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VARIAN ASSOCIATES - BOMAC DIVISION
Salem Road
Beverly, Massachusetts

BL-221 70 Gc MAGNETRON PRODUCTION ENGINEERING MEASURE

Seventh Quarterly Progress Report
6 February 1963 to 6 May 1963

CONTRACT NO: DA-36-039-SC-85974

CONTRACTING AGENCY: U. S. Army Signal Supply Agency
225 South Eighteenth Street
Philadelphia 3, Pennsylvania

ATTENTION: Contracting Officer
PEM and Facilities Procurement Branch
Procurement Management Division "C"

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Beverly, Massachusetts

BL-221 70 Gc MAGNETRON PRODUCTION ENGINEERING MEASURE

Seventh Quarterly Progress Report
6 February 1963 to 6 May 1963

OBJECT:	To investigate minor constructional modifications in the present design, evaluate a pre-production run of thirty (30) tubes and set up manufacturing facilities capable of producing fifty (50) tubes per month
CONTRACT NO:	DA-36-039-SC-85974
SIGNAL CORPS REQUIREMENTS:	SCS-70 dated 23 September 1959

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SEVENTH QUARTERLY PROGRESS REPORT

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1. PURPOSE

The purpose of this PEM Program is to investigate minor constructional modifications in the present BL-221 magnetron design and to set up a manufacturing facility capable of producing at a rate of fifty (50) tubes per month.

Among the constructional design modifications to be undertaken will be:

a) Construction and evaluation of a BL-221 tube with a permanently attached Vac-Ion Pump.

b) Replacement of the present glass output window assembly with a ceramic or sapphire structure.

Four (4) model tubes incorporating the design modifications adopted are to be delivered to the Signal Corps for evaluation purposes and thirty (30) additional tubes are to be manufactured after approval by the Contracting Agency.

2. ABSTRACT

Work performed during this quarterly period included the following:

2.1 The problem of cathode poisoning resulting in tube power output deterioration is believed to have been solved through improvements made in anode processing.

2.2 Use of a smaller diameter cathode was tried with some success in reducing leakage currents and improvement in tube power output. The combination however of this change and the new anode processing technique which employs electrolytic polishing resulted in a substantial increase in the peak anode voltage correction of which might require design changes in the anode and cathode.

2.3 Experimental work with cold anode hobbing was initiated. Although work with the first cold hob ground in the Bomac anode facility proved unsuccessful much was learned as a result of this experience. Materials best suited for cold hobs were ordered and received and a study of copper treatment necessary for this type of hobbing work was undertaken.

3. FACTUAL DATA

3.1 Construction and Evaluation of Bomac Facility Anode Tubes:

Twelve (12) additional tubes with Bomac Facility manufactured anodes were constructed and tested during this quarterly period. Test data and other pertinent information are presented on pages 7 through 9.

Although much improved for leakage current and power output over the previous lot of tubes discussed in Progress Report No. 6 as a result of using a smaller diameter cathode, (0.0955" instead of 0.0965" O.D.) the peak anode voltage (epy) on four (4) of these tubes exceeded the maximum specified limit by an average of approximately 450 volts. The first two (2) tubes built on this lot (#33 and #34) were out of spec for resonant frequency and one (#38) failed to meet the power output requirement during the initial electrical tests. Four (4) additional tubes (#35, #36, #37 and #42) as will be seen in the individual tube data sheets suffered severe deterioration in power output during a storage period ranging from two to eight weeks. While the cause for the two high frequency tubes(#33 and #34) was traced to anode dimensions being out of spec the analysis

3. FACTUAL DATA

3.1 Construction and Evaluation of Bomac Facility Anode Tubes: (cont'd.)

of the low power tubes indicated that this condition was due to cathode poisoning. This indication was strongly confirmed by the severity of errosion observed at the tips of the anode vanes, the increase in peak anode voltage during storage time and, as will be seen in the following tabulation the drop in dc cathode emission.

Comparative DC Emission Tests

Tube No.	I_s Before Tube Packaging (magnet assembly)	I_s Before Tubes were cut open
35	220 ma	150 ma
36	220 ma	130 ma
37	220 ma	172 ma
38	215 ma	138 ma
42	220 ma	150 ma

NOTE: The cathode emission tests were made under the following conditions: E_h = 6.3 volts; E_s = 100 volts, dc.

Since however on four (4) out of the five (5) tubes under discussion the power deterioration and increase in peak anode voltage took place during tube storage impurities other than copper deposition from vane errosion were suspected as

3. FACTUAL DATA

3.1 Construction and Evaluation of Bomac Facility Anode Tubes: (cont'd.)

possible reasons for this situation. With the anode considered as the most likely source of origin for these impurities various changes in the processing techniques were tried. Tubes #44 and #49 in the lot were constructed with electrolytically polished anodes while tubes #55 and #57 were built with anodes processed according to the schedules listed below:

1. Processing Schedule for the Anode used in Tube No. 55

   a) Completed anode was ultrasonically cleaned for one hour in chloroform.

   b) Boiled in distilled water for fifteen (15) minutes.

   c) Rinsed in alcohol and dried.

   d) Electrolytically polished.

   e) Washed in running tap water for fifteen (15) minutes.

   f) Rinsed in distilled water.

   g) Rinsed in alcohol and dried.

   h) Vacuum fired for two (2) hours at 850°C.

2. Processing Schedule for the Anode used in Tube No. 57:

   a) Completed anode was ultrasonically cleaned for one hour in chloroform.

   b) Boiled in distilled water for fifteen (15) minutes.

3. FACTUAL DATA

3.1 Construction and Evaluation of Bomac Facility Anode Tubes:

2. (cont'd.)

   c) Rinsed in alcohol and dried.

   d) Electrolytically polished.

   e) Washed in running tap water for fifteen (15) minutes.

   f) Rinsed in distilled water.

   g) Rinsed in alcohol and dried.

   h) Oxidized (heated in air by RF to 400°C for five (5) minutes).

   i) Etched in a mild solution of potassium cyanide and potassium hydroxide.

   j) Washed in running tap water for fifteen (15) minutes.

   k) Rinsed in distilled water.

   l) Rinsed in alcohol and dried.

   m) Fired in wet hydrogen for fifteen (15) minutes at 925°C.

   n) Vacuum fired for two (2) hours at 850°C.

While the test data compiled from these tubes (#44, #49, #55 and #57) indicate encouraging results, pages 7, 16, 17, 18, and 19, additional storage tests information and operational life data must be compiled before a definite conclusion can be reached as to the adequacy and effectiveness of the new anode processing techniques employed. Such storage and operational life test data on the four (4) tubes mentioned above will be compiled and analyzed during the next quarterly period.

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TEST DATA

(Bomac Facility Anode Tubes)

Tube No.	Test Date	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Anode Hob
		Starting		Operating													
		E_h (V)	I_h (A)	E_h (V)	I_h (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (μsec's)	prf (pps)	du	Type Pulser		
33	2/14/63	6.3	2.5	3.0	1.13	9.0	4.8	14.1	7.0	14.0	71.55	0.06	8,350	0.0005	HTM	$1x10^{-8}$	B-2
34	2/19/63	6.3	2.5	3.0	1.13	9.0	5.7	14.0	7.2	14.4	71.20	0.06	8,350	0.0005	HTM	$1.5x10^{-7}$	B-2
35	2/18/63	6.3	2.6	2.7	1.15	9.0	5.4	13.9	9.5	19.0	70.40	0.06	8,350	0.0005	HTM	1×10^{-8}	B-2
36	2/21/63	6.3	2.6	2.7	1.15	9.0	4.6	13.8	8.3	16.6	69.60	0.06	8,350	0.0005	HTM	$1x10^{-8}$	B-2
37	2/25/63	6.3	2.5	2.7	1.14	9.0	4.8	14.0	8.2	16.4	70.50	0.06	8,350	0.0005	HTM	$1x10^{-8}$	B-2
38	3/ 1/63	6.3	2.6	2.7	1.15	9.0	5.2	14.0	3.0	6.0	70.05	0.06	8,350	0.0005	HTM	$1x10^{-7}$	B-2
41	3/13/63	6.3	2.6	2.7	1.15	9.0	4.5	14.2	8.3	16.6	69.40	0.06	8,350	0.0005	HTM	$1x10^{-8}$	B-2
42	3/ 8/63	6.3	2.6	2.7	1.15	9.0	4.5	14.2	5.8	11.6	70.20	0.06	8,350	0.0005	HTM	$1x10^{-8}$	B-2
44	4/ 3/63	6.3	2.6	2.7	1.15	9.0	4.5	14.5	8.8	17.6	69.00	0.06	8,350	0.0005	HTM	$1x10^{-8}$	B-2
49	4/ 9/63	6.3	2.55	2.7	1.13	9.0	4.5	14.6	8.0	16.0	69.25	0.06	8,350	0.0005	HTM	$1x10^{-8}$	B-2
55	4/26/63	6.3	2.6	2.7	1.15	9.0	4.5	14.8	10.2	20.4	69.90	0.08	6,250	0.0005	HTM	$1x10^{-8}$	B-2
57	5/ 6/63	6.3	2.6	2.7	1.15	9.0	5.0	14.7	11.0	22.0	69.10	0.08	6,250	0.0005	HTM	$1x10^{-8}$	B-2

NOTE:

1) The increase in peak anode voltage (epy) in this group of tubes as compared with previous lots discussed in Progress Reports #5 and #6 is attributed to the smaller diameter cathode used---change in cathode diameter was from 0.096"+0.0005" -000 to 0.095"+.0005" -000

Tubes #44, #49, #55 and #57 suffered further in this respect because of electrolytic polishing used in anode processing causing the anode diameter to increase by approximately 0.0005".

2) Circled values indicate out of spec tubes.

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TEST DATA

TUBE NO. 33

Test Date	Tests	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Life Cycles
		Starting		Operating													
		Eh (V)	Ih (A)	Eh (V)	Ih (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (μsec's)	prf (pps)	du	Type Pulser		
2/14/63	Initial																
	Osc. 2	6.3	2.5	3.0	1.13	9.0	4.8	14.1	7.0	14.0	71.50*	0.06	8,350	0.0005	HTM	1×10^{-8}	
		Following the above test the Vac-Ion Pump was pinched-off and tube was permanently packaged, regaussed, etc.															
2/19/63	Final																
	Osc. 1	6.3	2.5	2.7	1.10	9.0	3.3	14.2	3.17	14.4	71.50*	0.022	10,000	0.00022	HTM	---	
	Osc. 2	6.3	2.5	3.0	1.13	9.0	4.8	14.2	7.20	14.4	71.55*	0.06	8,350	0.0005	HTM	---	
	Osc. 3	6.3	2.5	4.0	1.20	9.0	4.5	14.2	7.20	14.4	71.55*	0.21	2,380	0.0005	HTM	---	
3/21/63	Shelf Osc. 3	6.3	2.5	3.0	1.13	9.0	4.6	14.8+	6.80+	13.6+	71.55*	0.06	8,350	0.0005	HTM	---	

* Frequency failure in this tube was believed to have been caused by out of spec anode dimensions.

+ The increase in peak anode voltage (epy) and slight drop in power output observed under shelf life may be an indication of deterioration in cathode emission.

NOTE: The Bomac anode used in this tube was processed according to the regular schedule.

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TEST DATA

TUBE NO. 34

Test Date	Tests	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Life Cycles
		Starting		Operating													
		Eh (V)	Ih (A)	Eh (V)	Ih (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (μsec's)	prf (pps)	du	Type Pulser		
2/19/63	Initial																
	Osc. 1	6.3	2.5	2.7	1.10	9.0	3.8	14.0	3.3	15.0	71.2*	0.02	10,000	0.0002	HTM	1.5x10-[illegible]	
	Osc. 2	6.3	2.5	3.0	1.13	9.0	5.7	14.0	7.2	14.4	71.2*	0.06	8,350	0.0005	HTM	1.5x10-[illegible]	
	Osc. 3	6.3	2.5	4.0	1.20	9.0	5.4	14.0	8.8	17.6	71.2*	0.21	2,380	0.0005	HTM	1.5x10-[illegible]	
		Following the above tests the Vac-Ion Pump was pinched-off and tube was permanently packaged, regaussed, etc.															
	Final																
2/21/63	Osc. 2	6.3	2.5	3.0	1.13	9.0	4.6	14.8+	7.0+	14.0+	71.2*	0.06	8,350	0.0005	HTM	---	
5/6/63	Shelf																
	Osc. 2	6.3	2.5	3.0	1.13	9.0	4.9	14.8+	6.6+	13.2+	71.2*	0.08	6,250	0.0005	HTM	---	
	*	Frequency failure in this tube was believed to have been caused by out of spec anode dimensions															
	+	Increase in peak anode voltage (epy) and slight drop in power output observed during final and shelf tests may indicate deterioration in cathode emission															

NOTE: The Bomac anode used in this tube was processed according to the regular schedule.

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TEST DATA

TUBE NO. 35

Test Date	Tests	Heater Conditions: Starting E_h (V)	Starting I_h (A)	Operating E_h (V)	Operating I_h (A)	Input Conditions: ib (A)	Ib (Ma)	epy (kv)	Output: Po (W)	po (kw)	Fo (Gc)	Pulse Conditions: tp (μsec's)	prf (pps)	du	Type Pulser	Internal Tube Pressure (mmHg)	Life Cycles
2/18/63	Initial																
	Osc. 1	6.3	2.6	2.5	1.12	9.0	3.8	13.9	4.2	19.0	70.4	0.02	10,000	0.0002	HTM	1×10^{-8}	
	Osc. 2	6.3	2.6	2.7	1.15	9.0	5.4	13.9	9.5	19.0	70.4	0.06	8,350	0.0005	HTM	1×10^{-8}	
	Osc. 3	6.3	2.6	3.0	1.18	9.0	4.5	13.9	9.5	19.0	70.4	0.21	2,380	0.0005	HTM	1×10^{-8}	
		Following these tests the Vac-Ion Pump system was pinched-off and the tube was permanently packaged, regaussed, etc.															
2/19/63	Final																
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.5	15.4*	6.0	12.0	70.4	0.06	8,350	0.0005	HTM	---	
3/ 4/63	Shelf																
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.6	16.3*	3.0*	6.0*	70.4	0.06	8,350	0.0005	HTM	---	
	*	Deterioration in power output and increase in pav observed under final and shelf life tests were attributed to cathode poisoning most likely caused by contaminants originating with the anode. Examination of this tube revealed excessive vane errosion and heavy discoloration (deposits) of large areas in the anode and pole pieces.															

NOTE: The Bomac anode used in this tube was processed according to regular schedule.

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TEST DATA

TUBE NO. 36

Test Date	Tests	Heater Conditions: Starting E_h (V)	Starting I_h (A)	Operating E_h (V)	Operating I_h (A)	Input Conditions: ib (A)	Ib (Ma)	epy (kv)	Output: Po (W)	po (kw)	Fo (Gc)	Pulse Conditions: tp (μsec's)	prf (pps)	du	Type Pulser	Internal Tube Pressure (mmHg)	Life Cycles
2/21/63	Initial																
	Osc. 1	6.3	2.56	2.5	1.12	9.0	3.2	13.8	3.4	16.6	69.6	0.02	10,000	0.0002	HTM	$1x10^{-8}$	
	Osc. 2	6.3	2.56	2.7	1.15	9.0	4.6	13.8	8.3	16.6	69.6	0.06	8,350	0.0005	HTM	$1x10^{-8}$	
	Osc. 3	6.3	2.56	3.0	1.18	9.0	4.6	13.8	8.3	16.6	69.6	0.21	2,380	0.0005	HTM	$1x10^{-8}$	
		Following the above tests Vac-Ion Pump system was pinched-off and the tube was permanently packaged, regaussed, etc.															
2/25/63	Final																
	Osc. 2	6.3	2.56	2.7	1.15	9.0	4.6	13.8	8.3	16.6	69.6	0.06	8,350	0.0005	HTM	---	
3/ 1/63	Shelf																
	Osc. 2	6.3	2.56	2.7	1.15	9.0	4.5	14.1	9.5	19.0	69.6	0.06	8,350	0.0005	HTM	---	
3/21/63	Shelf																
	Osc. 2	6.3	2.56	2.7	1.15	9.0	4.5	14.2	6.3	12.6	69.6	0.06	8,350	0.0005	HTM	---	
4/5/63	Shelf																
	Osc. 2	6.3	2.56	2.7	1.15	9.0	5.1	16.1*	3.6*	7.2*	69.6	0.06	8,350	0.0005	HTM	---	

* Deterioration in power output and increase in pav observed under the last shelf life test were attributed to cathode poisoning believed to have originated with the anode. Vane errosion and deposits on large anode and pole piece areas as explained for tube #35 were seen in this tube also.

NOTE: The Bomac anode used in this tube was processed according to the regular schedule.

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TEST DATA

TUBE NO. 37

Test Date	Tests	Heater Conditions: Starting Eh (V)	Starting Ih (A)	Operating Eh (V)	Operating Ih (A)	Input Conditions: ib (A)	Ib (Ma)	epy (kv)	Output: Po (W)	po (kw)	Fo (Gc)	Pulse Conditions: tp (μsec's)	prf (pps)	du	Type Pulser	Internal Tube Pressure (mmHg)	Life Cycles
2/25/63	Initial																
	Osc. 1	6.3	2.5	2.5	1.12	9.0	3.9	14.0	3.6	16.4	70.5	0.022	10,000	0.00022	HTM	1×10^{-8}	
	Osc. 2	6.3	2.5	2.7	1.14	9.0	4.8	14.0	8.2	16.4	70.5	0.06	8,350	0.0005	HTM	1×10^{-8}	
	Osc. 3	6.3	2.5	3.0	1.17	9.0	4.6	14.0	8.2	16.4	70.5	0.21	2,380	0.0005	HTM	1×10^{-8}	
		Following the above tests the Vac-Ion Pump system was pinched-off and tube was permanently packaged, regaussed, etc.															
2/27/63	Final																
	Osc. 1	6.3	2.5	2.5	1.12	9.0	3.8	14.1	2.64	12.0	70.5	0.022	10,000	0.00022	HTM	---	
	Osc. 2	6.3	2.5	2.7	1.14	9.0	4.8	14.1	6.0	12.0	70.5	0.06	8,350	0.0005	HTM	---	
	Osc. 3	6.3	2.5	3.0	1.17	9.0	4.6	14.1	6.0	12.0	70.5	0.21	2,380	0.0005	HTM	---	
3/1/63	Shelf																
	Osc. 2	6.3	2.5	2.7	1.14	9.0	5.2	14.2	5.4	10.8	70.5	0.06	8,350	0.0005	HTM	---	
3/21/63	Shelf																
	Osc. 2	6.3	2.5	2.7	1.14	9.0	5.2	14.5*	4.7	9.4*	70.5	0.06	8,350	0.0005	HTM	---	
3/26/63	Shelf																
	Osc. 2	6.3	2.5	2.7	1.14	9.0	6.0*	15.4*	2.3*	4.6*	70.5	0.06	8,350	0.0005	HTM	---	

NOTE: * Deterioration in power output and increase in epy observed under the shelf life test as was the case with **tubes #35 and #36** examined previously were attributed to cathode poisoning believed to have originated with **the anode. The Bomac anode used in this tube was** processed according to the regular schedule.

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TEST DATA

TUBE NO. 38

Test Date	Tests	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Life Cycles
		Starting		Operating													
		E_h (V)	I_h (A)	E_h (V)	I_h (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (μsec's)	prf (pps)	du	Type Pulser		
3/1/63	Initial																
	Osc. 2	6.3	2.6	2.7	1.15	9.0	5.2	14.0	3.0*	6.0*	70.05	0.06	8,350	0.0005	HTM	$1x10^{-8}$	

* Initial test reject for power ouput. This tube had severe mode interference. When this was corrected through cathode centering power output dropped to below the minimum specified limit of 5.0W. Condition was attributed to severe cathode and anode arcing taking place during the tube aging process. On examining the tube the anode vanes were found in a severely erroded condition.

NOTE: The Bomac anode in this tube was processed according to the regular schedule.

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TEST DATA

TUBE NO. 41

Test Date	Tests	Heater Conditions Starting E_h (V)	Starting I_h (A)	Operating E_h (V)	Operating I_h (A)	Input Conditions ib (A)	Ib (Ma)	epy (kv)	Output Po (W)	po (kw)	Fo (Gc)	Pulse Conditions tp (μsec's)	prf (pps)	du	Type Pulser	Internal Tube Pressure (mmHg)	Life Cycles
3/13/63	Initial																
	Osc. 1	6.3	2.6	2.5	1.12	9.0	3.2	14.2	3.8	17.3	69.4	.022	10,000	0.00022	HTM	$1x10^{-8}$	
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.5	14.2	8.3	16.6	69.4	.06	8,350	0.0005	HTM	$1x10^{-8}$	
	Osc. 3	6.3	2.6	3.0	1.18	9.0	4.5	14.2	8.3	16.6	69.4	.21	2,380	0.0005	HTM	$1x10^{-8}$	
		Following the above tests the Vac-Ion Pump system was pinched-off and tube was permanently packaged, regaussed, etc.															
4/11/63	Final																
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.5	14.2	9.7	19.4	69.4	.08	6,250	0.0005	HTM	---	
5/2 /63	Shelf																
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.5	14.2	9.4	18.8	69.4	.08	6,250	0.0005	HTM	---	

NOTE: The Bomac anode used in this tube was processed according to the regular schedule. This is the only tube in the lot manufactured with regular schedule anode processing which did not suffer deterioration in power output

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TEST DATA

TUBE NO. 42

Test Date	Tests	Heater Conditions Starting E_h (V)	Starting I_h (A)	Operating E_h (V)	Operating I_h (A)	Input Conditions ib (A)	Ib (Ma)	epy (kv)	Output Po (W)	po (kw)	Fo (Gc)	Pulse Conditions tp μsec's)	prf (pps)	du	Type Pulser	Internal Tube Pressure (mmHg)	Life Cycles
3/ 8/63	Initial																
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.5	14.2	5.8	11.6	70.2	0.06	8,350	0.0005	HTM	1×10^{-8}	
3/22/63	Shelf	6.3	2.6	2.7	1.15	9.0	5.6	15.7*	3.5*	7.0*	70.2	0.06	8,350	0.0005	HTM	1×10^{-8}	
	Osc. 2																

* Power deterioration and increase in epy during the two weeks hold period with the Vac-Ion Pump on were found to be of a permanent nature. Condition was attributed to cathode poisoning believed to have originated with the anode.

NOTE: The Bomac anode used in this tube was processed according to the regular schedule.

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TEST DATA

TUBE NO. 44

Test Date	Tests	Heater Conditions: Starting E_h (V)	Starting I_h (A)	Operating E_h (V)	Operating I_h (A)	Input Conditions: ib (A)	Ib (Ma)	epy (kv)	Output: Po (W)	po (kw)	Fo (Gc)	Pulse Conditions: tp (µsec's)	prf (pps)	du	Type Pulser	Internal Tube Pressure (mmHg)	Life Cycles
4/3/63	Initial																
	Osc. 1	6.3	2.6	2.5	1.12	9.0	3.1	14.5*	3.88	17.6	69.0	0.022	10,000	0.00022	HTM	1×10^{-8}	
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.5	14.5*	8.8	17.6	69.0	0.06	8,350	0.0005	HTM	1×10^{-8}	
	Osc. 3	6.3	2.6	3.0	1.18	9.0	4.5	14.5*	8.8	17.6	69.0	0.21	2,380	0.0005	HTM	1×10^{-8}	
		Following the above tests the Vac-Ion Pump system was pinched off and tube was permanently packaged, regaussed, etc.															
4/11/63	Final																
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.5	14.5*	10.0	20.0	69.0	0.08	6,250	0.0005	HTM	---	
5/27/63	Shelf																
	Osc. 2	6.3	2.6	2.7	1.15	9.0	4.5	14.5*	9.8	19.6	69.0	0.08	6,250	0.0005	HTM	---	

* The out of spec pav on this tube was attributed to the smaller diameter cathode used and electrolytically polished anode (anode bore out as a result of the polishing treatment increased by approximately 0.0005")

NOTE: The Bomac anode used in this tube was electrolytically polished for the removal of vane burrs, etc.

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TEST DATA

TUBE NO. 49

Test Date	Tests	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Life Cycles
		Starting		Operating													
		E_h (V)	I_h (A)	E_h (V)	I_h (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (μsec's)	pri (pps)	du	Type Pulser		
4/ 9/63	Initial	6.3	2.55	2.7	1.13	9.0	4.5	14.6*	8.0	16.0	69.25	0.06	8,350	0.0005	HTM	$1x10^{-8}$	
	Osc. 2																
		Following the above test the Vac-Ion Pump system was pinched-off and tube was permanently packaged, regaussed, etc.															
4/22/63	Final																
	Osc. 2	6.3	2.55	2.7	1.13	9.0	4.5	14.6*	8.4	16.8	69.25	0.08	6,250	0.0005	HTM	---	
4/26/63	Shelf																
	Osc. 2	6.3	2.55	2.7	1.13	9.0	4.5	14.6*	8.5	17.0	69.25	0.08	6,250	0.0005	HTM	---	

* The out of spec pav on this tube was attributed to the smaller diameter cathode used and electrolytically polished anode (anode bore out as a result of the polishing treatment increased by approximately 0.0005").

NOTE: The Bomac anode used in this tube was electrolytically polished for the removal of vane burrs, etc.

BL-221
TEST DATA

TUBE NO. 55

Test Date	Tests	Heater Conditions				Input Conditions			Output			Pulse Conditions				Internal Tube Pressure (mmHg)	Life Cycles
		Starting		Operating													
		Eh (V)	Ih (A)	Eh (V)	Ih (A)	ib (A)	Ib (Ma)	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (μsec's)	prf (pps)	du	Type Pulser		
4/26/63	Initial	- -															
	Osc. 2	6.3	2.5	2.7	1.15	9.0	4.5	14.8*	10.2	20.4	69.9	0.08	6,250	0.0005	HTM	1x10-8	
4/29/63	Osc. 2	6.3	2.5	2.7	1.15	9.0	4.5	14.8*	10.0	20.0	69.9	0.08	6,250	0.0005	HTM	1x10-8	
		Following the above test the Vac-Ion pump system was pinched-off and tube was permanently packaged, regaussed, etc.															
5/ 1/63	Final																
	Osc. 2	6.3	2.5	3.0	1.13	9.0	4.5	14.8*	9.5	19.0	69.9	0.08	6,250	0.0005	HTM	---	
5/ 6/63	Shelf	6.3	2.5	3.0	1.13	9.0	4.5	14.8*	9.5	19.0	69.9	0.08	6,250	0.0005	HTM	---	
		* The high pav on this tube was attributed to the smaller diameter cathode used and special processing of anode employed.															
		Operational life test evaluation of this tube is scheduled to take place during the next quarterly period.															

NOTE: The Bomac anode used in this tube was processed according to the revised Schedule #1 described in this report, Page 5 .

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TEST DATA

TUBE NO. 57

Test Date	Tests	Heater Conditions: Starting E_h (V)	Starting I_h (A)	Operating E_h (V)	Operating I_h (A)	Input Conditions: ib (A)	Ib (Ma)	epy (kv)	Output: Po (W)	po (kw)	Fo (Gc)	Pulse Conditions: tp (μsecs)	prf (pps)	du	Type Pulser	Internal Tube Pressure (mmHg)	Life Cycles
5/6/63	Initial																
	Osc. 1	6.3	2.6	2.5	1.12	9.0	3.9	14.7*	4.8	22.0	69.1	0.022	10,000	0.00022	HTM	1×10^{-8}	
	Osc. 2	6.3	2.6	2.7	1.15	9.0	5.0	14.7*	11.0	22.0	69.1	0.08	6,250	0.0005	HTM	1×10^{-8}	
	Osc. 3	6.3	2.6	3.0	1.18	9.0	5.0	14.7*	11.0	22.0	69.1	0.21	2,380	0.0005	HTM	1×10^{-8}	

* The high pav on this tube was attributed to the smaller diameter cathode used and special processing of anode employed.

This tube will next have the split exhaust magnets removed, the vac-ion pump systems pinched off. Tube will then be permanently packaged, regaussed and final tested. After additional tests are made tube will be evaluated under operational life test conditions scheduled to take place during the next quarterly period.

The Bomac anode used in this tube was processed according to the revised schedule #2 described in this report, Pages 5 and 6.

3. FACTUAL DATA

3.2 Hot Anode Hobbing:

The effort concerning the manufacture of anodes under the hot hobbing process during this quarterly period was directed primarily towards the control of impurities associated with the various hobbing operations and materials used. Three basic types of impurities or contaminants against which controlling safeguards were instituted were as follows: a) Oxide particles embedded or pressed into the copper during the hobbing process; b) residues from the filler material used for preventing resonator distortion during the machining operations, and c) contaminants originating with machining coolants or lubricants used. Lowering the hobbing temperature from 850°C to 750°C helped to eliminate the oxide particles pressed into the copper. The solution of the filler residue and contaminants associated with machining lubricants used is believed to have been attained by the employment of either of the processing schedules described earlier in this report.

3.3 Anode Fabrication

The basic steps in the fabrication of anodes under the hot hobbing technique are summarized as follows:

3. FACTUAL DATA

3.3 Anode Fabrication (cont'd.)

3.3.1 The Hob

a) Material: Vitallium or cobalt-chromium alloy No. L605 purchased in .515" dia. rods from Austenal Labs of 224 E. 39th Street, New York. Hardness of material when received is slightly over 30 Rockwell's.

b) The Vitallium rod is cut to length and machined to within 0.010" of print dimensions. See Figure No. 1, Page 28.

c) Heat treatedat 1300°F for eight (8) hours for bringing the Rockwell hardness to 50-55 "C."

d) Outside diameters and length machined to specified or print dimensions.

e) Hob blades are now ground to print tolerances. See Figure No. 2, Page 29.

3.3.2 Hobbing and Machining of Anode

a) The certified OFHC copper is first machined to a blank configuration as shown on Figure No. 3, Page 30.

b) The blank is then jigged in the hobbing machine under approximately three pounds of forming gas pressure and heated to 725°C - 750°C.

3. FACTUAL DATA

3.3 Anode Fabrication

3.3.2 Hobbing and Machining of Anode (cont'd.)

c) Hob is now driven into the anode blank in one continuous stroke until a penetration of 0.160" is attained.

d) When cooled to room temperature and with the hob still in the blank outside diameter is machined to specified dimensions. The hob removal is aided by applying a small amount of heat on the outside surface of the blank.

e) Hobbed end of blank is now faced or final machined.- Note Fig. 4, Page 31. The unit is then jigged, filled with transoptic potting powder #1385 manufactured by Buehler Ltd., of Evanston, Illinois, heated to a temperature of 200°C (soaking time approximately one minute) and pressed in the Buehler Speed Press at a pressure of 4200 pounds per square inch.

f) When cooled to room temperature machining of both open and closed ends of anode are performed to specified tolerances.

g) Filler material in anode cavities is now dissolved by a three hour immersion in industrial chloroform, and machining burrs are carefully removed under a 30 power microscope using a #11 ex-acto blade.

3. FACTUAL DATA

3.3 Anode Fabrication

3.3.2 Hobbing and Machining of Anode (cont'd.)

h) Anode at this point is set up in the output fixture using the Jones-Lamson Comparator to obtain the desired alignment with respect to the output cavity and counterbores 0.1875" and 0.406" are made.

i) Following completion of output section anode is degreased in trichlorethelene and inspected for dimensional requirements specified. Figure No. 5, Page 32 illustrates a completed anode.

3.3.3 Tooling and Machining Coolant Used:

a) For rough machining of counterbores 0.469", 0.406", 0.312", 0.2860", and 0.187" flute end mills are used.

b) Final machining of counterbores indicated above is done by the use of a modified 5/16" #883 carbide tool bit with the following rakes.

1) Front rake 7° to 10°

2) Top rake 10° to 14°

3) Side rake 15° to 20°

c) For the anode bore-out (0.122") and 0.133" counterbore 5/16" high speed tool bits are chosen.

3. FACTUAL DATA

3.3 Anode Fabrication

3.3.3 Tooling and Machining Coolant Used: (cont'd.)

d) For all anode machining work Vytron Concentrate is preferred.

3.4 Cold Anode Hobbing:

In conjunction with the hot anode hobbing activity a considerable amount of exploratory work was also done with cold hobbing during this quarterly interval. One hob ground from Carpenter High Shock "60" steel was tried without success -- the blades on this hob twisted before the desired penetration into the anode blank was reached. This was not surprising however since the amount of force necessary to drive the hob into the untreated or unannealed OFHC copper was about six (6) tons or approximately 453,000 p.s.i. (hob area being 0.0265 in.^{2})
The tensile strength for the High Shock "60" steel at a Rockwell hardness of 58"C" is in the proximity of 360,000 p.s.i.
Other materials recommended as suitable for cold hobbing are Ferro-Tick Grade "C" steel and UHB Sverker "3" Swedish steel. Sample material of both were ordered and received. Grinding work of a new hob using Ferro-Tick Grade "C" steel was already initiated. A study program on copper hardness and/or grain size to determine suitability of

3. FACTUAL DATA

3.4 Cold Anode Hobbing (cont'd.)

material was also launched. Shipment of smallest grain size OFHC copper to be used in this work is promised for delivery by Revere Copper and Brass Inc., sometime during the next quarterly period.

4. CONCLUSIONS

4.1 Hot Anode Hobbing

Although the amount of information compiled is far from sufficient to enable one to draw a positive conclusion as to the effectiveness of the new anode processing techniques introduced observations made during initial tests of two (2) tubes, with regard to general tube performance, were very encouraging.

4.2 Cold Anode Hobbing

Although Bomac's attempt at cold anode hobbing proved unsuccessful a great deal was learned from this initial effort. Acceleration of future efforts in the development of this type of anode hobbing technique will depend on the results of our present effort with hot hobbing.

4.3 Manufacture of Tubes With Bomac Facility Hot Hobbed Anodes

While the initial test data on the lot of tubes manufactured during this quarterly period appears encouraging with regard

4. CONCLUSIONS

4.3 Manufacture of Tubes With Bomac Facility Hot Hobbed Anodes

to suppression of leakage current, elimination of vane burrs and impurities detrimental to cathode emission associated with anode manufacturing additional effort to determine a better set of anode-cathode parameters or conditions to lower the peak anode voltage (epy) is necessary.

4.4 Use of Smaller Diameter Cathode

Although serving the purpose of minimizing leakage currents and improving tube power utilization of this change in cathode diameter caused the peak anode voltage to increase beyond the maximum specified limit. It is apparent from these results that new changes in the cathode and/or anode have to be made in order to bring the peak anode voltage within the specified range.

5. PROGRAM FOR THE NEXT QUARTERLY PERIOD

5.1 Shelf and operational life test evaluation of tubes constructed with especially processed hot hobbed Bomac Facility anodes.

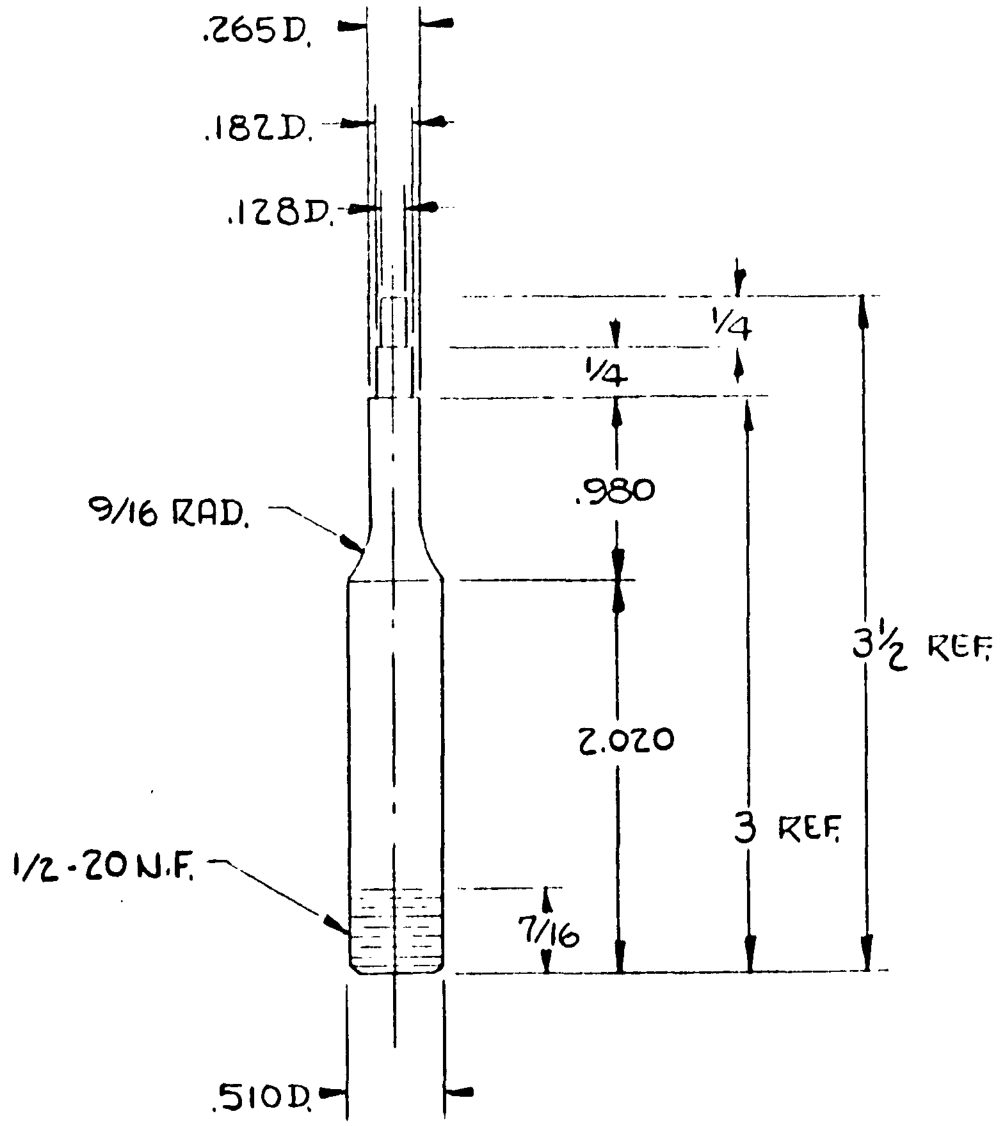
5.2 Consideration of design changes in the cathode and anode to correct the peak anode voltage.

5.3 Continuation of cold anode hobbing effort.

MAN HOURS OF WORK PERFORMED

1.	R. C. Sibley, Manager	48.00*
2.	R. S. Briggs, Senior Scientist	36.00*
3.	L. M. Vant, Chief Test Engineer	36.00*
4.	Gary G. Riska, Project Engineer	252.00
5.	Miscellaneous: This category includes all other man hours expended on the program in such areas as testing, processing, assembly work, drafting, incoming material inspection, test equipment work and maintenance, anode manufacturing, etc., etc.	902.08
	Total Time Expended	1,274.08

* This falls under the general company overhead category and is not added as a direct charge. It is included here however to indicate total effort and attention devoted to the BL-221 Project by Bomac.



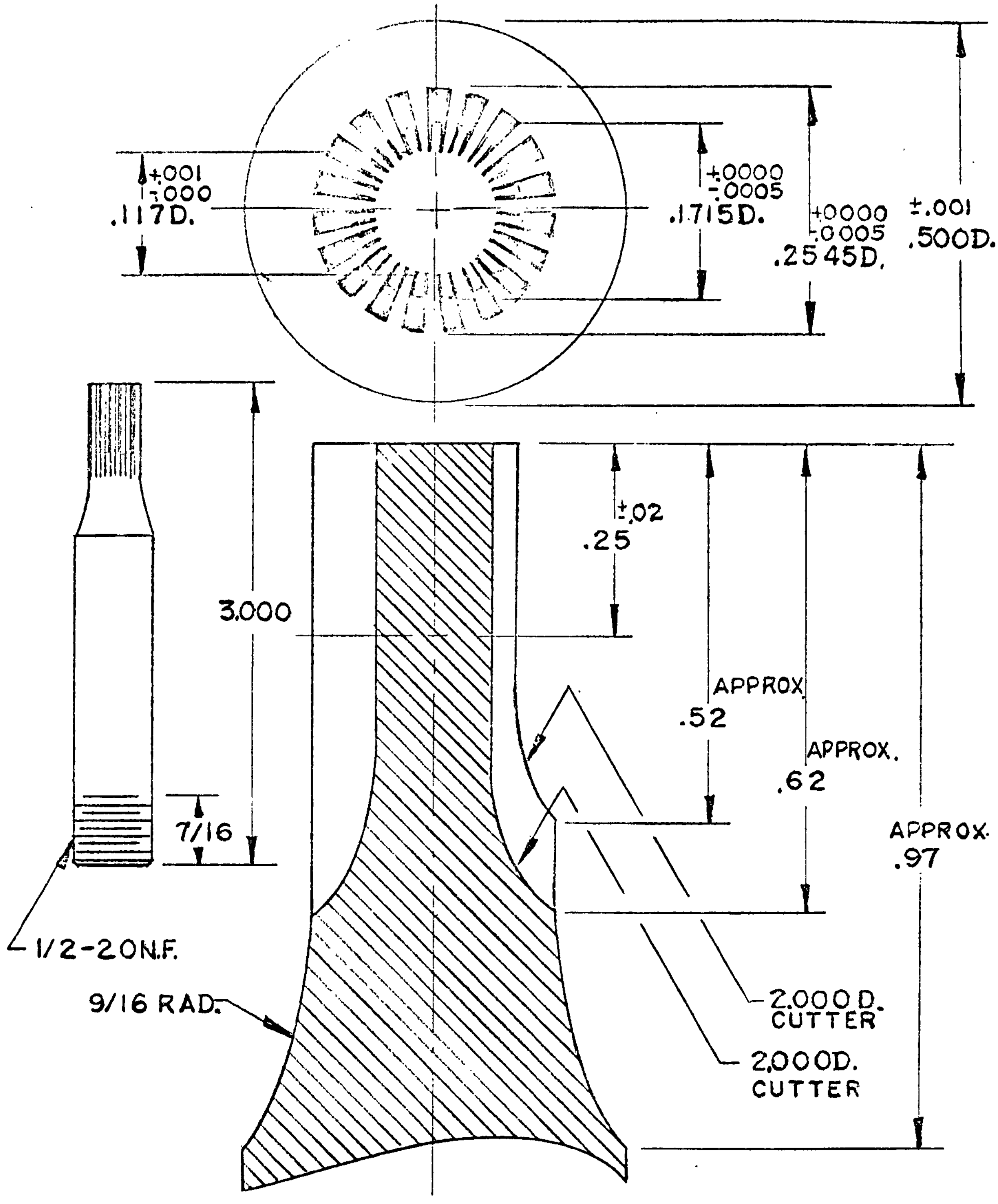
NOTE:

Diameters 0.128, 0.182, 0.265 and 0.510 shall be concentric within 0.002" TIR

TENTATIVE	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
Vitallium	Pre-Machined Hob	May, 1963

W-101

Figure 1

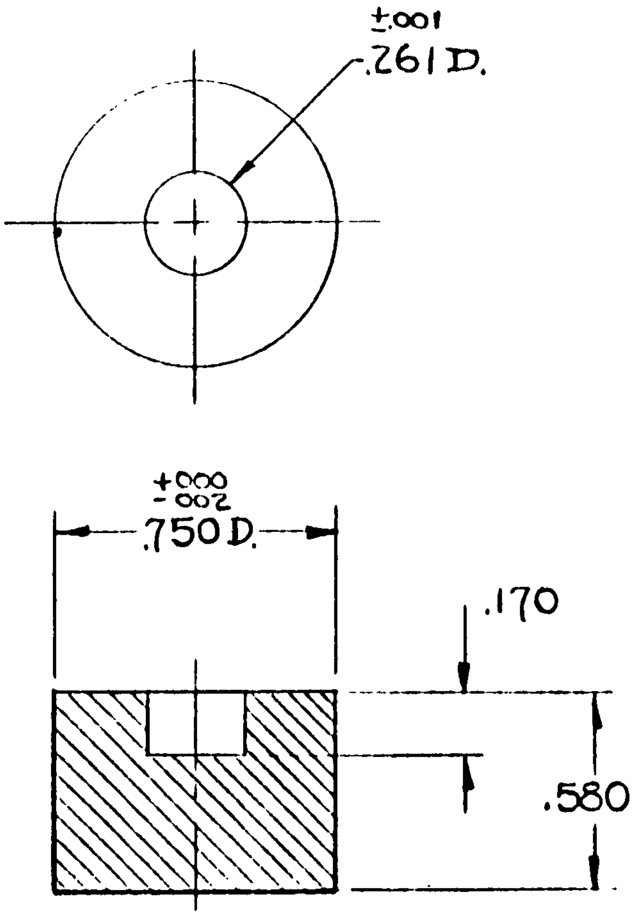


NOTE: 19 long and 19 short cutting sectors equally and alternately spaced within 0.0002"

TENTATIVE	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
	Completed Hob	May, 1963

W-101

Figure 2



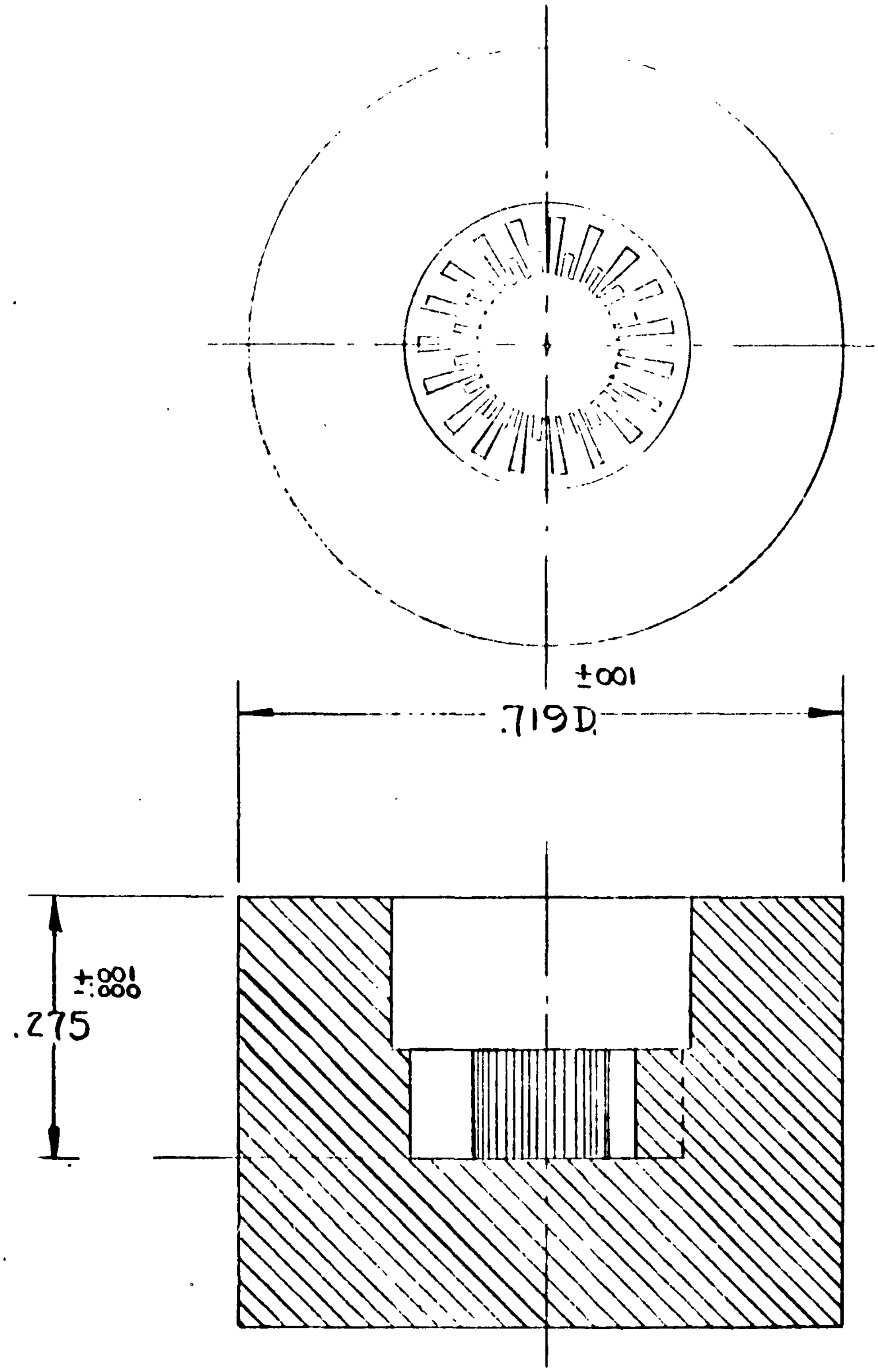
NOTE:

Diameter 0.261" and 0.750" concentric within 0.001"

TENTATIVE	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
OFHC Copper	Anode Blank	May, 1963

W-101

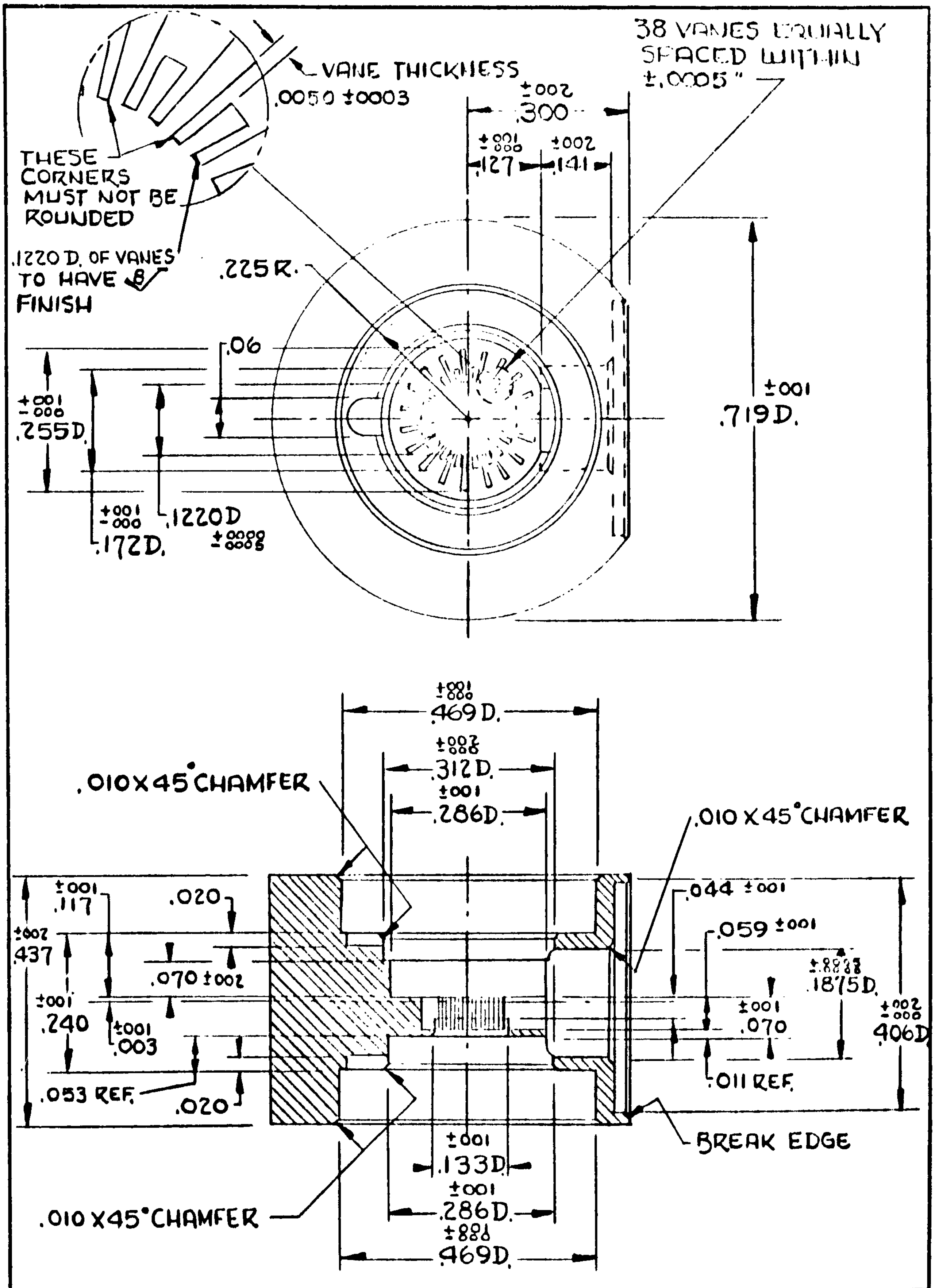
Figure 3



TENTATIVE	SPECIFICATION SHEET	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
	Hobbed Anode Blank	May, 1963

W-101

Figure 4



TENTATIVE	**SPECIFICATION SHEET**	BOMAC LABORATORIES INC. SALEM ROAD BEVERLY, MASSACHUSETTS
	Completed Anode	May, 1963

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Figure 5