UNITED

ELECTRONIC POWER TUBES

"MASTERPIECE OF SKILLED HANDS"

Presented to

Radio Station WHBI
Newark, New Jersey

B-484

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UNITED ELECTRONICS COMPANY

42 SPRING STREET **NEWARK 2, NEW JERSEY**

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CRAFTSMEN

"With the genius of skilled hands they have transformed wondrous inventions into physical being, thus contributing to the progress of our modern age and to the comforts of all mankind."

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High Vacuum Tubes

(Oscillators • Modulators • Amplifiers)

CV-11	FV-20	204-A	261-A	305-D	805	834	851
UX CV-11	KU-23	211	276-A	310	813	838	860
HV-12	HV-27	211-C	284-D	311-CH	830	842	949-A
HV-18	V-70-D	212-E	303-U	311-CT	830-B	845	949-H
JV-19	203-A	242-B		311-T	833-A	849	952

Mercury Vapor Rectifiers

866-A, 872, 872-A, 315-A, Z-225, 975-A, ESU-300

High Vacuum Rectifiers

217-C, 878, 371-B, V-1901

Mercury Vapor Grid Controlled Rectifiers

967, 973, UX-973

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TUBE PRICES IN EFFECT MAY 1, 1945

UNITED TYPE	CORRESPONDING TYPE	CLASS	CODE	FUNCTION	LIST PRICE
			HIGH VACUUM TUBES		
			(Modulators — Oscillators — Amplifiers)		
†CV-11	.....	Triode	FNBZ	High Frequency Oscillator R.F. Amplifier	$10.00
†UX-CV-11	841-SW	Triode	UXXN	Heavy Duty Replacement Tube	10.00
†HV-12	814-T	Triode	HVOO	Heavy Duty Oscillator R.F. Amplifier	18.00
†HV-18	HF & T-200	Triode	HVPZ	High Frequency Oscillator R.F. Amplifier	22.50
†JV-19	HF-250	Triode	TFIF	High Frequency Oscillator R.F. Amplifier	26.50
†FV-20	.....	Triode	FVER	High Frequency Oscillator R.F. Amplifier	17.50
†KU-23	HF-300	Triode	HFTH	High Frequency Oscillator R.F. Amplifier	35.00
†HV-27	822	Triode	HVLE	Heavy Duty Oscillator Amplifier—Cl. B. Modulator	18.00
†V-70-D	T-55	Triode	VDDD	Heavy Duty Replacement Tube	8.00
†203-A	303-A	Triode	UABO	Oscillator-Amplifier—Cl. B. Modulator	10.00
†204-A	304-A	Triode	UCOF	Oscillator R.F. Amplifier—Cl. B. Modulator	85.00
†211	311	Triode	UFEN	General Purpose	10.00
†211-C	311-C	Triode	UDCA	Low Capacitance General Purpose	16.00
†212-E	312-E	Triode	UGAR	Oscillator Modulator A.F. Amplifier	85.00
†242-B	342-B	Triode	UWIN	Cinema Sound Amplifier	15.00
†261-A	361-A	Triode	UHUP	General Purpose	16.00
†276-A	376-A	Triode	UJIL	General Purpose	16.00
†284-D	384-D	Triode	USND	Theater Type Audio Amplifier	15.00
†303-U	303-C	Triode	USWH	Heavy Duty Oscillator—R.F. Amplifier	18.00
‡305-D	205-D	Triode	UNED	General Purpose—Cinema Sound Amplifier	6.00
†310	801	Triode	UBOY	Oscillator—Cl. B. Modulator—R.F. Amplifier	3.45
†311-CH	211-CH	Triode	UDEZ	Heavy Duty Oscillator—R.F. Amplifier	18.00
†311-CT	211-C	Triode	USUU	Heavy Duty Oscillator—R.F. Amplifier	16.00
†311-T	211-D	Triode	USQC	Heavy Duty Oscillator—R.F. Amplifier	16.00
†805	905	Triode	UQUE	Oscillator—Amplifier Cl. B. Modulator	13.50
†813	.....	Beam Tetrode	UMPS	Oscillator—R.F. Amplifier	Inquire
†830	930	Triode	UKIN	Oscillator—Amplifier Modulator	8.75
†830-B	930-B	Triode	ULNA	Oscillator—R.F. Amplifier—Cl. B. Modulator	10.00
‡833-A	.....	Triode	UMKA	Oscillator—Amplifier—Cl. B. Modulator	Inquire
‡834	BW-11-304-B	Triode	BWEL	High Frequency Oscillator—R.F. Amplifier	12.00
†838	938	Triode	UATE	Oscillator—R.F. Power Amplifier—Cl. B. Modulator	11.00
†842	942	Triode	UVAP	A.F. Amplifier—Modulator	4.50
†845	945	Triode	UMBE	A.F. Amplifier—Modulator	10.00
†849	949	Triode	USEM	General Purpose	120.00
†851	951	Triode	UONP	R.F. Amplifier—Modulator	160.00
†860	960	Tetrode	UJAE	Amplifier—Modulator	Inquire
†949-A	849-A	Triode	UXEL	Oscillator—R.F. Amplifier—Cl. B. Modulator	135.00
†949-H	849-H	Triode	UHEH	High Frequency Oscillator—R.F. Amplifier	135.00
			HIGH VACUUM RECTIFIERS		
†217-C	317-C	Diode	TSEE	Half-Wave, High Vacuum Rectifier	$20.00
†371-B	.....	Diode	VHAM	Half-Wave, High Vacuum Rectifier	Inquire
‡878	978	Diode	AIET	Half-Wave, High Vacuum Rectifier	11.00
‡V-1901	.....	Diode	HIMS	Half-Wave, High Vacuum Rectifier	Inquire
			MERCURY VAPOR RECTIFIERS		
‡866-A	966/966-A	Diode	RIJO	Half-Wave Mercury (Shielded)	1.50
‡872	972	Diode	RETA	Half-Wave Mercury Rectifier (Unshielded)	7.50
‡872-A	972-A	Diode	RAPL	Half-Wave Mercury Rectifier	7.50
‡975-A	875-A 575-A	Diode	REDF	Half-Wave Mercury Rectifier	27.50
‡315-A	315-A	Diode	TRVA	Half-Wave Mercury Rectifier	35.00
‡Z-225	.....	Diode	ZEET	Half-Wave (Compact 866-A) Mercury Rectifier	1.65
†ESU-300	.....	Diode	RAME	Half-Wave Mercury Rectifier	Inquire
			MERCURY VAPOR GRID CONTROLLED RECTIFIERS		
‡967	FG-17	Thyratron	INDO	General Industrial	6.00
‡973	FG-27	Thyratron	ILER	General Industrial	17.25
‡UX-973	.....	Thyratron	IMPA	General Industrial	17.25

† Processed Graphite Anode

‡ United Processed Metal Anode

All prices subject to change without notice.

Deliveries F. O. B. Factory or nearest warehouse point.

Inquiries are cordially invited and best delivery date will be quoted.

UNITED ELECTRONICS

DIRECT REPLACEMENT GUIDE AND INTERCHANGEABILITY CHART

List of Other Make Tubes with Correct UNITED Replacement

Replace Old Tube	with	UNITED New Tube
BW-11	>	**834**
FG-17	>	**967**
FG-27	>	**973**
UH-50	>	**834**
HY-51-A	>	**UX-CV11**
T-55	>	**V-70-D**
RK-57	>	**805**
RK-58	>	**838**
HF-120	>	**311-T**
T-125	>	**FV-20**
HF-140	>	**311-T**
HF-150	>	**311-CH**
NU-150	>	**311-CH**
FP-195	>	**952**
WL-195	>	**952**
FP-197	>	**311-T**
C-200	>	**HV-18**
HF-200	>	**HV-18**
NU-200	>	**HV-18**
T-200	>	**HV-18**
HD-203C	>	**303-U**
203-H	>	**303-U**
203-U	>	**303-U**
WE 205-D	>	**305-D**
WL211	>	**311-T**
211-B	>	**311-T**
HD-211-C	>	**311-CT**
211-D	>	**311-T**
211-H	>	**311-CH**
211-HD	>	**311-CH**
FP-252A	>	**FV-20**
FP-285	>	**311-CT**
C-300	>	**KU-23**
DR-300	>	**KU-23**
HF-300	>	**KU-23**
NU-300	>	**KU-23**
303A	>	**203-A**
303C	>	**303-U**
304-A	>	**204-A**
304-B	>	**834**
311	>	**211**
312-E	>	**212-E**
342-A	>	**242-A**
342-B	>	**242-B**
361-A	>	**261-A**
375-A	>	**975-A**
376-A	>	**276-A**
384-D	>	**284-D**
C-455	>	**830**
WL-460	>	**HV-18**
WL-463	>	**KU-23**
WL-469	>	**311-T**
WL-471	>	**311-CH**
575A	>	**975-A**
801A/801	>	**310**
814(T)	>	**HV-12**
T-822	>	**HV-27**
T-841S-W	>	**UX-CV11**
849-A	>	**949-A**
849-H	>	**949-H**
852	>	**952**
866	>	**866-A**
905	>	**805**
930	>	**830**
930-B	>	**830-B**
938	>	**838**
945	>	**845**
949	>	**849**
951	>	**851**
966	>	**866-A**
966-A	>	**866-A**
972	>	**872**
972-A	>	**872-A**
1276	>	**305-D**
3572	>	**866-A**
3581	>	**HV-27**
3593	>	**HV-12**

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High Vacuum Tubes (OSCILLATORS MODULATORS AMPLIFIERS)

STATIC CHARACTERISTICS AND CONTINUOUS SERVICE RATINGS

INTERMITTENT SERVICE RATINGS DIATHERMY, R.F. HEATING, ETC.

UNITED TYPE	Class	Max. Plate Dissipation Watts	Filament		Maximum DC Plate Volts		Maximum DC Plate Current		Max. D C Grid Current (Ma.)	Amp. Factor (μ)	Inter-Electrode Capacitances			RP Ohms	Principal Purpose and Function	Maximum Plate			Approx. Output per Tube (Watts)
			Volts	Amps.	Modulated	Un-Modulated	Modulated	Un-Modulated			G-P μμfd	G-F μμfd	F-P μμfd			Meters	A C Volts	D C Volts	
CV-11	Triode	75	10.0	2.5	....	1500	....	.165	.025	14	9.0	5.0	2.3	3220	Diathermy	15 10 7.5 6	1500 1400 1300 1250	1350 1250 1150 1100	170 140 100 90
UX-CV-11	Triode	75	10.0	2.5	....	1500	....	165	.025	14	9.0	5.0	2.3	3220	Diathermy	15 10 7.5 6	1500 1400 1300 1250	1350 1250 1150 1100	170 140 100 90
HV-12	Triode	200	10.0	4.0	2000	2500	.175	.210	.060	12	14.0	8.5	4.0	2000	Diathermy Amplifier Class B Modulator	15 10 7.5 6	2250 2000 1800 1750	2000 1750 1600 1500	300 250 200 160
HV-18	Triode	200	10.0	3.85	2000	2500	.175	.210	.060	18	6.5	5.0	1.5	3600	Diathermy HF Heating Amplifier Class B Modulator	15 10 7.5 6	2800 2500 2500 2400	2500 2250 2250 2000	325 300 275 250
JV-19	Triode	150	10.0	4.0	.....	2500	....	.200	....	18	5.8	....	....	....	Diathermy	15 10 7.5 6			
FV-20	Triode	150	10.0	3.75	1750	1500	.175	.200	.060	20	6.8	5.1	3.5	5000	Diathermy Amplifier Class B Modulator	15 10 7.5 6	2000 1800 1700 1600	1750 1500 1400 1300	260 220 200 190
KU-23	Triode	200	11.0	4.0	2200	3000	.275	.275	.060	23	6.5	6.0	1.4	4100	HF Heating Oscillator Amplifier Class B Modulator				
HV-27	Triode	200	10.0	4.0	2000	2500	.175	.210	.060	27	14.5	8.5	3.5	4000	Diathermy Oscillator Amplifier Class B Modulator	15 10 7.5 6	2250 2000 1800 1750	2000 1750 1600 1500	300 250 200 160
V-70-D	Triode	70	7.5	3.25	....	1500	....	.165	.025	28	4.5	4.5	1.7	7200	Diathermy	15 10 7.5 6	1500 1400 1300 1250	1350 1250 1150 1100	160 140 130 110
203-A	Triode	100	10.0	3.25	1000	1250	.150	.175	.060	25	14.5	6.5	5.5	6000	Oscillator Amplifier Class B Modulator				
204-A	Triode	250	11.0	3.85	2000	2500	.275	.275	,080	23	15.0	12.5	2.3	6300	Oscillator Amplifier Class B Modulator				
211	Triode	100	10.0	3.25	1000	1250	.150	.175	.050	12	14.5	6.0	5.5	3400	Oscillator Amplifier Modulator				
211-C	Triode	100	10.0	3.25	1000	1250	.150	.175	.050	12	9.0	6.0	5.0	3400	Oscillator Amplifier Modulator				
212-E	Triode	350	14.0	6.0	1500	3000	.325	.350	.125	16	18.8	14.9	8.6	1900	Oscillator Amplifier Modulator				
242-B	Triode	85	10.0	3.25	1000	1250	.040	.060	....	12	14.5	6.0	5.5	3400	Oscillator Amplifier Class A Modulator				
261-A	Triode	100	10.0	3.25	1000	1250	.150	.175	.050	12	9.0	6.0	5.0	3400	Oscillator Amplifier Modulator				
276-A	Triode	100	10.0	3.25	1000	1250	.150	.175	.050	12	9.0	6.0	5.0	3400	Oscillator Amplifier Modulator				
284-D	Triode	100	10.0	3.25	1000	1250	.150	.175	.050	48	8.3	6.0	5.6	1900	Oscillator Amplifier Modulator				

High Vacuum Tubes (Cont'd) (OSCILLATORS MODULATORS AMPLIFIERS)

STATIC CHARACTERISTICS AND CONTINUOUS SERVICE RATINGS

INTERMITTENT SERVICE RATINGS DIATHERMY, R.F. HEATING, ETC.

UNITED TYPE	Class	Max. Plate Dissipation Watts	Filament		Maximum DC Plate Volts		Maximum DC Plate Current		Max. DC Grid Current (Ma.)	Amp. Factor (μ)	Inter-Electrode Capacitances			RP Ohms	Principal Purpose and Function	Maximum Plate			Approx. Output per Tube (Watts)
			Volts	Amps.	Modulated	Un-Modulated	Modulated	Un-Modulated			G-P μμfd	G-F μμfd	F-P μμfd			Meters	AC Volts	DC Volts	
303U	Triode	125	10.0	3.75	....	....	....	.200	.060	21	9.0	7.0	4.0	4200	Diathermy	15 10 7.5 6	1800 1700 1600 1550	1500 1400 1300 1250	250 210 190 175
305-D	Triode	14	4.5	1.60	350	375	.040	.050	.010	7	4.8	5.2	3.3	4450	Oscillator Amplifier Modulator				
310	Triode	20	7.5	1.25	500	600	.060	.070	.015	8	7.0	4.0	2.2	5000	Oscillator Amplifier Modulator				
311-CH	Triode	125	10.0	3.25	....	1800	....	.200	.050	12	8.0	5.5	4.5	2550	Diathermy	15 10 7.5 6	1800 1700 1600 1550	1500 1400 1300 1250	250 210 190 175
311-CT	Triode	120	10.0	3.25	....	1500	....	.200	.050	12	8.0	5.5	4.0	2550	Diathermy	15 10 7.5 6	1500 1400 1400 1400	1350 1250 1250 1250	200 190 170 140
311-T	Triode	100	10.0	3.25	....	1500	....	.200	.050	12	13.0	6.0	5.0	2550	Diathermy	15 10 7.5 6	1500 1400 1400 1300	1350 1250 1250 1150	200 190 170 130
805	Triode	125	10.0	3.25	1250	1500	.175	.210	.070	100	6.5	8.5	10.5	12500	Oscillator Amplifier Class B Modulator				
813	Beam Tetrode	100	10.0	5.0	2000	2000	.100	.180	.025	100	0.2	16.3	14.0	27000	R. F. Amplifier				
830	Triode	40	10.0	2.0	....	800	....	.110	.018	8	9.9	4.9	2.2	4000	Diathermy	15	800	600	55
																This type is not recommended for operation below 15 meters			
830-B	Triode	60	10.0	2.0	....	1000	....	.150	.030	25	9.5	5.0	2.0	8130	Diathermy	15	1250	1000	
																This type is not recommended for operation below 15 meters			
833-A	Triode	450	10.0	10.0	3000	4000	.300	.500	.025	35	5.5	10.1	6.4	....	R. F. Heating Oscillator Amplifier Class B Modulator				
834	Triode	50	7.5	3.25	1250	1250	.100	.100	.020	11	2.5	2.0	0.7	5500	UHF Oscillator RF Amplifier Class B Modulator				
838	Triode	100	10.0	3.25	1000	1250	.150	.175	.070	100	8.0	6.5	5.5	12500	Oscillator Amplifier Class B Modulator				
842	Triode	15	7.5	1.25	425	....	.035	....	....	3	7.0	4.0	3.0	2500	Amplifier Modulator				
845	Triode	75	10.0	3.25	1000	1250	.065	.095	.040	5	13.5	6.0	6.5	1800	Amplifier Modulator				
849	Triode	400	11.0	5.0	2000	3000	.350	.350	.125	19	33.5	17.0	3.0	3200	Oscillator Amplifier Modulator				
851	Triode	750	11.0	15.5	2500	3000	.1000	.1000	.200	20.5	47.0	25.5	4.5	1500	HF Heating Oscillator Amplifier Modulator				
860	Tetrode	100	10.0	3.25	2000	3000	.085	.150	.15	200	0.08	7.75	7.5	....	Oscillator Amplifier Modulator				
949-A	Triode	500	11.0	7.7	3500	4000	.500	.500	.110	19	11.5	14.0	1.7	2500	Oscillator Amplifier Modulator				
949-H	Triode	500	11.0	7.7	3500	4000	.500	.500	.110	19	11.5	10.0	1.8	2500	HF Heating Oscillator Amplifier				
952	Triode	100	10.0	3.25	....	3000	....	.150	.040	12	2.6	1.9	1.0	10000	Diathermy	7.5 10 15 6	2500 2500 3000 2250	2250 2250 2500 2000	160 180 210 140

UNITED ELECTRONICS

MERCURY VAPOR RECTIFIERS

Characteristics and Ratings

UNITED TYPE	FILAMENT		MAXIMUM PEAK INVERSE VOLTAGE	MAXIMUM PEAK PLATE CURRENT AMPERES	AVERAGE PLATE CURRENT AMPERES
	VOLTS	AMPERES			
866-A	2.5	5.0	10,000	1.0	0.250
872	5.0	10.0	7,500	5.0	1.250
872-A	5.0	6.75	10,000	5.0	1.250
975-A	5.0	10.0	15,000	6.0	1.500
315-A	5.0	10.0	12,500	7.0	1.750
Z-225	2.5	5.0	10,000	1.0	0.025
ESU-300	4.0	15.0	7,000	3.0	0.750

HIGH VACUUM RECTIFIERS

Characteristics and Ratings

UNITED TYPE	FILAMENT		MAXIMUM PEAK INVERSE VOLTAGE	MAXIMUM PEAK PLATE CURRENT AMPERES	AVERAGE PLATE CURRENT AMPERES
	VOLTS	AMPERES			
217-C	10.0	3.25	7,500	0.60	.015
371-B	5.0	10.3	25,000	1.50	.300
878	2.5	5.0	20,000	0.020	.005
V-1901	16.5	15.25	70,000	1.20	.040

MERCURY VAPOR GRID CONTROLLED RECTIFIERS

Characteristics and Ratings

TYPE	FILAMENT		MAXIMUM PEAK		AVERAGE PLATE CURRENT AMPERES	TYPE OF GRID CONTROL	CONDENSED MERCURY TEMPERATURE RANGE ° C.
	VOLTS	AMPERES	INVERSE VOLTAGE	PLATE CURRENT AMPERES			
967	2.5	5.0	2,500	2.0	.50	Neg.	40° - 80°
973	5.0	6.75	3,000	10.0	2.50	Neg.	40° - 80°
UX-973	5.0	6.75	3,000	10.0	2.50	Neg.	40° - 80°

UNITED ELECTRONICS

ELECTRONIC TUBES --- BASIC THEORY

Electrons, Atoms, Ions

Electronics deals with electrons, their sources and their movements through conductors and through electronic tubes. The electron is a negative particle of electricity of definite charge and mass. It is repelled by other negative charges and attracted by positive charges.

Polished metal, when examined under a microscope, reveals small crystals, resembling distorted polygons. If these crystals could be further magnified or examined geometrical figures called space-lattices and composed of atoms would be detected. Atoms are composed of one or more electrons rotating around a much heavier nucleus. The nucleus contains a number of positive charges equalling the number of electrons contained in the atom. Therefore an atom which contains its full quota of electrons is electrically neutral. The dissimilarities among the 92 basic elements are based upon differences in the nucleus and the number of associated electrons and not upon variations in the character of the electron. In some substances atoms combine to form close-knit groups called molecules. For example, an atom of sodium may join an atom of chlorine to form one molecule of table salt or sodium chloride.

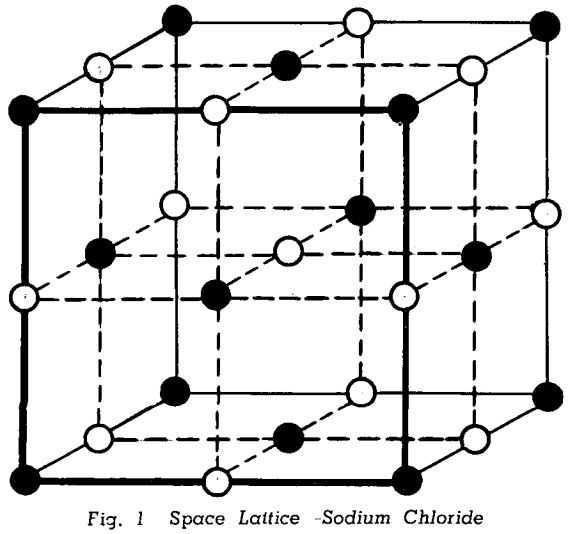


Fig. 1 Space Lattice -Sodium Chloride

If atoms or molecules lose one or more electrons, positive ions result. Positive ions are not all alike and may differ in charge and weight. They are much heavier than electrons and resemble the molecule or atom from which they were derived. Ions are designated according to their origin, i.e., mercury ions, hydrogen ions, etc.

Current

Normally, the motion of atoms and molecules is unaffected by electric and magnetic fields. Positive and negative charges such as ions and electrons, however, are influenced by such fields. Thus an electron will be attracted to a positively charged electrode while a positive ion will be attracted to a negatively charged electrode.

The term "free electrons" is applied to those electrons which have strayed from the immediate influence of their atomic nucleus. If an electromotive force or potential is applied to these free electrons they will drift in the direction of the positive terminal. The flow of free electrons constitutes electric current.

The magnitude of the electric current is governed by the number of electrical charges which pass a given point in a definite time interval. The number of electrical charges, or the quantity of electricity is commonly denoted by Q and is measured in coulombs. A current whose magnitude or intensity is one ampere is said to flow when one coulomb of electricity passes a given point in one second.

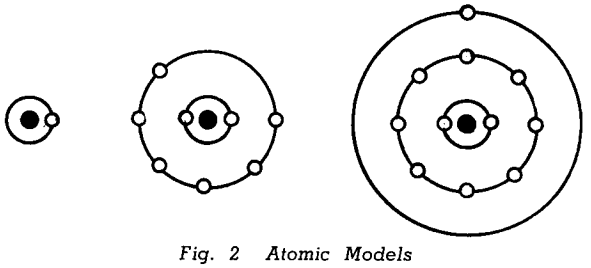


Fig. 2 Atomic Models

The direction of current flow was postulated before the true nature of electricity became known. It was arbitrarily decided that current in an electrical network travelled from the positive to the negative terminal. This was analogous to the flow of water from a high to a low elevation. However, since electrons are attracted to a positive terminal, actual electron flow in a circuit is opposite in direction to conventional current flow.

Electron Emission

The electrode in an electronic tube which serves as a source of electrons is known as a cathode. The ability of a cathode to supply *the required* number of electrons to the vacuous or gaseous space in an electronic tube is worthy of study. It is common practice to refer to a directly-heated cathode as a filament.

The principal methods of obtaining a flow of electrons are:

1. thermionic emission—where electron flow is the result of heat energy,
2. photoelectric emission—where electron flow is the result of light energy,
3. high field or cold-cathode emission—where electron flow is the result of intense electric fields.
4. secondary emission—where electron flow is a result of the bombardment of a surface by electric charges, and
5. radioactive emission—where electron flow is a result of the disintegration of radioactive materials.

Since transmitting tubes rely mainly upon thermionic emission, we shall disregard other types of emission in the discussion.

A desirable emitter should have a high melting point, a low work function, and long life. By work function is meant the amount of energy in volts, which is required to remove an electron from a metallic surface.

Usual filament materials are tungsten, thoriated-tungsten, and the oxide-coated metals. The emission efficiency of a filament or cathode is specified in terms of space current in amperes per watt of filament or heater power.

Each of the various emitting materials has its appropriate place depending on operational requirements and tube design.

Tungsten Filaments

Tungsten, a commonly used metallic emitter, has a melting point of 3643° K. and a work function of 4.52 volts. Since tungsten has a rather large work function and must operate at high temperatures (white heat) its emission efficiency is rather low. Tungsten is used principally as a directly heated filament in large transmitting and rectifying tubes where high operating temperatures (approximately 2500° K.) are feasible.

Tungsten filaments must be properly aged before put into service. This is done by heating the filament slightly above operating temperature and then *"flashing"* for a short time at a very high (approximately 3000° K.) temperature. This process removes any foreign gases from the filament and leaves it with a clean surface.

The ability of tungsten to resist destructive effects such as filament evaporation, chemical poisoning, and mechanical failure is outstanding. It is much less subject to loss of emission from positive ion bombardment resulting from residual gas than other emitters. Tungsten, because of recrystallization, is mechanically fragile; electrically, however, it is very rugged.

Hot tungsten is attacked by water vapor and nitrogen but is unaffected by mercury vapor and the noble gases, neon, helium, argon, krypton, and xenon.

Tungsten finds greatest application in high-voltage x-ray and power tubes where positive ion bombardment is severe.

Reference to Table I indicates that because of the high ratio of hot-to-cold resistance of tungsten a dangerously high initial current may be drawn by the filament; time delay relays or reactance regulators are recommended to limit the current to a safe value; e.g. 150% of rated current for large tubes.

Thoriated-Tungsten Filaments

If from one to two percent of thorium oxide (thoria) is added to pure tungsten powder before it is sintered, swedged, and drawn into wire form, a thoriated-tungsten wire results.*

A thoriated filament has the mechanical properties of tungsten but the addition of thorium to tungsten filaments increases its emissive ability about thousandfold for a given filament operating temperature.

Thorium alone has a melting point of 2118° K. but when absorbed by tungsten can be used at much higher temperatures. The work function of a thoriated tungsten filament is approximately 2.6 volts. Thoriated-tungsten filaments are used in a majority of transmitting tubes and in many receiving tubes. They are normally operated in the temperature range from 1800° K. to 2000° K.

The behavior of a thoriated-filament during operation consists of the reduction of thorium oxide to metallic thorium, diffusion of thorium toward the surface, and evaporation of thorium from the surface. These processes are a function of the filament temperature. The activation, i.e., amount of thorium coating on a filament, depends on the balance between the rates of loss and supply of thorium which exist at any given temperature. The emission life of a thoriated tungsten filament depends upon the reserve supply of thorium available, and the rate at which the thorium is being used up. The latter, of course, depends upon the operating temperature of the filament. It is apparent that the correct voltage or temperature ratings of thoriated tungsten filaments must be employed if a proper thorium coating is to be formed.

*It is possible to prepare thoriated-tungsten by an electrolytic process also.

Carburization

The emissive qualities of a thoriated-tungsten filament are greatly improved by a process called carburization. The thoriated-tungsten filament is operated in a temperature range of from 1600° K. to 2000° K. in a convenient hydrocarbon vapor (acetylene, naphthalene, or benzol) until its resistance increases by 10 to 20 per cent. Molecules of the hydrocarbon strike the filament and decompose into carbon and hydrogen. The carbon which is deposited on the surface diffuses into the tungsten forming tungsten carbide. The presence of this carbide layer reduces the subsequent evaporation of thorium from the tungsten sixfold and therefore increases the life of the filament.

The advantages of the thoriated tungsten filaments include suitability for operation at fairly high voltages and medium (bright yellow) temperatures, and a high emission efficiency. Residual gas in an electronic tube may cause rapid de-activation of a thoriated-tungsten filament because of positive ion bombardment.

Reference to Table I indicates that because of the high ratio of hot-to-cold resistance of thoriated-tungsten, a dangerously high initial current may be drawn by the filament; time delay relays or reactance regulators are recommended to limit the current to a safe value; e.g. 150% of rated current for large tubes.

Oxide-Coated Filaments

The oxide-coated filament consists of a metallic base coated with some of the alkaline-earth metals, i.e., barium, strontium, or calcium. The metallic base may be nickel, tungsten, tungsten electroplated with copper, konel or platinum alloys. Since the oxides of these metals are unstable in air, they are first coated with the alkaline-earth carbonates, nitrates, or hydroxides and then heated in vacuum. The coatings are reduced to oxides and the gas generated in the process is removed by high speed pumps. The filament is then "activated." This process consists of further heating, application of anode voltages, and r-f bombardment. The emergent filament has a very high emission efficiency, emitting electrons as plentifully at 1000° K. as does a tungsten filament at 2300° K.

Oxide-coated filaments operate in the range of 1000° K. to 1250° K. and have a work function of approximately 1-2 volts.

When indirectly-heated oxide-coated cathodes are used, an equipotential cathode surface results; that is, no voltage drop because of heater-current exists in the cathode.

The advantages of the oxide-coated cathodes include a very high emission efficiency, and the fact that filament and heater burnouts are minimized because of the low (dull red) temperatures used.

Emitter Ratings

TABLE I

Type of Filament	Efficiency MA per CM^2 per Watt	Work Function in Volts	Operating Temperature ° K.	Ratio Hot-to-Cold Resistance
Tungsten	2-10	4.52	2500-2600	14:1
Thoriated-Tungsten	5-100	2.6	1800-2000	10:1
Oxide-Coated	100-1000	1-2	1000-1250	2.5 to 5.5:1

In general, the choice of a filament for a specific transmitting tube is governed by the following considerations:

(a) oxide-coated — for power outputs up to 100 watts and plate voltage ratings to 600 volts.
(b) thoriated-tungsten filaments — for power outputs of 100-1000 watts and plate voltage ratings to 3500-4000 volts.
(c) tungsten filaments — for power outputs of 1 kilowatt and up, and plate voltage ratings in excess of 3500-4000 volts.

Notable exceptions to the above ratings occur in mercury-vapor and other tubes where end-use conditions predicate special design.

Space Charge

When a tube filament is heated, electrons are emitted into the region immediately surrounding the filament. These electrons form a cloud of variable density, closely bunched near the filament and thinned-out with increasing distance from the filament. The effect of the space charge upon individually emitted electrons varies with the position of the electron under consideration. For a position close to the filament the space charge will exert a powerful retarding effect upon the electron tending to push it back into the filament. As the electron moves farther out, the repulsion due to the negative space charge will accelerate the electron to the anode.

The space charge limits the number of electrons reaching the anodes of high-vacuum tubes. Space charge can be minimized by the use of high plate potentials in vacuum tubes.

The effects of the space charge may be neutralized by the presence of positive ions. In tubes containing gas or mercury-vapor, positive particles resulting from ionization are attracted to the filament where neutralization of the negative space charge occurs. This changes the potential distribution between filament and plate and results in a large increase in emission and total tube current.

TUBE CLASSIFICATIONS AND CHARACTERISTICS

Diodes

A two electrode tube is called a diode and contains an electron emitter or cathode and an electron collector or anode (plate). Electrons from the negative cathode are attracted to the positive anode; from there they travel through the load circuit and eventually return to the cathode thus completing the electrical circuit.

The relation between plate voltage and plate current through a tube at a given filament temperature is shown in Fig. 3. This curve is obtained by holding filament temperature fixed and increasing the plate voltage. The plate current increases until electrons are taken from the filament as fast as they are given off. This condition is indicated by the flattening of the curve and is known as voltage saturation. More electrons and higher plate current can be provided only by raising the filament temperature.

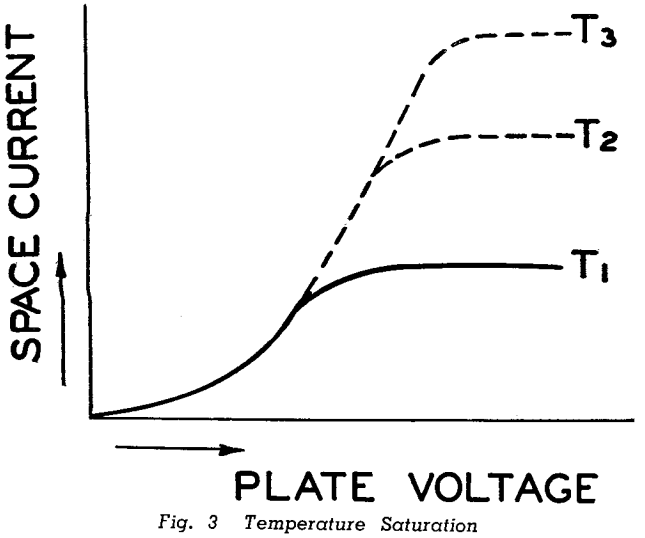


Fig. 3 Temperature Saturation

The dependence of plate current upon filament temperature for a given plate voltage is shown in Fig. 4. Plate current flows when the filament gets hot enough to emit electrons. The plate current increases as filament temperature is raised subject to the negative space charge which builds up sufficiently to limit the current. This is indicated by the *flattening of* the curve and is known as temperature saturation. A larger current can flow only if a higher plate voltage is applied with consequent reduction in space charge.

Applications

Diodes are used in transmitting and industrial service to provide rectified d-c voltages for plate, screen and grid-bias supplies. In receiving service, diodes may also be used as detectors. Detectors and rectifiers though differing in size and current capacity exhibit the same general characteristics.

A simple diode acts on only one-half of an alternating voltage cycle and is known as a half-wave rectifier. The placement of two diode plates in one bulb gives rise to a full-wave rectifier which acts upon both halves of the alternating voltage cycle.

High internal resistance in a diode leads to a large voltage drop within the tube. Such a condition leads to poor regulation and low efficiency. The internal resistance depends upon the shape and spacing of the cathode and the plate. For a given tube structure the voltage drop within the tube depends on the negative space charge.

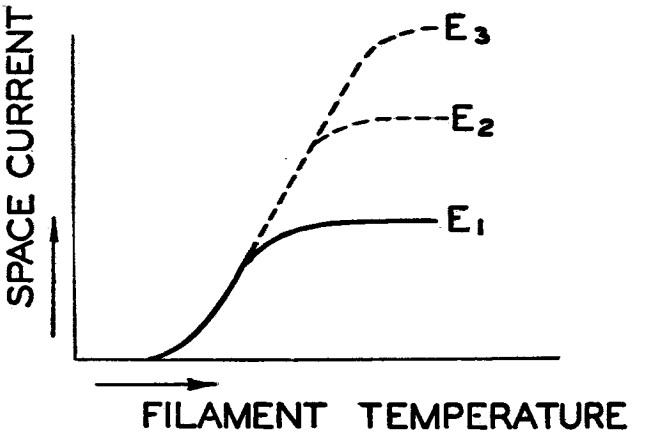


Fig. 4 Voltage Saturation

The internal resistance of a diode may be greatly reduced by introducing mercury-vapor at low pressure into the evacuated tube.

Diode applications are governed by the tube's inherent properties. The current rating of a diode is essentially small because of negative space charge limitations while the voltage drop across the tube is high and varies with anode current. Diodes will stand a high inverse peak voltage and will not arc-back readily. Hence the use of the diode is ideal for high voltage, low current rectification. Logical applications for diodes are in power supplies for high d-c voltages for X-ray equipment, cathode-ray tubes, smoke and dust precipitators, etc.

Triodes

Thermionic tubes containing a third electrode or grid are called triodes. The grid is a mesh or coil of wire placed between plate and filament. Increase or decrease of plate current is effected by varying the grid voltage. A positive grid potential will neutralize part of the negative space charge thus in-

creasing current flow through the tube; a negative grid potential aids the negative space charge in curtailing plate current flow. The triode makes possible control of large plate currents by means of small independent grid voltages.

Triodes are normally operated at fixed voltages. Under these conditions the important tube characteristics are given by the following curves:

1. plate current vs. plate voltage (I_b—E_b)at a constant grid voltage, or plate characteristic curve,
2. plate current vs. grid voltage (I_b—E_c) at a constant plate voltage, or mutual (transfer) characteristic curve, and
3. grid current vs. grid voltage (I_c—E_c) at a constant plate voltage, or grid characteristic curve.

These curves are static, that is, taken under "no load" conditions. Since a tube can be operated with a wide variety of load impedances it is impractical to give curves for all values. Static curves, however, can be converted to dynamic curves which show actual operating conditions.

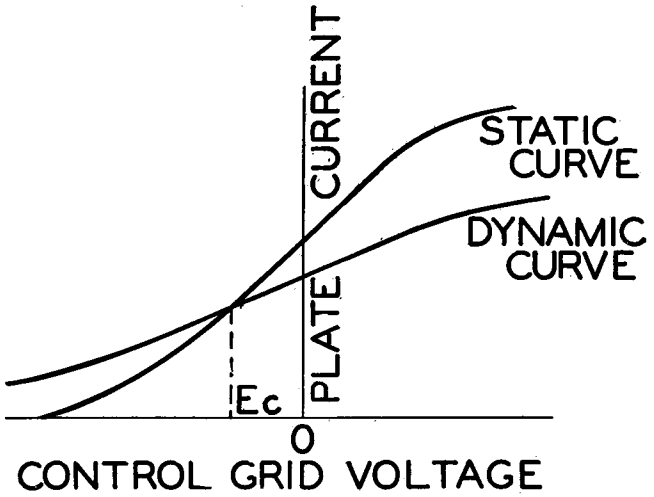


Fig. 5 Static and Dynamic Curves

Interelectrode Capacitances

There are several important vacuum tube constants which determine tube suitability for a particular purpose.

Since the vacuum tube elements are conductors separated from each other, an interelectrode capacitance exists between these elements. In a triode the grid to plate, plate to cathode, and the grid to cathode capacitances are of importance in determining tube adaptability for operation at specific frequencies.

In the original design of a given tube type, values of interelectrode capacitances to give optimum operating performance are chosen.

An inherent characteristic of a triode creates feedback of energy from the plate circuit to the grid circuit through the grid to plate interelectrode capacitances. This can be eliminated by a neutralizing circuit to balance out the action of the plate to grid coupling.

Vacuum Tube Coefficients

Three very important characteristics of a triode can be expressed in terms of coefficients which eliminate the necessity of recourse to graphical analyses of the characteristic curves. These coefficients or "constants" are the amplification factor, μ, the dynamic plate resistance, r_p, and the mutual conductance, g_m.

Amplification Factor

The amplification factor is a measure of the effectiveness of the grid with respect to the plate in controlling plate current. It is determined by the geometrical structure of the plate, grid, and cathode and may be calculated in terms of the distances and dimensions involved. The amplification factor depends primarily upon the grid and the completeness with which the grid shields the cathode from the plate. Increased diameter and closer spacing of grid wires tend to increase the amplification factor.

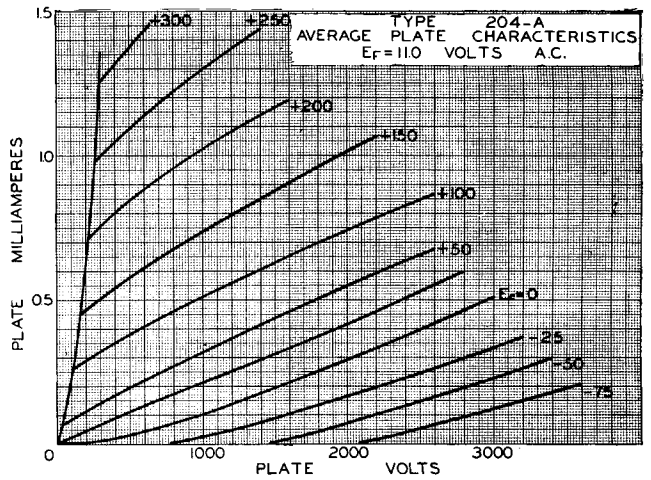


Fig. 6 Average Plate Characteristics

The amplification factor is often expressed as

$$\mu = \left.\frac{de_b}{de_c}\right|_{i_b \text{ constant}}$$

The amplification factor, thus, is the ratio of a small change in plate voltage to the change in grid voltage required to bring the plate current back to the value it had before the plate voltage was changed.

The amplification factor is a voltage ratio and is expressed as a numeric, i.e., has no dimensions.

Plate Resistance

The plate resistance as specified in technical tube data refers to the opposition offered to the flow of alternating current in the plate circuit. The plate resistance is given by the inverse slope of the plate-current plate-voltage characteristic at a given point. In general, a different value of plate resistance is obtained for each operating point. The mathematical representation for plate resistance is given by

$$r_p = \left.\frac{de_p}{di_p}\right|_{e_c \text{ constant}}$$

The plate resistance, thus, is the ratio of a small change in plate voltage to the change in plate current when the grid voltage is fixed.

Mutual Conductance

The mutual conductance g_m is defined as the ratio of a small change in plate current to the change in grid voltage when the plate voltage is fixed. It may be expressed as

$$g_m = \left.\frac{di_p}{de_c}\right|_{e_b \text{ constant}}$$

The mutual conductance is commonly given in mhos or micromhos.

The mutual conductance shows, roughly, the design merit of a tube since the latter is indicated by a desirably high μ to r_p ratio.

If the mutual conductance of a tube in mhos is multiplied by the grid signal voltage, the plate signal current results.

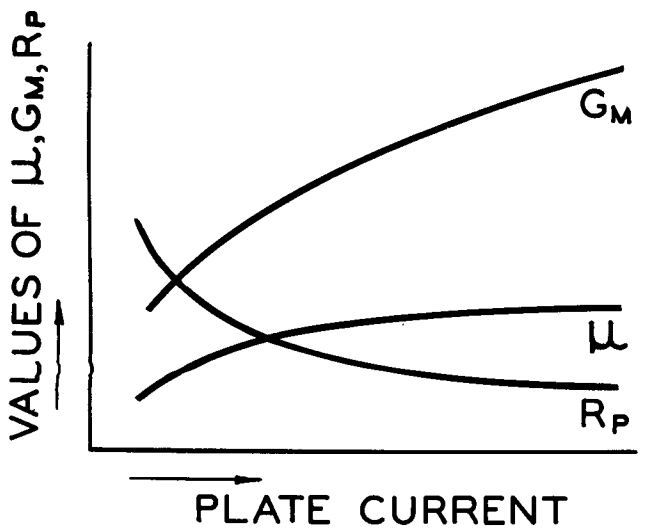


Fig. 7 Vacuum Tube Coefficients

The three coefficients, amplication factor μ, plate resistance r_p, and mutual conductance, g_m, will define tube behavior for given values of plate and grid voltages. When the families of the characteristic curves, are straight, parallel and equidistant from each other the above mentioned coefficients will be constants. This condition however is never realized perfectly in actual practice. Hence, μ, r_p and g_m for a given tube may vary with conditions of operation.

The three coefficients are related by the formula

$$\mu = g_m r_p$$

Consequently if two coefficients at the same operating condition are known then the third coefficient may easily be calculated.

Triode Operation

The input terminals to a triode are the grid and cathode, while the output terminals are the anode and cathode. The d-c static characteristics of such a tube are readily observed if sources of input and output voltages and appropriate meters are included for proper appraisal of tube action.

It is seen that for all negative grid voltages, the input current is negligible. That is, the input impedance of the tube is high. Further, since current flows in the output circuit only when the anode is positive, current flow through the tube must be unidirectional in nature.

For a given plate load resistor the plate current is a function of both the plate and grid voltages. That these relationships are in general not linear, is shown by reference to the characteristic curves of Fig. 6. The tube voltage drop is the difference between the power supply voltage and the drop through the plate load resistor, that is, E_b—I_b R_l. For given values of plate and grid voltage the plate current depends upon the plate load resistor.

When the grid bias of a triode is made more negative the plate current decreases. Hence the voltage drop across the plate load resistor also decreases. Consequently the tube voltage drop, i.e. the power supply voltage less the drop through the plate load resistor, is actually increased. A triode therefore serves as a 180° phase shifting network for a resistive load, that is, the grid and plate voltages are 180° out of phase. The grid voltage and plate current, however, are in phase.

It is readily observed that the output currents and voltages are larger than the input currents and voltages. Hence the tube acts as a current, voltage, and power amplifier.

Triode Applications

The high vacuum triode can be employed in a multiplicity of uses.

In the field of communications the following applications are at once evident. UNITED specially processed tubes are used in:

1. Broadcasting (AM and FM)
2. Television (including radio relay systems)
3. Point to point commercial communication
4. Liaison communications (aircraft to aircraft, aircraft to ground, police radio, etc.)
5. Airway-course and range-finding and landing aids
6. Facsimile
7. Supersonics.

In the field of physio-therapy, specially designed UNITED tubes have earned an enviable reputation. These tubes find application in:

1. Professional medical diathermy
2. Home treatment diathermy
3. Surgical cutting, cautery, and dessication

In the field of high frequency heating, more and more equipment manufacturers and end users are specifying UNITED tubes. Exceptionally rugged construction and design fit these triodes for:

1. Induction heating — high speed brazing, hardening, and annealing of conductive materials,
2. Dielectric heating — high speed heat treatment for non-conductive and insulating materials, e.g., foods, plastics, laminated plywoods, etc.

Other uses of the high-vacuum triode in industrial applications are in the field of electronic regulation. Some of the advantages of electronic regulation over other control devices are:

1. smooth, continuous, and complete control of power output,
2. a very large output (up to several hundred kilowatts) may be controlled by a small amount of power in the grid or input circuit,
3. the energy passing through the electronic tube may be transformed into almost any voltages and currents that may be desired,
4. ruggedness, stability and long life are easily attained with proper design, installation and maintenance,
5. a wide variety of functions can be performed, for example, amplification, oscillation, modulation, demodulation, rectification, inversion, frequency conversion, and use in trigger, relay, and switching circuits.

Tetrodes

The addition of a second grid between the control grid and anode of a high-vacuum triode results in a four element tube, the tetrode. The screen grid is usually placed in the "shadow" of the control grid in order to minimize the effect of electrons impingeing on the grid.

The purpose of the screen grid is two-fold.

Firstly, it serves to reduce the interelectrode capacitance between control grid and plate. The reduction of grid-plate capacitance cuts down reactions between grid and plate and permits very large values of amplification to be obtained. The "heterodyning" or squeal which may exist in a triode because of the large grid to plate capacitance is eliminated in the tetrode without the use of neutralizing circuits.

Secondly, the screen grid shields the plate from the cathode, thus making the plate voltage much less effective in attracting electrons from the cathode. The influence of the control grid on the electron stream, however, is not impaired. Hence the grid is much more effective in changing the plate current than is the plate and as a result the tetrode exhibits a high amplification factor.

The screen grid is operated at a positive potential, hence the resultant screen grid current must be considered in the design and analysis of circuits employing tetrodes. The relatively high screen grid voltage enhances secondary emission effects from the plate. If the screen grid is more positive than the anode, electrons bombarding the plate will cause screen grid current to rise and plate current to fall; hence the plate characteristics become distorted. In general, operating voltages must be such that the tube does not operate in the distorted or "critical" portion of the tube characteristic.

In the critical region an increase in plate voltage is accomplished by a decrease in plate current and the term "negative resistance" is sometimes used to describe this phenomenon. The negative resistance principle finds application in dynatron oscillatory circuits. The total space current in a tetrode is a function, primarily, of the control and screen grid potentials and is consequently independent of the anode voltage.

The grid to plate interelectrode capacitance in a tetrode is generally small enough to make neutralization unnecessary.

Pentodes

The pentode or five-element tube has three grids, namely, the control, screen, and suppressor grids. The suppressor grid is located between screen grid and anode. It is connected either internally or externally to the cathode and therefore is at a negative potential with respect to the anode. Because of this negative potential secondary emitted electrons from the anode will be repelled back into the anode and not permitted to reach the positive screen grid.

The suppressor grid eliminates the critical portion of the tetrode characteristic thus retaining the advantages but not the disadvantages of that tube. The electrostatic field in a pentode depends primarily upon control and screen grid potentials and tube geometry. It is relatively unaffected by anode voltages because the cathode is effectively shielded from the anode by the screen and suppressor grids. The grid to plate interelectrode capacitance in a pentode is small enough to make neutralization unnecessary.

The pentode tube, in general, exhibits higher values of plate resistance and amplification factor than either a triode or a tetrode. The distortion, however, is usually greater in a pentode than in a triode or tetrode.

Remote Cutoff Tubes

The point in the plate characteristic curve where the plate current becomes zero is identified as the cutoff point and the grid voltage (for a specified plate voltage) at which cutoff occurs is known as cutoff grid voltage. In a tube designed for a sharp cutoff the plate current reduces abruptly to zero as the grid voltage is made sufficiently negative.

In contrast to sharp cutoff construction it is possible to design a tube so that the current does not reach zero until extremely large grid voltages are applied. Remote-cutoff tubes employ supercontrol or variable-μ grids. The control grid is purposely made non-uniform with a wider spacing of the grid wires at the center than at the ends of the grid structure. The effectiveness of these grids in controlling the current varies with the d-c values of grid voltage. Hence the amplification factor of such a tube is dependent upon the grid or bias circuit.

Beam Power Tubes

The beam power tube is generally a tetrode, which operates like a pentode, and has advantages over the pentode type. The cathode, control grid, and screen grid structures are designed to produce electron beams which impinge upon the anode. This focusing action is aided by beam-forming plates which concentrate the electrons into beams. The latter act as a virtual suppressor grid and force the secondary emitted electrons back to the anode. Because of the absence of the suppressor grid, proper, the effective anode area which can be utilized for collecting electrons is greater than in a conventional pentode. Furthermore, suppressor action is more complete because the suppressing field is continuous rather than distributed by wires as in the conventional grid structure.

The screen grid in a beam power tube is spiral-wound like the control grid and is shaded from the cathode by the turns of a control grid. Hence very few electrons hit the screen grid and screen grid current is very low. The low loss in the screen grid circuit of a beam power tube leads to very high efficiency and power sensitivity. The power handling capacity of a beam power tube is very large in relation to its size.

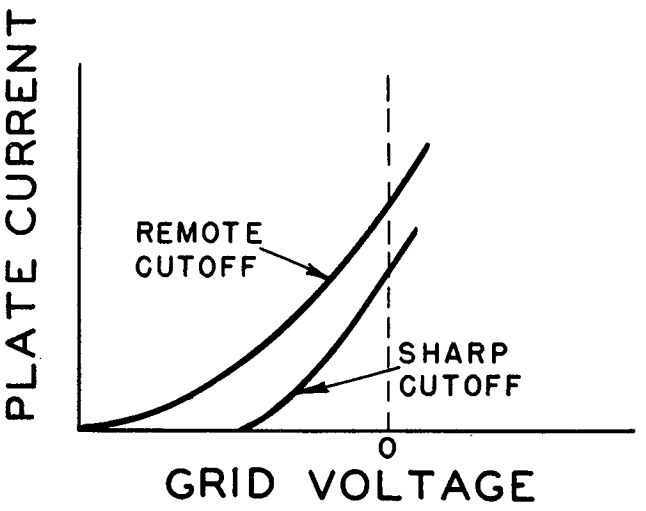


Fig. 8 Sharp vs. Remote Cutoff

MERCURY VAPOR ELECTRONIC TUBES

Ionization

The operation of mercury vapor diodes and triodes depends on the phenomenon of ionization. Electrons from a hot cathode move to the anode with great velocity. In the space between cathode and anode the electrons collide with mercury-vapor molecules which are present. If these electrons attain a velocity sufficient to break through a potential difference of 10.4 volts (for mercury vapor) they knock electrons out of the atoms with which they collide. Because of these collisions the mercury vapor breaks up into positive and negative particles. This process is called ionization.

Mercury is introduced into an evacuated rectifier tube to neutralize the negative space charge. The mercury vaporizes because of the low pressure in the tube and when plate voltage is applied the mercury becomes ionized. The negative ions or electrons are readily attracted to the plate. The massive positive ions however are pulled to the cathode where neutralization of the space charge is effected. Since the space charge is the factor limiting current flow and causing a voltage drop within a high-vacuum tube, reduction of space charge will give high current flow with a low voltage drop, in other words, efficient rectification.

Elimination of the negative space charge lessens opposition to electron flow and reduces the voltage drop across the tube to a low and constant value. A considerable reduction in anode heating as well as an improvement in voltage regulation of the load current is thus achieved.

The voltage drop across a gas diode must be high enough to give the ions sufficient velocities to cause ionization by collision with electrons. For a mercury vapor tube the theoretical ionizing potential is about 10.4 volts. This voltage drop is independent of current flow.

Mercury vapor rectifiers are characterized by an internal voltage drop of 10-15 volts. This drop, while practically independent of d-c load current, does depend somewhat upon the condensed mercury vapor temperatures. The constant tube drop in mercury-vapor rectifiers allow their use where excellent voltage regulation of the power supply is desired.

Since the power loss in a tube at any instant is the product of the anode voltage and current, it follows that for a given structure there will be less wasted power in a mercury vapor than in a high-vacuum tube. Power transfer through a mercury vapor tube is very efficient. Also, a mercury-vapor filled tube can operate with much higher currents than a vacuum tube of the same size. For reasons of economy, therefore, mercury-vapor tubes are used in heavy current applications.

Study of the output voltages and currents of a mercury-vapor diode yields interesting results. At very low plate voltages, current flow through the tube is negligible; however, as the plate voltage is increased a certain critical value (between 10-25 volts) is reached where the plate current rises to a high and constant value. This current is limited only by the plate load resistance and the plate voltage in accordance with Ohm's law.

If the plate voltage is reduced again, the plate current will decrease to a negligible value.

The operation of a mercury-vapor diode thus indicates that it can be used as a voltage-controlled switch to turn plate current on and off. For most practical purposes the tube is used to conduct on an all-or-nothing basis.

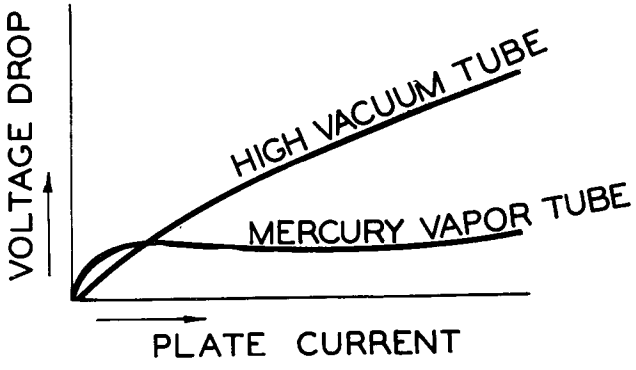


Fig. 9 Tube Voltage Drop vs. Plate Current

Grid-Controlled Rectifiers

The addition of a grid to a gas-filled or mercury-vapor diode creates a gas triode or grid-controlled rectifier tube.

The grid in this tube prevents current flow until the anode is sufficiently positive to draw electron current from the negative space charge region surrounding the cathode. When current flow is initiated, however, the gas or mercury vapor ionizes and a sheath of positive ions surrounds the grid. The positive ion sheath neutralizes the negative potential on the grid causing the latter to lose control. The positive ions also largely neutralize the space charge so that a low voltage is sufficient to send a large current through the tube.

The tube conduction can be stopped by reducing the anode voltage to zero. Deionization results with positive and negative ions recombining to leave the mercury vapor in a neutral condition.

The anode voltage required to initiate conduction is a function of the grid voltage. The control characteristic for any particular tube is given in the technical data. Tubes may be designed for either positive or negative grid control.

The vapor pressure of mercury depends upon temperature; hence mercury vapor grid-controlled rectifiers should be operated within the given condensed mercury temperatures. The latter is the temperature of the coolest part of the bulb. It is this relatively cool region which controls the mercury vapor pressure and indirectly sets up the control characteristic of the tube.

The internal voltage drop in high-vacuum rectifiers is proportional to the d-c load current. In general varying d-c load currents in these tubes lead to poorer voltage regulation than can be obtained from mercury vapor rectifiers. The filaments of gas filled tubes should always be at correct operating temperature before application of plate voltage. This will ensure a sheath of negative electrons around the filament to protect it from positive ion bombardment which can ruin an oxide-coated filament.

Operation

Regarding the operation of a grid-controlled gaseous tube, interesting observations are obtained by the measurement of input and output currents when the input and output voltages are varied. The following is readily observed:

1. Tube conduction is a function of the grid and plate voltages.
   (a) For a given grid voltage the tube conducts current suddenly at some positive plate voltage.
   (b) For a given positive plate voltage the tube conducts current suddenly at some critical grid voltage.
2. The critical grid voltage needed to initiate conduction is a fairly definite fraction of the applied plate voltage over a considerable range. This critical grid voltage may be either positive or negative depending upon the tube design.
   (a) A relatively large grid current, even with a negative grid is observed when the tube is conducting plate current.
   (b) Before the critical voltage is reached the tube input resistance is fairly high; beyond the critical grid voltage however, the tube input resistance is low. Thus the "switch" action in the plate circuit, i.e. sudden changes from high to low plate current, and vice versa, is also observed in the input grid circuit. It will be observed that both input and output currents increase simultaneously.
3. The critical grid and plate voltages in a mercury-vapor filled tube depend somewhat upon the temperature at which the tube is operated.

A diagram may be set up to indicate conditions under which a tube will conduct current. This diagram is obtained by plotting the grid and plate voltages for the condition at which tube suddenly becomes conducting. Such a curve divides the tube characteristics into conducting and non-conducting regions. The current through a mercury vapor tube is limited only by the external load and the ability of the cathode to supply electrons.

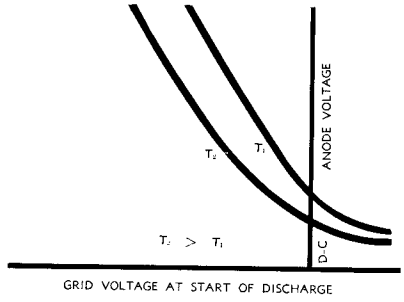


Fig 10 Tube Conduction Curves

Once conduction starts in a tube, the grid loses control and the tube, in general can be made nonconducting only by removal of plate voltage. The region between the curves of Fig. 10 depends upon the tube ambient temperature.

A linear relation exists between the grid and plate voltages needed to produce breakdown or conduction over an appreciable portion of the curve. For a given temperature, the ratio of the plate voltage to the grid voltage required to initiate ionization is called the control factor. The latter is analogous to the amplification factor in vacuum tubes. For gas-filled tubes there are no significant coefficients similar to the plate resistance and mutual conductance of vacuum tubes.

Once the gas within the tube becomes ionized, gaseous tubes have much lower internal resistance than vacuum tubes. Consequently greater currents may be passed by these tubes than by vacuum tubes of equivalent structure. For gas and vapor tubes having pressures of a fraction of a millimeter the maximum obtainable current is equal to the current which the cathode can supply.

Mercury-vapor filled tubes are incapable of giving instantaneous control of current, but are capable of controlling the desired average current. Consequently, they are given average current ratings.

UNITED ELECTRONICS

TUBE MANUFACTURE

Manufacturing Considerations

Long and dependable tube life is based upon both mechanical and electrical design. The care and precision entering into the design of UNITED transmitting and rectifier tubes is reflected in the ever increasing demand for them by equipment manufacturers, engineers, and Government services.

The quality of an electronic tube is a function of proper choice of electrode materials and of the processing and production techniques employed in manufacture. The materials used should have good mechanical strength and ductility, high resistance to heating effects, low vapor pressure, and easy degasifying properties.

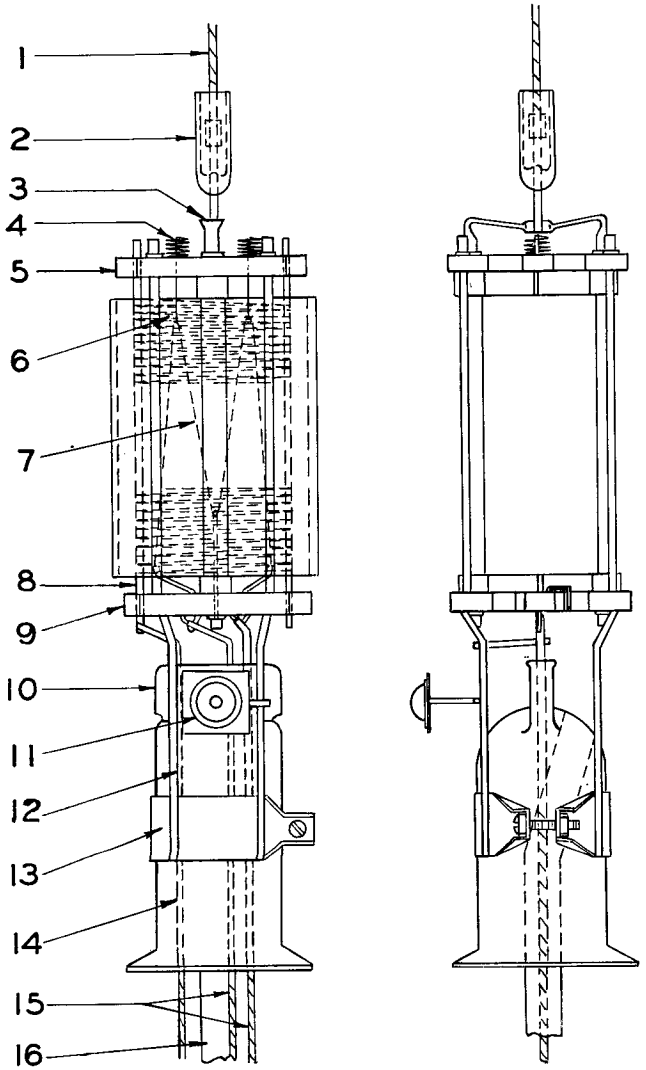


Fig. 11 Vacuum Tube Mounts

1. plate lead
2. bead
3. yoke
4. filament spring hook
5. lava spacer (upper)
6. grid wires
7. thoriated tungsten filament
8. grid support rods
9. lava spacer (lower)
10. glass stem press
11. getter assembly
12. collar support rods
13. collar assembly
14. grid lead
15. filament leads
16. exhaust tubing

Tube Parts

From all parts of the world come materials to be used in electronic tubes. Infinite care is exercised in the procurement of highest quality components for UNITED transmitting and rectifier tubes. Carefully selected sources of supply, extremely rigid inspection and test techniques, and scrupulous cleanliness and control during manufacture insure that each tube is a quality product.

After raw materials have been inspected and found acceptable for use in tube manufacture they must be formed into the required shapes and subassemblies. Specially designed machinery is used in the UNITED factories to process and manufacture required tube parts.

The fabrication of all parts is guided by rigid construction and process specifications. Construction specifications give detailed information about manufacture and assembly of component parts while process specifications are used to designate the treatment of these parts.

Cathodes are discussed under tube fundamentals. The use of bulb, anode, and grid materials will be discussed in some detail in the following paragraphs.

Bulbs

Bulbs used in UNITED transmitting and rectifier tubes are primarily of hard (borosilicate) glass which can stand much rougher usage than soft glass. Although requiring higher working temperatures than soft glass, the hard glass bulbs are eminently better suited for transmitting tube applications. The use of hard glass instead of soft glass allows a reduction in bulb size.

Glass bulbs must meet the following requirements:

1. mechanical strength to withstand air pressure, high temperatures, and thermal shock as well as to provide support for internal parts.
2. ability to form air-tight metal-to-glass seals sufficiently strong to endure internal strains resulting from thermal changes.
3. ability to resist the corrosive effects of atmospheric gases.
4. electrically the bulb must be a non-conductor at operating temperatures, so that leakage through the envelope and glass seals is minimized.

A considerable portion of the heat radiated from the plate is absorbed by the glass bulb. If convection alone is insufficient to cool the bulb to a proper value, forced-air or water-cooling should be used.

Anode Materials

The anode in an electronic tube is continually bombarded by electrons and becomes very hot. Anode design therefore must provide for dissipation of heat sufficient to prevent dangerous temperature rises. The anodes of medium-power transmitting tubes are cooled principally by radiation. Various expedients are used to increase the radiation of heat from the anode; for example, anode fins may be added to increase the thermal emissivity. In the design of the anode, the permissible heat dissipation of the anode material may not be exceeded.

All anode materials contain imbedded gases which must be removed. Expulsion of these gases is accomplished by a preliminary processing of the anode material and by a three-fold process during the exhaust procedure.

The latter process includes:

(a) baking of the bulb with resultant heat radiation to the anode,

(b) application of a high positive voltage to accelerate electron bombardment of the anode, and

(c) radio-frequency heating of the anode by means of a "bombarder" or induction-heater.

In addition to foreign gases imbedded in anode materials, another source of trouble is the evaporation or sputtering of the anode material itself. Anode deposits upon the electrodes and the bulb may result in radio-frequency power losses, localized heating effects, and interelectrode leakage.

Mechanically, an anode material must be sufficiently ductile to be readily worked and yet maintain its shape at high temperatures without warping.

The amount of power a tube will handle depends in large degree on the ability of the anode to dissipate the heat engendered by operation. The ability of an anode material to dissipate heat depends upon its radiating emissivity and its thermal conductivity.

Graphite, molybdenum, nickel, and tantalum are the most common anode materials. Choice of a specific material is determined by operational requirements, end use, and tube design.

Graphite

The graphite anodes used in UNITED tubes are specially processed and treated to give long and gas-free life. These anodes provide a gettering action which allows a very good vacuum to be attained and kept throughout the life of the tube. Since graphite is practically a black body, heat radiation from it is exceptionally high. At 1000° C. the radiating emissivity of graphite is 94 per cent of black body radiation. This compares with a value of 10.5 per cent for tungsten and molybdenum.

At 510° C. a tube which would dissipate 70 watts with a specially processed graphite anode, would dissipate only 16 watts with a molybdenum anode, 20 watts with a tungsten anode, and 14 watts with a tantalum anode.

The thermal conductivity of these processed graphite anodes compares very favorably with other anode materials. Comparative values of thermal conductivity for some anode materials are: graphite—1.92, molybdenum—1.46, nickel—0.586, tantalum—0.544. A high value of thermal conductivity results in a rapid and uniform distribution of heat throughout the anode and prevents hot spots which may result in warping and fusing of anode material.

The low operating temperature of a graphite anode, 500°-600° C., results in a reduction of primary and secondary grid emission effects and permits an increase in the allowable power dissipation.

The one piece construction of graphite anodes eliminates contact resistances which may exist when two or three metal plates are joined together. Graphite can be readily machined into desired shapes of precise dimensions.

The vapor pressure of graphite is sufficiently low to prevent evaporation and bulb blackening during exhaust.

Molybdenum

Molybdenum (melting point—2620° C.) is used commonly as an anode material. Although its properties greatly resemble that of tungsten it is fairly ductile and more easily worked than tungsten. When properly pre-treated and cleaned of surface contaminations molybdenum may be readily degassed. Molybdenum has excellent thermal and electrical properties as well as low vapor pressure. The dissipation of heat from molybdenum anodes is improved by sand or carborundum blasting which roughens the surface and makes it a better radiator. Radiating fins are often added to increase the anode radiating area and aid in anode cooling.

Molybdenum, because of its linear thermal expansion, is used a great deal for making seals with hard glass.

At normal operating temperatures molybdenum anodes may evince an orange-red color which is a rough indication of the operating efficiency or plate dissipation of the tube. The normal operating temperature of a molybdenum anode is approximately 700° to 850° C.

Tantalum

The properties of tantalum are quite similar to those of molybdenum. Its melting point is higher (2850° C.) and vapor pressure lower than that of molybdenum. Tantalum is more ductile than molybdenum and is more readily formed or worked into required shapes. The thermal conductivity of tantalum is relatively low compared to that of graphite and molybdenum.

Tantalum has a gettering action that aids in the clean-up of gases. Fins and surface roughening are a usual resort in increasing its emissive power. The orange-red color of tantalum plates is an indication of the operating efficiency or plate dissipation of the tube. The normal operating temperature of a tantalum anode is approximately 900° to 1000° C.

Nickel

Nickel because of its high ductility is very easily worked into required shapes. Nickel oxide does not form readily and when formed can be easily removed in a hydrogen furnace. Nickel anodes are usually carbonized. This process deposits a layer of amorphous carbon on the nickel anode greatly improving its emissive qualities.

The chief disadvantage of nickel lies in its low melting point (1452° C.) which limits its use to low powered tubes. The exhaust schedule for tubes containing nickel must be watched carefully to prevent warping and sagging of the nickel elements. Nickel is easily welded and because of its light weight needs very little support from other structures.

Grid Materials

Metals which are used for grids include molybdenum, molybdenum-tungsten alloys, nickel alloys, tantalum and tungsten. These materials may be carbonized to reduce secondary emission effects and to increase heat dissipating qualities.

Grid material requirements are, in general, the same as for anode materials. Easy degasification, *mechanical strength* at high temperatures, and low gas content are the features most desired. If the tube characteristics are to stay uniform, no deformation or warping of the grid materials is permissible, and the grid must be rigidly supported.

The grid may be a mesh of woven wire or the wire may be wound on support rods to which the turns are welded. In gas or vapor-filled tubes perforated sheets of nichrome or other alloys may be used to form the grid structure.

Grid structures may be processed to minimize primary and secondary emission effects. Primary emission from untreated grids may result when they have been driven positive during operation and are bombarded by electrons from the filament. The temperature of these grids may rise sufficiently for thermionic emission to take place. The loss of electrons from the grid because of primary emission limits electron flow through the grid leak resistor and therefore reduces grid bias.

The electrons bombarding the grid may cause many other electrons to be ejected from the grid wires thus producing secondary emission. Secondary emission also causes a reduction in grid bias with resulting circuit unbalance.

"RUGGEDIZED" CONSTRUCTION

At the instance of the armed services, United Electronics Company developed a new tube construction to cope with the severe impact and vibration conditions to which tubes are subjected during actual combat usage. This new design embraces improved element anchorages and special processing of components to dampen unfavorable harmonic vibrations, and to preclude filament breakage and inter-element shorts. These "ruggedized" tubes at present include most of the single-ended "50 Watter" group. They are distinguished by a suffix letter "W" assigned by the government to denote that they measure to "Warized" specifications, more exacting than those prescribed for conventional joint Army-Navy approved types. For example, the UNITED approved ruggedized version of tube type 838 is branded 838W under JAN-1A specifications.

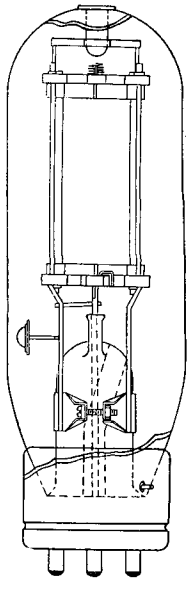


Fig. 12 "Ruggedized" Construction

Mounting and Sealing

During the assembly (mounting) of a tube cleanliness is absolutely essential. Greasy fingers and careless handling will cause a tube to become gassy during operation. Tube parts must be handled with frequently changed clean white gloves or pincers.

Before a tube can be successfully evacuated the tube components must be cleaned and degasified. This is necessary because of absorbed gases and oxides, which are present in most metals. Preliminary degasification of most metals is generally accomplished by heating in specially designed hydrogen furnaces.* The hydrogen prevents oxidation of the metals and reduces already formed oxides to give a clean metallic surface.

After the parts have been allowed to cool in a hydrogen atmosphere they are ready for mounting. The metal parts are assembled on metal supports to which they are attached, in general, by spot welding techniques. The entire assembly is then mounted on a glass flare. The lead-in wires, which are to go to the base pin terminals, are rigidly clamped in a glass pinch at one end of the flare. The leads are first encased in "beads" of a special sealing glass. The end of the flare is then heated until it fuses around the beaded leads and forms a unit mass of glass which pinches the lead-in wires very firmly.

At the same time, a long piece of exhaust tubing is sealed through the pinch or press to permit the evacuation of the tube in a subsequent operation. After the flare has been processed as indicated it is usually referred to as a stem. The other end of the stem is then sealed to the base end of the glass bulb and the tube is ready to be evacuated.

Exhausting and Basing

The long piece of glass tubing which projects from the stem is then connected to the pumping system. The latter consists of a series arrangement of mechanical roughing (reciprocating or rotary) and oil diffusion pumps. The specially designed roughing or fore pump reduces the gas pressure in the tube to a low enough value so that the diffusion pumps can operate efficiently.

As the diffusion pumps are working an oven is lowered over the bulb "baking" it while the metal parts are heated to a bright color by r-f induction heaters, or bombarders.

The baking process is essentially for the removal of adsorbed moisture from the glass. The water vapor is removed because, during tube operation, it will attack the filament coating, causing low emission and tube deterioration.

The tube is "aged" in order to stabilize its characteristics. The filament voltage is increased approximately 25 per cent above normal and a positive potential is applied to the plate, or to the grid, or to the plate and grid leads which may be tied together. The effects of ageing are to clean the grid of dirt and adsorbed gas, fully activate the filament and increases the emission qualities of the tube. The effect of the r-f bombardment is to open the pores and interstices of the anode structure and increase its adsorbing qualities. Ageing is due largely to gas adsorption by the anode; the latter because of its relatively large area can safely adsorb non-oxidizing gases.

In many tubes further exhaust is effected by introducing a getter pellet into the tube. The getter when partially flashed forms a coating which condenses on the tube walls. This coating occludes a large amount of gases during condensation and tends to keep the tube free of gas during operation. The getter must be properly placed inside the tube in order to prevent excess metal from condensing on the stem where it may cause leakage. Some of the usual gettering materials are barium, magnesium, calcium, and combinations thereof.

Most tube types after evacuation, are cemented to low loss phenolic, ceramic, or other bases. The lead-in wires are soldered to the tube prongs. The prongs are usually made of hollow brass tubing plated to prevent corrosion. Tube caps are handled similarly—the cap is cemented to the tube and the lead-in wire is soldered to the cap.

Test

After an electronic tube has been exhausted, based, and capped it goes to the test department. The proper and careful testing of electronic tubes is essential if high quality is desired. Ruggedness, long life, and satisfactory operation are safeguarded by proper test techniques. The purpose of the testing procedure is to discover any mechanical or electrical weaknesses which would limit adversely the operation of the tube. Tube testing, during the manufacturing process, may be broadly classified into production, design, and life tests.

Production tests are performed upon all tubes which are manufactured. Tubes which fail in any of these tests are rejected.

Design tests are performed upon a certain percentage of tubes of a given type which are selected at random. Failure of a specified number of these tubes may be cause for rejection of the entire tube

*Carbonized plates and certain metals are degasified in air furnaces instead of hydrogen furnaces.

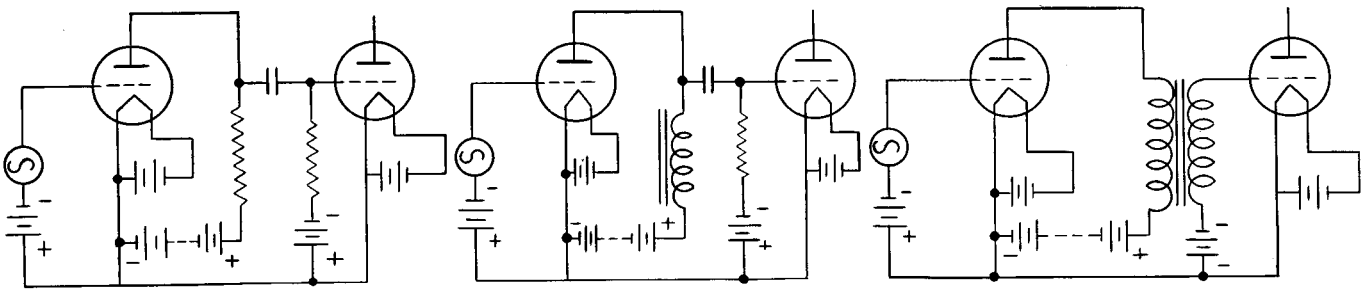
Classification of Amplifiers

Various classifications have been adopted for vacuum tube amplifiers. Two broad classifications are based on the frequency of the energy being amplified, namely, audio-frequency amplification and radio-frequency amplification. These classifications are further subdivided into voltage, power, and current amplifiers. The method of coupling employed in the amplifier as well as the different modes of operation also serve to classify amplifiers. Thus we have resistance-coupled, impedance-coupled, and transformer-coupled amplifiers as well as class A, class AB, class B, and class C amplifiers.

Voltage and Current Amplification

It is the purpose of a voltage amplifier to increase the voltage to the maximum value consistent with allowable distortion. A voltage amplifier tube is not required to furnish power to the succeeding tube because the latter is biased sufficiently negative to prevent grid current flow. Without grid current no power can be consumed by the input circuit.

A voltage amplifier tube is generally small in size; the varying signal current through the tube is used to produce high voltages and low currents. In general, voltage amplifier tubes are used for all but the last, or "power" stages of multi-stage amplifiers. Selection of a voltage amplifier tube depends upon the voltage amplification required, the amplification factor of the tube, the load impedance offered by the circuit, and the plate voltage supply.



(a) resistance (b) impedance (c) transformer

Fig. 14 Types of Coupling

A-F and R-F Amplification

The fundamental operation of audio and radio frequency amplifiers is the same and is not effected by the frequency to be amplified.

The characteristics of these amplifiers are:

1. a small signal voltage will control a relatively large plate output.
2. the grids of the tubes must be properly biased.
3. the amplifier tubes must work into proper load impedances.

The basic difference between audio and radio frequency amplifiers is that the former use a plate load resistor or audio transformer while the latter employ a parallel resonant circuit as a plate load impedance.

The audio frequency amplifier uses a plate resistor or audio transformer to obtain high fidelity and negligible distortion.

The r-f amplifier uses a tuned circuit to reduce plate power losses in the load impedance and to improve selectivity and sensitivity. A radio frequency choke is commonly employed in the grid circuit to prevent shorting of the r-f signal to ground.

Current amplifiers find chief application in research equipment and for the amplification of small currents. Current amplifiers generally include several stages of voltage amplification. These tubes have amplification factors approaching unity and hence do not give any voltage amplification. Current amplifiers are generally designed to operate without grid current flow.

Power Amplification

Power amplifiers work into power-consuming loads and therefore must be capable of supplying heavy currents to the existing load impedances. Power amplifiers are used to provide excitation or drive for modulated class C amplifiers, and larger amplifier stages. Most power amplifiers are preceded by a number of stages of voltage amplification.

Power tubes have larger permissible plate dissipation values than voltage amplifiers; this arises from the heavier plate, grid, and filament structures used. The amplification factors of "power" tubes are usually smaller than those of voltage amplifiers.

MODES OF OPERATION

Class A Operation

By definition, "a class A amplifier is an amplifier in which the grid bias and alternating grid voltages are such that plate current in a specific tube flows at all times."

In a class A amplifier the output wave shape faithfully reproduces the input wave shape; i.e., the excitation a-c grid voltage. For maximum output with minimum distortion it is important that the grid bias value be carefully chosen.

The grid excitation voltage and the operating point of a class A amplifier must be so chosen that the grid is neither driven positive nor to plate current cut-off. The plate current as read by a d-c meter is constant and is unaffected by the input excitation voltage. The operating characteristic of a class A amplifier indicates that a considerable portion of the linear characteristic falls in the positive grid region. Therefore only a limited portion of the linear characteristic can be used if grid current is to be prevented. This fact leads to a low value of plate circuit efficiency for a class A amplifier, namely 20 to 40 per cent at full output depending upon tube design and operating conditions. The theoretical plate circuit efficiency of a class A amplifier is 50 per cent.

Class A amplifiers are used as power amplifiers in audio systems. Class A voltage amplifiers are used in stages preceding the power output in audio systems and as r-f amplifiers in receiving systems. Correct biasing conditions for tube operation are given in the Engineering Information sheets.

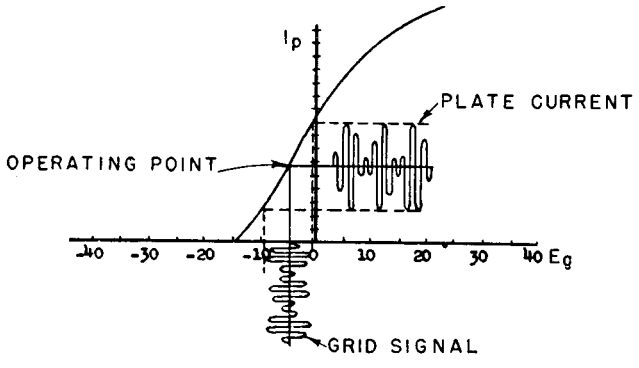


Fig. 15 Class "A" Amplifier

Class AB Operation

By definition, "a class AB amplifier is an amplifier in which the grid bias and alternating grid voltages are such that plate current in a specific tube flows for appreciably more than half but less than the entire cycle."

Because the fixed grid bias in such an amplifier is higher than for a class A amplifier, the resting (no excitation) plate current is reduced. Hence, higher plate voltages may be used without exceeding the maximum permissible plate dissipation of the tube. In other words class AB operation will *permit* a higher power output than is obtainable from class A operation.

Classes AB_1 and AB_2 are used to denote, respectively, that grid current does not, or does flow. In a class AB_1 amplifier the peak signal voltage does not exceed the negative grid bias voltage. In a class AB_2 amplifier, the grid signal voltage exceeds bias voltage on the peaks and causes grid current to flow.

For minimum distortion class AB amplifiers should be operated push-pull. Class AB_2 operation will give more power output than class AB_1 because positive grid voltage values allow a greater portion of the linear characteristic to be utilized. The grids of class B amplifiers draw current and therefore power driver stages are required.

Class B Operation

By definition "a class B amplifier is an amplifier in which the grid bias is approximately equal to the cut-off value so that the plate current is approximately zero when no exciting grid voltage is applied, and so that plate current in a specific tube flows for approximately one-half of each cycle when an alternating grid voltage is applied."

The plate current in a class B amplifier flows for only a half cycle. Hence for audio amplification purposes, two tubes in push-pull must be used.

The grid bias voltage for class B amplification is usually adjusted to slightly above cut-off so that the plate current is at a low value without grid excitation voltage. The signal voltage in a class B amplifier is such that the entire linear portion of the tube characteristic is utilized.

The class B amplifier delivers much more power for a given tube size than a class A amplifier.

Since the grid of a class B amplifier consumes power during the positive portion of the grid cycle, the preceding driver stage must be more powerful than for class A operation.

Class B r-f amplifiers operate into a tuned circuit and cover a small range of frequencies whereas class B a-f amplifiers work, generally, into a resistive or untuned load and may cover a very large range of frequencies.

Class B r-f amplifiers are used as "linear" amplifiers to raise the output power level of modulated class C stages. The term "linear" is used because the output voltage is essentially a linear function of the grid signal voltage. The a-c component of plate current in a class B amplifier depends on the excita-

tion voltage. Since power in the plate circuit is proportional to the square of the current, it follows that the power output of a class B amplifier is proportional to the square of the excitation voltage.

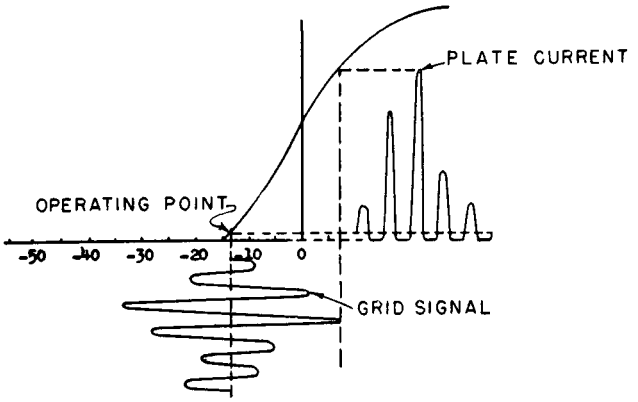


Fig. 16 Class "B" Amplifier

Class B amplifiers are characterized by a maximum theoretical plate efficiency of 78 per cent and practical efficiencies of 50 to 65 per cent at maximum signal for c.w. amplifiers and about 33 per cent efficiency for linear amplifiers.

The class B amplifier delivers more power for a given tube size than a class A amplifier. High power audio-frequency and linear radio-frequency amplifiers are generally operated class B.

Class C Operation

By definition, "a class C amplifier is an amplifier in which the grid bias is appreciably greater than the cut-off value so that the plate current in a tube is zero when no alternating grid voltage is applied, and so that plate current flows in a specific tube for appreciably less than one-half of each cycle when an alternating grid voltage is applied."

In class C operation the a-c component of plate current is directly proportional to the plate voltage; hence the output power is also proportional to the plate voltage.

Bias of two or more times cut-off is used in class C operation and the plate current flows for only approximately 120 degrees of the 360 degrees excitation cycle.

A class C amplifier gives high distortion and therefore is not used for audio work. Class C amplification is employed solely for radio frequencies and uses a tuned circuit impedance as a load.

Grid Bias for Amplifiers

Proper grid bias may be obtained from fixed, cathode, or grid-leak biasing arrangements.

Fixed bias is generally used in class B audio frequency amplifiers where the d-c plate current varies during operation. Use of a resistor to provide bias is impractical in this case because the bias value would vary during operation. The source used to supply fixed bias is generally either a d-c power supply or C-battery.

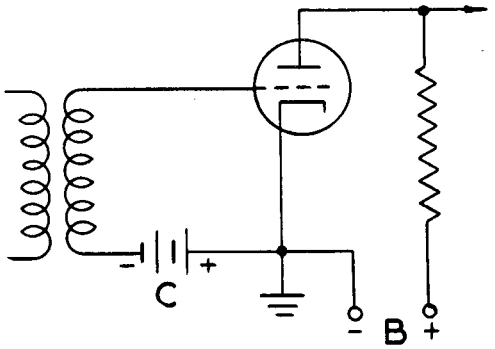


Fig. 17 Fixed Bias

Cathode bias is almost always used for class A audio-frequency amplifiers where the plate current is constant for both signal and no-signal voltages on the grid. The d-c plate current which flows through the cathode resistor causes a voltage drop which is used to bias the grid negatively with respect to the cathode. The value of the cathode resistor may be determined by Ohm's Law:

$$Rc = \frac{E}{Ic}$$

where Rc = cathode bias resistor in ohms
E = desired bias voltage
Ic = total d-c cathode current in amperes.

A by-pass condenser is always shunted across the cathode resistor to prevent the a-c component of the plate current from affecting the d-c bias value.

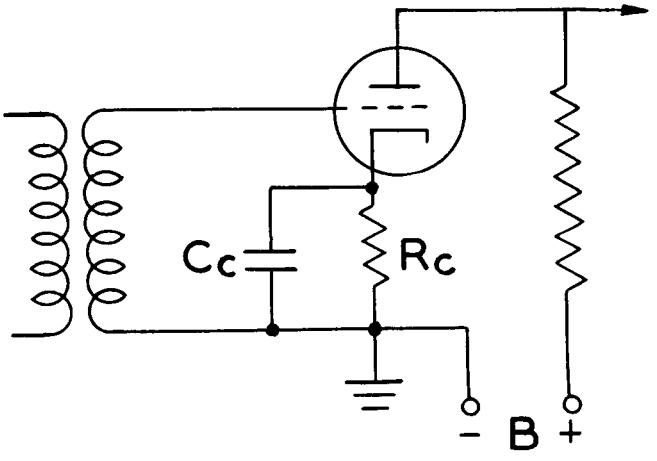


Fig. 18 Cathode Bias

It is usual to combine cathode with grid-leak biasing in order to provide tube protection against excessive currents in the event of failure of a driver stage.

Grid-leak bias is used chiefly for class C r-f power amplifiers. Grid-leak bias can be used only when grid current flows for a portion of the input cycle. The effect of grid current flowing through the grid-leak resistor is to cause a voltage drop that causes the grid to be negatively biased. The value of the grid-leak resistor may be determined by Ohm's Law:

$$Rg = \frac{E}{Ig}$$

where Rg = grid-leak resistance in ohms
E = desired bias voltage
Ig = d-c grid current in millamperes.

To keep the grid bias constant and unaffected by variations in a-c grid voltage a grid condenser of proper size must be used. The time constant of the resistor-condenser combination must be large as compared to one cycle of exciting grid voltage.

For power amplifier service, combinations of the above biasing arrangements are often used.

Rectification

A rectifier is a device which conducts current in one direction only, and is of extreme importance in a great many applications. Thus, radio, street railway motors, and electroplating are just a few of the applications requiring direct current. Since about 85 to 90 per cent of the electrical energy in this country is generated and transmitted as alternating current, the utility of rectifying devices is apparent.

The most suitable way of converting alternating to direct current is usually determined by the amount of d-c power required.

For units of small power capacity, copper oxide, selenium, electrolytic, cold cathode, and thermionic tube rectifiers are used.

For units of medium power capacity, mercury-arc rectifiers, high vacuum and mercury vapor tubes, and motor-generator sets are generally employed.

For units of large power capacity, mercury-arc rectifiers, motor-generator sets and synchronous converters are a usual resort.

In most electronic circuits, the sources of high direct voltage are generally electronic rectifier tubes of either the high vacuum or mercury vapor type. The advantages of electron tube rectifiers over rotating machines and generators are numerous. Considerations of expense, size, weight and operation favor tube rectifiers.

Rectifier Considerations

Electronic rectifier systems consist of transformer, electronic tube, and filter combinations. Such systems must meet certain specifications, which are based on output voltages and currents, allowable ripple voltage, per cent voltage regulation, and the rectifier impedance.

The output voltages and currents of a rectifier system or power supply depend upon the circuits selected and the rectifier tubes and their associated equipment. Information concerning output voltages and currents is given in the Rectifier Data table.

The output of a rectifier system contains an a-c component which is derived from the a-c source. This a-c component, called "ripple" must be of a value which will not interfere with the operation of the rectifier system in its intended use. Filters are used to reduce the ripple voltage to the desired value. The reduction of ripple and ripple voltage in the filter is a function of the filter components. Filters can be designed to reduce the ripple to any desired value. The allowable ripple in the output of a rectifier system is an important specification of the supply.

Internal resistance in a rectifier system tends to reduce the terminal voltage when increased current is drawn. The percentage change in voltage for a change in load is given by the formula,

$$\text{Percentage Voltage Regulation} = \frac{(\text{No load voltage} - \text{Full load voltage}) \times 100}{\text{Full load voltage}}$$

As the difference between full-load and no-load voltage is decreased, the percentage voltage regulation is reduced. A low value of voltage regulation in a rectifier system is desirable.

In certain instances, the output current of a rectifier system changes rapidly in response to changes in the load resistance. This occurs, for example, when the rectifier system is used for the plate supply of a class A amplifier. The plate current in the latter, varies at an audio rate and causes the output filter of the rectifier system to contain an a-c as well as a d-c component. Hence, the problem of keeping the output voltage constant as the current varies, arises. In practice, this is done by keeping the internal impedance of the rectifier system as measured from the output terminals, as low as possible for the frequencies at which the load current will vary. The output impedance is normally considered equal to the reactance of the filter output condenser.

Ripple, voltage regulation and output impedance are largely dependent upon the filter employed. Space does not permit discussion of filter design but the reader is referred to standard texts.

The rectifying action of an electronic tube results because current flows only when the anode potential is positive with respect to the cathode. Various circuits have been devised to utilize the unilateral conductivity of electronic tubes.

Half Wave Rectification

The half wave rectifier circuit is the simplest of these circuits. Tube conduction occurs only when the anode is positive, i.e., on alternate cycles. The current through the load is pulsating and contains both an a-c and a d-c component.

The single phase half wave rectifier is seldom used in practice. Although it is simple and inexpensive it has the disadvantages of excessive ripple, low voltage output, low transformer efficiency, and the need for a comparatively expensive filter. The ripple frequency of a half wave rectifier is the same as that of the a-c supply and because of its low value is difficult to smooth.

Since the flow of current through the transformer is unidirectional, the transformer core tends to become saturated and hence the transformer must be fairly large in size.

In a half wave rectifier using a purely resistive load the instantaneous current is proportional to the instantaneous voltage.

Half wave rectifiers are used mainly for electrochemical applications such as the charging of batteries and electroplating.

Current Wave Forms

The effect of adding inductance to the load of the rectifier is such as to oppose any changes in current values. Therefore, with large values of inductance, the load current assumes a practically constant value, and square topped current pulses result.

If a resistance load is shunted by a capacitance, current flow is restricted to those intervals in which the induced voltage exceeds the voltage across the capacitor. For large values of resistance and capacitance, current pulses of short duration will flow at induced voltage peaks.

A choke input to the filter is recommended whenever possible because it will decrease the ratio of peak current to load current in the rectifier tubes. Condenser input is not recommended as the peak current may become three or four times as high as the load current in certain rectifier applications.

Full Wave Rectification

For voltages and currents below 1000 volts and 1 ampere, respectively, the single phase full wave connection is generally employed. In such a circuit the lower as well as the upper half of the alternating input cycle is utilized. One tube passes current for one half-cycle and the other tube passes current for the next half-cycle.

The full wave circuit will give, for the same peak current values, a direct current twice as large and a power output four times as large as in a half wave circuit. Furthermore if power losses in individual tubes are considered, the loss in the full wave circuit is only one-quarter of the loss in the half wave circuit for the same direct output current and load.

Therefore the total loss in the two rectifier tubes of a full wave circuit is only one-half of that in the half wave rectifier tube. For equal outputs, the power ratings of rectifier tubes used in full wave circuits may be materially less than for a rectifier tube in a half wave circuit.

The ripple frequency in a full wave rectifier is twice that of the a-c supply and the ripple amplitude permits ready filtering. Because both half-cycles of supply voltage are utilized in a full wave rectifier, a greater efficiency of rectification is achieved than in a half wave rectifier.

Bridge Circuit

The bridge connection as commonly used is an arrangement of rectifier tubes permitting full wave rectification from a single phase source. This circuit utilizes four rectifier tubes; two of the tubes are in series on each side of a single phase transformer secondary. The peak inverse voltage to which each of these tubes is subjected is only half of that encountered in half or full wave circuits because of the voltage drop is distributed between two tubes.

The bridge circuit utilizes a smaller transformer than is needed for full wave rectification and only two windings (no center-tap) are employed.

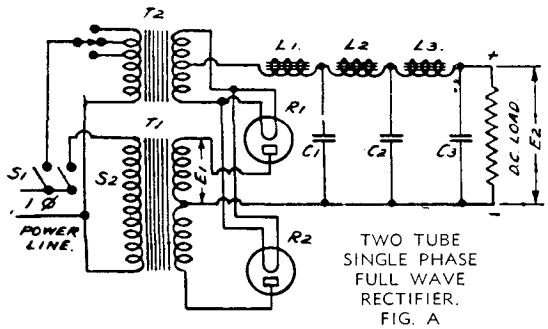
The bridge circuit requires the use of four filament transformers. Because the voltage drop across two tubes must be taken into account, the efficiency of rectification is somewhat lower than in the single phase full wave circuit.

The bridge circuit given two times the d-c output voltage that can be obtained from a full wave rectifier circuit for the same total transformer voltage and d-c output current. It is generally used for the rectification of high voltages.

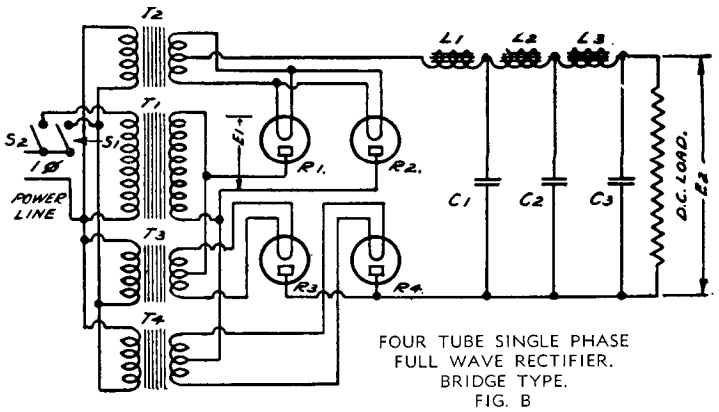
The preceding discussion of half wave and full wave rectification holds only generally, for gas-filled and mercury vapor tubes. Circuits employing the latter tubes operate somewhat differently than high-vacuum rectifier circuits. The reason for this behavior is that current in gas filled tubes does not begin to flow until the voltage drop across the tube reaches a certain constant value.

UNITED ELECTRONICS

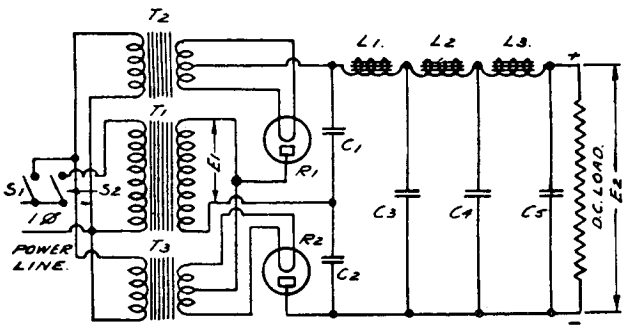
RECTIFIER CIRCUITS



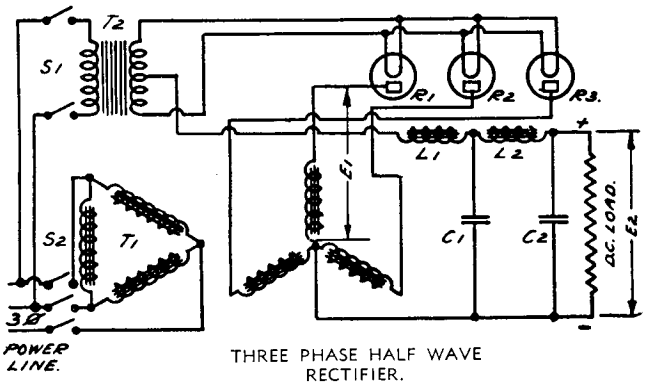
TWO TUBE SINGLE PHASE FULL WAVE RECTIFIER. FIG. A



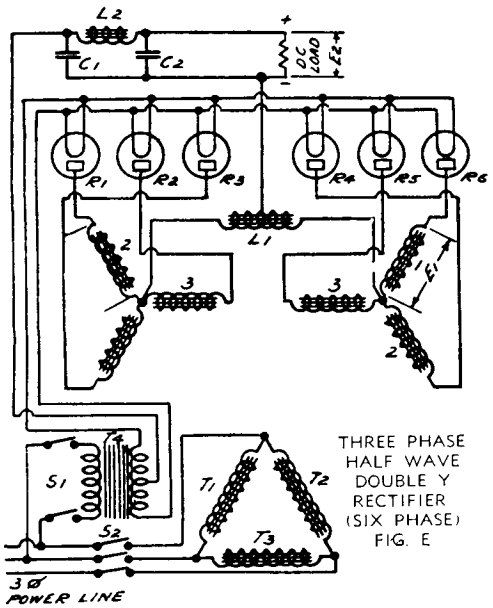
FOUR TUBE SINGLE PHASE FULL WAVE RECTIFIER. BRIDGE TYPE. FIG. B



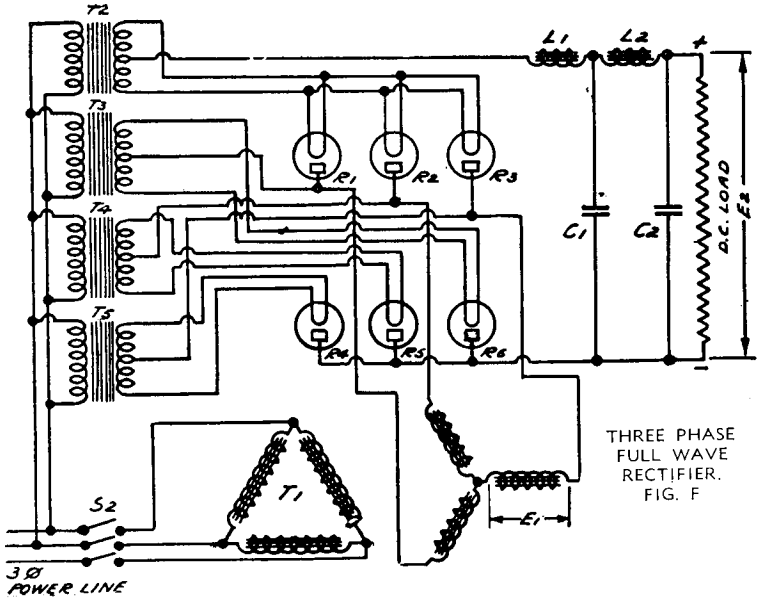
TWO TUBE HALF WAVE VOLTAGE DOUBLER RECTIFIER. FIG. C



THREE PHASE HALF WAVE RECTIFIER. FIG. D



THREE PHASE HALF WAVE DOUBLE Y RECTIFIER (SIX PHASE) FIG. E



THREE PHASE FULL WAVE RECTIFIER. FIG. F

UNITED ELECTRONICS

VOLTAGE AND CURRENT RELATIONS IN TYPICAL RECTIFIER CIRCUITS

FIGURE	RECTIFIER CIRCUIT	MAX. INPUT VOLTS R. M. S. E_1	D. C. OUTPUT VOLTS E_2 (Not Deducting Filter Drop)	MAX. D. C. OUTPUT CURRENT I_2
A	Single Phase Full Wave (2 Tube)	.353 MPIV	.9 E_1 .318 MPIV	.636 MPPC
B	Single Phase Full Wave (Bridge) 4 Tube	.70 MPIV	.9E_1 .63 MPIV	.636 MPPC
C	Single Phase Half Wave Voltage (Doubling 2 Tube)	Variable—Depends on Size of C_1 and C_2		
D	Three Phase (Half Wave)	.41 MPIV	1.17 E_1 .48 MPIV	.827 MPPC
E	Three Phase Half Wave (Double "Y" 6 Phase)	.41 MPIV	1.17 E_1 .48 MPIV	1.91 MPPC
F	Three Phase Full Wave	.41 MPIV	2.34 E_1 .959 MPIV	.955 MPPC

MPIV = maximum peak inverse voltage rating of rectifier tube.

MPPC = maximum peak plate current rating of rectifier tube.

The values given in the above table are based on ideal conditions, assuming sine wave supply, pure resistance load, no filter used, the tube drop equal to zero, balanced phase voltages.

A choke input to the filter is recommended whenever possible as this decreases the ratio of peak current to load current in the rectifier tubes. Condenser input is not recommended as the peak current may become as high as three or four times the load current under some conditions with this type of circuit.

Modulation

Modulation is defined as "the process whereby the amplitude (or other characteristic) of a wave is varied as a function of the instantaneous value of another wave. The first wave, which is usually a single-frequency wave, is called the 'carrier wave'; the second wave is called the modulating wave." Modulation is also described as "the variation of the amplitude, frequency, or phase of a radio-frequency wave at an audio rate." The envelope of amplitude modulated waves contains a component of the same wave form as the modulating frequency. Amplitude modulation only will be discussed here.

In amplitude modulation, a carrier of constant frequency is varied in magnitude in accordance with an audio wave. Conventional modulation technique is illustrated in Fig. 19. The lower part of the figure shows a single audio-frequency current which modulates the carrier shown above.

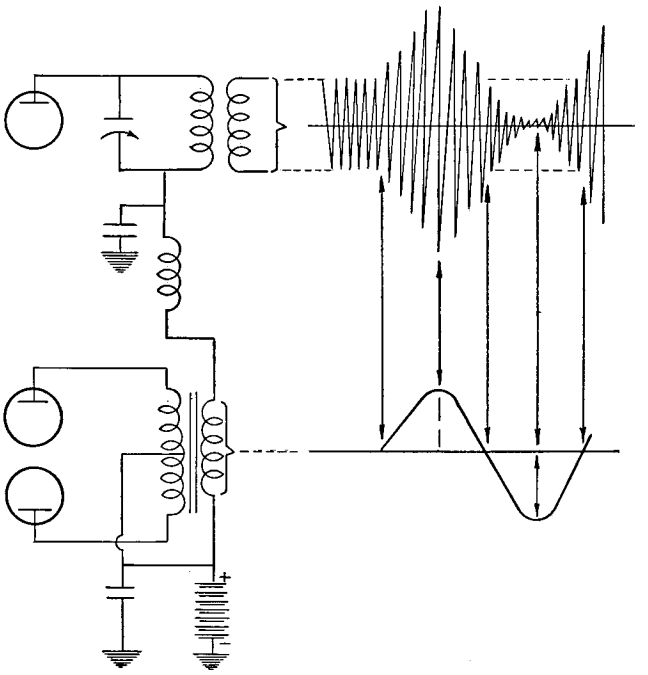


Fig. 19 Plate Modulation Technique

The peak amplitude of the carrier without modulation, is fixed; however, with modulation, the peak amplitude of each cycle is constantly varied. The outline of the modulated wave is generally called the modulation envelope.

Modulation Percentage

A carrier can be modulated either a small or large amount. The degree of modulation may be expressed by a percentage of the deviation from the normal value of the r-f carrier. The percentage modulation, denoted by M, is given by the relation

$$M = \frac{(I_{max} - I_{min}) \times 100 \text{ per cent}}{2\,I_0}$$

where

I_{max} = maximum peak value of carrier current
I_{min} = lowest peak value of carrier current
I_0 = normal peak value of carrier current

The intensity of a modulated wave is proportional to the square of the percentage of modulation. Thus a 10 watt carrier modulated 100 per cent is as effective as a 40 watt carrier modulated 50 per cent. A wave may be modulated more than 100 per cent, i.e. over-modulated, but such action is undesirable because of resultant distortion.

The amount of power required to modulate an r-f carrier is a function of the percentage of modulation and the number of audio-frequency components.

It is possible to modulate r-f waves at one frequency; this results in a tone-modulated wave which may be transmitted in forms of dots and dashes, i.e., continuous-wave telegraphy. R-F waves may also be modulated with voice frequencies; this results in voice telephony.

It can be shown that any alternating current which is not of sine wave form contains more than one frequency component. If these non-sine wave forms repeat themselves at regular intervals, then the wave form is composed of a fundamental frequency and certain harmonic frequencies which are exact multiples of the fundamental. The figure below shows the wave shape which results from the combination of a fundamental wave and its third harmonic.

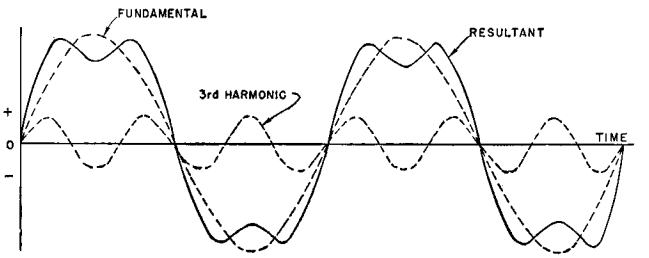


Fig. 20

If the deviations in each cycle of a given wave form are not exactly alike but are periodic and produce a low frequency variation in amplitude, then the frequency components will consist of a fundamental wave of the same frequency as the resultant, and two waves differing from the fundamental frequency by plus and minus the aforementioned low frequency variation in amplitude.

A wave of this nature is called an amplitude modulated wave; the fundamental frequency is referred to as the "carrier" frequency, and the components above and below the "carrier" are denoted respectively as upper and lower "sideband" frequencies.

The figure below shows a modulated wave in its simplest form, that is, when the modulating envelope is a sine wave. In this instance the modulated wave (10 c.p.s.) is produced by a carrier (10 c.p.s.) and two sideband frequencies (8 and 12 c.p.s.). Note that the upper sideband frequency (12 cp.s.) is the sum of the carrier (10 c.p.s.) and the modulating envelope (2 c.p.s.) while the lower sideband frequency (8 c.p.s.) is the difference between the carrier (10 c.p.s.) and the modulating envelope (2 c.p.s.).

4. The amplitude of each sideband is just half the carrier amplitude. If the carrier current were one ampere, each side band would contain currents of one-half ampere. By calculating the power contained in both the carrier and the sidebands, it is found that the total power of the modulated wave is increased 1.5 times by modulation for a sine wave of audio frequency. Power relations for the case of voice modulation show a much smaller increase in power.

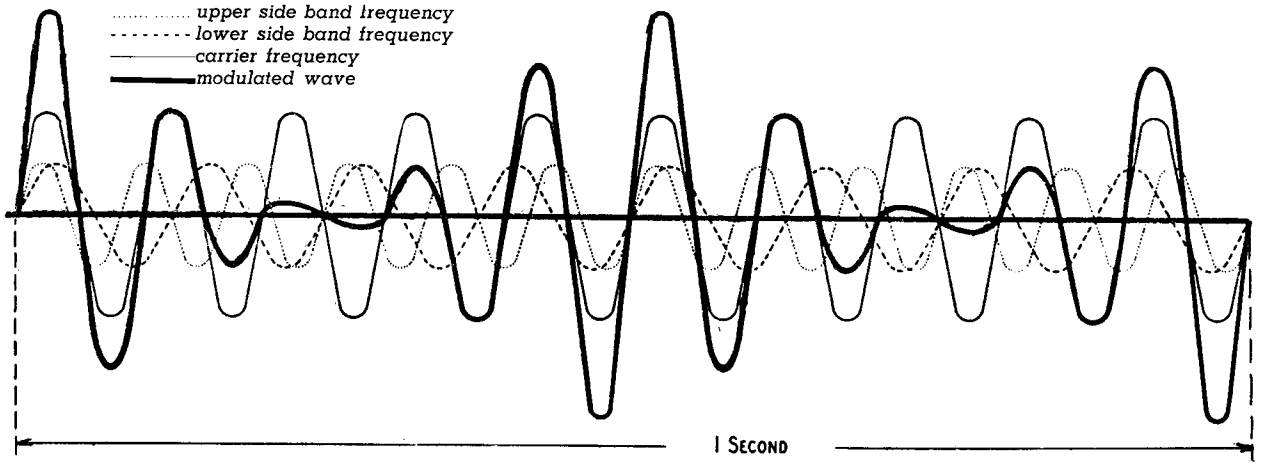


Fig. 21 Modulation Components

In the above example the modulating frequency was taken as 2 cycles per second. In actual broadcast practice the modulating frequencies comprise a band 10 kilocycles wide. If a given receiver is too selective some of these frequencies will be cut off and suppressed during reception.

In order to modulate a carrier 100 per cent with a single sine wave of audio frequency the following conditions must apply:

1. The peak audio voltage must equal the carrier voltage. Therefore, for 100 per cent modulation the peak r-f current or voltage must reach a value equal to two times normal at one point in the a-f cycle and diminish to zero at another point.
2. Because the peak audio voltage equals the carrier voltage, the total instantaneous plate voltage applied to the modulated amplifier or oscillator varies from zero to two times the carrier voltage.
3. Since the power is proportional to the square of voltage or current, the peak r-f power must be equal to four times the unmodulated power.
5. Since the r-f output power is 1.5 times the modulated power the output of the modulator must be equal to 50% of the carrier power.
6. Since 100% modulation increases power output 1.5 times, the antenna current must increase as the square root of 1.5 or 1.22 times. This applies only to an audio-frequency sine wave.

Methods of Modulation

Various methods may be used for the modulation of an amplifier or oscillator. Some of these methods are:

1. application of the a-f modulating voltage to the plate, or plate modulation,
2. application of the a-f modulating voltage to the control grid, or grid-bias modulation,
3. application of the a-f modulating voltage to the screen grid, or screen-grid modulation,
4. application of the a-f modulating voltage to the suppressor grid, or suppressor-grid modulation,
5. application of the a-f modulating voltage to the cathode, or cathode modulation.

Plate Modulation

Plate modulation calls for a modulator audio power output equal to one-half the d-c plate input to the modulated r-f stage if 100 per cent modulation is to be attained. This is evident since for 100 per cent modulation the r-f output power increases 1.5 times. The modulator tube, therefore, supplies power for the sidebands.

An increase in modulator current causes an equivalent decrease in r-f amplifier plate current. Since the total current value remains fixed this system is often called constant-current modulation.

In 100 per cent modulation the total instantaneous plate voltage reaches a value equal to twice the r-f carrier voltage. Unless the tube's plate voltage rating is reduced, a dangerously high plate dissipation value will be reached. That is the reason Engineering Information sheets show lower values of plate voltage for modulated services than for unmodulated services.

The power output of the r-f amplifier varies as the square of the plate voltage. If linear modulation is to be obtained, therefore, the amplifier must be operated class C.

Grid-Bias Modulation

In grid-bias modulation the r-f carrier and the audio frequency modulating wave are both impressed in the grid circuit of a class C amplifier. Modulation, however, occurs in the plate circuit. The audio voltage is brought to the grid of the r-f amplifier through the secondary of an audio-frequency output transformer. The audio voltage varies the grid bias of the amplifier at an audio rate and increases the average power output of the amplifier stage although the d-c input power to the amplifier remains constant.

In grid-bias modulation, the modulating voltage determines the plate current and plate efficiency. At modulation peaks both the plate current and plate efficiency are twice their carrier values, i.e. peak power is four times carrier power. Therefore, the r-f carrier voltage is set equal to half the peak voltage *as a base* about which the modulating voltages vary. R-f carrier efficiency can only be one-half of the peak efficiency. Since the latter in practical circuits is approximately 70 to 80 per cent, then carrier efficiencies are approximately half of these values.

In grid-bias modulation employing negative bias negligible a-f and r-f power is required. The power increases resulting from modulation are supplied from the class C amplifier plate supply.

Cathode Modulation

Cathode modulation is essentially a *combination* of plate and grid bias modulation. In this type of modulation both the grid bias and plate voltage vary with the result that the plate efficiency varies too. The carrier efficiency is approximately 45%, a value which is higher than the value obtained with grid-bias modulation but lower than that obtained with plate modulation. Carrier efficiency may be bettered by increasing the percentage of plate modulation as compared to the grid-bias modulation. As percentage plate modulation is increased, more modulator audio power and r-f excitation power is required.

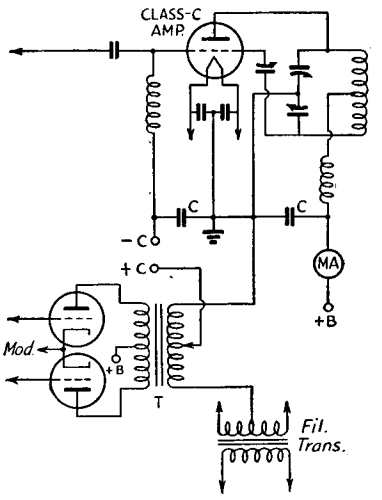


Fig. 22 Cathode Modulation

Oscillation

An oscillating current is defined as "a current which alternately increases and decreases in magnitude with respect to time according to some fixed law."

Oscillating currents may be generated by electro-mechanical devices such as a-c generators and vibrator units as well as by vacuum tubes. This discussion will deal with the latter only because the electro-mechanical devices are limited in practice to about 15 K.C. whereas vacuum tube oscillators can produce frequencies as high as several thousand megacycles per second. Moreover, the vacuum tube oscillator can produce oscillations of practically any desired frequency and wave-form if the proper circuits and circuit components are employed.

An oscillator is often defined as a "self-excited amplifier." Any amplifier circuit has an amount of power available in the plate circuit which is in excess of the grid excitation power. If a portion of this plate power is diverted or fed-back to the grid input circuit in the proper phase and magnitude a self-excited amplifier or oscillator results. The tube, of

course, may be operated as a class A, AB, B, or C amplifier. Thus an audio-frequency oscillator is usually operated in class A_2, that is, with the grid driven slightly positive. Other oscillators are usually operated class C because of the high efficiency which may thus be obtained.

It is important to note however that the oscillator must have a resonant circuit load impedance and not purely resistive load impedance. The plate power in a class C amplifier or in an oscillator may be negative during part of the cycle. If no provision is made for storing energy in a resonant circuit, and if a resistance load is used, then oscillations would cease every time the plate power was zero or negative. In other words energy would not be supplied from the plate to the grid circuit.

Frequency Classifications

Oscillators may be classified according to the frequencies generated. Audio-frequency oscillators generate frequencies in the approximate range of 15 to 15000 cycles per second. Carrier-frequency oscillators, so-called because of their use in "carrier" telephony, generally operate in the range of 50 kilocycles to 1.5 megacycles. Higher frequency oscillators are generally given names to correspond with the frequency designations given in Table 2.

Table 2

Radio Frequency Classifications

(Official FCC designations as of March 2, 1943)

Frequency in Kilocycles		*Designation*	*Abbreviation*
10 —	30	Very Low	VLF
30 —	300	Low	LF
300 —	3,000	Medium	MF
3,000 —	30,000	High	HF
30,000 —	300,000	Very High	VHF
300,000 —	3,000,000	Ultra High	UHF
3,000,000 —	30,000,000	Super High	SHF

Fundamental Theory

A momentary voltage or pulse of energy when supplied to a "tank" circuit composed of inductance, L, and capacitance, C, sets up oscillations of a certain resonant frequency which is determined by the L and C values. To prevent these oscillations from dying out, losses due to the circuit resistance must be supplied from some energy source. Since one energy pulse is sufficient to start oscillations, other pulses of energy, suitably spaced, will produce sustained oscillations.

In the fundamental oscillator circuit, below, a pulse of energy produces oscillations in the L_1C_1 circuit. The varying voltage across the L_1C_1 tank is impressed on the grid of the vacuum tube and causes a varying plate current to flow. This varying plate current represents energy from the B battery and while passing through L_2 is coupled into the L_1C_1 tank circuit by means of the mutual inductance between L_1 and L_2. It is necessary that this induced energy pulse be of a nature to reinforce and continue the oscillations and not to neutralize or cancel them. In other words, the phase of the energy coupled into the tank must be correct. Also, the magnitude of the energy pulse must be sufficiently large to supply circuit losses and maintain the oscillations. The oscillating tank circuit stores more energy than is lost per oscillatory cycle. Hence to keep the circuit in an oscillating condition it is only necessary to supply enough energy to compensate for resistance losses. The tank itself does not oscillate but only serves as a valve to control the release of energy into the oscillating circuit.

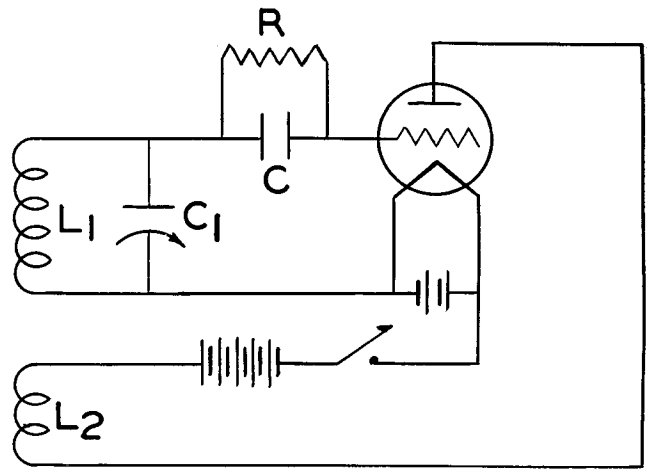


Fig. 23 Tuned Grid Oscillator

In order for d-c energy to be converted into a-c energy efficiently a continuous energy supply is unnecessary. A means of supplying automatic grid bias, however, is required. This bias is needed since a continuous energy flow would be wasteful and inefficient. If the tube is operated class C the pulses of energy are sufficient to maintain oscillations. Fixed bias cannot be used if the oscillation is to be self starting because it is the original build-up of plate current which induces the first pulse of voltage into the tuned circuit and starts oscillations. The bias must be zero to start (oscillator tube is most sensitive at this point) so that a pulse of energy of proper phase will cause oscillation; and it must build up

gradually to class C values so that oscillator efficiency will be high. In practical oscillators a high negative bias is used and therefore plate current flows only on the peaks of the positive grid alternations. Since class C oscillators generally employ a grid leak-condenser combination for bias the time constant of the RC combination must be of a small enough value to obviate blocking and intermittent operation of the oscillator.

The greater the value of the inductance, L_1, the longer will it take for the condenser, C_1, to discharge through it. Likewise the greater the value of C_1, the longer will be the time required for charge and discharge. Since the velocity of electrical flow is substantially constant, values of L_1 and C_1 determine the time for a complete cycle of oscillation. The resonant frequency of the tank is given by the expression

$$f_r = \frac{1}{2\pi \sqrt{LC}}$$

where

f_r = resonant frequency in cycles per second
L = inductance in henries
C = capacitance in farads

The higher the value of the L to C ratio, the greater the Q (figure of merit) of the circuit will be. The Q of most stable class C oscillators is about 12.

The vacuum tube acts as an automatic valve which tends to keep the amplitude of the oscillations constant between the points where I_p is equal to zero, and where I_p is equal to the saturation value. This automatic valve effect tends to maintain the amplitude of the oscillations at a constant level regardless of the increase in grid swing. In practical oscillators the tube operates with high negative bias which permits plate current to flow only on the positive peaks of the grid alternations.

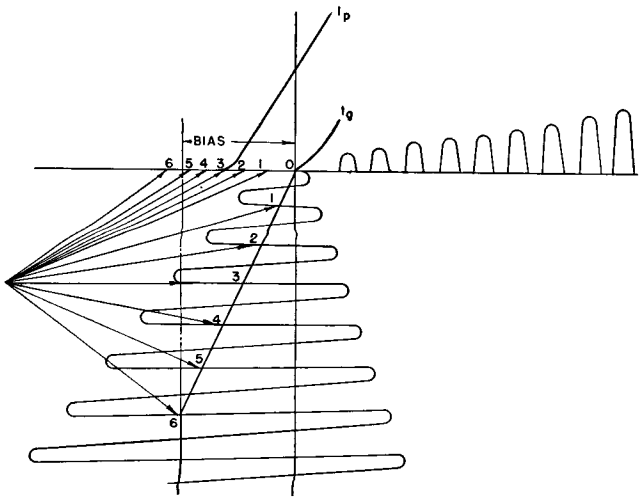


Fig. 24 Operational Bias of Oscillator

Oscillation Requirements

From the preceding discussion we may summarize the requirements for oscillation. These are:

1. the tube must be able to amplify,
2. energy must be fed-back from the plate to the grid circuit,
3. The feedback must be of proper magnitude and phase,
4. a resonant circuit must be included,
5. a source of energy must exist, and
6. the bias must be self regulating.

Although the resonant circuit is used in most oscillators, it is possible to use piezoelectric and magnetrostrictive devices also.

Practical Oscillator Circuits

The high frequencies necessary for communication, diathermy, electronic heating, etc., may be generated by a large number of oscillator circuits. Only a few of those circuits can be considered here.

The circuit of fig. 23 is referred to as a tuned-grid oscillator because the tuned tank is located in the grid circuit of the vacuum tube. The operation of this type of oscillator has already been described.

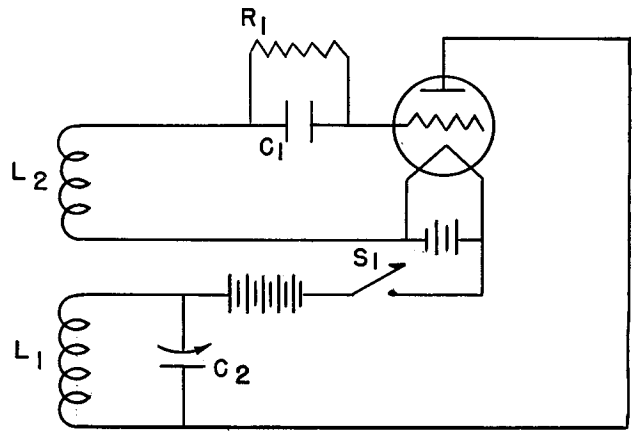


Fig. 25 Tuned Plate Oscillator

Tuned-Plate Oscillator

When a tuned circuit is used in the plate instead of the grid circuit a tuned-plate oscillator results. Closing switch S_1 causes a surge of plate current through the inductance L_1 and creates an oscillatory discharge in the L_1C_2 circuit. The alternating expanding and contracting magnetic field in L_1 induces a voltage in L_2 whose frequency is the same as that of the oscillatory discharge in L_1C_2. Furthermore since L_2 is connected directly to the grid circuit, the grid potential will vary and cause plate current variation of the same frequency as that of the oscillatory

current in the tuned L_1C_2 circuit. The varying plate current releases energy into the L_1C_2 to maintain the oscillations and thus complete the cycle.

Since both the tuned-grid and tuned-plate oscillators employ the mutual inductance between two coils to couple energy from the plate to the grid circuit, they are termed inductive feedback oscillators.

Hartley Oscillator

The distinguishing feature of a Hartley oscillator is that the condenser C_2 does not tune either L_1 or L_2, alone, but instead tunes the series inductance of the two coils. In other words, the oscillatory circuit is common to both the plate and grid circuits.

Closing the switch S_1 results in a surge of plate current through L_1 and causes oscillations in the tank circuit. The oscillating current causes a voltage drop across the coils L_1 and L_2. The varying potential aross L_2 is impressed directly upon the grid causing a varying plate current of oscillatory frequency to flow. The a-c component of plate current which flows through the tank circuit supplies enough energy to produce sustained oscillations.

The radio frequency choke allows only d-c through it and the resistor R_1. The resulting voltage drop across R_1 is used as negative bias.

The Hartley oscillator uses the mutual inductance between L_1 and L_2 for feedback and hence is referred to as an inductive feedback oscillator. The magnitude of the feedback is largely dependent on the L_1 to L_2 turns ratio.

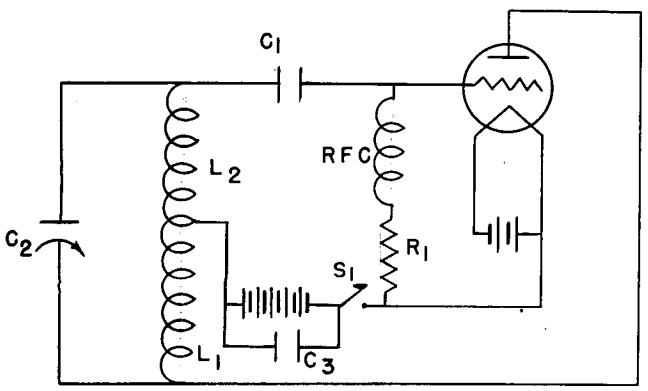


Fig. 26 Hartley Oscillator

Colpitts Oscillator

The Colpitts oscillator employs a tank circuit which as in the Hartley oscillator is common to both the plate and grid circuits. In this case, however, the coil L_1 is shunted across two condensers, C_1 and C_2 in series.

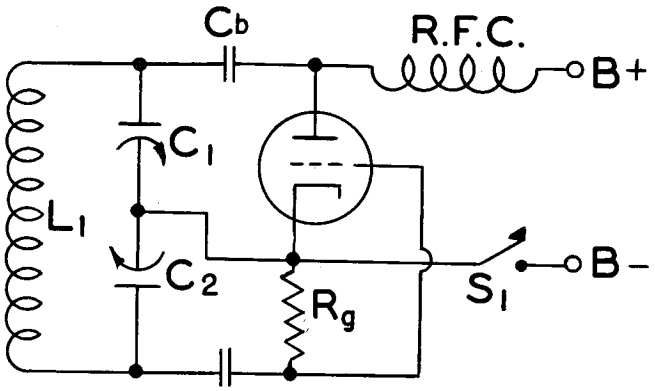


Fig. 27 Colpitts Oscillator

In the Colpitts oscillator a plate current surge when the switch S_1 is closed will charge condenser C_2. Because L_1 and C_1 in series shunt the condenser C_2, then C_1 will also be charged. The inductances of L_1 will cause the voltage across C_1 to build up more slowly than the voltage across C_2. This difference in voltage causes the tuned circuit composed of L_1, and C_1, and C_2 to oscillate. The oscillating current across C_1 produces an a-c voltage drop which is applied to the grid of the tube. The plate current therefore varies at the oscillatory frequency. The a-c component of plate current cannot flow through the radio frequency choke and hence goes to the tank circuit where it supplies the required energy to maintain oscillations.

Grid bias in the Colpitts oscillator is obtained in the same manner as in the Hartley oscillator. The feedback in a Colpitts oscillator is both inductive and capacitive. The magnitude of the feedback depends on the ratio of C_1 to C_2.

Tuned Plate-Tuned Grid Oscillator

The tuned-plate tuned-grid oscillator contains tuned tanks in the plate and grid circuits. Closing switch, S_1, causes a surge of plate current through L_2 in the plate tank. The energy thus imparted is sufficient to set the tuned circuit into oscillation. The oscillating current causes an alternating voltage to be developed across the tuned circuit which is in series with the d-c supply voltage. The resultant plate voltage varies at the oscillating frequency and causes an alternating current through the interelectrode grid to plate capacitance, C_{gp}, through C_3 and the tuned grid circuit, L_1C_1, and back to the filament.

If L_1C_1 is tuned to approximately the same frequency as the tuned plate circuit, a high impedance will be offered to the feedback current. Hence a voltage will be developed across the grid tank causing oscillation. Since the oscillating tank is directly connected to the grid, variations in plate current of the

oscillatory frequency will ensue. The a-c component of the plate current supplies energy to the plate tank and keeps the latter in oscillation thus completing the cycle. A small frequency variation between the plate and grid tanks is permissible.

It is to be noted that the feed-back in a tuned-plate oscillator is through C_{gp}, the interelectrode grid to plate capacitance. In practice, oscillator frequency is governed mainly by the plate tuned circuit. The grid tuned circuit serves to control the excitation to the oscillator.

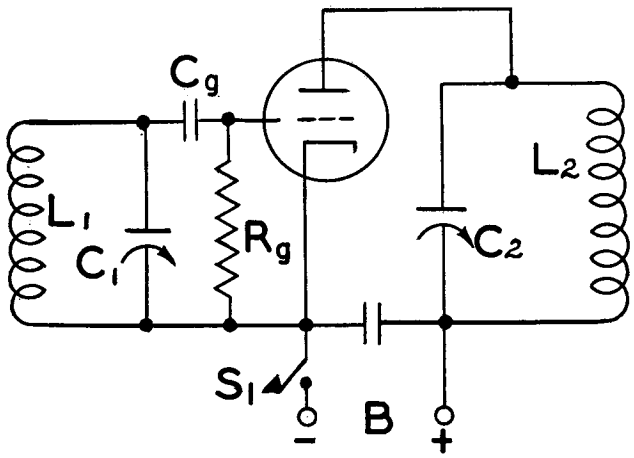


Fig. 28 TPTG Oscillator

Crystal Oscillator

Certain crystalline substances, such as quartz, will vibrate if a voltage is applied across them. Conversely, if the crystal is mechanically stressed a voltage difference will be found to exist across the crystal. This phenomenon is known as the piezo-electric effect and crystals having the properties described are known as piezo-electric crystals. These crystals will vibrate with much greater amplitude at one particular frequency than at other frequencies. This frequency is often referred to as the natural frequency of the crystal.

A crystal placed in a resonant circuit acts like a high Q resonant circuit and is often used to control the frequency of a vacuum tube oscillator in place of a tuned circuit.

One type of crystal oscillator is shown below. In this oscillator the crystal is placed in grid circuit.

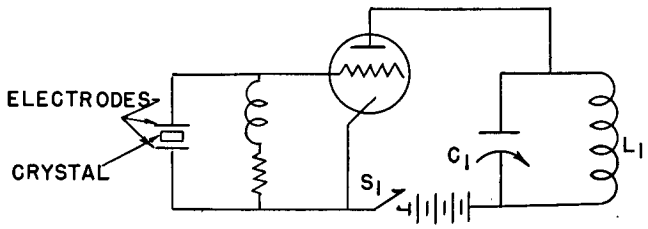


Fig. 29 Crystal Oscillator

Closing of the switch, S_1, creates a surge of plate current which causes the tuned circuit L_1 C_1 to oscillate. The alternating voltage of the tank is impressed between plate and filament and is fed back to the grid-filament or crystal circuit through the plate to grid interelectrode capacitance. This voltage across the crystal sets it into vibration thus producing a voltage across the crystal electrodes which is impressed upon the grid circuit. This causes a varying plate current which provides the energy required for the maintenance of oscillations. Some of the energy is fed back again to the circuit through the plate to grid interelectrode capacitance, C_{gp} and causes increased vibration of the crystal. This action results in a continuous increase of oscillation until the oscillator is delivering its maximum power to the load for a given set of operating conditions.

Crystal controlled oscillator tubes generally have ratings below 50 watts since tubes with larger ratings tend to break the crystals.

UNITED ELECTRONICS

END USES OF ELECTRONIC TUBES

The development of the electronic tube has provided a tremendous impetus to the progress of civilization. In factory and in home, in city and in hamlet — electronic tubes are revolutionizing traditional modes of life. Electronic devices have become so intimately connected with everyday life as to appear commonplace. Although the field of electronic application is already enormous in scope the trend points to still greater growth based on the further development of the electronic tube.

The fields of application for electronic tubes are restricted only by the limitations of human ingenuity. In industry and in offices, in communications and power work, in engineering, medicine, and research the electronic tube has proven its worth.

The manufacture of transmitting and rectifier tubes of distinction is an art carefully nurtured at United Electronics Company. The following electronic tube types, with the UNITED brand, have gained favorable recognition throughout the electronics industry.

1. High Vacuum Tubes — oscillators, amplifiers, modulators
2. High Vacuum Rectifiers
3. Mercury Vapor Rectifiers
4. Grid Controlled Rectifiers — gas or mercury vapor

The following summary presents an outline picture of electronic tubes in actual service.

COMMUNICATION USES

Telephony and Telegraphy

The vacuum tube has made possible long distance communication by means of wire telephony. This has been accomplished by electronic amplification which performs two functions:

1. increases signal strength above initial level, and
2. compensates for loss in signal strength during transmission.

Since telegraph offices require a source of direct current for various signalling circuits, rectifier tubes find ready application. Mercury vapor rectifiers are used widely to supply direct current thus replacing many of the small motor-generator sets.

In carrier telegraphy, many different and simultaneous transmissions in different frequency ranges are sent over the same channel. This is made possible by vacuum tube detectors and amplifiers.

The use of radio to supplement the wire services of telephony and telegraphy has been extensively employed since the early part of this century. Ship to shore, aircraft to ground, police radio, transoceanic, overland, railway, and special purpose radio communication augment the great mass entertainment field — Broadcasting. Television, and frequency modulation, too, are here. In radio-telephony and radio-telegraphy, advanced techniques of multichannel operation use electronic tubes for rectification, amplification, modulation, oscillation and detection.

The trend of modern practice in telephony, telegraphy, and radio-telephony and telegraphy indicates the use of higher frequencies and a greater number of circuits per path. This trend calls for vacuum tubes which are fitted for difficult service.

Facsimile

Facsimile is a means of rapid and inexpensive communication based upon electronic principles. Although the fundamentals of facsimile were understood for a long time, practical considerations such as methods for the preparation of copy and lack of suitable amplifying devices for long-range transmission prevented its growth.

With the advent of electronic tubes facsimile surged forward rapidly. Photoelectric cells scan unprepared subject copy, and the vacuum tube amplifiers project the transmission as far as desired.

Present uses of facsimile include the transmission of photographs for news gathering agencies, local pick-up and delivery of telegrams, and multiple-recording of telegraphed matter. Facsimile makes the transmission of messages by telegraph much easier. In the future, facsimile machines in factories, offices, and homes, and in railroad and plane terminals is a distinct possibility.

Sound Systems

The importance of industrial sound systems is readily apparent when the extent of such systems is reviewed. Sound motion pictures, sound recording, public address systems (indoors and outdoors), broadcast station uses, intercommunication and paging systems are just a few examples of industrial sound application.

Electronic tubes for sound systems are usually designed for audio-frequency voltage and power amplification. The development of sound recording and talking pictures depended greatly upon the development of vacuum tube amplifiers. The latter makes possible the simultaneous engraving of many records, "equalization" for disc recording, volume limiting, the improvement of electrical pickups and of frequency response, as well as many other uses.

INDUSTRIAL USES

Resistance Welding Control

Resistance welding is defined as "a pressure welding process wherein the welding heat is obtained by passing an electric current between the contact areas to be welded."

Resistance welding is just one method of fusing metals together. Arc welding, brazing, torch welding, soldering, etc. are examples of other ways to do the same thing.

The actual weld which is obtained in resistance welding depends upon a number of factors. Thus the physical structure of the electrodes, the applied pressure, between electrodes, the characteristics of the metal to be welded, the magnitude of the welding current, the time of current flow determine the quality of a given weld. While most of these factors can be controlled mechanically, the magnitude of welding current, and time of current flow are best controlled by electronic means.

Actual welding current required depends upon the physical characteristics of the metal to be welded. For metals of low resistance up to 60,000 amperes may be required, while the high resistance metals may be welded by current of the order of 1000 amperes.

To obtain consistent results the welding current should be applied for a definite time interval and the welding circuit should always be closed at a definite point on the alternating voltage or current wave.

Electronic control of resistance welders allows accurate starting and finishing values of current for all welds. The heat required to fuse the metals varies as the square of the welding current. A small variation in welding current therefore may have a very appreciable effect on the generated heat.

The use of electronic tubes allows smooth, continuous adjustment of welding current and makes possible controlled starting of welding current at each half cycle. Grid controlled rectifiers and ignitrons are the principal tubes used in this service.

D-C Motor Control

The use of d-c motors for certain industrial applications is extremely desirable because the speed and torque of such motors can be ready controlled.

However, a-c power distribution systems are so widespread that in a great many communities d-c motors cannot, ordinarily, be utilized.

The problem is overcome by the use of electronic tubes to convert a-c to d-c and by a rheostat in the shunt field winding to control the speed of the motor. For speed ranges greater than 4 to 1 variable-voltage control systems are used instead of a rheostat.

Electronic motor control allows the operation of d-c motors from standard a-c distribution systems with refinements which even exceed the results obtained from an original d-c supply. The grid-controlled rectifiers are commonly employed to convert a-c to d-c, start the motor and regulate its speed, and to supply the d-c power necessary for operation.

Power

The future of electronics and electronic tubes in the power industry is practically unlimited. The electronic tube has proved itself to be a reliable and worthy tool requiring very little maintenance. In many power installations equipment has been modernized and improved by the addition of electronic circuits. Most new installations are being designed to take full advantage of electronic tubes and devices.

Some of the low current applications of electronic tubes to power systems are in electronic wattmeters, synchroscopes, amplifiers, electronic relays, cable fault and pipe locators, telemetering of voltage, current, wattage, pressure, etc.

Medium current applications include use of high-vacuum, mercury-vapor, and grid-controlled gas-filled tubes for rectification purposes. The d-c voltages obtained are used for charging power station batteries, for voltage regulators, controls, etc. The grid-controlled rectifier is often used to control the voltage of a rotary or an electronic exciter which in turn fixes the voltage of a large alternator.

In the field of heavy current, the electronic applications include the use of mercury-arc rectifiers for conversion of a-c to d-c in public utility services.

High Frequency Heating

The heating of materials by the action of electromagnetic fields is now being employed throughout industry. The early application of high-frequency heating units to the heating of vacuum tube electrodes has been overshadowed by a multiplicity of other uses.

The term "induction heating" generally refers to the heating of an electrically conductive material by the varying electromagnetic field of an inductance coil. The load is generally placed inside a coil through which high-frequency current flows. The load may be likened to a short-circuited secondary of a transformer whose primary is the heating coil.

The term "dielectric heating" generally refers to the heating of an electrically non-conductive or insulating material by the varying electrostatic field of two electrodes which together with the load form a capacitor arrangement.

Induction heating may be used for applications such as high-speed brazing, hardening, annealing, soldering, and other special heat treatment of conductive materials.

Dielectric heating may be used for applications such as the high-speed heat treatment of non-conductive materials e.g. processing and preserving of food, dehydration, heat treatment and processing of plastics, bonding and lamination of plywoods, curing, drying, and seasoning of wood, etc.

Vacuum tube oscillators have been used for high frequency heating in the frequency range from 50 kilocycles to 50 megacycles with power outputs up to hundreds of kilowatts. The oscillator circuits most commonly used are the Hartley, Colpitts, and tuned-plate tuned-grid types.

High frequency apparatus consists essentially of an oscillator unit to supply the required r-f power and a rectifier unit which supplies the required d-c potentials for the oscillator tubes.

Physio-Therapy

Present day diathermy technique is a result of one of the oldest forms of therapy, namely, the application of heat to injured or diseased parts of the human body. Such treatment is of recognized value in the alleviation of surface conditions and deep-seated inflammations of the human body.

It is believed that the benefits of diathermy treatment for surface conditions are related to the increased flow of blood through the dilated vessels of the injured tissue. Such dilation and flow is produced by heat. The salutary effect of diathermy on the deeper tissues to which heat cannot penetrate is of a reflex nature and involves the nervous systems.

Most diathermy equipment at present consists of self-rectifying push-pull oscillators of 200 to 400 watt output and operating at a wave length of 6 to 15 meters. Crystal controlled oscillators are also used. In medical diathermy, as described above, the r-f currents flow through a wide area and thus produce only moderate heating.

In surgical diathermy a large electrode is placed on the patient's back and the r-f current passes from a small electrode to the tissue. This results in the production of a high temperature in a small area. The current may be varied so that either predominantly coagulative or cutting effects can be obtained.

INSTALLATION OF ELECTRONIC TUBES

Mechanical

UNITED electronic tubes are thoroughly tested before they leave the factory. Though packaged carefully to insure safe arrival, they should be examined when received for possible damage resulting during transit.

New transmitting tubes may be tested when received, as follows:

1. Before application of plate voltage, apply rated filament voltage for approximately five minutes.
2. The plate voltage should be at a low value when first applied and it should be increased carefully to the desired operating condition.
3. The tube should be operated at normal loading conditions for approximately thirty minutes.

Tubes which are not put into immediate service should be stored carefully and tested again at three month intervals.

The required socket or mounting for each tube is specified in the Engineering Information sheets. The vertical, base-down position is the preferred mounting position for all electronic tubes and is mandatory for the oxide-coated mercury vapor types. Angular or horizontal mountings are permissible in some instances provided that the plane of the filament is kept vertical. The Engineering Information sheets should be consulted for mounting instructions for any given tube type.

If the tubes may be subjected to unusual shock and vibration, shock-absorbing suspensions should be employed. The UNITED "ruggedized" tubes are especially recommended for use where difficult conditions of operation are anticipated.

Tube terminals should make good electrical contact with all current carrying connectors. Connections to terminal caps should be made by means of flexible leads in order to minimize glass strains. The leads employed should be of sufficient size to carry the required currents without harmful heating effects. To prevent the possibility of glass strains and damage to bulb seals, metal caps should not be used to support circuit components, nor should they ever be *soldered directly* to connectors.

Ample separation should be provided between the bulb and all wiring and circuit elements to minimize danger of glass puncture. The bulb should be protected from moisture, metallic objects and operational hazards which otherwise might break the glass.

Cooling

Excessive operating temperatures in electronic tubes may lead to harmful effects such as cracked seals, electrode warping, and gassy conditions. The dissipation of heat from the anodes of transmitting and rectifying tubes is a governing factor of their operation.

In most installations of UNITED tubes free-air cooling is sufficient to keep the bulb at a reasonable temperature, that is, below 135° C. for borosilicate glasses. Cabinet ventilation should be such that free circulation of air is provided.

Forced-air cooling should be used in installations where poor air circulation and operation at maximum allowable plate dissipation causes unduly high bulb temperatures. When forced-air cooling is employed precautions should be taken to have the bulb cooled as uniformly as possible.

Mercury vapor tubes in rectifier installations may, because of space limitations, be installed rather closely to each other. Radiation of heat from such tubes is adversely affected and forced-air cooling becomes advisable. The effect of such cooling is to narrow the difference between the condensed mercury vapor temprature and the ambient temperature with a resultant increase in operational safety. If forced-air cooling is used for mercury vapor tubes the air stream should be directed at the lower end of the tube and just above the filament base.

Generally very simple forced-air installations will suffice to cool the tubes adequately. In a typical arrangement, air passes through a filter to an inlet air chamber which is at the bottom of the installation, and then is circulated by a centrifugal fan or blower around the tube or tubes after which the air is expelled through outlet louvres at the top or sides.

Proper cooling becomes increasingly important at the higher frequencies because losses in metal-to-glass seals, grid leads, and the bulb create sufficient heat to seriously limit tube operation.

When forced-air cooling is used for high voltage mercury-vapor rectifiers, it is advisable to insert ambient temperature relays in the circuit to insure proper air circulation.

Mercury Vapor Rectifiers

Because mercury may be splashed on tube elements due to shipment or handling, new tubes should be operated at rated voltage for approximately 15 minutes without plate voltage. This process will distribute the mercury properly and prevent a condition which may cause arc-back. The above procedure need not be repeated unless the tube is removed from the socket and is handled so that mercury is splashed on the tube elements.

Mercury-vapor rectifier cathodes should reach proper operating temperature before plate voltage is applied. Proper pre-heating times for individual tubes are given in the Engineering Information sheets. The condensed mercury temperature for each tube should be within the proper operating range, as specified in the Engineering Information sheets, before loading the tube. This may require a longer time than to heat the cathode. Any evidence of arc-back in the tube should be met with an increase in time delay sufficient to prevent this condition.

Filament Circuits

Although filament operation from both d-c and a-c sources is permissible, convenience usually favors an a-c source unless hum effects are troublesome. Filament circuits employing a-c, should be wired so that grid, plate, and other circuit return leads go to the mid-tap of the filament transformer winding. When rheostat control of an a-c filament supply is used, the rheostat should be placed in the primary circuit of the filament transformer. In d-c filament circuits, return leads should connect with the negative filament terminal. To insure uniform electron evaporation along the filament, leads in d-c service, may be interchanged at regular intervals; e.g. 500 service hours.

A suitable voltmeter should be connected permanently across tube filament terminals. Rated filament voltages should not vary more than 5% for thoriated-tungsten and oxide-coated filaments or loss of filament emission may result. The effects of transmitter and power supply variation should be kept within this tolerance. Thoriated-tungsten and oxide-coated filaments should be kept at rated voltage, and tungsten filaments at 80% of rated voltage, during "standby" periods.

The use of d-c plate and grid circuit milliammeters is urged if maximum ratings are not to be exceeded.

Isolation of input and output circuits by means of r-f filter circuits and shielding is necessary if the tube is to be subjected to external high voltage or high frequency fields during operation.

Safety Precautions (Tubes)

In vacuum and mercury-vapor tubes as well as in other devices "an ounce of prevention is worth a pound of cure." Factors of operation and end use which are beyond the manufacturer's control are important in the proper conservation of electronic tubes.

Abnormal operating conditions such as failure of a driver stage and consequent loss of bias, or detuning of the plate tank circuit, may lead to excessive and ruinous plate currents. The effect of such overloads is to increase the plate dissipation of the tube and decrease the plate efficiency. The persistence of such abnormal conditions may damage the tube.

Various protective devices may be used to minimize the possibility of tube damage resulting from overloads. Effective protective devices must provide rapid, positive action. Devices in common use include the following:

1. d-c plate current overload relays and circuit breakers to remove applied plate voltages,
2. High voltage fuses placed in the B+ lead and designed to open at 150 per cent of the rated d-c plate current value,
3. a cathode resistor which is designed to furnish protective bias in the event of failure of a preceding driver stage,
4. a series current limiting resistor designed to limit surge currents to a reasonable value is useful when making circuit changes and adjustments.

Safety Precautions (Equipment)

All metal parts of high voltage equipment which may come into contact with operating personnel should be at ground potential. No reliance should be placed upon meter case insulation or tuning and control knobs for protection.

The B— lead or chassis, of all plate power supplies, and the B+ leads of all bias supplies, should be connected to a common ground such as a water-pipe.

Possibilities of harm to the operator exist when internal adjustments such as coil changes, neutralization, coupling changes, or trouble shooting must be made. Such dangers may be avoided by use of a suitable interlock system or combined safety signal and switch for all cabinet doors and lids.

The use of red pilot lights to show that a circuit is "on" is not satisfactory. An unlit pilot lamp may mean that the circuit is turned off; it may also mean that the circuit is on but the lamp is burned out or not making contact.

Wherever possible double-pole switches should be used to break both leads to the power supply. Switches that open one lead only do not afford complete protection as it is sometimes possible to complete a primary circuit through a short or accidental ground.

Use of a d-c milliammeter in the filament to the ground return lead or negative high voltage supply lead means that the r-f amplifier stage or rectifier chassis will be at high voltage with respect to ground in case the meter develops an open circuit from any cause. Use of a high resistance shunt across the meter will eliminate this possibility.

UNITED ELECTRONICS

TUBE RATINGS

Maximum Ratings

Maximum ratings which are published in the Engineering Information sheets are the results of exhaustive analyses and life tests upon electronic tubes. The first consideration in the formulation of these ratings is to provide a basis for long, satisfactory, and economical operation. None of the Maximum Ratings is to be exceeded if maximum tube life is to be attained.

Maximum Ratings are only applicable up to certain frequencies which are specified for each tube type in the Engineering Information sheets.

In order to prevent the possibility of overloading a tube, it is desirable to set up average values which take into account the voltage fluctuations arising from power supply, load, and manufacturing variations. These average values safeguard the tube against overload at ratings in excess of the Maximum Ratings.

Maximum Ratings for UNITED electronic tubes are conservative and include allowances for accidental overloads and shelf deterioration. These ratings, however, do not represent the fullest capabilities of these rugged UNITED tubes.

Published ratings, except where specifically indicated otherwise, presuppose continuous tube operation, and set up long life as the main objective to be attained. In certain fields, such as aviation, amateur radio, medical applications of electronics, etc., long tube life is outweighed by space, weight, and power considerations. In such fields of application, tube service is intermittent and short-time loads prevail. Under such conditions, the power handling ability of a tube becomes considerably greater than would be the case for continuous service. It is entirely possible for a small tube operated under higher, intermittent ratings to perform the functions of a larger tube operated under continuous, maximum ratings.

Various manufacturers list so-called ICAS ratings for intermittent tube operation. In general, such ratings are omitted from the UNITED Engineering Information sheets because of the belief that variations in operating conditions, types of service, duty cycles, etc., make them exceedingly approximate.

Intermittent ratings for the UNITED tube types will be furnished upon request for specific service applications.

Maximum Ratings for High-Vacuum Tubes

Maximum Plate Voltage

The maximum plate voltage rating is the highest d-c voltage which may be impressed safely between the plate and the other elements.

Theoretically, the highest instantaneous voltage which may be put across a tube is limited only by the appearance of spurious emissions in the tube. Actually, however, imperfect vacuum conditions and limitations of the tube parts lower the theoretical limit. The peak instantaneous plate voltage is a function of tube geometry, end use, and other considerations.

For the various classes of operation, different ratios of peak to d-c voltage value prevail. This means that the maximum permissible d-c plate voltage will vary with conditions of tube use. Thus if a class C oscillator sets up a carrier wave which is to be modulated 100% it is found that the instantaneous applied peak plate voltage will rise to twice the *D-C plate voltage* which exists under carrier conditions. To ensure safe operation in such an event, it is necessary to reduce the maximum permissible value of plate voltage.

Maximum Plate Current

The maximum plate current rating is the highest permissible average d-c plate current which may be drawn through the tube.

In tube performance calculations, the current value is averaged over a complete audio cycle.

The plate current flow through a tube is limited by the total available filament emission. Since in normal operation grid and plate currents are drawn at the same time, it is necessary to allow for the grid current in estimating the maximum permissible plate current.

A definite ratio exists between the maximum instantaneous current value and the average d-c plate current. The ratio differs for each class of operation and is modified in class C operation by the portion of the cycle during which plate current flows.

This ratio of the maximum instantaneous plate current to the average d-c plate current is the determining factor in the computation of the maximum plate current rating.

Maximum Plate Dissipation

The maximum plate dissipation rating is the largest permissible difference between the d-c input and the power output of a tube.

The effective plate dissipation is the sum of the instantaneous power dissipated by the anode over a complete a-f or r-f cycle. The maximum plate dissipation of a tube varies with the class of operation and the percentage modulation employed.

The factors limiting the plate dissipation rating of a tube are the heat-radiating ability of the plate, the melting point of the anode material, plate emission, and bulb temperature.

Maximum Grid Current

The maximum d-c grid current rating is the highest permissible average d-c grid current which may be drawn through the grid.

The purpose of this rating is to prevent excessive heating of the grid structure. The grid, during positive parts of the grid cycle, is bombarded and heated by electrons. Although the fundamental limitation upon the grid is the heat in watts which the grid can dissipate, the d-c grid current value is used because it can be more readily observed.

Maximum Peak Inverse Voltage

The maximum peak inverse voltage rating is the highest instantaneous voltage that a rectifier tube can safely stand in the direction opposite to that in which it is designed to pass current.

This rating gives the safe limit before arc-back or flashover of the tube operating within the specified temperature range, can occur.

Maximum Peak Anode Current

The maximum peak anode current rating is the highest peak current that a rectifier tube can safely stand in the direction in which it is designed to pass current.

The non-observance of this rating may lead to cracked seals, a gassy condition, and general warping of the elements.

TYPICAL OPERATING CONDITIONS (DEFINITIONS)

Typical Operation Conditions as given in the Engineering Information serve as an invaluable tube selection guide for particular applications. These values, when used as a reference for proper electrode voltages and currents, will eliminate possibilities of tube damage which may result from unwise operation.

Typical Operation Conditions are not ratings. Different combinations of these values, within the maximum ratings, may be used to obtain equivalent end results.

Typical Operation Conditions that may be given in published technical data are defined below:

Filament Voltage is the voltage between the terminals of a filament.

Thermionic Emission represents the sum of the peak grid and plate currents that can be drawn from a filament at rated filament voltage.

Available Thermionic Emission represents the optimum value of total space current which may be drawn from a filament.

*D-C Grid Voltage is the voltage between the grid and the filament.**

Peak A-F Grid Voltage is the peak value of the audio-frequency voltage which must be applied between the grid and the filament in order to obtain a specified power output.*

Peak R-F Grid Voltage or grid voltage swing, is the peak value of the radio-frequency voltage, measured from the bias point, that must be applied between the grid and the filament in order to obtain a specified power output.*

D-C Plate Current is the average d-c value of current in the plate supply circuit.

D-C Grid Current is the average d-c value of current in the grid return circuit.

Zero Signal Plate Current is the average or steady d-c value of the current in the plate supply circuit with no signal voltage applied between grid and filament.

*Maximum Signal Plate Current** is the average d-c value of the current in the plate supply circuit when a maximum amplitude signal voltage of sine wave form is applied constantly between the grid and the filament.** (The maximum amplitude signal voltage corresponds to the peak a-f grid input voltage.)

Driving Power is the value of audio or radio frequency power that must be applied between the grid and the filament in order to obtain a specified power output. It may also be defined as the average power dissipated in the grid and biasing device of the tube.*

Load Resistance is the value of impedance in the plate circuit that is required for the specified values of power input and output. (This impedance is assumed to be resistive for all cases of calculated operating conditions.)

Power Output is the plate power output obtained when circuit losses are neglected.

Plate Dissipation is the difference between the d-c input and the power output.

*For a-c filament operation grid, plate, and other circuit returns should be connected to the mid-tap on the filament transformer winding or to the mid-tap of a potentiometer connected across the filament terminals. For d-c filament operation all circuit returns should connect to the negative terminal of the filament.

**This term is used only in Class AB and B audio operation.

UNITED ELECTRONICS

RATINGS OF MERCURY VAPOR TUBES

Long life and satisfactory operation of mercury vapor tubes is readily obtained if some regard is given to the subject of tube ratings. The Engineering Information sheets give operating values designed to define and limit the power to be controlled by any tube type.

Hot Cathode Ratings

Cathode Voltage is the voltage applied to the filament or heater and is measured at the base pins.

Cathode Current is an average value of current for the specified cathode voltage.

Cathode Heating Time is the minimum time required for the cathode to reach emitting temperature.

Anode Ratings

Maximum Peak Forward Anode Voltage is the highest rated instantaneous voltage between anode and cathode in the direction in which the tube is designed to pass current.

This is the maximum anode voltage which can be blocked by grid action.

Maximum Peak Inverse Voltage is the highest instantaneous voltage that a rectifier tube can safely stand in the direction opposite to that in which it is designed to pass current.

Maximum Average Anode Current is the highest average value of current that the tube is rated to carry continuously in the direction in which the tube is designed to pass current.

When operation employs a repeating duty cycle, this value may be read on a d-c meter. Otherwise, the average current should be calculated over a period not greater than the maximum averaging time.

Maximum Peak Anode Current is the highest peak current that a rectifier tube can safely stand in the direction in which the tube is designed to pass current.

This value is dependent upon current wave-form and load conditions. It should be determined by an oscillograph or other dependable means.

Maximum Surge Anode Current is the largest transient current that the tube is rated to carry in the direction in which the tube is designed to pass current without being rendered immediately inoperative.

This rating is intended as a basis for equipment design only. The duration of the surge current should not exceed one-tenth of a second.

Grid Ratings

Average Grid Current is the grid current as measured with the grid voltage sufficiently negative to just prevent the tube from conducting.

Maximum Average Grid Current is the highest average current which the tube is rated to carry to the grid continuously in the normal direction of current flow.

Maximum Peak Grid Current is the highest instantaneous current which the tube is rated to carry to the grid recurrently in the normal direction of current flow.

Other Ratings

Tube Voltage Drop in a gas tube is the anode voltage during the conducting period.

Ionization Time is the time required for a sufficient number of positive ions to be formed around the cathode to allow the maximum peak current to pass without damage to the cathode.

Deionization Time is the time required under normal conditions to clear the space inside the bulb of positive ions and to regain grid control.

This rating is based on a condition of maximum anode current flow.

Maximum Averaging Time is the longest period over which the current should be averaged regardless of wave form.

Optimum Condensed Mercury Temperature Range is that range, measured at the junction of the cathode base and bulb, at which the tube will operate most satisfactorily.

Operation at temperatures higher than recommended may result in arc-back and loss of grid control; operation at temperatures lower than recommended may result in loss of emission and damage to the cathode surface.

UNITED ELECTRONICS

TUBE CONSERVATION

Although UNITED tubes bear the highest reputation for long life and efficient operation, it is apparent that actual life will depend in large measure upon operating conditions. Intelligent use of electronic tubes will pay high dividends in terms of long life and satisfactory economical operation.

An understanding of the factors determining tube life is essential before effective tube conservation can be practiced. The most important factors affecting tube life are filament voltage, plate dissipation, operating temperature, grid dissipation, operating interruptions, residual gas content, and metal fatigue.

Filament Voltage

The usefulness of a transmitting tube depends more upon filament life than perhaps any other factor. Filament voltage, and consequently filament temperature, is the most important consideration in filament life. The use of a filament voltmeter permanently connected across the filament terminals allows a continuous check upon filament voltage.

(a) Tungsten Filaments

The theoretical life of tungsten filaments is based upon the normal evaporation from these filaments. Peak currents equivalent to the total emission may be drawn continuously from tungsten filaments without damage. A reduction of the filament voltage and hence the emission is accompanied by a considerable increase in tube life. A graph of filament life against filament voltage shows that a decrease of 5% in filament voltage will double filament life.

Permissible output distortion should be checked before the tungsten filament voltages are reduced because of the possible flattening of the positive peaks of the output voltages.

All tubes are designed to give a specified emission at a given voltage. If the end uses to which these tubes are put do not require their full emission capabilities, it becomes possible to greatly increase the life expectancy.

(b) Thoriated-Tungsten Filaments

Thoriated-tungsten filaments are operated at such temperatures that evaporation of the tungsten is negligible. Since tube life does not depend upon the reduction of tungsten as in the case of the bright tungsten filament, it cannot be extended by operation at reduced voltage.

During the operation of a thoriated-tungsten filament, the surface layer of thorium which is responsible for emission is constantly being removed by evaporation and bombardment and is constantly being replenished from within the wire. In order to maintain this balance between loss and replenishment of the thorium layer, operation must be maintained within a relatively narrow temperature range.

The life of thoriated-tungsten filaments is markedly decreased by operation much above or below the rated values. Filament voltage should be maintained at rated value for full load conditions. At very light loads, a 5% filament voltage reduction is permissible.

A further precaution in the use of thoriated-tungsten filaments lies in the fact that they should never be operated at or near saturation. The peak currents drawn from thoriated-tungsten filaments should not exceed more than one-half of the maximum available filament emission. These filaments are designed to produce at least double the emission that would be needed in normal operation.

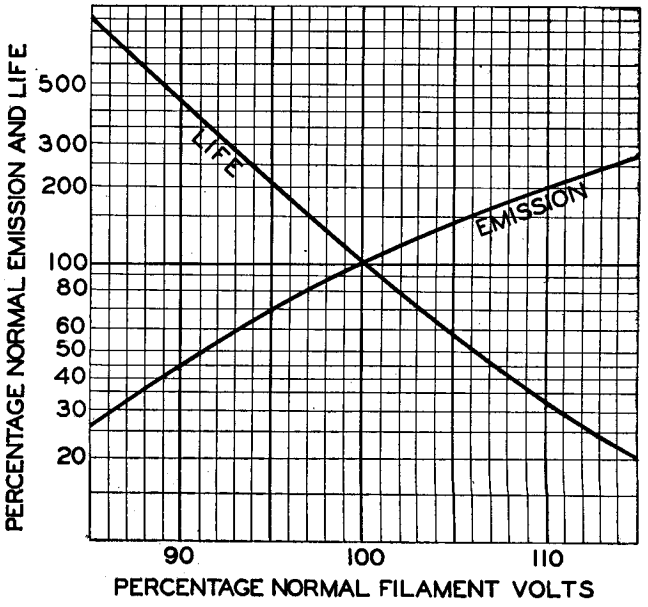


Fig. 30

(c) Oxide-Coated Filaments

Oxide-coated filaments are designed for operation at specific temperatures and voltages. The performance of these filaments depends upon the formation of a proper amount of metallic barium upon the surface. Short life may result from the operation of these tubes either above or below the specific filament voltage or temperature.

Plate Dissipation

The life of a tube is a direct function of the power or heat which the plate must dissipate. If the plate dissipation is reduced, tube life increases proportionally.

The plate dissipation of a tube may be reduced by observing the following rules:

1. All circuits should be properly tuned to required frequency. Detuning increases the plate current, causes a rise in plate dissipation and decreases the r-f current in the tank circuit, thus lowering the efficiency. Circuits which become detuned as the transmitter warms up should be adjusted.
2. Avoid stray circuit losses in r-f stages. If the unloaded plate current is unreasonably high vary coil location, coil design, L/C ratio, bias, etc. until the unloaded plate current approaches approximately 1/10 the loaded plate current for class C r-f stages.
3. Parasitic oscillations (oscillations of undesired frequency) may cause ruinous plate currents and overloads in a vacuum tube. Parasitics are usually eliminated by decreasing the excitation voltage to the affected circuit.

Grid Dissipation

The amount of heat which the grid must dissipate should be limited to the lowest value consistent with efficiency requirements. Excessive grid dissipation may lead to cracked seals and grid warping.
sheets.

At the higher frequencies, the r-f grid current becomes a limiting factor in the use of a tube. Excessive r-f grid currents will ruin grid seals and lead to bulb puncture.

Operating Interruptions

Operating interruptions cause the filament to undergo thermal shocks because of the resultant alternate heating and cooling cycles. The resultant expansions and contractions in the filament set up strains which operate to shorten tube life.

Residual Gas Content — Metal Fatigue

Residual gas content and metal fatigue are other factors tending to shorten tube life. Observance of tube ratings and avoidance of damaging overloads will minimize these effects.

POWER TUBE STANDARDIZATION

Coordinated industry activity during the past two decades, has resulted in a highly perfected standardization program on radio receiving tubes. The Engineering Department of the Radio Manufacturers Association instituted and developed this very important work. It founded the RMA Data Bureau for correlation and dissemination of information regarding tube standards and type designation. Since the beginning of World War No. 2 the RMA program has been expended to include radio transmitting tubes, and various RMA Committees have collaborated closely with the Navy Department, and with the Signal Corps.

Prior to the war there was virtually no coordinated industry standardization program for transmitting tubes. Credit for the first serious effort pointing toward a standardization program for transmitting and other non-receiving type tubes must go to the Army and Navy, and to the National Electrical Manufacturers Association.

Shortly after World War No. 1, the Signal Corps created a series of tube standards for Army requirements—the old familiar Signal Corps VT Specifications. Simultaneously, the Navy Department through the Bureau of Ships and Naval Research Laboratories built its own separate standards program, which also embraced "type approval" requirements. Under most circumstances no tube manufacturer was qualified to supply tubes to the Navy without first having submitted specimen tubes for acceptability tests and having received type approval. These Army and Navy standards embraced receiving as well as transmitting tubes, but each service had its own separate pattern as to standards.

A uniform set of standards for both services had long been indicated as desirable, and with the approach of World War No. 2 the foundation was set for what is now the Joint Army-Navy Specifications for both receiving and transmitting tubes, known as JAN-1A. This is administered jointly by the Signal Corps Standards Agency and the Electronics Division, Bureau of Ships. JAN-1A has greatly streamlined the tube engineering and production work. It represents a milestone of advancement, and industry will probably follow on with a somewhat similar pattern postwar.

The tube manufacturing industry, in its commercial outlook prior to the war collaborated through two associations, namely, the National Electrical Manufacturers Association (NEMA), and the Radio Manufacturers Association (RMA). Tube work centered in the Electronics Section of NEMA as well as in the Tube Division and the Transmitter Division of RMA. Transmitting and industrial tubes were the main interest of NEMA, whereas RMA dealt principally with receiving tubes. For several years past there has been much overlapping of scope, standards planning, and other effort embracing electron tubes. Some knotty problems were involved, but through tireless striving by both RMA and NEMA executive bodies, a very promising solution has been obtained by organization of the Joint Electron Tube Engineering Council. This new tube standardization agency is sponsored jointly by RMA and NEMA and has recently been approved by the respective Boards of Governors of each association.

The agency is headed by two directors, one representing NEMA, and one representing RMA. JETEC is operated by a council of four—two engineer representatives from NEMA and two from RMA. In instances where the council is unable to reach a decision, such questions are referred to the directors who will act as a policy committee, for action.

All future tube standards will be developed by JETEC, recommended by its various committees and reviewed by the JETEC council and staff before transmittal to RMA and NEMA for approval.

The various committees of JETEC, covering all the range of electron tube applications, radio receiving, transmitting, industrial and special purpose are as follows:

1. Pool Tubes
2. High Vacuum Power Tubes
3. Cathode Ray Tubes
4. Vacuum Sealed Devices
5. Receiving Tubes
6. Phototubes
7. Gas Tubes
8. Type Designatoins
9. Mechanical Standardization
10. Electron Tube Packaging
11. Sampling Procedure

The problems that have been involved in the evolution and development of electronic tubes and their application have been legion. There are many unsung champions. Besides the work of NEMA and RMA, much has been accomplished in the way of standardization by the Institute of Radio Engineers (I.R.E.) and the American Institute of Electrical Engineers (A.I.E.E.)

The future uses of electron tubes are seemingly boundless and it is reasonable to expect that an industry program of standardization will enhance these opportunities and furnish economic advantages which will be of great value to the general public.

UNITED ELECTRONICS

DEFINITIONS OF ELECTRICAL TERMS

NOTE: The following definitions were selected from "American Standard Definitions of Electrical Terms," approved August 12, 1941 by the American Standards Association, and sponsored and published by the American Institute of Electrical Engineers, 33 West Thirty-ninth Street, New York.

ADMITTANCE, ELECTRODE—Electrode admittance is the quotient of the alternating component of the electrode current by the alternating component of the electrode voltage, all other electrode voltages being maintained constant. *Note: As most precisely used, the term refers to infinitesimal amplitudes.*

AMPLIFICATION, CURRENT—Current amplification is the ratio of the alternating current produced in the output circuit of an amplifier, to the signal current supplied to the input circuit.

AMPLIFICATION, POWER—Power amplification is the ratio of the power delivered by the output circuit of an amplifier containing a source of local power to the power supplied to its input circuit.

AMPLIFICATION, VOLTAGE—Voltage amplification is the ratio of the alternating voltage produced at the output terminals of an amplifier, to the voltage impressed at the input terminals.

AMPLIFIER—An amplifier is a device which, by enabling a received wave to control a local source of power, is capable of delivering an enlarged copy of the wave.

AMPLIFIER, CLASS A—A class A amplifier is an amplifier in which the grid bias and alternating grid voltages are such that plate current in a specific tube flows at all times. *Note: To denote that grid current does not flow during any part of the input cycle, the suffix 1 may be added to the letter or letters of the class identification. The suffix 2 may be used to denote that grid current flows during some part of the cycle.*

AMPLIFIER, CLASS AB—A class AB amplifier is an amplifier in which the grid bias and alternating grid voltages are such that plate current in a specific tube flows for appreciably more than half but less than the entire electrical cycle. *Note: See note under Amplifier, class A.*

AMPLIFIER, CLASS B—A class B amplifier is an amplifier in which the grid bias is approximately equal to the cut-off value so that the plate current is approximately zero when no exciting grid voltage is applied, and so that plate current in a specific tube flows for approximately one-half of each cycle when an alternating grid voltage is applied. *Note: See note under Amplifier, Class A.*

AMPLIFIER, CLASS C—A class C amplifier is an amplifier in which the grid bias is appreciably greater than the cut-off value so that the plate current in each tube is zero when no alternating grid voltage is applied, and so that plate current flows in a specific tube for appreciably less than one-half of each cycle when an alternating grid voltage is applied. *Note: See note under Amplifier, Class A.*

ANGLE, PHASE—The phase angle of a periodic quantity, for a particular value of the independent variable, is the angle obtained by multiplying the phase by 2π if the angle is to be expressed in radians, or by 360 degrees if the angle is to be expressed in degrees.

ANODE (Of a Vacuum Tube) (Plate)—An anode of a vacuum tube is an electrode to which a principal electron stream flows.

ANTENNA—An antenna is a conductor or a system of conductors for radiating or receiving radio waves exclusive of the connecting wires between its main portion and apparatus associated with it.

ATTENUATION—The attenuation of a periodic wave is the decrease in amplitude with distance in the direction of wave propagation when the amplitude at any given place is constant in time or the decrease in amplitude with time at a given place.

AUTOTRANSFORMER—An autotransformer is a transformer in which part of the winding is common to both the primary and the secondary circuits.

BAND, FREQUENCY—A frequency band is a continuous range of frequencies extending between two limiting frequencies.

BATTERY, "A"—An "A" battery is a battery designed or employed to furnish current to heat the filaments of the tubes in a vacuum tube circuit.

BATTERY, "B"—A "B" battery is a battery designed or employed to furnish the plate current in a vacuum tube circuit.

BATTERY, "C"—A "C" battery is a battery designed or employed to furnish voltage used as a grid bias in a vacuum tube circuit.

BEATING—Beating is a phenomenon in which two or more periodic quantities of different frequencies add linearly to produce a resultant having pulsations of amplitude.

BIAS, DIRECT GRID—Direct grid bias is the direct component of grid voltage. *Note: This is commonly called grid bias.*

CAPACITANCE, INTERELECTRODE—Interelectrode capacitance is the direct capacitance between two electrodes.

CAPACITANCE, OUTPUT—The output capacitance of a vacuum tube is the sum of the direct capacitances between the output electrode (usually the plate) and the cathode and such other electrodes as are operated at the alternating potential of the cathode. *Note: This is not the effective capacitance, which is a function of the impedances of the associated circuits.*

CAPACITANCE—Capacitance is that property of a system of conductors and dielectrics which permits the storage of electricity when potential differences exist between the conductors. Its value is expressed as the ratio of a quantity of electricity to a potential difference. A capacitance value is always positive.

CAPACITANCE, ELECTRODE—Electrode capacitance is the capacitance of one electrode to all other electrodes connected together.

CAPACITANCE, INPUT—The input capacitance of a vacuum tube is the sum of the direct capacitances between the control grid and the cathode and such other electrodes as are operated at the alternating potential of the cathode. *Note: This is not the effective capacitance, which is a function of the impedances of the associated circuits.*

CATHODE (of a vacuum tube)—A cathode of a vacuum tube is an electrode which is the primary source of an electron stream.

CATHODE, INDIRECTLY HEATED—(Equipotential Cathode) (Unipotential Cathode). An indirectly heated cathode is a cathode of a thermionic tube to which heat is supplied by an independent heater element.

CHANNEL, RADIO—A radio channel is a band of frequencies of a width sufficient to permit its use for radio communication. The width of a channel depends upon the type of transmission.

CHANNEL, TELEGRAPH—A telegraph channel is a path which is suitable for the transmission of telegraph signals between two telegraph stations. *Note: The term "channel" is used to denote either a one-way channel providing transmission in one direction only or a two-way channel providing transmission in both directions. Three basically different kinds of telegraph channels used in providing a number of telegraph channels over a circuit are:*

1. *One of a number of paths for simultaneous transmission in the same frequency range as in bridge duplex, differential duplex and quadruplex telegraphy.*
2. *One of a number of paths for simultaneous transmission in different frequency ranges as in carrier telegraphy.*
3. *One of a number of paths for successive transmission as in multiplex printing telegraphy.*

Combinations of these three types may be used on the same circuit.

CHANNEL, TELEPHONE—A telephone channel is a path suitable for the transmission of voice-controlled electric waves between two stations. *Note: The term "channel" is used to denote either a "one-way channel" providing transmission in one direction only or a "two-way channel" providing transmission in both directions.*

CHARACTERISTIC, CONTROL—The control characteristic of a gas tube is a relation, usually shown by a graph, between critical grid voltage and anode voltage.

CHARACTERISTIC, ELECTRODE—An electrode characteristic is a relation, usually shown by a graph, between an electrode voltage and current, other electrode voltages being maintained constant.

CHARACTERISTIC, EMISSION—An emission characteristic is a relation, usually shown by a graph, between the emission and a factor controlling the emission (as temperature, voltage, or current of the filament or heater).

CHARACTERISTIC, TRANSFER—A transfer characteristic is a relation, usually shown by a graph, between the voltage of one electrode and the current to another electrode, all other voltages being maintained constant.

CIRCUIT, OSCILLATORY—An oscillatory circuit containing inductance and/or capacitance and resistance, so arranged or connected that a voltage impulse will produce a current which periodically reverses.

COLUMN, POSITIVE—The positive column is the luminous glow, often striated, in a discharge tube between the Faraday dark space and the anode.

CONDENSER, ELECTROLYTIC—An electrolytic condenser is a combination of two conductors, at least one of which is a valve metal, separated by an electrolyte, and between which a dielectric film is formed adjacent to the surface of one or both of the conductors.

CONDUCTANCE, ELECTRODE — Electrode conductance is the quotient of the in-phase component of the electrode alternating current by the electrode alternating voltage, all other electrode voltages being maintained constant. *Note: This is a variational and not a total conductance. As most precisely used the term refers to infinitesimal amplitudes.*

COUNTERPOISE—A counterpoise is a system of wires or other conductors, elevated above and insulated from the ground, forming the lower system of conductors of an antenna.

COUPLING—Coupling is the association of two circuits or systems in such a way that power may be transferred from one to the other.

COUPLING, CAPACITIVE—Capacitive coupling is the association of one circuit with another by means of mutual capacitance.

COUPLING, DIRECT—Direct coupling is the association of two circuits by means of a self inductance, capacitance, resistance or a combination of them which is common to the circuits.

COUPLING, INDUCTIVE—Inductive coupling is the association of one circuit with another by means of inductance mutual to the circuits. *Note: This term, when used without modifying words, is commonly used for coupling by means of mutual inductance, whereas coupling by means of self inductance common to the circuits is called direct inductive coupling.*

COUPLING, RESISTIVE—Resistive coupling is the association of one circuit with another by means of mutual resistance.

CURRENT, CATHODE—Cathode current is the total current passing to or from the cathode through the vacuous space.

CURRENT, CRITICAL GRID—Critical grid current in a gas tube is the instantaneous value of grid current when the anode current starts to flow.

CURRENT, DIELECTRIC—The dielectric current flowing at any instant through any surface in an isotropic dielectric, which is in a changing electric field, can usually be considered as having four components, namely

1. Displacement current.
2. Absorption current.
3. Conduction current.
4. Decaying conduction current.

Of these currents, the displacement current is the only one that is present in every dielectric.

CURRENT, DIRECT (continuous current)—A direct current is a unidirectional current in which the changes in value are either zero or so small that they may be neglected. A given current would be considered a direct current in some applications, but would not necessarily be so considered in other applications.

CURRENT, DIRECTION OF—The direction of a current through a surface is, by agreement, taken as the direction of the movement of the positive electricity when it is the predominating component in motion and as the direction opposite to the direction of movement of the negative electricity when the latter is the predominating component in motion.

CURRENT, ELECTRODE—Electrode current is the current passing to or from an electrode through the vacuous space.

CURRENT, FILAMENT—Filament current is the current supplied to a filament to heat it.

CURRENT, GAS—Gas current is a current flowing to an electrode and composed of positive ions which have been produced as a result of gas ionization by an electron current flowing between other electrodes.

CURRENT, HEATER—Heater current is the current flowing through a heater.

CURRENT, IONIZATION—Ionization current is the electric current resulting from the movement of electric charges in an ionized medium, under the influence of an applied electric field.

CURRENT, LEAKAGE—Leakage current is a conductive current which flows between two or more electrodes by any path other than across the vacuous space.

CURRENTS, EDDY—Eddy currents are those currents which are induced in the body of a conducting mass by a variation of magnetic flux. *Note: The variation of magnetic flux may be the result of a varying magnetic field or of a relative motion of the mass with respect to the magnetic field.*

CYCLE—A cycle is the complete series of values of a periodic quantity which occur during a period.

DECIBEL—The decibel is one-tenth of a bel, the number of decibels denoting the ratio of two amounts of power being 10 times the logarithm to the base 10 of this ratio. The abbreviation db is commonly used for the term decibel. Note with P and P designating two amounts of power and n the number denoting their ratio:

$$n = 10 \log_{10} (P_1/P_2) \text{ db}$$

When the conditions are such that ratios of currents or ratios of voltages (or analogous quantities in other fields) are the square roots of the corresponding power ratios, the number of decibels by which the corresponding powers differ is expressed by the following formulas:

$$n = 20 \log_{10} (I_1/I_2) \text{ db}$$

$$n = 20 \log_{10} (V_1/V_2) \text{ db}$$

where I_1/I_2 and V_1/V_2 are the given current and voltage ratios, respectively. By extension, these relations between numbers of decibels and ratios of currents or voltages are sometimes applied where these ratios are not the square roots of the corresponding power ratios; to avoid confusion, such usage should be accompanied by a specific statement of this application.

DEMODULATION—Demodulation is the process whereby a wave resulting from modulation is so operated upon that a wave is obtained having substantially the characteristics of the original modulating wave.

DETECTION—Detection is any process of operation on a modulated signal wave whereby the signal imparted to it in the modulation process is obtained.

DETECTION, LINEAR—Linear detection is that form of detection in which the output voltage under consideration is substantially proportional to the carrier voltage throughout the useful range of the detecting device.

DETECTION, POWER—Power detection is that form of detection in which the power output of the detecting device is used to supply a substantial amount of power directly to a device such as a loud speaker or recorder.

DETECTOR—A detector is a device having an asymmetrical conduction characteristic which is used for operation on a frequency or combination of frequencies to produce certain desired frequencies or changes in current.

DIATHERMY—Diathermy is the therapeutic use of a high frequency current to generate heat within some part of the body. *Note: The frequency is greater than the maximum frequency for neuromuscular response, and ranges from several hundred thousand to millions of cycles per second.*

DIELECTRIC—A dielectric is a medium having the property that the energy required to establish an electric field is recoverable, in whole or in part, as electric energy. A vacuum is a dielectric.

DIODE—A diode is a two-electrode vacuum tube containing an anode and a cathode.

DISSIPATION, ELECTRODE—Electrode dissipation is the power dissipated in the form of heat by an electrode as a result of electron and/or ion bombardment.

DROP, TUBE VOLTAGE—Tube voltage drop in a gas tube is the anode voltage during the conducting period.

DUTY—Duty is a requirement of service which defines the degree of regularity of the load.

DUTY, CONTINUOUS—Continuous duty is a requirement of service that demands operation at a substantially constant load for an indefinitely long time.

DUTY, INTERMITTENT—Intermittent duty is a requirement of service that demands operation for alternate intervals of (1) load and no-load; or (2) load and rest; or (3) load, no-load and rest; such alternate intervals being definitely specified.

EFFICIENCY—Efficiency of a device with respect to a physical quantity which may be stored, transferred or transformed by the device is the ratio of the useful output of the quantity to its total input. Unless specifically stated otherwise, the term *efficiency* means efficiency with respect to power.

EMISSION, GRID—Grid emission is electron or ion emission from a grid.

EMISSION, SECONDARY—Secondary emission is electron emission due directly to the impact of electrons or ions.

EMISSION, THERMIONIC—Thermionic emission is electron or ion emission due directly to the temperature of the emitter.

FACTOR, AMPLIFICATION—Amplification factor is the ratio of the change in plate voltage to a change in control electrode voltage, under the conditions that the plate current remains unchanged and that all other electrode voltages are maintained constant. It is a measure of the effectiveness of the control-electrode voltage relative to that of the plate voltage upon the plate current. The sense is usually taken as positive when voltages are changed in opposite directions. *Note: As most precisely used, the term refers to infinitesimal changes. Amplification factor is a special case of mu factor.*

FACTOR, FORM D-C—The d-c form factor is the ratio of the average unidirectional output current of a rectifier to the rms value of this same current.

ELECTRODE, CONTROL—A control electrode is an electrode on which a voltage is impressed to vary the current flowing between two or more other electrodes.

ELECTRODESICCATION—Electrodesiccation is the destruction of animal tissue by high-frequency electric sparks whose action is controlled by a movable electrode.

ELECTRONICS—Electronics is that branch of science and technology which relates to the conduction of electricity through gases or in vacuo.

ELECTROSTATICS—Electrostatics is that branch of science which deals with the laws of electricity at rest.

ELECTROTHERAPY—Electrotherapy is the art of treating disease by means of electricity.

EMISSION, ELECTRON—Electron emission is the liberation of electrons from an electrode into the surrounding space. Quantitatively, it is the rate at which electrons are emitted from an electrode.

FACTOR, MODULATION—The modulation factor is the ratio of the maximum departure (positive or negative) of the envelope of a modulated wave from its unmodulated value to its modulated value. *Note: In linear modulation the average amplitude of the envelope is equal to the amplitude of the unmodulated wave provided there is no zero-frequency component in the modulating signal wave. For modulating signal waves having unequal positive and negative peak values both modulation factors must be given separately.*

FACTOR, MU—Mu factor is the ratio of the change in one electrode voltage to the change in another electrode voltage, under the conditions that a specified current remains unchanged and that all other electrode voltages are maintained constant. It is a measure of the relative effect of the voltages on two electrodes upon the current in the circuit of any specified electrode. *Note: As most precisely used, the term refers to infinitesimal changes.*

FADING—Fading is the variation of the signal intensity received at a given location from a radio transmitting station as a result of changes in the transmission media.

FIDELITY—Fidelity is the degree to which a system, or a portion of a system, accurately reproduces at its output the form of the signal which is impressed upon its input.

FILAMENT—A filament is a cathode of a thermionic tube, usually in the form of a wire or ribbon, to which heat may be supplied by passing current through it.

FLASHOVER—A flashover is a disruptive discharge around or over the surface of a solid or liquid insulator.

FOCUSING, ELECTROSTATIC—Electrostatic focusing is a method of focusing an electron stream in which focus is produced through the action of an electric field.

FOCUSING, GAS—Gas focusing is a method of focusing an electron stream in which focus is produced through the action of ionized gas.

FOCUSING, MAGNETIC—Magnetic focusing is a method of focusing an electron stream in which focus is produced through the action of a magnetic field.

FREQUENCY, AUDIO—An audio frequency is a frequency corresponding to a normally audible sound wave. *Note: Audio frequencies range roughly from 20 to 15,000 cycles per second.*

FREQUENCY, FUNDAMENTAL—A fundamental frequency is the lowest component frequency of a periodic quantity.

FREQUENCY, INTERMEDIATE—Intermediate frequency, in superheterodyne reception, is a frequency resulting from the combination of the received frequency and locally generated frequency and is usually equal to their difference.

FREQUENCY, RADIO—A radio frequency is a frequency usually higher than those corresponding to normally audible sound waves and lower than those corresponding to heat and light waves. *Note: The present practicable limits of radio frequency are roughly 10 kilocycles per second to 2,000 megacycles per second.*

FUSE—A fuse is an overcurrent protective device with a circuit opening fusible member directly heated and destroyed by the passage of overcurrent through it.

ELECTRON—An electron is the natural, elementary quantity of negative electricity. The quantity of electricity on an electron is 1.592×10^{-19} coulomb, or 4.774×10^{-10} electrostatic unit. The mass of an electron at rest is 9.00×10^{-28} gram.

GAUGE, VACUUM—The vacuum gauge is a device which indicates the absolute gas pressure in the evacuated parts of the rectifier. The absolute gas pressure is expressed in microns, one micron being the pressure which will support a column of mercury 1/1000 of a millimeter high. *Note: There are two types of vacuum gauges in common use: the McLeod type, which measures only the sum of the partial pressure of the uncondensed (or non-condensing gases); and the hot-wire type which measures the total pressure of all gases contained in the rectifier tank.*

GLOW, CATHODE (CROOKE'S DARK SPACE)—The cathode glow is the luminous glow which covers the surface of the cathode in a discharge tube, between the cathode and the cathode dark space.

GLOW, NEGATIVE—The negative glow is the luminous glow in a discharge tube between the cathode dark space and the Faraday dark space.

GRID—A grid is an electrode having one or more openings for the passage of electrons or ions.

GRID, CONTROL—A control grid is a grid, ordinarily placed between the cathode and an anode, for use as a control electrode.

GRID, SCREEN—A screen grid is a grid placed between a control grid and an anode, and usually maintained at a fixed positive potential, for the purpose of reducing the electrostatic influence of the anode in the space between the screen grid and the cathode.

GRID, SPACE-CHARGE—A space-charge grid is a grid which is placed adjacent to the cathode and positively biased so as to reduce the limiting effect of space charge on the current through the tube.

GRID, SUPPRESSOR—A suppressor grid is a grid which is interposed between two electrodes (usually the screen grid and plate), both positive with respect to the cathode, in order to prevent the passing of secondary electrons from one to the other.

GROUND—A ground is a conducting connection, whether intentional or accidental, between an electric circuit or equipment and earth, or to some conducting body which serves in place of the earth.

HARMONIC—A harmonic is a component of a periodic quantity which is an integral multiple of the fundamental frequency. For example, a component the frequency of which is twice the fundamental frequency is called the second harmonic.

HEATER—A heater is an electric heating element for supplying heat to an indirectly heated cathode.

HEPTODE—A heptode is a seven-electrode vacuum tube containing an anode, a cathode, a control electrode and four additional electrodes ordinarily in the nature of grids.

HEXODE—A hexode is a six-electrode vacuum tube containing an anode, a cathode, a control electrode and three additional electrodes ordinarily in the nature of grids.

IMPEDANCE, ELECTRODE—Electrode impedance is the reciprocal of the electrode admittance.

INDUCTANCE—Inductance is the (scalar) property of an electric circuit, or of two neighboring circuits, which determines the electromotive force induced in one of the circuits by a change of current in either of them.

ION—An ion is an electrified portion of matter of subatomic, atomic or molecular dimensions.

IONIZATION—Ionization is the process of producing ions.

KVA, RATED—The rated kva of a transformer is the output which can be delivered for the time specified at rated secondary voltage and rated frequency without exceeding the specified temperature limitations.

MODULATION—Modulation is the process whereby the amplitude (or other characteristic) of a wave is varied as a function of the instantaneous value of another wave. The first wave, which is usually a single-frequency wave, is called the "carrier wave"; the second wave is called the "modulating wave".

MODULATION, CROSS—Cross modulation is a type of intermodulation due to modulation of the carrier of the desired signal by an undesired signal wave.

MODULATOR—A modulator is a device to effect the process of modulation. It may be operated by virtue of some non-linear characteristics or by a controlled variation of some circuit quantity.

MODULATOR, MAGNETIC—A magnetic modulator is a modulator employing a magnetic circuit as the modulating element.

MODULATOR, VACUUM TUBE—A vacuum tube modulator is a modulator employing a vacuum tube as the modulating element.

OCTODE—An octode is an eight-electrode vacuum tube containing an anode, a cathode, a control electrode and five additional electrodes ordinarily in the nature of grids.

OSCILLATION—Oscillation is applied to the state of a physical quantity when, in the time interval under consideration, the value of the quantity is continually changing in such a manner that it passes through the maxima and minima. Examples: Oscillating pendulum, oscillating electric current, oscillating electromotive force. *Note: Vibration is sometimes used synonymously with oscillation, but is more properly applied to the motion of a mechanical system in which the motion is in part determined by the elastic properties of the body.*

OSCILLATOR, MASTER—A master oscillator is an oscillator of comparatively low power so arranged as to establish the carrier frequency of the output of an amplifier.

OSCILLOSCOPE—An oscilloscope is an instrument for making visible the presence and/or the nature and form of oscillations or irregularities of an electric current. *Note: There are several different types of instrument serving this general purpose which have been designated by this name.*

PENTODE—A pentode is a five-electrode vacuum tube containing an anode, a cathode, a control electrode and two additional electrodes ordinarily in the nature of grids.

PHOTOTUBE (PHOTOELECTRIC TUBE)—A phototube is a vacuum tube in which one of the electrodes is irradiated for the purpose of causing electron emission from that electrode.

PLATE—Plate is a common name for the principal anode in a vacuum tube.

POWER, GRID DRIVING—Grid driving power is the average product of the instantaneous value of the grid current and the alternating component of the grid voltage over a complete cycle. *Note: This comprises the power supplied to the biasing device and the grid dissipation.*

PROTON—A proton is the natural, elementary quantity of positive electricity when associated with a mass of atomic magnitude. The mass of the proton is 1847 times the mass of the electron; i.e., 1.662×10^{-24} gram. The quantity of positive electricity on the proton is numerically equal to the quantity of negative electricity on the electron.

RATING—A rating of a machine, apparatus or device is a designated limit of operating characteristics based on definite conditions. *Note: Such operating characteristics as load, voltage, frequency, etc., may be given in the rating.*

RECEPTION, AUTODYNE—Autodyne reception is a system of heterodyne reception through the use of a device which is both an oscillator and a detector.

RECEPTION, HETERODYNE—Heterodyne reception is the process of receiving radio waves by combining in a non-linear circuit element a received radio-frequency voltage (or group of voltages resulting from modulation) with a locally generated alternating voltage, with the result that in the output there are frequencies equal to the sum and difference of the combining frequencies. If the received waves are continuous waves of constant amplitude, as in telegraphy, it is customary to adjust the locally generated frequency so that the difference frequency is audible. If the received waves are modulated the locally generated frequency is generally such that the difference frequency is superaudible and an additional operation is necessary if the original signal wave is to be reproduced.

RECEPTION, HOMODYNE—Homodyne reception is a system of reception by the aid of a locally generated voltage of carrier frequency. (Homodyne reception is sometimes called zero-beat reception.)

RECEPTION, SUPERHETERODYNE—Superheterodyne reception is a method of receiving radio waves in which the process of heterodyne reception is used to convert the voltage of the received wave into a voltage of an intermediate, but usually superaudible, frequency, which at the intermediate frequency is then detected with or without amplification.

RECTIFICATION—Rectification is the conversion of alternating current into unidirectional current by means of electric valves.

RECTIFICATION, FULL-WAVE—Full-wave rectification is rectification in which both halves of the alternating-current cycle are transmitted as unidirectional current.

RECTIFICATION, HALF-WAVE—Half-wave rectification is rectification permitting only one-half of the alternating-current cycle to be transmitted as unidirectional current.

RECTIFIER—A rectifier is a device which converts alternating current into unidirectional current by virtue of a characteristic permitting appreciable flow of current in only one direction.

RECTIFIER, FULL-WAVE—A full-wave rectifier is a double element rectifier which allows unidirectional current to pass to the load circuit during each half cycle of the alternating-current supply, one element functioning during positive half cycles and the other during negative half cycles.

RECTIFIER, HALF-WAVE—A half-wave rectifier is a rectifer which changes alternating current into pulsating current, utilizing only one-half of each cycle.

RECTIFIER, LINEAR—A linear rectifier is a rectifier the output current or voltage of which contains a wave having a form identical with that of the envelope of an impressed signal wave.

REGENERATION—Regeneration is the process by which a part of the power in the output circuit of an amplifying device reacts upon the input circuit in such a manner as to reinforce the initial power, thereby increasing the amplication. (This is sometimes called feed-back or reaction.)

RELAY—A relay is an electromechanical device by means of which a change of current or potential in one circuit can be made to produce a change in the electrical condition of another circuit.

RESISTANCE, ELECTRODE—Electrode resistance is the reciprocal of the electrode conductance.

RESISTIVITY—The resistivity of a material is the reciprocal of its conductivity.

RESONANCE, PARALLEL—Parallel (phase) resonance is the steady-state condition which exists in a circuit comprising inductance and capacitance connected in parallel, when the current entering the circuit from the supply line is in phase with the voltage across the circuit.

RESONANCE, SERIES—Series (phase) resonance is the steady-state condition which exists in a circuit comprising inductance and capacitance connected in series, when the current in the circuit is in phase with the voltage across the circuit.

SENSITIVITY, DEFLECTION—The deflection sensitivity of a cathode-ray oscillograph tube is the quotient of the displacement of the electron beam at the place of impact by the change in the deflecting field. *Note: It is usually expressed in millimeters per volt applied between the deflection electrodes, or in millimeters per gauss of the deflecting magnetic field.*

SIDEBANDS—Sidebands are the frequency bands on either side of the carrier frequency within which fall the frequencies of the waves produced by the process of modulation. Usually the width of a transmitted sideband is limited to a band width no greater than the band width of the modulating wave.

SIDETONE—Sidetone is the transmission and reproduction of sounds through a local path from the transmitter to the receiver of the same telephone station.

SPACE, CATHODE DARK—The cathode dark space is the relatively non-luminous region in a discharge tube between the cathode glow and the negative glow.

SPACE, FARADAY DARK—The Faraday dark space is the relatively non-luminous region in a discharge tube between the negative glow and the positive column.

SUBHARMONIC—A subharmonic is a sinusoidal quantity having a frequency which is an integral submultiple of the frequency of some other sinusoidal phenomenon to which it is referred. For example, a wave the frequency of which is half the fundamental frequency of another wave is called the second subharmonic of that wave.

SUPPLY, FILAMENT POWER—The filament power supply for a thermionic vacuum tube is the means for supplying and delivering power with proper regulation to the filament for the heating of the filament. *Note: This term is also applied to the means for supplying power to the heaters of tubes of the unipotential cathode type.*

SUPPLY, GRID VOLTAGE—The grid voltage supply of a thermionic vacuum tube is the means for supplying and applying with proper regulation a potential to the grid of the vacuum tube, which is usually negative with respect to the cathode.

SUPPLY, PLATE POWER—The plate power supply of a thermionic vacuum tube is the means for supplying power to the plate of the vacuum tube at a properly regulated voltage which is usually positive with respect to the cathode.

TELEGRAPHY, CARRIER—Carrier telegraphy is that form of telegraphy in which, in order to form the transmitted signals, alternating current is supplied to the line after being modulated under the control of the transmitting apparatus.

TELEPHONY, CARRIER—Carrier telephony is that form of telephony in which carrier transmission is used, the modulating wave being a voice-frequency wave. This term is ordinarily applied only to wire telephony.

TELEGRAPHY, VOICE-FREQUENCY CARRIER — Voice-frequency carrier telegraphy is that form of carrier telegraphy in which the carrier currents have frequencies such that the modulated currents may be transmitted over a voice-frequency telephone channel.

TELEPHONY, VOICE-FREQUENCY—Voice-frequency telephony is that form of telephony in which the frequencies of the components of the transmitted electric waves are substantially the same as the frequencies of corresponding components of the actuating acoustical waves. This type of electric wave is called a "voice-frequency electric wave."

TELEVISION—Television is the electric transmission and reception of transient visual images, in such a way as to give a substantially continuous and simultaneous reproduction to the eye at a distance.

TEMPERATURE, AMBIENT—Ambient temperature is the temperature of the surrounding cooling medium, such as gas or liquid, which comes into contact with the heated parts of the apparatus.

TETRODE—A tetrode is a four-electrode vacuum tube containing an anode, a cathode, a control electrode and one additional electrode ordinarily in the nature of a grid.

TIME, CATHODE HEATING—Cathode heating time is the time required for the cathode to attain operating temperature with normal voltage applied to the heating element.

TIME, TUBE HEATING—Tube heating time in a mercury-vapor tube is the time required for the coolest portion of the tube to attain operating temperature.

TOLERANCE—The frequency tolerance of a radio transmitter is the extent to which the frequency of a transmitter may be permitted to vary above or below the frequency assigned.

TRANSADMITTANCE—Transadmittance from one electrode to another is the quotient of the alternating component of the current of the second electrode by the alternating component of the voltage of the first electrode, all other electrode voltages being maintained constant. *Note: As most precisely used, the term refers to infinitesimal amplitudes.*

TRANSCONDUCTANCE—Transconductance from one electrode to another is the quotient of the in-phase component of the alternating current of the second electrode by the alternating voltage of the first electrode, all other electrode voltages being maintained constant.

TRANSCONDUCTANCE, CONTROL-GRID—PLATE—Control-grid—plate transconductance is the name for the plate current to control-grid voltage transconductance. *Note: This is ordinarily the most important transconductance and is commonly understood when the term conductance or mutual conductance is used.*

TRANSMISSION, FACSIMILE—Facsimile transmission is the electric transmission of a graphic record having a limited number of shade values.

TRANSMISSION, PICTURE—Picture transmission is the electric transmission of a picture having a gradation of shade values.

TRANSMISSION, RADIO—Radio transmission is the transmission at radio frequencies of signals by means of radiated electromagnetic waves.

TRANSRECTIFIER—A transrectifier is a device, ordinarily a vacuum tube, in which rectification occurs in one electrode circuit when an alternating voltage is applied to another electrode.

TRIODE—A triode is a three-electrode vacuum tube containing an anode, a cathode and a control electrode.

TUBE, CATHODE-RAY—A cathode-ray tube is a discharge tube with a thin window at the end opposite the cathode to allow the cathode rays to pass outside.

TUBE, CATHODE-RAY OSCILLOGRAPH—A cathode-ray oscillcgraph tube is a vacuum tube in which the deflection of an electron beam, effected by means of applied electric and/or magnetic fields, indicates the instantaneous values of the actuating voltages and/or currents.

TUBE, CROOKES—Crookes tube is an early form of discharge tube devised by Sir William Crookes and used by him for the study of cathode rays. *Note: The density of gas is roughly one-millionth that of the atmosphere.*

TUBE, DISCHARGE—A discharge tube is an evacuated enclosure containing a gas at low pressure which permits the passage of electricity through the gas upon application of sufficient voltage. *Note: The tube is usually provided with metal electrodes, but one form permits an electrodeless discharge with induced voltage.*

TUBE, GAS—A gas tube is a vacuum tube in which the pressure of the contained gas or vapor is such as to affect substantially the electrical characteristics of the tube.

TUBE, GEISSLER — A Geissler tube is a special form of discharge tube for showing the luminous effects of discharges through rarefied gases. *Note: The density of gas is roughly one-thousandth of that of the atmosphere.*

TUBE, HIGH-VACUUM—A high-vacuum tube is a vacuum tube evacuated to such a degree that its electrical characteristics are essentially unaffected by gaseous ionization.

TUBE, HOT-CATHODE—Hot-cathode tube is a vacuum tube in which the cathode is electrically heated (usually to incandescence) in order to increase the emission of electrons.

TUBE, MERCURY-VAPOR—A mercury-vapor tube is a gas tube in which the active contained gas is mercury vapor.

TUBE, MULTIPLE-UNIT—A multiple-unit tube is a vacuum tube containing within one envelope two or more groups of electrodes associated with the independent electron streams. *Note: A multiple-unit tube may be so indicated, as, for example: duodiode, duotriode, diode-pentode, duodiode-triode, duodiode-pentode and triode-pentode.*

TUBE, THERMIONIC—A thermionic tube is a vacuum tube in which one of the electrodes is heated for the purpose of causing electron or ion emission from that electrode.

TUBE, VACUUM—A vacuum tube is a device consisting of an evacuated enclosure containing a number of electrodes between two or more of which conduction of electricity through the vacuum or contained gas may take place.

TUBE, X-RAY—An x-ray tube is a vacuum tube designed for producing x-rays by accelerating electrons to a high velocity by means of an electrostatic field and then suddenly stopping them by collision with a target.

TUBE, VALVE—A valve tube is an electric valve consisting of a vacuum tube having for one electrode a hot filament.

TUBE, X-RAY GAS—A gas x-ray tube is an x-ray tube in which the emission of electrons from the cathode is produced by positive ion bombardment.

TUNING—Tuning is the adjustment in relation to frequency of a circuit or system to secure optimum performance; commonly the adjustment of a circuit or circuits to resonance.

VOLTAGE, ELECTRODE—Electrode voltage is the voltage between an electrode and a specified point of the cathode.

VOLTAGE, FILAMENT—Filament voltage is the voltage between the terminals of a filament.

VOLTAGE, CRITICAL GRID—Critical grid voltage in a gas tube is the instantaneous value of grid voltage when the anode current starts to flow.

VOLTAGE, HEATER—Heater voltage is the voltage between the terminals of a heater.

VOLTAGE, PEAK (OR CREST) FORWARD ANODE—Peak (or crest) forward anode voltage is the maximum instantaneous anode voltage in the direction in which the tube is designed to pass current.

VOLTAGE, PEAK (OR CREST) INVERSE ANODE—Peak (or crest) inverse anode voltage is the maximum instantaneous anode voltage in the direction opposite to that in which the tube is designed to pass current.

WAVE, CARRIER—A carrier wave is a wave having those characteristics which are essential in order that the modulated wave may be transmitted through a particular physical system.

WAVES, INTERRUPTED CONTINUOUS — Interrupted continuous waves are obtained from continuous waves by interrupting them in a substantially periodic manner.

WAVE, MODULATED—A modulated wave is a combination of two or more waves which results in the production of frequencies not present in the original waves, these new frequencies being ordinarily made up of sums and differences of integral multiples of the frequencies present in the original waves. As an example a modulated wave which is a combination of a carrier wave and a signal wave is employed to transmit signals or speech through a particular physical system. In this case the frequency of the modulated wave is usually taken as the frequency of the carrier wave.

WAVES, TELEGRAPH-MODULATED—Telegraph-modulated waves are continuous waves, the amplitude or frequency of which is varied by means of telegraphic keying.

WAVES, TONE-MODULATED—Tone-modulated waves are waves obtained from continuous waves by modulating them at audio-frequency in a substantially periodic manner.

WAVELENGTH, UNITS OF—Spectral radiant-energy measurements necessitate some statements as to the unit of wavelength used, since four different units are in use, as shown in the table.

WAVELENGTH UNITS

Name	Abbreviation	Value
Micron	μ	$1\ \mu = 10^{-3}$ mm.
Millimicron	$m\mu$	$1\ m\mu = 10^{-6}$ mm.
Angstrom	A	1 A $= 10^{-7}$ mm.
X-unit	X U	1 X U $= 10^{-10}$ mm.

Note: It was formerly thought satisfactory to express wavelength in microns, but if this unit is used, the wavelengths of the entire visible and ultra-violet spectrum are expressed by fractions. To avoid the use of fractions many authors express wavelengths in millimicrons. Using this unit, the wavelengths of the visible spectrum are expressed by three figures before the decimal point. For most work in radiation measurements, wavelengths expressed by three figures seem to be accurate enough, but some workers express wavelengths in angstrom units in all cases; hence it seems impossible to get unity of action even among workers in radiation measurements. The spectroscopist uses angstrom units for all of his work except in the x-ray region, where the unit XU (XU = 0.001A) is often used.

WIDTH, BAND—The band width of a frequency band is the number of cycles per second expressing the difference between its limiting frequencies.

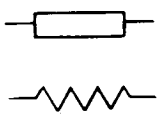
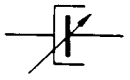
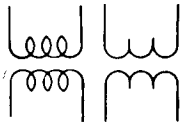
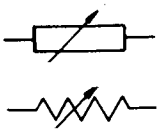
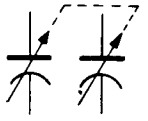
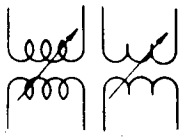
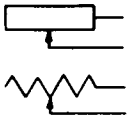
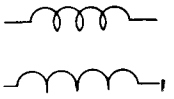
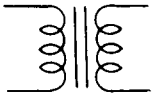
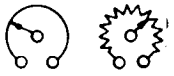
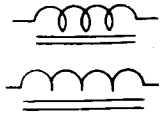
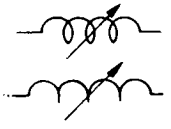
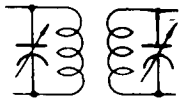
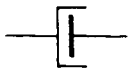
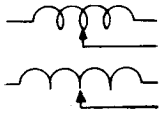
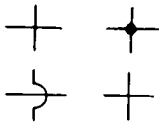
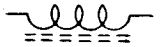
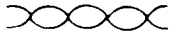
UNITED ELECTRONICS

ELECTRICAL CIRCUIT SYMBOLS

The standardization of circuit symbols for electrical components has been a long felt need. The independent development of graphical symbols by communication engineers, on the one hand, and by power, control, and measurement engineers, on the other, led to confusing and possible dangerous wiring and maintenance situations. Thus, the zigzag symbol indicated either a resistor or an inductor and a symbol composed of two short parallel lines represented either a condenser or a contactor. This situation was especially unfortunate in the case of electronic equipment which of course is used in industry as well as in communications. Also, in many industries, electrical equipment is manufactured by both power and communications manufacturers.

The solution to this dilemma was inaugurated by the A.I.E.E. publication of standardized symbols for the conflicting fields. This project was sponsored by the American Institute of Electrical Engineers and the American Society of Mechanical Engineers. The symbols were approved as an American Standard by the American Standards Association.

The symbols listed in the following tabulation represent a compromise arrangement effected in March, 1944 between the communications, and the power, control, and measurement fields. It also includes symbols which have not as yet been coordinated for these fields.

Fixed Resistor 	Variable Condenser, Shielded 	Air Core Transformer, or Inductively Coupled Coils 
Variable Resistor 	Variable Condensers, Ganged 	Air Core Transformer, or Inductively Coupled Coils (Coupling Variable) 
Resistance, Rheostat or Potentiometer, Adjustable (in steps) 	Inductor or Reactor 	Iron Core Transformer 
Rheostat 	Inductor or Reactor, Iron Core 	Link Coupled Coils
Fixed Condenser	Inductor or Reactor, Variable 	Tuned Air Core Transformer 
Fixed Condenser, Shielded 	Inductor or Reactor, Adjustable (in steps) 	Wiring Diagram Devices: Top Symbol— Wires Connected, Bottom Symbol— No Connection 
Variable Condenser	Inductor or Reactor, Powdered Iron Core 	Twisted-Pair Cable 

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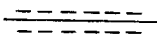
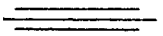
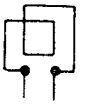
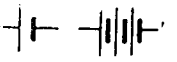
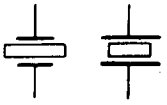
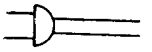
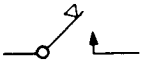
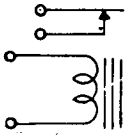
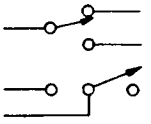
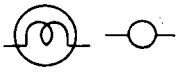
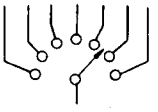
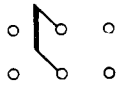
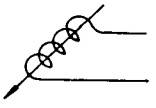
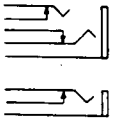
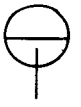
Shielded Conductor 	Antenna	Power Switch
Coaxial Cable 	Counterpoise	Fuse
Shielding	Loop Antenna 	Dry Cell or Battery (long line denotes positive terminal) 
Piezoelectric Plate and Mounting 	Ground	A-C Plug for power outlet 
Rectifier— Crystal Detector	Key 	A-C Receptacle
Relay 	Switch, single-pole double-throw 	Thermionic Cathode
Lamp 	Switch, rotary 	Cathode, Cold Discharge
Arc	Switch, double-pole doube-throw 	Cathode, Photoemissive
Phonograph **Pick-up** 	Jacks 	Cathode, Pool Type 
Thermoelement	Plug	Filament-Thermionic Cathode

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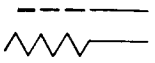
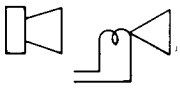
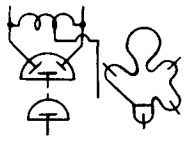
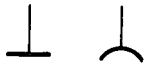
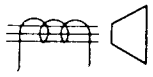
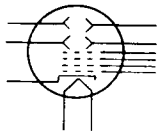
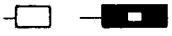
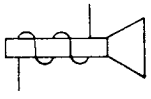
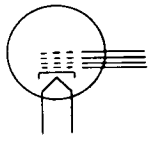
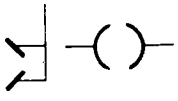
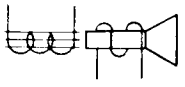
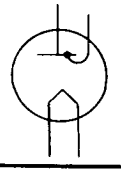
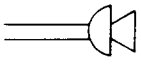
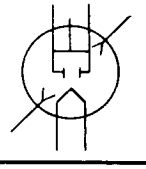
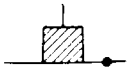
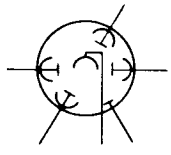
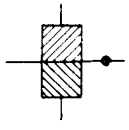
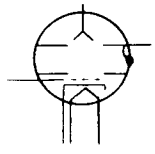
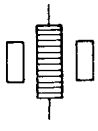
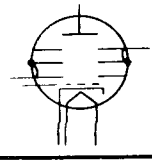
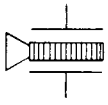
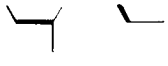
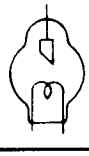
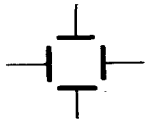
Grid 	Loudspeaker 	Mercury Arc Rectifier 
Plate or Anode 	Loudspeaker magnetic 	Cathode-Ray Tube—Electrostatic Deflection 
Plate or Anode 	Loudspeaker, permanent magnet 	Cathode-Ray Tube—Magnetic Deflection 
Beam Forming Electrodes 	Loudspeaker, electrodynamic 	Magnetron, Resonant (with electro-magnetic loop coupling) 
Microphone 	Envelope or shell (general)	Magnetron, Transit-time (with stabilizing electrodes) 
Microphone, Single Button Carbon 	Shell with contact	Phototube Multiplier 
Microphone, Double Button Carbon 	Envelope or Shell, gas filled	Velocity-Modulation tube, Single cavity (with reflecting electrode) 
Microphone, Ribbon or velocity 	Envelope or Shell—Shielding indicated by dotted line	Velocity-Modulation tube, Double cavity (with collecting electrode) 
Microphone, Crystal 	Target Electrodes 	Beam Tube
Telephone headset	X-Ray Tube 	Deflecting Plates 

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FREQUENCY CONVERSION

(Meters to Kilocycles and Megacycles)

Meters	Kc.	Mc.	Meters	Kc.	Mc.
1	300,000	300.0	51	5,882	5.88
2	150,000	150.0	52	5,769	5.76
3	100,000	100.0	53	5,660	5.66
4	75,000	75.0	54	5,555	5.55
5	**60,000**	**60.0**	**55**	**5,454**	**5.45**
6	50,000	50.0	56	5,357	5.35
7	42,857	42.8	57	5,263	5.26
8	37,500	37.5	58	5,172	5.17
9	33,333	33.3	59	5,048.7	5.04
10	**30,000**	**30.0**	**60**	**5,000**	**5.00**
11	27,272	27.27	61	4,918	4.91
12	25,000	25.00	62	4,838	4.83
13	23,076	23.07	63	4,761	4.76
14	21,428	21.42	64	4,687	4.68
15	**20,000**	**20.0**	**65**	**4,615**	**4.61**
16	18,750	18.75	66	4,545	4.54
17	17,647	17.64	67	4,477	4.47
18	16,666	16.66	68	4,411	4.41
19	15,789	15.78	69	4,347	4.34
20	**15,000**	**15.00**	**70**	**4,285**	**4.28**
21	14,285	14.28	71	4,225	4.22
22	13,636	13.63	72	4,166	4.16
23	13,043	13.04	73	4,109	4.10
24	12,500	12.50	74	4,054	4.05
25	**12,000**	**12.0**	**75**	**4,000**	**4.00**
26	11,538	11.53	76	3,947	3.94
27	11,111	11.11	77	3,896	3.89
28	10,714	10.7	78	3,846	3.84
29	10,344	10.34	79	3,797	3.79
30	**10,000**	**10.0**	**80**	**3,750**	**3.75**
31	9,677	9.67	81	3,703	3.70
32	9,375	9.37	82	3,659	3.65
33	9,090	9.09	83	3,614	3.61
34	8,823	8.82	84	3,571	3.57
35	**8,571**	**8.57**	**85**	**3,529**	**3.52**
36	8,333	8.33	86	3,488	3.48
37	8,108	8.10	87	3,448	3.44
38	7,894	7.89	88	3,409	3.40
39	7,692	7.69	89	3,370	3.37
40	**7,500**	**7.50**	**90**	**3,333**	**3.33**
41	7,317	7.31	91	3,296	3.29
42	7,142	7.14	92	3,260	3.26
43	6,976	6.97	93	3,225	3.22
44	6,818	6.81	94	3,191	3.19
45	**6,666**	**6.66**	**95**	**3,157**	**3.15**
46	6,521	6.52	96	3,124	3.12
47	6,382	6.38	97	3,092	3.09
48	6,250	6.25	98	3,061	3.06
49	6,122	6.12	99	3,030	3.03
50	**6,000**	**6.00**	**100**	**3,000**	**3.00**

UNITED ELECTRONICS

TEMPERATURE CONVERSION TABLE

Centigrade - Fahrenheit

° C	° F	° C	° F	° C	° F	° C	° F	° C	° F
0	32.0	46.0	114.8	91.0	195.8	136.0	276.8	181.0	357.8
1.0	33.8	47.0	116.6	92.0	197.6	137.0	278.6	182.0	359.6
2.0	35.6	48.0	118.4	93.0	199.4	138.0	280.4	183.0	361.4
3.0	37.4	49.0	120.2	94.0	201.2	139.0	282.2	184.0	363.2
4.0	39.2	**50.0**	**122.0**	**95.0**	**203.0**	**140.0**	**284.0**	**185.0**	**365.0**
5.0	**41.0**	51.0	123.8	96.0	204.8	141.0	285.8	186.0	366.8
6.0	42.8	52.0	125.6	97.0	206.6	142.0	287.6	187.0	368.6
7.0	44.6	53.0	127.4	98.0	208.4	143.0	289.4	188.0	370.4
8.0	46.4	54.0	129.2	99.0	210.2	144.0	291.2	189.0	372.2
9.0	48.2	**55.0**	**131.0**	**100.0**	**212.0**	**145.0**	**293.0**	**190.0**	**374.0**
10.0	**50.0**	56.0	132.8	101.0	213.8	146.0	294.8	191.0	375.8
11.0	51.8	57.0	134.6	102.0	215.6	147.0	296.6	192.0	377.6
12.0	53.6	58.0	136.4	103.0	217.4	148.0	298.4	193.0	379.4
13.0	55.4	59.0	138.2	104.0	219.2	149.0	300.2	194.0	381.2
14.0	57.2	**60.0**	**140.0**	**105.0**	**221.0**	**150.0**	**302.0**	**195.0**	**383.0**
15.0	**59.0**	61.0	141.8	106.0	222.8	151.0	303.8	196.0	384.8
16.0	60.8	62.0	143.6	107.0	224.6	152.0	305.6	197.0	386.6
17.0	62.6	63.0	145.4	108.0	226.4	153.0	307.4	198.0	388.4
18.0	64.4	64.0	147.2	109.0	228.2	154.0	309.2	199.0	390.2
19.0	66.2	**65.0**	**149.0**	**110.0**	**230.0**	**155.0**	**311.0**	**200.0**	**392.0**
20.0	**68.0**	66.0	150.8	111.0	231.8	156.0	312.8	201.0	393.8
21.0	69.8	67.0	152.6	112.0	233.6	157.0	314.6	202.0	395.6
22.0	71.6	68.0	154.4	113.0	235.4	158.0	316.4	203.0	397.4
23.0	73.4	69.0	156.2	114.0	237.2	159.0	318.2	204.0	399.2
24.0	75.2	**70.0**	**158.0**	**115.0**	**239.0**	**160.0**	**320.0**	**205.0**	**401.0**
25.0	**77.0**	71.0	159.8	116.0	240.8	161.0	321.8	206.0	402.8
26.0	78.8	72.0	161.6	117.0	242.6	162.0	323.6	207.0	404.6
27.0	80.6	73.0	163.4	118.0	244.4	163.0	325.4	208.0	406.4
28.0	82.4	74.0	165.2	119.0	246.2	164.0	327.2	209.0	408.2
29.0	84.2	**75.0**	**167.0**	**120.0**	**248.0**	**165.0**	**329.0**	**210.0**	**410.0**
30.0	**86.0**	76.0	168.8	121.0	249.8	166.0	330.8	215.0	419.0
31.0	87.8	77.0	170.6	122.0	251.6	167.0	332.6	220.0	428.0
32.0	89.6	78.0	172.4	123.0	253.4	168.0	334.4	225.0	437.0
33.0	91.4	79.0	174.2	124.0	255.2	169.0	335.2	230.0	446.0
34.0	93.2	**80.0**	**176.0**	**125.0**	**257.0**	**170.0**	**338.0**	235.0	455.0
35.0	**95.0**	81.0	177.8	126.0	258.8	171.0	339.8	240.0	464.0
36.0	96.8	82.0	179.6	127.0	260.6	172.0	341.6	245.0	473.0
37.0	98.6	83.0	181.4	128.0	262.4	173.0	343.4	**250.0**	**482.0**
38.0	100.4	84.0	183.2	129.0	264.2	174.0	345.2		
39.0	102.2	**85.0**	**185.0**	**130.0**	**266.0**	**175.0**	**347.0**		
40.0	**104.0**	86.0	186.8	131.0	267.8	176.0	348.8		
41.0	105.8	87.0	188.6	132.0	269.6	177.0	350.6		
42.0	107.6	88.0	190.4	133.0	271.4	178.0	352.4		
43.0	109.4	89.0	192.2	134.0	273.2	179.0	354.2		
44.0	111.2	**90.0**	**194.0**	**135.0**	**275.0**	**180.0**	**356.0**		
45.0	**113.0**								

CONVERSIONS

Inches - Millimeters

Inches		Millimeters	Inches		Millimeters
0.03937	=	1	1	=	25.4001
0.07874	=	2	2	=	50.8001
0.11811	=	3	3	=	76.2002
0.15748	=	4	4	=	101.6002
0.19658	=	5	5	=	127.0003
0.23622	=	6	6	=	152.4003
0.27559	=	7	7	=	177.8004
0.31496	=	8	8	=	203.2004
0.35433	=	9	9	=	228.6005

METRIC PREFIXES

Mega -	=	1,000,000	=	10^{6}	Centi -	=	1/100	=	10^{-2}
Myria -	=	10,000	=	10^{4}	Milli -	=	1/1,000	=	10^{-3}
Kilo -	=	1,000	=	10^{3}	Micro -	=	1/1,000,000	=	10^{-6}
Hecto -	=	100	=	10^{2}	Millimicro -	=	1/1,000,000,000	=	10^{-9}
Deka -	=	10	=	10^{1}	Micromicro -	=	1/1,000,000,000,000	=	10^{-12}
Deci -	=	.1	=	10^{-1}					

UNITED ELECTRONICS

TEMPERATURE PROPERTIES OF MATERIALS

Material	Symbolic Composition	Resistivity at 20° C.	Temperature Coefficient At 20° C.	Melting Point ° C.	Boiling Point ° C.
Advance	55% Cu, 45% Ni	48.8	0.000018	1260	.....
Aluminum	Al	2.83	0.0039	660	1800
Antimony	Sb	41.7	0.0036	630	1440
Bismuth	Bi	119	0.004	271	1450
Brass (Spring)	67% Cu, 33% Zn	7	0.002	965	.....
Cadmium	Cd	7.6	0.0038	320.9	770
Chromium	Cr	2.6 (0° C.)	.....	1615	2200
Constantan	60% Cu, 40% Ni	49	0.000008	1280	.....
Copper, (annealed standard)	Cu	1.724	0.00393	1083	2310
Gold	Au	2.44	0.0034	1063	2600
Ia Ia	60% Cu, 40% Ni	49	0.000005	1230	.....
Iridium	Ir	1.92 (186° C.)	0.00411	2350	74800
Iron, Commercial	Fe	11-13.5	0.0055	1535	3000
Lead	Pb	22	0.0039	327.2	1620
Magnesium	Mg	4.6	0.004	651	1110
Manganese	Mn	5.0	.....	1260	1900
Manganin	84% Cu, 12% Mn, 4% Ni	42-74	0.00003	910	.....
Mercury	Hg	96	0.00089	—38.87	356.9
Molybdenum	Mo	5.7	0.0033	2620 ±10	3700
Nichrome	60% Ni, 24% Fe, 16% Cr, 0.1% C	99.6	0.00044	1350	.....
Nickel	Ni	7.8	0.0048	1452	2900
Platinum	Pt	10	0.003	1755	4300
Rhodium	Rh	4.69 (0° C.)	0.00443	1955	72500
Silver	Ag	1.6	0.0038	960.5	1950
Tantalum	Ta	15.5	0.0031	2850	74100
Thorium	Th	40.1 (0° C.)	0.0021	1845	73000
Tin	Sn	11.5	0.0042	231.85	2260
Titanium	Ti	3.2	.....	1800	73000
Tungsten	W	5.51	0.0051	3370	5900
Zinc	Zn	6.3	0.004	419.4	907
Zirconium	Zr	41	0.0044	1700	72900

DIELECTRIC STRENGTHS

Material	Dielectric Strength in Kilovolts per Meter (Average)
Air	3,000
Bakelite	21,000
Ebonite	70,000
Glass	35,000
Gutta percha	14,000
Lava	4,000
Mica	50,000
Paraffin	29,000
Polystrene	30,000
Porcelain	10,000
Pyranol	20,000
Rubber	70,000
Steatite	8,000
Transit Oil	10,000

DIELECTRIC CONSTANTS

Material	Dielectric Constant (Average)
Acetone	26.6
Air (0°C., 760 mm)	1.0006
Alcohol (0° C.)	
amyl	17.4
ethyl	28.4
methyl	35
Ammonia	22
Bakelite	5
Benzene	2.3
Ebonite	2.7
Glass	
flint	9.9
hard crown	7.0
lead	6.6
Glycerine	56.2
Gutta percha	4.1
Lava	5
Mica	5.8
Paraffin	2.1
Petroleum	2.1
Polystyrene	2.6
Porcelain	6
Pyranol	5
Quartz	5
Rubber	2.5
Shellac	3.1
Steatite	6
Transit Oil	2.5
Water (pure)	81

DRILL SIZES

LETTER SIZES OF DRILLS

Diameter Inches	Decimals of 1 inch	Diameter Inches	Decimals of 1 inch	Diameter Inches	Decimals of 1 inch
A 15/64	.234	J	.277	S	.348
B	.238	K 9/32	.281	T 23/64	.358
C	.242	L	.290	U	.368
D	.246	M 19/64	.295	V 3/8	.377
E 1/4	.250	N	.302	W 25/64	.386
F	.257	O 5/16	.316	X	.397
H 17/64	.261	P 21/64	.323	Y 18/32	.404
G	.266	Q	.332	Z	.413
I	.272	R 11/32	.339		

DECIMAL EQUIVALENTS

8ths:

1	=	.125	
3	=	.375	
5	=	.625	
7	=	.875	

16ths:

1	=	.0625	
3	=	.1875	
5	=	.3125	
7	=	.4375	
9	=	.5625	
11	=	.6875	
13	=	.8125	
15	=	.9375	

32nds:

1	=	.03125	
3	=	.09375	
5	=	.15625	
7	=	.21875	
9	=	.28125	
11	=	.34375	
13	=	.40625	
15	=	.46875	
17	=	.53125	
19	=	.59375	
21	=	.65625	
23	=	.71875	
25	=	.78125	
27	=	.84375	
29	=	.90625	
31	=	.96875	

64ths:

1	=	.015625	
3	=	.046875	
5	=	.078125	
7	=	.109375	
9	=	.140625	
11	=	.171875	
13	=	.203125	
15	=	.234375	
17	=	.265625	
19	=	.296875	
21	=	.328125	
23	=	.359375	
25	=	.390625	
27	=	.421875	
29	=	.453125	
31	=	.484375	
33	=	.515625	
35	=	.546875	
37	=	.578125	
39	=	.609375	
41	=	.640625	
43	=	.671875	
45	=	.703125	
47	=	.734375	
49	=	.765625	
51	=	.796875	
53	=	.828125	
55	=	.859375	
57	=	.890625	
59	=	.921875	
61	=	.953125	
63	=	.984375	

UNITED ELECTRONICS

Resistance of International Standard Annealed Copper Wire

American Wire Gauge (B. & S.)

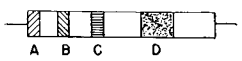
B. & S. Gauge No.	Diameter in Mils, d	Area in Circular Mils d^2	Ohms per 1000 ft. at 20° C. or 68° F.	Pounds per 1000 ft.
0000	460.00	211,600	0.04901	640.5
000	409.64	167,810	0.06180	508.0
00	364.80	133,080	0.07793	402.8
0	324.86	105,530	0.09827	319.5
1	289.30	83,694	0.1239	253.3
2	257.63	66,373	0.1563	200.9
3	229.42	52,634	0.1970	159.3
4	204.31	41,742	0.2485	126.4
5	181.94	33,102	0.3133	100.2
6	162.02	26,250	0.3951	79.46
7	144.28	20,816	0.4892	63.21
8	129.49	16,509	0.6282	50.13
9	114.43	13,094	0.7921	39.75
10	101.89	10,381	0.9989	31.43
11	90.742	8,234.0	1.260	24.93
12	80.808	6,529.9	1.588	19.77
13	71.961	5,178.4	2.003	15.68
14	64.084	4,106.8	2.525	12.43
15	57.068	3,256.7	3.184	9.858
16	50.820	2,582.9	4.016	7.818
17	45.257	2,048.2	5.064	6,200
18	40.303	1,624.3	6.385	4.917
19	35.890	1,288.1	8.051	3.899
20	31.961	1,021.5	10.15	3.092
21	28.462	810.10	12.80	2.452
22	25.347	642.40	16.14	1.945
23	22.571	509.45	20.36	1.542
24	20.100	404.01	25.67	1.223
25	17.900	320.40	32.37	0.9699
26	15.940	254.10	40.81	0.7692
27	14.195	201.50	51.47	0.6100
28	12.641	159.79	64.90	0.4837
29	11.257	126.72	81.83	0.3836
30	10.025	100.50	103.2	0.3042
31	8.928	79.70	130.0	0.2413
32	7.950	63.21	164.1	0.1913
33	7.080	50.13	206.9	0.1517
34	6.305	39.75	260.9	0.1203
35	5.615	31.52	329.0	0.0954
36	5.000	25.00	414.8	0.0757
37	4.453	19.82	523.1	0.0600
38	3.965	15.72	659.6	0.0476
39	3.531	12.47	831.8	0.0377
40	3.145	9.89	1,049	0.0299

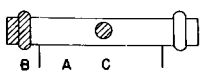
UNITED ELECTRONICS

STANDARD RESISTOR AND CAPACITOR COLOR CODE GUIDE

(Courtesy of RMA)

Color	Significant Figure	Decimal Multiplier	Tolerance %		Capacitor Voltage Ratings (Volts)
			Resistors	Capacitors	
Black	0	1		....	....
Brown	1	10		1	100
Red	2	100		2	200
Orange	3	1,000		3	300
Yellow	4	10,000		4	400
Green	5	100,000		5	500
Blue	6	1,000,000		6	600
Violet	7	10,000,000		7	700
Gray	8	100,000,000		8	800
White	9	1,000,000,000		9	900
Gold	....	0.1	±5	5	1000
Silver	....	0.01	±10	10	2000
No color	....	....	±20	20	500





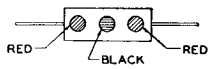
RESISTORS

The color of the resistor body (A) represents the first figure of the resistance value. One tip (B) is colored to represent the next figure. A band or dot (C) of color represents the number of zeros following the first two figures, is located within the body color. Color "D" on the body of the axial resistor and appearing on the end of the axial lead type is used to indicate the tolerance value.

Example 1. Assume a resistor whose body is yellow, tip blue, and dot red; thus we get yellow 4, blue 6 and red 2, or 4600 ohms.

CAPACITORS

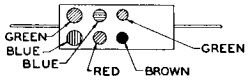
Small mica type condensers are marked with colored dots, using an arrow or other mark to indicate sequence. The resistor color marking code shown above is the same for capacitors.



Example 2. The value of the condenser would be as follows: Red dot 2, black dot 0, red dot 2, or 2-0-00 or 2,000 μμfd (.002 μfd).

Some capacitors are color-coded to indicate tolerance and working voltage rating. *If a single row of* three colored markings appear on the capacitor the voltage rating is 500 volts. (Refer Example 2.)

When two rows of colored markers are used, the top row indicates the significant figures, read from left to right; the bottom row the decimal multiplier, tolerance, and voltage rating, read from right to left. Capacitance is read in micromicrofarads. (Refer Example 3.)



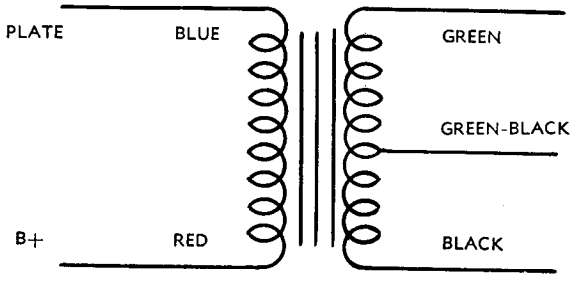
Example 3. Green (5), Blue (6), Green (5), Brown (10), or 5650 μμfds Red = 2% tolerance, Blue = 600 working volts.

UNITED ELECTRONICS

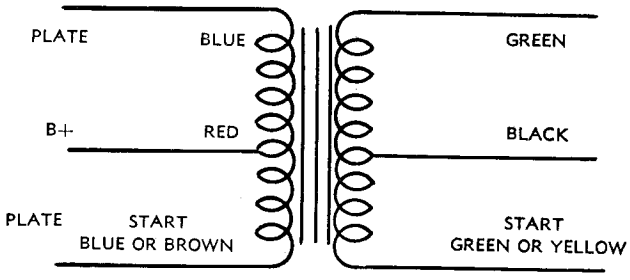
(THROUGH COURTESY OF RMA)

TRANSFORMER COLOR CODE

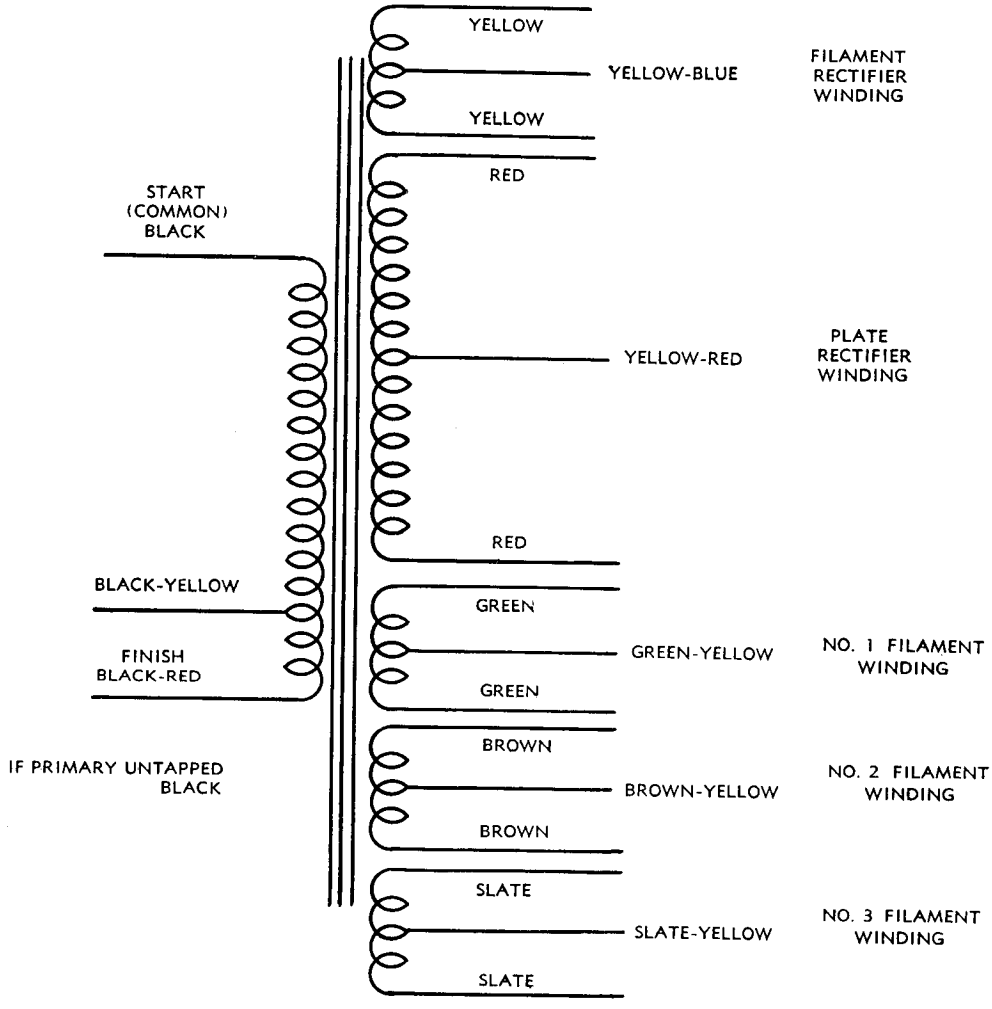
AUDIO TRANSFORMER



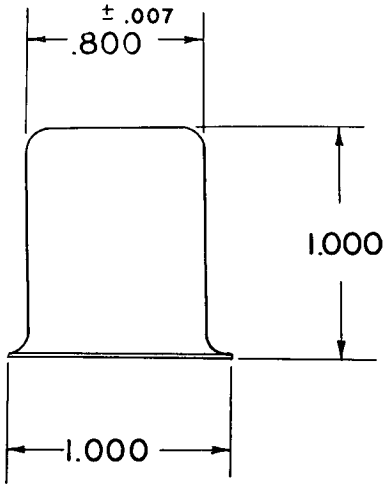
I. F. TRANSFORMER



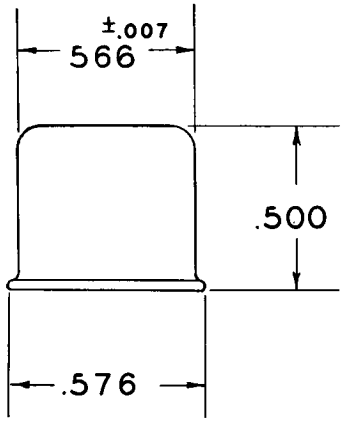
POWER TRANSFORMER



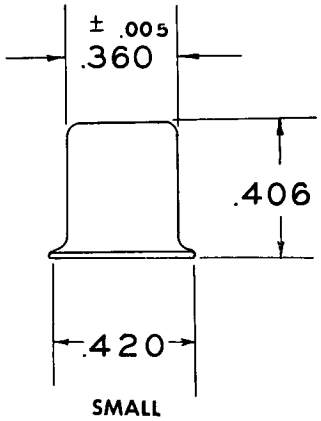
CAP DIMENSIONS



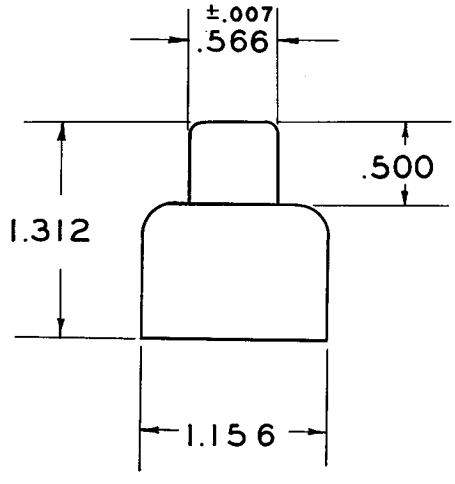
LARGE



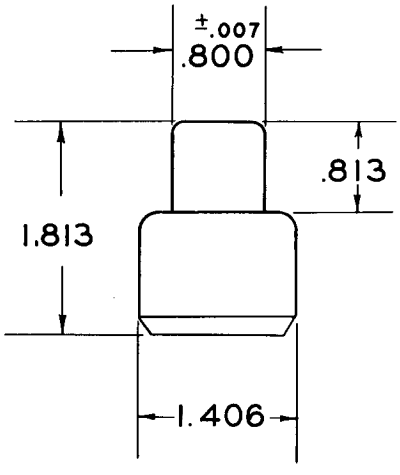
MEDIUM



SMALL

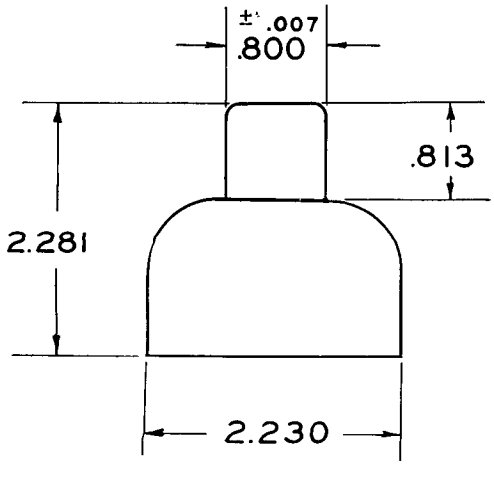


SKIRTED MEDIUM

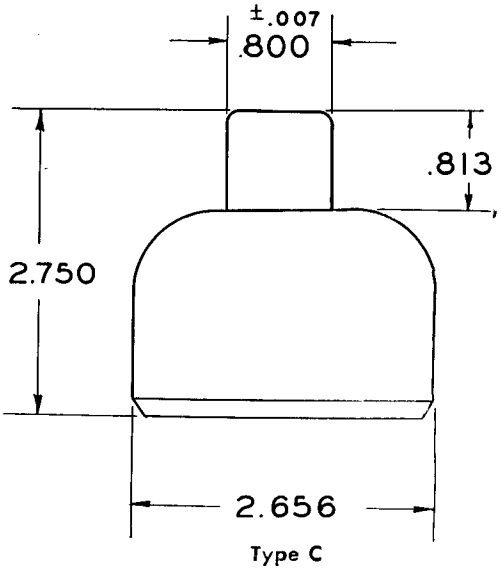


SKIRTED LARGE

SKIRTED



Type B



Type C

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UNITED ELECTRONICS

TYPE CV-11

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

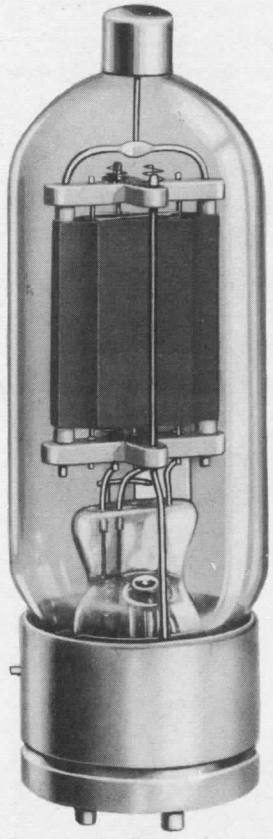
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	2.5 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: 65 ma. Plate Current	
Amplification Factor	14
Plate Resistance	3500 ohms
Mutual Conductance	4000 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	9.0 uuf
Grid to Filament	5.0 uuf
Plate to Filament	2.4 uuf
Maximum Overall Dimensions:	
Length	6 1/2 inches
Diameter	2 1/16 inches
Bulb	T-16
Cap	Medium Metal
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	5½ oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1250	volts
Maximum D-C Plate Voltage Unmodulated	1500	volts
Maximum D-C Plate Current Modulated	125	ma.
Maximum D-C Plate Current Unmodulated	150	ma.
Maximum Plate Dissipation	65	watts
Maximum D-C Grid Current	25	ma.
Maximum R-F Grid Current	6	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	30	megacycles
Above	10	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*85	megacycles
Above	*3.5	meters

*For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings and Typical Operating Conditions. The R-F grid current should never exceed the maximum rated value.



UNITED TYPE CV-11

This sturdy triode has a plate dissipation of 65 watts for class C telegraph and class B service. A pair of these tubes in class B audio service will deliver 215 watts output.

INSTALLATION

The base of the UNITED CV-11 is designed for mounting in a standard Jumbo 4-Large Pin, bayonet type socket The tube may be mounted either vertically, or horizontally with the plane of the filament on edge. Ample air space should be provided for ventilation.

The filament of the CV-11 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential, the filament of the CV-11 should be operated from an a-c source.

The plate dissipation of the CV-11 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant-inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage	1500	volts
Maximum D-C Plate Current (Averaged over any audio-freq. cycle)	150	ma.
Maximum Plate Dissipation (Averaged over any audio-freq. cycle)	65	watts

Typical Operation (2 tubes):

Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	1000	1250	1500	volts
Grid Voltage	—70	—90	—110	volts
Zero-Sig. Plate Cur.	30	30	30	ma.
Max.-Sig. Plate Cur.	240	240	225	ma.
Load Res. (plate to plate)	8000	11200	14400	ohms
Power Output (2 tubes)	185	200	215	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	1500	volts
Maximum D-C Plate Current	120	ma.
Maximum Plate Dissipation	65	watts
Maximum R-F Grid Current	6	amp.

Typical Operation:

Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	1000	1250	1500	volts
Grid Voltage	—70	—90	—110	volts
D-C Plate Current	95	80	65	ma.
Peak Power Output	120	128	128	watts
Nominal Carrier Power Output	30	32	32	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	1250	volts
Maximum D-C Plate Current	150	ma.
Maximum Plate Dissipation	30	watts
Maximum R-F Grid Current	5	amp.
Maximum D-C Grid Current	25	ma.

Typical Operation:

Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	1000	1250	1500	volts
Grid Voltage	—200	—250		volts
D-C Plate Current	120	130		ma.
D-C Grid Current†	7	6		ma.
Driving Power†	3	3		watts
Power Output	84	120		watts

R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

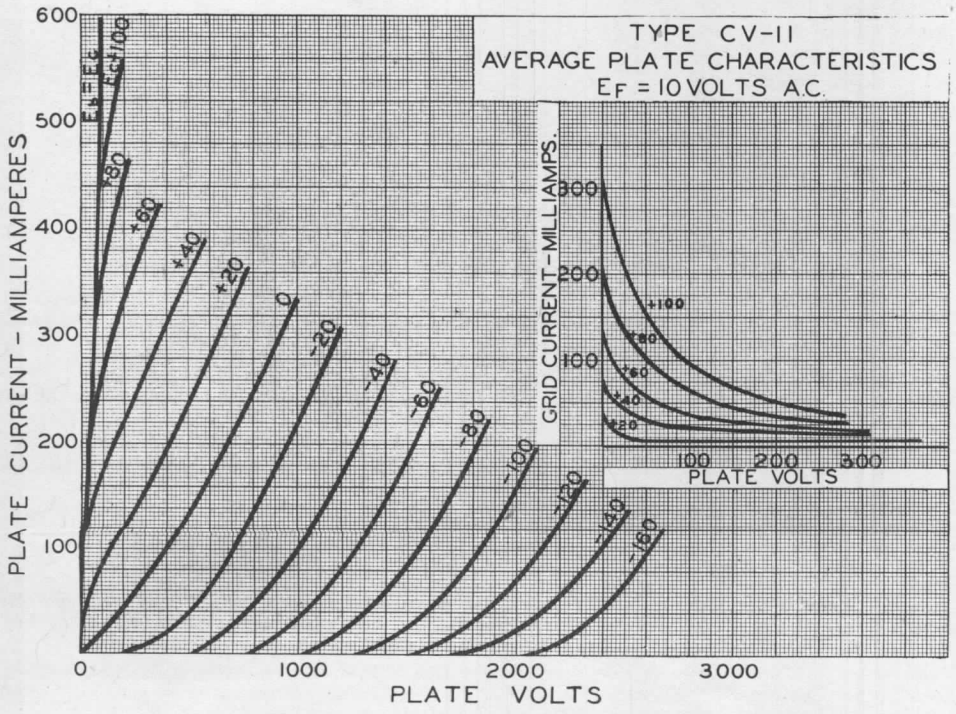
(Key-down Conditions)

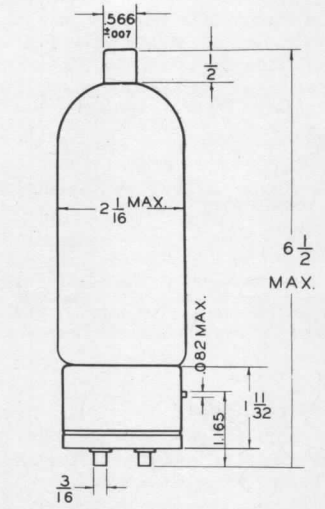
Maximum D-C Plate Voltage	1500	volts
Maximum D-C Plate Current	150	ma.
Maximum Plate Dissipation	65	watts
Maximum R-F Grid Current	6	amp.
Maximum D-C Grid Current	25	ma.

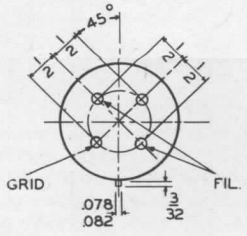
Typical Operation:

Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	1000	1250	1500	volts
Grid Voltage	—145	—180	—215	volts
D-C Plate Current	130	120	120	ma.
D-C Grid Current†	6	7	6	ma.
Driving Power†	3	3	3	watts
Power Output	90	115	140	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE UXCV-11

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes 3
Filament Voltage .....10 volts
Current .....2.5 amperes
Type .....Thoriated Tungsten

Average Characteristic Values Calculated at:
65 ma. Plate Current

Amplification Factor 14
Plate Resistance .....3500 ohms
Mutual Conductance .....4000 micromhos

Average Direct Interelectrode Capacities:

Grid to Plate .....9.0 uuf
Grid to Filament .....5.0 uuf
Plate to Filament .....2.4 uuf

Maximum Overall Dimensions:

Length .....7 1/4 inches
Diameter .....2 1/16 inches
Bulb T-16
Cap .....Medium Metal
Base .....Medium 4-Pin
Type of Cooling .....Air
Net Weight .....5½ oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1250	volts
Maximum D-C Plate Voltage Unmodulated	1500	volts
Maximum D-C Plate Current Modulated	125	ma.
Maximum D-C Plate Current Unmodulated	150	ma.
Maximum Plate Dissipation	65	watts
Maximum D-C Grid Current	25	ma.
Maximum R-F Grid Current	6	amp.

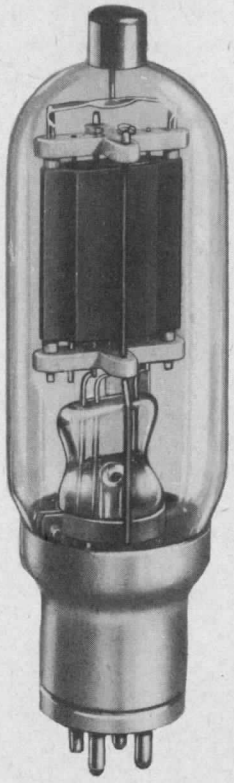
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:

Below .....30 megacycles
Above .....10 meters

*Maximum Frequency Rating with Reduced Power Input and Output:

Below .....*85 megacycles
Above .....*3.5 meters

*For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings and Typical Operating Conditions. The R-F grid current should never exceed the maximum rated value.



UNITED TYPE UXCV-11

This sturdy triode has a plate dissipation of 65 watts for class C telegraph and class B service. A pair of these tubes in class B audio service will deliver 215 watts output.

INSTALLATION

The base of the UNITED UXCV-11 is designed for mounting in a standard Medium 4-Pin, bayonet type socket. The tube may be mounted either vertically, or horizontally with the plane of the filament on edge. Ample air space should be provided for ventilation.

The filament of the UXCV-11 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential, the filament of the UXCV-11 should be operated from an a-c source.

The plate dissipation of the UXCV-11 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant-inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage			1500	volts
Maximum D-C Plate Current	Averaged over any audio-freq. cycle		150	ma.
Maximum Plate Dissipation			65	watts
Typical Operation (2 tubes):				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	1000	1250	1500	volts
Grid Voltage	—70	—90	—110	volts
Zero-Sig. Plate Cur.	30	30	30	ma.
Max.-Sig. Plate Cur.	240	240	225	ma.
Load Res. (plate to plate)	8000	11200	14400	ohms
Power Output (2 tubes)	185	200	215	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			1500	volts
Maximum D-C Plate Current			120	ma.
Maximum Plate Dissipation			65	watts
Maximum R-F Grid Current			6	amp.
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	1000	1250	1500	volts
Grid Voltage	—70	—90	—110	volts
D-C Plate Current	95	80	65	ma.
Peak Power Output	120	128	128	watts
Nominal Carrier Power Output	30	32	32	watts

PLATE MODULATED R-F POWER AMPLIFIER
CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

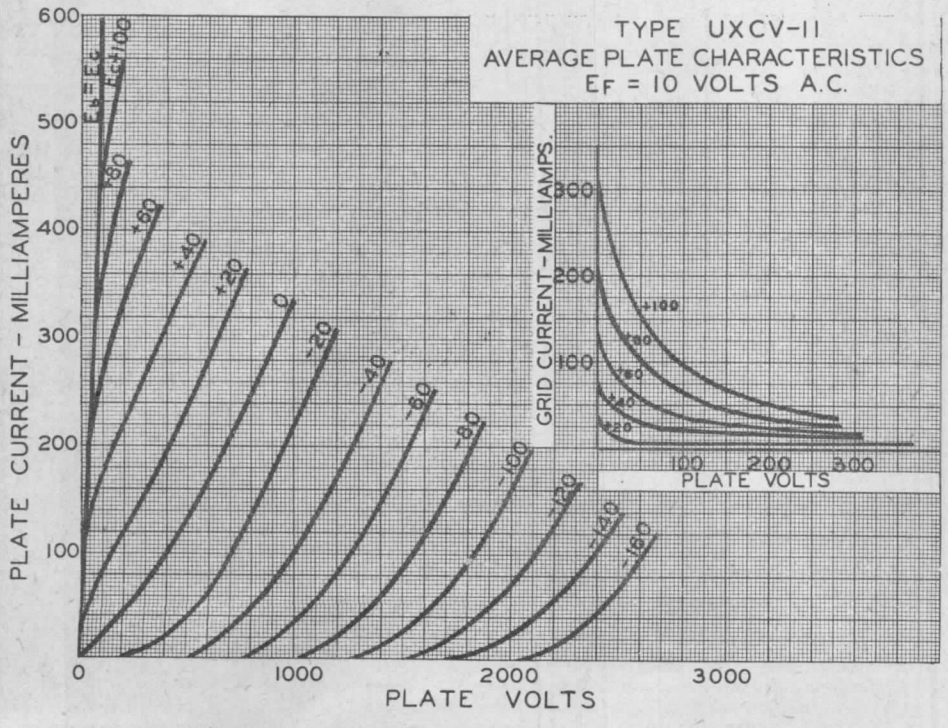
Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			150	ma.
Maximum Plate Dissipation			30	watts
Maximum R-F Grid Current			5	amp.
Maximum D-C Grid Current			25	ma.
Typical Operation:				
Filament Voltage	10	10		a-c volts
D-C Plate Voltage	1000	1250		volts
Grid Voltage	—200	—250		volts
D-C Plate Current	120	130		ma.
D-C Grid Current†	7	6		ma.
Driving Power†	3	3		watts
Power Output	84	120		watts

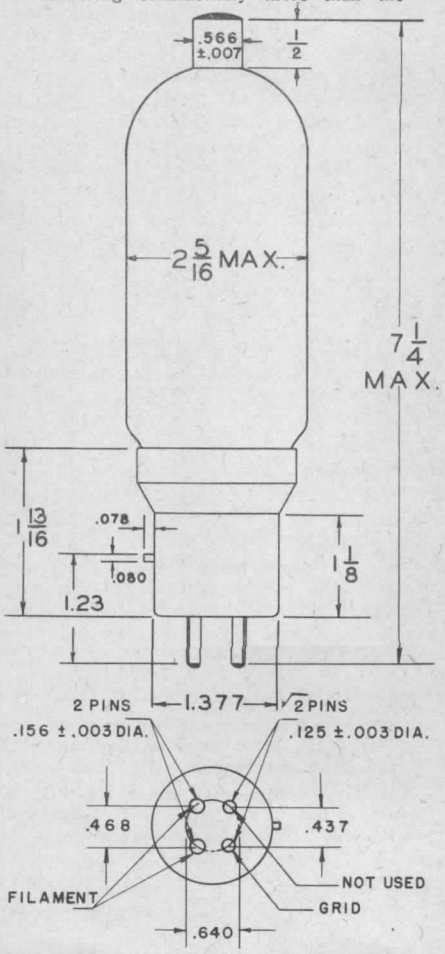
R-F POWER AMPLIFIER AND OSCILLATOR
CLASS C TELEGRAPHY

(Key-down Conditions)

Maximum D-C Plate Voltage			1500	volts
Maximum D-C Plate Current			150	ma.
Maximum Plate Dissipation			65	watts
Maximum R-F Grid Current			6	amp.
Maximum D-C Grid Current			25	ma.
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	1000	1250	1500	volts
Grid Voltage	—145	—180	—215	volts
D-C Plate Current	130	120	120	ma.
D-C Grid Current†	6	7	6	ma.
Driving Power†	3	3	3	watts
Power Output	90	115	140	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE HV-12

R-F POWER AMPLIFIER, OSCILLATOR, CLASS B MODULATOR

ENGINEERING INFORMATION

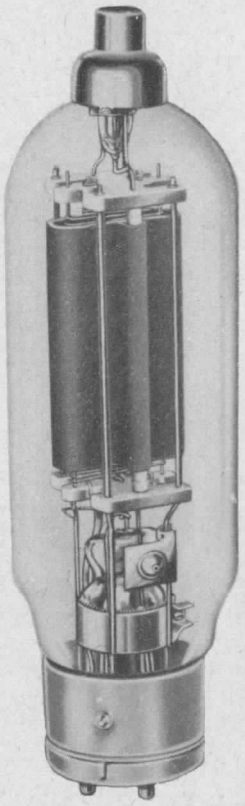
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	4.0 amperes
Type	Thoriated Tungsten
Average Characteristic Values at:	
150 ma.	Plate Current
Amplification Factor	12
Plate Resistance	2000 ohms
Mutual Conductance	6000 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	14 uuf
Grid to Filament	8.5 uuf
Plate to Filament	4 uuf
Maximum Overall Dimensions:	
Length	9 1/2 inches
Diameter	2 5/8 inches
Bulb	T-21
Cap	Medium Skirted
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	9 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2000	volts
Maximum D-C Plate Voltage Unmodulated	2500	volts
Maximum D-C Plate Current Modulated	175	ma.
Maximum D-C Plate Current Unmodulated	210	ma.
Maximum Plate Dissipation	200	watts
Maximum D-C Grid Current	60	ma.
Maximum R-F Grid Current	7.5	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	30	megacycles
Above	10	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*85	megacycles
Above	*3.5	meters

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



UNITED TYPE HV-12

High frequency triode for heavy duty industrial and communications uses.

INSTALLATION

The base of the UNITED HV-12 is designed for mounting in a standard "50-watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the HV-12 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life. The filament of the HV-12 should be operated preferably from an a-c source.

A heavy ribbon grid lead, which is brought out through the side wall of the cathode stem, is used to reduce r-f losses at the high frequencies.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		2000	volts
Maximum D-C Plate Current	Averaged over	210	ma.
Maximum Plate Input	any audio	400	watts
Maximum Plate Dissipation	freq. cycle	200	watts

Typical Operation (2 tubes):

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	1750	2000	volts
D-C Grid Voltage	—140	—160	volts
Peak A-F Grid to Grid Voltage	310	350	volts
Zero-Sig. D-C Plate Current (per tube)	60	50	ma.
Max.-Sig. D-C Plate Current (per tube)	300	275	ma.
Load Resistance (per tube)	3000	3600	ohms
Effective Load Res. (plate to plate)	12000	14400	ohms
Max.-Signal Driving Power approx.	6	7	watts
Power Output approx.	400	400	watts

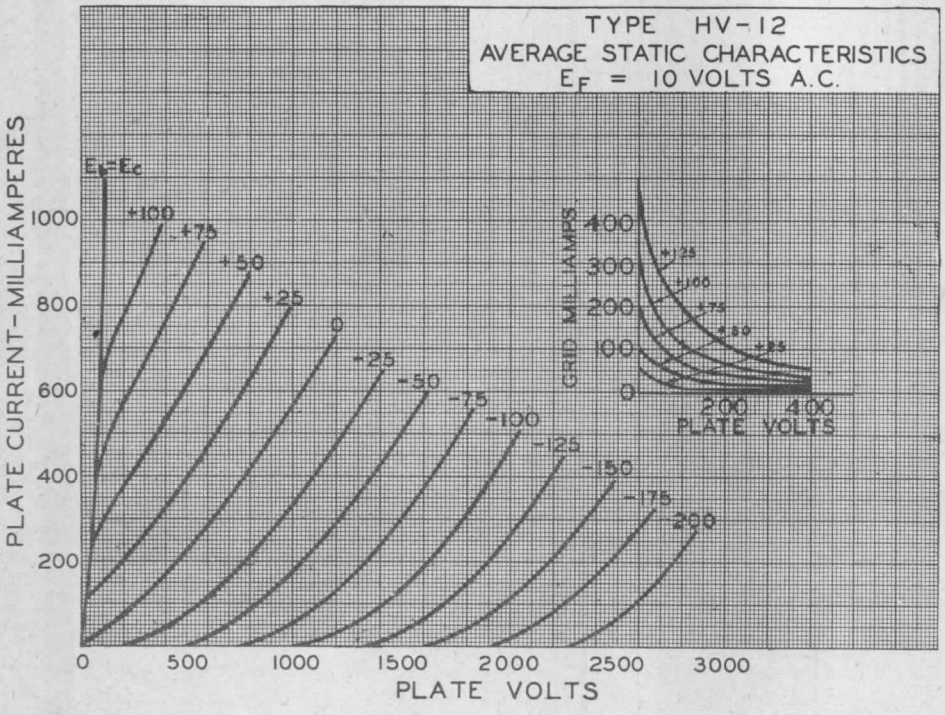
R-F POWER AMPLIFIER AND OSCILLATOR
CLASS C TELEGRAPHY
(Key Down Conditions)

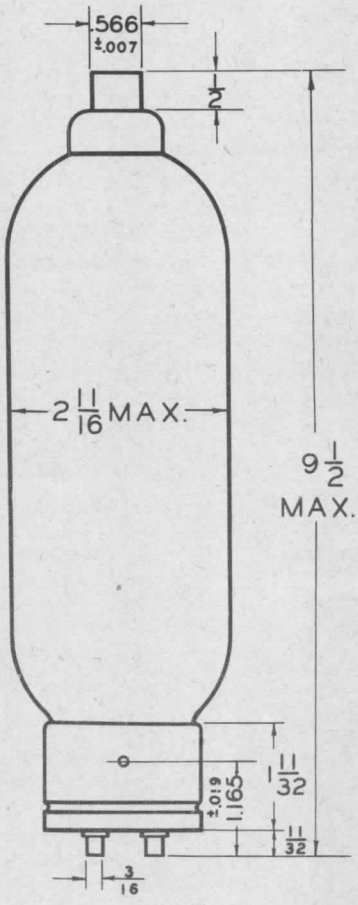
Maximum D-C Plate Voltage	2500		volts
Maximum D-C Plate Current	210		ma.
Maximum Plate Input	400		watts
Maximum Plate Dissipation	200		watts
Maximum D-C Grid Voltage	—400		volts
Maximum D-C Grid Current	60		ma.
Maximum R-F Grid Current	7.5		amp.

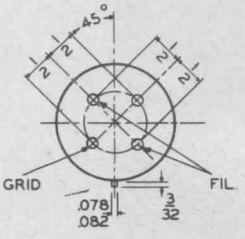
Typical Operation:

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	1750	2000	volts
D-C Grid Voltage	—250	—300	volts
Peak R-F Grid Voltage	380	410	volts
D-C Plate Current	200	200	ma.
D-C Grid Current approx.	11	9	ma.
Driving Power† approx.	9	8	watts
Power Output† approx.	260	300	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE HV-18

R-F POWER AMPLIFIER, OSCILLATOR, CLASS B MODULATOR

ENGINEERING INFORMATION

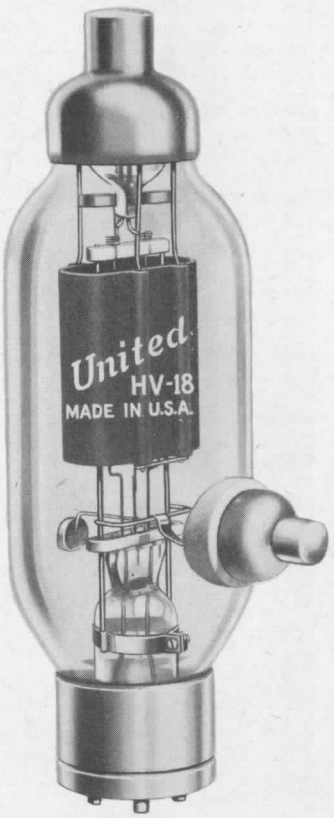
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.85 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: 150 ma. Plate Current	
Amplification Factor	18
Plate Resistance	3600 ohms
Mutual Conductance	5000 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	6.5 uuf
Grid to Filament	5.0 uuf
Plate to Filament	1.5 uuf
Maximum Overall Dimensions:	
Length	9 7-8 inches
Diameter	2 15-16 inches
Diameter plus Grid Terminal	4 1-16 inches
Bulb	T-23
Cap	Medium Metal
Grid Cap	Lava Insulated Medium Metal
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	9 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2000	volts
Maximum D-C Plate Voltage Unmodulated	2500	volts
Maximum A-C Plate Voltage R. M. S.	2500	volts
Maximum D-C Plate Current Modulated	175	ma.
Maximum D-C Plate Current Unmodulated	210	ma.
Maximum Plate Dissipation	200	watts
Maximum D-C Grid Current	60	ma.
Maximum R-F Grid Current	10	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	50	megacycles
Above	6	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*85	megacycles
Above	*3.5	meters

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



INTERCHANGES WITH TYPE 200

High frequency triode for heavy duty industrial and communications uses.

INSTALLATION

The base of the UNITED HV-18 is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the HV-18 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life.

The plate dissipation of the HV-18 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

A heavy ribbon grid lead, which is brought out through the side wall of the bulb, is used to reduce R-F losses at the higher frequencies.

GRAPHITE ANODE

A graphite anode is used in this type tube because of several specific advantages over metals such as tantalum, molybdenum and nickel. The radiating area of graphite is approximately twice the projected area due to its surface porosity. Moreover, because of the black body principle, it will dissipate four times more heat than metal.

Graphite, being infusible, will not warp or twist. Therefore, it maintains its exact form under all temperatures, the result being constant inter-element relationship. The low operating temperature of the graphite anode tends to keep the grid cool, reduces overload hazards, and prevents gas current. The inherent qualities of graphite over metal as outlined above, are advantages of primary importance in designing tubes of this type for long and satisfactory service life.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage	2500	volts
Maximum D-C Plate Current	200	ma.
Maximum Plate Input (Averaged over any audio freq. cycle)	450	watts
Maximum Plate Dissipation	150	watts

Typical Operation (2 tubes):

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	2000	2500	volts
D-C Grid Voltage	—100	—130	volts
Peak A-F Grid to Grid Voltage	420	410	volts
Zero-Sig D-C Plate Cur.	60	60	ma.
Max.-Sig. D-C Plate Cur.	380	320	ma.
Load Resistance (per tube)	2800	4000	ohms
Effective Load Res. (plate to plate)	11200	16000	ohms
Max.-Signal Driving Power	9	2.5 approx.	watts
Power Output	500	500 approx.	watts

R-F POWER AMPLIFIER — CLASS B TELEPHONY

(Carrier Conditions — Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2500	volts
Maximum D-C Plate Current	150	ma.
Maximum Plate Input	250	watts
Maximum Plate Dissipation	150	watts
Maximum R-F Grid Current	10	amp.

Typical Operation:

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	2000	2500	volts
D-C Grid Voltage	—110	—140	volts
Peak R-F Grid Voltage	125	130	volts
D-C Plate Current	110	90	ma.
D-C Grid Current†	0.5	0 approx.	ma.
Driving Power†	6	4 approx.	watts
Power Output	80	80 approx.	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2000	volts
Maximum D-C Plate Current	200	ma.
Maximum Plate Input	400	watts
Maximum Plate Dissipation	120	watts
Maximum D-C Grid Voltage	—500	volts
Maximum D-C Grid Current	50	ma.
Maximum R-F Grid Current	10	amp.

Typical Operation:

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	1750	2000	volts
D-C Grid Voltage	—300	—350	volts
Peak R-F Grid Voltage	475	500	volts
D-C Plate Current	200	160	ma.
D-C Grid Current†	30	20 approx.	ma.
Driving Power†	14	9 approx.	watts
Power Output	270	250 approx.	watts

R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

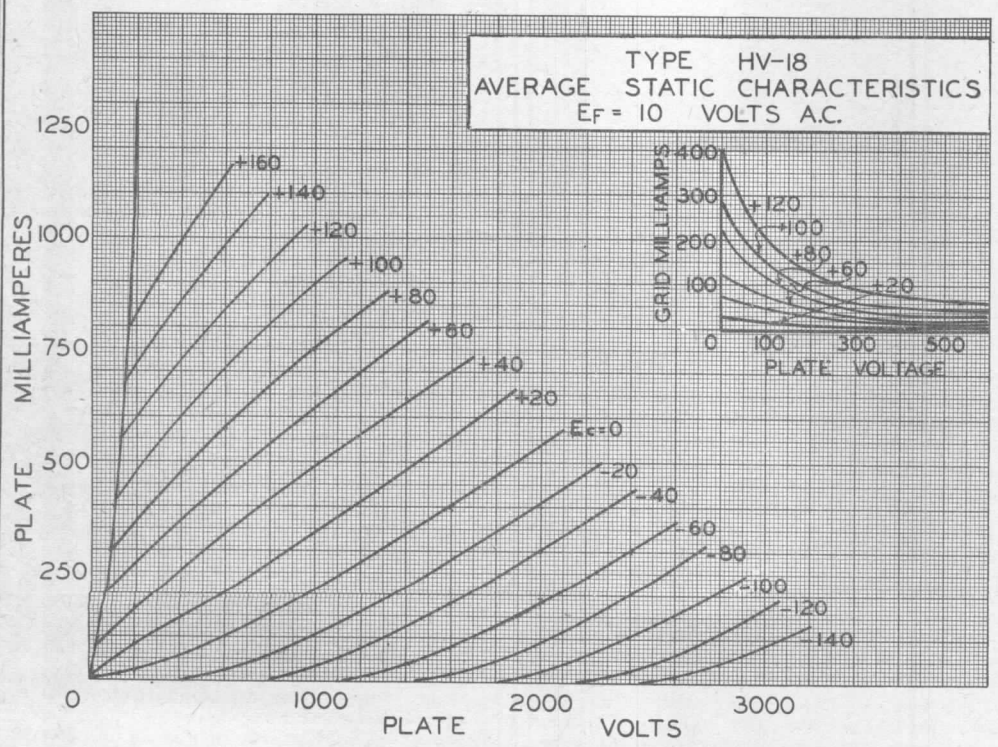
(Key Down Conditions)

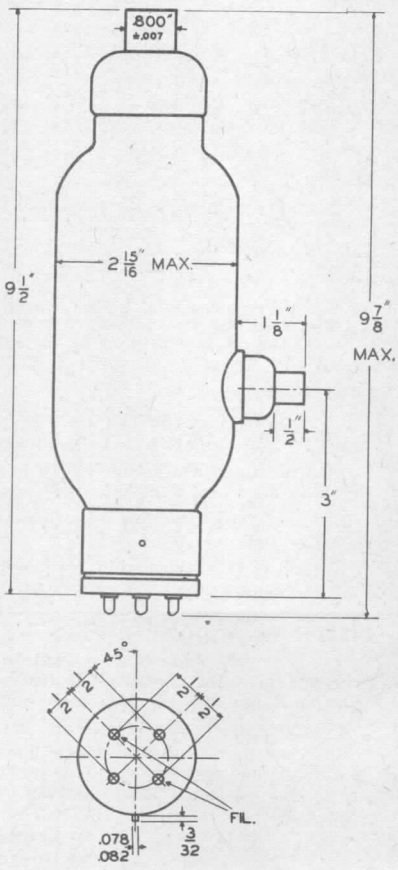
Maximum D-C Plate Voltage	2500	volts
Maximum D-C Plate Current	200	ma.
Maximum Plate Input	550	watts
Maximum Plate Dissipation	150	watts
Maximum D-C Grid Voltage	—500	volts
Maximum D-C Grid Current	70	ma.
Maximum R-F Grid Current	10	amp.

Typical Operation:

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	2000	2500	volts
D-C Grid Voltage	—250	—300	volts
Peak R-F Grid Voltage	400	450	volts
D-C Plate Current	200	200	ma.
D-C Grid Current	23	18 approx.	ma.
Driving Power†	9	8 approx.	watts
Power Output†	300	380 approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE KU-23

MODULATOR, A-F AND R-F POWER AMPLIFIER, U.H.F. OSCILLATOR

ENGINEERING INFORMATION

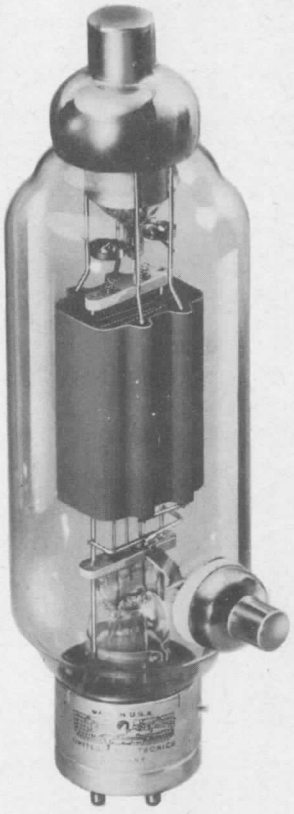
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	11.0 volts
Current	4.0 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: 150 ma. Plate Current	
Amplification Factor	23
Plate Resistance	4100 ohms
Mutual Conductance	5600 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	6.5 uuf
Grid to Filament	6.0 uuf
Plate to Filament	1.4 uuf
Maximum Overall Dimensions:	
Length	10 1/4 inches
Diameter (excluding Grid Arm)	3 inches
Bulb	T-24
Cap	Standard 250-Watt
Base	Jumbo 4-large Pin
Type of Cooling	Air
Net weight	10 1/8 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2200	volts
Maximum D-C Plate Voltage Unmodulated	3000	volts
Maximum D-C Plate Current Modulated	275	ma.
Maximum D-C Plate Current Unmodulated	275	ma.
Maximum Plate Dissipation	200	watts
Maximum D-C Grid Current	60	ma.
Maximum R-F-Grid Current	12	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	30	megacycles
Above	10	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	60	megacycles
Above	5	meters

*For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



Typical UNITED ELECTRONICS refinements of design are revealed in the above illustration of type KU-23. Individually supported and isolated grid-filament assembly gives this tube the necessary separation between elements for its heavy input ratings. The large anode and wide spacing are design features contributing to the modern efficieny standards which this tube exemplifies.

INSTALLATION

The base of the UNITED KU-23 is designed for mounting in a standard "50-Watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the KU-23 should be operated at the rated value of 11 volts. Operation at other than rated value may result in loss of filament emission and short life. The filament of the KU-23 should be operated preferably from an a-c source.

The plate dissipation of the KU-23 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

When the KU-23 is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

GRAPHITE ANODE

A graphite anode is used in this type because of several specific advantages over metals such as tantalum, molybdenum and nickel. The radiating area of graphite is approximately twice the projected area due to its surface porosity. Moreover, because of the black body principle, it will dissipate four times more heat than metal.

Graphite, being infusible, will not warp or twist. Therefore, it maintains its exact form under all temperatures, the result being constant inter-element relationship. The low operating temperature of the graphite anode tends to keep the grid cool, reduces overload hazards, and prevents gas current. The inherent qualities of graphite over metal as outlined above, are advantages of primary importance in designing tubes of this type for long and satisfactory service life.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		3000	volts
Maximum D-C Plate Current	Averaged over	275	ma.
Maximum Plate Input	any audio	600	watts
Maximum Plate Dissipation	freq. cycle	200	watts

Typical Operation (2 tubes):

A-C Filament Voltage	11	11	11	a-c volts
D-C Plate Voltage	2000	2500	3000	volts
D-C Grid Voltage	—85	—100	—125	volts
Peak A-F Grid to Grid Voltage	420	430	450	volts
Zero-Sig. D-C Plate Cur.	60	60	60	ma.
Max.-Sig. D-C Plate Cur.	500	440	400	ma.
Load Resistance (per tube)	2150	3000	4000	ohms
Effective Load Res. (plate to plate)	8600	12000	16000	ohms
Max.-Sig. Driving Power approx.	11.3	7.3	5.4	watts
Power Output approx.	665	740	800	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2500	volts
Maximum D-C Plate Current	275	ma.
Maximum Plate Input	320	watts
Maximum Plate Dissipation	200	watts
Maximum R-F Grid Current	10	amp.

Typical Operation:

A-C Filament Voltage	11	11	a-c	volts
D-C Plate Voltage	2000	2500		volts
D-C Grid Voltage	—90	—105		volts
Peak R-F Grid Voltage	182	175		volts
D-C Plate Current	145	120		ma.
D-C Grid Current† approx.	20	5		ma.
Driving Power† approx.	4	2		watts
Power Output approx.	101	106		watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2200	volts
Maximum D-C Plate Current	275	ma.
Maximum Plate Input	600	watts
Maximum Plate Dissipation	200	watts
Maximum D-C Grid Voltage	—500	volts
Maximum D-C Grid Current	60	ma.
Maximum R-F Grid Current	10	amp.

Typical Operation:

A-C Filament Voltage	11	11	volts
D-C Plate Voltage	1500	2000	volts
D-C Grid Voltage	—150	—200	volts
Peak R-F Grid Voltage	334	382	volts
D-C Plate Current	275	275	ma.
D-C Grid Current† approx.	47	37	ma.
Driving Power† approx.	14.5	13.4	watts
Power Output approx.	298	405	watts

R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

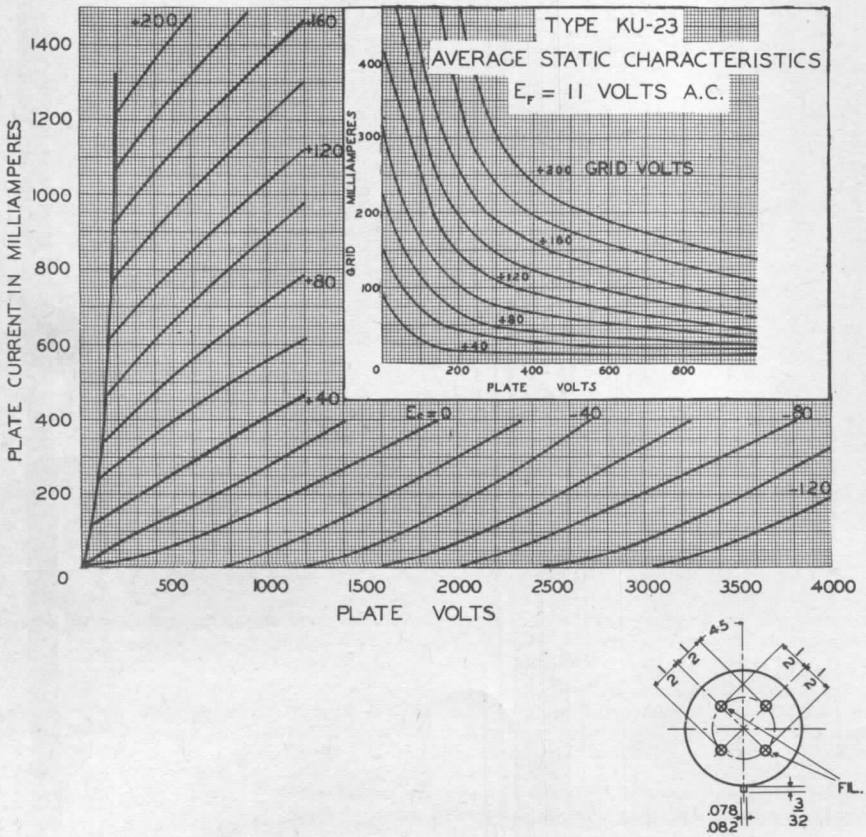
(Key Down Conditions)

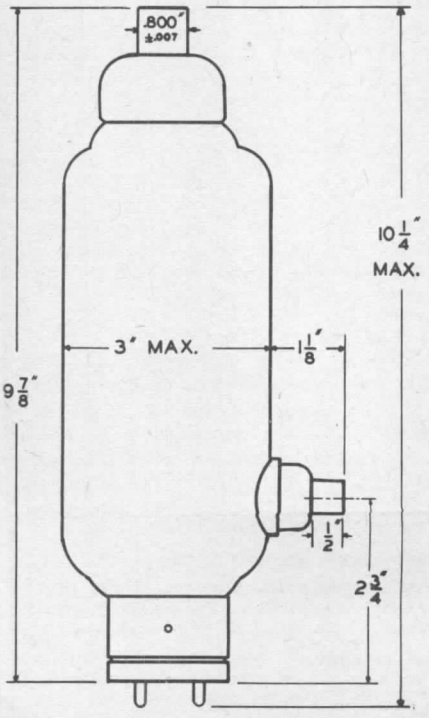
Maximum D-C Plate Voltage	3000		volts
Maximum D-C Plate Current	275		ma.
Maximum Plate Input	750		watts
Maximum Plate Dissipation	200		watts
Maximum D-C Grid Voltage	—500		volts
Maximum D-C Grid Current	60		ma.
Maximum R-F Grid Current	12		amp.

Typical Operation:

A-C Filament Voltage	11	11	11	volts
D-C Plate Voltage	2000	2500	3000	volts
D-C Grid Voltage	—200	—250	—300	volts
Peak R-F Grid Voltage	474	435	378	volts
D-C Plate Current	273	270	250	ma.
D-C Grid Current approx.	35	29	21	ma.
Driving Power† approx.	12.3	11.7	9.5	watts
Power Output† approx.	400	510	570	watts

†Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE HV-27

R-F POWER AMPLIFIER, OSCILLATOR, CLASS B MODULATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	4.0 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at:	
150 ma	Plate Current
Amplification Factor	26
Plate Resistance	4000 ohms
Mutual Conductance	6500 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	14.5 uuf
Grid to Filament	7.5 uuf
Plate to Filament	2.9 uuf
Maximum Overall Dimensions:	
Length	9 1/2 inches
Diameter	2 5/8 inches
Bulb	T-21
Cap	Medium Skirted
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	9 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2000	volts
Maximum D-C Plate Voltage Unmodulated	2500	volts
Maximum D-C Plate Current Modulated	175	ma.
Maximum D-C Plate Current Unmodulated	210	ma.
Maximum Plate Dissipation	200	watts
Maximum D-C Grid Current	60	ma.
Maximum R-F Grid Current	7.5	amp.

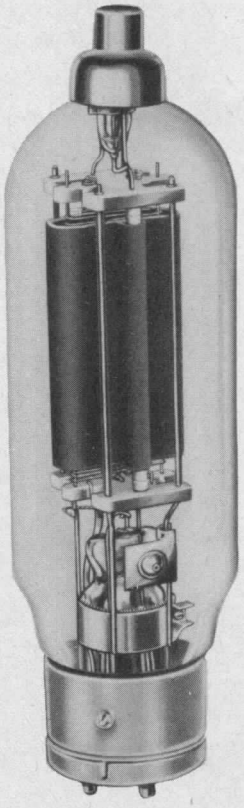
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:

Below	30 megacycles
Above	10 meters

*Maximum Frequency Rating with Reduced Power Input and Output:

Below	*85 megacycles
Above	3.5 meters

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



INTERCHANGES WITH TYPE 822

High frequency triode for heavy duty industrial and communications uses.

INSTALLATION

The base of the UNITED HV-27 is designed for mounting in a standard "50-watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the HV-27 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life. The filament of the HV-27 should be operated preferably from an a-c source.

A heavy ribbon grid lead, which is brought out through the side wall of the cathode stem, is used to reduce r-f losses at the high frequencies.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

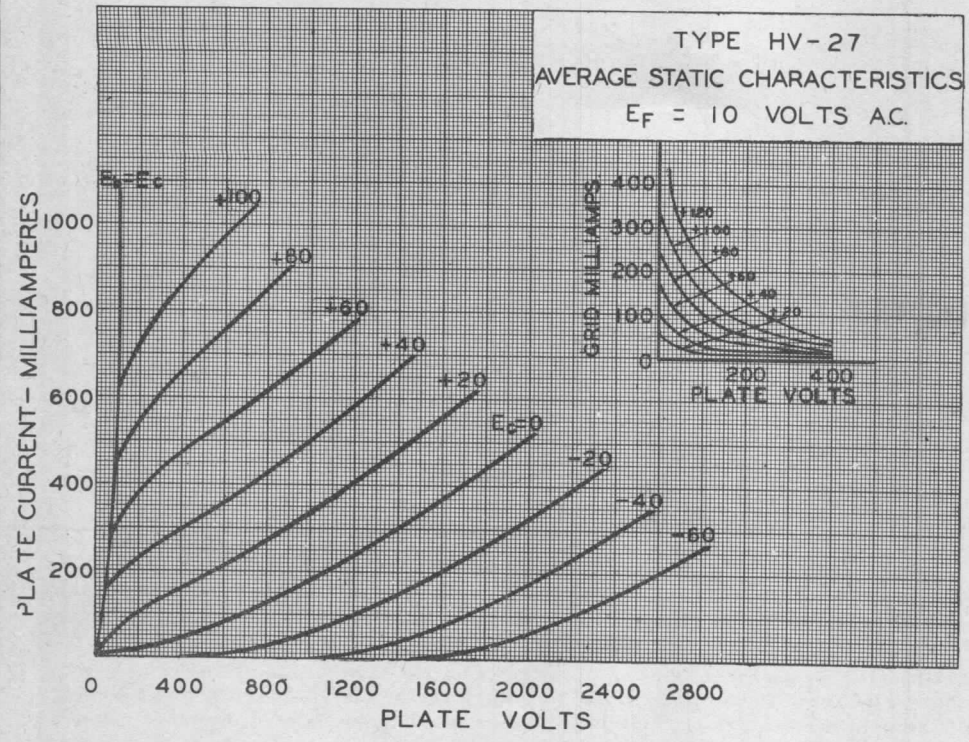
A-F POWER AMPLIFIER AND MODULATOR—CLASS B

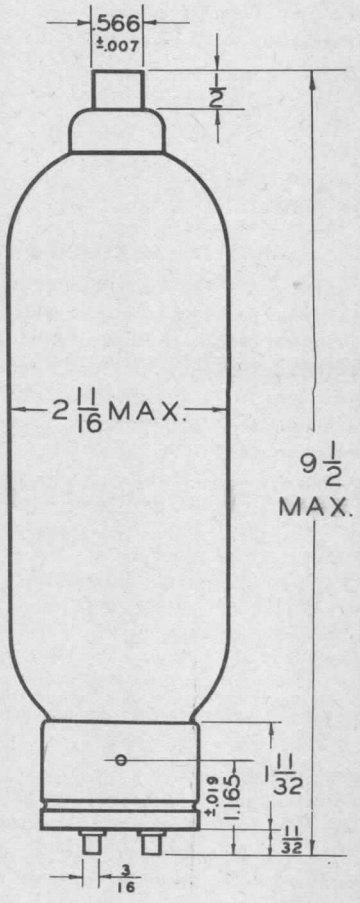
Maximum D-C Plate Voltage		2000	volts
Maximum D-C Plate Current	Average over	210	ma.
Maximum Plate Input	any audio	315	watts
Maximum Plate Dissipation	freq. cycle	200	watts
Typical Operation (2 tubes):			
A-C Filament Voltage	10	10	volts
D-C Plate Voltage	1750	2000	volts
D-C Grid Voltage	—50	—60	volts
Peak A-F Grid to Grid Voltage	405	430	volts
Zero-Signal D-C Plate Current (per tbue)	60	60	ma.
Max.-Signal D-C Plate Current (per tube)	360	325	ma.
Load Resistance (per tube)	2500	3100	ohms
Effective Load Resistance plate to plate)	10000	12400	ohms
Maximum-Signal Driving Power....approx.	10	9	watts
Power Output .....approx.	400	400	watts

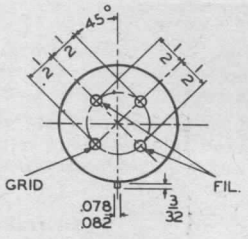
R-F POWER AMPLIFIER AND OSCILLATOR
CLASS C TELEGRAPHY
(Key Down Conditions)

Maximum D-C Plate Voltage		2500	volts
Maximum D-C Plate Current		210	ma.
Maximum Plate Input		400	watts
Maximum Plate Dissipation		200	watts
Maximum D-C Grid Voltage		—400	volts
Maximum D-C Grid Current		60	ma.
Maximum R-F Grid Current		7.5	amp.
Typical Operation:			
A-C Filament Voltage	10	10	volts
D-C Plate Voltage	1750	2000	volts
D-C Grid Voltage	—200	—300	volts
Peak R-F Grid Voltage	400	425	volts
D-C Plate Current	200	200	ma.
D-C Grid Current .....approx.	15	12	ma.
Driving Power† .....approx.	10	9	watts
Power Output† .....approx.	260	300	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 203-A

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

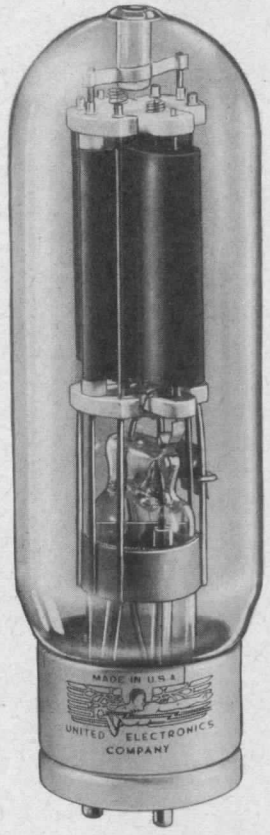
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.25 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Eb = 1000, Ec = —10, Ef = 10 D-C	
Plate Current	0.072 amperes
Amplification Factor	25
Plate Resistance	6000 ohms
Mutual Conductance	4200 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	14.5 uuf
Grid to Filament	6.5 uuf
Plate to Filament	5.5 uuf
Maximum Overall Dimensions:	
Length	7 7/8 inches
Diameter	2 5/16 inches
Bulb	T-18
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1000	volts
Maximum D-C Plate Voltage Unmodulated	1250	volts
Maximum A-C Plate Voltage R. M. S.	1250	volts
Maximum D-C Plate Current Modulated	150	ma.
Maximum D-C Plate Current Unmodulated	175	ma.
Maximum Plate Dissipation	125	watts
Maximum D-C Grid Current	60	ma.
Maximum R-F Grid Current	7.5	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	15	megacycles
Above	20	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*80	megacycles
Above	*3.75	meters

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 303-A

"Ruggedized" construction enables type 203-A to withstand unusual shock and vibration conditions. This is one of the most enduring types of transmitting tubes.

INSTALLATION

The base of the UNITED 203-A is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 203-A should be operated at the rated value of 10 volts. Operation at other than the rated value may result in loss of filament emission and short life.

While the ratings printed herein are conservative, it is important to observe the requirements of good engineering practice as to transmitter design and operation. Adequate cabinet ventilation should be provided to carry off the heat dissipated during operation. Tube sockets should be inspected to avoid high resistance contacts to the base-pin terminals.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage	1250	volts
Maximum D-C Plate Current } Average over any	175	ma.
Maximum Plate Dissipation } audio-freq. cycle	100	watts
Maximum Plate Input	220	watts

Typical Operation (2 tubes):

Filament Voltage	10	10	a-c volts
D-C Plate Voltage	1000	1250	volts
D-C Grid Voltage	—35	—45	volts
Zero-Signal Plate Cur.	26	26	ma.
Max.-Signal Plate Cur.	320	320	ma.
Load Resistance (per tube)	1725	2250	ohms
Effec. Load Res. (plate to plate)	6900	9000	ohms
Power Output	200	260	approx. watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	1250	volts
Maximum D-C Plate Current	150	ma.
Maximum Plate Dissipation	100	watts
Maximum Plate Input	150	watts
Maximum R-F Grid Current	6	amp.

Typical Operation:

Filament Voltage	10	10	a-c volts
D-C Plate Voltage	1000	1250	volts
D-C Grid Voltage	—35	—45	volts
Peak R-F Grid Voltage	95	90	volts
D-C Plate Current	130	106	ma.
Peak Power Output	160	170	approx. watts
Power Output	40	42.5	approx. watts

PLATE MODULATED R-F POWER AMPLIFIER
CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	1000	volts
Maximum D-C Plate Current	175	ma.
Maximum Plate Dissipation	67	watts
Maximum Plate Input	175	watts
Maximum R-F Grid Current	6	amp.
Maximum D-C Grid Current	60	ma.

Typical Operation:

Filament Voltage	10	10	a-c volts
D-C Plate Voltage	750	1000	volts
D-C Grid Voltage	—100	—135	volts
D-C Plate Current	150	150	ma.
D-C Grid Current†	50	50	ma.
Driving Power†	12	14	watts
Power Output	65	100	approx. watts

R-F POWER AMPLIFIER AND OSCILLATOR
CLASS C TELEGRAPHY

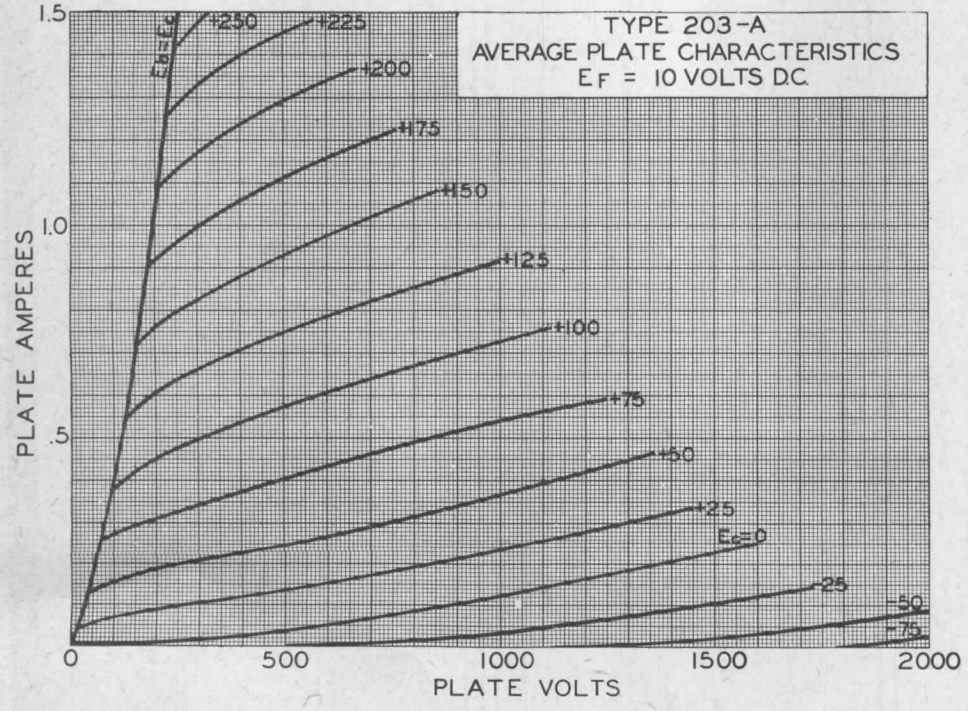
(Key Down Conditions)

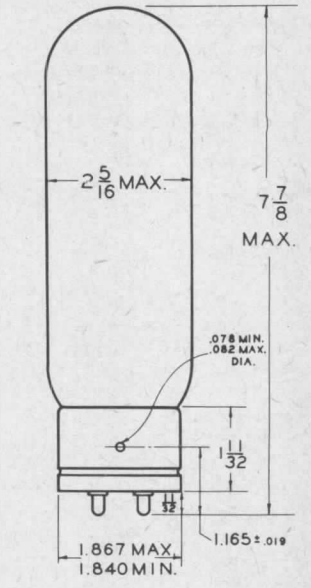
Maximum D-C Plate Voltage	1250			volts
Maximum D-C Plate Current	175			ma.
Maximum Plate Dissipation	100			watts
Maximum Plate Input	220			watts
Maximum R-F Grid Current	7.5			amp.
Maximum D-C Grid Current	60			ma.

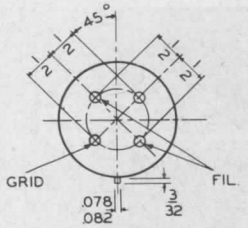
Typical Operation:

Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage	—75	—100	—125	volts
D-C Plate Current	150	150	150	ma.
D-C Grid Current†	25	25	25	ma.
Driving Power†	5	6	7	watts
Power Output	65	100	130	approx. watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 204-A

R-F POWER AMPLIFIER, OSCILLATOR, CLASS B MODULATOR

ENGINEERING INFORMATION

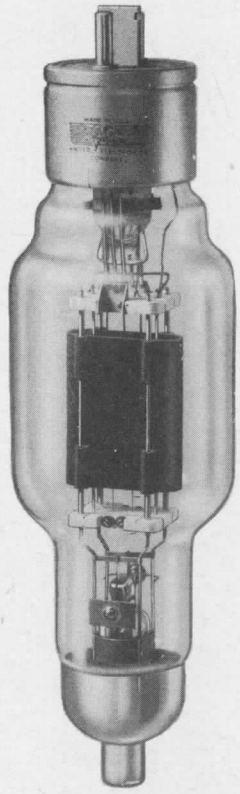
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	11 volts
Current	3.85 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Ep = 2000, Ec = −32, Ef = 11 A-C	
Plate Current	0.125 amperes
Amplification Factor	23
Plate Resistance	6300 ohms
Mutual Conductance	4000 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	15.0 uuf
Grid to Filament	12.5 uuf
Plate to Filament	2.3 uuf
Maximum Overall Dimensions:	
Length	14 3/8 inches
Diameter	4 1/16 inches
Bulb	T-32
Cap	Standard 250-Watt
Base	Jumbo 3-Pin
Type of Cooling	Air
Net Weight	23 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2000	volts
Maximum D-C Plate Voltage Unmodulated	2500	volts
Maximum A-C Plate Voltage R.M.S.	3000	volts
Maximum D-C Plate Current Modulated	275	ma.
Maximum D-C Plate Current Unmodulated	275	ma.
Maximum Plate Dissipation	250	watts
Maximum D-C Grid Current	80	ma.
Maximum R-F Grid Current	10	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	3	megacycles
Above	100	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*30	megacycles
Above	*10	meters

*For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings and Typical Operating Conditions. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 304-A

Typical UNITED ELECTRONICS refinements of design are revealed in the above illustration of type 204-A.

INSTALLATION

The base of the UNITED 204-A is designed for mounting in a "250 watt" socket of the three-pin type. The tube may be mounted either in a vertical position with the filament base end up, or in a horizontal position with the plate on edge. Ample air space should be provided for ventilation.

The filament of the 204-A should be operated at the rated value of 11 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential, the filament of the 204-A should be operated preferably from an a.-c source.

The plate dissipation of the 204-A should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A graphite anode is used in this type tube because of several specific advantages over metals such as tantalum, molybdenum and nickel. The radiating area of graphite is approximately twice the projected area due to its surface porosity. Moreover, because of the black body principle, it will dissipate four times more heat than metal.

Graphite being infusible, will not warp or twist. Therefore, it maintains its exact form under all temperatures, the result being constant inter-element relationship. The low operating temperature of the graphite anode tends to keep the grid cool, reduces overload hazards, and prevents gas current. The inherent qualities of graphite over metal as outlined above, are advantages of primary importance in designing tubes of this type for long and satisfactory service life.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage	3000	volts
Maximum D-C Plate Current (Averaged over any audio freq. cycle)	275	ma.
Maximum Plate Dissipation (Averaged over any audio freq. cycle)	250	watts
Maximum Plate Input (Averaged over any audio freq. cycle)	650	watts

Typical Operation (2 tubes):

Filament Voltage	11	11	11	a-c volts
D-C Plate Voltage	1500	2000	2500	volts
Grid Voltage	—40	—60	—85	approx. volts
Zero-Sig. Plate Cur. (per tube)	37	37	27	ma.
Max.-Sig. Plate Cur. (per tube)	250	250	210	ma.
Load Resistance (per tube)	1950	2200	3280	ohms
Effective Load Res. (plate to plate)	7800	8800	13120	ohms
Power Output	400	600	650	approx. watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2500	volts
Maximum D-C Plate Current	225	ma.
Maximum Plate Dissipation	250	watts
Maximum Plate Input	400	watts
Maximum R-F Grid Current	8	amp.

Typical Operation:

Filament Voltage	11	11	a-c	volts
D-C Plate Voltage	1500	2000		volts
Grid Voltage	—50	—70	approx.	volts
D-C Plate Current	200	160		ma.
Driving Power	18	15	approx.	watts
Peak Power Output	320	400	approx.	watts
Carrier Power Output	80	100	approx.	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2000	volts
Maximum D-C Plate Current	275	ma.
Maximum Plate Dissipation	167	watts
Maximum R-F Grid Current	8	amp.
Maximum D-C Grid Current	80	ma.

Typical Operation:

Filament Voltage	11	11	a-c	volts
D-C Plate Voltage	1500	2000		volts
Grid Voltage	—200	—250	approx.	volts
D-C Plate Current	250	250		ma.
D-C Grid Current†	35	35		ma.
Driving Power†	20	20	approx.	watts
Power Output	225	350	approx.	watts

R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

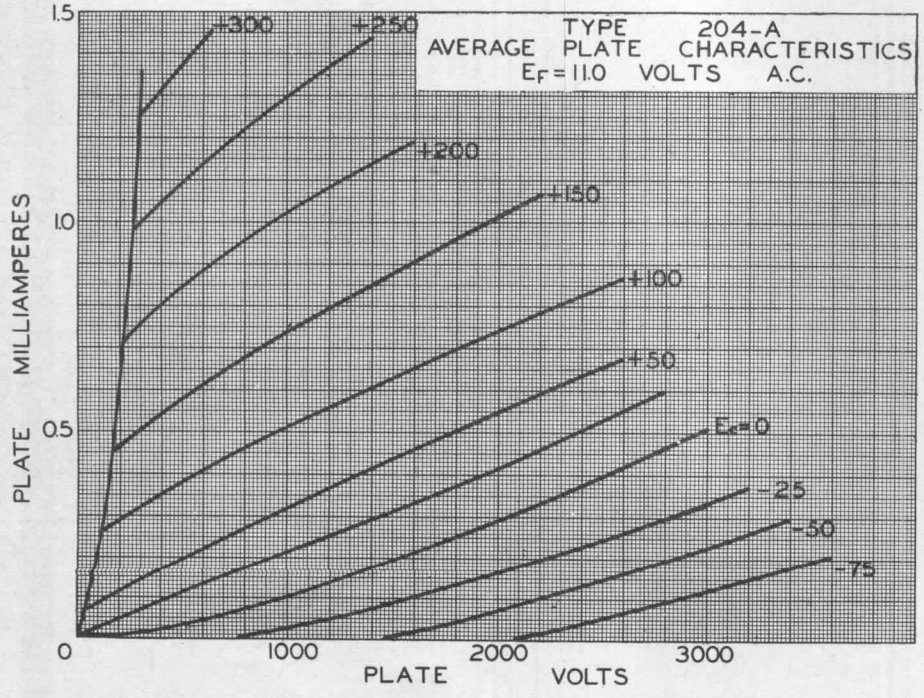
(Key Down Conditions)

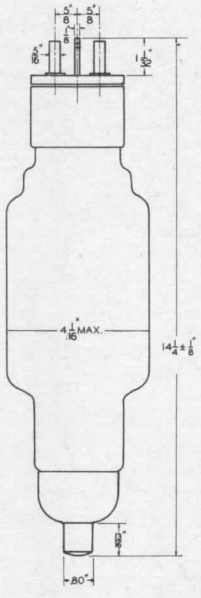
Maximum D-C Plate Voltage	2500	volts
Maximum D-C Plate Current	275	ma.
Maximum Plate Dissipation	250	watts
Maximum Plate Input	690	watts
Maximum R-F Grid Current	10	amp.
Maximum D-C Grid Current	80	ma.

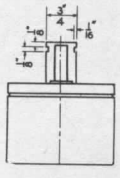
Typical Operation:

Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	1500	2000	2500		volts
Grid Voltage	—150	—175	—200		volts
D-C Plate Current	250	250	250		ma.
D-C Grid Current†	30	30	30	approx.	ma.
Driving Power†	15	15	15	approx.	watts
Power Output	240	350	450	approx.	watts

†Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 211

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

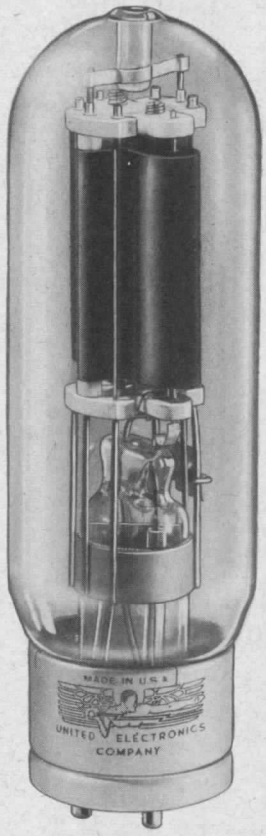
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.25 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Eb = 1000, Ec = —50, Ef = 10 D-C	
Plate Current	0.072 amperes
Amplification Factor	12
Plate Resistance	3400 ohms
Mutual Conductance	3530 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	14.5 uuf
Grid to Filament	6.0 uuf
Plate to Filament	5.5 uuf
Maximum Overall Dimensions:	
Length	7 7/8 inches
Diameter	2 5/16 inches
Bulb	T-18
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1000	volts
Maximum D-C Plate Voltage Unmodulated	1250	volts
Maximum A-C Plate Voltage R. M. S.	1250	volts
Maximum D-C Plate Current Modulated	150	ma.
Maximum D-C Plate Current Unmodulated	175	ma.
Maximum Plate Dissipation	125	watts
Maximum D-C Grid Current	50	ma.
Maximum R-F Grid Current	7.5	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	15	megacycles
Above	20	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*80	megacycles
Above	*3.75	meters

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 311

"Ruggedized" construction enables type 211 to withstand unusual shock and vibration conditions. This is one of the most enduring types of transmitting tubes.

INSTALLATION

The base of the UNITED 211 is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 211 should be operated at the rated value of 10 volts. Operation at other than the rated value may result in loss of filament emission and short life.

While the ratings printed herein are conservative, it is important to observe the requirements of good engineering practice as to transmitter design and operation. Adequate cabinet ventilation should be provided to carry off the heat dissipated during operation. Tube sockets should be inspected to avoid high resistance contacts to the base-pin terminals.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage			1250	volts
Maximum Plate Dissipation			100	watts
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage	—46	—61	—80	volts
Peak Grid Swing	41	56	75	approx. volts
D-C Plate Current	34	53	60	ma.
Plate Resistance	4400	3800	3600	ohms
Mutual Conductance	2750	3150	3300	umhos
Load Resistance	8800	7600	9200	ohms
U. P. O. (5% 2nd harmonic)	5.6	12.0	19.7	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current } Averaged over any			175	ma.
Maximum Plate Dissipation } audio-freq. cycle			125	watts
Typical Operation (2 tubes):				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	1000	1250		volts
D-C Grid Voltage	—77	—100		volts
Zero-Sig. Plate Cur. (per tube)	10	10		ma.
Max.-Sig. Plate Cur. (per tube)	160	160		ma.
Load Res. (plate to plate)	6900	9000		ohms
Power Output	200	260		watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			150	ma.
Maximum Plate Dissipation			125	watts
Maximum R-F Grid Current			6	amp.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	1000	1250		volts
D-C Grid Voltage	—77	—100		volts
D-C Plate Current	130	160		ma.
Peak Power Output	160	170		watts
Power Output	40	42.5		watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

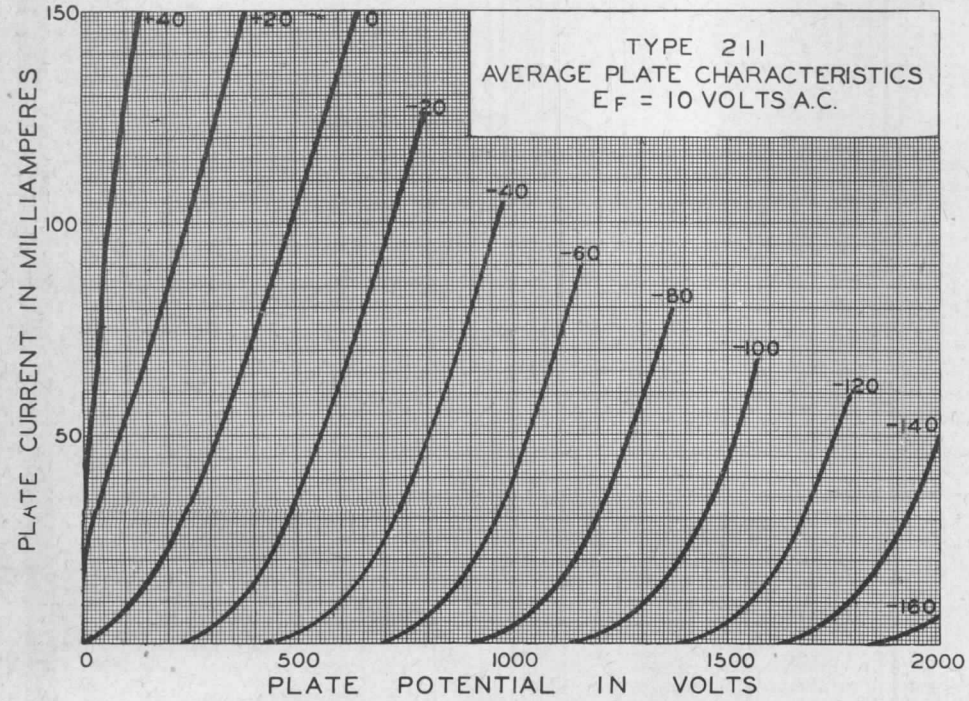
Maximum D-C Plate Voltage			1000	volts
Maximum D-C Plate Current			175	ma.
Maximum Plate Dissipation			85	watts
Maximum R-F Grid Current			6	amp.
Maximum D-C Grid Current			50	ma.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	750	1000		volts
D-C Grid Voltage	—200	—260		volts
D-C Plate Current	150	150		ma.
D-C Current†	35	35		ma.
Driving Power†	12	14		watts
Power Output	65	100	approx.	watts

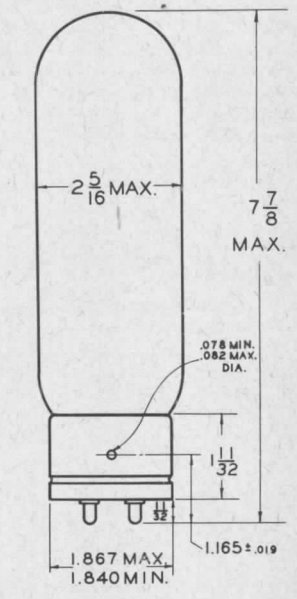
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

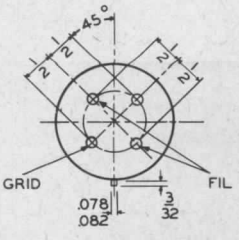
(Key-Down Conditions)

Maximum D-C Plate Voltage				1250	volts
Maximum D-C Plate Current				175	ma.
Maximum Plate Dissipation				125	watts
Maximum R-F Grid Current				7.5	amp.
Maximum D-C Grid Current				50	ma.
Typical Operation:					
Filament Voltage	10	10	10	a-c	volts
D-C Plate Voltage	750	1000	1250		volts
D-C Grid Voltage	—135	—175	—225		volts
D-C Plate Current	150	150	150		ma.
D-C Grid Current†	18	18	18		ma.
Driving Power†	5	6	7		watts
Power Output	65	100	130	approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 211-C

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes 3

Filament Voltage .....10 volts
Current .....3.25 amperes
Type .....Thoriated Tungsten

Average Characteristic Values Calculated at:
Eb = 1000, Ec = —50, Ef = 10 D-C
Plate Current .....0.072 amperes
Amplification Factor 12
Plate Resistance .....3400 ohms
Mutual Conductance .....3530 micromhos

Average Direct Interelectrode Capacities:
Grid to Plate .....9.0 uuf
Grid to Filament .....6.0 uuf
Plate to Filament .....5.0 uuf

Maximum Overall Dimensions:
Length .....7 7/8 inches
Diameter .....2 5/16 inches
Bulb T-18
Base .....Jumbo 4-Large Pin
Type of Cooling .....Air
Net Weight .....8 oz.

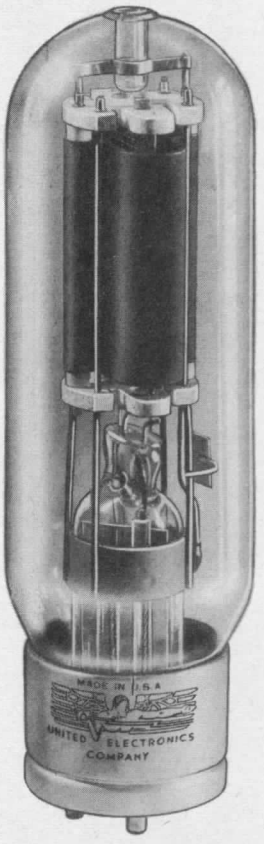
MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1000	volts
Maximum D-C Plate Voltage Unmodulated	1250	volts
Maximum A-C Plate Voltage R. M. S.	1250	volts
Maximum D-C Plate Current Modulated	150	ma.
Maximum D-C Plate Current Unmodulated	175	ma.
Maximum Plate Dissipation	125	watts
Maximum D-C Grid Current	50	ma.
Maximum R-F Grid Current	7.5	amp.

Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:
Below .....15 megacycles
Above .....20 meters

*Maximum Frequency Rating with Reduced Power Input and Output:
Below .....*80 megacycles
Above .....*3.75 meters

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 311-C

"Ruggedized" construction enables type 211-C to withstand unusual shock and vibration conditions. Type 211-C has lower interelectrode capacitances than type 211, but all other characteristics are similar.

INSTALLATION

The base of the UNITED 211-C is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 211-C should be operated at the rated value of 10 volts. Operation at other than the rated value may result in loss of filament emission and short life.

While the ratings printed herein are conservative, it is important to observe the requirements of good engineering practice as to transmitter design and operation. Adequate cabinet ventilation should be provided to carry off the heat dissipated during operation. Tube sockets should be inspected to avoid high resistance contacts to the base-pin terminals.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage			1250	volts
Maximum Plate Dissipation			100	watts
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage	—46	—61	—80	volts
Peak Grid Swing	41	56	75	approx. volts
D-C Plate Current	34	53	60	ma.
Plate Resistance	4400	3800	3600	ohms
Mutual Conductance	2750	3150	3300	umhos
Load Resistance	8800	7600	9200	ohms
U. P. O. (5% 2nd harmonic)	5.6	12.0	19.7	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		1250	volts
Maximum D-C Plate Current } Averaged over any audio-freq. cycle		175	ma.
Maximum Plate Dissipation }		125	watts
Typical Operation (2 tubes):			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	1000	1250	volts
D-C Grid Voltage	—77	—100	volts
Zero-Sig. Plate Cur. (per tube)	10	10	ma.
Max.-Sig. Plate Cur. (per tube)	160	160	ma.
Load Res. (plate to plate)	6900	9000	ohms
Power Output	200	260	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			150	ma.
Maximum Plate Dissipation			125	watts
Maximum R-F Grid Current			6	amp.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	1000	1250		volts
D-C Grid Voltage	—77	—100		volts
D-C Plate Current	130	160		ma.
Peak Power Output	160	170		watts
Power Output	40	42.5		watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

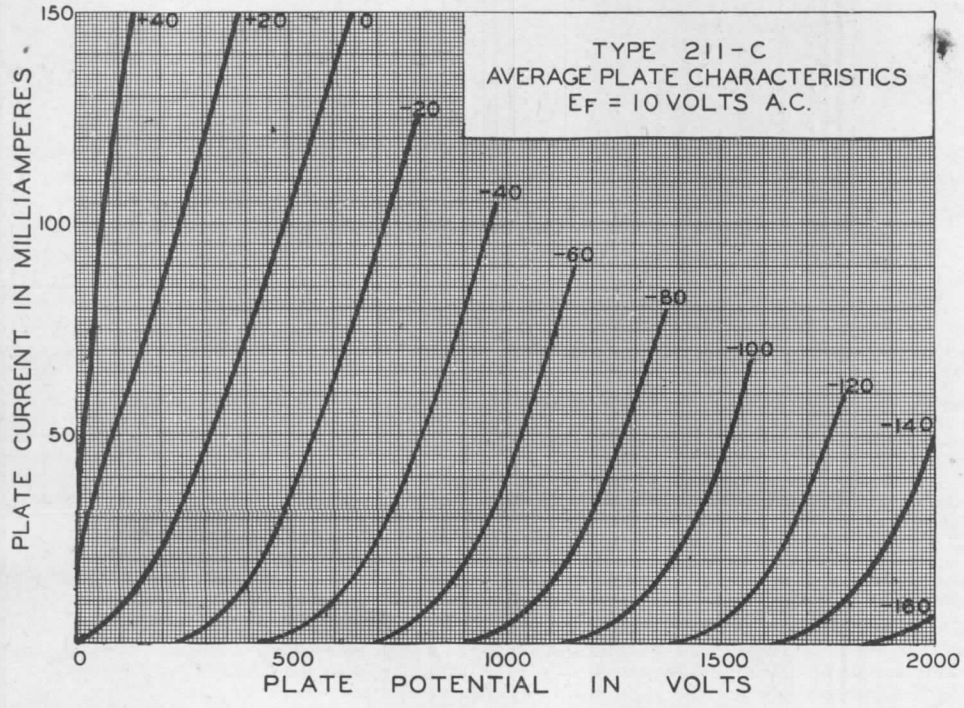
Maximum D-C Plate Voltage			1000	volts
Maximum D-C Plate Current			175	ma.
Maximum Plate Dissipation			85	watts
Maximum R-F Grid Current			6	amp.
Maximum D-C Grid Current			50	ma.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	750	1000		volts
D-C Grid Voltage	—200	—260		volts
D-C Plate Current	150	150		ma.
D-C Current†	35	35		ma.
Driving Power†	12	14		watts
Power Output	65	100	approx.	watts

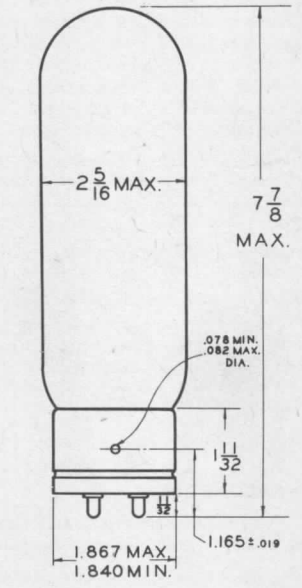
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

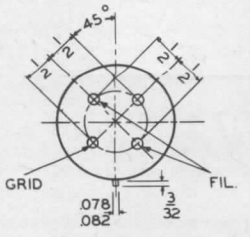
(Key-Down Conditions)

Maximum D-C Plate Voltage				1250	volts
Maximum D-C Plate Current				175	ma.
Maximum Plate Dissipation				125	watts
Maximum R-F Grid Current				7.5	amp.
Maximum D-C Grid Current				50	ma.
Typical Operation:					
Filament Voltage	10	10	10	a-c	volts
D-C Plate Voltage	750	1000	1250		volts
D-C Grid Voltage	—135	—175	—225		volts
D-C Plate Current	150	150	150		ma.
D-C Grid Current†	18	18	18		ma.
Driving Power†	5	6	7		watts
Power Output	65	100	130	approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 212-E

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

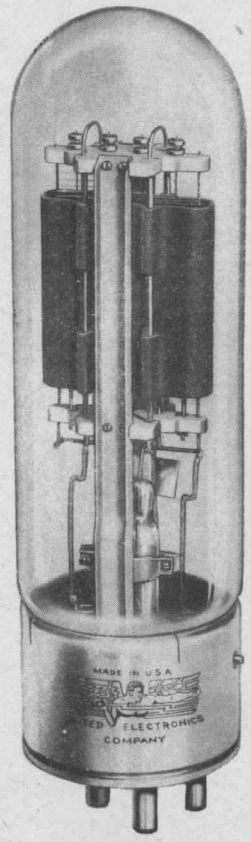
GENERAL RATINGS

Number of electrodes	3
Filament Voltage	14 volts
Current	6 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Eb = 2000 Ec = —90	
Plate Current	170 ma.
Amplification Factor	16
Plate Resistance	1900 ohms
Mutual Conductance	8500 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	18.8 uuf
Grid to Filament	14.9 uuf
Plate to Filament	8.6 uuf
Maximum Overall Dimensions:	
Length	13 5/8 inches
Diameter	3 5/8 inches
Bulb	T-28
Base	Large 4-Pin
Type of Cooling	Air
Net Weight	21 1/2 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1500	volts
Maximum D-C Plate Voltage Unmodulated	3000	volts
Maximum D-C Plate Current Modulated	325	ma.
Maximum D-C Plate Current Unmodulated	350	ma.
Maximum Plate Dissipation	350	watts
Maximum D-C Grid Current	125	ma.
Maximum R-F Grid Current	10	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	1.5	megacycles
Above	200	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*4.5	megacycles
Above	*67	meters

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 312-E

This sturdy triode has a plate dissipation rating of 325 watts for class B and class C service. A pair of these tubes in class B audio service will deliver 650 watts.

INSTALLATION

The base of the UNITED 212-E is designed to fit a Western Electric 113A or similar type socket. The tube may be mounted either in a vertical position, or in a horizontal position with the plate on edge. Ample air space should be provided for ventilation.

The filament of the 212-E should be operated at the rated value of 14 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential the filament of the 212-E should be operated preferably from an a-c source.

The plate dissipation of the 212-E should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A. F. POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D. C. Plate Voltage	1500		volts
Maximum Plate Dissipation	275		watts
Typical Operation:			
Filament Voltage	14	14	a-c volts
D. C. Plate Voltage	1250	1500	volts
D. C. Grid Voltage	—40	—57	volts
Peak Grid Swing	35	52	volts
D. C. Plate Current	200	170	ma.
Plate Input	250	255	watts
Load Resistance	3000	5000	ohms
Power Output	40	50	watts

GRID BIAS MODULATOR

Maximum D. C. Plate Voltage	3000		volts
Maximum Plate Dissipation	200		watts
Typical Operation:			
Filament Voltage		14	a-c volts
D. C. Plate Voltage		3000	volts
D. C. Grid Voltage		—260	volts
Load Impedance		8000	ohms
Peak Power Output		200	watts

A. F. POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D. C. Plate Voltage	2000		volts
Maximum D. C. Plate Current (Averaged over any audio-freq. cycle)	325		ma.
Maximum Plate Dissipation (Averaged over any audio-freq. cycle)	300		watts
Typical Operation (2 tubes):			
Filament Voltage	14	14	a-c volts
D. C. Plate Voltage	1500	2000	volts
D. C. Grid Voltage	—75	—105	volts
Zero-Sig. Plate Cur. (per tube)	50	40	ma.
Max.-Sig. Plate Cur. (per tube)	300	300	ma.
Load Resistance (per tube)	1475	2000	ohms
Effective Load Res. (plate to plate)	5900	8000	ohms
Power Output	500	650	watts

R. F. POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions — Modulation Factor = 1.0)

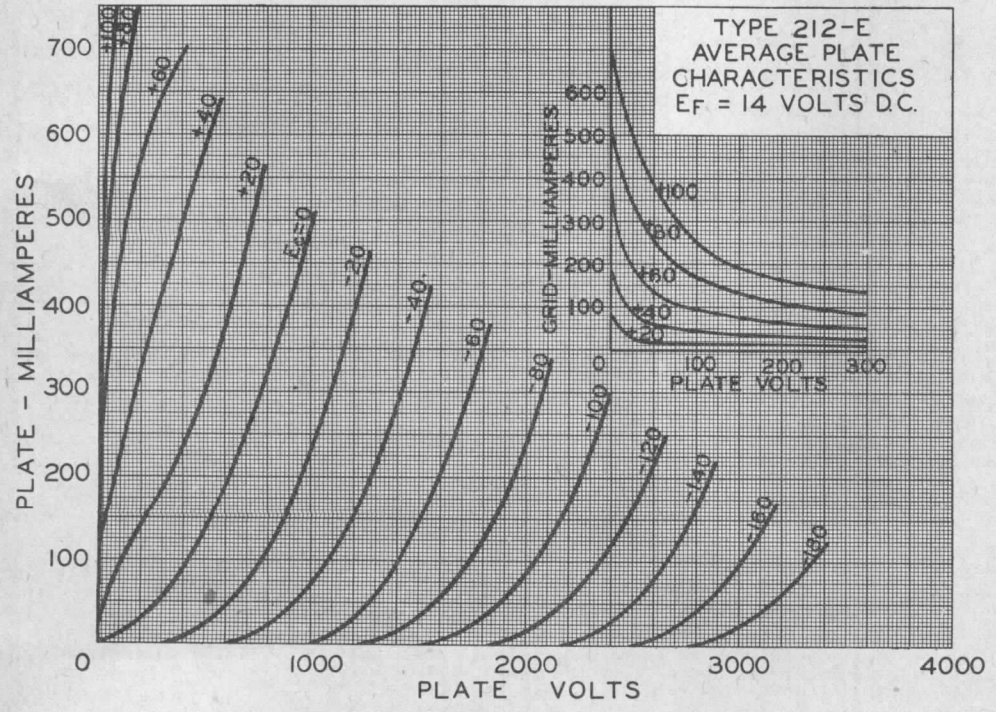
Maximum D. C. Plate Voltage	2000		volts
Maximum D. C. Plate Current	300		ma.
Maximum Plate Dissipation	325		watts
Maximum R. F. Grid Current	8		amp.
Typical Operation:			
Filament Voltage	14	14	a-c volts
D. C. Plate Voltage	1500	2000	volts
D. C. Grid Voltage	—90	—120	volts
D. C. Plate Current	300	300	ma.
Power Output	150	200	watts

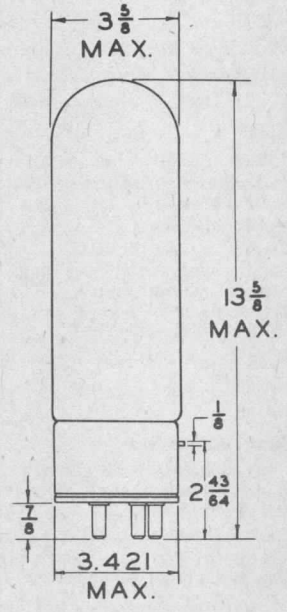
PLATE MODULATED R. F. POWER AMPLIFIER CLASS C TELEPHONY

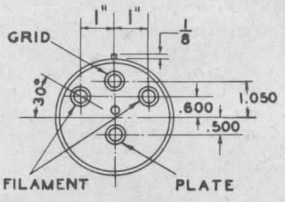
(Carrier Conditions — Modulation Factor = 1.0)

Maximum D. C. Plate Voltage	1500		volts
Maximum D. C. Plate Current	300		ma.
Maximum Plate Dissipation	325		watts
Maximum R. F. Grid Current	8		amp.
Maximum D. C. Grid Current	80		ma.
Typical Operation:			
Filament Voltage	14	14	a-c volts
D. C. Plate Voltage	1000	1500	volts
D. C. Grid Voltage	—125	—200	volts
D. C. Plate Current	300	300	ma.
D. C. Grid Current†	30	16	ma.
Driving Power†	12	7	watts
Power Output	200	300	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 242-B

A-F POWER AMPLIFIER, CLASS A, AB$_1$ MODULATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.25 amperes
Type	Thoriated Tungsten

Average Characteristic Values Calculated at:
Eb = 1000, Ec = —50, Ef = 10 D-C

Plate Current	0.072 amperes
Amplification Factor	12
Plate Resistance	3400 ohms
Mutual Conductance	3530 micromhos

Average Direct Interelectrode Capacities:

Grid to Plate	14.5 uuf
Grid to Filament	6.0 uuf
Plate to Filament	5.5 uuf

Maximum Overall Dimensions:

Length	7 7/8 inches
Diameter	2 5/16 inches
Bulb	T-18
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

MAXIMUM RATINGS

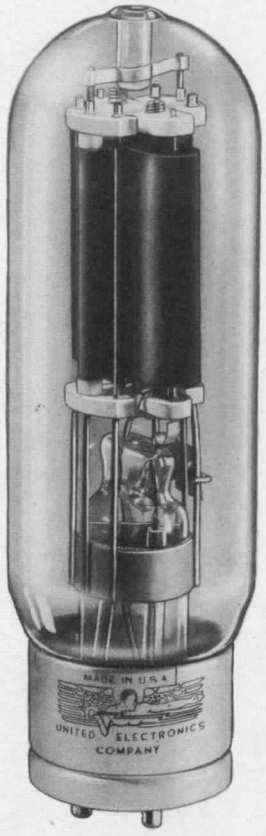
Maximum D-C Plate Voltage	1250 volts
Maximum Plate Dissipation	100 watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage	1250 volts
Maximum D-C Plate Current	85 ma.
Maximum Plate Dissipation	85 watts

Typical Operation:

Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
Grid Voltage	—46	—61	—80	volts
Peak Grid Swing	41	56	75	approx. volts
D-C Plate Current	34	53	60	ma.
Plate Resistance	4400	3800	3600	ohms
Mutual Conductance	2750	3150	3300	umhos
Load Resistance	8800	7600	9200	ohms
U. P. O. (5% 2nd harmonic)	5.6	12.0	19.7	watts



INTERCHANGES WITH TYPES 242-A, 342-B

UNITED type 242-B is widely used for many audio applications and in motion picture sound amplifiers.

INSTALLATION

The base of the UNITED 242-B is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 242-B should be operated at the rated value of 10 volts. Operation at other than the rated value may result in loss of filament emission and short life.

UNITED type 242-B is especially designed for use as a Class A and AB$_1$ audio-frequency Amplifier and Modulator; for other classes of service UNITED type 211 is to be preferred.

While the ratings printed herein are conservative, it is important to observe the requirements of good engineering practice as to transmitter design and operation. Adequate cabinet ventilation should be provided to carry off the heat dissipated during operation. Tube sockets should be inspected to avoid high resistance contacts to the base-pin terminals.

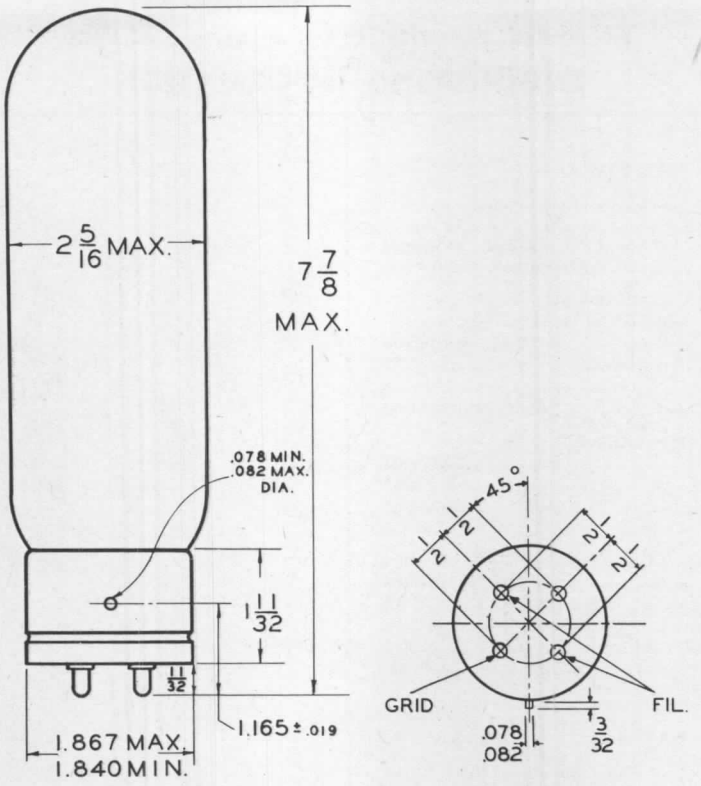
GRAPHITE ANODE

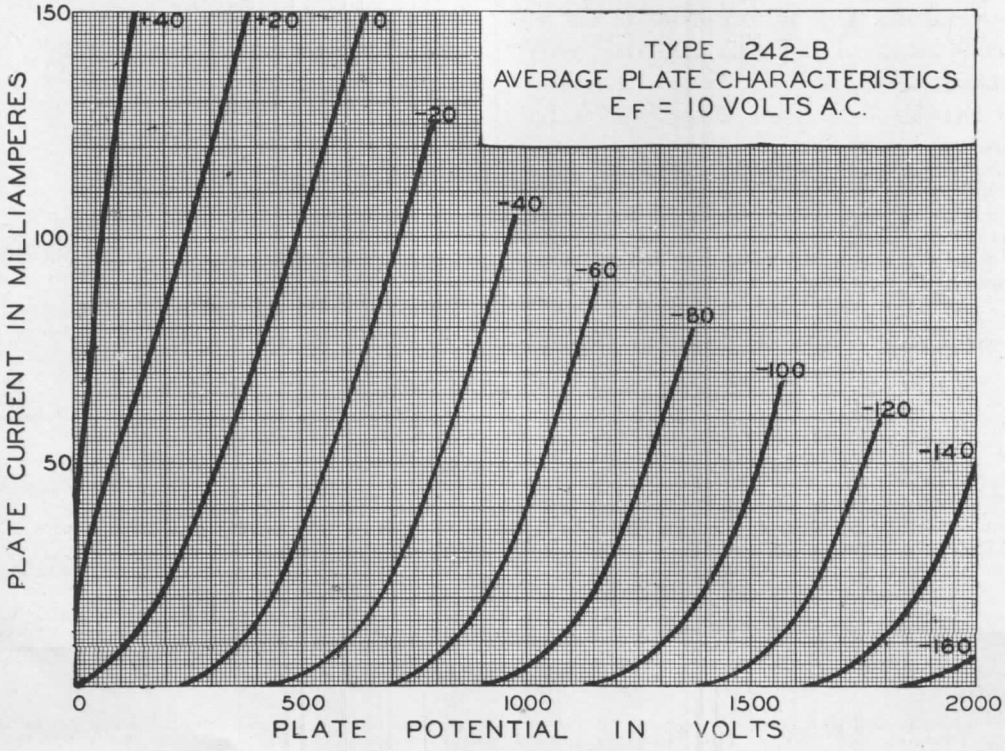
A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United


2 5/16 MAX.
7 7/8
MAX.
.078 MIN.
.082 MAX.
DIA.
1 11/32
11/32
1.165 ± .019
1.867 MAX.
1.840 MIN.
45°
GRID
FIL.
.078
.082
3/32


TYPE 242-B
AVERAGE PLATE CHARACTERISTICS
EF = 10 VOLTS A.C.
PLATE CURRENT IN MILLIAMPERES
150
100
50
+40
+20
0
-20
-40
-60
-80
-100
-120
-140
-160
0
500
1000
1500
2000
PLATE POTENTIAL IN VOLTS

UNITED ELECTRONICS

TYPE 261-A

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

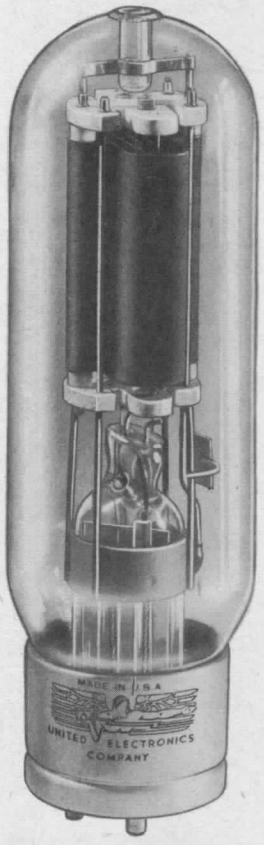
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.25 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Eb = 1000, Ec = −50, Ef = 10 D-C	
Plate Current	0.072 amperes
Amplification Factor	12
Plate Resistance	3400 ohms
Mutual Conductance	3530 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	9.0 uuf
Grid to Filament	6.0 uuf
Plate to Filament	5.0 uuf
Maximum Overall Dimensions:	
Length	7 7/8 inches
Diameter	2 5/16 inches
Bulb	T-18
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1000	volts
Maximum D-C Plate Voltage Unmodulated	1250	volts
Maximum A-C Plate Voltage R. M. S.	1250	volts
Maximum D-C Plate Current Modulated	150	ma.
Maximum D-C Plate Current Unmodulated	175	ma.
Maximum Plate Dissipation	125	watts
Maximum D-C Grid Current	50	ma.
Maximum R-F Grid Current	7.5	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	15	megacycles
Above	20	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*80	megacycles
Above	*3.75	meters

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 361-A

"Ruggedized" construction enables UNITED type 261-A to withstand unusual shock and vibration conditions. Type 261-A has a high insulation ceramic shoulder around the plate terminal pin and is used in many airway installations.

INSTALLATION

The base of the UNITED 261-A is designed for mounting in a Western Electric 112-A or similar type "50 watt" socket. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 261-A should be operated at the rated value of 10 volts. Operation at other than the rated value may result in loss of filament emission and short life. UNITED type 261-A has added insulation protection at the plate terminal and is featured by the UNITED "Ruggedized" construction. It is especially designed for aircraft and other installations where adverse conditions of shock, vibration, humidity, and temperature may be encountered.

While the ratings printed herein are conservative, it is important to observe the requirements of good engineering practice as to transmitter design and operation. Adequate cabinet ventilation should be provided to carry off the heat dissipated during operation. Tube sockets should be inspected to avoid high resistance contacts to the base-pin terminals.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage			1250	volts
Maximum Plate Dissipation			100	watts
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage	—46	—61	—80	volts
Peak Grid Swing	41	56	75	approx. volts
D-C Plate Current	34	53	60	ma.
Plate Resistance	4400	3800	3600	ohms
Mutual Conductance	2750	3150	3300	umhos
Load Resistance	8800	7600	9200	ohms
U. P. O. (5% 2nd harmonic)	5.6	12.0	19.7	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		1250	volts
Maximum D-C Plate Current } Averaged over any		175	ma.
Maximum Plate Dissipation } audio-freq. cycle		125	watts
Typical Operation (2 tubes):			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	1000	1250	volts
D-C Grid Voltage	—77	—100	volts
Zero-Sig. Plate Cur. (per tube)	10	10	ma.
Max.-Sig. Plate Cur. (per tube)	160	160	ma.
Load Res. (plate to plate)	6900	9000	ohms
Power Output	200	260	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			150	ma.
Maximum Plate Dissipation			125	watts
Maximum R-F Grid Current			6	amp.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	1000	1250		volts
D-C Grid Voltage	—77	—100		volts
D-C Plate Current	130	160		ma.
Peak Power Output	160	170		watts
Power Output	40	42.5		watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

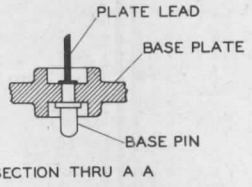
Maximum D-C Plate Voltage			1000	volts
Maximum D-C Plate Current			175	ma.
Maximum Plate Dissipation			85	watts
Maximum R-F Grid Current			6	amp.
Maximum D-C Grid Current			50	ma.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	750	1000		volts
D-C Grid Voltage	—200	—260		volts
D-C Plate Current	150	150		ma.
D-C Current†	35	35		ma.
Driving Power†	12	14		watts
Power Output	65	100	approx.	watts

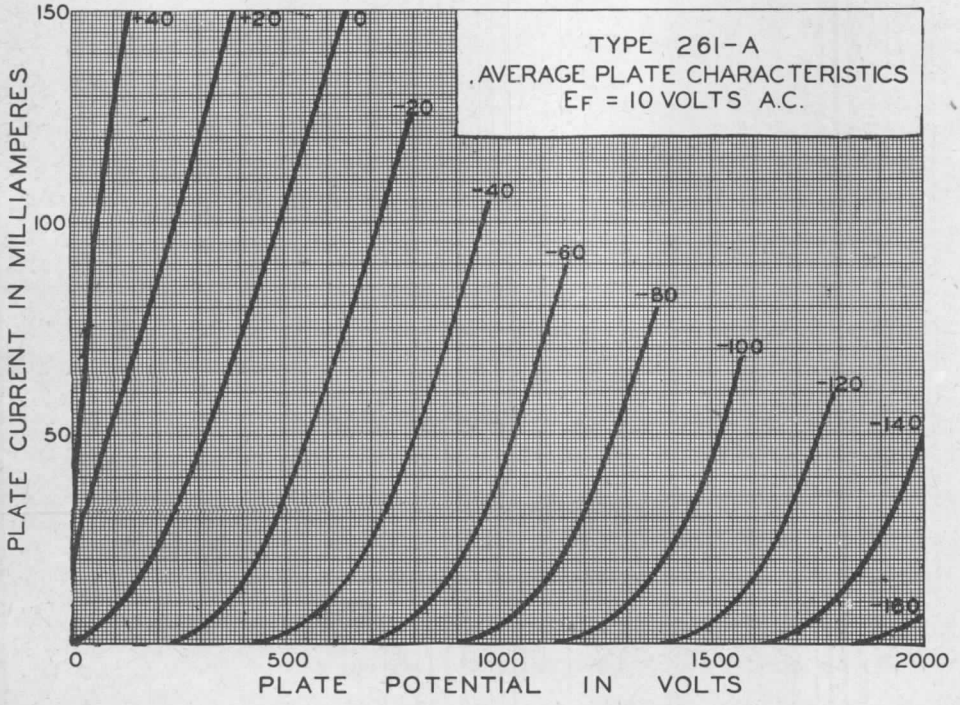
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

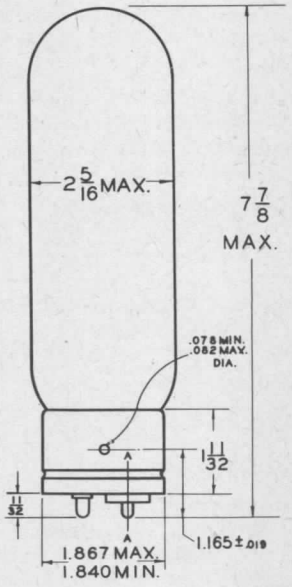
(Key-Down Conditions)

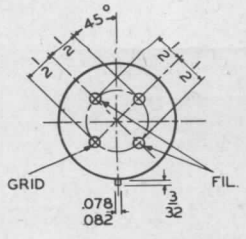
Maximum D-C Plate Voltage				1250	volts
Maximum D-C Plate Current				175	ma.
Maximum Plate Dissipation				125	watts
Maximum R-F Grid Current				7.5	amp.
Maximum D-C Grid Current				50	ma.
Typical Operation:					
Filament Voltage	10	10	10	a-c	volts
D-C Plate Voltage	750	1000	1250		volts
D-C Grid Voltage	—135	—175	—225		volts
D-C Plate Current	150	150	150		ma.
D-C Grid Current†	18	18	18		ma.
Driving Power†	5	6	7		watts
Power Output	65	100	130	approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.









UNITED ELECTRONICS

TYPE 276-A

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

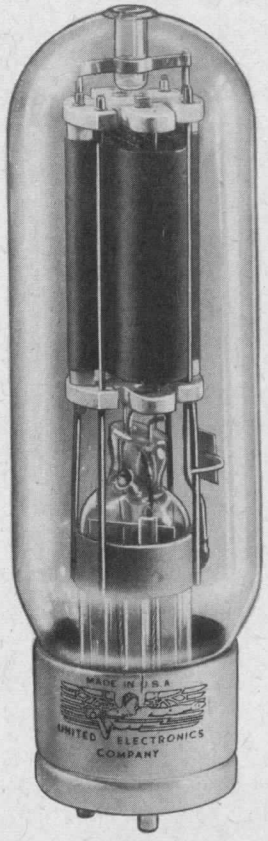
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.00 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Eb = 1000, Ec = −50, Ef = 10 D-C	
Plate Current	0.072 amperes
Amplification Factor	12
Plate Resistance	3400 ohms
Mutual Conductance	3530 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	9.0 uuf
Grid to Filament	6.0 uuf
Plate to Filament	5.0 uuf
Maximum Overall Dimensions:	
Length	7 7/8 inches
Diameter	2 5/16 inches
Bulb	T-18
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1000	volts
Maximum D-C Plate Voltage Unmodulated	1250	volts
Maximum A-C Plate Voltage R. M. S.	1250	volts
Maximum D-C Plate Current Modulated	150	ma.
Maximum D-C Plate Current Unmodulated	175	ma.
Maximum Plate Dissipation	125	watts
Maximum D-C Grid Current	50	ma.
Maximum R-F Grid Current	7.5	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	15	megacycles
Above	20	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*80	megacycles
Above	*3.75	meters

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED 376-A

"Ruggedized" construction enables type 276-A to withstand unusual shock and vibration conditions. Type 276-A is used in many airway, police, and broadcast transmitters.

INSTALLATION

The base of the UNITED 276-A is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 276-A should be operated at the rated value of 10 volts. Operation at other than the rated value may result in loss of filament emission and short life.

While the ratings printed herein are conservative, it is important to observe the requirements of good engineering practice as to transmitter design and operation. Adequate cabinet ventilation should be provided to carry off the heat dissipated during operation. Tube sockets should be inspected to avoid high resistance contacts to the base-pin terminals.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage			1250	volts
Maximum Plate Dissipation			100	watts
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage	—46	—61	—80	volts
Peak Grid Swing	41	56	75	approx. volts
D-C Plate Current	34	53	60	ma.
Plate Resistance	4400	3800	3600	ohms
Mutual Conductance	2750	3150	3300	umhos
Load Resistance	8800	7600	9200	ohms
U. P. O. (5% 2nd harmonic)	5.6	12.0	19.7	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		1250	volts
Maximum D-C Plate Current } Averaged over any audio-freq. cycle		175	ma.
Maximum Plate Dissipation }		125	watts
Typical Operation (2 tubes):			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	1000	1250	volts
D-C Grid Voltage	—77	—100	volts
Zero-Sig. Plate Cur. (per tube)	10	10	ma.
Max.-Sig. Plate Cur. (per tube)	160	160	ma.
Load Res. (plate to plate)	6900	9000	ohms
Power Output	200	260	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			150	ma.
Maximum Plate Dissipation			125	watts
Maximum R-F Grid Current			6	amp.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	1000	1250		volts
D-C Grid Voltage	—77	—100		volts
D-C Plate Current	130	160		ma.
Peak Power Output	160	170		watts
Power Output	40	42.5		watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

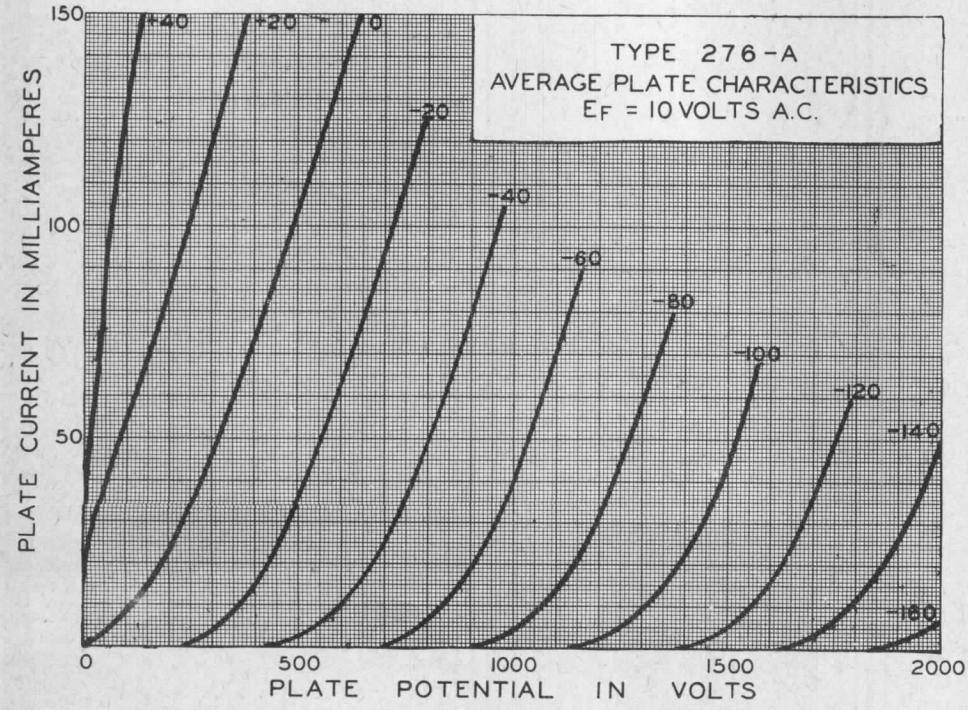
Maximum D-C Plate Voltage			1000	volts
Maximum D-C Plate Current			175	ma.
Maximum Plate Dissipation			85	watts
Maximum R-F Grid Current			6	amp.
Maximum D-C Grid Current			50	ma.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	750	1000		volts
D-C Grid Voltage	—200	—260		volts
D-C Plate Current	150	150		ma.
D-C Current†	35	35		ma.
Driving Power†	12	14		watts
Power Output	65	100	approx.	watts

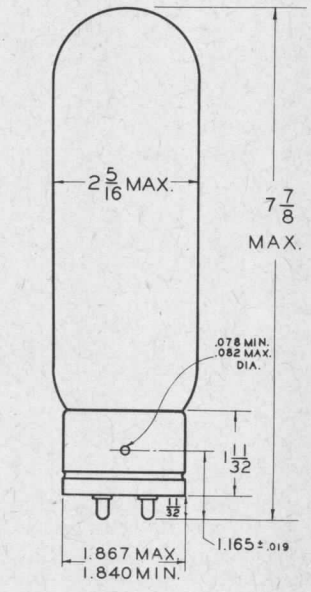
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

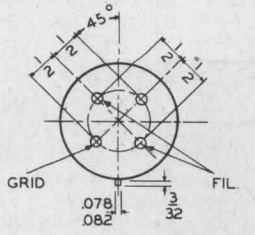
(Key-Down Conditions)

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			175	ma.
Maximum Plate Dissipation			125	watts
Maximum R-F Grid Current			7.5	amp.
Maximum D-C Grid Current			50	ma.
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage	—135	—175	—225	volts
D-C Plate Current	150	150	150	ma.
D-C Grid Current†	18	18	18	ma.
Driving Power†	5	6	7	watts
Power Output	65	100	130 approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 284-D

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

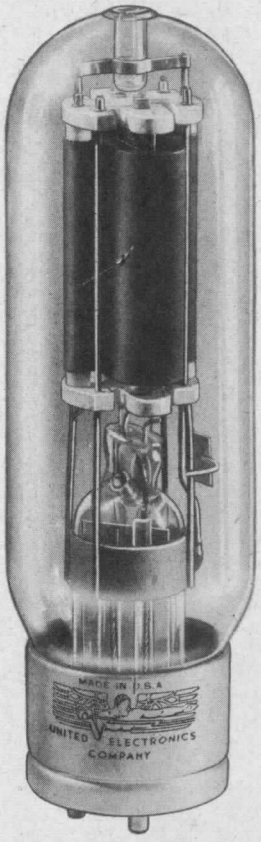
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.25 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Eb = 1250, Ec = −220, Ef = 10 D-C	
Plate Current	0.064 amperes
Amplification Factor	4.8
Plate Resistance	1900 ohms
Mutual Conductance	2500 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	8.3 uuf
Grid to Filament	5.0 uuf
Plate to Filament	5.6 uuf
Maximum Overall Dimensions:	
Length	7 7/8 inches
Diameter	2 5/16 inches
Bulb	T-18
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1000	volts
Maximum D-C Plate Voltage Unmodulated	1250	volts
Maximum A-C Plate Voltage R. M. S.	1250	volts
Maximum D-C Plate Current Modulated	150	ma.
Maximum D-C Plate Current Unmodulated	175	ma.
Maximum Plate Dissipation	100	watts
Maximum D-C Grid Current	50	ma.
Maximum R-F Grid Current	7.5	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	30	megacycles
Above	10	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*60	megacycles
Above	*5	meters

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 384-D

This rugged, specially designed low mu tube is ideally suited for audio applications. It may also be used for general purposes in accordance with the ratings shown.

INSTALLATION

The base of the UNITED 284-D is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 284-D should be operated at the rated value of 10 volts. Operation at other than the rated value may result in loss of filament emission and short life.

While the ratings printed herein are conservative, it is important to observe the requirements of good engineering practice as to transmitter design and operation. Adequate cabinet ventilation should be provided to carry off the heat dissipated during operation. Tube sockets should be inspected to avoid high resistance contacts to the base-pin terminals.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage			1250	volts
Maximum Plate Dissipation			85	watts
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage	—109	—166	—225	volts
Peak Grid Swing	—104	161	220	volts
D-C Plate Current	100	80	64	ma.
Plate Resistance	1550	1720	1900	ohms
Mutual Conductance	3100	2800	2500	umhos
Load Resistance	8000	8500	10000	ohms
U.P.O. (5% 2nd harmonic)	5.6	12.0	19.7	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		1250	volts
Maximum D-C Plate Current (Averaged over any audio-freq. cycle)		175	ma.
Maximum Plate Dissipation (Averaged over any audio-freq. cycle)		100	watts
Typical Operation (2 tubes):			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	1000	1250	volts
D-C Grid Voltage	—195	—250	volts
Zero-Sig. Plate Cur. (per tube)	15	15	ma.
Max.-Sig. Plate Cur. (per tube)	100	100	ma.
Load Res. (plate to plate)	8800	11200	ohms
Power Output (2 tubes)	110	140	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage		1250	volts
Maximum D-C Plate Current		150	ma.
Maximum Plate Dissipation		100	watts
Maximum R-F Grid Current		6	amp.
Typical Operation:			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	1000	1250	volts
D-C Grid Voltage	—225	—280	volts
D-C Plate Current	100	100	ma.
Peak Power Output	160	170	watts
Power Output	40	43	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

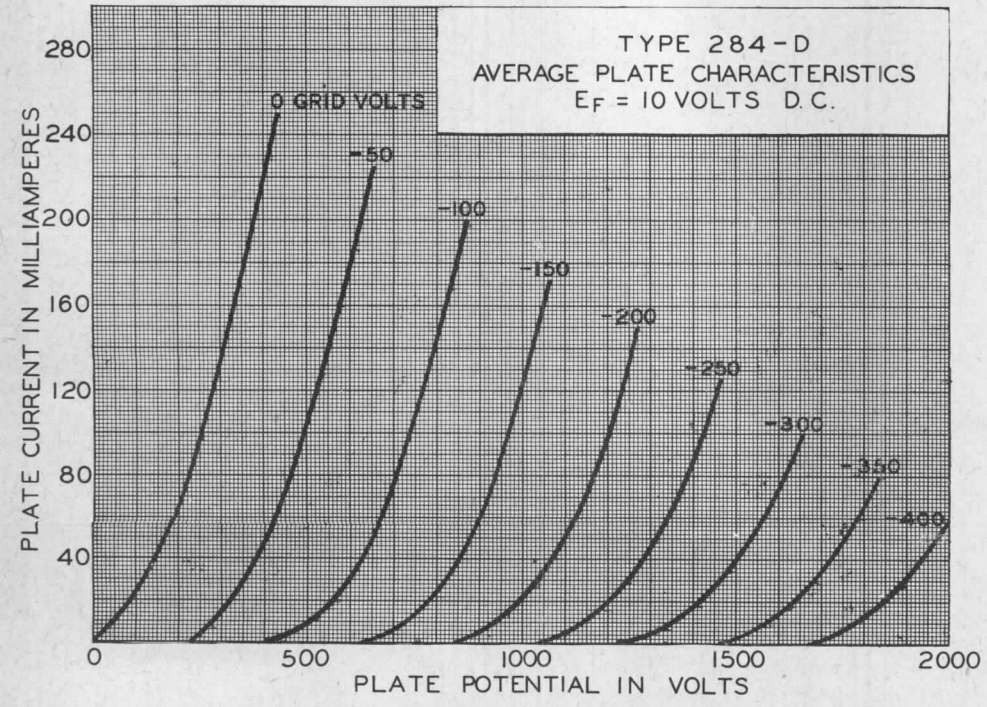
Maximum D-C Plate Voltage		1000	volts
Maximum D-C Plate Current		175	ma.
Maximum Plate Dissipation		67	watts
Maximum R-F Grid Current		6	amp.
Maximum D-C Grid Current		50	ma.
Typical Operation:			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	750	1000	volts
D-C Grid Voltage	—340	—450	volts
D-C Plate Current	150	150	ma.
D-C Grid Current†	50	50	ma.
Driving Power†	12	14	watts
Power Output	75	100	watts

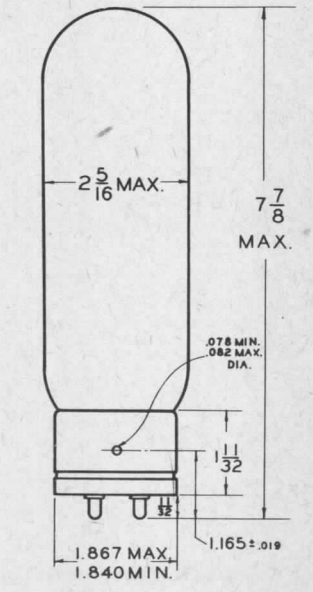
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

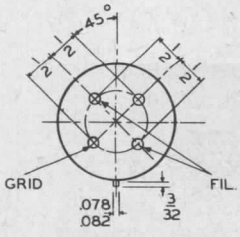
(Key-Down Conditions)

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			175	ma.
Maximum Plate Dissipation			100	watts
Maximum R-F Grid Current			7.5	amp.
Maximum D-C Grid Current			50	ma.
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
D-C Grid Voltage	—315	—417	—520	volts
D-C Plate Current	150	150	150	ma.
D-C Grid Current†	20	20	20	ma.
Driving Power†	5	6	7	watts
Power Output	75	100	125	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 805

R. F. POWER AMPLIFIER, OSCILLATOR, CLASS B MODULATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.25 amperes
Type	Thoriated Tungsten

Average Characteristic Values Calculated at:
Ep = 1250, Ec = 0, Ef = 10 D-C

Plate Current	0.060 amperes
Amplification Factor	100
Plate Resistance	12500 ohms
Mutual Conductance	8000 micromhos

Average Direct Interelectrode Capacities:

Grid to Plate	6.5 uuf
Grid to Filament	8.5 uuf
Plate to Filament	10.5 uuf

Maximum Overall Dimensions:

Length	8 1/2 inches
Diameter	2 5/16 inches

Bulb	T-18
Cap	Medium Metal
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1250	volts
Maximum D-C Plate Voltage Unmodulated	1500	volts
Maximum A-C Voltage R. M. S.	1800	volts
Maximum D-C Plate Current Modulated	175	ma.
Maximum D-C Plate Current Unmodulated	210	ma.
Maximum Plate Dissipation	125	watts
Maximum D-C Grid Current	70	ma.
Maximum R-F Grid Current	7.5	amp.

Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:

Above	10 meters
Below	30 megacycles

*Maximum Frequency Rating with Reduced Power Input and Output:

Above	*3.5 meters
Below	*85 megacycles

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.

Replaces UNITED Type 905

A zero bias amplifier under certain conditions shown in tables of following page, type 805 has attained great favor in new transmitter design.

Typical UNITED design and processing enhances performance and service life expectancy.

INSTALLATION

The base of the UNITED 805 is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 805 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life.

The plate dissipation of the 805 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

Extra ruggedness of the 805 is accomplished through the use of a plate support at the top in addition to the conventional cathode collar support. An improved insulator is used to give added insulation protection and maintain perfect element alignment.

The Maximum Ratings should not be exceeded for satisfactory operation and full service life.

GRAPHITE ANODE

A graphite anode is used in this type tube because of several specific advantages over metals such as tantalum, molybdenum and nickel. The radiating area of graphite is approximately twice the projected area due to its surface porosity. Moreover, due to the black body principle, it will dissipate four times more heat than metal.

Graphite, being infusible, will not warp or twist. Therefore, it maintains its exact form under all temperatures, the result being constant inter-element relationship. The low operating temperature of the graphite anode tends to keep the grid cool, reduces overload hazards, and prevents gas current. The inherent qualities of graphite over metal as outlined above, are advantages of primary importance in designing tubes of this type for long and satisfactory service life.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage			1500	volts
Maximum D-C Plate Current	Averaged over		210	ma.
Maximum Plate Input	any audio		315	watts
Maximum Plate Dissipation	freq. cycle		125	watts
Typical Operation (2 tubes):				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	1250	1500		volts
D-C Grid Voltage	—0	—16		volts
Peak A-F Grid to Grid Voltage	235	280		volts
Zero-Sig. D-C Plate Cur. (per tube)	74	42		ma.
Max-Sig. D-C Plate Cur. (per tube)	200	200		ma.
Load Resistance (per tube)	1675	2050		ohms
Effective Load Res. (plate to plate)	6700	8200		ohms
Max.-Signal Driving Power	6	7	approx.	watts
Power Output	300	370	approx.	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			1500	volts
Maximum D-C Plate Current			150	ma.
Maximum Plate Input			185	watts
Maximum Plate Dissipation			125	watts
Maximum R-F Grid Current			6	amp.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	1250	1500		volts
D-C Grid Voltage	0	—10		volts
Peak R-F Grid Voltage	75	70		volts
D-C Plate Current	135	115		ma.
D-C Grid Current†	15	15	approx.	ma.
Driving Power†	11	7.5	approx.	watts
Power Output	55	57.5	approx.	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

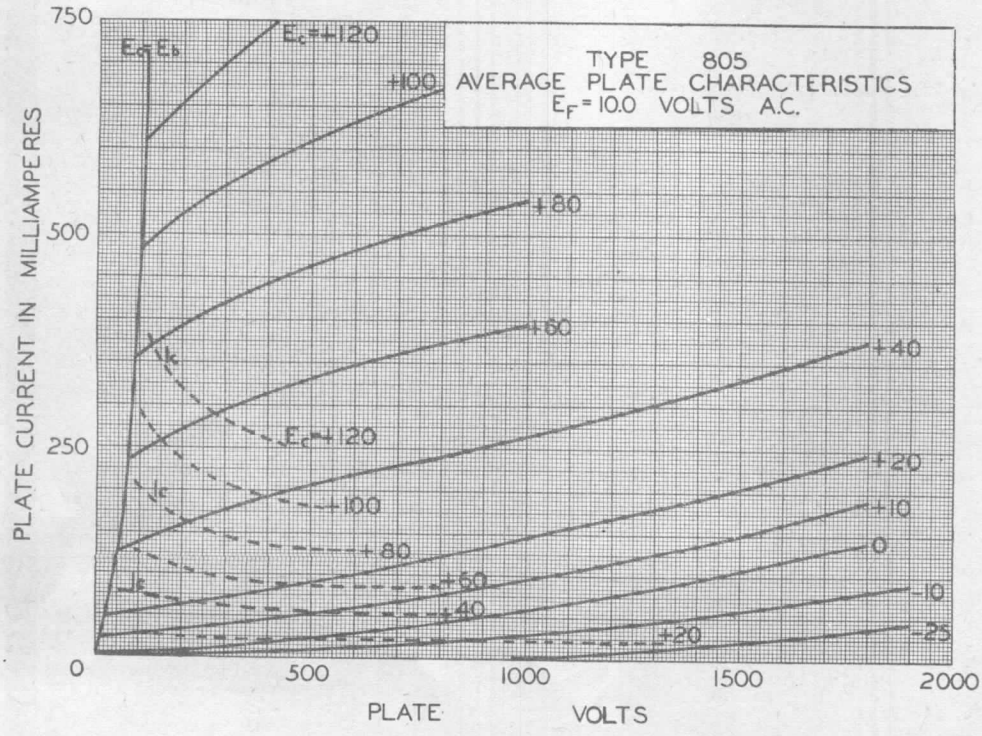
Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			175	ma.
Maximum Plate Input			220	watts
Maximum Plate Dissipation			85	watts
Maximum D-C Grid Voltage			—500	volts
Maximum D-C Grid Current			70	ma.
Maximum R-F Grid Current			6	amp.
Typical Operation:				
Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	1000	1250		volts
D-C Grid Voltage	—155	—160		volts
Peak R-F Grid Voltage	295	300		volts
D-C Plate Current	160	160		ma.
D-C Grid Current†	60	60	approx.	ma.
Driving Power†	16	16	approx.	watts
Power Output	110	140	approx.	watts

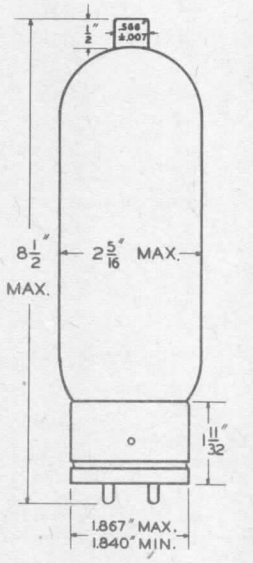
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

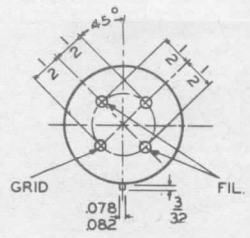
(Key Down Conditions)

Maximum D-C Plate Voltage				1500	volts
Maximum D-C Plate Current				210	ma.
Maximum Plate Input				315	watts
Maximum Plate Dissipation				125	watts
Maximum D-C Grid Voltage				—500	volts
Maximum D-C Grid Current				70	ma.
Maximum R-F Grid Current				7.5	amp.
Typical Operation:					
Filament Voltage	10	10	10	a-c	volts
D-C Plate Voltage	1000	1250	1500		volts
D-C Grid Voltage	—95	—100	—105		volts
Peak R-F Grid Voltage	225	230	235		volts
D-C Plate Current	200	200	200		ma.
D-C Grid Current	40	40	40	approx.	ma.
Driving Power†	8.5	8.5	8.5	approx.	watts
Power Output†	130	170	215	approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 813

TRANSMITTING BEAM POWER AMPLIFIER

ENGINEERING INFORMATION

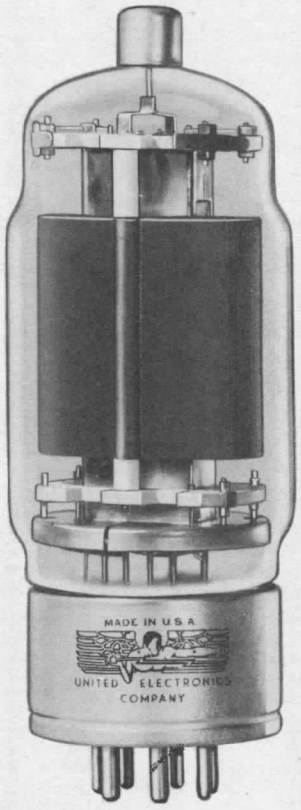
GENERAL RATINGS

Number of Electrodes	4
Filament Voltage	10.0 volts
Current	5.0 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: 50 ma. Plate Current	
Amplification Factor	100
Plate Resistance	27,000 ohms
Mutual Conductance	3750 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate (with external shielding)	0.2 uuf
Grid to Filament	16.3 uuf
Plate to Filament	14.0 uuf
Maximum Overall Dimensions:	
Length	7 1/2 inches
Diameter	2 9/16 inches
Bulb	T-20
Cap	Medium Metal
Base	Giant 7-Pin, Bayonet
Type of Cooling	Air
Net Weight	7 5/8 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2000	volts
Maximum D-C Plate Voltage Unmodulated	2000	volts
Maximum D-C Plate Current Modulated	100	ma.
Maximum D-C Plate Current Unmodulated	180	ma.
Maximum Plate Dissipation	100	watts
Maximum D-C Grid Current	25	ma.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	30	megacycles
Above	10	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	120	megacycles
Above	2.5	meters

*For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



Extremely high power sensitivity and low driving power requirements make this rugged UNITED 813 a popular choice for final stage power amplification and high-power frequency multiplier service.

INSTALLATION

The base of the UNITED 813 is designed for mounting in a special 7-contact transmitting socket. The tube may be mounted either vertically, in the base-down or base-up position with filament axis vertical, or horizontally, with the filament base pins mounted in the vertical plane so that the plate will also be vertical (on edge). Ample air space should be provided for ventilation.

The beam forming plates of the 813 should always be operated at zero potential with respect to the filament. The beam forming plates should be connected to the midpoint of the filament circuit when an A-C filament supply is used, and to the negative end of the filament when a D-C filament supply is used.

A protective device, such as a high-voltage fuse, should be used to protect both the plate and screen against overloads.

Shielding and isolation of the input and output circuits are necessary for stable operation. If an external shield is used with the 813, it should be designed to enclose the base end of the tube and extend up to a position level with the internal circular shield disc located below the plate.

Neutralization is unnecessary in adequately shielded circuits.

GRAPHITE ANODE

A graphite anode is used in this type because of several specific advantages over metals such as tantalum, molybdenum and nickel. The radiating area of graphite is approximately twice the projected area due to its surface porosity. Moreover, because of the black body principle, it will dissipate four times more heat than metal.

Graphite, being infusible, will not warp or twist. Therefore, it maintains its exact form under all temperatures, the result being constant inter-element relationship. The low operating temperature of the graphite anode tends to keep the grid cool, reduces overload hazards, and prevents gas current. The inherent qualities of graphite over metal as outlined above, are advantages of primary importance in designing tubes of this type for long and satisfactory service life.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2000	volts
Maximum D-C Plate Current	100	ma.
Maximum Plate Input	150	watts
Maximum Screen Input	15	watts
Maximum Plate Dissipation	100	watts

Typical Operation:

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	1500	2000	volts
D-C Screen Voltage	400	400	volts
D-C Grid Voltage	—60	—75	volts
Peak R-F Grid Voltage	70	80	volts
Beam Forming Plate Voltage	0	0	volts
D-C Plate Current	100	75	ma.
D-C Screen Current	4	3	ma.
Power Output ..... approx.	50	50	watts

GRID MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2000	volts
Maximum D-C Plate Current	100	ma.
Maximum Plate Input	150	watts
Maximum Screen Input	15	watts
Maximum Plate Dissipation	100	watts
Maximum D-C Screen Voltage	400	volts
Maximum D-C Grid Voltage	—200	volts
Maximum D-C Grid Current	25	ma.

Typical Operation:

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	1500	2000	volts
D-C Screen Voltage	400	400	volts
D-C Grid Voltage	—140	—120	volts
Peak R-F Grid Voltage	145	120	volts
Peak A-F Grid Voltage	60	60	volts
Beam Forming Plate Voltage	0	0	volts
D-C Plate Current	70	75	ma.
D-C Screen Current	16	20	ma.
D-C Grid Current ..... approx.	—	—	
Driving Power † ..... approx.	—	—	watts
Power Output ..... approx.	40	50	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	1600	volts
Maximum D-C Plate Current	150	ma.
Maximum Plate Input	240	watts
Maximum Screen Input	15	watts
Maximum Plate Dissipation	67	watts
Maximum D-C Screen Voltage	400	volts
Maximum D-C Grid Voltage	—300	volts
Maximum D-C Grid Current	25	ma.

Typical Operation:

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	1250	1600	volts
D-C Screen Voltage	400	400	volts
D-C Grid Voltage	—120	—130	volts
Peak R-F Grid Voltage	195	210	volts
Beam Forming Plate Voltage	0	0	volts
D-C Plate Current	150	150	ma.
D-C Screen Current	16	20	ma.
D-C Grid Current † ..... approx.	4	6	ma.
Driving Power † ..... approx.	.7	1.2	watts
Power Output ..... approx.	135	175	watts

R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

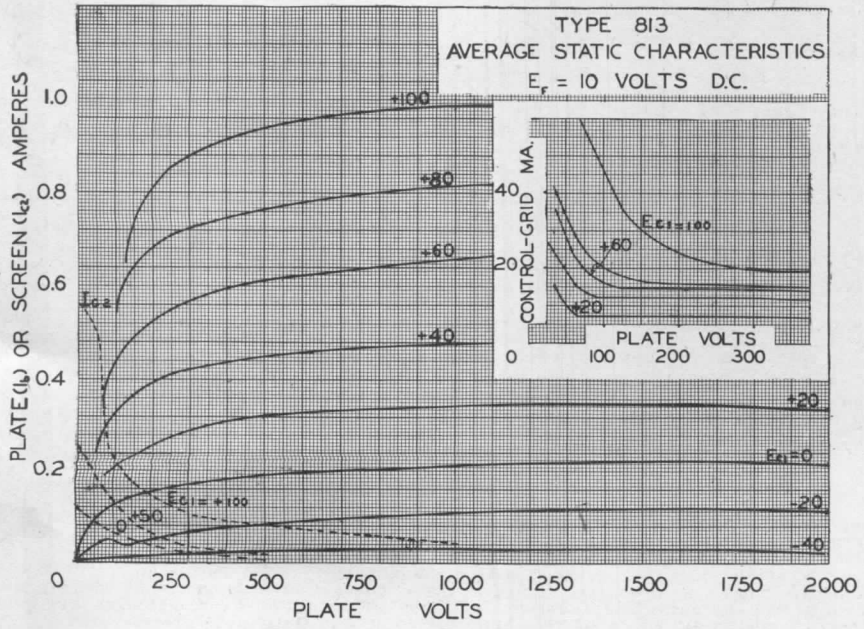
(Key Down Conditions)

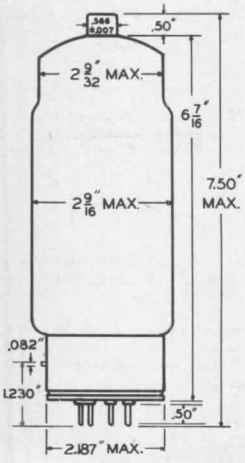
Maximum D-C Plate Voltage	2000		volts
Maximum D-C Plate Current	180		ma.
Maximum Plate Input	360		watts
Maximum Screen Input	22		watts
Maximum Plate Dissipation	100		watts
Maximum D-C Screen Voltage	400		volts
Maximum D-C Grid Voltage	—300		volts
Maximum D-C Grid Current	25		ma.

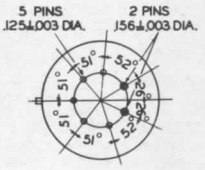
Typical Operation:

A-C Filament Voltage	10	10	10	volts
D-C Plate Voltage	1250	1500	2000	volts
D-C Screen Voltage	300	300	400	volts
D-C Grid Voltage	—60	—70	—90	volts
Peak R-F Grid Voltage	145	150	160	volts
Beam Forming Plate Voltage	0	0	0	volts
D-C Plate Current	180	180	180	ma.
D-C Screen Current	23	20	15	ma.
D-C Grid Current † ..... approx.	7	6	3	ma.
Driving Power † ..... approx.	1	0.8	0.5	watts
Power Output ..... approx.	155	190	260	watts

†Subject to wide variations depending on the impedence of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 830

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	2 amperes
Type	Thoriated Tungsten

Average Characteristic Values Calculated at:
Eb = 425, Ec = —35, Ef = 10 D-C

Plate Current	0.020 amperes
Amplification Factor	8
Plate Resistance	4000 ohms
Mutual Conductance	2000 micromhos

Average Direct Interelectrode Capacities:

Grid to Plate	9.9 uuf
Grid to Filament	4.9 uuf
Plate to Filament	2.2 uuf

Maximum Overall Dimensions

Length	5 7/8 inches
Diameter	2 1/16 inches
Bulb	T-16
Base	Medium 4-Pin Ceramic Bayonet
Type of Cooling	Air
Net Weight	4 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	600	volts
Maximum D-C Plate Voltage Unmodulated	750	volts
Maximum A-C Plate Voltage R. M. S.	600	volts
Maximum D-C Plate Current Modulated	100	ma.
Maximum D-C Plate Current Unmodulated	110	ma.
Maximum Plate Dissipation	40	watts
Maximum D-C Grid Current	18	ma.
Maximum R-F Grid Current	6	amp.

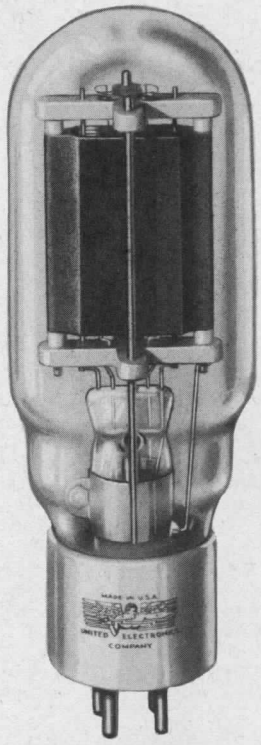
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:

Below	15 megacycles
Above	20 meters

*Maximum Frequency Rating with Reduced Power Input and Output:

Below	*30 megacycles
Above	*10 meters

*For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings. and Typical Operating Conditions. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 930

Plate dissipation of this small but sturdy triode is 40 watts for class C telegraph and class B service. A pair of these tubes in class B audio service will deliver over 100 watts output.

INSTALLATION

The base of the UNITED 830 is designed for mounting in a standard four-prong, bayonet type socket. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 830 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life.

The plate dissipation of the 830 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage			750	volts
Maximum Plate Dissipation			30	watts
Typical Operation:				
Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	450	600	750	volts
Grid Voltage	—40	—55	—75	volts
Peak Grid Swing	35	50	70	volts
D-C Plate Current	30	43	40	ma.
Mutual Conductance	2850	2960	4000	umhos
Plate Resistance	2800	2900	2000	ohms
Load Resistance	8000	8500	9000	ohms
U. P. O. (5% 2nd harmonic)	1.9	4.0	6.3	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage			750	volts
Maximum D-C Plate Current } Averaged over any			110	ma.
Maximum Plate Dissipation } audio freq. cycle			40	watts
Typical Operation (2 tubes):				
Filament Voltage	10	10		a-c volts
D-C Plate Voltage	600	750		volts
D-C Grid Voltage	—65	—85		volts
Zero-Sig. Plate Cur. (per tube)	10	10		ma.
Max.-Sig. Plate Cur. (per tube)	110	110		ma.
Load Res. (Plate to Plate)	7000	9000		ohms
Power Output (2 tubes)	80	102		approx. watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			750	volts
Maximum D-C Plate Current			70	ma.
Maximum Plate Dissipation			40	watts
Maximum R-F Grid Current			6	amp.
Typical Operation:				
Filament Voltage	10	10		a-c volts
D-C Plate Voltage	600	750		volts
D-C Grid Voltage	—70	—100		volts
D-C Plate Current	70	70		ma.
Peak Power Output	42	52		approx. watts
Nominal Carrier Power Output	10.5	13		approx. watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

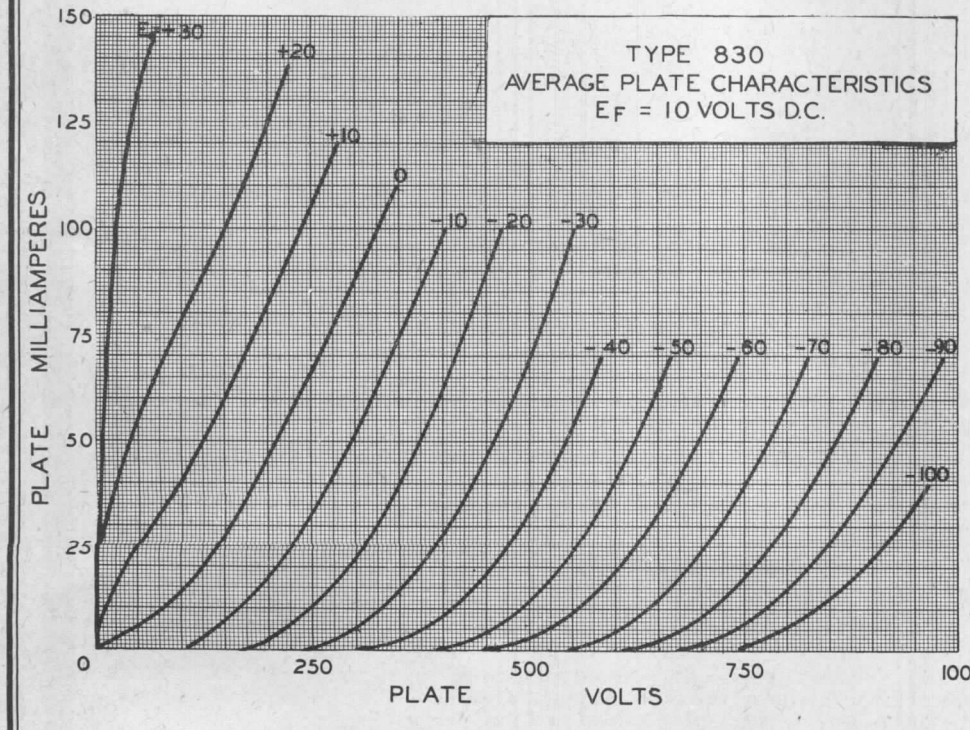
Maximum D-C Plate Voltage			600	volts
Maximum D-C Plate Current			100	ma.
Maximum Plate Dissipation			30	watts
Maximum R-F Grid Current			5	amp.
Maximum D-C Grid Current			18	ma.
Typical Operation:				
Filament Voltage	10	10		a-c volts
D-C Plate Voltage	500	600		volts
D-C Grid Voltage	—180	—220		volts
D-C Plate Current	100	100		ma.
D-C Grid Current†	15	15		ma.
Driving Power†	5	6.5		approx. watts
Power Output	33	50		approx. watts

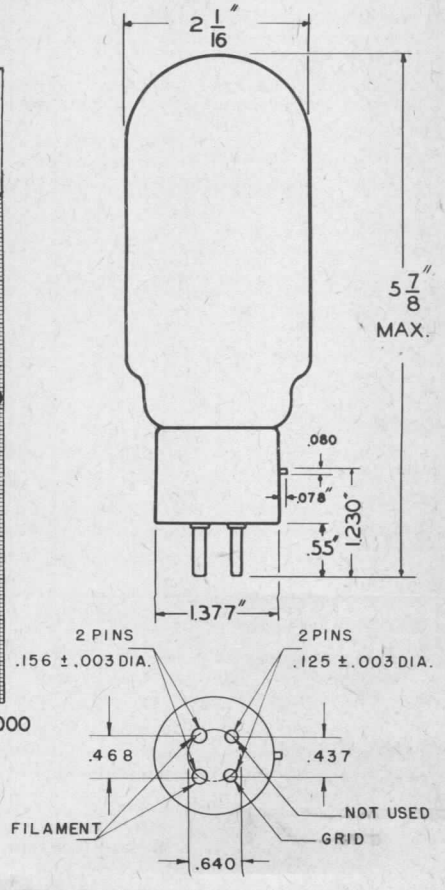
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

(Key-down Conditions)

Maximum D-C Plate Voltage			750	volts
Maximum D-C Plate Current			110	ma.
Maximum Plate Dissipation			40	watts
Maximum R-F Grid Current			6	amp.
Maximum D-C Grid Current			18	ma.
Typical Operation:				
Filament Voltage	10	10		a-c volts
D-C Plate Voltage	600	750		volts
D-C Grid Voltage	—150	—180		volts
D-C Plate Current	100	110		ma.
D-C Grid Current†	15	15		ma.
Driving Power†	4.5	5		approx. watts
Power Output	40	55		approx. watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE 830-B

CLASS B MODULATOR, R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

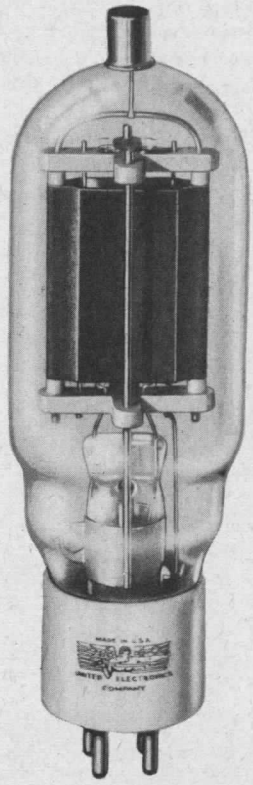
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	2.0 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Eb = 1000, Ec = —16, Ef = 10 D-C	
Plate Current	0.041 amperes
Amplification Factor	25
Plate Resistance	8130 ohms
Mutual Conductance	3080 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	11.0 uuf
Grid to Filament	5.0 uuf
Plate to Filament	1.8 uuf
Maximum Overall Dimensions:	
Length	6 5/8 inches
Diameter	2 1/16 inches
Cap	Small Metal
Bulb	T-16
Base	Medium 4-Pin Ceramic Bayonet
Type of Cooling	Air
Net Weight	4 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	800	volts
Maximum D-C Plate Voltage Unmodulated	1000	volts
Maximum A-C Plate Voltage R. M. S.	1000	volts
Maximum D-C Plate Current Modulated	100	ma.
Maximum D-C Plate Current Unmodulated	150	ma.
Maximum Plate Dissipation	60	watts
Maximum D-C Grid Current	30	ma.
Maximum R-F Grid Current	7.0	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	15	megacycles
Above	20	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*60	megacycles
Above	*5	meters

*For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



REPLACES UNITED TYPE 930-B

Typical United design and processing enhances the performance and service life expectancy of this sturdy tube.

INSTALLATION

The base of the UNITED 830-B is designed for mounting in a standard four-prong, bayonet type socket. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 830-B should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life.

The plate dissipation of the 830-B should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

Extra ruggedness of the 830-B is accomplished by the use of a plate support at the top in addition to the conventional cathode collar support. An improved insulator is used to give added insulation protection and maintain perfect element alignment.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		1000	volts
Maximum D-C Plate Current	Average over	150	ma.
Maximum Plate Input	any audio	150	watts
Maximum Plate Dissipation	freq. cycle	60	watts

Typical Operation (2 tubes):

Filament Voltage	10	10	a-c volts
D-C Plate Voltage	800	1000	volts
D-C Grid Voltage	—27	—35	volts
Peak A-F Grid to Grid Voltage	250	270	volts
Zero-Sig. D-C Plate Cur. (per tube)	10	10	ma.
Max.-Sig. D-C Plate Cur. (per tube)	140	140	ma.
Load Resistance (per tube)	1500	1900	ohms
Effective Load Res. (plate to plate)	6000	7600	ohms
Max.-Signal Driving Power	5	6 approx.	watts
Power Output	135	175 approx.	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage		1000	volts
Maximum D-C Plate Current		100	ma.
Maximum Plate Input		90	watts
Maximum Plate Dissipation		60	watts
Maximum R-F Grid Current		5.5	amp.

Typical Operation:

Filament Voltage	10	10	a-c volts
D-C Plate Voltage	800	1000	volts
D-C Grid Voltage	—27	—35	volts
Peak R-F Grid Voltage	85	85	volts
D-C Plate current	95	85	ma.
D-C Grid Current†	7	6 approx.	ma.
Driving Power†	9	6 approx.	watts
Power Output†	23	26 approx.	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0

Maximum D-C Plate Voltage		800	volts
Maximum D-C Plate Current		100	ma.
Maximum Plate Input		80	watts
Maximum Plate Dissipation		40	watts
Maximum D-C Grid Voltage		—300	volts
Maximum D-C Grid Current		30	ma.
Maximum R-F Grid Current		5.5	amp.

Typical Operation:

Filament Voltage	10	10	a-c volts
D-C Plate Voltage	600	800	volts
D-C Grid Voltage	—140	—150	volts
Peak R-F Grid Voltage	255	265	volts
D-C Plate Current	95	95	ma.
D-C Grid Current†	30	20 approx.	ma.
Driving Power†	7	5 approx.	watts
Power Output	38	50 approx.	watts

R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

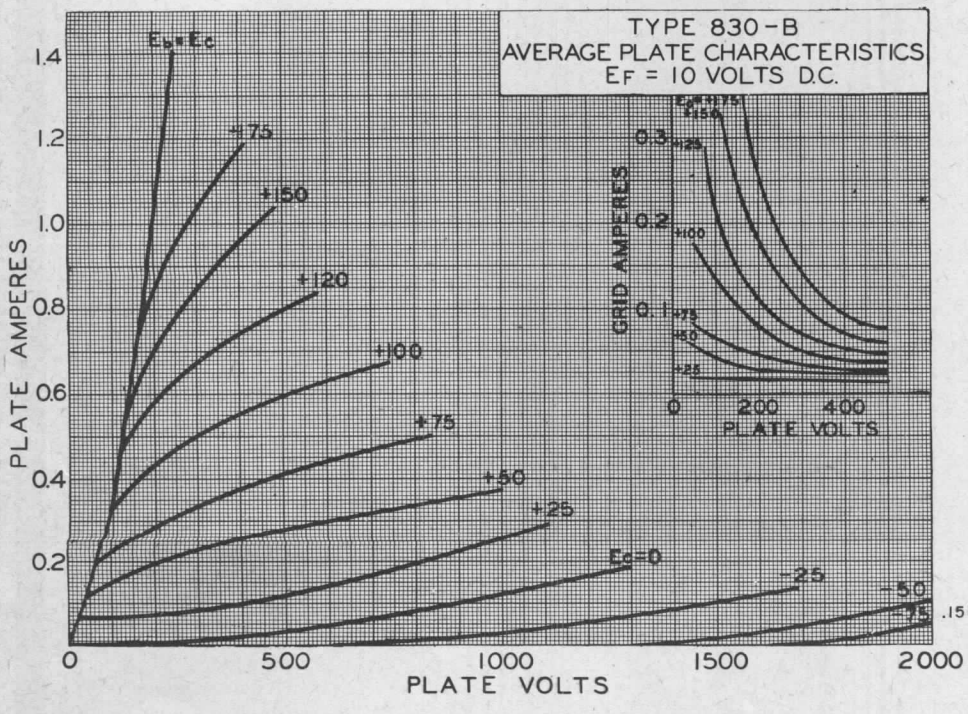
(Key Down Conditions)

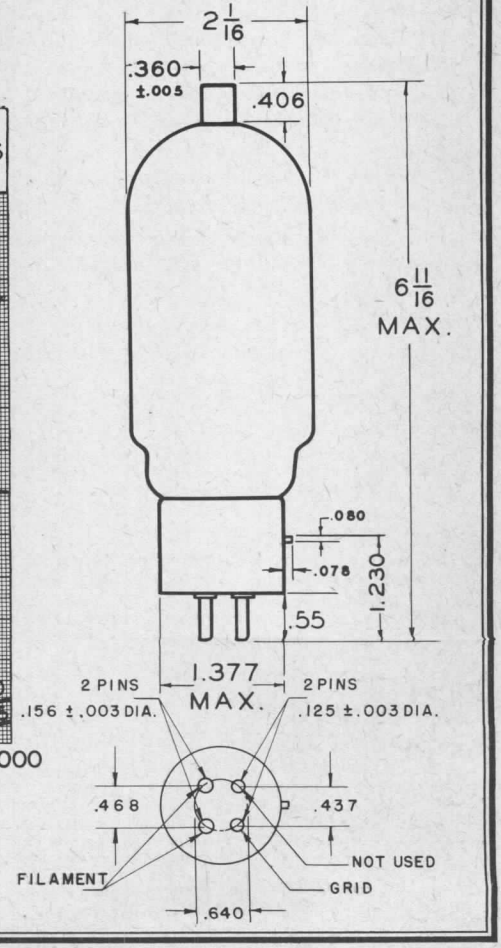
Maximum D-C Plate Voltage			1000	volts
Maximum D-C Plate Current			150	ma.
Maximum Plate Input			150	watts
Maximum Plate Dissipation			60	watts
Maximum D-C Grid Voltage			—300	volts
Maximum D-C Grid Current			30	ma.
Maximum R-F Grid Current			7	amp.

Typical Operation:

Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	600	800	1000	volts
D-C Grid Voltage	—95	—105	—110	volts
Peak R-F Grid Voltage	235	245	250	volts
D-C Plate current	140	140	140	ma.
D-C Grid Current†	30	30	30 approx.	ma.
Driving Power†	7	7	7 approx.	watts
Power Output	45	70	90 approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE 833-A

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

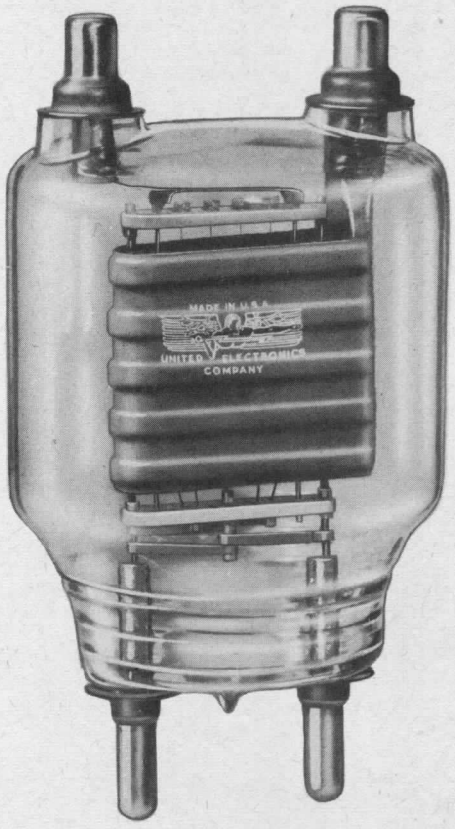
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	10 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Eb = 1500, Ec = +100, Ef = 10 A-C	
Amplification Factor	35
Plate Resistance	2200 ohms
Mutual Conductance	16200 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	6.3 uuf
Grid to Filament	12.3 uuf
Plate to Filament	8.5 uuf
Maximum Overall Dimensions:	
Length	8 13/16 inches
Diameter	4 19/32 inches
Bulb	T-32
Base	See Outline
Type of Cooling	Air
Net Weight	1 lb.

MAXIMUM RATINGS

	Cooling: Free-Air	Cooling: Forced-Air	
Max. D-C Plate Voltage Modulated	3000	4000	volts
Max. D-C Plate Voltage Unmodulated	3000	4000	volts
Max. D-C Plate Current Modulated	400	450	ma.
Max. D-C Plate Current Unmodulated	500	500	ma.
Max. Plate Dissipation	300	400	watts
Max. D-C Grid Current	100	100	ma.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:			
Below	30	20	mgcs.
Above	10	15	meters
*Maximum Frequency Rating with Reduced Power Input and Output:			
Below	*100	*100	mgcs.
Above	*3	*3	meters

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



UNITED TYPE 833-A

High Perveance

Low Driving Power — High Plate Efficiency

100 Watt Filament — 2000 Watts Input

INSTALLATION

The design of the United 833-A eliminates the conventional base structure in favor of two sturdy filament-post terminals. The tube may be mounted in a vertical position with the filament-end down, or in a horizontal position with the plate on edge.

The filament of the 833-A should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential, the filament of the 833-A should be operated preferably from an a-c source.

When free-air cooling is employed adequate cabinet ventilation should be provided. If forced-air cooling is used, an air flow of 40 cubic feet per minute should be directed downward between plate and grid seals. Bulb temperature between seals should not exceed 145°C.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

	Free-Air Cooling	Forced-Air Cooling	
Maximum D-C Plate Voltage	3000	4000	volts
Maximum D-C Plate Current*	500	500	ma.
Maximum Plate Input*	1125	1600	watts
Maximum Plate Dissipation*	300	400	watts
Typical Operation (2 tubes):			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	3000	4000	volts
D-C Grid Voltage	—70	—100	volts
Zero-Sig. Plate Cur. (per tube)	100	100	ma.
Max.-Sig. Plate Cur. (per tube)	750	800	ma.
Load Resistance (per tube)	2375	3000	ohms
Eff. Load Res. (plate to plate)	9500	12000	ohms
Max. Sig. Driving Power	20	29	watts
Max. Sig. Power Output	1650	2400	watts

* Average over any audio-frequency sine wave cycle.

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions — Modulation Factor = 1.0)

	Free-Air Cooling	Forced-Air Cooling	
Maximum D-C Plate Voltage	3000	4000	volts
Maximum D-C Plate Current	300	300	ma.
Maximum Plate Input	450	600	watts
Maximum Plate Dissipation	300	400	watts
Typical Operation:			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	3000	4000	volts
D-C Grid Voltage	—70	—120	volts
Peak R-F Grid Voltage	90	120	volts
D-C Plate Current	150	150	ma.
Driving Power	10	14 approx.	watts
Power Output	150	225 approx.	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

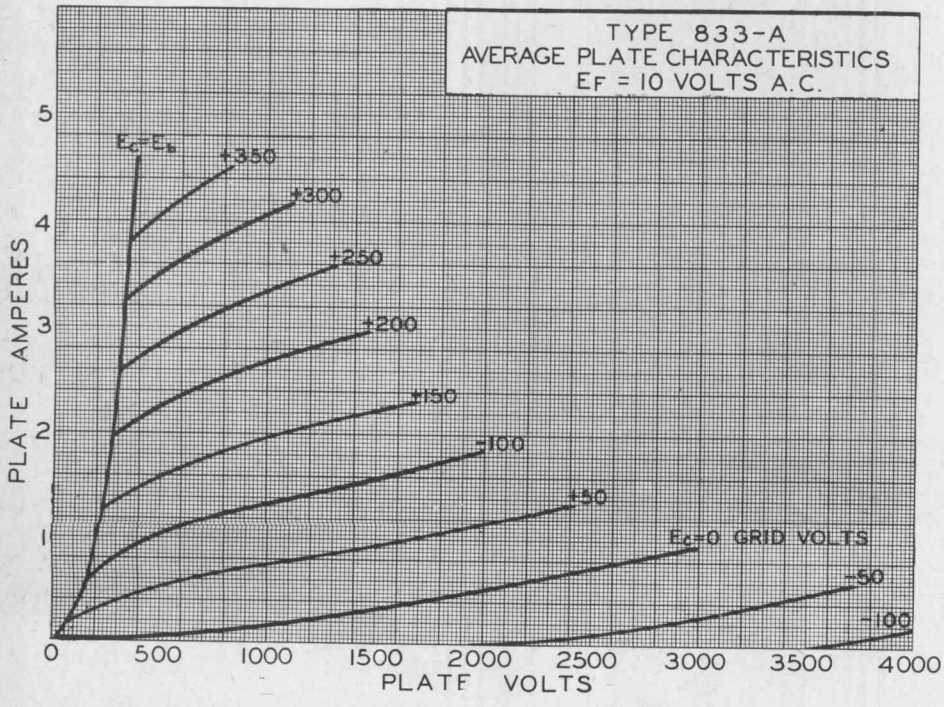
(Carrier Conditions — Modulation Factor = 1.0)

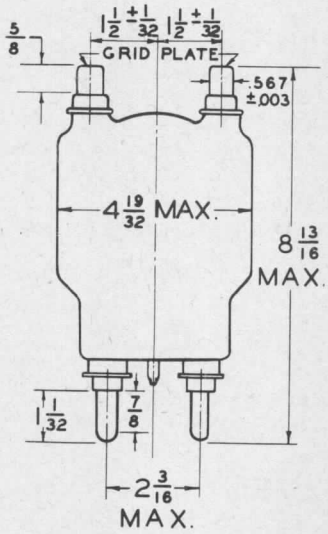
	Free-Air Cooling	Forced-Air Cooling	
Maximum D-C Plate Voltage	2500	3000	volts
Maximum D-C Grid Voltage	—500	—500	volts
Maximum D-C Plate Current	400	450	ma.
Maximum D-C Grid Current	100	100	ma.
Plate Input	835	1250	watts
Plate Dissipation	200	270	watts
Typical Operation:			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	2500	3000	volts
D-C Grid Voltage	—300	—300	volts
Peak R-F Grid Voltage	460	490	volts
D-C Plate Current	335	415	ma.
D-C Grid Current	75	85 approx.	ma.
Driving Power	30	37 approx.	watts
Power Output	635	1000 approx.	watts

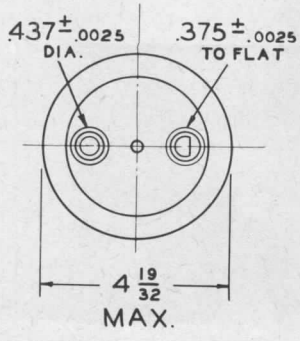
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

(Key Down Conditions)

	Free-Air Cooling	Forced-Air Cooling	
Maximum D-C Plate Voltage	3000	4000	volts
Maximum D-C Grid Voltage	—500	—500	volts
Maximum D-C Plate Current	500	500	ma.
Maximum D-C Grid Current	100	100	ma.
Maximum Plate Input	1250	1800	watts
Maximum Plate Dissipation	300	400	watts
Typical Operation:			
Filament Voltage	10	10	a-c volts
D-C Plate Voltage	3000	4000	volts
D-C Grid Voltage	—200	—200	volts
Peak R-F Grid Voltage	360	375	volts
D-C Plate Current	415	450	ma.
D-C Grid Current	55	75	ma.
Driving Power	20	26	watts
Power Output	1000	1440	watts







UNITED ELECTRONICS

TYPE 834

NORMAL AND HIGH FREQUENCY RANGE
R-F POWER AMPLIFIER, OSCILLATOR, CLASS B MODULATOR
ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes 3

Filament Voltage ..... 7.5 volts
Current ..... 3.25 amperes
Type ..... Thoriated Tungsten

Average Characteristic Values Calculated at:
40 ma. Plate Current

Amplification Factor 11
Plate Resistance ..... 5500 ohms
Mutual Conductance ..... 2000 micromhos

Average Direct Interelectrode Capacities:
Grid to Plate ..... 2.5 uuf
Grid to Filament ..... 2.0 uuf
Plate to Filament ..... 0.7 uuf

Maximum Overall Dimensions:
Length ..... 6 7/8 inches
Diameter ..... 2 11/16 inches

Bulb S-21

Base ..... Medium 4-Pin Bayonet

Type of Cooling ..... Air

Net Weight ..... 3 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1250	volts
Maximum D-C Plate Voltage Unmodulated	1250	volts
Maximum D-C Plate Current Modulated	100	ma.
Maximum D-C Plate Current Unmodulated	100	ma.
Maximum Plate Dissipation	50	watts
Maximum D-C Grid Current	20	ma.
Maximum R-F Grid Current	5	amp.

Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:

Below ..... 100 megacycles

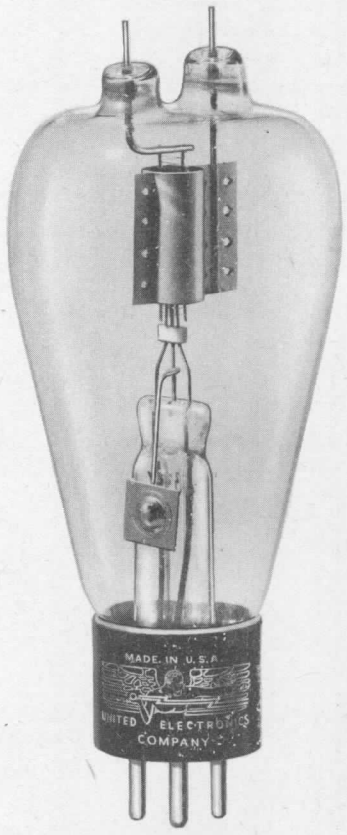
Above ..... 3 meters

*Maximum Frequency Rating with Reduced Power Input and Output:

Below ..... 350 megacycles

Above ..... .85 meter

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



United type 834 is used in medium power ultra-high frequency applications. Interchanges directly with types 304-B, BW-11.

INSTALLATION

The base of the UNITED 834 is designed for mounting in a standard four prong socket but only the filament terminals of this socket are connected since the grid and plate leads come out at the bulb top. The tube may be mounted either in the base-down or base-up position but the axis of the filament should always be vertical. Ample air space should be provided for ventilation.

The filament of the 834 should be operated at the rated value of 7.5 volts. Operation at other than rated value may result in loss of filament emission and short life.

The plate dissipation of the 834 should never exceed the values given under Maximum Ratings and Typical Operation Conditions

Excellent high frequency characteristics are obtained from the manner in which the electrodes of the 834 are assembled. The plate, grid and filament are supported from separate points and their relative spacing maintained without the use of insulating separators other than the NONEX glass bulb. Short heavy leads are brought out from the plate and grid. This construction provides the low inductance, resistance and capacitance values so essential for ultra high frequency operation.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A. F. POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current	Averaged over any		100	ma.
Maximum Plate Dissipation	audio freq. cycle..		50	watts
Typical Operation (2 tubes):				
Filament Voltage (A-C)	7.5	7.5	7.5	volts
D-C Plate Voltage	750	1000	1250	volts
Grid Voltage	—55	—85	—110	volts
Zero-Signal Plate Current	40	40	40	ma.
Maximum-Signal Plate Current	200	200	200	ma.
Load Resistance (per tube)	1750	2500	3500	ohms
Effective Load Res. (plate to plate)	7000	10000	14000	ohms
Power Output (2 tubes)	85	120	170	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			100	ma.
Maximum Plate Dissipation			50	watts
Maximum R-F Grid Current			5	amp.
Typical Operation:				
Filament Voltage	7.5	7.5	7.5	volts
D-C Plate Voltage	750	1000	1250	volts
Grid Voltage	—55	—85	—110	volts
D-C Plate Current	50	50	50	ma.
Peak Power Output	50	66	84	watts
Carrier Power Output	12.5	16.5	21	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

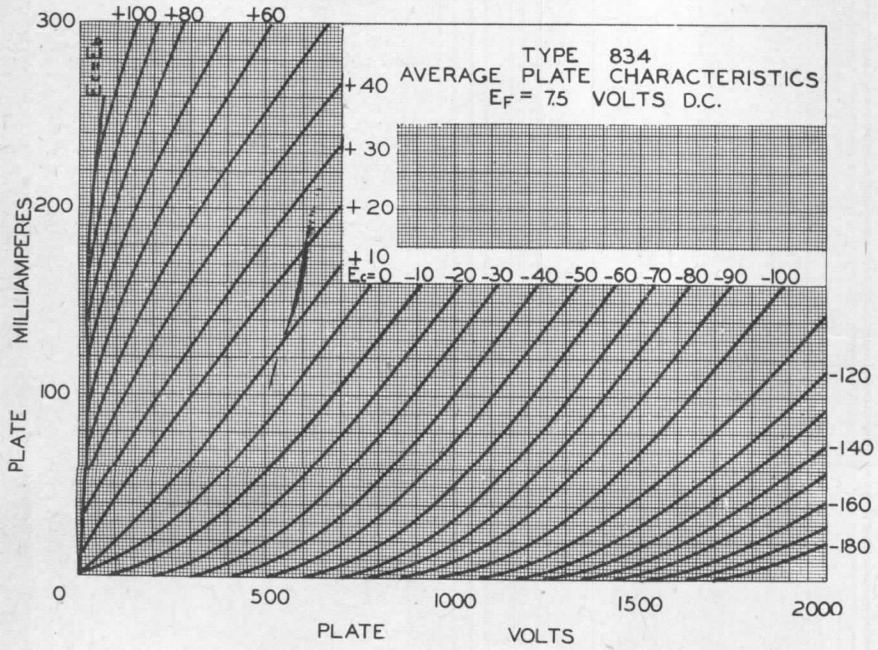
Maximum D-C Plate Voltage			1000	volts
Maximum D-C Plate Current			100	ma.
Maximum Plate Dissipation			50	watts
Maximum R-F Grid Current			5	amp.
Maximum D-C Grid Current			20	ma.
Typical Operation:				
Filament Voltage (A-C)	7.5	7.5		volts
D-C Plate Voltage	750	1000		volts
Grid Voltage	—135	—180		volts
D-C Plate Current	100	100		ma.
D-C Grid Current†	15	15		ma.
Driving Power†	4.0	4.5		watts
Nominal Carrier Power Output	50	65		watts

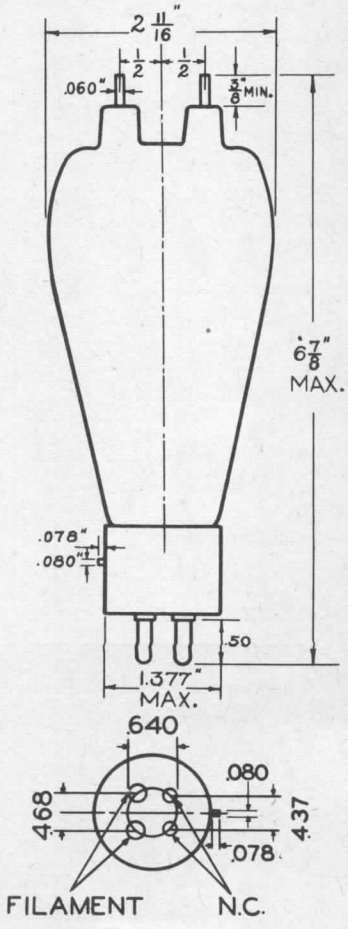
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

(Key Down Conditions)

Maximum D-C Plate Voltage			1250	volts
Maximum D-C Plate Current			100	ma.
Maximum Plate Dissipation			50	watts
Maximum R-F Grid Current			5	amp.
Maximum D-C Grid Current			20	ma.
Typical Operation:				
Filament Voltage (A-C)	7.5	7.5	7.5	volts
D-C Plate Voltage	750	1000	1250	volts
Grid Voltage	—135	—180	—225	volts
D-C Plate Current	100	100	100	ma.
D-C Grid Current†	15	15	15	ma.
Driving Power†	4.0	4.0	4.0	watts
Nominal Power Output	50	65	85	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE 838

CLASS B MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

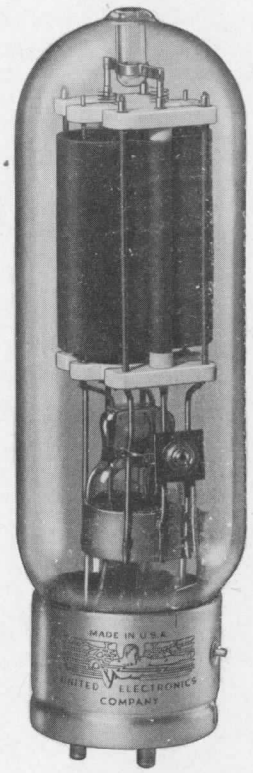
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.25 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Ep = 1250, Ec = 0, Ef = 10 D-C	
Plate Current	0.060 amperes
Amplification Factor	100
Plate Resistance	12500 ohms
Mutual Conductance	8000 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	8.0 uuf
Grid to Filament	6.5 uuf
Plate to Filament	5.5 uuf
Maximum Overall Dimensions:	
Length	7 7/8 inches
Diameter	2 5/16 inches
Bulb	T-18
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	7 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	1000	volts
Maximum D-C Plate Voltage Unmodulated	1250	volts
Maximum A-C Plate Voltage R. M. S.	1250	volts
Maximum D-C Plate Current Modulated	150	ma.
Maximum D-C Plate Current Unmodulated	175	ma.
Maximum Plate Dissipation	100	watts
Maximum D-C Grid Current	70	ma.
Maximum R-F Grid Current	7.5	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	30	megacycles
Above	10	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*120	megacycles
Above	*2.5	meters

* For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



INTERCHANGES WITH UNITED TYPE 938

"RUGGEDIZED" construction enables type 838 to withstand unusual shock and vibration conditions such as encountered in wartime military usage.

INSTALLATION

The base of the UNITED 838 is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 838 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life.

Type 838 is a high-mu triode particularly well suited for use as a zero-bias class B modulator or a-f power amplifier. In class B amplifier service type 838 will give high output with low distortion.

GRAPHITE ANODE

A graphite anode is used in this type tube because of several specific advantages over metals such as tantalum, molybdenum and nickel. The radiating area of graphite is approximately twice the projected area due to its surface porosity. Moreover, because of the black body principle, it will dissipate four times more heat than metal.

Graphite being infusible, will not warp or twist. Therefore, it maintains its exact form under all temperatures, the result being constant inter-element relationship. The low operating temperature of the graphite anode tends to keep the grid cool, reduces overload hazards, and prevents gas current. The inherent qualities of graphite over metal as outlined above, are advantages of primary importance in designing tubes of this type for long and satisfactory service life.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage	1250	volts
Maximum D-C Plate Current (Averaged over any audio freq. cycle)	175	ma.
Maximum Plate Dissipation (Averaged over any audio freq. cycle)	100	watts

Typical Operation (2 tubes):

Filament Voltage	10	10 a-c	volts
D-C Plate Voltage	1000	1250	volts
Grid Voltage	0	0	volts
Zero-Signal Plate Cur. (per tube)	53	74	ma.
Max.-Signal Plate Cur. (per tube)	160	160	ma.
Load Resistance (per tube)	1725	2250	ohms
Effective Load Res. (plate to plate)	6900	9000	ohms
Power Output (2 tubes)	200	260 approx.	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	1250	volts
Maximum D-C Plate Current	150	ma.
Maximum Plate Dissipation	100	watts
Maximum R-F Grid Current	6	amp.

Typical Operation:

Filament Voltage	10	10	volts
D-C Plate Voltage	1000	1250	volts
Grid Voltage	0	0	volts
D-C Plate Current	130	106	ma.
Peak Power Output	160	170 approx.	watts
Carrier Power Output	40	42.5 approx.	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	1000	volts
Maximum D-C Plate Current	175	ma.
Maximum Plate Dissipation	67	watts
Maximum R-F Grid Current	6	amp.
Maximum D-C Grid Current	70	ma.

Typical Operation:

Filament Voltage	10	10	a-c	volts
D-C Plate Voltage	750	1000		volts
Grid Voltage	—100	—135	approx.	volts
D-C Plate Current	150	150		ma.
D-C Grid Current	60	60		ma.
Driving Power†	14	16		watts
Power Output	65	100	approx.	watts

R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

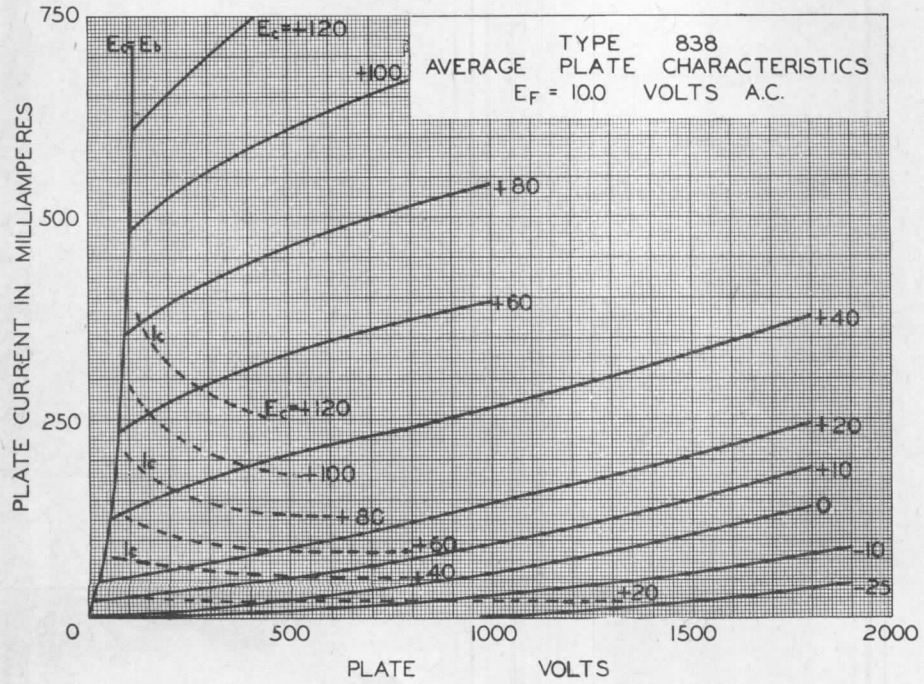
(Key Down Conditions)

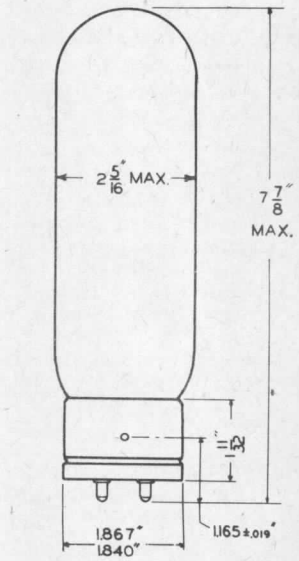
Maximum D-C Plate Voltage	1250				volts
Maximum D-C Plate Current	175				ma.
Maximum Plate Dissipation	100				watts
Maximum R-F Grid Current	7.5				amp.
Maximum D-C Grid Current	70				ma.

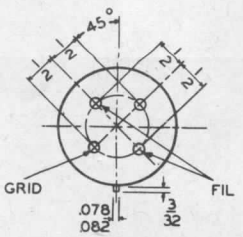
Typical Operation:

Filament Voltage	10	10	10	a-c	volts
D-C Plate Voltage	750	1000	1250		volts
Grid Voltage	—80	—85	—90	approx.	volts
D-C Plate Current	150	150	150		ma.
D-C Grid Current†	30	30	30		ma.
Driving Power†	6	6	6		watts
Power Output	65	100	130	approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 845

A-F POWER AMPLIFIER, CLASS A, AB$_1$ MODULATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	10 volts
Current	3.25 amperes
Type	Thoriated Tungsten

Average Characteristic Values Calculated at:
Eb = 1000, Ec = —147, Ef = 10 D-C

Plate Current	0.075 amperes
Amplification Factor	5
Plate Resistance	1800 ohms
Mutual Conductance	3000 micromhos

Average Direct Interelectrode Capacities:

Grid to Plate	13.5 uuf
Grid to Filament	6.0 uuf
Plate to Filament	6.5 uuf

Maximum Overall Dimensions:

Length	7 7/8 inches
Diameter	2 5/16 inches
Bulb	T-18
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

MAXIMUM RATINGS

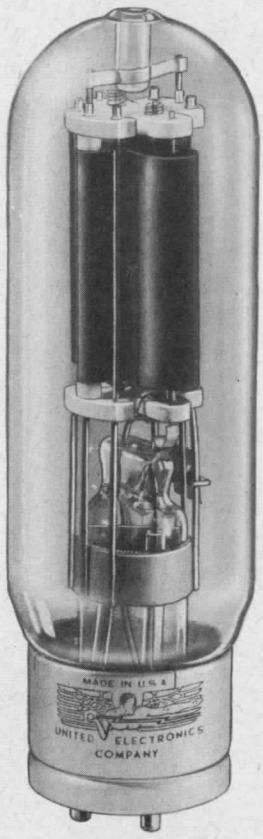
Maximum D-C Plate Voltage	1250	volts
Maximum D-C Plate Current	95	ma.
Maximum Plate Dissipation	100	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage	1250	volts
Maximum Plate Dissipation	100	watts

Typical Operation:

Filament Voltage	10	10	10	a-c volts
D-C Plate Voltage	750	1000	1250	volts
Grid Voltage	—98	—155	—209	approx. volts
Peak Grid Swing	93	150	204	volts
D-C Plate Current	95	65	52	ma.
Mutual Conductance	3100	2800	2500	umhos
Plate Resistance	1700	1900	2100	ohms
Load Resistance	3400	9000	16000	ohms
U. P. O. (5% 2nd harmonic)	15	21	24	watts



REPLACES TYPE 945

UNITED type 845 is a popular choice for all radio transmitting and motion picture sound installations.

INSTALLATION

The base of the UNITED 845 is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 845 should be operated at the rated value of 10 volts. Operation at other than the rated value may result in loss of filament emission and short life.

Transformer or impedance coupling devices are recommended. If it is desired to use resistance coupling, the grid resistor should not exceed 0.5 megohm when self-bias is used. With fixed bias the maximum allowable resistance for the grid resistor is 0.1 megohm.

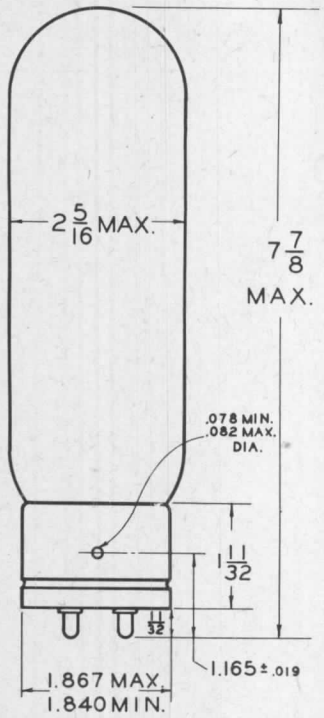
GRAPHITE ANODE

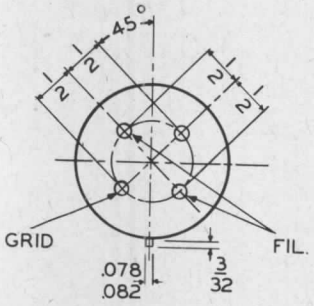
A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United


2 5/16 MAX.
7 7/8
MAX.
.078 MIN.
.082 MAX.
DIA.
1 11/32
1/32
1.165 ± .019
1.867 MAX.
1.840 MIN.


45°
GRID
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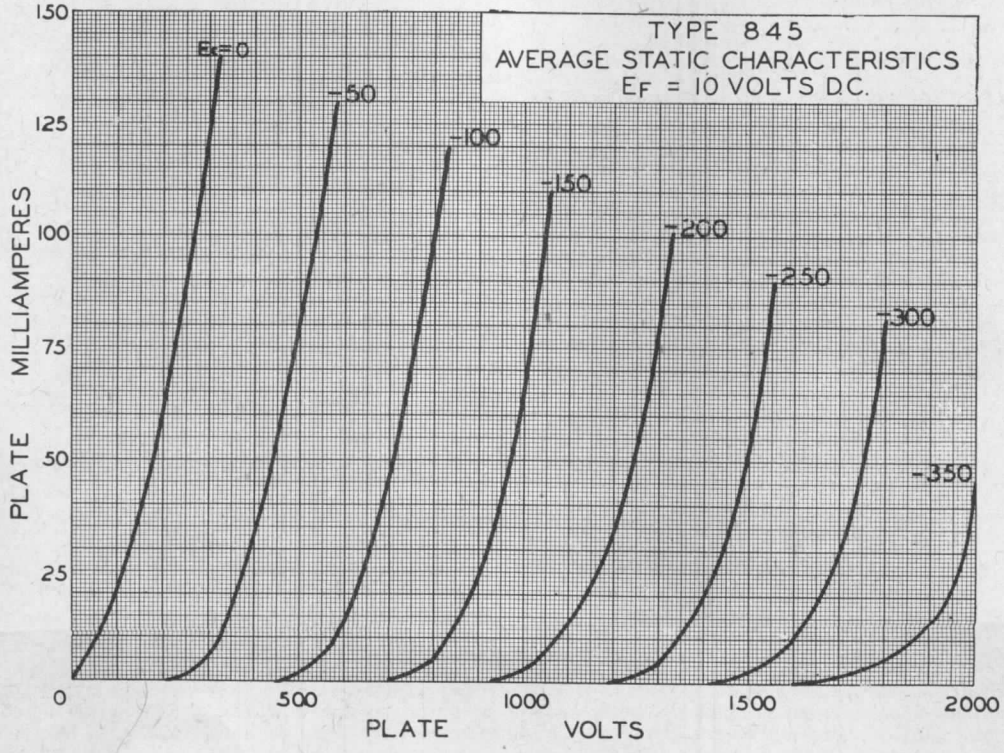
.078
.082
3/32


TYPE 845
AVERAGE STATIC CHARACTERISTICS
EF = 10 VOLTS D.C.
Ec=0
-50
-100
-150
-200
-250
-300
-350
PLATE MILLIAMPERES
150
125
100
75
50
25
0
500
1000
1500
2000
PLATE VOLTS

UNITED ELECTRONICS

TYPE 849

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

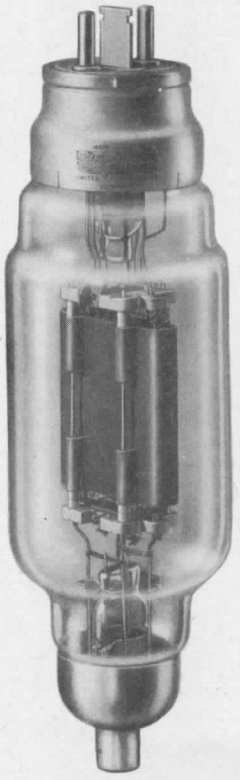
GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	11 volts
Current	5.0 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: Ep = 3000, Ec = —132, Ef = 11 A-C	
Plate Current	0.100 amperes
Amplification Factor	19
Plate Resistance	3200 ohms
Mutual Conductance	6000 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate	33.5 uuf
Grid to Filament	17.0 uuf
Plate to Filament	3.0 uuf
Maximum Overall Dimensions:	
Length	14 3/8 inches
Diameter	4 1/8 inches
Bulb	T-32
Cap	Standard 250-Watt
Base	Jumbo 3-Pin
Type of Cooling	Air
Net Weight	24 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2000	volts
Maximum D-C Plate Voltage Unmodulated	3000	volts
Maximum A-C Plate Voltage R. M. S.	3000	volts
Maximum D-C Plate Current Modulated	350	ma.
Maximum D-C Plate Current Unmodulated	350	ma.
Maximum Plate Dissipation	400	watts
Maximum D-C Grid Current	125	ma.
Maximum R-F Grid Current	10	amp.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	3	megacycles
Above	100	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	*30	megacycles
Above	*10	meters

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings and Typical Operation Conditions. The R-F grid current should never exceed the maximum rated value.



Replaces UNITED type 949

INSTALLATION

The base of the UNITED 849 is designed to fit the standard "250 watt" socket of the three-pin type. The tube may be mounted either in a vertical position with the filament base end up, or in a horizontal position with the plate on edge. Ample air space should be provided for ventilation.

The filament of the 849 should be operated at the rated value of 11 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential, the filament of the 849 should be operated preferably from an a-c source.

The plate dissipation of the 849 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A graphite anode is used in this type because of several specific advantages over metals such as tantalum, molybdenum and nickel. The radiating area of graphite is approximately twice the projected area due to its surface porosity. Moreover, because of the black body principle, it will dissipate four times more heat than metal.

Graphite, being infusible, will not warp or twist. Therefore, it maintains its exact form under all temperatures, the result being constant inter-element relationship. The low operating temperature of the graphite anode tends to keep the grid cool, reduces overload hazards, and prevents gas current. The inherent qualities of graphite over metal as outlined above, are advantages of primary importance in designing tubes of this type for long and satisfactory service life.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage			3000		volts
Maximum Plate Dissipation			300		watts
Maximum Plate Input			300		watts
Typical Operation:					
Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	2000	2500	3000		volts
D-C Grid Voltage	—74	—104	—132	approx.	volts
Peak A-F Grid Voltage	68	98	126	approx.	volts
D-C Plate Current	135	110	100		ma.
Mutual Conductance	6500	6050	5850		umhos
Plate Resistance	2950	3150	3250		ohms
Load Resistance	6000	12000	18000		ohms
U. P. O. (5% 2nd harmonic)	58	81	100		watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		3000	volts
Maximum D-C Plate Current	Averaged over any audio freq. cycle	0.35	amp.
Maximum Plate Dissipation		300	watts
Maximum Plate Input		825	watts

Typical Operation (2 tubes):

Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	2000	2500	3000		volts
D-C Grid Voltage	—105	—130	—155	approx.	volts
Zero-Sig.PlateCur.(per tube)	7	10	12		ma.
Max.-Sig.PlateCur.(per tube)	325	280	260		ma.
Load Resistance (per tube)	1600	2600	3200		ohms
Load Res. (plate to plate)	6400	10400	12800		ohms
Driving Power (per tube)	8	7	6	approx.	watts
Power Output (2 tubes)	900	1000	1100	approx.	watts

R-F POWER AMPLIFIER AND OSCILLATOR

(Carrier Conditions — Modulation Factor = 1.0)

Maximum D-C Plate Voltage			2500		volts
Maximum D-C Plate Current			350		ma.
Maximum Plate Dissipation			400		watts
Maximum Plate Input			600		watts
Maximum R-F Grid Current			8		amp.
Typical Operation:					
Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	1500	2000	2500		volts
D-C Grid Voltage	—70	—95	—125	approx.	volts
Peak R-F Grid Voltage	140	140	140	approx.	volts
D-C Plate Current	320	265	216		ma.
Driving Power†	18	15	12	approx.	watts
Power Output	150	170	180	approx.	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Key Down Conditions)

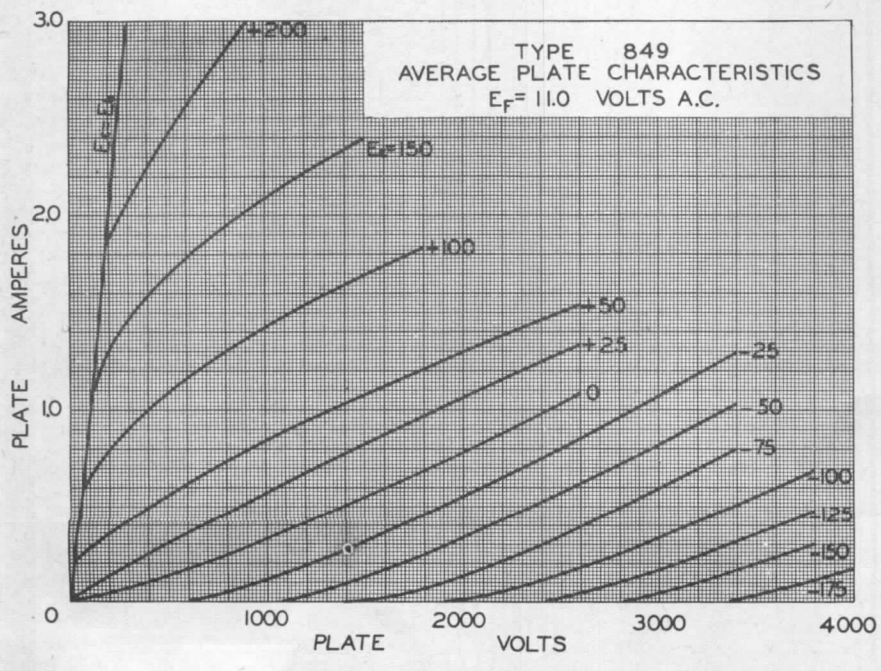
Maximum D-C Plate Voltage		2000		volts
Maximum D-C Plate Current		350		ma.
Maximum Plate Dissipation		270		watts
Maximum Plate Input		700		watts
Maximum D-C Grid Current		125		ma.
Maximum R-F Grid Current		8		amp.
Typical Operation:				
Filament Voltage	11	11	a-c	volts
D-C Plate Voltage	1500	2000		volts
D-C Grid Voltage	—250	—300	approx.	volts
Peak R-F Grid Voltage	400	450	approx.	volts
D-C Plate Current	300	300		ma.
D-C Grid Current†	35	30	approx.	ma.
Driving Power†	14	14	approx.	watts
Power Output	300	425	approx.	watts

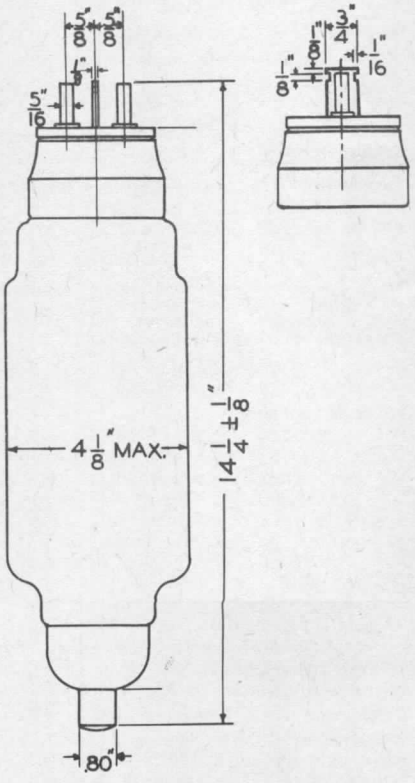
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

(Key Down Conditions)

Maximum D-C Plate Voltage			2500		volts
Maximum D-C Plate Current			350		ma.
Maximum Plate Dissipation			400		watts
Maximum Plate Input			875		watts
Maximum D-C Grid Current			125		ma.
Maximum R-F Grid Current			10		amp.
Typical Operation:					
Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	1500	2000	2500		volts
D-C Grid Voltage	—175	—200	—250	approx.	volts
Peak R-F Grid Voltage	310	325	360	approx.	volts
D-C Plate Current	300	300	300		ma.
D-C Grid Current†	35	25	20	approx.	ma.
Driving Power†	11	9	8	approx.	watts
Power Output	300	425	560	approx.	watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE 851

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	11 volts
Current	15.5 amperes
Type	Thoriated Tungsten

Average Characteristic Values Calculated at:
Ep = 2000 Ec = −65 Ef = 11 A-C

Plate Current	.270 amperes
Amplification factor	20.5
Plate Resistance	1500 ohms
Mutual Conductance	13700 micromhos

Average Direct Interelectrode Capacities:

Grid to Plate	47.0 uuf
Grid to Filament	25.5 uuf
Plate to Filament	4.5 uuf

Maximum Overall Dimensions:

Length	17⅝ inches
Diameter	6⅛ inches
Bulb	T-48
Cap	Skirted Large
Base	Jumbo 3-Pin
Net Weight	2 lb. 5 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2500	volts
Maximum D-C Plate Voltage Unmodulated	3000	volts
Maximum A-C Plate Voltage R. M. S.	3000	volts
Maximum D-C Plate Current Modulated	1.0	amp.
Maximum D-C Plate Current Unmodulated	1.0	amp.
Maximum Plate Dissipation	750	watts
Maximum D-C Grid Current	200	ma.
Maximum R-F Grid Current	10	amp.

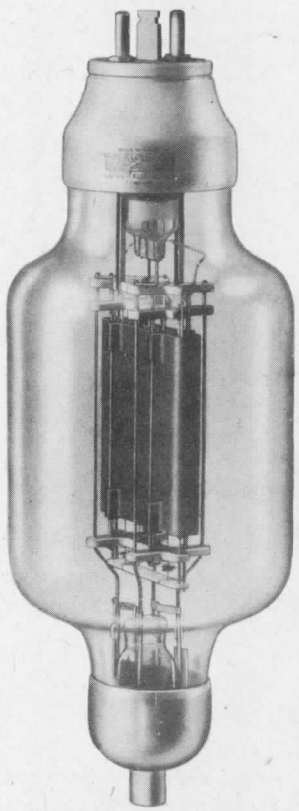
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:

Below	3 megacycles
Above	100 meters

*Maximum Frequency Rating with Reduced Power Input and Output:

Below	*15 megacycles
Above	*20 meters

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings and Typical Operation Conditions. The R-F grid current should never exceed the maximum rated value.



Interchanges with UNITED type 951

INSTALLATION

The base of the UNITED 851 is designed to fit the standard "250 watt" mounting. The tube may be mounted either in a vertical position with the filament base end up, or in a horizontal position with the plate on edge. Ample air space should be provided for ventilation.

The filament of the 851 should be operated at the rated value of 11 volts. Operation at other than rated value may result in loss of filament emission and short life. The filament of the 851 should be operated preferably from an a-c source.

The plate dissipation of the 851 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A graphite anode is used in this type tube because of several specific advantages over metals such as tantalum, molybdenum and nickel. The radiating area of graphite is approximately twice the projected area due to its surface porosity. Moreover, because of the black body principle, it will dissipate four times more heat than metal.

Graphite, being infusible, will not warp or twist. Therefore, it maintains its exact form under all temperatures, the result being constant inter-element relationship. The low operating temperature of the graphite anode tends to keep the grid cool, reduces overload hazards, and prevents gas current. The inherent qualities of graphite over metal as outlined above, are advantages of primary importance in designing tubes of this type for long and satisfactory service life.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage					2500 volts
Maximum Plate Dissipation					600 watts
Maximum Plate Input					600 watts
Typical Operation:					
Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	1500	2000	2500		volts
D-C Grid Voltage	—49	—65	—92		volts
Peak A-F Grid Voltage	44	60	87		volts
D-C Plate Current	175	270	240		ma.
Mutual Conductance	11400	13700	12800		umhos
Plate Resistance	1800	1500	1600		ohms
Load Resistance	3700	3100	5000		ohms
U. P. O. (5% 2nd harmonic)	46	100	160		watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage					3000 volts
Maximum D-C Plate Current	Averaged over				1.0 amp.
Maximum Plate Dissipation	any audio				750 watts
Maximum Plate Input	freq. cycle				2250 watts
Typical Operation (2 tubes):					
Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	2000	2500	3000		volts
D-C Grid Voltage	—85	—111	—135		volts
Zero-Sig. Plate Cur.	.120	.120	.110		amp.
Max. Sig. Plate Cur.	1.7	1.4	1.2		amp.
Load Resistance (per tube)	650	1000	1400		ohms
Load Res. (plate to plate)	2600	4000	5600		ohms
Driving Power	20	12	6		watts
Power Output	2.2	2.3	2.4		kw

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions — Modulation Factor = 1.0)

Maximum D-C Plate Voltage					2500 volts
Maximum D-C Plate Current					0.75 amp.
Maximum Plate Dissipation					750 watts
Maximum Plate Input					1100 watts
Maximum R-F Grid Current					8.0 amp.
Typical Operation:					
Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	1500	2000	2500		volts
D-C Grid Voltage	—60	—85	—110		volts
Peak R-F Grid Voltage	150	140	135		volts
D-C Plate Current	0.62	0.475	0.39		amp.
Driving Power†	40	25	20		watts
Power Output	275	300	325		watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions — Modulation Factor = 1.0)

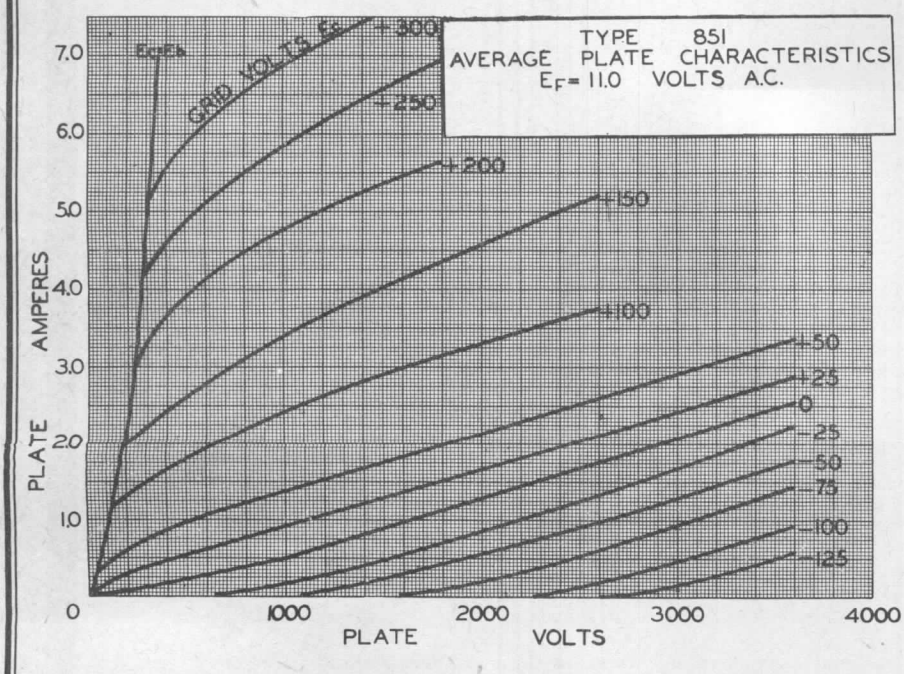
Maximum D-C Plate Voltage				2000 volts
Maximum D-C Plate Current				1.0 amp.
Maximum Plate Dissipation				500 watts
Maximum Plate Input				1800 watts
Maximum D-C Grid Current				0.2 amp.
Maximum R-F Grid Current				8.0 amp.
Typical Operation:				
Filament Voltage	11	11	a-c	volts
D-C Plate Voltage	1500	2000		volts
D-C Grid Voltage	—250	—300		volts
Peak R-F Grid Voltage	475	525		volts
D-C Plate Current	0.90	0.85		amp.
D-C Grid Current†	0.150	0.125		amp.
Driving Power†	75	65		watts
Power Output	900	1250		watts

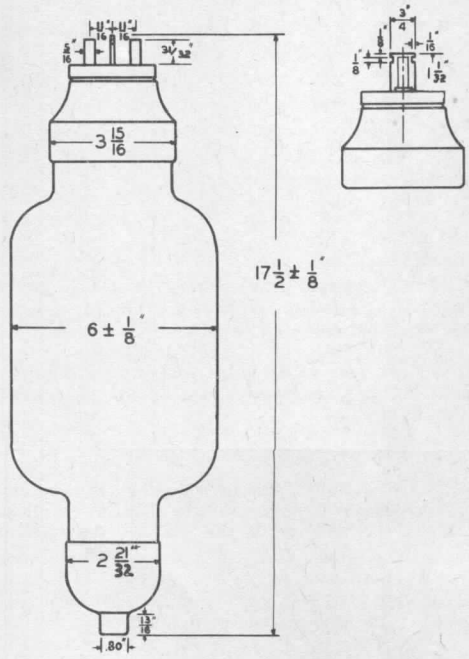
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

(Key-down Conditions)

Maximum D-C Plate Voltage					2500 volts
Maximum D-C Plate Current					1.0 amp.
Maximum Plate Dissipation					750 watts
Maximum Plate Input					2500 watts
Maximum D-C Grid Current					0.2 amp.
Maximum R-F Grid Current					10.0 amp.
Typical Operation:					
Filament Voltage	11	11	11	a-c	volts
D-C Plate Voltage	1500	2000	2500		volts
D-C Grid Voltage	—150	—200	—250		volts
Peak R-F Grid Voltage	375	425	450		volts
D-C Plate Current	0.9	0.9	0.9		amp.
D-C Grid Current†	0.15	0.12	0.10		amp.
Driving Power†	55	50	45		watts
Power Output	900	1250	1700		watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE 860

MODULATOR, AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

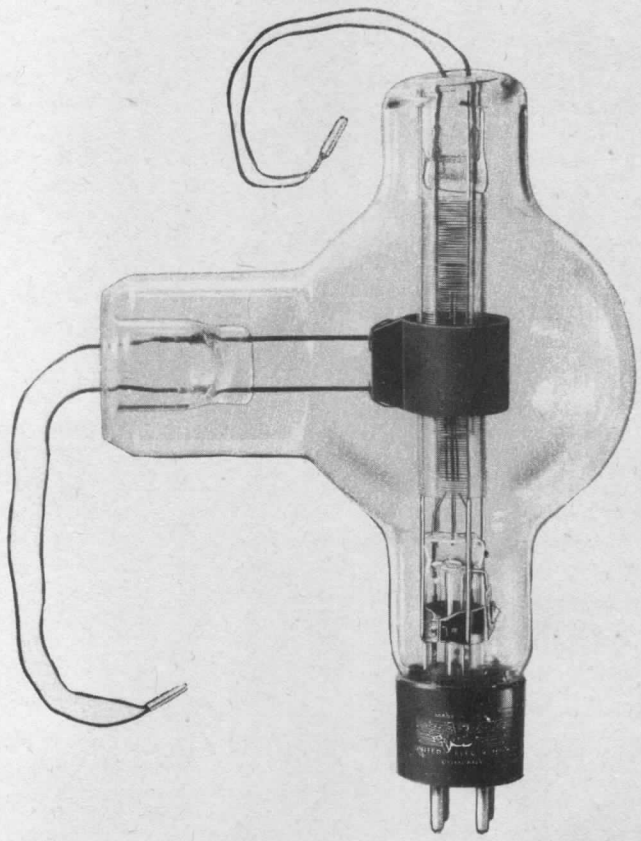
GENERAL RATINGS

Number of Electrodes	4
Filament Voltage	10.0 volts
Current	3.25 amperes
Type	Thoriated Tungsten
Average Characteristic Values Calculated at: 50 ma. Plate Current	
Amplification Factor (approx.)	200
Mutual Conductance	1100 micromhos
Average Direct Interelectrode Capacities:	
Grid to Plate (with external shielding) max.	0.08 uuf
Grid to Filament	7.75 uuf
Plate to Filament	7.5 uuf
Maximum Overall Dimensions:	
Length	8 3/4 inches
Radius	4 1/4 inches
Bulb	GT-30 with arm
Base	Medium 4-Pin Ceramic, Bayonet
Type of Cooling	Air
Net Weight	10 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	2000	volts
Maximum D-C Plate Voltage Unmodulated	3000	volts
Maximum D-C Plate Current Modulated	85	ma.
Maximum D-C Plate Current Unmodulated	150	ma.
Maximum Plate Dissipation	100	watts
Maximum D-C Grid Current	40	ma.
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:		
Below	30	megacycles
Above	10	meters
*Maximum Frequency Rating with Reduced Power Input and Output:		
Below	120	megacycles
Above	2.5	meters

*For operation at the higher frequencies, the plate voltage, plate current, plate dissipation, and d-c grid current should not exceed 50% of the Maximum Ratings. The R-F grid current should never exceed the maximum rated value.



UNITED TYPE 860

No Neutralization Required
High Interelectrode Insulation
Low Electrode Capacitances
High Power Sensitivity Low Driving Power

INSTALLATION

The base of the UNITED 860 is designed for mounting in a standard four-prong, bayonet type socket. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 860 should be operated at the rated value of 10 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential the filament of the 860 should be operated from an a-c source.

The plate dissipation of the 860 should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	3000	volts
Maximum D-C Screen Voltage	500	volts
Maximum D-C Plate Current	85	ma.
Maximum Plate Input	150	watts
Maximum Screen Input	10	watts
Maximum Plate Dissipation	100	watts

Typical Operation:

A-C Filament Voltage	10	10	volts
D-C Plate Voltage	2000	3000	volts
D-C Screen Voltage	300	300	volts
D-C Grid Voltage	—50	—50	volts
D-C Plate Current	60	43	ma.
Power Output approx.	30	40	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	2000	volts
Maximum D-C Plate Current	85	ma.
Maximum Plate Input	170	watts
Maximum Screen Input	6.7	watts
Maximum Plate Dissipation	67	watts
Maximum D-C Screen Voltage	500	volts
Maximum D-C Grid Voltage	—800	volts
Maximum D-C Grid Current	40	ma.

Typical Operation:

A-C Filament Voltage	10	10	10	volts
D-C Plate Voltage	1500	1800	2000	volts
D-C Screen Voltage	300	300	220	volts
D-C Grid Voltage	—225	—225	—200	volts
Peak R-F Grid Voltage	—	—	500	volts
D-C Plate Current	70	67	85	ma.
D-C Screen Current	—	—	25	ma.
D-C Grid Current† approx.	30	30	38	ma.
Driving Power† approx.	15	15	17	watts
Power Output approx.	45	60	105	watts

R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

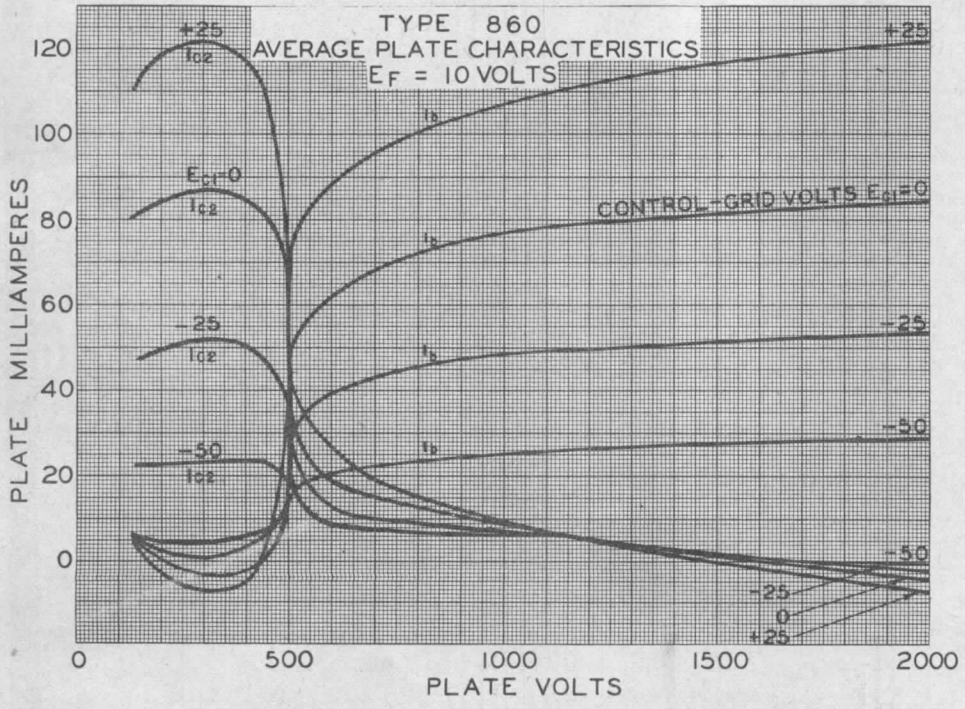
(Key Down Conditions)

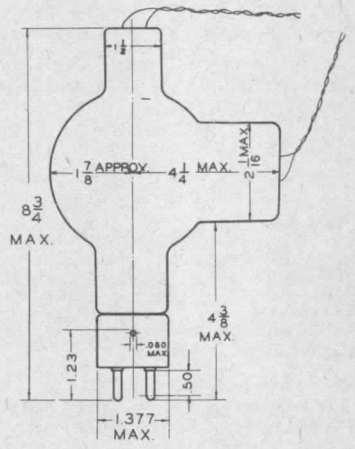
Maximum D-C Plate Voltage	3000	volts
Maximum D-C Plate Current	150	ma.
Maximum Plate Input	300	watts
Maximum Screen Input	10	watts
Maximum Plate Dissipation	100	watts
Maximum D-C Screen Voltage	500	volts
Maximum D-C Grid Voltage	—800	volts
Maximum D-C Grid Current	40	ma.

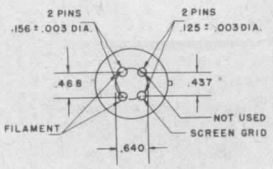
Typical Operation:

A-C Filament Voltage	10	10	10	10	volts
D-C Plate Voltage	1500	2000	2500	3000	volts
D-C Screen Voltage	300	300	300	300	volts
D-C Grid Voltage	—150	—150	—150	—150	volts
D-C Plate Current	90	90	90	85	ma.
D-C Grid Current† approx.	15	15	15	15	ma.
Driving Power† approx.	7	7	7	7	watts
Power Output approx.	60	100	135	165	watts

†Subject to wide variations depending on the impedence of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.







UNITED ELECTRONICS

TYPE 949-A

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	11 volts
Current	7.7 amperes
Type	Thoriated Tungsten

Average Characteristic Values Calculated at:
Eb = 3000, Ec = —130, Ef = 11 A-C

Plate Current	0,120 amperes
Amplification Factor	19
Plate Resistance @ 200 ma.	2500 ohms
Mutual Conductance @ 200 ma.	7600 micromhos

Average Direct Interelectrode Capacities:

Grid to Plate	11.5 uuf
Grid to Filament	14.0 uuf
Plate to Filament	1.7 uuf

Maximum Overall Dimensions:

Length	14 3/8 inches
Diameter	4 1/16 inches
Bulb	T-32
Cap	Skirted Large
Base	Jumbo 3-Pin
Type of Cooling	Air
Net Weight	23 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	3500	volts
Maximum D-C Plate Voltage Unmodulated	4000	volts
Maximum A-C Plate Voltage R. M. S.	4000	volts
Maximum D-C Plate Current Modulated	500	ma.
Maximum D-C Plate Current Unmodulated	500	ma.
Maximum Plate Dissipation	500	watts
Maximum D-C Grid Current	110	ma.
Maximum R-F Grid Current	10	amp.

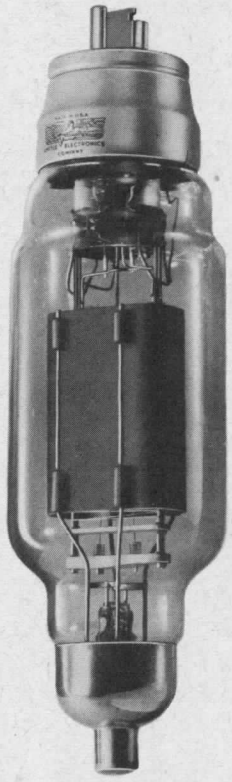
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:

Below	5 megacycles
Above	60 meters

*Maximum Frequency Rating and Reduced Power Input and Output:

Below	*15 megacycles
Above	*20 meters

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings and Typical Operation Conditions. The R-F grid current should never exceed the maximum rated value.



INTERCHANGES WITH TYPE 849-A

Typical UNITED ELECTRONICS refinements of design are revealed in the above illustration of type 949-A. Individually supported and isolated grid-filament assembly gives this tube the necessary separation between elements for its heavy input ratings. The large anode and wide spacing are design features contributing to the modern efficiency standards which this tube exemplifies.

INSTALLATION

The base of the UNITED 949-A is designed for mounting in a standard Jumbo 3-Pin socket. The tube may be mounted either in a vertical position with the filament base up, or in a horizontal position with the plate on edge. Ample air space should be provided for ventilation.

The filament of the 949-A should be operated at the rated value of 11 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential, the filament of the 949-A should be operated from an a-c source.

The plate dissipation of the 949-A should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage	4000			volts
Maximum Plate Dissipation	400			watts
Maximum Plate Input	400			watts
Typical Operation:				
Filament Voltage	11	11	11	a-c volts
D-C Plate Voltage	2500	3000	4000	volts
D-C Grid Voltage	—100	—130	—185	volts
Peak A-F Grid Voltage	94	125	180	volts
D-C Plate Current	135	120	100	ma.
Mutual Conductance	5750	5000	4000	umhos
Plate Resistance	3300	3400	3900	ohms
Load Resistance	12000	18000	30000	ohms
U. P. O. (5% 2nd harmonic)	82	105	150	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage	4000			volts
Maximum D-C Plate Current (Averaged over any audio freq. cycle)	500			ma.
Maximum Plate Dissipation (Averaged over any audio freq. cycle)	500			watts
Maximum Plate Input (Averaged over any audio freq. cycle)	1350			watts
Typical Operation (2 tubes):				
Filament Voltage	11	11	11	a-c volts
D-C Plate Voltage	2500	3000	3000	volts
D-C Grid Voltage	—118	—140	—140	volts
Zero-Sig. Plate Cur. (per tube)	60	100	100	ma.
Max.-Sig. Plate Cur. (per tube)	293	265	450	ma.
Load Resistance (per tube)	2000	3200	2000	ohms
Load Res. (plate to plate)	8000	12800	8000	ohms
Driving Power	6	12	40	watts
Power Output (2 tubes)	840	1100	1900	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage	3500			volts
Maximum D-C Plate Current	500			ma.
Maximum Plate Dissipation	500			watts
Maximum Plate Input	750			watts
Maximum R-F Grid Current	8			amp.
Typical Operation:				
Filament Voltaage	11	11	11	a-c volts
D-C Plate Voltage	2000	2500	3000	volts
D-C Grid Voltage	—80	—110	—140	volts
Peak R-F Grid Voltage	110	135	160	volts
D-C Plate Current	187	216	250	ma.
Driving Power†	9	12	18	watts
Power Output	132	190	270	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

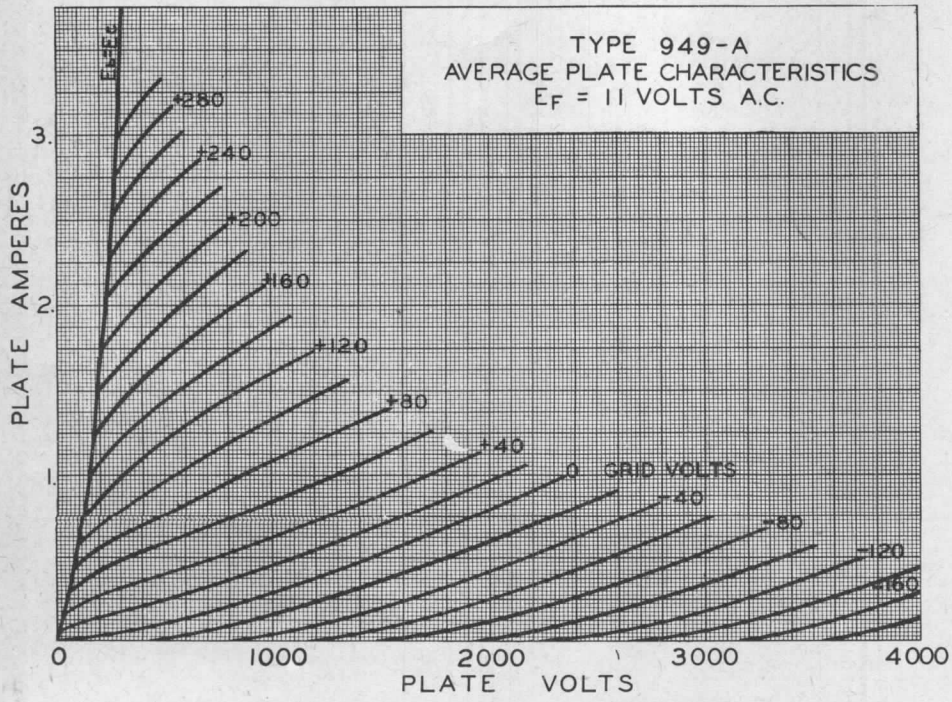
Maximum D-C Plate Voltage	3000			volts
Maximum D-C Plate Current	500			ma.
Maximum Plate Dissipation	400			watts
Maximum Plate Input	1250			watts
Maximum D-C Grid Current	100			ma.
Maximum R-F Grid Current	8			amp.
Typical Operation:				
Filament Voltaage	11	11		a-c volts
D-C Plate Voltage	2500	2500		volts
D-C Grid Voltage	—300	—300		volts
Peak R-F Grid Voltage	475	520		volts
D-C Plate Current	335	500		ma.
D-C Grid Current†	48	70		watts
Driving Power†	22	35		ma.
Power Output	680	960		watts

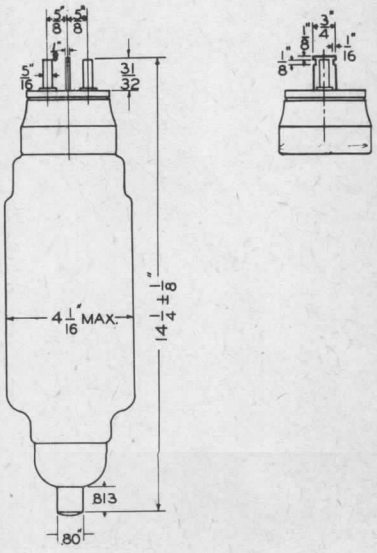
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

(Key-down Conditions)

Maximum D-C Plate Voltage	3500			volts
Maximum D-C Plate Current	500			ma.
Maximum Plate Dissipation	500			watts
Maximum Plate Input	1750			watts
Maximum D-C Grid Current	100			ma.
Maximum R-F Grid Current	8			amp.
Typical Operation:				
Filament Voltaage	11	11		a-c volts
D-C Plate Voltage	2500	3000		volts
D-C Grid Voltage	—300	—300		volts
Peak R-F Grid Voltage	—520	—500		volts
D-C Plate Current	500	500		ma.
D-C Grid Current†	70	50		ma.
Driving Power†	35	25		watts
Power Output	960	1180		watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

TYPE 949-H

MODULATOR, A-F AND R-F POWER AMPLIFIER, OSCILLATOR

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament Voltage	11 volts
Current	7.7 amperes
Type	Thoriated Tungsten

Average Characteristic Values Calculated at:
Eb = 3000, Ec = —130, Ef = 11 A-C

Plate Current	0,120 amperes
Amplification Factor	19
Plate Resistance @ 200 ma.	2500 ohms
Mutual Conductance @ 200 ma.	7600 micromhos

Average Direct Interelectrode Capacities:

Grid to Plate	11.5 uuf
Grid to Filament	10.0 uuf
Plate to Filament	2.0 uuf

Maximum Overall Dimensions:

Length	14 3/8 inches
Diameter	4 1/16 inches
Bulb	T-32
Cap	Skirted Large
Grid Cap	Skirted Medium
Base	Jumbo 3-Pin
Type of Cooling	Air
Net Weight	23 oz.

MAXIMUM RATINGS

Maximum D-C Plate Voltage Modulated	3500	volts
Maximum D-C Plate Voltage Unmodulated	4000	volts
Maximum A-C Plate Voltage R. M. S.	4000	volts
Maximum D-C Plate Current Modulated	500	ma.
Maximum D-C Plate Current Unmodulated	500	ma.
Maximum Plate Dissipation	500	watts
Maximum D-C Grid Current	110	ma.
Maximum R-F Grid Current	10	amp.

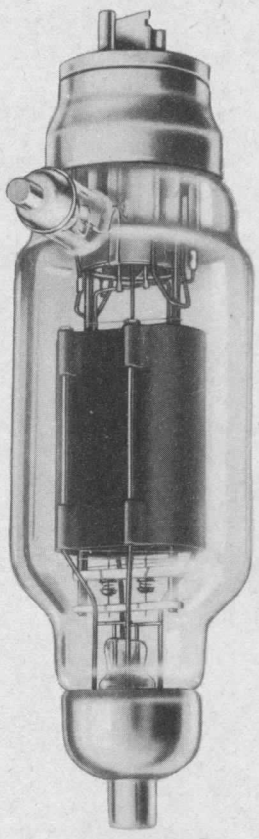
Frequency Rating for Operating Conditions with Maximum Rated Power Input and Nominal Output:

Below	5 megacycles
Above	60 meters

*Maximum Frequency Rating and Reduced Power Input and Output:

Below	*15 megacycles
Above	*20 meters

* For operation at the higher frequencies, the plate voltage, and plate input should not exceed 50% of the Maximum Ratings and Typical Operation Conditions. The R-F grid current should never exceed the maximum rated value.



INTERCHANGES WITH TYPE 849-H

The type 949-H is mainly a higher frequency version of UNITED 949-A. Distinguished from type 949-A by high insulation grid terminal arm at the side of the bulb, the 949-H will bear maximum rated inputs with greater efficiency than type 949-A.

INSTALLATION

The base of the UNITED 949-H is designed for mounting in a standard Jumbo 3-Pin socket. The tube may be mounted either in a vertical position with the filament base up, or in a horizontal position with the plate on edge. Ample air space should be provided for ventilation.

The filament of the 949-H should be operated at the rated value of 11 volts. Operation at other than rated value may result in loss of filament emission and short life. Except in cases where freedom from hum is essential, the filament of the 949-H should be operated from an a-c source.

The plate dissipation of the 949-H should never exceed the values given under Maximum Ratings and Typical Operation Conditions.

GRAPHITE ANODE

A specially processed graphite anode is used in this tube type because of several specific advantages over metals such as tantalum, molybdenum, and nickel. The radiating area of graphite is approximately twice the projected anode area because of its surface porosity and it will dissipate at least four times more heat than metal.

Graphite, being infusible will not warp or twist. The exact form of graphite is maintained under all temperatures; hence constant inter-element relationships and uniform characteristics result. The inherent advantages of graphite over metal are of primary importance in designing tubes of this type for long and satisfactory service.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United

A-F POWER AMPLIFIER AND MODULATOR—CLASS A

Maximum D-C Plate Voltage			4000	volts
Maximum Plate Dissipation			400	watts
Maximum Plate Input			400	watts
Typical Operation:				
Filament Voltage	11	11	11 a-c	volts
D-C Plate Voltage	2500	3000	4000	volts
D-C Grid Voltage	—100	—130	—185	volts
Peak A-F Grid Voltage	94	125	180	volts
D-C Plate Current	135	120	100	ma.
Mutual Conductance	5750	5000	4000	umhos
Plate Resistance	3300	3400	3900	ohms
Load Resistance	12000	18000	30000	ohms
U. P. O. (5% 2nd harmonic)	82	105	150	watts

A-F POWER AMPLIFIER AND MODULATOR—CLASS B

Maximum D-C Plate Voltage		4000	volts
Maximum D-C Plate Current	Averaged over any audio freq. cycle	500	ma.
Maximum Plate Dissipation		500	watts
Maximum Plate Input		1350	watts

Typical Operation (2 tubes):

Filament Voltage	11	11	11 a-c	volts
D-C Plate Voltage	2500	3000	3000	volts
D-C Grid Voltage	—118	—140	—140	volts
Zero-Sig. Plate Cur. (per tube)	60	100	100	ma.
Max.-Sig. Plate Cur. (per tube)	293	265	450	ma.
Load Resistance (per tube)	2000	3200	2000	ohms
Load Res. (plate to plate)	8000	12800	8000	ohms
Driving Power	6	12	40	watts
Power Output (2 tubes)	840	1100	1900	watts

R-F POWER AMPLIFIER—CLASS B TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

Maximum D-C Plate Voltage			3500	volts
Maximum D-C Plate Current			500	ma.
Maximum Plate Dissipation			500	watts
Maximum Plate Input			750	watts
Maximum R-F Grid Current			8	amp.
Typical Operation:				
Filament Voltaage	11	11	11 a-c	volts
D-C Plate Voltage	2000	2500	3000	volts
D-C Grid Voltage	—80	—110	—140	volts
Peak R-F Grid Voltage	110	135	160	volts
D-C Plate Current	187	216	250	ma.
Driving Power†	9	12	18	watts
Power Output	132	190	270	watts

PLATE MODULATED R-F POWER AMPLIFIER CLASS C TELEPHONY

(Carrier Conditions—Modulation Factor = 1.0)

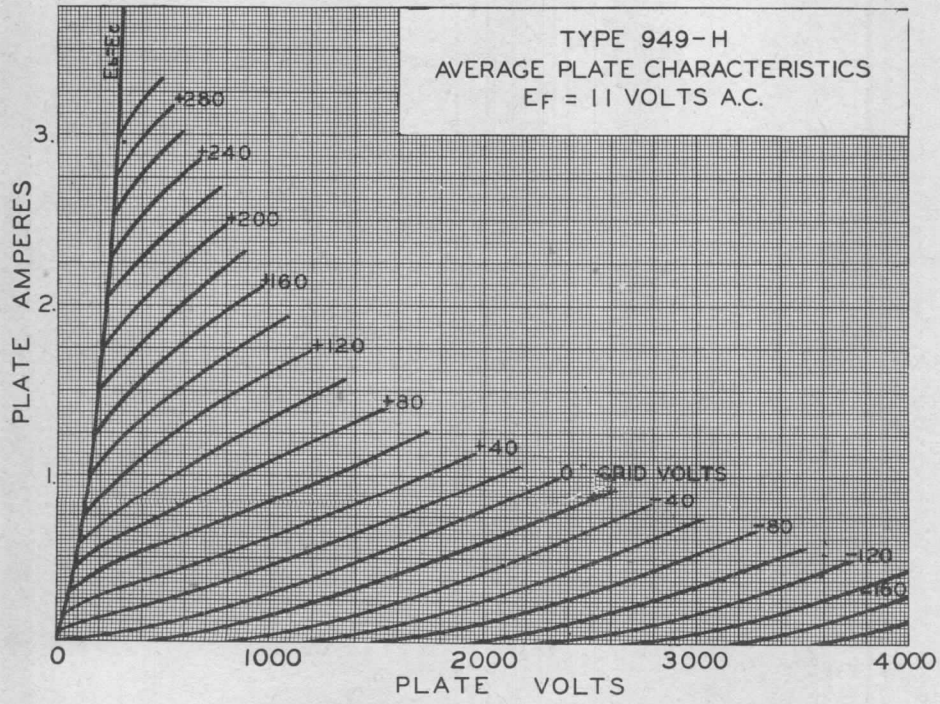
Maximum D-C Plate Voltage		3000	volts
Maximum D-C Plate Current		500	ma.
Maximum Plate Dissipation		400	watts
Maximum Plate Input		1250	watts
Maximum D-C Grid Current		100	ma.
Maximum R-F Grid Current		8	amp.
Typical Operation:			
Filament Voltaage	11	11 a-c	volts
D-C Plate Voltage	2500	2500	volts
D-C Grid Voltage	—300	—300	volts
Peak R-F Grid Voltage	475	520	volts
D-C Plate Current	335	500	ma.
D-C Grid Current†	48	70	watts
Driving Power†	22	35	ma.
Power Output	680	960	watts

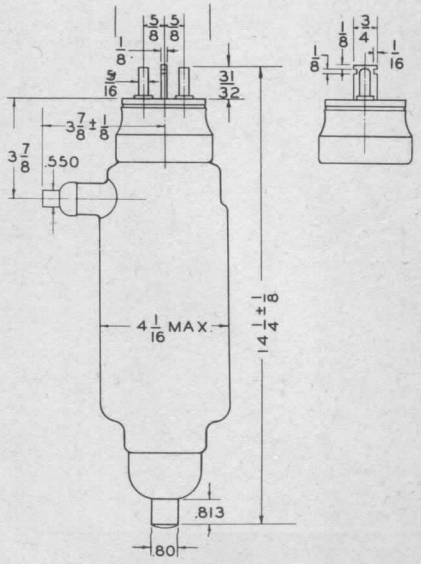
R-F POWER AMPLIFIER AND OSCILLATOR CLASS C TELEGRAPHY

(Key-down Conditions)

Maximum D-C Plate Voltage			3500	volts
Maximum D-C Plate Current			500	ma.
Maximum Plate Dissipation			500	watts
Maximum Plate Input			1750	watts
Maximum D-C Grid Current			100	ma.
Maximum R-F Grid Current			8	amp.
Typical Operation:				
Filament Voltaage	11	11	11 a-c	volts
D-C Plate Voltage	2500	3000		volts
D-C Grid Voltage	—300	—300		volts
Peak R-F Grid Voltage	—520	—500		volts
D-C Plate Current	500	500		ma.
D-C Grid Current†	70	50		ma.
Driving Power†	35	25		watts
Power Output	960	1180		watts

† Subject to wide variations depending on the impedance of the load circuit. The driver stage should have a tank circuit of good regulation and should be capable of delivering considerably more than the required driving power.





UNITED ELECTRONICS

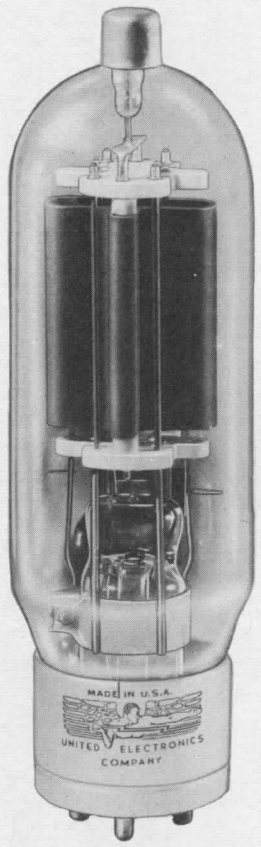
TYPE 217-C

HALF-WAVE HIGH-VACUUM RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	2
Filament Voltage	10.0 volts
Current	3.25 amperes
Type	Thoriated Tungsten
Operating Conditions:	
Maximum Peak Inverse Voltage	7500 volts
Maximum Peak Plate Current	600 ma.
Average Plate Current	150 ma.
Maximum Overall Dimensions:	
Length	8 1/2 inches
Diameter	2 5/16 inches
Bulb	T-18
Cap	Medium Metal
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	7 oz.



UNITED TYPE 217-C

This tube is particularly adapted to use in high voltage circuits where the operating conditions preclude the use of gas-filled or mercury vapor tubes.

INSTALLATION

The base of the UNITED 217-C is designed for mounting in a standard "50-Watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 217-C should be operated on alternating current at the rated value of 5.0 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 10.0 volts. **Caution — The filament winding is at high potential.**

Connection to the anode terminal cap should be made by means of spring clips attached to flexible leads which must not touch the glass bulb. If vibration will be encountered in the applications, shock absorbing mounting details should be employed. Overload protection should be provided so that the voltage is removed if the current through the tube exceeds 150 per cent of the rated value.

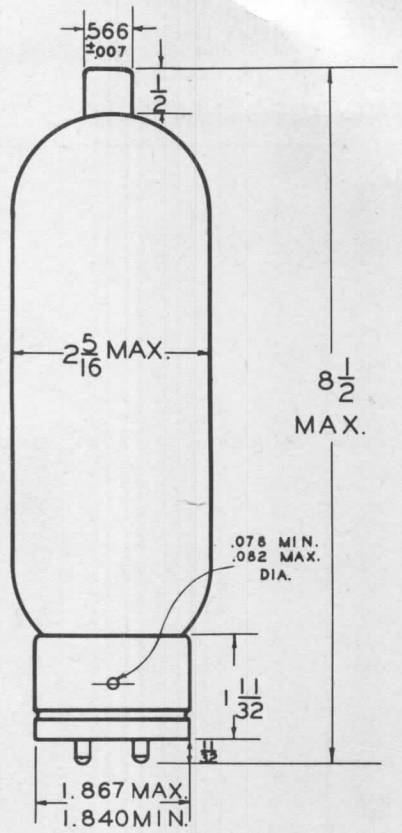
When the 217-C is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

DESIGN AND CHARACTERISTIC FEATURES

The UNITED type 217-C is a tube of exceptional physical ruggedness. This design not only takes into account important electrical and thermal considerations, but end use conditions involving vibration and shock such as encountered in industrial electronic equipment.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United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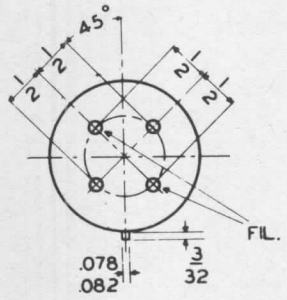
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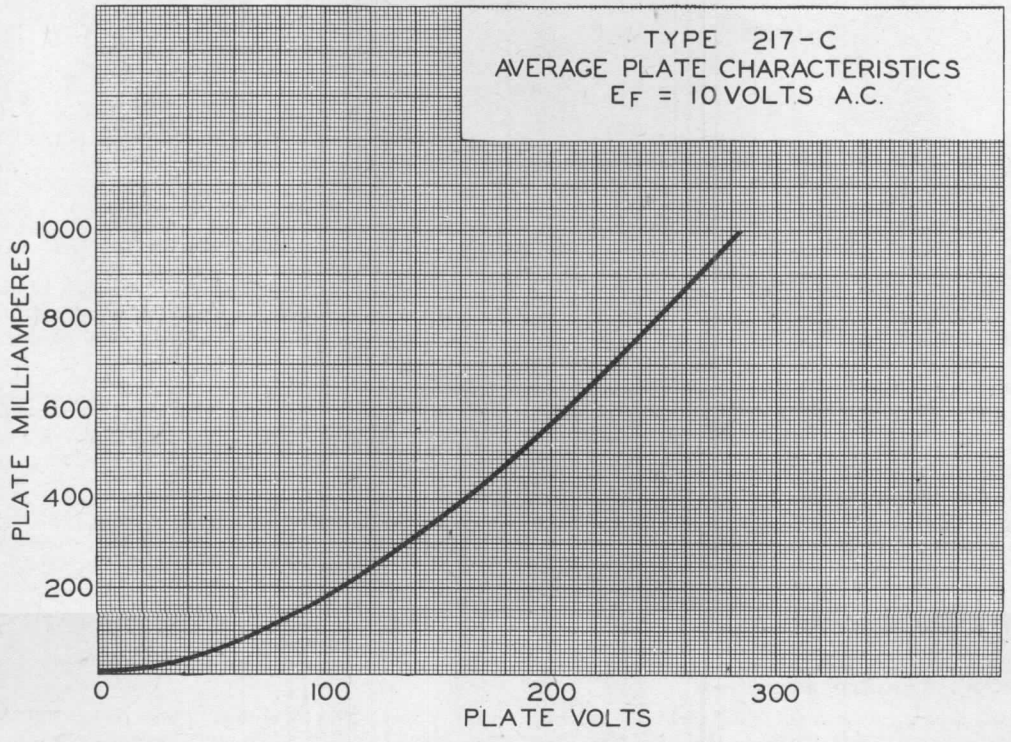
TYPE 217-C
AVERAGE PLATE CHARACTERISTICS
EF = 10 VOLTS A.C.
PLATE MILLIAMPERES
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800
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200
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PLATE VOLTS

UNITED ELECTRONICS

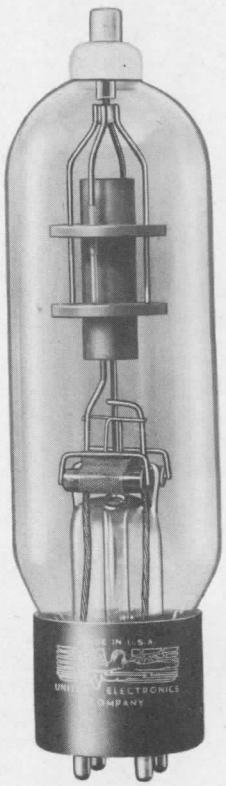
TYPE 371-B

HALF-WAVE HIGH-VACUUM RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	2
Filament Voltage	5.0 volts
Current	10.3 amperes
Type	Thoriated Tungsten
Operating Conditions:	
Maximum Peak Inverse Voltage	25,000 volts
Maximum Peak Plate Current	1.5 amperes
Average Plate Current	300 ma.
Maximum Overall Dimensions:	
Length	8 3/4 inches
Diameter	2 1/4 inches
Bulb	T-18
Cap	Small Metal
Base	Jumbo 4-Pin, Bayonet
Type of Cooling	Air
Net Weight	5 3/4 oz.



This tube is particularly adapted to use in high voltage circuits where the operating conditions preclude the use of gas-filled or mercury vapor tubes.

INSTALLATION

The base of the UNITED 371-B is designed for mounting in a standard "50-Watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 371-B should be operated on alternating current at the rated value of 5.0 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 5.0 volts. **Caution — The filament winding is at high potential.**

Connection to the anode terminal cap should be made by means of spring clips attached to flexible leads which must not touch the glass bulb. The unused base pins and the base shell of the 371-B should be connected to one filament *terminal* in the socket. If vibration will be encountered in the applications, shock absorbing mounting details should be employed. Overload protection should be provided so that the voltage is removed if the current through the tube exceeds 150 per cent of the rated value.

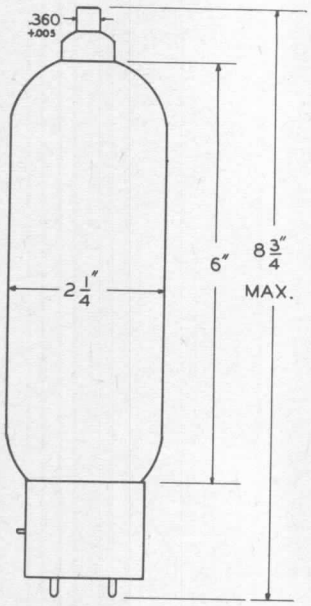
When the 371-B is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

DESIGN AND CHARACTERISTIC FEATURES

The UNITED type 371-B is a tube of exceptional physical ruggedness. This design not only takes into account important electrical and thermal considerations, but end use conditions involving vibration and shock such as encountered in industrial electronic equipment.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United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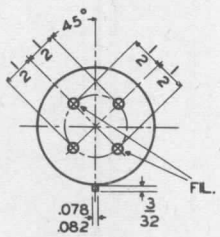
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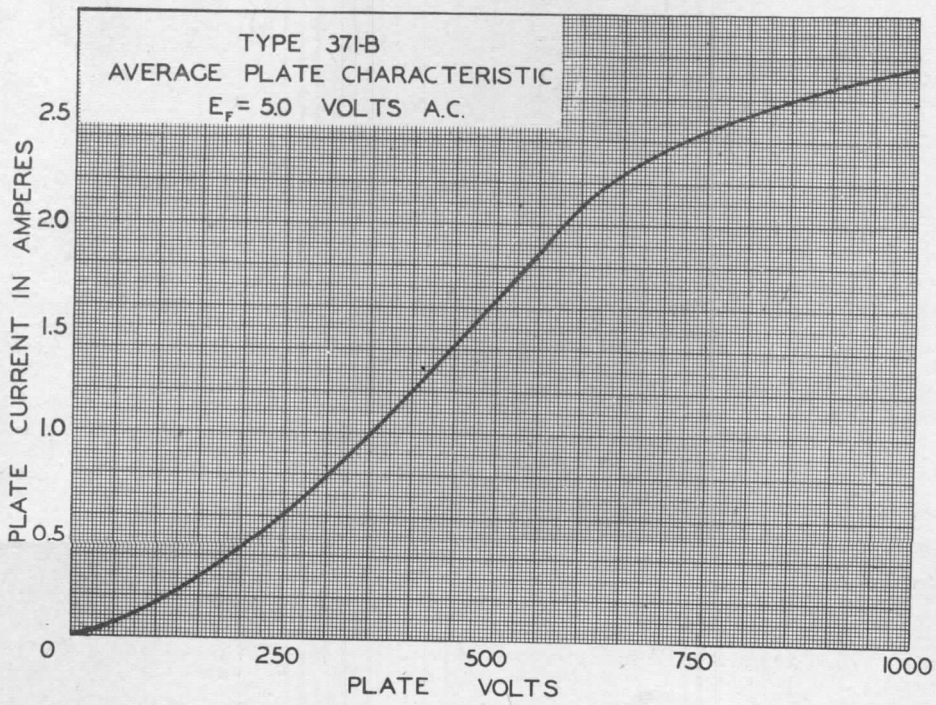
2
2
1/2
FL.
.078
.082
3/32


TYPE 371-B
AVERAGE PLATE CHARACTERISTIC
E_F = 5.0 VOLTS A.C.
PLATE CURRENT IN AMPERES
2.5
2.0
1.5
1.0
0.5
0
250
500
750
1000
PLATE VOLTS

UNITED ELECTRONICS

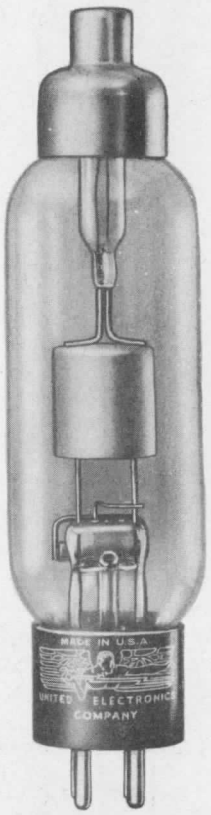
TYPE 878

HALF-WAVE HIGH-VACUUM RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	2
Filament Voltage	2.5 volts
Current	5.0 amperes
Type	Tungsten
Operating Conditions:	
Maximum Peak Inverse Voltage	20000 volts
Maximum Peak Plate Current	20 ma.
Average Plate Current	5 ma.
Maximum Overall Dimensions:	
Length	7 5/8 inches
Diameter	1 13/16 inches
Bulb	T-14
Cap	Medium Metal Skirted
Base	Medium 4-Pin
Type of Cooling	Air
Net Weight	2 3/4 oz.



This tube is used in suitable rectifying systems to supply the d-c voltage requirements of cathode-ray tubes, and for similar purposes.

INSTALLATION

The base of the UNITED 878 is designed for mounting in a standard socket of the four-pin type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 878 should be operated on alternating current at the rated value of 2.5 volts.

Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 2.5 volts.

It is important that the filament transformer secondary be insulated to withstand the maximum peak inverse voltage encountered in the installation. **Caution—The filament winding is at high potential.**

Filter requirements are ordinarily met by the use of a 0.5 to 2.0 uf condenser shunted across the bleeder circuit. The shunt condenser should have a rating sufficient to withstand the instantaneous peak value of the a-c input voltage. If this filtering is inadequate for a definite application, a two-section filter is recommended.

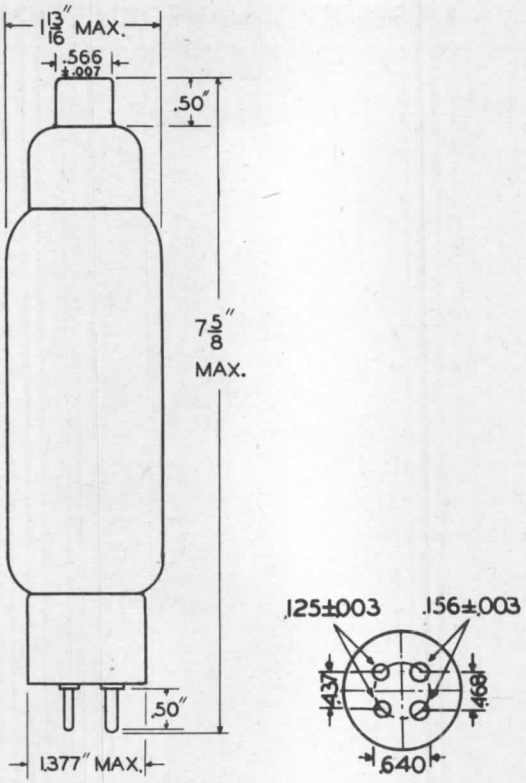
In a voltage doubler circuit, two UNITED 878's may be operated to deliver approximately twice the voltage obtainable from a half-wave rectifier circuit for the same a-c input voltage. However, a separate filament supply winding is required for each tube.

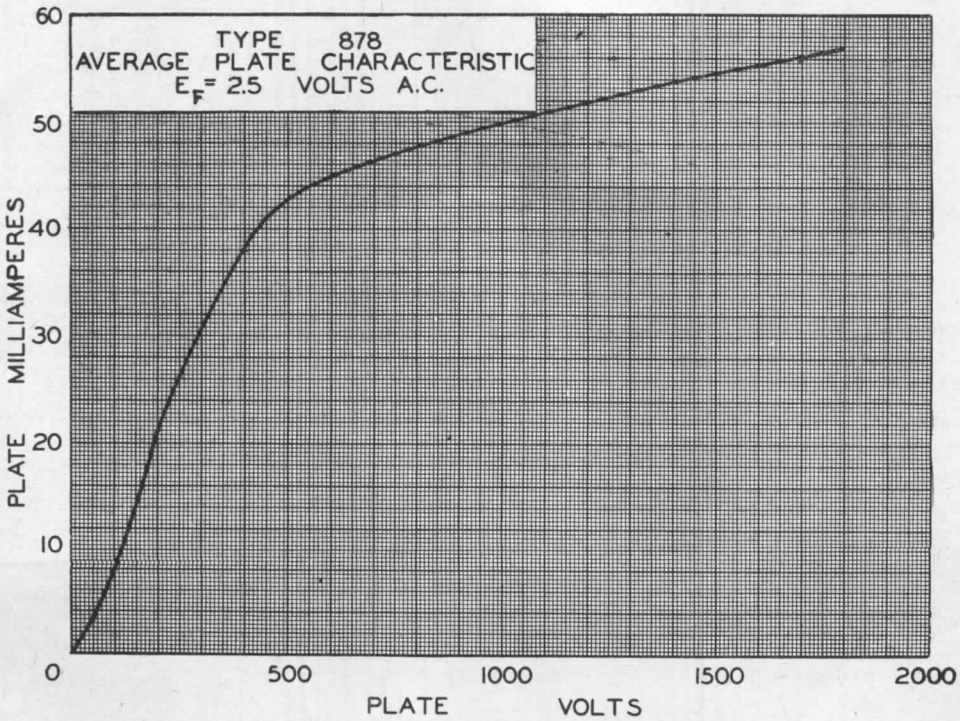
DESIGN AND CHARACTERISTIC FEATURES

The UNITED type 878 is a tube of exceptional physical ruggedness. This design not only takes into account important electrical and thermal considerations, but end use conditions involving vibration and shock such as encountered in industrial electronic equipment.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United


1 13/16" MAX.
.566 ±.007
.50"
7 5/8" MAX.
.50"
1.377" MAX.
.125±.003
.156±.003
.437
.468
.640


TYPE 878
AVERAGE PLATE CHARACTERISTIC
E_F = 2.5 VOLTS A.C.
PLATE MILLIAMPERES
60
50
40
30
20
10
0
500
1000
1500
2000
PLATE VOLTS

UNITED ELECTRONICS

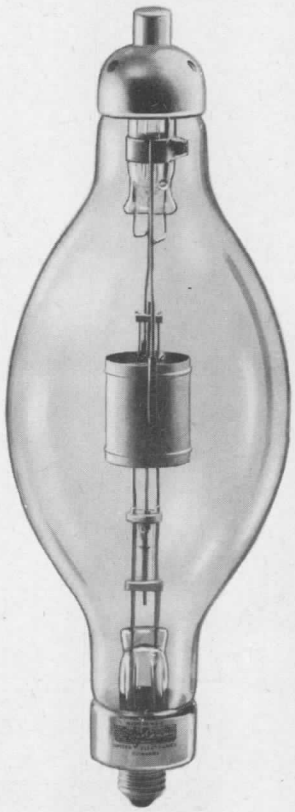
TYPE V-1901

HALF-WAVE HIGH VACUUM RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	2
Filament Voltage	16.5 volts
Current	15.25 amperes
Type	Tungsten
Operating Conditions:	
Maximum Peak Inverse Voltage	70,000 volts
Maximum Peak Plate Current	1.2 amperes
Average Plate Current	40 ma.
Maximum Overall Dimensions:	
Length	17½ inches
Diameter	6 inches
Bulb	GT-48
Cap Diameter	.75 inch
Base	Edison Screw
Type of Cooling	Air
Net Weight	22¼ oz.



INSTALLATION

The base of the UNITED V-1901 is designed for mounting in an Edison screw type socket. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the V-1901 should be allowed to come up to operating temperature before the plate voltage is applied.

The V-1901 is a rugged bright tungsten rectifier capable of delivering a rectified output current of 40 milliamperes at 10,000 volts with the filament voltage adjusted to maintain steady plate current flow. Operation at the maximum peak current of 1.2 amperes requires that precautions be taken to maintain exactly the filament voltage of 16.5 volts. When operating conditions are such, however, that the peak current is less than the full rated value, the regulation of the filament voltage need not be so exact. The permissible variation will depend on the magnitude of the peak current and will increase with decreased values of peak current. **Caution—The filament winding is at high potential.**

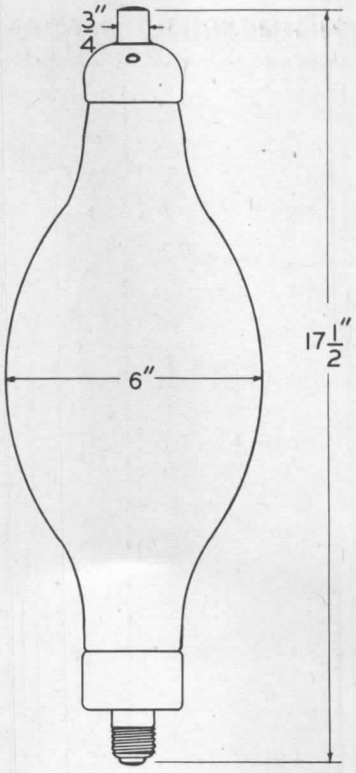
Since the V-1901 is used in high powered, high voltage systems, proper overload protection against excessive currents, and safety interlock circuits to safeguard personnel should be employed.

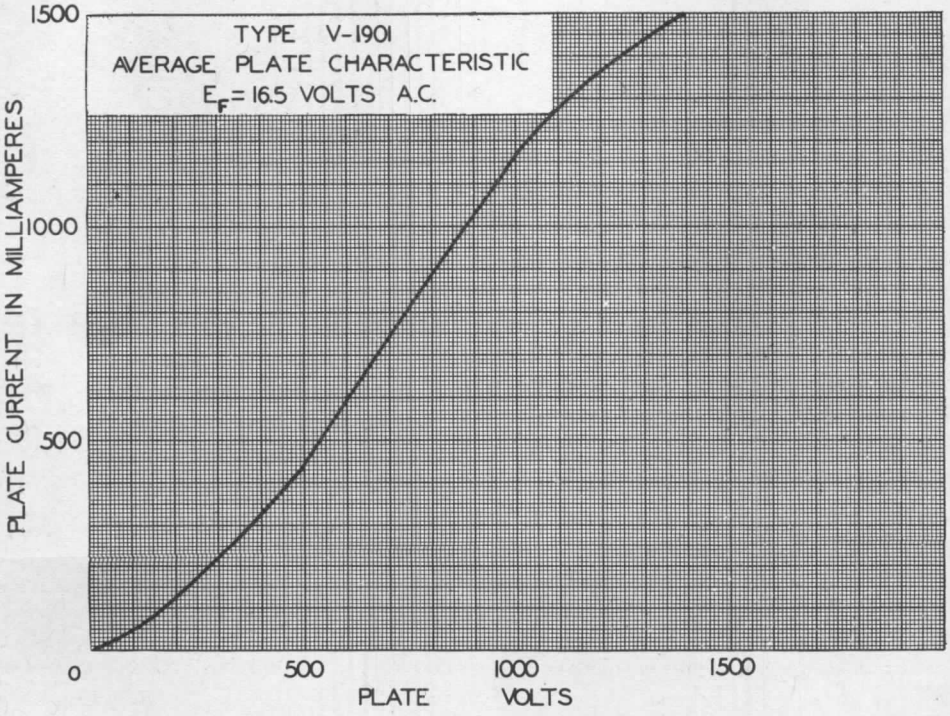
The filament circuit carries a fairly large current and precautions should be taken against voltage losses due to poor connections. All wires should be as far as reasonably possible from the glass of the tube in order to avoid the possibility of bulb puncture from corona discharges.

When the V-1901 is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United


3/4"
17 1/2"
6"


TYPE V-1901
AVERAGE PLATE CHARACTERISTIC
E_F = 16.5 VOLTS A.C.
PLATE CURRENT IN MILLIAMPERES
1500
1000
500
0
500
1000
1500
PLATE VOLTS

UNITED ELECTRONICS

TYPE Z-225

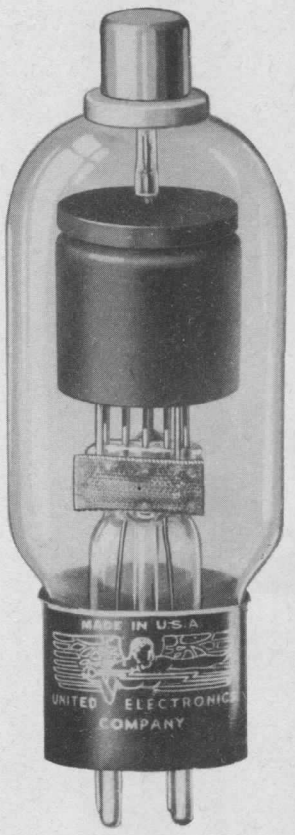
HALF-WAVE MERCURY RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	2
Filament:	
Voltage	2.5 volts
Current	5.0 amperes
Type	Shielded Coated
Heating Time*	10 seconds
Condensed Mercury Temperature Range 25° to 60° C.	
Supply Frequency up to	150 cycles
Maximum Peak Inverse Voltage	10000 volts
Maximum Peak Plate Current	1.0 amp.
Average Plate Current	.25 amp.
Condensed Mercury Temperature Range 25° to 70° C.	
Supply Frequency up to	150 cycles
Maximum Peak Inverse Voltage	10000 volts
Maximum Peak Plate Current	2.0 amp.
Average Plate Current	.25 amp.
Condensed Mercury Temperature Range 25° to 70° C.	
Supply Frequency up to	1000 cycles
Maximum Peak Inverse Voltage	5000 volts
Maximum Peak Plate Current	1.0 amp.
Average Plate Current	.25 amp.
Approximate Tube Voltage Drop	10-15 volts
Maximum Overall Dimensions:	
Length	5½ inches
Diameter	1¾ inches
Bulb	T-14
Cap	Medium Metal
Base	Medium 4-Pin Bayonet
Type of Cooling	Air
Net Weight	2½ oz.

* The filament should be allowed to come up to operating temperature before the plate voltage is applied.



TYPE Z225

Occupies less than one-half the cubic space required for types 866-866A, overall clearance dimensions considered. See comparative dimensional drawings on reverse side.

Type Z-225 is another outstanding development of UNITED ELECTRONICS COMPANY—notable producer of mercury rectifiers.

INSTALLATION

The base of the UNITED Z-225 is designed for mounting in a standard four-prong, bayonet type socket. The tube should always be mounted vertically with ample air space provided for ventilation. The condensed mercury temperature should not be less than 25° C. (77° F.) and not more than 60° C. (140° F.) to 70° C. (158° F.) depending on the peak inverse voltage used. When the maximum condensed mercury temperature exceeds these limits, forced ventilation should be used.

The filament of the Z-225 should be operated on alternating current at the rated value of 2.5 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 5.0 volts. **Caution—the filament winding is at high potential.**

Because the mercury may be splashed on the tube elements due to shipment or handling, the filament of the Z-225 should be operated at rated voltage for approximately 15 minutes without plate voltage in order to distribute the mercury properly when the tube is first placed in service. The above procedure need not be repeated unless the tube is removed from the socket and during handling the mercury becomes splashed on the tube elements.

The condensed mercury should be at operating temperature before the plate voltage is applied. This may be ordinarily accomplished by introducing a time lag of at least 10 seconds between the application of the filament and the plate voltages.

In the event that arc-back should occur when the plate voltage is applied, the pre-heating time of the filament should be increased.

When the Z-225 is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

DESIGN AND CHARACTERISTIC FEATURES

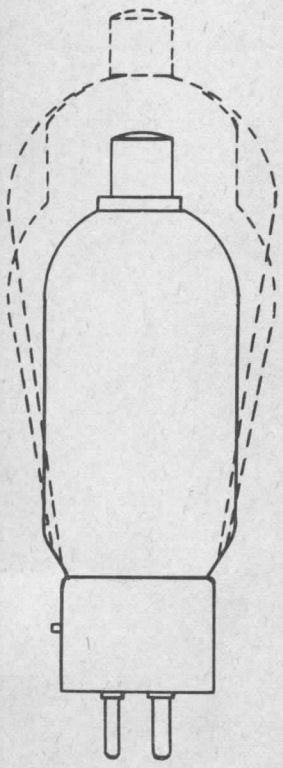
UNITED type Z-225 mercury rectifiers are distinguished for their measured mercury content. In contrast with tubes into which mercury is "dumped", the UNITED Z-225 is entirely free of excess mercury. Casual examination of the Z-225 will reveal little or no mercury.

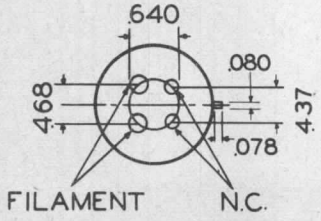
Type Z-225 is the exclusive solution for power supply design problems wherever space and weight factors are of importance. The use of the Z-225 instead of types 866-866A permit good engineering practice rather than space limitations to govern circuit selection.

Wherever 866-866A tubes are crowded and operating under poor temperature conditions, the use of UNITED type Z-225 is indicated. In such cases, the Z-225 permits a greater space for the free circulation of air and hence cooler operation.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United




640
.080
468
437
.078
FILAMENT
N.C.

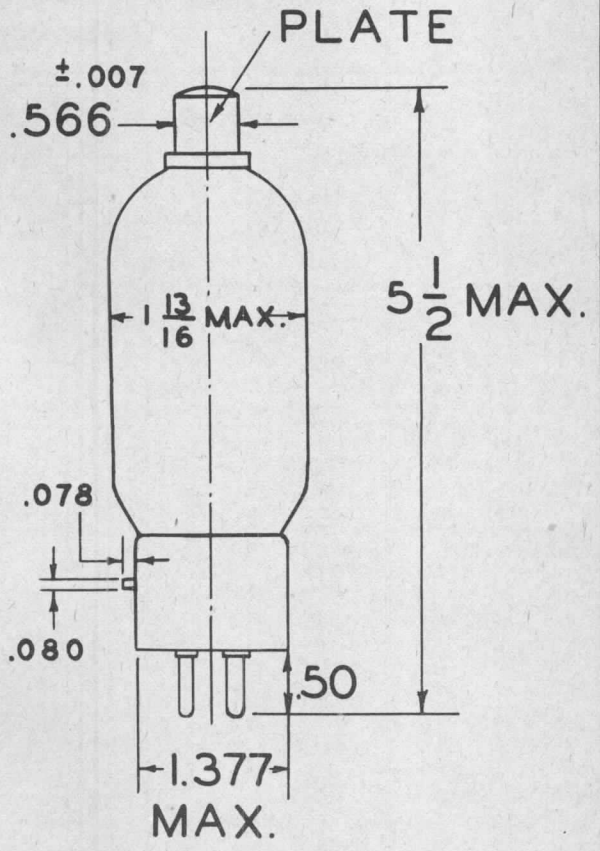
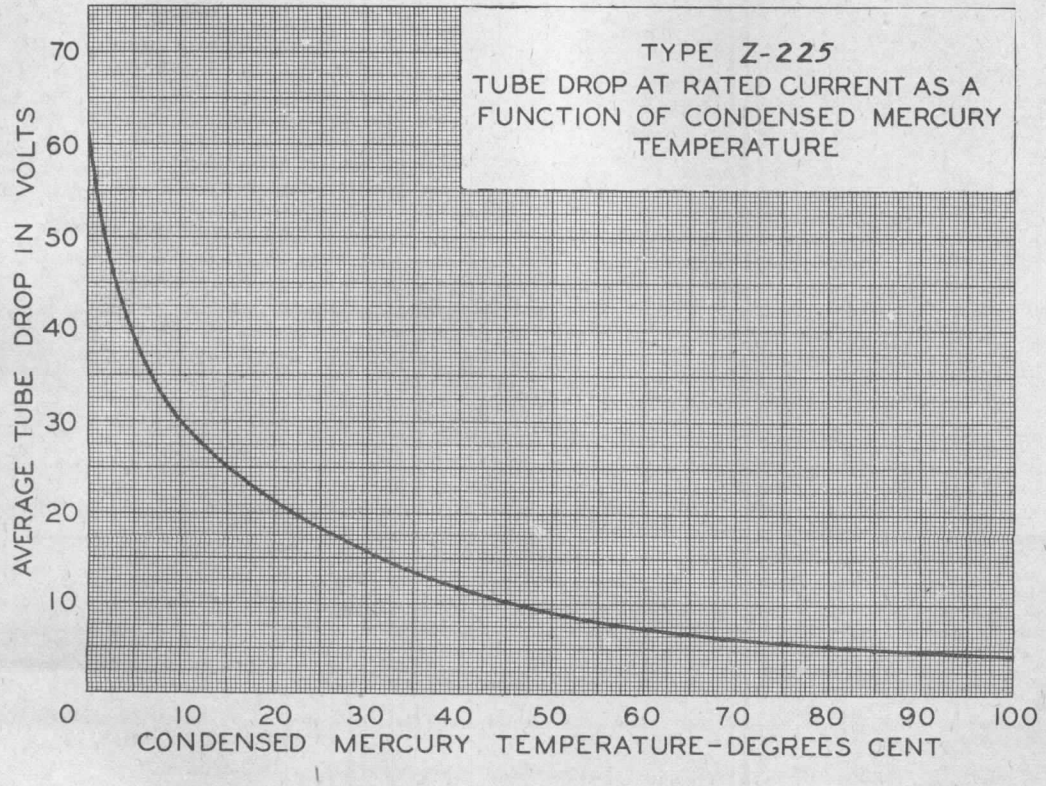


PLATE
±.007
.566
1 13/16 MAX.
5 1/2 MAX.
.078
.080
.50
1.377
MAX.


TYPE Z-225
TUBE DROP AT RATED CURRENT AS A FUNCTION OF CONDENSED MERCURY TEMPERATURE
AVERAGE TUBE DROP IN VOLTS
70
60
50
40
30
20
10
0
10 20 30 40 50 60 70 80 90 100
CONDENSED MERCURY TEMPERATURE-DEGREES CENT

UNITED ELECTRONICS

TYPE ESU-300

HALF-WAVE MERCURY RECTIFIER

ENGINEERING INFORMATION

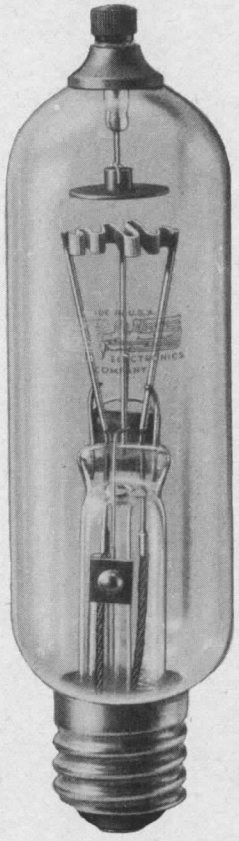
GENERAL RATINGS

Number of Electrodes	2
Filament:	
Voltage	4.0 volts
Current	15.0 amperes
Type	Coated
Heating Time	30 seconds
Condensed Mercury Temperature Range	20° to 65°C
Maximum Peak Inverse Voltage	7000 volts
Maximum Peak Plate Current	3.0 amperes
Supply Frequency up to	150 cycles
Maximum Average Plate Current (Averaged over period of 15 seconds)	750 ma.
Approximate Tube Voltage Drop	10 volts
Maximum Overall Dimensions:	
Length	9 13/16 inches
Diameter	2 9/16 inches
Bulb	T-20
Cap Diameter	.50 inch
Base	Goliath Edison Screw
Type of Cooling	Air
Net Weight	8 oz.

INSTALLATION

The base of the UNITED ESU-300 is designed for mounting in an Edison screw socket. The tube should always be mounted vertically with ample air space provided for ventilation. The condensed mercury temperature should not be less than 15°C. (59°F.) and not more than 65°C. (149°F.) for the maximum peak inverse voltage. When the condensed mercury temperature exceeds these limits, forced ventilation should be used.

The filament of the ESU-300 should be operated on alternating current at the rated value of 4.0 volts. Adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 4.0 volts. **Caution —The filament winding is at high potential.**



UNITED TYPE ESU-300

Oxide coated filaments are so suspended as to prevent sag and vibration in keeping with the general ruggedness of design. A minimum amount of mercury and getter is used, allowing greater heat radiation through clearer glass envelope.

Because the mercury may be splashed on the tube elements due to shipment or handling, the filament of the ESU-300 should be operated at rated voltage for approximately 15 minutes without plate voltage in order to distribute the mercury properly when the tube is first placed in service. The above procedure need not be repeated unless the tube is removed from the socket and during handling the mercury becomes splashed on the tube elements.

The condensed mercury should be at operating temperature before the plate voltage is applied. This may be ordinarily accomplished by introducing a time lag of at least 30 seconds between the application of the filament and plate voltages. It is advisable, however, to pre-heat the filament for 15 minutes before placing the ESU-300 in operation. During "standby" periods, the filament should be kept at rated voltage.

When the ESU-300 is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

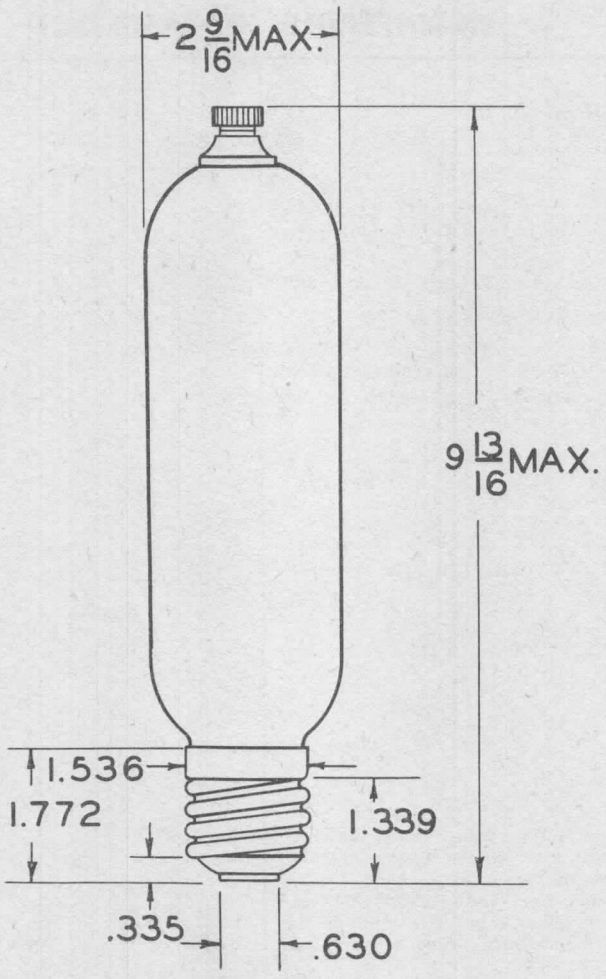
DESIGN AND CHARACTERISTIC FEATURES

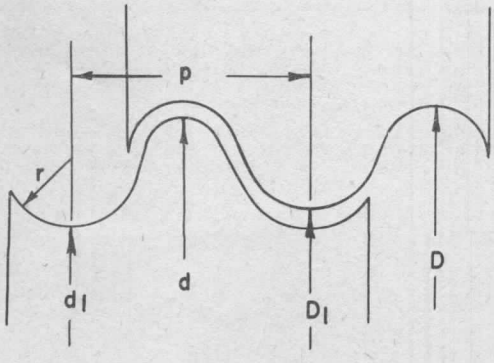
UNITED ELECTRONICS type ESU-300 mercury rectifiers are distinguished for their measured mercury content. Differing from other tubes of this type into which mercury is "dumped", the UNITED ESU-300 is entirely *free from excess* or free mercury. In fact in casual examination of the tube, little or no mercury is discernible at all.

In the UNITED type ESU-300 there are no harmful amalgams clinging to the elements or to getter coatings; hence, they are flexible in adaptation over a widely varying range of temperature, load, and general operating conditions.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United





	Min.	Max.
Cap Major Dia. d	1.5374	1.5551
Cap Minor Dia. d_1	1.3957	1.4134
Socket Major Dia. D	1.5591	1.5768
Socket Minor Dia. D_1	1.4173	1.4350

r = .0728
p = .2500

UNITED ELECTRONICS

TYPE 872

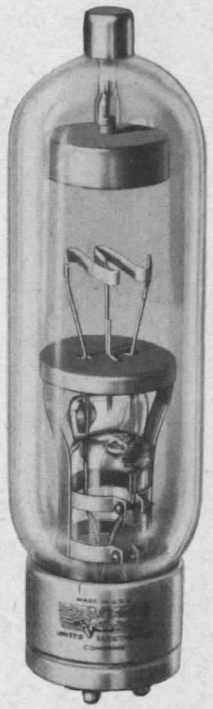
HALF-WAVE MERCURY RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	2
Filament:	
Voltage	5.0 volts
Current	10.0 amperes
Type	Coated
Heating time	30 seconds
Condensed Mercury Temperature Range 0°-65° C:	
Maximum Peak Inverse Voltage	7500 volts
Maximum Peak Plate Current	5.0 amperes
Supply Frequency up to	150 cycles
Maximum Average Plate Current (Averaged over period of 15 seconds)	1.25 amperes
Approximate Tube Voltage Drop	15 volts
Maximum Overall Dimensions:	
Length	8 1/2 inches
Diameter	2 5/16 inches
Bulb	T-18
Cap	Medium Metal
Base*	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	7 oz.

* Base shell not connected to any element of the tube.



REPLACES UNITED TYPE 972

Measured Mercury Content
Rapid Starting—Cold Climates
Heavy Duty Tube—50 Watt Filament

INSTALLATION

The base of the UNITED 872 is designed for mounting in a standard "50 watt" socket of the four pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation. The condensed mercury temperature should not be less than 15°C. (59°F.) and not more than 65°C. (149°F.) for the given maximum peak inverse voltage rating. When the maximum condensed mercury temperature exceeds these limits, forced ventilation should be used.

The filament of the 872 should be operated on alternating current at the rated value of 5.0 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 5.0 volts. **Caution—The filament winding is at high potential.**

Because the mercury may be splashed on the tube elements due to shipment or handling, the filament of the 872 should be operated at rated voltage for approximately 15 minutes without plate voltage in order to distribute the mercury properly when the tube is first placed in service. The above procedure need not be repeated unless the tube is removed from the socket and during handling the mercury becomes splashed on the tube elements.

The condensed mercury should be at operating temperature before the plate voltage is applied. This may be ordinarily accomplished by introducing a time lag of at least 30 seconds between the application of the filament and the plate voltages. During "standby" periods, the filament should be kept at rated voltage.

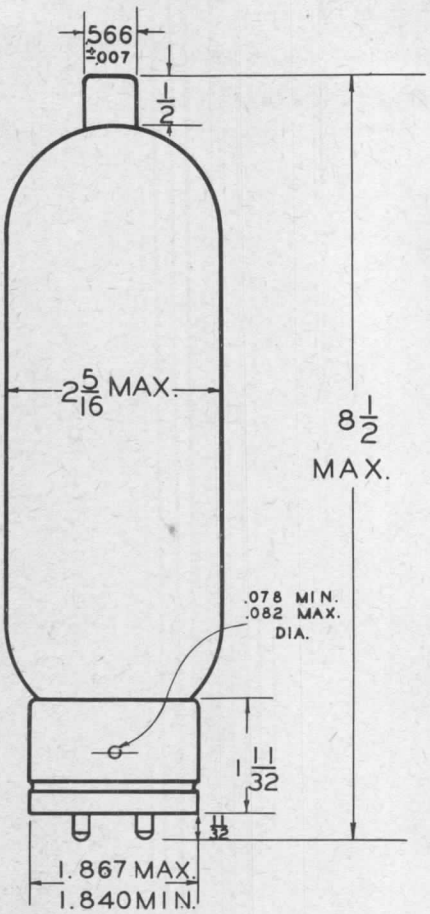
When the 872 is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

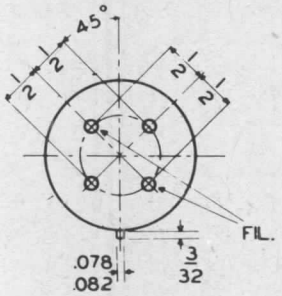
DESIGN AND CHARACTERISTIC FEATURES

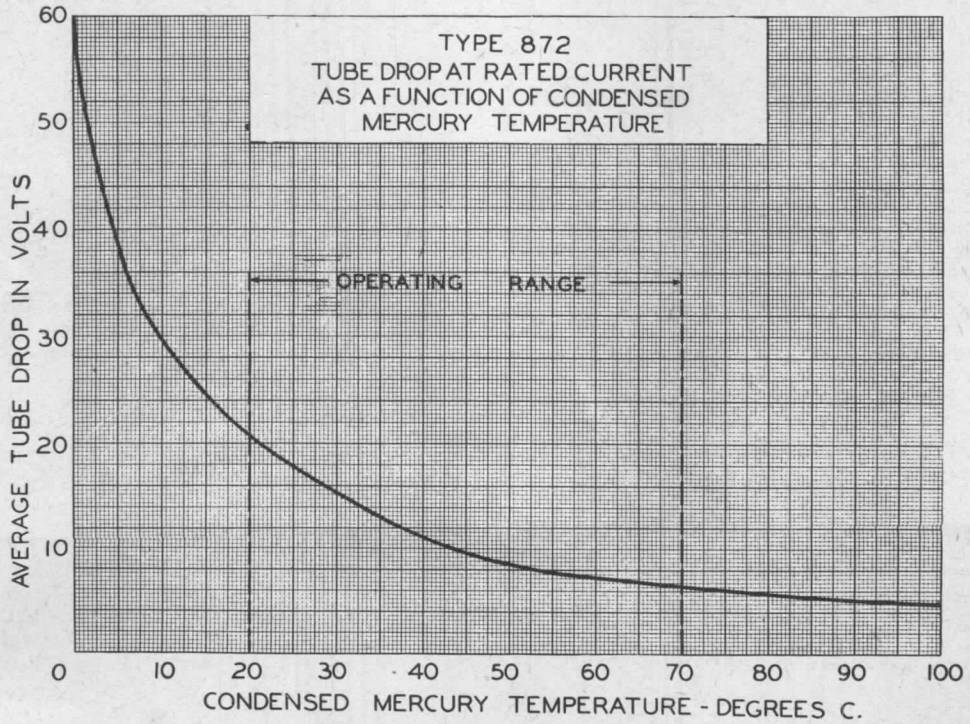
The UNITED type 872 is a tube of exceptional physical ruggedness. This design not only takes into account important electrical and thermal considerations, but end use conditions involving vibration and shock such as encountered in industrial electronic equipment.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United


.566
±.007
1/2
2 5/16 MAX.
8 1/2
MAX.
.078 MIN.
.082 MAX.
DIA.
1 11/32
11/32
1.867 MAX.
1.840 MIN.


45°
1/2
1/2
1/2
1/2
FIL.
.078
.082
3/32


TYPE 872
TUBE DROP AT RATED CURRENT
AS A FUNCTION OF CONDENSED
MERCURY TEMPERATURE
OPERATING RANGE
AVERAGE TUBE DROP IN VOLTS
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
CONDENSED MERCURY TEMPERATURE - DEGREES C.

UNITED ELECTRONICS

TYPE 872-A

HALF-WAVE MERCURY RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes*	2
Filament:	
Voltage	5.0 volts
Current	6.75 amperes
Type	Shielded Coated
Heating Time	30 seconds
Condensed Mercury Temperature Range 20° to 70° C	
Maximum Peak Inverse Voltage	5000 volts
Maximum Peak Plate Current	5.0 amperes
Supply Frequency up to	150 cycles
Condensed Mercury Temperature Range 20° to 60° C	
Maximum Peak Inverse Voltage	10000 volts
Maximum Peak Plate Current	5.0 amperes
Supply Frequency up to	150 cycles
Maximum Average Plate Current (Averaged over period of 15 seconds)	1.25 amperes
Approximate Tube Voltage Drop	10 volts
Maximum Overall Dimensions:	
Length	8 1/2 inches
Diameter	2 5/16 inches
Bulb	T-18
Cap	Medium Metal
Base*	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	8 oz.

*Base shell not connected to any element of the tube.

The above illustration shows the large shield of proportions scientifically determined as necessary in this class of tube. Proper relation between condensed mercury and ambient temperature is maintained. The cylindrical element shields the filament adequately and at the same time permits the needed thermal radiation to assure long service life.

INSTALLATION

The base of the UNITED 872-A is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation. The condensed mercury temperature should not be less than 20° C. (68° F.) and not more than 60° C. (140° F.) to 70° C.(158° F.) depending on the peak inverse voltage used. When the maximum condensed mercury temperature exceeds these limits, forced ventilation should be used.

The filament of the 872-A should be operated on alternating current at the rated value of 5.0 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 5.0 volts. **Caution—The filament winding is at high potential.**

Because the mercury may be splashed on the tube elements due to shipment or handling, the filament of the 872-A should be operated at rated voltage for approximately 15 minutes without plate voltage in order to distribute the mercury properly when the tube is first placed in service. The above procedure need not be repeated unless the tube is removed from the socket and during handling the mercury becomes splashed on the tube elements.

The condensed mercury temperature should be at least 15° C. before the plate voltage is applied. This may be ordinarily accomplished by introducing a time lag of at least 30 seconds between the application of the filament and the plate voltages. It is advisable, however, to pre-heat the filament for 15 minutes before placing the 872-A in operation. During "standby" periods, the filament should be kept at rated voltage.

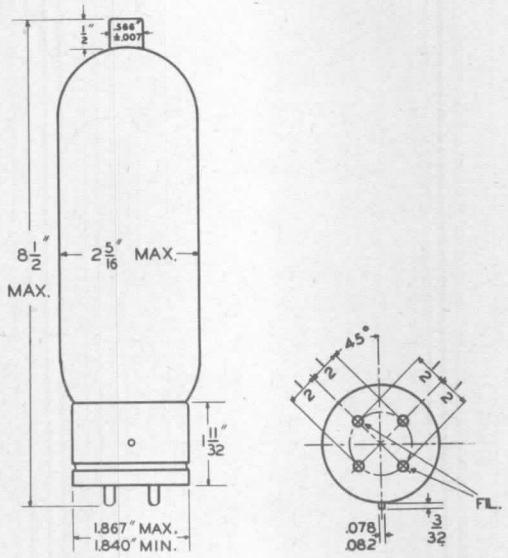
When the 872-A is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

DESIGN AND CHARACTERISTIC FEATURES

The UNITED type 872-A is a tube of exceptional physical ruggedness. This design not only takes into account important electrical and thermal considerations, but end use conditions involving vibration and shock such as encountered in industrial electronic equipment.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United


.386 ±.007
1/2"
8 1/2" MAX.
2 5/16" MAX.
1 11/32"
1.867" MAX.
1.840" MIN.
45°
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2
FIL.
.078
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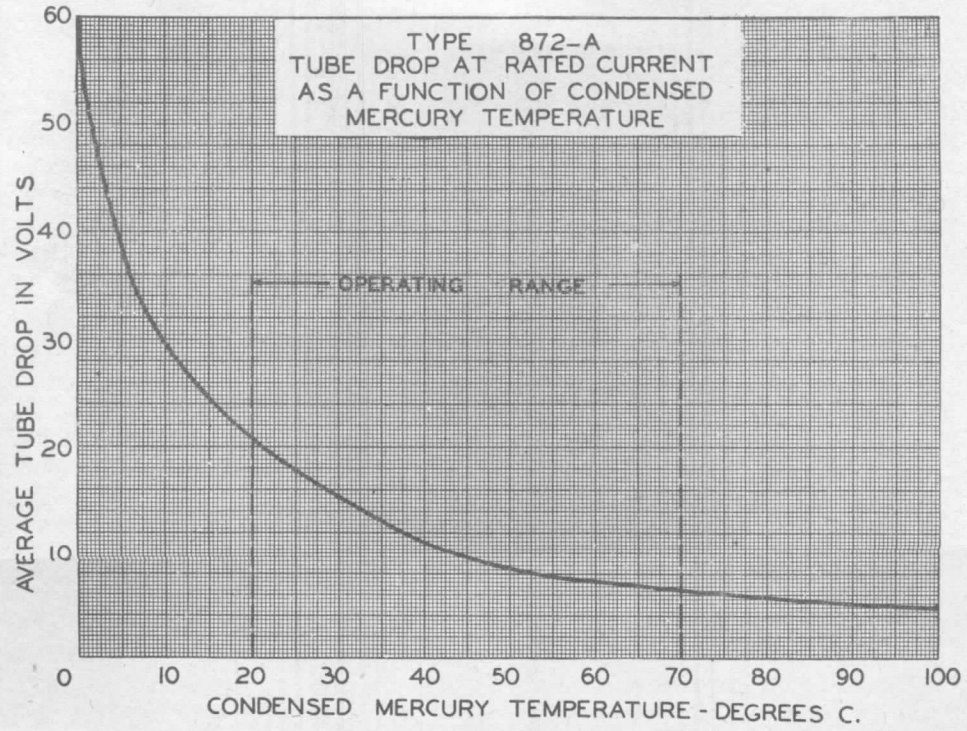
3/32


TYPE 872-A
TUBE DROP AT RATED CURRENT
AS A FUNCTION OF CONDENSED
MERCURY TEMPERATURE
OPERATING RANGE
AVERAGE TUBE DROP IN VOLTS
60
50
40
30
20
10
0
10
20
30
40
50
60
70
80
90
100
CONDENSED MERCURY TEMPERATURE - DEGREES C.

UNITED ELECTRONICS

TYPE 975-A

HALF-WAVE MERCURY RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes 2

Filament:

- Voltage ..... 5.0 volts
- Current ..... 10.0 amperes
- Type ..... Shielded Coated
- Heating Time ..... 30 seconds

Condensed Mercury Temperature Range 20° to 60° C.

- Maximum Peak Inverse Voltage ..... 15000 volts
- Maximum Peak Plate Current ..... 6.0 amperes
- Supply Frequency up to ..... 150 cycles

Maximum Average Plate Current
(Averaged over period of 15 seconds) ..... 1.5 amperes

Approximate Tube Voltage Drop ..... 10 volts

Maximum Overall Dimensions:

- Length ..... 11 1/16 inches
- Diameter ..... 3 1/16 inches

Bulb T-24

Cap ..... Skirted Medium

Base* ..... Jumbo 4-Large Pin

Type of Cooling ..... Air

Net Weight ..... 12 oz.

*Base shell not connected to any element of the tube.

INTERCHANGES WITH TYPE 375-A or 575-A

Oxide coated filaments are so suspended as to prevent sag and vibration in keeping with the general ruggedness of design. A minimum amount of mercury and getters is used, allowing greater heat radiation through clearer glass envelope.

INSTALLATION

The base of the UNITED 975-A is designed for mounting in a standard "50 watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation. The condensed mercury temperature should not be less than 20° C. (68° F.) and not more than 60° C. (140° F.) depending on the peak inverse voltage used.

The filament of the 975-A should be operated on alternating current at the rated value of 5.0 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 5.0 volts. **Caution—The filament winding is at high potential.**

Because the mercury may be splashed on the tube elements due to shipment or handling, the filament of the 975-A should be operated at rated voltage for approximately 15 minutes without plate voltage in order to distribute the mercury properly when the tube is first placed in service. The above procedure need not be repeated unless the tube is removed from the socket and during handling the mercury becomes splashed on the tube elements.

The condensed mercury temperature should be at least 15° C. before the plate voltage is applied. This may be ordinarily accomplished by introducing a time lag of at least 30 seconds between the application of the filament and the plate voltages. It is advisable, however, to pre-heat the filament for 15 minutes before placing the 975-A in operation. During "standby" periods, the filament should be kept at rated voltage.

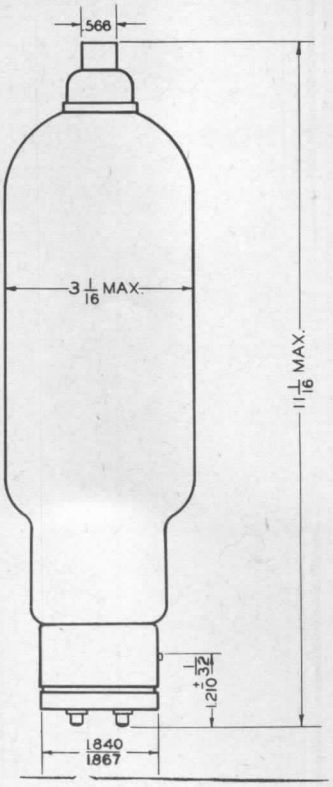
When the 975-A is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

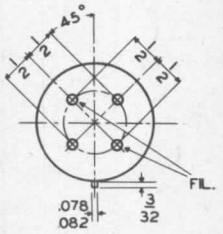
FULLY SHIELDED CONSTRUCTION EFFECTIVELY ISOLATES FILAMENT FROM EXTRANEOUS FIELDS. THE SHIELD MEMBER IS OF SUFFICIENT SIZE NEVERTHELESS TO PERMIT ADEQUATE THERMAL RADIATION FROM THE FILAMENT.

The above and other considerations contribute to longer and more stable life in tubes of this improved design.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United


.568
3 1/16 MAX.
11 1/16 MAX.
1/32
1/32
.1840
.1867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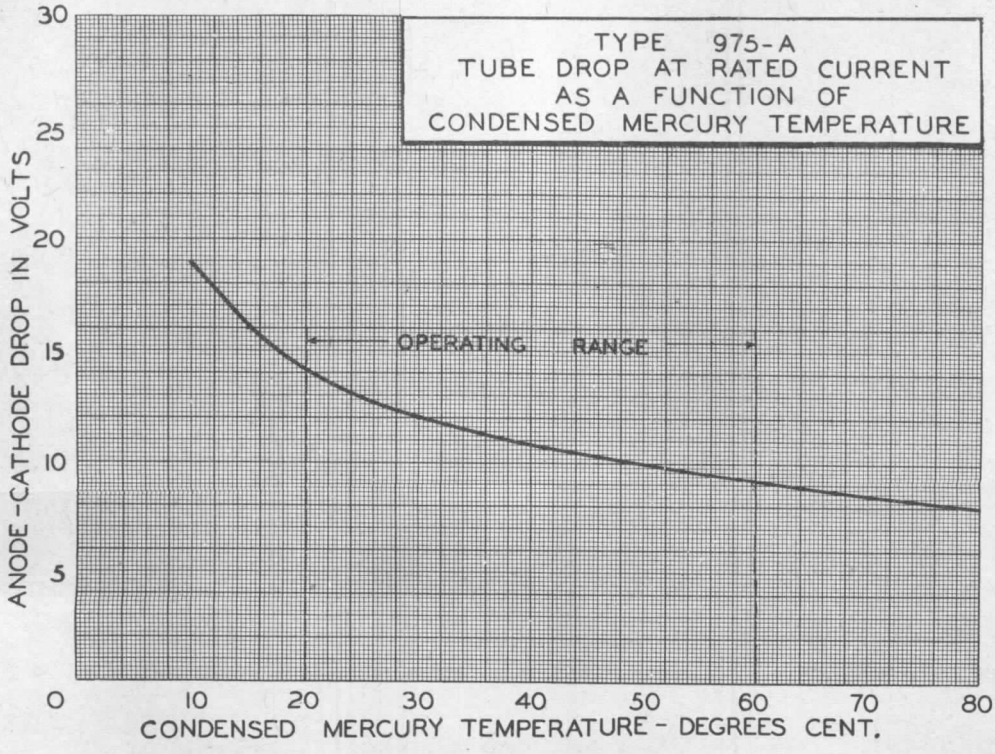
FIL.
.078
.082
3/32


TYPE 975-A
TUBE DROP AT RATED CURRENT
AS A FUNCTION OF
CONDENSED MERCURY TEMPERATURE
ANODE-CATHODE DROP IN VOLTS
30
25
20
15
10
5
0
OPERATING RANGE
10
20
30
40
50
60
70
80
CONDENSED MERCURY TEMPERATURE - DEGREES CENT.

UNITED ELECTRONICS

TYPE 967

MERCURY VAPOR GRID-CONTROLLED RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	3
Filament	Oxide Coated
Voltage	2.5 volts
Current	5.0 amps.
Heating Time	approx. 5 sec.
Single Phase—Half Wave Circuit—1 Tube	
Anode Voltage:	
Maximum Peak Inverse Voltage	2500 volts
Maximum Peak Forward Voltage	2500 volts
Maximum Anode Current:	
Instantaneous per tube	2.0 amp.
Average per tube	.50 amp.
Surge (should not last longer than 1 sec.)	20 amp.
Maximum Time of Average Anode Current	15 sec.
Maximum Grid Current:	
Instantaneous†	.25 amp.
Average	.05 amp.
Single Phase—Full Wave Circuit—2 Tubes	
Anode Voltage:	
Maximum Peak Inverse Voltage per tube	7500 volts
Maximum Peak Forward Voltage per tube	2500 volts
Tube Voltage Drop	10-24 volts

Approximate Starting Characteristics:

D-C Anode Voltage	Grid Voltage
30 volts	0 volts
100 volts	—2.25 volts
1000 volts	—5.0 volts

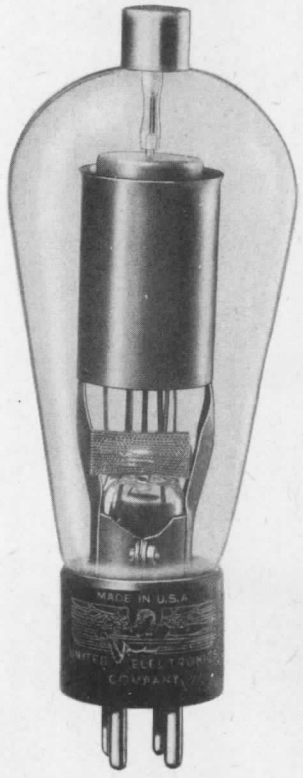
Temperature Limits:	
Condensed Mercury Temperature	40° to 80°C.
Ambient Temperature Range	25° to 65°C.
Deionization Time—approximate	1000 microsec.
Ionization Time	10 microsec.
Dimensions:	
Maximum Length	6 5/8 inches
Diameter	2 7/16 inches
Bulb	S-19
Cap	Medium Metal
Base	Medium 4-pin Bayonet
Type of Cooling	Air

* The filament should be allowed to come up to operating temperature before the plate voltage is applied.

† When operating at a frequency of less than 25 cycles, the maximum instantaneous current is reduced to twice the average current rating.

Return leads from anode and grid circuits should be connected to the center tap of the filament transformer winding when A-C is used on the filament. If D-C is used the return should be made to the negative filament terminal.

The deionization time of this type of tube is too long to allow it to be used with satisfaction for inverter circuits.



This tube is used considerably in industrial control and regulator circuits.

All mercury vapor or gas filled tubes require protective resistances in the grid and anode circuits to limit the current in these circuits to the rated values.

INSTALLATION

The base of the UNITED 967 is designed for mounting in a standard four-prong socket. The tube should be always mounted vertically with ample air space provided for ventilation. The ambient temperature should not be less than 25° C (77° F) and not more than 65° C (149° F) for the maximum peak inverse voltage. When the maximum ambient temperature exceeds these limits, forced ventilation should be used.

The filament of the 967 should be operated on alternating current at the rated value of 2.5 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high interval voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 2.5 volts.

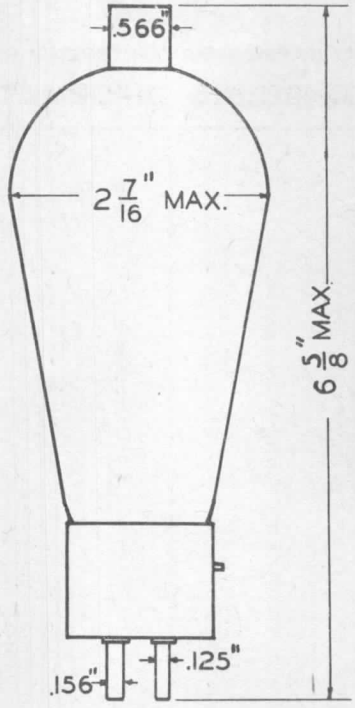
Because the mercury may be splashed on the tube elements due to shipment or handling, the filament of the 967 should be operated at rated voltage for approximately 3 minutes without plate voltage in order to distribute the mercury properly when the tube is first placed in service. The above procedure need not be repeated unless the tube is removed from the socket and during handling the mercury becomes splashed on the tube elements.

The condensed mercury temperature should be at least 25° C before the plate voltage is applied. This may be ordinarily accomplished by introducing a time lag of at least 30 seconds between the application of the filament and the plate voltages. In event that arc-back should occur when the plate voltage is applied, the pre-heating time of the filament should be increased.

When the 967 is subjected during operation to external high voltage or high frequency fields, shielding and R-F filter circuit should be provided.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United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6 5/8" MAX.
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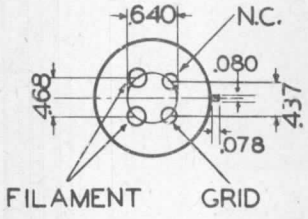
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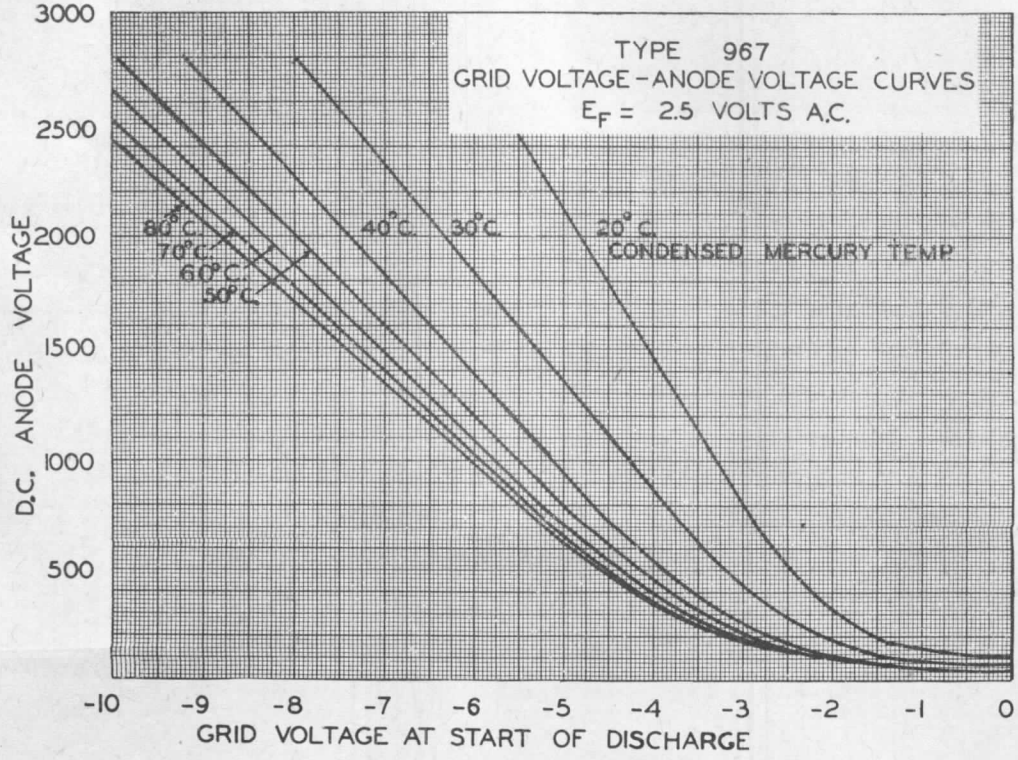
N.C.
.080
.468
.437
.078
FILAMENT
GRID


TYPE 967
GRID VOLTAGE-ANODE VOLTAGE CURVES
E_F = 2.5 VOLTS A.C.
80°C.
70°C.
60°C.
50°C.
40°C.
30°C.
20°C.
CONDENSED MERCURY TEMP.
D.C. ANODE VOLTAGE
3000
2500
2000
1500
1000
500
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
0
GRID VOLTAGE AT START OF DISCHARGE

UNITED ELECTRONICS

TYPE UX-973

MERCURY VAPOR GRID-CONTROLLED RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes 3

Filament ..... Oxide Coated
Voltage ..... 5.0 volts
Current ..... 6.75 amps.
Heating Time* ..... 45 sec.

Single Phase—Half Wave Circuit—1 Tube

Anode Voltage:
Maximum Peak Inverse Voltage ..... 3000 volts
Maximum Peak Forward Voltage ..... 3000 volts

Maximum Anode Current:
Instantaneous ..... 10.0 amp.
Average ..... 2.5 amp.
Surge (should not last longer than 1 sec.) ..... 90.0 amp.

Maximum Time of Averaging Anode Current ..... 15 sec.

Maximum Grid Current:
Instantaneous† ..... 1.0 amp.
Average ..... .25 amp.

Tube Voltage Drop ..... 10-15 volts

Approximate Starting Characteristics at Cond. Mercury Temp. of 50° C.

D. C. Anode Voltage	Grid Voltage
70	0
100	—3
1000	—5.5

Temperature Limits:
Condensed Mercury Temperature ..... 40° to 80° C.
Deionization Time—approximate ..... 1000 microsec

Ionization Time ..... 10 microsec

MOTOR CONTROL, WELDING, AND GENERAL INDUSTRIAL USE

Anode Voltage:
Maximum Peak Inverse Voltage ..... 1000 volts
Maximum Peak Forward Voltage ..... 1000 volts

Maximum Anode Current:
Instantaneous ..... 10.0 amp.
Average ..... 3.0 amp.
Surge (Should not last longer than 1 sec.) ..... 90.0 amp.

Dimensions:
Maximum Length ..... 9 1/8 inches
Diameter ..... 2 5/16 inches

Bulb T-18

Cap ..... Medium Metal

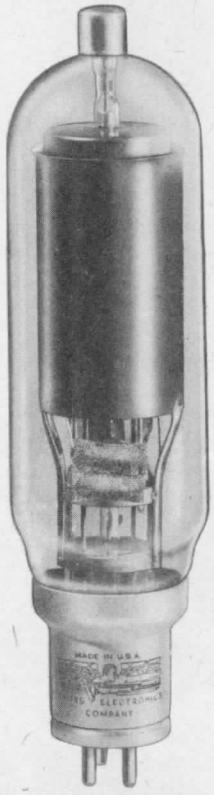
Type of Cooling ..... Air

Base ..... Medium 4-Pin

* The filament should be allowed to come up to operating temperature before the plate voltage is applied.

† When operating at a frequency of less than 25 cycles, the maximum instantaneous current is reduced to twice the average current rating.

Return leads from anode and grid circuits should be connected to the center tap of the filament transformer winding when A-C is used on the filament. If D-C is used the return should be made to the negative filament terminal.



Type UX-973 has attained great favor in motor control, welding, and general industrial applications.

All mercury vapor or gas filled tubes require protective resistances in the grid and anode circuits to limit the current in these circuits to the rated values.

INSTALLATION

The base of the UNITED UX-973 is designed for mounting in a standard 4-Pin Jumbo socket. The tube should always be mounted vertically with ample air space provided for ventilation. The ambient temperature should not be less than 25° C (77° F) and not more than 65° C (149° F) for the maximum peak inverse voltage. When the maximum ambient temperature exceeds these limits, forced ventilation should be used.

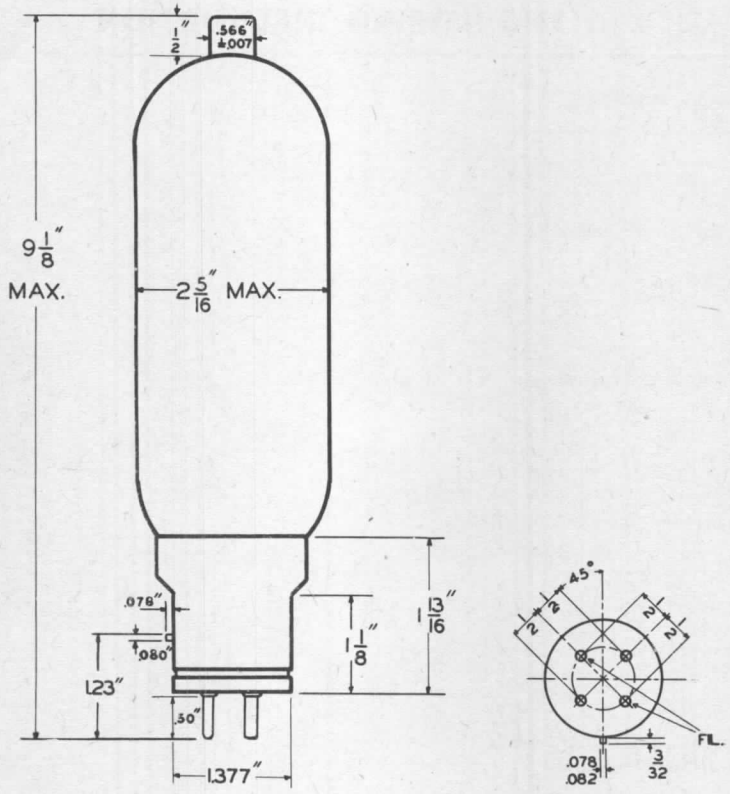
The filament of the UX-973 should be operated on alternating current at the rated value of 5.0 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 5.0 volts.

Because the mercury may be splashed on the tube elements due to shipment or handling, the filament of the UX-973 should be operated at rated voltage for approximately 3 minutes without plate voltage in order to distribute the mercury properly when the tube is first placed in service. The above procedure need not be repeated unless the tube is removed from the socket and during handling the mercury becomes splashed on the tube elements.

The condensed mercury temperature should be at least 25° C before the plate voltage is applied. This may be ordinarily accomplished by introducing a time lag of at least 45 seconds between the application of the filament and the plate voltages. In event that arc-back should occur when the plate voltage is applied, the pre-heating time of the filament should be increased.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United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1/2"
9 1/8" MAX.
2 5/16" MAX.
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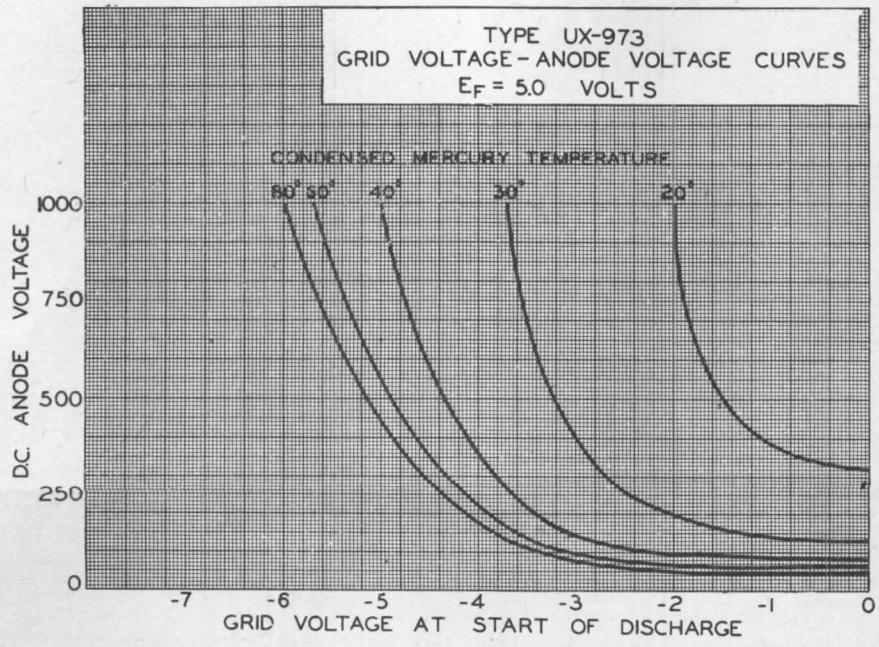

TYPE UX-973
GRID VOLTAGE - ANODE VOLTAGE CURVES
E_F = 5.0 VOLTS
CONDENSED MERCURY TEMPERATURE
80° 50° 40° 30° 20°
D.C. ANODE VOLTAGE
1000
750
500
250
0
-7 -6 -5 -4 -3 -2 -1 0
GRID VOLTAGE AT START OF DISCHARGE

UNITED ELECTRONICS

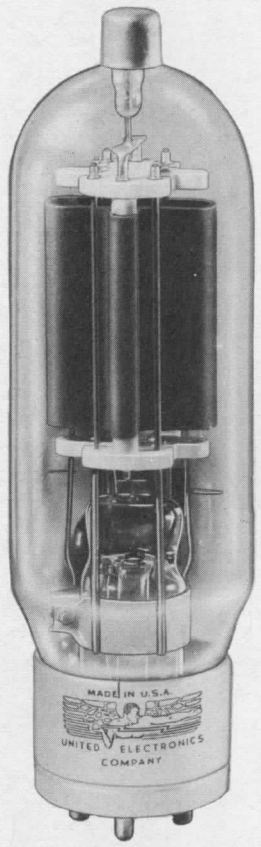
TYPE 217-C

HALF-WAVE HIGH-VACUUM RECTIFIER

ENGINEERING INFORMATION

GENERAL RATINGS

Number of Electrodes	2
Filament Voltage	10.0 volts
Current	3.25 amperes
Type	Thoriated Tungsten
Operating Conditions:	
Maximum Peak Inverse Voltage	7500 volts
Maximum Peak Plate Current	600 ma.
Average Plate Current	150 ma.
Maximum Overall Dimensions:	
Length	8 1/2 inches
Diameter	2 5/16 inches
Bulb	T-18
Cap	Medium Metal
Base	Jumbo 4-Large Pin
Type of Cooling	Air
Net Weight	7 oz.



UNITED TYPE 217-C

This tube is particularly adapted to use in high voltage circuits where the operating conditions preclude the use of gas-filled or mercury vapor tubes.

INSTALLATION

The base of the UNITED 217-C is designed for mounting in a standard "50-Watt" socket of the four-pin, bayonet type. The tube should always be mounted vertically with ample air space provided for ventilation.

The filament of the 217-C should be operated on alternating current at the rated value of 5.0 volts. The socket should make good contact to the tube pins and adequate current-carrying capacity leads to the secondary winding of the power transformer should be used. Operation of the filament at less than the rated voltage may result in a high internal voltage drop with subsequent loss of emission. A filament voltmeter should be connected permanently across the filament circuit at the socket terminals in order that the filament voltage can be maintained at 10.0 volts. **Caution — The filament winding is at high potential.**

Connection to the anode terminal cap should be made by means of spring clips attached to flexible leads which must not touch the glass bulb. If vibration will be encountered in the applications, shock absorbing mounting details should be employed. Overload protection should be provided so that the voltage is removed if the current through the tube exceeds 150 per cent of the rated value.

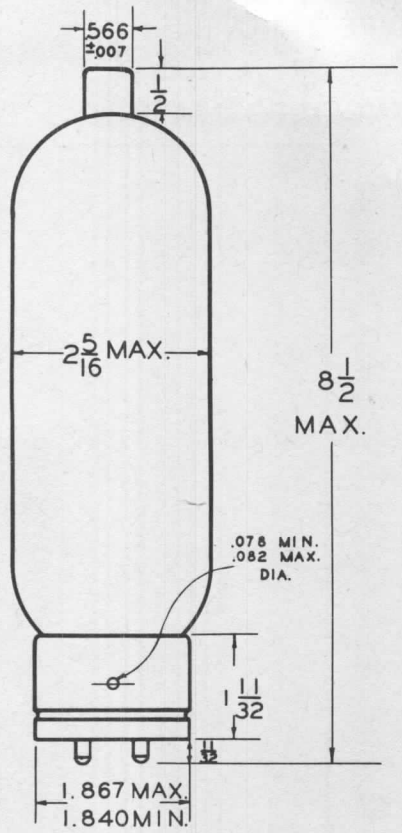
When the 217-C is subjected during operation to external high voltage or high frequency fields, shielding and r-f filter circuits should be provided.

DESIGN AND CHARACTERISTIC FEATURES

The UNITED type 217-C is a tube of exceptional physical ruggedness. This design not only takes into account important electrical and thermal considerations, but end use conditions involving vibration and shock such as encountered in industrial electronic equipment.

All ratings given are for continuous service. Higher ratings are permissible for intermittent operation. Additional data will be furnished upon request.

United


.566 ±.007
1/2
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8 1/2 MAX.
.078 MIN.
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1 11/32
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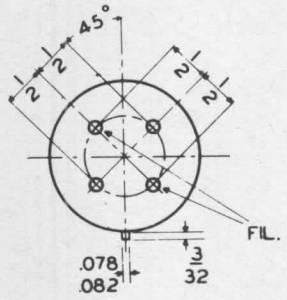
1.867 MAX.
1.840 MIN.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FIL.
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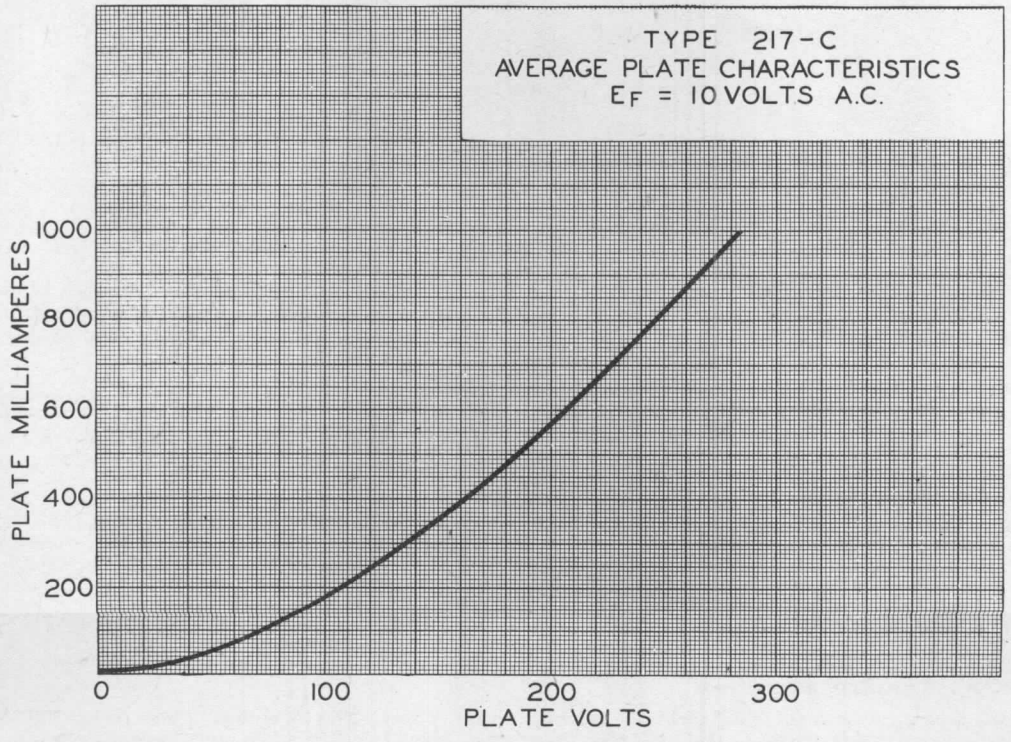
TYPE 217-C
AVERAGE PLATE CHARACTERISTICS
EF = 10 VOLTS A.C.
PLATE MILLIAMPERES
1000
800
600
400
200
0
100
200
300
PLATE VOLTS