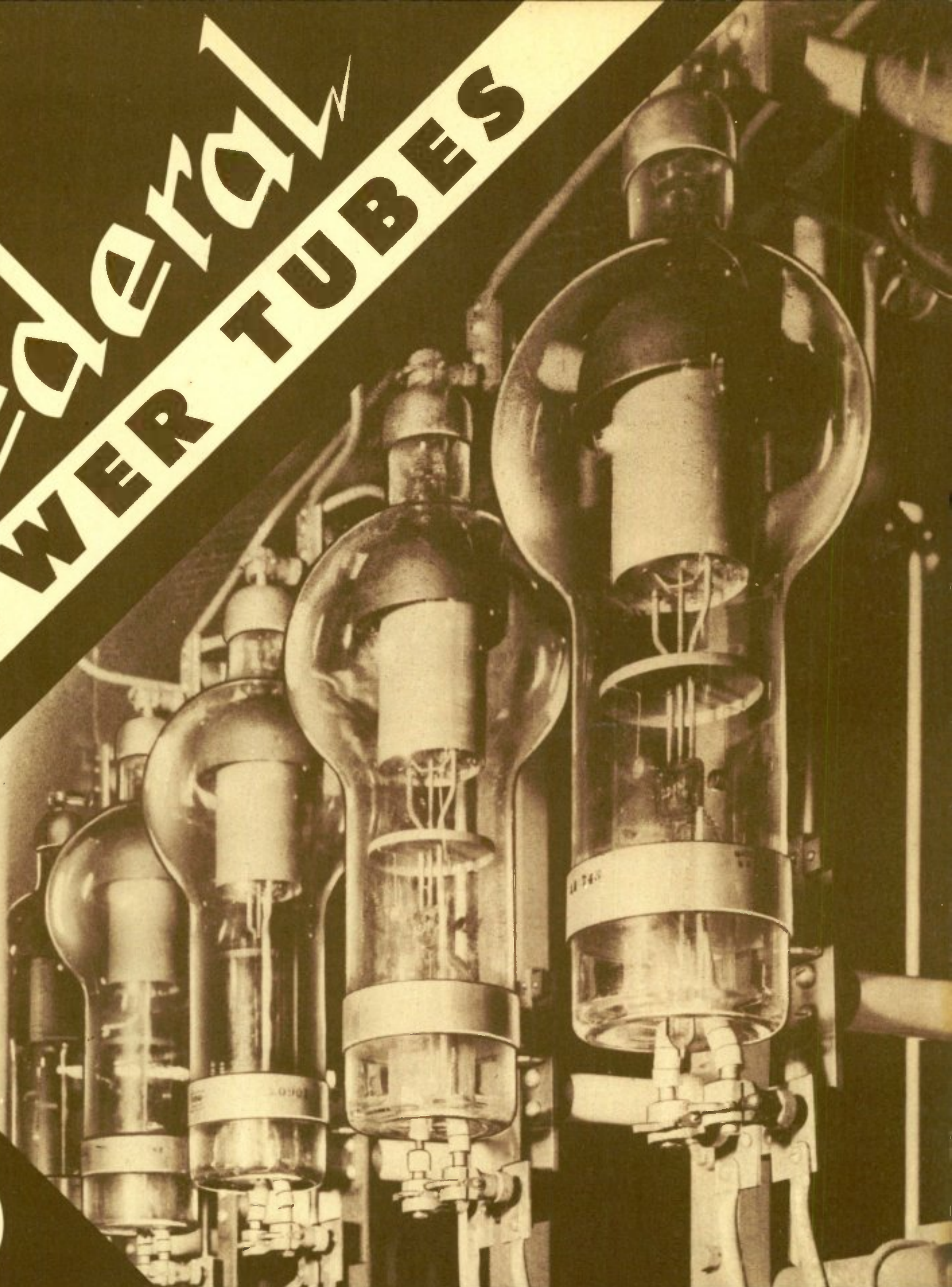
Federal POWER TUBES



FEDERAL FTR TELEPHONE & RADIO

Federal Telephone and Radio Corporation

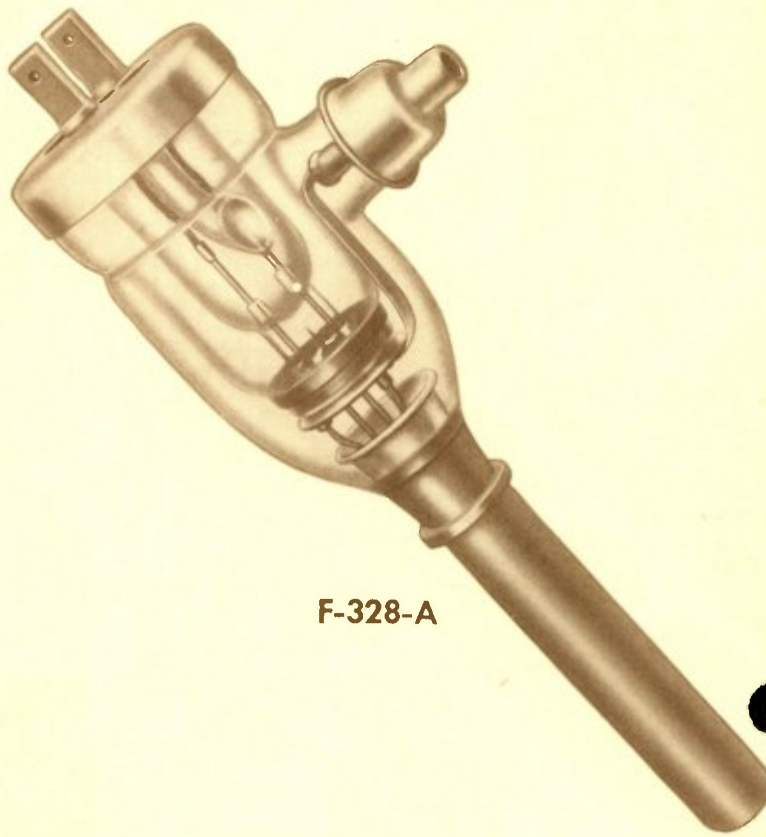
591 BROAD STREET, NEWARK 2, NEW JERSEY, U. S. A.

An IT&T ASSOCIATE

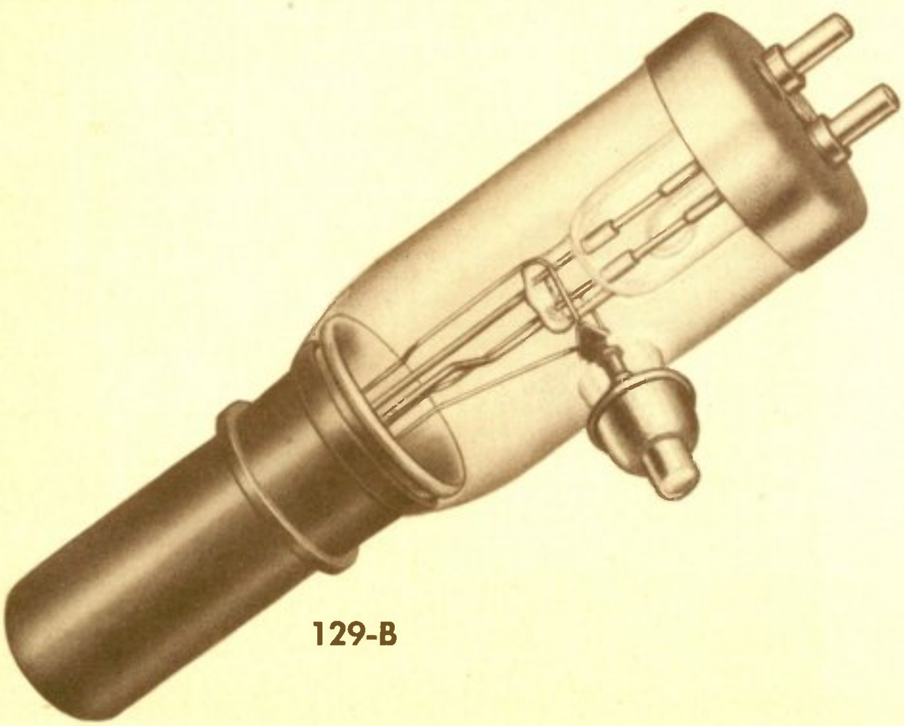
WATER COOLED — 5 KW PLATE DISSIPATION

TYPE	F-328-A	F-328-B	129-B
DESCRIPTION	GENERAL PURPOSE	GENERAL PURPOSE	HIGH FREQ. R.F. AMPLIFIER
MAX. PLATE DISSIPATION	5 KW	5 KW	5 KW
MAX. PLATE INPUT	10 KW	10 KW	18 KW
MAX. D.C. PLATE VOLTAGE	8000 V	8000 V	12,000 V
MAX. D.C. PLATE CURRENT	1.5 A	1.5 A	2.0 A
MAX. FREQUENCY FOR MAX. RATINGS	3 MC	3 MC	50 MC
AMPLIFICATION FACTOR (MU)	16	16	26
FILAMENT VOLTAGE	21.5 V	21.5 V	18 V
DIMENSION A	17 11/16"	17 5/16"	13 5/8"
DIMENSION B	7 1/16"	7 1/16"	4 15/16"
DIMENSION C	7 3/16"	7 3/16"	4"
DIMENSION D	1.480"	1.480"	2.022"
DIMENSION E	6"	6"	4 5/16"

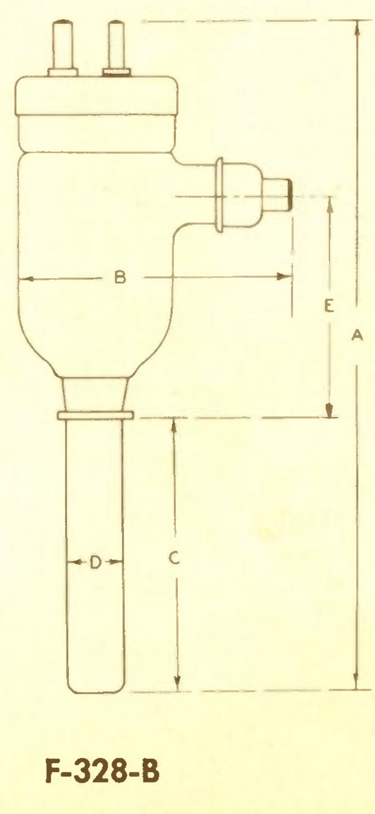
RATINGS FOR CLASS C TELEGRAPH OPERATION



F-328-A



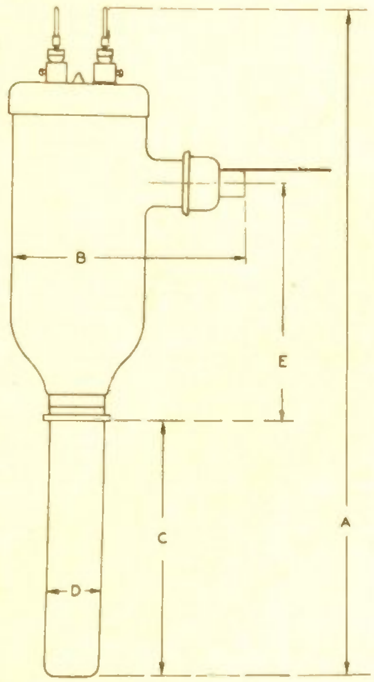
129-B



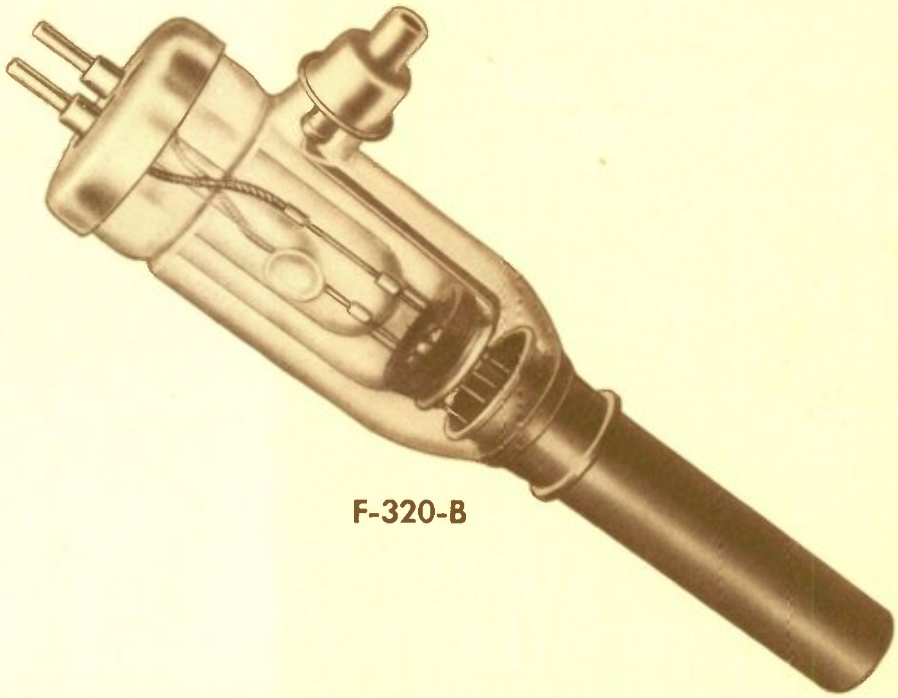
F-328-B

TRANSMITTING — INDUSTRIAL TUBES

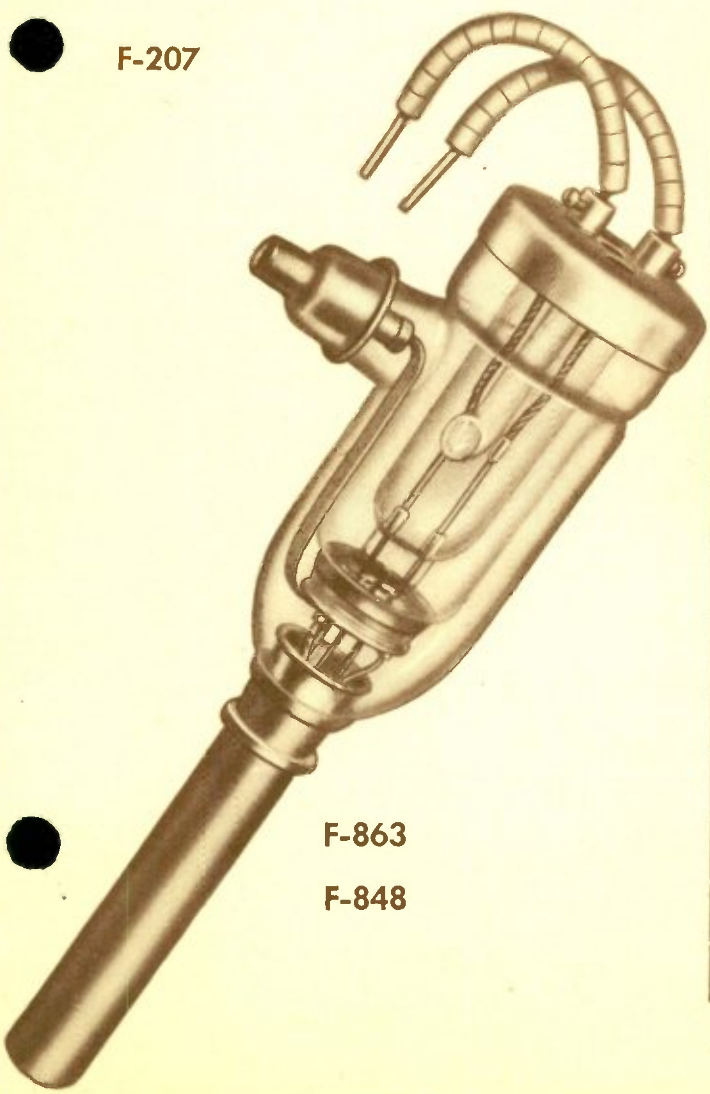
WATER COOLED 6 AND 10 KW PLATE DISSIPATION



F-207



F-320-B



F-863

F-848

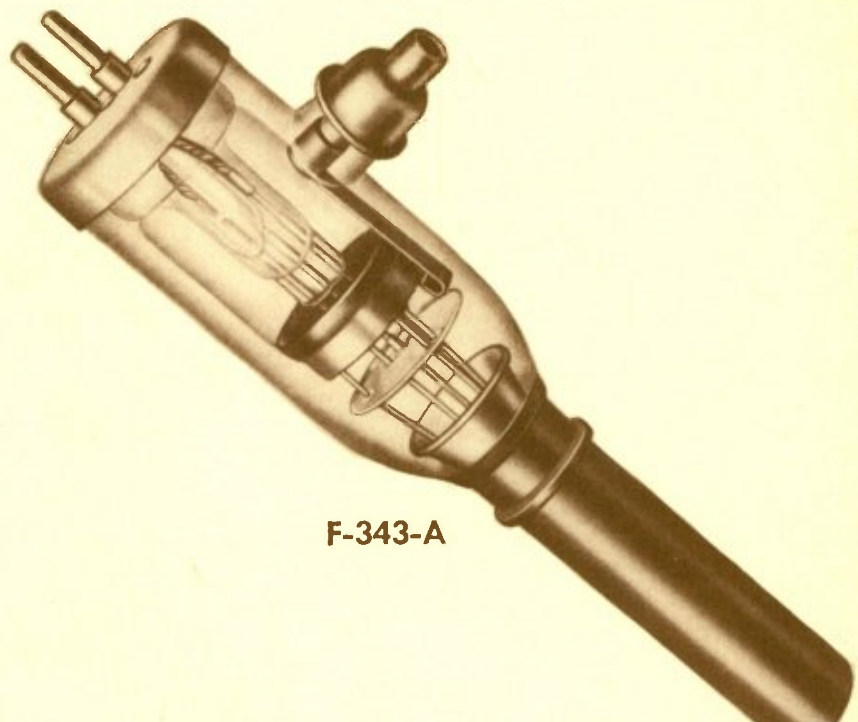
TYPE	F-207	F-848	F-863	F-320-B
DESCRIPTION	GENERAL PURPOSE	MODULATOR OR R.F. AMPLIFIER	R.F. AMPLIFIER OR CLASS B MODULATOR	GENERAL PURPOSE
MAX. PLATE DISSIPATION	10 KW	6 KW	10 KW	10 KW
MAX. PLATE INPUT	30 KW	18 KW	30 KW	22.5 KW
MAX. D.C. PLATE VOLTAGE	15,000 V	12,000 V	15,000 V	15,000 V
MAX. D.C. PLATE CURRENT	2.0 A	2.0 A	2.0 A	1.5 A
MAX. FREQUENCY FOR MAX. RATINGS	1.5 MC	1.6 MC	1.5 MC	4.0 MC
AMPLIFICATION FACTOR (MU)	20	8	50	40
FILAMENT VOLTAGE	22 V	22 V	22 V	21.5 V
DIMENSION A	27 5/16"	27 5/16"	27 5/16"	20"
DIMENSION B	7 1/16"	7 9/16"	7 9/16"	7 1/16"
DIMENSION C	8 1/16"	8 1/16"	8 1/16"	7 7/32"
DIMENSION D	1.580"	1.580"	1.580"	2.022"
DIMENSION E	7 9/16"	7 9/16"	7 9/16"	7 17/32"

RATINGS FOR CLASS C TELEGRAPH OPERATION

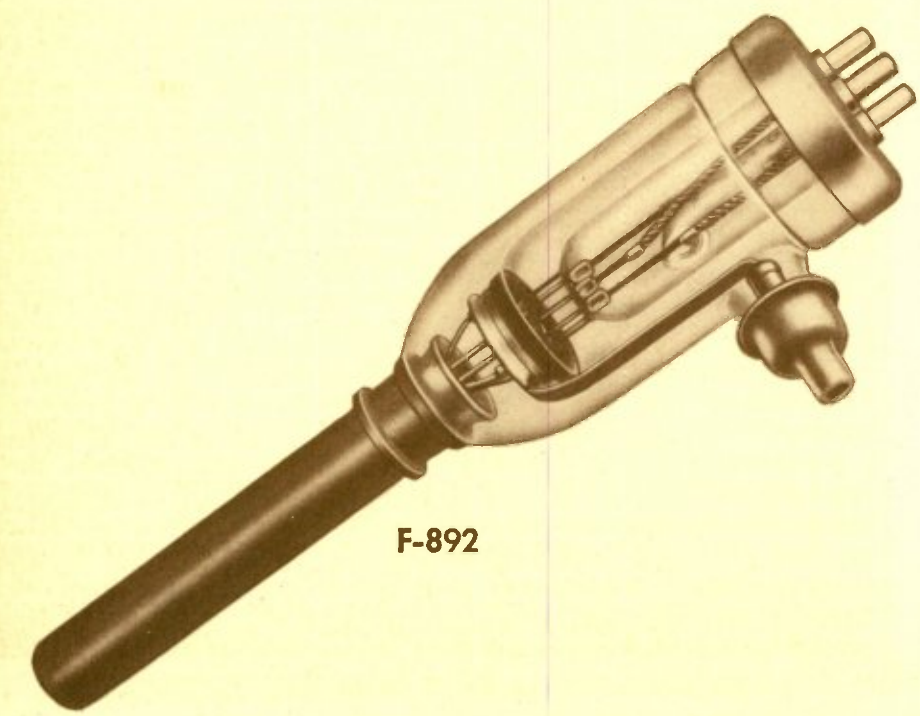
WATER COOLED 6 AND 10 KW PLATE DISSIPATION

TYPE	F-343-A	F-891	F-892
DESCRIPTION	GENERAL PURPOSE	MODULATOR OR R.F. AMPLIFIER	R.F. AMPLIFIER OR CLASS B MODULATOR
MAX. PLATE DISSIPATION	10 KW	6 KW	10 KW
MAX. PLATE INPUT	25 KW	18 KW	30 KW
MAX. D.C. PLATE VOLTAGE	15,000 V	12,000 V	15,000 V
MAX. D.C. PLATE CURRENT	2.0 A	2.0 A	2.0 A
MAX. FREQUENCY FOR MAX. RATINGS	4.0 MC	1.6 MC	1.5 MC
AMPLIFICATION FACTOR (MU)	40	8	50
FILAMENT VOLTAGE	21.5 V	11/22 V	11/22 V
DIMENSION A	20 7/32"	19 7/8"	19 7/8"
DIMENSION B	7 1/16"	7 1/16"	7 1/16"
DIMENSION C	7 7/32"	8 1/16"	8 1/16"
DIMENSION D	2.022"	1.580"	1.580"
DIMENSION E	7 3/8"	7 9/16"	7 9/16"

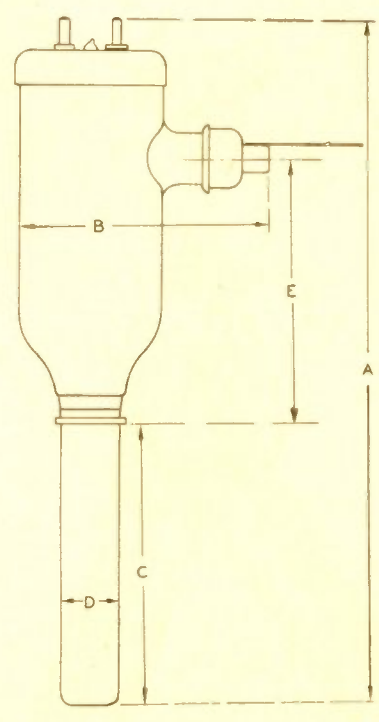
RATINGS FOR CLASS C TELEGRAPH OPERATION



F-343-A

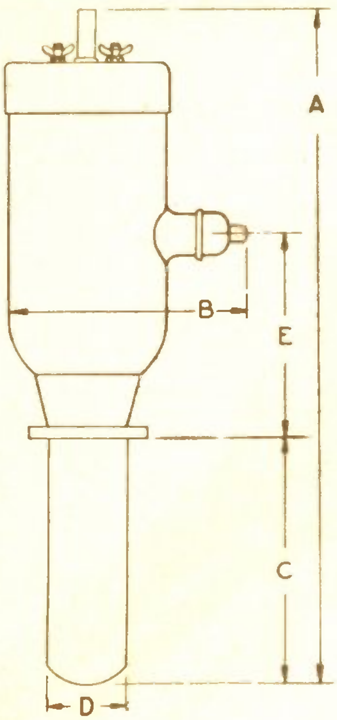


F-892

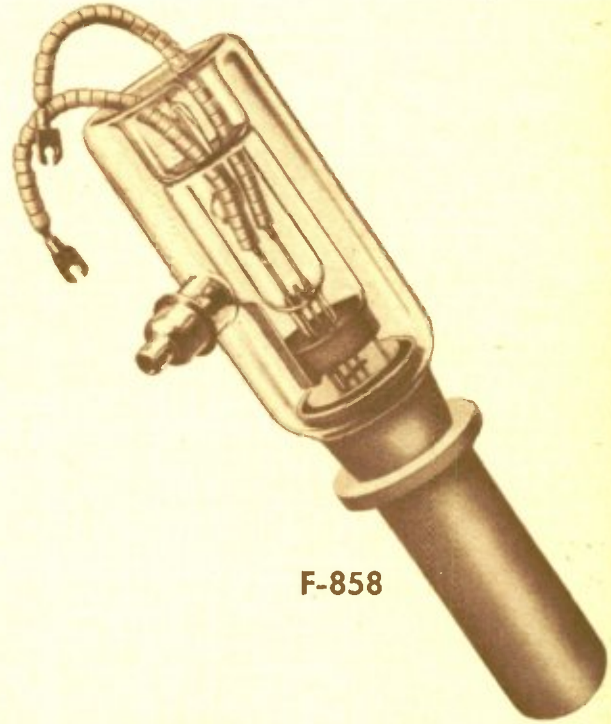


F-891

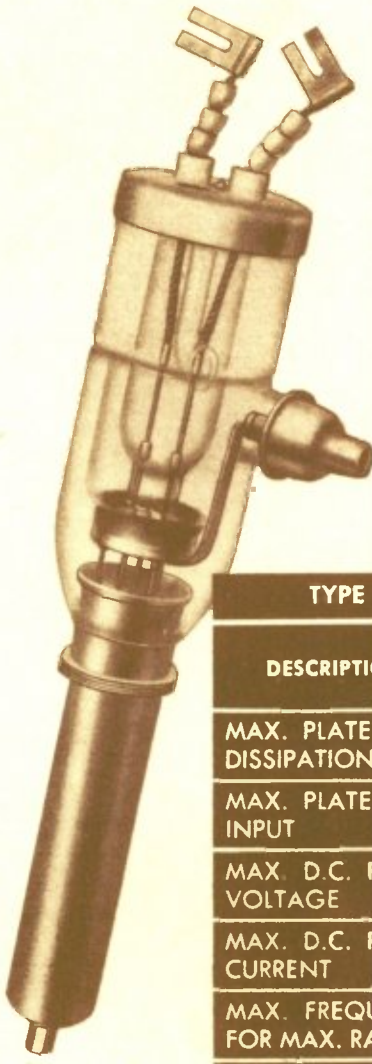
WATER COOLED 20 AND 25 KW PLATE DISSIPATION



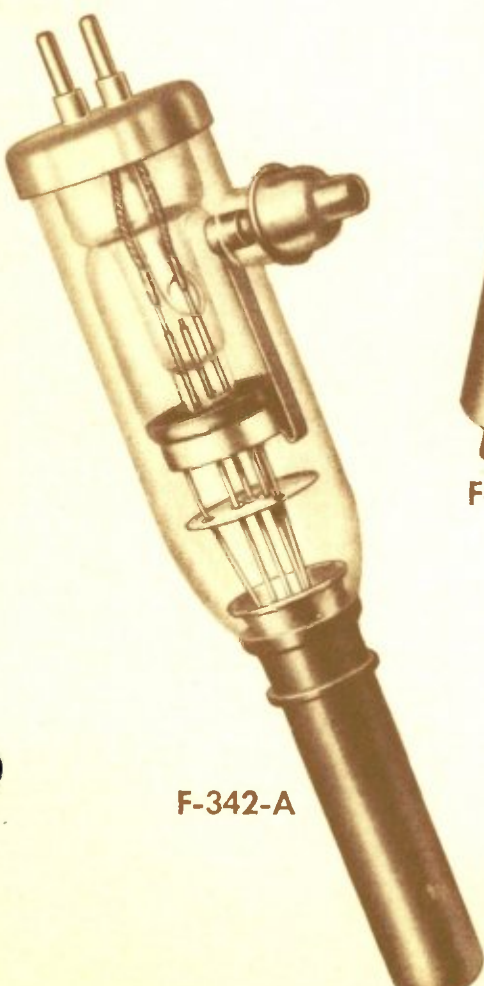
F-893



F-858



F-110-X



F-342-A

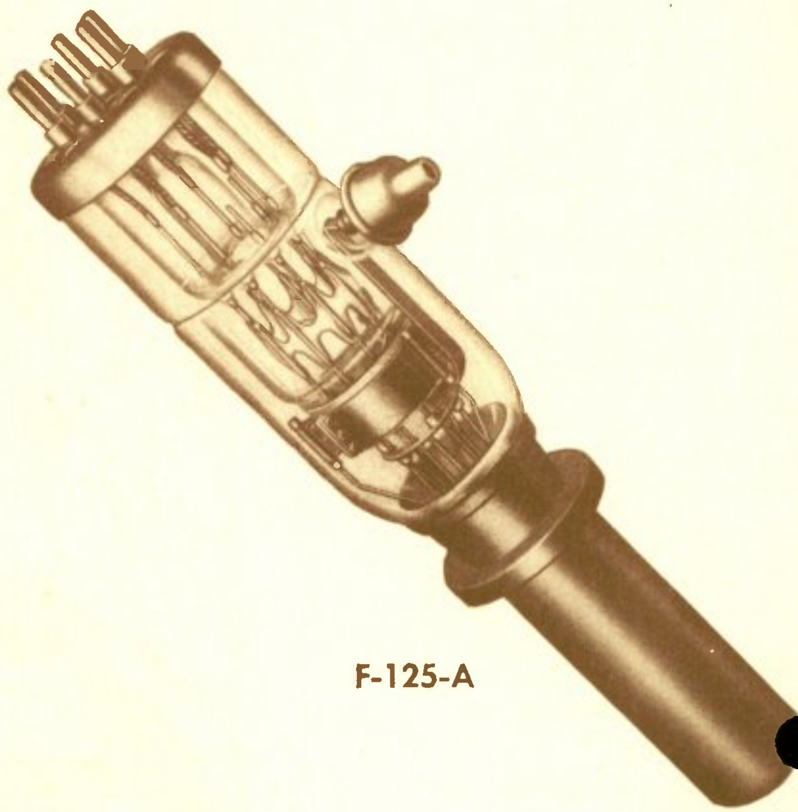
TYPE	F-893	F-858	F-342-A	F-110-X
DESCRIPTION	GENERAL PURPOSE	OSCILLATOR OR R.F. AMPLIFIER	GENERAL PURPOSE	R.F. AMPLIFIER & OSCILLATOR
MAX. PLATE DISSIPATION	20 KW	20 KW	25 KW	25 KW
MAX. PLATE INPUT	70 KW	40 KW	50 KW	50 KW
MAX. D.C. PLATE VOLTAGE	20,000 V	20,000 V	20,000 V	20,000 V
MAX. D.C. PLATE CURRENT	4.0 A	2.0 A	3.0 A	2.5 A
MAX. FREQUENCY FOR MAX. RATINGS	5 MC	1.5 MC	4.0 MC	3 MC
AMPLIFICATION FACTOR (MU)	36	42	40	40
FILAMENT VOLTAGE	10 V per strand	22 V	20 V	28 V
DIMENSION A	25 5/8″	24 1/2″	21 9/32″	23″
DIMENSION B	9 1/16″	8 1/4″	7 3/16″	7 1/16″
DIMENSION C	9 1/4″	9 1/4″	7 7/32″	8 3/4″
DIMENSION D	3 3/16″	3 3/16″	2.022″	2.000″
DIMENSION E	7 3/4″	7 7/8″	9 9/16″	6 1/4″

RATINGS FOR CLASS C TELEGRAPH OPERATION

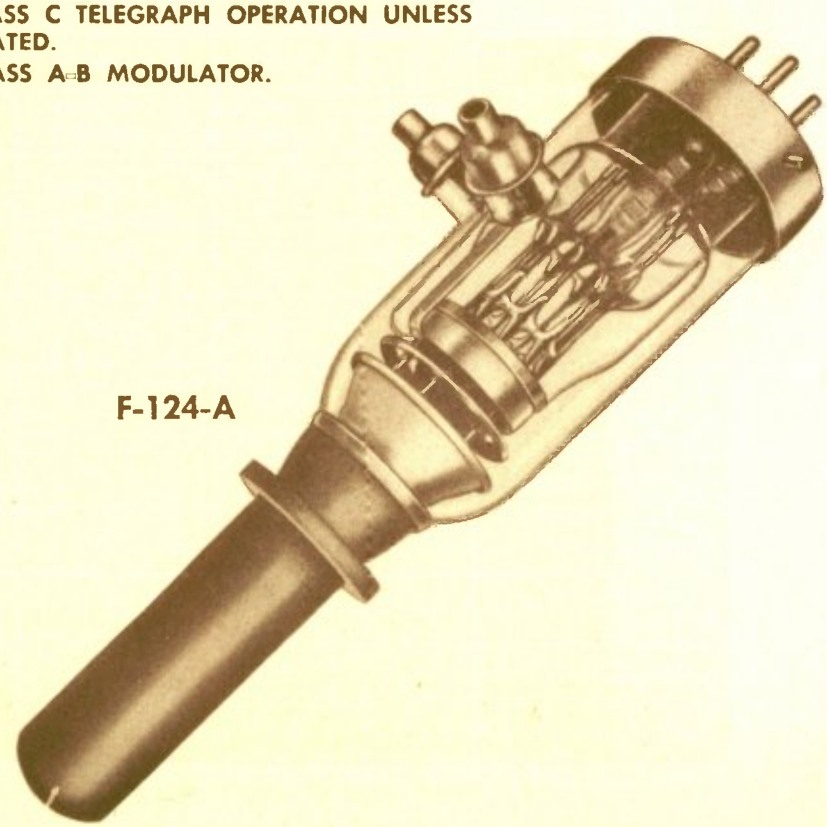
WATER COOLED 40 AND 100 KW PLATE DISSIPATION

TYPE	F-124-A	F-125-A*	F-862
DESCRIPTION	GENERAL PURPOSE	AUDIO AMPLIFIER	R.F. AMPLIFIER OR CLASS B MODULATOR
MAX. PLATE DISSIPATION	40 KW	40 KW	100 KW
MAX. PLATE INPUT	135 KW	100 KW	200 KW
MAX. D.C. PLATE VOLTAGE	20,000 V	15,000 V	20,000 V
MAX. D.C. PLATE CURRENT	7.0 A	10.0 A	10.0 A
MAX. FREQUENCY FOR MAX. RATINGS	20 MC		1.6 MC
AMPLIFICATION FACTOR (MU)	42	4.75	48
FILAMENT VOLTAGE	13.6 V per strand	13.6 V per strand	33 V
DIMENSION A	25 11/16"	25 11/16"	60 3/8"
DIMENSION B	8 7/8"	8 7/8"	10"
DIMENSION C	9 1/4"	9 1/4"	37 1/4"
DIMENSION D	3 1/4"	3 1/4"	4 3/16"
DIMENSION E	7 3/4"	7 3/4"	13"

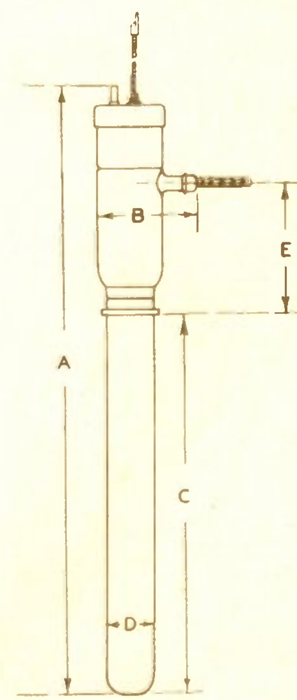
RATINGS FOR CLASS C TELEGRAPH OPERATION UNLESS OTHERWISE STATED.
*RATINGS FOR CLASS A-B MODULATOR.



F-125-A

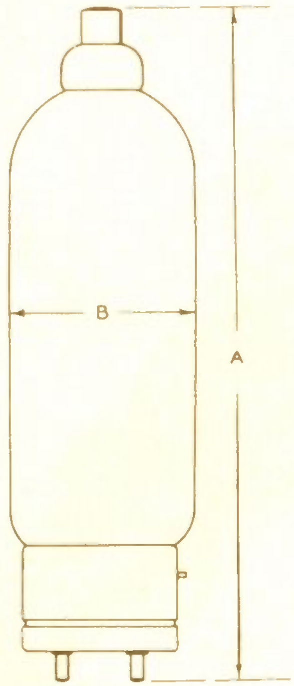


F-124-A

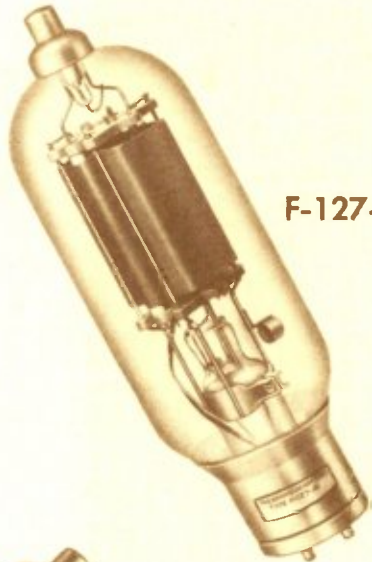


F-862

AIR COOLED 125 TO 400 W. PLATE DISSIPATION

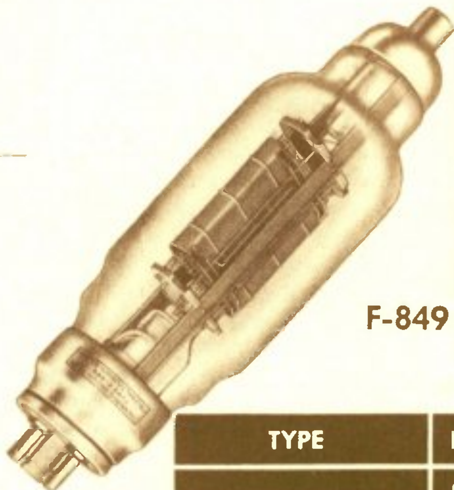


F-123-A

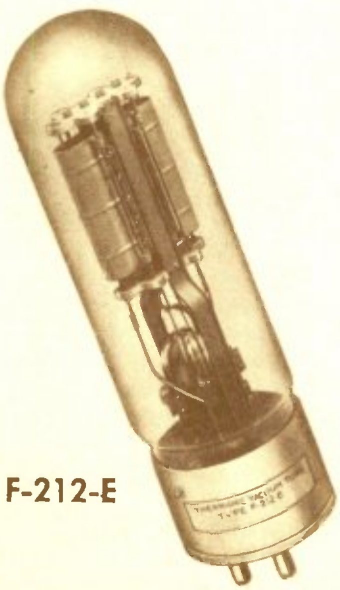


F-127-A

F-204-A



F-849



F-212-E

TYPE	F-123-A	F-127-A	F-204-A	F-212-E	F-849
DESCRIPTION	GENERAL PURPOSE	GENERAL PURPOSE	GENERAL PURPOSE	GENERAL PURPOSE	GENERAL PURPOSE
MAX. PLATE DISSIPATION	125 W	200 W	250 W	275 W	400 W
MAX. PLATE INPUT	375 W	950 W	690 W	700 W	875 W
MAX. D.C. PLATE VOLTAGE	2000 V	3000 V	2500 V	2000 V	2500 V
MAX. D.C. PLATE CURRENT	.250 A	.325 A	.275 A	.350 A	.350 A
MAX. FREQUENCY FOR MAX. RATINGS	30 MC	30 MC	3 MC	4.5 MC	3.0 MC
AMPLIFICATION FACTOR (MU)	14.5	38	23	16	19
FILAMENT VOLTAGE	10 V	10 V	11 V	14 V	11 V
DIMENSION A	8 1/2"	9 5/8"	14 1/4"	13 5/8"	14 1/4"
DIMENSION B	2 5/16"	3 1/32"	4 1/16"	3.421"	4 1/16"

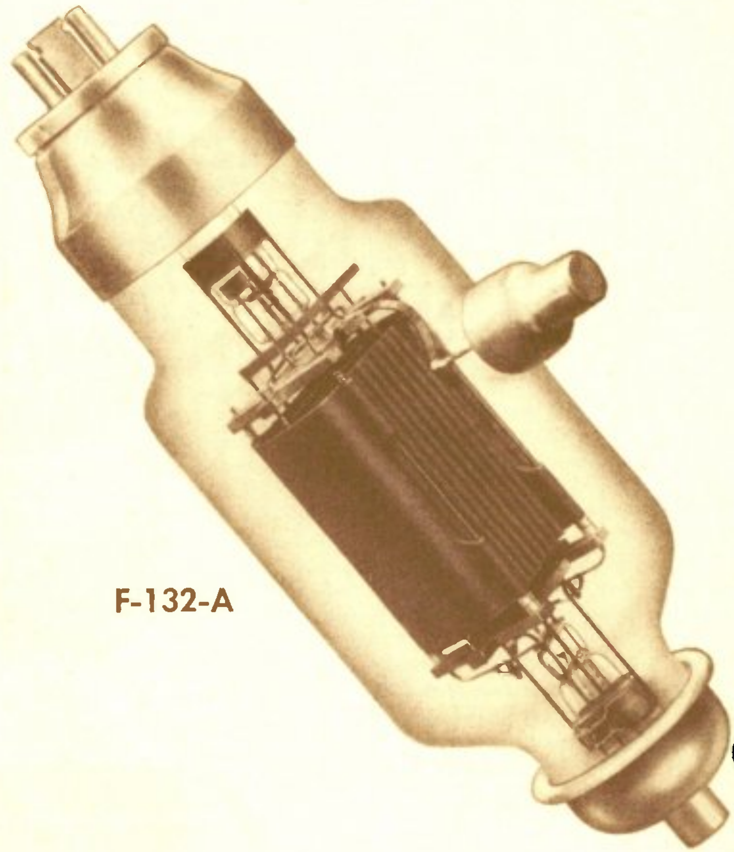
RATINGS FOR CLASS C TELEGRAPH OPERATION

AIR COOLED 450 TO 700 W. PLATE DISSIPATION

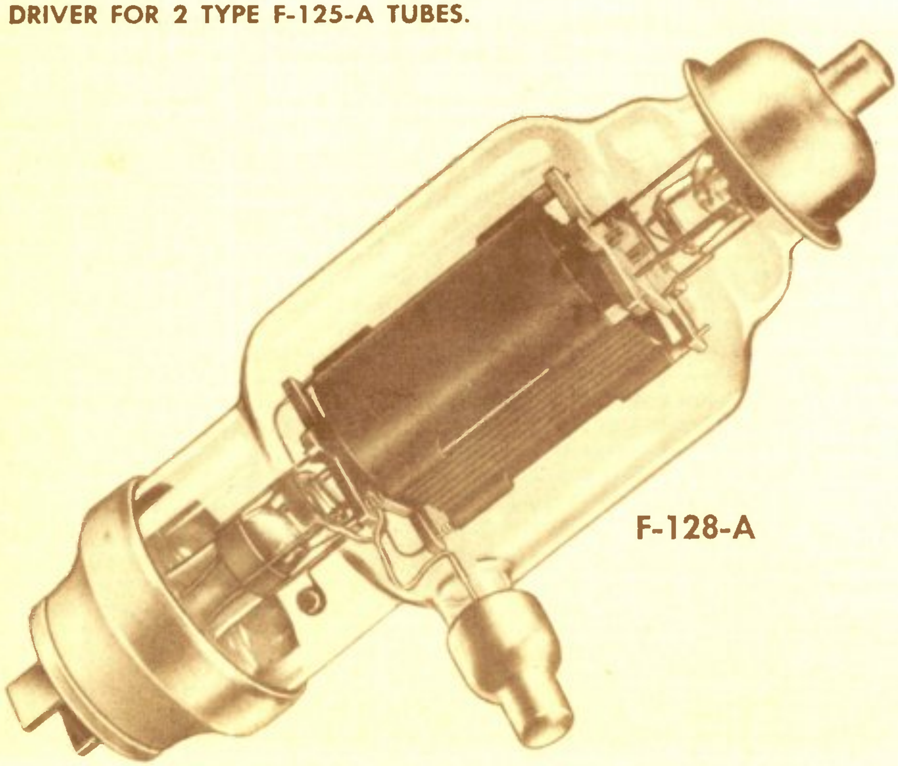
TYPE	F-450 TH	F-128-A	F-132-A*
DESCRIPTION	GENERAL PURPOSE	OSCILLATOR OR R. F. AMPLIFIER	AUDIO AMPLIFIER
MAX. PLATE DISSIPATION	450 W	700 W	600 W
MAX. PLATE INPUT	2500 W	3000 W	
MAX. D.C. PLATE VOLTAGE	6000 V	3500 V	3500 V
MAX. D.C. PLATE CURRENT	.500 A	1.0 A	
MAX. FREQUENCY FOR MAX. RATINGS	40 MC	30 MC	
AMPLIFICATION FACTOR (MU)	38	36	10
FILAMENT VOLTAGE	7.5 V	11 V	11 V
DIMENSION A	12 7/8"	15 1/2"	15 1/2"
DIMENSION B	5 1/32"		
DIMENSION C	5 1/16"	6 1/2"	9"
DIMENSION D	—	8"	8"

RATINGS FOR CLASS C TELEGRAPH OPERATION UNLESS OTHERWISE STATED

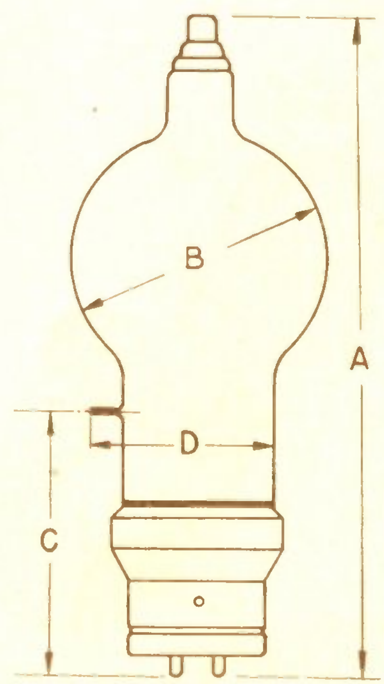
*MAXIMUM RATINGS FOR USE AS PUSH PULL CLASS A DRIVER FOR 2 TYPE F-125-A TUBES.



F-132-A



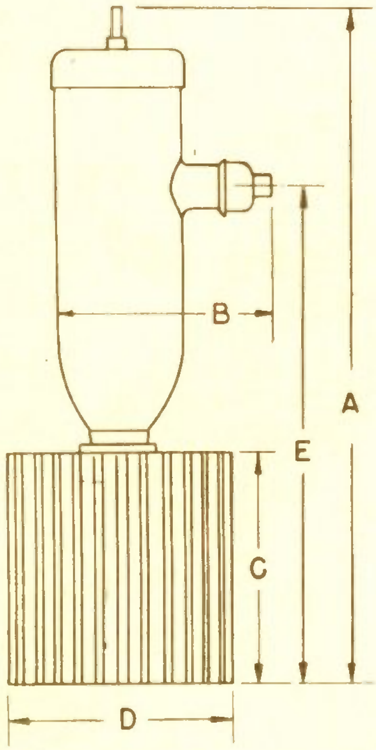
F-128-A



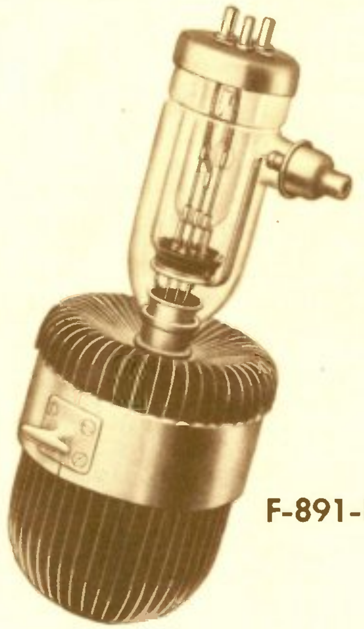
F-450 TH

TRANSMITTING — INDUSTRIAL TUBES

AIR COOLED 4 TO 10 KW PLATE DISSIPATION



F-343-R



F-891-R

F-129-R

F-892-R

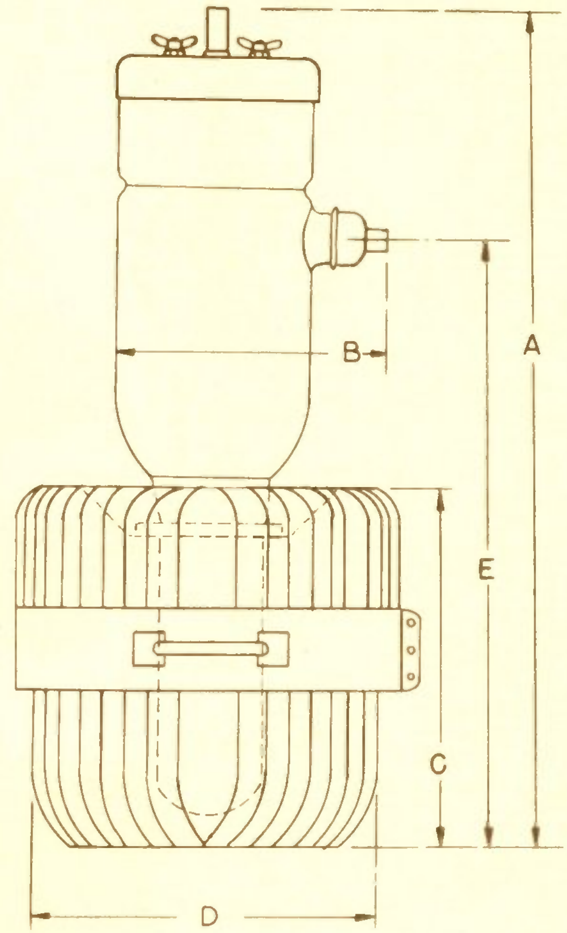
TYPE	F-129-R	F-891-R	F-892-R	F-343-R	F-342-R
DESCRIPTION	HIGH FREQUENCY R. F. AMPLIFIER	MODULATOR OR R. F. AMPLIFIER	R. F. AMPLIFIER OR CLASS B MODULATOR	GENERAL PURPOSE	GENERAL PURPOSE
MAX. PLATE DISSIPATION	5 KW	4 KW	4 KW	10 KW	10 KW
MAX. PLATE INPUT	18 KW	15 KW	18 KW	25 KW	50 KW
MAX. D.C. PLATE VOLTAGE	12,000 V	10,000 V	10,000 V	15,000 V	20,000 V
MAX. D.C. PLATE CURRENT	2.0 A	2.0 A	2.0 A	2.0 A	3.0 A
MAX. FREQUENCY FOR MAX. RATINGS	50 MC	1.6 MC	1.5 MC	4.0 MC	4.0 MC
AMPLIFICATION FACTOR (MU)	26	8	50	40	40
FILAMENT VOLTAGE	18 V	11/22 V	11/22 V	21.5 V	20 V
DIMENSION A	14 1/8″	21 1/16″	21 1/16″	20 15/32″	21 17/32″
DIMENSION B	4 15/16″	7 1/16″	7 1/16″	7″	7″
DIMENSION C	5 1/2″	10″	10″	7 15/32″	7 15/32″
DIMENSION D	5 7/8″	7 1/2″	7 1/2″	7 7/32″	7 7/32″
DIMENSION E	8 13/16″	16 13/16″	16 13/16″	14 27/32″	17 1/32″

RATINGS FOR CLASS C TELEGRAPH OPERATION

TRANSMITTING — INDUSTRIAL TUBES

AIR COOLED — 20 KW PLATE DISSIPATION

TYPE	F-893-R
DESCRIPTION	GENERAL PURPOSE
MAX. PLATE DISSIPATION	20 KW
MAX. PLATE INPUT	70 KW
MAX. D.C. PLATE VOLTAGE	20,000 V
MAX. D.C. PLATE CURRENT	4.0 A
MAX. FREQUENCY FOR MAX. RATINGS	5 MC
AMPLIFICATION FACTOR (MU)	36
FILAMENT VOLTAGE	10 V per strand
DIMENSION A	26 7/8"
DIMENSION B	9 1/16"
DIMENSION C	12 7/8"
DIMENSION D	11 5/8"
DIMENSION E	18 1/4"



F-893-R

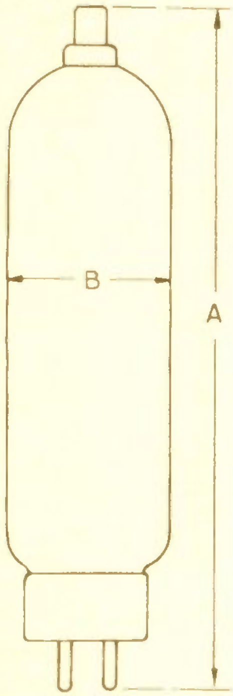
RECTIFYING TUBES

MERCURY VAPOR — 5 VOLT FILAMENT

TYPE	F-8008	F-267-B	F-872-A	F-315-A	F-375-A	F-869-B	F-857-B	F-266-B
MAX. PEAK INVERSE VOLTAGE	10,000 V	10,000 V	10,000 V	12,500 V	12,500 V	20,000 V	22,000 V	22,000 V
MAX. PEAK CURRENT (Amperes)	5.00	5.00	5.00	7.00	7.00	10.00	40.00	40.00
FILAMENT VOLTAGE	5 V	5 V	5 V	5 V	5 V	5 V	5 V	5 V
LENGTH	8 3/4"	8 3/4"	8 1/2"	12 1/4"	10 1/2"	14 1/4"	19 7/8"	21 3/4"
DIAMETER	2 1/4"	2 1/4"	2 1/4"	3 3/4"	3 3/4"	5 1/16"	7 1/8"	7 1/8"

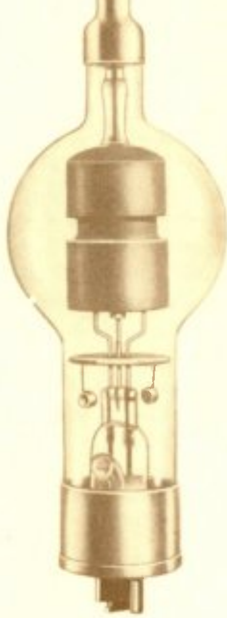
RECTIFYING TUBES

MERCURY VAPOR — 5 VOLT FILAMENT

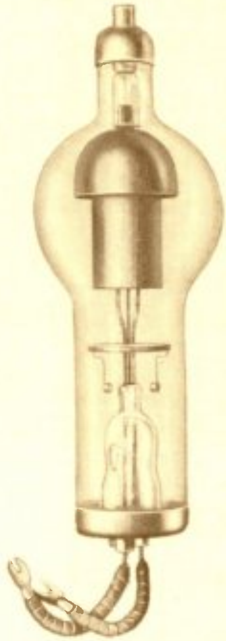


F-267-B

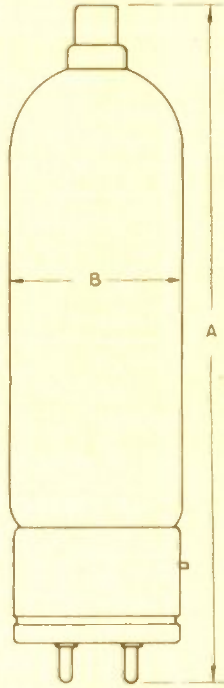
F-266-B



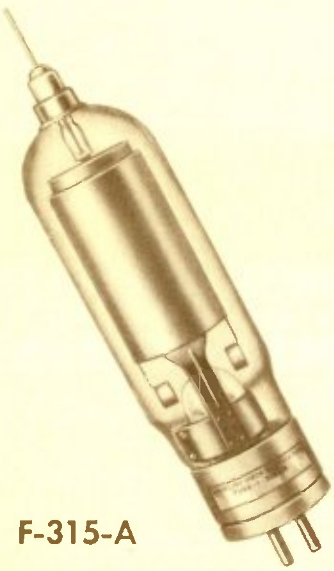
F-869-B



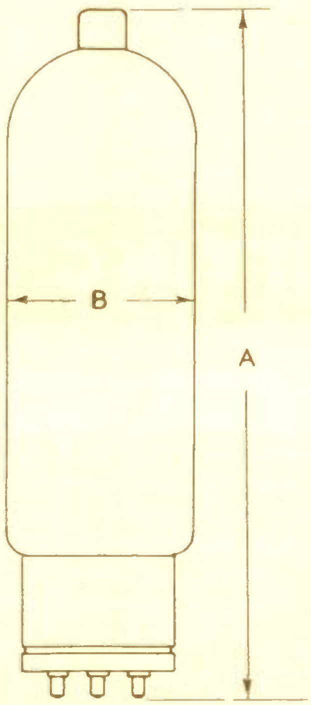
F-857-B



F-8008



F-315-A



F-872-A

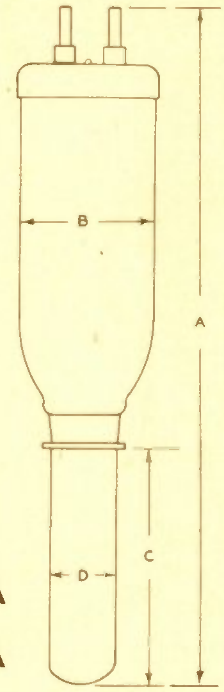
F-375-A

RECTIFYING TUBES

WATER COOLED

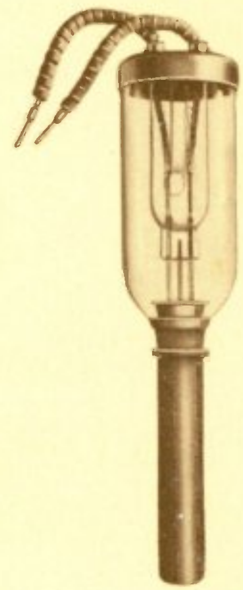
HIGH VACUUM

TYPE	F-222-A	F-237-A	F-214-A
MAX. PEAK INVERSE VOLTAGE	50,000 V	50,000 V	50,000 V
MAX. PEAK CURRENT (AMPERE)	5.50	8.00	7.5
FILAMENT VOLTAGE	21.5 V	20 V	22 V
DIMENSION A	20"	20"	20"
DIMENSION B	4 1/16"	4 1/16"	4 1/16"
DIMENSION C	7 7/32"	7 7/32"	8 1/16"
DIMENSION D	2.022"	2.022"	1.580"



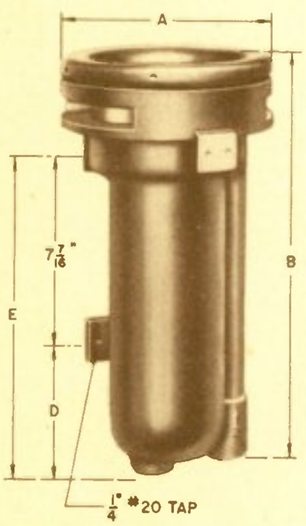
F-222-A

F-237-A



F-214-A

WATER JACKETS



WATER JACKET NUMBER	FITS TUBE TYPES		DIMENSIONS A	B	C	D	E
1000	F-207 F-848 F-863-A	F-891 F-892 F-214-A	6 1/2"	12 5/8"	2 3/4"	1 1/2"	
1001		110-X	6 1/4"	12"	2 1/8"	1 1/2"	
1005	F-320-B F-222-A F-237-A	F-343-A F-342-A	6 1/4"	11 3/4"	2 9/16"	1 1/2"	
1006	F-328-A	F-328-B	5 13/16"	11 7/8"	2 1/4"	1 1/2"	
1010	F-124-A F-893	F-125-A F-858	7 1/2"	15 3/8"	3 7/8"	3 13/32"	
1012	F-129-B		5 3/8"	7 1/2"	2 7/8"		4 7/8"

DIMENSION C = DISTANCE FROM FACE OF MOUNTING TAB TO CENTER LINE OF JACKET.

When Federal transmitting tubes are used in industrial heating oscillator applications the regular Class C Telegraph maximum ratings given in the catalog sheet will apply. THE "MAXIMUM RATINGS" SPECIFIED FOR ANY TUBE TYPE ARE ABSOLUTE MAXIMUM CONDITIONS THAT MUST NOT BE EXCEEDED UNDER ANY LOAD CONDITION TO BE ENCOUNTERED IN THE FIELD. This means that in most industrial heating applications the "normal load" condition must be set at some level considerably below the rated maximum conditions. In practice the actual level of "normal" operation will be determined by the particular circuit design chosen and the protective features incorporated. Particular care should be given to limiting the grid current rise when the plate circuit load is removed as well as to limiting the plate dissipation to a value below the rated maximum for all load conditions to be encountered.

A guarantee can be given only on Federal tubes used in equipment observing the precautions mentioned above.

Printed in U. S. A.

FEDERAL TELEPHONE & RADIO FTR

Federal Telephone and Radio Corporation

591 BROAD STREET, NEWARK 2, NEW JERSEY, U. S. A.

An IT&T ASSOCIATE

TUBE PRICE LIST

Effective April 1, 1946

TRANSMITTING TUBES — WATER COOLED

TYPE	PRICE	DESCRIPTION	Maximum Plate Dissipation	Mu	Maximum Plate Input	Maximum DC Plate Voltage	Maximum Frequency for Maximum Ratings	Filament Voltage
F-328-A	$249.00	General Purpose	5 KW	16	8 KW	8,000 V	3 MC	21.5 V
F-328-B	249.00	General Purpose (Two Phase Filament)	5	16	8	8,000	3	21.5
F-129-B	300.00	VHF Amplifier and Oscillator	5	26	18	12,000	50	18
F-889	160.00	VHF Amplifier and Modulator	5	21	16	8,500	50	11
F-891	170.00	Modulator or R.F. Amplifier	6	8	18	12,000	1.6	11/22
F-848	325.00	Modulator	6	8	18	12,000	1.6	22
F-207	220.00	General Purpose	10	20	30	15,000	1.5	22
F-320-B	290.00	General Purpose	10	40	22.5	15,000	4.0	21.5
F-343-A	290.00	General Purpose	10	40	25	15,000	4.0	21.5
F-863	325.00	Modulator or R.F. Amplifier	10	50	30	15,000	1.5	22
F-892	170.00	R.F. Amplifier or Modulator	10	50	30	15,000	1.5	11/22
F-893	450.00	General Purpose	20	36	70	20,000	5	10 per strand
F-858	275.00	Oscillator or R.F. Amplifier	20	42	40	20,000	1.5	22
F-342-A	480.00	General Purpose	25	40	50	20,000	4.0	20
F-124-A	700.00	General Purpose	40	42	135	20,000	20	13.6 per strand
F-125-A	800.00	Audio Amplifier	40	4.75	100	15,000		13.6 per strand
F-862-A	750.00	R.F. Amplifier or Modulator	100	48	200	20,000	1.6	33

WATER JACKETS

TYPE	DESCRIPTION	PRICE
F-1000	(For F-207, F-848, F-863, F-891, F-892)	$ 50.00
F-1005	(For F-320-B, F-343-A, F-342-A, F-222-A, F-237-A)	50.00
F-1006	(For F-328-A, F-328-B)	50.00
F-1010	(For F-893, F-858, F-124-A, F-125-A)	150.00
F-1012	(For F-129-B)	50.00

Inquiries are invited concerning tubes for specific applications not included herein.

Federal Telephone and Radio Corporation

Vacuum Tube Products

TUBE PRICE LIST

Effective April 1, 1946

TRANSMITTING TUBES — AIR COOLED

TYPE	PRICE	DESCRIPTION	Maximum Plate Dissipation	Mu	Maximum Plate Input	Maximum DC Plate Voltage	Maximum Frequency for Maximum Ratings	Filament Voltage
F-123-A	**$17.50**	General Purpose	125 W	14.5	375 W	2,000 V	30 MC	10 V
F-127-A	**40.00**	General Purpose	200	38	950	3,000	30	10
F-204-A	**85.00**	Oscillator, R.F. Amplifier, or Modulator	250	23	690	2,500	3	11
F-212-E	**70.00**	General Purpose	275	16	700	2,000	4.5	14
F-849	**120.00**	General Purpose	400	19	875	2,500	3.0	11
F-450TH	**60.00**	General Purpose	450	38	3 KW	6,000	40	7.5
F-128-A	**150.00**	Oscillator or R.F. Amplifier	600	36	3	3,500	30	11
F-132-A	**200.00**	Audio Amplifier	600	10	18	3,500		11
7C 25	**87.50**	Industrial	2.5 KW	25	5.6	4,500	50	11
F-891-R*	**315.00***	Modulator or R.F. Amplifier	4	8	15	10,000	1.6	11/22
F-892-R	**315.00***	R.F. Amplifier or Modulator	4	50	18	10,000	1.5	11/22
F-129-R*	**375.00***	High Frequency R.F. Amplifier	5	26	18	12,000	50	18
F-889-R	**280.00***	R.F. Amplifier and Modulator	5	21	16	8,500	25	11
F-343-R	**440.00***	General Purpose	10	40	25	15,000	4.0	21.5
F-342-R	**630.00***	General Purpose	10	40	50	20,000	4.0	20
F-124-R	**950.00***	General Purpose	20	42	100	20,000	20	13.6 per strand
F-893-R	**800.00***	General Purpose	20	36	70	20,000	5	10 per strand

*Credit allowed for return of radiator and crate in good condition as follows: in case of F-129-R, F-889-R, $50.00; in case of F-891-R and F-892-R, $100.00; in case of F-342-R and F-343-R, $125.00; in case of F-124-R and F-893-R, $200.00.

RECTIFYING TUBES

TYPE	PRICE	DESCRIPTION	Maximum Peak Inverse Voltage	Maximum Peak Current (Amperes)	Filament Voltage
F-315-A	**35.00**	Mercury Vapor	15,000	6	5
F-575-A	**30.00**	Mercury Vapor	15,000	6	5
F-869-B	**100.00**	Mercury Vapor	20,000	10	5
F-857-B	**160.00**	Mercury Vapor	22,000	40	5
F-266-B	**160.00**	Mercury Vapor	22,000	40	5
F-873	**12.00**	Grid Controlled Mercury Vapor	10,000	10	5
F-214-A	**250.00**	Water Cooled-High Vacuum	50,000	7.5	22
F-222-A	**220.00**	Water Cooled-High Vacuum	50,000	5.5	21.5
F-237-A	**435.00**	Water Cooled-High Vacuum	50,000	8	20

Tubes are sold F.O.B. Factory or Warehouse, 2% — 10 days, net — 30 days.
The foregoing prices do not exceed the applicable maximum prices, established by the O.P.A.

Federal Telephone and Radio Corporation

Vacuum Tube Products — An IT&T Associate — Newark 4, New Jersey

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Form G-100-A Superseding Form G-100

MERCURY VAPOR RECTIFIER TUBES

Suggestions for Use

PRINCIPLES OF OPERATION

The performance of the mercury vapor tube differs from that of the high vacuum thermionic tube principally in that the presence of the mercury vapor permits a comparatively low, and practically constant, voltage drop from anode to cathode in the conducting direction. This voltage drop will hereafter be referred to as the "space charge."

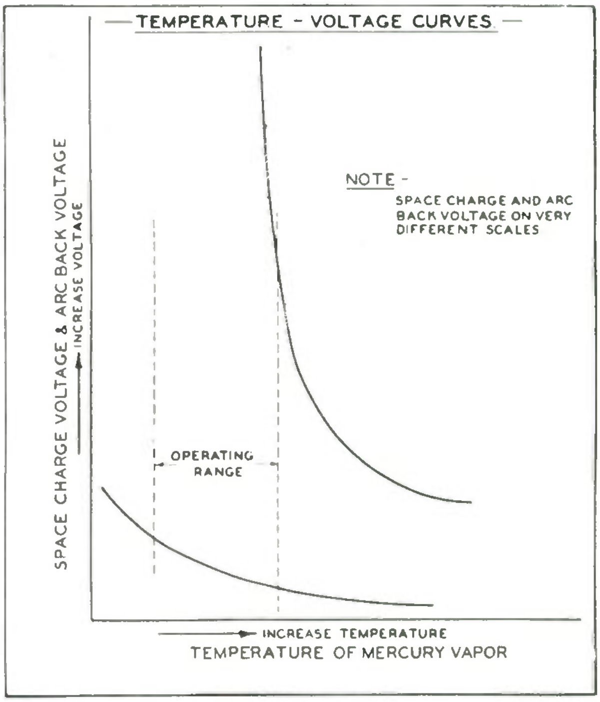
The space charge of the thermionic tube is dependent upon the configuration of the tube elements and the amount of current passing between the anode and cathode. These may result in variations of space charge from a few volts to several thousand volts. In the mercury vapor tube, however, the space charge is largely dependent upon the temperature of the mercury vapor which, within the allowable operating limits, may result in space charges of perhaps 8 to 20 volts regardless of the current drawn.

This space charge effect in the mercury vapor rectifier is, of course, negligible in comparison with the voltage output of a high voltage rectifier. It is important, therefore, only in connection with the effect this space charge may have on the tube itself.

In the lower curve shown in the accompanying illustration it is seen that the space charge is dependent upon the temperature of the mercury vapor in such a manner that the space charge increases as the temperature decreases. The heavy and comparatively immobile positively charged mercury vapor ions normally do not contribute to the space current, but if the vapor temperature becomes so low that the space charge exceeds what is considered a critical value of approximately 22 volts, the ions acquire sufficient velocity in the direction of the cathode to result in a damaging bombardment of the oxide coated cathode. This situation corresponds to a **mercury vapor** temperature somewhat less than 15°C.

If, on the other hand, the mercury vapor temperature is increased to avoid cathode disintegration, the effect of such increased temperature on the so-called "arc-back" voltage must be considered. An arc-back is caused by the inverse voltage to which the tube is subjected during the non-conducting portion of the cycle.

The upper curve illustrated shows qualitatively the relation between mercury vapor temperature and the arc-back voltage. This curve shows that as the temperature is increased beyond a point designated as the maximum allowable temperature, the arc-back voltage decreases very rapidly.



These curves do not have particular values of temperature or voltages noted since they are intended to apply generally to all sizes of mercury vapor tubes. The limiting conditions, however, can be taken from the published data for any particular type of tube.

In practice it is essential to know the relation between actual mercury vapor temperature and bulb temperature or, more specifically, the ambient temperatures and conditions of ventilation. It can be assumed that with unrestricted natural ventilation and with no other heat radiating bodies in the vicinity of the tube, the mercury vapor temperature will be approximately 15°C. higher than the ambient temperature for most tubes. With forced ventilation this difference in temperatures is considerably reduced.

Since most rectifier circuits involve the use of more than one tube, it usually becomes necessary to place one tube quite close to the other in order to conserve space. However, if the glass envelope of one tube is closer

MERCURY VAPOR RECTIFIER TUBES

Suggestions for Use

than about 6" from that of any adjacent tube, heat radiation from both tubes is unfavorably affected and must be considered in relation to the range of ambient temperatures to which the rectifier will be subjected.

It is apparent from the two curves shown that if the temperature range is narrowed by the use of forced draft ventilation and control of air temperature, the factors of safety will be greatly increased. In certain applications forced ventilation is provided by simply using a propeller type fan. For installations where quite high voltages are involved, which is usually the case where the larger sizes of mercury vapor rectifier tubes are used, forced ventilation is best provided by a centrifugal blower whose output is distributed through metal tubing in such a manner that an air blast is directed on each tube in the vicinity of the glass just above the base.

To avoid distortion of the electrostatic field about the tubes, a piece of insulating tubing should be used for the section of pipe that is adjacent to the glass wall of each tube. Where several tubes are used, the air should be distributed evenly between the various outlets.

Since the presence of the ionized mercury vapor serves only to reduce the space charge, the source of electronic current must come from the cathode itself. The cathodes are designed to furnish ample emission for the peak current values published. If for any reason the emission is reduced, the space charge will increase as the actual emission is exceeded, and may result in disintegration of the cathode.

A more common cause of low filament emission is improper cathode temperature. Hence, it becomes extremely important that the filament shall always be maintained at its correct operating voltage when the plate voltage is applied. In installations where the source of power cannot be relied upon to maintain its voltage within plus or minus 5%, including the effect of regulation due to variations in load upon the rectifier, it is desirable to employ some form of automatic voltage regulator in the filament primary power supply.

The mercury vapor within the tubes is capable of ionization, not only by the electrostatic field between anode and cathode, but by electrostatic fields introduced by extraneous forces. These may have an objectionable effect upon the operation of the tube, particularly if they are due to a field varying at a radio frequency rate. Such a field may be produced either by direct radiation from a radio transmitter or antenna system, or by radio frequency currents introduced in leads involving the rectifier circuit. The installation of composite equipment consisting of the rectifier and some piece of radio equipment should be made, therefore, with provisions for shielding the mercury vapor tubes from radio frequency fields. Radio frequency filters should be installed where necessary to isolate the rectifier circuit from radio frequency circuits.

Installation

The tube should be mounted in a vertical position with the filament (large base) end down. It will fit readily into a standard socket. The mounting should be so arranged as to prevent mechanical shocks or vibration from being transmitted to the tube.

Except as otherwise noted the tube is designed to operate satisfactorily when the ambient temperature is not less than 15°C. (59°F.) and not more than 50°C. (122°F.). Ambient temperatures are measured, where a natural air circulation installation is made, with thermometers placed at various points opposite the filament base at distances of 3 to 6 feet.

If forced draft cooling is used, the ambient temperature is measured by a thermometer placed in the cooling air stream before the air reaches the tube. The glass bulb of the tube should not be near nor in contact with any metallic body or inflammable material, nor should it be subjected to drops or spray of any liquid.

Circuit Requirements

Proper overload protection against excessive currents, and safety interlock circuits to safeguard personnel should be employed in proportion to the power and voltage involved in the rectifier installation.

Proper overload protection involves the following relays which act to open the circuit breaker in the primary of the high voltage transformers: (1) Instantaneous overcurrent relays in the primary supply line which, in a three phase system, are placed in two of the three phase leads to insure operation when any one phase of the primary is overloaded, (2) an instantaneous over-

MERCURY VAPOR RECTIFIER TUBES

Suggestions for Use

current relay in the grounded side of the output (DC) circuit to operate in case of a 100% overload, and (3) a time delay overcurrent relay in the grounded side of the output circuit to operate on continued overload.

If the rectifier tubes are operated at peak inverse voltages exceeding 10,000 volts, the voltage to the primary of the high voltage transformers should be applied in steps. This may be accomplished through the use of an induction type regulator. As an alternate arrangement, the main high voltage contactor may close the primary circuit through a resistance bank which is subsequently shorted out, after a pre-determined period, by a second contactor operated by a delay relay whose delay should be set for at least 5 seconds.

The rectifier filaments should be maintained at constant voltage rather than at constant current. Adjustments of the filament voltage may be made with a rheostat in the primary circuit of the filament transformer while observing a filament voltmeter, which should be connected to a separate voltmeter winding, or across the primary terminals of the filament transformer. With the high voltage transformer primaries open circuited, the rectifier filament voltages should be measured directly at the tube terminals to make certain that the voltage measured is that which is actually across the filament. The relation between this voltage and the corresponding reading of the installed filament voltmeter should be noted. If possible, the filament voltage should be finally adjusted to its proper value for each individual tube when the rectifier is operating under normal conditions.

CAUTION: The rectifier filament terminals may be at high voltage to ground when the rectifier is in operation and hence direct measurements of filament voltage should not be made when the high voltage transformers are excited. The filament connections should be large in order to assure a good contact. A relay, operating from the filament supply circuit, should be installed so that it will open the high voltage primary circuit in case the filament voltage fluctuates beyond the limits of plus or minus 5%. This relay should have a time delay of not more than 2 seconds to avoid opening of the circuit on transients.

When starting up the rectifier the filaments of the tubes must be lighted first, and the high voltage should not be applied until the filaments have had time to reach normal operating temperature. This condition is best obtained by the use of a time delay relay operating from the filament primary power supply and having a delay period adjustable to the value recommended for the particular type of tube used. The contact of this delay relay should be in series with the start circuit of the high voltage primary contactors. If it is necessary to decrease the heating time to a minimum, the time delay necessary for the particular installation may be determined in the following manner.

With the tube in the actual circuit under consideration, a DC voltage of at least 45 volts is connected between anode and cathode in series with a resistor sufficient to limit the current to .3 ampere. The anode is connected to the positive terminal of the DC voltage source and a voltmeter is connected between anode and cathode. The filament supply switch is closed and, assuming that the tube was cold at the start, the time required for the DC voltage drop across the tube to reach a constant value is noted. This time is measured for each of the rectifier tubes. The longest time measured is increased by 50% to give the shortest possible delay period permissible for the particular installation.

The space charge of a mercury vapor rectifier tube increases with age and this fact affords a means for anticipating the end of useful life of any particular tube. A record of the increase in space charge from day to day may be obtained by a simple arrangement in which a source of at least 20 volts direct current with a current capacity equal to that of the peak current rating of the rectifier tube can be connected to the anode of each tube in succession after the high voltage has been removed and the filament of the tube lighted at normal voltage. When the space charge reaches 18 to 20 volts, with the space current adjusted to the rated peak value, it may be an indication that the end of useful life for this tube is being approached.

The initial filament current when starting may be objectionably large if a current limiting reactor or resistance

MERCURY VAPOR RECTIFIER TUBES

Suggestions for Use

is not used. It is recommended, therefore, that a time delay device be used so that the initial application of filament voltage can be made through a current limiting device which, in turn, is subsequently shorted out after a delay of a few seconds. The peak rms value of current through the filament should be limited to something less than twice the normal filament current rating.

Operation

When the tube is first received it will undoubtedly have mercury deposited on all parts within the tube due to handling in shipment. A deposit of mercury on the plate or filament reduces the arc-back voltage. To avoid permanent injury, therefore, a slow treating schedule should be followed.

The new tube should be tested as described herein, and the same tests should be followed each time the tube is handled in such manner as to cause mercury to be deposited on the plate or filament. After the mercury has been properly distributed by the slow treating schedule, the tube should be mounted in a rack in its operating position (the filament end down). It should not be laid on its side in the rectifier unit. The tube will then be ready for replacement use by simply operating at rated voltage for the length of time specified, for the particular tube used, before applying the operating voltage.

The treatment prescribed in the following paragraph is intended particularly for new tubes which are to be placed in operation for the first time. It is suggested that this treatment be applied also to new tubes not placed in immediate service, and that the treatment be repeated every three months on tubes held in storage. The same treatment applies also where a tube has been operated improperly and shows a tendency to arc-back, since its condition may be much improved thereby.

The filament must be lighted at rated voltage for 15 minutes without any applied plate voltage in order to distribute the mercury to the tube properly. The supply voltage should be reduced to give a peak inverse voltage of approximately 4,000 volts, the high voltage primary circuit closed, and the rectifier operated for 5 minutes, after which the output potential should be increased gradually during a 15 minute period to obtain the normal operating value.

If the equipment does not permit of this procedure, the full plate voltage should be applied intermittently until the tube operates normally. If the tube gives evidence of flashing, the treating period should be prolonged so that stable operation may be obtained without injury to the tube. Then the tube should be operated under normal conditions for 15 minutes.

The peak inverse voltage will vary with the type of circuit and the wave shape. It should always be evaluated from a knowledge of these factors. The maximum rating of the tube refers to the actual inverse voltage and not to the calculated values. Therefore a cathode ray oscillograph, or spark gap, connected across the tube should be used to determine the actual voltage conditions.

The maximum peak current and voltage ratings must not be exceeded during operation and rectifiers must be designed accordingly. Where higher voltages are required than can be secured without exceeding the rating of the tube it is recommended that independent rectifiers be connected in series. This practice is to be preferred to that of connecting the tubes in series, since the resistance of the tube in the reverse direction may be variable and thus prevent equal voltage distribution.

For greater output currents, tubes may be connected in parallel. Balancing resistors should then be placed in series with each tube so that each tube carries its share of the load.

The published ratings and basic tube information are based upon use at frequencies less than 150 cycles per second. For use at higher frequencies the manufacturer should be consulted.

The inside surfaces of the glass of most types of mercury vapor rectifier tubes tends to darken with age in service. Excessive blackening of the tube envelope, while not of itself an indication of approaching failure, is a signal to increase the frequency of voltage drop measurements as outlined above. Likewise, any sudden change in the color of the mercury vapor discharge will aid in judging when to remove a tube.

Federal Telephone and Radio Corporation

Vacuum Tube Products — An IT&T Associate — Newark 4, New Jersey

Printed in U.S.A. Form F-202

THERMIONIC RECTIFIER TUBES

Suggestions for Use

Installation

In accordance with generally accepted practice, tubes should be mounted with the filaments in a vertical position. It is highly desirable that tubes be stored in racks which are protected from vibration as well as from moisture and extreme temperature changes.

During operation, water cooled tubes are naturally held in the correct vertical position, with the glass end up, by the water jackets designed to protect the tubes and effectively cool the anodes.

Installation of water cooled tubes is fairly simple if accomplished with reasonable care. Three gaskets are supplied with each tube to obviate the necessity of ever using gaskets other than those supplied with the tube. After placing the proper gasket on the anode, the tube should be placed in the water jacket very carefully and turned gently to make sure that the flange seats properly in the jacket. The tube should then be secured in the jacket by tightening the clamps just enough to prevent any water leaks, otherwise the flange may be distorted.

Following correct adjustment and clamping of the tube in the jacket, the filament leads should be connected so that no strain is placed upon them. These leads should always be disconnected before unclamping the tube and removing it from the water jacket. The moving parts of the water jacket should be kept covered with a film of oil to prevent corrosion and sticking.

Cooling

A water circulating system capable of passing a sufficient quantity of water through the water jacket and returning it to the source for recooling must, of course, be provided for cooling the anode of the tube.

Where few water cooled tubes are in service, the cooling system may consist of a fan cooled radiator, a pump and the water jacket interconnected in a closed circulating system. Such a system is usually insulated from the ground and has a water gauge to indicate the height of water in the radiator as well as a thermometer for recording the water temperature at the outlet of the water jacket. Where many water cooled tubes are employed, water is usually obtained from a large storage tank, a well, or from water mains — whichever is available.

In order to insure an adequate supply, water is circulated under pressure through an interconnected piping system and lengths of rubber hose carry the water from a grounded position in the system to and from the water jackets. It is extremely important that the hose be of sufficient length to reduce to a minimum the possibility of current leakage. The hose (connected both at the inlet and outlet sections of the water jacket) should be not less than fifteen feet each in length.

It is recommended that a supply of water be used having a specific resistance of not less than 4000 ohms. Distilled water or rain water caught in a storage tank is highly recommended. Water obtained from wells or water mains should be analyzed to determine the amount of carbonates, sulphates, etc., it contains. When the hardness of the water flowing through the cooling system is greater than 10 grains per gallon and the plate dissipation, water flow and outlet water temperature are normal, there is always the possibility of scale formation on the anode of the tubes.

Scale formation prevents proper cooling of the tubes, and this may damage them. Scale should be eliminated by the use of distilled water or a water softener. In emergency cases where it is absolutely necessary to use water which forms a scale on the anode, a regular

THERMIONIC RECTIFIER TUBES

Suggestions for Use

schedule should be adopted for cleaning the scale from the anode by means of dipping the anode in a 10% solution of hydrochloric acid until the scale is dissolved. Following this, the anode should be thoroughly rinsed in water. Care should be taken to prevent the acid solution from coming in contact with the anode near the region of the copper-to-glass seal. Since this procedure necessitates frequent removal of the tubes from the water jackets and increases the danger of accidental breakage, it should be avoided wherever possible.

The flow of water through the water jacket should consist of a thin stream evenly distributed over the anode to insure adequate cooling. It should be fast enough to prevent steam bubbles from forming on the surface of the anode. The water flowing through the water jacket should never reach the boiling point and in fact should never exceed 70°C. at the water outlet. The recommended flow is usually sufficient, but if a scale formation is present, better results will be obtained by a faster flow. A flowmeter may be installed, provided a location is selected in which air traps may be avoided. The filament and plate supply must always be interconnected with the water supply, so that in the case of water failure for any reason, the filament and plate voltages cannot be applied to the tubes. The heat from the filament alone is sufficient to cause serious damage.

In all cases the glass bulb of the tube should not be in contact with nor near any metallic body nor inflammable material, nor should it be subjected to drops or spray of any liquid.

Circuit Requirements

Inasmuch as the circuits in which these tubes operate comprise high powered, high voltage systems, proper overload protection against excessive currents and safety interlock circuits, to safeguard personnel, should be employed in proportion to the power and voltage involved in the rectifier installation. These involve relays described in pages featuring "Mercury Vapor Rectifier Tubes."

Since the filament circuit must carry a fairly large current, every precaution should be taken against voltage losses due to poor connections. Filament connections should be large, and securely fastened to insure good contacts. All wires and connections should be placed as far as possible from the glass of the tube in order to avoid the possibility of bulb puncture from corona discharges.

Operation

In order to insure satisfactory serviceability when needed, tubes should be tested and inspected immediately upon arrival. For tubes placed in storage this should be repeated approximately every three months. Best results are obtained by placing tubes in an actual working rectifier unit.

Essentially rectifier tubes are limited in two respects: **First,** by the maximum instantaneous peak current that the tube will pass. **Second,** by the maximum peak inverse voltage that can safely be applied while the tube is preventing the flow of current in the inverse direction.

Federal Telephone and Radio Corporation

Vacuum Tube Products — An IT&T Associate — Newark 4, New Jersey

Printed in U.S.A. Form F-195

WATER COOLED and AIR COOLED TUBES

Suggestions for Use

Water Cooled Tubes

In accordance with generally accepted practice, tubes should be mounted with the filaments in a vertical position. It is highly desirable, therefore, that tubes be stored in racks which are protected from vibration as well as from moisture and extreme temperature changes. In the case of water cooled tubes with flexible leads, care should be taken to prevent the filament leads from striking the glass with the resultant possibility of breakage.

During operation these tubes are naturally held in the correct vertical position with the glass end up, by the water jackets, since these are designed to protect the tubes and effectively cool the anodes.

Installation of water cooled tubes is fairly simple if accomplished with reasonable care. Spare gaskets are supplied with each tube to obviate the necessity of ever using gaskets other than those supplied with the tube. After placing the proper gasket on the anode the tube should be placed in the water jacket very carefully and turned gently to make sure that the flange seats properly in the jacket. The tube should then be secured in the jacket by tightening the clamps just enough to prevent any water leaks, otherwise, the flange may be distorted.

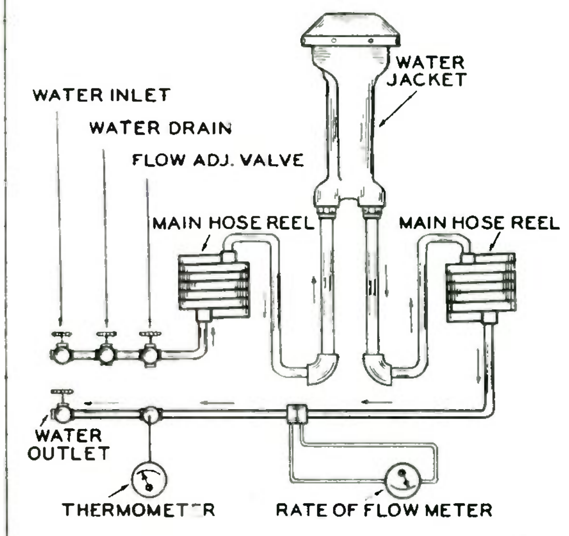
After correct adjustment and clamping of the tube in the jacket, the filament and grid leads should be connected in such a way that no strain is placed upon them. These leads should always be disconnected before unclamping the tube and removing it from the water jacket.

It is highly desirable that all the moving parts of the water jacket should be kept covered with a film of oil to prevent corrosion and sticking.

Cooling

A water circulating system capable of passing a sufficient quantity of water through the water jacket and returning it to the source for recooling must, of course, be provided for cooling the anode of the tube.

Where a small number of water cooled tubes is in service, the cooling system may consist of a fan cooled radiator, a pump and the water jacket interconnected in a closed circulating system. Such a system is usually insulated from the ground, and has a water gauge to indicate the height of water in the radiator as well as a thermometer for recording the water temperature at the outlet of the water jacket.



Where a number of water cooled tubes is employed, the water is usually obtained from a large storage tank, a well or from water mains, whichever is available. In order to insure an adequate supply, the water is circulated under pressure through an interconnected piping system and lengths of rubber hose or ceramic pipes carry the water from a grounded position in the system to and from the water jackets.

It is extremely important that the hose be of sufficient length to reduce the possibility of current leakage to a minimum. It is suggested that the hose (connected both at the inlet and outlet sections of the water jacket) be not less than fifteen feet each in length.

It is recommended that a supply of water be used having a specific resistance of not less than 4000 ohms. Distilled water or rain water caught in a storage tank is highly recommended. Where water is obtained from wells or water mains, it is suggested that it be analyzed to determine the amount of carbonates, sulphates, etc. contained in it. When the hardness of the water flowing through the cooling system is greater than ten grains per gallon and the plate dissipation, water flow and outlet water temperature are normal, there is always the possibility of scale formation on the anode of the tubes.

Scale formation prevents proper cooling of the tubes and may result in damage to them. It should be avoided,