  
Response characteristics - see note 1  
Burn in - see note 21



		(PERCENT DEFECTIVE)	LEVEL OR CODE	MIN.	MAX	UNIT
<u>Quality conformance inspection,</u>						
<u>1.</u>						
Background, contamination and photo-sensitivity	t= 2 minutes (see notes 5,6,10 and 12)	0.65	II	---	2	CPM
Starting Voltage	Pulse amplitude = 1 volt; Nps=100 (max); R1=330K $\Omega$ ; R2=C3=3M $\Omega$ ; C1=2.2 pf (see note 10) Figure 2	0.65	II	385	415	Vdc
Relative plateau Slope	Voltage Range = 490 to 650 Vdc Note 1	0.65	II	---	0.15	%/Vdc
End of plateau voltage	Ps=0.20%/Vdc see note 1	0.65	II	650	---	Vdc
Response count rate (gamma)	t= 2 minutes see notes 7 & 10 Ebb - 520 volts	0.65	II	1500	1700	CPS
Deadtime	Ebb = 520 Vdc					Microsec.
Beginning of Plateau Voltage	Ps = 0.15%/Vdc	---	---	490	---	Vdc
Pulse Shape	see note 13	---	---	---	---	---
<u>Quality conformance inspection, part 2.</u>						
Response Linearity	Gamma (Co <sup>60</sup> ) see note 14,10	---	---	---	---	---
Pulse Amplitude	Ebb =520 Vdc; pulse amplitude	---	---	---	25	v
Hysteresis	see note 15,10	---	---	---	2½	%
Sensitivity Stability	see note 16,10	---	---	-10%	+10%	CPS
Tube capacitance	---	---	---	---	3	picofard
Pulse risetime	see note 17	---	---	---	5	Microsec.
Beta sensitivity	see note 18,10	---	---	-30%	+30%	CPS
Sensitivity Stability	see note 19,10	---	---	---	---	---

REQUIREMENT OF TEST	CONDITIONS	ACL (PERCENT DEFECTIVE)	INSPECTION LEVEL OR CODE	LIMITS		UNIT
				MIN	MAX	
Quality Conformance Part 3						
Life-test end point	see note 9	---	---	$1 \times 10^{10}$	---	COUNTS
Periodic-check tests						
Fixed-frequency vibration	see notes 4, 11 and 10	---	---	---	---	
Temperature Cycling	see note 8,10	---	---	-50	+160	°F
Altitude	see note 20,10	---	---	---	---	---
Humidity	MIL STD 1311A Method 1011					

NOTES:

1. In meeting the requirements of this specification the performance of GM tube shall be rated on the basis of its operating in the circuit of figure 2 to produce the curve of figure 3. The contractor shall establish and maintain a GM tube plateau characteristic curve tracer. Each radiation counter shall have its plateau characteristic curve recorded on an X-Y plot, an example of which is shown in figure 3. The count rate and voltage extremes sweep rate shall be chosen such that slowing down the voltage sweep rate does not produce an observable change in the shape of the characteristic curve. The following information shall be obtainable from the plateau characteristic curve: (a) plateau slope, (b) beginning of plateau, (c) plateau length, and (d) starting voltage. The radiation source to detector distance shall be fixed so that variations in source to the tube distance cannot exceed 2 percent. The radiation source used for this test shall be calibrated and produce a count rate that shall be no more than one order of magnitude below the limit of tube response linearity.

DEFINITION OF TERMS: Specific definitions pertaining to this specification are as follows:

- A. Plateau Slope. The plateau slope is calculated for the total plateau length specified. The slope S is quoted in percent per 100 volts and can be calculated from:

$$S = 100 \frac{\frac{N_2 - N_1}{(N_1 + N_2)/2}}{(V_1 - V_2)/100}$$

- B. Beginning of Plateau. The midpoint of the first 10 volts increment after the starting voltage wherein the slope becomes equal or less than that specified.
  - C. Plateau Length. That portion of the characteristic curve where the slope remains within the specified value.
  - D. Starting Voltage. The lowest applied voltage at which a 1 volt pulse appears at point A of Fig. 2
  - E. Operating Point The voltage  $E_{bb}$  in figure 2.
2. A minimum of 28 samples shall be submitted for qualification testing. The samples to be submitted for qualification testing will be broken down into the following subgroups:
    1. Shelf life only 6
    2. Electrical, including life test 16
    3. Variable-frequency vibration 6
  3. Each tube shall be individually date coded showing the week and year of manufacture plus have the manufacturers name permanently marked on the tube.
  4. Criterion for passing this test shall be compliance after test of at least 80 percent of the tubes with the requirements for:
    - A. Starting voltage
    - B. Gamma response (count rate)
    - C. Pulse amplitude (1) and (2)
    - D. End of plateau voltage
    - E. Relative Plateau Slope

This data will be obtained from plateau characteristic curve taken during vibration.

5. In determining tube response (count rate)  $E_{bb} = 520$  Vdc. Tube count rates shall be determined using a scaler having discrimination level of 0.5 volts.
6. The tube shall be exposed to radiation from a General Electric 15 watt germicidal lamp and a General Electric 15 watt fluorescent lamp, or equivalents, with relative positions as shown on figure 4.
7. All radiation standards employed in the standardizations shall be traceable to the primary standard, The National Bureau of Standards.
8. With the tube in a field giving  $100 \pm 10$  CPS at 520 Vdc the plateau characteristic curve shall be obtained at each of the following temperatures and in the order shown.
  - A. Room temperature
  - B.  $-50^{\circ}\text{F}$
  - C.  $-70^{\circ}\text{F}$  (turn voltage off)
  - D.  $+100^{\circ}\text{F}$  (turn voltage off)
  - E.  $+160^{\circ}\text{F}$
  - F. Room temperature

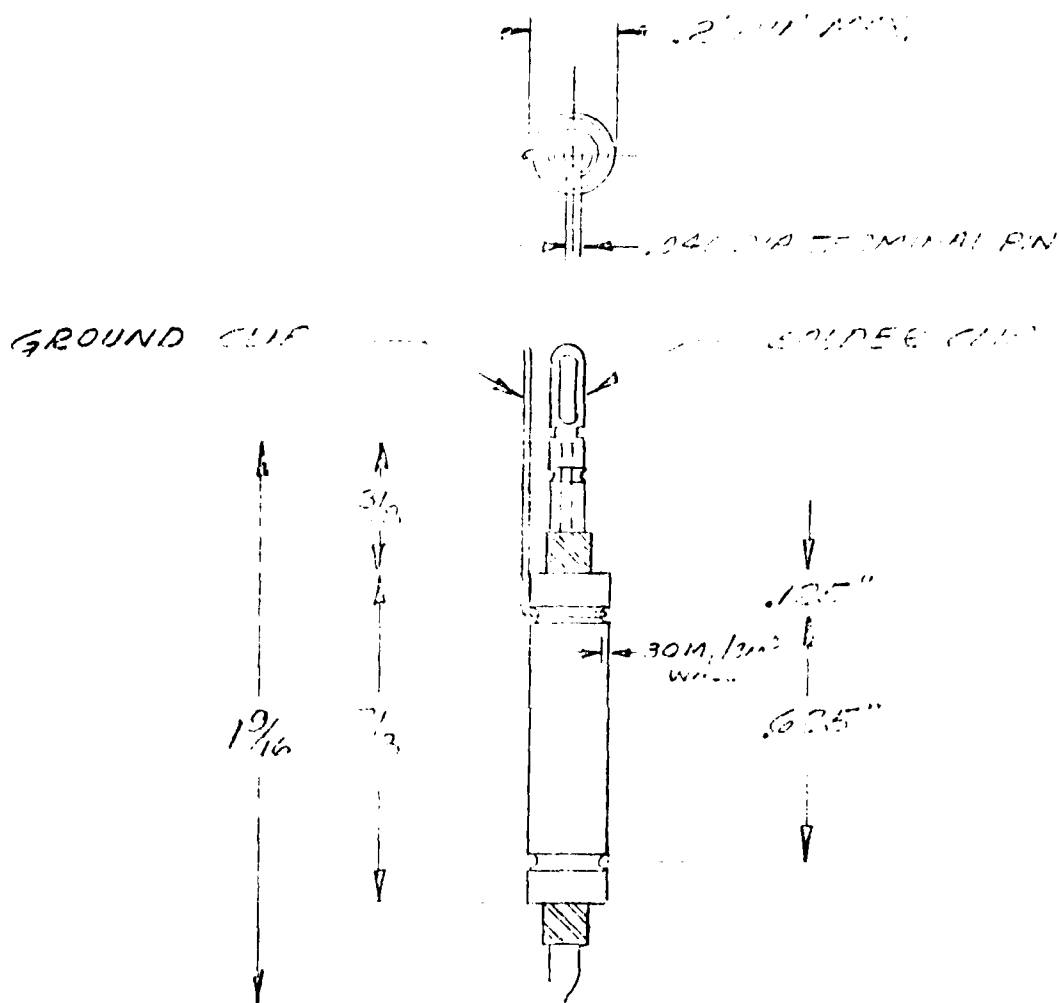
A minimum stabilization time of 30 minutes shall be allowed at each temperature. The starting voltage shall not shift throughout the operating temperature range more than  $\pm 10$  volts.

9. The limits for acceptability shall be as follows:

Background, contamination and photosensitivity: 2CPM maximum  
Starting Voltage:  $400 \pm 15$  volts  
Plateau length: 160 volts minimum  
Relative plateau slope: 0.15 percent/Vdc, maximum  
End-of-plateau voltage: 650 volts, minimum  
Gamma response (count rate):  $1600 \pm 100$  CPS  
Pulse amplitude: initial limits

10. This test to be performed at the conclusion of the holding period.
11. The tube shall be mounted with its longitudinal axis horizontal to the direction of motion by means of a rigid clamp at the center of the cathode. The tube shall have its characteristic curve taken while being subjected to 60 Hz vibration at an amplitude of 0.1 inches minimum. No change in characteristic is acceptable.
12. With the GM tube totally enclosed in nuclear radiation shield (outer layer of lead at least 50mm max. thick and inner layer of aluminum at least 3mm thick) the background shall be no greater than 2 counts per minute when the tube is connected as shown in figure 2.

13. The pulse shape shall be as illustrated in figure 5A when observed at point A of figure 2.
14. The count rate vs. field intensity of the radiation counter shall be as shown in figure 6, when the tube is operated in the D.C. mode. The count rate shall be linear within  $\pm 4\%$  of true value to count rate equivalent to a 1.0 r/hr field.
15. There may be a difference in the plateau obtained with an increasing voltage traverse and that with a decreasing voltage traverse. This effect is attributed to the charging of insulating surfaces in the counter. To test for hysteresis the plateau shall be traversed in an ascending and then a descending direction with a total elapsed time of less than one hour (much shorter than the charge leakage time constants of the insulating surfaces). The ascending and descending plateau curves shall be shown. There shall be no change in tube sensitivity due to hysteresis greater than  $\pm 5\%$ . The geiger threshold shall not shift due to this effect more than  $2\frac{1}{2}\%$  in volts, downscale. All measurements shall be taken from the RMS value of the curve which shall be drawn thru response characteristic.
16. The gamma sensitivity shall not vary, after the burn in period described in note more than  $\pm 10\%$  during the course of  $1 \times 10^{10}$  counts.
17. The pulse risetime is defined in figure 5B when observed at point A of figure 2 the pulse rise time shall be not greater than 5 microseconds.
18. The beta sensitivity of the tube shall be measured with the side window spaced  $0.05" \pm .005"$  from the source of radiation face plane. The beta radiation source shall be centered directly below the beta window. The tube shall be rotated about its longitudinal axis exposing at least three nonoverlapping views of beta window. The responses shall be within the  $\pm 30.0\%$ . All measurements shall be at least of two minutes duration.
19. The tube characteristics shall be recorded under a 5mr/hr field after which the tube shall be exposed to 5r/hr field for 30 min. The gamma sensitivity shall be recorded in a 5 mr/hr field during first 10 min. interval after exposure the tube shall be within specifications.
20. The G-M tube shall be subjected to a reduced pressure level of 0.320 in. of hg. abs.(simulating 100,000 feet above sea level) and shall be maintained at this pressure for a period of not less than 1 hour. Following the exposure period, the G-M tube shall be examined and operated to insure that no physical damage or degradation in performance has resulted.
21. There shall be a 100 hour period of operation of the tube into the test circuit (figure 2) in a 5 rad/hr field of CO 60 or Cs<sup>137</sup> radiation. Determination of compliance with this specification shall be made after this burn in period.



MATERIAL <i>STAINLESS STEEL</i>		TOL UNLESS OTHERWISE SPECIFIED		<b>ILND, INC.</b> 3230 LAWSON BLVD. OCEANSIDE, N. Y.	
BLANK SIZE		FRAC 8 V84 DEC 8 008 AUG 8 10			
DRAWN BY <i>[Signature]</i>		SCALE <i>EX</i>		TITLE <i>HALOGEN QUENCHED G.M. TUBE</i>	
APPROVED BY		REV		TUBE TYPE <i>71425</i>	PART NO. <i>71425</i>

FIGURE 1 (75)

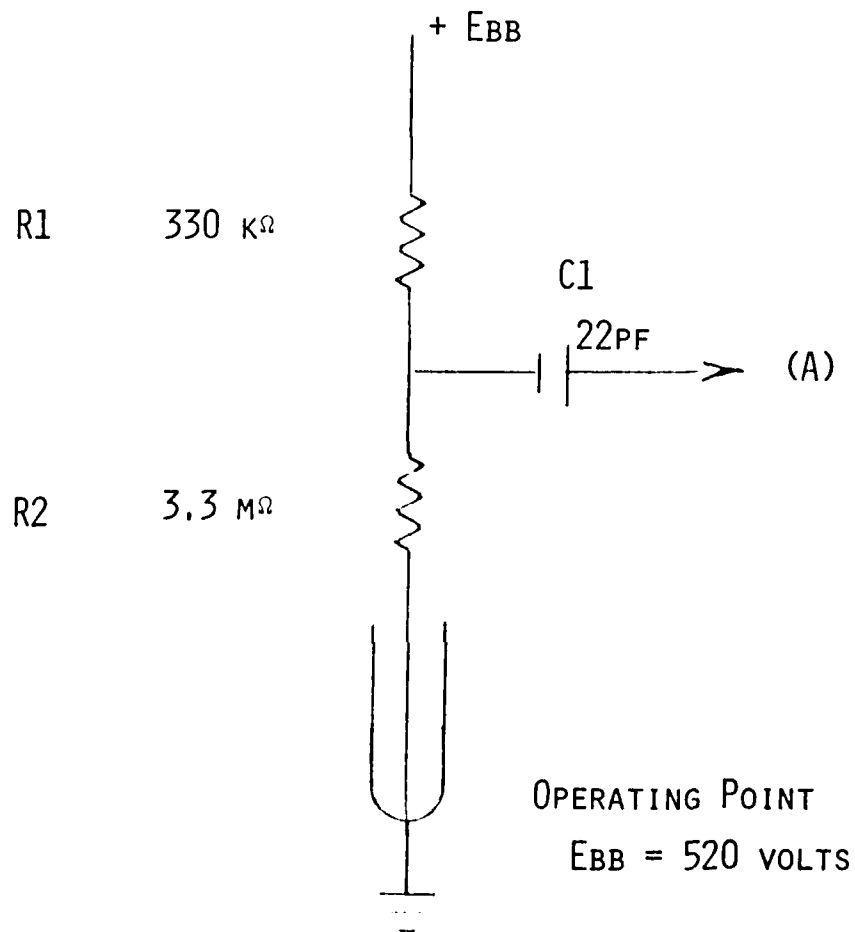


FIGURE 2 (76)

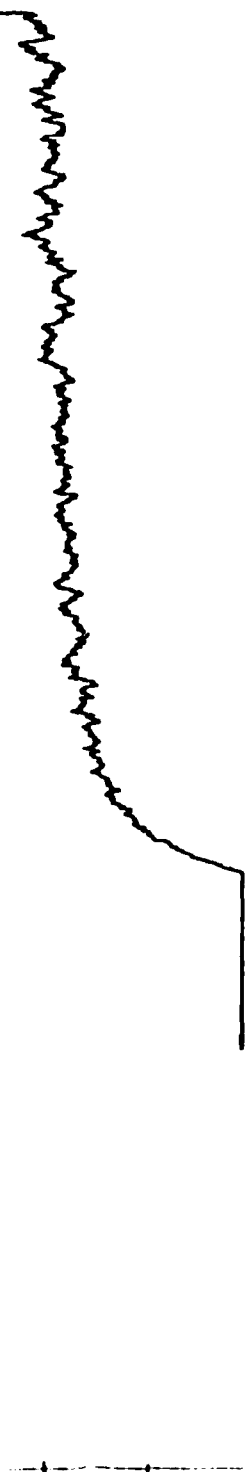
DATE Oct 28 SERIAL # 11  
BEGINNING OF PLATEAU 470  
PLATEAU SLOPE <.5%/100V  
END OF PLATEAU 870  
RADIATION SOURCE Ra<sup>226</sup>  
RADIATION INTENSITY FIXTURE

CPM X 1000

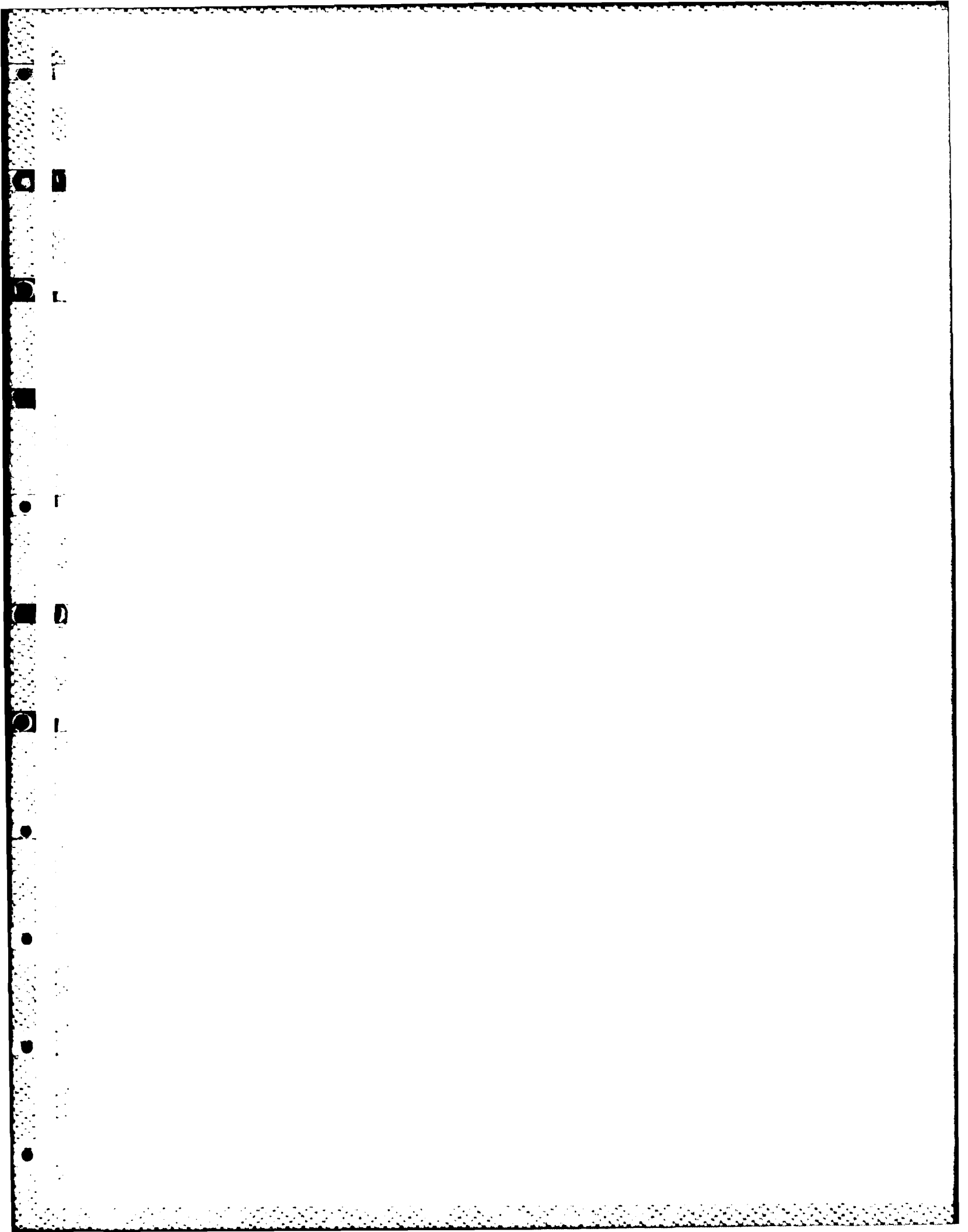
(77)

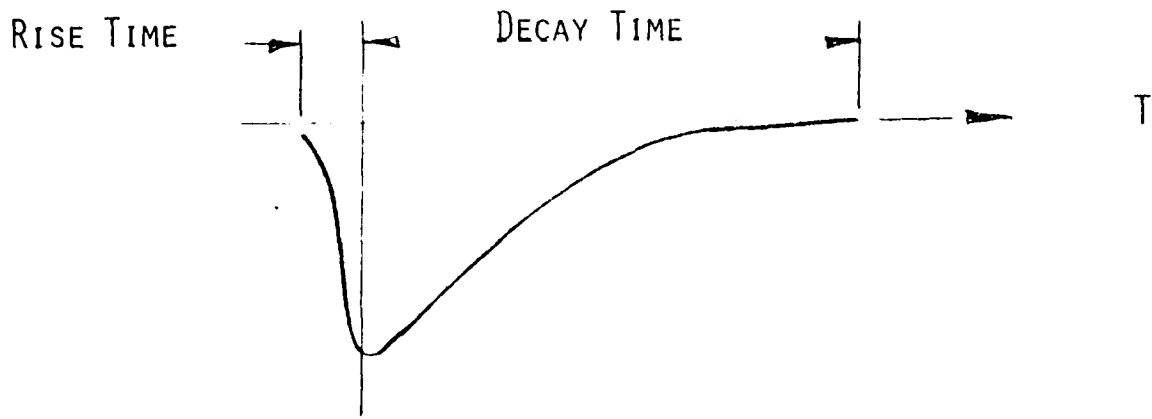
18  
14.4  
10.8  
7.2  
3.6

400 500 600 700 800 900  
VOLTAGE

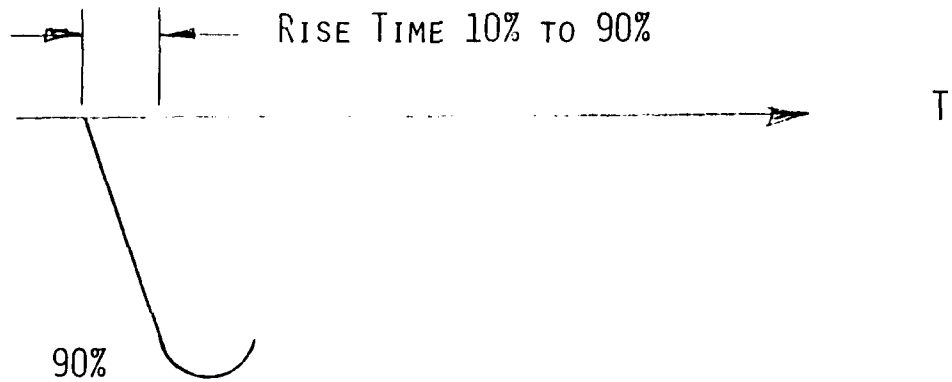




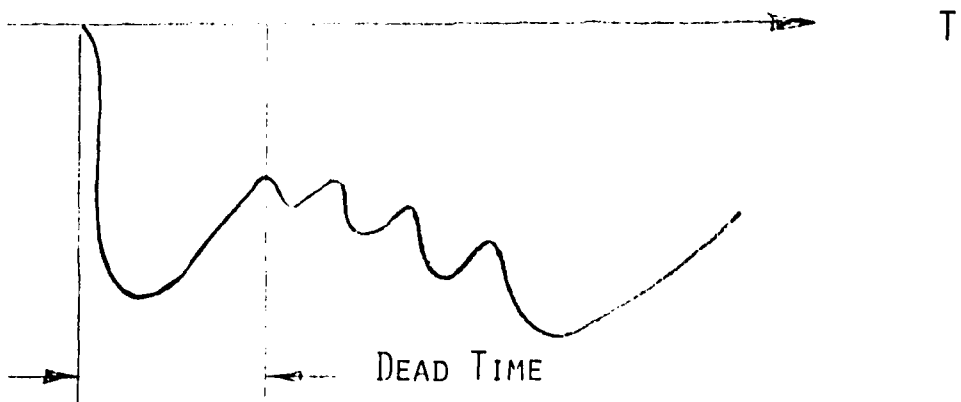




(A) PULSE SHAPE



(B) PULSE RISE TIME DEFINITION



(C) OSCILLOSCOPE DISPLAY OF DEAD TIME

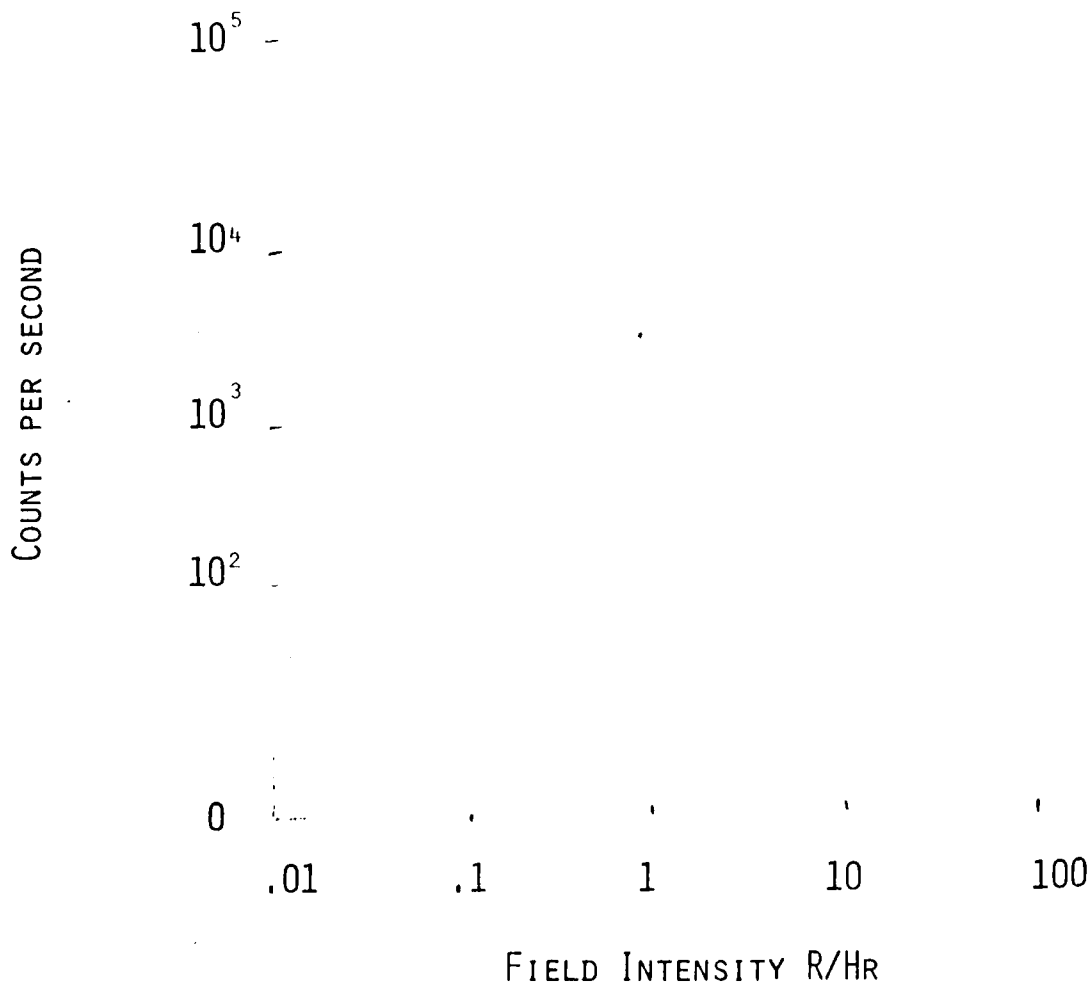


FIGURE 6: RESPONSE CHARACTERISTIC OF TYPICAL 71425

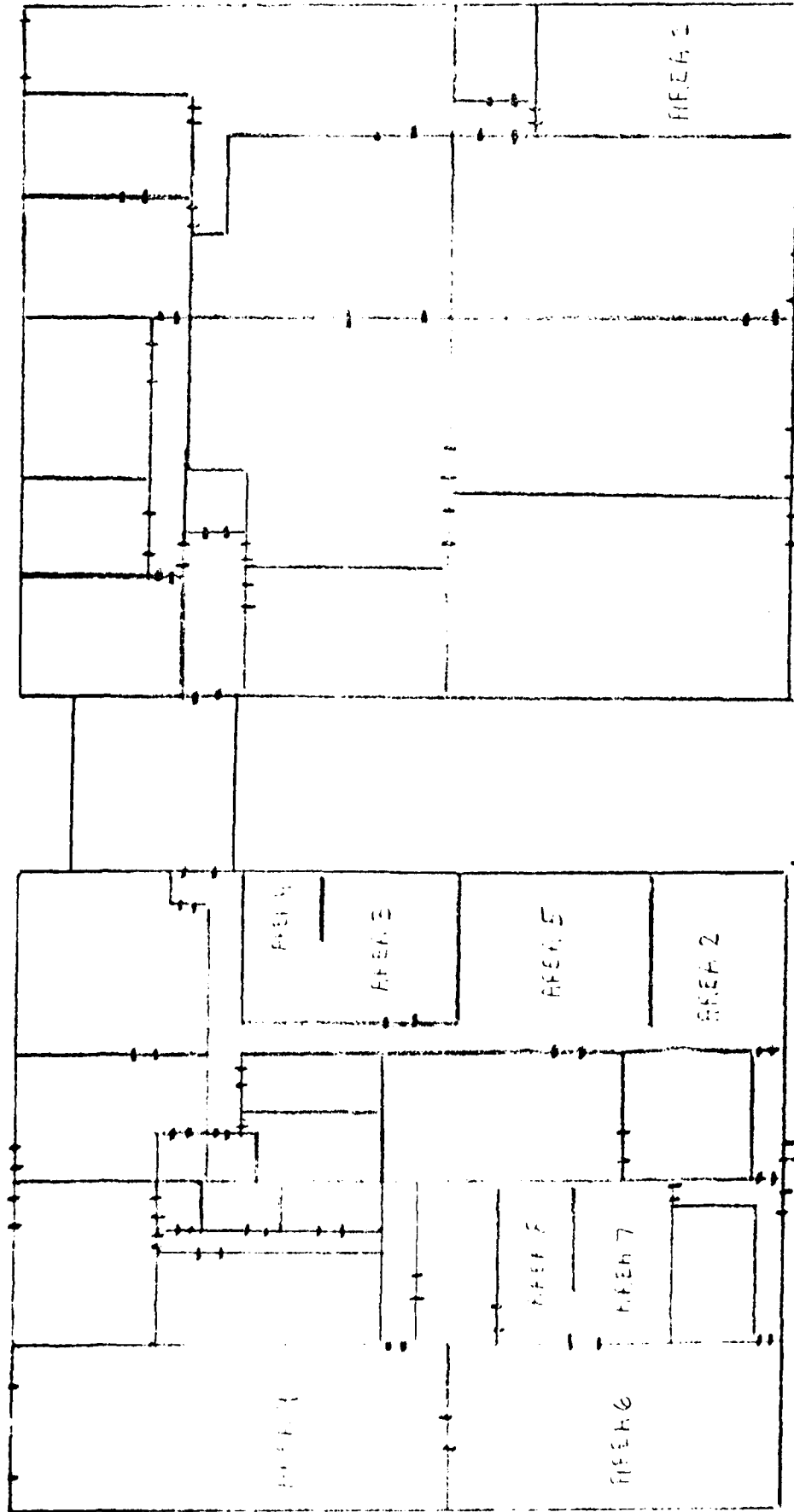


FIG. 25 LND FACILITIES SHOWING AREA'S USED IN MANUFACTURE OF HIGH RANGE GM COUNTER  
FOR AN/VDR-1

NOTE: NOT TO SCALE

## REQUIREMENT FOR PILOT LINE

FIGURE 25 IS AN OUTLINE OF THE LND FACILITY OUTLINING THE SPECIFIC AREA'S USED IN THE MANUFACTURE OF THE HIGH RANGE GM COUNTER FOR THE AN/VDR-1 INSTRUMENT. THESE AREA'S ARE DESCRIBED AND AN ANALYSIS OF EACH AREA OF OPERATION IS GIVEN.

### AREA 1 (CHEMICAL CLEANING)

1. SINKS
2. FUME HOOD
3. ULTRA SONIC CLEANER
4. CHEMICALS
5. AIR DRYER

### AREA 2 (PROCESSING)

1. R.F.GENERATOR
2. POWER CONTROLS & INTERLOCKS
3. ECCO UNIT FOR OUTGASING METALS
4. FOREPUMPS, DIFFUSION PUMPS, COLD TRAPS AND VALVING
5. GASES

### AREA 3 (ASSEMBLY)

1. HELIARC WELDER
2. SPOT WELDER
3. TWEEZER WELDER
4. GLASSING BENCHES
5. POWDER GLASS STIRRERS

### AREA 4 (FIRING)

1. 10,000 WATT GLASS FRIT AIR OVEN
2. 3000 WATT GLASS FRIT AIR OVEN
3. TEMPERATURE AND SOAK TIME CONTROLS

AREA 5 (LEAK CHECKING)

1. HELIUM MASS SPECTROMETER
2. CALIBRATED LEAK
3. LEAK TESTING MANIFOLD

AREA 6 (PUMP, BAKE AND FILL STATIONS)

1. TWO TWIN GM STATIONS
2. FOREPUMPS
3. DIFFUSION PUMPS
4. COLD TRAPS
5. OVENS
6. GAS MANIFOLDS
7. PRESSURE GAUGES
8. PRE-TEST EQUIPMENT

AREA 7 (TESTING)

1. POWER SUPPLY
2. TIMING SCALER
3. RATE METER
4. OSCILLOSCOPE
5. PULSE GENERATOR
6. ELECTROSTATIC VOLTMETER
7. PREAMPLIFIER
8. CHART RECORDER
9. DIGITAL VOLTMETER
10. ELECTROMETER
11. POLAROID SCOPE CAMERA
12. TENNY ENVIRONMENTAL CHAMBER
13. AUTOMATIC PLATEAU PLOTTER

14. RADIATION SOURCES

AREA 8 (FINISHED GOODS STOCK)

AREA 9 (SHIPPING)

1. PACKAGING EQUIPMENT
2. LABELING EQUIPMENT



## ANALYSIS OF AREA OPERATIONS

### AREA 1

IN CHEMICAL CLEANING THE PARTS ARE DEGREASED IN AN ULTRA SONIC CLEANER THEN BRIGHT DIPPED AND ETCHED AND AIR DRYED.

### AREA 2

AFTER CHEMICAL CLEANING THEY ARE PRECESSED IN AREA 2 BY VACUUM FIRING AT 900°C AND LET DOWN TO ROOM TEMPERATURE IN AN OXYGEN ATMOSPHERE.

### AREA 3

THE ANODES ARE SUBASSEMBLED AND THEN THE FINAL UNIT IS ASSEMBLED USING A POWDER GLASS FRIT AND SET INTO FIRING FIXTURES.

### AREA 4

THE FULL FIRING FIXTURES ARE PLACED IN TEMPERATURE CONTROLLED OVENS AND BAKED TO APPROXIMATELY 600°C WITH A CONTROLLED HIGH TEMPERATURE SOAK PERIOD.

### AREA 5

AFTER FIRING THE UNITS ARE LEAK CHECKED ON A HELIUM MASS SPECTRMETER ACCORDING TO SPECIFICATION M500140BA.

### AREA 6

THE UNITS THAT PASS THE HELIUM LEAK TEST ARE SEALED ONTO THE PUMPING SYSTEM. THEY ARE PUMPED, BAKED AND PROCESSED.

AREA 7

AFTER PROCESSING THE UNITS ARE TIPPED OFF (REMOVED FROM PUMPING STATION) AND TESTED TO SPECIFICATION IN THE TESTING

AREA 8

AFTER TESTING THE UNITS ARE PLACED IN FINISHED GOODS STORAGE FOR 30 DAYS THEN RETESTED AND PLACED IN STORAGE AWAITING SHIPMENT TO CUSTOMER

AREA 9

THE UNITS ARE REMOVED FROM FINISHED GOODS STORAGE AND LABELED, PACKAGED AND SHIPPED.

## CONCLUSION

IN THE PAST, SEVERAL MANUFACTURERS HAVE PROVIDED HIGH RANGE DETECTORS FOR USE IN THE AN/VDR-1 AND OTHER SIMILAR APPLICATIONS. IN GENERAL, IT WAS NOT DIFFICULT TO PROVIDE MOST OF THE OPERATING CHARACTERISTICS, HOWEVER, IT HAS BEEN SHOWN THAT TUBE STABILITY AND EXTENDED LIFE HAS BEEN EXTREMELY DIFFICULT TO OBTAIN. LND HAS EXTRACTED WHAT IT CONSIDERED THE MOST CHALLENGING AND DIFFICULT REQUIREMENTS OF THE GM TUBE SPECIFICATION AND HAS DISCUSSED IN SOME DETAIL ITS METHOD OF COMPLIANCE. OTHER SPECIFICATION REQUIREMENTS (TUBE CHARACTERISTICS) HAVE BEEN LISTED AND BRIEFLY DISCUSSED TO PROVIDE A COMPLETE UNDERSTANDING OF THE FINAL CONFIGURATION.

CERTAIN KEY PARAMETERS IN A GM COUNTER THAT CONTROL ITS CHARACTERISTICS, SENSITIVITY AND OPERATING CHARACTERISTICS ARE PROVIDED IN SPECIFICATION SCS-415C

SHAPE AND DIMENSION

TUBE WALL

GAS FILL

PHOTOSENSITIVITY

SENSITIVITY, STABILITY

TEMPERATURE EFFECTS

BACKGROUND

TEST CIRCUIT

CHARACTERISTIC CURVE REQUIREMENTS

PULSE DEAD TIME

OPERATING LIFE

THE PROPOSED TUBE PARAMETERS, CONSISTENT WITH THE ABOVE REQUIREMENTS, ARE PROVIDED IN THE FOLLOWING DESCRIPTION.

SHAPE AND DIMENSIONS:

THE PHYSICAL SIZE IS GIVEN (SEE FIGURE 2) THEREFORE ALL PARAMETERS SUCH AS GAMMA SENSITIVITY ARE LIMITED TO THE GIVEN DESIGN.

TUBE WALL

THE TUBE WALL THICKNESS OF  $30\text{MG}/\text{CM}^2$  LIMITS THE ENERGY DEPENDENCE AND BETA SENSITIVITY OF THE DETECTOR.

GAS FILL

THE GAS FILL PURITY AND TYPE WAS ONE OF THE KEY POINTS IN DETERMINING OPERATING VOLTAGE AND TUBE LIFE. THE GAS MIXTURE AND FILL PRESSURE IS GIVEN IN THE PUMP AND FILL SPECIFICATION.

PHOTOSENSITIVITY

THE TUBE IS NOT PHOTOSENSITIVE. THERE IS NO WINDOW SUCH THAT VISIBLE LIGHT CANNOT GAIN ACCESS TO THE COUNTING VOLUME TO CAUSE PHOTOSENSITIVITY. THE FOSTERITE INSULATORS ARE OPAQUE TO LIGHT.

SENSITIVITY STABILITY

THE GAMMA SENSITIVITY IS DETERMINED BY PHYSICAL SIZE AND SHAPE. TUBE STABILITY WAS ONE OF THE KEY FACTORS IN THIS PROGRAM. THE STABILITY OF A DETECTOR IS DETERMINED BY THE WORK FUNCTION OF THE INTERNAL SURFACES OF CATHODE AND ANODE. IF THE WORK FUNCTION IS HIGH SPURIOUS OR SECONDARY PULSES ARE HIGH CAUSING INSTABILITY.

CONTINUED OPERATION OF A DETECTOR CHANGES THE SURFACE WORK FUNCTION. IT IS A FACT THAT THE CATHODE SURFACE MUST BE TREATED TO MAKE THE DETECTOR UNEFFECTED BY CONTINUED OPERATION OF THE DETECTOR, AND DOES NOT IMPAIR THE INTERNAL SURFACES OF THE UNIT. STABILITY HAS BEEN OBTAINED AND DETECTORS MANUFACTURED ON A LIMITED PRODUCTION BASIS THAT MEET THE DESIRED STABILITY CHARACTERISTICS SET DOWN IN SCS-415B.

#### TEMPERATURE EFFECTS

THE OPERATING TEMPERATURE CHARACTERISTICS OF THE DETECTOR IS CONTROLLED BY THE OUTGASSING TEMPERATURE AND THE LENGTH OF TIME THE UNIT IS BAKED DURING THE PUMPING CYCLE.

#### BACKGROUND

THE BACKGROUND COUNTING RATE IS A DIRECT FUNCTION OF THE CATHODE SURFACE WORK FUNCTION. THIS WAS ANOTHER KEY POINT IN THE PEM PROGRAM. IT IS A FACT THAT BY PLACING A CHROME OXIDE SURFACE ON THE CATHODE THE BACKGROUND COUNT RATE WILL BE REDUCED INCREASING DETECTOR STABILITY.

#### TEST CIRCUIT

THE TEST CIRCUIT WILL DETERMINE TO SOME DEGREE THE OPERATING CHARACTERISTICS AND COUNTING LIFE OF THE DETECTOR. IF A LARGE PARASITIC CAPACITANCE IS PLACED ACROSS THE DETECTOR THE INCREASED CURRENT DRAWN WILL SHORTEN THE DETECTOR OPERATING LIFE. THE TEST CIRCUIT CURRENTLY USED IS A RESULT OF CONFERENCES BETWEEN LND AND THE MANUFACTURER OF THE AN/VDR-1 THIS EVALUATION OF TEST CIRCUITS HAS RESULTED IN ONE THAT REDUCES THE PARASITIC CAPACITANCE TO A MINIMUM .

### CHARACTERISTICS CURVE REQUIREMENTS

THE INITIAL DETECTOR CHARACTERISTICS ARE GIVEN BY TUBE DIMENSIONS, GAS TYPE AND PRESSURE. THE ONLY CONTROL ONE HAS IS TO ADJUST THE GAS MIXTURE.

### PULSE DEAD TIME

THE DEAD TIME IS A FUNCTION OF TUBE DIMENSIONS, GAS AND TEST CIRCUIT. ONE CAN ADJUST THE GAS AND TEST CIRCUIT TO GIVE THE DESIRED TUBE DEAD TIME.

### OPERATING LIFE

THE ENTIRE FUNCTION OF PEM WAS TO ADJUST PRODUCTION PROCEDURES TO MEET THE SCS-415B SPECIFICATIONS. OPERATING LIFE WAS ALTERED DRASTICALLY BY REDESIGN OF INSULATORS AND CATHODE PROCESSING. INITIALLY A TUBE LIFE OF  $10^9$  COUNTS ON PRODUCTION ITEMS SEEMED THE LIMIT WITH EXCEPTIONS GIVING A TUBE LIFE OF  $10^{10}$  COUNTS. OF THE ENTIRE 75 PILOT PRODUCTION RUN ALL UNITS ACHIEVED A COUNTING LIFE OF  $>10^{10}$  COUNTS AND ARE STILL FUNCTIONING.

## GLOSSARY

AVALANCHE THE CUMULATIVE PROCESS IN WHICH CHARGED PARTICLES ACCELERATED BY AN ELECTRIC FIELD PRODUCR ADDITIONAL CHARGED PARTICLES THROUGH COLLISION WITH NEUTRAL GAS MOLECULES OR ATOMS. (FROM IEEE STANDARDS PUBLICATION 160).

BACKGROUND COUNTS (RADIATION COUNTERS) COUNTS CAUSED BY RADIATION COMING FROM SOURCES OTHER THAN THAT TO BE MEASURED. (FROM IEEE STANDARDS PUBLICATION 160).

COUNT (RADIATION COUNTERS) A SINGLE RESPONSE OF THE COUNTING SYSTEM. SEE ALSO TUBE COUNT. (FROM IEEE STANDARDS PUBLICATION 160.)

COUNTER TUBE, EXTERNALLY QUENCHED A RADIATION COUNTER TUBE THAT REQUIRES THE USE OF AN EXTERNAL QUENCHING CIRCUIT TO INHIBIT RE-IGNITION. (FROM IEEE STANDARDS PUBLICATION 160).

COUNTER TUBE, GAS-FILLED, RADIATION A GAS TUBE USED FOR DETECTION OF RADIATION BY MEANS OF GAS IONIZATION (FROM IEEE STANDARDS PUBLICATION 160.)

COUNTER TUBE, GAS-FLOW A RADIATION-COUNTER TUBE IN WHICH AN APPROPRIATE ATMOSPHERE IS MAINTAINED BY A FLOW OF GAS THROUGH THE TUBE. (FROM IEEE STANDARDS PUBLICATION 160).

COUNTER TUBE, GEIGER-MUELLER A RADIATION-COUNTER TUBE OPERATED IN THE GEIGER-MULLER REGION, (FROM IEEE STANDARDS PUBLICATION 160).

COUNTER TUBE, SELF-QUENCHED A RADIATION-COUNTER TUBE IN WHICH RE-IGNITION OF THE DISCHARGE IS INHIBITED BY INTERNAL PROCESSES. (FROM IEEE STANDARDS PUBLICATION 160).

COUNTING EFFICIENCY (RADIATION COUNTER TUBES) THE RATIO OF THE NUMBER OF COUNTS TO THE TOTAL NUMBER OF IONIZING PARTICLES OR QUANTA ENTERING THE SENSITIVE VOLUME WHEN THE COUNTING RATE IS SO LOW THAT THE DEAD TIME CORRECTION IS UNNECESSARY.

COUNTING RATE VERSUS VOLTAGE CHARACTERISTICS THE RELATION BETWEEN COUNTING RATE AND VOLTAGE APPLIED TO A RADIATION-COUNTER TUBE FOR CONSTANT RADIATION INTENSITY. (FROM IEEE STANDARDS PUBLICATION 160).

DEAD TIME (RADIATION COUNTERS) THE TIME INTERVAL AFTER THE START OF AN ESSENTIALLY FULL AMPLITUDE PULSE, DURING WHICH A RADIATION COUNTER IS INSENSITIVE TO FURTHER IONIZING EVENTS. SEE ALSO RECOVERY TIME.



EFFICIENCY (RADIATION COUNTER TUBES) THE PROBABILITY THAT A TUBE COUNT WILL TAKE PLACE WITH A SPECIFIED PARTICLE OR QUANTUM INCIDENT IN A SPECIFIED MANNER. (FROM IEEE STANDARDS PUBLICATION 160.)

GAS AMPLIFICATION (RADIATION COUNTER TUBES) SEE GAS MULTIPLICATION FACTOR.

GAS MULTIPLICATION FACTOR (RADIATION COUNTER TUBES) THE RATIO OF 1 THE CHARGE COLLECTED FROM THE SENSITIVE VOLUME TO 2 THE CHARGE PRODUCED IN THIS VOLUME BY THE INITIAL IONIZING EVENT.

GEIGER-MULLER REGION (RADIATION COUNTER TUBES) THE RANGE OF APPLIED VOLTAGE IN WHICH THE CHARGE COLLECTED PER ISOLATED COUNT IS INDEPENDENT OF THE CHARGE LIBERATED BY THE INITIAL IONIZING EVENT (FROM IEEE STANDARDS PUBLICATION 160).

GEIGER-MULLER THRESHOLD (RADIATION COUNTER TUBES) THE LOWEST APPLIED VOLTAGE AT WHICH THE CHARGE COLLECTED PER ISOLATED TUBE COUNT IS SUBSTANTIALLY INDEPENDENT OF THE NATURE OF THE INITIAL IONIZING EVENT (FROM IEEE STANDARDS PUBLICATION 160).

HALF-AMPLITUDE RECOVERY TIME (GEIGER-MULLER COUNTERS) THE TIME INTERVAL FROM THE START OF A FULL AMPLITUDE PULSE TO THE INSTANT A SUCCEEDING PULSE CAN ATTAIN AN AMPLITUDE OF 50 PERCENT OF THE MAXIMUM AMPLITUDE OF A FULL AMPLITUDE PULSE.

INITIAL IONIZING EVENT (RADIATION COUNTER TUBES) AN IONIZING EVENT THAT INITIATES A TUBE COUNT. (FROM IEEE STANDARDS PUBLICATION 160).

MULTIPLE TUBE COUNTS (RADIATION COUNTER TUBES) SPURIOUS COUNTS INDUCED BY A PREVIOUS TUBE COUNTS. (FROM IEEE STANDARDS PUBLICATION 160).

PLATEAU (RADIATION COUNTER TUBES) THE PORTION OF THE COUNTING-RATE-VERSUS-VOLTAGE CHARACTERISTIC IN WHICH THE COUNTING RATE IS SUBSTANTIALLY INDEPENDENT OF THE APPLIED VOLTAGE. (FROM IEEE STANDARDS PUBLICATION 160).

PLATEAU LENGTH (RADIATION COUNTER TUBES) THE RANGE OF APPLIED VOLTAGE OVER WHICH THE PLATEAU EXTENDS. (FROM IEEE STANDARDS PUBLICATION 160).

PLATEAU SLOPE (RADIATION COUNTER TUBES) THE SLOPE OF THE PLATEAU EXPRESSED AS THE PERCENTAGE CHANGE IN COUNT RATE PER 100-VOLT CHANGE IN APPLIED VOLTAGE.

QUENCHING (RADIATION COUNTER TUBES) THE PROCESS OF TERMINATING A DISCHARGE IN A RADIATION-COUNTER TUBE BY INHIBITING RE-IGNITION. (FROM IEEE STANDARDS PUBLICATION 160).

RADIATION (NUCLEAR) IN NUCLEAR WORK, THE USUAL MEANING OF RADIATION IS EXTENDED TO INCLUDE MOVING NUCLEAR PARTICLES, CHARGED OR UNCHARGED. (FROM IEEE STANDARDS PUBLICATION 160).

RECOVERY TIME (GEIGER-MULLER COUNTERS) THE MINIMUM TIME FROM THE START OF A COUNTED PULSE TO THE INSTANT A SUCCEEDING PULSE CAN ATTAIN A SPECIFIED PERCENTAGE OF THE MAXIMUM AMPLITUDE OF THE COUNTED PULSE. (FROM IEEE STANDARDS PUBLICATION 160).

RE-IGNITION (RADIATION COUNTER TUBES) THE GENERATION OF SPURIOUS BY ATOMS OR MOLECULES EXCITED OR IONIZED IN THE DISCHARGE ACCOMPANYING A COUNT.

RESOLVING TIME (RADIATION COUNTERS) THE MINIMUM ACHIEVABLE PULSE SPACING BETWEEN COUNTS. (FROM IEEE STANDARDS PUBLICATION 160).

Note: This quantity is a property of the combination of the tube and recording circuit.

RISE TIME (RADIATION COUNTER TUBES) THE INTERVAL BETWEEN THE INSTANTS AT WHICH THE INSTANTANEOUS VALUE FIRST REACHES SPECIFIED LOWER AND UPPER LIMITS, NAMELY, 10 AND 90 PERCENT OF THE PEAK PULSE VALUE.

SENSITIVE VOLUME (RADIATION COUNTER TUBES) THAT PORTION OF THE TUBE RESPONDING TO SPECIFIC RADIATION. (FROM IEEE STANDARDS PUBLICATION 160).

VACUUM DEPOSITION A MATERIAL IS VAPORIZED IN A VACUUM THEN COOLED ONTO A SUITABLE SUBSTRATE.

HARD CHROME ELECTROPLATING THE PROCESS OS DEPOSITING CHROME BY ELECTROLYSIS.

BETA BACKSCATTER BETA RADIATION IS REFLECTED FROM A SURFACE TO BE MEASURED, DETECTED AND TRANSMITTED TO A SUITABLE ELECTRONIC SYSTEM.

ION ANALYZER AN INSTRUMENT THAT PROVIDES QUANTITIVE INFORMATION CONCERNING THE COMPOSITION OF SPUTTERED MATERIAL BY CONTINUOUSLY BOMBARDING THE SAMPLE AND SIMULTANEOUSLY MONITORING THE SECONDARY ION CURRENT OF A PRESELECTED MASS.

VAPOR DEGREASING THE USE OF VAPORIZED CLEANING AGENTS TO REMOVE GREASE AND OIL.

PICKLING A CHEMICAL BATH USED TO CLEAR METAL OF SCALE.

AREAL DENSITY THE RATIO OF THE MASS OF AN OBJECT TO ITS VOLUME.

ELECTRO POLISH THE PROCESS OF REVERSE ELECTROPLATING.

REVERSE BENDING THE PROCESS OF REPEATEDLY BENDING A SPECIMEN THROUGH AN ANGLE OF 180°

STAMPING USING A PUNCH OR PRESS REPEATEDLY TO ATTEMPT FRACTURING A PLATED SUBSTRATE.

SECTIONING THE PROCESS OF CUTTING, POTTING AND POLISHING A SUBSTRATE FOR MICROPHOTOGRAPHY.

SPURIOUS COUNT (RADIATION COUNTER TUBES) A COUNT CAUSED BY AN EVENT OTHER THAN THE PASSAGE INTO OR THROUGH THE COUNTER TUBE OF THE IONIZING RADIATION TO WHICH IT IS SENSITIVE.

TUBE COUNT (RADIATION COUNTER TUBES) A TERMINATED DISCHARGE PRODUCED BY AN IONIZING EVENT. (FROM IEEE STANDARDS PUBLICATION 160.)