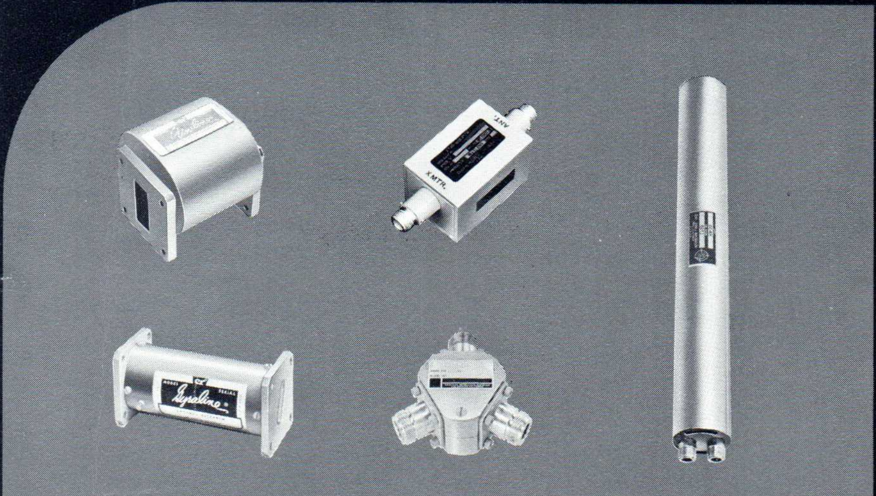
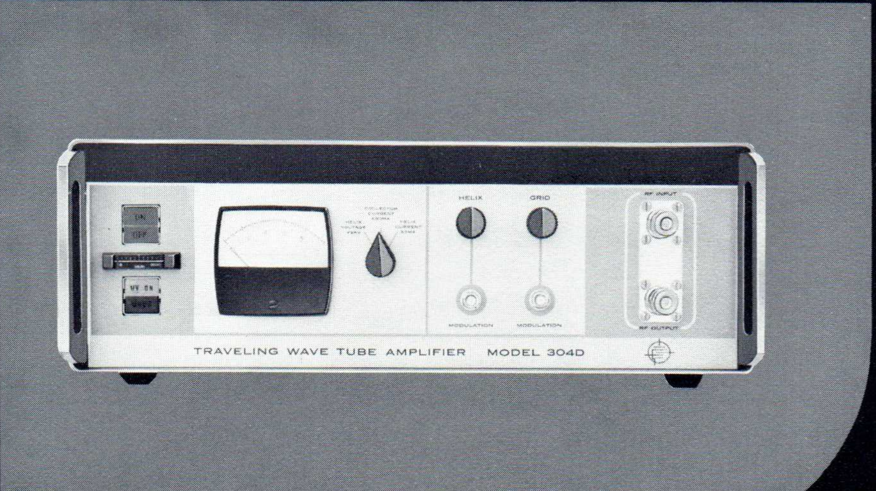
MICROWAVE COMPONENTS AND INSTRUMENTS



FERRITE COMPONENTS TRAVELING-WAVE TUBES

PAGES 23 THROUGH 31 OBSOLETE. SEE HUGGINS CASCADE RESEARCH FERRITE COMPONENTS CATALOGUE DATED MARCH 15, 1964 FOR REVISED DATA.



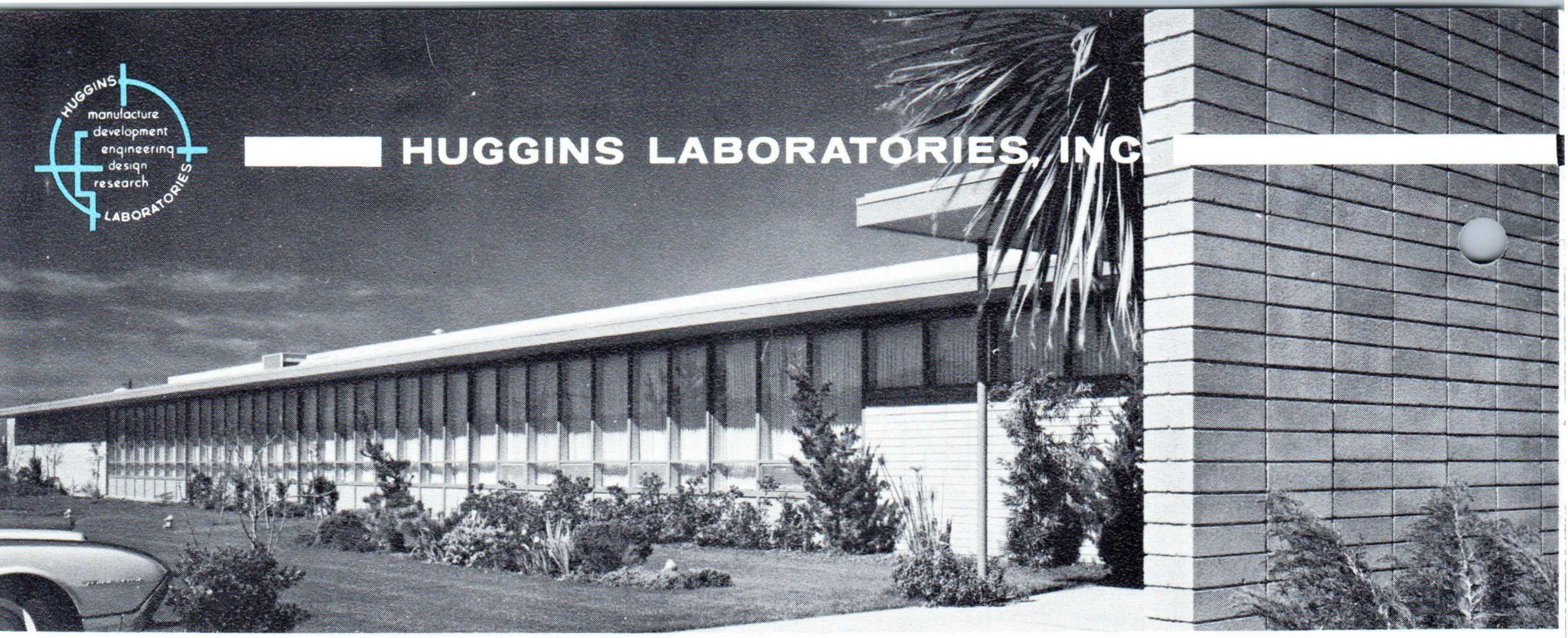
TWT AMPLIFIERS

September 1, 1963

HUGGINS LABORATORIES, INCORPORATED

999 East Arques Ave. • Sunnyvale, California • Phone 408-736-9330 • TWX 408-737-9992

HUGGINS LABORATORIES, INC



Since 1951 the name *Huggins* has been closely connected with the field of microwaves . . . initially as an individual doing pioneer TWT production in a garage shop . . . and today as the firm that paces the Microwave Instrumentation, Microwave Ferrite Component, and TWT industries.

Huggins Laboratories was formed to meet the microwave system industry's vital need for highly qualified talent in the areas of traveling wave tube research, design and manufacture. That the Laboratory has met this need is evidenced by its many contributions which have advanced the state-of-the-art.

Basic research at Huggins Laboratories led to the company's distinction as being the supplier of the first commercially available traveling wave tube . . . backward wave oscillator . . . low noise TWT . . . PPM-focused TWT . . . and electrostatically focused TWT. Further significant contributions lie in the fields of PM BWOs, white noise generation, ruggedization, high power–low noise TWTs, and loop memory tubes. In the area of manufacturing, contributions of Huggins-developed handling and production techniques have made possible both small and large quantity TWT production at economical costs.

To increase its technological capabilities, the company formed Menlo Park Engineering (MPE) in 1955. Operating as a wholly-owned subsidiary, MPE made traveling wave tube equipment available for both instrumentation purposes and system evaluation. Huggins Laboratories became more intimately involved in the instrumentation field by completely absorbing MPE in 1962. In a physical and administrative merger, MPE formed the nucleus for the Systems Division. Integrating both tube and instrumentation technologies provided the customer with more efficient and diversified services, greater design versatility, and more complete engineering assistance. A very significant result of the merger is found in the finest line of TWT Amplifier units and Electronically Swept Microwave Oscillators on today's market.

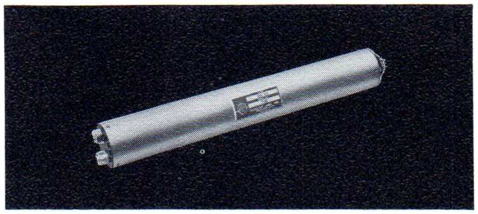
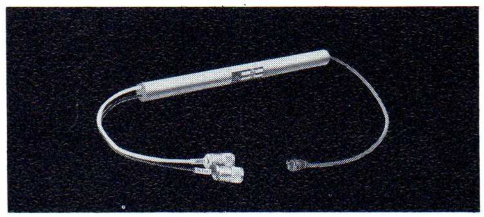
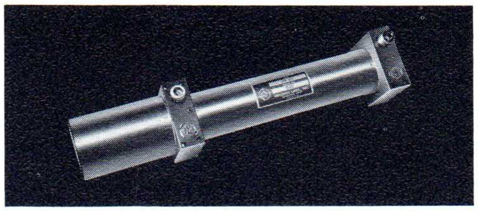
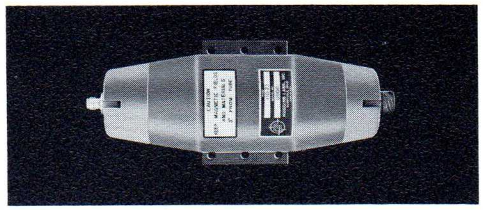
Fully confident in the future of microwaves, Huggins broadened its technological base even more in 1963 by purchasing the Cascade Research Corporation . . . the pioneer in engineering and manufacturing of ferrite components. In addition to diversifying the product line, creation of the Cascade Research Division extended Huggins' technical capabilities to include the development and production of ferrite isolators, circulators, switches, modulators, and phase shifters.

With the 1963 acquisition of Applied Systems Corporation as a subsidiary, the company further diversified its interests into the fields of infrared optics and high frequency transient detection.

Over the years Huggins Laboratories has become well established as the leading developer and manufacturer of traveling wave tubes. One key to the company's capacity to produce is found in its engineering-trained management team—men who fully understand the customer's needs. This technical insight enables management to effectively blend the efforts of the research and manufacturing staffs for optimum operation.

The same experienced technical direction and ability have been fully integrated into all operations at Huggins Laboratories. Consequently, the customer is assured that his TWT, Microwave Instruments, and Microwave Ferrite Component needs will be met with the same proven reliability and competence characterized by Huggins TWT operations.

TUBE DIVISION

CAPABILITIES

RESEARCH AND DEVELOPMENT

The TWT R & D Department is an efficient organization that combines intellectual curiosity, experience, facilities, and ability to provide advanced TWTs in minimum time at minmum development cost. Many of the engineers and technicians have worked with the TWT since its infancy.

As a result, R & D personnel possess a store of information and unequalled experience related to TWT-BWO design and development. Augmented by the most modern and advanced equipment obtainable, this technical know-how works daily for the customer on both externally and company sponsored programs.

Capabilities, talents, and interests of this group encompass such areas as the art of PM, MRPM, and PPM focusing . . . low-noise gun design . . . ruggedization procedures . . . white noise generation . . . radar augmenter tubes . . . BWO technology . . . and metal-ceramic techniques.

PRODUCTION

Huggins TWT Production Department is staffed, equipped, and geared to deliver traveling wave tubes in small and production quantities on short delivery schedules. This ability to produce is evidenced by the fact that Huggins Laboratories consistently achieves the industry's highest annual production figures . . . an enviable record of which we are proud.

Though mass production is not presently within the state of the TWT manufacturing art, Huggins has developed simplified handling and production techniques that minimize manufacture and assembly time while meeting rigid quality standards. Experienced personnel use these techniques and the industry's most up-to-date equipment to provide the customer with quality TWTs and BWOs in quantity.

Whether you require TWTs and BWOs in small or large quantities, let Huggins' years of experience in producing quality tubes work for you.

CONTENTS

ORDERING INFORMATION

ORDERING: Standard Tubes: Specify full tube nomenclature and primary performance specifications.

Custom Units: Many tubes whose characteristics fall outside those listed in this catalog are being made to individual customer specifications. Contact Huggins Sales Department, or our representative in your area, to discuss your special needs.

PRICES: F.O.B. Sunnyvale, California. Prices apply to small quantities only and are subject to change without notice.

TERMS: Net 30 days with approved credit.

DELIVERY: Indicated times represent normal delivery for small quantities. Consult Huggins Sales Department for latest quotations.

SHIPMENT: Via air freight unless requested otherwise.

SERVICE: Prompt technical service and assistance are readily available from factory-trained representatives and the manufacturer.

WARRANTY: All Huggins' TWTs and BWOs are thoroughly tested and inspected prior to shipment. Huggins' customers enjoy the most liberal warranty in the industry.

1 to 10 mw Amplifiers: 500 hours full guarantee, 2000 hours prorated.
100 mw and above: 250 hours full guarantee, 1000 hours prorated.
Low Noise Amplifiers: 500 hours full guarantee, 1500 hours prorated.
Backward Wave Tubes: 100 hours full guarantee, 500 hours prorated.
All Tubes: 12-month shelf life.

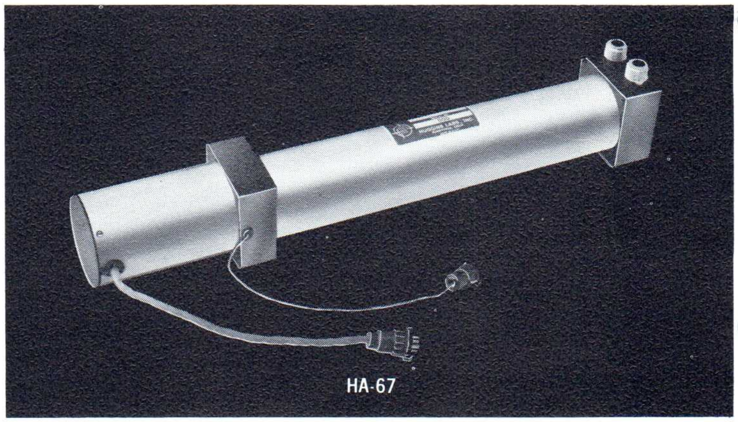
TRAVELING WAVE TUBES

VHF-BAND

	Focus	Type	Frequency (Gc)	Min S-S Gain (db)	Min Sat P_{OUT} (dbm)	Max Noise Fig (db)	Max I_K (ma)	Electrode Voltages, vdc Helix	Collector	Anode 1	Anode 2	Anode 3	Grid	Comments	Unit Price
LOW PWR AMP	PPM	HA-51[6]	0.25 to 0.5	20	17	25	10	150 to 250	350[2]	....	....	0 to 300	–50 to 0		$1,575
		HA-51D[6]	0.25 to 0.5	20	17	25	10	150 to 250	350[2]	....	....	0 to 300	–50 to 0	HUGGINS 200 (MPE 210)	1,575
		HA-51C[6]	0.25 to 0.5	20	17	20	10	150 to 250	350[2]	....	....	0 to 300	–50 to 0		1,575
		HA-51B[6]	0.3 to 0.4	25	17	20	10	150 to 250	350[2]	....	....	0 to 300	–50 to 0		1,675
MED PWR AMP	SOL	HA-8J[6]	0.3 to 0.5	25	30	30	70	400 to 600	400 to 600	....	....	0 to 500	0 to 200		$1,650
			0.3 to 0.4	25	30	30	70								
			0.4 to 0.5	30	30	30	70								

[2] Insulated Collector [6] Six to eight weeks delivery


HA-86


HA-67

UHF-BAND

	Focus	Type	Frequency (Gc)	Min S-S Gain (db)	Min Sat P_{OUT} (dbm)	Max Noise Fig (db)	Max I_K (ma)	Electrode Voltages, vdc Helix	Collector	Anode 1	Anode 2	Anode 3	Grid	Comments	Unit Price
LOW NOISE AMP	PPM	HA-67[8]	0.5 to 1.0	25	10	14	4.5	200 to 300	250 to 500[2]	150 to 350	0 to 50	0 to 50	–50 to 0		$2,500
		HA-67-1[8]	0.5 to 1.0	20	10	15	4.5	200 to 300	250 to 500[2]	....	....	75 to 300	–100 to 0		2,500
	SOL	HA-68[8]	0.5 to 1.0	25	3	6	2	75 to 120	300 to 500[2]	0 to 30	0 to 30	0 to 30	0 to 30		$3,250
		HA-86[8]	0.5 to 1.0	25	3	7	2	75 to 120	300 to 430[2]	0 to 30	0 to 30	0 to 30	0 to 30		3,000
		HA-86H[8]	0.5 to 1.0	25	3	7	2	75 to 120	300 to 430[2]	0 to 30	0 to 30	0 to 30	0 to 30	HUGGINS 101 (MPE TA-86)	3,000
		HA-86A[8]	0.8 to 1.2	25	0	7	2	75 to 120	350 to 430[2]	0 to 30	0 to 30	0 to 30	0 to 30		3,500
		HA-72[8]	0.5 to 1.0	25	3	8	2	70 to 120	270 to 400[2,5]	0 to 30	0 to 30	0 to 30	0 to 30		2,750
		HA-72A[8]	0.5 to 1.0	25	3	8	2	70 to 120	V_H + 300[2]	0 to 30	0 to 30	0 to 30	0 to 30	HUGGINS 102 (MPE TA-72)	2,750
		HA-72B[8]	0.5 to 1.1	25	0	8	2	70 to 120	380 to 500[2]	0 to 30	0 to 30	0 to 30	0 to 30		2,750
		HA-45[6]	0.5 to 1.0	25	5	10	2	75 to 120	270 to 400[2,5]	0 to 30	0 to 30	0 to 30	0 to 30		2,000
		HA-45D[6]	0.5 to 1.0	25	5	10	2	70 to 120	V_H + 300[2]	0 to 30	0 to 30	0 to 30	–50 to 50	HUGGINS 103 (MPE TA-45)	2,000
		HA-45E[6]	0.5 to 1.0	25	0	10	1.5	78 to 100	V_H + 300[2]	0 to 30	0 to 30	0 to 50	–50 to 50	ALFRED 5051	2,000
		HA-45B[6]	0.55 to 1.1	25	0	10	2	85 to 120	90 to 420[2]	0 to 30	0 to 30	0 to 30	–50 to 50		2,100
		HA-40[6]	0.5 to 1.0	25	5	15	2	75 to 120	270 to 400[2,5]	0 to 30	0 to 30	0 to 30	0 to 30		1,500
		HA-40MP[6]	0.5 to 1.0	25	5	15	2	70 to 120	V_H + 300[2]	0 to 30	0 to 30	0 to 30	–50 to 50	HUGGINS 104 (MPE TA-40)	1,500
LOW PWR AMP	PPM	HA-36[6]	0.5 to 1.0	25	13	25	8	180 to 300	180 to 300[2]	....	....	0 to 175	0[9]		$1,575
		HA-36N[6]	0.5 to 1.0	25	13	25	8	180 to 300	180 to 300[2]	....	....	0 to 175	0[9]	HUGGINS 203 (MPE 310)	1,575
		HA-36G[6]	0.8 to 1.2	30	10	25	6	180 to 260	180 to 260[2]	....	....	0 to 175	0[9]		1,575
	SOL	HA-7[6]	0.5 to 1.0	30	10	25	3.5	90 to 120	240 to 300[2,5]	....	....	0 to 100	0 to 5		$ 950
		HA-7E[6]	0.5 to 1.0	30	10	25	3.5	90 to 160	V_H + 150[2]	....	....	50 to 100	0 to 5	ALFRED 507	950
		HA-7G[6]	0.5 to 1.0	30	10	25	3.5	90 to 120	275[2]	....	....	0 to 100	0 to 5	HUGGINS 202 (MPE 307)	950
MED PWR AMP	PPM	HA-50[8]	0.5 to 1.0	30	30	25	65	400 to 500	400 to 500	....	....	0 to 500	0 to 200		$2,500
	SOL	HA-8[6]	0.5 to 1.0	30	30	25	60	400 to 500	400 to 500	....	....	0 to 500	0 to 200		$1,500
		HA-8-1[6]	0.5 to 1.0	30	33	30	70	400 to 600	400 to 600	....	....	0 to 500	0 to 200		1,650
		HA-8G[6]	0.5 to 1.0	30	30	25	60	400 to 500	400 to 500	....	....	0 to 500	0 to 200	HUGGINS 300 (MPE 308)	1,500

[2] Insulated Collector [5] Fixed anywhere within range [6] Six to eight weeks delivery [8] Eight to ten weeks delivery
[9] Negative voltage can be applied for RF attenuation

All Huggins TWT's and BWO's can be supplied to meet MIL-E-5400, Class II environmental specifications.

L-BAND

HA-80

HA-85

	Focus	Type	Frequency (Gc)	Min S-S Gain (db)	Min Sat P_{OUT} (dbm)	Max Noise Fig (db)	Max I_K (ma)	Electrode Voltages, vdc						Comments	Unit Price
								Helix	Collector	Anode 1	Anode 2	Anode 3	Grid		
LOW NOISE AMP	PPM	HA-85[8]	1.0 to 2.0	25	7	14	3	150 to 250	V_H+ 400[2]	0 to 100	0 to 100	0 to 150	–100 to 0		$2,500
		HA-85C[8]	1.0 to 2.0	25	7	14	3	150 to 250	V_H+ 400[2]	0 to 100	0 to 100	0 to 150	–100 to 0	HUGGINS 110 (MPE TA-85)	2,500
	SOL	HA-80[8]	1.0 to 2.0	25	5	7	2	165 to 200	V_H+ 350[2]	0 to 20	0 to 20	0 to 150	–25 to 25		$3,000
		HA-80C[8]	1.0 to 2.0	25	5	7	2	165 to 200	V_H+ 350[2]	0 to 20	0 to 20	0 to 150	–25 to 25	HUGGINS 106 (MPE TA-80)	3,000
		HA-73[8]	1.0 to 2.0	25	3	8	2	165 to 200	165 to 500[2]	0 to 20	0 to 20	0 to 150	–25 to 25		2,750
		HA-73D[8]	1.0 to 2.0	25	3	8	2	165 to 200	165 to 500[2]	0 to 20	0 to 20	0 to 150	–25 to 25	HUGGINS 107 (MPE TA-73)	2,750
		HA-14[8]	1.0 to 2.0	25	3	10	2	165 to 200	350 to 500[2,5]	0 to 20	0 to 20	0 to 120	–25 to 25		2,000
		HA-14A[8]	1.0 to 2.0	30	0	10	2	165 to 200	165 to 500[2]	0 to 20	0 to 20	0 to 100	–20 to 20		2,000
		HA-14MP[8]	1.0 to 2.0	25	3	10	2	165 to 200	165 to 350[2]	0 to 20	0 to 20	0 to 120	–20 to 20	HUGGINS 108 (MPE TA-14)	2,000
		HA-14J[8]	1.1 to 2.2	25	0	10	2	165 to 200	350 to 500[2,5]	0 to 20	0 to 20	0 to 120	–25 to 25		2,000
		HA-17[6]	1.0 to 2.0	25	5	15	2	165 to 200	350 to 500[2,5]	0 to 20	0 to 20	0 to 120	–25 to 25		1,500
		HA-17C[6]	1.0 to 2.0	25	0	14	1.5	165 to 200	V_H+ 280[2]	0 to 20	0 to 20	0 to 150	–25 to 25	ALFRED 5101	1,500
		HA-17D[6]	1.0 to 2.0	25	5	15	2	165 to 200	350 to 500[2,5]	0 to 20	0 to 20	0 to 120	–25 to 25	HUGGINS 109 (MPE TA-17)	1,500
		HA-19[4]	1.6 to 2.6	25	3	15	2	165 to 200	350 to 500[2,5]	0 to 20	0 to 20	0 to 120	–25 to 25		1,500
		HA-19D[4]	1.6 to 2.6	25	3	15	2	165 to 200	350 to 500[2,5]	0 to 20	0 to 20	0 to 120	–25 to 25	HUGGINS 112 (MPE TA-19)	1,500
LOW POWER AMP	PPM	HA-31[6]	1.0 to 2.0	30	10	25	6	180 to 220	180 to 220[2]	....	....	0 to 180	0[9]		$1,350
		HA-31J[6]	1.0 to 2.0	30	13	25	6	180 to 220	180 to 220[2]	....	....	0 to 180	0[9]		1,350
		HA-31C[6]	1.0 to 2.0	30	10	25	6	180 to 220	180 to 220[2]	....	....	0 to 180	0[9]	HUGGINS 205 (MPE 401)	1,350
	SOL	HA-5[4]	1.0 to 2.0	30	10	25	3.5	180 to 220	270 to 350[2,5]	....	....	0 to 150	0[9]		$ 850
		HA-5D[4]	1.0 to 2.0	30	10	24	3.5	170 to 230	V_H+ 150[2]	....	....	45 to 175	0[9]	ALFRED 505	850
		HA-5MP[4]	1.0 to 2.0	30	10	25	3.5	180 to 220	330 to 370[2]	....	....	0 to 150	0[9]	HUGGINS 207 (MPE 405)	850
		HA-22[4]	1.6 to 2.6	30	10	25	3.5	400 to 500	400 to 500[2]	....	....	0 to 400	0[9]		750
		HA-22AE[4]	1.6 to 2.6	30	10	25	3.5	425 to 525	425 to 525[2]	....	....	170 to 390	0[9]	ALFRED 522	750
		HA-22C[4]	1.6 to 2.6	30	10	25	3.5	400 to 500	400 to 500[2]	....	....	0 to 400	0[9]	HUGGINS 208 (MPE 422)	750
MEDIUM POWER AMP	PPM	HA-53[6]	1.0 to 2.0	30	33	30	75	800 to 1100	1200	....	....	300 to 600	0 to 100		$1,750
		HA-53L[6]	1.0 to 2.0	30	33	30	50	800 to 1000	1200[2]	....	....	200 to 600	–50 to 0		1,750
		HA-53H[6]	1.0 to 2.0	30	30	30	50	800 to 1000	1200[2]	....	....	200 to 600	–50 to 0	HUGGINS 324D	1,750
		HA-53J[6]	1.0 to 2.0	30	30	30	50	800 to 1000	1200	....	....	200 to 600	–50 to 0	HUGGINS 324 (MPE 412)	1,750
		HA-53F[6]	1.0 to 2.0	30	30	33	50	800 to 1000	500 to 1100[2]	....	....	200 to 600	–50 to 0		2,100
		HA-53C[6]	1.25 to 1.42	35	37	30	75	800 to 1100	1200	....	....	300 to 600	0 to 100		1,750
		HA-30B[4]	1.6 to 2.6	30	30	25	25	850 to 1250	850 to 1250	....	....	0 to 550	0[9]		1,350
	SOL	HA-18[8]	1.0 to 2.0	33	33	30	75	650 to 850	650 to 850	....	....	200 to 550	0 to 100		$1,000
		HA-18K[8]	1.0 to 2.0	33	33	30	50	650 to 850	650 to 850[2]	....	....	200 to 600	0[9]		1,000
		HA-18E[8]	1.0 to 2.0	30	33	30	75	650 to 850	650 to 850	....	....	100 to 500	0 to 100	HUGGINS 325 (MPE 418)	1,000
		HA-18L[8]	1.0 to 2.0	30	30	30	50	650 to 850	650 to 850[2]	....	....	200 to 600	0[9]	HUGGINS 325D	1,000
		HA-39[4]	1.6 to 2.6	30	30	25	25	850 to 1250	850 to 1250	....	....	0 to 450	0[9]		850
		HA-39C[4]	1.6 to 2.6	30	30	25	25	850 to 1250	850 to 1250	....	....	0 to 450	0[9]	HUGGINS 302 (MPE 439)	850

[2] Insulated Collector
[4] Four to six weeks delivery
[5] Fixed anywhere within range
[6] Six to eight weeks delivery
[8] Eight to ten weeks delivery
[9] Negative voltage can be applied for RF attenuation

All Huggins TWT's and BWO's can be supplied to meet MIL-E-5400, Class II environmental specifications.

HUGGINS LABORATORIES
manufacture development engineering design research

TRAVELING WAVE TUBES

S-BAND


HA-30


HA-89

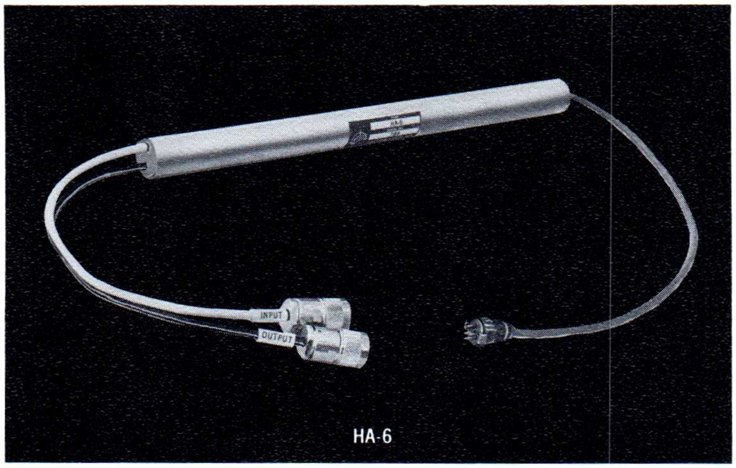
	Focus	Type	Frequency (Gc)	Min S-S Gain (db)	Min Sat P_{OUT} (dbm)	Max Noise Fig (db)	Max I_K (ma)	Electrode Voltages, vdc						Comments	Unit Price
								Helix	Collector	Anode 1	Anode 2	Anode 3	Grid		
LOW NOISE AMP	PPM	**HA-54[8]**	**2.0 to 4.0**	**25**	**5**	**15**	**2**	**400 to 500**	**600 to 800[2]**	**0 to 75**	**0 to 50**	**0 to 200**	**--200 to 0**		**$2,500**
		HA-54C[8]	2.0 to 4.0	30	7	17	2.5	425 to 550	600 to 800[2,5]	0 to 50	20 to 100	75 to 125	-150 to -50	Environmental Spec	2,650
	SOL	**HA-89[8]**	**2.0 to 4.0**	**25**	**10**	**8**	**2**	**375 to 450**	**V_H+ 400[2]**	**0 to 75**	**0 to 100**	**0 to 150**	**–75 to 0**		**$2,250**
		HA-89D[8]	2.0 to 4.0	25	10	8	2	375 to 450	850[2]	0 to 75	0 to 100	0 to 150	–75 to 0	HUGGINS 114 (MPE TA-89)	2,000
		HA-89E[8]	2.7 to 3.5	20	0	7	1.6	350 to 500	500[2]	0 to 75	0 to 150	0 to 150	–40 to 0		2,350
		HA-62[6,7]	**2.0 to 4.0**	**25**	**7**	**10**	**2**	**385 to 500**	**385 to 700[2]**	**0 to 75**	**0 to 150**	**0 to 150**	**–75 to 0**		**2,000**
		HA-62F[6]	2.0 to 4.0	25	7	10	2	385 to 500	385 to 700[2]	0 to 75	0 to 150	0 to 150	–75 to 0	HUGGINS 115 (MPE TA-62)	2,000
		HA-62E[6]	2.7 to 2.95	35	0	6.5	2	385 to 500	V_H+ 250[2]	0 to 50	0 to 100	0 to 150	–75 to 0		2,500
		HA-37[6,7]	**2.3 to 4.4**	**25**	**5**	**10**	**1.5**	**375 to 475**	**375 to 700[2]**	**0 to 50**	**0 to 80**	**0 to 150**	**–50 to 0**		**2,500**
		HA-37H[6]	2.3 to 4.4	25	5	10	1.5	375 to 475	375 to 700[2]	0 to 50	0 to 80	0 to 150	–50 to 0	HUGGINS 119 (MPE TA-37)	2,500
		HA-11[4]	**2.0 to 4.0**	**25**	**5**	**15**	**2**	**375 to 475**	**375 to 475[2]**	**0 to 50**	**0 to 80**	**0 to 150**	**–50 to 0**		**1,500**
		HA-11C[4]	2.0 to 4.0	25	5	15	2	385 to 500	V_H+ 250[2]	0 to 50	0 to 100	0 to 150	–75 to 0	HUGGINS 117 (MPE TA-74)	1,500
LOW POWER AMP	PPM	**HA-29[6]**	**2.0 to 4.0**	**30**	**10**	**30**	**4**	**400 to 525**	**400 to 525[2]**	....	....	**0 to 350**	**0[9]**		**$1,000**
		HA-29-1[6]	2.0 to 4.0	40	17	30	4	400 to 525	400 to 525[2]	....	....	0 to 350	0[9]		1,200
		HA-29AF[6]	2.0 to 4.0	40	10	24	5	550 to 700	550 to 700[2]	....	....	150 to 350	0[9]	Environmental Spec	1,200
		HA-29A[6]	2.0 to 4.0	30	10	25	4	400 to 525	400 to 525[2]	....	....	0 to 350	0[9]	HUGGINS 210 (MPE 510)	1,000
		HA-29-2[6]	2.0 to 4.0	35	10	30	5	550 to 700	700[2]	....	....	135 to 235	0[9]		1,100
		HA-29-3[6]	2.3 to 2.7	30	10	20	4	400 to 525	400 to 525[2]	....	....	0 to 350	–20 to 0		1,000
		HA-29AD[6]	2.5 to 3.5	40	20	30	5	550 to 700	700[2]	....	....	135 to 235	0[9]		1,200
		HA-29S[6]	3.0 to 5.0	30	10	30	4	550 to 700	550 to 700[2]	....	....	0 to 350	0[9]		1,200
	SOL	**HA-1[4]**	**2.0 to 4.0**	**30**	**10**	**25**	**3.5**	**400 to 525**	**400 to 525[2]**	....	....	**0 to 350**	**0[9]**		**$ 750**
		HA-1D[4]	2.0 to 4.0	30	10	25	3.5	400 to 500	400 to 500[2]	....	....	170 to 390	0[9]	ALFRED 501	750
		HA-1HP[4]	2.0 to 4.0	30	10	25	4	400 to 525	400 to 525[2]	....	....	150 to 350	0[9]		750
		HA-1MP[4]	2.0 to 4.0	30	10	25	3.5	400 to 525	400 to 525[2]	....	....	0 to 350	0[9]	HUGGINS 209 (MPE 501)	750
MEDIUM POWER AMP	PPM	**HA-30[4]**	**2.0 to 4.0**	**30**	**30**	**25**	**25**	**800 to 1100**	**800 to 1100**	....	....	**0 to 450**	**0[9]**		**$1,350**
		HA-30-1[4]	2.0 to 4.0	40	30	25	25	800 to 1100	800 to 1100	....	....	0 to 450	0[9]		1,450
		HA-30AA[4]	2.0 to 4.0	35	30	20	25	800 to 1100	800 to 1100[2]	....	....	0 to 450	0[9]	HUGGINS 304D	1,350
		HA-30-2[4]	2.0 to 4.0	35	30	25	25	800 to 1100	600	....	....	0 to 450	0[9]	Conduction Cooled	1,450
		HA-30A[4]	2.0 to 4.0	30	30	25	25	800 to 1100	800 to 1100	....	....	0 to 450	0[9]	HUGGINS 304 (MPE 512)	1,350
		HA-30M[4]	1.84 to 3.84	30	30	30	20	800 to 1100	800 to 1100	....	....	250 to 450	0[9]	Environmental Spec	1,525
		HA-30P[4]	2.55 to 2.70	30	33	25	25	800 to 1100	800 to 1100	....	....	0 to 450	0[9]		1,350
		HA-30C[4]	2.9 to 3.1	50	30	30	25	800 to 1100	800 to 1100	....	....	0 to 450	0[9]		1,350
	SOL	**HA-2[4]**	**2.0 to 4.0**	**30**	**30**	**25**	**25**	**800 to 1100**	**800 to 1100**	....	....	**0 to 450**	**0[9]**		**$ 850**
		HA-2L[4]	2.0 to 4.0	30	32	25	25	800 to 1100	800 to 1100	....	....	0 to 450	0[9]		850
		HA-2D[4]	2.0 to 4.0	30	30	25	20	800 to 1100	800 to 1100	....	....	225 to 435	0[9]	ALFRED 502	850
		HA-2E[4]	2.0 to 4.0	30	30	25	20	800 to 1000	800 to 1000	....	....	225 to 435	....	ALFRED 502A	850
		HA-2F[4]	2.0 to 4.0	30	30	25	25	800 to 1100	800 to 1100	....	....	0 to 450	0[9]	HUGGINS 303 (MPE 502)	850
		HA-2G[4]	2.0 to 4.0	30	30	25	25	800 to 1100	800 to 1100	....	....	0 to 450	....	HUGGINS 303, No grid	850
		HA-2HP[4]	2.0 to 4.0	30	27	30	25	800 to 1100	V_H+ 150	....	....	200 to 450	....		850
		HA-2HPA[4]	2.0 to 4.0	30	27	30	25	800 to 1100	V_H+ 150	....	....	200 to 450	....		850
BEAM PULSED AMP	PPM (0.1 max dty cycle)	**PA-10[8]**	**2.0 to 4.0**	**30**	**37[1]**	....	**60[1]**	**900 to 1100**	**900 to 1100**	....	....	**450 to 700[3]**	....		**$2,500**
		PA-10C[8]	2.0 to 4.0	30	37[1]	....	60[1]	900 to 1100	900 to 1100	....	....	450 to 700[3]	....	HUGGINS 404 (MPE 514)	2,500
		PA-6[4]	**2.0 to 4.0**	**30**	**30[1]**	....	**50[1]**	**800 to 1000**	**800 to 1000**	....	....	**0 to 600**	**0 to 150[3]**		**1,575**
		PA-6E[4]	2.0 to 4.0	30	30[1]	....	50[1]	800 to 1000	800 to 1000	....	....	0 to 600	0 to 150[3]	HUGGINS 307 (MPE 506)	1,575
		PA-6D[4]	2.3 to 2.7	30	33[1]	....	40[1]	800 to 1000	800 to 1000	....	....	50 to 500	50 to 125[3]		1,675
	SOL (0.1 max dty cycle)	**PA-3[4]**	**2.0 to 4.0**	**30**	**40[1]**	....	**60[1]**	**900 to 1100**	**900 to 1100[2]**	....	....	**0 to 600[3]**	....		**$1,250**
		PA-3C[4]	2.0 to 4.0	30	40[1]	....	60[1]	900 to 1100	900 to 1100[2]	....	....	0 to 600[3]	....	HUGGINS 403 (MPE 503)	1,250
		PA-4[4]	**2.0 to 4.0**	**33**	**30[1]**	....	**50[1]**	**800 to 950**	**800 to 950[2]**	....	....	**200 to 700**	**0 to 150[3]**		**1,000**
		PA-4A[4]	2.0 to 4.0	30	30[1]	....	45[1]	800 to 1000	800 to 1000[2]	....	....	0 to 435	0 to 150[3]	ALFRED 512	1,000
		PA-4MP[4]	2.0 to 4.0	30	30[1]	....	60[1]	800 to 1000	800 to 1000[2]	....	....	200 to 600	0 to 150[3]	HUGGINS 306 (MPE 504)	1,000

[1] Peak Values
[2] Insulated Collector
[3] Modulating Electrode
[4] Four to six weeks delivery
[5] Fixed anywhere within range
[6] Six to eight weeks delivery
[7] Sold for replacement
[8] Eight to ten weeks delivery
[9] Negative voltage can be applied for RF attenuation

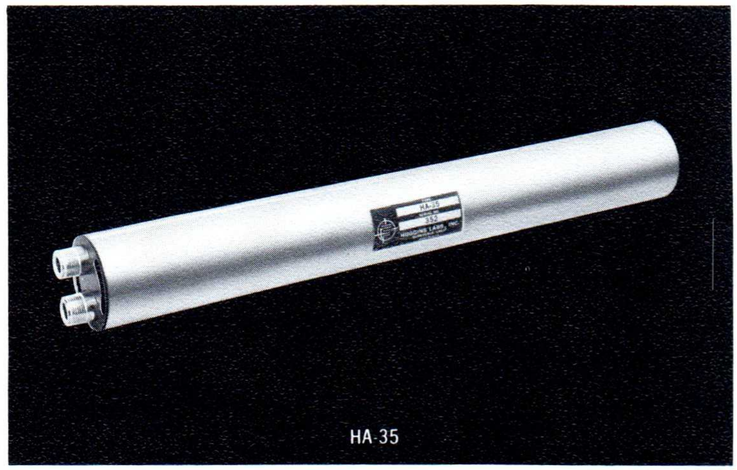
All Huggins TWT's and BWO's can be supplied to meet MIL-E-5400, Class II environmental specifications.

THE INDUSTRY'S broadest line

C-BAND



HA-6



HA-35

	Focus	Type	Frequency (Gc)	Min S-S Gain (db)	Min Sat P_{OUT} (dbm)	Max Noise Fig (db)	Max I_K (ma)	Electrode Voltages, vdc: Helix	Collector	Anode 1	Anode 2	Anode 3	Grid	Comments	Unit Price
LOW NOISE AMP	PPM	**HA-84**	**4.0 to 8.0**	**25**	**7**	**15**	....	....	....	....	....	....	....	**Under Development**	**$ ....**
	SOL	**HA-47[6]**	**4.0 to 8.0**	**25**	**3**	**10**	**2**	**500 to 700**	**700 to 800[2]**	**0 to 100**	**0 to 150**	**0 to 500**	**–150 to 0**		**$2,000**
		HA-47C[6]	4.0 to 8.0	25	3	10	2	500 to 700	500 to 800[2]	0 to 100	0 to 150	0 to 500	–150 to 0	HUGGINS 120 (MPE TA-47)	2,000
		HA-47E[6]	5.1 to 5.9	35	0	7	2	500 to 700	700 to 850[2]	0 to 100	0 to 150	0 to 500	–150 to 0		2,250
		HA-32[6]	**4.0 to 8.0**	**25**	**5**	**15**	**2**	**500 to 700**	**700 to 800[2,5]**	**0 to 100**	**0 to 150**	**0 to 500**	**–150 to 0**		**1,500**
		HA-32MP[6]	4.0 to 8.0	25	5	15	3	500 to 800	500 to 1000[2]	0 to 100	0 to 150	0 to 500	–150 to 0	HUGGINS 121 (MPE TA-32)	1,500
		HA-32B[6]	5.1 to 5.9	40	0	11	2	500 to 700	700 to 850[2]	0 to 100	0 to 150	0 to 500	–150 to 0		1,750
LOW POWER AMP	PPM	**HA-28[6]**	**4.0 to 8.0**	**30**	**10**	**30**	**2.5**	**650 to 800**	**650 to 800[2]**	....	....	**0 to 450**	**0[9]**		**$1,125**
		HA-28-1[6]	4.0 to 8.0	30	10	30	2.5	650 to 800	650 to 800[2]	....	....	0 to 450	0[9]		1,125
		HA-28A[6]	4.0 to 8.0	30	10	30	2.5	650 to 800	650 to 800[2]	....	....	0 to 450	0[9]	HUGGINS 212 (MPE 610)	1,125
		HA-28G[6]	4.0 to 8.2	30	10	30	2.5	650 to 800	650 to 800[2]	....	....	0 to 450	0[9]		1,238
		HA-28K[6]	5.0 to 6.0	46	16	25	2.5	650 to 800	650 to 800[2]	....	....	0 to 450	0[9]		1,125
	SOL	**HA-26[4]**	**4.0 to 8.0**	**30**	**10**	**25**	**2.5**	**650 to 800**	**650 to 800[2]**	....	....	**0 to 450**	**0[9]**		**$ 800**
		HA-26HP[4]	4.0 to 8.0	30	13	25	2.75	650 to 800	650 to 800[2]	....	....	0 to 450	0[9]		800
		HA-26HPA[4]	4.0 to 8.0	30	13	25	2.75	650 to 800	650 to 800[2]	....	....	0 to 450	0[9]		800
		HA-26MP[4]	4.0 to 8.0	30	10	25	2.5	650 to 800	650 to 800[2]	....	....	0 to 450	0[9]	HUGGINS 214 (MPE 626)	800
		HA-26D[4]	4.0 to 8.0	30	10	24	3.2	600 to 800	600 to 800[2]	....	....	150 to 435	0[9]	ALFRED 503, S/N 26 and up	800
		HA-26E[4]	4.0 to 8.0 4.4 to 5.6	30 30	10 13	24 24	3.2 3.2	600 to 800	600 to 800[2]	....	....	150 to 435	0[9]	ALFRED 503	800
		HA-26B[4]	5.6 to 5.9	30	16	25	2.5	650 to 800	650 to 800[2]	....	....	0 to 450	0[9]		800
MEDIUM POWER AMP	PPM	**HA-35[6]**	**4.0 to 8.0**	**30**	**27**	**30**	**20**	**1300 to 1600**	**1300 to 1600**	....	....	**0 to 700**	**0[9]**		**$2,000**
		HA-35-1[6]	4.0 to 8.0	30	27	30	25	1300 to 1600	700	....	....	0 to 700	0[9]	Conduction Cooled	2,250
		HA-35A[6]	4.0 to 8.0 4.5 to 7.5	30 30	27 30	30 30	20 20	1300 to 1500	1300 to 1500	....	....	0 to 700	0[9]	HUGGINS 309 (MPE 611)	2,000
		HA-35AL[6]	4.0 to 8.0	30	27	30	20	1300 to 1600	1300 to 1600[2]	....	....	0 to 700	0[9]		2,000
		HA-35AF[6]	3.8 to 6.5	30	30	30	20	1300 to 1600	1300 to 1600	....	....	0 to 700	0[9]		2,000
		HA-35S[6]	4.4 to 5.0	40	30	30	20	1300 to 1600	700	....	....	0 to 700	0[9]	Conduction Cooled	2,100
		HA-35AD[6]	5.3 to 6.5	40	30	30	20	1300 to 1500	1300 to 1500	....	....	0 to 700	0[9]		2,000
	SOL	**HA-6[4]**	**4.0 to 8.0**	**30**	**27**	**30**	**20**	**1200 to 1500**	**1200 to 1500**	....	....	**0 to 700**	**0[9]**		**$1,000**
		HA-6G[4]	4.0 to 8.0	30	30	30	20	1200 to 1500	1200 to 1500	....	....	0 to 705	....	HUGGINS 308 (MPE 606)**	1,000
		HA-6AD[4]	4.0 to 8.0	30	30	30	20	1200 to 1500	1200 to 1500	....	....	0 to 705	0[9]	HUGG 308 (MPE 606) BS-4C	1,000
		HA-6AF[4]	4.0 to 8.0	30	30	30	20	1200 to 1500	1200 to 1500	....	....	0 to 705	0[9]	HUGGINS 308 (MPE 606)	1,000
		HA-6Y[4]	4.0 to 8.0 4.5 to 7.5	30 30	27 30	30 30	20 20	1200 to 1600	1200 to 1600	....	....	352 to 650	....	ALFRED 506, S/N 90 and up	1,000
		HA-6E[4]	4.0 to 8.0 4.5 to 7.5	30 30	27 30	30 30	20 20	1200 to 1600	1200 to 1600	....	....	352 to 650	....	ALFRED 506, S/N 11 to 89	1,000
		HA-6P[4]	5.0 to 6.0	30	33	30	20	1200 to 1500	1200 to 1500	....	....	0 to 705	0[9]		1,000
		HA-6T[4]	7.0 to 8.5	27	27	30	20	1200 to 1500	1200 to 1500	....	...	0 to 700	0[9]	S-S G Fine Grain: ±.25db	1,000
BEAM PULSED AMP	PPM (0.1 max duty cycle)	**PA-8[6]**	**4.0 to 8.0**	**30**	**30[1]**	....	**60[1]**	**1200 to 1600**	**1200 to 1600**	....	....	**0 to 600**	**0 to 150[3]**		**$2,475**
		PA-8C[6]	4.0 to 8.0	30	30[1]	....	60[1]	1200 to 1600	1200 to 1600	....	....	0 to 600	0 to 150[3]	HUGGINS 312 (MPE 612)	2,475
	SOL (0.1 max duty cycle)	**PA-7[4]**	**4.0 to 8.0**	**30**	**30[1]**	....	**60[1]**	**1200 to 1600**	**1200 to 1600**	....	....	**0 to 600**	**0 to 150[3]**		**$1,250**
		PA-7D[4]	4.0 to 8.0	30	30[1]	....	60[1]	1200 to 1600	1200 to 1600[2]	....	....	0 to 600	0 to 150[3]	HUGGINS 311 (MPE 607)	1,250

[1] Peak Values
[2] Insulated Collector
[3] Modulating Electrode
[4] Four to six weeks delivery
[5] Fixed anywhere within range
[6] Six to eight weeks delivery
[9] Negative voltage can be applied for RF attenuation
** No Grid

All Huggins TWT's and BWO's can be supplied to meet MIL-E-5400, Class II environmental specifications.

HUGGINS LABORATORIES
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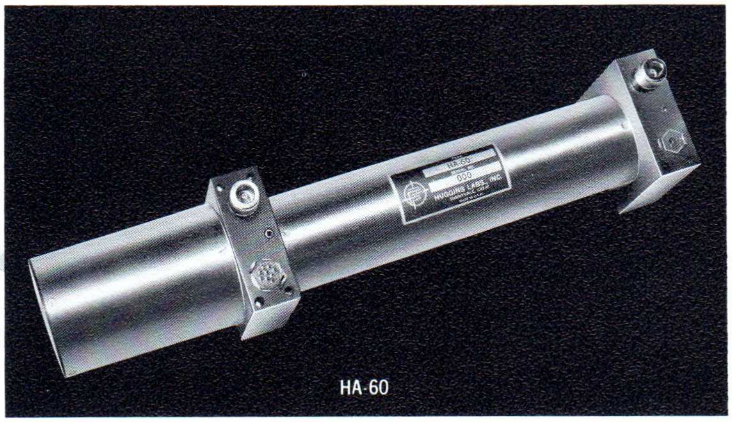
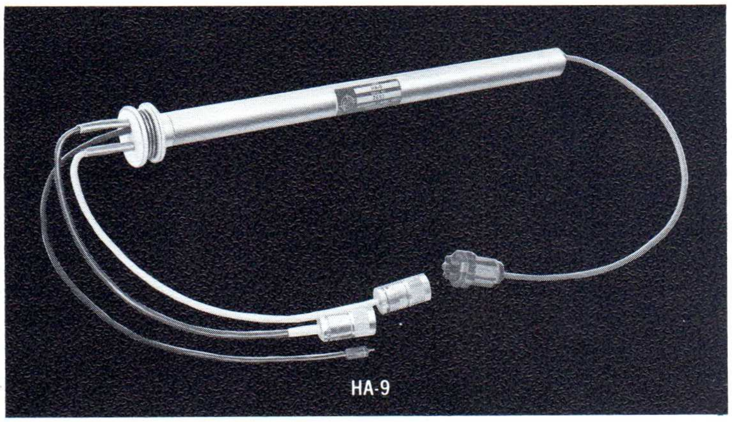
TRAVELING WAVE TUBES

X-BAND


HA-60


HA-9

	Focus	Type	Frequency (Gc)	Min S-S Gain (db)	Min Sat P_{OUT} (dbm)	Max Noise Fig (db)	Max I_K (ma)	Electrode Voltages, vdc						Comments	Unit Price
								Helix	Collector	Anode 1	Anode 2	Anode 3	Grid		
LOW NOISE AMP	PPM	**HA-60[8]**	**7.0 to 11.0**	**25**	**10**	**15**	**1.5**	**1050 to 1250**	**1300[2]**	**0 to 150**	**50 to 250**	**150 to 500**	**–100 to 0**		**$2,500**
		HA-60D[8]	7.0 to 11.0	25	10	15	1.5	1050 to 1250	1300[2]	0 to 150	50 to 250	150 to 500	–100 to 0	HUGGINS 123 (MPE TA-60)	2,500
	SOL	**HA-23[6]**	**8.2 to 12.4**	**25**	**5**	**10**	**2**	**1050 to 1250**	**1050 to 1250[2]**	**0 to 100**	**0 to 150**	**0 to 500**	**–50 to 0**		**$2,000**
		HA-23T[6]	7.0 to 12.0	25	0	11	2	1050 to 1250	V_H + 300[2]	0 to 100	0 to 150	0 to 450	–50 to 0		2,250
		HA-23H[6]	8.0 to 11.0	25	5	10	2	1050 to 1250	1050 to 1450[2]	0 to 100	0 to 150	0 to 450	–50 to 0	HUGGINS 125 (MPE TA-23)	2,000
		HA-23M[6]	8.0 to 12.0	25	0	10	2	1050 to 1250	V_H + 300[2]	0 to 100	0 to 150	0 to 500	–50 to 0		2,000
		HA-23AA[6]	8.5 to 9.5	25	0	8	2	1050 to 1250	1080 to 1500[2]	0 to 100	0 to 150	0 to 500	–50 to 0		2,000
		HA-61[6]	**7.0 to 14.0**	**25**	**0**	**15**	**2**	**1000 to 1300**	**1000 to 1500[2]**	**0 to 150**	**0 to 150**	**0 to 500**	**–50 to 0**		**2,000**
		HA-61A[6]	7.0 to 14.0	25	0	15	2	1000 to 1300	1000 to 1500[2]	0 to 150	0 to 150	0 to 500	–50 to 0	HUGGINS 124 (MPE TA-61)	2,000
		HA-44[6]	**8.2 to 12.4**	**25**	**0**	**15**	**2**	**1050 to 1250**	**1050 to 1250[2]**	**0 to 100**	**0 to 150**	**0 to 500**	**–50 to 0**		**1,500**
		HA-44E[6]	8.2 to 12.4	25	3	15	1.5	1000 to 1300	1000 to 1300[2]	0 to 100	0 to 150	0 to 450	–50 to 0	HUGGINS 128 (MPE TA-44)	1,500
MEDIUM POWER AMP	PPM	**HA-20[6]**	**8.0 to 12.4**	**30**	**10**	**30**	**2.5**	**1100 to 1300**	**1100 to 1300[2]**	....	....	**0 to 450**	**0[9]**		**$1,250**
		HA-20-1[6]	8.0 to 12.4	30	10	30	2.5	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]		1,250
		HA-20AU[6]	8.0 to 12.4	30	10	30	2.5	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]	HUGGINS 217 (MPE 702)	1,250
		HA-20BH[6]	7.0 to 10.0	30	10	27	2.5	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]		1,250
		HA-20BP[6]	7.0 to 11.0	33	10	30	3	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]		1,250
		HA-20AL[6]	7.5 to 11.0	30	10	25	2.5	1100 to 1350	1100 to 1850[2]	....	....	0 to 450	–15 to 0	△ S-S Gain ±2db	2,650
	SOL	**HA-4[4]**	**8.0 to 12.4**	**30**	**10**	**25**	**2.5**	**1100 to 1300**	**1100 to 1300[2]**	....	....	**0 to 450**	**0[9]**		**$ 850**
		HA-4MP[4]	8.0 to 12.4	30	10	25	2	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]	HUGGINS 215 (MPE 704)	850
		HA-4AE[4]	8.0 to 12.4	30	10	25	2.5	1100 to 1300	1100 to 1300[2]	....	....	180 to 435	0[9]	ALFRED 504, S/N 11 to 75	850
		HA-4D[4]	8.0 to 12.4	30	10	25	2.5	1100 to 1300	1100 to 1300[2]	....	....	180 to 435	0[9]	ALFRED 504, S/N 76 and up	850
		HA-4AB[4]	7.0 to 12.4	35	10	25	2.5	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]		850
		HA-4AD[4]	7.0 to 12.4	30	13	30	3	1100 to 1300	1100 to 1300[2]	....	....	150 to 450	0[9]		950
		HA-4HP[4]	7.0 to 12.4	30	13	25	2	1100 to 1250	1100 to 1250[2]	....	....	0 to 450	0[9]		850
		HA-4HPA[4]	7.0 to 12.4	30	13	25	2	1100 to 1250	1100 to 1250[2]	....	....	0 to 450	0[9]		850
LOW POWER AMP	PPM	**HA-21[6]**	**8.0 to 11.0**	**33**	**27**	**35**	**20**	**2000 to 2400**	**2000 to 2400**	....	....	**1000 to 2200**	**0[9]**		**$2,500**
		HA-21AH[6]	8.0 to 11.0 8.0 to 10.0	33 33	27 30	35 35	20 20	2000 to 2400	2000 to 2400	....	....	1000 to 2200	0[9]	HUGGINS 315 (MPE 712)	2,500
		HA-21E[6]	8.0 to 12.0	30	27	40	20	2000 to 2400	2000 to 2400	....	....	0 to 2200	0[9]		2,500
		HA-21L[6]	7.5 to 11.2	30	27	40	20	2000 to 2400	2000 to 2400	....	....	0 to 2200	0[9]		2,800
		HA-21AA[6]	8.5 to 10.0	45[5]	30[5]	35	20	2100 to 2300	2100 to 2300	....	....	1000 to 1500	0[9]	Environmental Spec	2,700
		HA-71[8]	**8.0 to 12.4**	**25**	**20**	**30**	**8**	**2000 to 2300**	**2000 to 2300**	....	....	**0 to 800**	**0[9]**		**1,600**
		HA-71C[8]	8.0 to 12.4	25	20	30	8	2000 to 2300	2000 to 2300	....	....	0 to 800	0[9]	HUGGINS 319 (MPE 711)	1,600
	SOL	**HA-9[6]**	**8.0 to 11.0**	**33**	**27**	**35**	**20**	**2000 to 2400**	**2000 to 2400[2]**	....	....	**1000 to 1800**	**0[9]**		**$1,500**
		HA-9E[6]	8.0 to 11.0	30	27	35	20	2000 to 2400	2000 to 2400[2]	....	....	0 to 1800	0[9]	HUGGINS 314 (MPE 709)	1,500
		HA-9G[6]	8.0 to 11.0	30	27	35	20	1900 to 2400	1900 to 2400[2]	....	....	0 to 2350	0[9]	ALFRED 509	1,500
		HA-9P[6]	7.0 to 11.0	30	27	35	20	2000 to 2400	2000 to 2400[2]	....	....	0 to 1800	0[9]		1,700
		HA-9K[6]	7.4 to 8.5	30	30	35	20	1900 to 2400	1900 to 2400[2]	....	....	0 to 2350	0[9]		1,500
		HA-9L[6]	8.0 to 9.6	30	32	35	20	2000 to 2400	2000 to 2400[2]	....	....	0 to 1800	0[9]		1,500
		HA-10[4]	**8.0 to 12.4**	**25**	**20**	**30**	**8**	**2000 to 2300**	**2000 to 2300**	....	....	**0 to 800**	**0[9]**		**1,000**
		HA-10D[4]	8.0 to 12.4	25	20	30	8	1900 to 2300	1900 to 2300	....	....	0 to 580	0[9]	HUGGINS 318 (MPE 710)	1,000
		HA-10E[4]	8.0 to 12.4	24	20	30	8	1900 to 2300	1900 to 2300	....	....	350 to 580	....	ALFRED 510	1,000
		HA-10M[4]	7.0 to 12.4 7.0 to 8.2 8.2 to 12.4	20 20 25	20 20 20	30 30 30	8 8 8	1900 to 2400	1900 to 2400	....	....	0 to 700	0[9]		1,000
		HA-10C[4]	8.4 to 9.6	27	27	30	8	1900 to 2300	1900 to 2300	....	....	350 to 580	....		1,000
BEAM PULSED	SOL (0.1 max duty cycle)	**PA-5[6]**	**8.0 to 12.4**	**30**	**25[1]**	....	**50[1]**	**1800 to 2300**	**1800 to 2300**	....	....	**0 to 750**	**0 to 250[3]**		**$1,250**

[1] Peak Values
[2] Insulated Collector
[3] Modulating Electrode
[4] Four to six weeks delivery
[5] Under input RF pulsed conditions
[6] Six to eight weeks delivery
[8] Eight to ten weeks delivery
[9] Negative voltage can be applied for RF attenuation

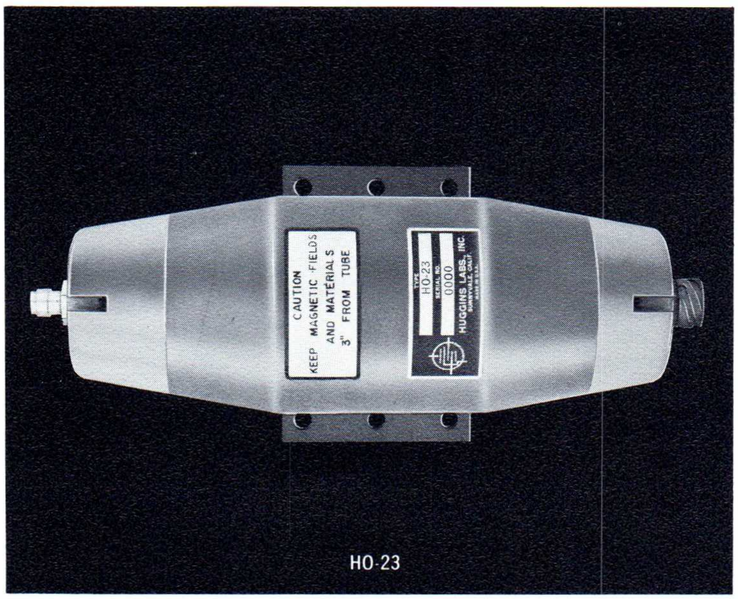
All Huggins TWT's and BWO's can be supplied to meet MIL-E-5400, Class II environmental specifications.

Ku-BAND

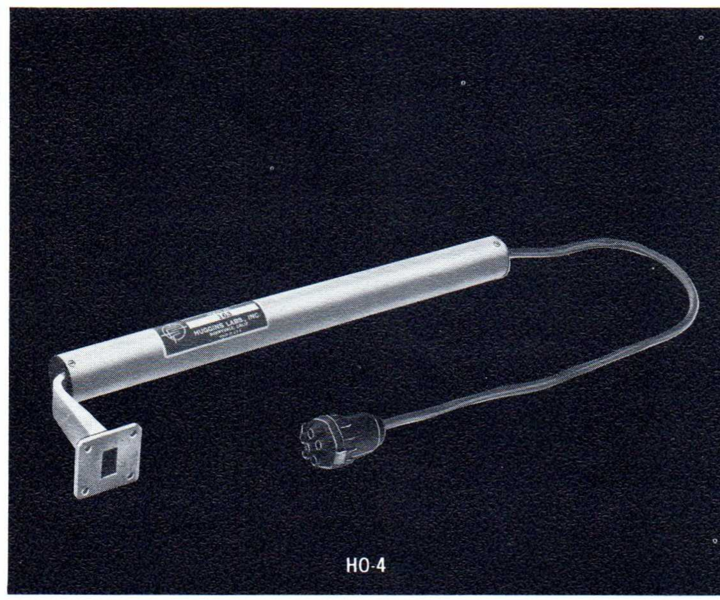
	Focus	Type	Frequency (Gc)	Min S-S Gain (db)	Min Sat P_{OUT} (dbm)	Max Noise Fig (db)	Max I_K (ma)	Electrode Voltages, vdc: Helix	Collector	Anode 1	Anode 2	Anode 3	Grid	Comments	Unit Price
LOW PWR AMP	SOL	HA-4-1[4]	7.0 to 14.0	30	7	30	2.5	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]		$ 900
		HA-24[4]	**12.4 to 16.0**	**25**	**7**	**30**	**2.5**	**1100 to 1300**	**1100 to 1300[2]**	....	....	**0 to 450**	**0[9]**		**1,000**
		HA-24-1[4]	7.0 to 15.0	25	7	30	2.5	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]		1,000
		HA-24A[4]	12.4 to 16.0	25	7	30	2.5	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]	HUGGINS 219 (MPE 824)	1,000
		HA-24B[4]	12.4 to 16.0	20	7	30	2.5	1100 to 1300	1100 to 1300[2]	....	....	0 to 450	0[9]		1,000

[2] Insulated Collector   [4] Four to six weeks delivery   [9] Negative voltage can be applied for RF attenuation

All Huggins TWT's and BWO's can be supplied to meet MIL-E-5400, Class II environmental specifications.



HO-23



HO-4

BACKWARD WAVE OSCILLATORS

Band	Focus	Type	Frequency (Gc)	Minimum Power Out (mw)	Maximum ΔP_{OUT} (db)	Maximum Spurious Output (db down)	Maximum I_K (ma)	Electrode Voltages, vdc: Helix	Collector	Anode	Grid	Comments	Unit Price
L	PM	HO-26	1.0 to 2.0	50	6	60	25	200 to 1500	200 to 1500	0 to 200	0	Under Development	$ ....
	SOL	HO-9[6]	1.0 to 2.0	10	8	40	25	200 to 2800	200 to 2800	40 to 200	**		1,500
S	PM	HO-25	2.0 to 4.0	50	6	60	25	200 to 1500	200 to 1500	0 to 200	0	Under Development	$ ....
	SOL	HO-1[4]	2.0 to 4.0	10	8	50	15	200 to 3400	200 to 3400	0 to 300	**		1,000
		HO-18[4]	2.0 to 4.0	1	9	50	15	200 to 3400	200 to 3400	0 to 300	**		750
C	PM	HO-24	4.0 to 8.0	50	6	60	25	200 to 1500	200 to 1500	0 to 200	0	Under Development	$ ....
	SOL	HO-20[6]	3.75 to 7.0	10	8	40	12	350 to 2600	350 to 2600	40 to 300	**		$1,000
		HO-3[4]	3.75 to 7.0	1	8	40	12	350 to 2600	350 to 2600	0 to 300	**		750
		HO-21[6]	4.0 to 8.0	10	8	40	12	240 to 2400	240 to 2400	40 to 300	**		1,000
		HO-13[4]	4.0 to 8.0	1	8	40	12	240 to 2400	240 to 2400	40 to 300	**		750
X	PM	HO-23[6]	7.0 to 11.0 8.2 to 12.4	50	4	60	16	350 to 2000	350 to 2000	0 to 350	0	Insulated Collector Available	$1,300
	SOL	HO-17[4]	7.0 to 11.0	1	6	50	10	350 to 2000	350 to 2000	0 to 300	**		750
		HO-2[6]	8.2 to 12.4	10	5	50	12	350 to 2000	350 to 2000	0 to 350	**		1,000
		HO-14[4]	8.2 to 12.4	1	5	50	12	350 to 2000	350 to 2000	0 to 350	**		750
Ku	SOL	HO-19[4]	12.0 to 18.0	1	6	50	10	400 to 2200	400 to 2200	0 to 350	**		1,250
		HO-4[4]	12.4 to 18.0	10	5	50	10	450 to 2200	450 to 2200	0 to 350	**		1,500
		HO-4HP[4]	12.4 to 18.0	10	5	50	10	450 to 2300	450 to 2300[2]	0 to 250	**		1,500

[2] Insulated Collector   [4] Four to six weeks delivery   [6] Six to eight weeks delivery   ** No Grid

All Huggins TWT's and BWO's can be supplied to meet MIL-E-5400, Class II environmental specifications.

HUGGINS manufacture development engineering design research LABORATORIES

TRAVELING WAVE TUBES

NOISE GENERATORS

Band	Focus	Type	Frequency (Gc)	Minimum S-S Gain (db)	Minimum Saturation Power Out (dbm)	Minimum Brdband Noise Out (dbm)	Maximum Cathode Current (ma)	Electrode Voltages, vdc: Helix	Collector	Anode	Grid	Comments	Unit Price
L	PPM	HA-31R[1,6]	1.0 to 1.5	35	7	....	10	180 to 250	180 to 250[2]	0 to 180	0	In cascade, broadband noise out is 0 dbm minimum	$1,350
		HA-31P[6]	1.0 to 1.5	35	7	....	10	180 to 250	180 to 250[2]	0 to 180	0		1,350
		HA-53E[6]	1.0 to 1.5	30	33	....	75	700 to 1000	1200	300 to 600	0 to 100	When cascaded with HA-31R and P, brdbnd noise is 33 dbm min	1,750
S	PPM	HA-29U[1,6]	2.0 to 4.0	33	....	—10	5	400 to 525	400 to 525[2]	0 to 350	0	In cascade, broadband noise out is 7 dbm minimum	$1,000
		HA-29Y[6]	2.0 to 4.0	33	10	....	5	400 to 525	400 to 525[2]	0 to 350	0		1,000
		HA-29T[1,6]	2.0 to 3.6	40	7	—5	4	400 to 525	400 to 525[2]	0 to 350	0	In cascade, broadband noise out is 30 dbm minimum	1,000
		HA-30S[6]	2.2 to 3.6	40	30	....	25	800 to 1100	800 to 1100	0 to 450	0		1,350
C	SOL	HA-26L[4]	5.85 to 6.0	**	10	**	3	650 to 800	650 to 800[2]	0 to 450	0	Operated with input terminated	$900

SERRODYNE TUBES

Band	Focus	Type	Frequency (Gc)	Maximum S-S Gain (db)	Minimum Saturation Power Out (dbm)	Minimum Sideband Suppression at 150 Kc (db)	Maximum Cathode Current (ma)	Electrode Voltages, vdc: Helix	Collector	Anode	Grid	Unit Price
C	PPM	HA-28-2[6]	5.0 to 6.5	30	10	33	2.5	600 to 800	600 to 800[2]	0 to 450	0	$1,200
	SOL	HA-26-1[4]	5.0 to 6.0	25	10	33	2.5	600 to 800	600 to 800[2]	0 to 450	0	$ 950
		HA-4F[4]	7.5 to 8.5	18	9[10]	33	3	1050 to 1275	$V_H +$ 200[2]	0 to 370	0	1,100
X	PPM	HA-20BN[6]	7.0 to 12.4	25	10	30	3	1100 to 1300	1100 to 1300[2]	0 to 450	0	$1,400
		HA-20G[6]	10.25 to 10.5	20	10	33	3	900 to 1400	900 to 1400[2]	0 to 500	—25 to 0	1,350
	SOL	HA-4Y[4]	9.0 to 10.0	30	10	20	3	1050 to 1275	1050 to 1275[2]	0 to 450	0	$1,100
		HA-4E[4]	9.0 to 10.2	15	7	33	2	900 to 1400	900 to 1400[2]	0 to 450	—50 to 0	1,100
		HA-4G[4]	10.0 to 10.5	18	3	33	2	900 to 1400	900 to 1400[2]	0 to 450	—50 to 0	1,100

FREQUENCY MULTIPLIERS

Band	Focus	Type	Frequency, Gc: Input	Output	Min Conv Gain (db)	Minimum Saturation Power Out (dbm)	Max Noise Figure (db)	Max Cathode Current (ma)	Electrode Voltages, vdc: Helix 1	Helix 2	Collector	Anode	Grid	Unit Price
UHF to S	SOL	HA-34[6]	0.4 to 1.0	2.0 to 4.0	—10	3	25	6	170 to 250	400 to 550	400 to 550[2]	0 to 200	0	$1,250
		HA-34G[6]	0.289 to 0.309	2.601 to 2.781	—20	—10	25	6	170 to 250	400 to 550	400 to 550[2]	0 to 200	0	1,400
		HA-34GE[6]	0.45 to 0.5	2.7 to 3.0	10	3	25	6	180 to 250	450 to 550	400 to 550[2]	0 to 200	0	1,250
L-X	SOL	HA-16B[6]	1.7 to 1.92	8.5 to 9.6		0	30	25	800 to 1100	....	800 to 1100	0 to 550	....	$1,000
S-C	PPM	HA-30L[4]	2.275	4.55		24	30	25	800 to 1100	....	800 to 1100	0 to 450	....	$1,350
S-X	**SOL**	**HA-16[6]**	**1.76 ± 10%**	**8.8 ± 10%**	**—10**	**3**	**30**	**25**	**850 to 1200**	....	**850 to 1200**	**0 to 550**	....	**$1,000**
C-X	SOL	HA-6AH[4]	4.75	9.50	....	30 at 4.75 Gc 23 at 9.5 Gc	30	20	1200 to 1500	....	1200 to 1500	0 to 705	0	$1,000

DISPERSIVE AMPLIFIERS (Voltage Tuned)

Band	Focus	Type	Frequency (Gc)	Small-Signal Gain (db): Swept Anode	Fixed Anode	Bandwidth 5 db Down (% of center f)	Maximum Cathode Current (ma)	Electrode Voltages, vdc: Helix	Anode (Fixed)	Collector	Unit Price
UHF	SOL	DA-3[8]	0.5 to 1.0	15 at 0.5 Gc 30 at 1.0 Gc	2 at 0.5 Gc 30 at 1.0 Gc	15 to 20	1.5	450 to 1065	450 to 1065[2]	0 to 450	$1,350
L		DA-2[8]	1.0 to 2.0	15 at 1.0 Gc 33 at 2.0 Gc	3 at 1.0 Gc 30 at 2.0 Gc	15 to 20	.75	330 to 1020	330 to 1065[2]	0 to 330	1,350
S		DA-1[8]	2.0 to 4.0	22 at 2.0 Gc 28 at 4.0 Gc	10 at 2.0 Gc 28 at 4.0 Gc	15 to 20	1.5	1110 to 2380	1110 to 1065[2]	0 to 650	1,350
C		DA-4[8]	4.0 to 8.0	25 at 4.0 Gc 15 at 8.0 Gc	25 at 4.0 Gc 10 at 8.0 Gc	15 to 20	1	1250 to 2500	1250 to 1065[2]	0 to 300	1,350

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

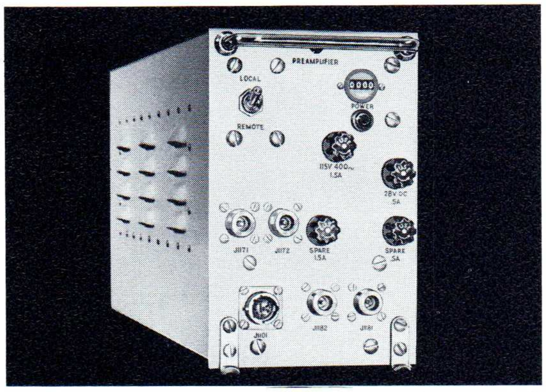
Band	Focus	Type	Frequency (Gc)	Minimum Saturation Power Out (dbm)	Minimum S-S Gain at Sync (db)	Sync Bandwidth (%)	Maximum Cathode Current (ma)	Electrode Voltages, vdc: Helix 1	Helix 2 and Collector	Anode	Unit Price
S	SOL	BA-1[8]	2.4 to 3.6	0	10	0.1 to 1.0	15	$V_{H2} \pm$ (0 to 300)	300 to 1500	0 to 500	$1,500

HIGH VACUUM DIODES

Type	Filament Voltage: Min	Max	Filament Current at $E_f = 16$ v: Min	Max	Cold Fil Res	Tube Voltage Drop at $I_B = 5$ amps: Min	Max	Limiter Service: Peak Inv Volt (E_B)	Pk Plate Curr (I_B)	Avg Plate Diss	Rectifier Service: Peak Inv Voltage	Pk Plate Current	Avg Plate Current $E_B \leq 40$ Kv	Avg Plate Current $E_B > 40$ Kv	Avg Plate Dissipation $E_B \leq 40$ Kv	Avg Plate Dissipation $E_B > 40$ Kv	Unit Price
HR-5973[4]	15.2 vac	16.8 vac	18 amps	20.2 amps	0.1 ohm	850 v	1050 v	75 Kv	20 amps	800 watts	75 Kv	5 amps	1.25 amp	1 amp	850 watts	800 watts	$ 350

[1] Driver Stage
[2] Insulated Collector
[4] Four to six weeks delivery
[6] Six to eight weeks delivery
[8] Eight to ten weeks delivery
[10] At —3dbm P_{IN}
** S-S Gain plus noise figure, 75db minimum

SYSTEMS DIVISION



RESEARCH AND DEVELOPMENT

Huggins Systems Division R & D section has been engaged in the research and development of microwave instrumentation and power supply design since 1955. Experience gained over the years has equipped this group to handle all engineering problems encountered in TWT packaging, power supply design, and low-power microwave work.

Close liaison between TWT and application engineers results in creative engineering with a sound approach to solving instrumentation and subsystems design problems. By combining both TWT manufacturing and packaging capabilities, Huggins Laboratories holds a unique position in the industry—a position that offers the customer obvious advantages in serving his microwave instrument requirements.

Through aggressive and progressive engineering, the R & D group has significantly advanced the state-of-the-art in developing extremely small TWT amplifier packages, nanosecond pulse generators, the industry's first 'portable" TWT amplifier, a modular plug-in approach to TWT packaging, and a completely new line of electronically swept oscillators which feature latest advances in modern circuitry.

Abilities and aptitudes of this group also include solid-state circuitry, microwave test instrumentation, and nanosecond pulse generation. Further areas of interest are concerned with infrared instrumentation and its application to military and industrial systems, ferro-electric and ferro-magnetic bolometers, and high frequency transient detection.

PRODUCTION

The Systems Production Department is well equipped and staffed with personnel specially trained for producing small or large quantities. Whether producing Huggins' standard line of *non-stop quality* instruments or custom units, this organization displays a high degree of efficiency which is achieved with only years' of experience. Because the manufacturing team takes pride in the products it produces, each instrument receives interested personal attention from every individual involved with its manufacture.

Production of Huggins' microwave instruments depends on the efforts of experienced industrial and product engineering specialists, sheet-metal personnel, and wiring technicians. The methods of production are determined in terms of highest quality, minimum time, and minimum cost.

Should your requirements demand volume manufacturing or custom fabrication, Huggins' experience and proven ability is at your disposal.

ORDERING INFORMATION

ORDERING

Standard Units: Specify name of instrument, model number, and primary performance specifications.

Special Units: Instruments requiring electrical and mechanical modifications, custom design, and non-standard input power characteristics are being furnished. Military environmental specifications are also being met. Contact Huggins' Sales Department, or our representative in your area, to discuss your specific requirements.

Parts: When ordering replacement parts, specify instrument model and serial numbers, part designation on the drawing, and manufacturer's part number.

PRICES

F.O.B. Sunnyvale, California. Prices apply to small quantities only and are subject to change without notice.

TERMS

Net 30 days with approved credit.

DELIVERY

Normal delivery for instruments and solenoids in small quantities is 30 days and 4 weeks respectively. Consult Huggins' Sales Department for latest quotations.

SHIPMENT

Via motor freight unless otherwise requested. Units are packed to withstand rough handling.

SERVICE

Prompt technical service and assistance is readily available from factory-trained representatives and the manufacturer.

WARRANTY

All Huggins' instruments and solenoids are thoroughly tested and inspected prior to shipment. Instruments and solenoids are warranted for one year to be free from defects in material and workmanship. Microwave tubes are covered by the tube manufacturer's warranty.

A NEW LINE OF PM-FOCUSED ELECTRONICALLY SWEPT OSCILLATORS

- Stable Reliable Operation
- Built-in RF Power Leveling
- CW or SWEEP Operation
- Operator-Designed Control Panels
- Designed for Easy Maintenance

Huggins *completely new* PM-focused Electronically Swept Microwave Oscillators provide a fast, convenient means of determining the wideband frequency response of microwave devices and systems. When used with reflectometers, for example, these oscillators reduce previously tedious VSWR measurements to a few seconds. In addition to directly measuring the transmission characteristics of filters, attenuators, ferrite devices, and amplifiers, Huggins Sweep Oscillators also prove valuable in ECM equipment design and broadband antenna development.

Seven standard models covering L through K-band are available. Each model in this series is a complete, self-contained rugged unit that features attractive and functional design and a functionally grouped control panel. Maintenance procedures and problems have been minimized: solid-state low voltage circuitry reduces the number of vacuum components, internal voltage adjustments are readily accessible, and removal of only the top dust cover and RF shield permits full and easy access to all electronic components.

Further, Huggins Sweep Oscillators are versatility engineered: Power output is leveled to ±0.75 db (X-band and below) and is adjustable from 0 to rated power; both CW and swept frequency operation are provided, during which AM, pulse, internal square wave, and FM modulation can be applied; sweep width and rate are independently adjustable; the sweep may be operated recurrently, triggered manually, or triggered externally; sweep and blanking outputs are available; and four slide rule readouts indicate start, stop, and two marker frequencies.

Conversion kits consisting of a BWO, logarithmic attenuator, directional coupler, crystal, and dial plate are available to change the frequency coverage of any model. Units which operate over bandwidths other than those given can be supplied on request.

MODEL	601D	604D	607D	612D	616D	618D	619D
Frequency, Gc	1.0 to 2.0	2.0 to 4.0	4.0 to 8.0	8.0 to 12.4	12.4 to 18.0	18.0 to 26.5	26.5 to 40.0
Minimum Power Out, mw	50	50	50	50	20	10	5
Power Out Level To, db	±0.75	±0.75	±0.75	±0.75	....	....	....
Peak Residual FM, Kc	10 at 1.0 Gc 6 at 2.0 Gc	20 at 2.0 Gc 12 at 4.0 Gc	40 at 4.0 Gc 24 at 8.0 Gc	80 at 8.0 Gc 37.2 at 12.4 Gc	248 at 12.4 Gc 108 at 18.0 Gc	360 at 18.0 Gc 159 at 26.5 Gc	530 at 26.5 Gc 240 at 40.0 Gc
RF Output Connector	N Female	N Female	N Female	Waveguide UG-135/U	Waveguide UG-419/U	Waveguide UG-595/U	Waveguide UG-599/U
Unit Price	$3,050	$2,950	$2,850	$2,850	$3,300	$5,420	$6,500

GENERAL SPECIFICATIONS

SWEEP MODE: Recurrent, manually triggered, and externally triggered. Sweep is continuously variable by two independently adjustable controls which determine the start and stop frequencies. Either control may be used to set the high or low frequency; thus, frequency either increases or decreases with time.

Sweep Width: Adjustable from 0 to 100% of operating bandwidth.

Sweep Rate: Continuously variable from 3 minutes to 0.001 seconds.

Sweep Linearity: RF frequency vs sweep time is linear within 1%.

Flyback: Less than 30 microseconds at any sweep rate.

External Sweep: DC coupled input; +12 volts gives 100% sweep; frequency increases.

Sweep Out: +12 v peak sawtooth (positive slope).

Blanking: 30 microseconds,—6 volt pulse.

Markers: Two calibrated markers, both adjustable over full frequency range of instrument.

FREQUENCY READOUT: Four slide rule dials accurate to 1% indicate start, stop, and two calibrated marker frequencies.

POWER OUTPUT: Adjustable from 0 to rated power.

RESIDUAL AM: At least 50 db below signal output.

PROTECTION: Main Power Fuse, High Votage Primary Fuse, Filament Fuse, and Filament Warmup.

CW MODE: Fixed frequency operation, continuously adjustable over full frequency range of instrument with either the Start, Stop, or two Marker controls.

MODULATION: Internal AM: Square wave, continuously variable between 800 and 1200 cps.

External AM: DC coupled Input—permits external programmed attenuation and application of modulating signals from DC to several megacycles; only on-to-off pulsing can be accomplished; at least —50 volts is required for full attenuation.

AC Coupled Input—permits pulsing from any output level to an on or off condition; 50 volts peak-to-peak superimposed on —25 volt bias gives 100% modulation; passband, 50 cps to several megacycles.

Internal FM: In CW Mode the fixed RF frequency can be swept from 0 to ±5%; modulating frequency can be varied between 50 and 1000 cps.

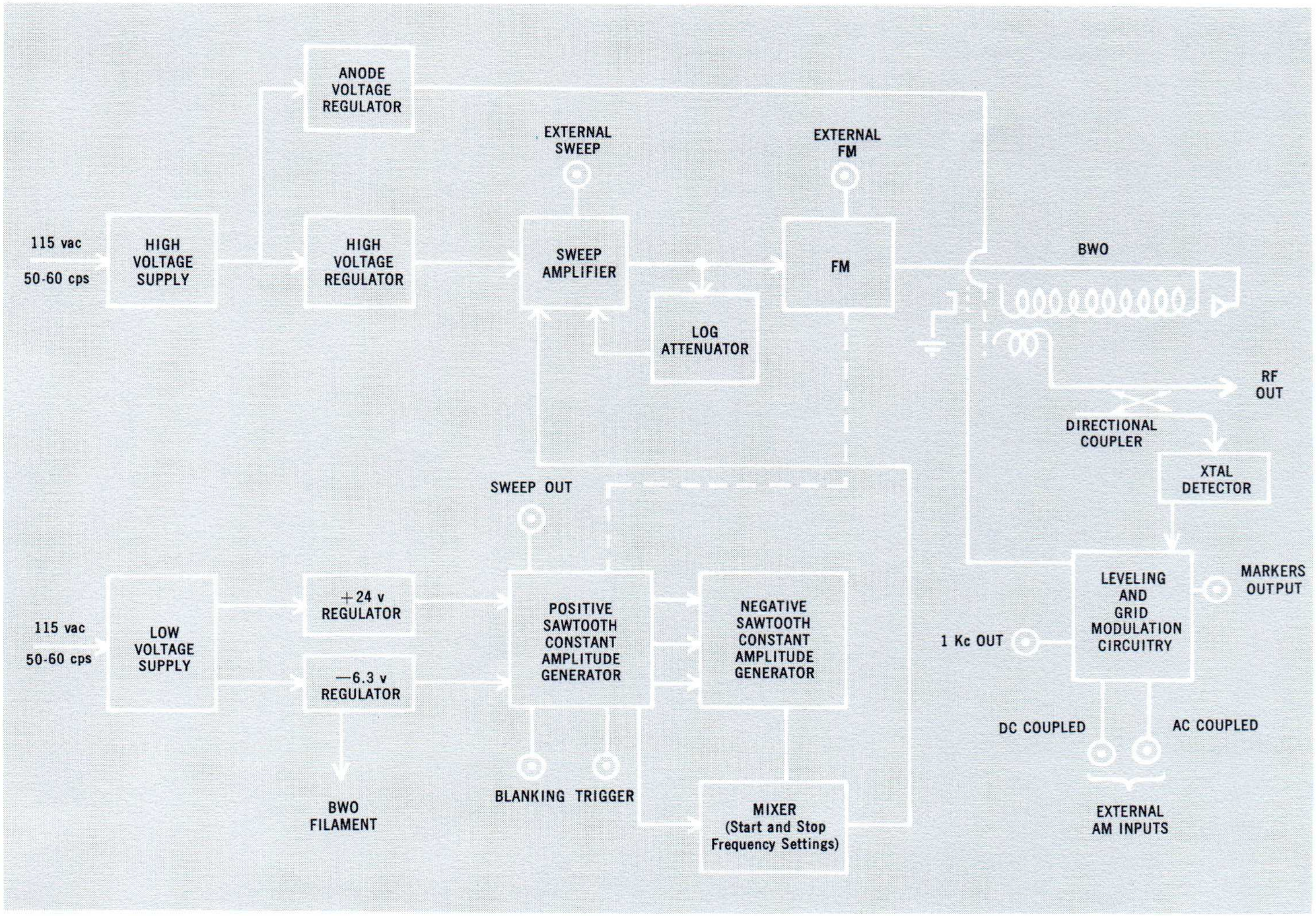
External FM: In either the CW or Sweep Mode the fixed RF frequency can be varied from 0 to ±5%; 12 volts peak-to-peak are required for ±5% deviation; modulating frequencies from 50 cps to 10 Kc can be used.

INPUT POWER: 115 vac, 50-60 cps, 150 watts.

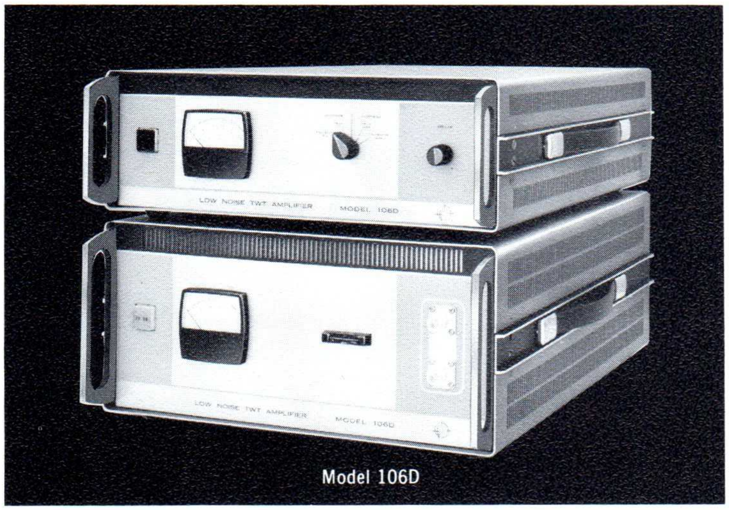
MOUNTING: Easily attached adapters are provided for standard rack and slide mounting.

WEIGHT: Approximately 55 pounds.

SIZE: Models 601D, 604D, 607D; 6-15/16" x 16-3/8" x 20-3/4" (H x W x D). Models 612D, 616D, 618D, 619D; 8-11/16" x 16-3/8" x 20-3/4" (HxWxD)



LOW NOISE TWT AMPLIFIERS



Model 106D

Solenoid models consist of two separate chassis units: one contains the high voltage supply and the other accommodates the TWT, solenoid, and solenoid supply. This configuration permits remote operation of the TWT at distances up to 100 feet.

The complete line of *new* low-noise amplifiers consists of units which are attractively and functionally designed. All operating controls and monitoring meters are located on operator-designed front panels. Adequate overload circuits are incorporated in the hybrid power supplies to prevent accidental damage. Such features as unitized mechanical construction, advanced electrical plug-in modules, conveniently located voltage adjustments and test points, and a *two-piece* dust cover permit a high degree of accessibility and contribute to easy maintenance.

From UHF to X-band, Huggins Laboratories offers a complete line of *non-stop quality* broadband low-noise TWT amplifiers with noise figures as low as 7 db. Both PPM and solenoid units are available. All models are inherently rugged and can be supplied to commercial or military specifications.

Stable, low-ripple power supplies minimize spurious modulation and degradation in TWT performance. The relatively high power output plus a low noise figure results in a maximum degree of linear operation which reduces the effects of intermodulation and cross-modulation when multi-signal reception is experienced. When used as an input stage in a receiver, these amplifiers provide crystal burnout protection (most units will withstand 4.5 watts average incident power), substantially reduce local oscillator radiation, and directly increase receiver sensitivity.

GENERAL SPECIFICATIONS

Small-Signal Gain: 25 db minimum.

Spurious Modulation: 40 db minimum below signal.

Input, Output Connectors: Type N, female.

Input, Output Impedance: 50 ohms, 2:1 maximum VSWR.

Controls: Power On-Off; High Voltage On-Off, Helix Voltage Adjust.

Metering: Helix and Collector Voltages; Helix Current; Collector Current; Solenoid Current where applicable.

Power Supply Regulation: ±0.1% High Voltage; 1.0% DC Filament Voltage; 20 mv peak ripple.

Protection: Main Power Fuse; High Voltage Primary Fuse; Filament Fuse; Filament Warmup; Solenoid Primary Fuse, delayed removal of solenoid field, and Solenoid Thermal Overload where applicable.

Input Power: 115 vac, 50-60 cps, 800 watts maximum.

Mounting: Easily attached adapters are provided for standard rack and slide mounting.

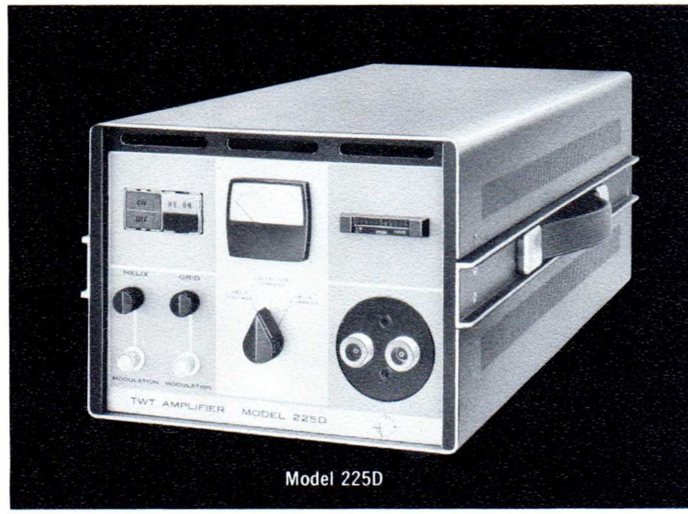
Size: PPM Units, 6-15/16" x 16-3/8" x 20-3/4" (HxWxD)
Solenoid Units, 5-3/16"x 16-3/8"x 20-3/4" (HxWxD) High Voltage Supply; 6-15/16" x 16-3/8" x 20-3/4"(HxWxD) Solenoid Supply

Focus	Model	Frequency (Gc)	Maximum Noise Figure (db)	Minimum S-S Gain (db)	Minimum Saturation Power Out (dbm)	Weight (lbs) TWT Supply	Weight (lbs) Solenoid Supply	Unit Price
PPM	110D	1.0 to 2.0	14	25	7	40	....	$3,980
	129D	2.0 to 4.0	11	30	7	40	....	4,430
	130D	2.0 to 4.0	15	35	30	40	....	3,950
	140D	2.0 to 4.0	15	25	5	40	....	3,980
	123D	7.0 to 11.0	15	25	10	40	....	3,980
	126D	8.0 to 12.0	12	30	7	40	....	3,780
SOLENOID	101D	0.5 to 1.0	7	25	3	35	65	$4,830
	102D	0.5 to 1.0	8	25	3	35	65	4,580
	103D	0.5 to 1.0	10	25	5	35	65	3,780
	104D	0.5 to 1.0	15	25	5	35	65	3,180
	106D	1.0 to 2.0	7	25	5	35	65	4,830
	107D	1.0 to 2.0	8	25	3	35	65	4,580
	108D	1.0 to 2.0	10	25	3	35	65	3,780
	109D	1.0 to 2.0	15	25	5	35	65	3,180
	112D	1.6 to 2.6	15	25	3	35	65	3,180
	114D	2.0 to 4.0	8	25	10	35	65	3,780
	115D	2.0 to 4.0	10	25	7	35	65	3,780
	117D	2.0 to 4.0	15	25	5	35	65	3,180
	119D	2.3 to 4.4	10	25	5	35	65	4,280
	120D	4.0 to 8.0	10	25	3	35	65	3,630
	121D	4.0 to 8.0	15	25	5	35	65	3,180
	124D	7.0 to 14.0	15	25	0	35	65	3,780
	125D	8.0 to 11.0	10	25	5	35	65	3,530
	128D	8.2 to 12.4	15	25	3	35	65	3,180

Requirements for small, lightweight broadband microwave amplifiers are met with this *completely new* line of Huggins Portable TWT Amplifiers. Advanced packaging techniques have produced rugged, attractive units which average a trim 28 pounds in weight and a compact 6⁷⁄₃₂″ x 8½″ x 20¾″ in size. Low power amplifiers are available in UHF through Ku-band and both intermediate power and low noise units are offered in L through X-band.

Designed for reliable operation in the field or on the bench, these portables are ideal for use in attenuation and antenna pattern measurements, buffer and augmenter applications, and ECM equipment design. All models are designed so that two units fit side-by-side for standard rack mounting, and the entire line exhibits the same easy maintenance features described on pages 16 and 17.

Special power, gain, or bandwidth specifications can also be supplied, as can units which meet commercial or military specifications.



Model 225D

GENERAL SPECIFICATIONS

Input, Output Connectors: Type N, female

Input, Output Impedance: 50 ohms, 2:1 maximum VSWR.

Focusing: PPM

Modulation: Front panel BNC grid connector on 200 and 300 series for AM or pulse modulation—AM passband DC to 100 Kc. Front panel BNC helix connector for helix modulation.

Controls: Power On-Off; High Voltage On-Off; Helix and Grid Voltage Adjusts.

Metering: Helix Voltage; Helix Current; Collector Current.

Power Supply Regulation: ±0.1% High Voltage; 2.0% AC Filament Voltage (200 and 300 Series); 1.0% DC Filament Voltage (100 Series); 20 mv peak ripple (200 and 300 Series, DC filament units available on special request).

Protection: Helix Overload (except 100 and 200 Series); Main Power Fuse; High Voltage Primary Fuse; Filament Fuse; Filament Warmup.

Input Power: 115 vac, 50-60 cps, 300 watts maximum.

Mounting: Easily attached adapters are provided for standard rack and slide mounting.

Size: 6-7/32″ x 8-1/2″ x 20-3/4″ (HxWxD).

LOW NOISE

Model	Frequency (Gc)	Maximum Noise Figure (db)	Minimum S-S Gain (db)	Minimum Saturation Power Out (dbm)	Spurious Modulation [below signal] (db)	Approximate Weight (pounds)	Unit Price
111D	1.0 to 2.0	14	25	7	40	27	$4,250
116D	2.0 to 4.0	11	30	7	40	27	4,750
131D	2.0 to 4.0	15	35	30	35	27	3,950
118D	2.0 to 4.0	15	30	10	40	27	3,750
122D	4.0 to 8.0	15	30	10	40	27	3,750
127D	7.0 to 11.0	15	25	10	40	27	4,250

LOW POWER

Model	Frequency (Gc)	Minimum S-S Gain (db)	Minimum Saturation Power Out (dbm)	Minimum Gain at Rated P_{OUT} (db)	Maximum Noise Figure (db)	Spurious Modulation [below signal] (db)	Minimum Grid On/Off Ratio	Maximum $V_{2\pi}$ (Helix Volts)	Approximate Weight (pounds)	Unit Price
201D	0.25 to 0.5	20	17	15	25	40	20 db at 30 v	30	30	$2,750
204D	0.5 to 1.0	25	13	15	25	35	30 db at —50 v	50	27	2,750
206D	1.0 to 2.0	30	13	20	25	35	30 db at —50 v	25	25	2,500
211D	2.0 to 4.0	30	10	20	25	35	30 db at —50 v	30	25	2,000
213D	4.0 to 8.0	30	10	20	30	35	30 db at —50 v	40	25	2,200
218D	8.0 to 12.4	30	10	23	30	35	30 db at —50 v	40	25	2,100
225D[1]	12.4 to 18.0	30	10	35	30	35	30 db at —50 v	40	25	On Reqst

INTERMEDIATE POWER

Model	Frequency (Gc)	Minimum S-S Gain (db)	Minimum Saturation Power Out (dbm)	Minimum Gain at Rated P_{OUT} (db)	Maximum Noise Figure (db)	Spurious Modulation [below signal] (db)	Minimum Grid On/Off Ratio	Maximum $V_{2\pi}$ (Helix Volts)	Approximate Weight (pounds)	Unit Price
343D	0.5 to 1.0	30	30	30	25	40	30 db at 30 v	....	40	$3,500
301D	1.0 to 2.0	30	30	27	30	40	15 db at 30 v	....	40	2,250
131D	2.0 to 4.0	35	30	30	15	35	20 db at 30 v	35	30	3,950
305D	2.0 to 4.0	35	30	27	20	35	20 db at 30 v	35	30	2,250
320D	4.0 to 8.0	30	27*	27	30	35	20 db at 30 v	60	30	2,250
310D	4.0 to 8.0	30	30	27	35	40	15 db at 30 v	100	40	2,850
313D	7.0 to 12.4	30	30	30	35	40	15 db at 30 v	100	40	2,850
323D	8.0 to 11.0	33	27**	27	35	35	25 db at 30 v	100	35	2,850

* 1 watt, 4.5 to 7.5 Gc   ** 1 watt, 8.0 to 10.0 Gc   [1] UG-419/U Waveguide

Model 212D

Huggins *non-stop quality* line of Traveling Wave Tube Amplifiers embodies a conceptually-fresh approach to TWT packaging—an approach which exemplifies quality and technological achievement. Compact, versatile microwave units covering the frequency range of 250 mc to 18.0 Gc are offered in the standard line. Broadband small-signal gain is typically 30 db, and output powers up to 2 watts are available as standard units. All models can be supplied to commercial or military specifications.

The broadband frequency characteristic of the TWT results in non-tuned band coverage, faithful amplification of RF signals, minimum pulse distortion, and other desirable characteristics. Stable, low-ripple power supplies minimize spurious modulation and permit full realization of the TWT's capabilities.

All amplifiers have provisions for grid and helix modulation. Accidental damage protection is adequately provided by overload circuits which are incorporated in the power supplies. Helix and grid voltage controls and a monitoring meter are located on a functionally-grouped, operator-designed control panel.

Maintenance ease is designed into the complete line with such unique features as unitized mechanical construction, modular plug-in electrical assemblies (including the front panel), and conveniently located voltage adjustments and test points. Hybrid power supplies using vacuum and solid-state components are conservatively designed. Removal of *only* the top dust cover permits access to the entire internal assembly, and maintenance procedures can be easily performed with the instrument operating by using an interconnecting test harness.

GENERAL SPECIFICATIONS

Modulation: BNC front panel connector for grid modulation; AM passband DC to 100 Kc. BNC front panel connector for helix modulation.

Input, Output Connectors: Type N, female.

Input, Output Impedance: 50 ohms, 2:1 maximum VSWR.

Spurious Modulation: 40 db minimum below signal on 200 Series; refer to Intermediate Power table for 300 Series specifications.

Controls: Power On-Off; High Voltage On-Off; Helix and Grid Voltage Adjusts.

Metering: Helix Voltage; Helix Current; Collector Current.

Power Supply Regulation: ±0.1% High Voltage; 2.0% AC Filament Voltage; 20 mv peak ripple (DC filament models available on special request).

Protection: Helix Overload (except 200 Series); Main Power Fuse; High Voltage Primary Power Fuse; Filament Fuse; Filament Warmup; Solenoid Primary Fuse, delayed removal of solenoid field, and solenoid thermal overload where applicable.

Input Power: 115 vac, 50-60 cps, 1000 watts maximum.

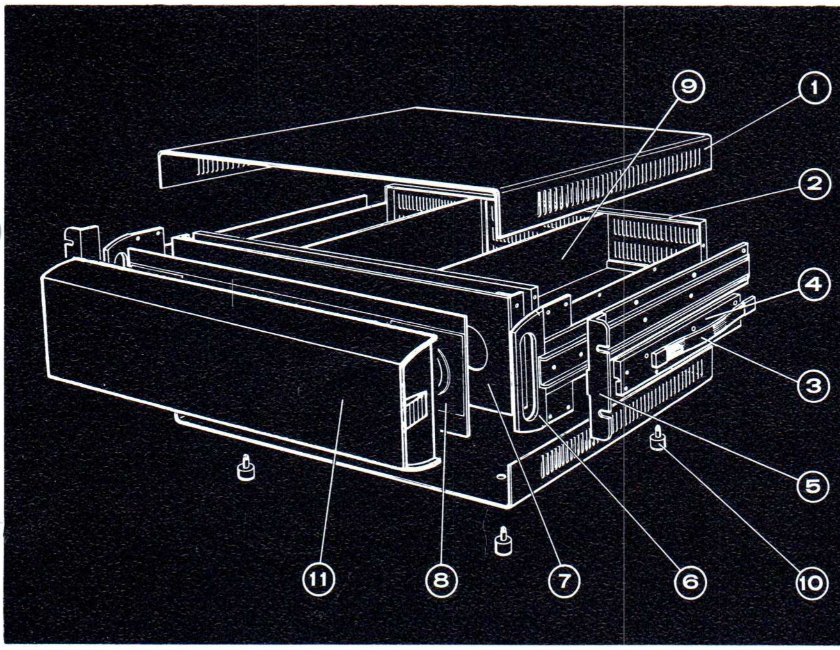
Mounting: Easily attached adapters are provided for standard rack and slide mounting.

Size: PPM Units, 5-3/16" x 16-3/8" x 20-3/4" (HxWxD).
Solenoid Units, 200 Series, 6-15/16" x 16-3/8" x 20-3/4" (HxWxD).
300 Series (except 321D, 322D), 6-15/16" x 16-3/8" x 20-3/4" (HxWxD).
321D and 322D, 8-11/16" x 16-3/8" x 20-3/4" (HxWxD)

Focus	Model	Frequency (Gc)	Minimum S-S Gain (db)	Minimum Saturation Power Out (dbm)	Minimum Gain at Rated P_{OUT} (db)	Maximum Noise Figure (db)	Spurious Modulation [below signal] (db)	Minimum Grid On/Off Ratio	Maximum $V_{2\pi}$ (Helix Volts)	Approximate Weight (pounds)	Unit Price
PPM	200D	0.25 to 0.5	20	17	15	25	40	20 db at 30 v	30	37	$2,530
	203D	0.5 to 1.0	25	13	15	25	40	30 db at —50 v	50	37	2,530
	205D	1.0 to 2.0	30	10	20	25	40	30 db at —50 v	25	37	2,280
	210D	2.0 to 4.0	30	10	20	25	40	30 db at —50 v	30	37	1,880
	212D	4.0 to 8.0	30	10	20	30	40	30 db at —50 v	40	37	2,030
	217D	8.0 to 12.4	30	10	23	30	40	30 db at —50 v	40	40	1,780
	220D[1]	12.4 to 18.0	30	10	25	30	35	30 db at —100 v	30	37	On Reqst
SOLENOID	202D	0.5 to 1.0	30	10	20	25	40	40 db at —60 v	25	55	$1,680
	207D	1.0 to 2.0	30	10	20	25	40	30 db at —50 v	25	60	1,555
	208D	1.6 to 2.6	30	10	20	25	40	30 db at —50 v	40	60	1,780
	209D	2.0 to 4.0	30	10	20	25	40	30 db at —50 v	30	60	1,405
	214D	4.0 to 8.0	30	10	20	25	40	30 db at —50 v	35	60	1,505
	216D	7.0 to 12.4	30	13	27	30	40	40 db at —50 v	40	60	1,780
	219D	12.4 to 16.0	25	7	15	30	40	30 db at —50 v	30	60	2,130

[1] UG-419/U Waveguide

Model 304D



1. **Cover Panels:** easily removed—durable vinyl coating—cooling vents
2. **Rear Panel:** vented—recessed
3. **Side Carrying Handle:** recessed in side channel—removes for rack adapter
4. **Slide Mount Bracket:** adapts to rack slides
5. **Rack Mount Flange:** mounts easily—adapts instruments to standard 19″ rack
6. **Front Handle Unit:** space saver—(form and function)
7. **Front Panel:** recessed for protection
8. **Front Overlay:** thin adhesive backed sheet—functional and durable
9. **Dividers:** module compartment structural dividers
10. **Feet:** snap-on easily—locate for stack positioning
11. **Front Panel Cover:** dust and front panel protection

Focus	Model	Frequency (Gc)	Minimum S-S Gain (db)	Minimum Saturation Power Out (dbm)	Minimum Gain at Rated P_{OUT} (db)	Maximum Noise Figure (db)	Spurious Modulation [below signal] (db)	Minimum Grid On/Off Ratio	Maximum $V_{2\pi}$ (Helix Volts)	Approximate Weight (pounds)	Unit Price
PPM	342D	0.5 to 1.0	30	30	30	25	40	30 db at 30 v	....	45	$3,500
	324D	1.0 to 2.0	30	30	27	30	40	15 db at 30 v	...	60	2,275
	130D	2.0 to 4.0	35	30	30	15	35	20 db at 30 v	35	27	3,950
	304D	2.0 to 4.0	35	30	27	20	35	20 db at 30 v	35	37	2,280
	309D	4.0 to 8.0	30	27[3]	27	30	35	20 db at 30 v	60	37	2,780
	326D	4.0 to 8.0	30	33	30	35	40	15 db at 30 v	100	37	3,530
	328D	7.0 to 12.4	30	30	30	35	40	15 db at 30 v	100	37	2,930
	315D	8.0 to 11.0	33	27[4]	27	35	35	25 db at 30 v	100	37	2,880
	319D	8.0 to 12.4	25	20	20	30	35	30 db at 30 v	75	37	2,730
	337D[1]	12.4 to 18.0	30	30	30	35	40	15 db at 30 v	150	37	On Reqst
SOLENOID	300D	0.5 to 1.0	30	30	30	25	40	30 db at 30 v	....	60	$2,880
	325D	1.0 to 2.0	30	33	27	30	40	15 db at 30 v	....	90	2,330
	302D	1.6 to 2.6	30	30	27	25	40	10 db at 30 v	....	90	2,180
	303D	2.0 to 4.0	30	30	30	25	40	20 db at 30 v	35	65	1,390
	308D	4.0 to 8.0	30	30	27	30	40	20 db at 30 v	60	85	2,330
	321D	7.0 to 12.4	30	30[5]	30	35	40	15 db at 30 v	100	90	2,930
	314D	8.0 to 11.0	30	27	27	35	35	25 db at 30 v	100	85	2,930
	318D	8.0 to 12.4	25	20	20	30	35	30 db at 20 v	75	85	2,155
	322D[1]	12.4 to 18.0	30	30	30	35	40	15 db at 30 v	150	90	4,030

[1] UG-419/U Waveguide [3] 30 dbm, 4.5 to 7.5 Gc [4] 30 dbm, 8.0 to 10.2 Gc [5] 33 dbm, 7.0 to 11.0 Gc

SOLENOID POWER SUPPLIES

The Huggins 806D and 807D variable power sources are ruggedly designed to operate most TWT and BWO focusing solenoids used in the field. Model 806D fulfills the need for an inexpensive unregulated supply which provides 0 to 105 vdc at 0 to 7.0 amperes. The 807D, on the other hand, satisfies requirements for a constant current source that is adjustable from 60 to 105 vdc at 1.5 to 7.0 amperes.

GENERAL SPECIFICATIONS

Controls: Power On-Off, Voltage Adjust.
Metering: Output Current and Voltage.
Protection: Main Power Fuse; Thermal Overload provisions.
Output Connectors: Two sets; banana plugs, spade lugs.
Input Power: 115 vac, 50-60 cps, 850 watts.
Size: 6-15/16″ x 16-3/8″ x 20-3/4″ (HxWxD).

Model	806D	807D
Voltage	0 to 105 vdc	60 to 105 vdc
Current	0 to 7.0 amperes	1.5 to 7.0 amperes
Current Regulation	Unregulated	1% line or load
Ripple	0.5% peak-to-peak	0.5% peak-to-peak
Response	....	5 seconds maximum
Blower Supply	115 vac, 50-60 cps	115 vac, 50-60 cps
Weight	70 pounds	80 pounds
Unit Price	$380.00	$480.00

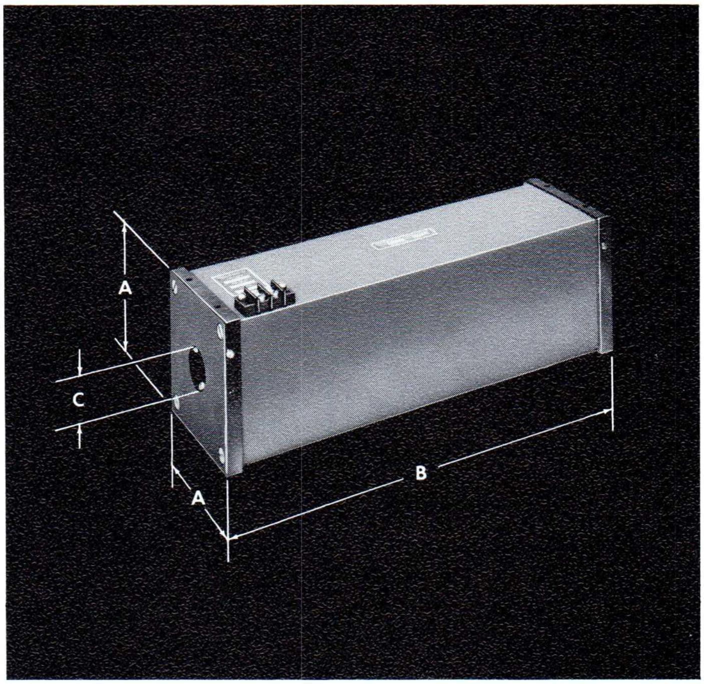
CONVECTION COOLED SOLENOIDS

Huggins solenoids are engineered to meet the exacting requirements encountered in focusing traveling-wave tubes and backward wave oscillators. These rugged units provide an exceptionally uniform field that is constant in strength to within 97% of the rated value.

Winding techniques which assure symmetrical and uniform turns are used to eliminate undesirable transverse field components. The added feature of double magnetic shielding minimizes solenoid field radiation and AC field penetration. To prevent damage from overheating, all standard units (except AS series) are equipped with a 200°F thermal switch rated at 2 amperes, 115 vac.

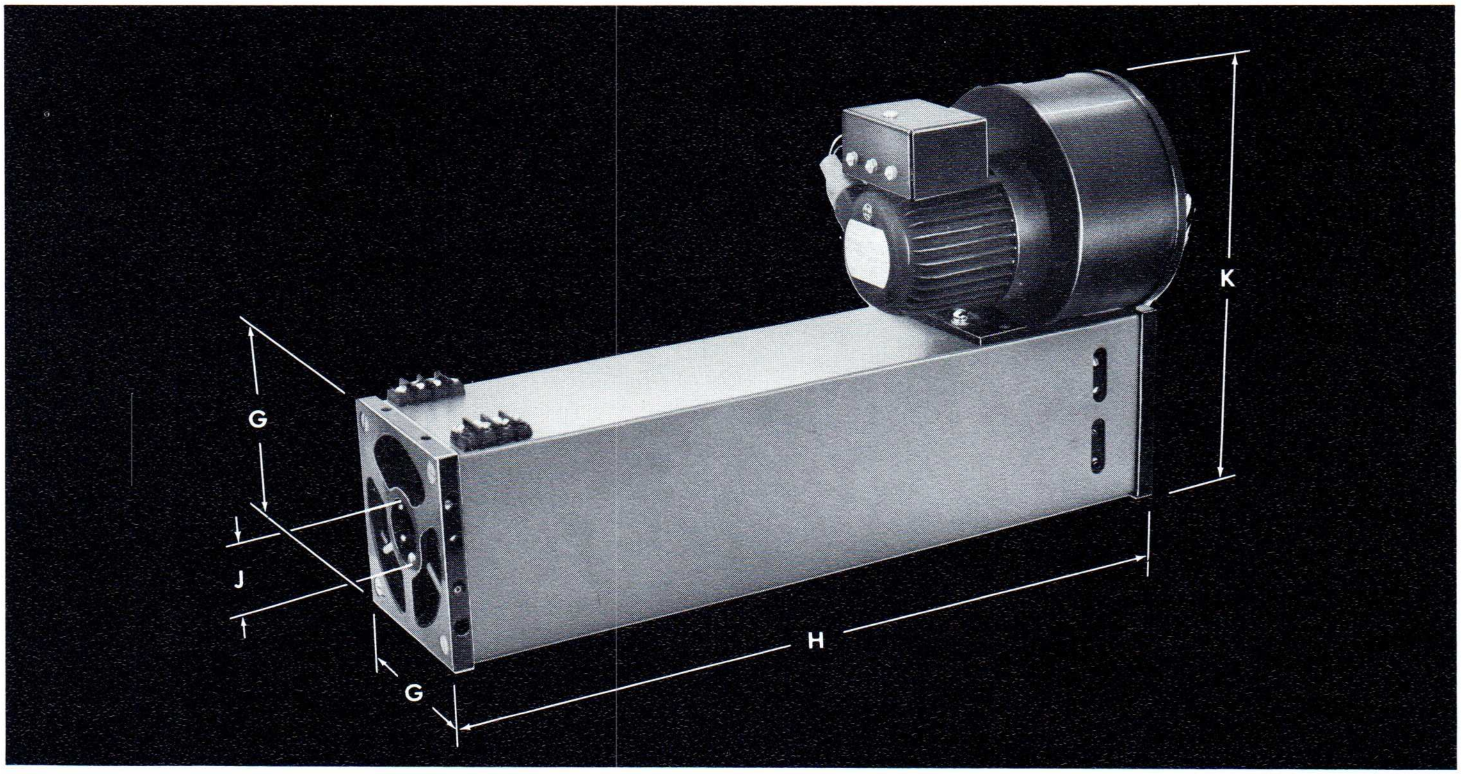
A spring-loaded button and 4 adjustment screw arrangement at both ends of the solenoid makes TWT focusing a simple operation. And once in focus, the TWT's position may be fixed by setting the adjustment locking screws.

Both convection and forced air cooled units are designed to meet most focusing requirements. The coil in convection cooled solenoids is encased in an epoxy resin to insure adequate heat conduction. On forced air cooled units, cooling air is supplied by an integrally mounted blower assembly, and a sufficient number of longitudinal openings through the windings permits air flow along at least one side of each layer.



Type	Field (Gauss)	Voltage	Current (Amperes)	Winding Length (Inches)	A (Inches)	B (Inches)	C (Inches)	Weight (Pounds)	Tube Type	Unit Price
AS-3	300	90 to 100	0.64	14	3⅜	15-3/16	1⅛	23	HA-1, HA-22	$175
AS-6	400	90 to 100	0.75	12¼	3⅞	13-7/16	1⅛	29	HA-4, HA-24, HA-26	190
AS-7	400	90 to 100	0.66	11	3⅞	12-3/16	1⅛	24	HA-3, DA-4	185
AS-10	500	90 to 100	1.35	16	4⅜	17-3/16	1⅛	52	HA-11	235
AS-19	250	90 to 100	0.48	15⅞	3¾	17-1/16	1⅛	26	DA-1, DA-2	175
AS-20	250	90 to 100	0.50	15⅞	3¾	17-1/16	1-7/16	26	DA-3	175
AS-21	500	90 to 100	1.10	14	4⅜	15-3/16	1⅛	45	HA-34	235
AS-22	400	90 to 100	0.77	13	3⅜	14-3/16	1⅛	21	HA-5	180
AS-25	300	90 to 100	0.66	14	4⅜	15¼	1½	36	HA-7	190
AS-28[1]	Shaped	80 to 110	3.00[2]	12⅛	4-11/16[3]	15¼	1⅝	35	RCA 4036	400
AS-68[4]	610	103 to 112	1.55	12½	4¼	14¼	1½	39	RCA 6861	400

[1] Equivalent to RCA MW4901 [2] Maximum [3] Diameter [4] Equivalent to RCA MW4900

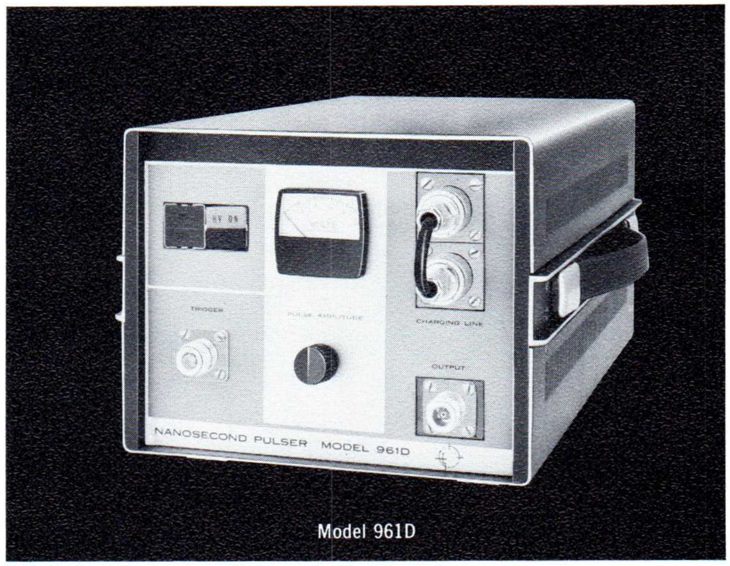


Type	Field (Gauss)	Voltage	Current (Amperes)	Winding Length (Inches)	G (Inches)	H (Inches)	J (Inches)	K (Inches)	Weight (Pounds)	Tube Type	Unit Price
BS-3C	1000	90 to 100	4.10	8½	4¼	11¼	1¼	9⅜	26	HO-2, HO-4, HO-10, HO-11, HO-14, HO-17, HO-19	$385
BS-4C	1000	90 to 100	4.90	11	4¼	13¾	1¼	9⅜	31	HA-10, HA-16, PA-3, PA-5, HO-13, HO-20, HO-21	385
BS-5C	760	90 to 100	4.30	13½	4¼	16¼	1¾	9⅜	43	BA-1, HO-1, HO-18	385
BS-9C	600	90 to 100	2.60	12½	4¼	15¼	1¼	9⅜	25	HA-2, HA-39, PA-4	385
BS-11C	1000	90 to 100	4.90	11	4¼	13⅜	1¼	9⅜	32	HA-9, PA-1	405
BS-26C	800	95 to 105	4.80	15	4¼	17¾	1½	9⅜	37	HA-40, HA-45, HA-72, HA-86	410
BS-27C	1000	90 to 100	6.50	14	4¼	16¾	1¼	9⅜	36	HA-14, HA-17, HA-19, HA-23, HA-32, HA-33, HA-44, HA-47, HA-61, HA-73, HA-80	385
BA-29[1]	600	90 to 100	2.50	12½	4¼	14⅛	1½	N/A	32	RCA 6861	385
BS-31C	900	90 to 100	3.54	10	4¼	12½	1¼	9⅜	26	SECO BWOs	385
BS-39C	1000	90 to 105	7.00	13⅜	4¾	16⅛	1⅝	11	48	WJ 211,212	475
BS-41C	750	90 to 100	3.60	14	4¼	16⅛	1¼	9⅜	38	HA-18	385
BS-43C	820	90 to 100	5.00	15	4¼	17½	1⅛	9⅜	33	HA-72B	385
BS-44E	Shaped	90 to 100	1.25[2]	19	4¼	21¾	1¼	9⅜	28	HA-37	385
BA-45[1]	1000	90 to 100	3.70	6⅝	5⅛	7-7/16	1¾	N/A	30	ITT F-6868, MEC M2404, M2405	300
BS-46C	560	90 to 100	2.50	15	4¼	17¾	1½	9⅜	37	HA-8	385
BA-47[1]	1200	90 to 100	4.80	6⅜	4¾	7¼	1⅜	N/A	23	MEC M2404, M2405	300
BS-49C	1100	90 to 100	5.20	11	4¼	13¾	1¼	9⅜	35	HA-6, PA-7	385
BS-53C	Shaped	90 to 100	0.80[2]	14	4¼	16⅛	1¼	9⅜	27	HA-62	385
BS-67C	Shaped	90 to 100	1.15[2]	14	4¼	16¾	1½	9¼	26	HA-89	405

[1] No blower supplied   [2] Typical   Forced air cooled units have 115 vac, 50-60 cps blowers. 28 vdc; 95 vdc; and 115 vac, 400 cps available on request.

Special Solenoids — Including Liquid Cooled Units — Also Available.

NANOSECOND PULSE GENERATORS



Model 961D

USES

- simulating scintillations for multiplier arrays
- photosynthesis timing
- impedance measurements
- multiplier phototube testing
- nanosecond response of photosensitive devices
- magnetic materials research

Here is a high level pulse generator which produces a 2 kilovolt pulse 2 to 20 nanoseconds wide with a half nanosecond rise and fall time. The Huggins 961D Pulse Generator may be used to excite a single nanosecond light source (such as the PEK 118) which requires no more than a 2 Kv pulse into 51 ohms. By using Huggins 961-T Splitting Transformers, this Pulse Generator will drive up to 64 nanosecond light sources which require a maximum 1 Kv pulse into 51 ohms.

When used with a nanosecond light source, the 961D can be used to simulate the scintillations from nuclear events or test the nanosecond response of photosensitive devices. The electrical pulse from the 961D is also used to measure the impedance of transmission lines. Further, the Model 961D Pulse Generator proves valuable in magnetic materials research.

GENERAL SPECIFICATIONS

Pulse Amplitude: Variable from 0 to 2000 volts with front panel control. Relative height given by front panel indicator which can be used to repeat pulse heights within 5% from a previous time.

Pulse Shape: Positive, ½ nanosecond rise and fall time (from 10-90% of pulse amplitude), width variable from 2 to 20 nanoseconds by using different charging lines. Standard units are supplied with a 2 nanosecond pulse width. Please specify width desired.

Amplitude Pulse Jitter: 4% maximum.

Pulse Repetition Rate: Line frequency (50-60 cps); push button actuated "single" pulse operation.

Output: 51 ohms; Type N, female.

Trigger Pulse Amplitude: 15 volts maximum at 2 Kv pulse output.

Trigger Pulse Shape: Positive leading edge, ½ nanosecond rise time (from 10-90% of trigger pulse amplitude), 2 to 20 nanoseconds wide, 70% maximum overshoot.

Trigger Output: Type UHF, female.

Remote Operation: Pulse generating module may be easily removed from the instrument, 18-inch cable provided.

Power Input: 961D; 115 vac, 50-60 cps, 25 watts.
961DA; 220 vac, 50-60 cps, 25 watts.

Size: 6-7/32" x 8-1/2" x 13-3/4" (HxWxD).

Weight: Approximately 30 pounds.

PRICES

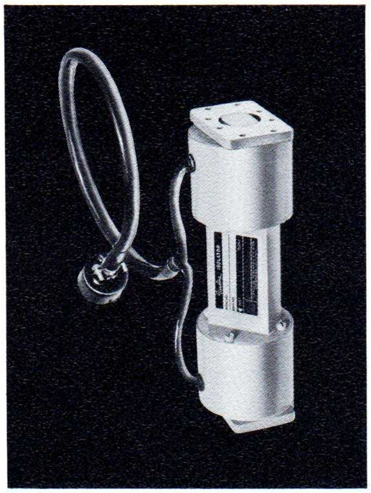
Model 961D Generator: $900.00

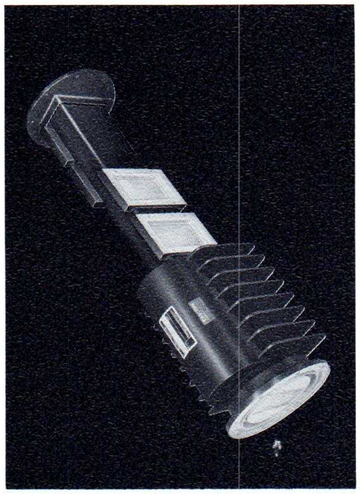
Model 961DA Pulse Generator: $950.00

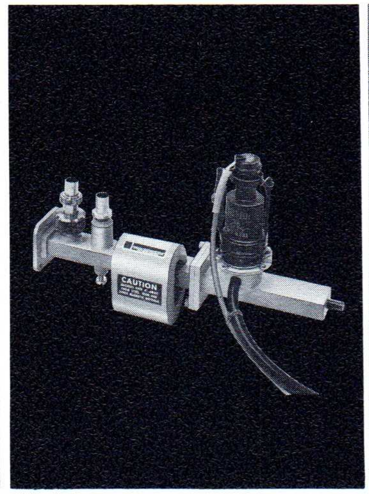
Charging Lines (other than 2 nanosecond): $25.00

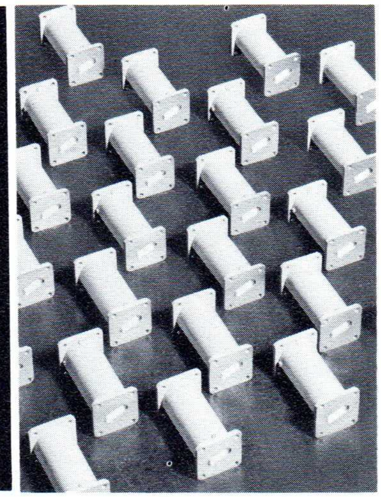
Model 961-T Splitting Transformer: $75.00

CASCADE RESEARCH DIVISION









CAPABILITIES

RESEARCH AND DEVELOPMENT

Staffed with leading scientists and engineers, the R & D section of the Cascade Research Division of Huggins Laboratories possesses a comprehensive understanding of the microwave and ferrite state-of-the-art.

Advanced thinking, engineering skills, precision workmanship, and modern equipment are blended to provide the customer with components and subassemblies for most microwave, radar, and communication equipment. This combination of talent, facilities, and matchless experience insures optimum performance in highly advanced, custom-engineered components and assemblies.

Technological capabilities of this group embrace microwave ferrite and solid-state components, attenuators, filters, mechanical phase shifters, windows, pressure adapters, transitions, varactors, dummy loads, waveguide subassemblies, and antennas.

PRODUCTION

A fully integrated and proven manufacturing facility processes over 1000 different microwave and ferrite components in all frequency ranges from below 700 mc to above 70.0 Gc.

In-house capabilities cover every step in the production process . . . from raw materials through plating, brazing, and painting to final performance testing. Techniques and knowledge are backed by nearly 12 years of unparalleled experience to provide the fastest possible delivery of either large or small quantities.

Complimented by the excellent facilities of Huggins Laboratories, the Cascade Research Production Department is equally adept at delivering large quantity orders or specially-fabricated items on schedule. Close liaison between engineering and manufacturing staffs creates the ability to produce reliable microwave and ferrite components and subassemblies which are needed for today's *and tomorrow's* system requirements.

If your application demands the best microwave and ferrite components available, turn to the acknowledged leader . . . Huggins Cascade Research Division.

ORDERING INFORMATION

ORDERING

Standard Units: Specify full unit nomenclature and primary performance specifications. Certified outline drawings and specifications are available on request.

Custom Units: Numerous components whose characteristics fall outside those listed in this catalog are being supplied to meet individual requirements. Military environmental specifications can also be met. Contact Huggins Sales Department, or our representative in your area, to discuss your special needs.

PRICES

F.O.B. Sunnyvale, California. Prices apply to small quantities only and are subject to change without notice.

TERMS

Net 30 days with approved credit.

DELIVERY

Many items can be delivered from stock. Maximum delivery on any standard unit is 30 days.

SHIPMENT

Via air freight unless requested otherwise.

SERVICE

Prompt technical service and assistance are readily available from factory-trained representatives and the manufacturer.

WARRANTY

All components manufactured by Huggins Cascade Research Division are thoroughly tested and inspected prior to shipment. Products are protected by the most liberal warranty available. All Huggins ferrite components are warranted for one full year to be free from defects in materials and workmanship.

WAVEGUIDE

Huggins *UNILINE* Load Isolators provide isolation between source and load with negligible loss in transmitted power. These characteristics are particularly important in radar systems where it is impractical to use resistive attenuators to improve magnetron or klystron stability. In communication systems, *UNILINE* Isolators provide isolation for the microwave transmitter tubes by absorbing energy reflected into the transmission line by the antenna; thus, phase distortion problems are substantially reduced.

UNILINE Isolators also eliminate long line effects . . . permit smoother magnetron and klystron tuning . . . smooth out power variations with tuning . . . improve the frequency spectrum of the magnetron . . . eliminate frequency pulling . . . and protect and prolong magnetron or klystron life. Huggins provides complete coverage of all frequency bands in the microwave region with both low and high power level units.

Communications Isolator

Low Power Isolator

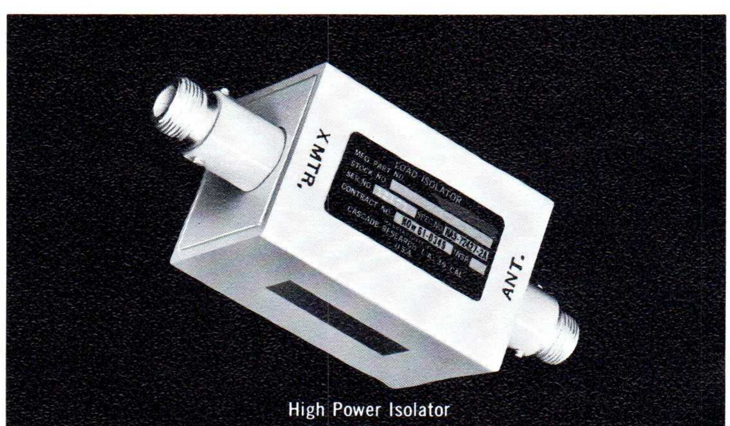
High Power Isolator

COAXIAL

Huggins Coaxial Load Isolators combine small size and light weight with extremely broadband characteristics. Available at frequencies from 750 mc to 10.7 Gc, Huggins Coaxial Isolators are ideal for use where moderate isolation and low insertion loss are required.

Special Coaxial Isolators can be supplied to meet shock, vibration, and environmental military specifications. All Coaxial Isolators can be supplied with magnetic shielding, internal DC blocks, dummy loads, signal samplers, power monitors, and bias injectors.

Low Power Isolator



High Power Isolator

UNILINE LOAD ISOLATORS

LOW POWER

	Band	Model	Frequency (Gc)	Peak Power (Kw)	Average Power (watts)	Band Edge Isolation (db)	Peak Isolation (db)	Maximum Insertion Loss (db)	Maximum Input VSWR	Guide Size	Type[2]	Length (inches)	Approximate Weight (lbs-oz)	Unit Price
WAVEGUIDE	S	S-13-1	2.8 to 3.2	50	50	22	25	1.0	1.15	RG-48/U	T	8.00	12-0	$ 450
	C	G-12-4	3.95 to 5.85	10	10	20	25	1.0	1.30	RG-49/U	T	8.00	5-0	295
		J-12-65	5.85 to 8.2	10	10	40	50	1.0	1.15	RG-50/U	T	8.00	4-6	240
		J-12-70	5.85 to 8.2	10	10	30	40	1.0	1.15	RG-50/U	T	8.00	4-6	225
	X	XL-12-7	7.0 to 10.0	10	10	40	50	1.0	1.15	RG-51/U	T	7.00	4-5	225
		XL-12-10	7.0 to 10.0	10	10	30	40	1.0	1.15	RG-51/U	T	7.00	4-6	195
		X-12-25	8.2 to 12.4	10	10	40	50	1.0	1.15	RG-52/U	T	9.00	4-13	195
		X-12-29	8.2 to 12.4	10	10	30	40	1.0	1.15	RG-52/U	T	9.00	4-13	175
	K	KU-14-3L	12.4 to 18.0	10	10	13	18	0.8	1.10	RG-91/U	T	4.50	2-1	195
		K-13-5L	23.0 to 25.0	10	10	17	30	1.0	1.30	RG-53/U	T	1.75	0-12	395
		K-13-1L	23.0 to 25.0	10	10	10	15	1.0	1.30	RG-53/U	T	1.56	0-8	395
		K-23-25	23.0 to 25.0	1	1	13	35	1.0	1.30	RG-53/U	T	2.63	0-6	495
		KA-13-1L	34.0 to 36.0	10	10	17	25	1.0	1.25	RG-96/U	T	2.00	1-3	395
COAXIAL	UHF	CN-12-74	0.75 to 1.0	10	10	10	15 to 30	1.0	1.30	Type N	C	10.00	3-0	$ 245
	L	CN-12-62	1.0 to 2.0	10	10	10	15 to 30	1.0	1.30	Type N	C	10.00	3-0	245
		CN-12-70	1.2 to 2.6	10	10	10	15 to 30	1.0	1.30	Type N	C	9.00	3-0	245
	S	CN-12-67	2.0 to 4.0	10	10	10	15 to 30	1.0	1.30	Type N	C	6.125	1-8	195
		CN-12-79	3.5 to 5.0	10	10	10	15 to 30	1.0	1.30	Type N	C	5.50	1-8	195
	C	CN-12-77	4.0 to 8.0	10	10	10	15 to 30	1.0	1.30	Type N	C	6.625	1-8	195
	X	CN-12-68	7.0 to 10.7	10	10	10	15 to 30	1.0	1.30	Type N	C	6.625	1-8	245

COMMUNICATIONS

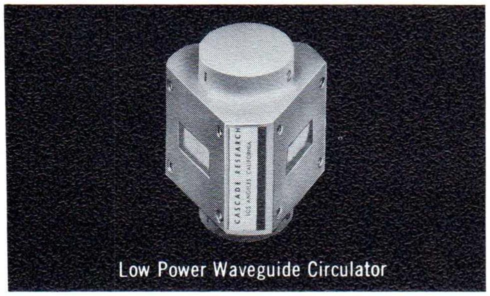
	Band	Model	Frequency (Gc)	Peak Power (Kw)	Average Power (watts)	Band Edge Isolation (db)	Peak Isolation (db)	Maximum Insertion Loss (db)	Maximum Input VSWR	Guide Size	Type[2]	Length (inches)	Approximate Weight (lbs-oz)	Unit Price
WAVEGUIDE	C	J-12-50A	5.925 to 6.425	20	20	40	50	0.8	1.15	RG-50/U	T	5.00	1-11	$ 150
		J-12-51A	6.575 to 6.875	20	20	40	50	0.8	1.15	RG-50/U	T	5.00	1-11	150
		J-12-52A	6.825 to 7.125	20	20	40	50	0.8	1.15	RG-50/U	T	5.00	1-11	150
		J-12-53A	7.125 to 7.65	20	20	40	50	0.8	1.15	RG-50/U	T	5.00	1-11	150
	X	XL-12-32	7.125 to 7.8	10	10	60	.....	1.0	1.15	RG-51/U	T	5.00	2-0	195
		XL-12-34	7.125 to 7.8	10	10	20	.....	0.5	1.15	RG-51/U	T	5.00	2-0	175
		XL-12-35	7.8 to 8.5	10	10	60	.....	1.0	1.15	RG-51/U	T	5.00	2-0	195
		XL-12-33	7.8 to 8.5	10	10	20	.....	0.5	1.15	RG-51/U	T	5.00	2-0	175
	M	M-12-1	10.5 to 11.7	5	5	40	.....	1.0	1.15	WR-75	T	3.00	2-0	175
		M-12-2	11.7 to 13.2	5	5	40	.....	1.0	1.15	WR-75	T	3.00	2-0	175

HIGH POWER

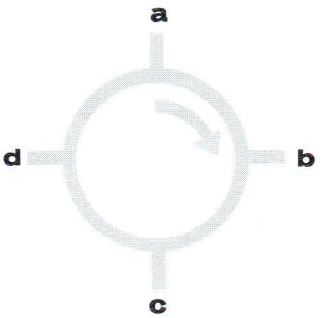
	Band	Model	Frequency (Gc)	Peak Power (Kw)	Average Power (watts)	Band Edge Isolation (db)	Peak Isolation (db)	Maximum Insertion Loss (db)	Maximum Input VSWR	Guide Size	Type[2]	Length (inches)	Approximate Weight (lbs-oz)	Unit Price
WAVEGUIDE	S	SL-17-2	2.4 to 2.5	1000	5000	10	10	0.8	1.20	RG-104/U	T	13.80	....	$1,250
		S-17-1	2.7 to 2.9	5000*	4000	10	12	0.8	1.10	RG-48/U	T	12.00	20-0	950
		S-15-1	2.7 to 2.9	750	750	10	13	0.8	1.15	RG-48/U	T	8.00	13-0	550
	C	G-19-1	5.4 to 5.9	3300	5500	8	8	0.5	1.25	RG-49/U	T	11.00	14-0	845
		G-16-1	5.4 to 5.9	1000*	1000	10	12	0.5	1.15	RG-49/U	T	12.00	13-9	415
		G-15-3	5.4 to 5.9	300	300	15	20	0.7	1.15	RG-49/U	T	5.00	3-8	275
	X	XL-12-6	7.5 to 8.5	100	200	10	15	0.5	1.20	RG-52/U	T	1.50	1-0	250
		XL-15-7	8.5 to 9.6	300	300	15	18	0.5	1.15	RG-51/U	T	2.50	2-0	175
		XL-15-10	8.6 to 9.4	300	300	13	16	0.6	1.15	RG-51/U	T	1.75	2-0	175
		X-12-1	8.2 to 12.4	200	400	20	22	1.4	1.15	RG-52/U	T	8.38	3-6	235
		X-12-0	8.2 to 12.4	200	400	10	11	0.7	1.15	RG-52/U	T	4.20	1-8	225
		X-12-6	8.5 to 9.6	200	200	25	30	1.0	1.20	RG-52/U	T	3.50	1-9	195
		X-12-5	8.5 to 9.6	100	100	10	15	1.0	1.10	RG-52/U	T	1.00	0-8	175
		X-14-6	8.5 to 10.2	200	200	15	19	0.5	1.10	RG-52/U	T	3.00	1-9	195
		X-12-7	8.9 to 9.3	100	100	10	15	0.5	1.10	RG-52/U	T	1.00	0-10	175
	K	KU-14-3	12.4 to 18.0	100	100	13	18	0.8	1.10	RG-91/U	T	4.50	2-1	195
		K-13-5	23.0 to 25.0	50*	25	17	30	1.0	1.30	RG-53/U	T	1.75	0-12	395
		K-13-1	23.0 to 25.0	50*	25	10	15	1.0	1.30	RG-53/U	T	1.56	0-8	395
		KA-13-1	34.0 to 36.0	25*	50	17	25	1.0	1.25	RG-96/U	T	2.00	1-3	395
COAXIAL	UHF	CN-14-4	0.75 to 1.0	10	250	10	15 to 30	1.0	1.30	Type N	C	10.00	3-0	$ 495
	L	CN-14-5	1.0 to 2.0	10	250	10	15 to 30	1.0	1.30	Type N	C	10.00	3-0	495
		CN-14-6	1.2 to 2.6	10	250	10	15 to 30	1.0	1.30	Type N	C	9.00	3-0	495
	S	CN-14-7	2.0 to 4.0	10	250	10	15 to 30	1.0	1.30	Type N	C	8.50	3-0	375
		CN-14-8	3.5 to 5.0	10	250	10	15 to 30	1.0	1.30	Type N	C	5.50	3-0	375
	C	CN-14-9	4.0 to 8.0	10	250	10	15 to 30	1.0	1.30	Type N	C	6.625	3-0	375
	X	CN-14-10	7.0 to 10.7	10	250	10	15 to 30	1.0	1.30	Type N	C	6.625	3-0	750

[2] T = Transverse Field; C = Coaxial   * Pressurized

Any Huggins Isolator can be fitted with an electromagnet by the manufacturer for use as a variable attenuator.



Low Power Waveguide Circulator



Huggins *Ferrite* Circulators are non-reciprocal microwave networks which transmit power from one terminal to another in sequence. Power introduced at port "a" leaves the network at port "b". . ."b" at "c" . . ."c" at "d". . . and "d" at "a". These Ferrite Circulators provide an entirely new parameter for the design of microwave circuits.

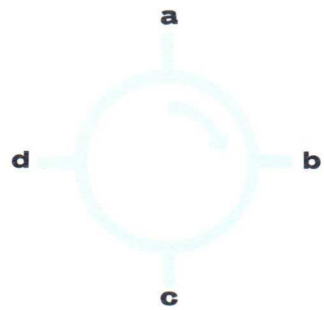
(continued on page 25)

	Band	Model[1]	Frequency (Gc)	Peak Power (Kw)	Average Power (watts)	Isolation (db)	Insertion Loss (db)	Maximum Input VSWR	Ports	Guide Size	Type[2]	Approx. Weight (lbs-oz)	Unit Price
WAVEGUIDE		SL-43-1	1.7 to 2.3	10	10	30	0.2	1.1	3	RG-105/U	J	5-0	$1,095
		SL-43-4	1.7 to 2.3	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-105/U	J	6-0	1,895
		SL-43-2	2.0 to 2.3	10	10	30	0.2	1.1	3	RG-105/U	J	5-0	1,095
		SL-43-5	2.0 to 2.3	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-105/U	J	6-0	1,895
		SL-43-3	2.3 to 2.6	10	10	30	0.2	1.1	3	RG-105/U	J	5-0	1,095
	S	SL-43-6	2.3 to 2.6	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-105/U	J	6-0	1,895
		S-43-2	2.7 to 2.9	10	10	30	0.2	1.1	3	RG-75/U	J	4-0	495
		S-43-8	2.7 to 2.9	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-75/U	J	5-0	745
		S-43-3	2.8 to 3.2	10	10	30	0.2	1.1	3	RG-75/U	J	4-0	495
		S-43-9	2.8 to 3.2	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-75/U	J	5-0	745
		S-43-4	3.1 to 3.7	10	10	30	0.2	1.1	3	RG-75/U	J	4-0	495
		S-43-10	3.1 to 3.7	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-75/U	J	5-0	745
		GL-43-3	3.7 to 4.2	10	10	30	0.2	1.1	3	WR-229	J	3-8	425
		GL-43-4	3.7 to 4.2	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	WR-229	J	4-8	425
		G-41-5	4.4 to 5.0	50	50	15	0.7	1.2	3	RG-49/U	D	8-0	950
		G-43-1	4.4 to 5.0	10	10	30	0.2	1.1	3	RG-95/U	J	3-0	375
	C	G-43-4	4.4 to 5.0	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-95/U	J	4-0	565
		G-43-2	5.2 to 5.9	10	10	30	0.2	1.1	3	RG-95/U	J	3-0	350
		G-43-5	5.2 to 5.9	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-95/U	J	4-0	565
		J-42-16	5.2 to 6.5	10	10	30	0.2	1.1	3	RG-106/U	J	2-8	425
		J-43-33	5.2 to 6.5	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-106/U	J	3-8	635
		XL-43-1	7.125 to 8.5	10	10	30	0.2	1.1	3	RG-51/U	J	1-8	345
		XL-43-4	7.125 to 8.5	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-51/U	J	2-0	545
		XL-41-2	8.5 to 9.6	10	10	30	0.2	1.1	3	RG-51/U	J	1-8	345
		XL-43-5	8.5 to 9.6	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-51/U	J	2-0	545
	X	X-43-10	8.2 to 10.2	10	10	30	0.2	1.1	3	RG-67/U	J	1-4	245
		X-43-19	8.2 to 10.2	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-67/U	J	2-0	395
		X-43-7[3]	8.6 to 9.6	5	5	20	0.5	1.2	4	RG-52/U	J	1-12	350
		X-43-16	10.0 to 10.7	10	10	30	0.2	1.1	3	RG-67/U	J	1-4	275
		X-43-20	10.0 to 10.7	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-67/U	J	2-0	395
	M	M-42-1	10.5 to 11.7	10	10	30	0.2	1.1	3	WR-75	J	1-0	395
		M-42-3	10.5 to 11.7	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	WR-75	J	1-8	695
	X	X-43-17	10.7 to 12.4	10	10	30	0.2	1.1	3	RG-67/U	J	1-4	275
		X-43-21	10.7 to 12.4	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-67/U	J	2-0	395
	M	M-42-2	11.7 to 13.2	10	10	30	0.2	1.1	3	WR-75	J	1-0	395
		M-42-4	11.7 to 13.2	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	WR-75	J	1-8	695
		KU-43-11	13.0 to 15.0	10	10	30	0.2	1.1	3	RG-91/U	J	0-12	250
		KU-43-15	13.0 to 15.0	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-91/U	J	1-0	475
		KU-43-13	14.0 to 16.0	10	10	30	0.2	1.1	3	RG-91/U	J	0-12	250
		KU-43-17	14.0 to 16.0	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-91/U	J	1-0	475
	K	KU-43-12	15.0 to 17.0	10	10	30	0.2	1.1	3	RG-91/U	J	0-12	250
		KU-43-16	15.0 to 17.0	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-91/U	J	1-0	475
		K-43-1	23.0 to 24.0	10	10	30	0.2	1.1	3	RG-53/U	J	0-8	995
		K-43-2	23.0 to 24.0	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.2	4	RG-53/U	J	0-12	1,495

[1] Junction Type: Specify "Y" or "T" configuration for 3-port units and "Pi" or "H" for 4-port units. "T" and "H" configurations priced slightly higher
[2] J = Junction Circulator; D = Differential Phase Shift [3] Any 300 mc

Any Huggins Circulator can be fitted with an electromagnet by the manufacturer for use as a circulator switch or attenuator. A circulator can also be used as an isolator by terminating one port with a load.

The duplexing effect of the circulator is ideal in both radar and microwave-relay applications. In microwave-relay applications, for example, the circulator permits transmission and reception on the same antenna, thereby simplifying filter problems. Huggins "Y," "T," "Pi", and "H" Circulators are new ferrite devices specially designed for applications where compact size is of particular advantage.




Low Power Coaxial Circulator

COAXIAL

Band	Model[1]	Frequency (Gc)	Peak Power (Kw)	Average Power (watts)	Isolation (db)	Insertion Loss (db)	Maximum Input VSWR	Ports	Guide Size	Type[2]	Approx. Weight (lbs-oz)	Unit Price
UHF	CN-41-4	0.495 to 0.605	10	100	20	0.4	1.25	3	Type N	J	3-0	$ **
	CN-42-24	0.495 to 0.605	10	100	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	6-0	**
	CN-42-9	0.6 to 0.8	10	100	20	0.4	1.25	3	Type N	J	3-0	**
	CN-52-25	0.6 to 0.8	10	100	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	6-0	**
	CN-42-10	0.8 to 1.0	10	100	20	0.4	1.25	3	Type N	J	2-0	**
	CN-42-26	0.8 to 1.0	10	100	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	5-0	**
L	CN-42-3	0.9 to 1.3	10	50	20	0.4	1.25	3	Type N	J	2-0	450
	CN-42-27	0.9 to 1.3	10	50	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	4-0	**
	CN-42-11	1.25 to 1.35	10	50	20	0.3	1.25	3	Type N	J	0-8	395
	CN-42-28	1.25 to 1.35	10	50	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	3-4	495
	CN-42-6	1.35 to 1.5	10	50	20	0.3	1.25	3	Type N	J	1-8	395
	CN-42-29	1.35 to 1.5	10	50	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	3-4	495
	CN-42-12	1.7 to 2.3	10	30	20	0.3	1.25	3	Type N	J	1-0	295
	CN-42-30	1.7 to 2.3	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	3-0	495
S	CN-42-13	2.0 to 2.5	10	30	20	0.3	1.25	3	Type N	J	1-0	245
	CN-42-31	2.0 to 2.5	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	2-8	495
	CS-40-1A	2.2 to 2.5	10	10	20	0.4	1.20	3	Microdot Miniature	J	0-3	395
	CN-42-14	2.7 to 3.4	10	30	20	0.3	1.25	3	Type N	J	0-8	275
	CN-42-32	2.7 to 3.4	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	1-8	445
	CN-42-15	3.3 to 4.0	10	30	20	0.3	1.25	3	Type N	J	0-8	275
	CN-42-33	3.3 to 4.0	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	1-8	445
C	CN-42-16	4.0 to 5.0	10	30	20	0.3	1.25	3	Type N	J	0-6	195
	CN-42-34	4.0 to 5.0	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	1-0	395
	CN-42-4	5.0 to 6.0	10	30	20	0.3	1.25	3	Type N	J	0-6	195
	CN-42-35	5.0 to 6.0	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	1-0	395
	CN-42-17	5.4 to 6.5	10	30	20	0.3	1.25	3	Type N	J	0-6	195
	CN-42-36	5.4 to 6.5	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	1-0	**
	CN-42-18	6.5 to 8.0	10	30	20	0.3	1.25	3	Type N	J	0-6	225
	CN-42-37	6.5 to 8.0	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	1-0	**
X	CN-42-19	8.0 to 12.0	10	30	20	0.3	1.25	3	Type N	J	0-6	475
	CN-42-38	8.0 to 12.0	10	30	20, 2-1 and 4-3; 35, 1-4 and 3-2	0.4, 1-2 and 3-4; 0.8, 2-3 and 4-1	1.20	4	Type N	J	0-12	**

[1] Specify "Y","T", or "L" (load) configuration for 3-port units and "Pi","H", or "L" for 4-port units. "T","H", and "L" configurations priced slightly higher
[2] J = Junction Circulator **Price on request

Any Huggins Circulator can be fitted with an electromagnet by the manufacturer for use as a circulator switch or attenuator. A circulator can also be used as an isolator by terminating one port with a load.

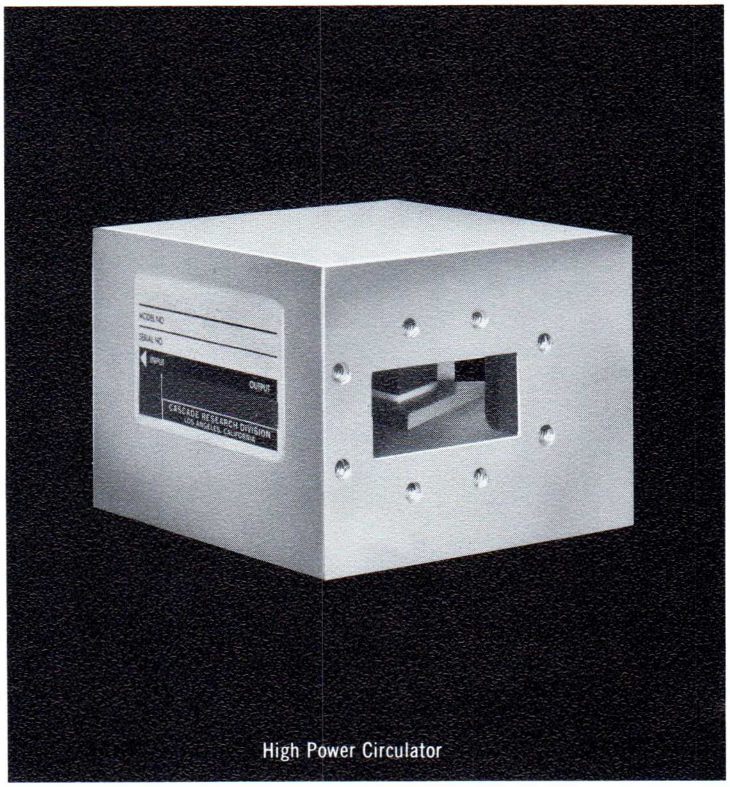
FERRITE CIRCULATORS

COMMUNICATIONS

	Band	Model[1]	Frequency (Gc)	Peak Power (Kw)	Average Power (watts)	Isolation (db)	Insertion Loss (db)	Maximum Input VSWR	Ports	Guide Size	Type[2]	Approx. Weight (lbs-oz)	Unit Price
WAVEGUIDE	C	G-44-3	6.425 to 6.875	150	150	20	0.5	1.2	4	RG-49/U	D	8-0	$ 595
	X	XL-44-9	7.5 to 8.5	300	250	20	0.5	1.2	4	RG-51/U	D	4-4	495
		XL-44-2	8.5 to 9.6	300	300	20	0.5	1.2	4	RG-51/U	D	4-4	495
		X-44-2A	8.5 to 9.6	250	250	20	0.5	1.2	4	RG-52/U	D	3-4	320
		X-43-8	8.6 to 9.6	50	50	20	0.5	1.2	4	RG-52/U	J	1-12	375
	K	KU-43-4	16.0 to 17.0	150	150	20	0.5	1.2	4	RG-91/U	D	2-8	925
		KA-43-3C	34.5 to 35.2	60*	25	20	0.5	1.2	4	RG-96/U	D	0-10	1,495

[1] Junction Type: Specify "Pi" or "H" configuration. "H" configuration priced slightly higher. [2] J = Junction Circulator; D = Differential Phase Shift *Pressurized

Communications Circulator



High Power Circulator

HIGH POWER

	Band	Model[1]	Frequency (Gc)	Peak Power (Kw)	Average Power (watts)	Isolation (db)	Insertion Loss (db)	Maximum Input VSWR	Ports	Guide Size	Type[2]	Approx. Weight (lbs-oz)	Unit Price
WAVEGUIDE	C	J-43-7	5.925 to 6.425	10	30	20	0.5	1.15	4	RG-50/U	D	6-13	$ 495
		J-42-14	5.925 to 6.425	10	10	30	0.2	1.10	3	RG-106/U	J	2-8	425
		J-43-34	5.925 to 6.425	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.20	4	RG-106/U	J	3-8	635
		J-43-3	6.425 to 6.875	10	30	20	0.5	1.15	4	RG-50/U	D	6-13	495
		J-42-15	6.575 to 6.875	10	10	30	0.2	1.10	3	RG-106/U	J	2-8	425
		J-43-35	6.575 to 6.875	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.20	4	RG-106/U	J	3-8	635
		J-43-4	6.875 to 7.150	10	30	20	0.5	1.15	4	RG-50/U	D	6-13	495
		J-43-26	6.875 to 7.150	10	10	30	0.2	1.10	3	RG-106/U	J	2-8	425
		J-43-36	6.875 to 7.150	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.20	4	RG-106/U	J	3-8	635
		J-43-5	7.125 to 7.750	10	30	20	0.5	1.15	4	RG-50/U	D	6-13	495
		J-42-17	7.125 to 7.750	10	10	30	0.2	1.10	3	RG-106/U	J	2-8	425
		J-43-37	7.125 to 7.750	10	10	20, 2-1 and 4-3 35, 1-4 and 3-2	0.3, 1-2 and 3-4 0.6, 2-3 and 4-1	1.20	4	RG-106/U	J	3-8	635

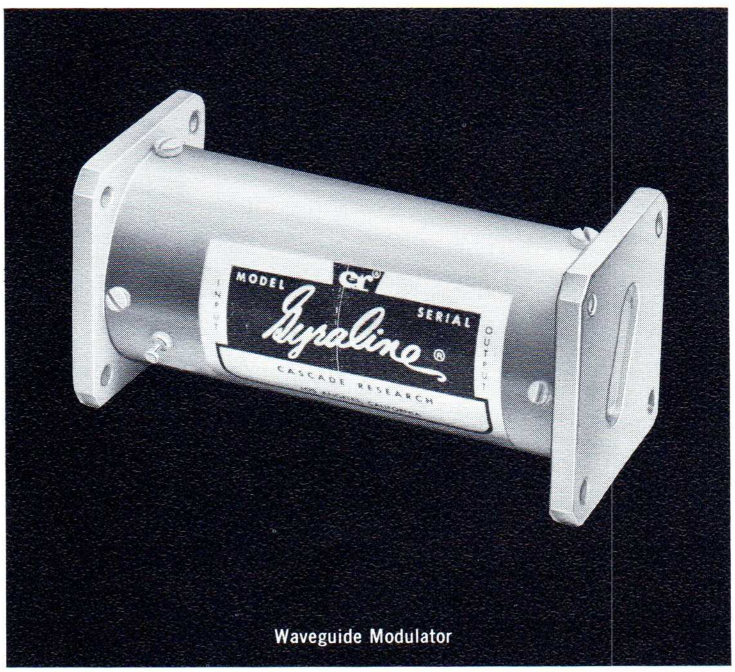
[1] Junction Type: Specify "Y"or "T" configuration for 3-port units and "Pi" or "H" for 4-port units. "T" and "H" configurations priced slightly higher.
[2] J = Junction Circulator; D = Differential Phase Shift

Any Huggins Circulator can be fitted with an electromagnet by the manufacturer for use as a circulator switch or attenuator. A circulator can also be used as an isolator by terminating one port with a load.

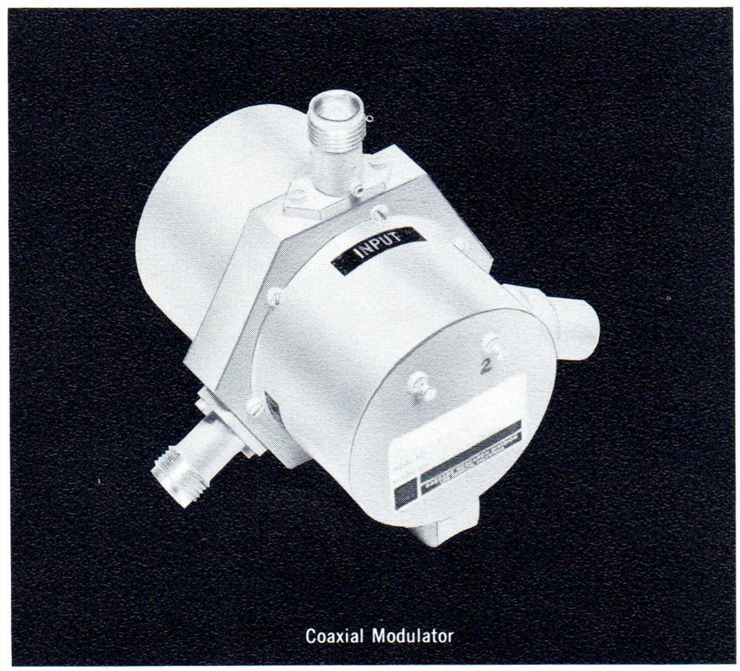
GYRALINE AMPLITUDE MODULATORS

Huggins *GYRALINE* Amplitude Modulators are electronically controlled variable attenuators. These units can be used as amplitude modulators, automatic gain controls, and as on-off switches when operated in conjunction with suitable electronic equipment. Slight modifications also permit their use as transfer switches.

GYRALINE-modulated CW signals eliminate frequency modulation and possible double moding which are frequently present with square-wave modulated klystron signals. All *GYRALINE* units can also be supplied as $\pm 90°$ rotators for use in single sideband modulation systems.



Waveguide Modulator



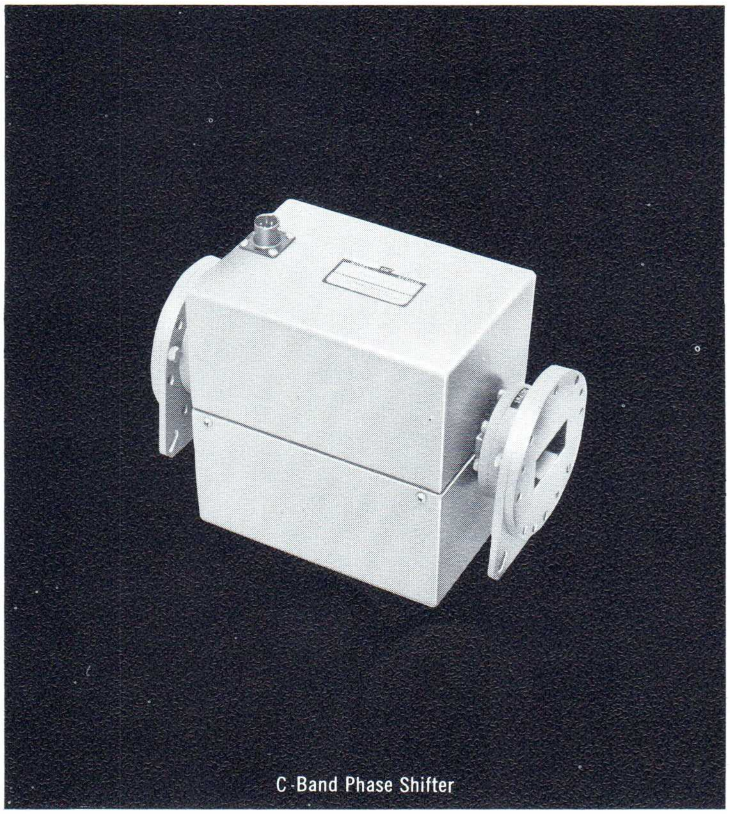
Coaxial Modulator

Band	Model	Frequency (Gc)	Average Power Absorbed (watts)	Minimum Attenuation (db)	Maximum Attenuation (db)	Nominal Current at Mid Band (Ma)	Maximum Input VSWR	Modulation Frequency (Kc)	Guide Size	Length (inches)	Approx. Weight (lbs-oz)	Unit Price
S	CN-22-3	2.0 to 4.0	5	1.0	10	225	1.30	.1	Type N	6.63	7-8	$ 395
	CN-22-2	2.5 to 3.8	5	1.0	10	225	1.30	.1	Type N	6.63	7-8	395
C	CN-22-4	4.0 to 7.0	5	1.0	10	250	1.25	.1	Type N	6.50	7-8	395
	RS-570	5.4 to 5.9	2	1.4	18	350	1.35	3	RG-50/U	5.45	2-2	645
	RS-570 (HF)	5.4 to 5.9	2	1.4	18	350	1.35	70	RG-50/U	5.45	2-2	745
	R-620	5.9 to 6.4	2	1.2	25	90	1.35	3	RG-50/U	5.60	2-2	645
	R-620 (HF)	5.9 to 6.4	2	1.2	25	90	1.35	70	RG-50/U	5.60	2-2	745
	R-670	6.4 to 6.9	2	1.0	25	90	1.30	3	RG-50/U	5.10	2-2	645
	R-670 (HF)	6.4 to 6.9	2	1.0	25	90	1.30	70	RG-50/U	5.10	2-2	745
	R-720	6.9 to 7.4	2	1.0	25	90	1.30	3	RG-50/U	4.10	1-2	645
	R-720 (HF)	6.9 to 7.4	2	1.0	25	90	1.30	70	RG-50/U	4.10	1-2	745
X	920-NA	8.2 to 10.6	2	1.0	25	10	1.45	.2	RG-52/U	3.50	0-14	325
	R-920	8.2 to 10.6	2	1.0	25	45	1.45	3	RG-52/U	3.50	0-11	315
	HF-920	8.2 to 10.6	2	1.0	25	85	1.45	70	RG-52/U	3.50	0-10	335
	X-22-17	10.25 to 10.5	2	1.0	30	250	1.15	50	RG-52/U	4.90	2-0	495
K	R-1350	13.5 to 15.0	1	1.0	25	30	1.30	3	RG-91/U	2.58	0-8	950
	R-1350 (HF)	13.5 to 15.0	1	1.0	25	30	1.30	70	RG-91/U	2.58	0-8	1,050
	R-1650	15.0 to 17.0	1	1.0	25	30	1.30	3	RG-91/U	2.58	0-8	950
	R-1650 (HF)	15.0 to 17.0	1	1.0	25	30	1.30	70	RG-91/U	2.58	0-8	1,050
	K-21-1	23.0 to 25.0	1	1.0	25	50	1.40	70	RG-53/U	2.63	0-6	745
	KA-21-1	34.0 to 35.5	1	1.0	25	75	1.50	70	RG-96/U	1.24	0-6	845

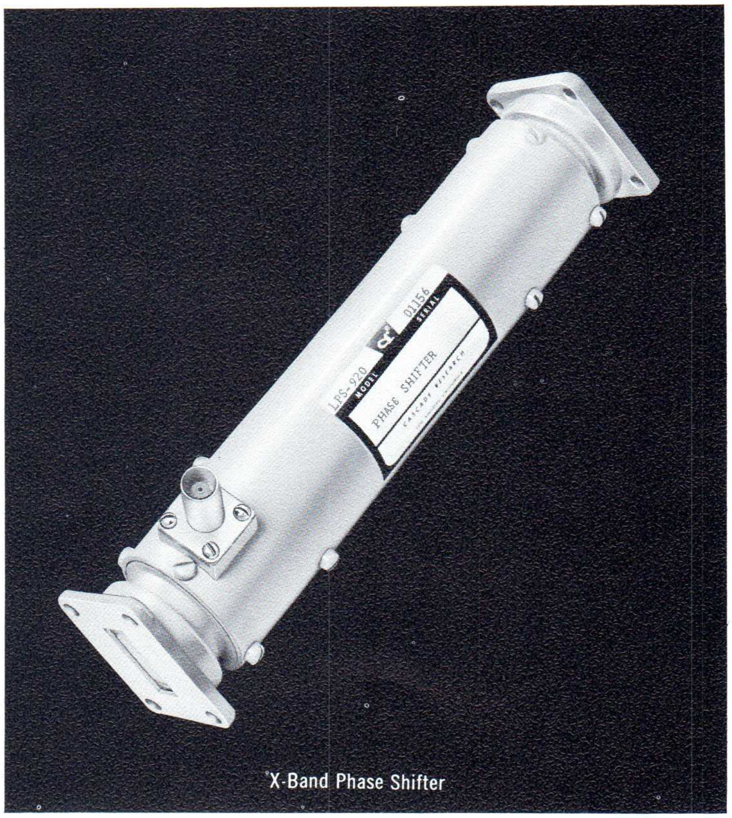
FERRITE PHASE SHIFTERS

Huggins *Ferrite* Phase Shifters are available in a variety of types. Stock designs include rectangular and circular waveguide, transverse and longitudinal field models. Coaxial and strip line units can also be supplied.

These Phase Shifters, manufactured by the Cascade Research Division of Huggins Laboratories, are particularly suited to phase modulation and electrical scan radar antenna applications. Designs of stock items can be modified or new designs developed to customer specifications. Special temperature compensated models are available on request.



C-Band Phase Shifter



X-Band Phase Shifter

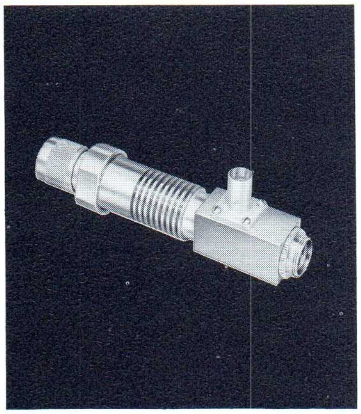
Band	Model	Frequency (Gc)	Peak Power (Kw)	Average Power (watts)	Phase Shift (degrees)	Maximum VSWR	Maximum Insertion Loss (db)	Guide Size	Type[2]	Approx. Weight (lbs-oz)	Unit Price
S	CN-33-1	2.8 to 3.2	1	1	180	1.5	1.0	Type N	L	7-8	$495
C	G-33-2	5.55 to 5.75	30	30	180	1.3	0.6	RG-48/U	T	19-0	650
X	LPS-920	8.8 to 9.6	1	10	360	1.3	1.5	RG-52/U	R	1-8	645
	X-32-4	9.1 to 9.4	10	10	180	1.2	0.5	RG-52/U	L	1-8	350
	X-32-5	9.1 to 9.4	1	1	360	1.2	1.0	RG-52/U	L	3-0	495
	LPS-1000	9.6 to 10.4	1	10	360	1.3	1.5	RG-52/U	R	1-8	985
K	KU-31-1[3]	12.8 to 18.0	1	1	360	1.3	1.0	RG-91/U	L	1-0	975
	K-31-1	23.0 to 25.0	1	1	180	1.5	1.0	RG-53/U	L	1-4	745
	KA-31-1	34.0 to 36.0	1	1	360	1.5	1.0	RG-96/U	L	0-12	975

[2] L = Longitudinal Field; T = Transverse Field; R = Faraday Rotation   [3] Any 200 mc

SPECIAL COMPONENTS & SUBASSEMBLIES

In addition to processing a broad line of microwave ferrite components, the Cascade Research Division of Huggins Laboratories is in a position to provide many custom-engineered microwave devices and subassemblies.
The following are typical examples.

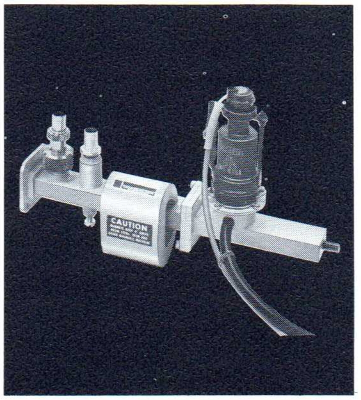
DIODE DETECTORS
Available from 100 mc to 7.0 Gc . . . 100 db dynamic range . . . units tested at 1 Kw peak and 12 watts average with no changes in performance . . . impedance independent of power level . . . 150 mv/mw sensitivity . . . excellent square wave law characteristics . . . response time less than 1.0 microseconds . . . heater operates at 6.3 volts, 135 ma.



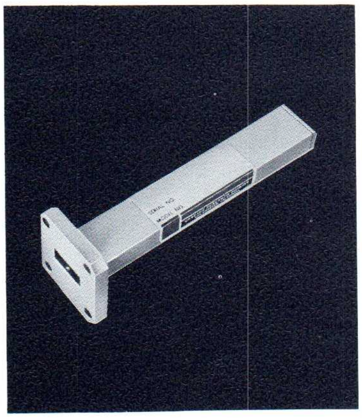
DIODE SWITCHES AND MODULATORS
Single and 2-cell K-band units, single cell and DPDT C-band units available . . . high "off" attenuation and low insertion loss . . . power handling capability of 1 watt average . . . maximum VSWR of 1.3 in the "on" condition . . . less than 10 nanoseconds response time . . . 20-35 db maximum attenuation . . . and 0.6-1.5 db minimum attenuation.

BROADBAND, HIGH POWER PRESSURE ADAPTERS AND WINDOWS
Units can be provided from 4.75 Gc to 11.0 Gc . . . 500 watts CW power . . . 0.05 db maximum insertion loss . . . 1.08 maximum VSWR . . . DR-19 waveguide . . . and 45 psig pressure.

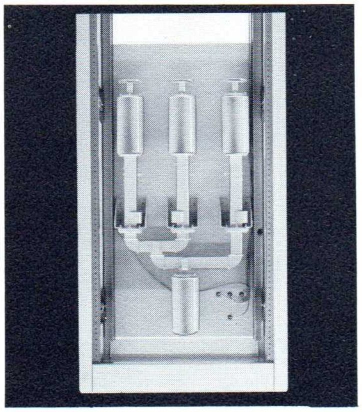
WAVEGUIDE SUBASSEMBLIES
Typical is the illustrated assembly which consists of a tube launcher, waveguide isolator, varactor modulator, and power monitor. These components are conveniently packaged to meet specific customer requirements.



MEDIUM POWER DUMMY LOADS
Designed to operate over the 23.0 to 25.0 Gc frequency band with a maximum VSWR of 1.10. Power handling capacity is 30 Kw peak, 10 watts average.

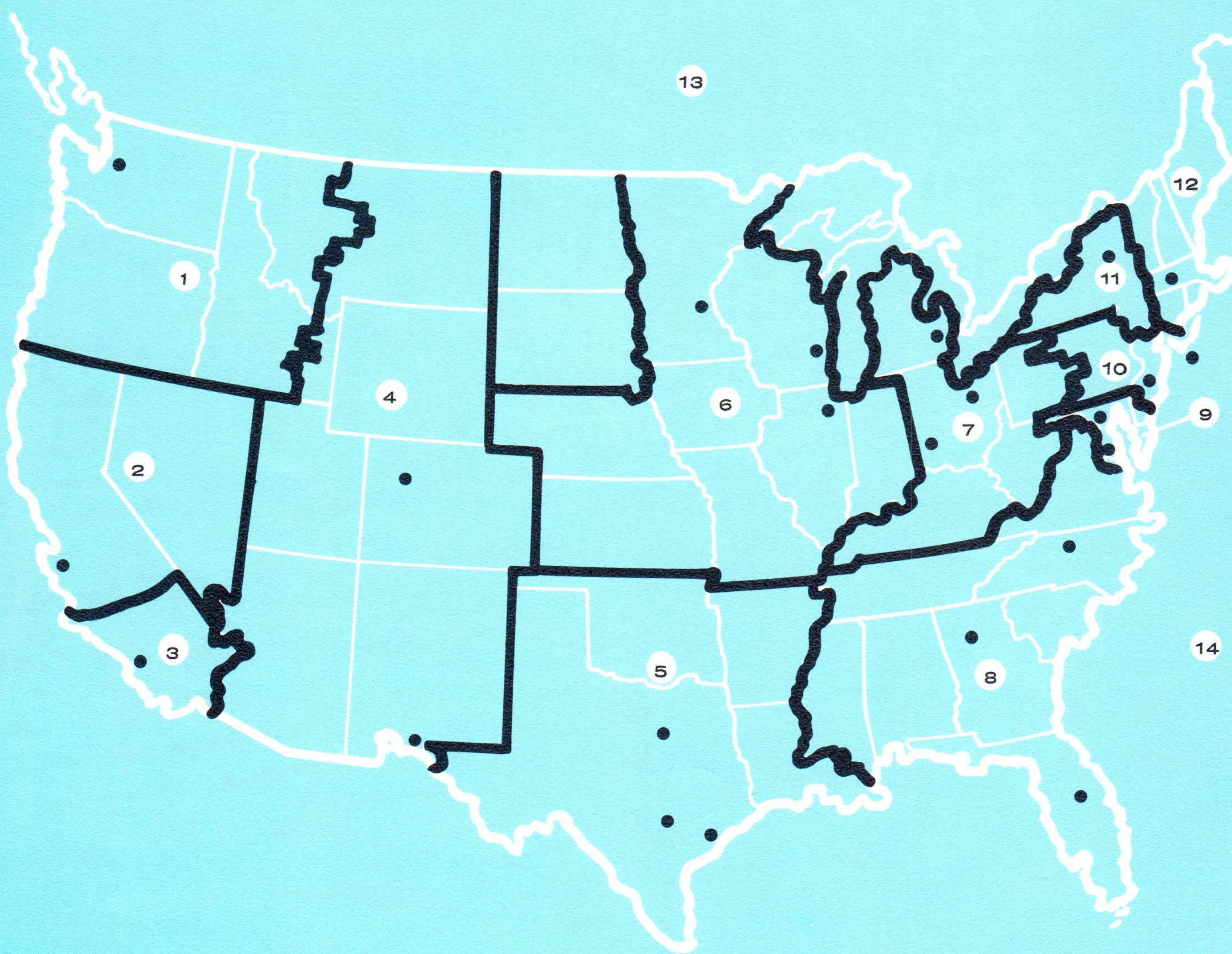


MICROWAVE TEST EQUIPMENT
A typical example is represented in the illustrated Monopulse Simulator. This equipment was specially designed for use at C-band to provide sum and difference signal simulation for testing high power fire control radar systems.



Other microwave products recently supplied by the Cascade Research Division include Varactor Multipliers . . . Beacon and Spiral Antennas . . . Weather and Ground Mapping Radar Antennas . . . Mechanical Attenuators and Phase Shifters . . . Communications Relay Subsystems . . . and Filters.

FOR FURTHER INFORMATION...



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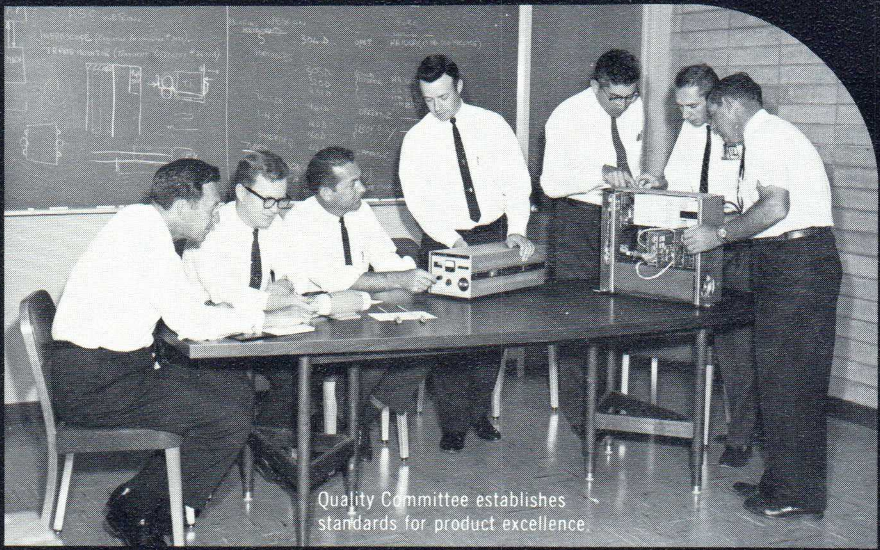
NON-STOP QUALITY


Metrology maintains accuracy of precision measuring equipment.


Final inspection insures product meets customer specifications.


Quality Committee establishes standards for product excellence.

NON-STOP QUALITY IS BUILT INTO EVERY HUGGINS PRODUCT

Huggins Laboratories Quality Program is a team effort based on the concept of "Total Quality Control." Each manager concerned with planning, design, manufacturing, purchasing, and sales is a member of this team; thus, every product produced by Huggins Labs inherently possesses **non-stop quality.** To the customer, this Total Quality Control concept delivers a high grade product at the lowest possible cost.

The Quality Program Department coordinates and integrates this concept from the time of proposal through order placement, product design, manufacturing, testing, and shipment. Other prime responsibilities include reliability and maintainability analysis to both increase product quality and meet customer requirements. This department is comprised of a Quality Committee, Quality Engineering, Inspection, and Metrology. The Quality Committee consists of the aforementioned team of management personnel. Quality Engineering – in addition to analyzing customer requirements and insuring that they are met – also performs the training and studies for improvement in the Quality Program. Necessary sorting and collection of data for assuring the required high quality level is accomplished by Inspection. Metrology maintains the consistency of highly accurate measuring devices so that the customer receives correlated data. This group also studies and develops new and improved measuring techniques and instrumentation to increase accuracy and efficiency. Each man in the Quality Program Department is selected for his high qualifications in quality mindedness, technical background, and his desire to maintain and assure the high quality level required at Huggins Laboratories. By maintaining quality standards in materials, components, and the finished product, the Quality Program Department makes certain that Huggins customers receive the best in traveling wave tubes, microwave instruments, and ferrite components. Material and component quality control and inspection are stressed throughout manufacturing; each part and assembly is closely inspected for adherence to the industry's highest standards. The over-all result is that extra dividends are passed on to the customer: high reliability . . maintenance ease . . . increased life expectancy . . . assurance that the product meets specifications . . and protection of the most liberal warranties available.

REPRESENTED BY

For further information about Huggins Quality Program, you are invited to contact our Sales Department for a copy of "Quality Program Summary."

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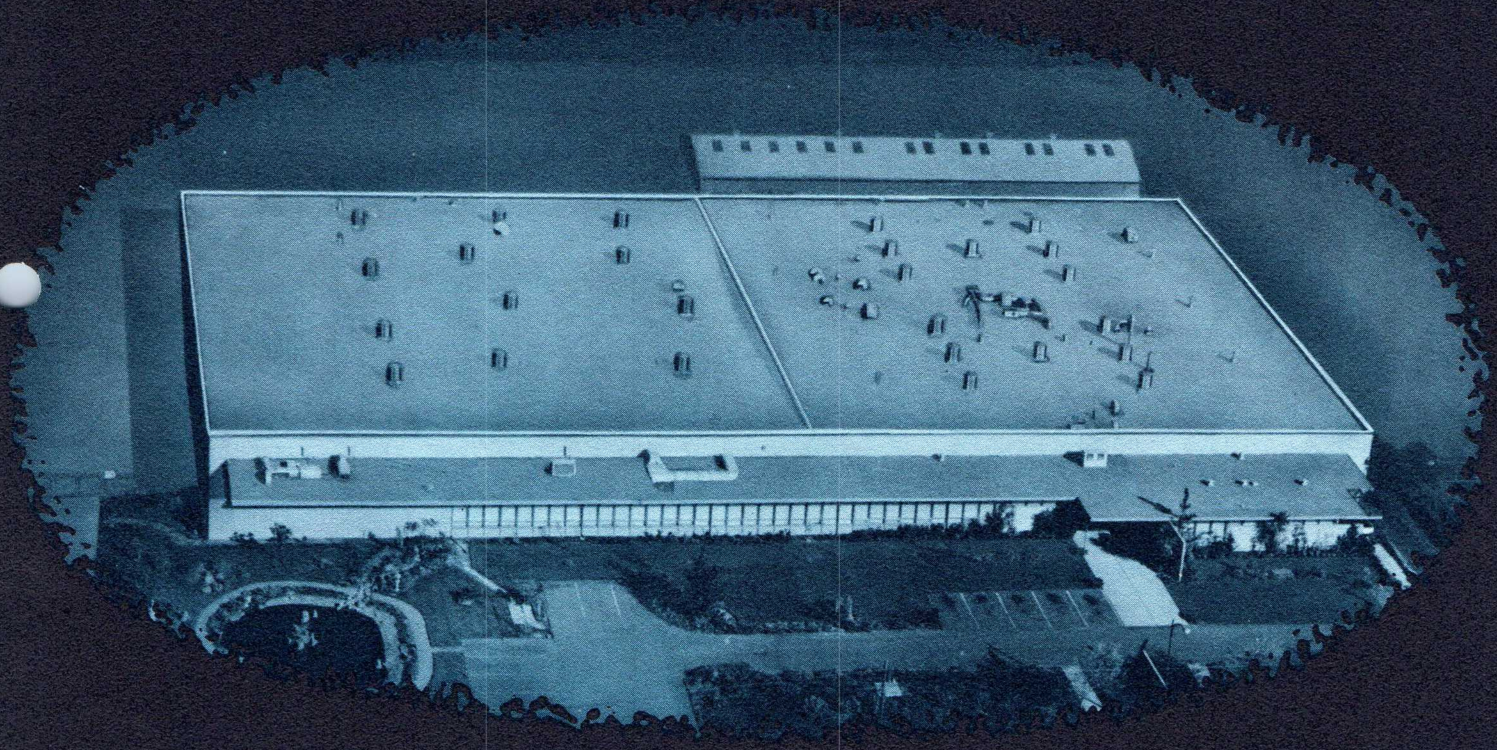
TRAVELING WAVE TUBES



BACKWARD WAVE AMPLIFIERS
FORWARD WAVE AMPLIFIERS
BACKWARD WAVE OSCILLATORS
SPECIAL PURPOSE TUBES

March 15, 1963

HUGGINS LABORATORIES, INCORPORATED

TUBE DIVISION

999 East Arques Avenue Sunnyvale, California Phone 408-736-9330 TWX 408-737-9992

HUGGINS LABORATORIES

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TRAVELING WAVE TUBES

LOW NOISE AMPLIFIERS

		VHF-BAND	UHF-BAND	L-BAND
	25 db min. small-signal gain 15 db max. noise figure		LNT HA–40* 0.5 TO 1.0 Gc $1,500.00	LNT HA–17* 1.0 TO 2.0 Gc $1,500.00 LNT HA–19§ 1.6 TO 2.6 Gc $1,500.00
SOLENOID FOCUSED	25 db min. small-signal gain 10 db max. noise figure		LNT HA–45* 0.5 TO 1.0 Gc $2,000.00	LNT HA–14* 1.0 TO 2.0 Gc $2,000.00
	25 db min. small-signal gain 8 db max. noise figure		LNT HA–72† 0.5 TO 1.0 Gc $2,750.00	LNT HA–73† 1.0 TO 2.0 Gc $2,750.00
	25 db min. small-signal gain 7 db max. noise figure		LNT HA–86† 0.5 TO 1.0 Gc $3,000.00	LNT HA–80† 1.0 TO 2.0 Gc $3,000.00
	25 db min. small-signal gain 6 db max. noise figure		LNT HA–68† 0.5 TO 1.0 Gc $3,250.00	
PPM FOCUSED	25 db min. small-signal gain 15 db max. noise figure		LNT HA–67† 0.5 TO 1.0 Gc 14 DB MAX. NOISE FIGURE $2,500.00	LNT HA–85† 1.0 TO 2.0 Gc $2,500.00

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	Voltage Tuned 0.1 to 1.0% bandwidth 15 db gain			

BACKWARD WAVE OSCILLATORS (Voltage Tuned)

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	1 MW min. power output			
	10 MW min. power output			BWO HO–9* 1.0 TO 2.0 Gc $1,500.00
PM FOCUSED	50 MW min. power output			

MANY MODIFICATIONS of these tubes have been made to customers' specifications. A technical staff is available for problems as well as for special research and development. Feel free to address us with your inquiry.

PRICE NOTE: Above prices apply to small quantities only and are subject to change without notice. A 10% credit will be allowed upon return of the used encapsulated tube when reordering. Shipment made from F.O.B. Sunnyvale, California, via air freight. Terms: Net 30 days.

DELIVERY QUOTATIONS given above represent the average situation. Consult us directly for latest quotations.

THE INDUSTRY'S **broadest line**

LOW NOISE AMPLIFIERS

S-BAND	C-BAND	X-BAND	Ku-BAND
LNT **HA–11§** 2.0 TO 4.0 Gc $1,500.00	LNT **HA–32*** 4.0 TO 8.0 Gc $1,500.00	LNT **HA–44*** 8.2 TO 12.4 Gc $1,500.00 LNT **HA–61†** 7.0 TO 14.0 Gc $2,000.00	
LNT **HA–62#** LNT **HA–37#** LNT HA–89†◆ 10 MW MIN POWER OUTPUT PRICE ON REQUEST	LNT **HA–47*** 4.0 TO 8.0 Gc $2,000.00	LNT **HA—23*** 8.0 TO 12.0 Gc $2,000.00	
LNT **HA–54†** 2.0 TO 4.0 Gc $2,500.00	**HA–84**[D] 4.0 TO 8.0 Gc	LNT **HA–60†** 7.0 TO 11.0 Gc $2,500.00	

FREQUENCY RANGE (Gc)	MAXIMUM NOISE FIGURE (DB)
2.0 TO 4.0	10.0
2.0 TO 4.0	8.0
2.2 TO 2.3	4.5
2.3 TO 2.7	4.5
2.3 TO 4.4††	10.0
2.7 TO 2.9	5.0
2.7 TO 3.6	7.0
2.9 TO 3.1	5.5
3.4 TO 3.6	5.5

††3 MW MIN POWER OUTPUT

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

S-BAND	C-BAND	X-BAND	Ku-BAND
BWA **BA–1†** 2.4 TO 3.6 Gc $1,500.00			

BACKWARD WAVE OSCILLATORS (Voltage Tuned)

S-BAND	C-BAND	X-BAND	Ku-BAND
BWO **HO–18§** 2.0 TO 4.0 Gc $750.00	BWO **HO–3§** 3.75 TO 7.0 Gc $750.00 BWO **HO–13§** 4.0 TO 8.0 Gc $750.00	BWO **HO–14§** 8.2 TO 12.4 Gc $750.00 BWO **HO–17§** 7.0 TO 11.0 Gc $750.00	BWO **HO–19§** 12.0 TO 18.0 Gc $1,250.00
BWO **HO–1§** 2.0 TO 4.0 Gc $1000.00	BWO **HO–20*** 3.75 TO 7.0 Gc $1,000.00 BWO **HO–21*** 4.0 TO 8.0 Gc $1,000.00	BWO **HO–2*** 8.2 TO 12.4 Gc $1000.00	BWO **HO–4§** 12.4 TO 18.0 Gc $1,500.00
	HO—24[D] 4.0 TO 8.0 Gc	BWO **HO—23** 7.0 TO 11.0 Gc OR 8.2 TO 12.4 Gc $1,300.00	

D Under development
§ 4 to 6 weeks delivery
* 6 to 8 weeks delivery
† 8 to 10 weeks delivery

◆ This performance obtained in a lightweight, low-power solenoid

Sold for replacement

LNT, BWA, BWO. Refer to Low Noise Tube, Backward Wave Amplifier, and Backward Wave Oscillator sections of Huggins TWT Catalog for detailed information.

Changes or additions to the September Short-Form Catalog

A CATALOG and Engineering Handbook are available for you. Please submit your request on company letterhead.

TRAVELING WAVE TUBES

HUGGINS manufacture development engineering design research LABORATORIES

BROADBAND FORWARD WAVE AMPLIFIERS

		VHF-BAND	UHF-BAND	L-BAND	
SOLENOID FOCUSED	10 MW min. power output 30 db min. small-signal gain		FWA **HA–7*** 0.5 TO 1.0 Gc $950.00	FWA **HA–5§** 1.0 TO 2.0 Gc $850.00	FWA **HA–22§** 1.6 TO 2.6 Gc $750.00
	1 W min. power output 30 db min. small-signal gain		FWA **HA–8*** 0.5 TO 1.0 Gc $1,500.00	FWA **HA–18†** 1.0 TO 2.0 Gc 2 W MIN. 33 DB MIN. S-S GAIN $1,000.00	FWA **HA–39§** 1.6 TO 2.6 Gc $850.00
	Beam Pulsed 1 W min. power output 30 db min. s-s gain 0.1 max. duty cycle				
PPM FOCUSED	10 MW min. power output 30 db min. small-signal gain	FWA **HA–51*** 250 TO 500 MC 20 DB MIN. S-S GAIN $1,575.00	FWA **HA–36*** 0.5 TO 1.0 Gc 20 DB MIN. S-S GAIN $1,575.00	FWA **HA–31*** 1.0 TO 2.0 Gc $1,350.00	
	1 W min. power output 30 db min. small-signal gain				
	2 W min. power output 30 db min. small-signal gain			FWA **HA–53*** 1.0 TO 2.0 Gc $1,750.00	
	Beam Pulsed 1 W min. power output 30 db min. s-s gain 0.1 max. duty cycle				

SPECIAL PURPOSE TUBES

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	Dispersive Amplifiers Voltage Tuned 20% Bandwidth		SPT **DA–3†** 0.5 TO 1.0 Gc $1,350.00	SPT **DA–2†** 1.0 TO 2.0 Gc $1,350.00
SOLENOID FOCUSED	Frequency multiplier tubes		SPT **HA–34*** UHF-BAND TO S-BAND $1,250.00	

A GRID ELECTRODE for attenuation and modulation is incorporated in all forward wave amplifiers and frequency multipliers.

COLD VSWR less than 1.7 to 1 over the specified operating range is attained in most tubes.

MANUFACTURE to meet rigid environmental requirements is possible. Send us your specifications.

THE INDUSTRY'S **broadest line**

BROADBAND FORWARD WAVE AMPLIFIERS

S-BAND	C-BAND	X-BAND	Ku-BAND
FWA **HA–1§** 2.0 TO 4.0 Gc $750.00	FWA **HA–26§** 4.0 TO 8.0 Gc $800.00	FWA **HA–4§** 8.0 TO 12.4 Gc $850.00	FWA **HA–24§** 12.4 TO 15.0 Gc 5 MW MIN. 20 DB MIN. S-S GAIN $1,000.00
FWA **HA–2§** 2.0 TO 4.0 Gc $850.00	FWA **HA–6§** 4.0 TO 8.0 Gc 500 MW MIN. $1,000.00	FWA **HA–9*** 8.0 TO 11.0 Gc 500 MW MIN. 33 DB MIN. S-S GAIN $1,500.00 FWA **HA–10§** 8.0 TO 12.4 Gc 100 MW MIN. 25 DB MIN. S-S GAIN $1,000.00	
PA **PA–4§** 2.0 TO 4.0 Gc 33 DB MIN. S-S GAIN $1,000.00 PA **PA–3§** 2.0 TO 4.0 Gc 10 W MIN. $1,250.00	PA **PA–7§** 4.0 TO 8.0 Gc $1,250.00	PA **PA–1*** 8.0 TO 11.0 Gc 0.03 MAX. DUTY CYCLE $1,750.00 PA **PA–5*** 8.0 TO 12.4 Gc 300 MW MIN. $1,250.00	
FWA **HA–29*** 2.0 TO 4.0 Gc $1,000.00	FWA **HA–28*** 4.0 TO 8.0 Gc $1,125.00	FWA **HA–20*** 8.0 TO 12.4 Gc $1,250.00	
FWA **HA–30§** 2.0 TO 4.0 Gc $1,350.00	FWA **HA–35*** 4.0 TO 8.0 Gc 500 MW MIN. $2,000.00	FWA **HA–21*** 8.0 TO 11.0 Gc 500 MW MIN. 33 DB MIN. S-S GAIN $2,500.00 FWA **HA–71†** 8.0 TO 12.4 Gc 100 MW MIN. 25 DB MIN. S-S GAIN $1,600.00	
PA **PA–6§** 2.0 TO 4.0 Gc $1,575.00 PA **PA–10†** 2.0 TO 4.0 Gc 10 W MIN. $2,500.00	PA **PA–8*** 4.0 TO 8.0 Gc $2,475.00	PA **PA–9*** 8.0 TO 11.0 Gc 0.03 MAX DUTY CYCLE $3,000.00	

SPECIAL PURPOSE TUBES

S-BAND	C-BAND	X-BAND	Ku-BAND
SPT **DA–1†** 2.0 TO 4.0 Gc $1,350.00	SPT **DA–4†** 4.0 TO 8.0 Gc $1,350.00		
SPT **HA–16*** S-BAND TO X-BAND $1,000.00			

D Under development
§ 4 to 6 weeks delivery
* 6 to 8 weeks delivery
† 8 to 10 weeks delivery

FWA, PA, SPT. Refer to Forward Wave Amplifier, Pulsed Amplifier, and Special Purpose Tube sections of Huggins TWT Catalog for detailed information.

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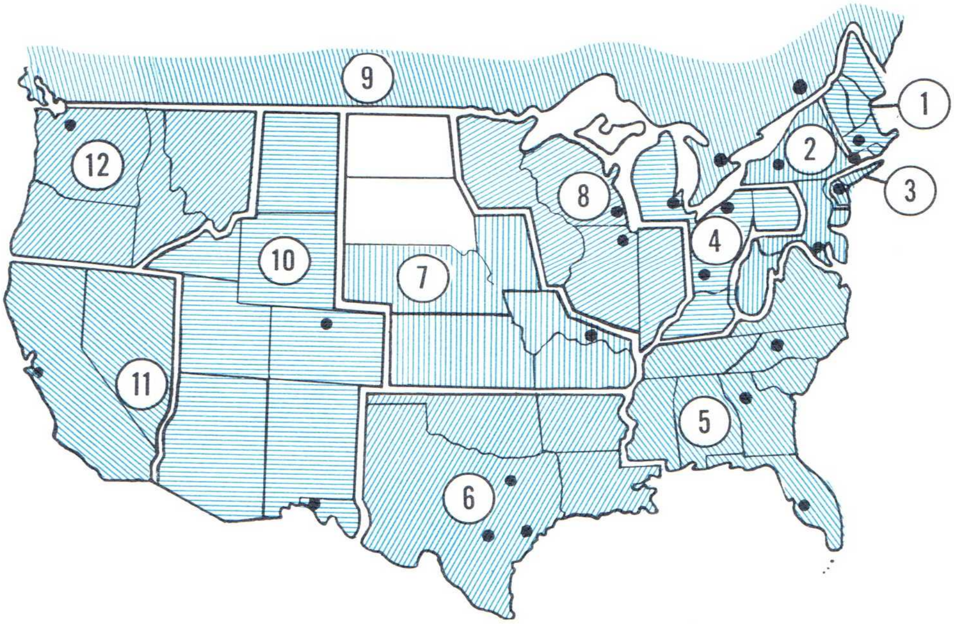
FOR FURTHER INFORMATION • • • • •



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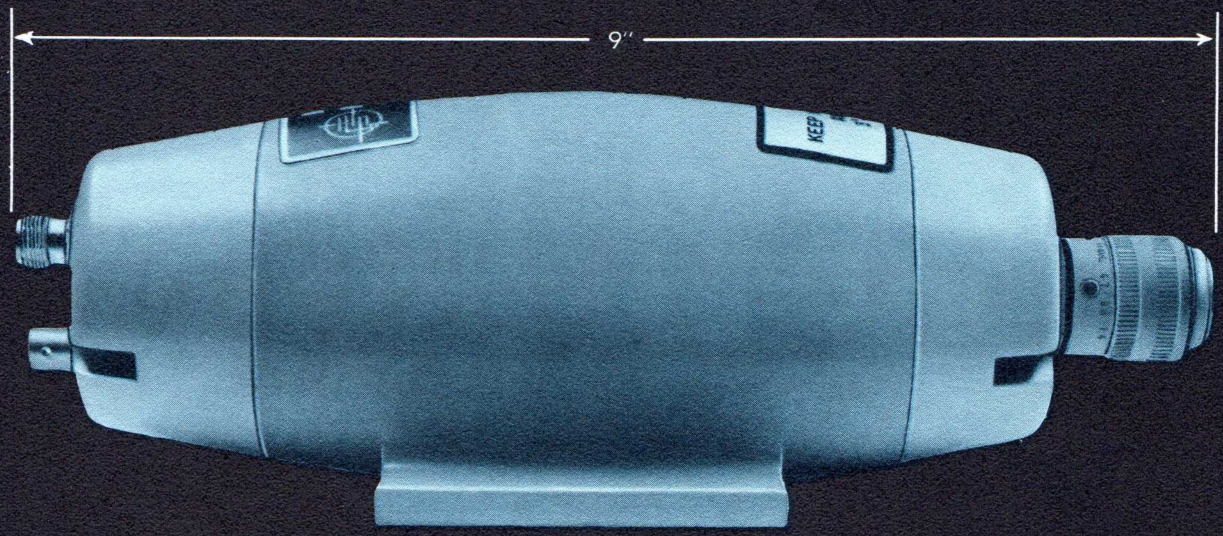
NEW PM FOCUSED X-BAND BACKWARD WAVE OSCILLATOR



HO-23

50 MILLIWATTS POWER OUTPUT • NO COOLING REQUIRED

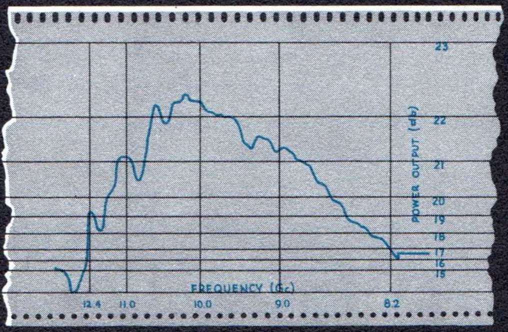
The HO-23 is the first in a broad line of voltage tunable PM focused BWOs now being developed at Huggins Laboratories. Military environmental considerations form an integral part of the design concept to produce compact, lightweight units which are rugged and reliable. C-band and S-band BWOs will soon be available.

GENERAL

Application versatility is designed into the HO-23: A grid is incorporated for gating or leveling purposes . . . packaging techniques minimize field leakage and permit adjacent operation of two or more units with no significant effect on operation . . . the BWO can be supplied for either grounded cathode or grounded collector operation . . . and repeatability of HO-23 electrical characteristics is excellent.

SPECIFICATIONS

Frequency: 8.2 to 12.4 Gc
Power Output: 50 mw min
Tuning Voltage: 350 to 2000 volts
Cathode Current: 10 ma max
Beam Cutoff: V_g = −50 volts max
Output Impedance: 50 ohms, 2:1 VSWR max
RF Connector: TNC, female
DC Connector: Amphenol 67-03E-14-9P
Weight: 9 lbs
Environment: Can be manufactured to MIL-E-5400, Class 2



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TUBE DIVISION
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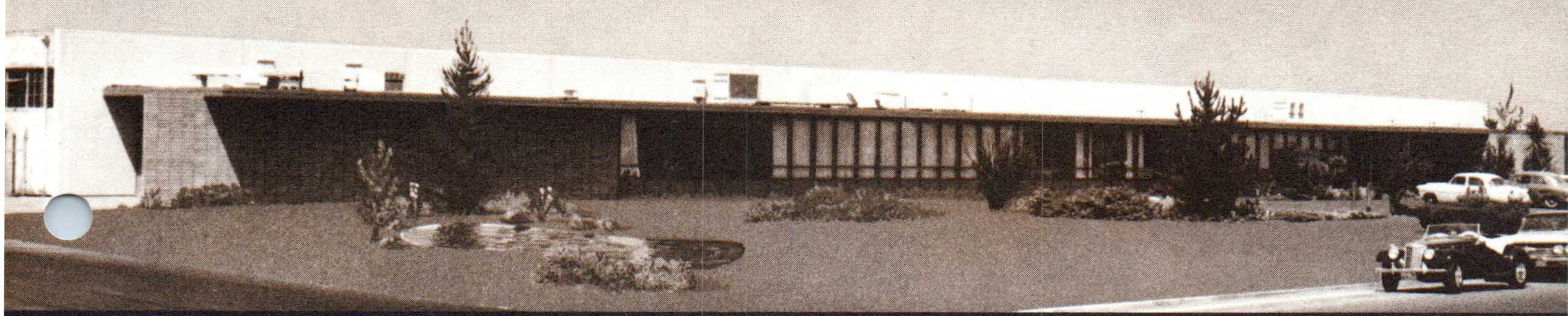

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TRAVELING WAVE TUBES

BACKWARD WAVE AMPLIFIERS
FORWARD WAVE AMPLIFIERS
BACKWARD WAVE OSCILLATORS
SPECIAL PURPOSE TUBES

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Effective September 1, 1962

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TRAVELING WAVE TUBES

LOW NOISE AMPLIFIERS

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	25 db min. small-signal gain 15 db max. noise figure		LNT **HA–40*** 0.5 TO 1.0 Gc $1,500.00	LNT **HA–17*** 1.0 TO 2.0 Gc $1,500.00 LNT **HA–19§** 1.6 TO 2.6 Gc $1,500.00
SOLENOID FOCUSED	25 db min. small-signal gain 10 db max. noise figure		LNT **HA–45*** 0.5 TO 1.0 Gc $2,000.00	LNT **HA–14*** 1.0 TO 2.0 Gc $2,000.00
SOLENOID FOCUSED	25 db min. small-signal gain 8 db max. noise figure		LNT **HA–72†** 0.5 TO 1.0 Gc $2,750.00	LNT **HA–73†** 1.0 TO 2.0 Gc $2,750.00
SOLENOID FOCUSED	25 db min. small-signal gain 7 db max. noise figure		LNT **HA–86†** 0.5 TO 1.0 Gc $3,000.00	LNT **HA–80†** 1.0 TO 2.0 Gc $3,000.00
SOLENOID FOCUSED	25 db min. small-signal gain 6 db max. noise figure		LNT **HA–68†** 0.5 TO 1.0 Gc $3,250.00	
PPM FOCUSED	25 db min. small-signal gain 15 db max. noise figure		LNT **HA–67†** 0.5 TO 1.0 Gc 14 DB MAX. NOISE FIGURE $2,500.00	LNT **HA–85†** 1.0 TO 2.0 Gc $2,500.00
PPM FOCUSED				

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	Voltage Tuned 0.1 to 1.0% bandwidth 15 db gain			

BACKWARD WAVE OSCILLATORS (Voltage Tuned)

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	1 MW min. power output			
SOLENOID FOCUSED	10 MW min. power output			BWO **HO–9*** 1.0 TO 2.0 Gc $1,500.00
PM FOCUSED	20 MW min. power output			
PM FOCUSED				

MANY MODIFICATIONS of these tubes have been made to customers' specifications. A technical staff is available for problems as well as for special research and development. Feel free to address us with your inquiry.

PRICE NOTE: Above prices apply to small quantities only and are subject to change without notice. A 10% credit will be allowed upon return of the used encapsulated tube when reordering. Shipment made from F.O.B. Sunnyvale, California, via air freight. Terms: Net 30 days.

DELIVERY QUOTATIONS given above represent the average situation. Consult us directly for latest quotations.

THE INDUSTRY'S **broadest line**

LOW NOISE AMPLIFIERS

S-BAND	C-BAND	X-BAND	Ku-BAND
LNT **HA–11§** 2.0 TO 4.0 Gc $1,500.00	LNT **HA–32*** 4.0 TO 8.0 Gc $1,500.00	LNT **HA–44*** 8.2 TO 12.4 Gc $1,500.00 LNT **HA–61†** 7.0 TO 14.0 Gc $2,000.00	
LNT **HA–62#** LNT **HA–37#** LNT HA–89†◆ 10 MW MIN POWER OUTPUT PRICE ON REQUEST	LNT **HA–47*** 4.0 TO 8.0 Gc $2,000.00	LNT **HA–23*** 8.2 TO 11.0 Gc $2,000.00	
LNT **HA–54†** 2.0 TO 4.0 Gc $2,500.00	**HA–84[D]** 4.0 TO 8.0 Gc	LNT **HA–60†** 7.0 TO 11.0 Gc $2,500.00	

FREQUENCY RANGE (Gc)	MAXIMUM NOISE FIGURE (DB)
2.0 TO 4.0	10.0
2.0 TO 4.0	8.0
2.2 TO 2.3	4.5
2.3 TO 2.7	4.5
2.3 TO 4.4††	10.0
2.7 TO 2.9	5.0
2.7 TO 3.6	7.0
2.9 TO 3.1	5.5
3.4 TO 3.6	5.5

††3 MW MIN POWER OUTPUT

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

S-BAND	C-BAND	X-BAND	Ku-BAND
BWA **BA–1†** 2.4 TO 3.6 Gc $1,500.00			

BACKWARD WAVE OSCILLATORS (Voltage Tuned)

S-BAND	C-BAND	X-BAND	Ku-BAND
BWO **HO–18§** 2.0 TO 4.0 Gc $750.00	BWO **HO–3§** 3.75 TO 7.0 Gc $750.00 BWO **HO–13§** 4.0 TO 8.0 Gc $750.00	BWO **HO–14§** 8.2 TO 12.4 Gc $750.00 BWO **HO–17§** 7.0 TO 11.0 Gc $750.00	BWO **HO–19§** 12.0 TO 18.0 Gc $1,250.00
BWO **HO–1§** 2.0 TO 4.0 Gc $1000.00	BWO **HO–20*** 3.75 TO 7.0 Gc $1,000.00 BWO **HO–21*** 4.0 TO 8.0 Gc $1,000.00	BWO **HO–2*** 8.2 TO 12.4 Gc $1000.00	BWO **HO–4§** 12.4 TO 18.0 Gc $1,500.00
		HO–23[D] 8.2 TO 12.4 Gc	

[D] Under development
§ 4 to 6 weeks delivery
* 6 to 8 weeks delivery
† 8 to 10 weeks delivery

◆ This performance obtained in a lightweight, low-power solenoid

Sold for replacement

LNT, BWA, BWO. Refer to Low Noise Tube, Backward Wave Amplifier, and Backward Wave Oscillator sections of Huggins TWT Catalog for detailed information.

Changes or additions to the March Short-Form Catalog

A CATALOG and Engineering Handbook are available for you. Please submit your request on company letterhead.

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TRAVELING WAVE TUBES

BROADBAND FORWARD WAVE AMPLIFIERS

		VHF-BAND	UHF-BAND	L-BAND	
SOLENOID FOCUSED	10 MW min. power output 30 db min. small-signal gain	**HA–79**[D] 250 TO 500 MC	FWA **HA–7*** 0.5 TO 1.0 Gc $950.00	FWA **HA–5§** 1.0 TO 2.0 Gc $850.00	FWA **HA–22§** 1.6 TO 2.6 Gc $750.00
	1 W min. power output 30 db min. small-signal gain	**HA–78**[D] 250 TO 500 MC	FWA **HA–8*** 0.5 TO 1.0 Gc $1,500.00	FWA **HA–18†** 1.0 TO 2.0 Gc 2 W MIN. 33 DB MIN. S-S GAIN $1,000.00	FWA **HA–39§** 1.6 TO 2.6 Gc $850.00
	Beam Pulsed 1 W min. power output 30 db min. s-s gain 0.1 max. duty cycle				
PPM FOCUSED	10 MW min. power output 30 db min. small-signal gain	FWA **HA–51*** 250 TO 500 MC 20 DB MIN. S-S GAIN $1,575.00	FWA **HA–36*** 0.5 TO 1.0 Gc 20 DB MIN. S-S GAIN $1,575.00	FWA **HA–31*** 1.0 TO 2.0 Gc $1,350.00	
	1 W min. power output 30 db min. small-signal gain				
	2 W min. power output 30 db min. small-signal gain			FWA **HA–53*** 1.0 TO 2.0 Gc $1,750.00	
	Beam Pulsed 1 W min. power output 30 db min. s-s gain 0.1 max. duty cycle				

SPECIAL PURPOSE TUBES

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	Dispersive Amplifiers Voltage Tuned 20% Bandwidth		SPT **DA–3†** 0.5 TO 1.0 Gc $1,350.00	SPT **DA–2†** 1.0 TO 2.0 Gc $1,350.00
SOLENOID FOCUSED	Frequency multiplier tubes		SPT **HA–34*** UHF-BAND TO S-BAND $1,250.00	

A GRID ELECTRODE for attenuation and modulation is incorporated in all forward wave amplifiers and frequency multipliers.

COLD VSWR less than 1.7 to 1 over the specified operating range is attained in most tubes.

MANUFACTURE to meet rigid environmental requirements is possible. Send us your specifications.

THE INDUSTRY'S **broadest line**

BROADBAND FORWARD WAVE AMPLIFIERS

S-BAND	C-BAND	X-BAND	Ku-BAND
FWA **HA–1§** 2.0 TO 4.0 Gc $750.00	FWA **HA–26§** 4.0 TO 8.0 Gc $800.00	FWA **HA–4§** 8.0 TO 12.4 Gc $850.00	FWA **HA–24§** 12.4 TO 15.0 Gc 5 MW MIN. 20 DB MIN. S-S GAIN $1,000.00
FWA **HA–2§** 2.0 TO 4.0 Gc $850.00	FWA **HA–6§** 4.0 TO 8.0 Gc 500 MW MIN. $1,000.00	FWA **HA–9*** 8.0 TO 11.0 Gc 500 MW MIN. 33 DB MIN. S-S GAIN $1,500.00 FWA **HA–10§** 8.0 TO 12.4 Gc 100 MW MIN. 25 DB MIN. S-S GAIN $1,000.00	
PA **PA–4§** 2.0 TO 4.0 Gc 33 DB MIN. S-S GAIN $1,000.00 PA **PA–3§** 2.0 TO 4.0 Gc 10 W MIN. $1,250.00	PA **PA–7§** 4.0 TO 8.0 Gc $1,250.00	PA **PA–1*** 8.0 TO 11.0 Gc 0.03 MAX. DUTY CYCLE $1,750.00 PA **PA–5*** 8.0 TO 12.4 Gc 300 MW MIN. $1,250.00	
FWA **HA–29*** 2.0 TO 4.0 Gc $1,000.00	FWA **HA–28*** 4.0 TO 8.0 Gc $1,125.00	FWA **HA–20*** 8.0 TO 12.4 Gc $1,250.00	
FWA **HA–30§** 2.0 TO 4.0 Gc $1,350.00	FWA **HA–35*** 4.0 TO 8.0 Gc 500 MW MIN. $2,000.00	FWA **HA–21*** 8.0 TO 11.0 Gc 500 MW MIN. 33 DB MIN. S-S GAIN $2,500.00 FWA **HA–71†** 8.0 TO 12.4 Gc 100 MW MIN. 25 DB MIN. S-S GAIN $1,600.00	
PA **PA–6§** 2.0 TO 4.0 Gc $1,575.00 PA **PA–10†** 2.0 TO 4.0 Gc 10 W MIN. $2,500.00	PA **PA–8*** 4.0 TO 8.0 Gc $2,475.00	PA **PA–9*** 8.0 TO 11.0 Gc 0.03 MAX DUTY CYCLE $3,000.00	

SPECIAL PURPOSE TUBES

SPT **DA–1†** 2.0 TO 4.0 Gc $1,350.00	SPT **DA–4†** 4.0 TO 8.0 Gc $1,350.00		
SPT **HA–16*** S-BAND TO X-BAND $1,000.00			

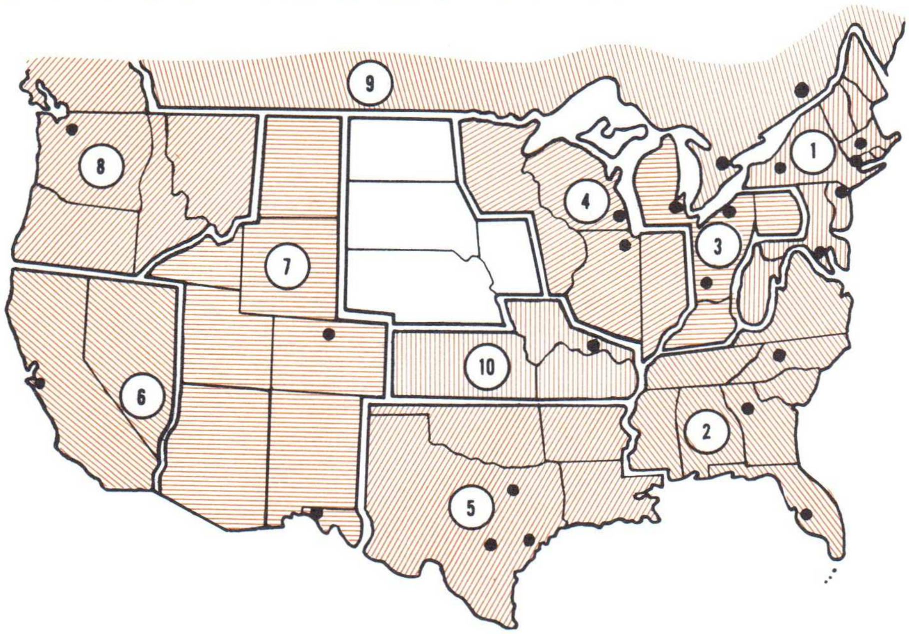
D Under development
§ 4 to 6 weeks delivery
* 6 to 8 weeks delivery
† 8 to 10 weeks delivery

FWA, PA, SPT. Refer to Forward Wave Amplifier, Pulsed Amplifier, and Special Purpose Tube sections of Huggins TWT Catalog for detailed information.

Changes or additions to the March Short-Form Catalog

A CATALOG and Engineering Handbook are available for you. Please submit your request on company letterhead.

FOR FURTHER INFORMATION • • • • •



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303 NORMANDY 7-1376

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514 REGENT 9-5517

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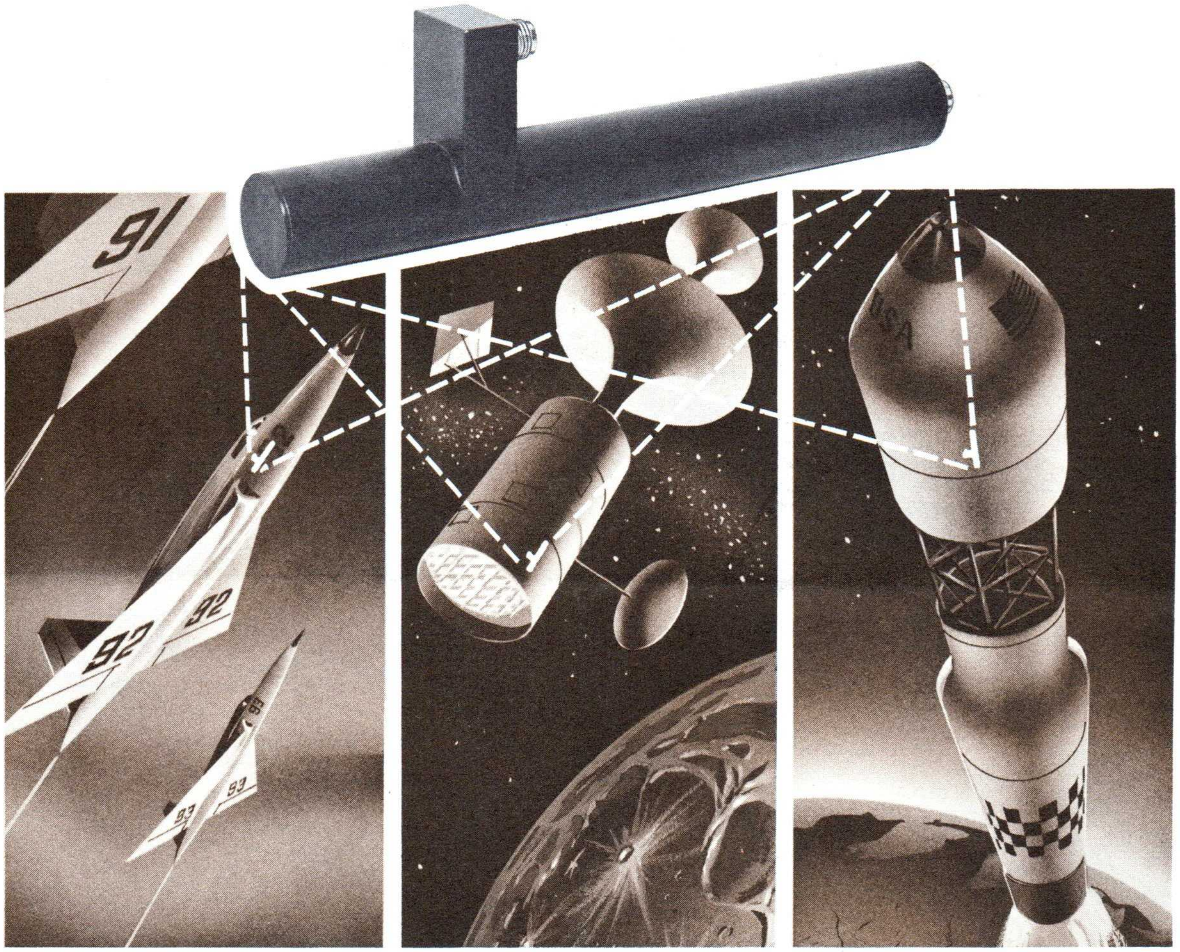
STILL the industry's broadest warranty
NOW the industry's broadest technology

INTRODUCING

HUGGINS' NEW CERAMIC TWTs



Space-Age requirements for extremely compact, lightweight, broadband amplifiers exhibiting high efficiency, gain, and power output are fulfilled by a new family of ceramic traveling-wave tubes. Recent advances in vacuum-tube technology at Huggins Laboratories have produced a TWT design capable of operating under the most severe shock, vibration, and temperature extremes encountered in tomorrow's military and space vehicles. This truly remarkable design demands a whole new concept of the performance capabilities of weapons systems such as radar augmenters and decoys, airborne communications, and many electronic countermeasures applications.

Huggins Laboratories continues to expand the industry's broadest line of glass traveling-wave tubes—TWTs that have the proven ability to withstand shock of 30 G . . . vibration of 15 G to 2000 cps . . . and operating temperature ranges from −65°F to +260°F.

PRINTED IN U.S.A.

HUGGINS LABORATORIES, INC.

999 EAST ARQUES AVE. • SUNNYVALE, CALIF. • 736-9330 AREA CODE 408 • TWX 408-737-9992

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Item (12)

RUGGEDIZATION

Huggins' low and medium power PPM-focused traveling-wave tubes perform over severe environmental extremes.

--Some Examples Of Huggins' TWTs Manufactured To MIL-E-5400--

Frequency Band	Tube Type	Class
UHF-band	HA-36	III
L-band	HA-31	I
	HA-53	I
S-band	HA-29	I
C-band	HA-28	I
	HA-35	III
X-band	HA-20	III
	HA-21	II

Years of TWT engineering know-how and experience have created sound ruggedization techniques which have given Huggins PPM traveling-wave tubes field-proven environmental capabilities.

Techniques such as...

...rigid support along the entire length of the slow-wave circuit, ceramic heater supports, a specially designed electron gun, additional inner capsule support, and a reinforced focusing structure minimize the effects of shock and vibration.

...hermetic sealing with thermoplastic compounds prevents damage from moisture.

...and an Alnico magnet focusing structure with compensating alloy shunts reduces gain and power output variations over wide temperature ranges.

If your application demands ruggedness and reliability, call on Huggins for complete assistance.

HUGGINS LABORATORIES, INC.

HUGGINS LABORATORIES — manufacture, development, engineering, design, research

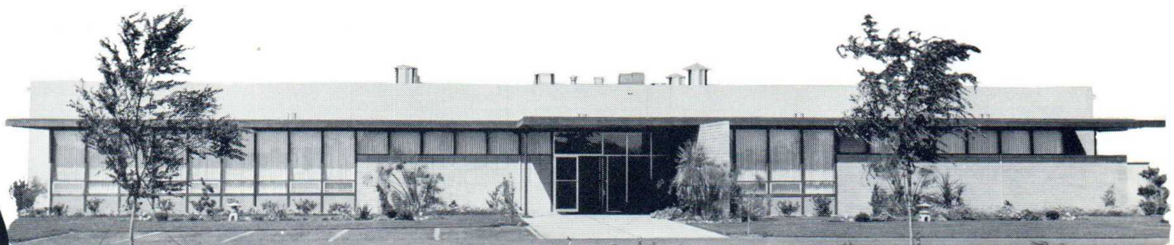
999 East Arques Avenue Sunnyvale, California Regent 6-9330

Item 11 HGL 1

Effective March 1, 1962

TRAVELING WAVE TUBES

BACKWARD WAVE AMPLIFIERS
FORWARD WAVE AMPLIFIERS
BACKWARD WAVE OSCILLATORS
SPECIAL PURPOSE TUBES



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TRAVELING WAVE TUBES

LOW NOISE AMPLIFIERS

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	25 db min. small-signal gain 15 db max. noise figure		LNT HA—40* 0.5 TO 1.0 KMC $1,500.00	LNT HA—17* 1.0 TO 2.0 KMC $1,500.00 LNT HA—19§ 1.6 TO 2.6 KMC $1,500.00
	25 db min. small-signal gain 10 db max. noise figure		LNT HA—45* 0.5 TO 1.0 KMC $2,000.00	LNT HA—14* 1.0 TO 2.0 KMC $2,000.00
	25 db min. small-signal gain 8 db max. noise figure		LNT HA—72† 0.5 TO 1.0 KMC $2,750.00	LNT HA—73† 1.0 TO 2.0 KMC $2,750.00
	25 db min. small-signal gain 7 db max. noise figure		LNT HA—86† 0.5 TO 1.0 KMC $3,000.00	HA—80 D 1.0 TO 2.0 KMC
	25 db min. small-signal gain 6 db max. noise figure			
PPM FOCUSED	25 db min. small-signal gain 15 db max. noise figure			LNT HA—85† 1.0 TO 2.0 KMC $2,500.00

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	Voltage Tuned 0.1 to 1.0% bandwidth 15 db gain			

BACKWARD WAVE OSCILLATORS (Voltage Tuned)

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	1 MW min. power output			
	10 MW min. power output			BWO HO—9* 1.0 TO 2.0 KMC $1,500.00
PM FOCUSED	20 MW min. power output			

MANY MODIFICATIONS of these tubes have been made to customers' specifications. A technical staff is available for your problems as well as for special research and development. Feel free to address us with your inquiry.

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2

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LOW NOISE AMPLIFIERS

S-BAND		C-BAND	X-BAND		Ku-BAND
LNT. HA—11§ 2.0 TO 4.0 KMC $1,500.00		LNT HA—32* 4.0 TO 8.0 KMC $1,500.00	LNT HA—44* 8.2 TO 12.4 KMC $1,500.00	LNT HA—61† 7.0 TO 14.0 KMC $2,000.00	
LNT HA—62*▲ 2.0 TO 4.0 KMC $2,000.00	LNT HA—37*▲ 2.3 TO 4.4 KMC $2,500.00	LNT HA—47* 4.0 TO 8.0 KMC $2,000.00	LNT HA—23* 8.2 TO 11.0 KMC $2,000.00		

LNT

HA—89†▲

10 MW MIN. POWER OUTPUT
PRICE ON REQUEST

FREQUENCY RANGE (KMC)	MAXIMUM NOISE FIGURE (DB)
2.0 TO 4.0	8.0
2.2 TO 2.3	4.5
2.3 TO 2.7	4.5
2.9 TO 3.1	5.5
3.4 TO 3.6	5.5

S-BAND	C-BAND	X-BAND	Ku-BAND
LNT HA—54† 2.0 TO 4.0 KMC $2,500.00	HA—84 D 4.0 TO 8.0 KMC	LNT HA—60† 7.0 TO 11.0 $2,500.00	

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

S-BAND	C-BAND	X-BAND	Ku-BAND
BWA BA—1† 2.4 TO 3.6 KMC $1,500.00			

BACKWARD WAVE OSCILLATORS (Voltage Tuned)

S-BAND	C-BAND		X-BAND		Ku-BAND
BWO HO—18§ 2.0 TO 4.0 KMC $750.00	BWO HO—3§ 3.75 TO 7.0 KMC $750.00	BWO HO—13§ 4.0 TO 8.0 KMC $750.00	BWO HO—14§ 8.2 TO 12.4 KMC $750.00	BWO HO—17§ 7.0 TO 11.0 KMC $750.00	BWO HO—19§ 12.0 TO 18.0 KMC $1,250.00
BWO HO—1§ 2.0 TO 4.0 KMC $1,000.00	BWO HO—20* 3.75 TO 7.0 KMC $1,000.00	BWO HO—21* 4.0 TO 8.0 KMC $1,000.00	BWO HO—2* 8.2 TO 12.4 KMC $1,000.00		BWO HO—4§ 12.4 TO 18.0 KMC $1,500.00
			HO—23D 8.2 TO 12.4 KMC		

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§ 4 to 6 weeks delivery
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† 8 to 10 weeks delivery

▲ This performance obtained in a lightweight, low-power solenoid

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	1 W min. power output 30 db min. small-signal gain	HA–78D 250 TO 500 MC	FWA HA–8* 0.5 TO 1.0 KMC $1,500.00	FWA HA–18† 1.0 TO 2.0 KMC 2 W MIN. 33 DB MIN. S-S GA $1,000.00	FWA HA–39§ 1.6 TO 2.6 KMC $850.00
	Pulsed: 1 W min. power output 30 db min. sat. gain 0.1 max. duty cycle				
PPM FOCUSED	10 MW min. power output 30 db min. small-signal gain	FWA HA–51* 250 TO 500 MC 20 DB MIN. S-S GAIN $1,575.00	FWA HA–36* 0.5 TO 1.0 KMC 20 DB MIN. S-S GAIN $1,575.00	FWA HA–31* 1.0 TO 2.0 KMC $1,350.00	
	1 W min. power output 30 db min. small-signal gain				
	2 W min. power output 30 db min. small-signal gain			FWA HA–53* 1.0 TO 2.0 KMC $1,750.00	
	Pulsed: 1 W min. power output 30 db min. sat. gain 0.1 max. duty cycle				

SPECIAL PURPOSE TUBES

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	Dispersive Amplifiers Voltage Tuned 20% Bandwidth		SPT DA–3† 0.5 TO 1.0 KMC $1,350.00	SPT DA–2† 1.0 TO 2.0 KMC $1,350.00
SOLENOID FOCUSED	Frequency multiplier tubes		SPT HA–34* UHF-BAND TO S-BAND $1,250.00	

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S-BAND	C-BAND	X-BAND	Ku-BAND
FWA HA—1§ 2.0 TO 4.0 KMC $750.00	FWA HA—26§ 4.0 TO 8.0 KMC $800.00	FWA HA—4§ 8.0 TO 12.4 KMC $850.00	FWA HA—24§ 12.4 TO 15.0 KMC 5 MW MIN. 20 DB MIN. S-S GAIN $1,000.00
FWA HA—2§ 2.0 TO 4.0 KMC $850.00	FWA HA—6§ 4.0 TO 8.0 KMC 500 MW MIN. $1,000.00	FWA HA—9* 8.0 TO 11.0 KMC 500 MW MIN. 33 DB MIN. S-S GAIN $1,500.00 FWA HA—10§ 8.0 TO 12.4 KMC 100 MW MIN. 25 DB MIN. S-S GAIN. $1,000.00	
PA PA—4§ 2.0 TO 4.0 KMC 33 DB MIN. S-S GAIN $1,000.00 PA PA—3§ 2.0 TO 4.0 KMC 10 W MIN. $1,250.00	PA PA—7§ 4.0 TO 8.0 KMC $1,250.00	PA PA—1* 8.0 TO 11.0 KMC 0.03 MAX. DUTY CYCLE $1,750.00 PA PA—5* 8.0 TO 12.4 KMC 300 MW MIN. $1,250.00	
FWA HA—29* 2.0 TO 4.0 KMC $1,000.00	FWA HA—28* 4.0 TO 8.0 KMC $1,125.00	FWA HA—20* 8.0 TO 11.0 KMC $1,250.00	
FWA HA—30§ 2.0 TO 4.0 KMC $1,350.00	FWA HA—35* 4.0 TO 8.0 KMC 500 MW MIN. $2,000.00	FWA HA—21* 8.0 TO 11.0 KMC 500 MW MIN. 33 DB MIN. S-S GAIN $2,500.00 FWA HA—71† 8.0 TO 12.4 KMC 100 MW MIN. 25 DB MIN. S-S GAIN $1,600.00	
PA PA—6§ 2.0 TO 4.0 KMC $1,575.00 PA PA—10† 2.0 TO 4.0 KMC 10 W MIN. $2,500.00	PA PA—8* 4.0 TO 8.0 KMC $2,475.00	PA PA—9* 8.0 TO 11.0 KMC 0.03 MAX. DUTY CYCLE $3,000.00	

SPECIAL PURPOSE TUBES

S-BAND	C-BAND	X-BAND	Ku-BAND
SPT DA—1† 2.0 TO 4.0 KMC $1,350.00	SPT DA—4† 4.0 TO 8.0 KMC $1,350.00		
SPT HA—16* S-BAND TO X-BAND $1,000.00			

ᴅ Under development
§ 4 to 6 weeks delivery
* 6 to 8 weeks delivery
† 8 to 10 weeks delivery

FWA, PA, SPT. Refer to Forward Wave Amplifier, Pulsed Amplifier, and Special Purpose Tube sections of Huggins TWT Catalog for detailed information.

Changes or additions to the November Short-Form Catalog

A CATALOG and Engineering Handbook are available for you. Please submit your request on company letterhead.

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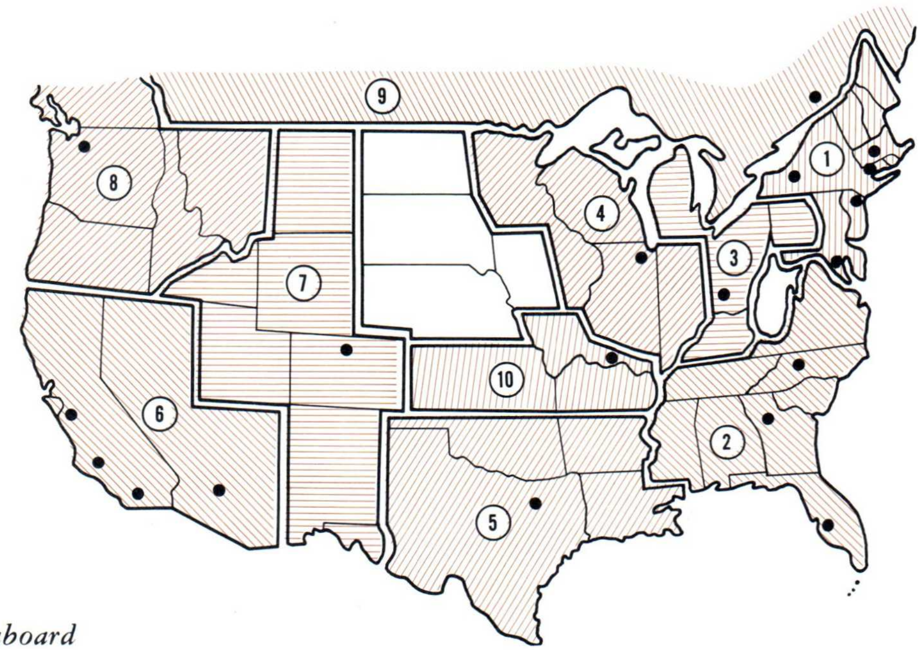

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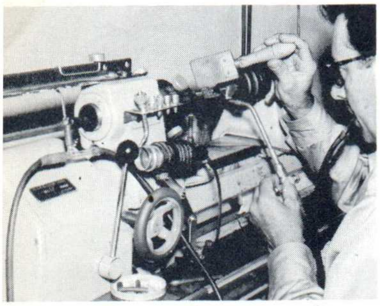

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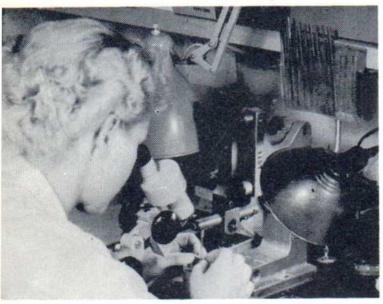
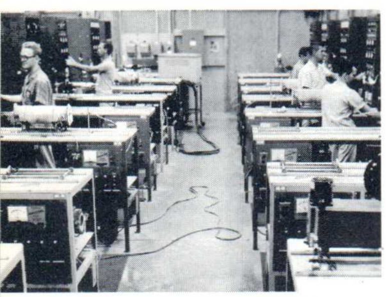


accurate assembly of delicate parts . . .



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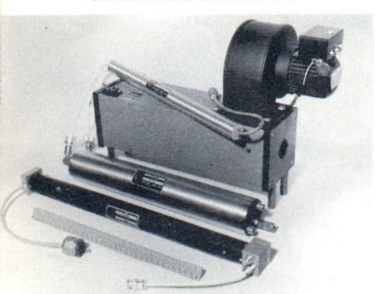
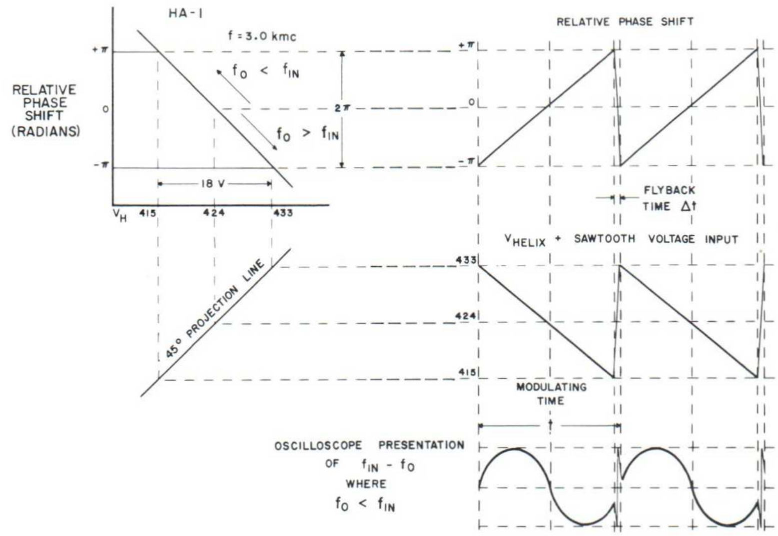


all are combined to bring you a dependable, long-lived product.

FREQUENCY SHIFTING WITH THE TRAVELING-WAVE TUBE



Phase Modulation Time Reference Diagram

Frequency shifting by phase modulation is one of the more important narrowband applications of the TWT. As a frequency translator the TWT finds use in doppler and coherent pulse simulators, homodyne systems, and similar frequency shift or frequency sensitive applications.

Though phase shifts of 2π radians can be obtained by modulating either the grid, anode, or helix, the latter proves most satisfactory from the standpoint of amplitude modulation. We will, therefore, confine the discussion to helix modulation.

Any change in helix voltage will affect electron beam velocity. The resulting velocity variation will either advance or retard the output phase relative to the input phase. Because phase shift is a near-linear function of helix voltage, we can sawtooth modulate the helix to obtain frequency shifts.

Referring to the above idealized time reference diagram for modulating a Huggins HA-1, we see that an 18 volt swing (433 v to 415 v) on the helix produces a relative phase shift of 2π radians (from $-\pi$ to $+\pi$).

A phase of $-\pi$ or $+\pi$ is functionally the same. Consequently, the helix voltage can be immediately returned from 415 v to 433 v with no apparent change in phase. We recognize the composite voltage change as a linear sawtooth with an infinitely rapid flyback time.

A repetitive sawtooth voltage modulation which changes the relative phase by 360° per voltage swing produces single sideband modulation in which the amount of frequency shift equals the modulating frequency (*i.e.*, $f_{in} - f_{out} = 1/t + \Delta t$, where $1/\Delta t$ represents a small energy component of the total frequency spectrum).

As applied to the helix, a negative slope on the modulating voltage gives a decrease in output frequency compared to the input. The converse is also true.

By using a TWT that is specially manufactured for low gain, frequency shifts in which unwanted sidebands that are 30 to 40 db below the carrier amplitude can be achieved.

A more comprehensive discussion on frequency translation is contained in Note 7, "Phase Modulation of Traveling Wave Tubes," in Volume I of our Engineering Handbook. This Note can be obtained by submitting a request on your company letterhead.

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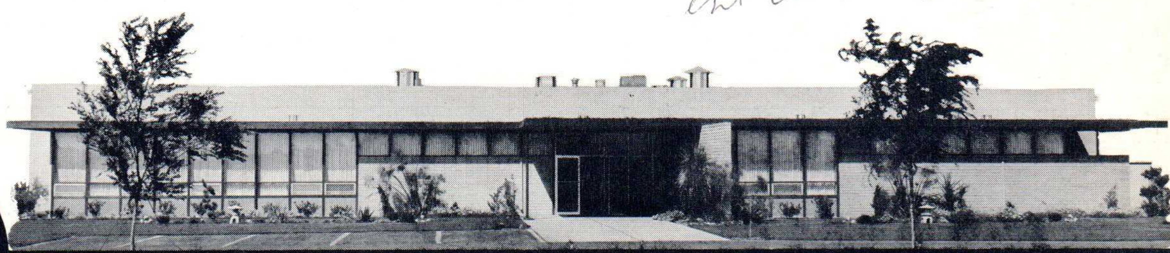
Effective July 15, 1961

TRAVELING WAVE TUBES

BACKWARD WAVE AMPLIFIERS
FORWARD WAVE AMPLIFIERS
BACKWARD WAVE OSCILLATORS
SPECIAL PURPOSE TUBES



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TRAVELING WAVE TUBES

LOW NOISE AMPLIFIERS

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	25 db min. small-signal gain 15 db max. noise figure		HA—40* 0.5 TO 1.0 KMC $1,500.00	HA—17* 1.0 TO 2.0 KMC $1,500.00 HA—19§ 1.6 TO 2.6 KMC $1,500.00
	25 db min. small-signal gain 10 db max. noise figure		HA—45* 0.5 TO 1.0 KMC $2,000.00	HA—14* 1.0 TO 2.0 KMC $2,000.00
	25 db min. small-signal gain 8 db max. noise figure		HA—72† 0.5 TO 1.0 KMC $2,750.00	HA—73† 1.0 TO 2.0 KMC $2,750.00
	25 db min. small-signal gain 7 db max. noise figure		HA—86† 0.5 TO 1.0 KMC $3,000.00	HA—80 D 1.0 TO 2.0 KMC
	25 db min. small-signal gain 6 db max. noise figure			
PPM FOCUSED	25 db min. small-signal gain 15 db max. noise figure			HA—85D 1.0 TO 2.0 KMC

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	Voltage Tuned 0.1 to 1.0% bandwidth 15 db gain			

BACKWARD WAVE OSCILLATORS (Voltage Tuned)

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	1 MW min. power output			
	10 MW min. power output			HO—9* 1.0 TO 2.0 KMC $1,500.00
PPM FOCUSED				
	10 MW min. power output			

MANY MODIFICATIONS of these tubes have been made to customers' specifications. A technical staff is available for your problems as well as for special research and development. Feel free to address us with your inquiry.

PRICE NOTE: Above prices apply to small quantities only and are subject to change without notice. A 10% credit will be allowed upon return of the used encapsulated tube when reordering. Shipment made from F.O.B. Sunnyvale, California, via air freight. Terms: Net 30 days.

DELIVERY QUOTATIONS given above represent the average situation. Consult us directly for latest quotations.

THE INDUSTRY'S **broadest line**

LOW NOISE AMPLIFIERS

S-BAND	C-BAND	X-BAND	Ku-BAND
HA—74 (HA—11)§ 2.0 TO 4.0 KMC $1,500.00	HA—32* 4.0 TO 8.0 KMC $1,500.00	HA—44* 8.2 TO 12.4 KMC $1,500.00 HA—61† 7.0 TO 14.0 KMC $2,000.00	HA—43† 12.0 TO 18.0 KMC 17 DB MAX. NOISE FIGURE $3,000.00
HA—62 (HA—37)* 2.0 TO 4.0 KMC 11 DB MAX. NOISE FIGURE $2,000.00	HA—47* 4.0 TO 8.0 KMC $2,000.00	HA—23* 8.2 TO 11.0 KMC $2,000.00	HA—46† 12.0 TO 18.0 KMC 12 DB MAX. NOISE FIGURE $3,500.00 HA—48* 12.0 TO 16.0 KMC 13 DB MAX. NOISE FIGURE $3,250.00
HA—75† 2.2 TO 3.7 KMC 30 DB MIN. S-S GAIN $2,150.00			
HA—70† 2.3 TO 3.5 KMC 30 DB MIN. S-S GAIN $2,300.00			
HA—76[D] 2.3 TO 2.9 KMC			
HA—54† 2.0 TO 4.0 KMC $2,500.00	HA—84[D] 4.0 TO 8.0 KMC	HA—60† 8.0 TO 11.0 KMC 17 DB MAX. NOISE FIGURE $2,500.00	

BACKWARD WAVE AMPLIFIERS (Voltage Tuned)

S-BAND	C-BAND	X-BAND	Ku-BAND
BA—1† 2.4 TO 3.6 KMC $1,500.00		BA—2† 8.2 TO 12.4 KMC $1,500.00	BA—4† 12.0 TO 18.0 KMC 30 DB GAIN $2,500.00

BACKWARD WAVE OSCILLATORS (Voltage Tuned)

S-BAND	C-BAND	X-BAND	Ku-BAND
HO—18§ 2.0 TO 4.0 KMC $750.00	HO—3§ 3.75 TO 7.0 KMC $750.00 HO—13§ 4.0 TO 8.0 KMC $750.00	HO—14§ 8.2 TO 12.4 KMC $750.00 HO—17§ 7.0 TO 11.0 KMC $750.00	HO—19§ 12.0 TO 18.0 KMC $1,250.00
HO—1§ 2.0 TO 4.0 KMC $1,000.00	HO—20* 3.75 TO 7.0 KMC $1,000.00 HO—21* 4.0 TO 8.0 KMC $1,000.00	HO—2* 8.2 TO 12.4 KMC $1,000.00	HO—4§ 12.4 TO 18.0 KMC $1,500.00
		HO—22† 8.5 TO 12.0 KMC 8.2 TO 12.4 KMC, 3 MW MIN. $2,000.00	

[D] Under development
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* 6 to 8 weeks delivery
† 8 to 10 weeks delivery

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TRAVELING WAVE TUBES

BROADBAND FORWARD WAVE AMPLIFIERS

		VHF-BAND	UHF-BAND	L-BAND	L-BAND
SOLENOID FOCUSED	10 MW min. power output 30 db min. small-signal gain	HA—79 D 250 TO 500 MC	HA—7* 0.5 TO 1.0 KMC $950.00	HA—5§ 1.0 TO 2.0 KMC $850.00	HA—22§ 1.6 TO 2.6 KMC $750.00
SOLENOID FOCUSED	1 W min. power output 30 db min. small-signal gain	HA—78 D 250 TO 500 MC	HA—8* 0.5 TO 1.0 KMC $1,500.00	HA—18† 1.0 TO 2.0 KMC 2 W MIN. 33 DB MIN. S-S GA $1,000.00	HA—39§ 1.6 TO 2.6 KMC $850.00
SOLENOID FOCUSED	Pulsed: 1 W min. power output 30 db min. sat. gain 0.1 max. duty cycle				
SOLENOID FOCUSED					
PPM FOCUSED	10 MW min. power output 30 db min. small-signal gain	HA—51* 250 TO 500 MC 20 DB MIN. S-S GAIN $1,575.00	HA—36* 0.5 TO 1.0 KMC 20 DB MIN. S-S GAIN $1,575.00	HA—31* 1.0 TO 2.0 KMC $1,350.00	
PPM FOCUSED	1 W min. power output 30 db min. small-signal gain				
PPM FOCUSED	2 W min. power output 30 db min. small-signal gain			HA—53* 1.0 TO 2.0 KMC $1,750.00	
PPM FOCUSED	Pulsed: 1 W min. power output 30 db min. sat. gain 0.1 max. duty cycle				
ELECTRO-STATICALLY FOCUSED	10 MW min. power output 30 db min. small-signal gain		HA—52† 0.5 TO 1.0 KMC 5 MW MIN. 20 DB MIN. S-S GAIN $2,250.00	HA—27† 1.0 TO 2.0 KMC $2,000.00	
ELECTRO-STATICALLY FOCUSED	1 W min. power output 30 db min. small-signal gain		HA—58† 0.5 TO 1.0 KMC $3,250.00	HA—63 D 1.0 TO 2.0 KMC	
ELECTRO-STATICALLY FOCUSED					

SPECIAL PURPOSE TUBES

		VHF-BAND	UHF-BAND	L-BAND
SOLENOID FOCUSED	Dispersive Amplifiers Voltage Tuned 20% Bandwidth		DA—3† 0.5 TO 1.0 KMC $1,350.00	DA—2† 1.0 TO 2.0 KMC $1,350.00
SOLENOID FOCUSED	Frequency multiplier tubes		HA—34* UHF-BAND TO S-BAND $1,250.00	

A GRID ELECTRODE for attenuation and modulation is incorporated in all forward wave amplifiers and frequency multipliers.

COLD VSWR less than 1.7 to 1 over the specified operating range is attained in most tubes.

MANUFACTURE to meet rigid environmental requirements is possible. Send us your specifications.

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S-BAND	C-BAND	X-BAND	Ku-BAND
HA–1§ 2.0 TO 4.0 KMC $750.00	HA–26§ 4.0 TO 8.0 KMC $800.00	HA–4§ 8.0 TO 12.4 KMC $850.00	HA–24§ 12.4 TO 15.0 KMC 5 MW MIN. 20 DB MIN. S-S GAIN $1,000.00 HA–25† 12.0 TO 18.0 KMC 5 MW MIN. $2,000.00
HA–2§ 2.0 TO 4.0 KMC $850.00	HA–6§ 4.0 TO 8.0 KMC 500 MW MIN. $1,000.00	HA–9* 8.0 TO 11.0 KMC 500 MW MIN. $1,500.00 HA–10§ 8.0 TO 12.4 KMC 100 MW MIN. 25 DB MIN. S-S GAIN $1,000.00	
PA–4§ 2.0 TO 4.0 KMC 33 DB MIN. S-S GAIN $1,000.00 PA–3§ 2.0 TO 4.0 KMC 10 W MIN. $1,250.00	PA–7§ 4.0 TO 8.0 KMC $1,250.00	PA–1* 8.0 TO 11.0 KMC 0.03 MAX. DUTY CYCLE $1,750.00 PA–5* 8.0 TO 12.4 KMC 300 MW MIN. $1,250.00	
HA–29* 2.0 TO 4.0 KMC $1,000.00	HA–28* 4.0 TO 8.0 KMC $1,125.00	HA–20* 8.0 TO 11.0 KMC $1,250.00	
HA–30§ 2.0 TO 4.0 KMC $1,350.00	HA–35* 4.0 TO 8.0 KMC 500 MW MIN. $2,000.00	HA–21* 8.0 TO 11.0 KMC 500 MW MIN. $2,500.00 HA–71† 8.0 TO 12.4 KMC 100 MW MIN. 25 DB MIN. S-S GAIN $1,600.00	
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		HA–65 D 8.2 TO 11.0 KMC	
HA–68 D 2.0 TO 4.0 KMC	HA–83 D 4.0 TO 8.0 KMC	HA–66 D 8.2 TO 11.0 KMC	

SPECIAL PURPOSE TUBES

DA–1† 2.0 TO 4.0 KMC $1,350.00	DA–4† 4.0 TO 8.0 KMC $1,350.00		
HA–16* S-BAND TO X-BAND $1,000.00			

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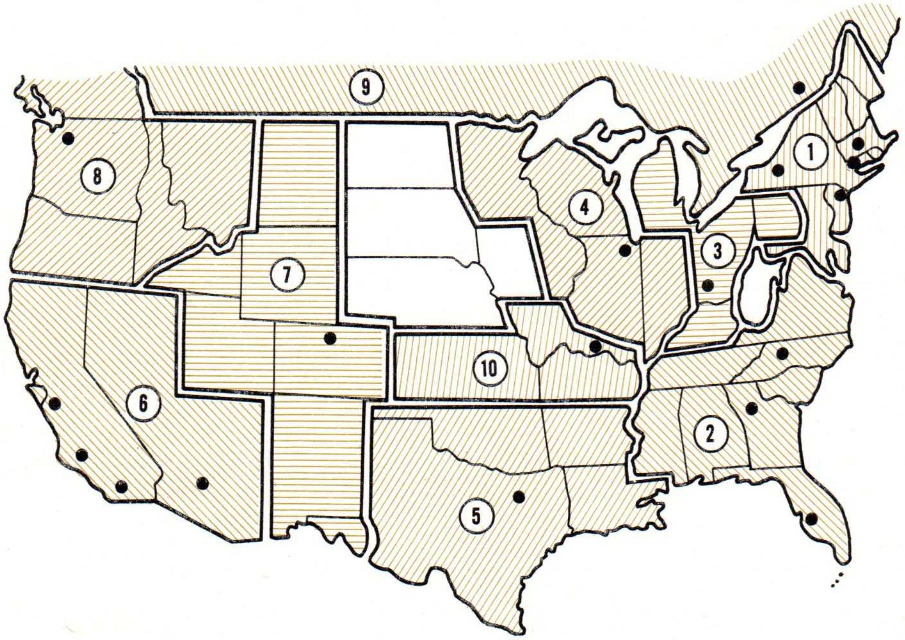

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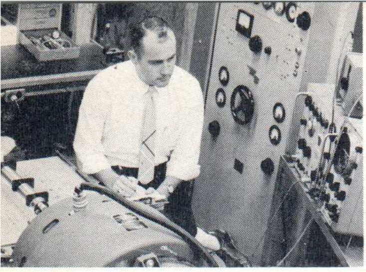
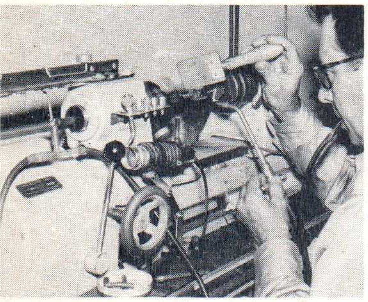
CONSTANT POWER SIGNAL SOURCE USES GRID CONTROL IN THE TWT



Versatile engineering . . .



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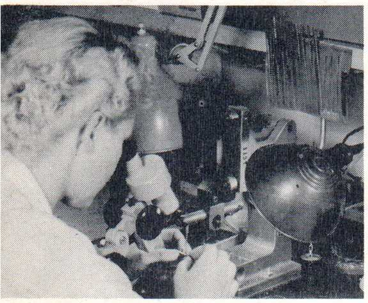

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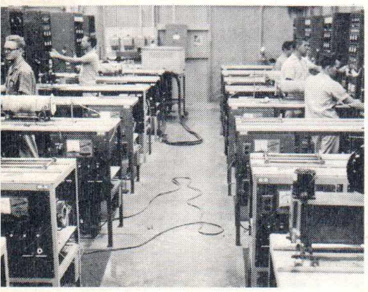
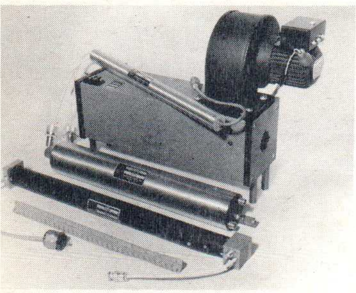


modern equipment and advanced skills . . .



all are combined to bring you a dependable, long-lived product.

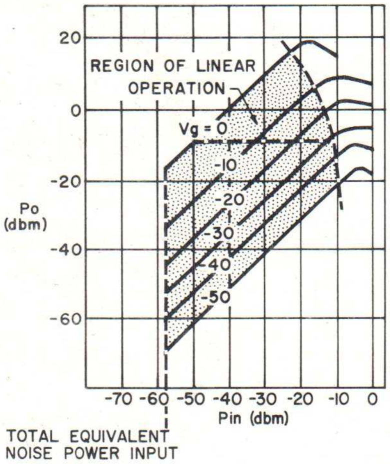


Figure 1.
HA-1 Transfer Characteristics

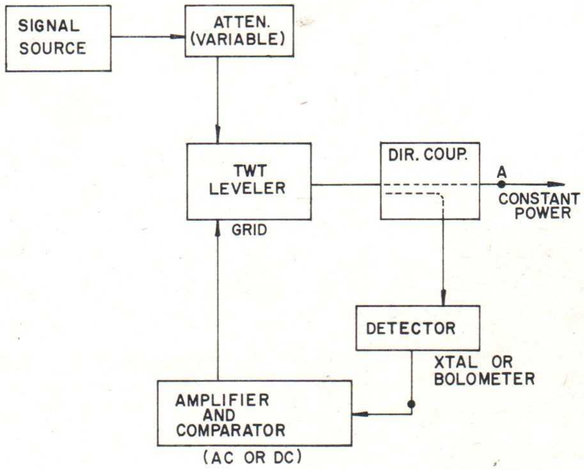


Figure 2.
Constant Power Output System Block Diagram

The advantages of a constant power output signal source become immediately apparent to the applications or systems engineer. Such a source can be designed around a TWT amplifier that operates in the linear region (small signal) of its transfer characteristic. Compared to limiter operation, small-signal operation gives a more constant output power and is freer from phase distortion.

Consider the transfer characteristics shown in Figure 1 of a Huggins HA-1 TWT amplifier. These curves were taken at 3.0 kmc, but similar curves are experienced at all other frequencies in the operating band. If an unsaturated power output is needed, the operating region is limited as indicated.

Assume that a constant power output of —10 dbm is desired. Readily seen is the fact that for all values of input power from —50 dbm to —12 dbm (a dynamic range of 38 db) there exists a corresponding grid voltage which will give a power output of —10 dbm.

A system which will provide a constant output power by controlling the TWT grid voltage is illustrated in Figure 2. A signal source, varying in both frequency and power output, drives a TWT amplifier through a variable attenuator of fixed value. A portion of the TWT's output is sampled by means of a directional coupler and detected by some convenient means (e.g., crystal or bolometer). This signal is amplified, compared with a reference, and applied to the TWT grid.

The control voltage applied to the TWT grid is proportional to the logarithm of the TWT's output power. If the power output increases, the grid control voltage increases in the negative direction to lower the TWT's output, and the converse is also true.

The constancy of power output at point A in Figure 2 as a function of frequency rests upon the frequency dependence of the directional coupler and detector.

When composed of a Huggins HO-2 backward wave oscillator as the signal source and a Huggins HA-4 TWT amplifier as the leveler, this system is capable of providing an output power at point A that is constant within ±0.7 db over an 8.2 to 12.5 kmc frequency range.

Note 8, "The Use of the TWT Amplifier in Constant Power Systems," in Volume I of our Engineering Handbook describes a modified version of the system in Figure 2 which produced a power output that was constant within ±0.3 db.

A copy of this Note can be obtained by submitting a request on your company letterhead.

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HUGGINS LABORATORIES, INC.

ENGINEERING NOTES

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Huggins Laboratories, Inc. Sunnyvale, California

LOW-NOISE TRAVELING-WAVE-TUBE AMPLIFIERS

J. C. Stevenson [β]

As the importance of long-range microwave communications increases, the low-noise capability of the traveling-wave tube becomes more significant that ever. Long-range communications usually involves receiving relatively weak signals, and successful reception of such signals requires a high receiver sensitivity.

Receiver sensitivity (commonly measured as <u>tangential sensitivity</u>, <u>i. e.</u>, the input signal power that is just equal to the total equivalent input noise of the receiver) depends upon the amount of spurious signals that are generated within the receiver. It then follows that internal noise generation by the receiver must be minimized if weak signals are to be detected. Especially is this true of the first amplifying stage, for receiver noise is largely determined by the noise figure (contribution of noise by the tube) of the input amplifier if the amplifier's gain is such that its noise overrides that of the following stages.

The ability to receive extremely low-level signals is closely allied with the noise bandwidth of the receiver. Many applications hinge upon broadband operation, either for versatility or the capacity to handle large amounts of information. Unfortunately, spurious signal generation increases with bandwidth. To detect weak signals then, we must either decrease the bandwidth or turn to a low-noise broadband amplifying device.

The traveling-wave tube is just such a device. TWT's with maximum noise figures of 5 to 8 db over octave bandwidths have been built, and TWT's having a maximum noise figure of 10 db over an octave bandwidth are readily available. With its low-noise and broadband capabilities, therefore, the traveling-wave tube has no peer as a preamplifier in many applications.

This Engineering Note is concerned with the more general aspects of low-noise traveling-wave tube amplifiers. The difference between thermal noise and tube noise is made, and the more important sources of tube noise are noted. A brief look at the

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existing noise theory is followed by a short discussion of the factors that influence noise figure. After examining some methods used to reduce TWT noise figures, the individual characteristic of the wave tube is probed.

Thermal And Tube Noise

The noise that exists in any amplifier consists of hum and random noise signals. The former is primarily a power supply problem; random noise signals, however, originate within the tube (tube noise) and its associated circuitry (thermal noise).

Thermal noise

The thermal energy of free electrons in a system's conductors causes a random movement of the electrons that is similar to Brownian motion. Because this movement is random in both time and space, a "thermal noise voltage" is produced.

If tube noise were nonexistent the minimum detectable signal would be set by the thermal noise level. Thermal noise power is expressed as:

$$N_t = KTB \qquad (1)$$

where, K = Boltzmann's constant (watt-second per degree Kelvin)

T = temperature (degrees Kelvin)

B = bandwidth (cps)

When the source and load in a transmission system are matched for maximum power transfer, thermal noise power at room temperature--as computed by equation 1--is 4.0×10^{-21} watts per cycle of bandwidth. A more convenient figure for the thermal noise level at room temperature is -114 dbm per megacycle of bandwidth.

Tube noise

Random motion of the electrons in thermionic vacuum tubes generates noise. Such phenomena as random division of electrons between electrodes and random emission of electrons from the cathode produce this random motion. And noise in a traveling-wave tube depends especially upon the amount of axial velocity fluctuations of the electrons.

Sources Of Tube Noise

Numerous sources of tube noise exist in a traveling-wave tube. Some of the more important are shot, secondary emission, and partition noise. Though it is debatable as to what percentage of total noise generation is accountable to each source, experience shows that none of these sources can be neglected if low noise figures are desired.

Shot noise

A variation in the number of electrons that are emitted by the cathode causes shot noise. The noise is in the form of current fluctuations in the beam that are introduced by the random changes in the time rate of emission of electrons about some mean value.

Secondary emission

Random fluctuations in the number of secondary electrons that are emitted when primary electrons strike one or more of the electrodes generate secondary emission noise. This action increases noise by adding shot current to the beam. Though secondary emission can occur at all positive electrodes, it is most prevalent at the collector.

Partition noise

The radial components of electron thermal velocity give rise to random fluctuations in the division of cathode current among two or more positive electrodes (e. g., helix and collector). These changes in division create partition noise.

Pierce [1] discusses the possibility of another source of noise in a TWT that is analogus to partition noise. Should the aforementioned radial components of thermal velocity alter electron position in the helix, a noise very similar to partition noise may arise--even though no electrons strike the helix.

Nature Of TWT Noise

In 1950 Pierce [1] discussed a simplified noise theory for traveling-wave tubes which predicted that noise in a TWT would take the form of a standing wave along the electron beam. Subsequent experiments by Cutler and Quate [2] produced qualitative agreement with the standing-wave theory.

As a result it is widely accepted that most of the noise generation in a TWT originates at the virtual cathode and that it takes the form of standing space-charge waves. Furthermore, these waves propagate along the electron beam in the same manner as electromagnetic energy propagates along a lossless, nonuniform transmission line.

Three phenomena set up noise standing waves. As the cathode emitts electrons at random, they move away under the influence of an accelerating anode. In so doing, the electrons exhibit minute changes in current density and emission velocity. Current density fluctuations occur in the axial direction only, but variations in emission velocity exist in both the transverse and axial directions. Only axial components contribute to beam noise. It is these current and velocity fluctuations that produce noise standing space-charge waves on the beam.

In addition to current and velocity produced space-charge waves, other waves are set up along the beam by a third phenomenon--perturbations in the beam. Perturbed electrons oscillate at their plasma frequency and give rise to space-charge waves [3]. These waves also apply to the transmission line analogy, an analogy of great importance to the reduction of TWT noise figures.

Factors Affecting Noise Figure

The noise figure (F) for any network or combination of networks is defined by the following equation:

$$F = \frac{(S/N)_i}{(S/N)_o} \qquad (2)$$

where, $(S/N)_i$ = signal-to-noise ratio at the input

$(S/N)_o$ = signal-to-noise ratio at the output

Equations 1 and 2 can be combined with the fundamental gain definition ($G = S_o/S_i$) to express the noise figure in terms of output quantities:

$$F = 1 + (N_a/N_t)_o \qquad (3)$$

where, N_a = the portion of output noise that is caused by the tube

N_t = the portion of output noise that results from the thermal noise at the input

Many factors contribute to the magnitude of the term N_a in equation 3. Yet to be understood is just how and to what extent all the variables in a TWT influence noise generation, but there are some factors which are fairly well understood. It is to these that we turn our attention.

Input coupler

Because any coupling loss at the input decreases the signal without affecting tube noise, the noise figure in db will be increased by the input coupler loss in db.

Perturbations

As mentioned previously, perturbations in the beam give rise to noise because perturbed electrons, which oscillate at their plasma frequency, set up standing space-charge waves on the electron beam.

Lens action

Electron lenses which are formed by the electrodes in the gun increase both partition noise and velocity fluctuations in a TWT. Already discussed is the fact that both transverse and axial velocity variations are present. In a high-velocity beam, the mean-square transverse velocity fluctuations greatly exceed the mean-square axial fluctuations.

In passing through a lens, the direction of motion of the electrons changes. Because of this action, velocity fluctuations in the axial direction may be changed into transverse fluctuations, and the converse, of course, is also true. As a result it is conceivable that more transverse fluctuations will be converted than axial. Should this be the case there would be an increase in axial fluctuations and noise figure.

Focusing field

The strength of the focusing field has a bearing on lens action and interception. A strong field can reduce lens effect. Partition noise increases in a high-energy beam if the focusing field is too weak. Also, the paths of electron groups from different parts of the cathode will cross should the focusing field be too weak, and if these groups have different velocity distributions, total beam noise increases.

Cathode

Several characteristics of the cathode come under careful scrutiny when we speak of lowering the noise figure. For example, the minimum theoretical noise figure is a direct function of cathode temperature [4]. Electrons that are emitted from a high work function cathode possess high thermal energy, and such emission produces a beam that has a greater velocity spread, more perturbations, and a higher noise temperature. A cathode whose surface is not uniform in density provides patchy or spotty emission which results in nonuniform charge density in the beam. Poor axial emission is caused by a rough emitting surface, and poor axial emission increases velocity fluctuations in the beam. All of these characteristics, either individually or collectively, increase the noise content of the beam

Lowering The Noise Figure

Numerous theories were advanced and many achievements were made by TWT engineers during the last 10 years. Historically, the achievements ran--and still are running--ahead of the theories.

In addition to theories dealing with lens action, perturbations, cathodes, et cetera, several ideas for lowering the noise figure by means of the electron gun were proposed over the years.

Experimental verification of the standing-wave theory by Cutler and Quate prompted the first suggestion: place the gun at some critical distance from the helix, the distance being selected to place a noise standing wave minimum at the entrance to the helix. Such a step did improve noise figures somewhat.

A much greater improvement was realized, however, with Watkins' velocity jump gun [5]. Following came the transmission line analog which led to the exponential gun [6]. The exponential gun represented a major contribution to lowering TWT noise figures, and it was with this gun that much success in the low-noise TWT field was realized. As we shall soon see, recent developments have brought about modifications in the original exponential gun. These modifications have made it possible to make further reductions in TWT noise figures.

The low-noise gun

Present low-noise theory and the transmission line analog make it possible to treat the electron gun as a space-charge wave transformer. The gun functions to match the effective beam impedance at the virtual cathode (potential minimum) to the desired beam impedance at the entrance to the helix. Matching these impedances makes the standing-wave ratio (SWR) of noise current relatively small and places a current minimum at the helix entrance. First order noise theory shows that these conditions give minimum noise figure.

Changing the characteristic beam impedance slowly and smoothly is the best way to match the beam impedance at the potential minimum to that at the helix entrance. An exponential transmission line can perform such an impedance transformation. We choose an exponential transformer because it can match widely different impedances over wide frequency ranges and because it provides a fairly good match over short electrical lengths.

An exponential transformer can be approximated by a properly designed multi-anode or multi-region electron gun. This type of gun is essentially a series of exponential transformers operating in cascade. A typical gun and its potential profile appears in Figure 1.

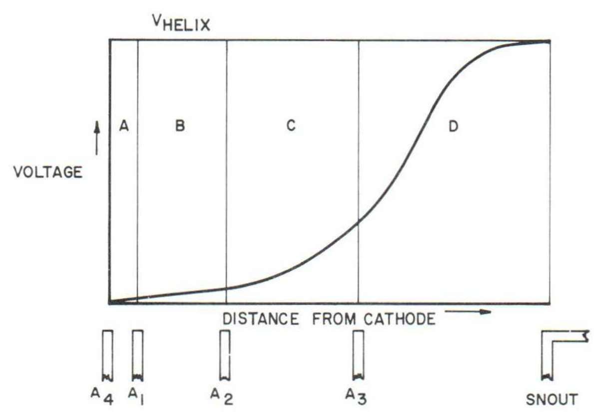

FIGURE 1. POTENTIAL PROFILE AND RELATIVE POSITION OF THE ELECTRODES IN A TYPICAL MULTI-REGION LOW-NOISE ELECTRON GUN.

Low mismatches in all regions of the gun provide a near unity SWR at the helix entrance. In regions B, C, and D, low mismatches are maintained by providing exponential transformations that are not too steep.

The one-dimensional theoretical transformation in region A for a parallel-flow beam is comparatively steep and undesirable. This transformation is based on the assumption that the noise parameters are invariant between the potential minimum and the helix. It has been found, however, that the noise parameters are not invariant in the immediate vicinity of the cathode.

Currie and Forster investigated the effects on beam noiseness of radical changes in the d-c potential distribution in the multi-velocity region near the cathode [7]. Results of their investigation led to a potential profile in region A that differs greatly from the profile previously used in low-noise guns. Figure 2 shows a comparison of the transformation curves prescribed for a one-dimensional beam and Currie's and Forster's "quasi-one-dimensional" beam.

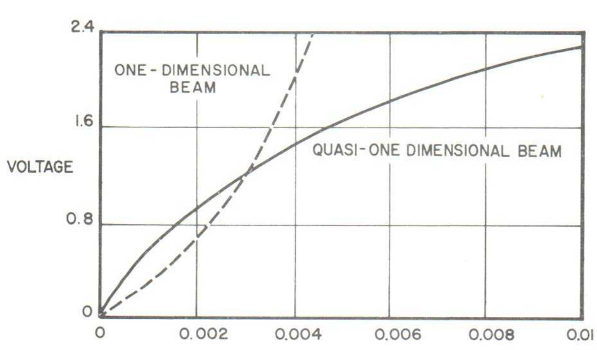

FIGURE 2. COMPARISON OF TRANSFORMATION CURVES IN THE ABSENCE OF SPACE CHARGE, FOR ONE-DIMENSIONAL AND QUASI-ONE-DIMENSIONAL ELECTRON BEAMS.

The Currie-Forster profile exhibits an extended low-velocity region in which the electrons are slowly accelerated immediately after leaving the cathode. In essence, this low-velocity region is considered to be a flexible noise transducer that transforms the variant noise parameters at the potential minimum to the single-velocity region in which the parameters are invariant.

Mueller and Currie calculated the characteristics of noise propagation through a multi-velocity region in which the d-c potential increases linearly [8]. They have shown that beam noiseness decreases as the rate of acceleration decreases in the multi-velocity region. Once the beam leaves the multi-velocity region, however, the single-valued velocity theory of space-charge wave propagation applies, and the previously discussed theory for regions B, C, and D in a multi-anode gun becomes valid.

Several important advantages are inherent in the multi-anode gun: 1) lens effect is reduced since the gun operates without sharp potential discontinuities, 2) the gun lends itself to quantity production because of its mechanical simplicity, and 3) the gun is flexible (i. e., the noise current minimum can be positioned electrically).

In addition to electron gun design, other steps must be taken to combat tube noise.

For example, the input coupler must be designed for minimum coupling loss so that the noise figure will not be greatly degraded. Regardless of the type of coupler used, its parameters are manipulated to give the best possible VSWR (i. e., the best signal transfer to the helix).

As another example, attention is given to the mechanical configuration and chemical composition of the collector with a view toward reducing secondary emission or its effects. The final design often requires that the collector be operated positive with respect to the helix for optimum noise figure.

Other steps taken to lower the noise figure are concerned with focusing and the cathode. Using a strong focusing field reduces lens effect, interception, and perturbations in the beam. Axial and even electron emission is approached by using cathodes with smooth, even-density coatings; high cathode temperatures and high thermal energies are avoided by employing low-work-function emitters such as oxide coated cathodes.

Each TWT Is Unique

In the present state of the art, each traveling-wave tube is an individual. Unlike 6SN7's, 5U4's, and other tubes of that breed, the TWT isn't compatible with direct interchangeability or replacement, for each TWT gives optimum performance under unique operating conditions.

This uniqueness stems from two facts: the electron gun is paramount to low TWT noise figures, and the potential profile associated with the gun is a function of the voltages applied to the anodes. Due to the many variables which influence noise, the anode voltages required to obtain the proper profile usually differ from gun to gun. Improper electrode voltages can, therefore, produce disappointing performance and possibly tube damage.

Accordingly, the manufacturer supplies with each tube a "data sheet" that gives all operating voltages and currents for that tube. Figure 3 shows an example of a data sheet for a Huggins HA-72 which has specified performance of 25 db minimum small-signal gain and 8 db maximum noise figure across the 0.5 to 1.0 kmc frequency range.

The voltages and currents on this data sheet are unique to the particular tube with which the sheet is supplied. The TWT's individuality is stressed by the improbability that another HA-72 will give optimum performance with identical voltages applied. Departure from gun voltages changes the all-important potential distribution of the electron gun and consequently moves the noise-current minimum relative to the helix entrance. Because the specified voltages represent optimum operating conditions, unsatisfactory performance usually results when operating the heater, helix, and collector at other than specified voltages. The dependence of noise figure on operating voltages is discussed in more detail in Note 3, Volume II, of Huggins Engineering Handbook.

There is, of course, a tolerance on the voltage specifications, but system requirements primarily determine the amount of tolerance. All TWT manufacturers are equipped and ready to assist the engineer in attaining best TWT performance in his particular application.

Future Low-Noise TWT Developments

Research in low-noise wave tubes is intense and widespread throughout the industry. Such research is pushing noise figures lower and lower, and in the not-too-distant future we

DATA SHEET

RETURN SHIPMENT OF THIS TUBE NOT ACCEPTED
WITHOUT HUGGINS LABORATORIES APPROVAL.

Tube Type HA-72
Serial No. 000

POWER SUPPLY CONNECTIONS:

WINCHESTER CONNECTOR M9P

A — ANODE NO. 2
B — ANODE NO. 3
C — CAPSULE GROUND
D — HELIX
E — HEATER
F — HEATER
H — ANODE NO. 1
J — ANODE NO. 4
K — CATHODE

WINCHESTER CONNECTOR SMIP IS COLLECTOR CONNECTION.

FREQ.	SMALL SIGNAL GAIN	POWER OUTPUT	GAIN	NOISE FIGURE	
		MEASURED AT: ( )MAX. OUTPUT (x)1 MW INPUT			
KMC	DB	DBM	DB	DB	
0.5	31	5	30	8.0	
0.6	35	5	32	7.5	
0.7	38	6	31	7.8	
0.8	38	6	30	8.0	
0.9	38	6	31	7.8	
1.0	36	4	30	8.0	

OPERATING CONDITIONS:

*	$V_{ANODE\ NO.\ 1}$	0
*	$V_{ANODE\ NO.\ 2}$	7.3
*	$V_{ANODE\ NO.\ 3}$	0
*	$V_{ANODE\ NO.\ 4}$	7.2
*	V_{HELIX}	81
*	$V_{COLL.}$	V_{Helix} + 300
	V_{HTR}	6.5

$I_{ANODE\ NO.\ 1}$	--
$I_{ANODE\ NO.\ 2}$	--
$I_{ANODE\ NO.\ 3}$	--
$I_{ANODE\ NO.\ 4}$	--
I_{HELIX}	0
$I_{COLL.}$	0.62 ma
$I_{CATH.}$	0.62 ma
$I_{HTR.}$	0.7 amp

SOL TYPE	BS-26C
V_{SOL}	105
I_{SOL}	4.8 amp
GAUSS	820

*MEASURED WITH RESPECT TO CATHODE.

TESTED BY ____________

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FIGURE 3. SAMPLE "DATA SHEET" FOR A HUGGINS LOW-NOISE TWT AMPLIFIER. SPECIFIED VOLTAGES REPRESENT OPTIMUM OPERATING CONDITIONS.

should see TWT's operating over octave bandwidths with significantly lower noise figures than presently obtained.

Much effort is being devoted to reducing the weight of low-noise TWT amplifiers. Special lightweight solenoids notwithstanding, substantial weight reduction is possible only by eliminating the solenoid.

One method of eliminating the solenoid is to use a straight-field permanent magnet for focusing; solenoid-focused low-noise TWT performance can be duplicated in such a focusing structure. Though PM focusing does lower system weight since no solenoid power supply is required, it may increase tube weight considerably [9]. Therefore, the industry is concentrating on periodic focusing, both magnetic and electrostatic.

Periodic focusing works very well for low and medium power amplifiers. In the present state of the art, however, PPM focusing of "low-noise" TWT's gives, at best, a 12 to 13 db noise figure over a 2 : 1 frequency range. An octave bandwidth noise figure of 25 db represents current achievements with electrostatic focusing. It appears that conflicting field strength requirements for gain and noise figure must be overcome before periodically focused wave tubes will operate over an octave bandwidth with a maximum noise figure of 10 db or less.

Backward wave amplifiers (BWA) form another important phase of low-noise research. Possibilities of extremely low noise figures in the BWA are great, for this type of TWT operates over a comparatively small bandwidth. Yet a BWA still has broadband capabilities since it is voltage tunable over a wide frequency range. Currie and Forster report reproducible maximum noise figures of 6 db for a 25 % tuning range and 4.5 db for a 10 % tuning range [10]. The two apparent problems that must be solved are reducing focusing requirements and limiting gain fluctuations as the tube is tuned.

The history of low-noise traveling-wave tube amplifiers is filled with many, many theories and proposed solutions to reducing noise figures. From each theory and from each solution have come other theories and solutions to push the noise figure progressively lower. This trend is certain to continue until the yet-to-be-determined limiting noise figure in the TWT is reached.

Acknowledgements

The author extends his thanks to D. E. MacKerrow, J. C. Mc Caig, and V. D. Varenhorst for their informative discussions on low-noise traveling-wave tubes.

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HUGGINS LABORATORIES, INC.

ENGINEERING NOTES

VOL. II, NO. 3 FEBRUARY, 1961

Huggins Laboratories, Inc. Sunnyvale, California

THE EFFECT OF OPERATING VOLTAGE VARIATIONS ON TWT NOISE FIGURE

J. C. Stevenson [β]

As discussed in Note 2, Volume II, "Low-Noise Traveling-Wave-Tube Amplifiers," the traveling-wave tube is an individual, and this characteristic of the TWT cannot be neglected if optimum tube performance is to be obtained. In harmony with this trait of individuality, Note 2 also points out that the manufacturer's prescribed voltages--which represent optimum performance--should be followed. Operation with different voltages usually gives other than optimum performance.

This Engineering Note is concerned with TWT noise figure specifications, the area of investigation being confined to the effect on noise figure of changes in the operating parameters (viz., the focusing field and the collector, helix, anode, and heater voltages). The dependence of noise figure on operating parameters is theoretically analyzed to lay a foundation for understanding the series of noise figure curves which are presented as a part of this Note. These curves graphically illustrate the importance of operating a wave tube with its optimum voltages applied.

An unsophisticated look at three concepts of the low-noise TWT amplifier will lead to an insight of how and why operating parameter changes affect noise figure.

Noise Standing Waves

That most of the noise generation in a wave tube originates at the virtual cathode (potential minimum) and that it takes the form of standing space-charge waves along the electron beam is widely accepted by low-noise TWT engineers. In addition, there is nearly universal agreement that a minimum noise figure for any given tube is theoretically attained when the noise standing wave goes through a minimum at the helix entrance. A standing wave and the critical placement of a standing-wave minimum immediately suggests an impedance matching problem.

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The Low-Noise Gun

In its simplest form, a low-noise electron gun can be thought of as a transformer which functions to match the characteristic beam impedance at the virtual cathode to the desired beam impedance at the helix entrance. Such an impedance transformation makes the SWR relatively small and places a standing-wave minimum at the entrance to the helix. More specifically, the electron gun can be treated as an exponential transformer which varies the beam impedance in the following manner:

$$Z = Z_0 e^{k\alpha} \qquad [1]$$

where, Z = characteristic beam impedance

Z_0 = characteristic beam impedance at the virtual cathode

k = "steepness factor"

$\alpha = \beta - \beta_0$ = total phase angle

The total phase angle will prove to be an important factor toward understanding why changes in operating parameters affect noise figure, and it may be defined as:

$$\alpha = \int_{Z_0}^{Z} \frac{2\pi}{\lambda_p}\, dz \qquad [2]$$

where, Z = distance along the beam (Z increases from cathode to collector)

λ_p = plasma wavelength

Because the total phase angle is important, the plasma wavelength or frequency is also essential to the purpose of this Note. The plasma frequency is associated with bunching in the electron beam. As electrons are displaced in the beam to form a bunch, there is a concentration of space charge in the bunch, and this concentration of space charge possesses a corresponding electric field. The electric field produces a restoring force on the electrons that is proportional to their displacement. As a result there is simple harmonic motion of the charge (<u>i.e.,</u> the charge oscillates at the plasma frequency).

Without going into the subtleties of plasma frequency and effective plasma frequency, only the infinitely broad electron beam case will be considered. In such a beam the plasma frequency may be defined as:

$$f_p = \frac{1.83 \times 10^8 \, J_0^{1/2}}{2\pi V_0^{1/4}} \qquad [3]$$

where, J_0 = d-c current density

V_0 = d-c beam voltage

Noise Temperature

The third and last concept to be examined is that of the noise temperature in the beam, and this will be merely defined as:

$$NT = \frac{f}{f_c} T_k \qquad [4]$$

where, f = frequency of interest

f_c = cyclotron frequency

T_k = cathode temperature

As revealed in elementary physics, the cyclotron frequency is related to the motion of a moving charged particle in a uniform magnetic field. For an electron, the cyclotron frequency may be expressed by the following equation:

$$f_c = \frac{q_e B}{m_e 2\pi} \qquad [5]$$

where, q_e = charge on the electron

m_e = mass of the electron

B = magnetic flux density

Interpreting The Equations

Certain conditions must be set before any correlation between the equations and operating parameter changes can be made. The following discussion will, therefore, be based upon the assumption that the TWT operating parameters are adjusted for optimum performance. Effects on output power and gain are ignored in this discussion since the noise figure is the characteristic of importance.

The impedance transformation between virtual cathode and helix entrance, according to equation 1, is dependent on the total phase angle, α, among other factors. From a matched condition, any change in α will 1) cause an impedance mismatch, 2) increase the SWR of the noise standing wave, and 3) move the standing-wave minimum relative to the helix entrance. These actions, of course, produce a change in the noise figure.

Equation 2 shows that α is a function of λ_p which, as stated in equation 3, is dependent upon current density and beam voltage. Changing the helix, heater, or any anode voltage will naturally affect the current density, the beam voltage, or both. It them follows that the noise figure is a function of a TWT's operating potentials. Though neither the current density or beam voltage is affected by a change in collector potential, the collector voltage does influence secondary emission. Thus, we would expect the noise figure to vary somewhat with a change in the collector voltage.

A glance at equations 4 and 5 instantly reveals that the noise figure varies with heater voltage and, in addition, the focusing field. The former determines cathode temperature and the latter determines the cyclotron frequency.

These equations in no way indicate the relative effect on noise figure of the various parameters, but the following noise figure curves do show that some parameters have more effect on noise figure than do others.

Noise Figure Curves

Noise figure data is presented on four Huggins low-noise amplifiers: a L-band HA-14, a S-band HA-37, a C-band HA-47, and a Ku-band HA-43. All four tubes provide 25 db minimum small-signal gain and 1 mw minimum power output over their specified frequency ranges. The HA-14 and HA-47 have maximum noise figures of 10 db over the 1.0 to 2.0 kmc and 4.0 to 8.0 kmc bands respectively. A maximum noise figure of 11 db across the 2.0 to 4.0 kmc range is attained with the HA-37, and the HA-43 has a maximum noise figure of 17 db over the 12.0 to 18.0 kmc band.

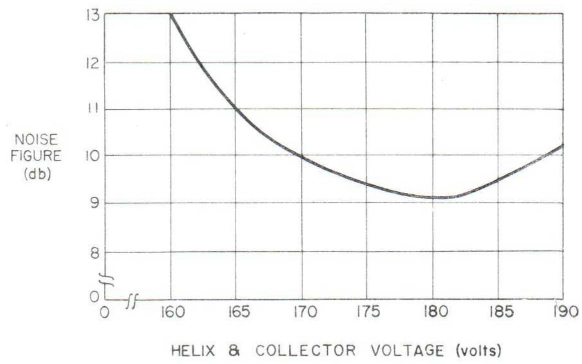
Each series of noise figure data was taken with the tube optimized for broadband gain, power output, and noise figure. The curves shown in Figures 1, 2, 3, and 4 are not presented as being typical of the applicable tube type, but they are representative of the fact that noise figure normally varies with each operating parameter.

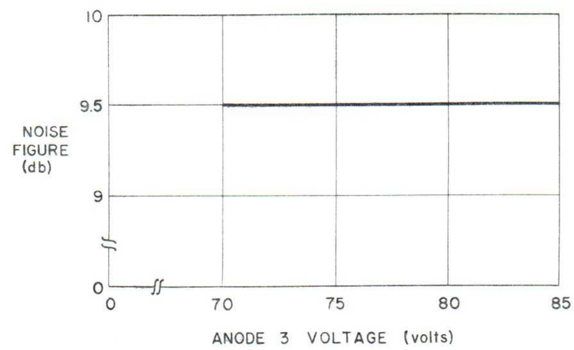
In a few cases a curve appears to be inconsistent with low-noise theory. For example, the noise figure should decrease to a limiting value as the focusing field increases. But the HA-37 and HA-43 data shows an increase in noise figure as the field is increased beyond its optimum value. Though contrary to theory, this phenomenon has no adverse effect on tube performance. At any rate inconsistencies do exist and provide further support to the fact that each TWT is indeed an individual.

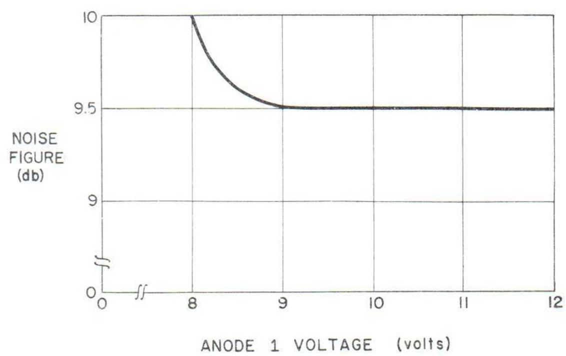
Acknowledgments

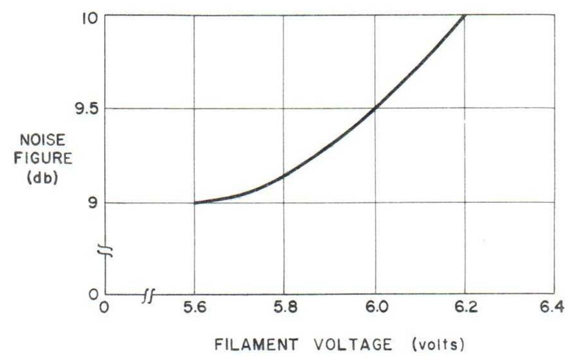
The author expresses his appreciation to J. C. McCaig and V. D. Varenhorst for their helpful suggestions and for their illuminating discussions on the relationships between TWT noise figure and operating parameters.

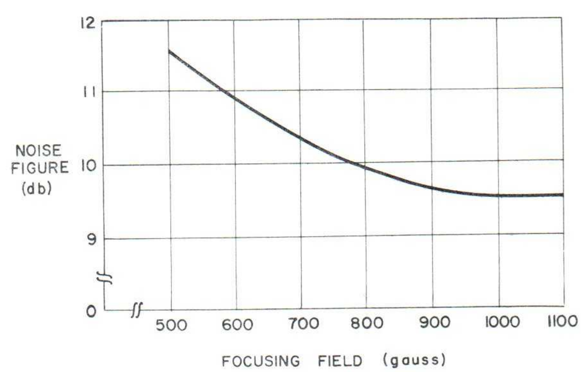
THE EFFECT OF OPERATING VOLTAGE VARIATIONS ON TWT NOISE FIGURE











HA – 14 (DATA TAKEN AT 1.5 KMC)

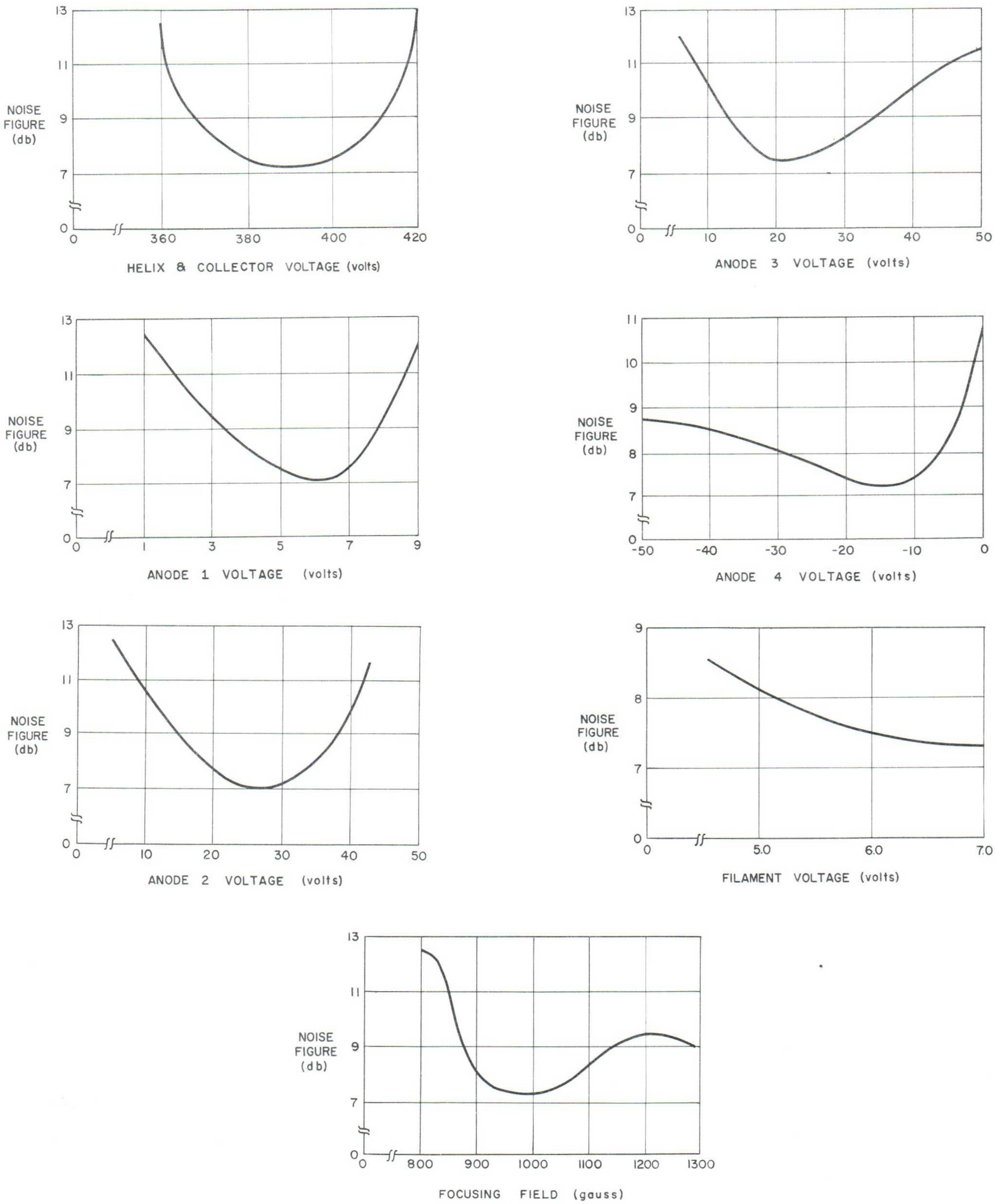
FREQUENCY RANGE, 1.0 TO 2.0 KMC; NF, 10 DB MAX; S–S GAIN, 25 DB MIN; POWER OUTPUT, 0 DBM MIN

OPTIMUM PARAMETERS

V_{A_1} = 10 V, V_{A_2} = 0 V, V_{A_3} = 80 V, V_{A_4} = 0 V, V_H = 186 V, V_C = 186 V, V_F = 6.0 V, AND B = 1100 GAUSS

FIGURE 1. HA – 14, NOISE FIGURE VS. OPERATING PARAMETERS

THE EFFECT OF OPERATING VOLTAGE VARIATIONS ON TWT NOISE FIGURE



HA – 37 (DATA TAKEN AT 3.0 KMC)

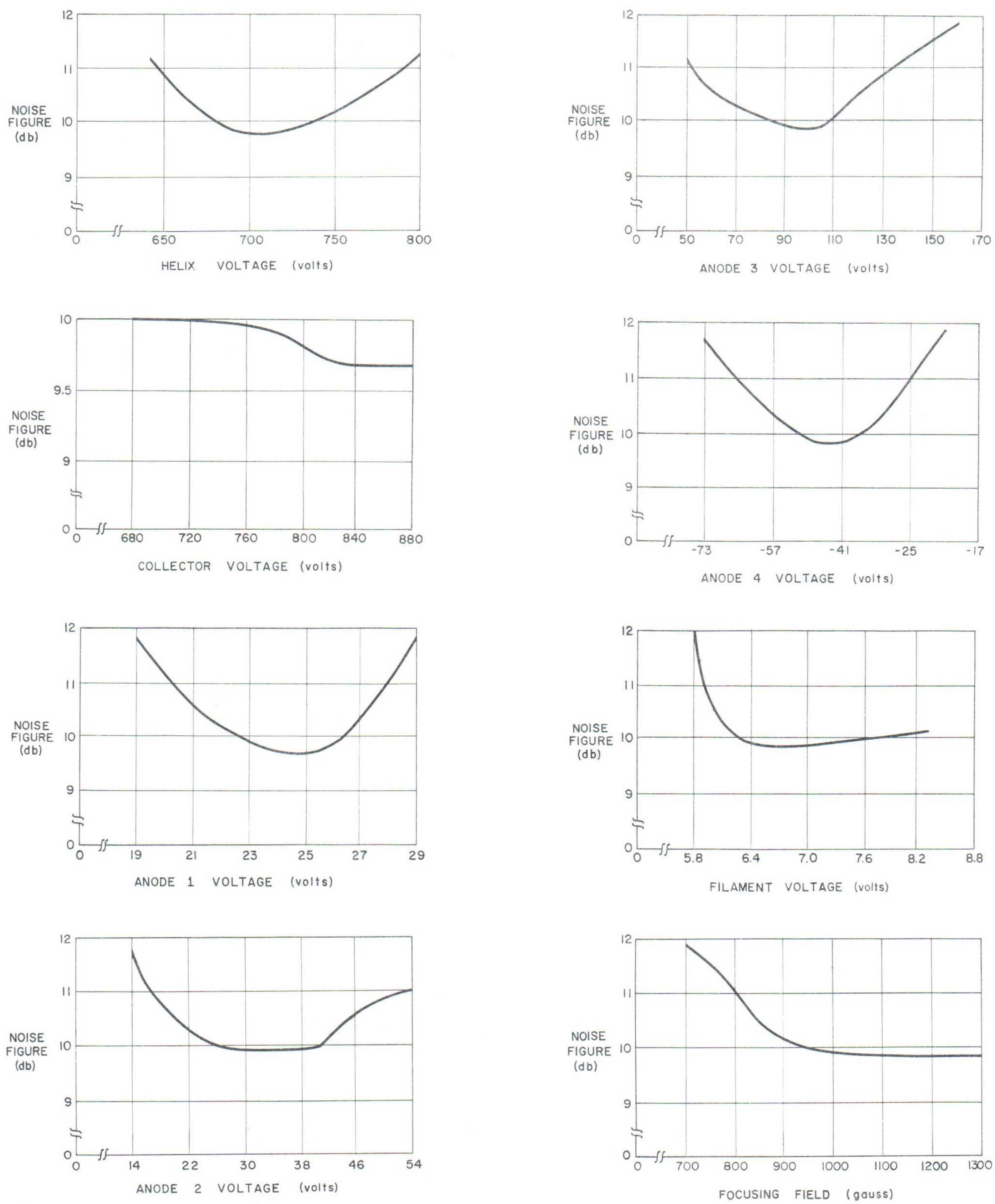
FREQUENCY RANGE, 2.0 TO 4.0 KMC; NF, 11 DB MAX; S–S GAIN, 25 DB MIN; POWER OUTPUT, 0 DBM MIN

OPTIMUM PARAMETERS

V_{A_1} = 5 V, V_{A_2} = 21 V, V_{A_3} = 21 V, V_{A_4} = –20 V, V_H = 400 V, V_C = 400 V, V_F = 6.3 V, AND B = 1000 GAUSS

FIGURE 2. HA – 37, NOISE FIGURE VS. OPERATING PARAMETERS

THE EFFECT OF OPERATING VOLTAGE VARIATIONS ON TWT NOISE FIGURE



HA – 47 (DATA TAKEN AT 4.0 KMC)

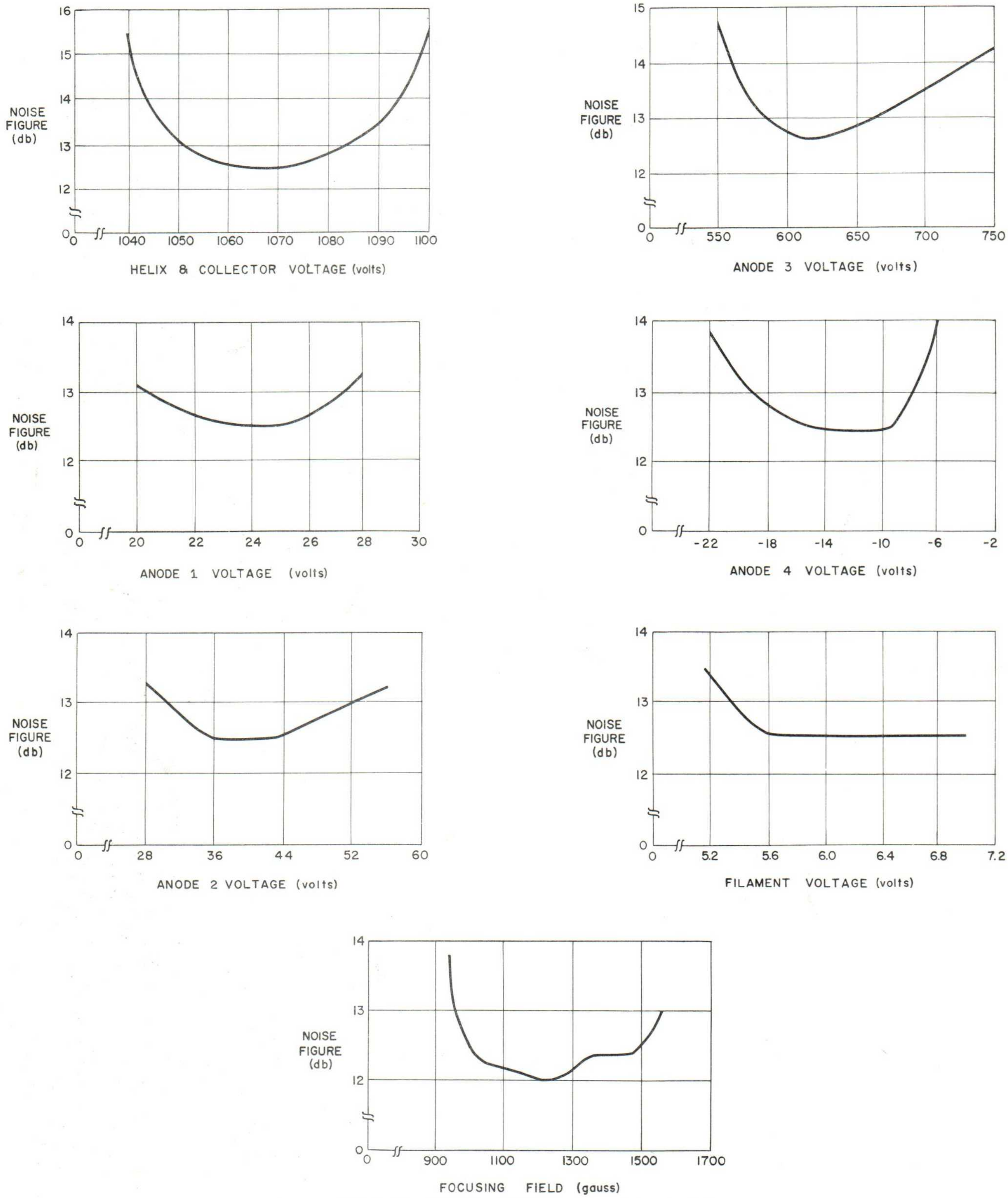
FREQUENCY RANGE, 4.0 TO 8.0 KMC; NF, 10 DB MAX; S-S GAIN, 25 DB MIN; POWER OUTPUT, 0 DBM MIN

OPTIMUM PARAMETERS

$V_{A_1} = 23$ V, $V_{A2} = 36$ V, $V_{A3} = 102$ V, $V_{A_4} = -49$ V, $V_H = 680$ V, $V_C = 780$ V, $V_F = 6.3$ V, AND B = 1000 GAUSS

FIGURE 3. HA – 47, NOISE FIGURE VS. OPERATING PARAMETERS

THE EFFECT OF OPERATING VOLTAGE VARIATIONS ON TWT NOISE FIGURE



HA – 43 (DATA TAKEN AT 12.0 KMC)

FREQUENCY RANGE, 12.0 TO 18.0 KMC; NF, 17 DB MAX; S–S GAIN, 25 DB MIN; POWER OUT, 0 DBM MIN

OPTIMUM PARAMETERS

V_{A_1} = 25 V, V_{A_2} = 42 V, V_{A_3} = 620 V, V_{A_4} = –10 V, V_H = 1070 V, V_C = 1070 V, V_F = 6.3 V, AND B = 1000 GAUSS

FIGURE 4. HA – 43, NOISE FIGURE VS. OPERATING PARAMETERS

FORWARD WAVE AMPLIFIERS

BACKWARD WAVE OSCILLATORS

BACKWARD WAVE AMPLIFIERS

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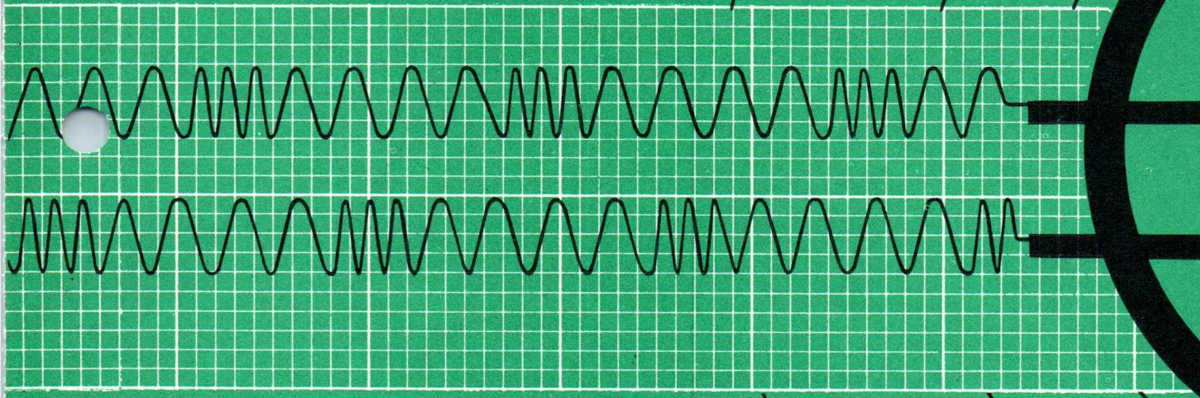

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BROADBAND FORWARD WAVE AMPLIFIERS

	UHF—BAND	L—BAND
10 MW STANDARD 30 DB MIN. SMALL SIGNAL GAIN 25 DB NOISE FIGURE	HA—7▲ 0.5—1.0 KMC $ 750.00 6-8 WEEKS DELIVERY	HA—5▲ 1.0—2.0 KMC $ 750.00 HA—22▲ 1.6—2.6 KMC $ 750.00 4—6 WEEKS DELIVERY
1 W STANDARD 30 DB MIN. SMALL SIGNAL GAIN 30 DB NOISE FIGURE	HA—8 D 0.5—1.0 KMC	HA—18 D 1.0—2.0 KMC
10 MW MEDIUM NOISE 30 DB MIN. SMALL SIGNAL GAIN 15 DB NOISE FIGURE		HA—17▲ 1.0—2.0 KMC $ 850.00 HA—19▲ 1.6—2.6 KMC $ 850.00 6—8 WEEKS DELIVERY
LOW NOISE 30 DB SMALL SIGNAL GAIN 10 DB MAX. NOISE FIGURE		HA—14▲ 1.0—2.0 KMC $ 1,500.00 6—8 WEEKS DELIVERY
PULSED: 1 W MIN. 30 DB MIN. SAT. GAIN 0.1 MAX. DUTY CYCLE		
PULSED: 2 W MIN. 30 DB MIN. SAT GAIN 0.1 MAX. DUTY CYCLE		
PULSED: 10 W MIN. 30 DB MIN. SAT. GAIN 0.1 MAX. DUTY CYCLE		

DISPERSIVE FORWARD WAVE AMPLIFIERS

	UHF—BAND	L—BAND
VOLTAGE TUNED 20 PER CENT BANDWIDTH 15 DB GAIN	DA—3 0.5—1.0 KMC $ 850.00 6—8 WEEKS DELIVERY	DA—2 1.0—2.0 KMC $ 750.00 6—8 WEEKS DELIVERY

BACKWARD WAVE AMPLIFIERS

	UHF—BAND	L—BAND
VOLTAGE TUNED 0.1 TO 1.0 PER CENT BANDWIDTH 15 DB GAIN		

PERMANENT MAGNET FOCUSED AMPLIFIERS

	UHF—BAND	L—BAND
10 MW STANDARD 30 DB SMALL SIGNAL GAIN		HA—31 D 1.0—2.0 KMC
1 W STANDARD 30 DB MIN. SMALL SIGNAL GAIN		

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		HA–23▲ 8.2–11.0 KMC $1,500.00 4–6 MONTHS DEL.	
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PA–3 2.0–4.0 KMC $1,000.00 6–8 WEEKS DELIVERY			

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BACKWARD WAVE AMPLIFIERS

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