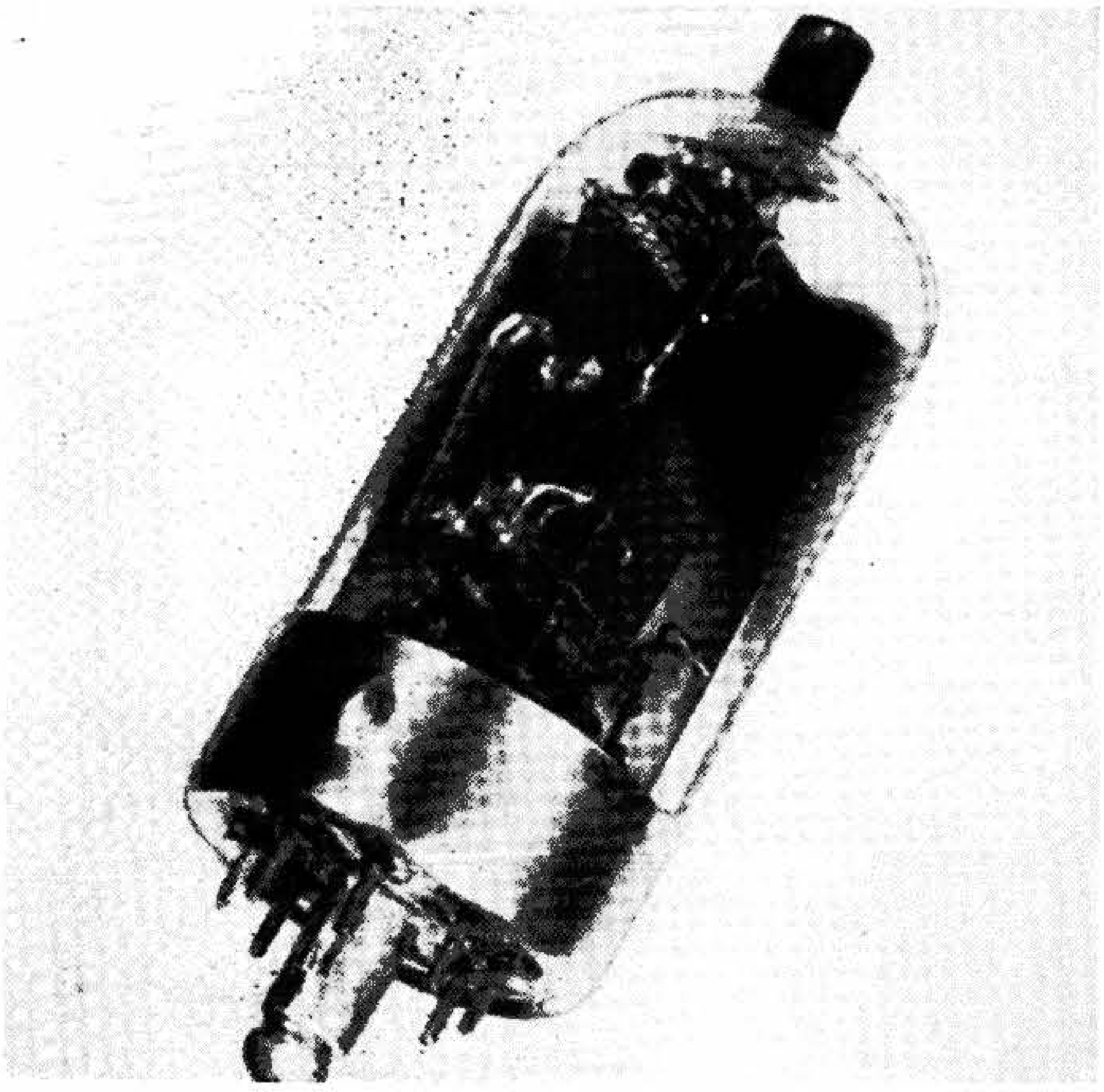
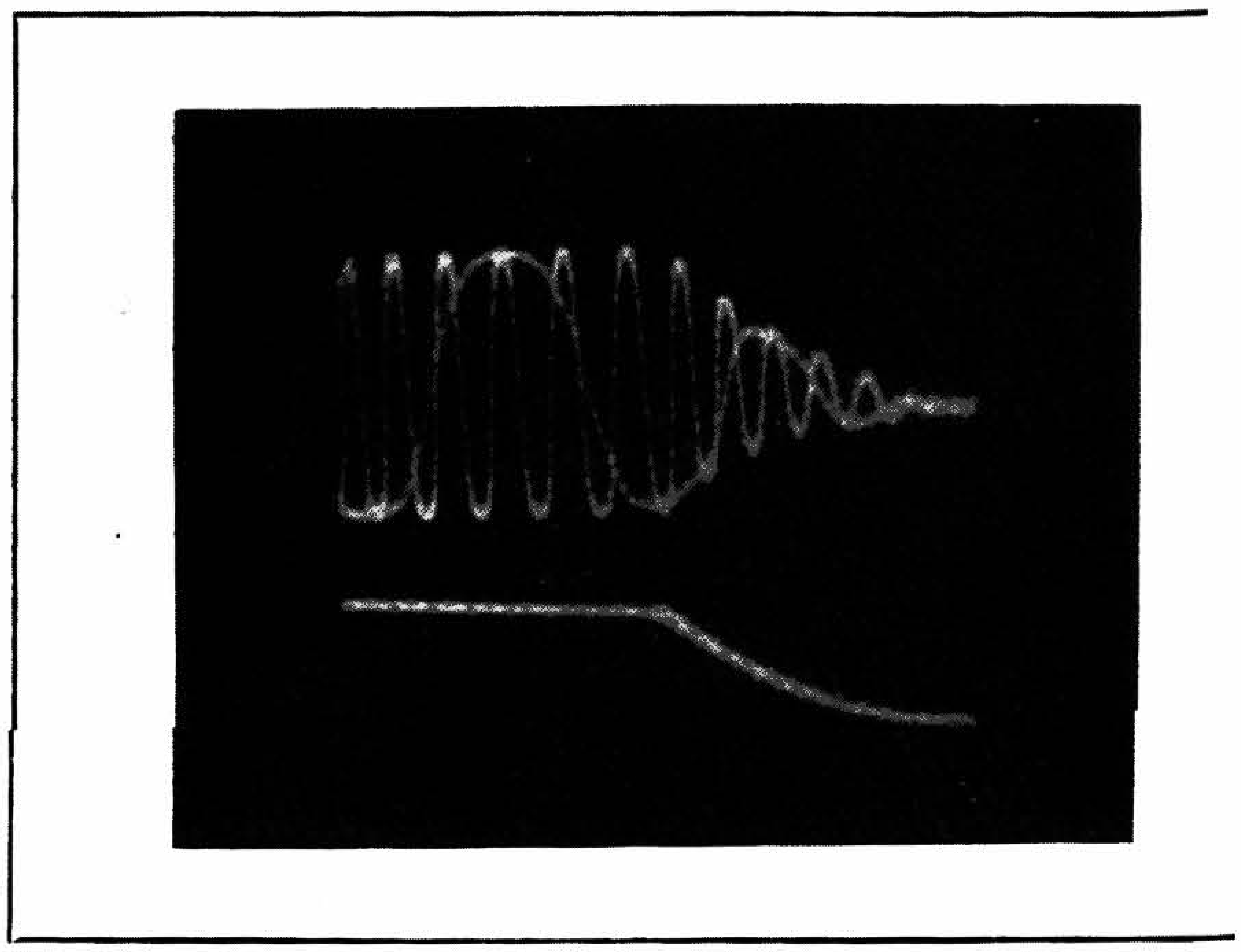


Anodyne tube utilizes T-9 bulb with grid cap



Input to deflection plates is modulated by control-grid

# Anode-Dynode Beam

**SUMMARY** —— Zero net operating plate current is achieved in amplifier using composite output element. Anode section gives positive transconductance. Dynode section gives negative transconductance. Tube is useful in gating circuits, difference amplifiers, voltage regulators, multivibrators, binary storage circuits and many others

CLASS-A amplification with zero quiescent plate current and other novel and useful operating characteristics may be achieved with the anode-dynode line beam deflection amplifier. The tube's characteristics are obtained by adding primary and secondary electron current through a common output load.

### Zero Quiescent Current

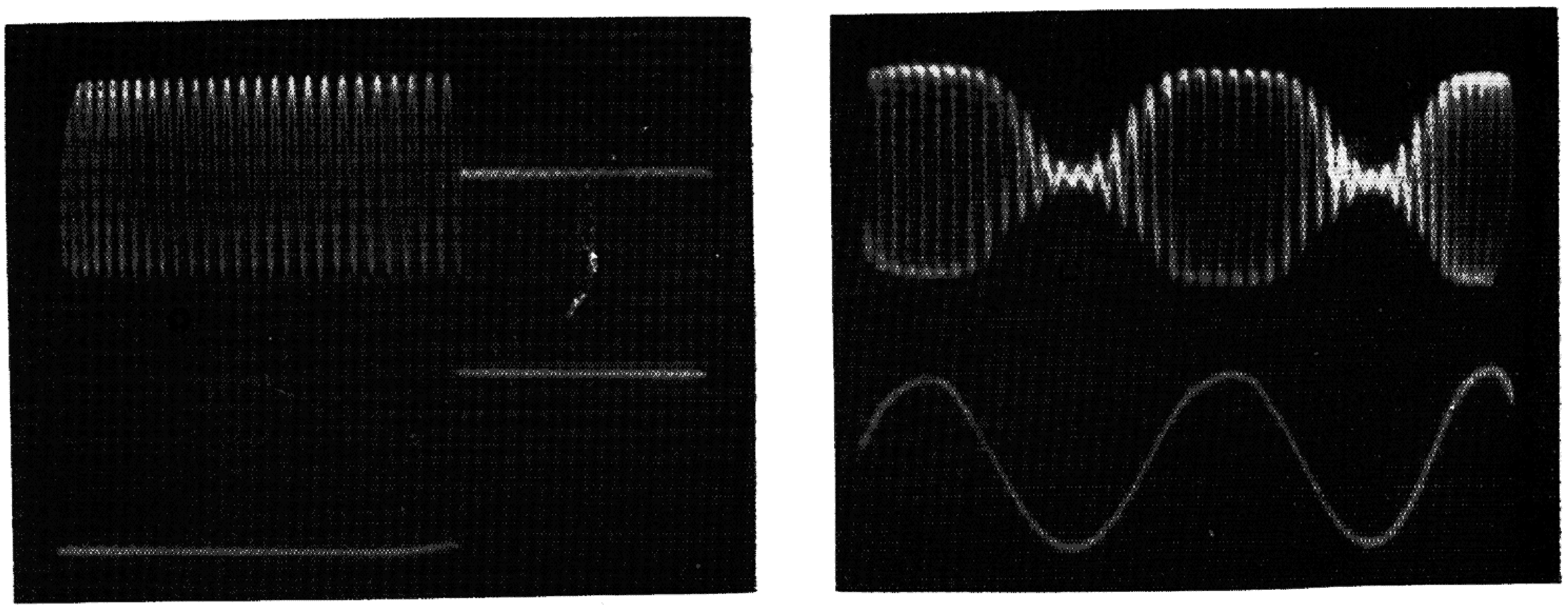
The static anode-dynode currents of the composite output element used in the tube are out of phase producing a net operating plate load current of zero. Dynamic currents obtained with signal variation, however, are in phase and additive. This mode of operation with zero quiescent current produces a composite output current-deflection voltage curve which is exceedingly linear, giving rise to comparatively constant transconductance for large signals.

On-off switching or coincidence operation of the tube is permitted at the zero current quiescent point without producing any undesirable plate current transient or distortion. Similarly, operation as a balanced modulator is obtained by insertion of inputs both on the deflection system and on the control grid located near the cathode. In addition, infinite variation of the transconductance of the tube is obtained without sacrificing operational linearity. This characteristic is ideal for automatic gain control.

Plate voltage-current characteristics of the anode-dynode tube can be made to exhibit linear negative as well as positive transconductance. This characteristic can be utilized with suitable interconnection to produce a number of negative resistance devices.

### Basic Tube Structure

Figure 1A illustrates a typical electrode layout employed to obtain zero quiescent current. As indi-



waveforms, bottom. Grid waveforms include saw tooth, left, square wave, center, and sine wave, right

# Deflection Amplifier

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cated, a line beam-forming electron gun is utilized with provisions for electrostatic beam focusing and deflection. The target contains an output anode and an output dynode or secondary-emissive surface. The dynode is physically separated from the anode by a suppressor element. This suppressor alters the potential gradient sufficiently to inhibit secondary electrons ejected from the anode.

A grid placed in front of the dynode and overlapping the anode serves as both a secondary electron collector and electron accelerator. The anode and dynode are electrically tied together and utilize a com-

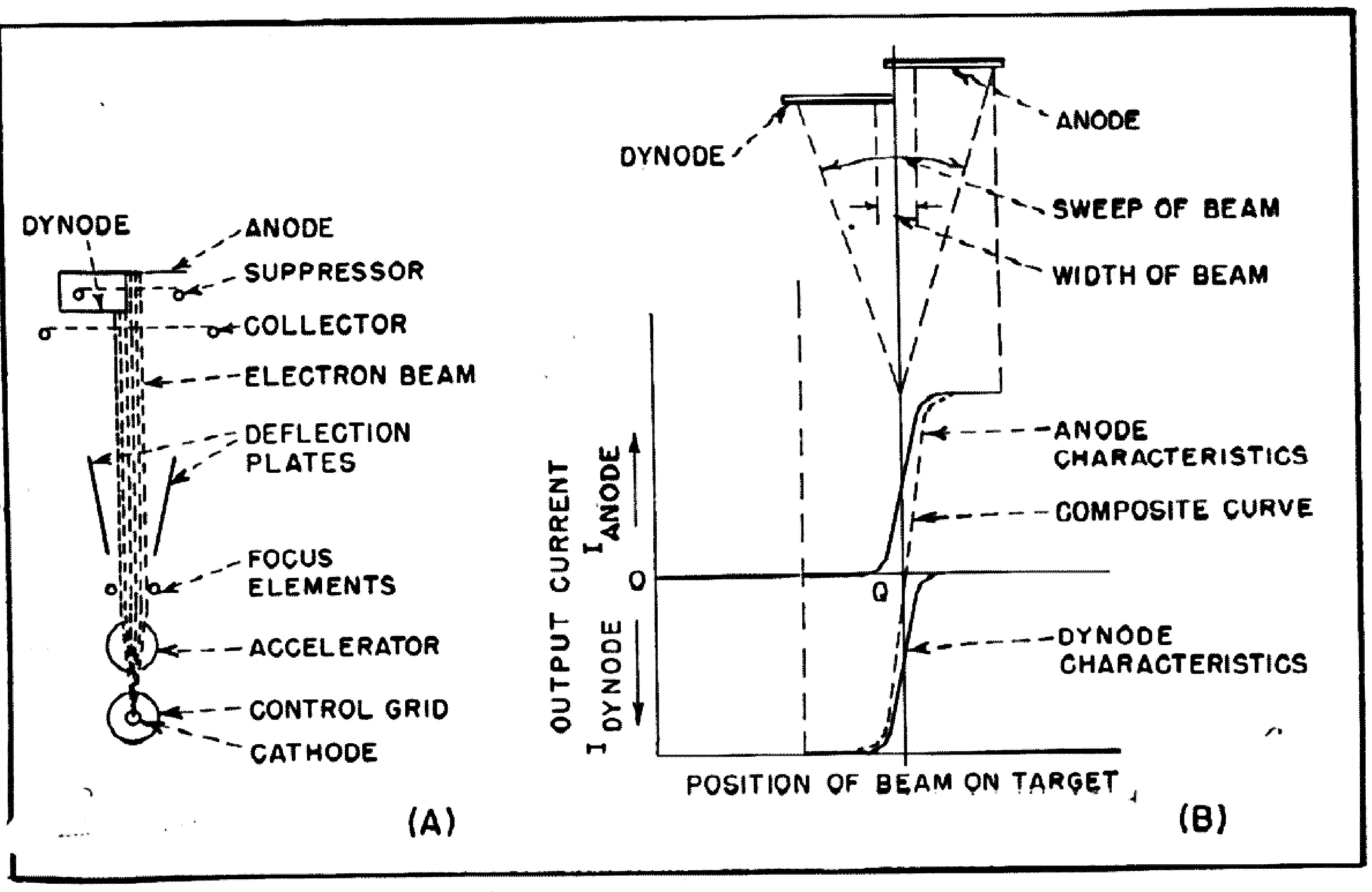

FIG. 1—Tube elements (A) and method of achieving composite anode-dynode characteristics (B)

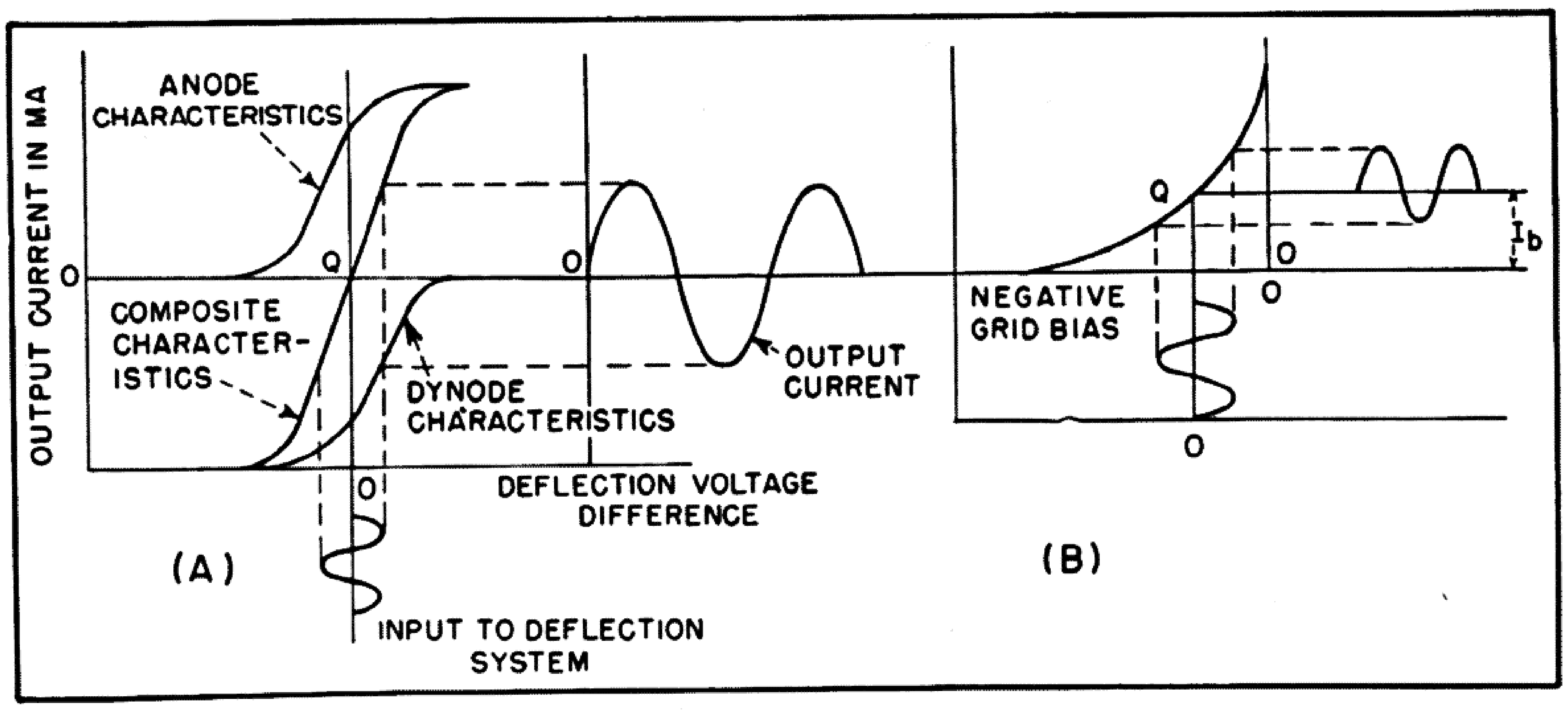

FIG. 2—Anode-dynode characteristics (A) compared with grid-plate transfer characteristic (B) of conventional amplifier

### Table I—Operating Conditions and Electrical Characteristics

| | |
|---|---|
| Typical Operating Conditions | |
| Accelerating anode | 300 v |
| Focusing anode | 0 v with adjustment for centering +15 v and −10 v rel to cathode |
| Control grid (cathode bias) | 0 v |
| Cathode bias resistor | 500 ohms |
| Mean deflection potential | 150 v |
| Anodyne | 225 v |
| Deflection $g_m$ | 1,200 μmho |
| Cathode current | 10 ma |
| Focusing anode current | 10 μa max |
| Control grid voltage for $I_b$ = 10 μa | 35 v |
| Electrical Characteristics | |
| Heater, unipotential cathode | |
| voltage | 6.3 ±10v a-c or d-c |
| current | 0.3 amp |
| Direct interelectrode capacitance | |
| Deflector plate No. 1 to all other elements, anodyne grounded | 3.5 μμf |
| Deflector plate No. 2 to all other elements, anodyne grounded | 3.5 μμf |
| Anodyne to deflector plate No. 1, all other elements at ground | 0.055 μμf |
| Anodyne to deflector plate No. 2, all other elements at ground | 0.055 μμf |
| Anodyne to all other electrodes, deflectors at ground | 4.2 μμf |
| Control grid to all other elements, anodyne at ground | 3.8 μμf |
| Control grid to anodyne, all other elements at ground | 0.0064 μμf |

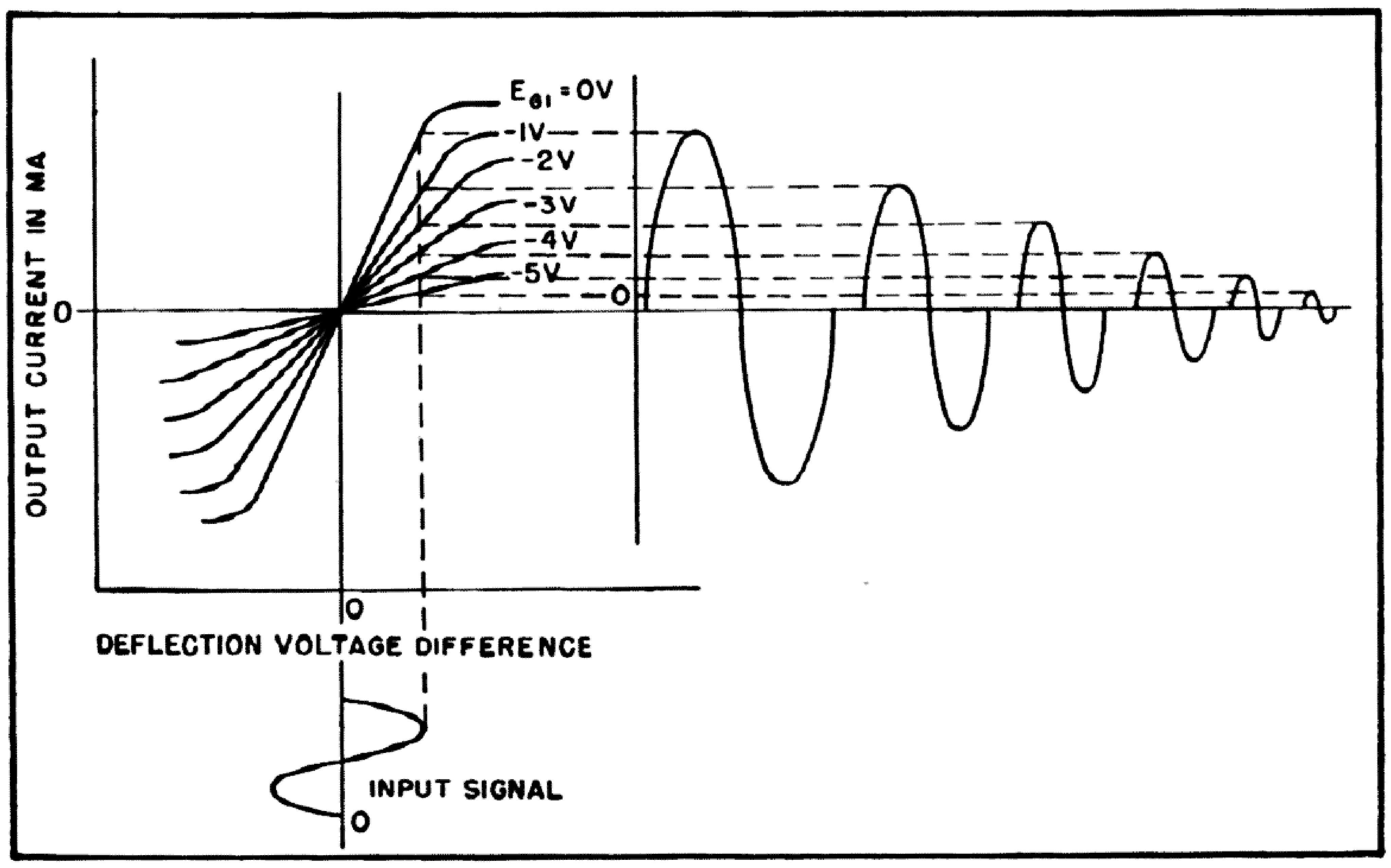

**FIG. 3—Output signal for several levels of control-grid bias illustrating almost infinite variation of transconductance**

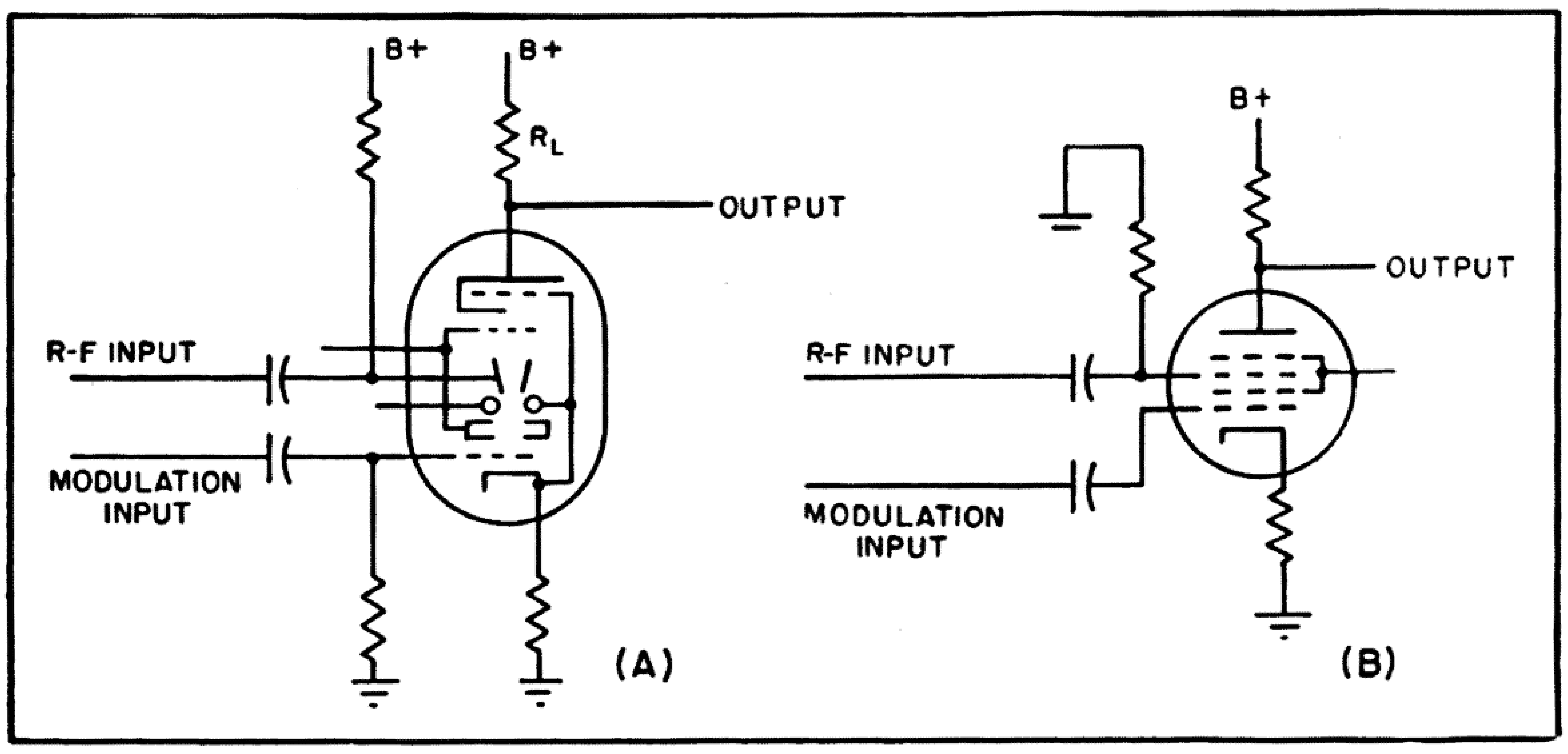

**FIG. 4—Gating or coincidence circuit using anodyne tube (A) and conventional multigrid mixer (B)**

mon output load. The interconnection of these two elements, anode an dynode has suggested the name anodyne whch is used to identify the type of tube. The anodyne tube is shown in the photograph.

### *Composite Characteristics*

Deflection of the focused line beam across the target produces the waveshape output relative to beam position along the target as indicated in Fig. 1B. The addition of separate out-of-phase currents at the intersection of the target produces a net current of zero for a secondary to primary electron ratio of two.

Dynamic deflection of the beam, however, produces current increments which are in phase and additive through the load. The addition of anode and dynode output forms the composite output curve known as the anodyne characteristic.

The composite curve (Fig. 1B) permits twice the deflection transconductance obtained from beam deflection tubes which do not have anode-dynode characteristics. Typical operating conditions and electrical characteristics of the tube are listed in Table I.

### *Operation of the Tube*

For dynamic operation of the tube, the beam is deflection centered so that net current through the output load is zero, point *Q* of Fig. 1B. Static centering thereby provides compensation if the dynode surface has a secondary emission ratio other than two as suggested. This mode of operation allows signal modulaton with no d-c load dissipation.

Figure 2A indicates the transfer characteristics of the tube as a beam deflection amplifier compared to a conventional grid-type amplifier, Fig. 2B. Dynamic transconductance measurements have indicated that the peak transconductance of the beam deflection tube is constant over a larger portion of the working range of the transfer curve. In addition to this property, constant beam current characteristics indicate an exceedingly large constant plate resistance over the same range.

Operation at zero quiescent current produces no degeneration due to d-c output element voltage level even with large loads. These characteristics provide for decreased output distortion as compared to conventional grid-type tubes.

Published dynamic coefficients for conventional grid-type tubes are generally associated with small-signal operation at a single operating point on the plate characteristic. Variation in tube coefficients for larger signals necessitates the use of graphical solutions. The linearity inherent in line beam deflection amplifiers extends the range over which the published coefficients apply. The equivalent a-c plate circuit theorem, therefore, holds for the anode-dynode tube over a wide variation of input signal amplitude with little or no variation in average tube coefficients.

## *Coincidence Gating*

In multigrid tubes, where coincidence gating or signal mixing is employed, operating parameters may be shifted from linear small-signal conditions to cutoff or saturation. The shift in operating range is accompanied by a radical departure from quiescent plate conditions where only a change in signal grid transconductance is desired. Rapid changes from quiescent operating conditions to obtain the shift in transconductance gives rise to undesired gating distortion in the output. Voltage increments due to this distortion often overshadow the signal content of the desired intelligence.

For the anode-dynode beam deflection tube, operation about zero quiescent current permits modulation of beam current by the cathode control grid (Fig. 1A) without producing a change in d-c voltage level through the load. At balance, that is, when primary current is equal to secondary current, reduction in total beam current does not affect the conditions of net zero load current.

Figure 3 indicates the relative transfer characteristics obtained at various levels of beam current. Maximum output is obtained at zero grid bias for a given deflection modulating voltage. For smaller values of beam current and the same signal modulation applied less output is obtained. Further increase in negative grid bias de-

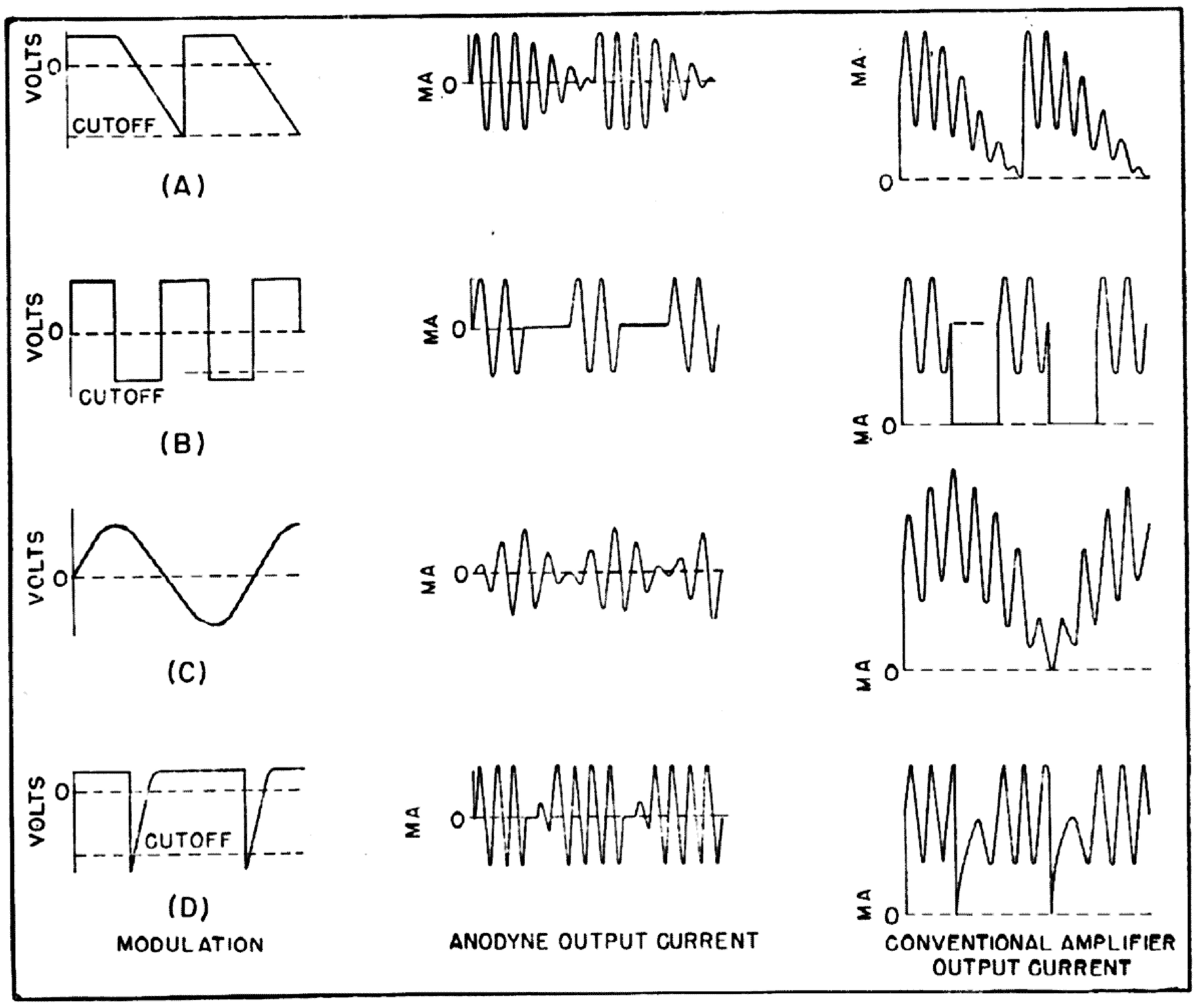

**FIG. 5—Response of anodyne and conventional gating circuit to various modulation waveforms**

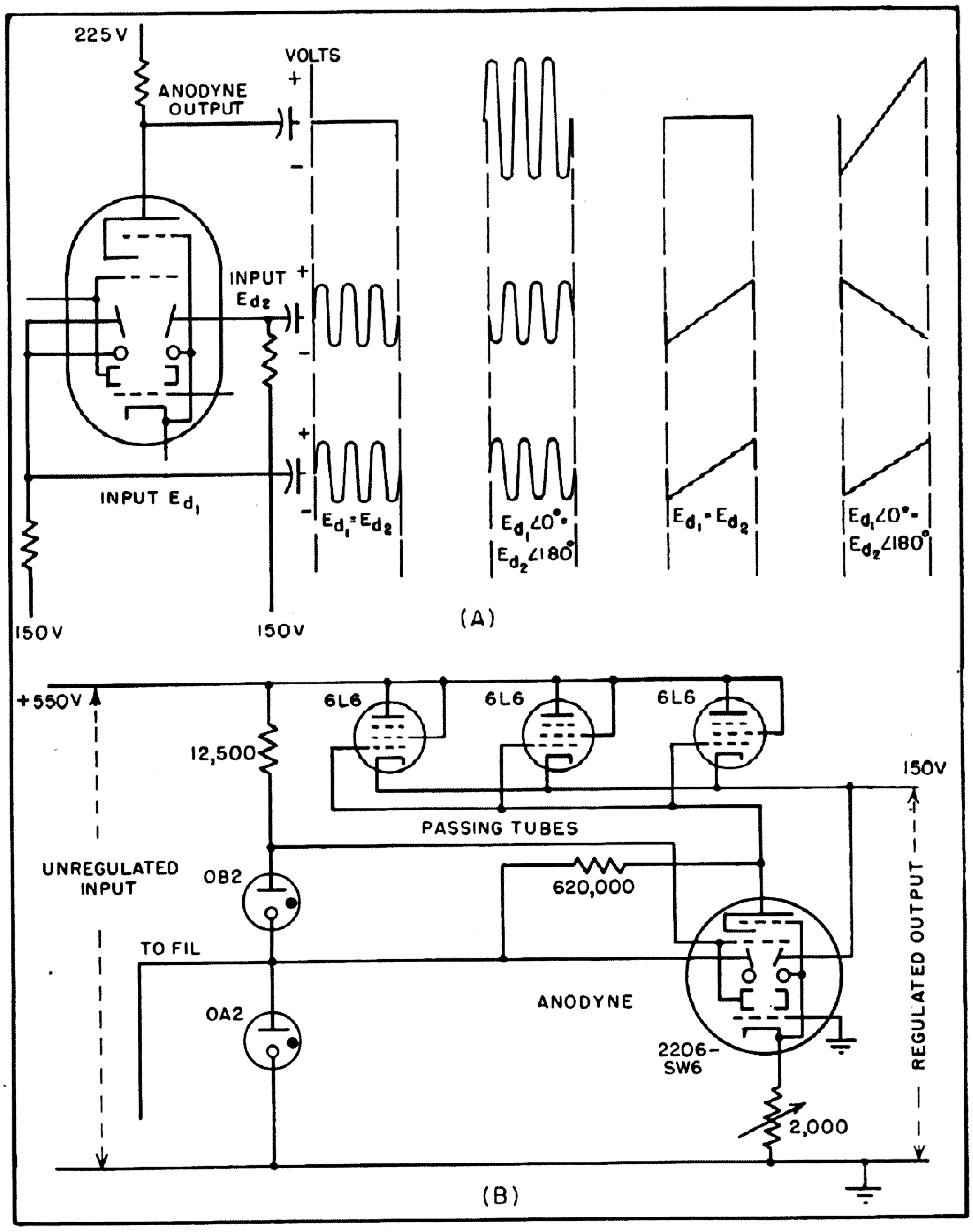

**FIG. 6—Circuit and waveforms of anodyne used as difference amplifier (A); circuit of regulated power supply (B)**

creases the signal output.

The control of beam current magnitude regulates the transconductance of the tube without shifting the operating point. In conventional tubes, changing the bias changes the operating point. This condition is pronounced when a conventional amplifier is driven from its operating point to cutoff producing a sharp rise in plate potential.

Figure 4A illustrates how the anodyne can be connected in a gat*ing point to cutoff producing a* shows a conventional multigrid mixer tube in the same type of circuit. Fig. 5 indicates the output of the anodyne and that of a conventional amplifier in the gating or coincidence circuit. The r-f input to both tubes is of constant amplitude. In addition, the various waveforms shown at the left in Fig. 5 are applied to the control grids of both tubes. The anodyne provides the output waveforms shown in the center column while the conventional multigrid mixer provides the output waveforms shown at the right.

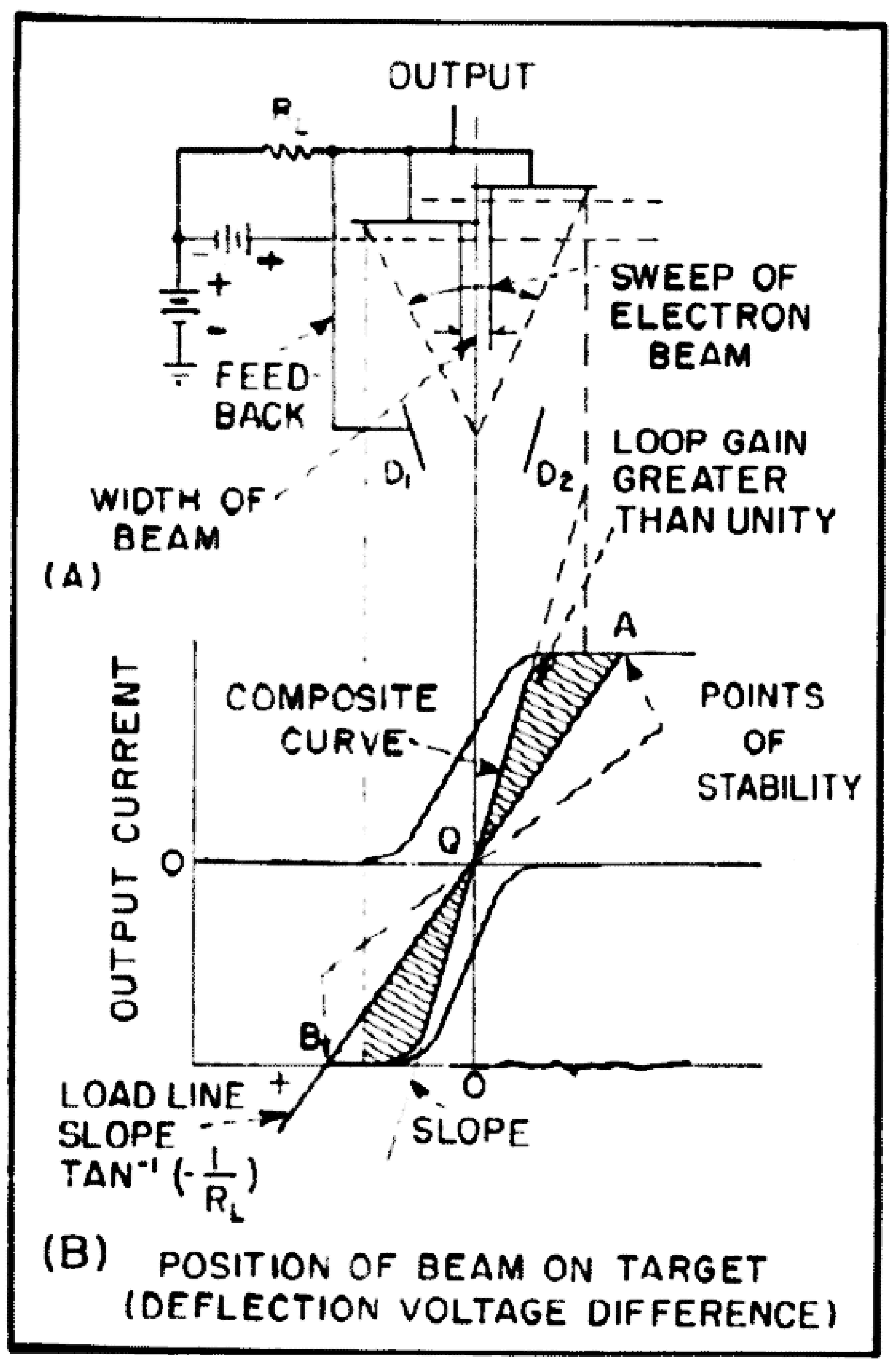

**FIG. 7—Beam deflection pattern (A) and corresponding tube characteristic (B) that provide two stable circuit current levels**

The important differences conveyed by the output characteristics indicate that the contour of the r-f voltage output from the anodyne essentially follows the waveshape applied to the control member. A *square wave B applied to the ano*dyne control grid produces a square wave of r-f voltage while the conventional tube gives rise to an extraneous signal. The application of a sine wave and pulse as indicated in *C* and *D* produce similar results.

Application of a negative linear saw tooth *A* produces a linear variation of transconductance from a maximum value to a value of zero without affecting output linearity. These characteristics are applicable to low-level balanced modulation where the signal applied to the control grid is balanced out in the absence of deflection plate modulation. The oscillograms show anodyne output waveforms, above, and corresponding control-grid waveforms, below.

### *Difference Amplifier*

The anodyne, because of beam deflection characteristics, can be used as a signal difference amplifier. The deflection transconductance of the device is necessarily common to both deflection plates and transfer balance is maintained at all times. In-phase signals of the same amplitude applied to both deflection plates will produce no output while out-of-phase signals will yield the sum of both signals. Figure 6A indicates operation of the device as a difference amplifier.

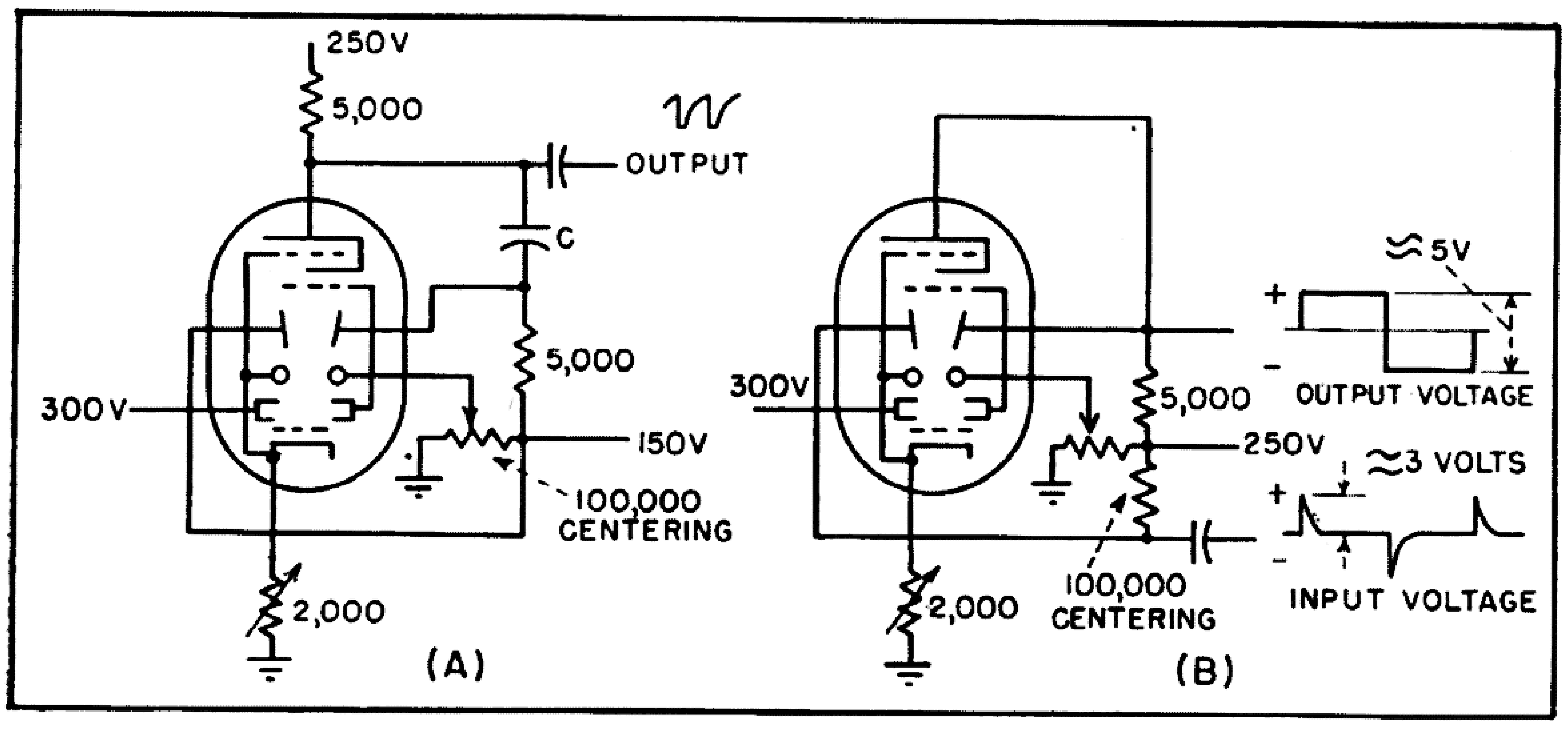

**FIG. 8—Multivibrator (A) and binary storage device (B) both using the anode-dynode tube**

### *Other Circuits*

The anodyne tube may be used as the control tube in a voltage regulator as shown in Fig. 6B.

The anodyne output characteristic and various modifications of that characteristic have been employed in a number of negative transconductance devices. Proper interconnection of the output to the deflection input terminals produces a two-terminal negative resistance device. This negative transconductance characteristic exhibited by the increase of output current with a decrease of relative deflection potential can be used with suitable load line and deflection plate connection to present two stable levels of circuit current.

The criteria for securing the two stable levels of circuit current are met in the simplified circuit of Fig. 7A. The feedback voltage produced by the current flow through $R_L$ enables sufficient regeneration to establish two points *A* and *B* of stable equilibrium. The composite curves for this negative transconductance and the points of circuit current stability are indicated in Fig. 7B.

Bistable holding points with separation of less than five volts have been achieved. This small voltage difference as compared to large voltage increments required for conventional grid-type binary-connected devices should be expected to provide fast operation and repetition rates.

### *Multivibrator*

The negative transconductance characteristics and the associated regeneration provide a means to produce fast multivibrator circuits, monostable flip-flops, counters, oscillators and harmonic generators.

A multivibrator circuit employing the anodyne tube is shown in Fig. 8A while the circuit of a binary storage clevice is given in Fig. 8B. Most circuits can be employed without the voltage-level coupling problems and the large associated time constants that burden conventional methods.