GR

November 19, 1947

14.5/904

Sylvania Electric Products, Inc.
500 Fifth Avenue
New York 18, N.Y.

Gentlemen:

We wish to secure technical information on your line of "Rocket" tubes. Our main interest is in some tube which will produce useful gain as a radio frequency amplifier in the range 1000 to 1500 megacycles per second.

The electrical characteristics we desire are grid-plate, grid-cathode and plate-cathode capacities; families of transconductance curves; grid-cathode electronic loading conductance and amplification factor.

We also wish to secure data on mechanical dimensions and tolerances along with any information you may have on performance of these tubes and associated cavities.

Very truly yours,

Grote Reber, Radio Physicist
Experimental Ionospheric Research Section
Central Radio Propagation Laboratory

GR:EQ

SYLVANIA ELECTRIC PRODUCTS INC.
Advanced Development Laboratory
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DESIGN PRINCIPLES OF PLANAR TRIODES

During the war requests were made by the armed forces for the development of a triode capable of operating at frequencies up to or beyond the 3000-megacycle region. The tube was also required to be capable of large-scale production, and to operate at a minimum of heater power so that it could be used in portable equipment. Types 2C36 and 2C37, and type SB-846B(experimental number) are three of the planar-grid, disc-seal triodes which Sylvania Electric developed to fulfill those conditions, and which are now available for civilian use.

Three design features of these tubes are of major importance to simplified and efficient operation at ultra-high frequencies: (1) the cathode-pencil design eliminates mechanical and electrical lumps from the heater-cathode line, (2) the stretched-grid method of making planar grids provides a means for obtaining uniformity and stability of performance characteristics, and (3) the disc-seal type of construction satisfies the requirement for low lead inductance, because the leads become zero in length. Part of the radio-frequency circuit then appears inside the tube envelope.

These tube types are provided with more simplified tuning features than are characteristic of other tubes which generate ultra-high frequencies, and are adaptable to a wide range of uses in the industrial-electronic, communication, and navigation fields. They can be used in relatively simple waveguide systems, largely because of such design features as described in (1) above.

A schematic assembly of the type 2C37 ultra-high-frequency triode is shown in Fig. 1. The glass envelope is sketched in thin lines and the metal parts in heavy lines. Shown from top to bottom, the component parts are: anode disc with anode insert riveted in place; grid disc with grid riveted in place; and cathode line with the heater and cathode assembly, visible through a cut-away portion of the outer cathode sleeve.

The area of the active electrodes is quite small in comparison with that of the discs. Interelectrode spacings have been exaggerated in the sketch for the sake of clarity. The disc and cathode lines are arranged so as to fit conveniently into a concentric transmission-line tuner.

The anode disc has a flat external surface to act as a reference plane and stop when the tube is inserted in the tuner, and in addition the large area of contact allows heat to be conducted away readily. The grid disc has a folded external surface with a rolled lower edge for insertion in a cylinder which forms one conductor of the concentric transmission line.

All external surfaces are silver plated for low radio-frequency resistance.

One of the advantages of this type of tube construction is the flexibility in disc arrangements to fit various types of circuits. Five types of disc-seal triodes are shown in Fig. 2, all having the same internal construction but differing externally. Featured left to right, are (1) folded anode disc, (2) flat grid disc, (3) inverted discs, (4) widely-spaced discs, and (5) type 2C37. A special long anode insert must be used with (4) but otherwise its internal construction is the same as the others.

Type 2C36

The type 2C36 ultra-high-frequency oscillator has three long rivets extending from the anode insert through holes in the grid and running down parallel to the outer cathode sleeve as shown by the dotted lines in Fig. 1. These long rivets provide feedback between the cathode and plate circuits for use as an oscillator at ultra-high frequencies. The type 2C36 is intended primarily for use as a pulse-modulated oscillator at frequencies up to approximately 1200 megacycles. The tentative ratings and characteristics are listed in Table 1.

The type 2C36 fits into a quarter-wave, concentric-line circuit similar to that shown for the 2C37 in Fig. 5. A small amount of adjustable, external feedback is generally necessary in order to obtain optimum power output at any given frequency. A feedback probe between the output line and input line may be used as shown in the figure. With plate-pulse modulation, the grid may be operated at zero bias, eliminating the necessity of insulating the cathode from the grid in the input-line plunger.

Type 2C37

The type 2C37 ultra-high-frequency triode is constructed as shown in Fig. 1. Since it has no internal feedback it is more of a general-purpose type than the 2C36, and it may be used as a grounded-grid amplifier, oscillator, or multiplier, at frequencies up to the 3000-megacycle region. Tentative ratings and characteristics appear in Table 11. The power required to operate the heater at 6.3 volts is approximately 2.5 watts. In any practical circuit the area of contact with the anode disc should be sufficiently large to allow adequate cooling so that 5.0 watts can be dissipated without exceeding the maximum allowable seal temperature. The principal difference in interelectrode capacitance between the 2C36 and 2C37 occurs in the value of output capacitance due to the feedback rivets.

A type 2C37 in a typical quarter-wave, concentric-line circuit is shown in Fig. 5. A feedback probe provides the external feedback necessary for oscillation. If the tube is used as an amplifier, the feedback probe may be removed and a loop or probe connected to the input line. This type of circuit limits operation in the quarter-wave mode to approximately 1500 megacycles. Higher frequencies may be reached by adjusting the input and output lines so that one is three-fourths wavelength and the other is five-fourths wavelength. Other circuits such as the re-entrant cavity shown in Fig. 6 may be used.

SB-846B

The type SB-846B is a developmental type identical to the 2C37 except for special cathode processing for pulse operation. It was developed primarily for use as a pulse-modulated oscillator at 3000 megacycles. Tentative ratings and characteristics are identical to those listed for the 2C37 in Table 11 except for the typical operating characteristics which are listed in Table 111. These conditions apply when the tube is operated in a half-wave re-entrant-cavity circuit as shown in Fig. 6.

In this circuit, the length of cylinder on the grid forming a half-wave transmission line determines the frequency of operation. Direct-current contact to the grid is made through a spring clip from the wall of the cavity, and it may be insulated from the cavity with a capacitance by-pass. For plate-pulse modulation the grid is operated at D.C. ground potential so that no insulation is necessary. Tuning the plunger optimizes power output with very little effect on frequency. Feedback is accomplished by the open-ended grid cylinder, allowing currents to flow from the output circuit to the input circuit. Power is coupled out by means of a probe or loop as usual.

Measurements of frequency drift caused by variations in heater voltage, plate voltage, and duty cycle have been made on the SB-846B in this circuit. Results appear in the curves of Fig. 7.

TABLE 1

Type 2036

Ultra-high-frequency oscillator

Tentative ratings and characteristics

Electrical

Heater voltage (AC or DC)	6.3 volts
Heater current	0.4 amperes
Maximum plate dissipation	5.0 watts
Maximum seal temperature	175 degrees C.
Maximum plate voltage (pulsed)	1500 volts
Maximum operating frequency	1200 megacycles

Direct Interelectrode Capcitances (average)

Grid-plate	2.40 micromicrofarads
Grid-cathode	1.40 micromicrofarads
Plate-cathode	0.36 micromicrofarads

Characteristics

Transconductance (E_b=180 volts D.C., R_k= 400 ohms)	4500 micromhos
Amplification factor " " " " " "	25
Plate current	11.5 milliamperes

Typical Operating Conditions

Ultra-high-frequency Oscillator - Plate Modulated

Plate voltage (peak)	1000 volts
Plate current (peak)	0.9 amperes
Grid voltage	0.0 volts
Pulse repetition frequency	2000 pulses per second
Pulse width	2.0 microseconds
Frequency of operation	1000 megacycles
Power output (peak)	200 watts

Mechanical

Maximum over-all length	2.34 inches
Maximum over-all diameter	1.01 inches

TABLE II

Type 2C37
Ultra-high-frequency, general-purpose triode

Tentative ratings and characteristics

Electrical

Heater voltage (A.C. or D.C.)	6.3 volts
Heater current	0.4 amperes
Maximum plate voltage	350 volts D.C.
Maximum plate dissipation	5.0 watts
Maximum seal temperature	175 degrees C.
Maximum operating frequency	3000 megacycles

Direct Interelectrode Capacitances (Average)

Grid-plate	1.85 micromicrofarads
Input	1.40 micromicrofarads
Output	0.02 micromicrofarads

Characteristics

Heater voltage	6.3 volts
Heater current	0.4 amperes
Plate voltage	180 volts D.C.
Cathode bias resistor	400 ohms
Plate current	11.5 milliamperes D.C.
Transconductance	4500 micromhos
Amplification factor	25
Grid voltage for I_b=10 microamperes D.C.	-13.0 volts D.C.

Typical Operating Conditions

Ultra-high-frequency Oscillator - continuous wave

Plate voltage	150 volts D.C.
Plate current	15 milliamperes D.C.
Grid resister	3000 ohms
Developed grid voltage (approximate)	-11.0 volts D.C.
Frequency	1000 megacycles
Power output	0.5 watts

Ultra-high-frequency Oscillator - continuous wave

Heater voltage	6.3 volts
Plate voltage	100.0 volts D.C.
Grid resister	470 ohms
Plate current	22 milliamperes
Frequency	1750 megacycles
Power Output	0.27 watts

Mechanical

Maximum over-all length	2.34 inches
Maximum over-all diameter	1.01 inches

TABLE 111

Type SB-846B

Developmental ultra-high-frequency triode

Typical Operating Conditions

Heater voltage	6.3	volts
Heater current	0.4	amperes
Plate voltage (peak)	800	volts
Plate current (peak)	0.7	amperes
Grid voltage	0.0	volts
Pulse repetition frequency	2000	pulses per second
Pulse width	1.0	microseconds
Frequency of operation	3000	megacycles
Power output (peak)	100	watts

SYLVANIA TYPE 2C37
U-H-F Triode - Schematic Assembly

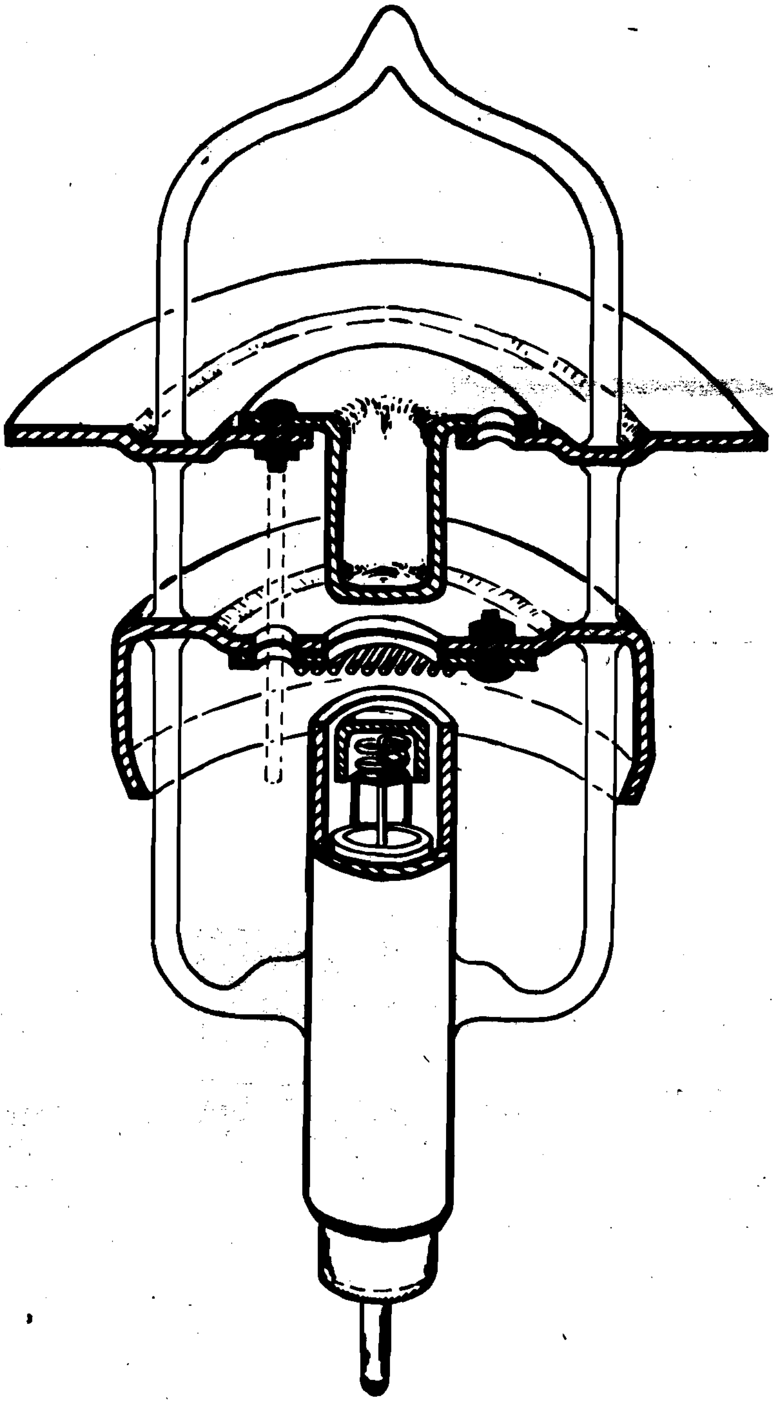


Fig. 1-Thin lines represent glass envelope, heavy lines, the metal parts. Top to bottom, the parts are: anode disc with anode riveted in place; grid disc with grid riveted in place; and cathode line with the heater and cathode assembly, visible through a cut-away portion of the outer cathode sleeve. Interelectrode spacings are exaggerated for the sake of clarity.

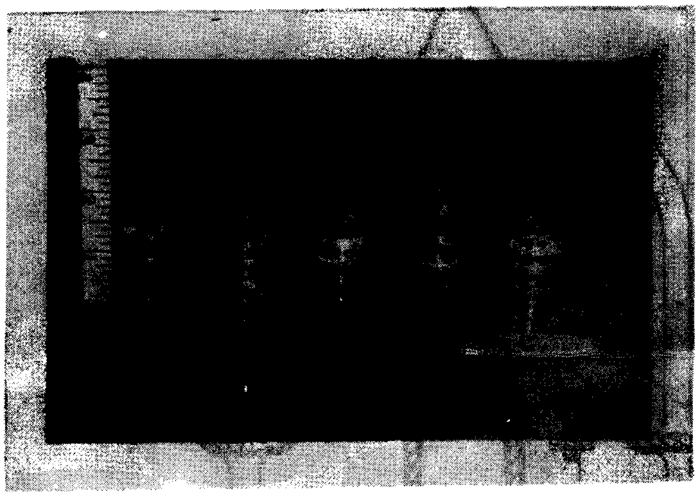
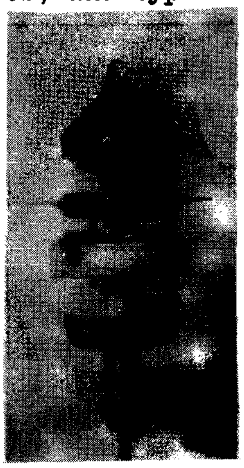


Fig. 2 - Five types of disc-seal triodes, all having the same internal construction, but differing externally. Left to right: folded anode disc, flat grid disc, inverted discs, widely-spaced discs, and type 2C37. Scale is in inches.



Actual size,
2C36, 2C37
and SB-846B

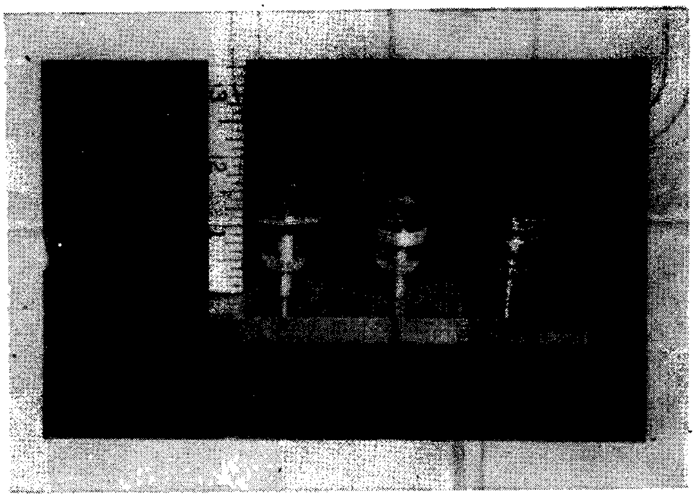


Fig. 3 - U H F diodes are constructed in much the same manner. Left to right: diode with a flat disc, diode with folded disc, and type 2C37 (for comparison)

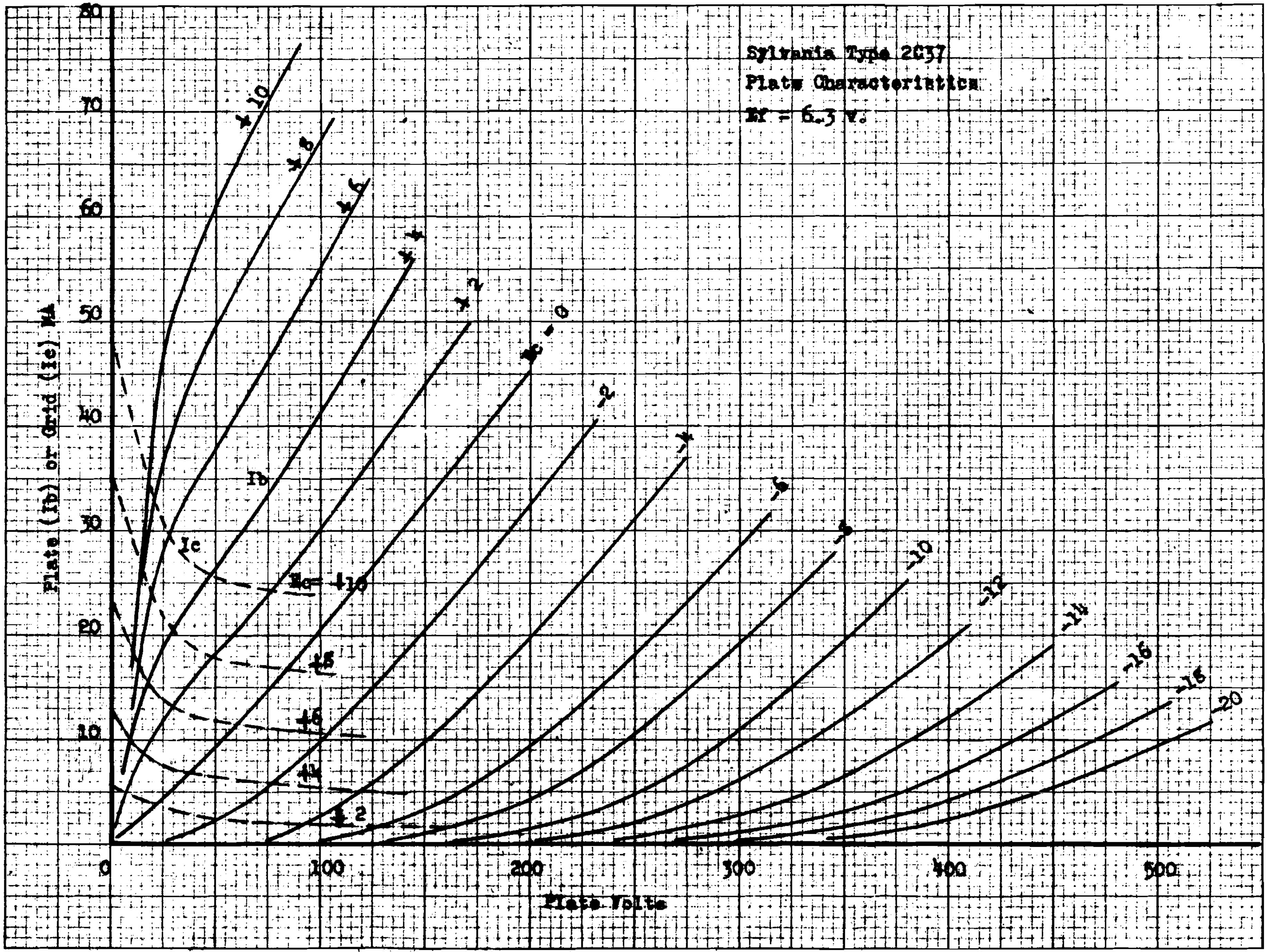

Sylvania Type 2C37
Plate Characteristics
Ef = 6.3 V.
Plate (Ib) or Grid (Ic) MA
Plate Volts
0
100
200
300
400
500
10
20
30
40
50
60
70
80
+10
+8
+6
+4
+2
Ec = 0
-2
-4
-6
-8
-10
-12
-14
-16
-18
-20
Ib
Ic
Ec = +10
+8
+6
+4
+2

Fig. 4a

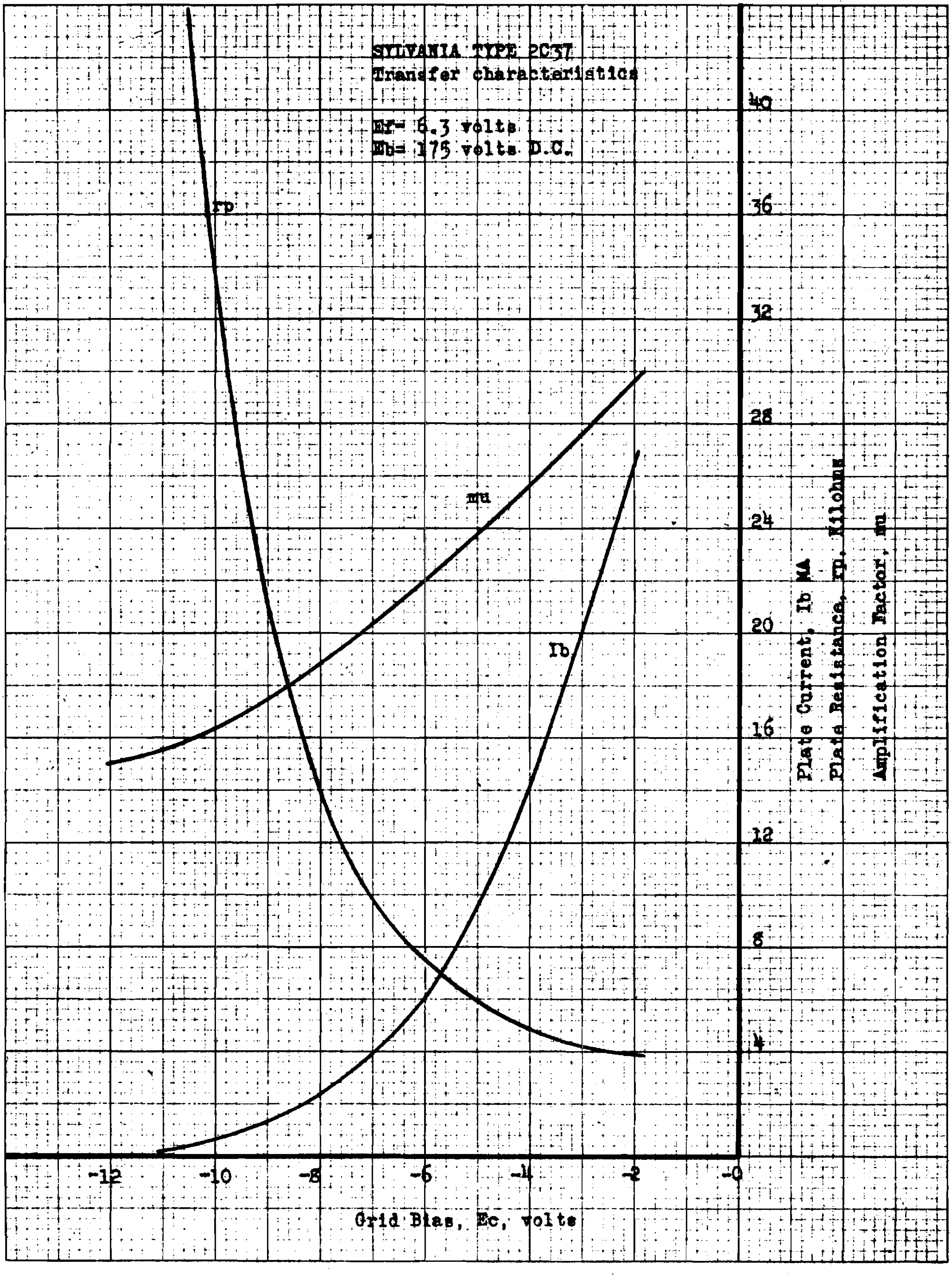

SYLVANIA TYPE 2C37
Transfer characteristics
Ef= 6.3 volts
Eb= 175 volts D.C.
rp
mu
Ib
-12
-10
-8
-6
-4
-2
-0
4
8
12
16
20
24
28
32
36
40
Grid Bias, Ec, volts
Plate Current, Ib MA
Plate Resistance, rp, Kilohms
Amplification Factor, mu

Fig. 4b

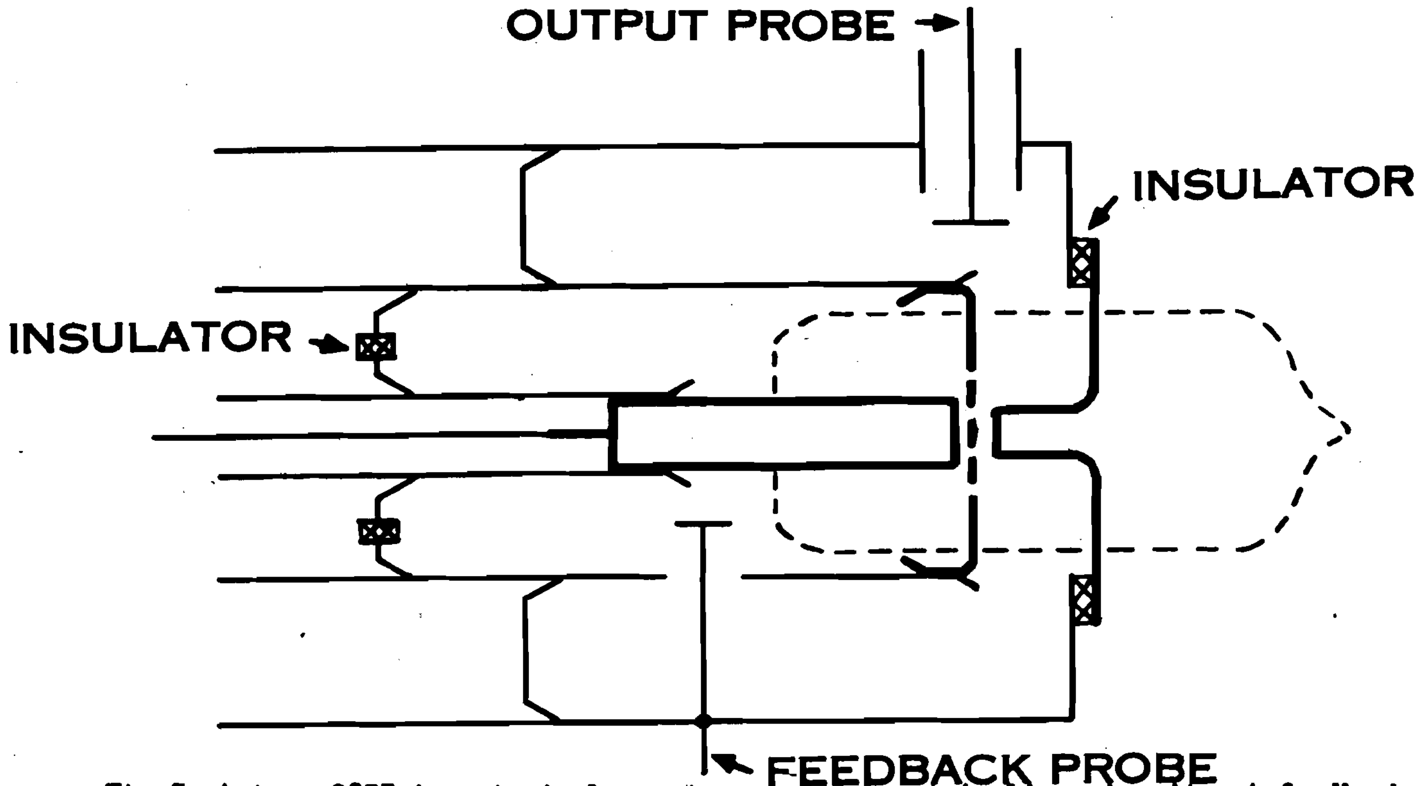


Fig.5- A type 2C37 in a typical quarter-wave concentric-line circuit. A feedback probe provides the external feedback necessary for oscillation. If the tube is used as an amplifier, the feedback probe may be removed and a loop or probe connected to the input line. This type of circuit limits operation in the quarter-wave mode to approximately 1500 mc. Higher frequencies may be reached by adjusting the input and output lines so that one is 3/4 wavelength and the other is 5/4 wavelength. Other circuits such as the re-entrant cavity shown in Fig. 6 may be used.

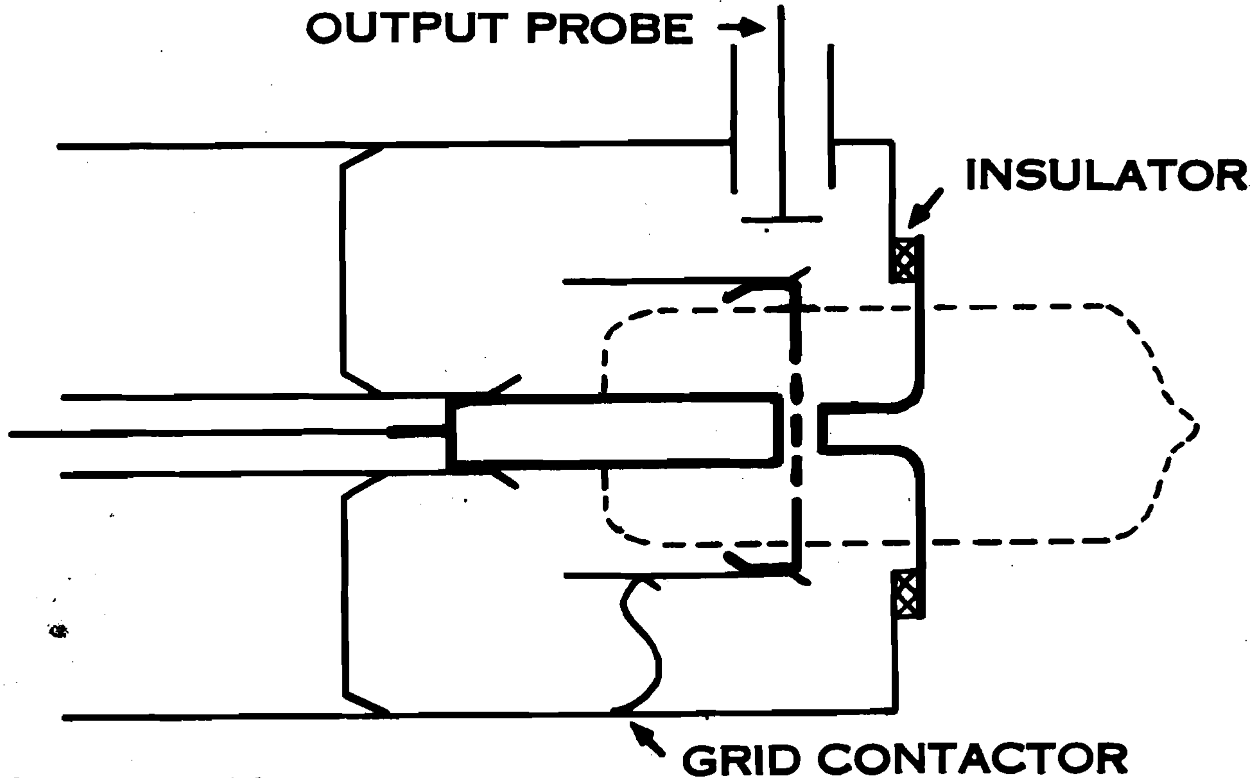
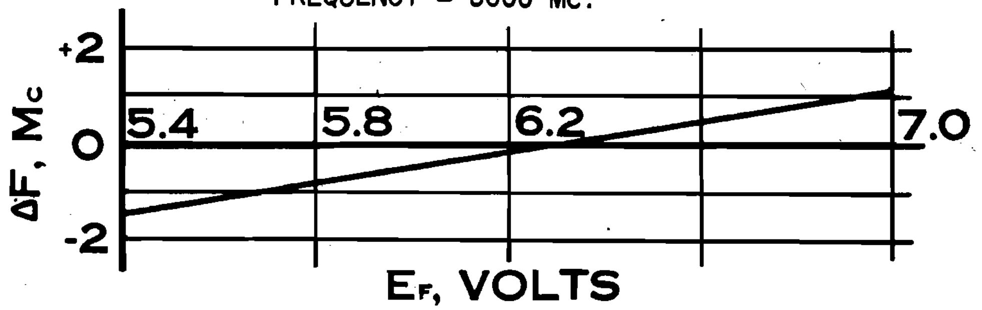


Fig. 6- A type SB-846B is shown in this circuit in which the length of cylinder on the grid forming a half-wave transmission line determines the frequency of operation. Direct current contact to the grid is made through a spring clip from the wall of the cavity, and it may be insulated from the cavity with a capacitance by-pass.

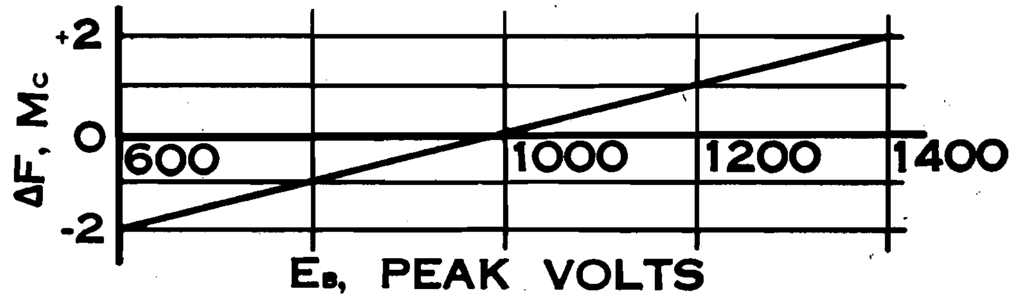
TYPE SB846-B

TYPICAL
FREQUENCY DRIFT CHARACTERISTICS

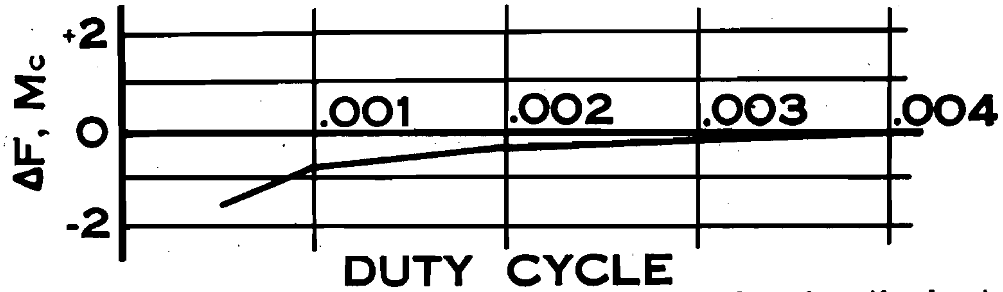
PULSE RATE = 2000 PULSES PER SECOND
PULSE DURATION = 2 MICROSECONDS
E_B = 1000 VOLTS PEAK
FREQUENCY ≈ 3000 Mc.



PULSE RATE = 2000 PULSES PER SECOND
PULSE DURATION = 2 MICROSECONDS
FREQUENCY = 3000 Mc.
E_F = 6.3 VOLTS



E_B = 1000 VOLTS PEAK
FREQUENCY = 3000 Mc.
E_F = 6.3 VOLTS



At 3000 Mc center frequency, the frequency drift in changing the heater voltage from 5.4 to 7.0 is in the order of 2 Mc per volt. Likewise, the drift in changing the peak plate voltage from 600 to 1400 is approximately one-half Mc per 100 volts. The total drift in changing the duty cycle from 0.0005 to 0.004 is in the order of 2Mc.

Fig. 7

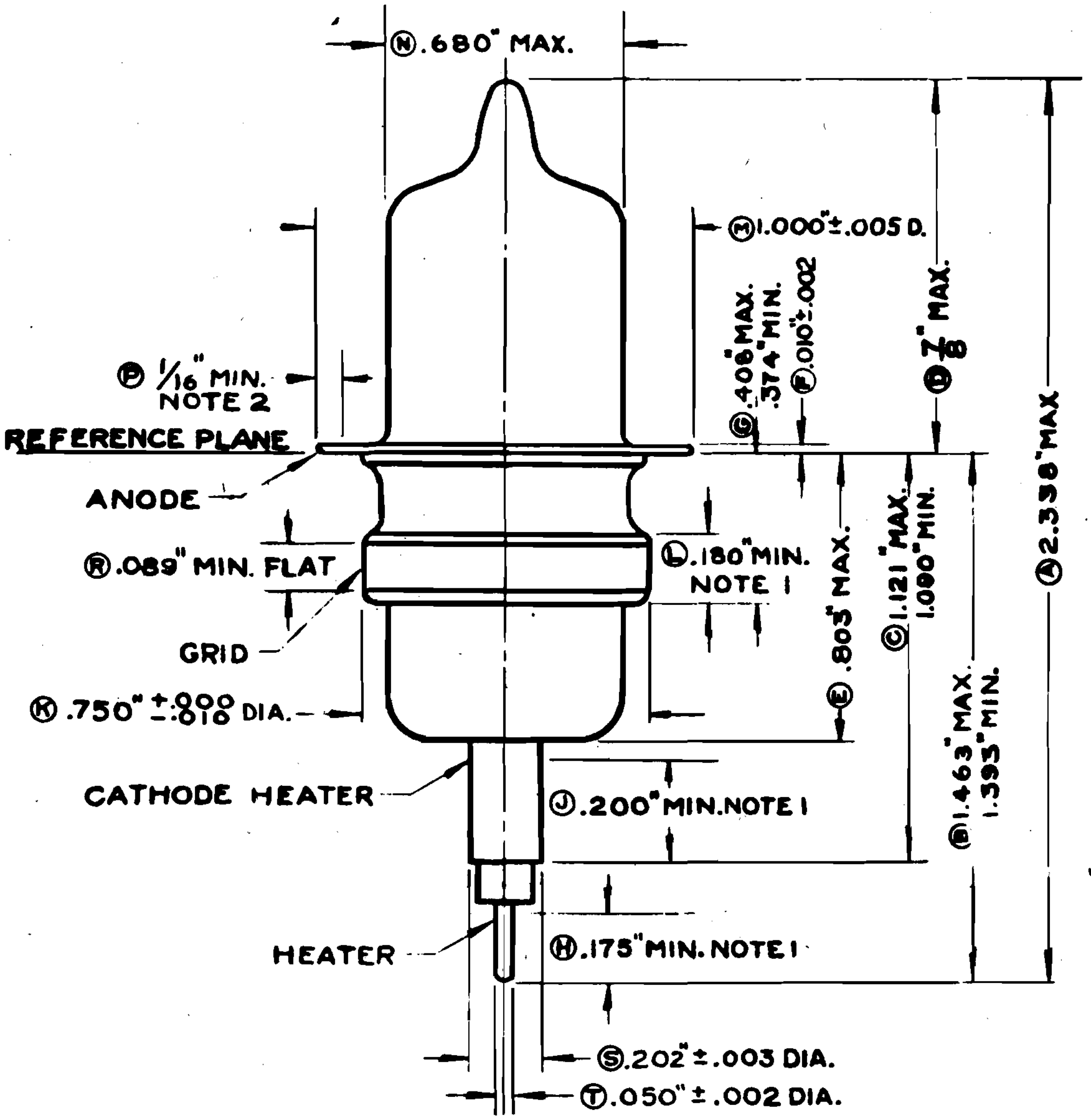


Fig. 8-Outline drawing showing the dimensions that are necessary for designing cavities. The dimensions are the same for each of the three tube types - 2C36, 2C37 and SB-846B