GRID CONTROLLED POWER SUPPLY IS A VERSATILE UNIT

Uses Pair of RCA-2050's for Wide Voltage Range

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A power supply that will deliver up to 200 mA at any voltage from about 50 to 400 volts! Does this appeal to you? If it does, and if you want this convenience at low cost without the losses of tapped bleeder resistors or expensive variable transformers, but with good voltage regulation, just by setting a small potentiometer — here's how!

It's done with grid-controlled rectifiers, commonly known as thyratrons. And what are they? They are simply rectifiers containing gas to reduce the voltage drop and to improve the efficiency, and having one or more grids interposed between the plates and cathodes to control the start of plate current flow.

In the power supply to be described, a pair of RCA 2050's are used to deliver the current at the desired voltage. Within its capabilities a unit like this permits the convenient reduction of power during tune-up of that new rig, and a moment later, its operation at full input. For experimental work, such a unit is an invaluable laboratory tool.

Theory of Operation

Refer to Figure 1, which illustrates the critical control characteristics of a thyratron tube.

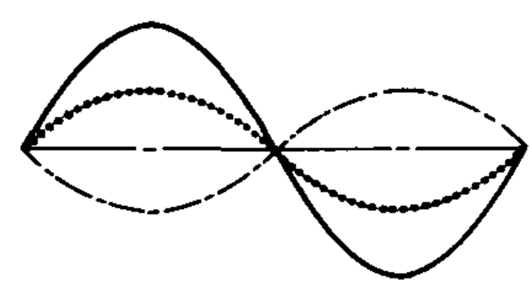


FIG. 1

The heavy solid line represents the ac voltage impressed on the plate of one of the rectifiers in a full-wave circuit; and the dashed line represents the critical instantaneous grid voltage that must simultaneously be put on the control grid of this tube to prevent it from ionizing or "firing". In this condition, neither tube will pass plate current, and the output of the rectifier will be zero.

The dotted line represents an in-phase voltage, which, if impressed upon the grid of the thyratron, will cause it to fire at the start of the cycle and conduct throughout its duration, at which time the plate voltage drops to zero and the tube deionizes, thereby restoring grid control. In this condition, both of the tubes act like regular diode rectifiers and deliver maximum power to the load.

Figure 2 shows the relationship of plate voltage versus critical-grid-voltage when a voltage of 90° displacement is impressed on the grid.

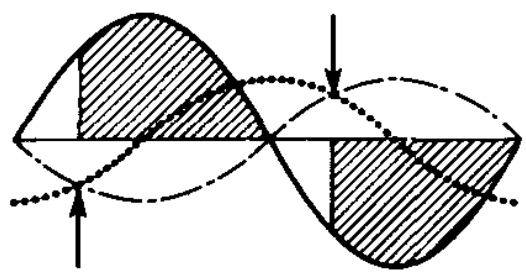


FIG. 2

The arrows indicate the instant where the actual negative grid voltage becomes more positive than the critical voltage for the applied plate voltage. At this point, ionization occurs, and current flows during the remaining part of the cycle as indicated by the shaded area. The dc output voltage delivered by the filter will be about three-quarters of the maximum obtainable. From this, it can be seen that variations in phase between applied anode voltage and grid voltage will produce more or less rectifier output. Carried to extremes, this means either full-voltage at full conduction or zero-voltage at zero conduction.

Phasing Circuit

Figure 3 shows the basic phase-controlling network.

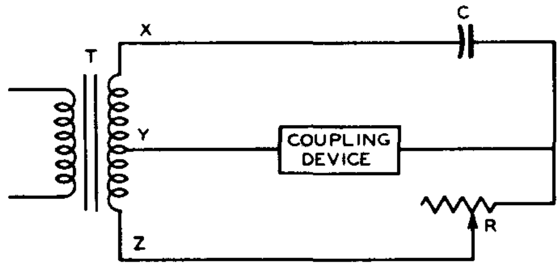


FIG. 3

Control characteristics of thyratron tubes and a basic phase controlling network.

A transformer (*T*) has a center-tapped secondary winding connected to the *coupling device*. If the center-tap (*Y*) is used as a zero point, the voltage on one side, (*X*), is 180° out of phase with the voltage on the other side (*Z*). Then, if the resistance (*R*) is high compared with the reactance of the capacitor (*C*), the *coupling device* is effectively connected across the upper half of the secondary (*XY*), and the voltage across it is in equal phase. But if the resistance (*R*) is low compared with the reactance of the capacitor (*C*), the coupling device is effectively connected across the lower half of the transformer secondary (*YZ*), and the voltage across it is now of reversed phase. In this position, the capacitor (*C*) is connected across the entire winding (*XZ*), but its reactance is high compared with the reactance of the transformer secondary, and no ill effects are produced. Intermediate values of resistance (*R*) will cause intermediate phase differences across the coupling device, and will provide the control that is so desirable.

Construction Details

Figure 4 shows the complete circuit of the unit illustrated in the photograph.

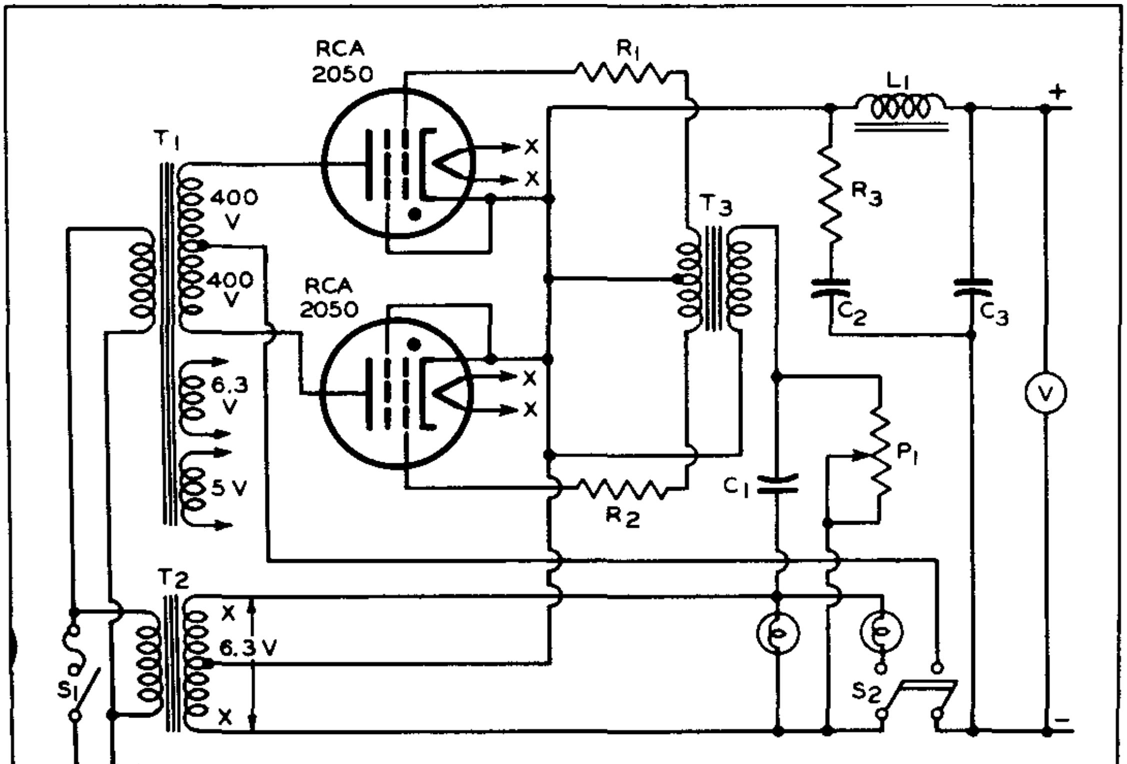


FIG. 4

Power supply schematic.

A separate filament transformer is used to heat the filaments of the RCA-2050's, light the pilot lamps, and supply the phasing voltage. A low-cost, unmounted transformer is used, and is located underneath the chassis.

The 6.3- and 5-volt windings on the power transformer are left free and available for heating the filaments of a wide variety of tubes operated from the power supply.

Since a capacitance input filter is employed, a resistor is used in series with the input capacitor to limit the peak current to the maximum rating.

The value of this series resistor is approximately equal to 0.9 ohm per RMS volt of 1/2 the total secondary voltage of the supply transformer.

- For an 800-volt center-tapped secondary, the value of the resistor is approximately 800/2 x 0.9, or about 360 ohms.

The 100,000-ohm grid resistors are used to prevent excessive 2050 grid current and consequent loading of the phasing transformer. It may be necessary to reverse the transformer grid connections to get a proper phase relation so that firing is prevented when the potentiometer is in a maximum-resistance position.

Don't worry about the 10-mF electrolytic capacitor being used in an ac circuit. Its reactance, or capacitance is practically the same in both directions, and the peak voltage of less than 10 is not high enough to cause it to be damaged.

The phasing transformer is a small size audio unit, single plate to push-pull grids. It is mounted underneath the chassis in a convenient position.

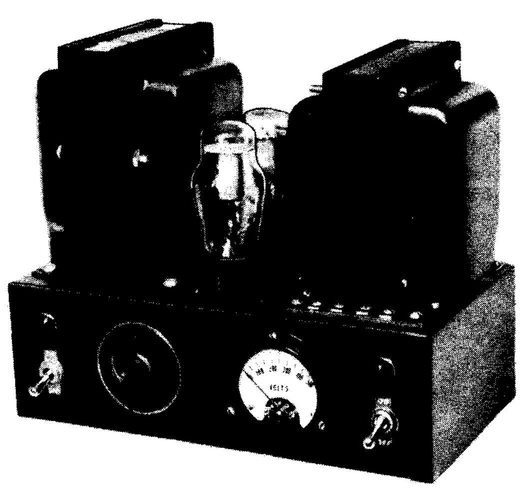
Two switches are used to cut the unit on and off. *S1* puts voltage on all tube heaters, and *S2* delivers high voltage to the rectifiers. *S2* should never be closed until the 2050 heaters have had a warm-up of at least 10 seconds, and preferably 30 seconds.

Operating Precautions

Because a capacitance input filter is used, the voltage regulation will compare favorably with regular high-vacuum rectifiers. Therefore, the output voltage will rise considerably if the load is removed. The use of a swinging choke at the input to the filter will provide equivalent voltage regulation to standard circuits, but it will also limit the dc output voltage to approximately 90% of the RMS voltage of one half the high voltage transformer winding.

The photograph illustrates one satisfactory mechanical arrangement. The electrolytic filter capacitor is mounted directly in back of the 2050 rectifier tubes.

THE VERSATILE UNIT READY FOR WORK



It delivers up to 200 Ma at any voltage from 50 to 450 volts.

PARTS LIST

- **T1** Power transformer, 800 V., center-tapped secondary, 200 Ma capacity
- **T2** Filament transformer, 6.3 V., 1.2 amps
- **T3** Interstage audio transformer, single-plate to P-P grids
- **C1** 10 μf, 150 V., electrolytic
- **C2 C3** 8 μf each, dual electrolytic, 450 V. working
- **R1, R2** 100,000 ohms, ½ watt, carbon
- **R3** 360 ohms (approx.), 25 watt, wire-wound (see text)
- **P1** 10,000 ohm wire-wound potentiometer
- **L1** Choke, 10 henries (approx.), 200 Ma.

Thyratrons

From *Wikipedia:*

A **thyratron** is a type of gas filled tube used as a high energy electrical switch. Triode, Tetrode and Pentode variations of the thyratron have been manufactured in the past, though most are of the triode design. Gases used include mercury vapor, xenon, neon, and (in special high-voltage applications or applications requiring very short switching times) hydrogen. Unlike a vacuum tube, a thyratron cannot be used to amplify signals linearly.

A thyratron is basically a "controlled gas rectifier".

A typical hot-cathode thyratron uses a heated filament cathode, completely contained within a shield assembly with a control grid on one open side, which faces the plate-shaped anode. When positive voltage is applied to the anode, if the control electrode is kept at cathode potential, no current flows. When the control electrode is made slightly positive, gas between the anode and cathode ionizes and conducts current. The shield prevents ionized current paths that might form within other parts of the tube. The gas in a thyratron is typically at a fraction of the pressure of air at sea level; 15 to 30 millibars (1.5 to 3 kPa) is typical.

Once turned on, the thyratron will remain on (conducting) as long as there is a significant current flowing through it. When the anode voltage or current falls to zero, the device switches off.

Small thyratrons were manufactured in the past for controlling electromechanical relays and for industrial applications such as motor and arc-welding controllers. Large thyratrons are still manufactured, and are capable of operation up to tens of kiloamperes (kA) and tens of kilovolts (kV).

Modern applications include pulse drivers for pulsed radar equipment, high-energy gas lasers, radiotherapy devices, and in Tesla coils and similar devices. Thyratrons are also used in high-power UHF television transmitters, to protect inductive output tubes from internal shorts, by grounding the incoming high-voltage supply during the time it takes for a circuit breaker to open and reactive components to drain their stored charges. This is commonly called a "crowbar" circuit.

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