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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"



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

Approved by:

Robert C. Sibley Manager, Power Tube Product Development Group

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.

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3.1 <u>Construction and Evaluation of Bomac Facility Anode Tubes:</u> 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

3.1 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.

Tube No.	Is Before Tube Packaging (magnet assembly)	Is 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

Comparative DC Emission Tests

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

3.1 <u>Construction and Evaluation of Bomac Facility Anode Tubes:</u> (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.

- 3.1 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.
 - 1) 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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(Bomac Facility Anode Tubes)

He	Heater		Conditions		Input	Condition	itions		Output	t		Pulse C	Conditions		Internal	
Sta	Starting		Operating	ing									-		Tube	-
ર હે		1	Eh Ih (V) (A)		ib (A) (Ib (Ma)	epy (kv)	Ро (W)	po (kw)	Fo (Gc)	tp (µsec's)	prf (pps)	du	Type Pulser	Fressure (mmHg)	A1:0de Hob
ف	m	2.53	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
1	6.3	2.53	3.0 1.	13 9.	0	5.7	14.0	7.2	14.4		0.06	8,350	0.0005	HTM	1.5x10- 7	B-2
1 -	6.3	2.612.	7	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
	6.3	٩	-	15 9.	0	4.6			و	69.60	0,06	8.350	0.0005	HTM	1×10-8	B-2
	6.3	2.5 2.	.71.	14 9.	0	4.8			4	70.50	0	8.350	0.0005	HTM	1×10-8	B-2
	6.3	2.6.2.		15 9.	0	5.2	14.0	6.0	6.0	70.05	0.06	8,350	0.0005	HTM	1×10-7	B-2
4	6.3	2. 6 .2	7	15:9.	0	4.5	14.2	8.3		69.40	0		0.0005	HTM	1×10-8	B-2
	6.3 i	2.6.2	7 1.	15 9.	0	4.5	14.2		11.6	70. 20	o	8,350	0.0005	HTM	1×10-8	B-2
L	6.3	2.6.2.	7 1.	15 9.	0	Ι.	14.5	8.8 8	17.6		0.06	8,350	0.0005	HTM	1×10-8	B-2
J	ь . 3 2.	. 55 12.	.71.	13 9.	0	4.5	14.6	8.0	16.0	69. 25	0.06	8.350	0.0005	HTM	1×10-8	B-2
	6.3	2.6 2.	.7 1.	15 9.	0	4.5	14.8	2					0.0005	HTM	1×10^{-8}	
	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	1×10-8	B-2
	The Increase		ih peak	andde vol		age (epy)	py) in t	his gr	group of	tubes	as	combared with	n previous	lots dis	cussed	
ž	in Pilogress	s Rep	Reports	#5 and	and #é ke	is attribut	ibuted t	b th	hmall	er dia	heter ca	er diatheter cathode used	Achange in	e in cathode	ode	
	diameter was		from	0. dþé	d 96 ''+0. 0005 ''	_	to 0.09	5"+. (005"							
					- odo			0 -	000							
Tubes	#44.	#49.	# 515	and #5	#57 s4f	suffered	further		hs res	pect b	in this reduct blecause d	f electro	of electrolytic polishing use	hing use	in ano. e	
ا نه ا	processing		catising the	se anode		diameter to		rease	JV ar	proxit	indrease oy anproximately 0	0005"	` •	1		
							~									
-	Circled val	values	indica	cate dut of		spec tul	tubes.									
		2	-			•		~					-			

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TUBE NO. 33

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		Hea	Heater (Condition	tion	Inp	Input Condition	ditions		Output	t l		Pulse C	Conditions		Internal	
E		Starting		Ope rating	ating											Tube	Life
Date	Tests	ы [V) (Г	1h (A)	ਪੂ ਪ੍ਰ ਪ	Ih (A)	di (A)	Ib (Ma)	epy (kv)	°₽́)	po (kw)	Fo (Gc)	tp (µsec's)	prf (pps)	du	Type Pulser	(mmHg)	l
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	1x10-8	
		Foll	Hiwo	Following the	abov	e test	म	Vac-lon F	Phmp was		pinched-	bff and	tube was p	permanently packaged	ly packa	ed.	
		regaussed,	15 5 C	d, etc.													
2/19/63 Final	Final		Ī														
	050. 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	8	
	Osc. 2	6.3	2.5	о. С	1.13	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	1	
											*						
3/21/63	Shelf	6.3	2.5	8.0	1.13	9.0	4.6	14.8	6.80 [†]	13.6 [†]	71.55	0.06	8,350	0.0005	IITM	:	
	Osc. 3																
														•			
		FT	equency		failur	di ja	this tube	was	lieved	l to ha	believed to have been	n caused	by out of	spec andde		dimensions.	
		+ The	e in	increa	ie in	peak a	e in beak ahode voltage		t py a	ils bui	cht dr	non ni n	(tpy) and slight drup in power output observed under	observed	under c	Jel	
		1 lif	e m	liffe may be	an ir	an indication of	on of d	deterior	tion	ih cath	iode en	orition in cathode emission					
														Î			

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

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TUBE NO. 34

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		He	Heater		Conditions	isu	Input	Input Condition	itíons		Output	••		Pulse C	Conditions		Internal	
ta e E		Stal	Starting		Operatin	ing											Tube	- 7 7
Date	Tests	чэ	μ	មុធ			~~~~	e 2	epy	Ъ		Э	ŧ	prf	qu	Type	(mmHg)	Luie Cycles
		2	<u>(</u>	ฏ	(V)	=	(V)	(Ma)	(kv)	۶	(M)	(Cc)	(usec's)	(pps)		Pulser	ò	
2/19/63	Initial				$\left \right $													
	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	1.5×10-	
	Овс. 2	i 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	1.5×10-4	
	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	1.5×10-4	
		Fo	Following	ing t	the al	above	tests	the V	Vac-lon	pump was		pinched	- off and	tube was	permanently	tly packaged	iged,	
		reg	regaussed,	sed,	etc.				_									
	Final		 		 													
2/21/63	Osc. 2	6.3	2	5 3.	01.	13	9.0	4.6	14.8+	7.0+	0+14.0+71	71.2*	0.06	8,350	0.0005	HTM	-	
		1		==1														
5/ 6/63	Shelf																	
	Osc. 2	6.3	2.	5 3.0	l.	13	9.0	4.9	14.8+	6.6+	6+13.2+	71.2*	0. 08	6, 250	0.0005	HTM	1	
						-												
				_														
	*	Ë	Frequenty		fallu	lurein	this	tube 🤟	was beli	eved b	to have	e been	caused	by out of a	spec anode	e dimensions	ions	
				_		_						·						
	+	Inc	rease	in	n peak	0 Re v	anode voltage		(epy) and	d slig	ht dro	d ui d	Wer out	slight drop in power output observed during final and	red durin	r final an	d	
		she	ir F	f tests	TUBY	may indicate		deteriqratio	Ē	In cathode	ode e	emissidn	Ľ					
		_																
					-											·		
				_	_	-												
				_	_	-												
																-		
				_														
				_		-												

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

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			Cycles																				
	Inte rnal	Tube	Fressure (mmHg)		1x10-8	1x10-8	1×10-8																
5	ß		Type Pulser		HTM	HTM	HTM	permanent			HTM			HTM	e tests	2	bration						
TUBE NO. 35	Pulse Conditions		qu		0.0002	0.0005	0,0005	tube was pe			0.0005			0.0005	shelf lif	'ieinatine	and heavy discoloration						
TUB	Pulse		prf (pps)		10,000	8,350	2,380	and the tu			8,350			8,350	final and	contaminants originating	n and hea						
			tp µsec's)		0.02	0.06	0.21	pinched-off			0.06			0.06	ed under	v contan	errosibn						
			Fo (Gc)		70.4	70.4	70.4	S			70.4			70.4	pbserv	used		kes.					
	Output		po (kw)		19.0	19.0	19.0	system wa			12.0			6.0*	pav	ely ca	51	nd pole pie					
			Po (W)		4.2	9.5	. 1				6.0			3.0*	ase in	bst lik	ed	nd po					
	tions		epy (kv)		13.9	13.9	13.9	n Pumb			15.4*			16.3*	d incr	ning m	revea	anode a					
	Input Conditions		Ib (Ma)		3.8	5.4	4.5	Vac-Ibn			4.5			4.6	output and in	poisoning	is tube	n the a					••••••
	Input		ib (A)		9.0	9.0	9.0	ts the	d, etc		9.0			9.0	 power ou	athode	Examination of this tub	areas in the					
	tions	Operating	Ih (A)		1.12	1.15	1.18	these telts	regaussed		1.15			1.15	in	ed to b	inati	arge					
	Conditions	Ope	۲) (۲)			2.7		- 1		 	2.7	ł		2.7	rhtion	thibut	Exam	e) of	_			_	
	Heater (Starting	$\begin{bmatrix} \mathbf{E}_{\mathbf{h}} & \mathbf{I}_{\mathbf{h}} \\ (\mathbf{V}) & (\mathbf{A}) \end{bmatrix}$		6.3 2.6	6.3 2.6	6.3 2.6	Following	packaged	 	6.3 2.6			6.3 2.6	 Deterioration	were attributed to cathode	anode.	(deposits)		 		 	
			Tests	Initial	Osc. 1	Osc. 2	Osc. 3			Final	Osc. 2		Shelf	Osc. 2	*							 	
			Test Date	2/18/63						 2/19/63			3/ 4/63										

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

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Test Date																	
Test Date	_	Heater	ter C	Conditions	ions	Input	Input Conditions	tions		Output			Pulse	Pulse Conditions	ŝ	Internal	
Test Date		Starting	ing	Operatin	atin											Tube Dressur	1 : fo
	Tests	ជូ ១	ਸੂ (ਵੇ	ធី៍៍៍	4 (¥)	સે (₹	Ъ (Ma)	epy (kv)	e (v	bo (kw)	Fo (Gc)	tp (µsec's)	prf (pps)	qr	Type Pulser	(mmHg)	0
2/21/63 In	Initial																
Ō	Osc. 1	6.32	. 56	2.5	1.12	9.0	3.2	13.8	3.4	16.6	69.6	0.02	10.000	0.0002	HTM	1×10-8	
Õ	Osc. 2	6.32	2.56	2.7	1.15	9.0	4.6	13.8	8.3	6	69.6	0.06	8,350		HTM	1×10-8	
Ó	Osc. 3	6.32	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	1×10 ⁻⁸	
***																1	
3-2		Foll	Following	the	abov	e tests	Vac-Jon	on Pump	p sys	system was		pinthed-off	and the	tube was p	permanently	uly	
	-	pack	tage	,rega	packagee,regaussed,	d, etc.											
F	_			·													
2/25/63 Fi	Final																
Õ	Овс. 2	i 6.32	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	1	
3/ 1/63Sh	Shelf																
Ö	Osc. 2	6.32.	56	2.7	1.15	9.0	4.5	14.1	9.5	19.0	69.6	0.06	8.350	0.0005	HTM	1	
3/21/63 Shelf	lelf																
ō	Osc. 2	6.32.	56	2.7 1	1.15	9.0	4.5	14.2	6.3	12.6	69.6	0.06	8,350	0.0005	HTM	8	
/5/ 63 Sh	Shelf																
Ō	Osc. 2	6.32	32.56	2.7 1	1.15	9.0	5.1	16.1*	3.6#	7. 2#	69.6	0.06	8,350	0.0005	HTM		
*	Dete	Deterioration		n power	ver	output	out and	increa	se in	pav ob	observed	under	the last sh	shelf life test	est were	attributed	
	to ca	to cathode		poinoning	bel	eved to have		origina	nated with	th the	anode	Vane	errosion	and deposits	5	large anodo	
	and	pole p	piece	areas	as	xplained	for		##5 were		seen in thi	s tube	lso.				
			=														
1					_												

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BL-221 JEST DATA The Bomac anode used in this tube was processed according to the regular schedule. NOTE:

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TEST DATA **BL-221**

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37 TUBE NO.

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		Heater		Conditions	ons	Input	t Conditio	itions		Output			Pulse Co	Conditions		Internal	
Teat		Starting Eh Ih		Operating Eh 11 h	ating Ih	ib	e A	eDV	Ро	0¢	Εo	ŧ		ţ	T	Tube Pressure	Life
Date	Tests		==		(Y)	(A)	(Ma)	(kv)	(M)	(kw)	(Gc)	(µsec's)	(sdd)	;	Pulser	(mmHg)	Cycles
2/25/63	Initial																
	Osc. 1	6.3 2.	5	2.5	.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	16.3 2.	Ś	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	3.01	.17	9.0	4.6	14.0	8.2	16.4	70.5	0.21		0.0005	HTM	1×10-8	
			+														
		Follo	wing	the	abov	Following the above tests the	the V	Vac-Ion	amn -	svsten	svstem was	pinched off and	off and tu	tube was permanently	ermanen	١v	
		packaged	Red	reg	regaussed	ed, etc											
			==														
2/27/63	Final																
	Osc. 1	6.3 2	5	2.5 1	. 12	9.0	3.8	14.1	2. 64 1	2.0	70.5	0.022	10,000	0.00022	HTM	-	
	Osc. 2	m	5	2.7 1	. 14	9.0	4.8	14.1	6.0 1	2.0	70.5	0.06	8.350		HTM	6	
	Osc. 3	6.3 2.	5	3.01		9.0	4.6	14.1	0	2.0	70.5	0.21	2,380		HTM		
ł			=														
3/ 1/63	Shelf	+	=		1												
	Osc. 2	6.3 2.	5	2.7 11	. 14	9.0	5.2	14.2	5.4 1	0.8	70.5	0.06	8.350	0.0005	HTM		
- 1 1			=		7												
3/21/63		-+	1		===												
	0sc. 2	1 (. 3 2.	5	2.7 1	.14	0.6	5.2	14.5*	4.7	9.4*70	70.5	0.06	8.350	0.0005	HTM	1	
3755762	1		-+-	╉	=		T	Ī									
	Shell	c c	14	1		4				T							
							# 0 0	15.4*	L. 3#4	3#4.6#	70.5	0.06	8.350	0.0005	WTH		
			╪		+			T	-+-								
			====	+-	===	\uparrow	1	T		-+-							
			+	+	+	T	1	Ī	T		T					Ī	
									†	1							
NOTE:	#	riorati	i i	n pou	ver o	utout a	nd inc	Teace		hear.		Deterioration in power output and increases in any observed wide the					
- 1	tube	tubes #35 a	nd #	30 e.	kamii	ned pro	evious]	y were	attrib	uted t	o cathe	Jde pois.	oning heli	snell lile test as was the case with soning believed to have originated v	ts the cat	and #30 examined previously were attributed to cathode poisoning helieved to have originated with	
2-	the	the anode.	ТÞ	e Bor	nac a	unode u	The Bomac anode used in this	this tu	tube was	i proc	essed	accordir	processed according to the regular	regular sc	schedule.	TOTO MIN	

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TUBE NO. 38

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		He	•	ł													
			ater	Con	Heater Conditions		Input Co. dition	ditions					Pulse	Pulse Conditions	15	Internal	
		Sta	Starting	d Q Z	Dperating		! 									Tube	
Test Date	Tests	<u>ц</u> у Ц	1 h (A)	Eh (V)	Ih (A)	4i (A)	Ib (Ma)	epy (kv)	Fо (W)	po (kw)	Fo (Gc)	tp (µsec's)	prf (pps)	du	Type Pulser	Fressure (mmHg)	Luite Cycles
3/1/63	Initial																
	Osc. 2	6.3	2.	6 2.7	7 1.15	5 9.0	5.2	14.0	3.0#	6.0470.	70.05	0.06	8,350	0.0005	HTM	1×10-8	
			μ														
	* Ini	Initial test		rejec	reject for	power	ouput.	This tu	tube had		re mo	severe mode interference.		<u>When this was corrected</u>	was cor	rected	
	th	rbugh	1 cat	hode	cente	ring po	through cathode centering power output d	put dro	pped t	o beld	rdpped to beldw the	minimur	fie	d limit of	5.0W.	Condition	
	Wa	was attributed to	njbu	ted to	o seve	re cat	severe cathode and	d anode	arcin	v taki	he pla	le durin	anodellarcing taking plade during the tube hoing process	arine pro	cess 0		
	ex	examining the	ing	the tu		the hnode	vanes		found in	a sev	severely	erroded	condition	•			
Γ				-													
				_													
				_													
-																	
											·						
		- 17															

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

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TUBE NO. 41

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		Hea	ter (Cond	Heater Conditions		Input Conditions	litions		Output	ų		Pulse C	Conditions		Internal	
		Star	ting	8	1 21	I	 									Tube	T :60
Test Date	Tests	ជ	<u>ר</u> ק €	ជីខិ	म (€	ନ୍ (୧ 	(Ma)	epy (kv)	е М	od (jw	Fo (Gc)	tp (µsec's)	prf (pps)	qu	Type Pulser	(mmHg)	()
3/13/63	Initial							₩									
	0sc.1	6.3	the second s	2.5	1.1	2 9.0	3.2	14.2	3.8	17.3	69.4	. 022	10,000	0.00022	HTM	1×10 ⁻⁸	
	Osc. 2	6.3	2.6	12.7	1.15	5! 9.0	4.5	14.2	8.3	16.6	69.4	.06	8,350	0.0005	HTM	1×10-8	
	Osc. 3	6.3	2	6 3.0	1.18	8 9.0	4.5	14.2	8.3	16.6	69.4	.21	2,380	0.0005	HTM	1×10-8	
		Fol	Following	ng th	the above	ve tests	the	Vac-lon	Pump	system	m was	pinched-off	and	tube was pe	permanently	1 _V	
		pac	packaged		recaussed.	sed. et	tt.										
4/11/63	Final																
	Osc. 2	6.3	2.6	12.7	1.15	5 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	12.7	1.15	5 9.0	4.5	14.2	9.4	18.8	69.4	. 08	6, 250	0.0005	HTM	-	
					_			-									
					_												
				_													
				_													
					_												
				_	4												
		_															
NOTE:		Bom	80 81	node	used	in this	tube w	as proc	essed	accor	ding to	the reg	The Bomac anode used in this tube was processed according to the regular schedule.	{	This is the only	only	
•	tube	t in th		*		tube in the lot manufactured with sources	teh unt			•	,		• • •				

tube in the lot manufactured with regular schedule anode processing which did not suffer deterioration in power output

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BL-221 TEST DATA

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TUBE NO. 42

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													IUBE NO.	J. 4 <i>C</i>			
		Heater		Conditions	ons	Input	Input Condition	tions		Output	It		Pulse	Pulse Conditions	IS	Internal	
Test	1	Starting Eh Ih		Operatin Eh Ih	atin Ih	ib	ደ	epy	Po	od.	Fo	t.	prf	qn	Type	Tube Pressure	Life
Date	Tests				(Y	(F)	(Ma)	(kv)	<u>(</u>)	(kw)		usec's)	(pps)		Pulser	(mmHg)	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	1x10-8	
3/22/63	Shelf	6.3 2.	9	12.7 h	. 15	9.0	5.6	15.7*	3.5*		0*70.2	0.06	8,350	0.0005	HTM	1×10-8	
	Osc. 2																
		•••••			-												
	* Pov	Power det	eric	deterioration		and increase	ease in	epy	during t	the two	b weeks	thold p	hold period with the	the Vac-Ion	Ion Pump	on were	
	four	found to be of	0	a per	mai	permanent nature	ure.			•		to cathe	cathode poisoning	ng believ	led to ha	1 0	
	with	h the anode	apor	1.	-												
			+=	+	=	T	T	Ī			T						
			ŧ	\dagger	ł												
			+	+													
			=														
			-														
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			=		- 1												
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			_													-	

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

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TUBE NO. 44

		Heater		Conditions		Input Conditions	onditi	ons		Output			Pulse C	Conditions		Internal	
Test Date	Tests	StartingEhIh(V)(A)		Operating E _h I _h (V) (A)		(Ma)) (E	epy (kv)	Po (W)	po (kw)	Fo (Gc)	tp (µsec's)	prf (pps)	np	Type Pulser	Tube Pressure (mmHg)	Life Cycles
4/3/63	Initial																
	Osc. 1	6.3 2.	6 2.	.5 11.1	12 9.	0 3.	1 1	14.5*	3.88 1	17.6	69.0	0.022	10,000	0.00022	HTM	1x10-8	
	Osc. 2	6.3 2.	9	7 11.	15 9.	0 4.	5 1	14.5*	8.8 1	9	69.0	0.06	8,350	0.0005	HTM	1×10-8	
	Osc. 3	6.3 2.	<u>ہ</u>	0 1.	18 9.	0 4.	5 1	4.5*	8.8 1	17.6	69.0	0.21	2,380	0.0005	HTM	1×10-8	
					_			-									
		Following		the ab	above tests	sts the	e Vac-I	ч	Pump system	ysteh		waspinched	off and	tube was pe	permanentav	>	
		packaged	sed.	regaussed		etć.											
4/11/63	Final								<u> </u>	†							
	Osc. 2	6.3 2.	6 2.	7 1.	15 9.	0 4.	5 1	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.	-1-	15 9.	0	 -	14.5#	9 8 1	19.6	69.0	0.08	6.250	0.0005	HTM	-	
Ī			-	-		-+		+									
			=		-		_						-				
	* The	뉭	spet r	pav on	this	tube was	is attril	outi	d to th	the sm	smaller	¢ iameter	cathode	used and	electrolytically	tically	
	polished	shed anode		(andde	bore o	out as ;	a resul	t of	the pp	pplishihg		tment if	treatment increased b		matelv	(5000 .	
			_	_													
			-														
			_														
								 	†	† -							
			=	_		_											

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

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TUBE NO. 49

		Cycles																		
Internal	Tube	(mmHg)	1×10-5					1					tically	.0005").						
		Type Pulser	HTM		manentl			HTM			HTM		Flectrol	mately						
Pulse Conditions		ηŋ	0.0005		e was pe			0.0005			0.0005		sed and	by approximately						
Pulse C		pri (pps)	8,350		linched-off and tube was permanent			6.250			6,250		cathode u							
		tp (µsec's) .	0.06		inched-b:			0.08			0.08		smaller ciameter	trestment increased						
		Fo (Gc)	69.25		was l			6 9. 25			<u>69.25</u>		aller							
Output		po (kw)	16.0		vstem		 	16.8	†		17.0		the sm	phiishihg	 					
		y. W	8.0		ump system			8.4			8.5		but d to t	the						
itions		epy (kv)	14.6*		c-Ion F			14.6#			14.6*		ttribut	result of						
Input Condition		Ib (Ma)	4.5		the Vat			4.5			4.5		Was	asar						
Inpu		ib (A)	9.0		e test	ed, et		9.0			9.0		is tub	re out						
ions	Operating	(A)	1.13		 abov	repaussed		1.13			1.13		on this	q						
Condit	Ope	<u>E</u> S	2.7		 ng the	4		12.7			2.7	 	e pav	el (andde	 	 	 			
Heater Conditions	Starting		6.32.55		 Following	package	 ,	6.32.55			6.32.55	 	put of spe	ed anode	 	 	 		 	
		Tests (Initial	Osc. 2			 Final	Osc. 2		Shelf	Osc. 2		* The p	polished	 	 			 	
	+ • •	Date	4/ 9/63				 4/22/63			4/26/63										

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

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TUBE NO. 55

		He	Heater	Cond	Conditions	Input	ut Condition	litions		Output	+		Pulse (Conditions	S	Internal	
f		5tar	Starting	0 De	Operating											Tube	
Lest Date	Tests	ч (^)	1 ^р (А)	र् य २	(A)	di (A)	Ib (Ma)	epy (kv)	Po (¥)	(kw)	Fo (Gc)	tp (µsec's)	prf (pps)	du	Type Pulser	Fressure (mmHg)	Life Cycles
4/26/63	Initial																
	Osc. 2	6.3		5.2.7	1.15		4.	14.8*	0	20.4	6.9	0.08	6, 250	0.0005	HTM	1×10-8	
4/29/63	Osc. 2	6.3	N	512.7	1.15	0.9	4	14.8*	10.0	20.0	6	0.08	6,250		HTM	1×10^{-8}	
				==													
		Ъо	Following	ng the		above test	the Vac	- Ion	pump s	ystem	was p	Inched-dff	ff and tube	was per	permanentl		
		pac	package	4	repaussed	sed. et											
27/1/3					-+-												
	F Inal	-		1			-+										
	0sc. 2	6.3	2.5	3.0	1.13	0.6	4.5	14.8*	9.5	19.0	69.9	0.08	6,250	0.0005	HTM		
51713	5				· ·		- - -							1			
	Shelt	0.0	2.2	0 7		0°6	4.5	14.8*	9.5	19.0	69.9	0, 08	6,250	0.0005	HTM	•	
					+						Ī						
		*	The h	high p	pav on	this	tube was	attr	ibuted to	the	smallen	diameter	er cathode	used and	special		
			droc	processing	2	a hode e	employed.	, p									
			Jpera	Ope rationa		life test e	evaluation	on of this	s tuba	is	schedule	d to take	e nlace du	ring the	next		
		0	luart	er ly	quarterly period												
				 +: -:		-											
		_															
				 						+							
					+-												
				=													
NOTE:		Bom	ac ai	node	used	in this	The Bomac anode used in this tube was	l a	ocessed	according		to the revised	ised Schedule	#	described in this	in this	
-	report,	ort,	Page	ŝ	•												
1																	

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														T UDE NO.	NO. 01			
		Hea	Heater (Cond	Conditions	Input	ut Coi	Conditions	8	Ō	Output			Pulse (Pulse Conditions	10	Internal	
		Stal	Starting	Ope	Operating		 	 									Tube	
Test Date	Tests	E (V) E	I ^b	र्ष रे	ч (А)	di (A)	Ib (Ma)	epy (kv)		Ро (W)	po (kw)	Fo (Gc)	tp (µsec's)	prf (pps)	du	Type Pulser	Fressure (mmHg)	Cycles
5/6/63	Initial																	
	Osc. 1	6.3	2.6	2.5	1.1	2 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.	0	69.1	0.08	6,250	0.0005	HTM	1×10-8	
	Osc. 3	6.9	2.6	3.0	1.18	6	0 5.0	0 14.	. 7*11	0	22.0 (0.21	2.380	0.0005	HTM	1x10-8	
						_			-									
		4	The 1	The high	pav on		this tube was		attributed	-8	the	malle	smaller diameter		cathode used and	id specia		
			proc	orocessin	J.	anode	employed											
			This	tube	will	This tube will text have the split	are th	e split	t exhaust		angat	magnets removed		the vac-ion number	n numn si	stems n	nchod óff	
			Tube	lliw!	Tube will then he	be pe:	rmane	permanently pa			egaus	sed ab		tested.	After addi	tional t	sts are	de
			ube	ube will he		evaluated under	dunde		operational	्रम	hfe test	conditions	tions so	σ	to take place	ce durint	the next	
			quar	quarterly	y perind.	pd.												
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			·		_													
										-		=						
											and the second se				of the local division			

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TUBE NO. 57

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

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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:

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3.3 Anode Fabrication (cont'd.)

- 3.3.1 The Hob
- a) <u>Material</u>: 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 treated at 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.

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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.

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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.
- 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.

3.3 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

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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 typę. of anode hobbing technique will depend on the results of our present effort with hot hobbing.

4.3 <u>Manufacture of Tubes With Bomac Facility Hot Hobbed Anodes</u> While the initial test data: on the lot of tubes manufactured during this quarterly period appears encouraging with regard

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4. CONCLUSIONS

4.3 <u>Manufacture of Tubes With Bomac Facility Hot Hobbed Anodes</u> 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

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

Total Time Expended 1,274.08

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* 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.









