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7086

XENON THYRATRON

NEGATIVE-CONTROL TRIODE TYPE

FORCED-AIR COOLED

GENERAL DATA

Electrical:

Filament, Coated:*		
Voltage.	2.5 ± 5%	ac volts
Current at 2.5 volts	92	amp
Minimum heating time, prior to tube conduction.	60	sec
Direct Interelectrode Capacitances:°		
Grid to anode.	44	μμf
Grid to filament	7.5	μμf
Ionization Time (Approx.).	10	μsec
Deionization Time#	1000	μsec
Maximum Critical Grid Current for instantaneous anode volts = 650 . .	50	μa
Peak Tube Voltage Drop . . . *See Characteristics Range Values*		
Maximum Commutation Factor⊕.	400	va/μsec^2
Grid Control Ratio (Approx.):		
Under conditions: 10000-ohm grid resistor, returns to filament terminal FS, voltage on filament terminal F in phase with anode voltage (with respect to voltage at FS), anode voltage between 100 and 700 volts, and plate load of 2000 ohms	100	

Mechanical:

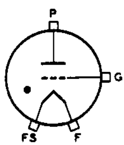
Operating Position	Any
Maximum Overall Length	11.8"
Maximum Radius (Including grid terminal)	2.88"
Maximum Diameter (Excluding grid terminal)	4.62"
Weight (Approx.)	3 lbs
Bulb	T36

Terminal Connections *(See Dimensional Outline)*:

P – Anode

G – Grid

F – Filament



FS – Filament Cathode Shield, Circuit Returns

Air Flow . . . . 60 cfm

The specified air flow, from a 2- to 3-inch diameter nozzle located about 12 inches from the anode end of the tube and on the tube axis, should be directed at the anode cup and permitted to flow freely around the outside of the anode cup, grid-seal band, and glass bulb. These requirements are for operation at sea level and at an ambient temperature of

*,°,#,⊕: See next page.

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30° C. At higher altitudes and ambient temperatures, the air flow must be increased to maintain the respective seal temperatures and the anode temperature within maximum ratings.

Anode Temperature (Measured within 1/2 inch of region where anode terminal blade joins anode surface)	300 max.	°C
Temperature of Anode Seal, Grid Seals, and Filament Seals	180 max.	°C

Maximum Ratings, *Absolute Values:*

For supply frequency of 25 to 60 cps

	Continuous Service■	*Intermittent Service*♠	
PEAK ANODE VOLTAGE:			
Forward	650 max.	650 max.	volts
Inverse	650 max.	650 max.	volts
GRID VOLTAGE:			
Peak, before tube conduction	−150 max.	−150 max.	volts
Average, during tube conduction	−10 max.	−10 max.	volts
ANODE CURRENT:			
Peak	160 max.	400 max.	amp
Average	40 max.●□	7 max.★□	amp
Fault, for duration of 0.1 second maximum	4000 max.	4000 max.	amp
GRID CURRENT:			
Average positive	2.0 max.	2.0 max.	amp
Peak positive with anode negative	0.1 max.	0.1 max.	amp
AMBIENT-TEMPERATURE RANGE	−55 to +75	−55 to +75	°C

Typical Operation:

For intermittent ac control of X-ray tube power utilizing inverse-parallel circuit of Fig. 1 with anode-supply frequency of 60 cps

"On" (Conduction) Period	2	sec
"Off" (Non-Conduction) Period	34	sec
RMS Anode-Supply Voltage	220	volts
Grid-Bias Voltage	−50	volts
Grid-Circuit Resistance	0.1	megohm
Grid-Pulse Voltage	60	volts
Anode Current (Per Tube):		
Peak	400	amp
Average▲	127	amp
Load RMS Demand Current	280	amp

*,○,#,⊕,■,♠,●,□,★,▲: See next page.

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Maximum Circuit Values:

	Continuous Service	*Intermittent Service*	
Grid-Circuit Resistance. . .	0.1 max.	0.1 max.	megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

Throughout Tube Life

	Note	*Min.*	*Max.*	
Filament Current	1	87	97	amp
Peak Tube Voltage Drop	1,2	–	40	volts
Peak Critical Anode Voltage.	1,3	–	100	volts

Note 1: With 2.5 volts rms on filament.

Note 2: With peak anode current of 400 amperes provided by a half-cycle pulse from a 60-cps sine wave. Pulse recurs once each second. Tube drop is measured by an oscilloscope connected between anode and the filament terminal FS. The grid is tied to anode through a 10,000-ohm resistor.

Note 3: The voltage at terminal F is in phase with the anode voltage (with respect to voltage at filament terminal FS). Circuit returns are made to terminal FS. Grid resistor = 0 to 100,000 ohms.

* In single-phase applications, to avoid excessive heating of the filament and for maximum tube life, the voltage at filament terminal F should be in phase with the voltage at the anode terminal (with respect to voltage at filament terminal FS). All returns should be made to filament terminal FS in order to reduce the amount of rms current flowing through the filament and filament leads. In polyphase installations, quadrature operation of the filament is recommended to reduce excessive heating of the filament and filament leads by the anode-return current. In quadrature operation, the filament and anode voltages should be 90° out of phase for optimum results. However, in practical applications, nearly full realization of the advantages of this type of excitation is possible with the filament and anode voltages between 60° and 120° out of phase. In polyphase operation where the anode voltage transfers from one phase to another during the current-conduction period, quadrature operation is obtained when the filament voltage passes through zero at the center of the current-conduction period.

○ Without external shield.

Measured by Capacitor-Discharge Method as described in "Standard on Electron Tubes: Methods of Testing, 1950 (50 IRE 7.S2)" available from The Institute of Radio Engineers, 1 East 79 St., New York 21, N. Y. Also available in "Proceedings of the I.R.E.", Vol.38, No.9, page 1092 (September 1950). Conditions of measurement involve anode-supply voltage (E_{bb}) of 300 volts, grid-supply voltage (E_{cc}) of −150 volts, grid resistor (r_g) of 5000 ohms and anode current (I_b) of 23 amperes.

⊕ Commutation factor is the product of the rate of current decay in amperes per microsecond just before conduction ceases and the rate of inverse-voltage rise in volts per microsecond following current conduction.

■ Continuous Service is defined as service where conduction recurs for each cycle of the anode-supply voltage.

♦ Intermittent Service is defined as service where conduction does not take place as often as every cycle of the anode-supply voltage.

● Averaged over any period of 15 seconds maximum.

□ This rating applies when the average or the rms load current is at a maximum with respect to the phase-retard angle. This condition obtains with zero phase-retard angle. As the phase-retard angle is increased, the average or rms load current is reduced but the severity of duty on the 7086 is not reduced.

★, ▲: See next page.

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The angle of phase retard is the angle by which the grid signal (or the resultant tube conduction) lags the time at which the incoming and outgoing tubes have equal instantaneous values of voltage from the sinusoidal supply.

★ Averaged over any period of 36 seconds maximum.

▲ Averaged over the "on" period of 2 seconds.

OPERATING CONSIDERATIONS

The *mounting* may support the 7086 in any position. A suitable mounting arrangement is provided by the use of three insulated 1/4-inch-diameter studs set perpendicularly in a rigid surface at locations which are spaced to correspond with the spacing of the terminal holes as shown on the Dimensional Outline. The studs should extend a minimum distance of 5 inches out from the surface, and should be threaded for a minimum length of 2 inches on their free end. Place a nut followed by a brass or copper washer on each stud so that 1-1/2 inches of the free end extends beyond the washer. Then mount the tube by slipping the holes of the tube's terminals onto the studs. The terminal lugs of the connecting leads to the tube can then be slipped onto their respective studs. Tighten the connection with a second nut on each stud. *In order not to subject the glass-to-metal seals to stress which may damage them, use two wrenches*--one on each side of the tube terminals when tightening a connection.

Filament leads should be made of No.2 stranded copper wire, or equivalent. The tube end of the wire lead should be hard soldered to a 225-ampere (minimum) copper terminal lug. Be sure that this terminal lug is placed in direct contact with the filament terminal before tightening the nut.

The anode lead should be made of No.5 copper wire, or equivalent, and terminate at the tube end in a 150-ampere (minimum) copper terminal lug.

The grid lead should terminate at the tube end in a lug that may be fastened to the grid terminal by a No.6 screw & nut.

Sufficient anode-circuit resistance, including the tube load, must be used under any conditions of operation to prevent exceeding the current ratings of the tube.

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Numerical Relationships Among Electrical Quantities

E = Trans. Sec. Voltage (RMS)
E_{av} = Average DC Output Voltage
E_{bmf} = Peak Forward Anode Voltage
E_{bmi} = Peak Inverse Anode Voltage
E_m = Peak DC Output Voltage
E_r = Major Ripple Voltage (RMS)
f = Supply Frequency
f_r = Major Ripple Frequency
I_{av} = Average DC Output Current
I_b = Average Anode Current
I_1 = RMS Load Current
I_p = Anode Current (RMS)
I_{pm} = Peak Anode Current
P_{ac} = Average Power in Load
P_{al} = Line Volt-Amperes
P_{ap} = Trans. Pri. Volt-Amperes
P_{as} = Trans. Sec. Volt-Amperes
P_{dc} = DC Power (E_{av} x I_{av})
P_p = Peak Load Volt-Amperes

Note: Conditions assumed involve sine-wave supply; zero voltage drop in tubes; no losses in transformer and circuit; no back emf in the load circuit; and no phase-back.

RATIO	Fig.1	Fig.2	Fig.3	Fig.4	Fig.5
Voltage Ratios					
E/E_{av}	-	-	2.22	1.11	1.11
E_{bmi}/E	1.41	1.41	1.41	2.83	1.41
E_{bmi}/E_{av}	-	-	3.14	3.14	1.57
E_m/E_{av}	-	-	3.14	1.57	1.57
E_r/E_{av}	-	-	1.11	0.472	0.472
E_{bmf}/E:					
Resistive Load	1.41	1.41	1.41	1.41	1.41
Inductive Load■	1.41	1.41	1.41	2.83	1.41
Frequency Ratio					
f_r/f	-	-	1	2	2
Current Ratios					
I_b/I_{av}	-	-	1	0.5	0.5
Resistive Load					
I_p/I_{av}	-	-	1.57	0.785	0.785
I_{pm}/I_{av}	-	-	3.14	1.57	1.57
I_{pm}/I_b	3.14	3.14	3.14	3.14	3.14
I_1/I_b	2.22	2.22k*	-	-	-
Inductive Load■					
I_p/I_{av}	-	-	-	0.707	0.707
I_{pm}/I_{av}	-	-	-	1	1
I_{pm}/I_b	-	-	-	2	2
I_b/I_{av}	-	-	-	0.5	0.5

■,*: See next page.

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RATIO	Fig.1	Fig.2	Fig.3	Fig.4	Fig.5
Power Ratios					
$P_{ac}/I_b E_{bmf}$	1.57	1.57	-	-	-
Resistive Load					
P_{as}/P_{dc}	-	-	3.49	1.74	1.24
P_{ap}/P_{dc}	-	-	2.69	1.23	1.24
P_{a1}/P_{dc}	-	-	2.69	1.23	1.24
Inductive Load■					
P_{as}/P_{dc}	-	-	-	1.57	1.11
P_{ap}/P_{dc}	-	-	-	1.11	1.11
P_{a1}/P_{dc}	-	-	-	1.11	1.11

■ The use of a large filter-input choke is assumed except for the circuit of Figs.1 and 2.

* k = 1/2 number of turns in secondary of transformer T_p divided by the number of turns in the primary of T_p.

CIRCUIT Single-Phase	MAX. TRANS. SEC. VOLTS (RMS) E	APPROX. DC OUTPUT VOLTS TO FILTER E_{av}	MAX. DC OUTPUT AMPERES I_{av}	MAX. DC OUTPUT KW TO FILTER P_{dc}	MAX. AV. AC OUTPUT KVA P_{ac}
Fig.1 Inverse-Parallel (AC Voltage Control)					
Intermittent Service	460	-	-	-	130▲ / 7♦ / 40♠
Continuous Service	460	-	-	-	
Fig.2 Full-Wave Reflected Impedance (AC Voltage Control)	460	-	-	-	40♠
Fig.3 Half-Wave (DC Voltage Control)	460	205	40	8	-
Fig.4 Full-Wave (DC Voltage Control)					
With Resistive Load	230	205	80	16	-
With Inductive Load	230	205	80	16	-
Fig.5 Series (DC Voltage Control)	460	410	80	32.5	-

▲ Under conditions with "on" period of 2 seconds and "off" period of 34 seconds.

♦ Averaged over any period of 36 seconds maximum.

♠ Averaged over any period of 15 seconds maximum.

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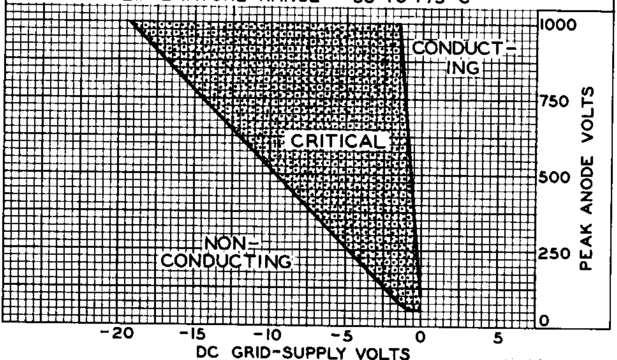
OPERATIONAL RANGE OF CRITICAL GRID VOLTAGE

RANGE IS FOR CONDITIONS WHERE:
E_f = 2.5 VOLTS AC ±5%. CIRCUIT RETURNS TO FILAMENT TERMINAL FS. FILAMENT VOLTAGE AT TERMINAL F IN PHASE WITH ANODE VOLTAGE (WITH RESPECT TO VOLTAGE AT FS).
THE RANGE INCLUDES INITIAL AND LIFE VARIATIONS OF INDIVIDUAL TUBES.
GRID RESISTOR = 0 TO 100000 OHMS
AMBIENT-TEMPERATURE RANGE = -55° TO +75° C



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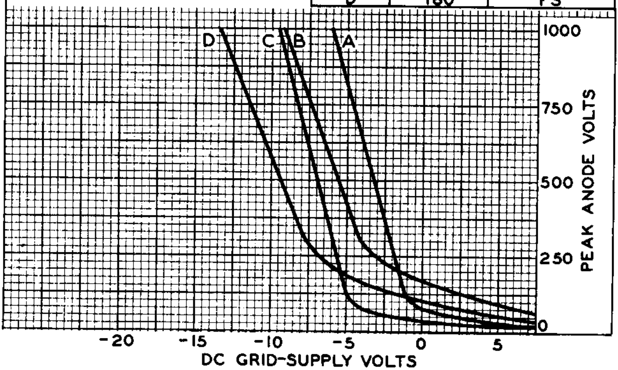
SHIFT OF TYPICAL CONTROL CHARACTERISTICS WITH CHANGE IN FILAMENT PHASING AND CIRCUIT RETURN

E_f = 2.5 VOLTS AC
GRID RESISTOR = 10000 OHMS
* BETWEEN FILAMENT VOLTAGE AT TERMINAL F AND ANODE VOLTAGE (WITH RESPECT TO VOLTAGE AT FS).

CURVE	PHASE ANGLE *	CIRCUIT RETURN TO FIL. TERM.
A	0°	FS
B	180°	F
C	0°	F
D	180°	FS



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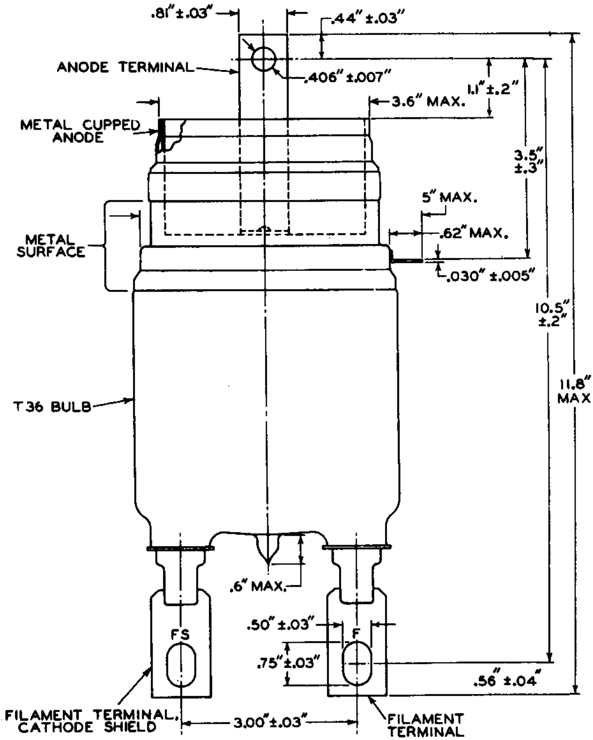

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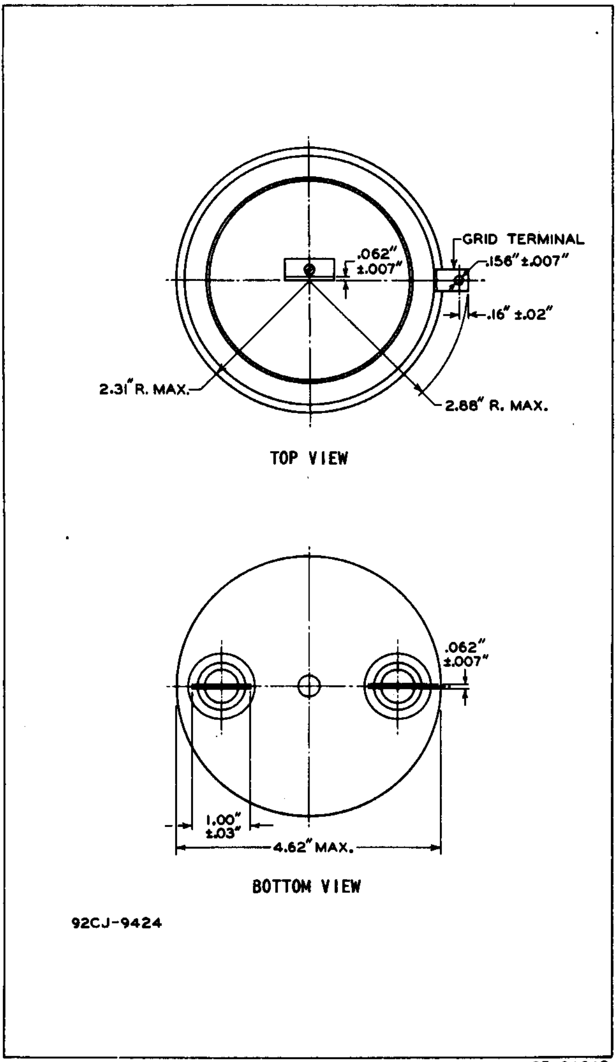

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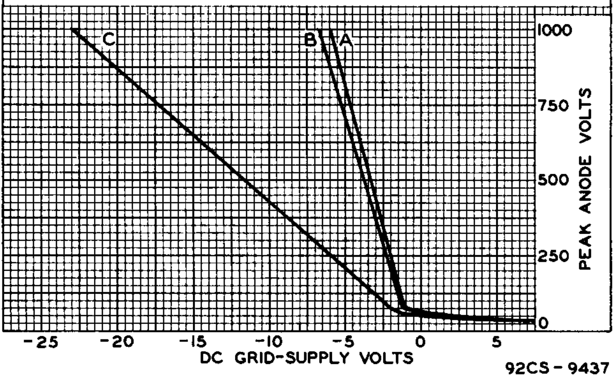
SHIFT OF CONTROL CHARACTERISTICS
WITH CHANGE IN GRID-RESISTOR VALUE

E_f = 2.5 VOLTS AC
* BETWEEN FILAMENT VOLTAGE AT TERMINAL F AND ANODE VOLTAGE (WITH RESPECT TO VOLTAGE AT FS).

CURVE	GRID RESISTOR MEGOHMS	CIRCUIT RETURN TO FIL. TERM.	PHASE ANGLE *
A	0.01	FS	0
B	0.1	FS	0
C	1	FS	0



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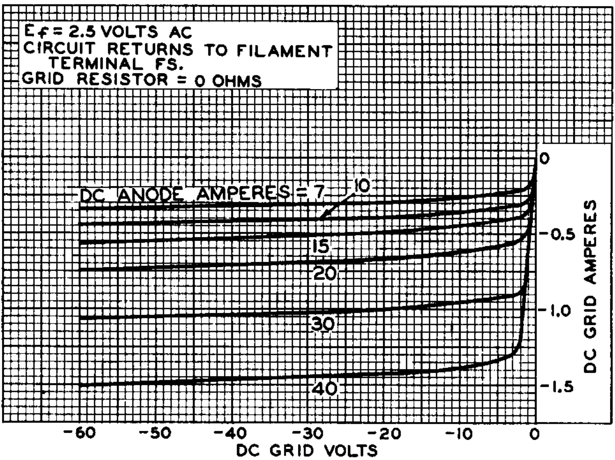
TYPICAL GRID CHARACTERISTICS
DURING TUBE CONDUCTION



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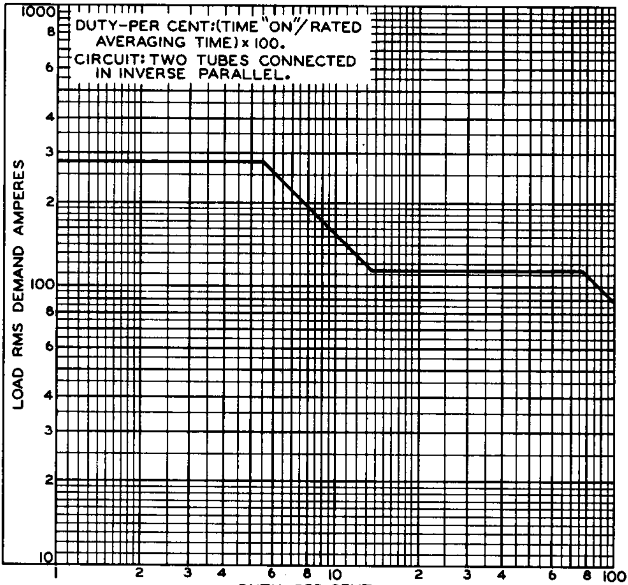
CURRENT DEMAND CHARACTERISTIC
AC VOLTAGE CONTROL SERVICE



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AC Voltage Control

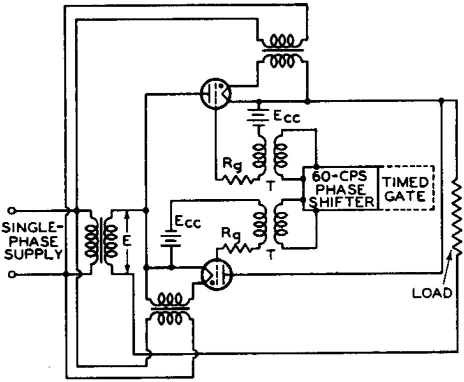

FIG. 1 SINGLE-PHASE INVERSE-PARALLEL

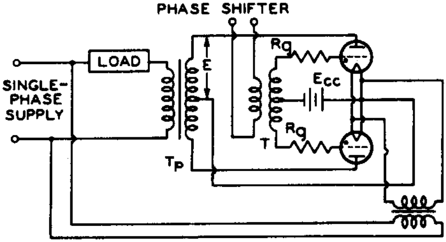

FIG. 2 FULL-WAVE SINGLE-PHASE REFLECTED IMPEDANCE

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DC Voltage Control

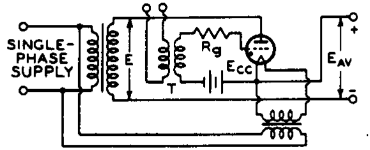

FIG.3 HALF-WAVE SINGLE-PHASE

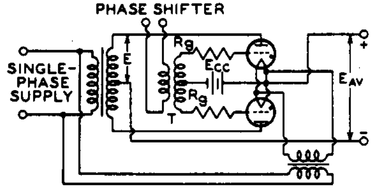

FIG.4 FULL-WAVE SINGLE-PHASE

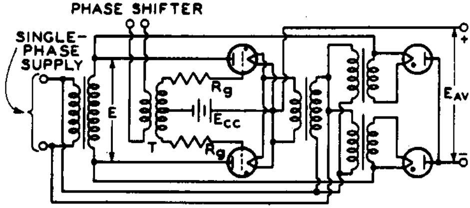

FIG. 5 SERIES SINGLE-PHASE

NOTES

E_{cc} = GRID-BIAS SUPPLY VOLTAGE
R_g = GRID CIRCUIT RESISTANCE
T = PEAKING TRANSFORMER
IN FIG. 5, THE RECTIFIER TUBES MAY BE USED AS DIODES. THE 7086 IS USED AS A DIODE BY CONNECTING THE GRID TO FILAMENT TERMINAL FS.

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