Cathode Modulation

for Economical Radiotelephony

By

Frank C. Jones

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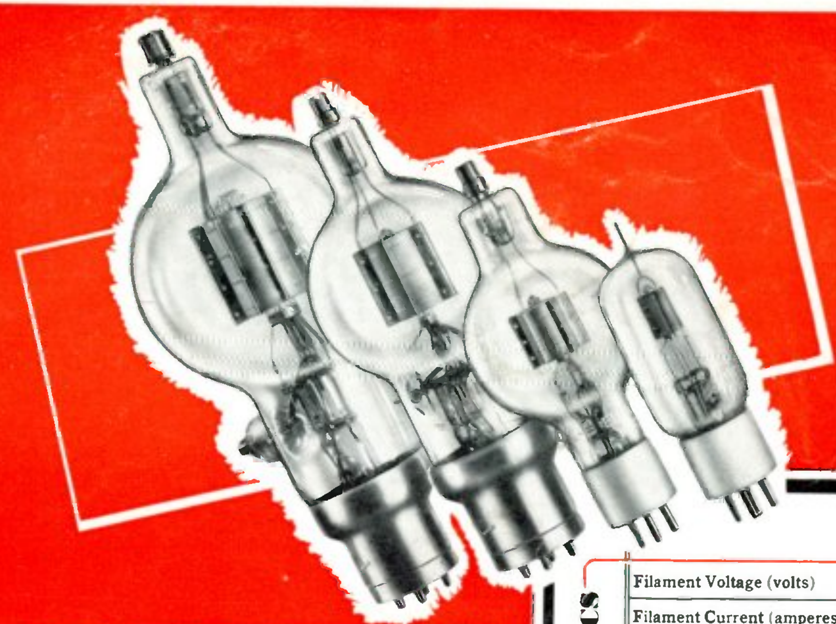
World Radio History



Eimac Tubes

UNCONDITIONALLY GUARANTEED AGAINST TUBE FAILURES WHICH RESULT FROM GAS RELEASED INTERNALLY

		35T 35TG*	75T	100 TL	100 TH	250 TL	250 TH	450 TL	450 TH	750 TL	1500 T	2000 T	UH 35	UH 50	UH 51	Twin 30	1000 UHF
CHARACTERISTICS	Filament Voltage (volts)	-5	5	5	5	5	5	7.5	7.5	7.5	7.5	10	5	7.5	5	6	7.5
	Filament Current (amperes)	4	6.5	6.5	6.5	10.5	10.5	12	12	21	26	26	4	3.25	6.5	4	16
	Amplification Factor	30	10.6	12	30	13	32	16	30	13.5	18.5	18.5	30	10.6	10.6	32	30
	Grid-Plate Capacity (mmfds)	1.9	2.3	2.3	2	3.5	3.3	4	4	4.5	7	9	1.6	2.6	2.3	2*	4
	Grid-Filament Cap. (mmfds)	4.0	2.2	2	2.2	3	3.5	4	4	6.0	10	13	1.4	2.2	2.2	1.9*	6
	Plate-Filament Cap. (mmfds)	.2	.3	.4	.3	.5	.3	.6	.6	.8	.9	1	1.9	.3	.3	.2	.6
	Bulb	T14 Nonex	G22 Nonex	GT25 Nonex	GT25 Nonex	GT30 Nonex	GT30 Nonex	GT40 Nonex	GT40 Nonex	GT56 Nonex	GT56 Nonex	GT64 Pyrex	T14 Nonex	S21 Nonex	S21 Nonex	T14 Nonex	GT40 Nonex
	Base	Isolantite UX4 Prong	Isolantite UX4 Prong	Isolantite UX4 Prong	Isolantite UX4 Prong	Standard 50 Watts	Standard 50 Watts	Standard 50 Watts	Standard 50 Watts	Special	Special	Special	Isolantite UX4 Prong	Isolantite UX4 Prong	Isolantite UX4 Prong	Isolantite UX4 Prong	Standard 50 Watts
	Overall Height (inches)	5½	7	7½	7½	9¾	9¾	12½	12½	16½	16½	17½	5½	6¾	6¾	4¾	12½
	Maximum Diameter (inches)	1¾	2¾	3⅛	3⅛	3¾	3¾	5	5	7	7	8	1¾	2⅝	2⅝	3	5
Maximum Ratings	Max. Plate Voltage (volts)	2000	3000	3000	3000	3000	3000	6000	6000	6000	6000	6000	2000	1250	2000	1500	6000
	Max. Plate Current (millamps)	150	175	225	225	350	350	500	500	1000	1250	1750	150	125	175	85*	750
	Max. Grid Current (millamps)	35	30	35	50	50	100	75	125	125	175	225	35	25	25	30*	125
	Plate Dissipation (watts)	70	75	100	100	250	250	450	450	750	1500	2000	70	50	50	30*	1000
	Power Output (watts)	240	300	400	400	800	800	1800	1800	3000	5000	7500	240	125	300	175	3500
FCC	Power Output (watts) High Level Modulated	50	100	100	100	350	350	500	500	1000 2500‡	2500	2500 7500‡	....	....	....	....	1000 2500‡
	Power Output (watts) Linear Amplifier	....	25	50	50	125	125	125	125	350	500	1000	....	....	....	....	350
	LIST PRICE	$6.00	$9.00	$13.50	$13.50	$24.50	$24.50	$75.00	$75.00	$175	$225	$300	$10.00	$12.50	$12.50	$13.50	$175

*Same as 35T except: Grid to filament capacity 1.9 Grid to plate capacity . . 1.7 ‡Two tubes *Characteristics per section

MERCURY VAPOR RECTIFIERS

	RX21	Grid Control KY21
Filament Voltage	2.5 volts	2.5 volts
Filament Current	10 amperes	10 amperes
Peak Inverse Voltage	11,000 volts	11,000 volts
Peak Plate Current	3 amperes	3 amperes
Average Plate Current	.75 amps.	.75 amps.

VACUUM TANK CONDENSER

This new condenser eliminates the use of the old fashioned open plate type, provides a positive, accurate means to determine the optimum "Q" of your tank circuit, assures proper load balance on each of the tubes and minimizes "splatter" on phone signals. No loss of power on a stray harmonic, no loss of efficiency.

The single units are available in 6, 12, 25, and 50 mmfd capacities . . . priced net at $7.50, $8.50, $10.50 and $12.50 respectively.

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Cathode Modulation

BY

FRANK C. JONES
RADIO ENGINEER

An Economical and Efficient System of Modulation for Radiotelephony

■

DRAFTINGS BY C. C. ANDERSON, W6FFP

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high-lights
of *Cathode Modulation*

□□ **1**— An Inexpensive System Of Modulation For Any R. F. Amplifier

□□ **2**— 100% Modulation Capability -- Up To 60% R. F. Efficiency

□□ **3**— Can Be Added To Any C. W. Transmitter With Comparative Ease

□□ **4**— Grid Drive Requirements Same As For C. W. Telegraphy

□□ **5**— Smaller And Cheaper Tuning Condensers in R. F. Amplifier

□□ **6**— Eliminates Cumbersome And Costly Modulation Transformers

□□ **7**— Smaller And Cheaper Tubes In Final Modulator Stage

□□ **8**— Low Voltage Power Supply For Modulator -- Smaller Tubes

□□ **9**— Occupies Less Space -- Has Less Weight -- Is More Portable

□□ **10**— Freedom From Distortion -- To "Trick" Circuits -- Foolproof

□□ **11**— No Special Parts -- Standard Components Available Anywhere

□□ **12**— Substantial Reduction In Overall Cost Of Transmitter

■■

Practical Examples of Modulator Economy

A Single 6F6 Pentode Will Modulate A 25-Watt Carrier
A Pair Of 6L6 Tetrodes Will Modulate 250-500 Watts
A Full Kilowatt Input Is Modulated With A Pair of 809s

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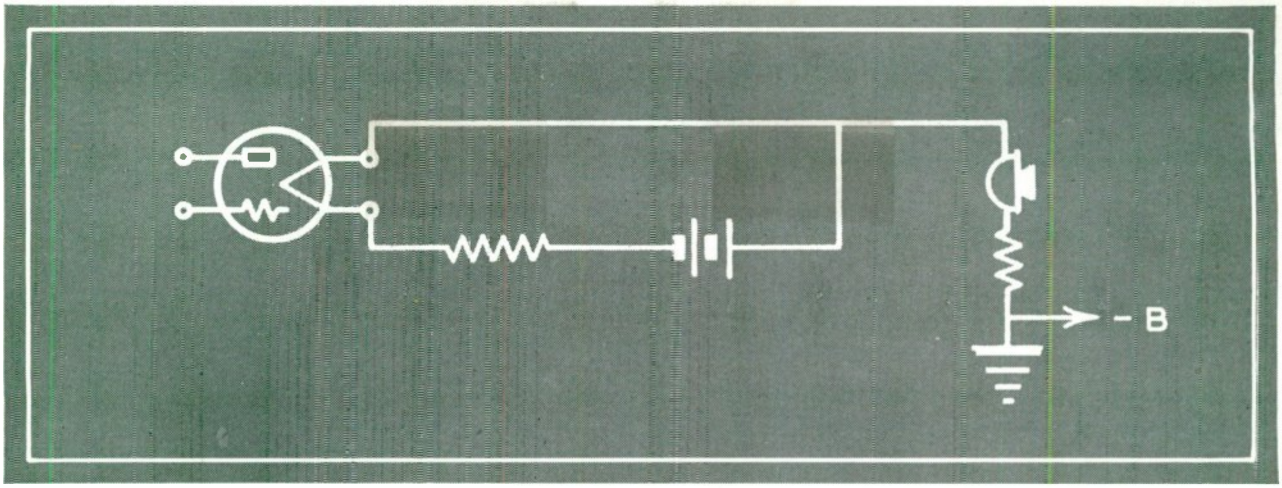

Cathode Modulation Introduced in 1934

■ In earlier days of radio circuit development, Frank C. Jones introduced a simple means for modulating the cathode of a vacuum tube in an ultra-high frequency radio transceiver. The circuit, reproduced above, was published in 1934 in the author's booklet, titled "5-Meter Radiotelephony", of which more than 80,000 copies were sold. Subsequently the circuit was published in several editions of the author's handbook, and further publicity was found in the amateur radio press. Cathode Modulation was one of the features of the world's first one-tube 5-meter transceiver, also developed by Frank C. Jones. The transmitter portion of this transceiver was modulated by means of a carbon microphone in the cathode circuit. The audio-frequency power developed by this microphone produced cathode modulation in a manner somewhat similar to that of cathode-modulation of the present day. This same transceiver made use of a cathode bias resistor in order to operate the tube on a portion of its characteristic suitable for cathode modulation. The output from the carbon microphone was not sufficient to modulate a high power transmitter, and a long series of experiments was conducted by the author in an endeavor to apply the principles of cathode modulation to transmitters of high power. Other experimenters joined in this research, with varying degrees of success. The principal obstacle encountered was that of determining the correct application of grid bias with respect to the values of fixed and grid-leak combination. Another problem was the determination of the correct load impedance of the Class-C circuit of the r.f. amplifier. No solution of these problems had ever been made public. It remained for the author to continue his research—and, after years of experimenting with cathode circuits for crystal oscillators, receivers, etc., Frank C. Jones now gives you one of the most useful, economical and far-reaching developments of his long and successful career.

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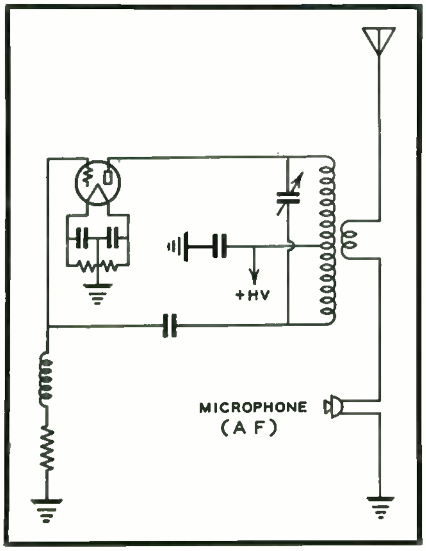

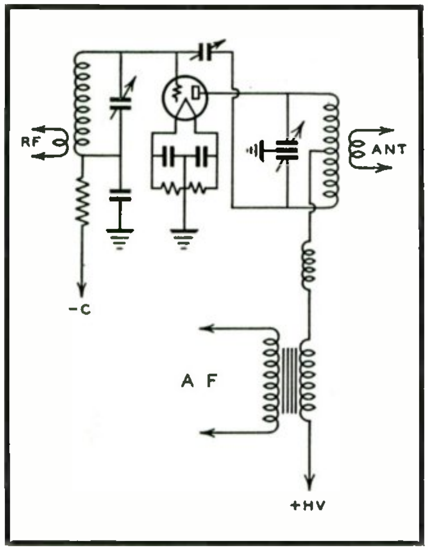

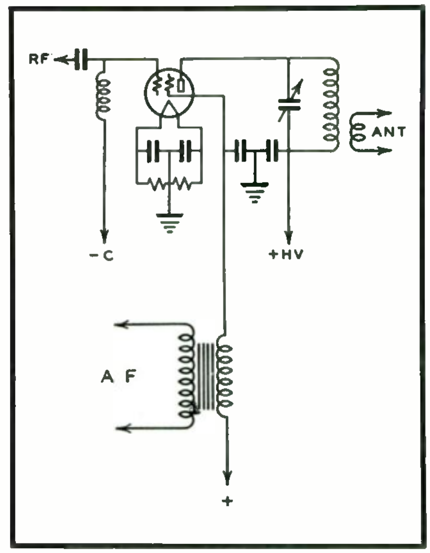

Absorption Modulation

■ The evolution of modulation from the time it was first used commercially, through the years to the present day, is detailed here and on the facing page. The fundamental circuit diagrams only are given, and the text is merely for the purpose of relating briefly the comparative advantages and disadvantages of the respective systems. One of the early systems of modulation was known as *"Absorption Modulation,"* wherein one or more carbon microphones are connected into the antenna circuit in such a manner as to vary the antenna current in accordance with the speech input. This system has untold disadvantages, principally the highly unsatisfactory degree and quality of modulation; furthermore, it is capable of modulating low power only. The carbon microphone acts as a variable resistor in this type of circuit; it absorbs radio-frequency power in an amount depending upon the intensity of speech input. In some applications, the microphone was coupled to the tuned circuit by a turn of wire, or loop, from which the expression *"Loop Modulation"* was derived. The radio-frequency power is limited to a few watts, the speech quality so poor that it is barely understandable. Many carbon microphones were ruined after being in service a short time only. *Absorption Modulation* was used prior to the World War and has been completely obsolete for many years.

Plate Modulation

■ The majority of present-day radiotelephone transmitters are plate-modulated. The radio-frequency amplifier operates at high efficiency, and excellent modulation quality, up to 100%, is attainable in practice. The actual voltage applied to the r.f. amplifier is varied from zero to twice the d.c. plate voltage for a condition of 100% modulation, and the plate current varies in a similar manner. *Plate Modulation* derives its name from the fact that audio-frequency power is applied to the plate circuit of a Class-C amplifier. The instantaneous plate voltage and plate current are varied in accordance with the wave form of speech; the result is a variation of power input to the tube being modulated. The audio-frequency power required for complete modulation is 50 percent of the d.c. power input to the r.f. amplifier. Early forms of *Plate Modulation* made use of a high inductance choke coil which was common to the r.f. and a.f. modulator tubes. A great improvement in this type of modulation was later brought about by means of transformer-coupling from the modulator to the Class-C amplifier plate circuit. Modulation transformers, particularly those required for high power transmitters, are costly and bulky. Large tubes are also needed for high power operation, and the modulator power supply is expensive.

Screen Modulation

■ The advent of screen grid tubes made possible another system of modulation, called Screen-Grid Modulation. The r.f. output of a screen-grid tube can be controlled by variation of the screen-grid voltage. If the d.c. screen voltage is reduced to a value which will also reduce the r.f. output to a fraction of its usual maximum output, an audio-frequency voltage can be applied in series with the screen supply. The positive audio peaks produce an increase of r.f. amplifier output, while the negative peaks produce a decrease of r.f. output, with respect to the carrier power level. This sytem of modulation requires only a small amount of audio-frequency power, but modulation is limited to approximately 60 percent, and for this reason *Screen-Grid Modulation* is seldom used. It is possible to obtain 100 percent modulation if two successive screen-grid stages are screen-modulated, but the transmitter becomes difficult to adjust for distortionless 100 percent modulation. Modulation is obtained by varying the efficiency of the screen-grid amplifier, rather than by variation of plate power input, as in the case of *Plate Modulation*

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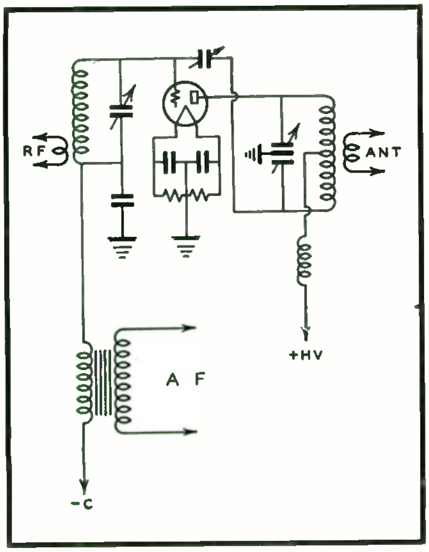
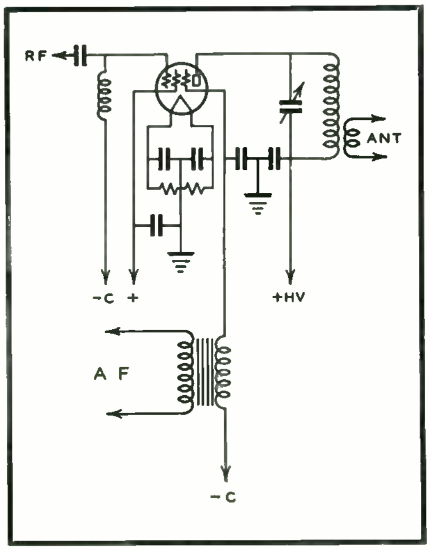
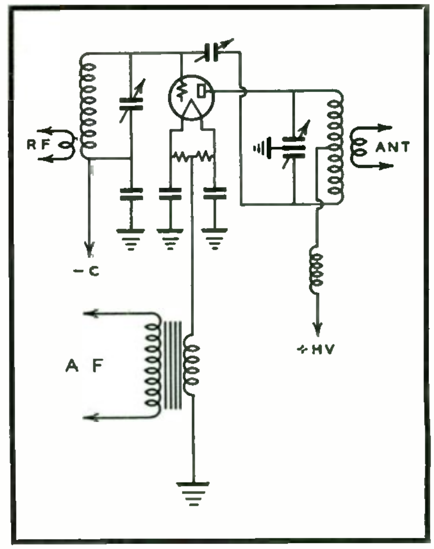
# of Modulation







Grid Modulation

■ There are many forms of *Grid Modulation,* the most commonly used is shown in the circuit diagram above. Here an audio frequency voltage is applied in series with the C-bias supply to the r.f. amplifier. The plate power input remains constant, and modulation is obtained by varying the operating efficiency of the tube over a range of 2-to-1 in the case of 100 percent modulation. The resting efficiency of the r.f. amplifier varies between 15 percent and 25 percent in distortionless forms of *Grid Modulation,* and may run as high as 30 to 40 percent if some distortion is tolerated. In either case, the efficiency is doubled at the time of peak audio-frequency input when 100 percent modulation is produced. The audio-frequency voltage adds to, and subtracts from, the d.c. value of grid-bias voltage and thus varies the r.f. power output of the Class-C amplifier. Grid-Modulated amplifiers are not as easily adjusted as plate modulated transmitters for distortionless modulation. The plate circuit efficiency is low, which means that large tubes must be used in the r.f. amplifier as compared to those used for *Plate Modulation.* The audio-frequency power, however, is a maximum of a few watts for *Grid Modulation,* and small audio-frequency amplifiers are therefore suitable for this purpose.

Suppressor Modulation

■ Pentode r.f. amplifier tubes incorporate an additional grid, called a suppressor-grid, placed between the screen and plate elements of the tube. The efficiency and r.f. output of a pentode screen-grid tube amplifier can be varied by changing the bias voltage on this grid. Greatest r.f. output occurs when the grid is slightly positive with respect to the filament or cathode. An audio-frequency voltage can be connected in series with the suppressor-grid bias supply, which will provide a simple means of obtaining satisfactory modulation, up to a level of nearly 100 percent, and *Suppressor-Grid Modulation* is the result. The suppressor-grid is normally biased to a negative voltage of from 45 to 100 volts, and the audio-frequency voltage varies the instantaneous bias over a linear portion of the tube's operating characteristic. The r.f. output must be reduced to one-fourth of that which can be obtained from the same tube when used in a conventional c.w. amplifier. The plate circuit efficiency is reduced 50 percent, and the tube operates in a form of efficiency modulation similar to *Screen-Grid* or *Ordinary Grid Modulation.* The r.f. input to the control grid is not critical in this case, as it would be in other forms of *Grid-Modulation.*

Cathode Modulation

■ The most recent development in modulation is a means for applying audio power to the cathode circuit of a Class-C r.f. amplifier. Some of the advantages of both *Plate* and *Grid Modulation* are evident in this newer system, yet with none of the disadvantages of the former. *Cathode Modulation* is a system in which a combination of *Plate* and *Grid Modulation* is combined to deliver high r.f. output up to a level of 100 percent. The audio-frequency power required for this system is slightly more than for *Grid Modulation,* but much less than for *Plate Modulation.* This audio-frequency power requirement is approximately 10 percent of the d.c. plate input power. For a given carrier output, this system of *Cathode Modulation* is more economical than any other known means. The plate dissipation of the modulated tube or tubes is approximately the same as for *Plate Modulation* during the period of high level modulation. The r.f. output is somewhat lower than in a *Plate-Modulated* transmitter using the same tubes, but is two or three times as great as the power obtained from a *Grid Modulated* transmitter. The numerous advantages of *Cathode Modulation* are related in the text which follows.

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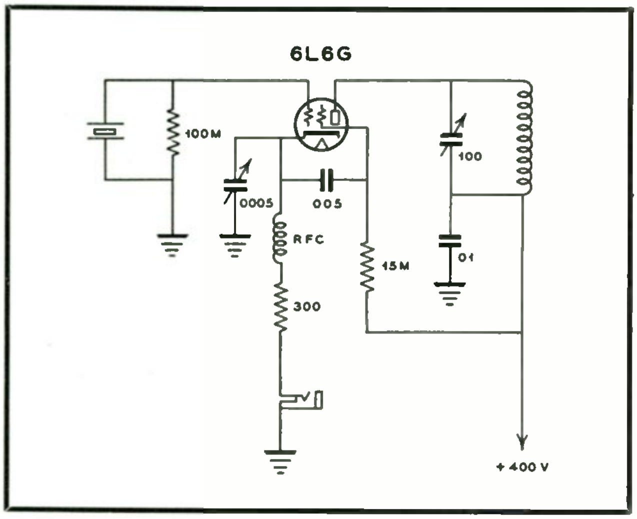
The newest Jones harmonic oscillator for wide-range operation

THE FIRST Jones Oscillator made its appearance many years ago. The circuit included a type 53 or 6A6 twin-triode tube, one triode section acting as a crystal oscillator, the other as a frequency doubler. The important detail of this circuit was the incorporation of cathode resistor bias—rather than grid-leak bias—in the crystal oscillator section in order to permit the application of higher plates voltages, with consequent higher power output for a given amount of crystal stress or heat. This was the first time that cathode bias was used in an oscillator tube circuit. The development of this oscillator came about by taking advantage of the tube's cathode for circuit improvement. Continued experimentation with cathode circuits of various kinds eventually resulted in the development of the *Jones Harmonic Oscillator* with 6L6 or 6L6G tubes. There were several circuit variations of this harmonic oscillator, all of which were dependent upon cathode action for oscillation and harmonic generation in a single tube and only one tuned circuit. These harmonic crystal oscillators provided output on the fundamental frequency of the crystal as well as on any harmonic to which the plate circuit was tuned. One of the principal reasons for the success of this oscillator is the fact that its output is very nearly the same on both the fundamental and second harmonic frequency. Cathode regeneration in the *Jones Harmonic Oscillator* provided a means for maintaining the crystal in a state of oscillation on its fundamental frequency, even when the plate circuit was tuned to some other frequency—such as a harmonic. The accompanying circuit diagram shows how the crystal and plate return circuits are connected together. A common reactance, either in the plate return circuit or directly in the cathode circuit, results in a form of *Pierce Oscillator,* which permits the crystal to oscillate even when the plate circuit is tuned to a higher harmonic of the crystal frequency. The correct value of cathode regeneration provides high output on the harmonics, without difficulty from self-excited oscillation, other than that of the crystal frequency.



IMPROVED JONES HARMONIC OSCILLATOR

In the *Improved Jones Harmonic Oscillator,* shown in the circuit diagram, the screen of the oscillator tube is by-passed directly to the cathode, rather than to ground, in order to produce a circuit which can be operated over a very wide range of frequencies without readjustment of the cathode control condenser. In this improved circuit, the .0005 mfd. semi-variable condenser in the cathode circuit is adjusted to a value which will be correct for 160, 80 and 40 meter crystals, operated on the fundamental or second harmonic, or 20 and 10 meter crystals operating straight through in the 20 and 10 meter bands, respectively. A radio-frequency choke is in series with the cathode; this prevents the r.f. current from passing through the 300-ohm cathode resistor, thereby effectively changing the capacity of the cathode regeneration control condenser. The value of the cathode condenser depends upon the plate and screen voltage applied to the oscillator, and to the load connected to the tuned plate circuit. For this reason it is desirable to use an adjustable mica trimmer condenser, which can be set to some value between .0003 and .0005 mfd.

Practically any pentode or tetrode is suitable for operation in this circuit, if appropriate plate voltage is applied. The only requirement is the need for good, active crystals for frequency doubling or tripling in the plate circuit. Frequency doubling cannot be accomplished with conventional 10 and 20 meter crystals because these already operate on the third harmonic; their use would result in sixth harmonic operation in the plate circuit.

The oscillator can be capacitively coupled to the grid of a buffer or doubler tube, or link coupled to a tuned grid circuit. Applications of this and other oscillator circuits are shown as part of the complete schematic diagrams for radiotelephone transmitters described elsewhere in these pages. The cathode circuit plays an important part in the crystal oscillator, also in the doubler and buffer stages, and finally in the modulator, where cathode modulation for radiotelephony is made practical for the first time.

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Cathode Modulation

Part I

WHEN SOUND energy of the human voice strikes the diaphragm of a microphone, an electrical signal is generated. This signal varies in amplitude and frequency in accordance with the changes in speech. The electrical energy is amplified to a value which will produce amplitude and modulation of the radio-frequency energy in a transmitter. Amplitude modulation can be graphically represented as illustrated in Fig. 1. The process consists of varying the amplitude of radio-frequency power in accordance with the speech input. The radio-frequency carrier is of constant amplitude, and side-band radio-frequency waves are radiated with the carrier in a process known as *amplitude modulation.* The side bands consist of two groups of the sum and difference frequencies, which vary in amplitude and differ from the carrier frequency by the value of audio-frequency impressed upon the modulator system.

The modulated signal is doubled in amplitude at the point of 100 percent modulation, and the instantaneous peak power output is four times as great as the unmodulated power. This is best illustrated in the case of plate modulation, in which the instantaneous plate voltage and plate current are both doubled, resulting in peak power input four times as great as the unmodulated power input. The power output in plate modulation is proportional to the power input, since the amplifier operates at constant efficiency. In the case of pure-tone modulation at a level of 100 percent, the average power will be 1.5 times the unmodulated power. The additional 50 percent increase is represented by the power in the two side bands. Amplitude modulation can be produced in a number of different circuits, as illustrated on pages 4 and 5.

Since the average power is increased to 1.5 times the unmodulated power, the antenna current will be 1.225 times the unmodulated value, because the power varies as the square of the current. This means a 22.5 percent increase in current for the point of 100 percent modulation with a pure tone or sine wave input. The antenna current is not increased to this value with speech input, due to the high harmonic content of the speech. The side-band power is increased only approximately half as much with speech input as with pure tone input; however, the peak

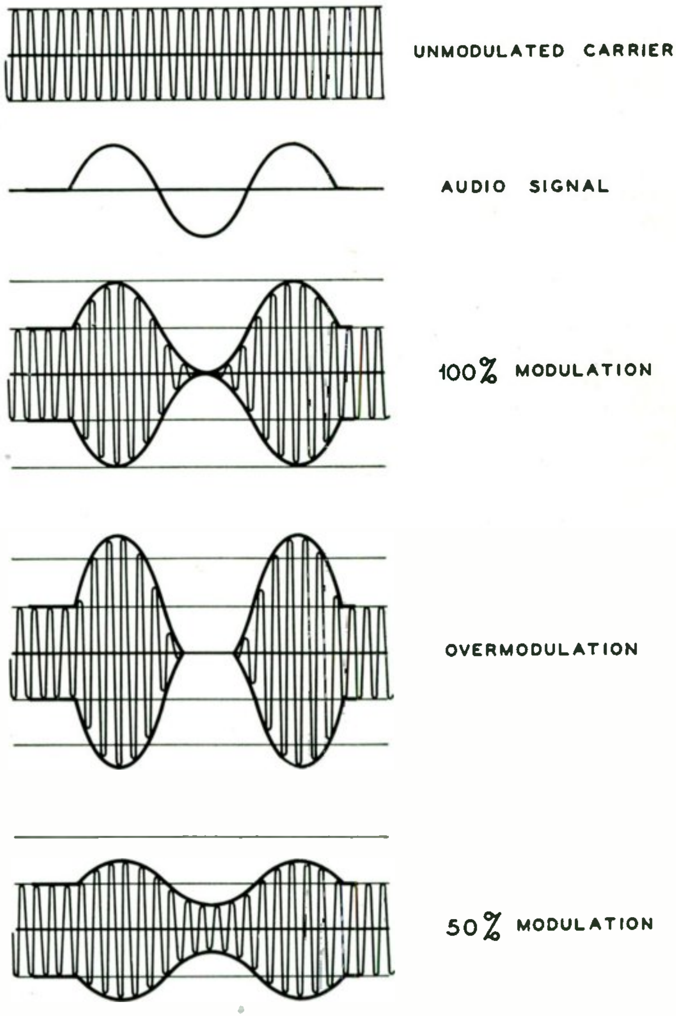

Fig. 1

value of power is still four times as great as the unmodulated power in either case. This means that the modulator must be able to supply the same peak audio power for either pure tone input or speech, but for the average power with speech input it is only about half as much as with sine wave input. This effect makes possible a certain saving in modu-

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lator design for any system of amplitude modulation, provided that the modulator is designed in such a manner as to be able to supply the peak audio power without appreciable distortion.

The graphic representations of modulated waves in Fig. 1 show the unmodulated radio-frequency carrier, and three modulated waves in which the amplitude of the audio-frequency signal is of different values. It is desirable to operate a radio transmitter with the average level of modulation as high as possible, but never exceeding 100 percent. Overmodulation produces spurious side bands and illegal interference in adjacent radio channels.

In order to thoroughly understand the theory of cathode modulation, it may be necessary for the reader to refresh his knowledge of plate and grid modulation.

IN PLATE modulation, both the plate voltage and plate current of the Class-C modulated amplifier are varied in accordance with the speech signal. The instantaneous plate voltage varies from zero to twice the d.c. plate voltage during the period of 100 percent modulation, and the instantaneous plate current varies in a similar manner. The d.c. plate current, as indicated by a d.c. milliammeter, remains constant. The amplifier operates at some fixed value of efficiency, which means that the radio-frequency output is directly proportional to the input at all times. The audio-frequency power required to produce 100 percent modulation with pure tone input is one-half the d.c. power input to the Class-C amplifier. The peak audio power, with either pure tone or speech signal input, is equal to the d.c. power input, in the case of 100 percent modulation. The Class-C amplifier is generally driven with high r.f. excitation and d.c. grid-bias of at least twice cut-off. No modulation takes place in the grid circuit. In order to obtain full modulation with a minimum amount of audio power, the modulator is connected to the Class-C amplifier through a transformer which changes the d.c. plate impedance of the Class-C amplifier to a value which will properly match the plate circuit of the audio-frequency modulator. With pure tone input, 100 percent modulation can be obtained with an average audio-frequency power of 50 percent of the d.c. power input to the Class-C amplifier. 50 percent plate modulation can be obtained with only one-quarter as much power as would be required for 100 percent modulation.

THE audio-frequency power is connected in series with the grid-bias supply of a Class-C amplifier for ordinary grid modulation. The plate voltage is not varied, as in the case of plate modulation. The audio-frequency voltage varies the amplitude of grid bias, which varies the output of the r.f. amplifier in the process of modulation. The r.f. grid excitation must be set at a critical value in order to obtain distortionless modulation. The variation of r.f. power output is accomplished by the change in plate circuit efficiency of the grid-modulated amplifier. If 100 percent modulation is desired, the plate circuit efficiency of the resting or unmodulated carrier condition will be only one-half that which would prevail at the point of full modulation. If the r.f. amplifier reaches a peak of 70 percent efficiency, the unmodulated carrier condition will require the amplifier to be adjusted to a value of 35 percent efficiency. The r.f. output is only 35 percent of the d.c. input to the modulated tube, or tubes; the remainder is dissipated in the form of heat in the plates of the tubes. This means that much larger r.f. vacuum tubes are needed for grid modulation than for plate modulation. On the other hand, the audio-frequency power required for grid modulation is only a fraction of that needed for plate modulation.

Process of Cathode Modulation

CATHODE modulation is a comparatively recent development in radiotelephony; it is more economical than plate modulation, and it possesses many exclusive advantages over other systems of modulation. The audio-frequency power is connected to the cathode or filament circuit of the Class-C r.f. amplifier, as shown in Fig. 2. Cathode modulation is essentially a combination of grid and plate modulation, as will be explained later in the text.

The audio-frequency power is connected to a circuit of low impedance which is common to both the grid and plate return circuits in the r.f. amplifier. The variation of audio-frequency voltage in the cathode circuit produces a certain degree of plate modulation in combination with grid-bias modulation. The two forms of modulation are in phase. The instantaneous audio voltage across the cathode winding of the modulation transformer may produce a positive voltage on the cathode, which is equivalent to increasing the negative C-bias on the r.f. amplifier; this reduces the radio-frequency output. The same positive voltage on the cathode reduces the instantaneous plate voltage, because this is in opposition

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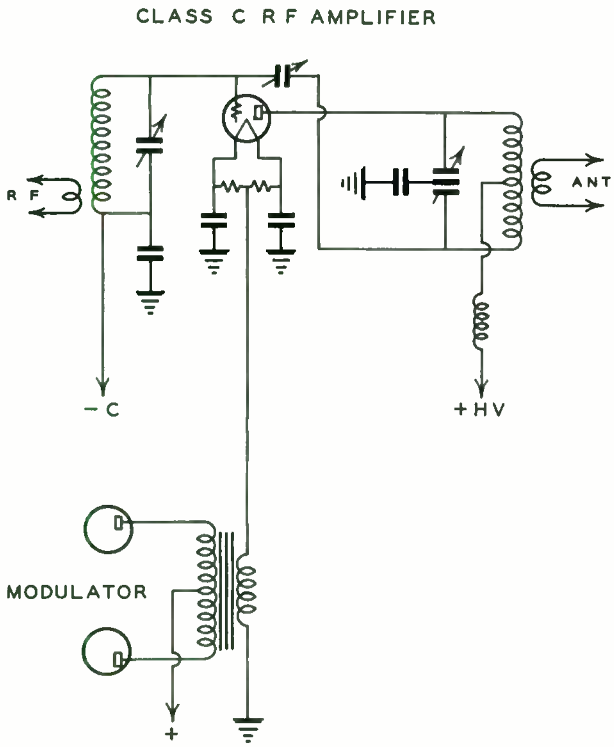

Fig. 2

THE process of cathode modulation can be illustrated graphically as shown in Fig. 3. The d.c. grid-bias is set at some value corresponding to two or three times cut-off. When an aduio-frequency voltage is applied to the grid circuit by means of the cathode impedance, it produces a variation in the instantaneous plate current, as indicated in Fig. 3. The instantaneous plate voltage is changed by an amount equal to the peak voltage across the cathode impedance at the same time that it is changing the grid-bias. This means that the r.f. amplifier is effectively operating as a modified form of expanding grid-modulated r.f. amplifier. The plate voltage does not remain constant, and the amplifier operates over a group of EgIp curves. In Fig. 3 the d.c. potential was chosen as 1000 volts and the amplifier operates in the region of from 850 to 1150 volts, due to the variation in audio-frequency voltage across the cathode impedance. A part or the whole of this same variation of 150 volts is applied to the grid-bias circuit. The d.c. meter reading, both of plate current and grid current, will remain constant, providing that the original operating conditions are chosen so that the average grid current is constant.

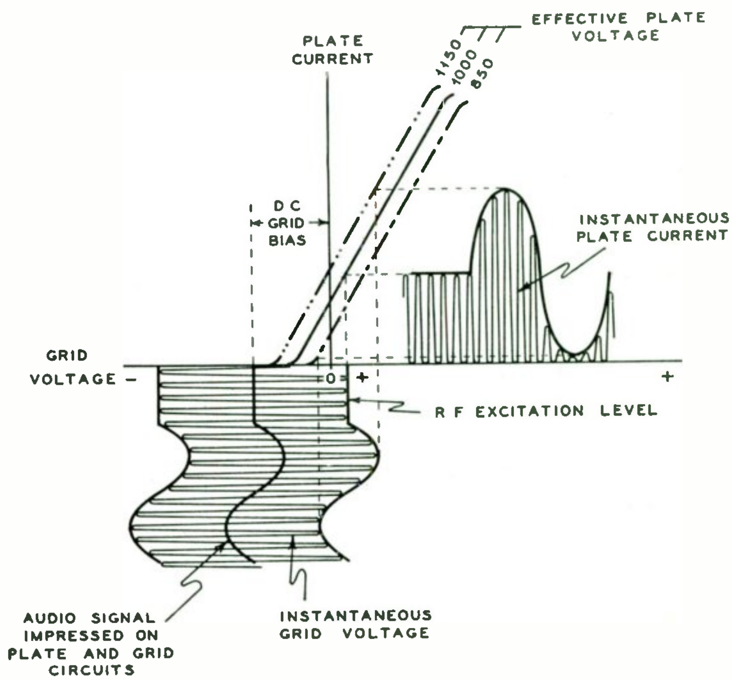

Fig. 3

It is possible to obtain 100 percent modulation by means of cathode modulation. The effective plate

to the positive d.c. plate voltage. This reduction in plate voltage also reduces the r.f. output, which means that the grid and plate modulation are both in the same direction, or in phase. At any instant when the audio-frequency voltage makes the cathode negative with respect to ground, the instantaneous total plate voltage is increased and the negative grid-bias decreased; this results in an increase of r.f. output.

The impedance of the cathode circuit is relatively low in value, ranging from 300 to 1,500 ohms in practice. The effective load impedance across the secondary winding of the modulation transformer is inversely proportional to the operating transconductance of the r.f. amplifier tube, or tubes. If a load impedance of 500 ohms is chosen for any Class-C r.f. amplifier, the operating conditions will be satisfactory—and very good quality of modulation can be obtained. Push-pull or parallel tubes in the r.f. amplifier have a lower load impedance, but for all practical purposes a value of 500 ohms has proven satisfactory. A relatively small impedance mismatch has no apparent effect upon the quality of modulation for communication service, although a small amount of audio power will be wasted. An impedance mismatch of 2-to-1 can be tolerated without ill-effect, probably due to the benefit of inverse feed-back in the r.f. amplifier.

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modulation may amount to some value between 25 and 40 percent, the remainder being in the form of grid modulation. As an example, a Class-C amplifier with an input of 200 watts would require 100 watts of sine-wave-form power to produce 100 percent plate modulation. 25 watts of audio-frequency will produce 50 percent modulation, in this same example. Similarly, 6.25 watts will produce 25 percent modulation. Approximately one watt of audio power will produce high-level grid modulation. When this power is applied in series with the cathode, about one watt is used in the grid circuit to produce grid-bias modulation of some value between 60 and 75 percent modulation, and the remainder is used to produce plate modulation. If the amplifier requires 25 percent plate modulation to reach the peak of 100 percent, this example would require 6.25 watts of audio across a plate circuit impedance. The cathode circuit impedance is in series with the plate circuit, but because this value is 500 ohms, rather than several thousand ohms, from two to three times as much audio power will be required to effectively plate-modulate the amplifier. This means that 6 watts in the plate circuit is approximately the same as 15 to 20 watts in the cathode circuit, because of the "impedance mismatch." Thus it can be seen that approximately 20 watts of audio-frequency in the cathode circuit will produce complete modulation of a Class-C r.f. amplifier with 200 watts plate supply. The audio-frequency power therefore required is approximately 10 percent of the d.c. power input to the modulated amplifier. This is a great deal less than for plate modulation, resulting in a considerable saving in modulator and power supply equipment.

R. F. Amplifier Efficiency

A GRID-modulated amplifier requires a condition of no d.c. grid current, in the case of distortionless modulation, or a very small value of d.c. plate current in ordinary grid-bias modulation. This condition is necessary in order that the amplifier may operate with an efficiency ratio of 2-to-1, from 100 percent to a condition of no modulation. If the amplifier operates at 70 percent efficiency at the point of 100 percent grid modulation, the unmodulated efficiency would be 35 percent. If the grid modulation is limited to some value between 60 and 75 percent, the unmodulated efficiency can be increased to a value of approximately 60 percent. Thus the same tube, or tubes, in the r.f. amplifier will produce a carrier power output of from two to three times that which could otherwise be obtained when the efficiency is in the vicinity of 30 percent. The unmodulated efficiency of a cathode-modulated amplifier ranges from 50 to 60 percent.

The efficiency of a plate-modulated r.f. amplifier ranges from approximately 65 to 75 percent. The cathode-modulated amplifier must be operated at approximately 15 percent lower efficiency in order to provide a condition for grid modulation. The r.f. output from a cathode-modulated amplifier approaches that of a plate-modulated amplifier. In a plate-modulated r.f. amplifier, the grid-bias and r.f. excitation are set at very high values, often to a point which produces saturation in the r.f. tube. In cathode modulation, the d.c. grid bias and r.f. excitation are set at values intermediate between those of grid and plate modulation.

Unlike grid modulation, it is possible to use grid-leak bias with cathode modulation because the d.c. grid current is high enough to provide a fairly constant grid-bias voltage. It is necessary to by-pass the grid-leak for audio frequencies in order to produce grid-bias modulation. In some cases, part of the grid-leak resistance should not be by-passed for audio frequencies, so as to limit the amount of grid modulation with respect to the effective plate modulation. Fortunately, in nearly all types of tubes used in r.f. amplifiers, cathode modulation automatically produces the desired ratio of plate and grid modulation. In some cases, the linearity of modulation is improved if a resistance is connected in series with the audio-frequency portion of the grid circuit in order to reduce the amount of grid modulation. In this case, sufficient audio power must be supplied to the cathode circuit to effectively plate-modulate the amplifier by an increased amount equal to the decreased percentage of grid modulation.

Cathode Modulation as Viewed on the Oscilloscope

THE oscillogram *A* illustrates the case of a cathode-modulated r.f. amplifier in which the percentage of grid modulation is too great in proportion to the amount of plate modulation. The effect is to produce a curvature on the sides of the trapezoid, which is characteristic of ordinary grid-bias modulation. Correct ratio of grid and plate modulation is illustrated by oscillograms *B* and *C*, which represent conditions of 100 percent modulation, and

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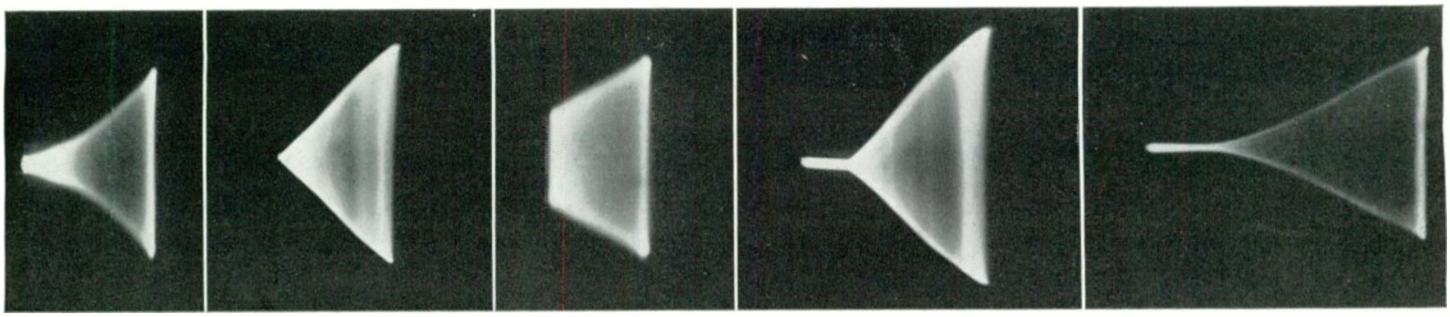
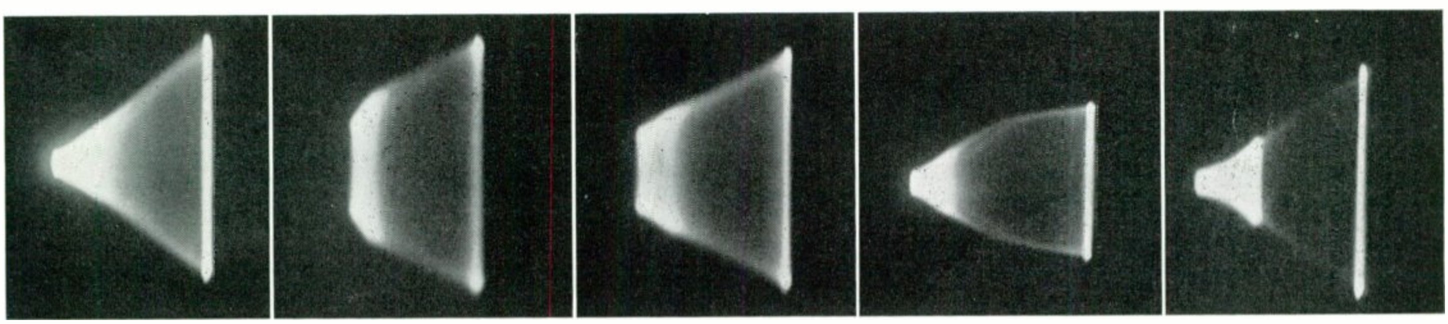


A B C D E

approximately 50 percent modulation, respectively.

Oscillograms *D* and *E* show conditions of overmodulation in an r.f. amplifier operating with fairly low d.c. grid current. Overmodulation in an amplifier operating with relatively high d.c. grid current is shown in oscillogram *F,* the overmodulation in this case being evidenced by a great increase in brilliancy toward the point of the trapezoid, and by a similar bright line at the rear point of the trapezoid. This bright line also tends to extend upward beyond the true edges of the triangle or trapezoid.



F G H I J

Oscillogram *G* represents the case of an r.f. amplifier operating with too-low a value of d.c. grid-bias. A condition of excessive r.f. excitation, even with proper d.c. grid voltage, is shown in oscillogram *H.* Another form of distortion is shown in oscillogram *I,* in which the antenna load was only a fraction of its normal value. Oscillogram *J* illustrates a case of severe overmodulation, in which the modulator and Class-C amplifier both were overloaded. The amplifier, in this case, was operating with sufficient grid excitation; no long "tail" is therefore shown in the oscillogram. In practice, the cathode-modulated r.f. amplifier will produce patterns intermediate between the two forms shown in *B* and *F.* The other oscillograms indicate various kinds of improper adjustments and operation of the modulated amplifier.

Grid-Bias for Cathode Modulation

THE d.c. grid-bias for a cathode-modulated stage can be obtained in a number of different ways. It is possible to use grid-leak bias, a combination of grid-leak and cathode-resistor bias, or fixed C-bias from C-batteries or C-bias supply. In any case, it is desirable to provide some means for adjusting the value of d.c. grid-bias voltage, if the transmitter is to operate in several bands. A variable d.c. grid-bias is a simple means of compensation for moderate variations in r.f. excitation. A transmitter designed for operation in several different bands does not usually have exactly the same r.f. excitation and d.c. grid current in all bands. A change of d.c. grid-bias by means of a switch and tapped resistor furnishes a very convenient method for maintaining the d.c. grid current at a value near the optimum condition for high-level modulation. For this reason most of the circuit diagrams shown in this book include variable d.c. grid-bias. The r.f. grid excitation should not be too high for cathode modulation, otherwise it will not be possible to obtain effective grid modulation. In nearly all cathode-modulated amplifiers, the d.c. grid current can be of any value between 5 and 15 ma. d.c. per tube. The d.c. grid-bias should prefer-

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ably be at least twice cut-off, and can be several times cut-off without any appreciable effect upon the quality of modulation. The r.f. grid excitation should be nearly that used for c.w. operation, and the d.c. grid current should be decreased to a value which will allow upward modulation of antenna current. For this reason, if grid-leak bias alone is used, the value of grid-leak may be somewhere between 4 and 8 times as large as that for c.w. transmission. The r.f. drive required for cathode-modulation is only approximately half as much as that needed for a plate-modulated amplifier.

By-passing the Circuits

THE r.f. paths in a cathode-modulated amplifier should be isolated from the audio-frequency circuits. The by-pass condensers across the filaments of the modulator tubes should have a value of approximately .002 mfd. in order to by-pass the r.f. to ground without effecting the usable voice-frequency range. If the filament by-pass condensers are too large in value, the voice quality will lose its brilliance, due to loss of the high audio frequencies. Fortunately, the modulator load impedance is approximately 500 ohms, which means that fairly large condensers in the cathode circuit can be used to by-pass r.f., without affecting the audio frequencies. The grid return circuit should be by-passed for radio frequencies with a .001 or .002 mfd. mica condenser, and the audio frequencies by-passed with either ½ or 1 mfd. paper condenser. The voltage applied across the by-pass condensers in the grid and filament circuits seldom exceeds 200 volts, except for very high power transmitters. Condensers rated at 600 volts, paper, can be used for those circuits. In the event that part of the grid-bias is obtained from a resistor in series with the cathode, it may be desirable to by-pass this resistor for audio frequencies in order to conserve audio power. If this resistance is greater than 200 ohms in value, the audio frequencies may be by-passed by connecting an 8 mfd. 450 volt electrolytic condenser across this resistance, the negative terminal of the condenser being connected to ground.

A .004 mfd. mica condenser can be connected across the primary of the Class-B modulation transformer in order to reduce the rising high-frequency impedance characteristic which often tends to produce spurious side-band frequencies in the output of the radio transmitter.

Connecting the Modulator

THE secondary of the cathode-modulation transformer should connect to the center-tap of the filament winding which supplies filament power to the modulated stage. No other r.f. stage should be operated from this same filament transformer. If the filament transformer has no center-tap, a center-tapped filament resistance of 50 or 75 ohms, rated at 10 watts, can be connected across the filament leads. This value of resistance is suitable for any type of tube, in any modulated circuit. Some hum may be introduced into the system if a center-tap is not provided.

C-Bias Supply

THE C-bias supply, if one is used, should be well filtered in order to prevent a.c. hum modulation. The voltage regulation of the C-bias supply is not critical, and condenser input can be used in a one- or two-section filter. The plate supply should also be well filtered with a two-section filter, preferably with choke-coil input to the filter. The modulation transformer and low-level audio-frequency transformers should be remote from strong r.f. and 60 cycle fields.

The r.f. driver stage should have a well-filtered plate supply.

Modulation Transformer

THE modulation transformer should have a low impedance secondary winding so as to transform the 500 ohm load up to the value recommended for the audio-frequency modulator tubes. The modulator, in most cases, operates in Class-B or Class-AB, with a plate-to-plate load impedance of from 5,000 to 15,000 ohms, depending upon the type of modulator tubes in service. The transformer should be large enough to handle the required audio power and d.c. plate currents which flow through the winding. *The largest audio transformer needed for amateur transmitters would be rated at 100-watts, in the case of a 1-kilowatt transmitter.* The transformer should be capable of handling an audio-frequency power approximately 10 percent of the d.c. power input to the modulated r.f. amplifier. The secondary winding of the transformer must be wound with wire large enough to safely carry the cathode current of the r.f. stage. This cathode current is equal to the sum of the d.c. grid and plate currents.

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R. F. Amplifier Tubes

NEARLY any tube, or tubes, may be used in a cathode-modulated r.f. amplifier. Tubes with an amplification constant of from 20 to 30 are most desirable from the standpoint of simplicity of adjustment. Very-high mu tubes and screen-grid tubes have such a high amplification constant that not much r.f. output can be obtained without resorting to very high d.c. plate voltage. High mu triodes can be used if the d.c. plate voltage is from 25 to 50 percent higher than that normally used for medium mu tubes. Triode tubes are more satisfactory than tetrodes or pentodes.

The Class-C amplifier tubes in cathode-modulated service are operated so that plate current flows in pulses of 140° to 160° of the full r.f. cycle of 360°. The tuned plate circuit must have sufficient fly-wheel effect to transform these pulses into sine-wave r.f. output, in order to minimize harmonic radiation. If the plate tank circuit *Q* is at least 10 for a push-pull amplifier and approximately 15 for a single-ended plate-neutralized amplifier, the harmonic radiation will be low, and the amplifier will operate in the proper manner. The d.c. plate resistance of an r.f. amplifier is directly proportional to the a.c. plate impedance; for the average cathode-modulated amplifier it is about 7,500 ohms for push-pull operation and 15,000 ohms for an amplifier with a single tube. These figures were used as a basis for the two charts of *Tank Circuit Capacities* for the plate circuit of cathode-modulated amplifiers. In some cases where the tubes operate with very high plate voltage, such as 3,000 or 4,000 volts, and at a relatively low d.c. plate current, the values of capacities listed in the *Charts* may be reduced considerably, if desired.

Tank Circuit Condensers

THE air-gap in the plate tuning condensers for cathode-modulated amplifiers should be approximately the same as for a c.w. transmitter, *or only about 60% of the spacing normally required for a plate-modulated amplifier.* This permits the use of smaller tuning condensers, resulting in a generous saving in cost. The neutralizing condensers should have an air-gap at least twice as great as that between plates in the plate-tuning condenser. The neutralizing condensers have a d.c. peak voltage equal to the sum of the d.c. plate voltage, d.c. grid bias, and the peak values of r.f. grid and plate voltages. The circuit diagrams, shown in the pages which follow, list recommended values of air-gap for each section of the plate tuning condenser. The neutralizing condenser in every circuit illustrated should have an air-gap of at least twice this value, and a capacity equal to the grid-to-plate capacity of the r.f. tube.

Single-Ended Plate-Neutralized Amplifier Tank Circuit Capacities

Band in Meters	Total Effective Tuning Capacity in Mmfd.	Recommended Split-Stator Tuning Condenser Capacity per Section—in Mmfd.
160	75	150 or 200
75	30	75 or 100
40	17	50
20	8	20
10	4	10

Push-Pull Amplifier Tank Circuit Capacities

Band in Meters	Total Effective Tuning Capacity in Mmfd.	Recommended Split-Stator Tuning Condenser Capacity per Section—in Mmfd.
160	90	200
75	40	100
40	20	50
20	10	20
10	5	10

Antenna Loading

THE antenna circuit can be coupled to the final r.f. amplifier in any conventional manner. The only precaution is to make certain that this coupling is sufficiently heavy to properly load the modulated amplifier. This condition can be checked by means of a simple diode-tube field-strength meter and small antenna, placed in the vicinity of the transmitting antenna, or with any type of r.f. indicator in the antenna feed line. The antenna coupling should be increased to the point where the antenna current, or field strength, begins to drop perceptibly. Any

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value of antenna coupling from the point at which maximum r.f. current or field strength is obtained, and up to the point of coupling which shows a noticeable decrease in antenna current, is satisfactory for normal operation. Too-low a value of antenna loading will prevent proper operation of the modulation system, with a consequent reduction in the percentage of modulation. The degree of antenna coupling, fortunately, does not affect the quality of modulation, but changes the degree of modulation of the carrier.

Link coupling to a tuned antenna circuit is very satisfactory for a cathode-modulated r.f. amplifier. Non-resonant 75, 300 or 600 ohm lines can be coupled to the final tank coil by means of from one to ten turns of heavily-insulated wire wound around the center of the plate coil. The number of turns depends upon the band of operation, determined by checking for a slight drop in r.f. feeder current, or antenna field strength, when the coupling to the final tank coil is varied. A very simple r.f. indicator for a check of this kind can be made by connecting a small flashlight lamp in series with an r.f. feeder in low power transmitters, or shunted across a few inches of one feeder wire in the case of high power transmitters. The plate circuit should be tuned to resonance as indicated by a dip in plate or cathode current. If the plate dissipation of the r.f. amplifier tubes is excessively high for proper antenna loading, the r.f. grid excitation can be reduced slightly.

Modulation Checking

IT is just as easy to overmodulate an r.f. amplifier with cathode-modulation as with plate-modulation. The diode-type of overmodulation indicator, or carrier-shift meter, should be employed to prevent operation at a point which will produce overmodulation and carrier shift. A cathode-ray oscilloscope can be connected with one set of its plates across the secondary of the modulation transformer, the other plates coupled by means of a turn or two of wire to the center of the plate tuned circuit so as to provide a trapezoidal-type of figure. The a.c. peak voltage ranges from 75 to 200 volts across the secondary of the modulation transformer, and the oscilloscope may therefore be connected directly to this part of the circuit.

Overmodulation preventing circuits are very desirable and should be built into the speech amplifier system. The type of circuit, known as "*AGC*" (automatic gain control), is useful not only because it prevents overmodulation when properly adjusted,

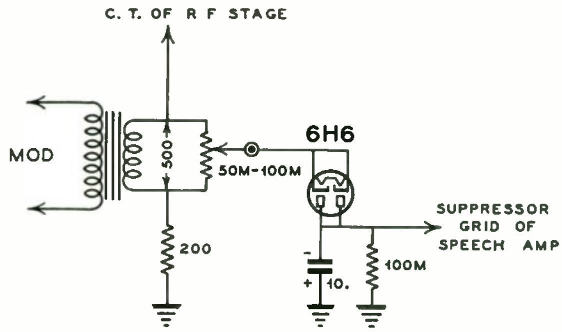

Fig. 4

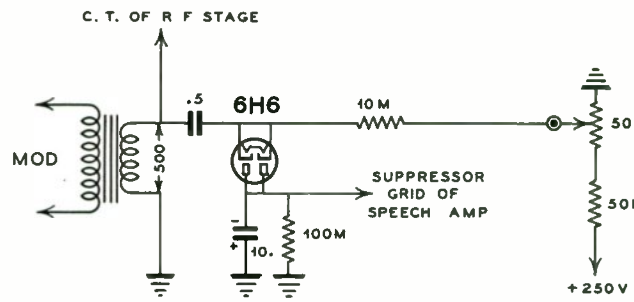

Fig. 5

but also because it allows the operator to maintain the average percentage of modulation at a high level, thereby effectively increasing the range of the transmitter. Any diode, such as a 6H6, can be connected to the secondary of a modulation transformer in order to rectify excessive audio-frequency peaks, and to supply a negative automatic volume control voltage to the suppressor or injector grid of the speech amplifier stage.

The circuits shown in Figs. 4 and 5 indicate two arrangements suitable for *AGC* connection to any cathode-modulated transmitter with input powers ranging from 100 watts to 1-kilowatt. In Fig. 4, the r.f. amplifier's cathode current flows through the 200 ohm resistor and supplies 20 to 50 volts of bias to the cathode of the 6H6 tube. This acts as a delay bias to prevent *AGC* action at low levels of speech input. The exact point of operation for the *AGC* circuit is adjusted by means of a 50,000 or 100,000 ohm potentiometer connected across the 500 ohm winding of the modulation transformer. The excessive audio peaks cause a flow of current in the 6H6 diode, and this provides a negative bias voltage across the 100,000 ohm resistor in the plate circuit of the 6H6 tube to ground. This voltage must be filtered, as shown in Fig. 6 or Fig. 7, in order to prevent audio-frequency feed-back into the speech amplifier. The circuit in

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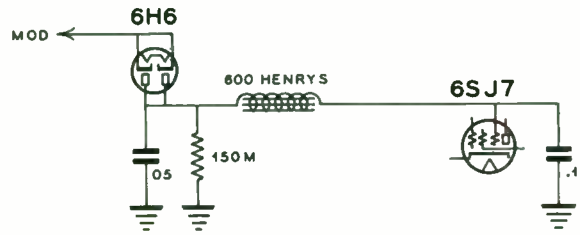

Fig. 6

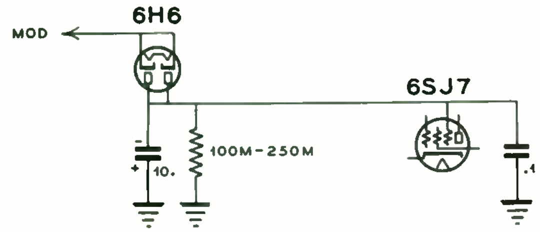

Fig. 7

Fig. 5 can be used when no r.f. amplifier cathode resistor is employed. Cathode delay bias is obtained by a potentiometer connected to the speech amplifier's plate supply. The exact point at which the *AGC* circuit begins to function is located by means of the 50,000 ohm potentiometer. The *AGC* level control, either in Figs. 4 or 5, should be mounted on the front panel of the transmitter, if possible, for convenience in setting it to a point which will prevent overmodulation. A carrier-shift meter, or cathode-ray oscilloscope, will determine the best setting for the *AGC* control potentiometer.

Cathode Modulation vs. Plate and Grid Modulation

THE adjustments for cathode modulation are no more critical than for plate modulation—and far less critical than for grid modulation. The power output of a cathode-modulated stage is from two to three times as great as that obtained from the same tubes in a grid-modulated amplifier operated with moderate d.c. plate voltage. The carrier output is from 10 to 40 percent less than from plate-modulation, when operating with the same plate dissipation. However, the peak plate current is less in a cathode-modulated stage than in a plate-modulated amplifier; the plate dissipation remains constant—or even decreases slightly in the former case, and increases during modulation when plate-modulated. *For this reason, the output of a cathode-modulated r.f. amplifier is very nearly equal to that of a plate-modulated amplifier when the tubes are operated within the manufacturers' ratings.*

Modulator Economy

A cathode-modulated transmitter is more economical than either a grid- or plate-modulated transmitter having the same carrier output. The grid-modulated transmitter does not require quite as much audio power, but calls for considerably larger r.f. tubes, because of the low operating efficiency. A plate-modulated transmitter requires a modulator having an output four to five times as great as that required for an equivalent cathode-modulated transmitter.

Excellent Voice Quality

THE quality of modulation is suitable for any type of communication service. It is comparable to plate or grid modulation, but considerably better than the type of grid modulation in which d.c. grid current is allowed to flow. It is not quite as linear as the system of grid modulation used in broadcast service, and in which no grid current is allowed to flow—nor is it quite as linear as a perfectly adjusted plate-modulated transmitter.

Fewer Parasitics

THE possibility of parasitics on peaks of modulation, with consequent distortion of tone quality in many short-wave transmitters, is considerably less with cathode modulation than with plate modulation, because the peak plate voltage is only a little more than half as great. The danger of parasitic oscillation in an r.f. amplifier increases greatly as the peak voltage is increased in the Class-C amplifier.

An audio-frequency parasitic oscillation may develop in a cathode-modulated r.f. amplifier operated with insufficient r.f. grid drive. This parasitic results from the fact that the reactance of the secondary winding of the modulation transformer is in series with the cathode of the r.f. amplifier. If the grid and plate by-pass condensers are of some critical value which will allow the circuit to oscillate at audio frequencies, there will be a tendency for the amplifier to oscillate or howl at an audio frequency whenever the grid circuit is detuned. This parasitic oscillation can be eliminated by changing the size of the audio-frequency by-pass condenser in the grid circuit. Any value from 0.5 mfd. to 20 mfd. will serve as an audio-frequency by-pass, and some value within this range will prevent the r.f. amplifier from acting as an audio-frequency oscillator.

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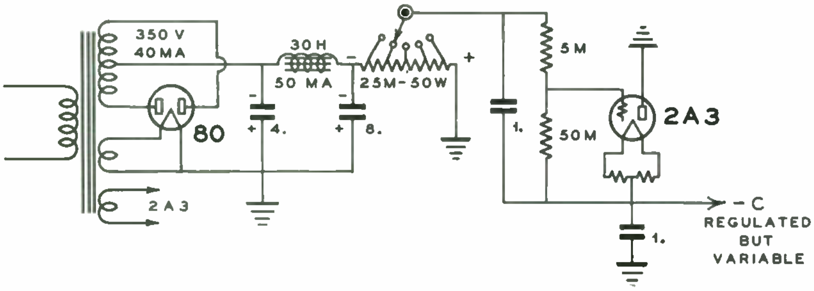
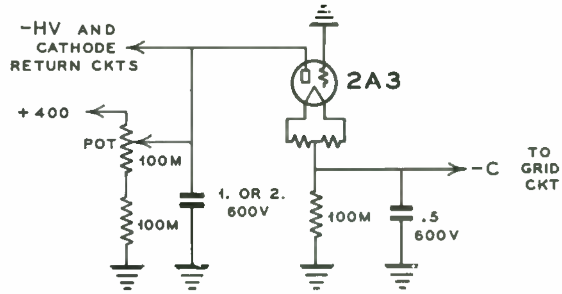


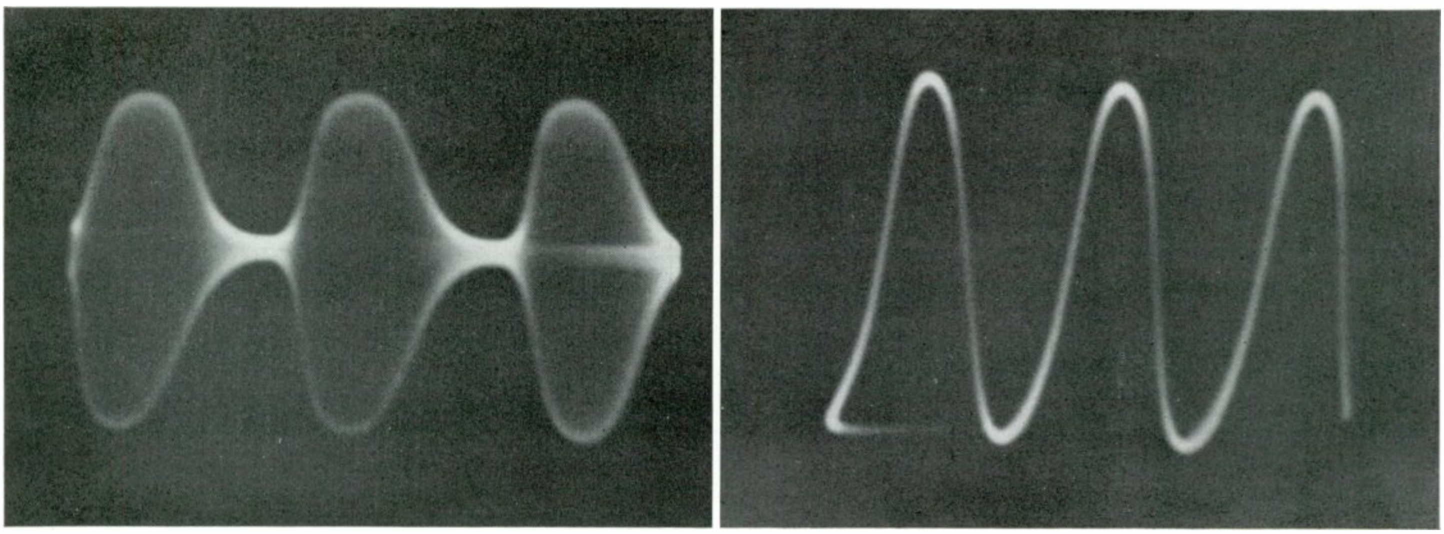


Regulated C-Bias Supplies

A TYPE 2A3 (or 45) triode can be connected as illustrated in the above circuits in order to supply a source of regulated C-bias voltage. Practically no current is drawn from the C-bias source in this type of circuit, and the d.c. grid current flows only through the regulator tube. C-bias can be obtained from the low voltage power supply, if the negative high voltage lead and modulation transformer return circuit are not connected to ground, but directly to the plate of the 2A3 regulator tube.

Sweep Circuit Patterns

THE type of oscilloscopic patterns shown in the accompanying photographs are sometimes valuable when checking the linearity and degree of modulation. The sine-wave pattern illustrates the audio-frequency signal input to the speech amplifier from a small audio test oscillator. The other pattern is a photograph taken from the r.f. output of a pair of T-40 triodes, cathode-modulated. The sweep circuit in the oscilloscope is synchronized with the applied audio frequency in order to obtain a steady pattern.



Oscilloscopic Patterns of Linearity and Degree of Modulation.

Circuit Adjustments

(1) The r.f. amplifier should be neutralized perfectly.

(2) The d.c. grid current should be adjusted to a value between 5 and 15 ma. per tube, by changing the value of d.c. grid-bias or grid-leak and, if necessary, by changing the coupling to the r.f. driver.

(3) The antenna coupling should be increased to a point slightly beyond that which gives maximum antenna field strength or r.f. feeder current.

(4) The modulator should be able to supply an undistorted output of 10 percent of the d.c. plate input to the modulated amplifier.

(5) Modulation quality should be checked with a 'phone monitor and some form of overmodulation indicator.

(6) The grid-bias should always be adjusted to a point which will allow upward variation of antenna current with modulation, as indicated by a small lamp and turn of wire coupled to the final tank circuit or antenna feeder.

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THE practical application of cathode modulation to radiotelephone transmitters has emerged from the laboratory. Much is still to be learned about this new system, and many applications for its use will be found in amateur, commercial, governmental and airway services.

■

CATHODE modulation can be operated with varying degrees of plate and grid modulation. The many circuit arrangements shown throughout this book were designed to give a fairly high degree of grid modulation as compared to plate modulation. In this case, the actual amount of audio power required is nearer 5 percent than the rule-of-thumb value of 10 percent, as related previously in these pages. In other words, while the text makes mention that 10 watts of audio power is required to cathode-modulate 100 watts of power input to the Class-C r.f. amplifier, it is possible to use only 5 watts of audio power. If the degree of grid modulation is decreased, and the effective plate modulation increased, so as to obtain higher operating efficiency in the Class-C amplifier, more audio power will be required. On the other hand, if no grid modulation at all is used, the audio power required for cathode modulation will be the same as that for plate modulation, and the load into which the modulator would work is then the same as for plate modulation. The cathode load impedance can be calculated if the audio power required for complete modulation is known. This power will vary from 5 to 50 percent of the d.c. power input to the modulated stage, depending upon the degree of plate modulation with respect to grid modulation.

The a.c. plate current in the modulated amplifier will be fully modulated at the point of 100 percent modulation, so that its peak value will be equal to the d.c. plate current. This means that the r.m.s. value of a.c. plate current for sine-wave input will be approximately 7/10ths of the d.c. plate current value. The audio power required to accomplish this condition is expressed by the relation:

$$W = Z \times I^2_{ac}$$

Since the a.c. current is equal to 7/10ths of the d.c. plate current for sine-wave conditions, the formula can be expressed as follows:

$$W = 1/2 \times Z \times I^2,$$

where W is the audio power in watts,
Z is the cathode impedance,
I is the d.c. plate current.

In most designs, it will be found that if the actual audio power is assumed to be 5 percent of the d.c. power input to the plate circuit of the modulated amplifier, the unknown cathode impedance can be easily calculated. For most transmitter designs, this value is 500 ohms for a push-pull r.f. amplifier, and 1,000 ohms for a single-ended r.f. amplifier. Practically all of the circuits in this book indicate a value of audio power equal to 10 percent of the d.c. power input. This value was chosen in order to allow a conservative design factor. Many small amplifiers or modulators will develop only half as much audio power into a 500 ohm load as might be expected in actual practice. The reason for not obtaining the full anticipated power output can be traced to a number of factors, principal among these being: (1) losses in power output transformers, (2) poor voltage regulation in the power supply, (3) lack of drive in the grid circuit, (4) effects of self-bias when 6L6 tubes are used, (5) low screen voltage, and (6) low plate voltage.

Excitation Control

MULTI-BAND transmitters must be provided with some means for controlling the grid excitation of a cathode-modulated transmitter. This can be accomplished by variation of the r.f. coupling between the exciter and the modulated amplifier, such as a variation in capacity of the coupling condenser, or a variation of the link coupling, if the latter is used. A more convenient method for control of grid excitation is an adjustment of the d.c. grid bias, so as to provide a fairly wide variation of r.f. excitation when changing from one band to another, or for a quick change from c.w. telegraphy to voice communication. A variable C-bias arrangement is a logical solution. This is accomplished by a tapped grid-leak, with the taps connected to a multi-tap switch mounted on the front panel of the transmitter. Another method would require a tap switch, connected to taps on the C-bias supply resistor. Still another method is the use of a voltage regulator tube with a potentiometer connected to the input portion of the regulator tube, as shown in the constructional data for the single T-40 transmitter, in Chapter III. The variable C-bias method has a distinct advantage in that it provides a quick change from c.w. to voice operation, since it is necessary to merely increase the d.c. grid voltage (decrease the d.c. grid current) to a value which will allow upward modulation of the antenna current. This variation has no appreciable effect upon the tuning of the exciter, and no effect upon the grid current in the final amplifier, whereas a variation of link or capacity coupling would require a readjustment of tuning controls.

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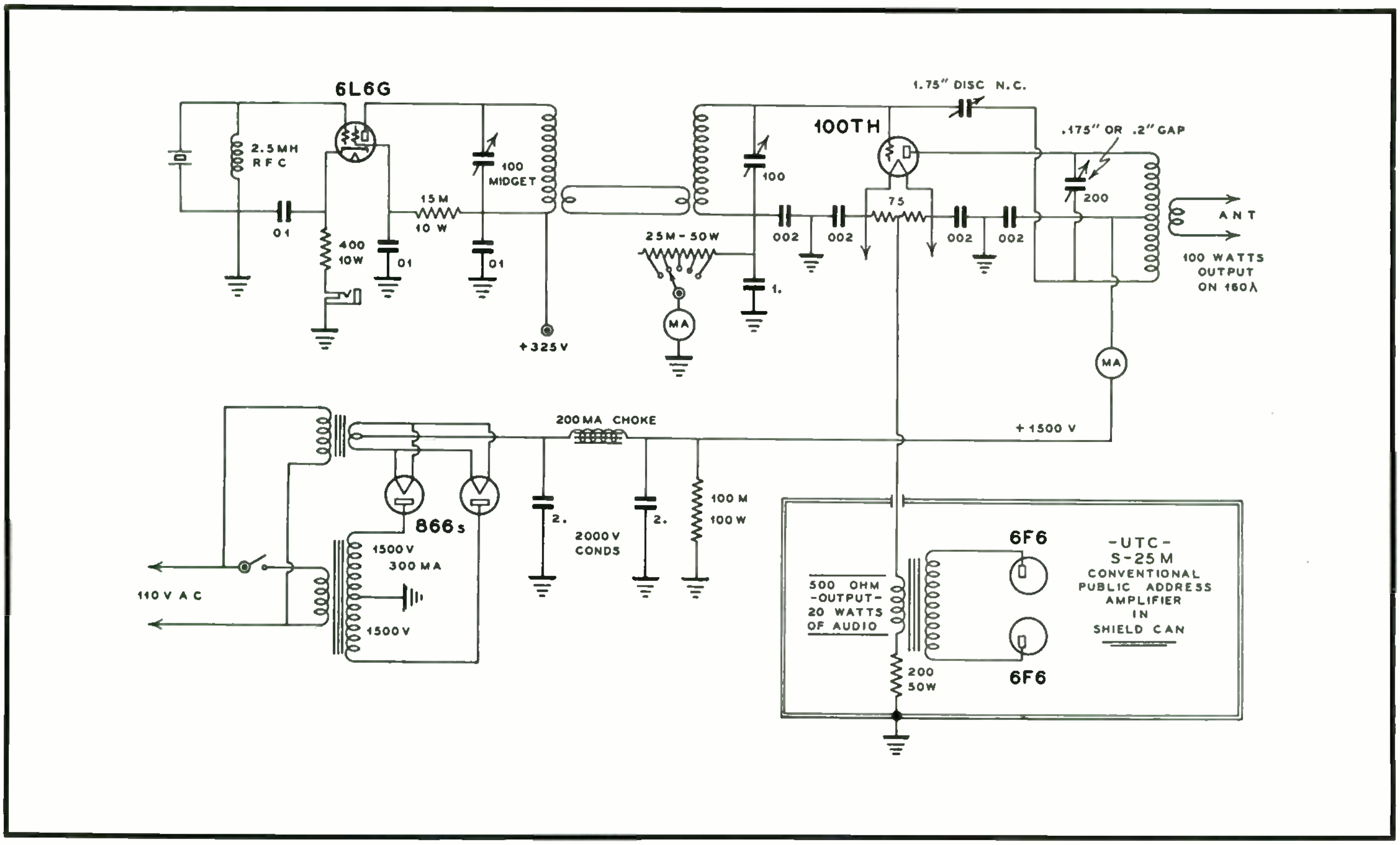


160-Meter Cathode-Modulated Transmitter and Conventional Public Address Amplifier for Modulating the R. F. Carrier

THE treatment of a circuit diagram for the r.f. portion of a 160 meter radiotelephone is given here. Some radio broadcast receivers are equipped with an audio amplifier capable of delivering from 10 to 20 watts of audio across a 500 ohm load, and provision is usually made for some form of microphone input to the audio channel. Small public address amplifiers, available almost anywhere, are suitable for cathode-modulating a 160 meter radiotelephone transmitter. These amplifiers are often designed with sufficient audio gain for connection to either a crystal or dynamic microphone.

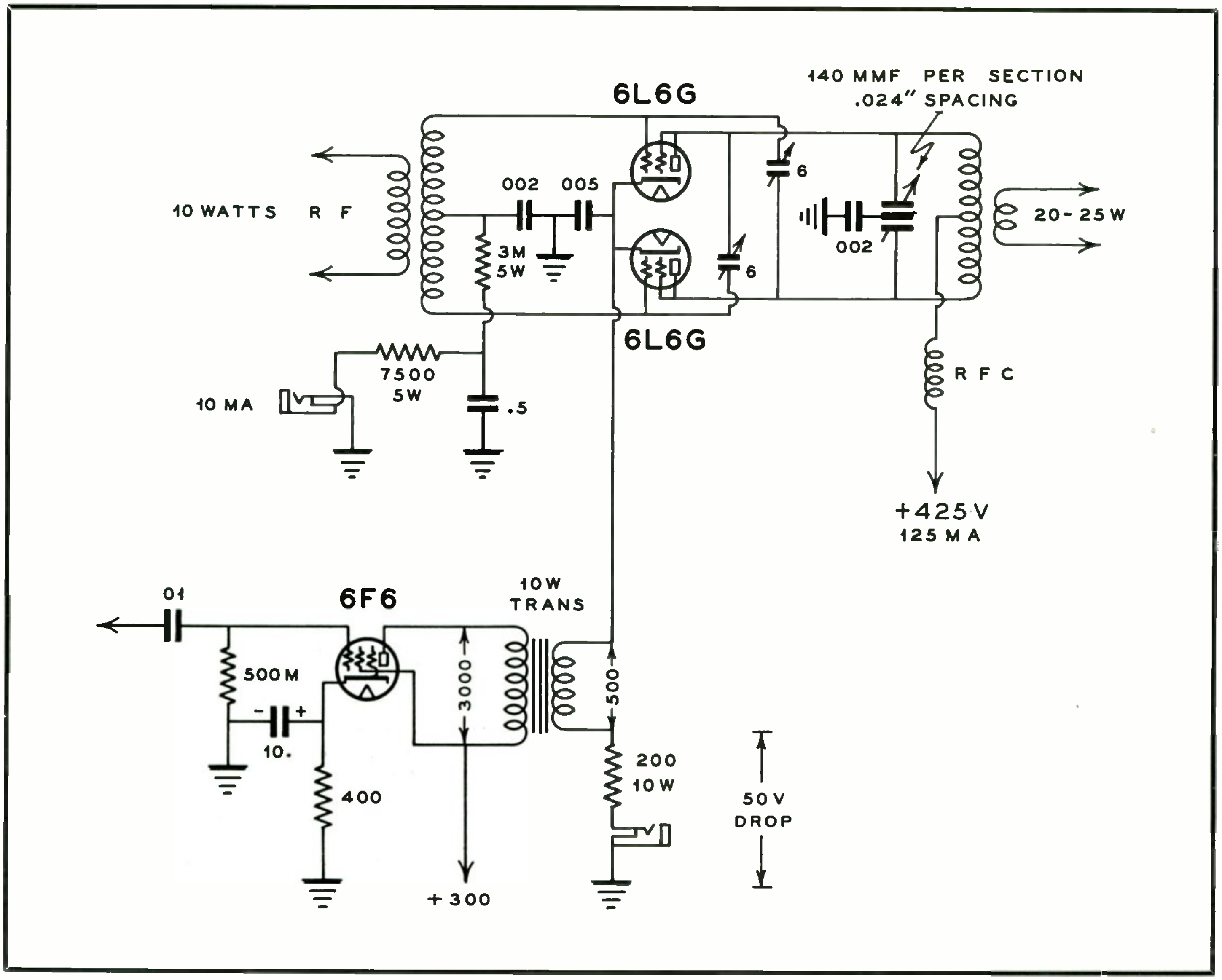
The transmitter circuit illustrated above can be fully modulated with considerably less than 20 watts of audio power. An *Eimac 100TH* with a plate dissipation rating of 100 watts, or any similar tube, can be used in the r.f. amplifier to supply an output of at least 100 watts in the 160 meter band. Other tubes, such as the *HK-254, RCA-810, Taylor T-125,* or even the older tubes such as the 211 or 203A are suitable for this transmitter by merely altering the filament voltage supply and selecting a neutralizing condenser of the proper capacity and rating. An adjustable d.c. grid bias is obtained from a tapped grid-leak, in order to derive at a condition most suitable for cathode modulation. Adjustment of the C-bias and r.f. excitation by means of link coupling will permit attainment by 100 percent modulation in the r.f. amplifier. The antenna coupling should be heavy enough to cause a plate current of from 120 to 140 ma. to flow when the d.c. grid current is approximately 10 ma. The grid circuit of the r.f. amplifier can be link-coupled to any r.f. exciter, such as a standard 6L6G crystal oscillator, as shown in the circuit diagram. The crystal oscillator will draw from 30 to 50 ma. of plate current; in some cases the oscillator can be connected to the same power supply that operates the speech amplifier. The high voltage power supply can be operated with either choke or condenser input, depending upon the rating of the transformer. Condenser input will provide a d.c. voltage somewhat in excess of the a.c. voltage rating of the power transformer. Choke input will allow more plate current to be drawn without over-loading the transformer, but the d.c. voltage will be some value between .8 and .9 of the r.m.s. rating. Choke input gives much better voltage regulation than can be obtained with condenser input. This is not an important consideration in the case of a properly adjusted r.f. amplifier, since the d.c. plate current is practically constant during modulation. A 200 ohm, 50 watt cathode resistor should be connected in series with the secondary winding of the modulation transformer in order to provide a certain amount of fixed C-bias. An alternative C-bias arrangement would be a variable grid-leak, connected in series with a fixed C-bias supply of from 90 to 150 volts.

World Radio History

Part II

Amplifier Circuit Constants and Tube Characteristics for Cathode Modulation

World Radio History



6L6G Triode-Connected R.F. Amplifier—Modulated by a Single 6F6

THE greatest economy of cathode modulation is evidenced in the case of medium and high power amplifiers, but a low power amplifier, such as one with a pair of 6L6G tubes, can be successfully cathode-modulated as shown in the circuit diagram. From 20 to 25 watts of carrier output can be obtained with a 425 to 450 volt power supply, and with a total input of approximately 45 watts to the r.f. amplifier. A portion of this power, and also a portion of the d.c. plate voltage, is consumed by the 200 ohm cathode resistor which serves as a protective device and also limits the d.c. grid-bias for the 6L6G tubes. Additional d.c. grid-bias is obtained from the 3,000 ohm and 7,500 ohm grid-leaks, the two being connected in series. An audio-frequency by-pass condenser of ½-mfd. capacity, as shown in the circuit, will allow very good linearity of modulation when the 6L6G tubes are connected as triode amplifiers. The screen and plates are connected together at the tube socket, and small neutralizing condensers with maximum capacity of approximately 6-mmfd. will allow neutralization of the amplifier.

The operation of 6L6G tubes as low-mu triodes in an experimental transmitter gave better results with cathode modulation than when the same tubes were used in the usual form of tetrode amplifier. From 4 to 5 watts of audio power can be obtained from a single 6F6 tube as a modulator, working into a transformer having a 3,000 to 500 ohm impedance ratio.

6L6G (Triode-Connected) Characteristics

Filament voltage	6.3 volts
Filament current	0.9 amperes
Amplification factor	6 (approx.)
Grid-to-plate capacity	5 to 6 mmfd.
Maximum d.c. plate voltage	400 volts
Maximum d.c. plate current	75 ma.
Normal plate dissipation	20 watts

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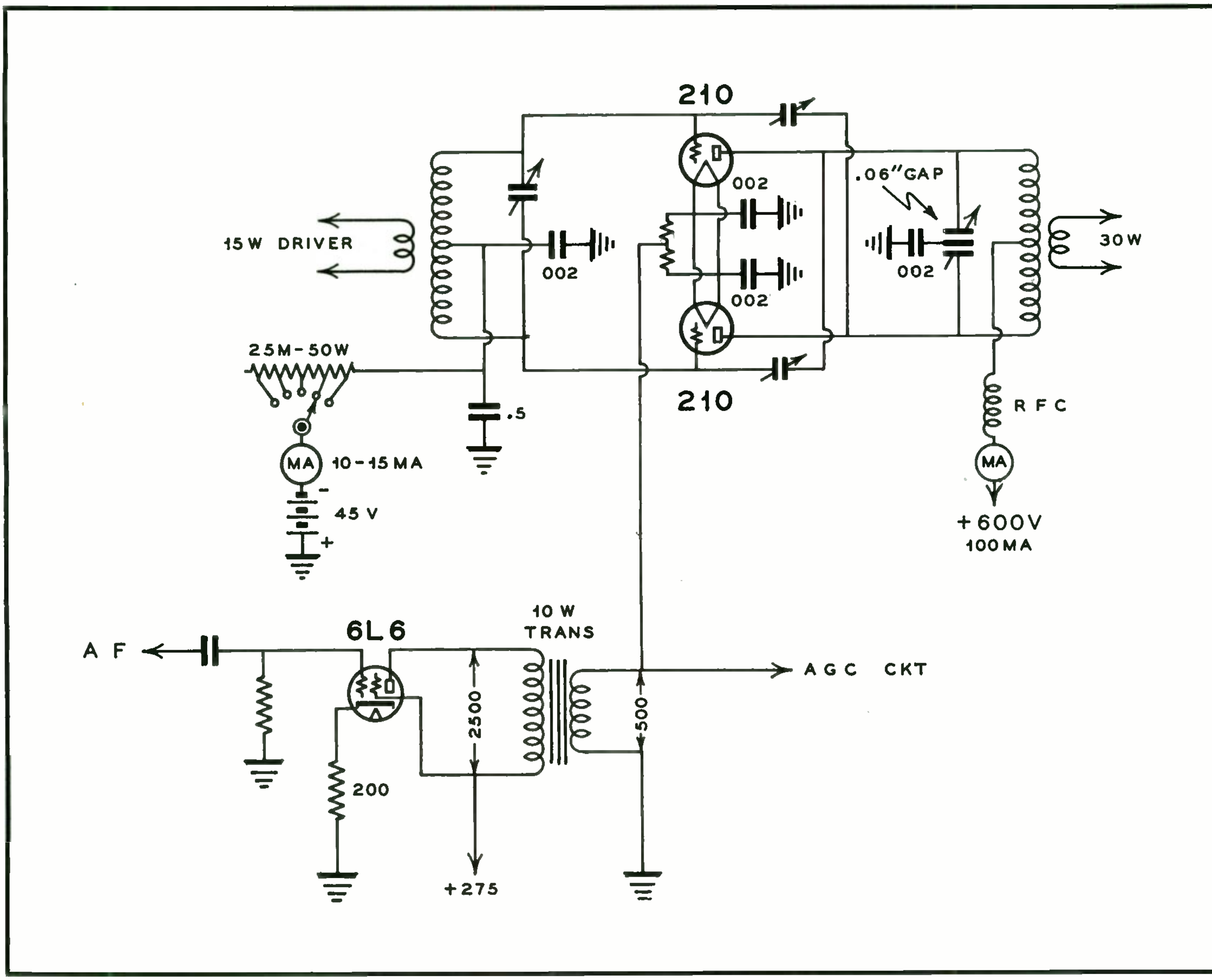

210 R.F. Amplifier—Modulated by 5 Watts of Audio

THE amateur's "junk box" usually reveals a pair of type 210 tubes; these can be modulated to obtain a carrier output of approximately 30 watts. It is not generally advisable to use more than 600 volts on the plates of these tubes in a Class-C r.f. amplifier. A 6A6 or 6L6 tube, with 15 watts input, will supply sufficient output to drive the modulated amplifier. The grid-bias is obtained from a combination of grid-leak and fixed grid-bias; a 45 volt B-battery or C-bias power supply is satisfactory for this purpose. Type 210 tubes are not very efficient in high-frequency service unless the tubes are equipped with ceramic bases. The molded bakelite-based 210 tube can be made to operate fairly effectively at high radio-frequencies, by carefully sawing slots through the bakelite base between the prongs. The r.f. amplifier can be modulated with a 6L6 or a pair of 45 tubes in push-pull. From 5 to 10 watts of audio into a 500 ohm load will deliver sufficient power for cathode modulation. A 6L6 in Class-A can be driven by any resistance-coupled speech amplifier. It is possible to connect a sensitive single button carbon microphone through a microphone transformer directly into the 6L6 grid circuit, but a medium-gain 6C5 speech amplifier with a conventional gain control is a more satisfactory arrangement.

210 Characteristics

Filament voltage	7.5 volts
Filament current	1.25 amperes
Amplification factor	8
Grid-to-plate capacity	8 mmfd.
Grid-to-filament capacity	3 mmfd.
Plate-to-filament capacity	4 mmfd.
Maximum d.c. plate voltage	450 volts
Maximum d.c. plate current	65 ma.
Maximum d.c. grid current	15 ma.
Normal plate dissipation	15 watts

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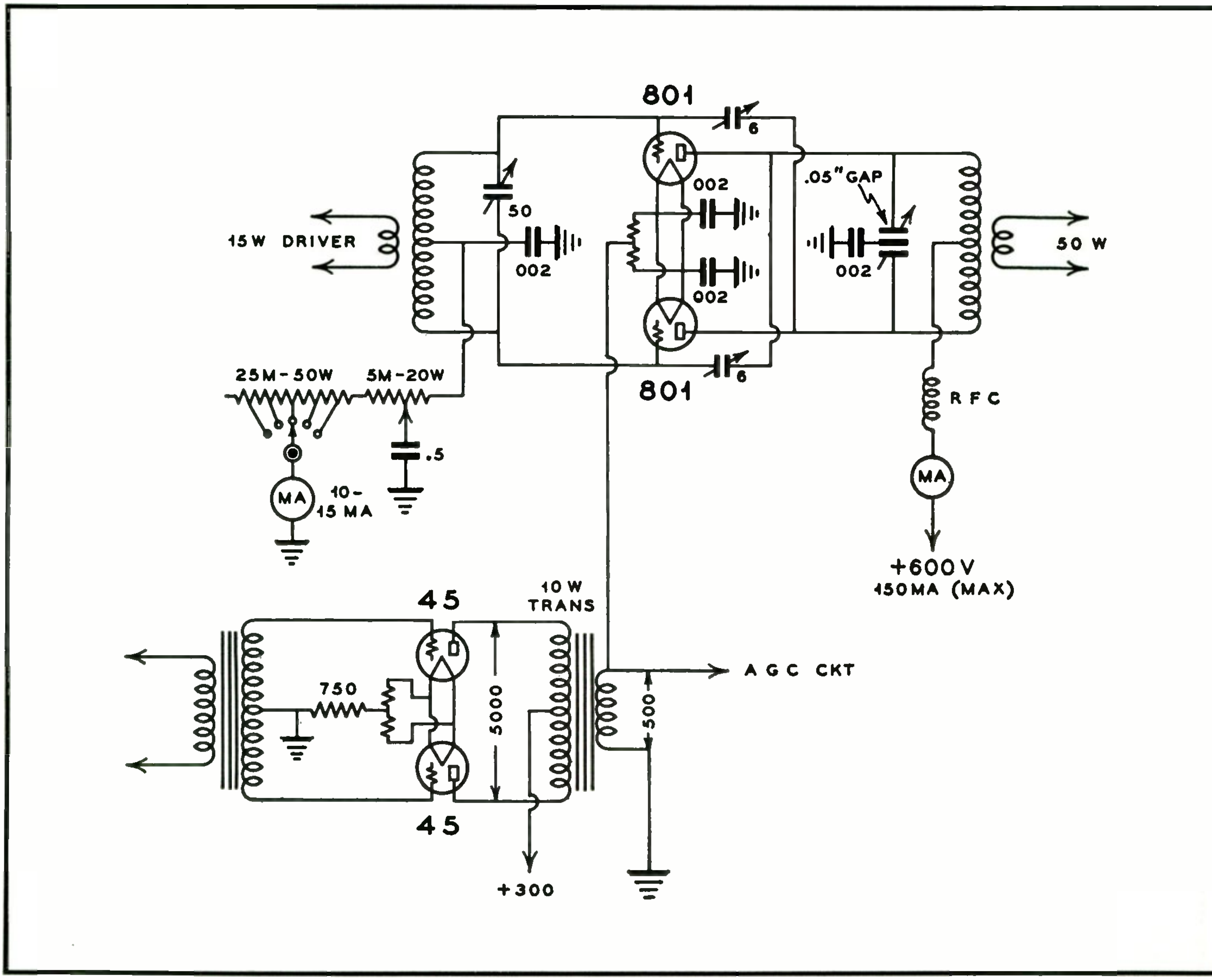


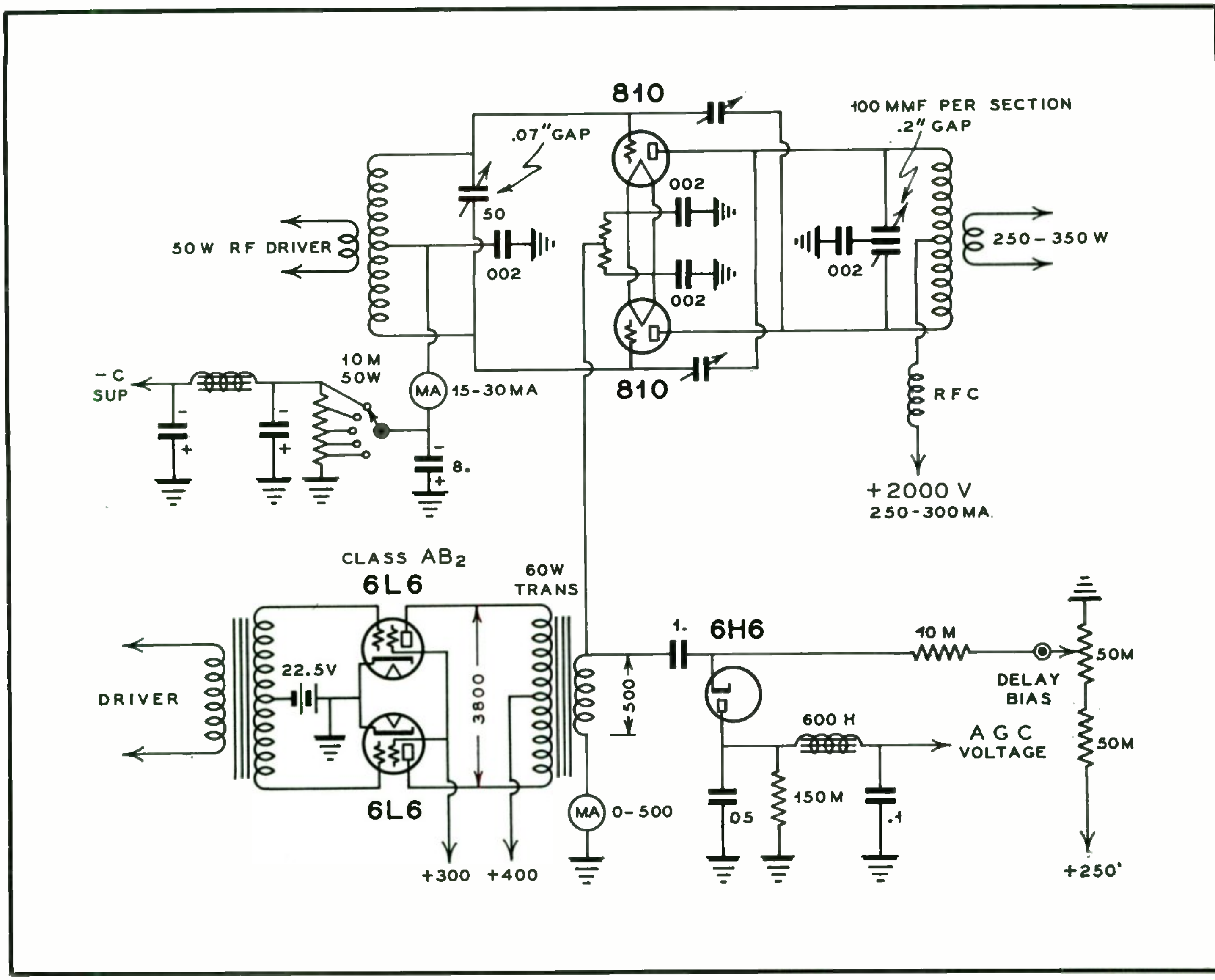
801 R.F. Amplifier—Modulated by a 10-Watt Audio Amplifier

SMALL triode tubes, such as the type 801, can be cathode-modulated by a pair of 45 tubes in push-pull. The audio-frequency power required for this purpose is not more than 10 watts and can be supplied by any push-pull amplifier with a pair of 6V6, 6F6, 42, or 2A3 tubes. A single 6L6 tetrode will also supply sufficient output for this purpose. A pair of 801 tubes in push-pull can be made to supply approximately 50 watts of carrier in this tye of circuit. No cathode-biasing resistor is shown, since the 801 tubes have a fairly-low amplification constant and would require a high value of cathode resistance if such a resistor is used for protecting the tube, or as a precaution against failure of excitation. Grid-bias is obtained entirely from the grid-leak circuit. If a plate supply of more than 600 volts is available, part of this voltage can be wasted in a cathode-bias resistor. Low-mu tubes, working at relatively low plate voltages, can be operated with grid-leak bias alone, or connected to a C-bias supply, in order to conserve plate voltage. A 6L6G exciter will deliver more than ample r.f. excitation to the grid circuits. The actual r.f. driving power for the 801 tubes does not exceed 5 watts. A 6A6, with its triodes in push-pull or parallel, can be used for the r.f. exciter.

801 Characteristics

Filament voltage	7.5 volts
Filament current	1.25 amperes
Amplification factor	8
Grid-to-plate capacity	6 mmfd.
Grid-to-filament capacity	4.5 mmfd.
Plate-to-filament capacity	1.5 mmfd.
Maximum d.c. plate voltage	600 volts
Maximum d.c. plate current	70 ma.
Maximum d.c. grid current	15 ma.
Normal plate dissipation	20 watts

World Radio History



RCA-810 Push-Pull R.F. Amplifier—Modulated by Class-B 6L6s

FROM 500 to 600 watts input to a push-pull RCA-810 Class-C amplifier will give a carrier output of from 250 to 300 watts with cathode modulation. Due to the high amplification factor of these tubes, it is desirable to use a 2,000 volt plate supply, capable of delivering from 250 to 350 ma. Fixed C-bias from a 250 to 300 volt C-bias should supply the d.c. grid bias for the r.f. amplifier. A 2,000 or 3,000 ohm grid-leak can be connected between the audio-frequency and r.f. by-pass condensers to improve the linearity of modulation—if desired. An 807 or 809 r.f. stage will drive the grid circuit of the 810 amplifier. A pair of 6L6 tubes in Class-AB_2 will furnish from 50 to 60 watts of audio power into a 500 ohm load, or a pair of 809 triodes in Class-B with a 500 volt plate supply will serve the same purpose. A 6F6, triode-connected, can be used as an audio-frequency driver in either case. A complete *AGC* circuit for connection to the speech channel is shown as part of the circuit diagram above. This form of *AGC* circuit is desirable when no fixed resistor is used in the cathode circuit of the modulated r.f. stage. The *AGC* voltage should be connected to the suppressor-grid of a 6SJ7, or to the injection-grid of a 6L7 tube in the speech amplifier. Another suitable arrangement would consist of four 6L6G tubes in push-pull parallel, Class-AB_1.

RCA-810 Characteristics

Filament voltage	10 volts
Filament current	4.5 amperes
Amplification factor	35
Grid-to-plate capacity	4.8 mmfd.
Grid-to-filament capacity	8.7 mmfd.
Plate-to-filament capacity	12 mmfd.
Maximum d.c. plate voltage	2000 volts
Maximum d.c. plate current	250 ma.
Maximum d.c. grid current	70 ma.
Normal plate dissipation	125 watts

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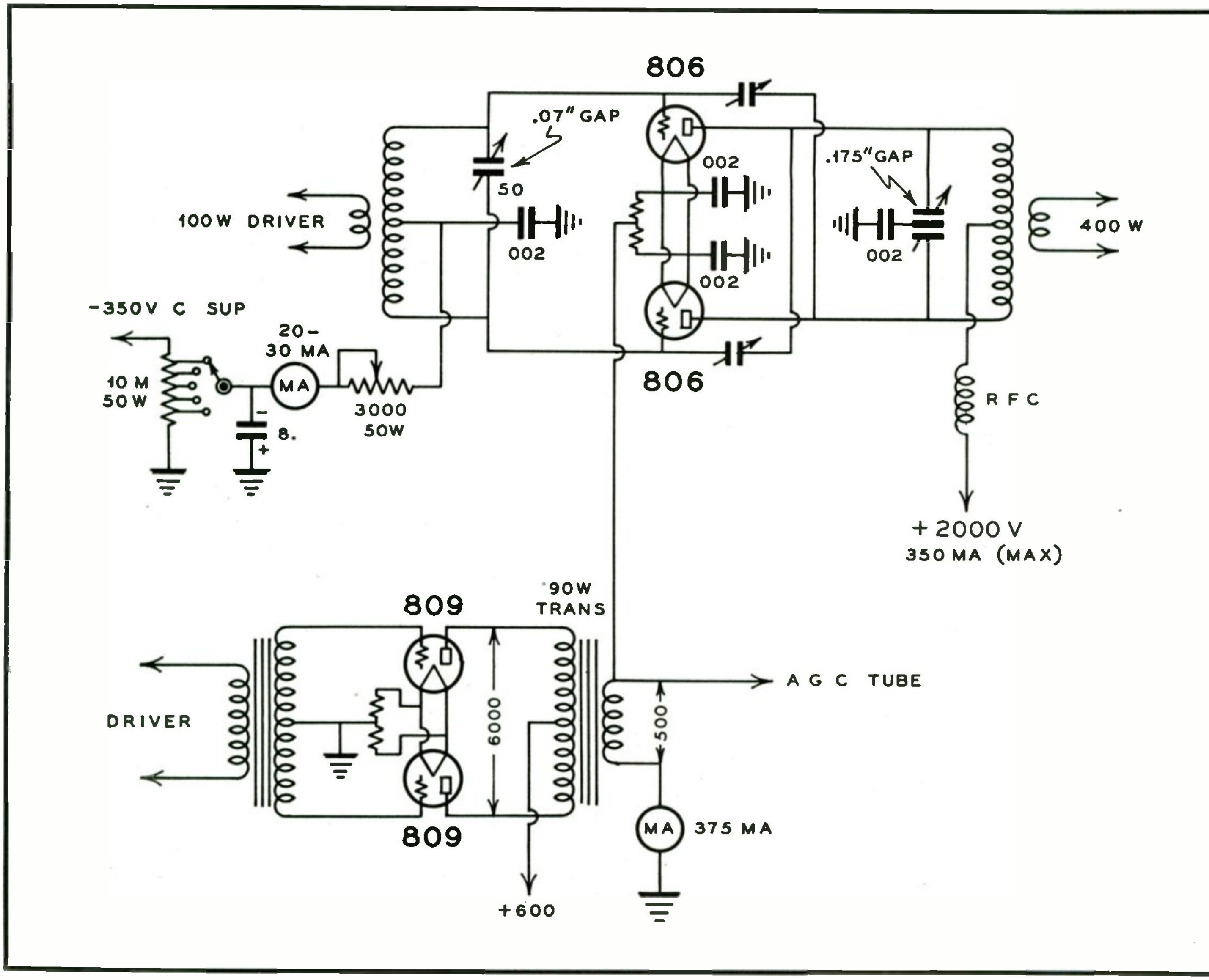

RCA-806 Push-Pull R.F. Amplifier—Modulated by Class-B 809s

A 700 watt r.f. amplifier with RCA-806 tubes in push-pull will furnish a carrier output of approximately 400 watts. A 2,000 volt, 350 ma. power supply will be needed to deliver d.c. power to the final amplifier plate circuit. The full plate dissipation rating of 150 watts per tube can be utilized in a cathode-modulated transmitter, resulting in a carrier output very nearly as great as in a plate-modulated transmitter using type 806 tubes. A pair of 809 triodes in push-pull will serve for the r.f. buffer stage to drive the grid circuit of the 806 amplifier. Fixed grid-bias from a C-bias supply is desirable for the type of amplifier shown in the circuit above. The amount of resistance in the grid-leak can be adjusted to that value which will produce most linear modulation when testing with an oscilloscope. The relative amount of grid modulation can be controlled by the amount of grid-leak in the 806 grid return circuit between the r.f. and audio-bypass condensers. Approximately 75 watts of audio power from a Class-B 809 modulator will fully modulate the 700 watt r.f. amplifier.

The 809 modulator stage can be driven by a pair of 45 or 2A3 low-mu triodes in push-pull, or by a 6L6 tetrode with inverse feed-back. The modulation transformer can be of the 90 watt standard size, with a 6,000 to 500 ohm impedance ratio.

RCA-806 Characteristics

Filament voltage	5 volts
Filament current	10 amperes
Amplification factor	12.6
Grid-to-plate capacity	3.4 mmfd.
Grid-to-filament capacity	6.1 mmfd.
Plate-to-filament capacity	1.1 mmfd.
Maximum d.c. plate voltage	3000 volts
Maximum d.c. plate current	200 ma.
Maximum d.c. grid current	50 ma.
Normal plate dissipation	150 watts

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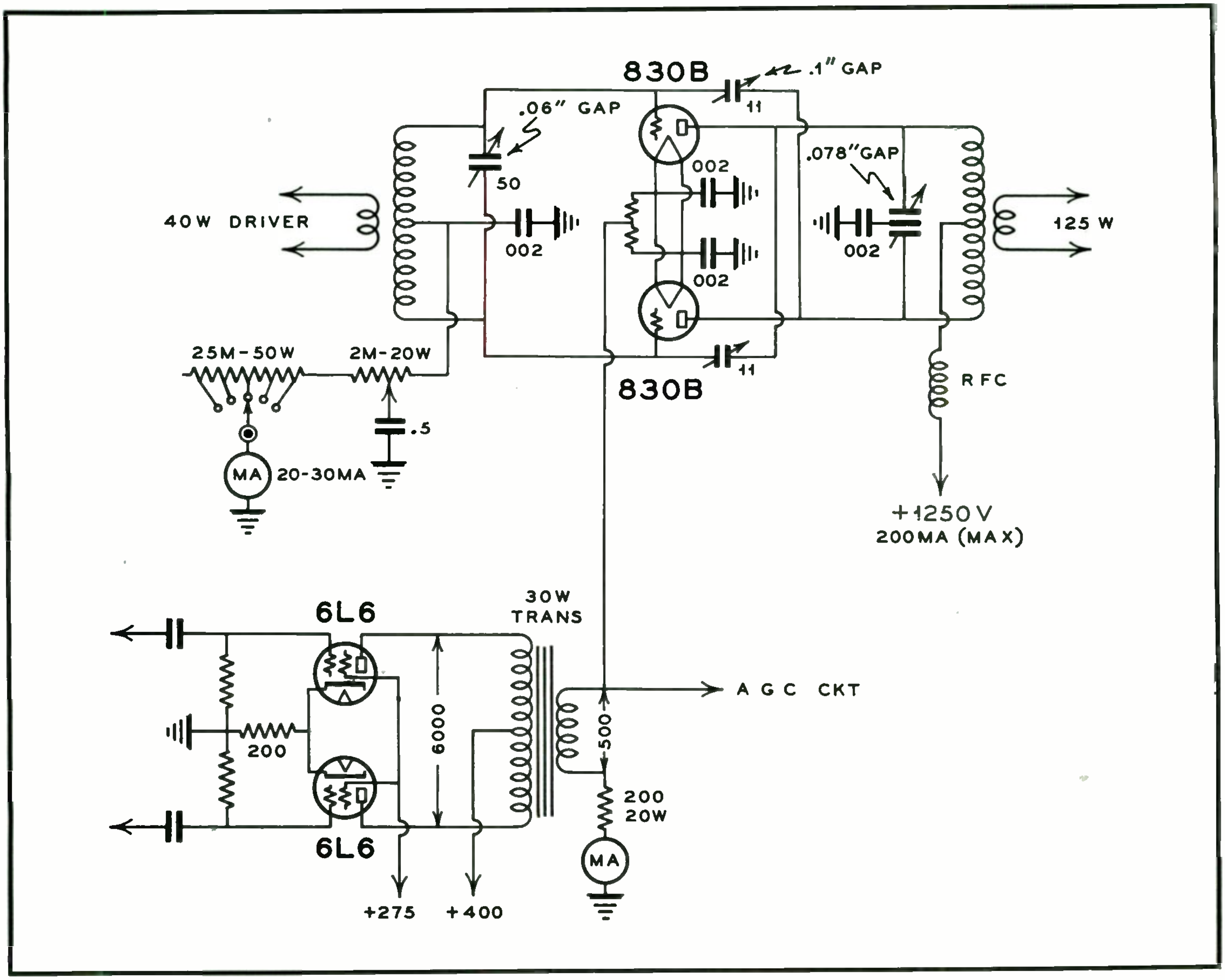

830B Push-Pull R.F. Amplifier—Modulated by Class-AB$_1$ 6L6s

A moderately high-mu tube, such as the 830B, is suitable for cathode modulation. The 830B has a relatively high plate dissipation rating, so that as much as 250 watts input can be run to a pair of these tubes when operated in push pull, and with the expectation of at least 125 watts of carrier output. A 1,250 volt plate supply, at 200 ma., is the maximum power needed for an 830B amplifier. An 807, link-coupled to the grid circuit of the 830B r.f. amplifier, will supply the required amount of grid excitation. A neutralized 809 buffer or doubler stage is also suitable for the r.f. driver. Approximately 25 watts of audio power is needed to produce complete modulation in the cathode circuit of the r.f. amplifier. Push-pull 6L6 or 6L6G tubes, connected in Class-AB$_1$, will deliver the required output into a 6,600 ohm plate-to-plate load. The output transformer should have an impedance ratio of 6,600-to-500, in order to make the 500 ohm cathode load appear to be about 6,600 ohms plate-to-plate load for the modulator tubes. The secondary winding of this transformer should be able to carry approximately 225 ma. d.c. without saturation or danger of overheating. A 30 watt rating for this transformer will usually meet these requirements. The 6L6 grid circuit can be resistance- or transformer-coupled to the preceding audio amplifier.

830-B Characteristics

Filament voltage	10 volts
Filament current	2 amperes
Amplification factor	25
Grid-to-plate capacity	11 mmfd.
Grid-to-filament capacity	5 mmfd.
Plate-to-filament capacity	1.8 mmfd.
Maximum d.c. plate voltage	1000 volts
Maximum d.c. plate current	150 ma.
Maximum d.c. grid current	60 ma.
Normal plate dissipation	60 watts

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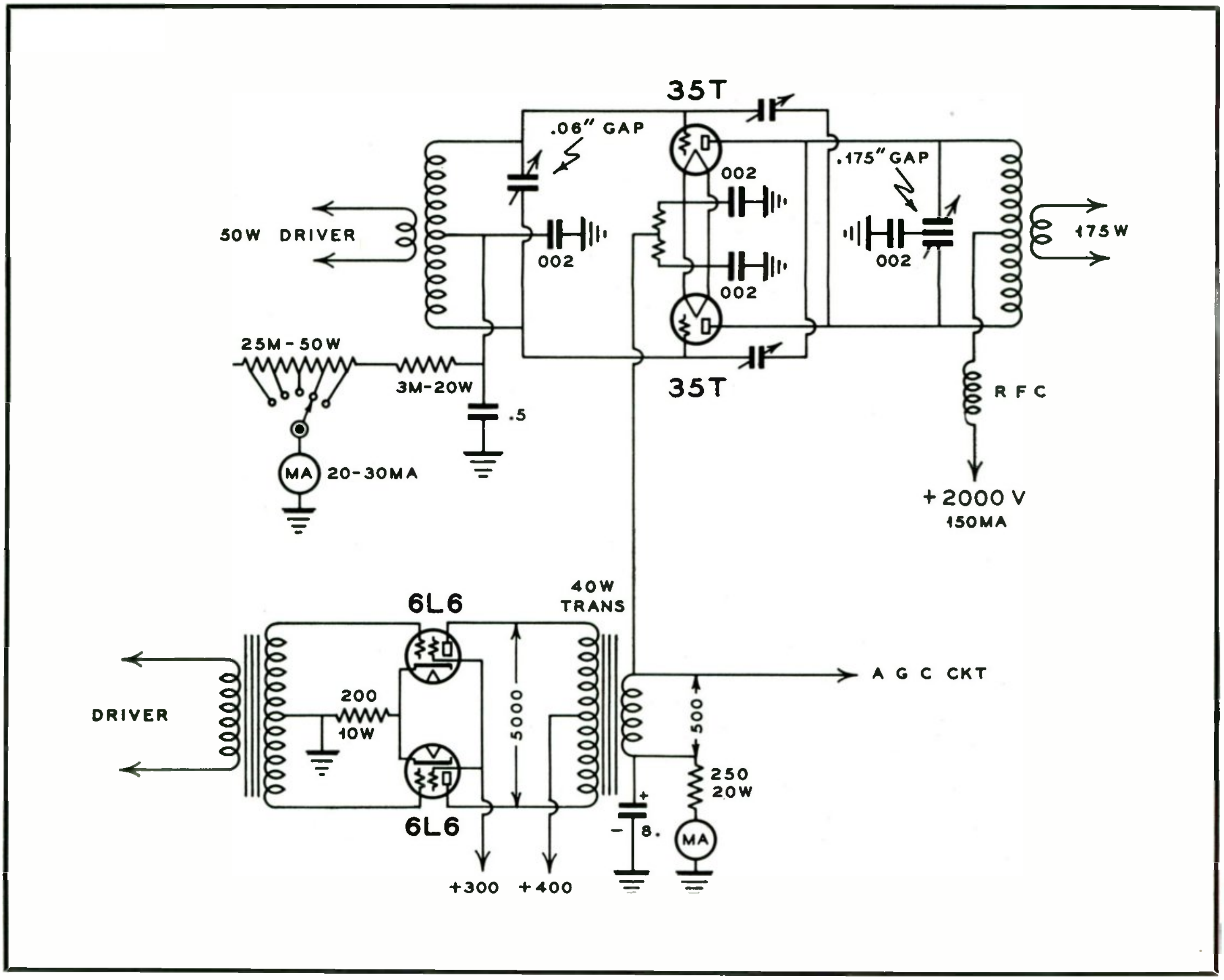

Eimac 35T Push-Pull R.F. Amplifier—Modulated by Class-AB$_1$ 6L6s

A pair of Eimac 35T triodes can be made to supply from 100 to 175 watts of carrier with plate potentials ranging from 1,250 to 2,000 volts. The normal plate dissipation of these tubes for plate modulation is 35 watts, and they are usually rated at 70 watts for c.w. service. A plate dissipation of from 50 to 70 watts can be tolerated in the cathode-modulated amplifier shown in the circuit above. A combination of grid-leak and cathode-bias resistance gives any desired d.c. grid bias. Both sources of bias are by-passed for audio frequencies. A pair of 6L6 tubes in Class-AB$_1$ will supply from 30 to 35 watts of audio power to effectively modulate a pair of 35Ts with an input of 300 watts to the plate circuit. Any of the *AGC* circuits shown in the preceding section of this book can be applied to this or any other cathode-modulated system in order to prevent overmodulation and at the same time to permit an average high level of modulation with speech input. A 35T doubler stage makes a very satisfactory r.f. driver. It is possible to use capacity-coupling rather than link-coupling as shown in the circuit, for this type of driver. The grids of the 35T modulated amplifier would be connected to the preceding tuned circuit at points approximately half way between the center-tap and ends of the coil, when capacity-coupling is used. An 807 or 809 buffer stage will also drive the 35T amplifier.

Eimac 35T Characteristics

Filament voltage	5 to 5.1 volts
Filament current	4 amperes
Amplification factor	30
Grid-to-plate capacity	1.9 mmfd.
Grid-to-filament capacity	not listed
Plate-to-filament capacity	not listed
Maximum d.c. plate voltage	2000 volts
Maximum d.c. plate current	150 ma.
Maximum d.c. grid current	35 ma.
Normal plate dissipation	35-70 watts

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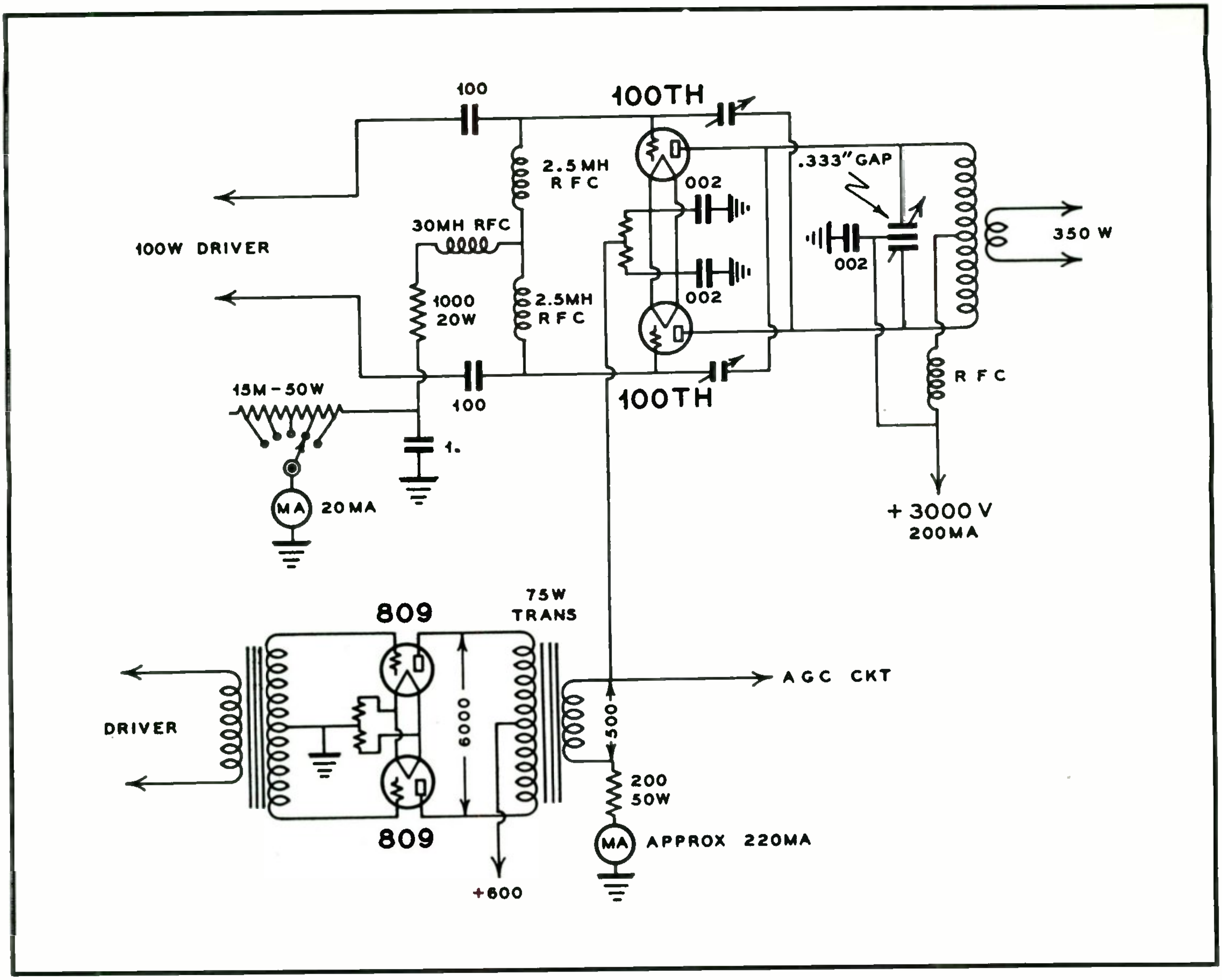

Eimac 100TH Push-Pull R.F. Amplifier—Modulated by Class-B 809s

It is possible to run an input as high as 600 watts to a cathode-modulated push-pull 100TH r.f. amplifier. With this input, the plate dissipation per tube will run between 120 and 150 watts. Almost 500 watts of input with a plate supply of from 2,000 to 2,500 volts can be used if the normal plate dissipation rating of these tubes is not exceeded. The 100TH tube has a high amplification constant and will therefore operate at highest efficiency when the plate supply delivers from 2,500 to 3,000 volts. A 35T r.f. driver can be capacitively-coupled, as shown in the circuit, or link-coupled to the 100TH stage, as desired. The audio-frequency by-pass condenser in the grid-leak circuit is connected across a portion of the grid-leak only, in order to obtain best linearity of modulation. A pair of 809 zero-bias tubes in the Class-B amplifier will supply the required audio power into a 500 ohm load. The modulator can be driven by a 6L6 driver with inverse feed-back, or by a pair of 45 low-mu triodes in push-pull. The cathode-bias resistor for the 100TH need not be by-passed for audio frequencies, since not more than 200 ohms of resistance is needed in this circuit for C-biasing. This cathode resistor protects the 100TH tubes in the event of failure in any portion of the r.f. exciter circuits. The d.c. voltage drop across this resistor also adds to the d.c. grid bias on the r.f. amplifier.

Eimac 100TH Characteristics

Filament voltage	5 to 5.1 volts
Filament current	6.5 amperes
Amplification factor	30
Grid-to-plate capacity	2.0 mmfd.
Grid-to-filament capacity	2.3 mmfd.
Plate-to-filament capacity	0.3 mmfd.
Maximum d.c. plate voltage	3000 volts
Maximum d.c. plate current	225 ma.
Maximum d.c. grid current	50 ma.
Normal plate dissipation	100 watts

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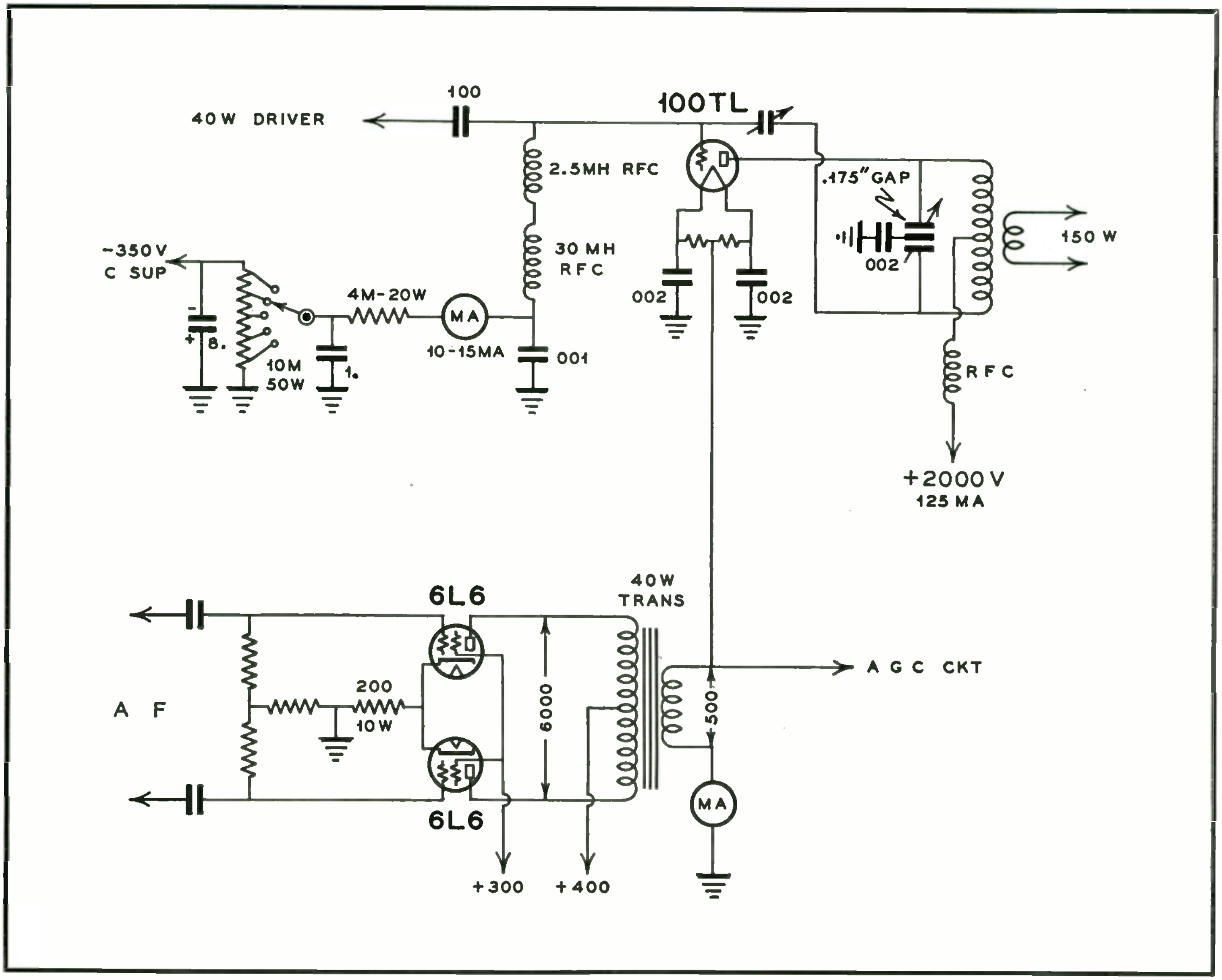

Eimac 100TL R.F.Amplifier—Modulated by Class-AB1 6L6s

A single Eimac 100TL can be capacitively- or link-coupled to an r.f. driver, such as an 807 or 809 buffer or doubler stage. If capacitively-coupled, it is sometimes necessary to use an r.f. grid choke which has a great many times the inductance of the plate r.f. choke, in order to prevent low-frequency parasitic oscillations in the form of a tuned-grid-tuned-plate oscillator. High inductance grid r.f. chokes, because of their relatively high distributed capacity, are not always effective at high radio-frequencies. A small r.f. choke can sometimes be connected in series with a large r.f. choke, as shown in the circuit diagram, so as to prevent excessive grid circuit losses. The 100TL can be operated with an input as high as ¼-kilowatt in this circuit, and will produce a carrier output of 150 watts. This medium-mu tube does not require plate supply higher than 2,000 volts in order to operate at relatively high plate circuit efficiency. Approximately 25 watts of audio power into the 500 ohm cathode impedance will produce 100 percent modulation. A pair of 6L6 or 6L6G tubes in Class-AB_1 will supply this amount of power into a plate-to-plate load of 6,000 ohms. Resistance- or transformer-coupling can be used from the preceding amplifier stage. Fixed grid-bias on the r.f. amplifier is desirable, since the 100TL is a medium-mu tube. The C-bias power supply should be well filtered in order to prevent a.c. hum modulation.

Eimac 100TL Characteristics

Filament voltage	5 to 5.1 volts
Filament current	6.5 amperes
Amplification factor	12
Grid-to-plate capacity	2.3 mmfd.
Grid-to-filament capacity	2 mmfd.
Plate-to-filament capacity	4 mmfd.
Maximum d.c. plate voltage	3000 volts
Maximum d.c. plate current	225 ma.
Maximum d.c. grid current	35 ma.
Normal plate dissipation	100 watts

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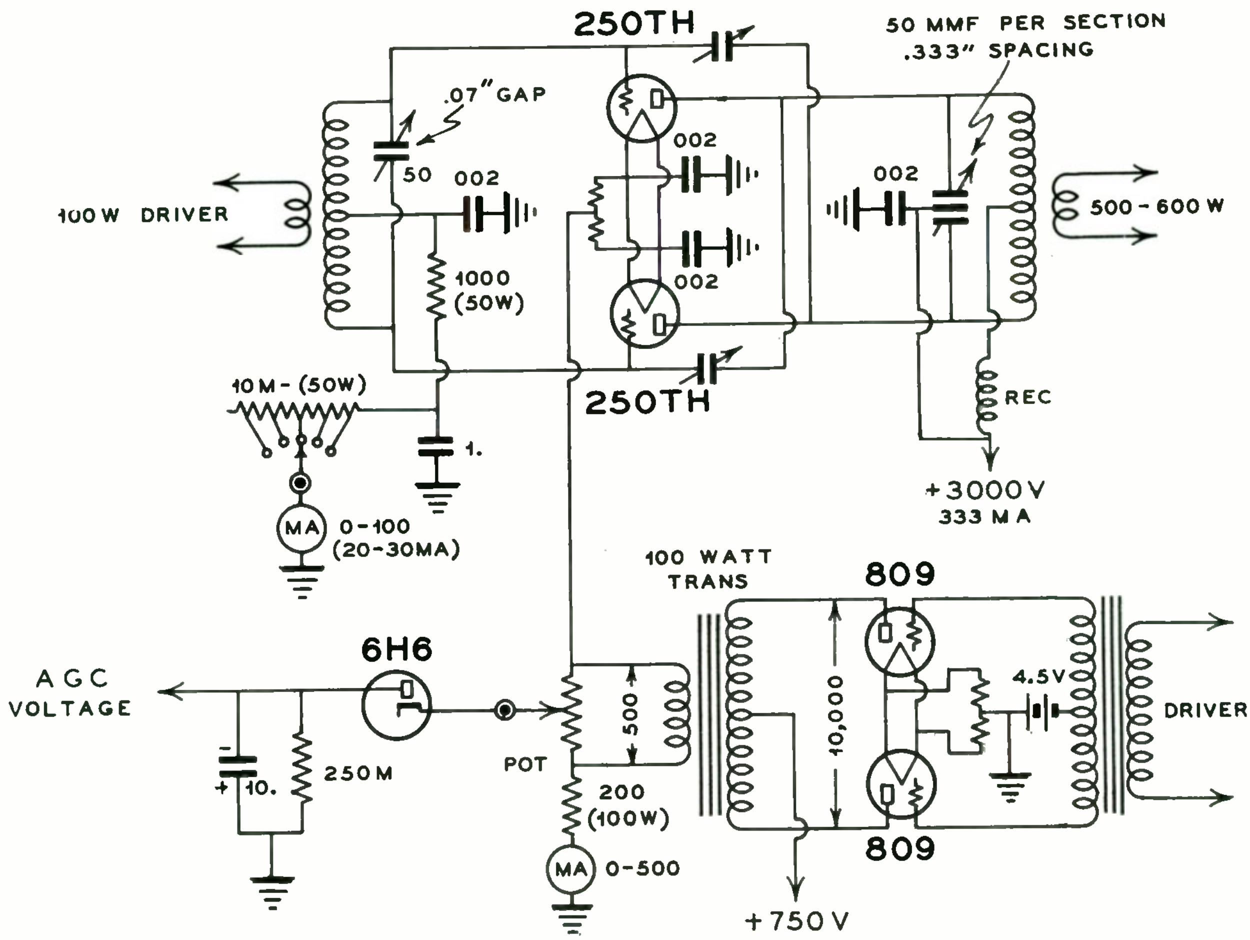

Eimac 250THs in Push-Pull—Modulated by Class-B 809s

TYPE 250TH or 250TL triodes, with from 2,000 to 3,000 volts plate supply, will deliver a carrier output of from 500 to 600 watts. The average 100 watt r.f. driver stage must be able to supply from 50 to 75 watts of grid excitation. A 1,000 ohm resistor is connected into the grid circuit between the grid r.f. return circuit and the l-mfd. audio-frequency by-pass condenser for the purpose of improving the linearity of modulation by reducing the effective grid modulation. The 10,000 ohm variable grid-leak can be tapped at equidistant points. If 250TL tubes are used, a 25,000 ohm grid-leak is desirable. A pair of 809 triodes, with a power supply that will deliver 750 volts at 200 ma., will give 100 watts of audio for modulating the r.f. amplifier. The modulation transformer should have a secondary-to-primary impedance of 500 up to 10,000 ohms. The Class-B modulator can be driven by a pair of 45 triodes, or by a 6L6 with inverse feed-back. The automatic-gain-control circuit obtains a delay bias due to the d.c. voltage drop across the 200 ohm cathode resistor, and the audio-frequency adjustment is by means of a 100,000 ohm potentiometer across the 500 ohm winding of the modulation transformer.

Eimac 250TH Characteristics

Filament voltage	5 to 5.1 volts
Filament current	10.5 amperes
Amplification factor	32
Grid-to-plate capacity	3.3 mmfd.
Grid-to-filament capacity	3.5 mmfd.
Plate-to-filament capacity	0.3 mmfd.
Maximum d.c. plate voltage	3000 volts
Maximum d.c. plate current	350 ma.
Maximum d.c. grid current	65 ma.
Normal plate dissipation	250 watts

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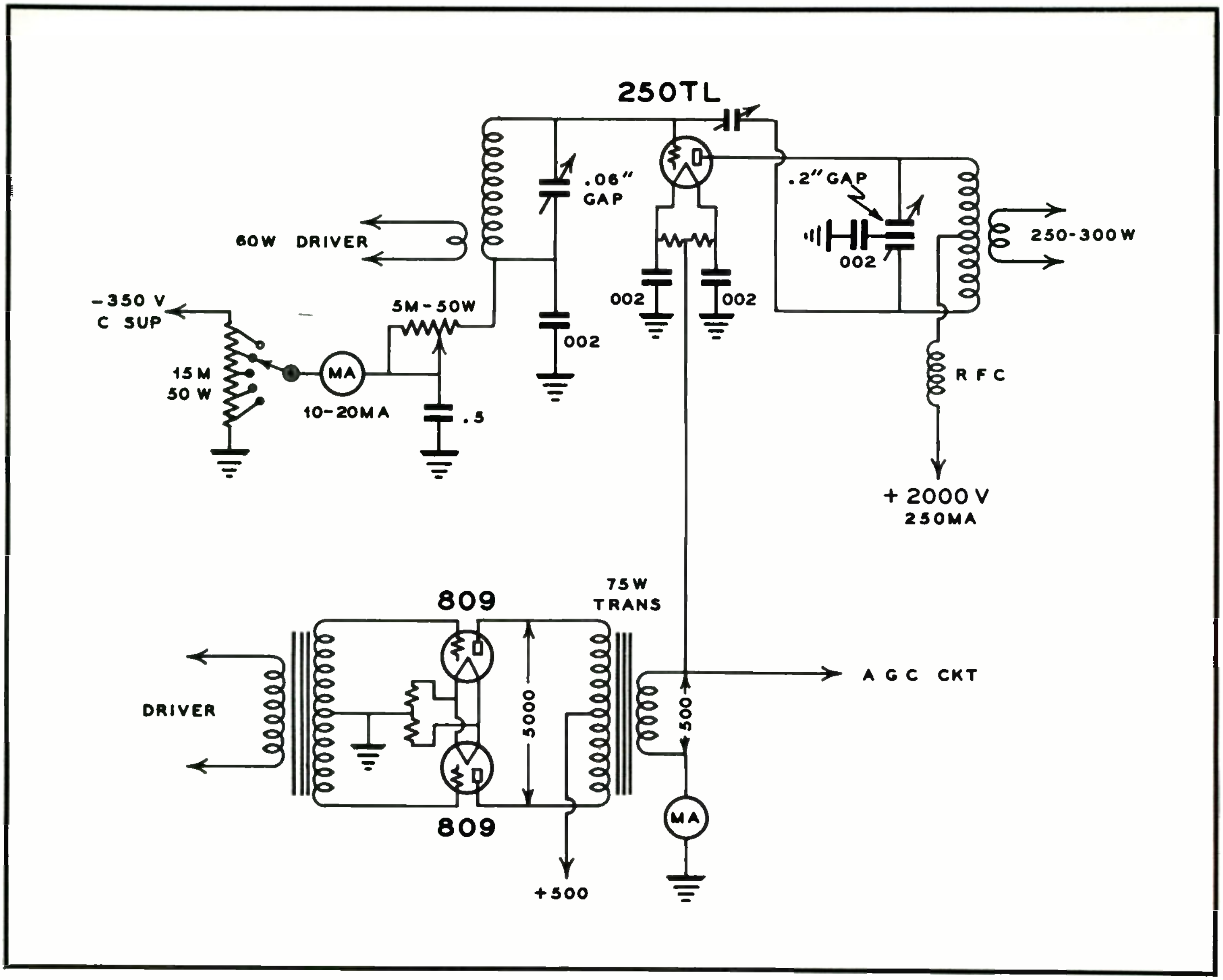


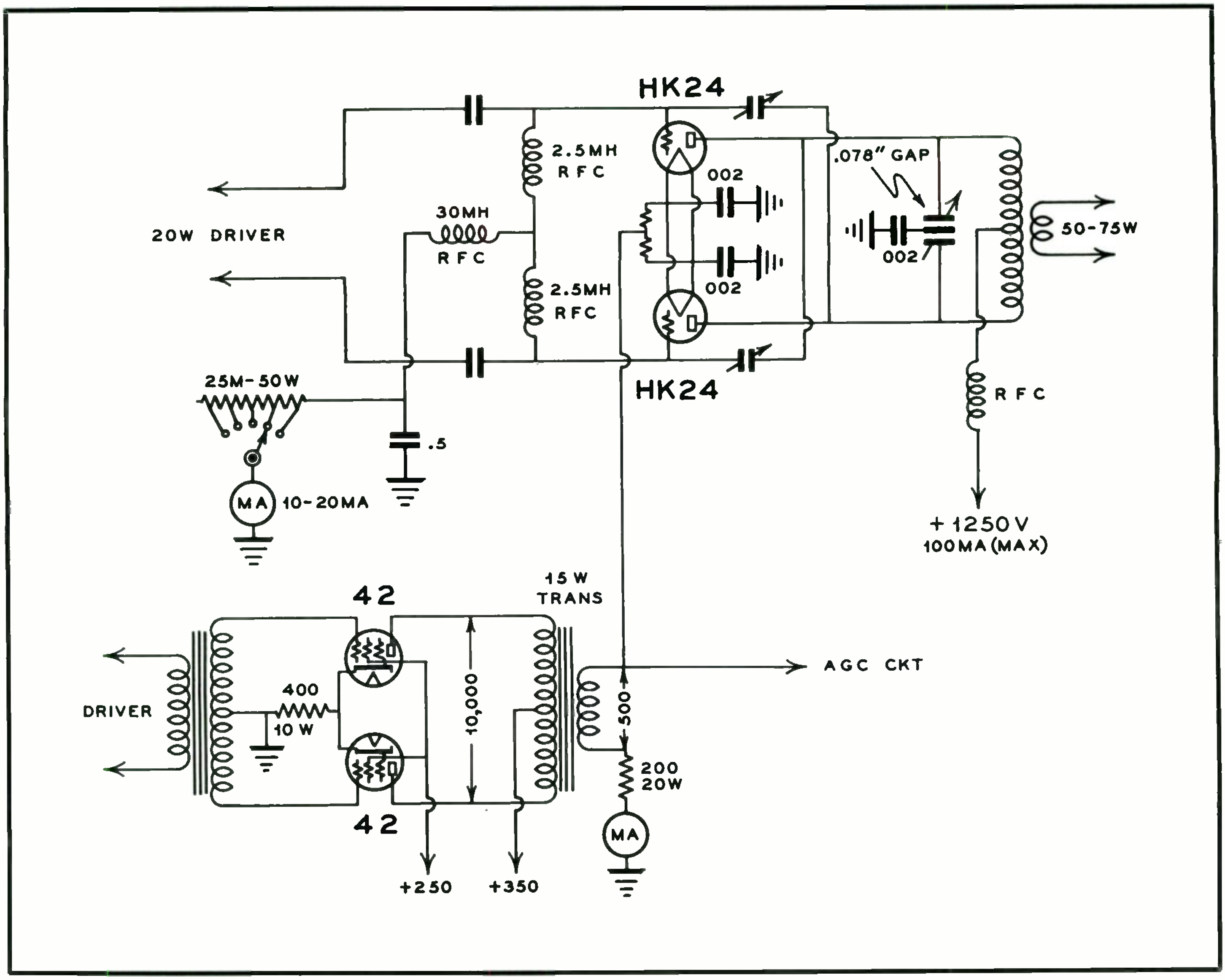
Eimac 250TL R.F. Amplifier—Modulated by Class-B 809s

A 250TL medium-mu triode will supply more carrier output than a 250TH at plate potentials ranging from 1,500 to 2,000 volts. With ½-kw input to a 250TL, from 250 to 300 watts of carrier output can be obtained, if the power supply delivers 2,000 volts. Approximately 40 watts of power is needed to drive the grid circuit of the modulated amplifier. Grid-bias should be obtained from a well-filtered C-bias supply, in which a tap switch provides a variation of d.c. bias voltage for quick adjustment of proper modulation when changing bands of operation in the r.f. amplifier. The r.f. amplifier can be link- or capacitively-coupled to the driver stage; this driver can be a 35T buffer or doubler. Sufficient output can be obtained from an 807 at 600 volts to drive the 250TL. Class-B 809 tubes with a 500 volt plate supply, will deliver approximately 50 watts of audio power to the cathode circuit of the r.f. amplifier, and modulation levels up to 100% will be obtained. The 809 modulator can be driven by a pair of 45s, or 42s, triode connected, or by a single 6L6 with inverse feed-back. In the latter, inverse feed-back is desirable in order to lower the plate impedance of the audio driver stage. Any audio modulator which will supply 50 watts of audio power to a 500 ohm load will modulate the r.f. amplifier.

Eimac 250TL Characteristics

Filament voltage	5 to 5.1 volts
Filament current	10.5 amperes
Amplification factor	13
Grid-to-plate capacity	3.5 mmfd.
Grid-to-filament capacity	3 mmfd.
Plate-to-filament capacity	0.5 mmfd.
Maximum d.c. plate voltage	3000 volts
Maximum d.c. plate current	350 ma.
Maximum d.c. grid current	50 ma.
Normal plate dissipation	250 watts

World Radio History



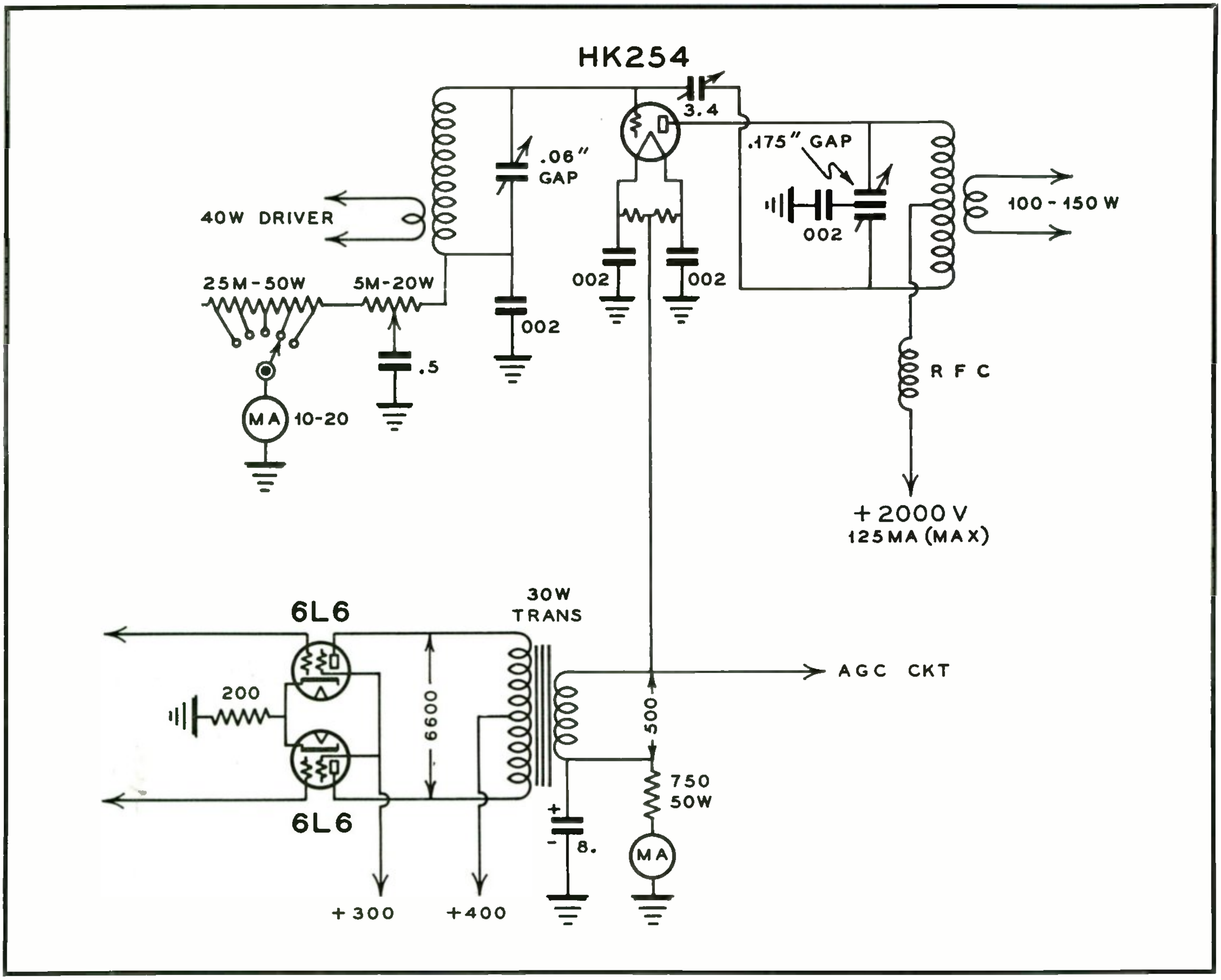
HK-24 Gammatrons in Push-Pull—Modulated by 10 Watts of Audio Power

FROM 50 to 75 watts of carrier output can be obtained from a pair of HK-24 Gammatrons on any band from 5 to 160 meters. The 1,250 volt plate supply should be capable of supplying 100 ma. of plate current to the r.f. amplifier. Another HK-24 doubler or buffer can be used as a driver for the grid circuit of the modulated amplifier, or a 6L6 exciter will also deliver ample r.f. grid drive. The d.c. grid-bias is obtained from a combination of variable grid-leak and a fixed cathode resistor. Approximately 10 watts of audio-frequency power in the cathode circuit of the r.f. amplifier will produce 100 percent modulation. This small amount of power can be obtained from several kinds of audio amplifiers, such as a pair of 42s, 2A3s,45s, 6V6s, or even a single 6L6 tube. The very small physical size of the HK-24 Gammatron makes this type of amplifier applicable for 2.5 and 5 meter operation, with cathode modulation. If the HK-24 tubes are used in a self-excited oscillator, the grid-bias and antenna loading must be carefully adjusted to obtain satisfactory modulation. The amount of r.f. grid excitation is also critical in a self-excited oscillator, such as the type of circuit used in the amateur 2.5 meter band. The filament supply for the modulated amplifier should be separate from any other source of audio- or radio-frequency filament supply in the transmitter. Care should be taken not to over-drive the grids of the HK-24 tubes.

HK-24 Characteristics

Filament voltage	6.3 volts
Filament current	3 amperes
Amplification factor	25
Grid-to-plate capacity	1.7 mmfd.
Grid-to-filament capacity	2.5 mmfd.
Plate-to-filament capacity	0.4 mmfd.
Maximum d.c. plate voltage	1500 volts
Maximum d.c. plate current	75 ma.
Maximum d.c. grid current	30 ma.
Normal plate dissipation	25 watts

World Radio History



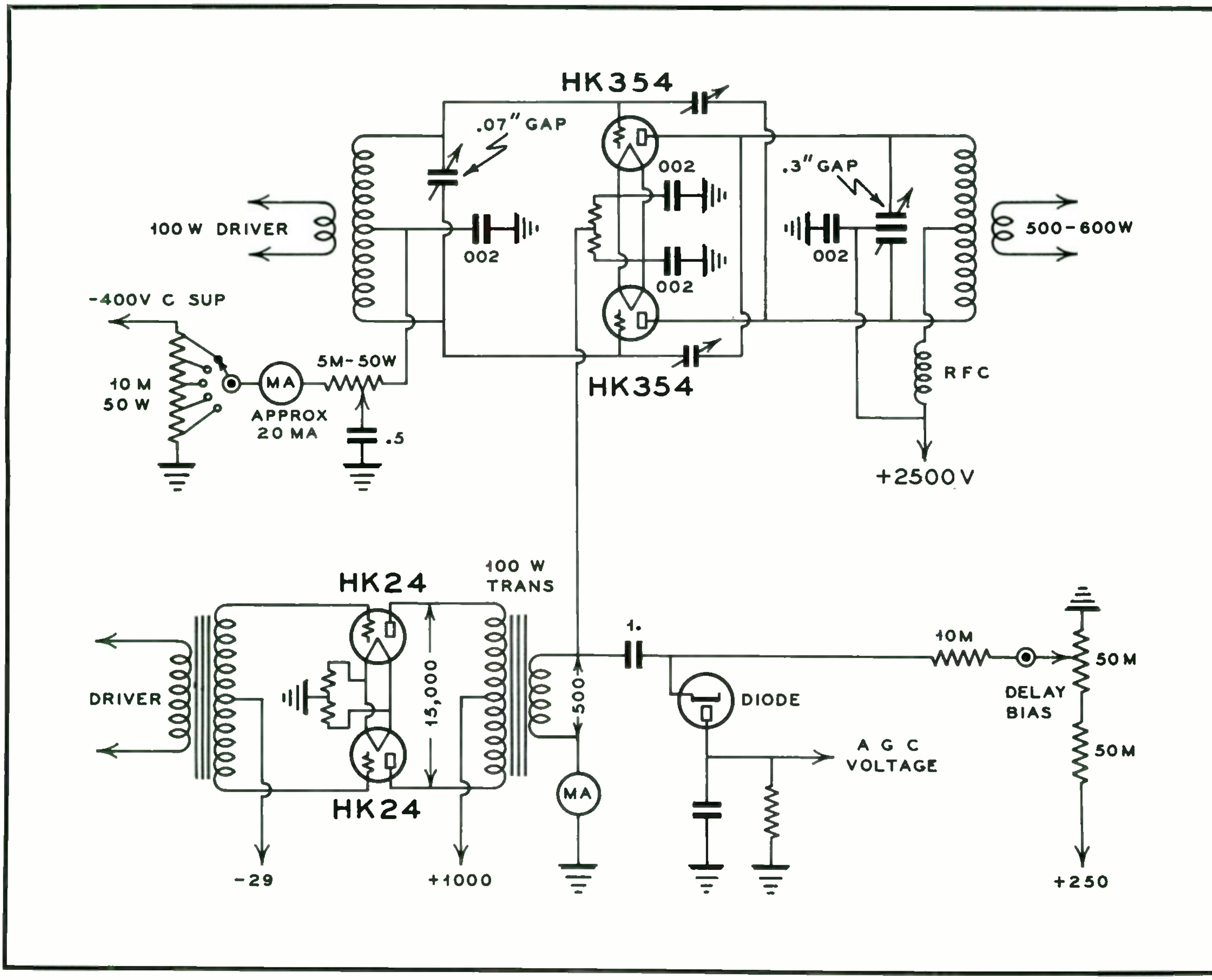
HK-254 Gammatron, Single Ended—Modulated by 6L6s in Class-AB1

A quarter-kilowatt of input to a single HK-254 triode amplifier will produce from 100 to 150 watts of carrier output. A potential of 2,000 volts at 125 ma. can be obtained from a power supply with condenser input to the filter—and a power transformer rated at 1,750 or 1,800 volts each side of center. Two 2-mfd. 2,000 volt filter condensers and a single 15 henry filter choke will give sufficient plate circuit filter for this type of amplifier. Grid-bias is obtained from a variable grid-leak and cathode-resistor-bias combination. Both bias arrangements are by-passed for audio frequencies, one with an 8-mfd. condenser and the other with a 0.5 mfd. condenser connected to a tap on the 5,000 ohm section on the grid-leak. For ordinary operation, the 0.5-mfd. condenser can be connected directly across the .002 mfd. r.f. by-pass condenser. Some improvement in modulation linearity can generally be obtained by connecting the 0.5 mfd. condenser from some point on the 5,000 ohm resistor to ground. A cathode-ray oscilloscope is required for this test. From 15 to 25 watts of r.f. power is needed to drive the grid circuit of the HK-254 amplier. Approximately 25 watts of audio power from a pair of 6L6 tubes in Class-AB_1 will modulate the r.f. amplifier. The 6L6 tubes can be resistance- or transformer-coupled to a push-pull audio amplifier or phase-inverter circuit.

HK-254 Characteristics

Filament voltage	5 volts
Filament current	7.5 amperes
Amplification factor	25
Grid-to-plate capacity	3.4 mmfd.
Grid-to-filament capacity	3.3 mmfd.
Plate-to-filament capacity	1.1 mmfd.
Maximum d.c. plate voltage	3000 volts
Maximum d.c. plate current	200 ma.
Maximum d.c. grid current	40 ma.
Normal plate dissipation	100 watts

World Radio History



HK-354s in Push-Pull—Modulated by Class-B HK-24s

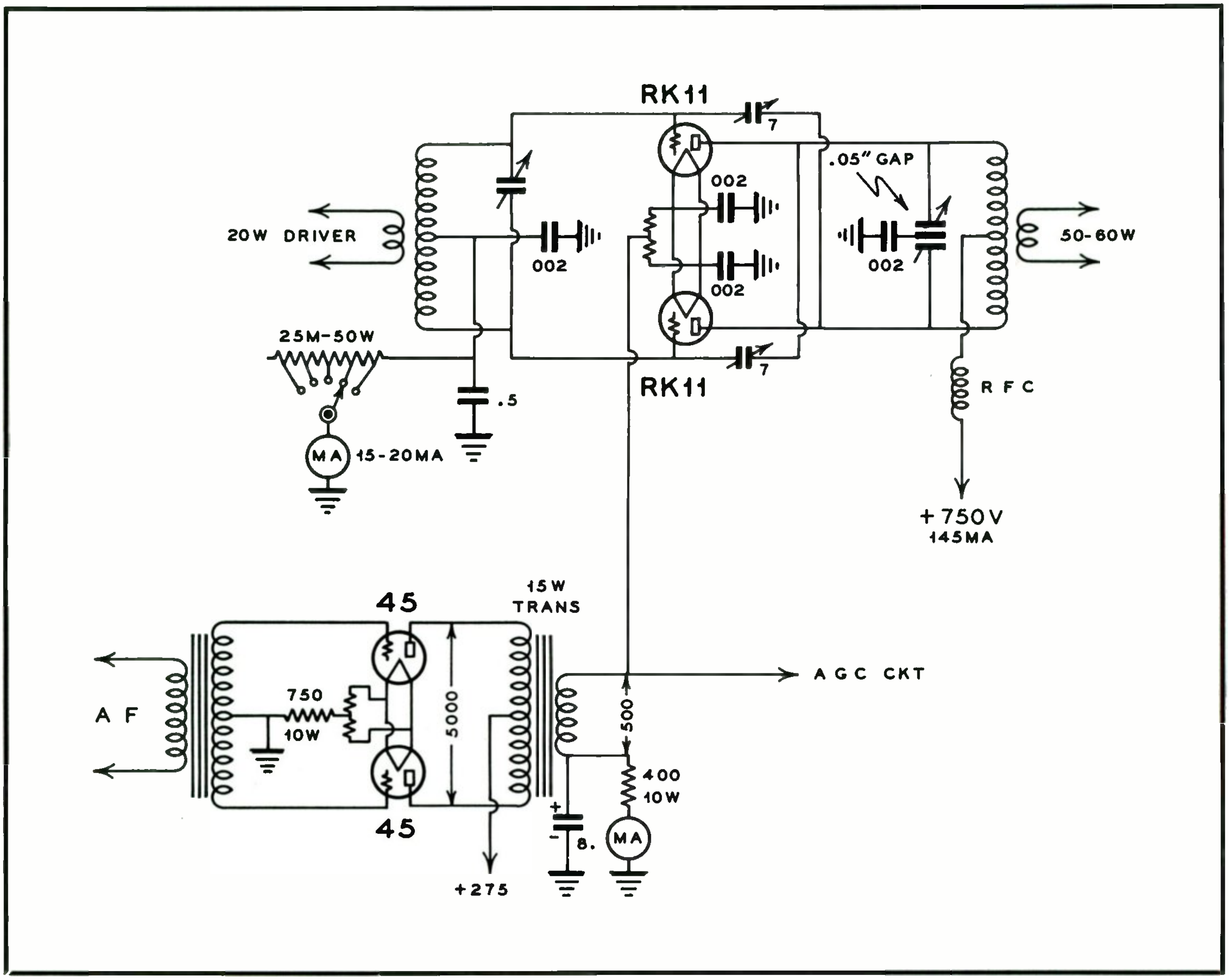
TYPE HK-354 triodes, with a 2,500 volt power supply operating at 400 ma. plate current, will supply a carrier output of from 500 to 600 watts. If the tubes are operated at this power input, forced ventilation by means of an electrically-driven fan will be needed to cool the glass envelopes of the r.f. tubes. The same circuit constants can be used with the higher-mu HK-354 series, such as the HK-354D or HK-354E. The tubes can be operated with a lower value of plate current by reducing the r.f. excitation. The linearity of modulation can be adjusted for optimum condition by means of an oscilloscope measurement, made while adjusting the slider on the 5,000 ohm grid-leak. This resistor tap effectively controls the degree of grid modulation in comparison to plate modulation. When the 0.5 mfd. condenser is connected from ground to the end of the resistor nearest the r.f. by-pass condenser, the ratio of grid modulation to plate modulation will be highest. Any well-filtered C-bias supply is suitable for providing d.c. bias to the r.f. amplifier.

A pair of HK-24 tubes in the Class-B modulator will supply 100 watts of audio to a 500 ohm load, as shown in the circuit diagram. A pair of 45 or 2A3 triodes will drive the Class-B modulator.

HK-354 Characteristics

Filament voltage	5.0 volts
Filament current	10 amperes
Amplification factor	14
Grid-to-plate capacity	4 mmfd.
Grid-to-filament capacity	9 mmfd.
Plate-to-filament capacity	0.2 mmfd.
Maximum d.c. plate voltage	3500 volts
Maximum d.c. plate current	300 ma.
Maximum d.c. grid current	50 ma.
Normal plate dissipation	150 watts

World Radio History



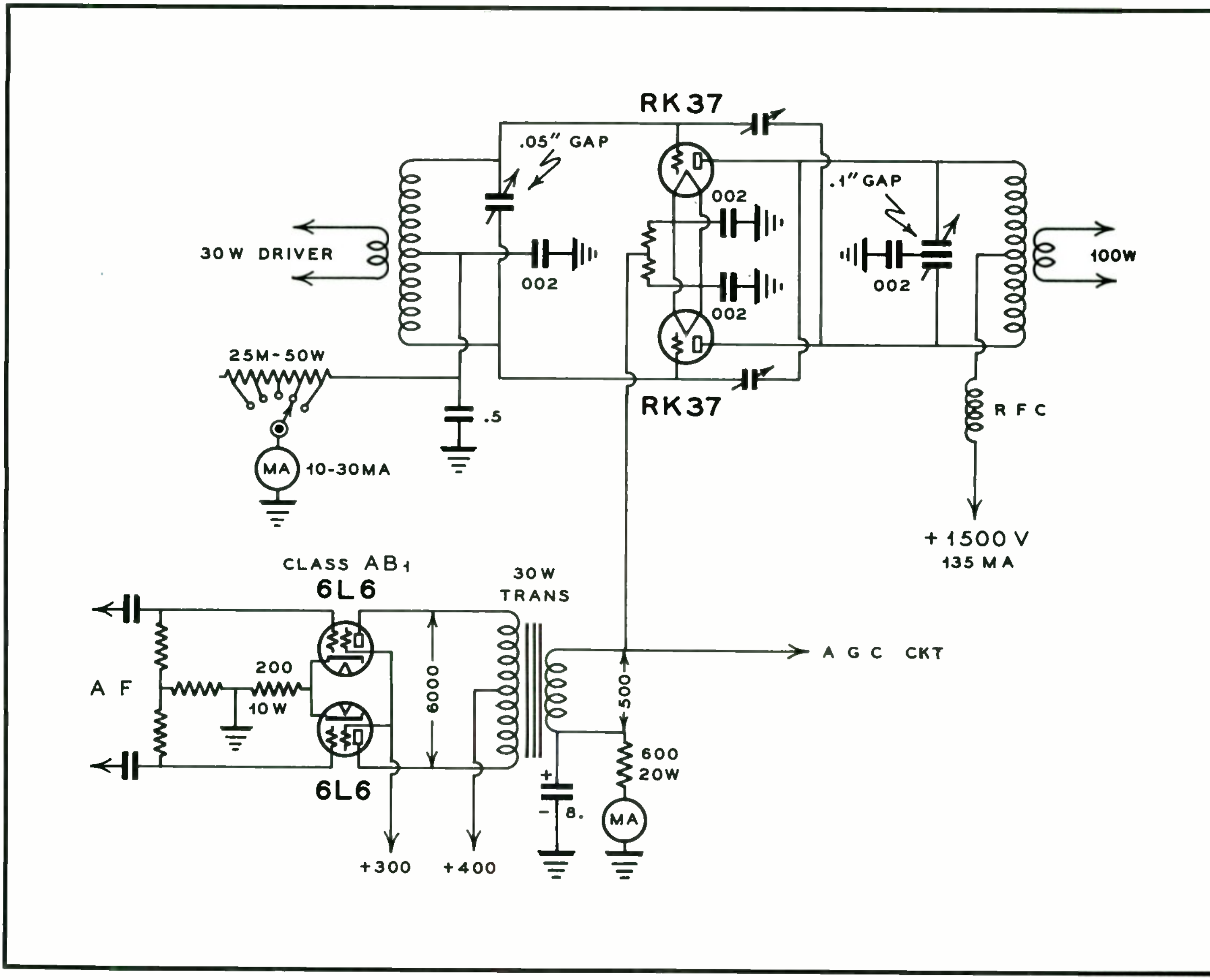
Raytheon RK-11 R.F. Amplifier—Modulated by Push-Pull 45s

PUSH-PULL RK-11 triodes can be cathode-modulated with approximately 100 watts input to the plate circuit. This will provide a carrier output of from 50 to 60 watts, without exceeding the plate dissipation rating of the tubes. A 750 volt plate supply, delivering 145 ma. plate current to the r.f. amplifier, will give an actual input of 100 watts after subtracting the power loss in the 400 ohm cathode resistor. The voltage drop across the latter provides an automatic grid-bias which is added to that of the d.c. grid current flowing through the grid-leak. Both the grid-leak and cathode resistor are by-passed for audio frequency. The r.f. amplifier can be driven by a 6L6 buffer or doubler, operating with from 15 to 30 watts input. A pair of 45 tubes in push-pull will supply sufficient audio power to cathode-modulate the r.f. amplifier. A small 15 watt output transformer with a primary winding designed to operate from a 5,000 ohm source to a 500 ohm secondary load will properly match the modulator to the cathode circuit of the r.f. amplifier. In any r.f. amplifier circuit, the filament center-tap resistor (50 to 75 ohms) can be eliminated if the filament transformer for that stage has a center-tap connection. The 45s can be driven by a single 76 or 56 triode, or two of these tubes can be used in push-pull, if desired. Approximately 10 watts of audio is needed for modulation.

Raytheon RK-11 Characteristics

Filament voltage	6.3 volts
Filament current	3 amperes
Amplification factor	20
Grid-to-plate capacity	7 mmfd.
Grid-to-filament capacity	7 mmfd.
Plate-to-filament capacity	0.9 mmfd.
Maximum d.c. plate voltage	750 volts
Maximum d.c. plate current	105 ma.
Maximum d.c. grid current	35 ma.
Normal plate dissipation	25 watts

World Radio History



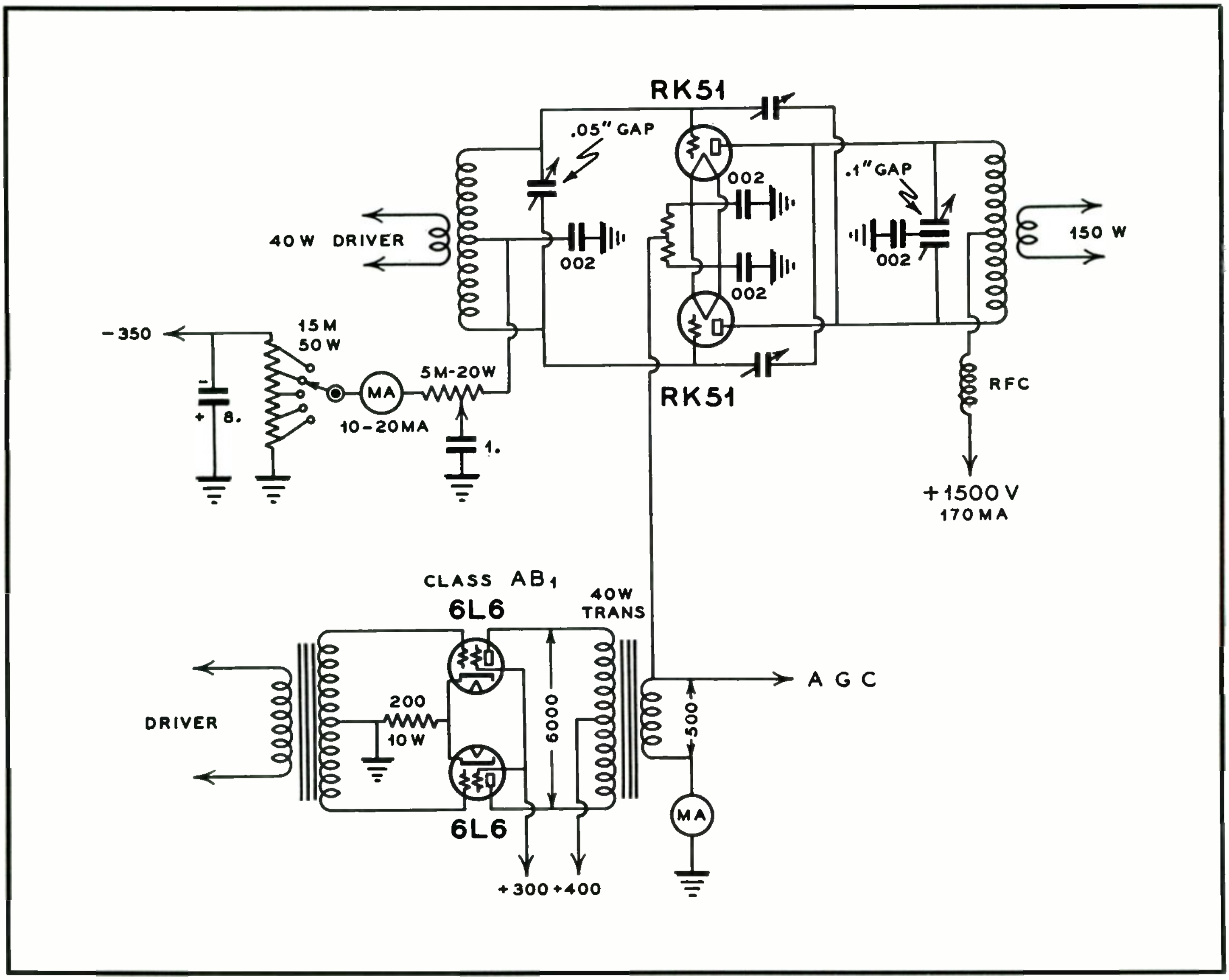
Raytheon RK-37 R.F. Amplifier—Modulated by Class-AB$_1$ 6L6s

RAYTHEON RK-37 high-mu triodes can be successfully cathode-modulated with approximately 20 watts of audio-frequency power across a 500 ohm cathode impedance. The r.f. amplifier tubes, because of their high amplification constant, should be connected to a d.c. plate supply of from 1,250 to 1,500 volts, since high-mu tubes require as high a plate voltage as possible, in order to operate at high plate efficiency. At least 100 watts of carrier output can be obtained on any band from 10 to 160 meters. Low-mu RK-35 tubes can be used for the same purpose, and will deliver the same carrier output in an r.f. amplifier with from 1,000 to 1,200 volts plate supply. A 6L6 or RK-39 r.f. driver stage will deliver ample grid excitation, the value of which can be set for optimum by a variation of link-coupling between the r.f. driver and the RK-37 tuned-grid circuit. A combination of grid-leak and cathode-resistor-bias is used in this amplifier. Both resistors are by-passed for audio frequencies. A pair of 6L6 tubes in Class-AB$_1$ will deliver more than ample audio power for complete modulation. If low-mu tubes are used, it is desirable to eliminate the cathode resistor by connecting the grid circuit to a C-bias power supply of 300 or 350 volts maximum. A tap switch across the bleeder resistor of the C-bias supply will allow selection of the desired value of d.c. grid-bias voltage which gives highest degree of cathode modulation in actual operation.

Raytheon RK-37 Characteristics

Filament voltage	7.5 volts
Filament current	4 amperes
Amplification factor	30
Grid-to-plate capacity	3.2 mmfd.
Grid-to-filament capacity	3.5 mmfd.
Plate-to-filament capacity	0.2 mmfd.
Maximum d.c. plate voltage	1500 volts
Maximum d.c. plate current	125 ma.
Maximum d.c. grid current	35 ma.
Normal plate dissipation	50 watts

World Radio History



Raytheon RK-51 Push-Pull R.F. Amplifier—Modulated by Class-AB$_1$ 6L6s

ANOTHER 250 watt r.f. amplifier with RK-51 tubes in push-pull can be modulated by a pair of 6L6s in Class-AB$_1$. A 1,500 volt, 170 ma. power supply will give sufficient input to obtain approximately 150 watts of carrier output from the r.f. amplifier. The r.f. exciter, with 40 watts input should supply from 15 to 25 watts of r.f. drive to the grid circuits of the RK-51 tubes. Fixed grid-bias from a well-filtered C-bias supply is shown for use with these tubes. The audio-frequency by-pass condenser of ½-mfd. or 1-mfd. capacity can be connected to a point on the 5,000 ohm grid-leak where best modulation linearity is secured. This adjustment can be made by connecting an oscilloscope to the audio-frequency and r.f. output while checking for modulation with a trapezoidal pattern. Approximately 25 watts of audio power into a 500 ohm load impedance will produce up to 100 percent modulation in the r.f. amplifier. The modulator can be connected to a speech amplifier by either transformer- or resistance-coupling, depending upon the impedance of the preceding speech amplifier tube or tubes. A 40 watt audio output transformer will provide an ample safety factor in the design of a cathode-modulated transmitter of the type described here. The modulation transformer should be connected to a center-tapped filament resistor, or to the center-tap of the filament winding of the transformer which delivers filament power to the modulated r.f. amplifier.

Raytheon RK-51 Characteristics

Filament voltage	7.5 volts
Filament current	3.75 amperes
Amplification factor	20
Grid-to-plate capacity	6 mmfd.
Grid-to-filament capacity	6 mmfd.
Plate-to-filament capacity	2.5 mmfd.
Maximum d.c. plate voltage	1500 volts
Maximum d.c. plate current	150 ma.
Maximum d.c. grid current	40 ma.
Normal plate dissipation	60 watts

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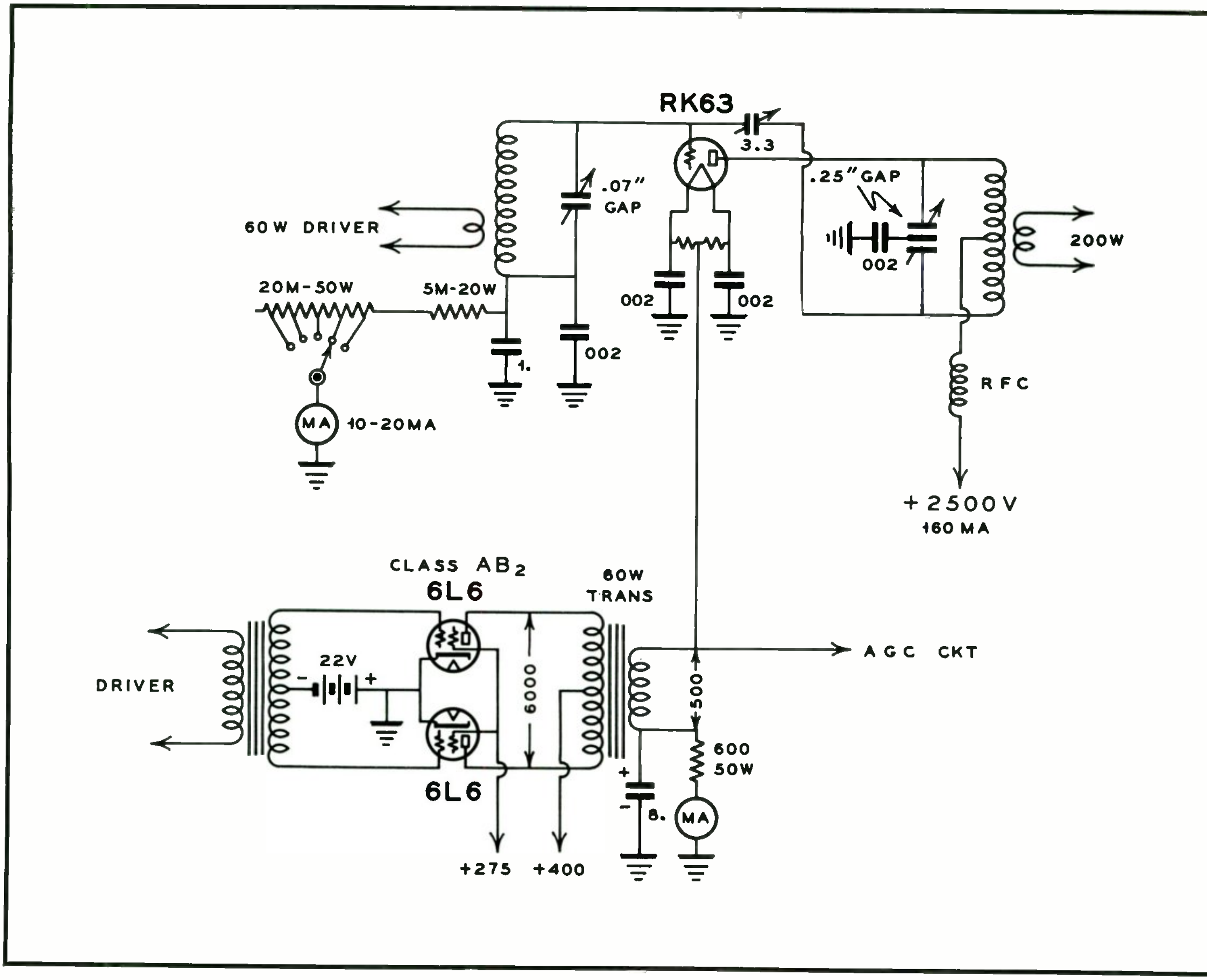

Raytheon RK-63 R.F. Amplifier—Modulated by Class-AB_2 6L6s

APPROXIMATELY 200 watts of carrier power output can be obtained from a Raytheon RK-63 triode, which has a plate dissipation rating of 200 watts. A combination of grid-leak and cathode-resistor-bias gives the desired grid-bias voltage. The actual r.f. grid drive will be between 25 and 40 watts, and the d.c. grid-bias voltage should be high enough to keep the d.c. grid current at some value between 10 and 20 ma. Both grid-bias circuits are by-passed for audio, and the audio-frequency power is applied across the 500 ohm impedance in the cathode circuit. A pair of 6L6 or 6L6G tubes in Class-AB_2 will deliver at least 40 watts of audio power for modulation. It is possible to obtain this amount of self-bias power from a 200 ohm cathode resistor in the 6L6 circuit, or a small 22.5 volt C-battery can be used for bias, as shown in the circuit diagram. The 6L6 stage can be driven by a 42 or 6F6, connected as a triode, and operated from a 275 volt power supply. The 60 watt type of output transformer, shown in the circuit diagram, is specified because it is a standard size produced by several transformer manufacturers. A doubler with an RK-37 tube, or even an RK-39 buffer, may be used to drive the grid circuit of the modulated r.f. amplifier.

Raytheon RK-63 Characteristics

Filament voltage	5 volts
Filament current	10 amperes
Amplification factor	37
Grid-to-plate capacity	3.3 mmfd.
Grid-to-filament capacity	2.7 mmfd.
Plate-to-filament capacity	1.1 mmfd.
Maximum d.c. plate voltage	3000 volts
Maximum d.c. plate current	250 ma.
Maximum d.c. grid current	60 ma.
Normal plate dissipation	200 watts

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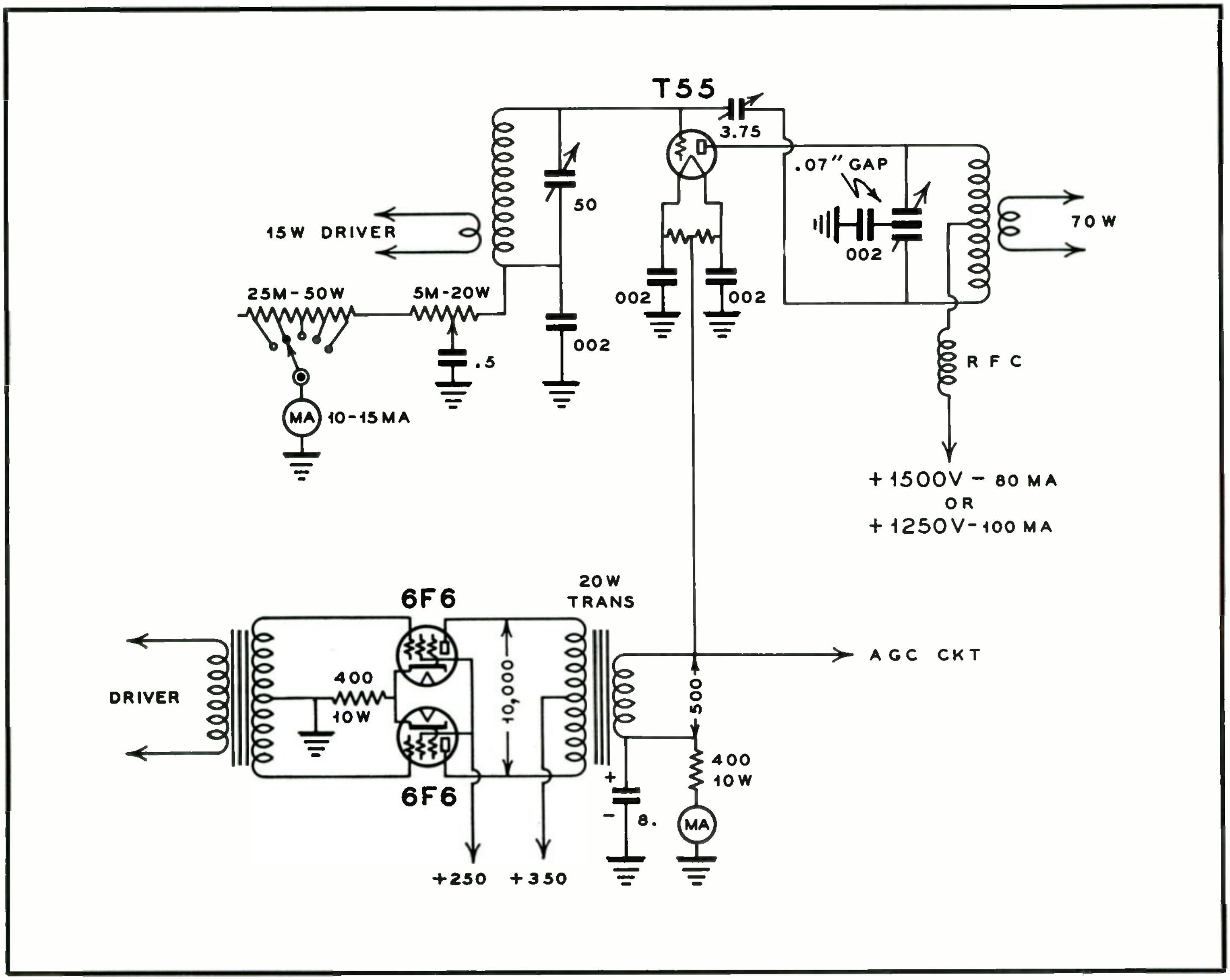

Taylor T-55 R.F. Amplifier—Modulated by 6F6 or 42 Pentodes

A single Taylor T-55 triode with a 1,500 volt, 80 ma., or 1,250 volt, 100 ma. plate supply, will deliver approximately 70 watts of carrier output. A single T-55 can be driven by a 6L6 exciter, capacitively- or link-coupled to the grid circuit of the amplifier. The 0.5 mfd. audio-frequency by-pass condenser in the grid-leak circuit can be connected to the 5,000 ohm grid-leak at a point where the best appearing oscilloscopic pattern is secured when testing for modulation. The oscillioscope should be connected with one set of its plates across the 500 ohm winding of the modulation transformer, and the other set of plates coupled to the center of the plate tank coil by means of a one- or two-turn r.f. pick-up coil. Proper location of the 0.5 mfd. condenser on the slider position of the 5,000 ohm grid-leak will tend to give a straight-sided trapezoid or triangular pattern on the oscilloscope when a steady tone input is used for testing the speech amplifier. Approximately 15 watts of audio power from a pair of 6F6 or 42 pentodes will fully modulate the single-ended T-55 amplifier. These audio tubes can be driven by a 6F6, triode connected, or by a pair of 6C5 tubes in push-pull. A push-pull T-55 r.f. amplifier will supply approximately twice as much output as a single-ended amplifier, but will require a larger modulator, such as a pair of 6L6 tubes. The amplifier shown in the circuit diagram operates with an input of approximately 125 watts.

Taylor T-55 Characteristics

Filament voltage	7.5 volts
Filament current	3 amperes
Amplification factor	20
Grid-to-plate capacity	3.75 mmfd.
Grid-to-filament capacity	4 mmfd.
Plate-to-filament capacity	1.5 mmfd.
Maximum d.c. plate voltage	1500 volts
Maximum d.c. plate current	150 ma.
Maximum d.c. grid current	40 ma.
Normal plate dissipation	55 watts

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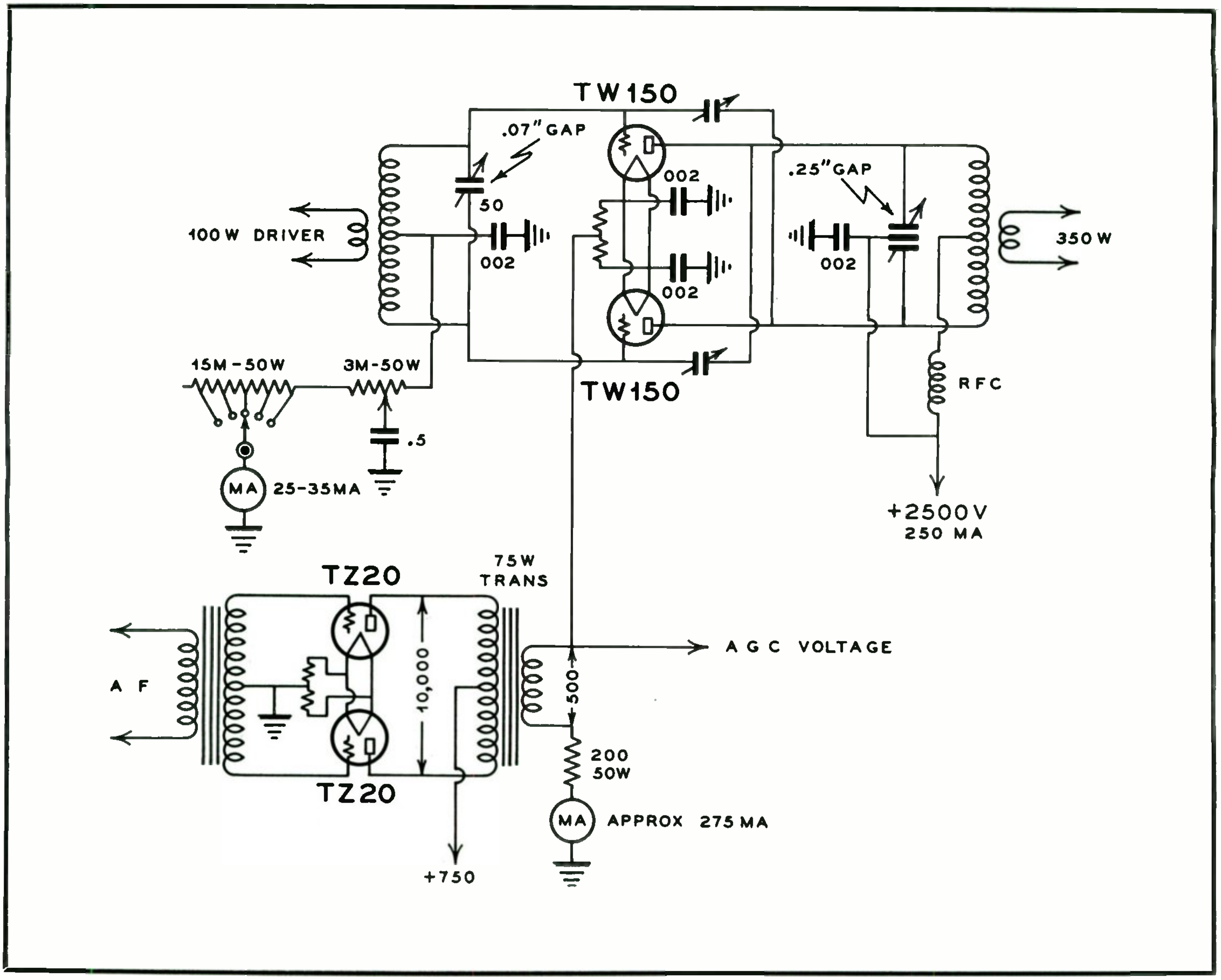

Taylor TW-150 R.F. Amplifier—Modulated by TZ20s in Class-B

A pair of the new Taylor TW-150 thin-wall carbon-plate triodes, and a 2,500 volt power supply, will deliver as much as 350 watts of output—with approximately 600 watts of input. From 2,500 to 3,000 volts plate supply is desirable, because these tubes are of the high mu construction, which requires high plate voltage in order to obtain maximum output from the least amount of plate modulation in a cathode-modulated circuit. This type of r.f. amplifier can be driven by any r.f. stage capable of handling up to 100 watts input as a buffer or doubler. The actual grid excitation is approximately 25 or 30 watts. A 3,000 ohm resistor in the grid-bias circuit will provide a means for a high degree of modulation linearity. The audio-frequency by-pass condenser, connected to the slider tap on this resistor, can be set to the correct point by means of a trapezoidal oscilloscopic measurement of modulation linearity. The r.f. amplifier requires a modulator capable of supplying at least 60 watts of audio power. A pair of Taylor TZ-20 tubes in a Class-B amplifier will deliver this amount of power into a 500 ohm load. Any low-impedance Class-B driver which will supply an audio power of approximately 5 watts can be used to drive the modulator.

Taylor TW-150 Characteristics

Filament voltage	10 volts
Filament current	4.1 amperes
Amplification factor	35
Grid-to-plate capacity	2.3 mmfd.
Grid-to-filament capacity	4.4 mmfd.
Plate-to-filament capacity	0.5 mmfd.
Maximum d.c. plate voltage	3000 volts
Maximum d.c. plate current	200 ma.
Maximum d.c. grid current	60 ma.
Normal plate dissipation	150 watts

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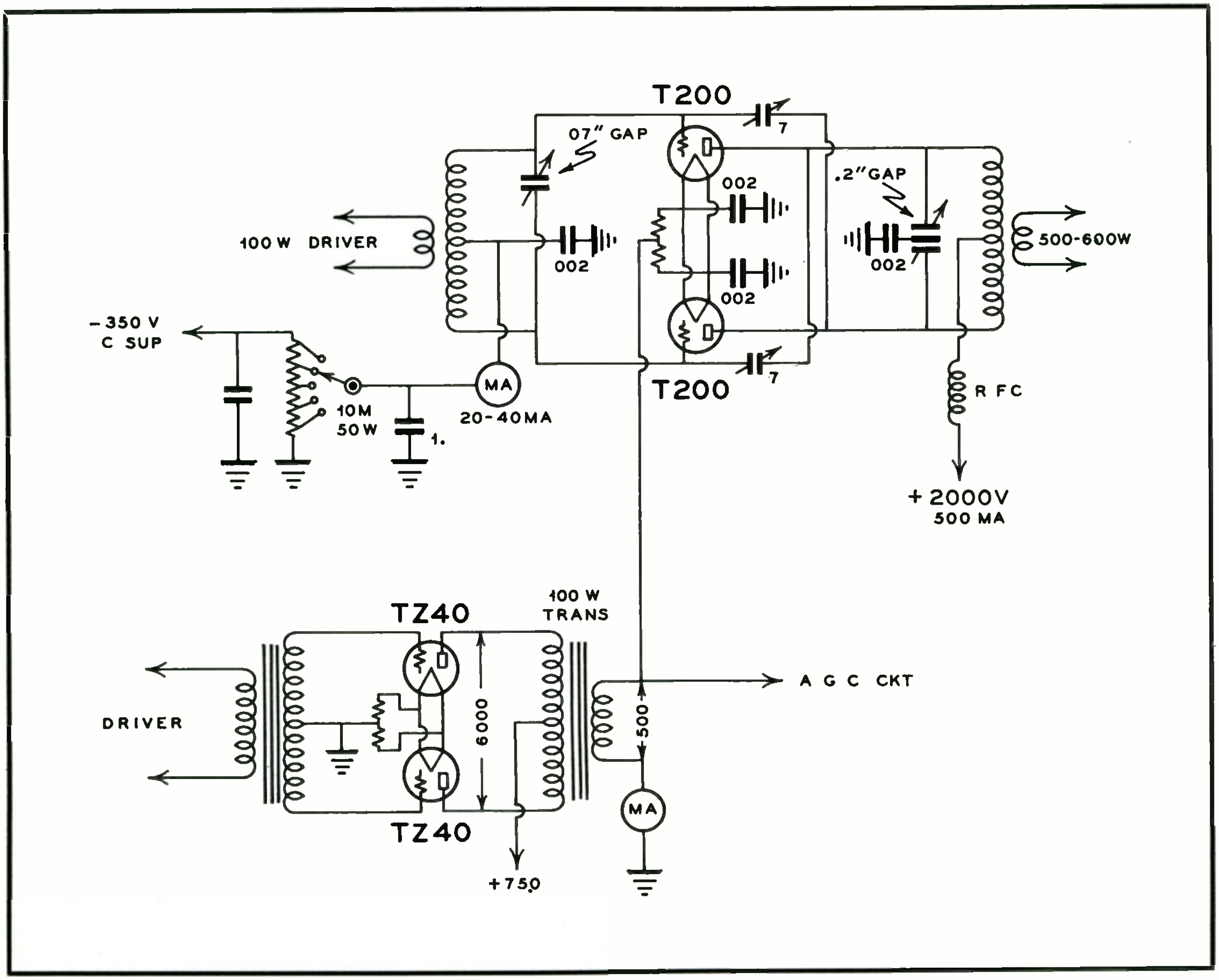

Taylor T-200 Push-Pull R.F. Amplifier—Modulated by TZ-40 or TZ-20 Tubes

A high power radiotelephone transmitter with an input of 1-kw can be built with a pair of Taylor T-200 tubes in the Class-C modulated r.f. amplifier. Approximately 100 watts of audio power from a pair of Taylor TZ-40 (or TZ-20) tubes will produce 100 percent modulation with 1-kw plate input to the cathode-modulated amplifier. A 2,000 volt, 500 ma. plate supply can be used for T-200 tubes, and a carrier output of from 500 to 600 watts will be obtained. Fixed C-bias from a well-filtered C-bias supply, having a maximum d.c. potential of 350 volts, will provide the most satisfactory form of C-bias for this type of amplifier. A TZ-40 with 1,000 volts plate supply will drive the grid circuit of the T-200 r.f. amplifier. The circuit diagram shows TZ-40 tubes in the modulator, in preference to TZ-20s, because of the ease with which 100 watts of audio can be obtained with a 750 volt power supply. Larger tubes are more effective at this value of plate voltage when working into a 500 ohm load than would be the case if the smaller type TZ-20 tubes were used in Class-B. A pair of 45 tubes in push-pull, or a single 6L6G with inverse feed-back, can be used for the audio-frequency driver stage. An automatic gain control system should be applied to the speech amplifier for this type of transmitter, as is likewise desirable for any type of modulated transmitter, in order to prevent overmodulation.

Taylor T-200 Characteristics

Filament voltage	10 volts
Filament current	5.75 amperes
Amplification factor	16.6
Grid-to-plate capacity	7 mmfd
Grid-to-filament capacity	5 mmfd.
Plate-to-filament capacity	3 mmfd.
Maximum d.c. plate voltage	2500 volts
Maximum d.c. plate current	350 ma.
Maximum d.c. grid current	80 ma.
Normal plate dissipation	200 watts

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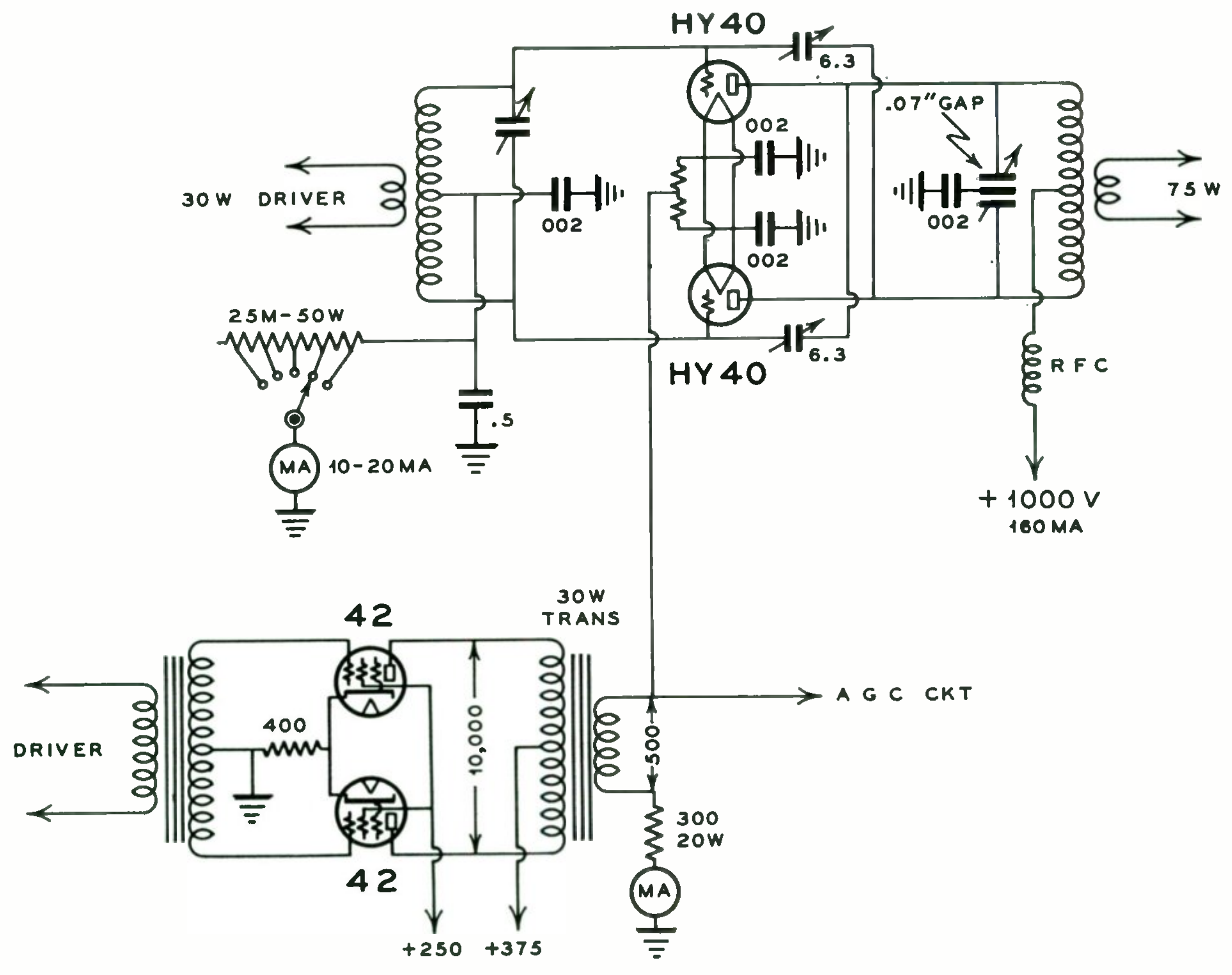

Hytron HY-40 Triodes—Modulated by a 15-Watt Class-B Amplifier

A very economical cathode-modulated transmitter with 75 watts of carrier output can be built around the Hytron HY-40 triodes. A 6L6 oscillator and doubler will drive the grid circuit of the r.f. amplifier. The plate supply should deliver approximately 1,000 volts, if maximum output from the r.f. tubes is desired. A combination of cathode-bias and grid-leak bias furnishes the d.c. grid-bias for the modulated amplifier. The audio-frequency power required for complete modulation is approximately 15 watts into a 500 ohm load. A pair of 42 or 6F6 tubes in Class-AB will deliver this required amount of power when the plate-to-plate load impedance is 10,000 ohms. A standard 30 watt output transformer for connection to a 500 ohm line or load is suitable for the modulation transformer. The modulator can be driven by a single 42 tube, connected as a triode, and with a plate supply of 250 volts. The ½-mfd. condenser in the grid circuit of the r.f. amplifier is by-passed with a .002 mfd. small mica condenser in order to provide an effective r.f. path for the grid return circuit. If it were possible to perfectly balance the r.f. amplifier, the r.f. by-pass condensers in the grid and filament circuits would not be required.

Hytron HY-40 Characteristics

Filament voltage	7.5 volts
Filament current	2.25 amperes
Amplification factor	25
Grid-to-plate capacity	6.3 mmfd.
Grid-to-filament capacity	5.8 mmfd.
Plate-to-filament capacity	1.8 mmfd.
Maximum d.c. plate voltage	1000 volts
Maximum d.c. plate current	115 ma.
Maximum d.c. grid current	25 ma.
Normal plate dissipation	40 watts

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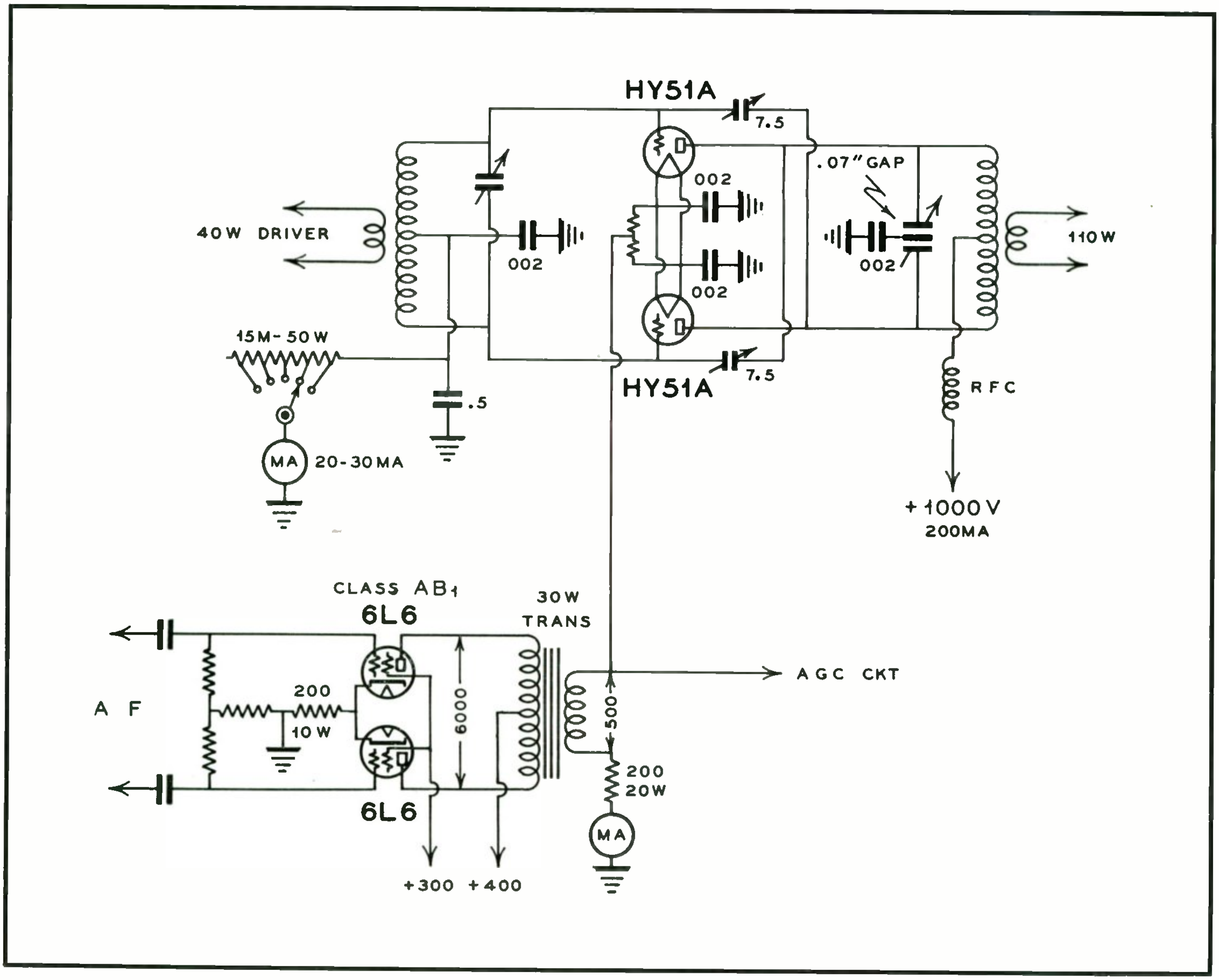

Hytron HY-51A R.F.Amplifier—Modulated by 6L6s in Class-AB1

A 200 watt cathode-modulated amplifier can be designed with HY-51A tubes in a conventional push-pull circuit. At least 100 watts of carrier output can be obtained if the plate supply is rated at 1,000 volts, 200 ma. The HY-51A tubes can be driven by an exciter which will deliver approximately 40 watts input to the plate of the driver tube. The actual grid-circuit driving power will vary from 10 to 20 watts over the amateur bands. Somewhat more power is needed for the 10 and 20 meter bands, due to increased circuit and tube losses at these frequencies. Grid-bias is obtained from a combination of variable grid-leak and cathode-resistor voltage drop. A 0.5 mfd. condenser bypasses the grid-leak for audio frequencies. Approximately 20 watts of audio power into a 500 ohm load impedance will produce complete modulation of the r.f. amplifier. A pair of 6L6 tubes in Class-AB_1 will supply sufficient output; these modulator tubes can be driven by a 6N7 phase-inverter. For this purpose, one grid of the 6N7 would be connected back to the mid-point of the two grid resistors in the 6L6 circuit and the grid of the other 6N7 triode is driven by a preceding speech amplifier stage. The 6L6 grid-leaks can be ¼- or ½-watt carbon resistors; the mid-point connection is through a 100,000 ohm resistor to ground.

Hytron HY-51A Characteristics

Filament voltage	7.5 volts
Filament current	3.5 amperes
Amplification factor	25
Grid-to-plate capacity	7.5 mmfd.
Grid-to-filament capacity	6 mmfd.
Plate-to-filament capacity	2 mmfd.
Maximum d.c. plate voltage	1000 volts
Maximum d.c. plate current	175 ma.
Maximum d.c. grid current	25 ma.
Normal plate dissipation	65 watts

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Part III

Construction of Cathode-Modulated Radiotelephone Transmitters

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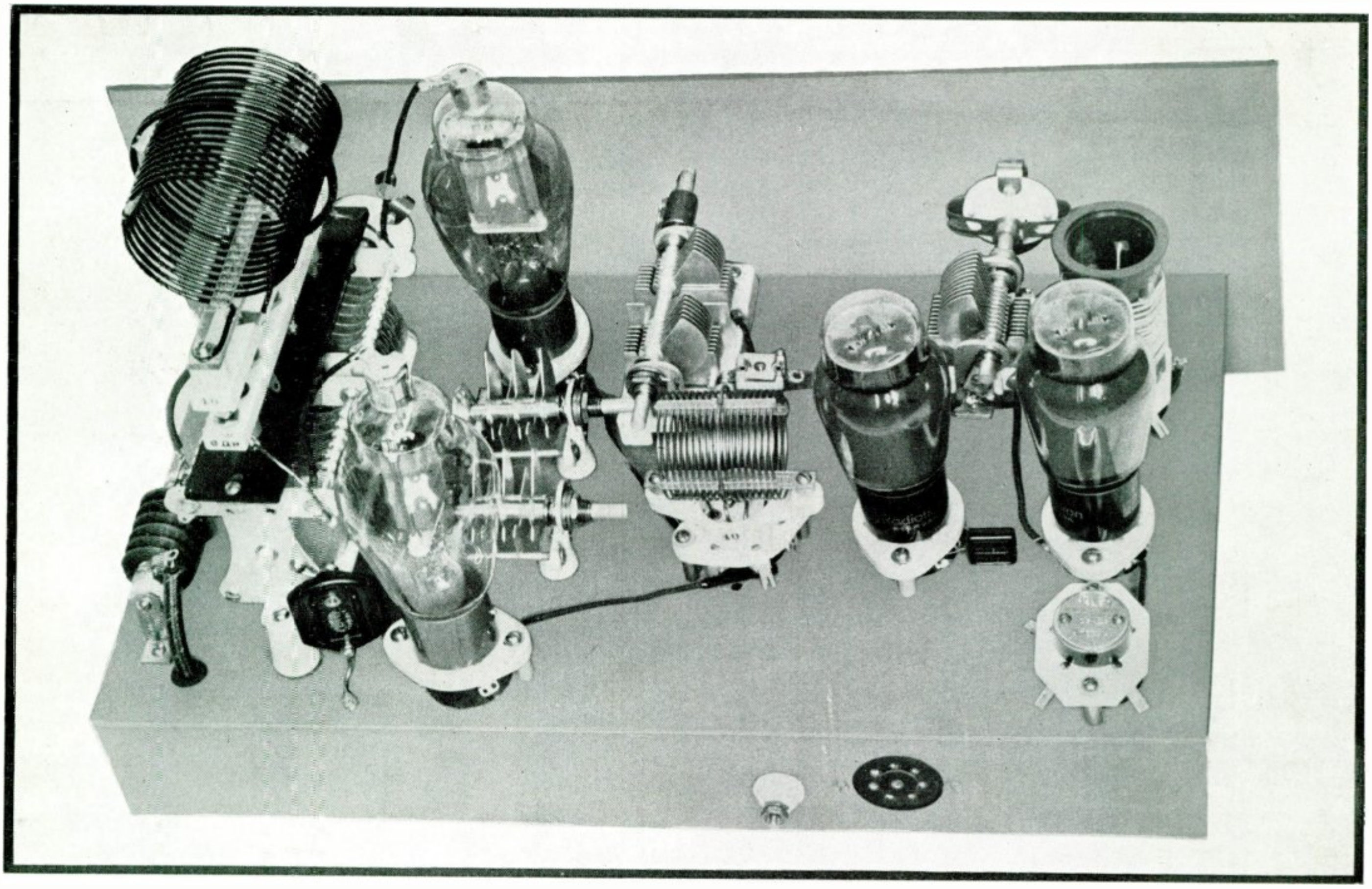

■ Built on three small steel chasses, one for the oscillator, buffer-doubler and final r.f. amplifier stages, another for the modulator units, and only one chassis for the power supply components, this cathode-modulator transmitter is one of the smallest and most inexpensive radiotelephones ever designed for 200 watts input. High power output is made possible by the new 50-watt RCA-812 triodes, which resemble the RCA-809 in size and shape. Note the small size of the final plate tuning condenser for 10, 20 and 40 meter operation. This condenser is a standard Bud Radio item. Bud air spaced plug-in coils are used throughout the entire transmitter, excepting in the oscillator stage. Coil winding data for the oscillator coil is the same as that for other transmitters described in this Chapter.

The New RCA-812 50-Watt Triodes in a 200-Watt Cathode Modulated-Transmitter

A complete transmitter with the new *RCA-812* triodes in the final amplifier is illustrated in the accompanying photographs. These new tubes have a 6.3 volt, 4 amp. filament; the grid-to-plate capacity is 5.3 mmfd., the plate dissipation rating is 50 watts. The input to the final amplifier will run between 200 and 235 watts, with a carrier output of from 125 to 150 watts. The grid circuit of the push-pull amplifier is driven by a 6L6 neutralized amplifier or doubler which, in turn, is driven by a conventional 6L6G crystal oscillator. Provision is made for control of r.f. grid excitation in the final r.f. amplifier and d.c. grid-bias by means of two 6-point *Yaxley* tap switches. Two 25,000 ohm, 50 watt resistors connect to these switches, one of which serves as a variable grid-leak, the other as a voltage divider for varying the d.c. screen voltage of the 6L6G buffer stage. The r.f. output of this stage is controlled by variation of the screen voltage, thereby controlling the grid excitation of the final amplifier.

Bud Radio plug-in coils are used in the buffer and final amplifier stages, and they can also be used in the crystal oscillator.

The transmitter was designed primarily for operation in the 10, 20 and 40 meter bands, but it can also be used for 75 and 160 meters by substituting larger grid and plate tuning condensers. The final grid leads are tapped to the buffer coil at points two-thirds of the way upward from the center-tap.

Audio Amplifier

A speech amplifier for modulating this transmitter consists of a pair of 6L6G tubes, resistance-coupled to a 6N7 phase inverter. The details of the construction and operation of this speech amplifier are similar to those described for other transmitters in this Chapter.

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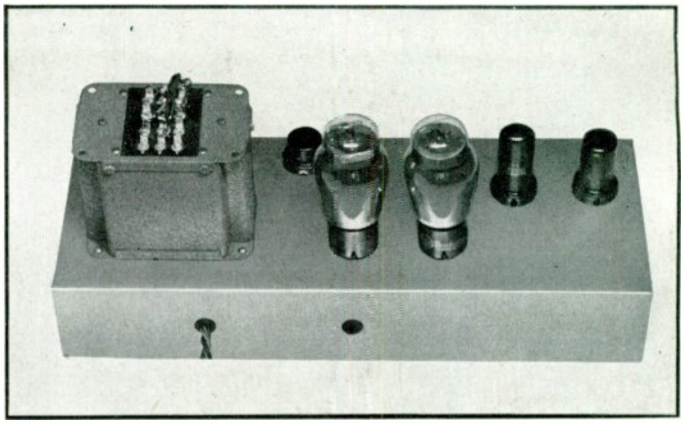
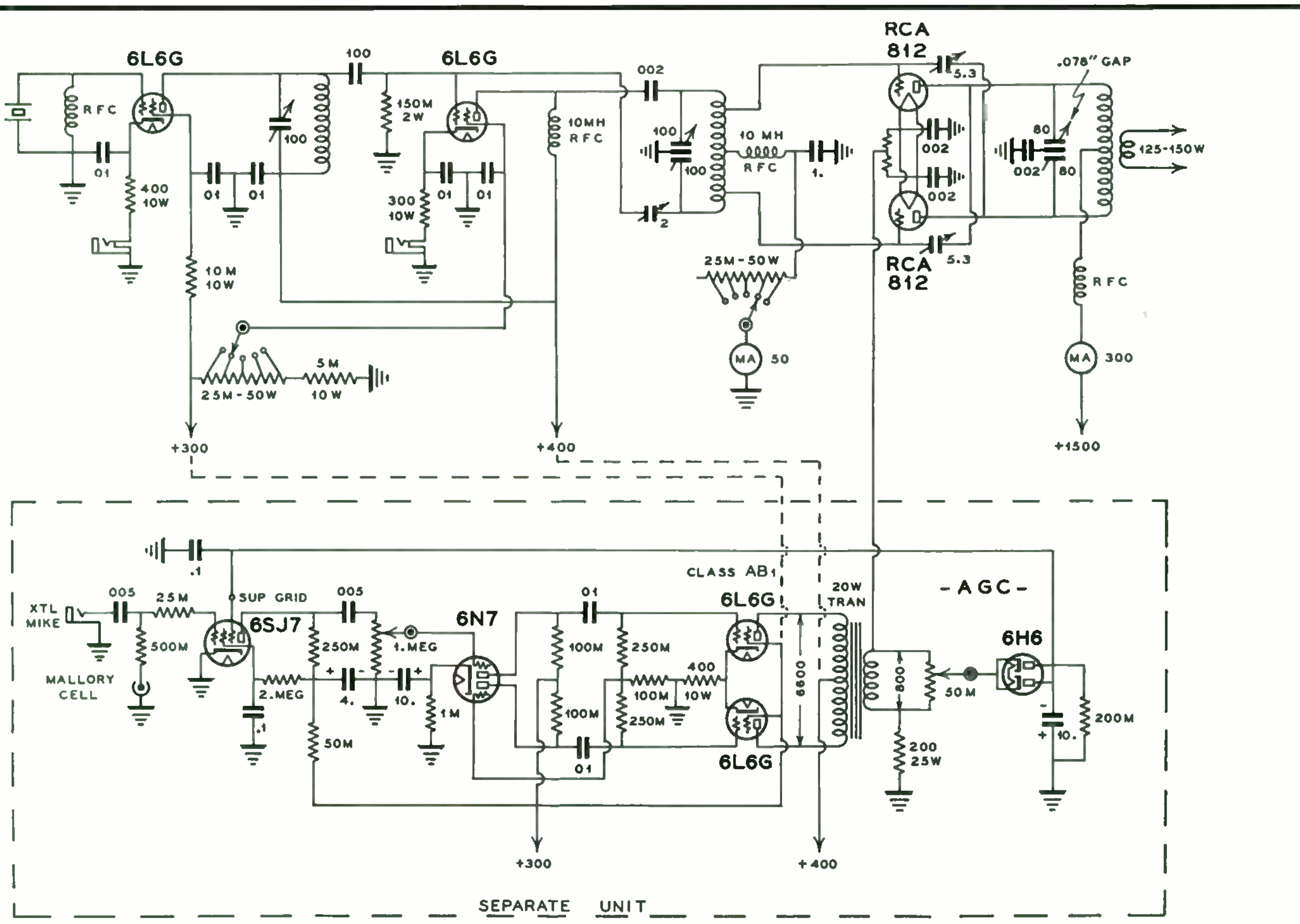
RCA-812 Characteristics

Filament Voltage	6.3 volts
Filament Current	4 amps.
Amplification Factor	29
Grid-to-Plate Capacity	5.3 mmfd.
Grid-to-Filament Capacity	5.3 mmfd.
Plate-to-Filament Capacity	0.8 mmfd.
Base	Med. 4-pin Micanol
Max. D.C. Plate Voltage	1,500 volts
Max. D.C. Plate Current	150 ma.
Max. Plate Dissipation	55 watts
Max. D.C. Grid Current	35 ma.

THE adjustments for proper operation of this transmitter are the same as for any other cathode-modulated transmitter described in this Chapter. The only precautions are the correct setting of the buffer-doubler screen voltage and proper value of d.c. grid bias for the final r.f. amplifier. The antenna coupling is conventional.



■ The speech amplifier and modulator, with small modulation transformer. A standard 20-watt UTC modulation transformer of either the "S" or "CM" series is suitable for this unit; the new UTC type CM16 is preferable. The audio channel has an automatic gain control circuit, shown in the diagram below.



CIRCUIT DIAGRAM OF RCA-812 CATHODE-MODULATED TRANSMITTER

■ The r.f. section is conventional in every respect, except for the manner in which grid bias adjustments are made. Ohmite "Multivolt" tapped resistors, 25,000 ohms, 50 watts each, are required for the buffer-doubler and final r.f. grid circuits, as shown. The taps on these resistors are connected to Yaxley multi-point rotary switches, mounted on the front panel of the r.f. deck. Adjustment of resistor values for proper operation of a cathode-modulated transmitter is fully treated elsewhere.

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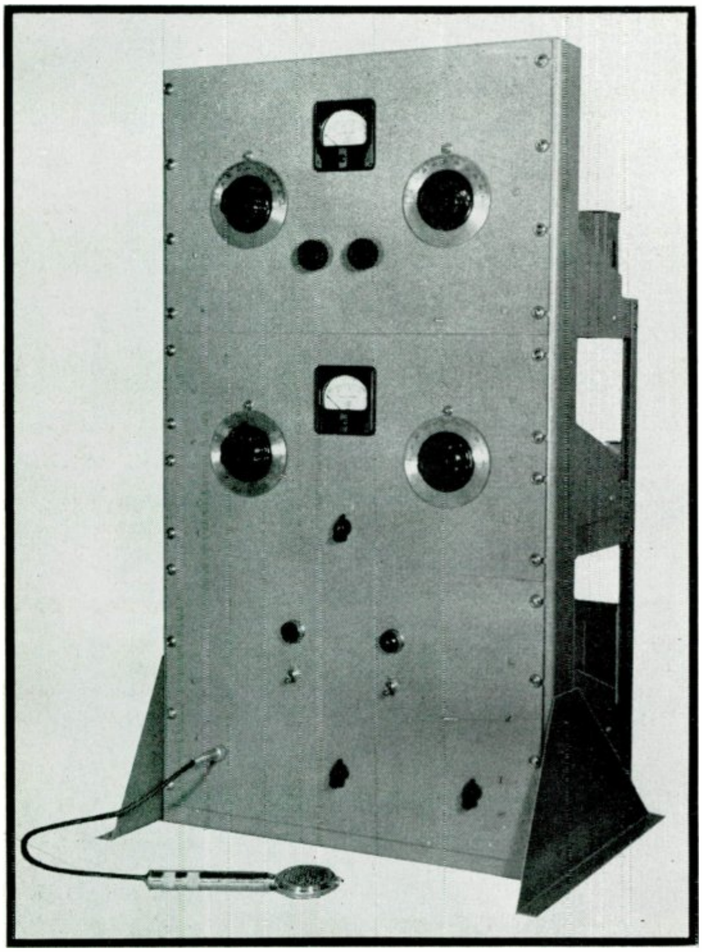
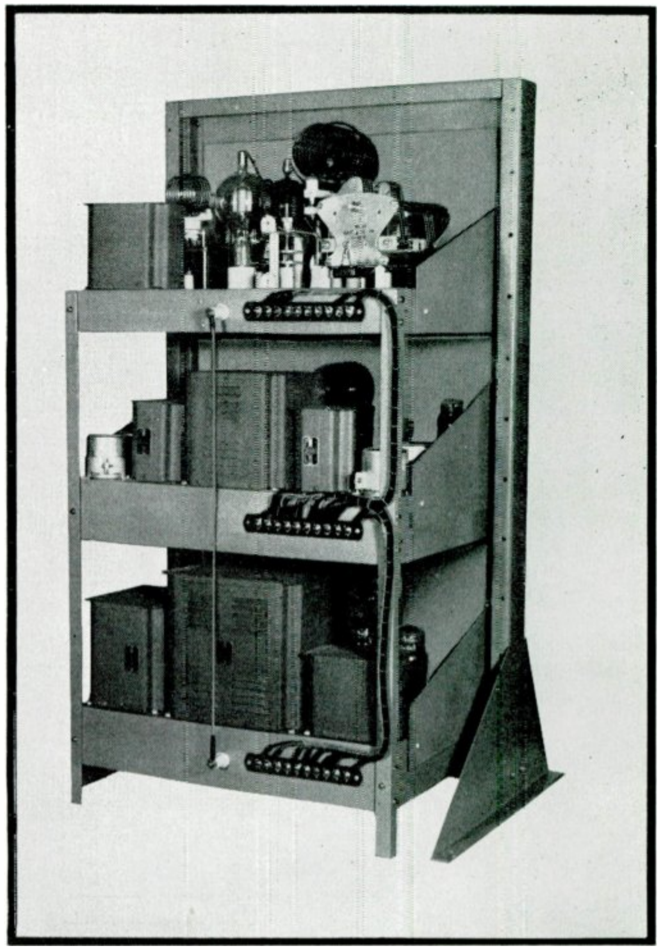


■ Front view, showing variable grid-bias controls on upper panel. The meter switch is on the center panel, and pilot lights, on-off switches ana audio controls are on the lower panel.



■ Rear view of 75T transmitter. Symmetrical layout and placement of parts contribute to professional appearance. The oscillator and buffer-doubler stages are on the middle deck.

350-Watt Cathode-Modulated Transmitter with Eimac 75T Push-Pull R. F. Amplifier

THE simplicity and compactness of a cathode-modulated radiotelephone transmitter of intermediate power is clearly shown in the illustrations which accompany this text. The power input of this transmitter is 350 watts, conservatively rated, and the carrier output is more than 200 watts from a pair of Eimac 75T triodes in the push-pull r.f. amplifier. The entire transmitter is mounted on a 3-foot relay rack. The photographs show the small physical size of the modulation transformer, speech amplifier and 6L6G modulator stage. Contrast these with a plate-modulated transmitter of comparable power output, and it will be evident why cathode modulation has such wide appeal for amateur and commercial service. Small tuning condensers in the plate circuit of the final amplifier enable the use of a small chassis, resulting in a more compact transmitter, plus a substantial overall reduction in cost.

A GLANCE at the schematic circuit diagram shows that a 6V6 beam tetrode serves in the crystal oscillator portion of the transmitter. This oscillator delivers output on 160, 80, 40 and 20 meters by means of a single tuning condenser and only one plate coil. The circuit operates as a modified untuned *Pierce Oscillator* for 80 and 160 meters, with no switching of circuits, other than the short-circuiting of the plate tuning condenser. This tuning condenser is short-circuited by bending the edges of two adjacent stator plates in such a manner that they short-circuit the rotor and stator when the condenser is turned to its setting of maximum capacity. For operation in the 160 and 80 meter bands, crystals of these same frequencies should be used. For operation in the higher frequency bands, 20, 40 and 80 meter crystals are suitable, although it is possible to use an 80 meter crystal even when the transmitter operates in the 10 meter band. The crystal

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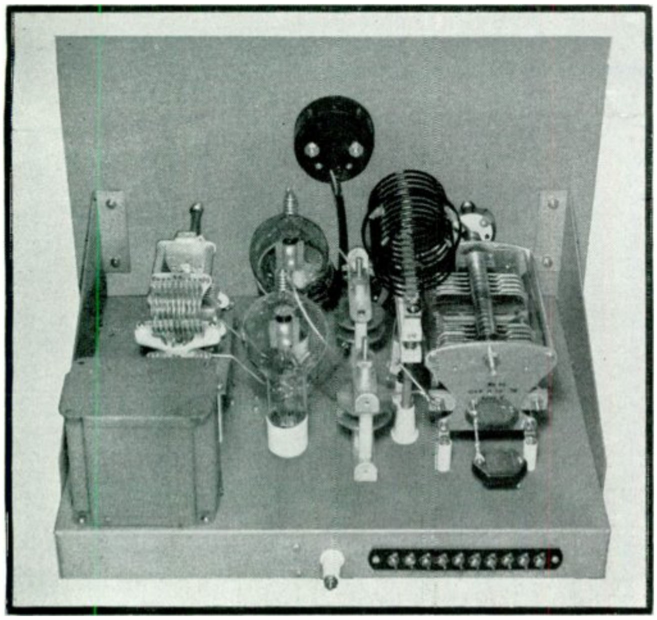
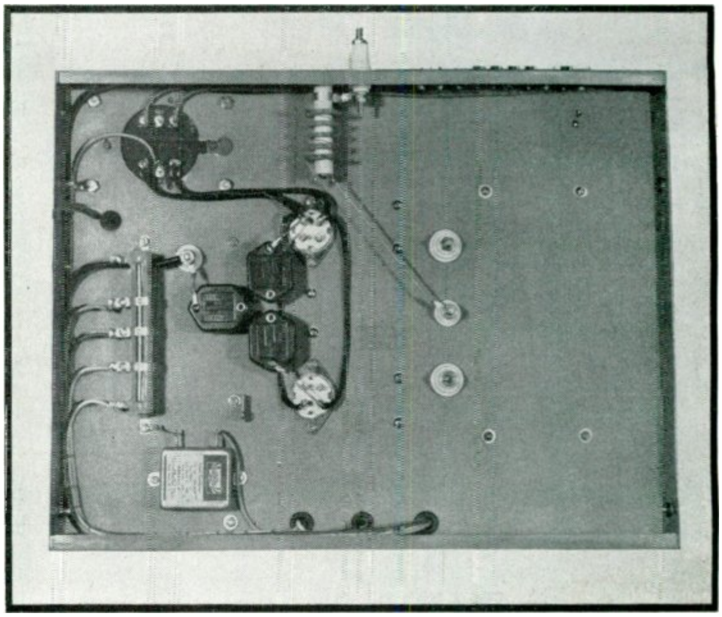


▪ Final amplifier deck, including tuned grid circuit and filament transformer for the 75Ts. BUD RADIO variable condensers, neutralizing condensers, and buffer circuit components are clearly shown.



▪ Under-chassis view of the final amplifier deck, showing placement of r.f. choke, by-pass condensers, resistor, and tube sockets. The parasitic suppressor is mounted above chassis, between the 75Ts.

oscillator functions on its harmonics when operating in the 40, 20 and 10 meter bands. Its plate circuit is tuned to either 20 or 40 meters by the 150-mmfd. plate tuning condenser. Regeneration in the oscillator circuit is controlled by a multi-plate mica trimmer condenser which has a maximum capacity of approximately .0005 mfd. This condenser is connected from ground to the plate and grid return circuits of the 6V6 tube; it is easily adjusted to a value that gives sufficient regeneration for output on 20 and 40 meters, at the same time allowing oscillation as an untuned *Pierce Oscillator* for 160 and 80 meter operation.

Buffer-Doubler Circuit

AN 807 serves as a buffer or doubler, with its plate circuit tuned to any band from 10 to 160 meters by means of plug-in coils. A similar set of plug-in coils in the grid circuit of the final amplifier is link-coupled to the 807 plate circuit.

Final R. F. Amplifier

TWO 75T triodes in push-pull, with cross neutralization, are used in the final r.f. amplifier, which is cathode-modulated. It was found necessary to insert a parasitic suppressor in the grid circuit of one of the 75T tubes in order to eliminate an ultra-high frequency tuned-grid-tuned-plate oscillation. Parasitic oscillations are common in a great number of Class-C amplifiers, both for phone or c.w. operation. The short grid leads, in this particular r.f. amplifier, resonated with the plate circuit leads and formed an ultra-high frequency oscillator circuit. This parasitic oscillation prevented normal operation of the amplifier and greatly reduced the r.f. output on the desired frequency. Furthermore, the plate dissipation was greatly increased. A simple parasitic suppressor consisting of a 300 ohm resistor, shunted by a coil of 8 turns of No. 14 wire, ½-inch diameter, space wound, completely eliminated this parasitic oscillation. The parasitic produced d.c. grid current in the final r.f. amplifier, even when the coupling link to the exciter was removed from the circuit. Under these conditions the d.c. grid current indicated oscillation, even though the amplifier was correctly neutralized for its normal frequency of operation. Modulated amplifiers should always be entirely free from parasitic oscillation, if good voice quality and high output are desired.

Plate Circuit

ONE of the advantages of cathode modulation is that the variable tuning condensers require only a small air-gap, no greater than for c.w. operation, and without danger of flash-over during peaks of modulation. The plate tuning condenser in this transmitter is a standard *Bud Radio* 70-mmfd. per section, 0.1-inch air-gap condenser, which has ample capacity for tuning the 10, 20 and 40 meter bands. It is desirable, however, to use a larger capacity for tuning the 75 and 160 meter bands, and this additional capacity can be secured by connecting a fixed air condenser in shunt with the variable tuning condenser. This fixed condenser should have an air-gap of .144-inch.

The filament transformer for the 75T tubes is mounted to one side of the final amplifier chassis in order to provide short connecting leads to the tube filaments. The under-chassis view of the amplifier shows the arrangement of by-pass condensers and other small components. The tapped 25,000-ohm 50-watt grid-leak resistor is also mounted under this same chassis, and the resistor taps are connected to a multi-point switch for variation of d.c. grid bias. A 5,000-ohm 20-watt wire-wound rheostat serves as part of the

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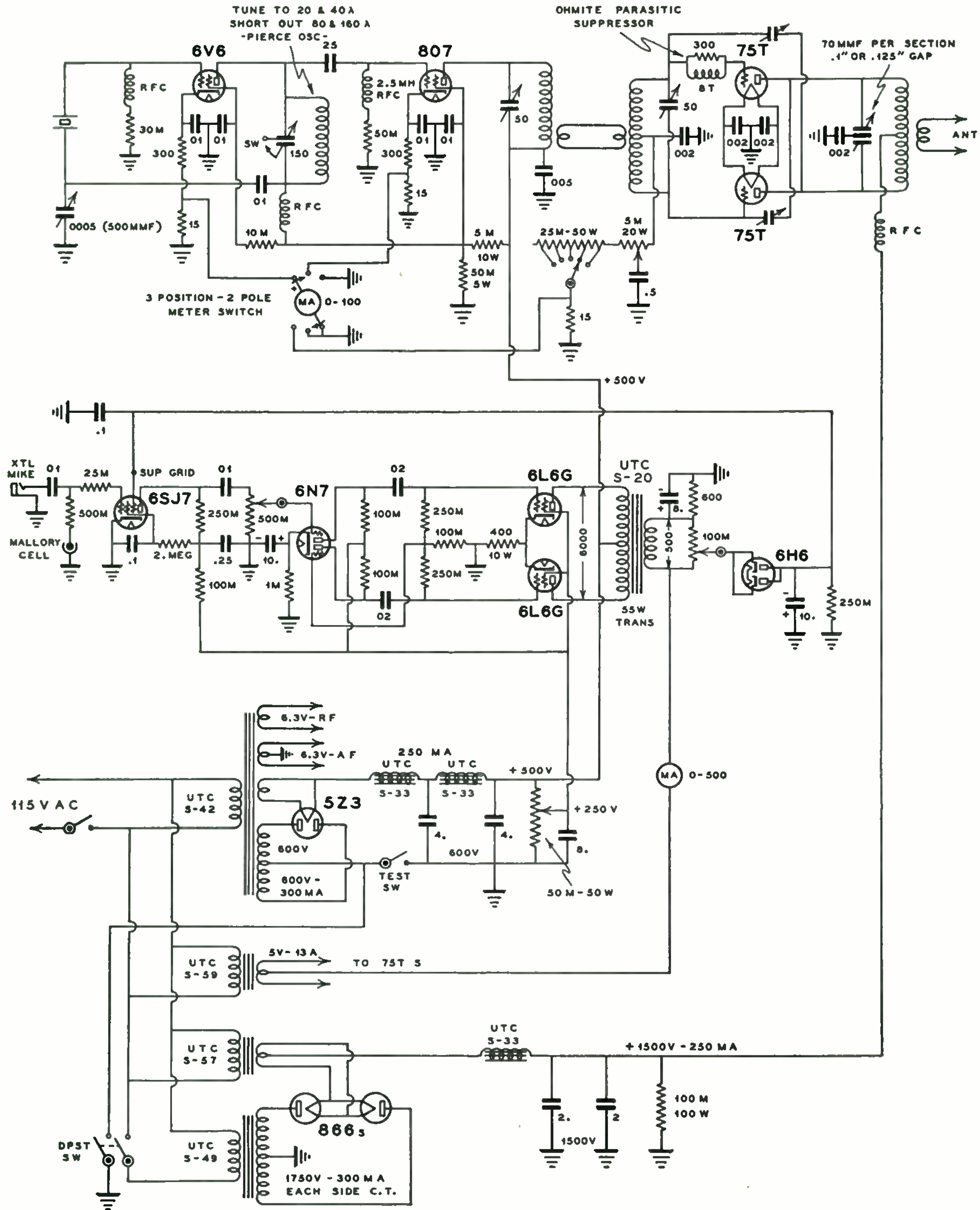

COMPLETE SCHEMATIC DIAGRAM FOR 350-WATT 75T TRANSMITTER

■ This circuit includes all of the latest improvements in radiotelephone transmitter design, such as an overmodulation and automatic gain control circuit, wide-range harmonic oscillator for all-band operation, YAXLEY meter switch—which reduces the number of meters required to two, and an audio amplifier which is capable of delivering excellent quality. The audio circuit also includes a 6N7 phase inverter. The modulation transformer can be either a UTC S20, or the new UTC CM-16, designed especially for cathode modulation. Standard BUD RADIO plug-in coils are used throughout the r.f. section. The final plate coil for 10 meters must have 6 turns of No. 10 wire, 2½-in.

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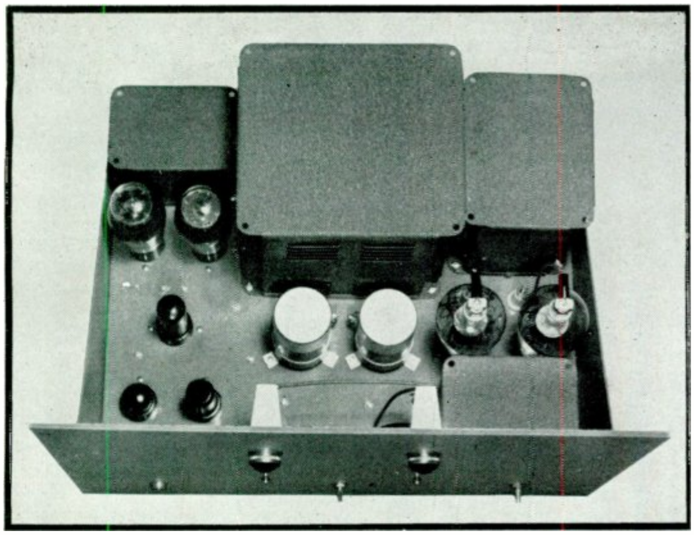
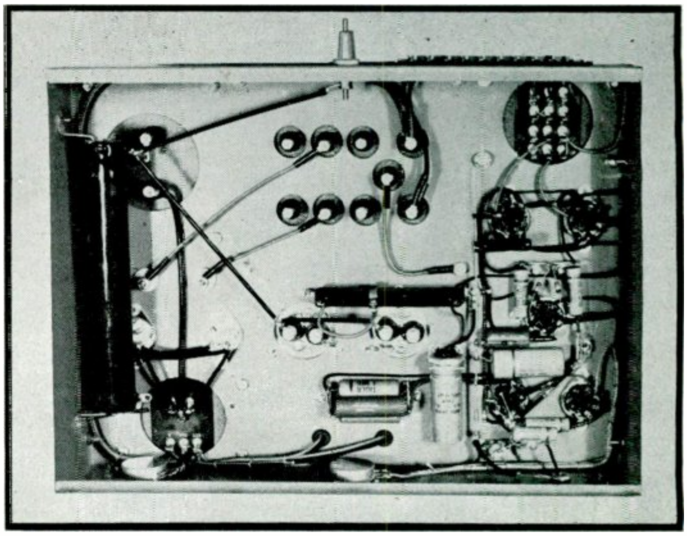


■ Top view of final power supply, showing UTC plate and filament transformers, rectifier tubes, small metal tubes for the audio amplifier, and, at the far left rear, the modulation transformer and a pair of 6L6G tubes.



■ The wiring for the high voltage and modulator deck is neat and symmetrical. High voltage leads are protected with heavy spaghetti sleeving, and the numerous small paper condensers are grouped neatly between tube sockets.

grid-leak, and the moving arm of this resistor is connected to a 0.5-mfd. by-pass condenser. The adjustment of this resistor varies the relative amount of grid modulation with respect to plate modulation, in the process of cathode modulation.

Audio Circuits

THIS transmitter was designed for connection to a crystal microphone. A high-gain 6SJ7 pentode is resistance-coupled to a 6N7 phase inverter. The suppressor-grid of the 6SJ7 is connected back to a 6H6 diode in an automatic gain control circuit which prevents overmodulation when excessive audio input is applied to the speech amplifier. The 6N7 twin-triode serves as a phase inverter in a stabilized type of circuit which employs inverse feed-back. This feed-back connection permits the use of fixed resistors, none of a critical value, and the stability of the phase inverter circuit is not affected when 6H6 tubes are replaced. The phase inverter drives a pair of 6L6G tubes in a push-pull amplifier circuit, operated in Class-AB_1. Less than 35 watts of audio power is required to completely modulate the final r.f. amplifier. This amount of power can be obtained easily from a pair of 6L6G tubes, operated from a 500 volt plate supply, and approximately 250 volts in the screen circuit. The value of the cathode resistor in the 6L6G stage must be higher than normal because of the high plate voltage. The circuit constants for this stage are such that operation from a 500 volt plate supply will not materially shorten the life of the 6L6G tubes.

Modulator Circuit

THE modulation transformer is a *U.T.C.* Type S-20, rated at 55 watts, and connected in such a manner that its windings provide a 6,000 ohm primary for a 500 ohm secondary load. A 100,000 ohm potentiometer, connected across the 500 ohm winding of this transformer, serves as an AGC (automatic gain control) adjustment. The d.c. voltage drop across the 600 ohm cathode resistor provides a fixed bias to the final amplifier, as well as a delay bias to the AGC circuit. Adjustment of the 100,000 ohm potentiometer permits the operator to set the AGC circuit to the desired point which prevents overmodulation. This adjustment can be checked with the aid of an overmodulation indicator or oscilloscope. The audio-frequency in the plate circuit of the AGC diode is by-passed to ground with a 10-mfd. 100 volt electrolytic condenser; audio-frequency feed-back into the suppressor-grid circuit of the 6SJ7 is thereby eliminated. The 600 ohm cathode resistor in the 75T circuit is by-passed for audio frequencies with an 8-mfd. electrolytic condenser. The d.c. voltage developed across this resistor, due to the cathode current of the final r.f. amplifier, is used to furnish a portion of the d.c. grid bias to the amplifier. It is necessary to use a combination of grid-leak and fixed grid-bias in order to obtain linearity of modulation. A correct balance of these two forms of grid-bias will permit full modulation without appreciable flicker in plate current of the final amplifier. Fixed bias can be obtained from either a cathode resistor or C-bias supply.

Power Supplies

TWO power supplies are required for this transmitter, one for the combination of 500 volts and 275 volts for the exciter and speech amplifier, the other a 1,500 volt 300 ma. supply for the final r.f. amplifier. The low voltage power supply has a 1,200 volt center-tapped transformer, rated to carry a 300 ma. load. The actual d.c. load current is less than 250 ma. This low voltage power supply is placed directly behind the r.f. exciter. The high voltage supply, with its filter choke and condensers, is mounted on the lower deck and the entire audio channel is at one side of this chassis. The speech amplifier is also built on this same chassis, because resistance coupling is used throughout. Metal tubes in the speech amplifier are a distinct aid for preventing 60-cycle a.c. and r.f. feed-back from getting into other portions of the transmitter. The photographs of the individual chasses illustrate a neat arrangement of wiring and placement of parts.

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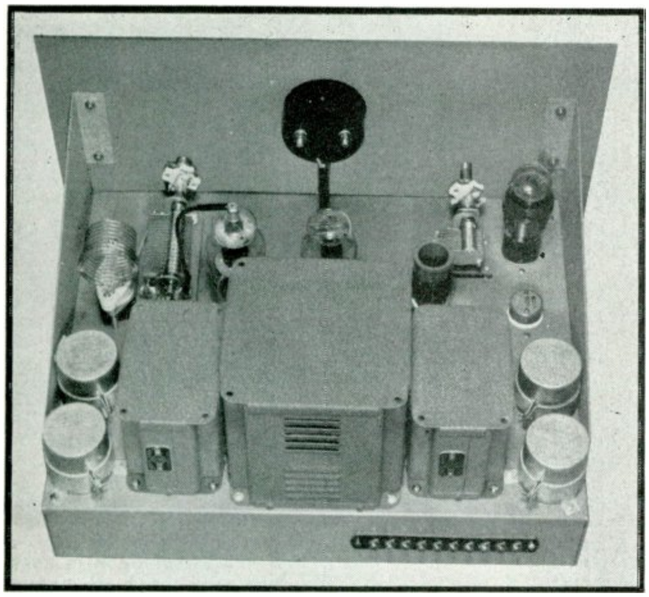
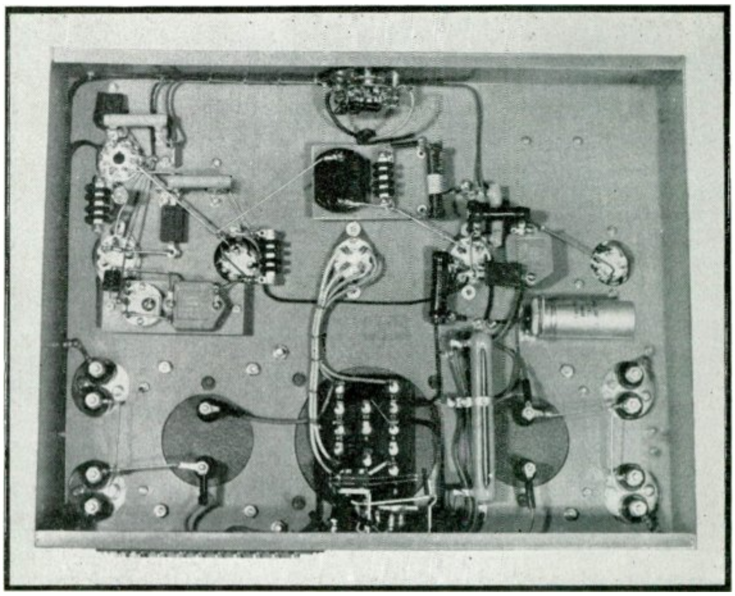


■ The middle deck holds the oscillator, buffer-doubler, low voltage power transformer, chokes and filter condensers. The Bliley crystal and its mounting socket are at the far right. With 40-meter crystals in use, the oscillator coil has 10 turns, No. 20 enameled wire, space-would to cover a winding length of 1-inch, on a 1¼-inch dia. form. Standard plug-in coils used throughout.



■ Neat workmanship characterizes the under-chassis arrangement of parts and wiring. The variable trimmer condenser (YAXLEY) for the oscillator, and small by-pass condensers for the same circuit, are mounted on bakelite sub-panels. The YAXLEY meter switch is seen at the top center portion of the photograph. All resistors on this chassis are by Ohmite.

Adjustments and Operation

FOR operation in the 80 and 160 meter bands, the plate tuning condenser of the crystal oscillator should be rotated to the position where the condenser plates are short-circuited. The plate circuit of the 807 stage should then be tuned for maximum dip, and the grid circuit of the final amplifier tuned for maximum grid current. A one-turn link is usually satisfactory for all bands of operation. If there is too much excitation in the final r.f. grid circuit, it will not be possible to obtain 100 percent modulation. The regeneration condenser in the oscillator circuit should be set to as high a value of capacity as will permit oscillation with 80 and 160 meter crystals in this type of *Pierce Oscillator* circuit. The reading of final amplifier grid current is an aid to determine the correct setting of the oscillator regeneration condenser. The adjustment of this condenser is made with a screwdriver, since the condenser is placed near the crystal oscillator plate coil. The final amplifier should be neutralized in the 10 and 20 meter bands because the point of exact neutralization is more easily determined in these high-frequency bands. When tuning the final amplifier, the antenna coupling should be sufficient to provide a cathode current of from 200 to 250 ma. when the d.c. grid current is from 5 to 10 ma. This grid current can be reduced to between 5 and 10 ma. by means of the tap switch that connects to the grid-leak. If this current cannot be reduced to some value below 5 ma., it is an indication that there is too much link coupling between the 807 plate circuit and the grid of the final r.f. amplifier.

It is possible to increase the r.f. current of the final amplifier, if desired, and still obtain modulation above 90 percent. The actual audio-frequency power required for full modulation is approximately 1/20th of the d.c. power input to the r.f. amplifier. Excess audio power can be used to advantage by increasing the secondary load impedance of the modulation transformer winding, and at the same time reducing the degree of grid modulation by changing the location of the point where the 0.5 mfd. audio by-pass condenser connects to the 5,000 ohm grid-leak. The condenser should be moved toward the side which connects to the 25,000 ohm grid-leak. An oscilloscope or diode overmodulation indicator should be available for preliminary tests and occasional checking of the transmitter.

Miscellaneous

A 0-500 ma. d.c. milliammeter is connected permanently in the cathode circuit of the final r.f. amplifier, and another meter, 0-100 ma., is connected to a 3-point switch, as shown in the circuit diagram. The points on this switch are shunted with 15 ohm ½-watt resistors in order to complete the cathode and grid circuits to ground when the meter is switched from one point to another. The 0-100 ma. meter reads cathode current in the oscillator and 807 stages, and grid current in the final r.f. amplifier stage. The oscillator cathode current will vary between 15 and 30 ma. for the several bands of operation. Similarly, the 807 cathode current will vary from approximately 50 to 80 ma. Resistors in the speech amplifier circuit are rated at ½-watt throughout, except those indicated otherwise in the circuit diagram.

Mechanical Design

THE complete transmitter is built on three separate steel chasses, each 13 x 17 x 2 inches. The front panels for the final r.f. amplifier and the high voltage deck are 12¼ x 19 inches. The center panel is 10½ x 19 inches. Panels and chasses are finished in gray lacquer, which gives the transmitter a dignified, commercial appearance.

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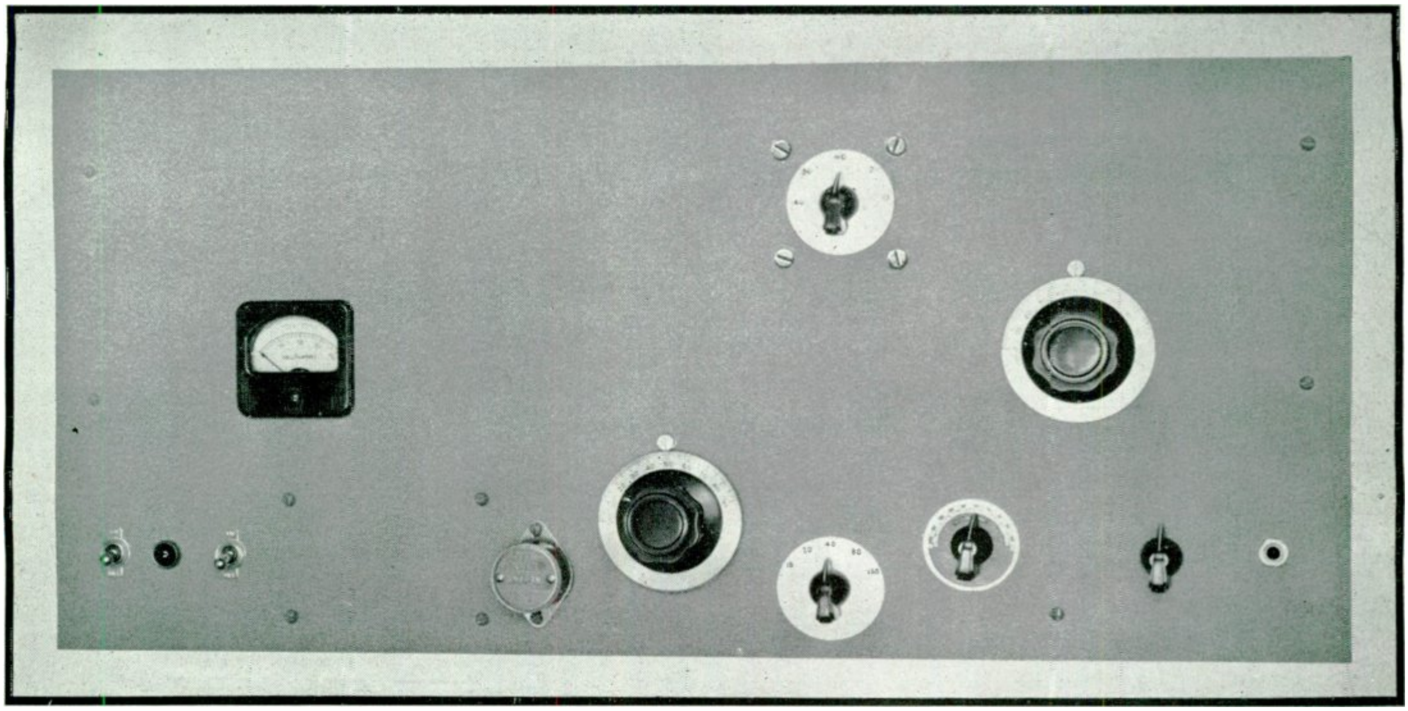

■ Front view of all-band HK-257 Transmitter, showing front panel controls for band-switching, both for the exciter and final r.f. amplifier. Bliley crystals plug into a holder mounted on the front panel. Only one d.c. milliammeter is required.

Two-Tube All-Band Cathode-Modulated Transmitter with New HK-257 Beam Pentode Amplifier

THE new HK-257 pentode lends itself admirably to the design of an all-band cathode-modulated radiotelephone transmitter. Such a transmitter is described here in detail. It functions in all of the amateur bands, from 10 to 160 meters, and it incorporates band-switching in the crystal oscillator and r.f. amplifier circuits. The new heavy-duty *HK* band switch is used in the final amplifier, the new *BUD RADIO* all-band unit in the oscillator plate circuit. The *HK-257* requires only a small amount of r.f. excitation; a single 6V6 metal tube in the oscillator circuit will drive the r.f. amplifier to more than 100 watts output in all of the amateur bands. The *HK-257* is shielded internally and no neutralization of the r.f. circuit is therefore required. The grid circuit of the final amplifier is shielded from the plate circuit by mounting the *HK-257* part way below the transmitter chassis in such a manner that the internal flange shield of the tube is flush with the chassis deck. This form of construction makes it impossible to show clearly the position of the tube in the accompanying photograph, yet the top view of the chassis carries a plainly-marked identification of the location of the tube with respect to other circuit components. The *HK-257* has a tantalum plate which serves a very useful purpose as a tuning indicator, because maximum antenna output always occurs at the point of minimum plate color. This form of tuning is even more convenient than the indication of maximum dip of plate or cathode current as shown by a milliammeter. The plate current dip is rather small at the point of resonance, or when the antenna coupling is sufficiently heavy to insure linear modulation in the process of cathode modulation.

Power output was measured in the 75-meter band and found to be approximately 114 watts when the input to the plate was 175 watts. The plate loss was 61 watts, which is less than the rated value of 75 watts. The operating efficiency was approximately 65%. These values were obtained with the optimum value of antenna coupling which provided a condition suitable for 100 percent modulation with very good linearity. The efficiency drops to approximately 60 percent with slightly greater values of antenna coupling, and this condition can be used in practice to insure good linearity of modulation. Proper increase of antenna current will not be obtained if the antenna coupling is of an insufficient value, and this condition should therefore be avoided in practice. The oscilloscopic patterns of this transmitter under modulation show excellent linearity, comparable to that of any plate-modulated transmitter.

In the past, it has been customary to use pentode tubes in suppressor-grid-modulated transmitters. It is interesting to state here that cathode modulation gives between two and three times as much output as can be obtained from suppressor-grid-modulation, and with equal or better tone quality. The *HK-257* can be cathode-modulated with approximately 10 watts of audio power, obtainable from several combinations of tubes, such as push-pull 2A3 or 45 triodes, or from a pair of 6V6, 6F6 or 6L6 tubes.

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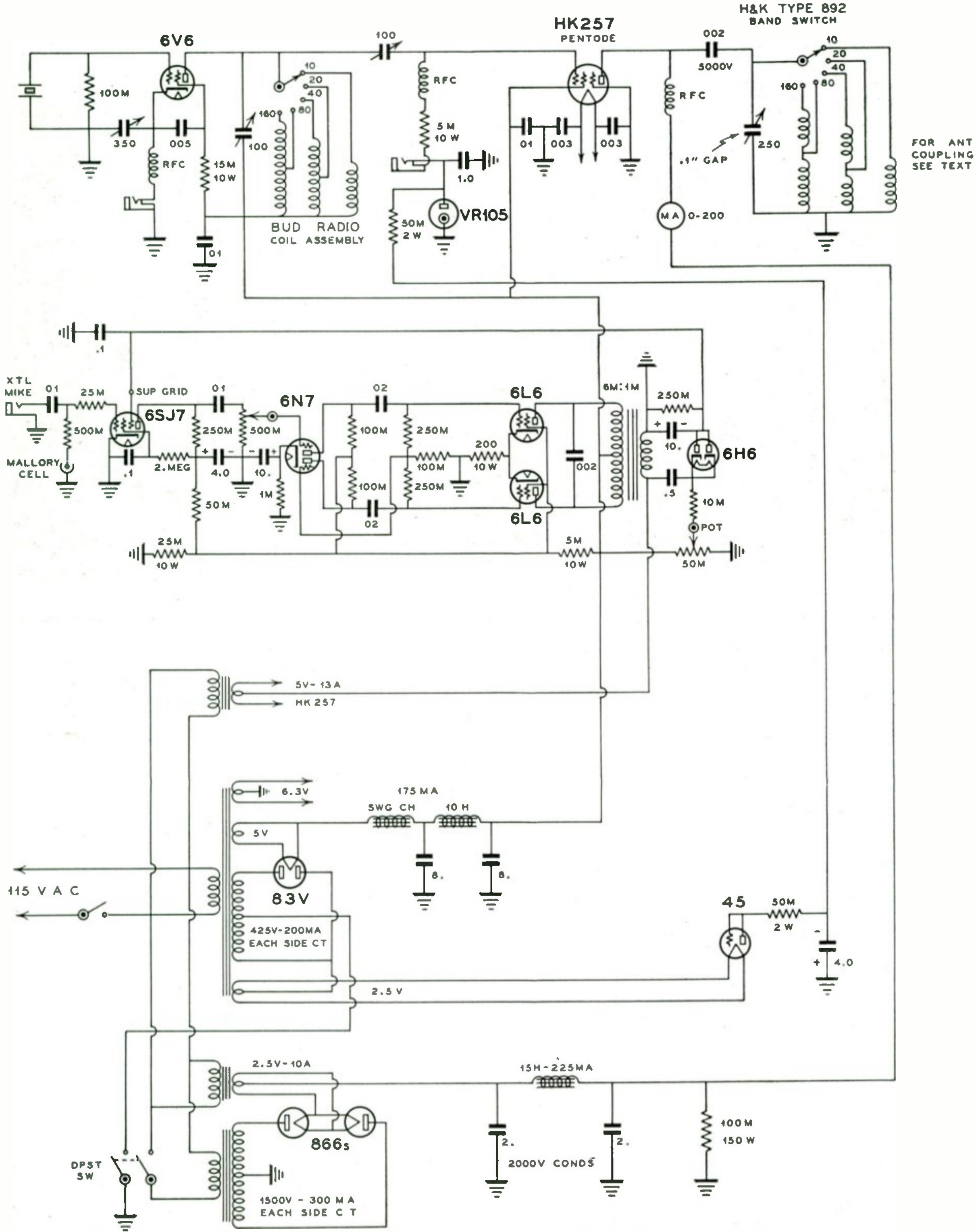

HK-257 BEAM PENTODE TRANSMITTER CIRCUIT

■ This circuit is self-explanatory. The all-band coil-switching assembly is the new BUD RADIO low-power unit, complete with switch. The coil assembly is mounted under the chassis. Transformers are of the UTC Special Series, as follows: Plate Transformers: UTC S40 and S47; Modulation Transformer: UTC S18 or CM15 (optional); Filament Transformers: UTC S57 and S59; Filter Chokes: UTC S29, S30, S31, one of each. Heavy duty resistors are by OHMITE, filter condensers by YAXLEY, and the numerous r.f. components are by BUD RADIO. The crystal microphone is an ASTATIC.

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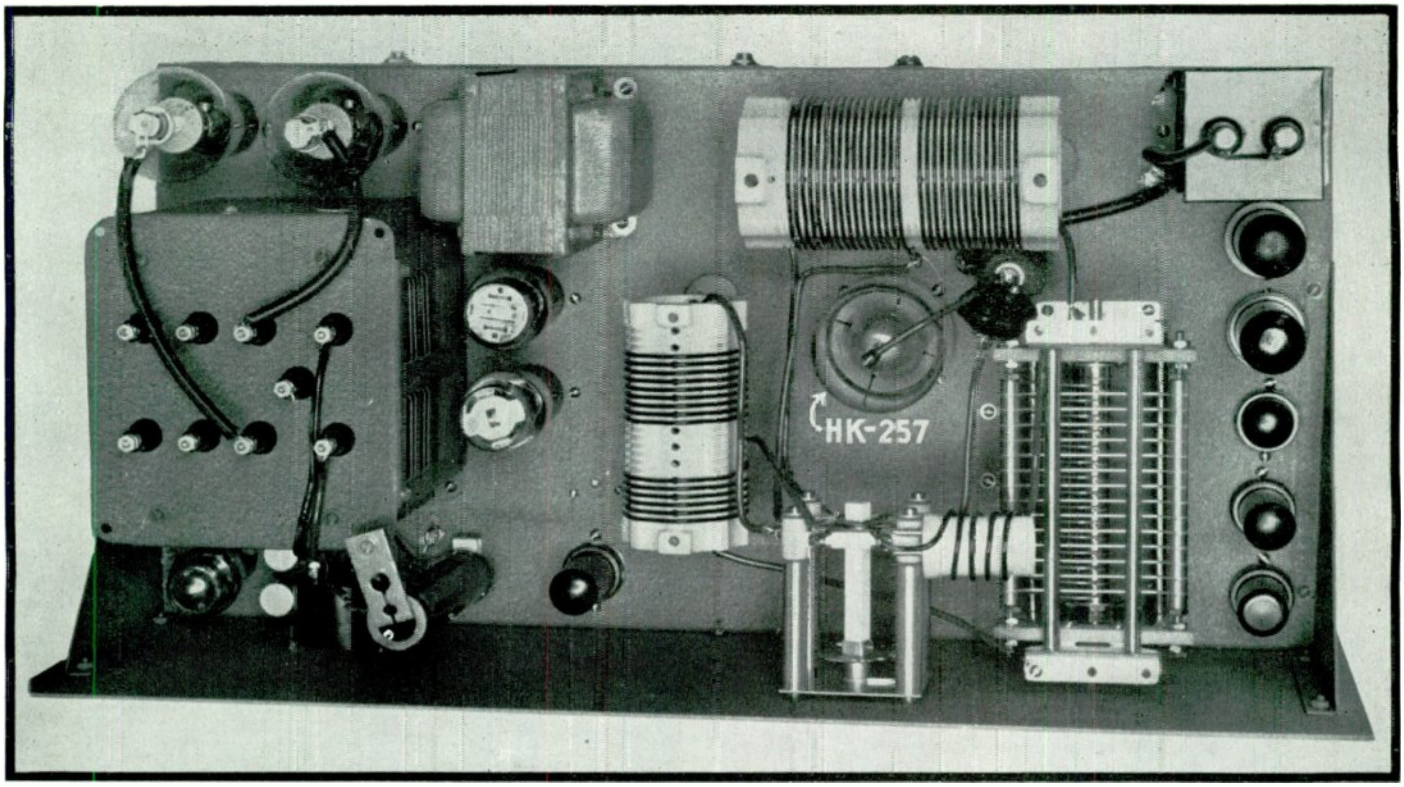

■ Looking down on the HK-257 Transmitter, the placement of all components is clearly seen. To the left is the high voltage plate supply with UTC transformer, heavy-duty OHMITE resistor, and rectifier tubes. The audio channel is to the far right, with all tubes in a straight line near the edge of the chassis. The HK-257 beam pentode is in the center of the final amplifier coil group, the HK heavy-duty band-change switch is secured to the front panel directly forward of this coil group. The final plate tuning condenser is a BUD RADIO product, as are the ceramic coil forms for the final amplifier coils. The final plate tuning condenser is secured directly to the metal chassis, because shunt-feed is used for the plate circuit.

The Audio Channel

THE modulator for this transmitter has a pair of metal 6L6 tubes, together with metal tubes in the speech amplifier, in order to shield the audio channel from the plate circuit of the final amplifier. The audio tubes are mounted in a straight line along one end of the chassis near the final tank tuning condenser. The 6L6 tubes are driven by a 6N7 phase inverter with resistance coupling. One section of the 6N7 twin-triode is driven by the 6SJ7 high-gain pentode speech amplifier. The suppressor-grid of the 6SJ7 is connected back to the plate circuit, through an audio filter of the 6H6 *AGC* tube. The cathode of the 6H6 diode is connected to the high side of the secondary of the modulation transformer through a ½-mfd. condenser in order to rectify excessive peaks of audio voltage. Delay bias in the 6H6 is provided by means of a resistor network and a 50,000 ohm potentiometer which connects to the 250 volt tap of the power supply.

The cathode impedance of a single *HK-257* pentode, operating under the conditions shown for this transmitter, is approximately 1,000 ohms. The small *U.T.C.* modulation transformer is tapped in such a manner that it will have a plate-to-plate impedance of 6,000 ohms when the secondary is connected to a 1,000 ohm load. This gives a correct impedance match for the 6L6 push-pull modulator.

A .002 mfd. 1,200 volt mica condenser is connected from plate to plate of the 6L6 tubes in order to prevent a tendency toward side-band splatter at high levels of modulation, due to a slight rising audio-frequency characteristic in the output transformer. No difficulty was encountered from r.f. or a.c. hum in any part of the speech channel, even though the complete transmitter is built on a single chassis. This chassis measures 24 x 12 x 4 inches, with a front panel 12 x 25 inches.

Crystal Oscillator

THE crystal oscillator consists of a 6V6 metal tube connected to a *Bud Radio* band-switching coil unit, which tunes the plate circuit to 10, 20, 40, 80 and 160 meters with a 100-mmfd. variable condenser. The 10 meter coil must be cut down to three turns, so that it will resonate properly over the entire 10 meter band. The grid of the *HK-257* pentode is capacity-coupled to the oscillator in order to provide a simple control of r.f. excitation when changing from band to band, or when crystals of various frequencies are substituted. This coupling condenser is a single-spaced 100-mmfd. midget variable, mounted near the final amplifier tube socket, and adjusted by a knob on the front panel of the transmitter.

The 6V6 oscillator has an r.f. choke in its cathode circuit, together with an adjustable mica condenser for controlling the amount of regeneration in this circuit. This condenser must be set to a value that allows the plate circuit to be tuned

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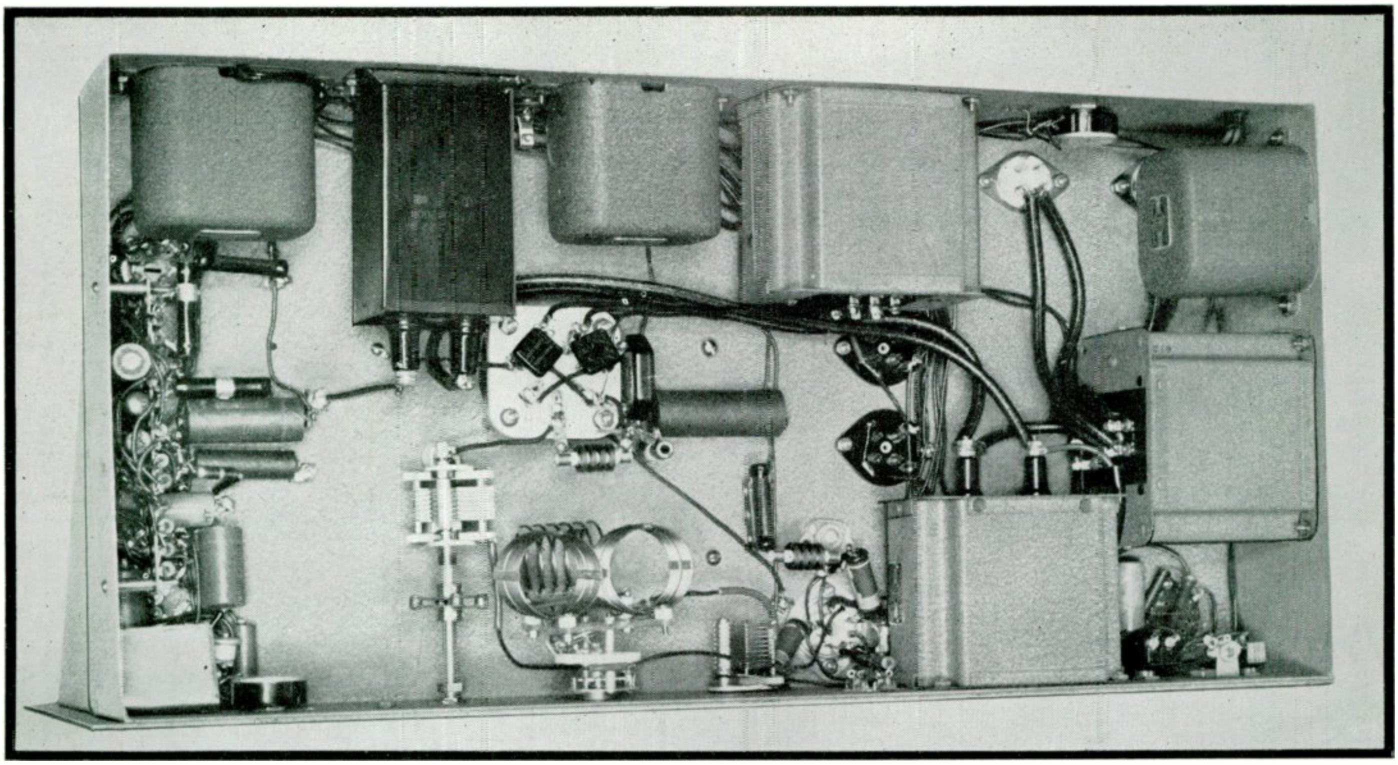

■ The special chassis must be 4-inches deep, in order to allow space for mounting the numerous components under the chassis. This photograph shows the placement of the low-voltage power supply units, chokes and modulation transformer.. Note compact grouping of small parts for the audio channel at the far left. The coil-switching unit and oscillator condenser are directly in front of the final amplifier tube socket. The high-voltage filter condenser at the left, rear, is a Mallory product.

to the second harmonic of 80 and 160 meter crystals. For 10 and 20 meter operation, crystals of these respective frequencies should be used. The cathode regenerative circuit is a distinct aid in obtaining good output from 10 and 20 meter crystals. The 6V6 metal tube shields the crystal oscillator circuit from the final amplifier plate circuit.

Grid Bias

GRID bias for the final amplifier is obtained from a combination of grid-leak and fixed C-bias. The fixed C-bias supply utilizes a half-wave rectifier, consisting of a type 45 tube with its grid and plate tied together, and with its filament connected to one side of the 425 volt winding of the low voltage power transformer. Two 50,000 ohm, 2-watt resistors and a 4-mfd., 450 volt electrolytic condenser are included in the C-bias filter circuit, with the output connected to a type VR-105 gaseous rectifier regulator tube. This tube maintains the C-bias at a negative potential of 105 volts over the complete range of grid current for c.w. or voice operation. The d.c. grid current of the final amplifier flows through the VR-105 tube, rather than through the C-bias rectifier circuit. This type of C-bias supply is very economical and occupies a minimum of space. The VR-105 is by-passed with a 1-mfd. condenser in order to insure an audio-frequency by-pass circuit to the lower end of the 5,000 ohm grid-leak. The degree of grid modulation is limited, because the 5,000 ohm grid-leak is in series with the audio by-pass circuit, so that it is effectively in series with both the audio-frequency and d.c. grid currents. The small mica by-pass condensers in the filament and screen-grid circuits of the *HK-257* are grouped around the terminals of the tube socket and connected to a common ground point, which, in this case, is one of the suppressor-grid leads. A connecting lead is then taken at this point and carried to the plate tuning condenser, as well as to the common ground point of the oscillator circuit.

The *HK-257* is shunt-fed in order to remove the positive d.c. potential from the r.f. coils, tuning condenser, and band switch. The plate tuning condenser is a *Bud Radio* stock item, having a maximum capacity of 250-mmfd. and a minimum of 22-mmfd., with a 0.1-inch air-gap. This condenser is secured directly to the chassis.

The coil switch in the final r.f. amplifier is the new heavy-duty *HK* 6-contact switch, of which only five contacts are used for the five amateur bands.

Final Plate Coils

THE 10 meter coil has 4½ turns of No. 10 wire, wound around a 1⅛-inch ceramic form; the length of the winding is approximately 1¼-inches. The 20 and 40 meter coils are wound on *Bud Radio* 2½-in. dia. ceramic forms, 5 turns for the 20 meter coil and 9 additional turns for the 40 meter coil. The 9-turn winding is spaced approximately 1-inch from the 5-turn winding, and the two windings are connected in series to give a coil of 14 turns for 40 meter operation. The 80 and 160 meter coils are wound in a similar manner on a 3-in. diameter ceramic form. The 80 meter section of this coil has 12½ turns, the 160

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meter coil has a total of 28½ turns. This coil is ribbed so that it will accommodate approximately 7 turns per inch of No. 12 enameled wire. The 20-40 meter coil is wound with the same size wire, 6 turns per inch. All of the coils are grouped around the *HK-257* pentode, as shown in the top view of the transmitter, with the high-frequency coils mounted close to the *HK* band-change switch. If operation in the 160 meter band is not contemplated, a smaller tuning condenser than the one shown in the specifications should be used. It should likewise have a lower minimum capacity in order to provide greater operating efficiency in the 10 meter band. The output of this transmitter falls to slightly less than 100 watts on 10 meters, but rises to more than 100 watts in any of the other amateur bands.

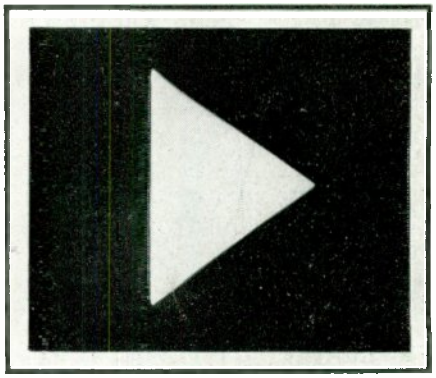
Antennas can be coupled to the tuned plate circuits by link coupling to external tuned antenna circuits, or by inductive coupling with a few turns of wire wound directly over the coil forms. It is also possible to tap the antenna directly to one of the turns of the tuned plate circuit when operation in the low-frequency bands is desired.

Power Supply

TWO separate power supplies are built into this transmitter, one of which supplies 325 volts to the crystal oscillator and audio channel as well as C-bias for the final amplifier, the other a high voltage supply connected to the plate circuit of the final r.f. amplifier. The latter consists of a 3,000 volt center-tapped *U.T.C.* transformer, a pair of 866 rectifier tubes, and a single filter choke circuit with condenser input. Since the plate current drain is rather low, condenser input increases the d.c. plate voltage to a value between 1,800 and 2,000 volts, depending upon the a.c. line voltage. A d.p.s.t. toggle switch, capable of carrying at least 5 amps., controls the high and low voltage power supplies simultaneously. Some of the filament transformers and chokes are mounted under the chassis.

The *AGC* control potentiometer is mounted at the rear of the chassis; jacks for metering the cathode current of the crystal oscillator and grid current for the r.f. amplifier are also mounted at the rear. The grid circuit jack is supported by insulated washers, so as to avoid a short-circuit to the metal chassis. The 200-ma. d.c. milliammeter can be connected permanently in series with the cathode or plate circuit of the final r.f. amplifier. Crystals are plugged into a socket on the front panel in order to insure quick change of frequency or bands. The complete transmitter should be housed in a compact metal cabinet as a safety measure against accidental contact with high voltage leads.

■ Oscilloscopic pattern of fully modulated carrier for 75 meter operation. This pattern shows good linearity of modulation up to practically 100 percent. This picture was secured by connecting one set of plates of the oscilloscope across the output winding of the modulation transformer, the other coupled to the final amplifier tank coil.



Tuning Procedure

THE 866 rectifier tubes are first removed from their sockets and the crystal oscillator checked for operation in all bands. A small d.c. milliammeter should be plugged into the grid circuit jack of the final amplifier in order to check the output of the crystal oscillator. The grid current should be approximately 5 ma., although as much as 10 ma. can be tolerated for voice communication. The plate current of the final r.f. amplifier should be from 80 to 100 ma., the oscillator cathode current approximately 20 ma. It is good practice to tune the final r.f. amplifier on each band with the aid of a 100-watt *Mazda* lamp as a dummy antenna load, in order to observe the color of the tantalum plate of the *HK-257* pentode under operation, to make certain that maximum antenna output is obtained—and that the antenna current increases during modulation. The d.c. plate current reading and the color of the plate of the *HK-257* should be observed during operation while the 100-watt *Mazda* lamp serves as a dummy load, after which the regular transmitter antenna can be connected to the final amplifier. The antenna load, in every case, should be the same—and sufficient to insure proper operation. The tuning procedure of a transmitter using the new *HK-257* pentode is somewhat unconventional when compared with that of a neutralized triode amplifier. For this reason, it is desirable to provide some means for indicating the amount of antenna or feeder current at all times.

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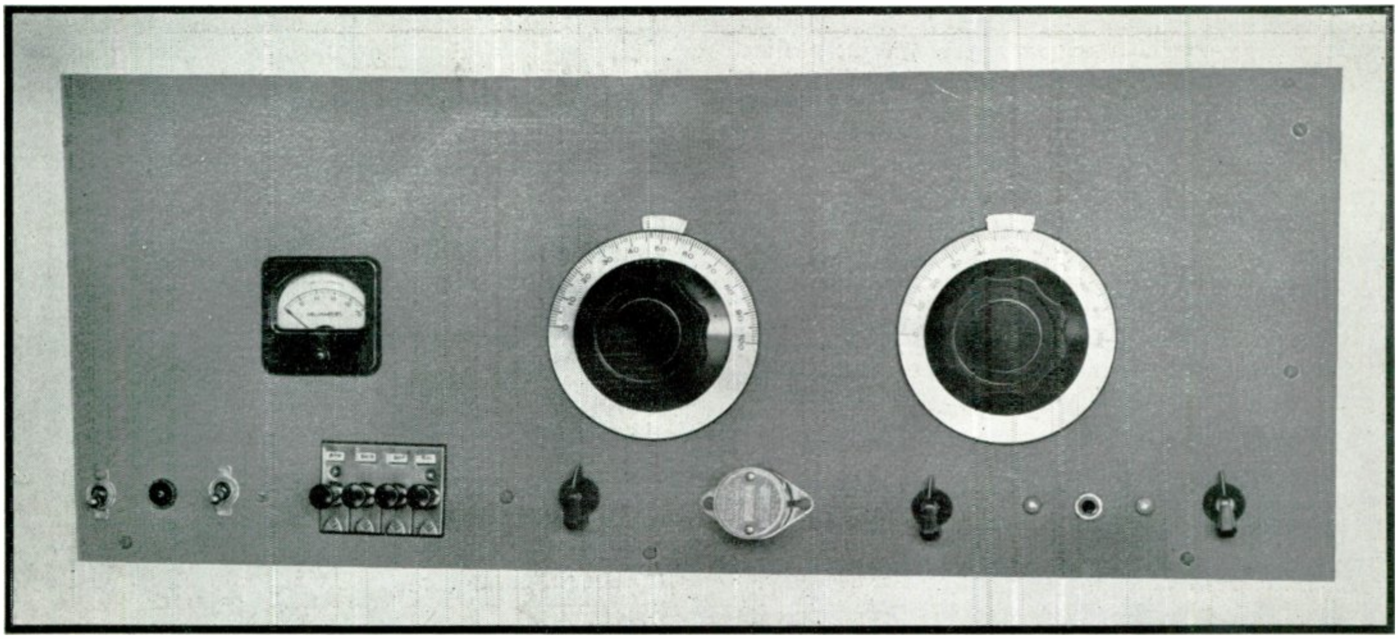

■ Front view of 120-watt T-40 or TZ-40 transmitter, complete on a single chassis. To the left is the Yaxley push-button band-change switch. The Bliley crystal is mounted on the front panel for quick band change. The panel measures 25x10 inches.

120 Watt T-40 Cathode-Modulated Transmitter

HERE is a complete cathode-modulated transmitter on a single chassis, and with sufficient power output to satisfy the requirements of many amateurs. This transmitter, under test, proved that a remarkably high carrier output is obtainable with plate circuit efficiency of 65% in the 75 meter 'phone band. The power output is 85 watts, and the input is only 128 watts. The plate loss is approximately 50 watts, which is slightly in excess of the rating of a single T-40, yet the plate of the tube shows no color under operation. The oscilloscopic pattern indicates good linearity of modulation, the equivalent of other cathode-modulated transmitters described in this book.

The R. F. Amplifier

THE r.f. section of the transmitter is mounted in the mid-portion of the chassis. The audio channel is at one end, and the power transformers at the other. A single 24 x 12 x 3 inch chassis with a 25 x 10 inch front panel constitutes the mounting assembly. The transmitter can be housed in a cabinet with hinged lid, so that it can be mounted on the operating table near the receiver for convenience of operation.

The r.f. exciter consists of two 6L6G tubes which deliver output on any band from 160 to 10 meters. The crystal oscillator serves as an untuned *Pierce Oscillator* when used with 80 and 160 meter crystals; in this case the plate circuit is short-circuited by bending the tips of the tuning condenser plates so that the condenser is short-circuited at its setting of maximum capacity. The oscillator tuning condenser and coil are mounted under the chassis close to the oscillator tube socket. The 150-mmfd. tuning condenser covers the amateur 20 and 40 meter bands with a single 16-turn coil, wound to cover a length of 1-inch on a ¾-inch form. The regeneration control condenser is also mounted under the chassis; it can be adjusted with a screwdriver from either side of the chassis. It is set at a value which will allow oscillation with 160 and 80 meter crystals in the *Pierce Oscillator* circuit, and it also allows harmonic oscillation when the plate circuit is tuned to 20 or 40 meters. This adjustment remains the same for all bands of operation. If the capacity setting of this regeneration condenser is too-high, the output on 20 and 40 meters will be very low, and the output from 160 meter crystals will be nil. If the capacity of the condenser is too low, there will be a tendency for self-excited oscillation, which is not controllable by the crystal when operating in the 20 and 40 meter bands. A single turn of wire connected to a lamp and coupled to the oscillator coil, or a neon glow lamp held against the plate circuit of the oscillator, will give a good indication of the proper adjustment of this regeneration condenser. It is possible to use 80 meter crystals when the final amplifier is operated in the 40, 20 and 10 meter bands. This crystal oscillator will also function with 20 meter crystals, or with active 40 meter crystals when the plate circuit is tuned to 20 meters.

The second 6L6G serves as an unneutralized buffer or doubler. No neutralization is needed when the tube acts as a doubler. Its plate circuit can be tuned to 40, 80 or 160 meters when the crystal oscillator plate circuit is short-circuited so that the first 6L6 tube acts as an untuned *Pierce Oscillator*. Operation on 40 meters is best obtained from an 80 meter crystal with the tuned circuit of the first tube short-circuited and the second 6L6 plate circuit tuned to 40 meters. The grid circuit of the final amplifier is tapped part of the way down on the second tuned circuit in order to prevent over-excitation for cathode modulation.

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■ Top view of complete transmitter, showing placement of r.f., audio and power supply components. The plate transformers are UTC S39 and S45, the modulation transformer a UTC CM15 or S18. All r.f. components are of BUD RADIO manufacture.

Neutralization

THE single-ended T-40 r.f. amplifier can be neutralized in the 10 or 20 meter bands and it will then remain in neutralization for all other bands of operation. The plate-to-filament capacity of the T-40 tube is balanced by a small neutralizing condenser connected from the opposite stator section to ground. This gives a balanced circuit similar to that of a push-pull amplifier. The balancing condenser is of the type generally used for neutralizing 6L6G tubes. It has two circular plates approximately 1-inch in diameter. The neutralizing condenser functions in its normal manner, and the process of neutralization is the same as that for any conventional r.f. amplifier. The additional balancing condenser can be set with its plates approximately ⅛-inch apart, and a check made under actual operation in the several bands to determine if the circuit is perfectly neutralized with a common setting of the neutralizing condenser.

Bias Supply

THE grid circuit of the final amplifier makes use of a combination of grid-leak and fixed bias from a C-bias supply. The audio-frequency circuit is completed through a 0.5-mfd. condenser and 30 mh. r.f. choke, as shown in the circuit diagram. The 30-mh. r.f. choke is needed for the purpose of preventing a low-frequency parasitic oscillation, because the plate and other grid r.f. chokes are similar in size.

The fixed C-bias voltage is obtained from the same 325 volt power supply which furnishes plate current to the exciter and audio channel. The negative high voltage and cathode return circuit of the final amplifier are connected to a 50,000 ohm potentiometer shunted across a portion of the 325 volt supply. This potentiometer can be of the 1-watt size, since no plate or grid current flows through it. A type 45 triode serves as a C-bias voltage regulator. The d.c. grid current of the final amplifier flows through this tube, rather than through the 50,000 ohm potentiometer. The potentiometer allows the fixed C-bias to be set at any value from approximately 70 volts up to nearly 200 volts. The circuit constants were chosen so that the actual grid bias on the T-40 tube, with respect to its cathode, can be varied over a range of approximately 100 volts by control of this 50,000 ohm potentiometer. This provides a convenient means for reducing the grid excitation or d.c. grid current to a value which will allow cathode modulation when changing bands. Operation for c.w. can be attained by decreasing the fixed C-bias to its minimum value. Either a T-40 or TZ-40 tube can be used in the final amplifier without circuit changes, other than the substitution of a 2,000 ohm grid-leak for the 5,000 ohm leak when a TZ-40 is used in place of a T-40.

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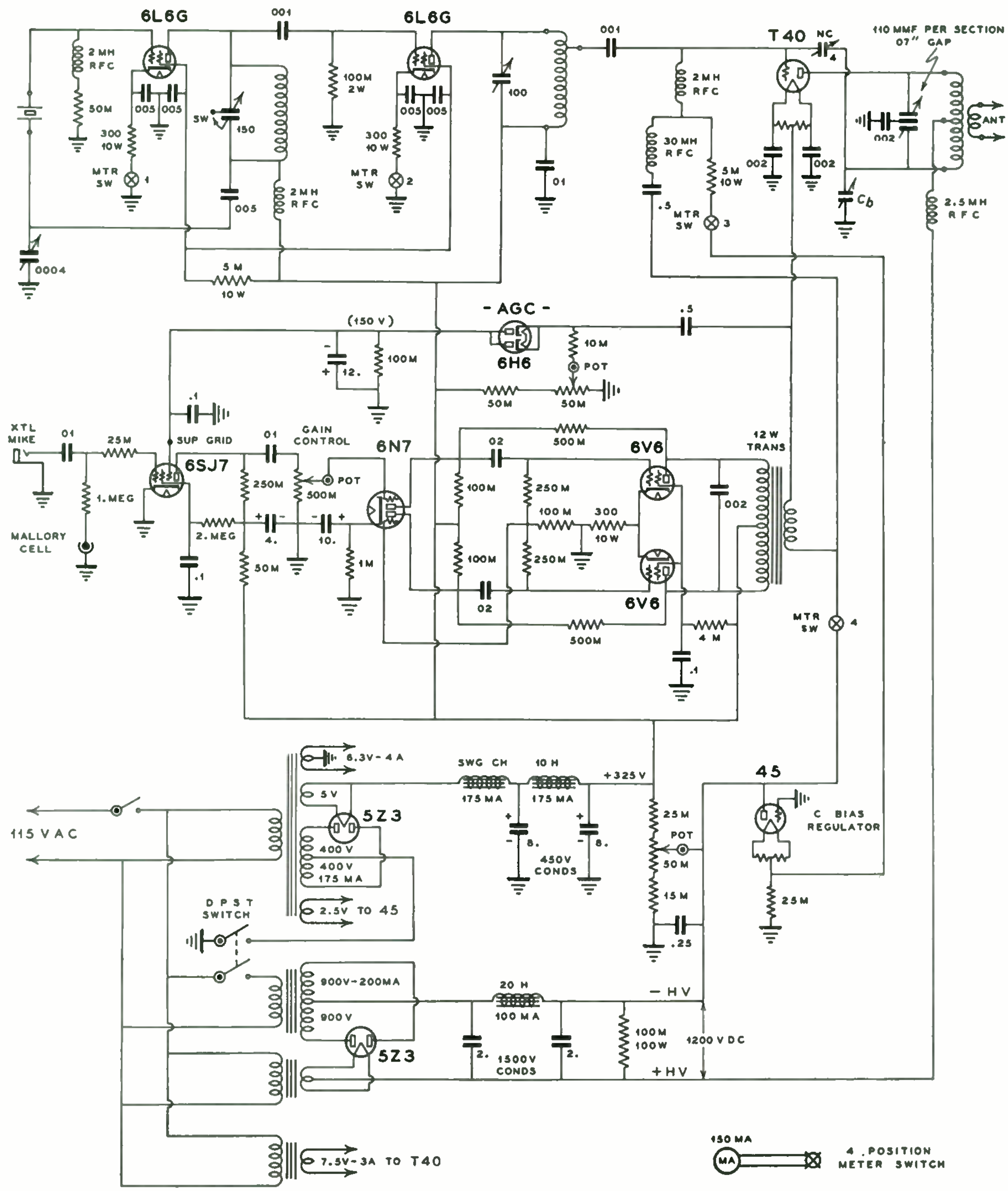

■ Two power supplies furnish plate voltage and grid bias for the complete transmitter. In the high voltage supply, a high-vacuum 5Z3 full-wave rectifier is connected across an 1,800-volt center-tapped power transformer. The total plate current drain is less than 125 ma., so that no difficulty is experienced due to possible failure of the 5Z3 rectifier tube. A more conservative design would be a pair of 866-Jr. rectifier tubes, and a 2.5-volt 5-amp. filament transformer. Condenser input in the filter for the high voltage supply was chosen in order to secure as high a value of plate voltage as possible from a small plate transformer. The d.c. plate potential, measured from plate to cathode, is approximately 1,200 volts when the final amplifier tube draws 100 ma. At this high plate voltage, it is necessary to use only 2 to 5 ma. of grid current. The cathode current of the 6L6G stages is from 40 to 60 ma., depending upon the band of operation. A single milliammeter, connected to a Yaxley self-circuit-closing push-button switch, serves for measuring cathode and grid currents.

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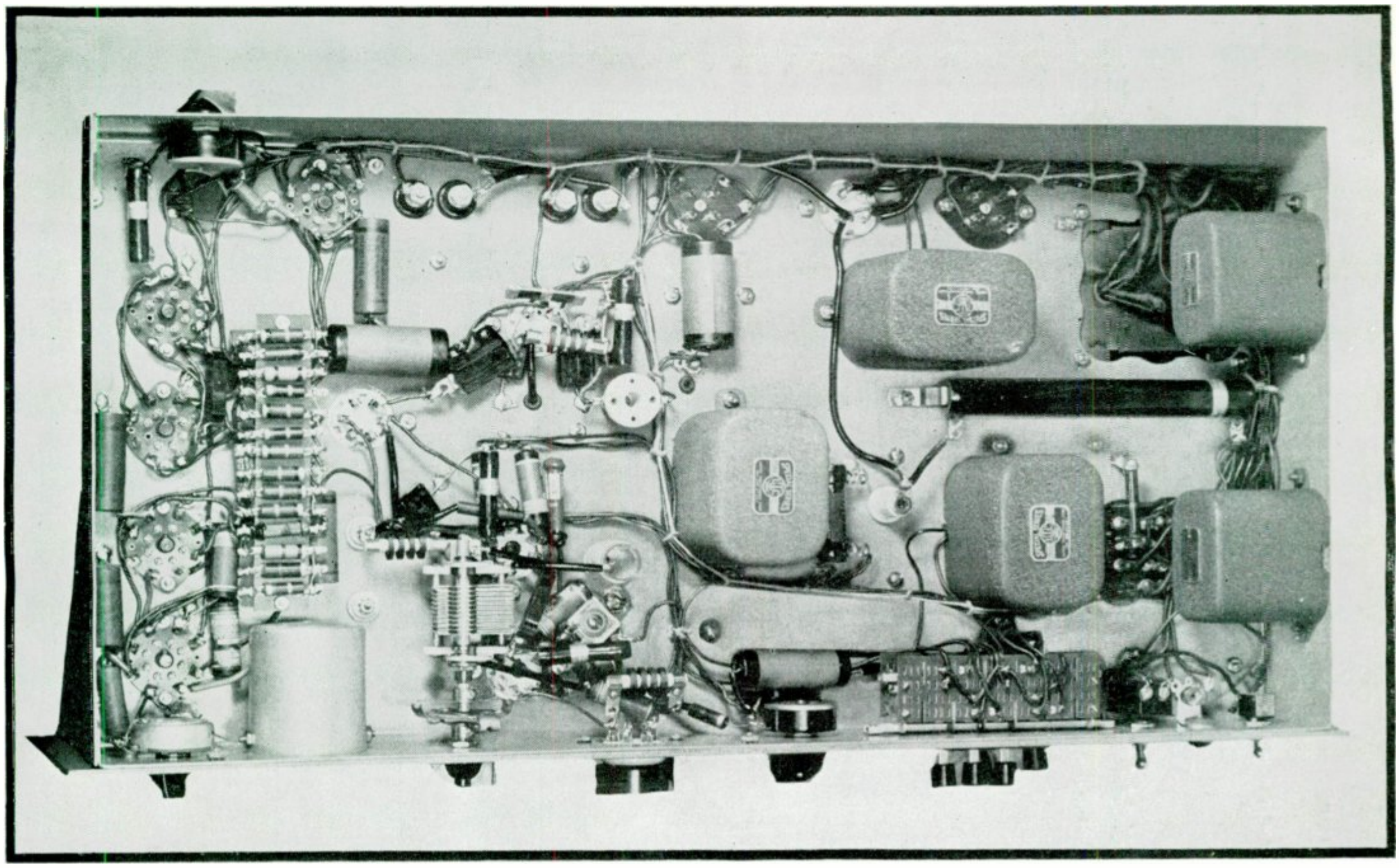

■ Under-chassis view, showing location of Yaxley push-button band-change switch (to right). The chassis is 4-inches deep, allowing space for mounting the UTC S54 and S56 filament transformers and UTC S28, S29 and S30 filter chokes, one each.

The Audio Amplifier

THE audio channel consists of a 6SJ7 high-gain pentode amplifier with its suppressor-grid connected to an automatic gain control circuit which can be used to prevent overmodulation. The 50,000 ohm potentiometer which controls the delay bias in the AGC circuit is mounted at the rear of the chassis near the modulation transformer. A 6H6 diode, with its elements connected in parallel, rectifies the audio peaks which would tend to cause overmodulation. The actual audio power required to fully modulate the final amplifier when operating with 120 watts input is only 6 watts. The a.c. peak current flowing in the cathode circuit at 100 percent modulation was measured and found to be 100 ma. when the d.c. cathode current was 100 ma. The cathode impedance can be calculated from the formula:

$$Z = \frac{2 \times P}{I^2}$$

where P is the audio power required, I is the d.c. current.

The cathode load impedance, in this case, is approximately 1,000 ohms. The plate-to-plate impedance of the 6V6 can be any value from approximately 5,000 to 8,000 ohms, because of the inverse feed-back action. The small U.T.C. 12-watt output transformer in this transmitter has its windings tapped so as to give a plate-to-plate load of approximately 6,000 ohms when the secondary load is 1,000 ohms. The primary of this transformer is shunted with a .002-mfd. 1000 volt mica condenser in order to reduce the tendency toward a high audio-frequency peak in the output transformer, which would produce side-band splatter even when the carrier is not fully modulated with normal voice frequencies.

Coil Data for T-40 Transmitter

BAND	BUFFER COIL	FINAL PLATE COIL
10 Meters	3½ turns No. 16 Enam. 1½-in. dia., 1¼-in. long. No tap.	6 turns No. 10 Enam. 2½-in. dia., 2½-in. long. Center-tapped.
20 Meters	7½ turns No. 18 Enam. 1½-in. dia., 1½-in long. Tapped 5 turns up from plus B end.	10 turns No. 14 Enam. 2¾-in. dia., 4-in. long. Center-tapped.
80 Meters	30 turns No. 20 DCC. 1½-in. dia., 1¾-in. long. Tapped 18 turns up from plus B end.	34 turns No. 14 Enam. 2¾-in. dia., 4-in. long. Center-tapped.
160 Meters	60 turns No. 22 DCC. 1½-in. dia. Close wound. Tapped at center.	34 turns No. 14 Enam. 4-in. dia., 4-in. long. Shunted by 25-mmfd. fixed air condenser.

OSCILLATOR COIL—16 turns No. 22 D.C.C., 1-in. long, ¾-in. diameter.

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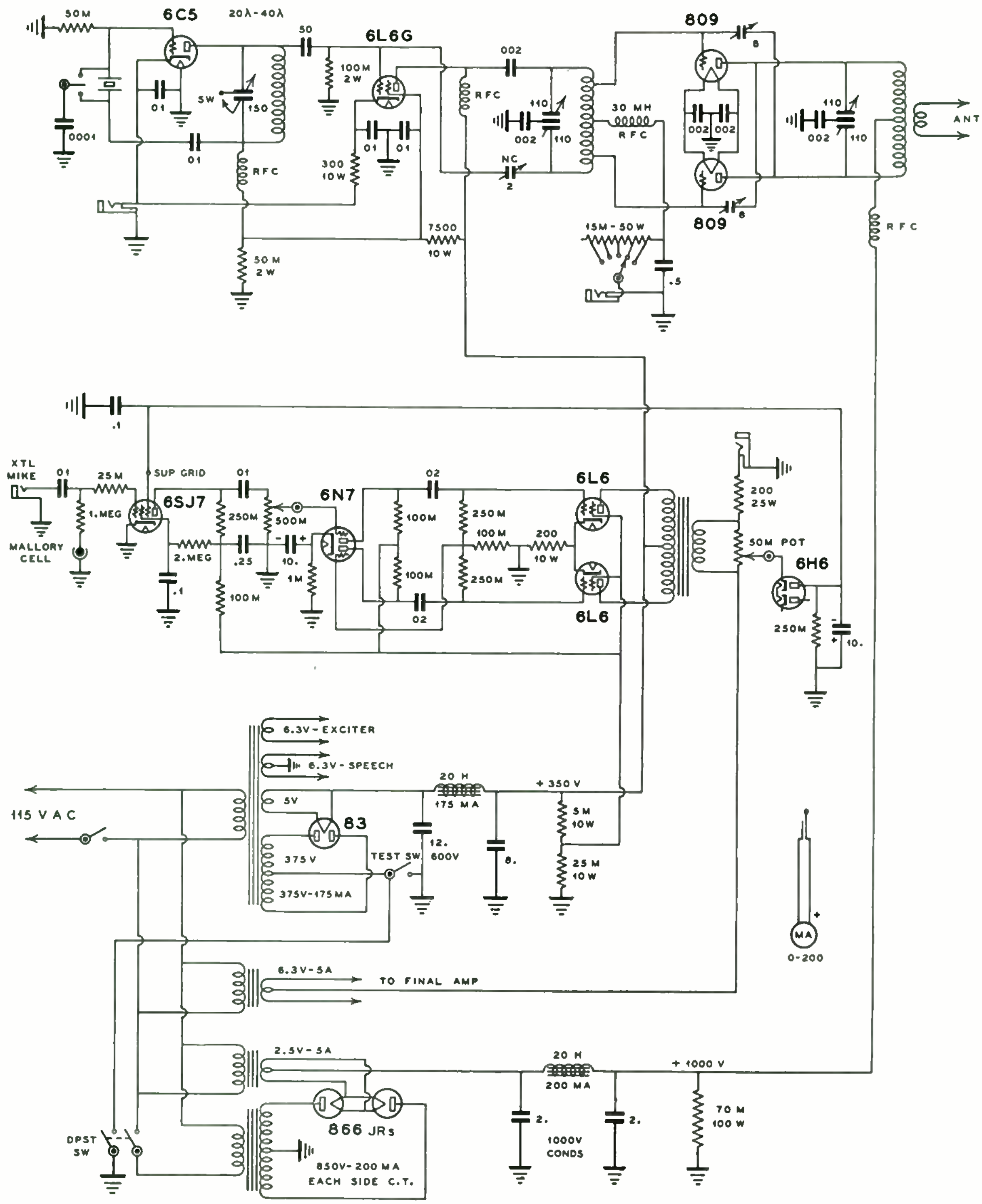
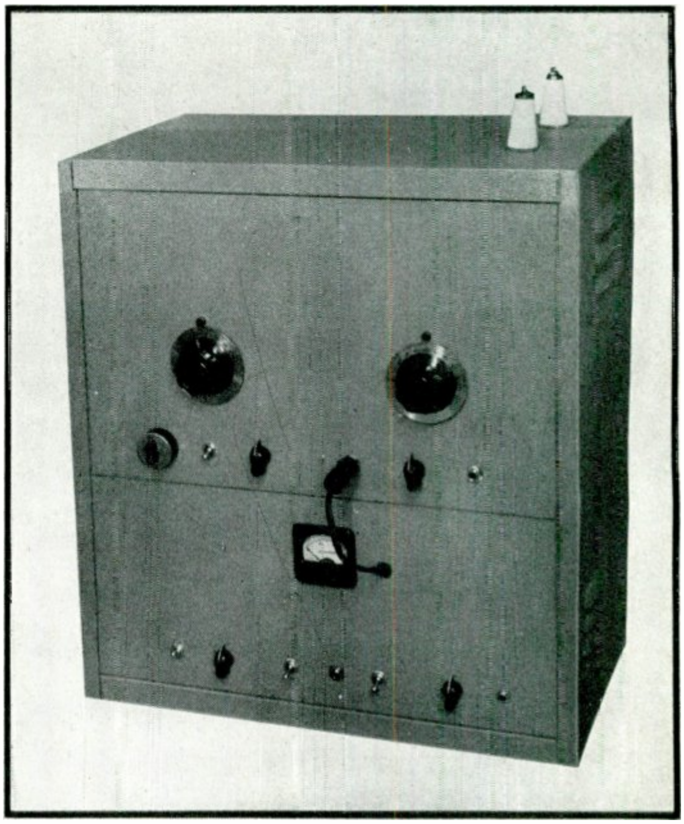


COMPLETE CIRCUIT DIAGRAM OF RCA-809 TRANSMITTER

■ The components for this transmitter are so small that only two chassis decks are required. The power supply and audio channel can be built on one deck. A UTC type CM-15, or the UTC Special Series modulation transformer of the same rating will be satisfactory for the modulator stage. The variable grid-leak in the final r.f. circuit is a tapped OHMITE resistor, with taps connected to a YAXLEY rotary switch. The audio amplifier includes a phase inverter and automatic gain control circuit.

RCA-809 Cathode-Modulated Transmitter—Delivers Same Output as When Plate-Modulated at Maximum Rated Power Input



■ A small BUD RADIO cabinet houses the complete transmitter.

THE popular RCA-809 triodes can be cathode-modulated very efficiently with plate potentials ranging from 900 to 1,000 volts. Operated in this manner, the carrier output will be approximately 75 watts without exceeding the rated plate dissipation of the tubes. *This is the same output that can be obtained from a plate-modulated push-pull 809 amplifier operating at maximum rated power input.* The actual instantaneous plate voltage of the cathode-modulated transmitter illustrated here is approximately the same as that of a plate-modulated transmitter.

Very Low Audio Power Required

THIS transmitter can be modulated with only 10 watts of audio power, and this amount of power can be obtained from several different tube combinations. A pair of 6L6 tubes, operated in ordinary Class-A from a 350 volt power supply, will deliver more than ample power output to completely modulate the 809 r.f. amplifier. Type 6L6 tubes were chosen for this particular transmitter because of the ease with which they can be driven by a 6N7 phase inverter.

In order to prevent overmodulation, a 6H6 diode is connected across the output of the modulator; automatin gain control voltage is thereby introduced back into the 6SJ7 pentode speech amplifier. The AGC voltage is connected to the suppressor-grid of the 6SJ7 for the purpose of automatically reducing the gain of this tube when excessive audio output voltage is applied to the cathode circuit of the modulated amplifier. Delay bias is supplied to the 6H6 by reason of the d.c. voltage drop across the 200 ohm cathode resistor in the 809 circuit. The amount of audio voltage applied to the AGC circuit is controlled by a 50,000 ohm potentiometer connected across the output winding of the modulation transformer. The d.c. delay bias is approximately 25 volts, and this voltage—with respect to the audio peak voltage applied to the 6H6 tube—determines the point at which AGC action takes place. In operation, the 50,000 ohm potentiometer is adjusted to a point which will prevent overmodulation of the r.f. carrier, as indicated by some form of overmodulation meter, such as an oscilloscope or diode rectifier.

The modulation transformer should preferably be connected so that the modulator works into a 6,600 ohm load with an actual secondary load impedance of 700 ohms. If the output transformer is designed to work into a 500 ohm load, the impedance match will be quite satisfactory, since the full output of the 6L6 modulator is not required.

The Exciter

THE exciter was designed to deliver output on any band from 10 to 160 meters, by means of a single set of plug-in coils. The 6C5 triode serves as an untuned *Pierce Oscillator* for 80 and 160 meter operation, with a small .0001 mfd. mica condenser connected directly to the grid of the 6C5 tube for operation in these two bands. The 6C5 plate tuning condenser has the edges of two of its stator plates bent inward, so as to short-circuit the rotor plates when the condenser is turned to its setting of maximum capacity. The untuned *Pierce Oscillator* on 80 and 160 meters drives the neutralized 6L6G buffer stage, which is directly coupled to the grid circuit of the final amplifier. Shunt-feed of plate current in the 6L6G tube allows the grid tap of the final amplifier to be connected directly into the tuned circuit winding, as illustrated in the circuit diagram. The grids must be tapped well down on the coil in order to prevent over-excitation of the grid circuit for proper operation for cathode modulation. The center-tap of this tuned circuit connects through a 30-mh. r.f. choke to the variable grid-leak and audio by-pass condenser. A large r.f. choke is used in the grid circuit in order to prevent it from resonating with the r.f. choke in the plate circuit, otherwise a low-frequency parasitic oscillation may be encountered. It is sometimes necessary to use a large r.f. choke in the plate circuit of the 6L6G tube for the same reason, although the shunt capacities in that part of the

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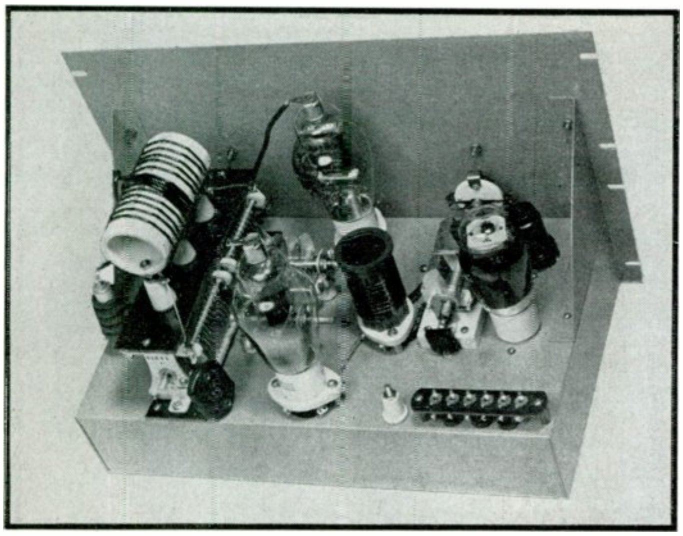
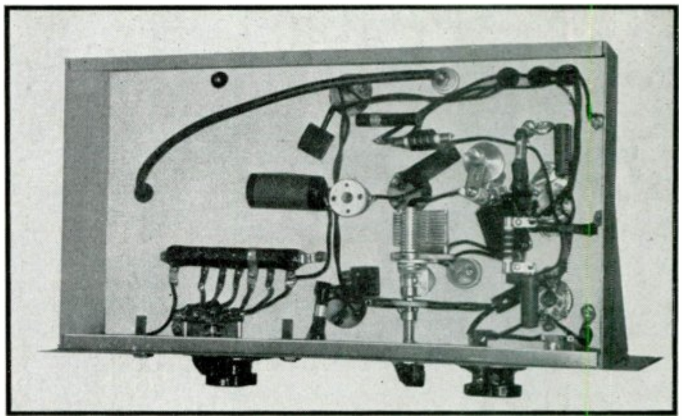


■ Push-Pull RCA-809 r. f. amplifier deck, including 6C5 oscillator and 6L6G buffer-doubler stages. Small BUD RADIO parts used throughout. The final amplifier coil is supported on a bakelite strip atop the final plate tuning condenser.



▫ Under-chassis view of exciter and final amplifier deck, showing placement of OHMITE tapped resistor and YAXLEY tap switch. The oscillator tuning condenser and 6L6G neutralizing condenser are also mounted under the chassis.

circuit will usually detune even the 2.5 mh. choke and thereby prevent parasitic oscillation. The tapped grid-leak provides a convenient adjustment of d.c. grid bias in the cathode-modulated stage.

For 10, 20 and 40 meter operation, the 6C5 crystal oscillator functions as a harmonic generator, with the .0001 mfd. condenser connected to the grid and plate return circuits rather than to the grid of the 6C5 tube. This changeover is accomplished by a single-pole-double-throw toggle switch, mounted on the front panel adjacent to the crystal socket. The plate circuit of the 6C5 is tuned to either 20 or 40 meters by the 150-mmfd. midget variable condenser which is mounted below the chassis. The oscillator coil has 16 turns of No. 22 d.c.c. wire on a ¾-inch diameter form, spaced to cover a winding length of 1-inch. This coil is mounted under the chassis near the oscillator tuning condenser. The 6L6G stage can be operated as either a buffer or doubler in the high-frequency bands. 20 or 40 meter crystals should be used for 10 meter operation. It is possible to use 80 meter crystals for 20 meter operation, if desired. The final plate coils are wound on 2-inch diameter porcelain forms because of the limited space available above the r.f. chassis.

Power Supplies

THE lower deck contains the two power supplies and a very compact audio amplifier. The complete audio channel for crystal microphone input can be built into a space approximately 6-inches square, which leaves sufficient room for the two plate voltage supplies, one of which delivers from 900 to 1,000 volts at 125 ma., the other a 350 volt supply at 175 ma. A small 10-amp. d.p.s.t. switch controls the high and low voltages simultaneously for switching the carrier on and off. A single 0-200 ma. d.c. milliammeter terminates in a plug which connects to closed-circuit jacks in the several r.f. tube circuits. It is possible to use a 5Z3 full-wave rectifier in place of a pair of 866-Jr. tubes, as shown in the circuit diagram, since the load current is low.

Current Readings

THE cathode current of the exciter reads from 40 to 70 ma., depending upon whether the 6L6G operates as a buffer or doubler. The final grid current should read between 5 and 10 ma. for 'phone operation. The grid-leak resistance is increased until the grid current is reduced to this value. If it is still impossible to sufficiently reduce the grid current, the 809 grid circuit taps can be moved closer to the center of the tuned circuit. The cathode current in the final amplifier should read from 100 to 135 ma. The antenna load must be sufficient to draw this amount of current, at resonance, with a grid current of from 5 to 10 ma.

Coil Data for Transmitter Using RCA-809 Tubes

BAND	BUFFER COIL	FINAL PLATE COIL
10 Meters	4½ turns No. 16 Enam. 1½-in. dia., 1½-in. long. Center-tapped. Grid taps at ends.	6 turns No. 12 Enam. 3-in. long, 2-in. dia. Center-tapped.
20 Meters	10 turns No. 16 Enam. 1½-in. dia., 1½-in. long. Center-tapped. Grid tap 3 turns from center-tap.	10 turns No. 12 Enam. 3-in. long, 2-in. dia. Center-tapped.
80 Meters	36 turns No. 20 DCC. 1½-in. dia. Close wound. Center-tapped. Grid tap 8 turns from center-tap.	36 turns No. 16 Enam. 3-in. long, 2-in. dia. Center-tapped.
160 Meters	70 turns No. 24 Enam. 1½-in. dia. Close wound. Center-tapped. Grid tap 12 turns from center-tap.	76 turns No. 20 DCC. 3½-in. long, 2-in. dia. Center-tapped.

OSCILLATOR COIL—16 turns No. 22 D.C.C., 1-in. long, ¾-in. diameter.

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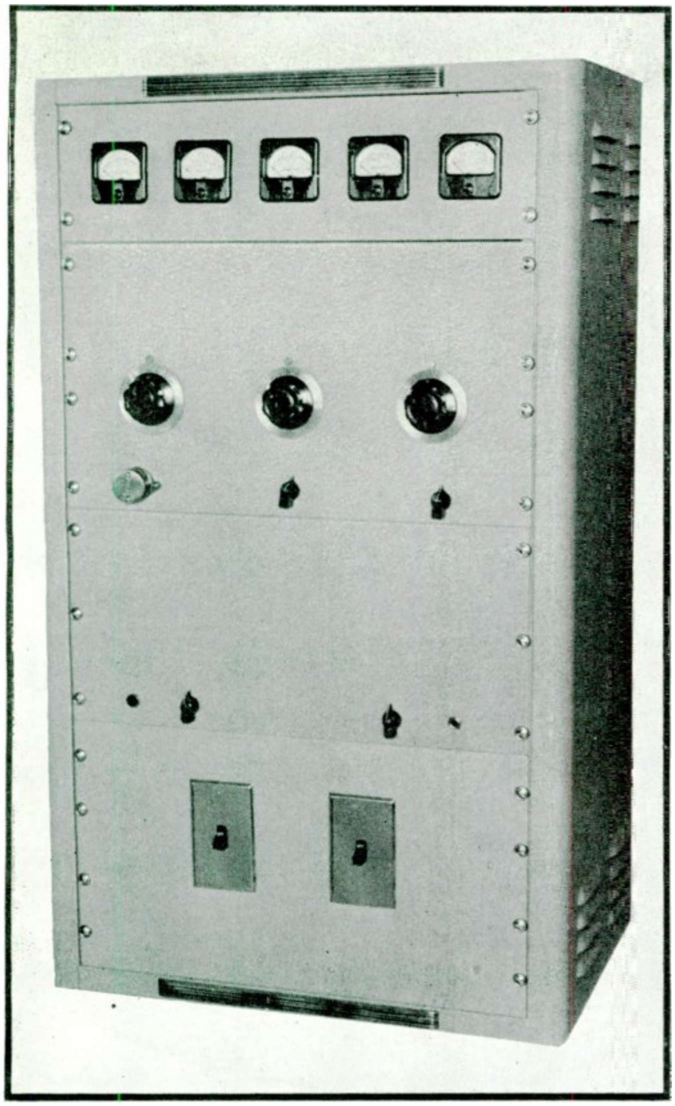

■ A streamlined Bud Radio cabinet houses the transmitter.

■ Rear view, showing complete assembly and cable wiring.

250-Watt HK 54 Cathode-Modulated Transmitter

Excellent design of a cathode-modulated transmitter is shown in the accompanying photographs of a push-pull HK-54 modulated amplifier. The lower deck of the transmitter contains the high-voltage power supply, built on a 12 x 17 x 2 inch chassis, with a 10½ x 19 inch front panel. The power supply delivers ample output to operate the HK-54 buffer and final amplifier for either c.w. or phone communication. The low-voltage power supply and audio system are on the middle chassis, 12 x 17 x 2 inches. The audio channel is similar in every respect to those shown in other transmitters described in this Chapter.

THE complete r.f. channel is built on a single chassis. It consists of a 6C5 untuned *Pierce Oscillator* which drives a 6L6G buffer or doubler. The circuit constants for the 6C5 were chosen so that 160, 80 or 40 meter crystals can be used; these crystals plug into a socket on the front panel. The 6L6G is capacitively-coupled to a neutralized HK-54 buffer or doubler stage, which is operated with extremely high value of grid-leak and cathode-biasing resistors. The final amplifier is capacitively-coupled to the buffer stage and the grid taps are connected toward the center of the buffer plate coil, far enough down to prevent over-excitation to the final amplifier when using cathode modulation. A variable grid-leak provides a means for adjusting the grid excitation for either c.w. or phone operation in any of the five amateur bands. The final plate tuning condenser is shunted by a fixed condenser when the transmitter is operated in the 75 and 160 meter bands. The air-gap of this fixed condenser should be .144-in. The grid circuit includes a 30 mh. r.f. choke in series with the return lead of the smaller r.f. chokes, in order to prevent resonance at low radio-frequencies with the plate r.f. choke. The grid circuit is by-passed for audio frequencies; the degree of grid mod-

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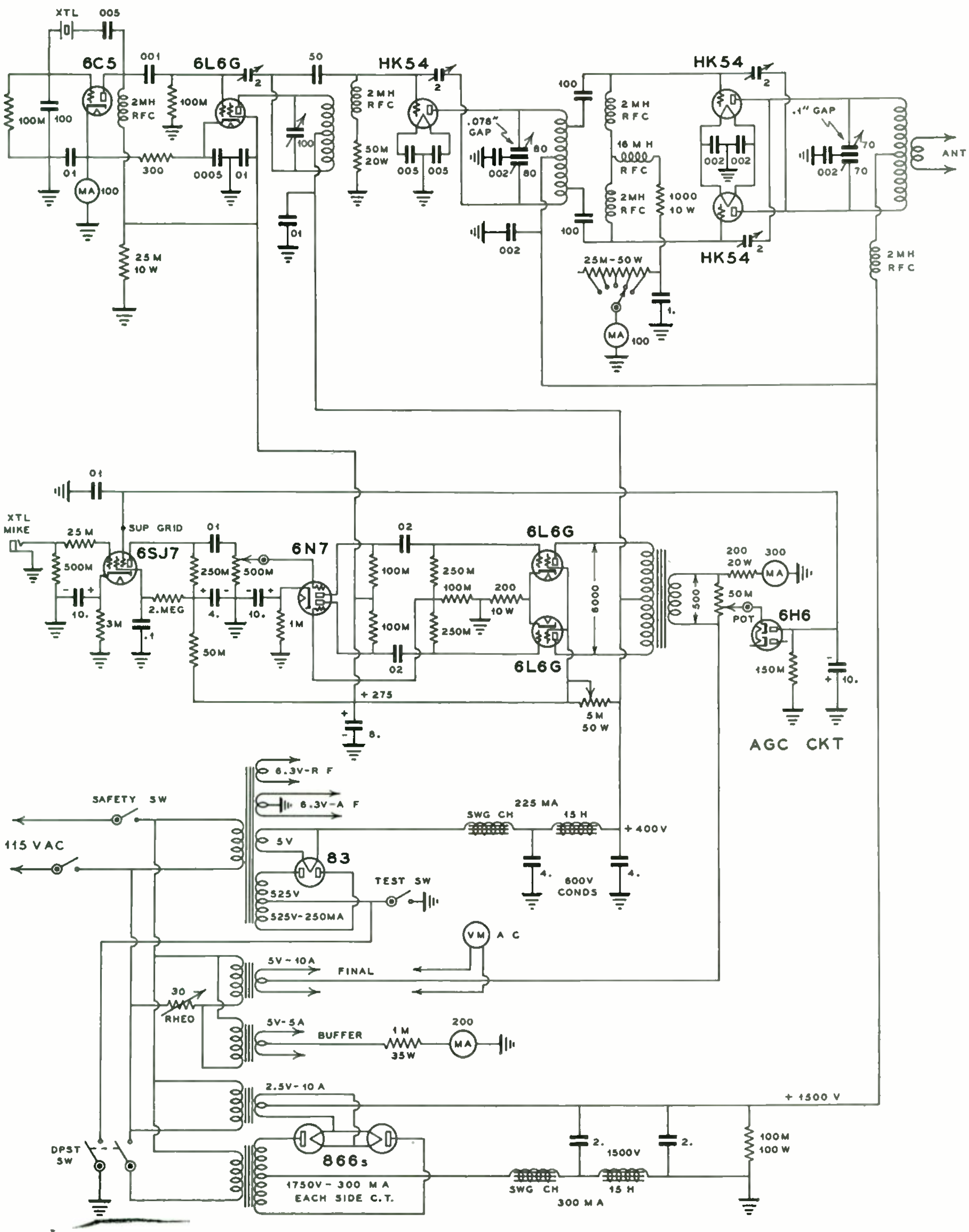

COMPLETE CIRCUIT DIAGRAM FOR 250-WATT HK-54 TRANSMITTER

■ Although the circuit diagram specifies a 70-mmfd. split-stator tuning condenser in the final r.f. amplifier, an additional shunting condenser of 50-mmfd. should be used for 75 and 160 meter operation in order to provide a better circuit "Q". The 25,000 ohm 50 watt tapped grid resistor in the grid circuit of the final r.f. amplifier is an Ohmite "Multivolt", connected to a Yaxley switch. Transformers required are the following: UTC S40 and S49 plate transformers, each one; 1 UTC CM16 or S20 modulation transformer; UTC S54, S57, S59 filament transformers, one each. UTC S31, S32, S33, S34 filter chokes, one each.

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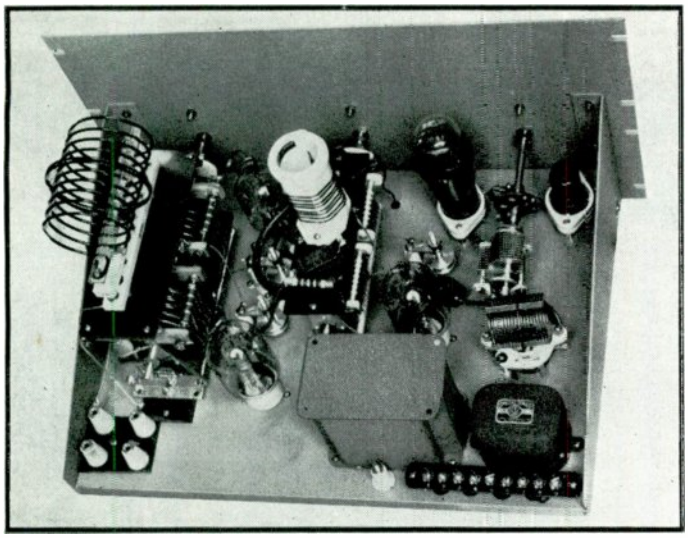


■ Oscillator, buffer-doubler and final r.f. amplifier deck. Note insulators for mounting additional fixed plate tuning condenser for 75 and 160 meter operation.

ulation, however, is limited by connecting a 1,000 ohm fixed resistor in series with the audio-frequency circuit.

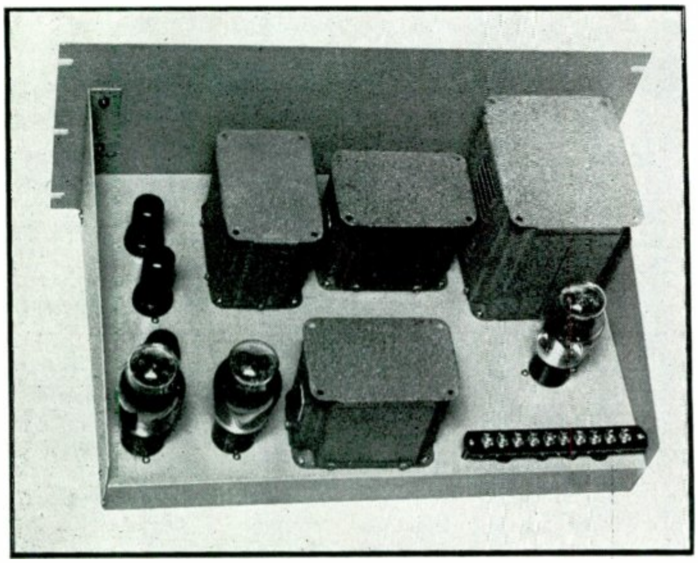
The cathode impedance of the final amplifier ranges from 500 to 700 ohms, depending upon the antenna load, and thus the modulation transformer can be connected permanently to the 500 ohm taps. The plate-to-plate impedance of the 6L6G modulator stage can be any value from 5,000 to 7,000 ohms.

The grid-to-plate capacity of the HK-54 triodes is so low that the neutralizing condensers can be very small; two 1-in. dia. plates, spaced a little more than 1/8-in. apart, will prove satisfactory. The 6L6G tubes can be neutralized with condensers of similar size.

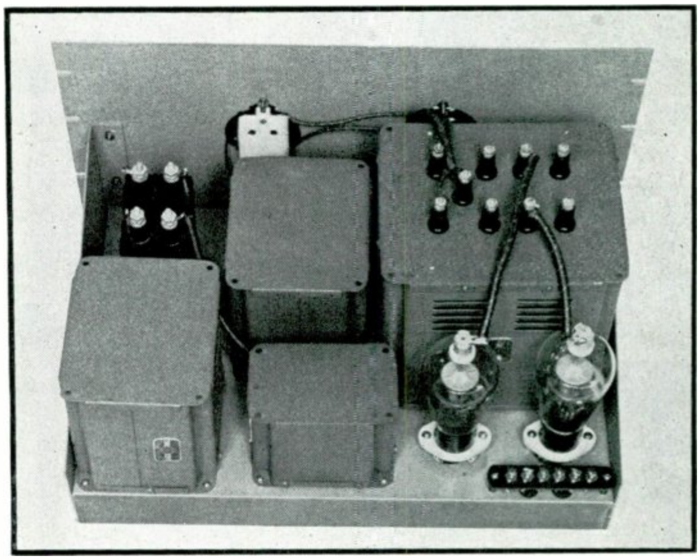
THIS transmitter under test, with 290 watts input and 180 watts carrier output, has an efficiency of 62%. The linearity of modulation, up to nearly 100 percent, is excellent when viewed on an oscilloscope. As much as 200 watts of carrier output can be obtained by slightly overloading the final amplifier tubes. The cathode current of the 6C5 and 6L6G tubes ranges from 40 to 60 ma., depending upon whether the 6L6G operates as a buffer or doubler. The cathode current of the HK-54 is from 30 to 40 ma. for buffer service, and approximately 60 ma. when operating as a doubler. Grid current in the final amplifier for voice operation should be some value between 15 and 20 ma. The antenna should be coupled to the final tank coil in such a manner that the cathode current will be from 175 to 200 ma. in the final amplifier.

Coil Winding Data For HK-54 Transmitter

BAND	6L6G STAGE	HK-54 BUFFER CERAMIC COIL FORMS	FINAL PLATE COIL
10 Meters		5 turns No. 16 Enam. 1¾-in. dia. 2-in. long. Center-tapped, also tapped 1-in. from end.	4 turns No. 8 Enam. 2¼-in. dia. 3-in. long. Center-tapped.
20 Meters	8 turns No. 18 Enam. 1½-in. dia. 1½-in. long. Center-tapped.	10 turns No. 16 Enam. 1¾-in. dia. 2-in. long. Center-tapped, also tapped 2 turns from end.	10 turns No. 10 Enam. 2½-in. dia. 3½-in. long. Center-tapped.
80 Meters	27 turns No. 20 DCC. 1½-in. dia. 1½-in. long. Center-tapped.	44 turns No. 20 DCC. 1¾-in. dia. 2¼-in. long. Center-tapped, also tapped 14 turns from end.	20 turns No. 12 Enam. 3-in. dia. 3-in. long. Center-tapped. Shunted with 50-mmfd. condenser.
160 Meters	55 turns No. 24 DCC. Close-wound. 1½-dia. Center-tapped.	90 turns No. 24 DCC. 1¾-in. dia. Close-wound. Center-tapped, also tapped 27 turns from end.	34 turns No. 14 Enam. 3⅞-in. dia. 3¾-in. long. Center-tapped. Shunted with 50-mmfd. condenser.

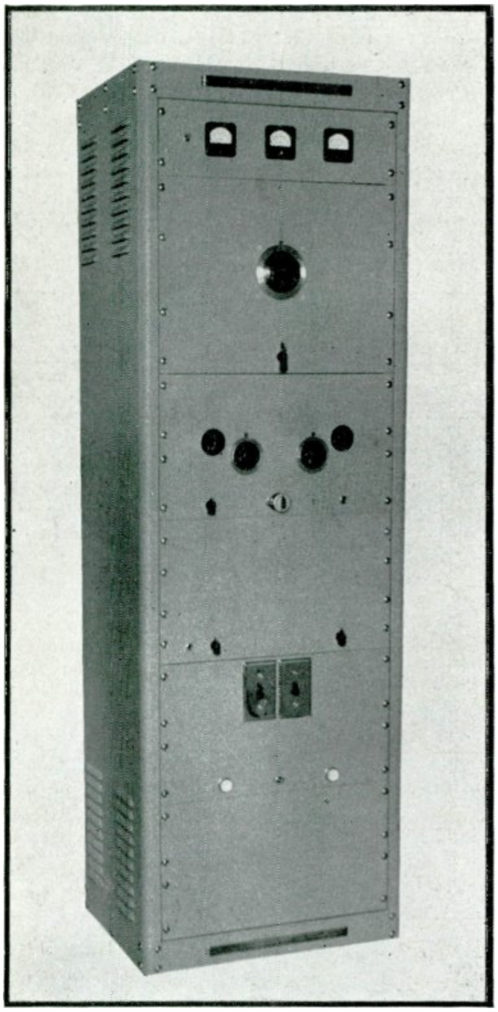


■ Low voltage power supply, speech and modulator components.



■ High voltage supply, with UTC units, for final r.f. amplifier.

World Radio History



■ A Modernistic Bud Metal Cabinet lends beauty and professional appearance to the transmitter.

■ Rear view, showing compactness and small size of components for a high power cathode-modulated transmitter.

High Power Cathode-Modulated Transmitter with Eimac 100TH Push-Pull R.F. Amplifier

AN efficient, well-designed high power cathode-modulated transmitter, rated at from 500 to 700 watts input is illustrated in the accompanying photographs.

At its conservative input rating of 500 watts, the carrier output will be 300 watts, with normal plate loss of 100 watts per tube. It is possible to operate the 100TH tubes with considerably higher plate dissipation when cathode-modulated, and the carrier output will then be more than 400 watts. Power supply components are the standard, low-priced *U.T.C.* amateur series, rated to supply a maximum output of approximately 750 watts. Since the power input is limited to this value by the rating of the power supply, it was not found desirable to use type 250TH tubes in the final amplifier.

The r.f. exciter consists of a T-21 harmonic crystal oscillator with a *BUD* band-switching coil unit in the plate circuit. This coil-switching unit enables the transmitter to operate with 10, 20, 40, 80 and 160 meter crystals—or the plate circuit can be tuned to twice the crystal frequency when 80 and 160 meter crystals are used. The T-21 is similar to a 6L6G tube, with the exception of the base, which is a 6-prong isolantite. The crystal oscillator drives a 35T buffer or doubler stage which, in turn, is capacitively-coupled to the final amplifier. The 35T stage incorporates a 100-watt *BUD* band-switching coil unit, which allows the plate circuit to be tuned to any band from 10 to 160 meters. The r.f. excitation to the final stage is controlled, to some extent, by means of a tapped 50,000 ohm grid-

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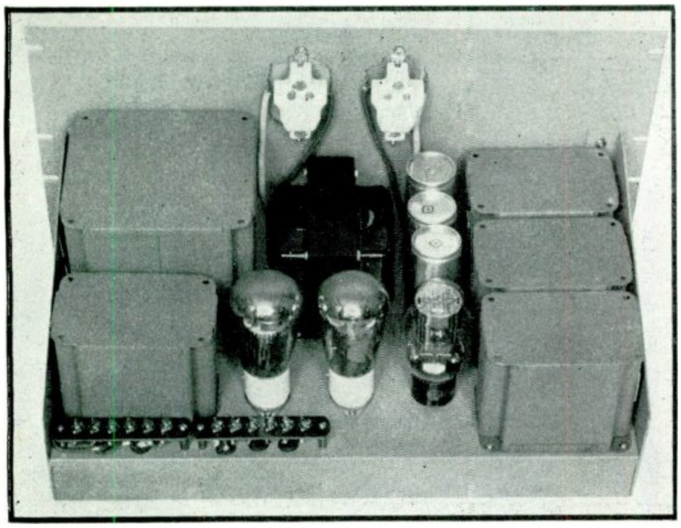
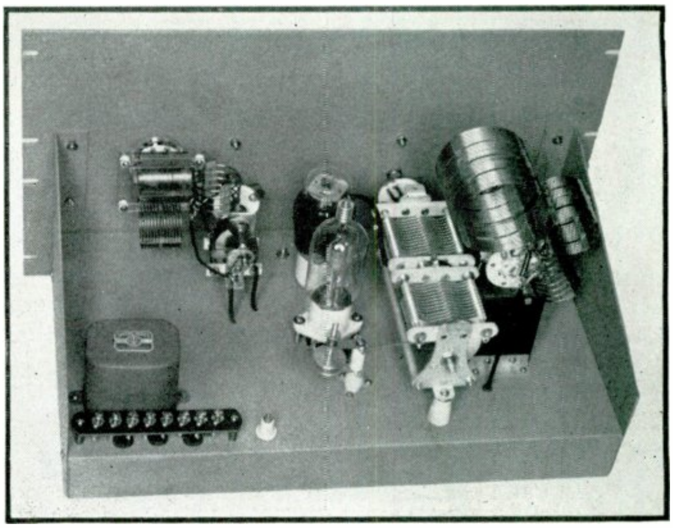


■ Power supply components for buffer-doubler and TZ20 modulator. 866-Jr. rectifier tubes are used. Chassis is 10x17x2 in.



■ Oscillator and buffer-doubler with Bud Radio band-switching units in both stages. Filament transformer is on same deck.

leak in the grid circuit of the 35T stage. A 6-point *YAXLEY* tap switch on the front panel of the transmitter provides a convenient and necessary means for adjusting the r.f. excitation to the final amplifier.

A few turns of wire must be removed from each of the 10 meter coils in the exciter coil-switching unit. The 100 watt coil-switching unit is mounted between a pair of bakelite subpanels, placed so that the leads to the tuning condenser in the 35T stage are very short and direct.

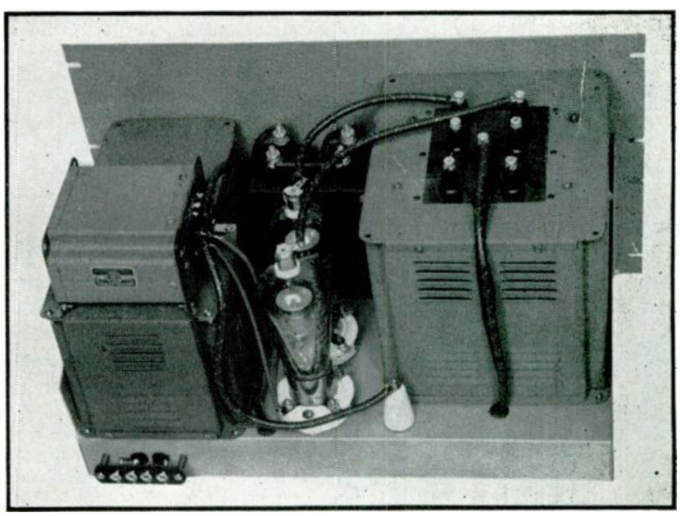
The 35T stage is coupled to the push-pull 100TH amplifier through a pair of 50-mmfd. double-spaced midget variable condensers. These condensers can be set to approximately 30-mmfd., in which case the grid excitation will be nearly constant for the various bands of operation. Adjustment of the grid-leak switch in the 35T circuit will then provide a means for obtaining the same value of d.c. grid current in the final amplifier for each band of operation. This tapped grid-leak in the final amplifier also makes it simple to change from c.w. to voice operation, and it is likewise an aid in reducing the grid current to the desired value for 'phone operation. The d.c. current will vary between 10 and 25 ma. for 'phone operation, depending upon the amount of power used in the plate circuit. It is possible to operate with even lower values of grid current, because the plate voltage is relatively high.

Plug-in coils are used in the final amplifier only. The L/C leads are extremely short, and the neutralizing condensers are attached directly to the *A-B* "propeller-type" plate tuning condenser. The neutralizing condenser disks have a diameter of 2-inches each.

The variable grid coupling condensers are mounted on "through-type" insulators supported on the under-side of the final amplifier chassis. Leads from these condensers connect to the two stators of the plate tuning condenser in the 35T stage. The grid coupling condensers are double spaced and have a capacity of 50-mmfd. each.

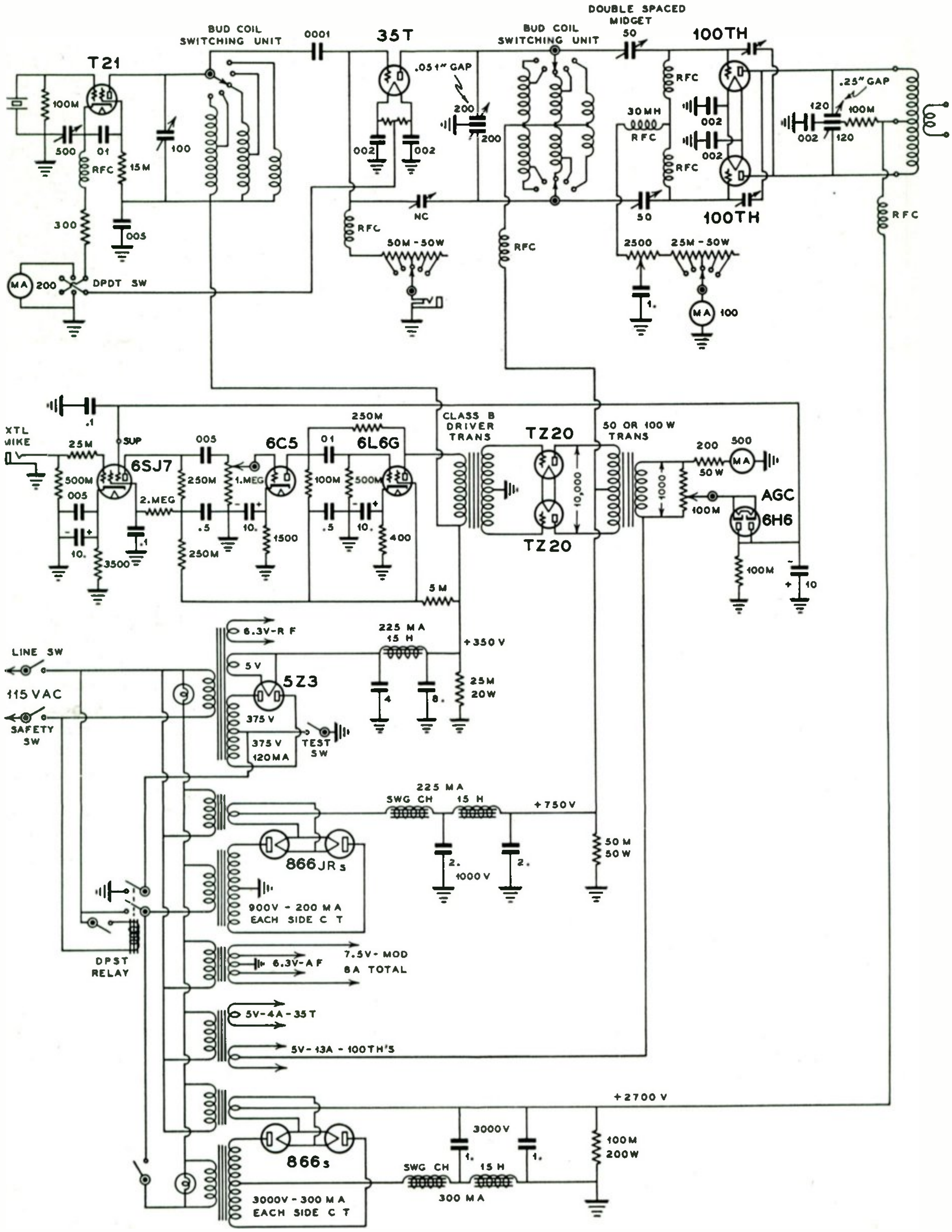
Audio Channel

THE audio channel consists of a 6SJ7 input stage for connection to a high impedance dynamic, or crystal microphone. The suppressor-grid of this tube is connected back to a 6H6 diode in an automatic gain control circuit. The adjustments of this AGC circuit are the same as those described for other AGC circuits in this Chapter. The 6SJ7 is resistance-coupled to a 6C5 triode which, in turn, is resistance-coupled to a 6L6G driver stage. The latter uses inverse feed-back in order to reduce its plate circuit impedance for service as a Class-B driver. The modulator uses a pair of TZ-20 zero-bias tubes, which operate from the same 750 volt power supply that furnishes plate current to the 35T buffer stage. The modulator has sufficient output to overmodulate the final r.f. amplifier and it is therefore



■ High voltage supply for final r.f. amplifier—on one chassis.

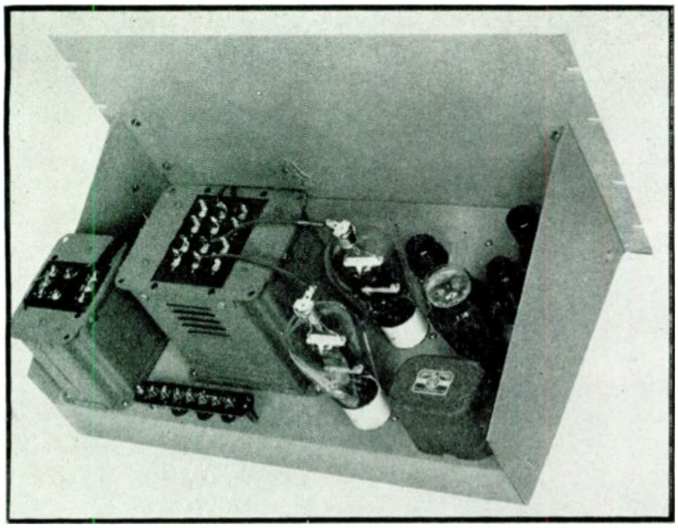
World Radio History



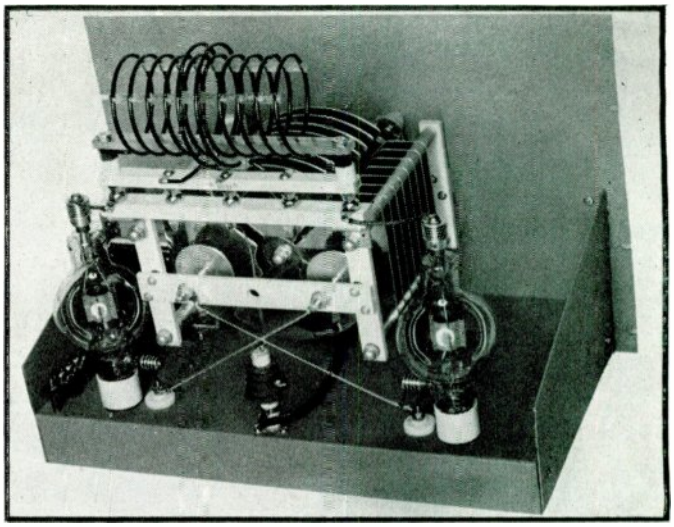
COMPLETE CIRCUIT DIAGRAM FOR EIMAC 100TH TRANSMITTER

■ Parts required for the power supplies are as follows: Power transformers—1 each, UTC R4, S45, S50. Modulation transformer: UTC S21 or UTC CM-17 (either is satisfactory). Filter Chokes: two UTC S31, one each UTC S32, S33, S34. Filament transformers: 2 UTC S57, and one each UTC S54, S59, S61. The Class-B driver transformer is a UTC S8. The tapped grid resistors in the buffer-doubler and final r.f. amplifier stages are Ohmite "Multi-volts," connected to Yaxley rotary switches.

World Radio History



■ This photograph illustrates the small modulator components required for high power cathode modulation. The speech stage is designed for crystal microphone input. The microphone used for testing this transmitter was an Astatic Model JT-30.



■ Final r.f. amplifier with A-B propeller-type plate tuning condenser and Eimac 100TH triodes. The tube leads are equipped with heat-dissipating disk connectors. Rotor and stator plates of the tuning condenser must be insulated from the panel.

possible to use this excess power to increase the proportion of plate modulation with respect to grid modulation, by increasing the secondary load impedance of the modulation transformer. When this load impedance in the cathode circuit of the modulated stage is increased, it is then necessary to decrease the degree of grid modulation by connecting the 1-mfd audio by-pass condenser to the point on the 2,500 ohm resistor nearest the 25,000 ohm tapped grid-leak. The final amplifier operates with a combination of grid-leak and cathode-resistor bias.

■

THREE power supplies are needed for the complete transmitter. A small 375 volt, each side of center-tap, 120 ma. transformer furnishes approximately 350 volts d.c. for the crystal oscillator and speech amplifier stages. A 900 volt, each side of center-tap, 200 ma. d.c. transformer furnishes approximately 750 volts for the 35T r.f. buffer and Class-B modulator stages. The final r.f. amplifier transformer is rated at 300 ma. d.c., at 3,000 volts each side of center-tap.

All chasses are 10 x 17 x 2 inches, although larger sizes could be used to advantage for the high power supply and final amplifier decks. All of the front panels, except those for the final amplifier and meters, are 10½ x 19 inches.

Coil Data

COILS for this transmitter are standard *Bud Radio,* plug-in type. Heavy duty 1-kilowatt coils should be used in the final r.f. amplifier for 10, 20, 40 and 75 meter operation. The *A-B* propeller type condenser in the final r.f. amplifier does not have sufficient capacity for tuning over the 160 meter band; for this reason it will be necessary to shunt an *Eimac* high voltage vacuum type condenser of fixed capacity across the *A-B* propeller condenser. The physical size of this *Eimac* condenser is small, and it can be mounted directly to the framework of the main tuning condenser. The buffer-doubler stage is equipped with a standard 100 watt *Bud* coil switching unit for operation in any of the amateur bands. The smaller 50 watt *Bud* coil switching unit in the oscillator stage should have its 10 meter coil reduced to three turns.

Current Readings

CURRENT readings for the various stages of this transmitter are as follows: oscillator—60 ma., 35T buffer—40 to 75 ma., final grid current—20 ma., or less, if lower output is desired; final cathode current—250 ma.

CONCLUSION

THE numerous cathode-modulated transmitters described in this Chapter employ various types of oscillators, several forms of bias adjustment, different methods for exciting the grid circuit of the final r.f. amplifier, and variations in circuit design for speech amplifiers and modulators. For this reason, the reader should familiarize himself with all of the newer circuit modifications before attempting to build a cathode-modulated transmitter. Space does not permit duplication of such details as tuning, neutralization, parasitic suppression, grid-bias control, antenna coupling, etc.—yet these are treated, wholly or in part, in every descriptive article in this Chapter.

World Radio History

New UTC Cathode Modulation Transformers

SPECIFIED BY FRANK C. JONES

New UTC units employing special secondary taps to effect perfect matching with minimum audio power requirements.

UTC modulation transformers were chosen by Frank C. Jones for use in the cathode modulation circuits because of their unprecedented value and excellent operating characteristics. Frank C. Jones specifies in his engineering data that a 500 ohm secondary impedance, as in the standard Special Series units, is GENERALLY satisfactory for AVERAGE purposes.

Through additional research with Mr. Jones, UTC has developed the new CM type modulation transformers with special taps, arranged so that even better impedance matching is obtained for cathode modulation. These new impedances, ranging from 300 to 2,000 ohms, just developed by UTC, assure lower audio power requirements. With perfect matching only 5% of the RF power input need be available from the audio modulator for full modulation. The three new CM modulation transformers are described below:

UP TO 200 WATTS RF INPUT

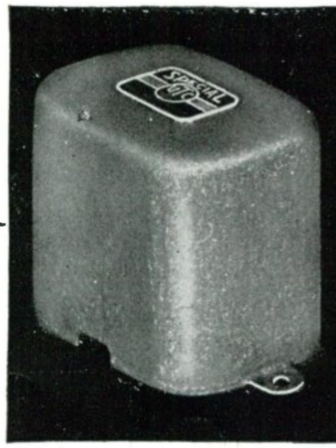
Type CM-15 cathode modulation transformer, tapped secondary 300 to 2,000 ohms, will handle 15 watts audio.

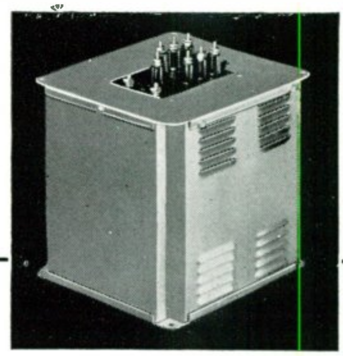
Net Price **$2.40**

UP TO 500 WATTS RF INPUT

Type CM-16 cathode modulation transformer with variable tapped secondary 300 to 2,000 ohms, audio power 35 watts.

Net Price **$3.30**





UP TO 1 KW RF INPUT

Type CM-17 cathode modulation transformer, tapped secondary impedance 300 to 2,000 ohms, for modulating 1 KW plus RF input. This transformer handles 100 watts audio power.

Net Price **$7.20**

Insist that your dealer sells you the new JONES APPROVED UTC Special Series modulation equipment. Enclosed in the carton with each type CM modulation transformer you will find a UTC chart that gives the correct values for accurately matching the impedance of the cathode circuit. UTC cuts the cost of the Jones' economy method of modulation still further with these new more efficient transformers . . . THE ONLY TRANSFORMERS AVAILABLE, SPECIFICALLY DESIGNED FOR CATHODE MODULATION.

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A COMPLETE LINE of UTC TRANSFORMERS and KITS FOR CATHODE MODULATION

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The new Jones Cathode Modulation System takes the high cost out of radio telephony. The combination of this new low cost modulation system and UTC low cost transformers sets a new high in transmitter value per dollar. Now you can get your voice on the air cheaply, effectively, and in the most modern manner. Cathode Modulation enables you to use low power at negligible cost for modulator equipment . . . or high power at low cost. Unprecedented value in amplifier kits and power supplies for RF and AF units is effected through the use of UTC Special Series units.

RF POWER SUPPLY COMPONENTS

Cathode modulation takes the high cost out of Radio Telephony, and UTC takes the high cost out of transformers for cathode modulation. Now you can get your voice on the air cheaply, effectively, and in the most modern manner. Cathode modulation enables you to use low power at negligible cost for modulator equipment... or high power at low cost. UTC "Special Series" transformers set a new precedent in transformer value.

UTC POWER TRANSFORMERS for RF AMPLIFIER SERVICE

RF POWER INPUT	UTC TRANSFORMER	NET PRICE
2,600 v. 300 ma.	S-50	$12.90
1,500 v. 300 ma.	S-49	$10.80
1,000 v. 200 ma. (condenser input)	S-46	$5.70
400 v. 250 ma.	S-31	$2.10

UTC BIAS TRANSFORMERS for HIGH-POWER TRANSMITTERS

C-Bias Supply Transformer, 75-400 volts, UTC S-52 .... Net $4.20

Filter chokes for above transformer, S-31, S-32 .... Net Each $2.10

UTC FILAMENT TRANSFORMERS

5v. 13 amps. UTC S-59	Net $2.10
5v. 22 amps. UTC S-60	Net $4.50
7.5v., 6.3v. 8 amps. UTC S-61	Net $2.10
10v. 10 amps. UTC S-62	Net $2.40

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For 2,600 v. 300 ma. supply, UTC S-33, S-34 .... Net Each $3.00

For 1,500 v. 300 ma. supply, UTC S-33, S-34 .... Net Each $3.00

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For 400 v. 250 ma. supply, UTC S-31, S-32 .... Net Each $2.10

STANDARD TRANSFORMERS for CATHODE MODULATION

UTC standard Special Series transformers, having a 500 ohm secondary plus variable voice coil winding, were originally used by Frank C. Jones for his cathode modulation units, and effect ideal simple modulation.

UP TO 100 WATTS RF INPUT

The S-15 modulation transformer is an ideal standard unit to modulate RF input up to 100 watts .... Net Price $2.10

UP TO 250 WATTS RF INPUT

The S-16 modulation transformer is suitable for the popular 200-250 watts RF input transmitter .... Net Price $2.85

UP TO 1000 WATTS RF INPUT

The S-21 varimatch modulation transformer will modulate 1 KW RF input. Maximum audio power 110 watts .... Net Price $6.00

S-25C

The S-25C audio amplifier has been designed specifically for the high power modulator field. This unit employs 6L6 tubes in the output stage to obtain 25 watts of undistorted power, sufficient for modulating up to 500 watts RF input. The circuit is simple but highly efficient, effecting sufficient gain in three stages to operate from crystal or similar microphones. The tone and volume controls are mounted with the dual high impedance, high and low gain input jacks on one etched panel. A universal output plug is provided on the back of the chassis. The power supply is unusually rugged and employs a two-section filter for optimum regulation and hum reduction. The kit is supplied with CM-16 output transformer. The tubes required are one 6J7, one 6C5, two 6L6's and one 83. The S-25C kit is supplied completely mounted, ready to wire, less tubes, including all components, accessories, dust cover, etched plate, etc. Size 17" long x 7" wide x 9¼" high. Weight 32 pounds. Net Price $30.00

S-15C same as S-25C but 15 watts output (CM-15 output transformer) Net Price $24.00

S-100C

The S-100C audio amplifier is an ideal inexpensive unit for amateur use. Four highly efficient stages are employed, permitting crystal, microphone input and 100 watt undistorted output. Four 6L6 tubes are employed in the output stage for maximum tube economy and minimum plate potential. Fixed bias is employed on the output stage, permitting peak power handling ability appreciably over the normal rating. A modern etched panel sets off the attractive appearance of the gray crinkle cabinet. Tone and volume controls are provided. High impedance, high or low gain, dual input is arranged using standard jacks. A CM-17 modulation transformer is employed to effect maximum flexibility for cathode modulating any RF stage up to 1 KW. Tubes required are one 6J7, one 6C5, two 6F6's, four 6L6's, three 83's. The kit is supplied completely mounted, ready to wire, less tubes and dust cover, including all components, accessories, etched plate, etc. Size, less cabinet, 17" long x 12" wide x 9¼" high; with cabinet, 18" long x 13" wide x 12½" high. Weight 59 pounds. .... Net Price $52.50

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Cathode modulation takes the high cost out of Radio Telephony. Now you can get your voice on the air cheaply, effectively, and in the most modern manner. Cathode modulation enables you to use low power at negligible cost for modulator equipment . . . or high power at low cost. UTC "Special Series" transformers for Cathode Modulation set a new precedent in transformer value.

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UTC standard Special Series transformers, having a 500 ohm secondary plus variable voice coil winding, were originally used by Frank C. Jones for his cathode modulation units, and effect ideal simple modulation.

UP TO 100 WATTS RF INPUT

The S-15 modulation transformer is an ideal standard unit to modulate RF input up to 100 watts .... Net Price $2.10

UP TO 250 WATTS RF INPUT

The S-16 modulation transformer is suitable for the popular 200-250 watts RF input transmitter .... Net Price $2.85

VARIMATCH

The S-21 varimatch modulation transformer can be used for plate or Cathode Modulation. Maximum audio power 110 watts. Net Price $6.00

UTC

POWER TRANSFORMERS for RF AMPLIFIER SERVICE

RF Power Input	UTC Transformer	Net Price
2,600 v. 300 ma.	S-50	$12.90
1,500 v. 300 ma.	S-49	10.80
1,000 v. 200 ma. (condenser input)	S-46	5.70
400 v. 250 ma	S-31	2.10

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BIAS TRANSFORMERS for HIGH-POWER TRANSMITTERS

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Filter chokes for above transformer, S-31, S-32. Net Each $2.10

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FILAMENT TRANSFORMERS

5v. 13 amps. UTC S-59 Net $2.10

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7.5v., 6.3v. 8 amps. UTC S-61 Net $2.10

10v. 10 amps. UTC S-62 Net $2.40

UTC

FILTER CHOKES

For 2,600 v. 300 ma. supply, UTC S-33, S-34 Net Each $3.00

For 1,500 v. 300 ma. supply, UTC S-33, S-34 Net Each $3.00

For 1,000 v. 200 ma. supply (Condenser Input), UTC S-31 .... Net $2.10

For 400 v. 250 ma. supply, UTC S-31, S-32 Net Each $2.10

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EDITED BY FRANK C. JONES

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Filament, volts	5.0
Filament, Amps.	7.5

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257

PRICE $22.00

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BY the simple process of consistently using Simpson Panel Instruments in his cathode modulation circuits, Frank C. Jones has placed the stamp of highest authority on Simpson Instruments in the most direct and forceful way.

The Simpson D'Arsonval movement with its bridge type construction and soft iron pole pieces gives every Simpson Instrument the *lasting accuracy* that exacting technicians demand. It is a movement in which the best basic design and construction is carried out with a precision that sets new standards for instrument quality.

Yes, Simpson Instruments have rapidly become the first choice of the most critical users of instruments—men who place merit first and price second. But the remarkable fact remains that they actually *cost no more than the ordinary run of instruments.*

Typical Simpson Panel Instruments and Testing Equipment are illustrated and briefly described here. Every detail of these instruments is held to the same standard that is found in the Simpson movement. Simpson Instruments are not only the most beautiful to behold. They are also the most beautiful in design, workmanship and on-the-job performance. Ask for complete descriptions. See them at your jobber's.

Typical Simpson Panel Instruments

R. F. AMMETERS—Internal, thermo-couple radio frequency ammeters (1, 1½, 2, 2½, 3 or 5 Amps)
Your net price.. **$4.67**

HIGH RANGE VOLTMETERS—D.C. plate voltmeters, complete with external resistors, (1,000 - 1,500 - 2,000 - 2,500 - 3,000 or 4,000 volts). Your net price.......................... **$9.07**
(5,000 volt range $12.00 net)

DECIBEL METERS—Rectifier type volume level indicator [0-10 to +6 db (500 ohm line; 6 M. W.)]
Your net price.. **$8.00**

OTHER OUTSTANDING VALUES ARE: D.C. plate milliammeters (all popular ranges from 0-5 to 0-1,000 milliamps) List $6.35.
Your net price.. **$4.23**

A. C. filament voltmeters (0-10 or 0-15 C.) List price $6.35.
Your net price.. **$4.23**

Illuminated dials for all popular ranges, including 6 V. lamp, 50c net additional.

SIMPSON ELECTRIC CO., 5216 Kinzie Street, Chicago, Ill.

SIMPSON

INSTRUMENTS THAT STAY ACCURATE

TESTING EQUIPMENT THAT SETS ITS OWN STANDARDS—

MODEL 325
GIANT TUBE TESTER

Tests All Tubes—Filament Voltage 1.5 to 120 Volts

• Has handsome, illuminated red, green and black scale on a silver etched dial with full 9-inch meter. Checks each element separately; shorts on dual-sensitivity neon tube. Has jack for noise test. Convenient drawer contains neat tube charts. Meter is reversible for horizontal use. Wings available for rack mounting.
Your price.... **$34.50**

MODEL 320
GIANT SET TESTER

• First set tester with giant (9-inch scale) illuminated dial meter—first with 50 ranges which include nine voltage ranges both A.C. and D.C.; six milliampere ranges; five resistance ranges; four capacity ranges; seven Decibel ranges. Test leads, insulated for 5,000 volts furnished with each tester. Entirely A.C. operated — no batteries needed. Wings are available for rack mounting.
Your Price......... **$37.50**

MODEL 440 "TEST MASTER"

Tests All Tubes—Tests All Circuits. Filament Voltage 1.5 to 120 Volts.

• Makes every tube and set test that can be desired in every branch of servicing. Has screen fluorescence and angle test; hot cathode-leakage neon test; "high sensitivity" neon short check; "good" and "bad" scale, and "noise test". Has six A.C. and D.C. voltage ranges; three resistance ranges; four milliampere ranges; six Decibel ranges. Your price............... **$59.00**

MODEL 260

• The new high sensitivity set tester for television and radio servicing. At 20,000 ohms per volt this instrument is far more sensitive than any other in its price range. Six voltage ranges, both A.C. and D.C. Resistance ranges from ½ ohm to 10 megohms. Current readings from 1 microamp to 500 milliamps.
Your Price......... **$27.50**
(Similar model, No. 215, with 5,000 ohms per volt at $22.85.)

World Radio History

DIRECT CALIBRATED BANDSPREAD on the "HQ-120-X" is unquestionably the greatest operating convenience ever offered the radio amateur. The four main bands, 80, 40, 20, and 10, appear on the dial in megacycles and cover over 310 degrees. This wide spread and "wrist level" placement of the large tuning knob allow effortless tuning. When used with a reasonable amount of precaution, the bandspread dial is accurate to better than 1/10%. Therefore, it is no longer necessary to guess at the frequency of a received signal. In addition to the four calibrated scales (see illustration), the bandspread dial has a 0 — 200 arbitrary scale for calibration and logging in other parts of the tuning range. The main tuning dial is also accurately calibrated in megacycles throughout the entire range of from 31 to .54 mc. (9.7 — 555 meters). Make a note of all the features you have always wanted in a receiver. Then, try an "HQ-120-X" and you will find them all there.

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HAMMARLUND MFG. CO., INC.
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CANADIAN OFFICE: 41 WEST AVE. NO., HAMILTON, ONTARIO

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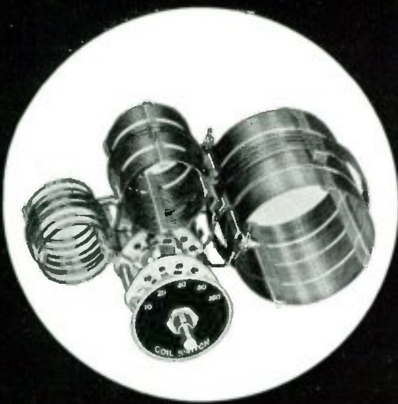
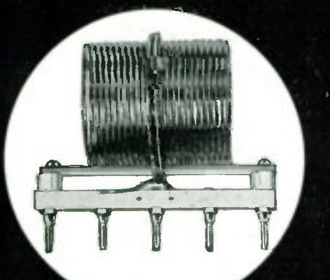
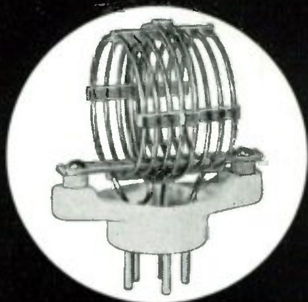
BUD PARTS FB *for* CATHODE MODULATION







Always something new in ham gear for every amateur

This new series of five types of band switching components, for practically any circuit, will give complete coverage of all amateur bands from 10 to 160 meters in an instant. The coils are air wound. Switches have silver plated contacts and Isolantite insulation.

OCS-1—50 watt assembly for pentode oscillator or buffer stages that are capacity coupled to the following stage. List price. $5.50.

XCS-1—100 watt assembly for push-pull grid or plate circuits, or single ended plate circuits where plate neutralization is used. Coils are center tapped and center linked. List price $10.00.

OCS-3—50 watt assembly for use in same circuits and same construction as XCS-1. List price $9.00.

XCS-2—100 watt assembly for single ended plate circuits and single ended grid circuits. All coils are end linked. List price $9.00.

OCS-2—50 watt assembly for use in same circuits and same construction as XCS-2. List price $7.50.

BUD OSCILLATOR and BUFFER coils are air wound inductances mounted on ceramic plug-in bases which fit standard 5 prong sockets. Made for all amateur bands from 5 to 160 meters. Available in either end or center linked types. List price $1.25 to $1.50.

For the Final Amplifier, use BUD VCL 500 Watt coils. A size for each band. List price $2.75 to $4.50 or BUD MCL coils for that kilowatt rig. List price $6.00 to $9.50.

RACKS and CABINETS

There are many sizes and types to choose from in the vast BUD line for every requirement. All designed in modern styling and for sturdy construction. Handsomely finished.

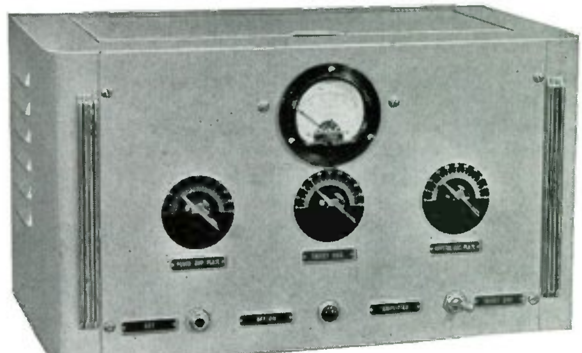
House your equipment in BUD CABINETS and RACKS for added beauty and sturdy protection.

A complete line of associate parts, such as Chassis, Panels, Brackets, Shields, etc., are also available.

WRITE FOR FREE CATALOG CM39

TRANSMITTER KITS

Designed for efficiency, with at least 25 watts output on all bands from 10 to 160 meters. Uses R. K.-25 in Tritet oscillator and two 6L6G's in output stage. Ask for BUD XT-25C transmitter kit. Complete parts, **including** cabinet—$32.00 list. Meter, coils and tubes not included.



XC-25 Kit. Same parts as in XT-25C except supplied with rack mounting panel instead of cabinet. Makes an ideal exciter for amplifiers up to 500 watt input, such as Bud BPA-500 Kit. List $30.00.

BUD RADIO, INC.

BUD

CLEVELAND, OHIO

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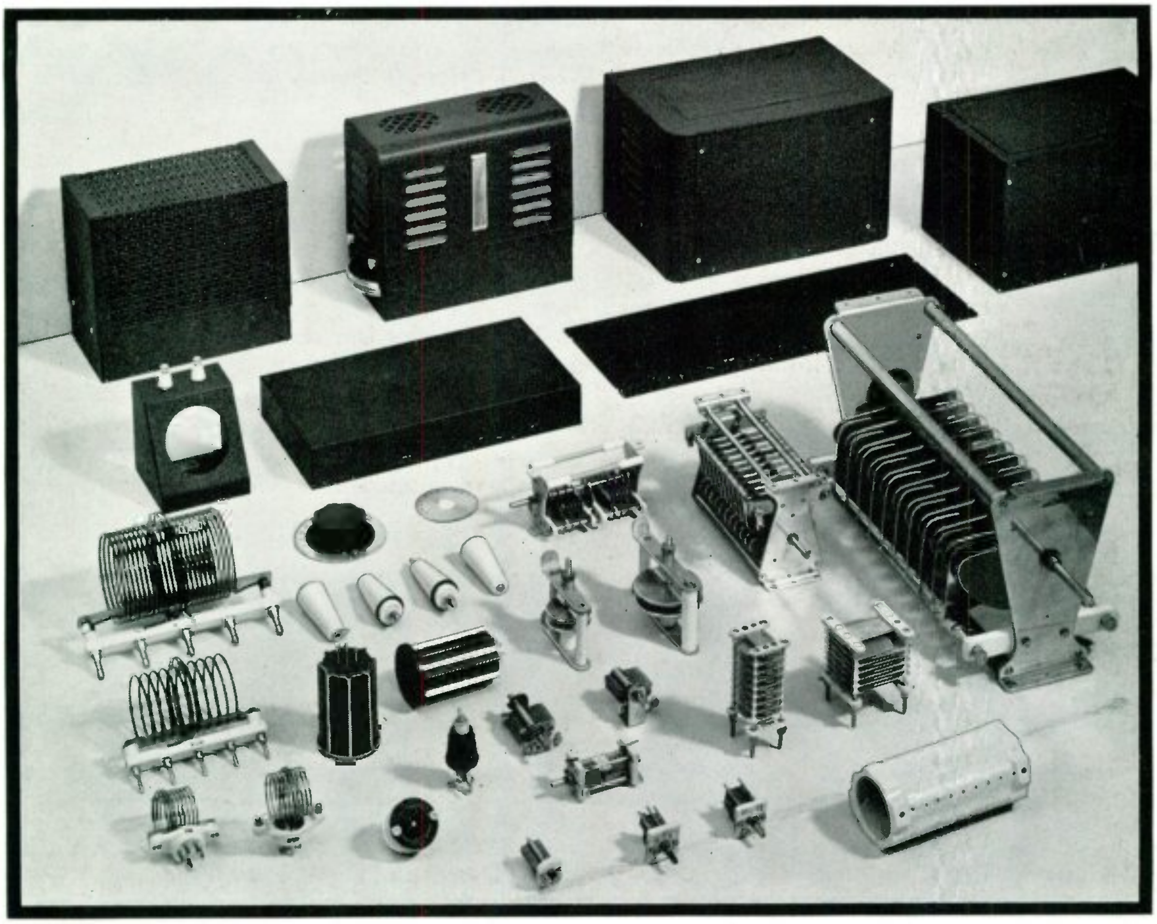
BUD PARTS CHOSEN BY JONES

When a new circuit is published by Frank C. Jones, you can bet your last dollar that it was designed for greater efficiency in operation, simplicity in construction and economy in cost. Frank C. Jones has chosen BUD CONDENSERS, COILS, R. F. CHOKES and other BUD COMPONENTS to assure greater efficiency, their rugged construction, and reasonable cost.

BUD CABINETS were chosen to add the professional appearance and provide proper protection.



CHOOSE WISELY and use BUD PARTS in your rig too.

Buy BUD parts from your radio jobber.

BUD

BUD RADIO, INC.

CLEVELAND, OHIO

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Down goes the cost of Radio Telephony with "HAM-PRICED" items . . .

NEWARK WILL HAVE ALL THE PARTS USED IN ANY CATHODE MODULATED UNIT

A SPECIAL VENTILATED CABINET for CATHODE MODULATED UNITS

Here's a Real Bargain!

Again NEWARK scores with this smash value — proof of NEWARK'S "on their toes" look-out for items of merit for the Amateurs. Here's a black crackle finish heavy gauge Metal Cabinet with hinged top door, 12¼" high, 19" wide, 11½" deep. Just the right cabinet for an FB table model rig or for that mobile job. We guarantee you'll like this cabinet and it's priced at a real saving.

No. PX-1—Complete with front panel to match $2.00

Chassis to fit this Cabinet, 10" x17"x3" .... $.80

Shipping weight 16 lbs.

WHILE THEY LAST. THESE WILL NOT LAST LONG AT THE PRICES.

A COMPLETE LINE of UTC TRANSFORMERS and KITS for CATHODE MODULATION

Now you can get your voice on the air cheaply, effectively, and in the most modern manner. Cathode Modulation enables you to use low power at negligible cost for modulator equipment . . . or high power at low cost. Unprecedented value in amplifier kits and power supplies for RF and AF units is effected through the use of UTC Special Series units.

UTC has developed the new CM type modulation transformers with special taps, arranged so that even better impedance matching is obtained for cathode modulation. These new impedances, ranging from 300 to 2,000 ohms, just developed by UTC, assure lower audio power requirements. With perfect matching only 5% of the RF power input need be available from the audio modulator for full modulation. The three new CM modulation transformers are described below:

UP TO 200 WATTS RF INPUT

Type CM-15 cathode modulation transformer, tapped secondary 300 to 2,000 ohms, will handle 15 watts audio .... Net Price $2.40

UP TO 500 WATTS RF INPUT

Type CM-16 cathode modulation transformer with variable tapped secondary 300 to 2,000 ohms, audio power 35 watts. Net Price $3.30

UP TO 1 KW RF INPUT

Type CM-17 cathode modulation transformer, tapped secondary impedance 300 to 2,000 ohms, for modulating 1 KW plus RF input. This transformer handles 100 watts audio power........ Net Price $7.20

AEROVOX "HYVOL"

Oil-Impregnated and Wax-Filled In Rectanlar Metal Cans

Recommended for use where economy is a necessity. Come complete with Universal Mounting bracket as illustrated.

Type 1011-1000v. D.C.W.

Mfds.	L.W.D.	Net
1	2⅛x1-13/16x1-1/16	$1.08
2	4 x1-13/16x1-1/16	1.47
4	4¾x2½x1-3/16	1.96

Type 1511-1500v. D.C.W.

1	4 x1-13/16x1-1/16	$1.43
2	4¼x2½x1-3/16	1.96
4	4¾x3¾x1¼	3.18

Type 2011-2000v. D.C.W.

Mfds.	L.W.D.	Net
1	3⅜x2½x1-3/16	$1.72
2	4x3¾x1¼	2.40
4	4x3¾x2¼	4.56

Type 3011-3000v. D.C.W.

1	4¼x3¾x2¼	$2.45
2	4¼x3¾x3-3/16	4.85

Your CALL LETTERS in GOLD 10c

Big shadowed decalcomania letters nearly TWO INCHES high. Put them on your HAM SHACK door, auto window, etc. Send dime for yours today. Be sure to give your call letters.

FREE!

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Thousands of items for the Ham. Sets, parts, accessories, and supplies, fully illustrated and described, with lowest prices. Newark's most complete Amateur Radio Catalog.

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- EXCLUSIVELY COMMUNICATION PRODUCTS ASSURES THE LARGEST STOCKS OF ALL LEADING LINES
- A TECHNICAL STAFF THAT UNDERSTANDS YOUR ORDERS AND YOUR PROBLEMS

NEWARK Electric Company
323 W. MADISON ST.
CHICAGO, ILL.

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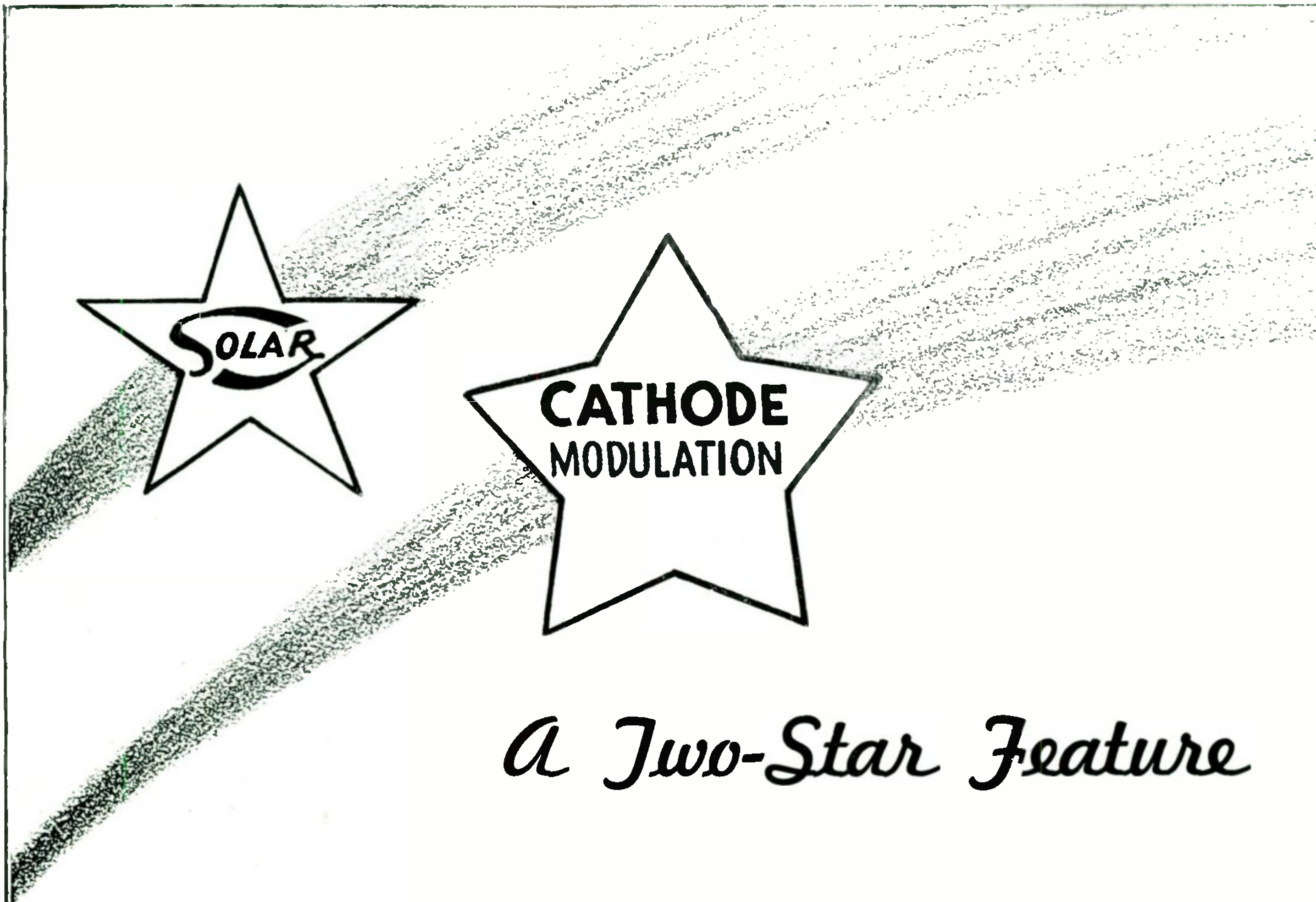

A Two-Star Feature

1. . . . SOLAR CAPACITORS
2. . . . CATHODE MODULATION

The Result — Stellar Performance

**See Reverse Side
of This Page
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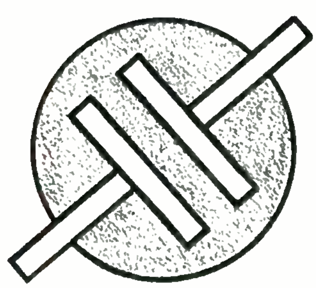
Complete Listing
of SOLAR
CAPACITORS
for
CATHODE
MODULATION**



**Every Time You See
This Symbol in a
Circuit Diagram
by Frank C. Jones,
You Know That a**

SOLAR

**CONDENSER
Is Required**

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CAPACITORS for CATHODE MODULATION

TRANSMICA
TYPE XA

HIGH VOLTAGE
MICA TYPE XM

HIGH VOLTAGE MOLDED
MICA WITH LEADS
TYPE XB

SEALDTITE WAX-MOLDED
TUBULAR PAPER

DOMINO
PAPER CAPACITORS
MOLDED IN BAKELITE

SOLAREX

OIL IMPREGNATED OIL FILLED TRANSMITTING CAPACITORS

Solarex Filter Capacitors are ideal for the advanced amateur and general transmitting use where value is a consideration. Oil impregnated under high vacuum, oil filled and hermetically sealed Solarex are supplied with detachable mounting rings.

Catalog Number	Capacity Mfd.	Dimensions, Inches Diameter	Can Height	List Price
600 D.C. or 440 R.M.S. Rect. A.C. W.V.—1200 Volts D.C. Test				
X-062	2	2	2 3/8	$3.25
X-064	4	2	3 5/8	4.50
1000 D.C. or 660 R.M.S. Rect. A.C. W.V.—2000 Volts D.C. Test				
X-11	1	2	1 7/8	2.75
X-12	2	2	2 5/8	3.75
X-14	4	2	4 1/8	4.75
1500 D.C. or 1000 R.M.S. Rect. A.C. W.V.—3000 Volts D.C. Test				
X-011	1	2	2 5/8	3.50
X-012	2	2	3 5/8	4.75
X-014	4	2 1/2	4 3/8	6.25
2000 D.C. or 1500 R.M.S. Rect. A.C. W.V.—4000 Volts D.C. Test				
X-21	1	2	3 3/8	4.50
X-22	2	2 1/2	3 5/8	5.00
X-24	4	3	4 1/4	7.00
3000 D.C. or 2200 R.M.S. Rect. A.C. W.V.—6000 Volts D.C. Test				
X-31	1	2 1/2	4 5/8	9.00
X-32	2	3	4 1/4	11.00

Send for free copy of Catalog No. 10
listing units approved by Frank C. Jones
for Cathode Modulation circuits

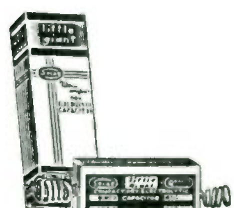
TRANSOIL
RECTANGULAR FILTER
TYPE XL

OIL-FILLED
TYPE XD

OIL-FILLED
TYPE XC

OIL TYPE TUBULAR
TYPE XT

MINICAP
METAL ENCASED
ELECTROLYTIC



LITTLE GIANT
DRY ELECTROLYTIC

SOLAR MANUFACTURING CORPORATION

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Buy from your local jobber

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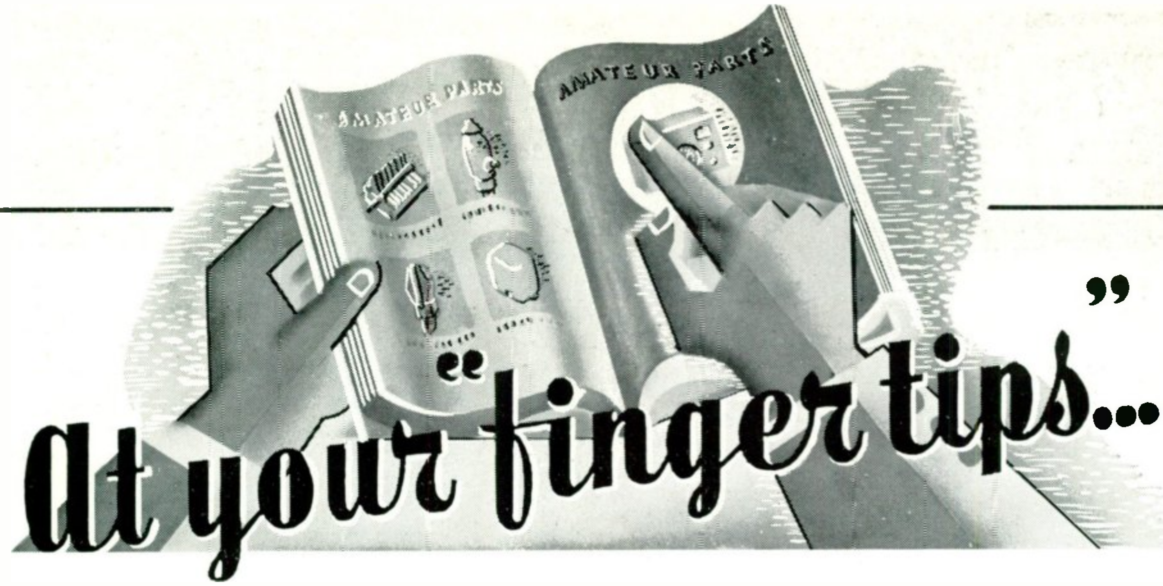

EVERY NATIONALLY ADVERTISED LINE . . . *At Big Savings!*

CATHODE MODULATION takes the high cost out of radio telephony . . . and our new, 1940 catalog shows you component values that will reduce the cost even more . . . You'll have at your finger tips our carefully indexed, easy reference to every desired part. We carry the lines of every recommended manufacturer of Cathode Modulation parts: UTC, Hammarlund, Bud, Ohmite, RME, Astatic, Guthman, RCA, Eimac, Heintz and Kaufman . . .

UTC TRANSFORMERS are particularly suited for this new Cathode Modulation. In fact, units have been SPECIFICALLY DESIGNED for this purpose.

Now you can get your voice on the air cheaply, effectively and in the most modern manner. Use low power at negligible cost for modulator equipment . . . or high power at low cost.

UTC POWER TRANSFORMERS for RF AMPLIFIER SERVICE

RF POWER INPUT	UTC TRANSFORMER
2,600 v. 300 ma.	S-50
1,500 v. 300 ma.	S-49
1,000 v. 200 ma. (condenser input)	S-46
400 v. 250 ma.	S-31

UTC BIAS TRANSFORMERS for HIGH-POWER TRANSMITTERS

C-Bias Supply Transformer, 75-400 volts, UTC S-52.

Filter chokes for above transformer. S-31, S-32.

UTC FILAMENT TRANSFORMERS

5v. 13 amps. UTC S-59.
5v. 22 amps. UTC S-60.
7.5v., 6.3v. 8 amps. UTC S-61
10v. 10 amps. UTC S-62.

UTC FILTER CHOKES

For 2,600 v. 300 ma. supply, UTC S-33, S-34.

For 1,500 v. 300 ma. supply, UTC S-33, S-34.

For 1,000 v. 200 ma. supply (Condenser Input), UTC S-31.

For 400 v. 250 ma. supply, UTC S-31, S-32.

S-15C

15 Watts audio output will modulate up to 300 Watts RF input.

S-25C

25 Watts audio output will modulate up to 500 Watts RF input.

S-100C

For cathode modulating any RF stage up to 1 KWT.

Write for detailed information on the new Cathode Modulation transmitter kits

For a big, FREE, up-to-the-minute and money saving catalog, listing literally thousands of items . . . WRITE NOW

Special sheets listing parts for Cathode Modulation and prices also available.

Radio Wire Television Inc.

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TRANSMITTER CONSTRUCTION

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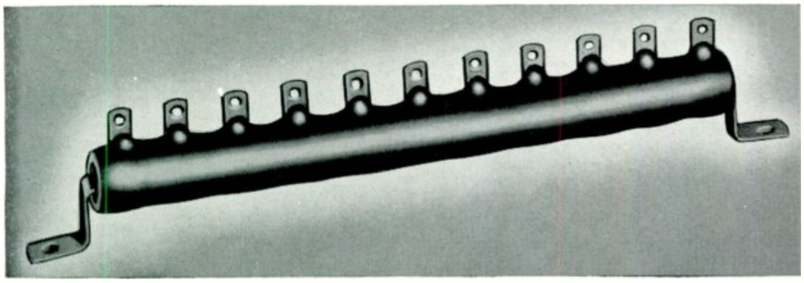
Here's the OHMITE MULTIVOLT RESISTOR exactly as specified by *Frank C. Jones*



For sure-fire Cathode Modulation and economical Radiotelephony

This is the Ohmite Multivolt multi-tap Resistor used by Frank C. Jones in his new system of Cathode Modulation. It's essential in order to secure the proper impedance match of the modulator to the filament or cathode circuit of the final r.f. amplifier. It provides the exact control needed for correct cathode modulation.

★

The Ohmite Multivolt Resistor has ten equal sections. The resistance wire is accurately wound on porcelain core and permanently protected by Ohmite vitreous enamel. It is extra-sturdy and thoroughly dependable.

50 Watt Size

Stock No. 1206—10,000 ohms—List Price $2.15
Stock No. 1209—25,000 ohms—List Price 2.50

You can get them from your Ohmite Jobber.

Ohmite Multivolt Resistors are also handy voltage dividers, etc. They are available in many resistances in 50, 75 and 150 watt sizes.

—and You'll Want These Other OHMITE Parts In Your Rig!

OHMITE DUMMY ANTENNA—to check the output of your transmitter, determine transmission line losses, check line to antenna impedance match, for tuning up to peak efficiency. Built like a vacuum tube. Non-inductive, non-capacitive, constant in resistance.
Model D-100—100 watt rating in 73 ohms and 600 ohms (also in 13, 18, 34, 64, 100, 146, 219, 300, 400, and 500 ohm values). Dia. 3⅛". Ht. 4⅜". List price..........$5.50
Model D-250—250 watt rating, in 73 ohms and 600 ohms. Dia. 2½". Ht. 9". List Price..........$11.00

OHMITE PARASITIC SUPPRESSOR—to prevent u.h.f. parasitic oscillations associated with push-pull and parallel tube circuits. Non-inductive resistor and choke combined in one small, compact unit. **Model P-300.** List Price..........$1.50

OHMITE CENTER-TAPPED RESISTORS—for use across transmitter tube filaments, etc. Resistances from 10 to 200 ohms.
"Wirewatt" 1 watt center-tapped. List Price..........$0.35
"Brown Devil" 10 watt center-tapped. List Price.......... .50

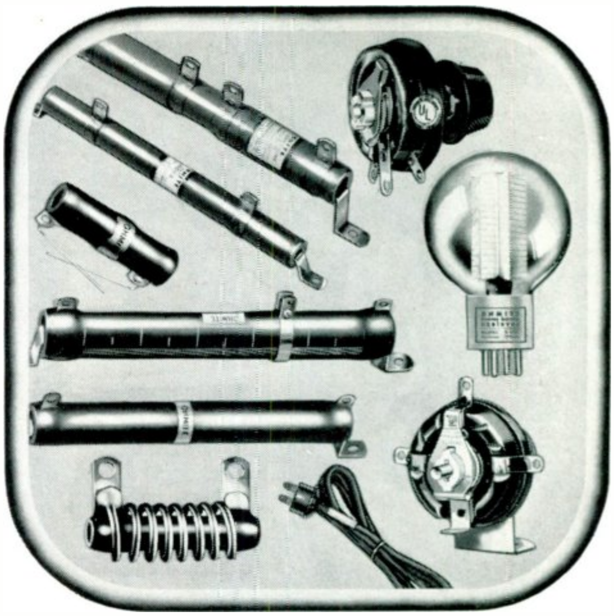
OHMITE BROWN DEVIL RESISTORS—for bleeders, bias units, voltage dropping, etc. Time-proved, extra-sturdy, wire-wound, all porcelain, vitreous-enameled construction.
10 Watt Size— 1 to 50,000 ohms. List Price..........$0.40
20 Watt Size— 5 to 15,000 ohms. List Price.......... .65
20 Watt Size—20,000 to 50,000 ohms. List Price.......... .75
20 Watt Size—55,000 to 100,000 ohms. List Price.......... 1.00

OHMITE DIVIDOHM RESISTORS—easily adjustable to exact resistance, or tapped where needed. Convenient voltage divider. Wire is permanently held in place and insulated by special Ohmite vitreous enamel. Handy percentage of resistance scale. Available in 10, 25, 50, 75, 100, 160 and 200 watt sizes in all standard resistance values.

OHMITE FIXED RESISTORS available in sizes from 25 to 200 watts. *Ask Your Jobber or See Ohmite Catalog 17.*

OHMITE RHEOSTATS—for permanently smooth, close control of tube filaments for best operating efficiency. All-porcelain vitreous enamel construction. Nothing to smoke, char, shrink or shift. Wide Range of Sizes from 25 to 1000 watts in many resistances. *Ask Your Jobber or See Ohmite Catalog 17.*

Also, Ohmite R.F. Plate Chokes and Power Line Chokes, Band Switch, New All-enclosed High Current Power Tap Switches, Cordohms, etc.



Get These Ohmite Parts From Your Jobber. • Send Today for FREE Ohmite Catalog 17.

OHMITE MANUFACTURING COMPANY • 4856 Flournoy Street • Chicago, U.S.A.

Be Right with **OHMITE**

RHEOSTATS • RESISTORS • TAP SWITCHES

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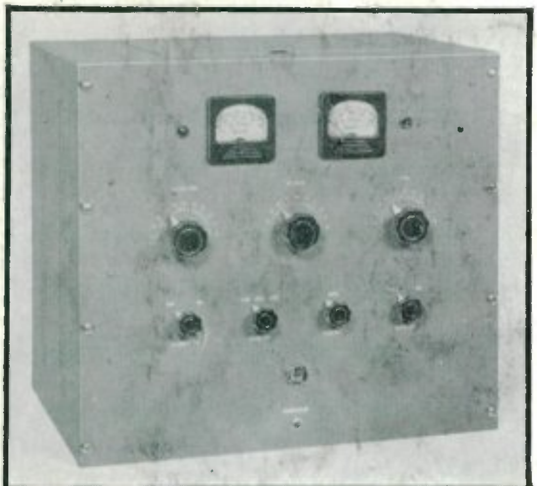
HIGHER OUTPUT—LOWER COST
with *Frank C. Jones* CATHODE MODULATION

HM-170 TRANSMITTER

Frank C. Jones designed this ultra efficient, operating desk size transmitter. **The output on phone is 75 watts fully modulated, and 100 watts on CW.** The quality is equal to high level modulation. The cabinet size is 19 inches wide, 13 inches deep and 17½ inches high.

ECONOMICAL Radiotelephony —at last!



The HM-170 is another custom built "Hughes-Mitchell" product. Each component is of the highest quality and the transformer complement is UTC throughout. The simplicity of operation should be appealing ... no trick controls. The HM-170 is furnished Wired and Tested, with tubes, and coils for one band, less crystal. Additional coils may be had for a small extra charge. Licensed by RCA, of course.

HM-170 TRANSMITTER
$179.50 NET
F.O.B., Los Angeles

"X-EC" Crystal and EC Oscillator Variable Frequency Control

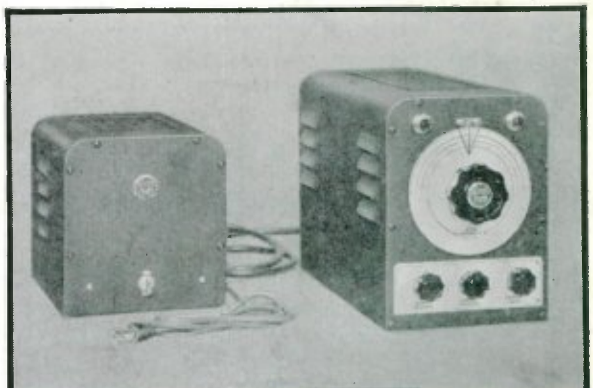
The "X-EC" is not an ordinary electron coupled oscillator for "shifting frequency". It is a definite, absolute method of FREQUENT CONTROL.

The "X-EC" at a Glance:

1. Positive "X-EC" Stability
2. Isolated Power Supply
3. "EC" or "Xtal"
4. RF Isolation
5. No Plug-in Coils
6. Vibration-Free Mounting
7. Regulated Bandspread
8. 40 or 80 Meter Output
9. Calibrated Vernier Dial

The "X-EC" comes to you complete with isolated, well regulated, power supply, shielded connecting cable and a set of RCA tubes. The "X-EC" is furnished wired and tested less crystals for $42.50, net, F.O.B., Los Angeles.

X-EC HM-103
$42.50 NET
F. O. B. Los Angeles



Should you desire to build your own transmitter, remember Radio Television Supply Company, Inc., is the largest parts distributor in the entire West. Quotations gladly given on kits or individual parts.

Descriptive Bulletins Available
HM-170 Transmitter .... No. 25
HM-103 "X-EC" .... No. 22

RADIO-TELEVISION SUPPLY COMPANY, Inc.
1701 So. Grand Ave. Los Angeles, Calif.

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Perfect Portable Power

for Transmitters, Receivers, P. A. Systems with Vibrapack

Mallory Vibrapacks have won top honors with radio operators, engineers and public address men everywhere as the most economical source of plate voltage for battery operated equipment. The Vibrapack line includes types for 6, 12 and 32 volt operation, with outputs up to 60 watts in the new dual units. Send for free booklet giving complete technical data.

P. R. MALLORY & CO. Inc.

MALLORY Transmitting Capacitors

Mallory Transmitting Capacitors are a real safeguard for expensive rigs. Constructed with an exclusive impregnating compound that gives longer life and greater dependability . . . Not a wax . . . not an oil. Its high dielectric constant and unusual heat resistance assures good power factor with extremely stable DC resistance. See your distributor for TX, TR and TZ types.

..*for* Band Switching ..*for* Meter Switching

Here are two Mallory-Yaxley switches that open new operating vistas for amateurs. The push button switch makes it possible to measure a number of circuits with a single meter while other circuits connected remain closed. The HamBand Switch brings new convenience to band switching . . . makes it as easy as receiver band switching. Unique design offers wide range of applications. Write for details.

Other MALLORY-YAXLEY *Products for Amateurs*

Dry Electrolytic Condensers
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Tip Jacks and Plugs
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Jacks and Jack Switches
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Vitreous Resistors
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Radio Convenience Outlets
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Send for complete catalog and separate technical bulletins on Mallory Grid Bias Cells, Vibrapacks, Switches, etc.

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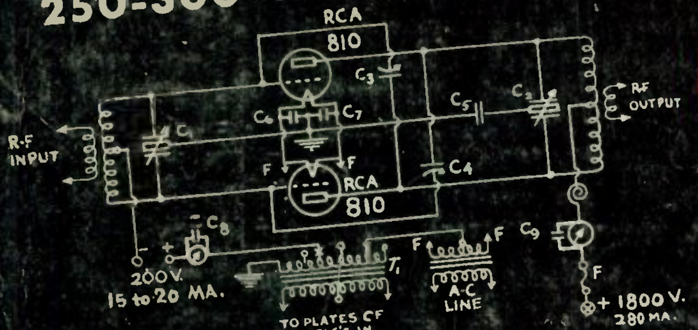
World Radio History

for a 2-Way Saving...

CATHODE MODULATED 810's 250-300 WATTS OUTPUT



$C_5 = .005 \mu f$, 2500 V.
$C_6, C_7 = .001 \mu f$
$C_8, C_9 = .005 \mu f$

$C_1 = 1 \mu\mu f$ /METER/SECTION
$C_2 = 1 \mu\mu f$ /METER/SECTION
$C_3, C_4 = 5 \mu\mu f$ APPROX.
T_1 = 75-WATT MODULATION TRANSFORMER
PLATE-TO-PLATE IMPEDANCE = 3800 OHMS.
SECONDARY CURRENT RATING = 300 MA DC.
SECONDARY IMPEDANCE = 0-3000 OHMS

NOTE: SET CATHODE TAP AT 450 OHMS IMPEDANCE AND GRID TAP AT 40 OHMS IMPEDANCE.

JONES CATHODE MODULATION

Plus

RCA HIGH-PERVEANCE TUBES

When you start out with Jones Cathode Modulation for economical radiotelephony, go *all* the way! Get *double* economy plus extra efficiency by using RCA high-perveance transmitting tubes. RCA Tubes last longer. They give you greater power output with less driving power for a given plate voltage. You can get not only 100% modulation, but also relatively high plate-circuit efficiency and high carrier output with the push-pull 810's shown in the circuit above. The high-perveance of the 810's permits you to obtain optimum results with a low-power, inexpensive modulator such as the push-pull 6L6's shown in this circuit. And remember! A cw transmitter using RCA-810's can be changed over to 'phone cheaply and easily. Grid drive requirements are no greater, and a large, high-power modulation transformer is unnecessary.

In short, RCA's are not only economical in themselves but they pave the way for economies throughout your rig—and assure you of ample power to put your signals "where you want them when you want them!"

Following are ICAS Class C Telephony Ratings on three popular RCA Tubes especially suited for use with the Jones Cathode Modulation system:*

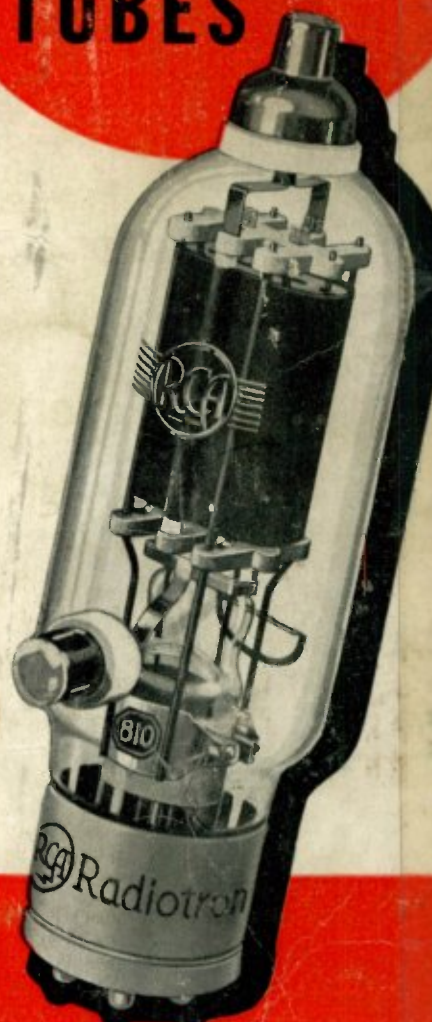
RCA-806—Tantalum-plate triode.
Max. plate voltage . . . . . . 3000 V.
Max. plate dissipation . . . . 150 W.
\$22.00 Amateur Net

RCA-809—High-mu triode.
Max. plate voltage . . . . . . 750 V.
Max. plate dissipation . . . . . 25 W.
\$2.50 Amateur Net

RCA-810—High-mu triode.
Max. plate voltage . . . . . . 1800 V.
Max. plate dissipation . . . . 125 W.
\$13.50 Amateur Net

* *Now!* HIGHER RATINGS ON RCA TRANSMITTING TUBES

Write for bulletin describing the RCA dual-rating system for air-cooled transmitting tubes which makes it possible to choose ratings most closely approximating your own operating conditions. Ratings given above are the new RCA Intermittent Commercial and Amateur Service (ICAS) Ratings and allow ample safety factor under average conditions of intermittent use. The RCA Continuous Commercial Service (CCS) Ratings are naturally somewhat lower, being based on 18 hours a day or more continuous use in the world's most exacting applications.



RCA

RadioTubes

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A Service of The Radio Corporation of America

FIRST IN METAL—FOREMOST IN GLASS—FINEST IN PERFORMANCE

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