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U-H-F BEAM-DEFLECTION MIXER

1636

RCA-1636 is a mixer tube designed primarily for operation at the ultra-high frequencies from 400 to 600 megacycles. It employs a new principle in that the operation of the tube depends on the movement of an electron beam, by a pair of deflecting electrodes, across narrow apertures. The deflecting electrodes, because they are not in the electron stream, require very little power and, therefore, the input-circuit loading is low at the ultra-high frequencies. By this method of control, also, coupling between the input and the output circuits is reduced to a very low value. A well-defined electron beam and narrow apertures are used to obtain a high ratio of transconductance to effective beam current. In addition, the 1636 includes a single stage of secondary-emission multiplication to increase the overall transconductance. As compared with conventional tubes at the ultra-high frequencies, the 1636 is capable of providing a several-fold improvement in gain and a signal-to-noise ratio which is several db better.

Additional features of the 1636 are its low input capacitance together with short deflecting-electrode leads which permit the use of a relatively large external circuit, and the low power required from the local oscillator.

TENTATIVE DATA

HEATER VOLTAGE (A.C. or D.C.)	6.3	Volts
HEATER CURRENT	0.3	Ampere
DIRECT INTERELECTRODE CAPACITANCES:		
Each Deflecting Electrode to Grid-Anode	1	μμf
Deflecting Electrode DJ_1 to Deflecting Electrode DJ_2	1 *max.*	μμf
Dynode to Grid-Anode	1.4	μμf
OVERALL LENGTH	4-11/16" ± 1/8"	
MAXIMUM SEATED HEIGHT	4-1/4"	
RADIUS	1-1/8" ± 1/16"	
BULB	T-10-1/2	
CAPS (Three)	Terminals	
BASE	Medium Shell Octal 8-Pin	

Maximum Ratings Are Design-Center Values

MAXIMUM RATINGS and TYPICAL OPERATING CONDITIONS

GRID-ANODE (Grids No.2,3,4) VOLTAGE	300 *max.*	Volts
DYNODE VOLTAGE	250 *max.*	Volts
DEFLECTING ELECTRODE VOLTAGE (Focusing)	150 *max.*	Volts
GRID-ANODE DISSIPATION	3 *max.*	Watts
TYPICAL OPERATION:		
Grid-Anode Voltage	300	Volts
Dynode Voltage	240	Volts
Deflecting Electrode Focusing Voltage ##	140	Volts
Deflecting Electrode Centering Voltage *	-5 to +5	Volts
Cathode Shield (Grid No.1)	0	Volts
Cathode Bias	**	
Deflecting Electrode Voltage for Operation on Oscillator Fundamental Frequency	1 *max.*	Volt#

* Centering voltage is given with respect to deflecting-electrode focusing voltage.
\# Peak-to-peak volt.
** 1000-ohm cathode resistor is recommended.
\## Must be adjustable to ±15 volts in order to focus the electron beam.

BEAM-DEFLECTION MIXER CONSIDERATIONS

A beam-deflection mixer is a vacuum tube whose basis of operation is deflection control of an electron beam. In the 1636, a well-defined rectangular beam of electrons, focused on a barrier, is deflected across two narrow apertures by a signal voltage and a local oscillator voltage impressed on the deflecting electrodes.

The operation of the 1636 is most readily discussed with reference to Fig. 1 in which the essential parts are identified. The cathode, the cathode shield (Grid No. 1), and the first and second apertures (Grids No. 2 and 3) serve to produce, form and accelerate the electron beam. The deflecting electrodes move the beam across two parts of the third aperture (Grid No. 4). In addition, the deflecting electrodes are used to focus and center the beam on the barrier in Grid No. 4. Grids No. 2, 3, and 4 are operated at a common positive voltage with respect to the cathode, and they are constructed in a single assembly in the tube. This assembly, called the grid-anode, takes its name from the combined functions of the three parts.

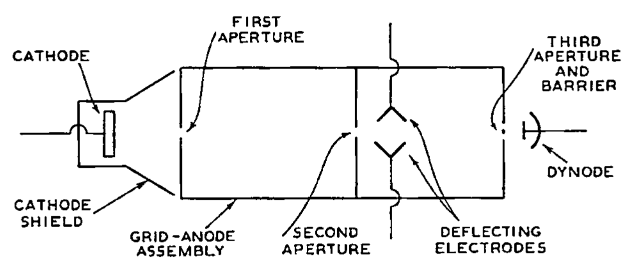


Fig. 1 - Schematic arrangement of type 1636 structure.

A dynode, or secondary-emission multiplier, is located just past the Grid No. 4 so that it intercepts the electron beam when the beam is deflected to either side of the barrier in Grid No. 4. Since the dynode is operated at a lower voltage with respect to the cathode than the grid-anode, secondary electrons from the dynode are attracted to the grid-anode. The output of the 1636 appears in the dynode, grid-anode circuit.

The apertures in Grid No. 4 are formed by a barrier which divides a rectangular opening in the center lengthwise. The barrier is lined up with the apertures in Grids No.2 and 3 so that it effectively blocks the electron beam, for the no-signal operating condition, from the dynode when the beam is centered and focused.

Emission from the dynode depends on the bombardment of the dynode by the electron beam. When the beam is deflected to either side of the barrier in Grid No.4, electrons will flow from the dynode to the grid-anode. As the beam is deflected further to either side, it is cut off from the dynode by the limits of the two apertures of Grid No.4. The output current characteristic for a properly centered and focused beam is then as shown in Fig. 2.

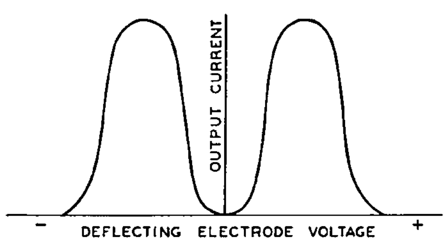


Fig. 2 - Proper output current characteristic.

Efficient operation of the 1636 depends on the ability of Grid No.4 to block or to pass all the electrons passing through the series of apertures. If the beam is not accurately focused on the barrier in Grid No.4, the quiescent output current will be high. External magnetic fields may so distort the beam that the apertures of Grid No.4 are scanned diagonally. Such operation will deform the output current characteristic as illustrated in Fig. 3.

The best operation of the tube is obtained by adjustment of the deflecting-electrode focusing and centering voltages to give the lowest minimum current between the two maximums. The two maximums should be about equal and the minimum should be but a small fraction of the maximum.

INSTALLATION

The *base* of the 1636 fits the standard octal socket which may be installed to hold the tube in any position. Connection to the dynode is made to the terminal at the top of the bulb, while connections to the deflecting electrodes are made to the two terminals at the side of the bulb. Leads to all of the terminals must be sufficiently flexible so that normal expansion will not place a strain on the glass at the seals. The lead wires whould be connected to the terminals by means of clamps attached to the leads before connections to the tube are made. The clamps should be sprung slightly so that they can be slipped on the terminals easily. Connections should never be soldered to the terminals as the heat of soldering may result in cracking of the seals. The terminals should never be used to support circuit parts.

The *heater* voltage, under any conditions of operation, should not be allowed to vary more than ± 10% from the rated value. Conventional heater-cathode circuits may be used.

The *cathode shield*, Grid No. 1, may be operated either with a bias or connected directly to the cathode. A self-biasing resistor of 1000 ohms connected between shield and cathode is recommended. The cathode shield is then placed at ground potential.

The *deflecting electrodes*, in addition to the adjustable positive voltage (for focusing), should be supplied with an adjustable voltage for centering the beam on the barrier in Grid No.4. A range of plus or minus five volts is sufficient. The beam should not be allowed to remain stationary on the dynode longer than is necessary to make circuit adjustments.

The dynode is supplied with a positive voltage somewhat lower than that of grid-anode.

APPLICATION

As a mixer, the 1636 may be operated on the fundamental of the local oscillator, or on the second or third harmonic of the local-oscillator frequency. This flexibility is made possible by the nature of the output-current, deflecting-electrode-voltage characteristic. Operation on the fundamental frequency of the local oscillator is recommended because of the better signal-to-noise ratio.

A typical mixer circuit is shown in Fig. 4. The signal voltage and the local oscillator voltage are both impressed across the deflecting electrodes. The input circuit may consist of a

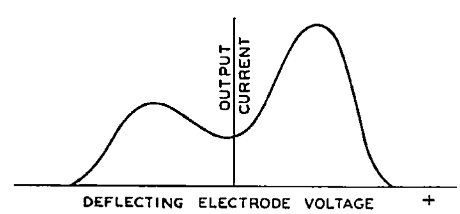


Fig. 3 - Deformed output current characteristic.

balanced line arranged to that d-c voltages may be fed to the deflecting electrodes. The line should be well shielded to minimize radiation loss. Adjustment of the circuit for best operation should begin with the deflecting-electrode voltages. With voltages of approximately the values shown under TYPICAL OPERATING CONDITIONS applied to the tube, the deflecting-electrode focusing and centering voltages should be adjusted simultaneously for the lowest current at the minimum-current point of the characteristic curve (see Fig. 2). This operation focuses and centers the beam on the barrier in Grid No.4.

Apply a signal voltage and tune the input circuit for the maximum step-up from the input line as indicated by an increase in output current.

This may be done easily with a signal in the order of 20 millivolts and without the local oscillator in operation. The local oscillator is then coupled to the input circuit and its frequency and amplitude are adjusted so that the dynode current is from 10 to 20 per cent of the maximum

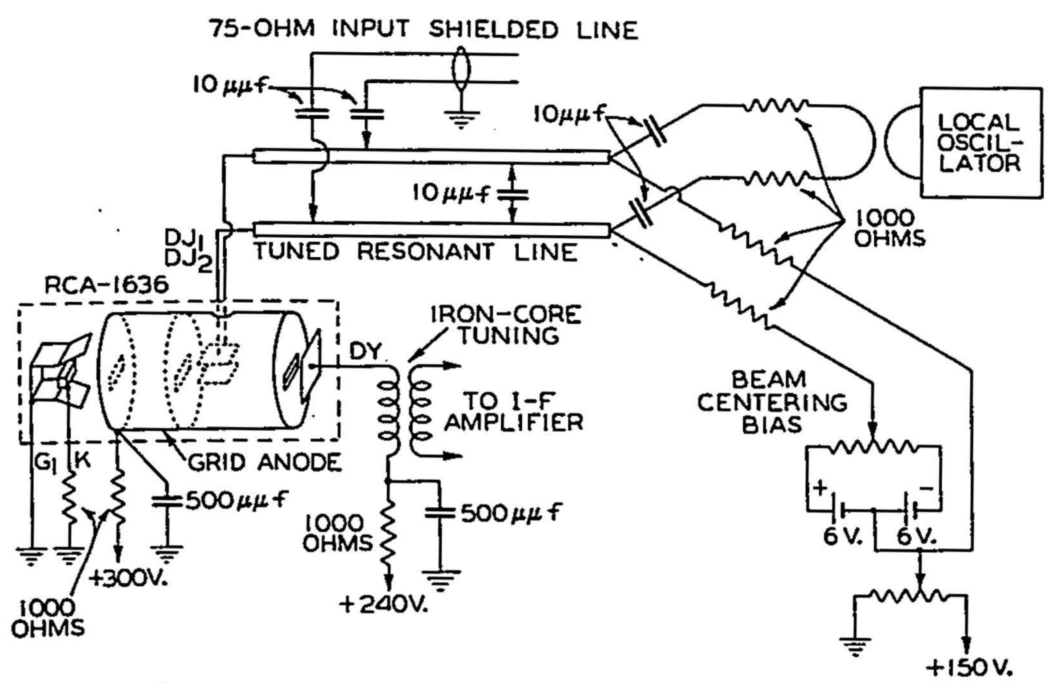


Fig. 4 - Typical mixer circuit for RCA-1636.

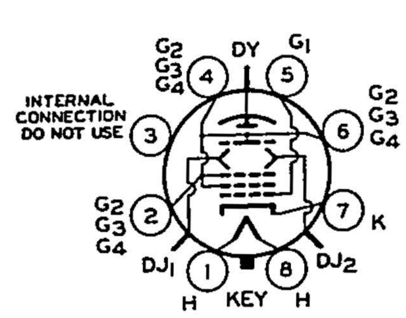
instantaneous dynode current (current at the maximum-current point of the characteristic curve Fig. 2). A final adjustment of the deflecting-electrode focusing and centering voltages for the condition producing the best gain should be made.

The *signal-to-noise ratio* can be improved by increasing the signal input coupling slightly higher than for the condition producing the maximum gain. The local oscillator output should be slightly lower than for maximum gain.

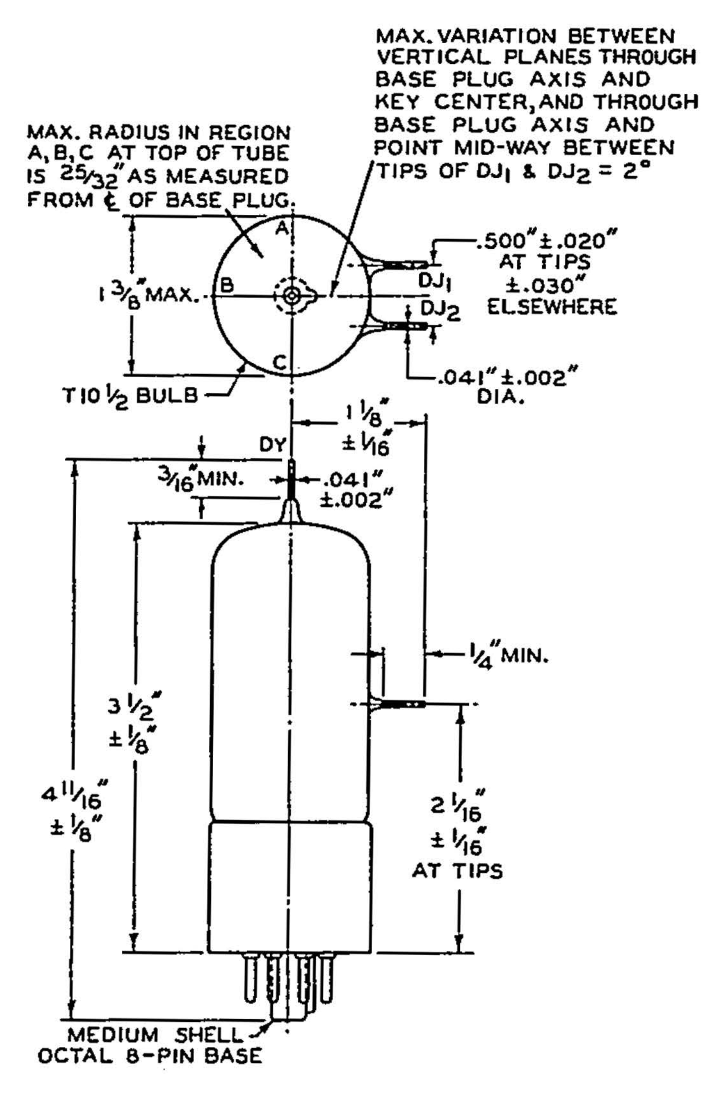
Second-harmonic operation requires that the beam centering voltage on the deflecting electrodes be adjusted to a point of maximum slope on the characteristic curve. Local oscillator excitation must be increased over that needed for operation on the fundamental. Third harmonic operation is obtained with the same centering adjustment as for fundamental operation but twice the oscillator excitation is required. Operation on either the second or third harmonic results in slightly less gain than with fundamental operation and a signal-to-noise ratio which is considerably poorer.

The equivalent noise voltage of a receiver using this tube in the first stage is in the order of 13 db above the thermal noise of a dummy antenna when the tube is used at oscillator fundamental in the frequency range for which it was designed (400 to 600 mc). This is about 3 db better than the capability of any commercial type previously available for use at the ultra-high frequencies.

Bottom View of Socket Connections



DY = DYNODE
DJ_1, DJ_2 = DEFLECTING ELECTRODES
G_1 = CATHODE SHIELD
G_2, G_3, G_4 = GRID-ANODE
H = HEATER
K = CATHODE



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