RCA Ham Tips
PUBLISHED - IN - THE - INTEREST - OF - RADIO - AMATEURS - AND - EXPERIMENTERS
VOLUME VI, No. 3 EDITORIAL OFFICES, RCA, HARRISON, N. J. NOV.—DEC. 1946

NEW "HAM" RATINGS ANNOUNCED FOR RCA RECEIVING TUBES

GRID CONTROLLED POWER SUPPLY IS A VERSATILE UNIT

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

By J. H. OWENS, W2FTW
and G. D. HANCHETT, W1AK/2

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. 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

(Continued on Page 3, Column 1)

REAL "HAM" VALUE

Here's another instance which proves "Hams" get the most for their money when they use RCA tubes. In a series of studies recently concluded by the Tube Department and covering the sale of 100,000,000 receiving tubes on which field records were obtained, less than 1½% were involved in defective claims. Only 1% were found to be actually defective. A major factor in this remarkable record has been the accumulation and carryover of RCA "know-how" to answer the requirements of modern electronic equipment.

DATA GUIDES RECEIVING TYPE USE IN LOW POWER TRANSMITTER STAGES

For you Hams who use receiving tubes for low power transmitting applications—and was there ever a Ham who did not—here are regular rf class C ratings for nine popular RCA receiving types. These tubes are favored for oscillators, buffers, frequency multipliers, and low-power final amplifiers because they supplement the regular line of small transmitting tubes. Therefore, most of them have become standard equipment in Ham Shacks. Their limitations, however, have frequently been a matter of conjecture. With the new ratings now established, all Amateurs have a reliable guide for obtaining the most hours of useful life from RCA receiving tubes in transmitting applications.

For Hams Only

When we said the new ratings were established for you, the Amateurs, we meant *only* and *solely* and *strictly* for you, and for no one else. However, because Amateur rf use of these tubes represents something less than one per cent of the main use of the tubes, their characteristics cannot be determined solely by the requirements of this particular class of service.

In the course of time, receiving tubes may be modified to give major users more performance for less money. Progressive work of this nature has resulted in benefits well known to those who use the tubes. Unfortunately, such progress may result in changes in tubes which, although representing real improvement in their normal receiver function, may require redesign of transmitter equipment in which the tubes are used.

Hams welcome improvements and price reductions in tubes, and are quick to modify their gear to adjust for or take advantage of any changes which may be made. Manufacturers, on the other hand, rightfully expect and demand that no changes be made in tubes which will adversely affect their performance in commercial or production equipment. Therefore, manufacturers should not use these tubes according to the Ham ratings.

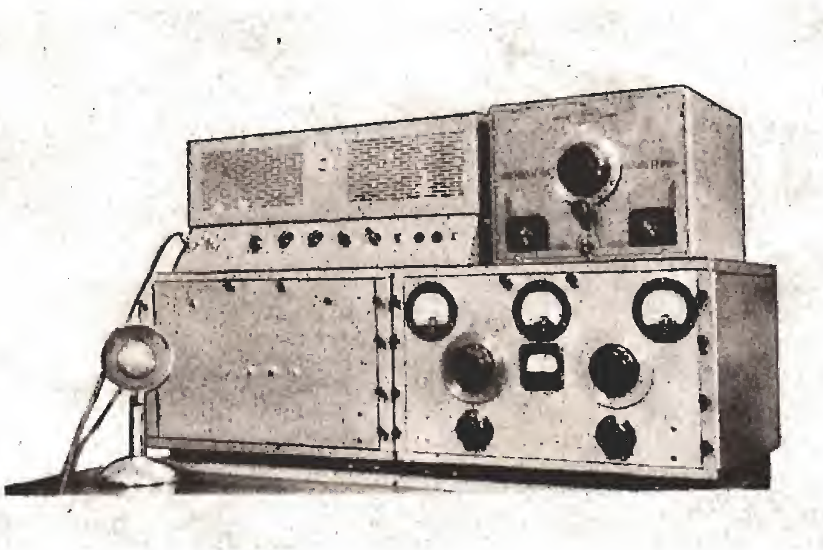
It should be recognized that Ham ratings are subject to change at a moment's notice and some of them may even be withdrawn.

Proceed With Caution

A quick examination of the accompanying table shows that the tubes have been given higher input ratings than heretofore. No longer do you have to learn the hard way what the margin of safety is for receiving tubes in transmitting practice, that is, by blowing up tubes. The tubes will take just as much, but no more, power input than be-

(Continued on Page 2, Column 1)

THIS MONTH'S PRIZE WINNER



James E. Hausser, W8LB, Cleveland, Ohio, takes top honors this month for this photo of his RCA tube equipped rig. Jim writes in to say he has worked Maine to California on 10-meter phone with R9 plus reports.

The lower right unit is the rf section; a Meissner Signal Shifter feeds an 807 which works into push-pull 807's. The unit at lower left houses the power supply, the modulation transformer, and the complete bias supply for the transmitter. Modulator is an RCA 50-watt amplifier, and the microphone, an RCA-MI-6206. Nice going, Jim, for a swell looking rig. Your $10.00 check is in the mail.

And to the rest of you tinkering, ingenious "Hams", let's have some photos of those rigs you've gotten together. Remember—if it's RCA tube equipped, you stand a bang-up chance to walk off with the month's prize money.

RECEIVING TUBE CLASS C TELEGRAPHY RATINGS ※ EXCLUSIVELY FOR THE HAM

RCA Tubes (Type)	Maximum Plate Supply (Volts) Ebb	Maximum Screen Grid (Volts) E_{c2}	Maximum Control Grid (Volts) E_{c1}	Maximum Plate (Milliamperes) Ib	Maximum Screen Grid (Milliamperes) I_{c2}	Maximum Control Grid (Milliamperes) (Note 2) I_{c1}	Maximum Plate Dissipation (Watts) Pp	Maximum Screen Grid Dissipation (Watts) P_{c2}	Power Output (Watts) (Note 1) Po	Maximum Frequency (Megacycles)* Mc	Grid Bias Calculator Mu Factor (Approximate)† μ	Grid to Plate Capacitance (uuf) Cgp	Input Capacitance (uuf) Cin	Output Capacitance (uuf) Cout
6AG7	375	250	−75	30	9	5.0	9.0	1.5	7.5	10	22	max. 0.06	13	7.5
6AK6	375	250	−100	15	4	3.0	3.5	1.0	4.0	54	9.5	0.12	3.6	4.2
6AQ5	350	250	−100	47	7	5.0	8.0	2.0	11.0	54	10	0.35	7.6	6.0
6C4	350	—	−100	25	—	8.0	5.0	—	5.5	54	18	1.6	1.8	1.3
6F6	400	275	−100	50	11	5.0	12.5	3.0	14	10	7	0.2	6.5	13
6L6	400	300	−125	100	12	5.0	21	3.5	28	10	8	0.4	10	12
6N7	350	—	−100	30 (per plate)	—	5.0 (per grid)	5.5 (per plate)	—	14.5 (total)	10	35	—	—	—
6V6GT	350	250	−100	47	7	5.0	8.0	2.0	11.0	10	9	0.7	9.5	7.5
12AU7	350	—	−100	12 (per plate)	—	3.5 (per grid)	2.75 (per plate)	—	6.0 (total)	54	18	1.5	1.6	0.5 (approx.)

Notes (1) Power output based upon plate circuit efficiency of 70%.
(2) 100,000 ohms maximum grid resistor.
* Maximum frequency for full power output and input.
† For pentodes this is the grid-screen amplification factor.
※ Maximum ratings are absolute maximum values not to be exceeded under any conditions of operation.

NEW "HAM" RATINGS

(Continued from Page 1, Column 4)

fore, the difference is that now you have exact information on which to base your operating practice.

In return for this confidence, it is expected that you will accept the ratings in good faith and not attempt to "stretch" them further. Reduced power should be used during tune-up, and other precautions taken to keep the tubes within the ratings.

Screen Grid Tubes Critical

Many of you Hams have found that triodes will stand more abuse than pentodes. The reason is that with pentodes and beam tubes it is comparatively easy to overload the screen. In triodes, the important limiting factor usually is only plate dissipation. Thus, in screen grid tubes we have two important limiting conditions, screen dissipation and plate dissipation. The need to watch both dissipation limits in the case of screen grid tubes is the price that has to be paid for the additional advantages gained. Good design practice indicates that the screen grid voltage should be adjusted at about 80% of the maximum value shown in the table.

When screen grid tubes are used as class C amplifiers, the screen current goes up directly with an increase in applied grid drive. This means increased screen dissipation. Therefore, grid driving power should be kept as low as possible, consistent with good power conversion efficiency.

General Application Notes

Specific conditions were not set up for the tubes as plate-modulated or plate-and-screen modulated amplifiers, because this use is a minor one. When such service is contemplated, the plate voltage should be reduced 20%, the screen grid (if present) voltage maintained, and the grid drive adjusted as recommended for doubler service. These modifications will protect the tubes and take into account the additional grid drive that is necessary.

When tubes are used as doublers or triplers, their efficiency is less than when they are used as straight-through amplifiers. For example, the plate circuit efficiency of a class C amplifier can easily be 70%, but the efficiency of a multiplier will ordinarily be something near the reciprocal of the order of the harmonic; viz., 50% (=½) for a doubler, and 33 1/3% (=1/3) for a tripler.

The significance of this is tbat because the efficiency is less, less power gets transferred to the load, hence more is dissipated in the tube. Therefore, as the plate efficiency goes down, the power input must also go down, otherwise the plate and screen dissipation ratings may be exceeded.

Tubes used as oscillators should be handled quite like class C amplifiers. The big difference between the two is that in oscillator service, the tubes must supply their own driving power. The power output will be equal to the plate power input, minus grid-driving power, copper losses, dielectric losses, radiation losses, harmonic losses, and the power dissipated in the plate and other tube electrodes. Efficiencies vary more widely in oscillators than in amplifiers, and on an average range from 25 to 60%.

Frequency Limits

The tubes may be operated at frequencies higher than those given in the table, but of course the power output will go down accordingly. As the power goes down, the plate (and screen) dissipation goes up; therefore, the power input must be reduced to prevent dissipation ratings from being exceeded.

As an indication of service ability, the octal types in the table perform usefully in the six-meter band, while the miniatures give a fair account of themselves in the two-meter band. To be on the safe side at these higher frequencies, reduce all ratings about 20% from the values shown in the table.

Neutralization

With the possible exception of 3 types, all of the tubes in the group positively require neutralization when used as 1 to 1 amplifiers. It may be possible to use the 6AG7, 6AK6, and 6F6 (metal) without neutralization because the average tube has relatively low grid-plate capacitance. This characteristic is usually not strictly controlled in production because it has no importance in audio output applications. Neutralize all the tubes and be sure.

A FEW OF THE TUBES HAVING NEW HAM RATINGS

Amateurs now have a reliable guide for obtaining the most hours of useful life from these tubes in transmitting applications.

Amplifier and Oscillator Conditions

Now we get down to the pleasurable business of putting the tubes to work, and the question is, "How do we use the new ratings?" They are all maximum permissible values, while the Amateur demand is for "typical operating conditions".

For oscillator and amplifier service, divide the plate voltage by the Mu factor. For a beam tube or pentode, divide the screen grid voltage by the Mu factor. This gives you the approximate bias for plate current cutoff. Double this and you have the correct value for class C operation. For the 6C4 with 350 plate volts grid bias will be approximately 40 volts.

The value of grid current is an arbitrary one. We have selected 80% of the maximum rated value as a satisfactory figure. That gives 6.5 Ma for the 6C4. The grid-leak bias resistor can be selected by dividing the grid bias by the grid current. Thus 40 ÷ 0.0065 = 6,000 ohms (approx.) which is the proper value for the 6C4. It should be noted that 100,000 ohms is the maximum amount of resistance that should be used in the grid circuit of any of the tubes in the table.

Typical Multiplier Conditions

For doubler service, divide the plate voltage by the Mu factor, and multiply by three. Calculate the value of grid-leak bias resistance in the same manner as in amplifier and oscillator conditions. Normal grid current will be the same.

The foregoing grid-bias formulas anticipate normal power output and plate circuit efficiency consistent with minimum grid drive and the least amount of unwanted harmonics. Higher bias will make possible somewhat more output at the expense of increased grid-drive requirements. Optimum conditions for frequency multiplier service may demand bias values near the maximums shown in the table.

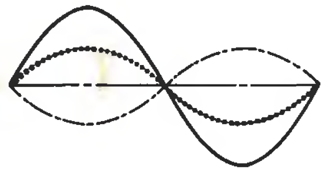


FIG. 1

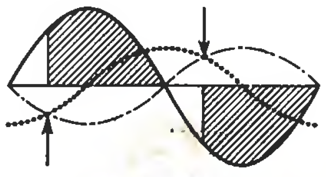


FIG. 2

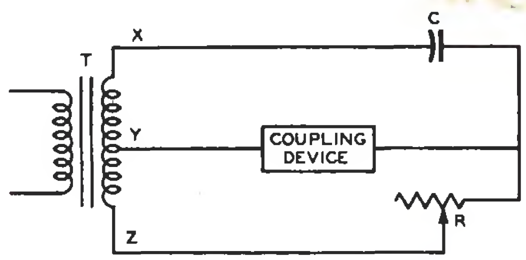


FIG. 3

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

POWER SUPPLY

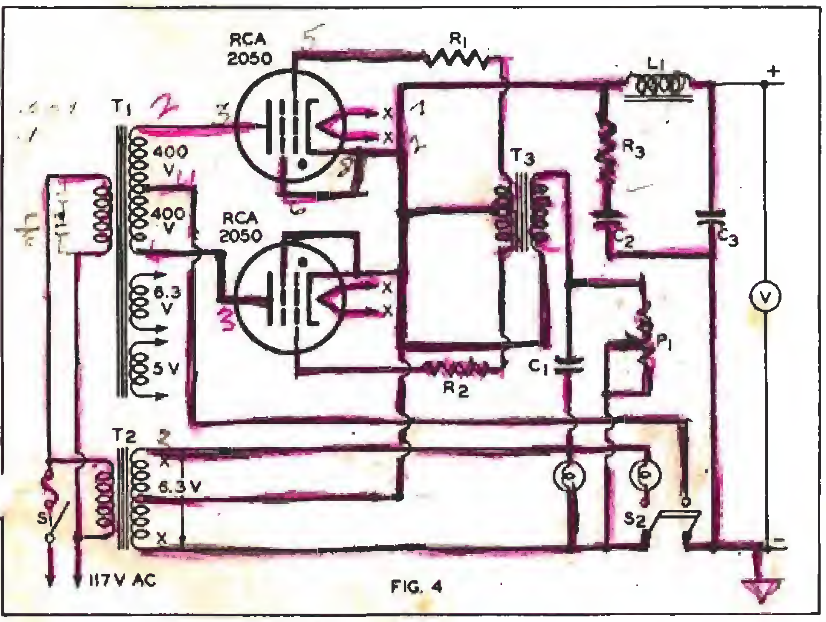
(Continued from Page 1, Column 1)

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. 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. 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, of course, 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.



Power supply schematic.

Construction Details

Figure 4 shows the complete circuit of the unit illustrated in the photograph. 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 ½ 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 proper phase relation so that firing is prevented when the potentiometer is in a maximum-resistance position.

Don't worry about the 10-uf 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

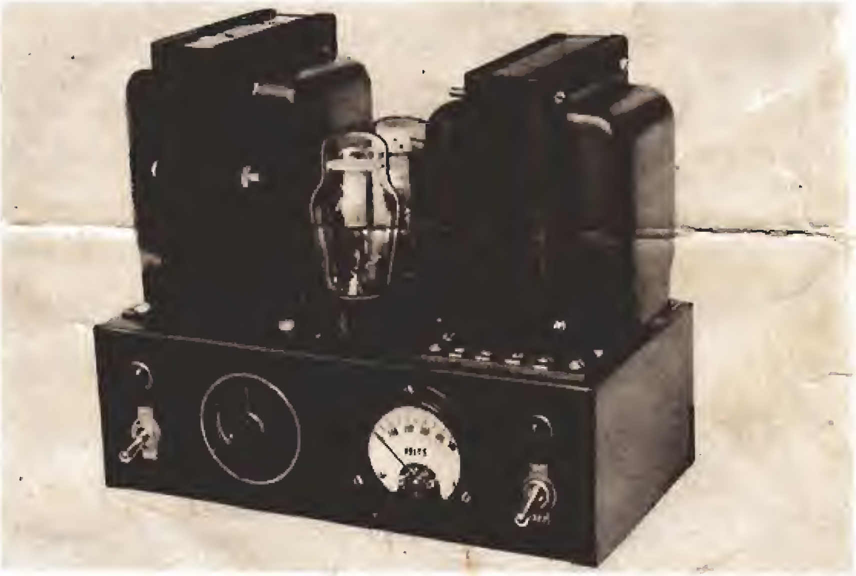
Because a capacitance-input filter is used, the voltage regulation will compare favorably with regular high-vacuum rectifiers. Therefore, the output voltage will rise considerably if the load is removed. The use of a swinging choke at the input to the filter will provide equivalent voltage regulation 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.

Benefits

All we can say here is that once you have built and used one of these grid-controlled thyratron power supplies, you will wonder how you ever managed to do without it in the past.

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.

ECHOS

In the September issue of Ham Tips, as well as in the letter-size data sheets which we distributed concerning the new ICAS ratings on the 813, we used poor arithmetic.

In the table under class C Telephony, ICAS, with 2000 volts on the plate, a grid resistor value of 41,250 ohms is shown. The correct value is 11,000 ohms for a grid current of 16 milliamperes.

RCA-2050 THYRATRON

HOT-CATHODE GAS-TETRODE *Amateur Net* **$1.70**

RCA 2050

Features

- *Excellent Efficiency.* SMALL TUBE DROP PERMITS GOOD RECTIFIER VOLTAGE REGULATION.
- *High Sensitivity.* AVERAGE PLATE-GRID CONTROL RATIO IS 250 TO 1.
- *Infinitesimal Grid Drive.* LESS THAN 0.1 MICROAMPERE CURRENT REQUIRED FOR FIRING.
- *Inert-Gas Filled.* EFFECTS OF AMBIENT TEMPERATURE CHANGES ARE NEGLIGIBLE.
- *Optional Mounting Position.* USE OF A HEATER-CATHODE DESIGN TOGETHER WITH AN INERT GAS ALLOW THE TUBE TO BE MOUNTED IN ANY POSITION.
- *Tetrode Construction.* ADJUSTMENT OF SHIELD-GRID VOLTAGE PERMITS CONTROL GRID TO HAVE EITHER NEGATIVE OR POSITIVE CONTROL CHARACTERISTICS.

Application

Rectifier Service. Choke-input filtering is recommended. If capacitance-input filtering is used, sufficient series impedance is required to keep the peak cathode current within rating.

Relay Service. With 60-cycle anode supply the grid regains control at the end of each positive half-cycle of the anode voltage, thereby providing on-off control. The grid can be excited from dc or from ac pulses up to 2 megacycles in frequency.

Bias Service. In low-voltage dc regulator circuits, a few ohms of resistance should be placed in series with any capacitance across the tube. Drop across the tube can be reduced about two volts by connecting the shield grid to the anode.

Photo-Relay Service. The tube will operate directly from a phototube. In this class of service, a grid resistance as high as 10 megohms may be used. The shield grid must be tied to the cathode.

Relaxation Oscillator Service. Shield the tube from rf fields and put rf impedances in series with the elements, otherwise the tube cannot deionize when the plate voltage drops below the sustaining potential.

Inverter Service. RCA-2050's can be used in inverter service at frequencies up to approximately 1000 cycles per second.

Remote Control Service. A number of remote circuits can be independently step-controlled over one pair of wires by using a 2050 at each remote circuit and having each 2050 arranged to operate at a different control-grid voltage.

RCA-2050 THYRATRON — Gas-Tetrode

GENERAL DATA

Electrical:			
Heater for Unipotential Cathode			
Voltage*	6.3		ac or dc volts
Current	0.6		amp
Direct Interelectrode Capacitances (Approx.):§			
Grid No. 1 to Anode	0.26		μμf
Input	4.2		μμf
Output	3.6		μμf
Tube Voltage Drop	8		volts
Control Ratio at Breakdown (Approx.)			
Grid No. 1 to Anode (Grid-No. 2 Voltage = 0)		250	
Grid No. 2 to Anode (Grid-No. 1 Voltage = 0)		800	

HAM TIPS is published by the RCA Tube Department, Harrison, N. J., and is made available to Amateurs and Radio Experimenters through RCA tube and parts distributors.

H. S. STAMM .... *Editor*
J. H. OWENS .... *Technical Editor*

Maximum Ratings, Absolute Values:

Peak Forward Anode Voltage	180 max.	650 max. volts
Peak Inverse Anode Voltage	360 max.	1300 max. volts
Grid-No. 2 (Shield Grid) Voltage		
Before Conduction	—100 max.	—100 max. volts
During Conduction	—10 max.	—10 max. volts
Grid-No. 1 (Control Grid) Voltage		
Before Conduction	—250 max.	—250 max. volts
During Conduction	—10 max.	—10 max. volts
Peak Grid-No. 1-to-Anode Voltage (Grid negative with respect to anode)	—	750 max. volts
Peak Cathode Current	1.0 max.	1.0 max. amp.
Average Cathode Current†	200 max.	100 max. ma.
Surge Cathode Current for 0.1 sec. max.	10 max.	10 max. amp.
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	100 max.	100 max. volts
Heater positive with respect to cathode	25 max.	25 max. volts
Ambient Temperature Range	—75 to +90	—75 to +90 °C

Typical Operating Conditions for Relay Service:

RMS Anode Voltage*	400	volts
Grid-No. 2 Voltage	0	volts
RMS Grid-No. 1 Bias Voltage**	5	volts
Peak Grid-No. 1 Signal Voltage	5	volts
Anode Circuit Resistance‡	2000	ohms
Grid-No. 1 Circuit Resistance	1.0	megohm

Maximum Circuit Values:

Grid-No. 1 Circuit Resistance:	
For Average anode current of 100 ma. max.	10 megohms
For Average anode current of 200 ma. max.	2 megohms

§Without external shield.

*Heater voltage must not deviate more than 10% from the rated value and must be applied at least 10 seconds before start of conduction.

†Averaged over any 30-second interval.

**Approximately 180° out of phase with the anode voltage.

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