Western Electric

228A Vacuum Tube

Classification—Filamentary water-cooled triode

May be used as an audio-frequency amplifier or as a radio-frequency oscillator, amplifier or modulator.

Dimensions—Dimensions and outline diagrams are shown in Figure 1. The overall dimensions are:

Maximum overall length	18″
Maximum diameter	3½″

Mounting—W. E. 126A or similar socket. The tube should be mounted only in a vertical position with the anode end down.

Filament—Tungsten

Filament voltage	21.5 volts, a.c.
Nominal filament current	41.0 amperes
Average thermionic emission	7.0 amperes

Average Direct Interelectrode Capacitances

Plate to grid	23.8 $\mu\mu$f.
Grid to filament	25.9 $\mu\mu$f.
Plate to filament	3.1 $\mu\mu$f.

Characteristics—Performance data given below are based upon a typical set of conditions. Variations can be expected with different circuits and tubes.

Figures 2 and 3 give the static characteristics of a typical tube plotted against grid and plate voltages.

Average Characteristics at plate voltage of 5000 and plate current of 0.9 ampere, $E_c = -100$ volts (approximately).

Amplification factor	16
Plate resistance	2500 ohms
Grid to plate transconductance	6500 micromhos

Operation

Maximum Ratings

Max. direct plate voltage	6000 volts
Max. direct plate current	1.5 amperes
Max. plate dissipation	5000 watts
Max. grid dissipation	100 watts
Max. r-f grid current	20 amperes
Max. frequency for the above ratings	3 megacycles
Max. plate voltage for upper frequency limit of 6 Mc.	3000 volts
Max. plate voltage for frequencies between 3 and 6 Mc. in proportion	

Class A Audio Amplifier or Modulator

Direct plate voltage	5000	6000 volts
Grid bias	−100	−170 volts
Direct plate current	.85	.80 ampere
Plate dissipation	4250	4800 watts
Load impedance	5000	7500 ohms
Undistorted output	125	285 watts

Class B Audio Amplifier or Modulator for Balanced 2 Tube Circuit

Direct plate voltage	5000	4000 volts
Grid bias	−265	−200 volts
Direct plate current per tube		
No drive	0.15	0.15 ampere
Max. drive	0.60	0.70 ampere
Plate dissipation	1125	1300 watts
Load resistance plate-to-plate	8400	5000 ohms
Load resistance per tube	2100	1250 ohms
Approximate max. output—2 tubes	3750	3000 watts
Recommended power for driving stage	200	200 watts

Class B Radio-Frequency Amplifier

Direct plate voltage	5000	4000 volts
Direct plate current for carrier conditions	0.65	0.65 ampere
Grid bias	−325	−275 volts
Approximate carrier watts for use with 100% modulation	1100	900 watts

Class C Radio-Frequency Oscillator or Power Amplifier—Unmodulated

Direct plate voltage	6000	4000 volts
Direct plate current	1.25	1.25 amperes
Grid bias	−600 to −800	−450 to −550 volts
Nominal power output	5000	3300 watts
Plate dissipation	2500	1700 watts

Class C Radio-Frequency Amplifier—Plate Modulated

Direct plate voltage	4000	3000 volts
Direct plate current	1.25	1.3 amperes
Grid bias	−500	−300 volts
Max. direct grid current	150	150 milliamperes
Nominal carrier power output	2500	2000 watts

Operating Precautions

Mechanical—Figure 1 shows the overall dimensions and basing arrangement for the tube.

The tubes should not be subjected to mechanical shock or excessive vibration. Mechanical vibration may cause breakage of the tungsten filaments.

A free circulation of air must be provided to insure adequate cooling of the glass during operation.

The cooling water should be of sufficient purity to retard the tendency toward the formation of scale on the anode. Formation of scale would have the effect of insulating the anode from the water and the ineffective cooling of the anode would result in failure of the tube. It is therefore recommended that distilled water be used in the cooling system.

The temperature of the water and rate of flow should be such that there is no tendency to boil, as indicated by a hissing sound, under maximum dissipation. In general, the outlet water temperature should not exceed 75° C. and the rate of flow should be not less than 3 gallons per minute. The minimum length of hose which can be used to insulate the plate from the water supply which is usually grounded will depend upon the resistivity of the water used and the leakage current that can be tolerated. In no case must this be less than 10 feet. The hose connections must always be made so that the water flows in at the center port of the tube socket.

Provision should be made in the circuit to safeguard against the filament and plate voltages being applied until the cooling water is circulating at the proper rate and temperature, and for the immediate cut-off of the filament and plate voltages if the circulating rate falls below the allowed minimum or the temperature exceeds the allowable maximum. A momentary interruption of the water circulation during operation of the tube may cause immediate failure.

Electrical—Overload protection should always be provided for the plate circuit. A suitable fuse or circuit breaker should remove the plate voltage if the plate current exceeds 2 amperes. Although the tube is sufficiently rugged to withstand momentary overloads, a prolonged overload caused by inefficient adjustment of the circuit, may damage the tube. When adjusting a new circuit or installing a new tube, reduced plate voltage or a series resistance of 1000 to 5000 ohms in the plate circuit should be used until it is operating properly.

The filament should always be operated at the rated voltage, measured at the tube terminals. A 5% decrease in filament voltage reduces the thermionic emission approximately 35%. If satisfactory operation can be obtained at lower than the rated voltage, an increase in filament life may be obtained, i.e., if the filament voltage can be reduced to 21 volts the burnout life may be increased approximately 50%. Either direct or alternating current may be used for heating the filament. If direct current is used, the plate and grid circuit returns should be connected to the positive filament terminal. Also the connections to the filament terminals should be reversed periodically. If alternating current is used, the circuit returns should be connected to the center tap of the filament heating transformer winding or to the center tap of a resistor placed between the filament terminals. A resistance of 50 to 75 ohms of 100 watt rating is suitable.

Some provision should be made to limit the initial filament current, when the filament is cold. This may be done by inserting additional resistance in the filament circuit when voltage is first applied or by using a transformer having sufficiently high reactance.

Audio Amplifier or Modulator

Class A—Peak grid drive equal to or less than the grid bias.

Grid bias may be obtained from the drop across a resistance in the plate current return or from a battery or rectifier supply.

Plate dissipation allowable for this type of service is generally lower than is safe for other uses since the energy is dissipated in the plate in smaller areas due to relatively high voltage drop in the tube.

The plate dissipation is equal to the plate voltage multiplied by the normal plate current. Performance data are based upon the use of a resistance load. Undistorted output is calculated on the basis of 5% second harmonic distortion.

Class B—Grid bias practically at cut-off and grid driving voltage higher than the bias.

Two tubes may be used in a balanced circuit. An adequate driving stage and an input transformer with good regulation must be used so that the grid current drawn during positive grid swings does not produce appreciable distortion. The output transformer must transform the load impedance to the proper value for the tubes used. The power output obtainable will be determined by the quality of the transformer used and the amount of distortion which can be tolerated. The output can be increased or the distortion decreased by the use of degenerative feedback. The grid bias must be held constant and therefore cannot be obtained by grid leak or series resistor methods. A battery or other source having good regulation is necessary.

The power required of a modulator for complete modulation of a Class C amplifier is one-half the direct power input to the plates of the Class C amplifier.

Radio-Frequency Oscillator or Power Amplifier

Class B—Radio-Frequency Amplifier

The Class B radio-frequency amplifier is used to amplify a modulated radio-frequency carrier wave without appreciable distortion. It operates similarly to the Class B audio amplifier except that a single tube may be used, the tuned output circuit serving to preserve the wave shape. The push-pull circuit, however, eliminates the even order harmonics and thus increases the efficiency slightly.

Class C—Radio-Frequency Oscillator or Power Amplifier—Grid bias below cut-off

Unmodulated

This type of operation is suitable for telegraphy, or the production of a continuous flow of radio-frequency power for purposes other than communication.

Plate Modulated

This type of operation is for use when the modulating voltage is superimposed on the plate supply voltage and to obtain good quality the output power should vary as the square of the plate voltage. For complete or 100% modulation, the plate voltage varies from zero to twice the applied direct value during a cycle of the audio frequency. With no modulation applied, the plate voltage is, of course, the direct value and the carrier power output is one-fourth of the peak power output under 100% modulation. In this case, since the plate voltage varies with modulation, the direct value must be rated lower than for other types of operation.

High Frequency Ratings

The frequency limits specified under maximum ratings are based on the tube being used as an oscillator. The tube may be used at full rating up to 3 megacycles. When operating at higher frequencies, the dielectric losses, charging currents and lead-in heating are increased greatly. The plate voltage and hence plate dissipation must be reduced to values specified for the upper frequency limit and for frequencies between these two limits the plate voltage should be proportionately reduced.

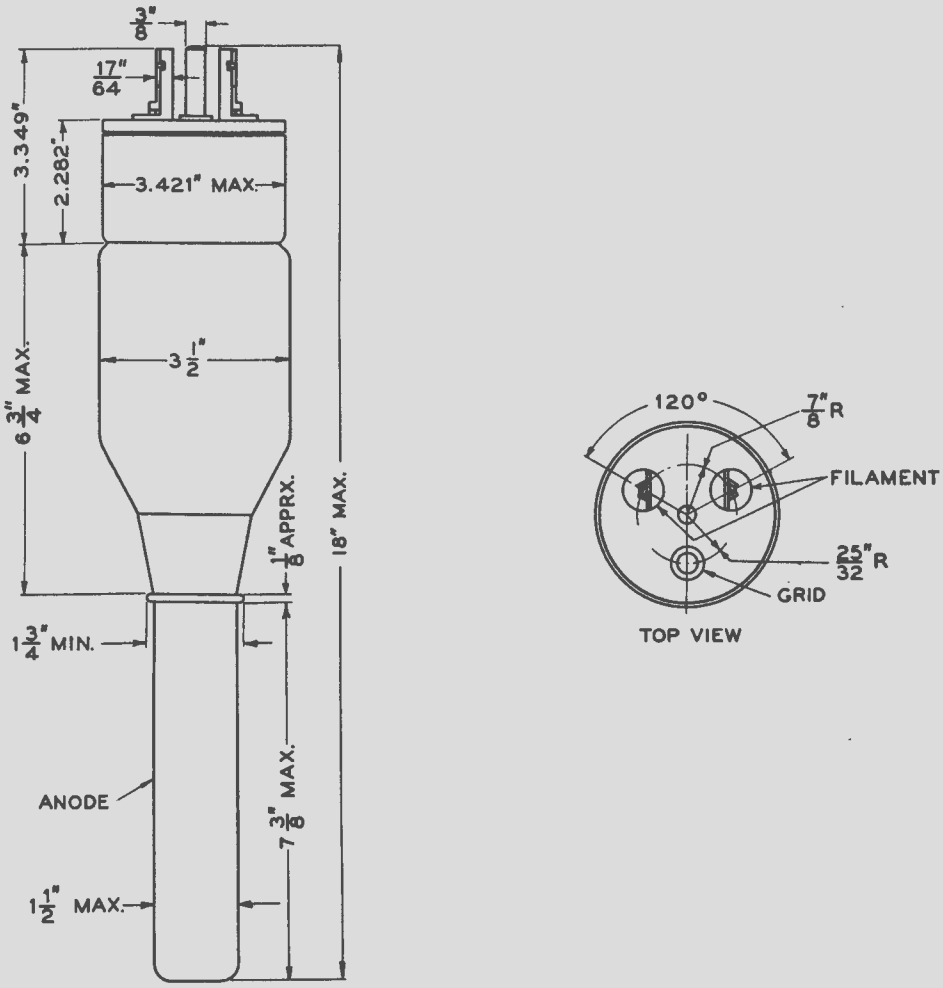

FIG. 1

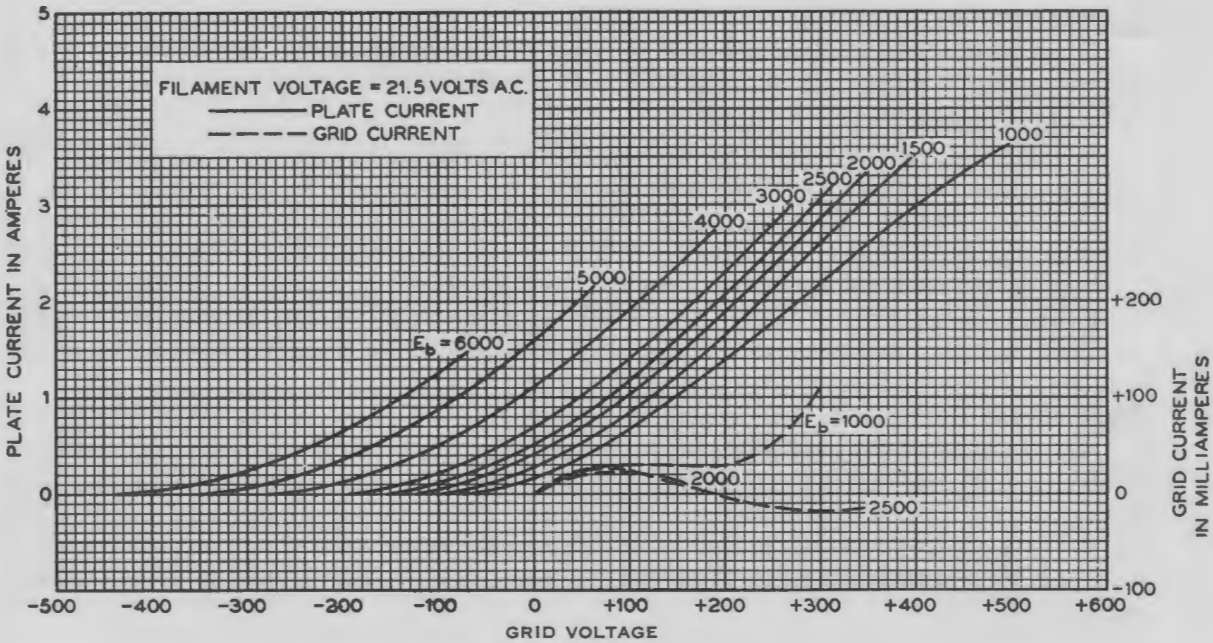
FILAMENT VOLTAGE = 21.5 VOLTS A.C.
PLATE CURRENT
GRID CURRENT
PLATE CURRENT IN AMPERES
GRID CURRENT IN MILLIAMPERES
GRID VOLTAGE
E_b = 6000
5000
4000
3000
2500
2000
1500
1000
E_b = 1000
2000
2500
-500
-400
-300
-200
-100
0
+100
+200
+300
+400
+500
+600
+200
+100
0
-100

FIG. 2

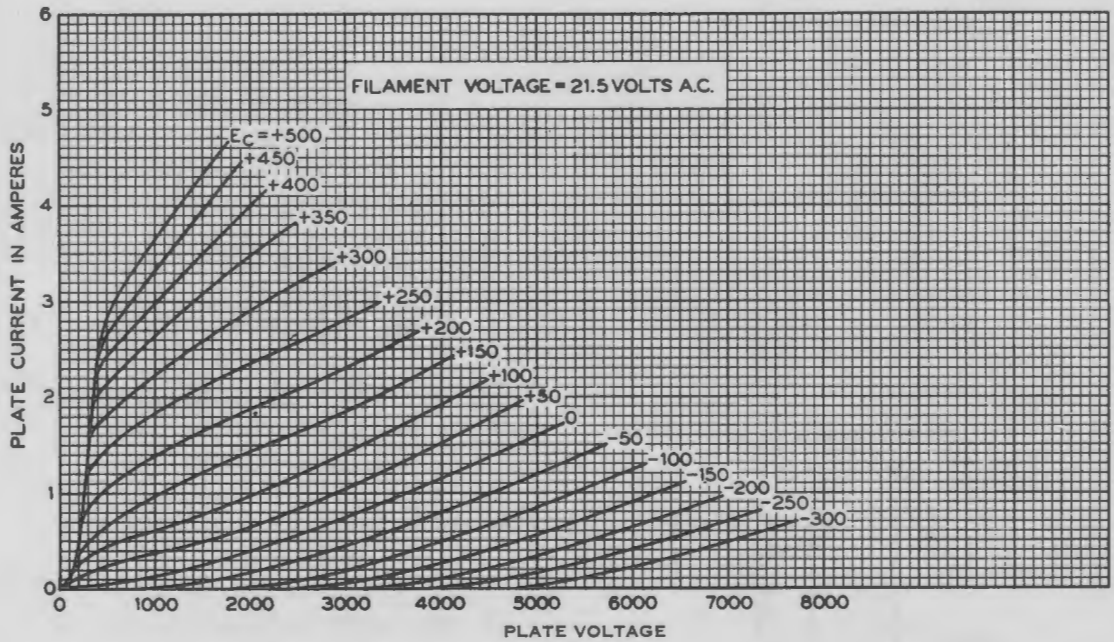
FILAMENT VOLTAGE = 21.5 VOLTS A.C.
PLATE CURRENT IN AMPERES
PLATE VOLTAGE
E_c = +500
+450
+400
+350
+300
+250
+200
+150
+100
+50
0
-50
-100
-150
-200
-250
-300
0
1000
2000
3000
4000
5000
6000
7000
8000

FIG. 3