7086

XENON THYRATRON

Forced-Air Cooled
High Peak Current

Negative-Control Triode Type
TENTATIVE DATA

11-3/4" Overall Length
4-1/2" Diameter Bulb

RCA-7086 is a three-electrode, forced-air cooled xenon thyratron having a negative-control characteristic, high commutation factor, and relatively short deionization time. It is designed primarily for use in applications in which high peak currents are required such as in welding and in X-ray tube operation. It can also be used for grid-controlled rectifier or inverter service.

In a typical two-tube inverse-parallel X-ray tube control circuit in which the anode-supply voltage is 220 volts rms and in which the tubes are operated with an "on" period of 2 seconds and an "off" period of 34 seconds, each tube can provide a peak anode current of 400 amperes and an average anode current of 127 amperes during the "on" period. Such current capability in combination with this circuit permits the control of 280 amperes rms through the primary of the power transformer of a single-phase full-wave rectifier delivering a dc current of 100 milliamperes at a voltage suitable for X-ray tube operation.

In grid-controlled rectifier or inverter service, the 7086 can deliver a maximum peak anode current of 160 amperes and a maximum average anode current of 40 amperes.

The negative-control characteristic of the 7086 is essentially independent of ambient temperature over the wide range from -55° to $+75^{\circ}$ C by virtue of the xenon gas content.

Design features of the 7086 include the use of a copper grid having high heat conductivity to provide cool operation of the grid and resultant reduced grid emission; a large cup-shaped anode with a copper face to provide uniform heat distribution over the faced area; and heavy copper filament leads and terminals. The cup-shaped anode forms one end of the tube and is in direct contact with the ambient air. The grid is terminated in a large area metal band which is a part of the tube envelope and thus is effectively cooled by the ambient air.

GENERAL DATA

Electrical:

Filamentary Cathode, Coated:*		
Voltage (AC)	2.5 ± 5%	volts
Current at 2.5 volts	92	amp
Minimum heating time, prior to tube conduction	60	sec
Direct Interelectrode Capacitances (With no external shield):		
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	μamp
Peak Tube Voltage Drop . See *Characteristics Range Values*		
Maximum Commutation Factor⊕	400	va/μsec²
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"
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 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 the anode surface)	300 max.	°C
Temperature of Anode Seal, Grid Seals, and Filament Seals	180 max.	°C
Weight (Approx.)	3	lbs

Maximum Ratings, *Absolute Values:*

For supply frequency of 25 to 60 cps

	Continuous■	*Intermittent*♦	
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--Intermittent AC Control of X-Ray Tube Power Utilizing Inverse-Parallel Circuit of Fig.6:

For anode-supply frequency of 60 cps

"On" (Conduction) Period	2	sec
"Off" (Non-Conduction) Period	34	sec
AC Anode-Supply Voltage (RMS)	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

Maximum Circuit Values:

For Continuous or Intermittent Service

Grid-Circuit Resistance	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
Critical Anode Voltage	1,3	-	100	peak 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.

\# 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.

★ Averaged over any period of 36 seconds maximum.

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

□ 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 the rms load current is reduced but the severity of duty on the 7086 is not reduced.

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.

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are limiting values above which the serviceability of the 7086 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

The *maximum fault anode current rating* shown in the tabulated data is the highest value of abnormal peak current of short duration (0.1 second maximum) that should pass through the tube under the most adverse conditions of service. This rating is intended to assist the equipment designer in a choice of circuit components such that the tube will not be subjected to disastrous currents under abnormal conditions approximating a short circuit. It is not intended for use under normal operating conditions because even a single fault current at the maximum value may impair tube life. Repeated fault currents will seriously reduce or even terminate tube life. The equipment designer should also note that if the maximum fault-current rating is exceeded, the thyratron may cease to conduct

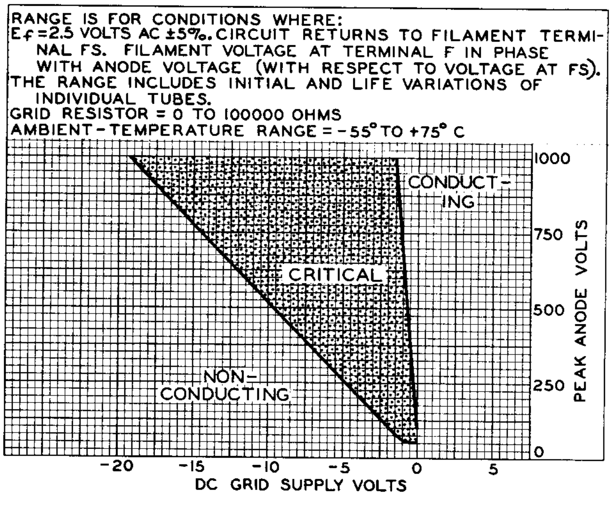

Fig. 1 - Operational Range of Critical Grid Voltage.

momentarily with the result that excessive surge voltages are developed in the associated components, thereby causing their failure. The magnitude of any fault current which might occur under abnormal conditions should be limited by the internal impedance of the transformer or other circuit components, to the rated value.

The *maximum temperatures* in the tabulated data for the anode seal, grid seal, and filament seals are tube ratings and are to be observed in the same manner as other tube ratings. The temperature of the respective seals and of the anode may conveniently be measured with temperature-sensitive paint such as Tempilaq. The latter is made by the Tempil Corporation, 132 W. 22nd Street, New York 11, N.Y. in the form of liquid and stick.

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.

The *filament voltage*, measured directly at the filament terminals, should not vary more than ±5 per cent from the rated value. Less than the rated value may result in a high tube drop with consequent bombardment of the filament and eventual loss of emission. Greater than rated voltage will cause excessive evaporation of the filament coating with resultant increase in grid emission and shortened filament life.

It is essential that the filament terminals of the tube be kept clean at all times to minimize contact resistance. Always be sure that connections are securely tightened because of the high current involved. The filament terminal FS not only carries the normal filament current but also the anode-return current. The combined currents may reach a value as high as 120 amperes when the tube delivers full anode current. For operating procedure to reduce the magnitude of combined currents, refer to note * under tabulated data.

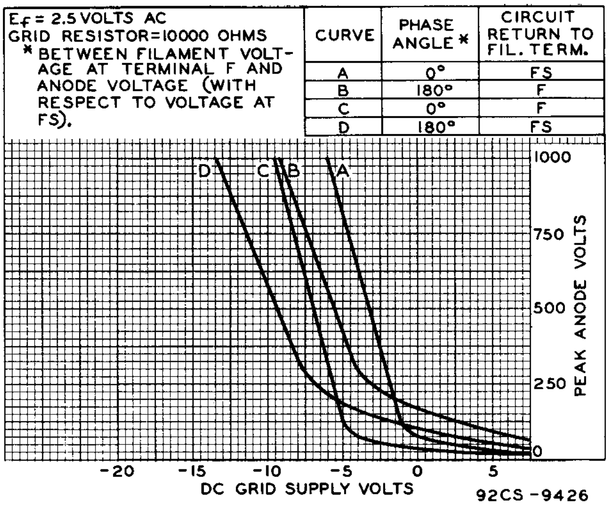

Fig. 2 - Shift of Typical Control Characteristics With Change in Filament Phasing and Circuit Return.

The filament should be allowed to reach operating temperature before tube conduction is permitted to start. The delay period should be not less than 60 seconds after application of filament voltage. Unless this recommendation is followed, the filament may be damaged. Tube conduction may be delayed by the application of adequate negative bias to the grid for the specified minimum filament heating time.

Circuit returns should be made to filament terminal FS.

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.

The anode voltages at which the 7086 is operated are extremely dangerous to the user. The tube and its associated apparatus, especially all parts which may be at high potential above ground, should be housed in a protective enclosure. The protective housing should be designed with interlocks so that personnel cannot possibly come in contact with any high-potential point in the electrical systems. The interlock devices should function to break the primary circuit of the anode supply when any gate or door on the protective housing is opened, and should prevent the closing of this primary circuit until the door is again locked.

The 7086 has a *critical grid voltage* which will initiate tube conduction for any positive anode voltage. If the grid is maintained more negative than this critical voltage, the tube does not conduct and the anode current remains zero.

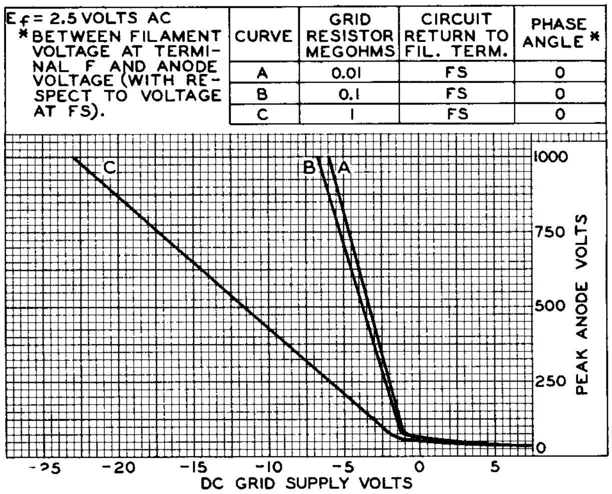

Fig.3 - Shift of Control Characteristics With Change in Grid-Resistor Value.

If the grid is made less negative than this critical voltage, the tube will conduct and the anode current assumes a value determined by the applied anode voltage and the impedance in the anode circuit. In the conducting condition, the 7086 has a voltage drop which is relatively low, substantially constant over the rated anode-current range, and independent of grid bias. Conduction may be stopped and the grid allowed to regain control by reducing the anode voltage to zero or making it negative.

The value of critical grid voltage is affected by several factors including: the operating anode voltage, variation of filament-supply voltage,

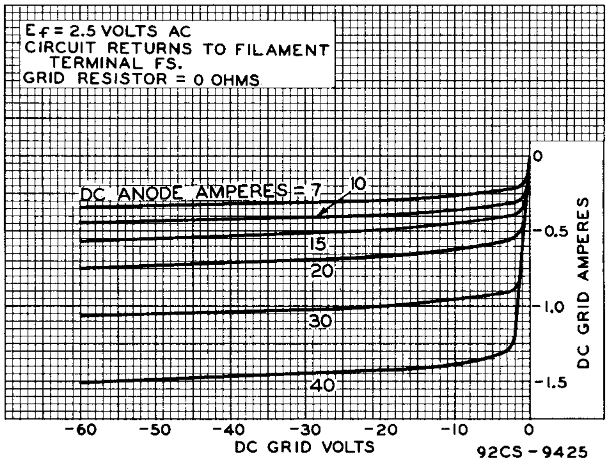

Fig.4 - Typical Grid Characteristics During Tube Conduction.

filament phasing and circuit return, value of grid resistor, and individual tube variation both initially and during life. Fig.1 shows the range of critical grid voltage. The equipment designer should give careful consideration to the range values shown in Fig.1. From them he can determine for specified operating conditions not only the proper value of grid bias necessary to prevent conduction until it is desired, but also the magnitude of the signal (triggering) voltage necessary to initiate conduction. Ample triggering voltage should always be provided to insure anode conduction even under the worst operating conditions to which the equipment will usually be subjected.

The effect of change in filament phasing and circuit return is shown in Fig.2; and the effect of change in value of grid resistor is shown in Fig.3.

The *grid characteristics* of the 7086 during tube conduction are shown in Fig.4.

The *anode voltage* for the 7086 may be obtained from either an ac or dc source. When a dc supply is used, the circuit has a lock-in feature because the grid loses control when conduction starts. In order for the grid to regain control and restore the tube to the non-conducting condition, it is necessary to remove the anode voltage momentarily. When an ac supply is used, the circuit has no lock-in feature because the anode becomes negative during the negative half of the ac cycle and thus allows the grid to resume control before the next positive half-cycle.

With ac supply, control of the firing of the 7086 may be accomplished by varying the amplitude of an ac grid voltage, by varying a dc bias applied to the grid, by phasing a sinusoidal grid voltage with respect to the anode voltage, by phasing a peaked grid voltage with respect to the anode voltage, or by a combination of these methods.

With *ac amplitude control*, several degrees of control are available depending on the phase angle of the grid voltage relative to the anode voltage. If the grid voltage lags the anode voltage by 180°, change in amplitude of the grid voltage will initiate tube conduction early in the positive half-cycle of the anode voltage, and thus effectively connect the load to the anode voltage supply for most of the half-cycle to provide maximum dc voltage output. This type of operation gives abrupt change from zero to full dc output voltage as the amplitude is decreased. If the grid voltage lags the anode voltage by something less than 180°, change in amplitude of the grid voltage can be used to cause the tube to conduct at only a few points in the positive half-cycle with the result that the dc output voltage can not be varied smoothly from the maximum value to zero.

The *dc bias method of control* can initiate tube conduction only over the first 90° of the positive half-cycle of anode voltage. Initiation of conduction at the beginning of the half-cycle will connect the load to the anode voltage supply for most of the half-cycle to provide maximum dc voltage output. If conduction is initiated at the 90° point, the dc voltage output will be approximately one half of the maximum value. If it is desired to control the output voltage over a wider range, then this method by itself is not practical.

With the *phase-shift method of control utilizing a sinusoidal grid voltage*, a wide range of control is available. If the grid voltage lags the anode voltage by about 170°, conduction occurs near the end of the positive half-cycle, and consequently the load is connected to the anode voltage supply for a small part of the half-cycle to provide minimum dc voltage output. If the phase of the grid voltage is advanced so that the grid voltage lags the anode voltage by less than 170°, tube conduction is initiated over a greater part of the positive half-cycle, and the dc output voltage will vary gradually from the minimum value to maximum. With this method, the use of adequate grid voltage will insure reliable control of the dc output voltage.

The *phase-shift method of control utilizing a peaked grid voltage* is a preferred method in that it provides a wide range of control with the most accurate timing for initiating conduction, positive blocking of anode current, and optimum conditions for deionization. If the peaked grid voltage lags the anode voltage up to 180°, tube conduction is initiated whenever the peak occurs in the positive half-cycle. The conduction angle, or time during which anode current flows, is equal to 180° minus the angle of lag. Maximum dc output voltage occurs when the peaked voltage swings positive at the same time as the anode voltage. If the peaked voltage leads the anode voltage up to 180°, no conduction occurs.

Since the 7086 is a negative-control tube, provision must be made to supplement the peaked grid voltage with a bias voltage which may be either dc or ac that is 180° out of phase with the anode voltage. With this control method, the magnitude of the peaked grid voltage should be adequate to swing the grid well into the positive region.

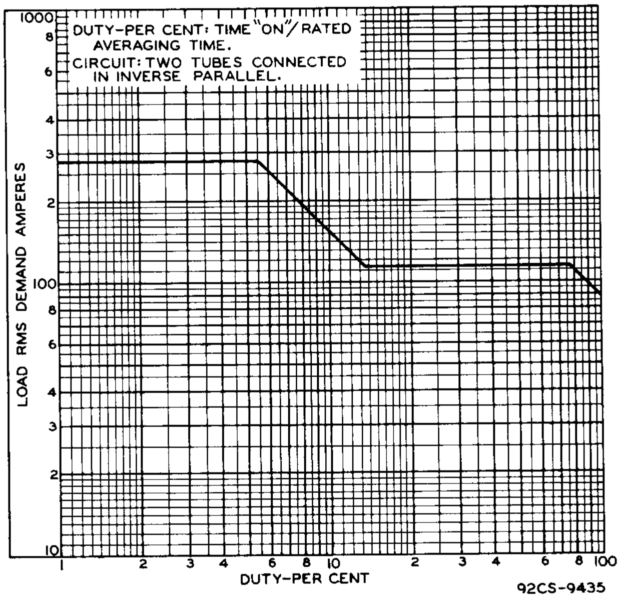

Fig.5 - Current Demand Characteristic of Type 7086 in AC Voltage Control Service.

As indicated above, these methods may be combined to give additional flexibility of control. For example, a variable dc grid bias can be obtained with an ac voltage having constant amplitude and lagging the anode voltage by about 90°, to provide control of the dc output voltage from zero to maximum value.

A complete discussion of these control methods will be found in the references below. These references will also provide other references.

Fig.5 is a graph showing demand current versus duty for the two-tube inverse-parallel ac control circuit of Fig.6. When the timed gate provides a grid pulse every cycle of the supply frequency, the continuous operating ratings in the tabulated data apply. The duty is then 100%. These ratings permit a maximum average anode current of 40 amperes which when multiplied by the value of 2.22 shown in Table I gives the load current of 89 amperes. Starting at the 89-ampere, 100%-duty

AC Voltage Control

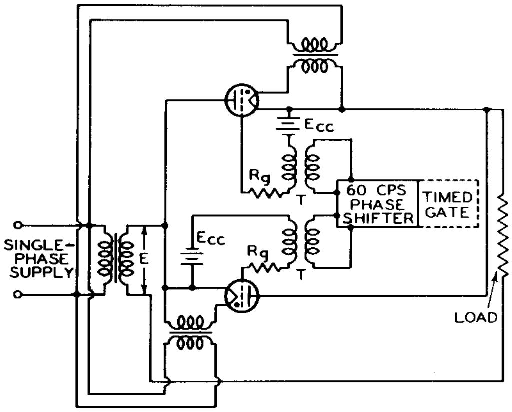

FIG.6 SINGLE-PHASE INVERSE-PARALLEL

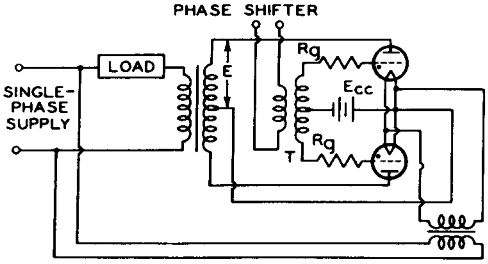

FIG.7 FULL-WAVE SINGLE-PHASE REFLECTED IMPEDANCE

DC Voltage Control

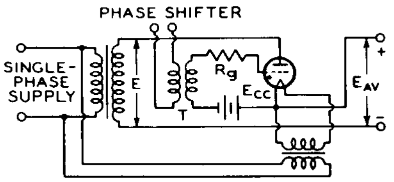

FIG.8 HALF-WAVE SINGLE-PHASE

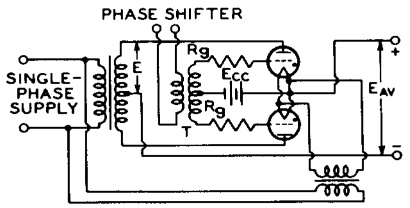

FIG.9 FULL-WAVE SINGLE-PHASE

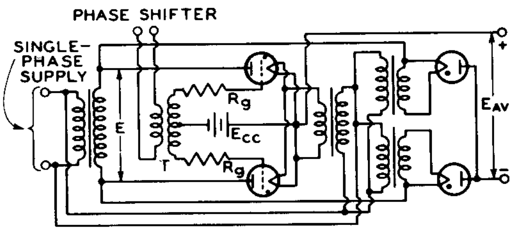

FIG.10 SERIES SINGLE-PHASE

92CL-9438

TABLE I

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_l = 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 ($E_{av} \times I_{av}$)
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.6	Fig.7	Fig.8	Fig.9	Fig.10
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_l/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
Power Ratios					
P_{ac}/I_bE_{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_{al}/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_{al}/P_{dc}	–	–	–	1.11	1.11

■ The use of a large filter-input choke is assumed except for the circuit of Figs.6 and 7.

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

NOTES
Ecc = GRID-BIAS SUPPLY VOLTAGE
Rg = GRID-CIRCUIT RESISTANCE
T = PEAKING TRANSFORMER

IN FIG.10, THE RECTIFIER TUBES MAY BE 7086'S USED AS DIODES. THE 7086 IS USED AS A DIODE BY CONNECTING THE GRID TO FILAMENT TERMINAL FS.

TABLE II

For circuits, see Figs. 6, 7, 8, 9 and 10.

CIRCUIT	MAX. TRANSFORMER SEC. VOLTS (RMS) E	APPROX. DC OUTPUT VOLTS TO FILTER E_{av}	MAX. DC OUTPUT AMPERES I_{av}	MAX. DC OUTPUT TO FILTER P_{dc}	MAX. AV. AC OUTPUT KVA P_{ac}
Fig. 6 Single-Phase Inverse-Parallel (AC Voltage Control)					
Intermittent Service	460	–	–	–	130▲ / 7⧫
Continuous Service	460	–	–	–	40♦
Fig. 7 Full-Wave Single-Phase Reflected Impedance (AC Voltage Control)	460	–	–	–	40♦
Fig. 8 Half-Wave Single-Phase (DC Voltage Control)	460	205	40	8	–
Fig. 9 Full-Wave Single-Phase (DC Voltage Control)					
With Resistive Load	230	205	80	16	–
With Inductive Load	230	205	80	16	–
Fig. 10 Series Single-Phase (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.

point, a 45° line extends up and to the left. Along this 45° line, the average current through each tube is 40 amperes because demand and duty are inversely proportional. Below 78.7% duty, a horizontal line is drawn through the value of 113 amperes. This value is the maximum permissible rms demand current through the load when the peak anode current is limited to 160 amperes. Below 13.8% duty, the intermittent ratings in the tabulated data take effect. If the 45° line through the 113-ampere, 13.8%-duty point is extended to 100% duty, it will pass through an rms demand (load) current for the circuit of 15.5 amperes. Dividing by 2.22 to obtain the average current for each tube gives the 7 amperes which is the average current rating as shown in the tabulated data. Everywhere along this 45° line, the average current through each tube is 7 amperes. Below 5.5% duty ("on" time of 2 seconds divided by averaging time of 36 seconds), the rms demand current is limited by the maximum intermittent peak anode current rating. The peak anode current rating of 400 amperes multiplied by 0.707 gives the maximum permissible rms demand current of 280 amperes (left horizontal line of Fig. 5)

Fig. 6 shows a typical single-phase two-tube inverse-parallel circuit for ac voltage control. In intermittent operation of this circuit, a timed gate permits the 7086 to be triggered to pass any number of half-cycle sine-wave pulses while its companion 7086 passes the alternate half-cycle pulses, thus allowing the passage of any number of full-cycle sine-waves to the load. Pulse duration may be varied by the use of phase-back. When this circuit does not utilize a timed gate, the tubes operate in continuous service and are triggered each cycle. In this case, also, the pulse duration may be varied by the use of phase-back. This circuit with timed gate is also used commonly in spot resistance-welding service.

The *full-wave, single-phase ac control circuit of Fig. 7* is sometimes known as the *reflected-impedance circuit* since the impedance as represented by the maximum voltage and current ratings of the thyratron is reflected to the primary circuit through the power transformer. The turns ratio of the power transformer is selected so that the maximum voltage and maximum current ratings of the tube are matched to the required ac load impedance. When the phase of the grid signal is such as to permit the grid bias to block the thyratrons, the input impedance of the transformer is a maximum; and the ac load voltage is a minimum. When the phase of the grid signal is such as to fire the thyratrons near the start of their positive half-cycle, the transformer secondary is short circuited. The reflected short-circuit permits maximum ac voltage to be applied to the load. Intermediate phase settings permit intermediate rms values of ac voltage to be applied to the load. A further advantage of this circuit over that of Fig.6 is that both cathodes are at the same potential. This circuit, therefore, permits the use of a common grid-bias supply.

Grid-controlled rectifier circuits suitable for use with the 7086 are shown in Figs.8, 9, and 10.

The simplicity of the *half-wave, single-phase circuit* in Fig.8 makes this circuit useful for special applications but its performance is characterized by poor transformer utilization factor, low output voltage, and high ripple output.

In Fig.9 is shown a *full-wave, single-phase circuit* which retains the simplicity of the circuit of Fig.8 but in comparison has improved transformer utilization factor and lower ripple output. This circuit is popular for applications requiring relatively low power.

In the *series, single-phase* circuit of Fig.10, two tubes conduct in series. This arrangement provides high output voltage for a given peak inverse anode voltage per tube.

Table I shows the numerical relationships among the various electrical quantities in the circuits of Figs.6, 7, 8, 9, and 10 when they employ the 7086 operated with a grid signal such that it behaves as a conventional gas control tube.

Table II shows the maximum transformer-secondary voltage which can be safely applied to the 7086 when operated in the circuits of Figs.6, 7, 8, 9, and 10. For the circuits of Figs.8, 9, and 10, the table shows the corresponding approximate dc output voltage to filter which may be varied between zero and the tabulated value by adjusting the phase of grid voltage with respect to the anode voltage. Also shown is the maximum dc output current which can be supplied by each of these circuits. When phase-back is employed, care should be taken not to exceed the peak anode current rating of the 7086. For the circuits of Figs.6 & 7 the table shows the maximum ac output obtainable.

Filter circuits for the 7086 should be of the choke-input type, except for the circuits shown in Figs.6 and 7, in order to limit the magnitude of the peak anode current.

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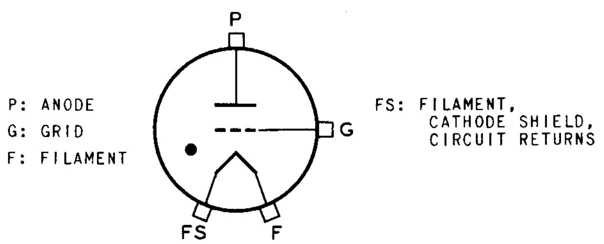
TERMINAL CONNECTIONS



DIMENSIONAL OUTLINE