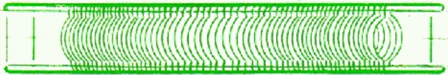
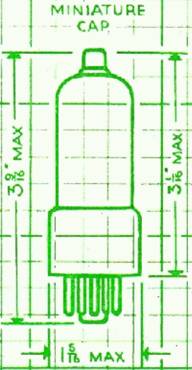
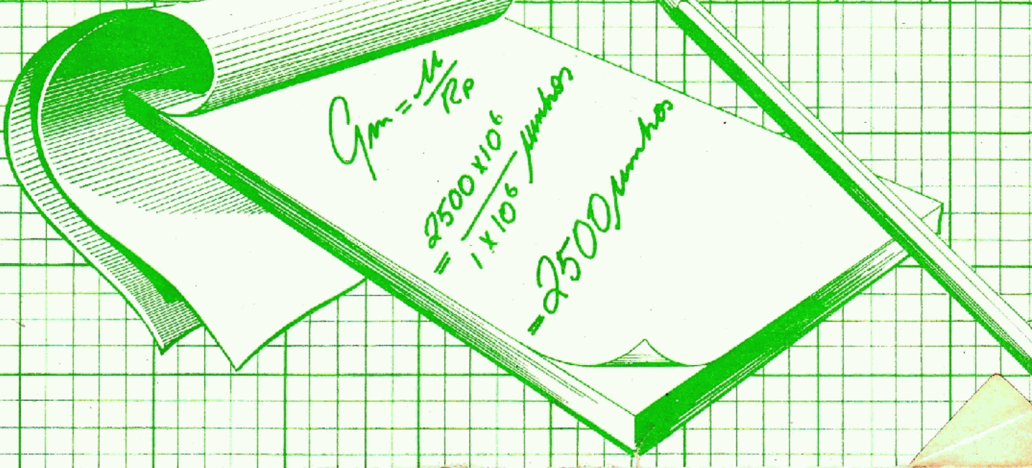
Radiotronics

SEPTEMBER-OCTOBER 1949 Number 139



Employing a formed grid construction the Australian made Radiotron 6AR7-GT, in conjunction with Radiotron types X61M and KT61 enables 5 valve receiver performance to be obtained economically from 4 valves.





RADIOTRON TYPES 6AR7-GT
DUO-DIODE-PENTODE

Type 6AR7-GT is a high performance, completely self-shielded double-diode supercontrol voltage amplifier pentode of Australian design and manufacture, which is intended primarily for use in the i-f detector stage of straight and reflexed 4 valve broadcast receivers.

The pentode section has a maximum transconductance of 2500 μmhos and a plate resistance of approximately 1 megohm. This high performance has been achieved by the use of the modern "formed" grid, which hugs the cathode, and thus makes full use of the cathode surface. This formed control grid of course gives high gain without any increase of cathode heater power.

The interelectrode capacitances are sufficiently low to enable high overall stage gains (i-f pentode grid —a-f grid) at 455 Kc/s exceeding 100 times to be achieved on straight stages and exceeding 3000 times in reflexed stages, with negligible "play through" effect, at minimum volume. The super-control characteristic is such that the valve is capable of handling high signal levels at low distortion. Electrode operating voltages have been chosen to enable flexible and low cost operation in conjunction with other standard types. Characteristics of this valve appeared in Radiotronics 138.

Full shielding is provided, both internal and external. Internally, the pentode is well shielded, and the grid plate capacity is very low, satisfying the demands of a high gain stage from the point of view of stability. The diodes are thoroughly shielded from pentode control grid, plate, and screen grid, an important factor in reducing "play through". Externally a modern low cost extruded shield is provided so that the valve can be used in the most sensitive receivers without an extra shield such as a screening can.

The 6AR7-GT is particularly suitable for use with types 6A8-G, KT61 and 6X5-GT in an economy 4 valve mantel receiver from which a sensitivity as good as 20-25 μV can be obtained on broadcast unreflexed. With reflexed i-f amplifier, the sensitivity can be increased to between 1-2 μV, without negative feedback. In dual-wave receivers type X61M can be used to give improved short-wave performance.

RCA RECEIVING TUBE MANUAL

Copies of the RCA Receiving Tube Manual (R.C.15) are now available from the Valve Company, 47 York Street, Sydney. Price 5/9 ea.

Radiotronics

Number 139 **Sept.-Oct., 1949**

A Radiotron technical release
published in Sydney, N.S.W., by
Amalgamated Wireless Valve Company Pty. Ltd.

Technical Editor
F. Langford-Smith, B.Sc., B.E.,
Senior Member I.R.E. (U.S.A.).

Asst. Tech. Editor
Ian C. Hansen, Member I.R.E. (U.S.A.).

All communications should be directed in Australia to
Amalgamated Wireless Valve Co. Pty. Ltd.,
(Sales Promotion Department),
47 York Street, Sydney, N.S.W.
in New Zealand to —
Amalgamated Wireless (Australasia) Ltd.,
P.O. Box 830, Wellington, C1, N.Z.

CONTENTS of this ISSUE

Radiotronics is published six times a year as part of "Radiotron technical publishing Service" for which the annual (January-December) mailing fee is 5/-.

Wholly set up and printed by
Cloister Press (D. & W. Short), Redfern, N. S. W

Radiotron Receiver R.C.44

The addition to the Radiotron range of the X61M triode hexode frequency changer makes possible the design of an economical high performance 5 valve dual-wave receiver when this valve is used in conjunction with the single-ended types 6SK7GT, 6SQ7GT and a 6V6GT.

The aerial sensitivity of the R.C.44 receiver is better than 2.8µV over the whole of the medium-wave band and varies from 8.5µV to 11.0µV over the short-wave band. Delayed a.v.c. is used on both bands.

While the circuit is of conventional design, a few of the main features are worth outlining.

Circuit details

In any receiver design maximum economy of components will be achieved if a number of electrodes are supplied from a single dropping resistor and, for this reason the −3 volt grid bias condition for types X61M and 6SK7GT was chosen. The screen voltages are also supplied from a common source.

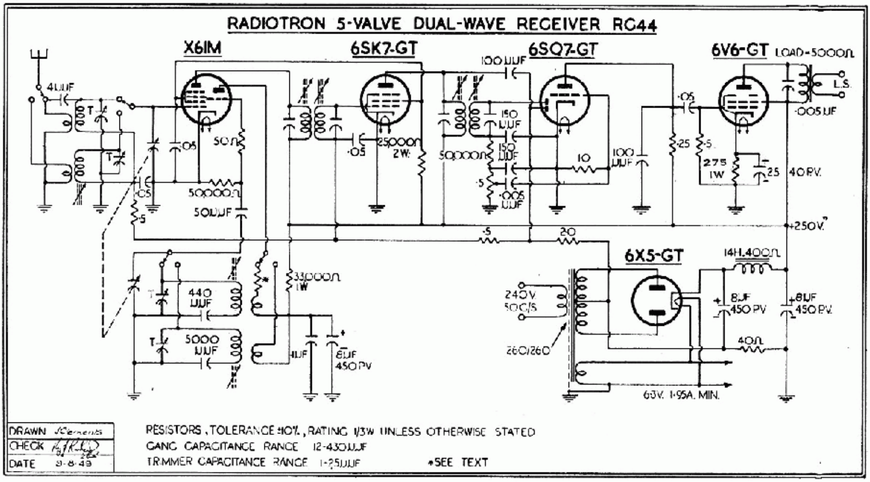
Considering first the grid bias voltage, as this is the same for both valves, it may be fed via the a.v.c. line and at the same time can be used to provide the delay voltage for the a.v.c. network. As the bias for the two valves is fed directly to the grids, the cathodes may be grounded, and this allows a simpler wiring layout. The 3 volts negative bias is developed across the 43 ohm back bias resistor.

Some care in the layout of components is advisable and it was found preferable to wire the first 0.5 megohm a.v.c. filter resistor as near as possible to the diode pin and the 0.05µF a.v.c. decoupling condenser in the aerial stage directly from the short-wave aerial coil *L2* to earth by the shortest possible leads. The best position for the screen decoupling condenser was found to be from the X61M screen pin directly to earth.

While it has not been shown in the circuit diagram, a 0.1µF condenser from B+ to earth may be found necessary and if so, it should be wired directly across the 6SK7GT valve socket, as this assists in the shielding of the control grid from the plate.

The 50 ohm resistor in the oscillator circuit was included (wired directly to the grid pin) to ensure stable operation at the high frequency end of the short-wave band under all conditions. It need not be used unless it is found to be necessary to avoid excessive rise in oscillator grid current at the high frequency end of the band and the consequent possibility of squegging or mixer instability.

The tuning capacitances used in the i-f transformers are 115µµF. This value gives adequate stage gains without resulting in tuned circuit impedances high enough to produce an asymmetrical selectivity curve due to feedback across the i-f amplifier. The larger tuning capacitance (compared with the more normal 70µµF) also reduces detuning of the circuit with respect to any small input capacitance changes with a.v.c. Selectivity also is improved because the lower tuned circuit impedance is less damped by parallel impedances in the receiver so that a higher effective tuned circuit *Q* is maintained. It was found possible with this transformer tuning capacitance to use identical transformers for the first and second positions. The measured *Q* of each coil uncoupled was 110.



RADIOTRON 5-VALVE DUAL-WAVE RECEIVER RC44

DRAWN
CHECK
DATE 9-8-49

RESISTORS, TOLERANCE ±10%, RATING 1/3W UNLESS OTHERWISE STATED
GANG CAPACITANCE RANGE 12-430UUF
TRIMMER CAPACITANCE RANGE 1-25UUF
*SEE TEXT

Both short-wave coils are shown in the diagram as having dust cores, but where cost is the prime consideration these may be omitted and the coils adjusted during winding to the predetermined value.

Grid leak bias has been used for the 6SQ7GT as this is simple and allows the cathode to be earthed. The 100µµF capacitor from plate to earth of the 6SQ7GT may, in some cases, be omitted.

The design of the output stage and the power supply follow conventional practice.

SENSITIVITIES

				E.N.S.I.
6V6GT	grid	400 c/s	0.8 volt	
6SQ7GT	grid	400 c/s	0.013 volt	
6SQ7GT	diode	455 Kc/s	0.18 volt	
6SK7GT	grid	455 Kc/s	1,300 µV	
X61M	grid	455 Kc/s	18 µV	
X61M	grid	600 Kc/s	21 µV	
X61M	grid	1400 Kc/s	20 µV	
X61M	grid	6 Mc/s	21 µV	
X61M	grid	18.2 Mc/s	26 µV	
Aerial		600 Kc/s	2.8 µV	0.42 µV
Aerial		1000 Kc/s	2.7 µV	0.62 µV
Aerial		1400 Kc/s	2.4 µV	0.65 µV
Aerial		6 Mc/s	11.0 µV	1.0 µV
Aerial		11 Mc/s	8.5 µV	1.3 µV
Aerial		18.2 Mc/s	10.0 µV	3.0 µV

STAGE GAINS

	Frequency	Gain
Aerial	600 Kc/s	7.5
Aerial	1000 Kc/s	7.4
Aerial	1400 Kc/s	8.3
X61M	1000 Kc/s	62
6SK7GT	455 Kc/s	138
6SQ7GT	400 c/s	61.5

SELECTIVITY, 1,000 Kc/s INPUT TO AERIAL

Input — db Down	Bandwidth Kc/s
10	6
20	11
30	16.5
40	21.5
50	27.0
60	35.0
70	44.5
80	61.0

OSCILLATOR GRID CURRENT M.W. BAND

Frequency	Grid Current	
	(Without 1,000 ohm series resistor)	*(With 1,000 ohm series resistor)*
540 Kc/s	350 µA	300 µA
600 Kc/s	400 µA	345 µA
1000 Kc/s	530 µA	430 µA
1400 Kc/s	580 µA	445 µA
1620 Kc/s	610 µA	442 µA

S.W. BAND

Frequency	Grid Current
6 Mc/s	205 µA
11.0 Mc/s	345 µA
18.2 Mc/s	290 µA

A.V.C. CHARACTERISTIC

Input µV	Output (0 db=0.5W)	A.V.C. Volts
3	− 9.0	0
10	+ 5.5	0
30	+ 13.0	1.0
100	+ 18.0	2.0
300	+ 20.5	3.5
1,000	+ 23.0	6.5
3,000	+ 24.5	7.5
10,000	+ 26.0	9.5
30,000	+ 27.0	13.0
100,000	+ 28.0	15.0
300,000	+ 28.5	22.0
1,000,000	+ 28.5	31.0

NO SIGNAL VOLTAGES AND CURRENTS

(All voltages measured with 1,000 ohm per volt Meter)

	Plate Voltage	Screen Voltage	Plate Current	Screen Current
X61M Hexode	250 volts	102 volts	3.0 mA	3.4 mA
X61M Triode	110 volts	—	5.0 mA	—
6SK7GT	250 volts	102 volts	9.5 mA	3.0 mA
6SQ7GT	90 volts	—	0.66 mA	—
6V6GT	235 volts	250 volts	41.5 mA	2.7 mA

Negative bias to a.v.c. line	3.0 volts
Cathode bias of 6V6GT	12.0 volts
Total B+ current drain	69 mA
6X5GT anode voltage	240-0-240 r.m.s.

COIL DETAILS

AERIAL COILS.

M.W. Band (535 – 1620 Kc/s)

Primary Winding	Secondary Winding	Coil Former
300 turns of 9/41 Litz, wound in a single pie $\frac{5}{32}$" wide.	144 turns of 9/41 Litz wound in three pies of 48 turns per pie, spacing between each pie $\frac{1}{16}$". Spacing between secondary and primary $\frac{3}{16}$".	$\frac{7}{16}$" diam. Paxolin.

S.W. Band (5.9 – 18.2 Mc/s)

Primary Winding	Secondary Winding	Coil Former
2 turns of 28 SWG enam. interwound at the earthy end of the secondary	8.5 turns of 23 SWG enam., solenoid wound 16 T.P.I.	$\frac{3}{4}$" diam. Paxolin, with $\frac{1}{2}$" x $\frac{3}{8}$" iron core.

OSCILLATOR COILS.

M.W. Band (535 – 1620 Kc/s)			S.W. Band (5.9 – 18.2 Mc/s)		
Tuned Winding	**Feedback Winding**	**Coil Former**	**Tuned Winding**	**Feedback Winding**	**Coil Former**
80 turns of 40 SWG D.C.C. wound in a single pie. $\frac{3}{16}$" wide, inner lead earthy.	60 turns of 40 SWG D.C.C. wound in a single pie $\frac{3}{16}$" wide, spaced $\frac{1}{32}$" from the tuned winding.	$\frac{7}{16}$" diam. Paxolin, with $\frac{1}{2}$" x $\frac{3}{8}$" iron core.	8 turns of 23 S W G enam., solenoid wound 16 T.P.I.	5.7 turns of 36 S W G enam. interwound at the earthy end of the tuned winding.	$\frac{3}{4}$" diam. Paxolin with $\frac{1}{2}$" x $\frac{3}{8}$" iron core.

Radiotron "Subminiature" Types 1AC5, 1AD5, 1E8, and 1T6

Data contained herein is published for general information. No stocks of this valve are at present held in Australia.

RCA has just announced a line of "subminiature" valves consisting of four types—a power pentode 1AC5, a sharp-cutoff pentode 1AD5, a pentagrid converter 1E8, and a diode-pentode 1T6.

These four types provide a complete complement for the design of very compact, light-weight, portable receivers operating in the standard A-M broadcast band and having extremely low A-battery drain—only 0.04 ampere per valve.

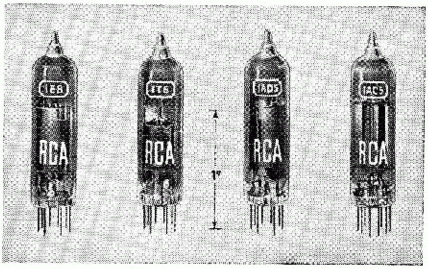
Constructed with a very small glass-button 8-pin base sealed to the glass bulb, these subminiature valves have a seated length of 1½ inches and a diameter only slightly greater than ⅜ of an inch.

Radiotron 1AC5 is a power-pentode of the subminiature 8-pin type designed especially for use as an output valve in small, compact, battery-operated radio receivers for the standard A-M broadcast band. It is capable of moderate power output with a very small input voltage. The 1AC5 features extremely low filament drain and its filament can be operated directly from a 1.5-volt dry cell.

Radiotron 1AD5 is a sharp-cutoff pentode of the subminiature 8-pin type designed especially for use as a r-f or i-f amplifier in small, compact, radio receivers for the standard A-M broadcast band. Because of internal shielding feature, an external bulb shield is not needed, but socket shielding is essential if minimum grid-plate capacitance is to be obtained. The 1AD5 features extremely low filament drain and its filament can be operated directly from a 1.5-volt dry cell.

Radiotron 1E8 is a pentagrid converter of the subminiature 8-pin type designed especially for use in small, compact, battery-operated radio receivers for the standard A-M broadcast band. It performs simultaneously the function of a mixer (first detector) valve and of an oscillator valve in superheterodyne circuits. The 1E8 has a conversion transconductance of 150 micromhos with 67.5 volts on the plate, and features extremely low filament drain. Its filament can be operated directly from a 1.5-volt dry cell.

Radiotron 1T6 is a diode-pentode of the subminiature 8-pin type designed especially for use as a detector valve and as an audio amplifier in small, compact, battery-operated receivers for the standard A-M broadcast band. It features extremely low filament drain and its filament can be operated directly from a 1.5-volt dry cell. The 1T6 together with Radiotron subminiature types 1AC5, 1AD5, and 1E8 comprise a complete valve complement for lightweight portable receivers having extremely low battery drain.



Installation and application.

The base pins of these valves fit a subminiature 8-pin socket such as Cinch No. 54A13686. The socket may be mounted to hold the valve in any position. Considering their small size, the base pins are sturdy but can be bent. It is essential, therefore, that the pins be straight before attempting to insert them in the socket. Insertion will be facilitated by first aligning pins 1 and 8 with their respective socket holes and then gently pressing the valve into the socket. Do not attempt to solder the pins to any circuit elements, since the heat of the soldering operation may crack the glass seal.

The filament of all these valves may be connected directly across a dry-cell battery rated at a terminal potential of 1.5 volts. In no case should the voltage across the filament ever exceed 1.6 volts.

Darkroom Timer

By A. STUART MACKAY and RICHARD R. SOULE

Reprinted from Electronics, January 1949, by permission of the McGraw-Hill Publishing Co.

Photographic darkroom workers, faced with the necessity of spending much time and money making test strips to determine proper exposure for enlargements, have devised various photoelectric timing circuits.

Ideally, such a timer should be adaptable to any enlarger and so constituted that a single pushbutton turns on the enlarger and starts the timer, which will in turn automatically turn off the enlarger at the end of the proper exposure. It should also operate efficiently regardless of line voltage, degree of enlargement, aperture and negative density. This article describes such a timer that is small, simple and can be permanently attached to any enlarger.

Most timing circuits that have been described are modifications of the basic resistance-capacitance circuit. The charging or discharging of a capacitor is controlled by the internal resistance of a phototube that is exposed to the same light as the enlarging paper. When the voltage across the capacitor reaches a preassigned value, a relay trips turning off the enlarger. Because the phototube current integrates the light intensity continuously during each exposure, the circuit responds not only to the gross phenomena of negative density, degree of enlargement and lens opening, but also to smaller variables such as lamp brightness, variations with line voltage, and bulb blackening with age.

Modifications have suffered from low sensitivity and leakage currents. Because of some timers' low sensitivity to light, the enlarger must often be rebuilt to include an optical beam splitter that delivers an appreciable portion of light directly to the photocell or phototube in order that there be adequate light to activate the device. Furthermore, leakage currents, which may be comparable to the phototube current, make timing erratic.

Both of these limitations are overcome by using a multiplier phototube. In such a tube the current produced by the incident light is repeatedly amplified by secondary emission from the arrangement of dynodes. This amplification, taking place within the phototube, raises the output current to the order of a milliampere before leakage currents can affect it. The sensitivity of photomultiplier tubes is so great that they can give a direct indication of the intensity of light that is so weak that it would take two hours' exposure to affect the best photographic emulsions. If such a tube is used to control the charge on a capacitor of good quality, leakage currents are negligible.

Regulated high-voltage supply

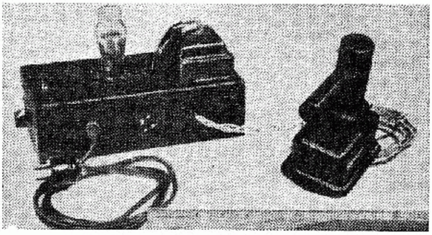
Although using a photomultiplier tube eliminates the sources of error commonly encountered in self-adjusting timers, one slight complication is introduced: the photomultiplier tube requires a high voltage that must be regulated. Even if a conventional regulated supply is used, tube operation may be unsatisfactory because of the redistribution of potential along the divider for the chain of dynodes when their currents vary by amounts comparable to the divider current. A lower-impedance divider could be used, but it is better to regulate each dynode potential individually.

Quarter-watt neon lamps are ideal for regulating the dynode potentials of a multiplier phototube because of the low current drawn by the tube. If several such lamps are connected in series and this string placed in series with a dropping resistor, the voltage across the strings is fairly independent of the applied voltage. A difference of about 55 volts appears across each lamp. The measured a.c. resistance of the lamps operating in this current range is about 1,500 ohms, which, in conjunction with a fairly high dropping resistance, gives adequate regulation for most photographic purposes. Because the d.c. resistance of the lamps is much higher, the driver current is small.

Satisfactory operation can usually be obtained from photomultiplier tubes operated in autorectifier circuits; that is, with alternating voltage applied to the voltage divider, the tube passing current only when its anode is positive. The fact that the tube is operative less than the full time is equivalent to a reduction in amplification, which can be gained by increasing the voltage on one dynode. However, because the neon string is being repeatedly fired (twice each power cycle), the voltage across each lamp rises to its ignition potential of about 70 volts, or about a third higher than the operating voltage. Thus, at the start of each half cycle the voltage across the string of lamps will momentarily rise too high by several hundred volts if all the lamps light simultaneously. During this period of high voltage the current amplification of the photomultiplier will be much greater than during the remainder of its cycle. An appreciable portion of the total capacitor current will flow during this ignition interval, making the timing sensitive to line voltage variations.

The spike can be minimized by making the lamps ignite in sequence, starting with the first dynode. The small spikes that result are unimportant because so many occur at low voltages, where the amplification is down. The firing sequence can be controlled by attaching a graded-capacitor voltage divider across the string of lamps, the largest capacitor being across the last lamp to fire. In this way the final spike is only 20 volts. This arrangement eliminates possible variations in the time at which the lamps light and the duration of the action. In choosing the sizes of the capacitors, the lower limit is set by stray capacitances and the upper limit by the necessity for the largest capacitance to have a small reactance compared to the resistance of the dropping resistor so excessive phase shift will not be produced. The intermediate values of capacitance are convenient ones approximately evenly spaced. Several lamps can be allowed to ignite together in the early part of the cycle when the voltage is low, thus reducing the number of capacitors. By placing two lamps between some dynodes the amplification can be increased. With the circuit shown, the current amplification is about 80,000.

The lamps, their associated capacitors and the phototube are housed in a pickup head so that a long multiconductor cable, whose capacitance might interfere with the divider action, need not be used.



Darkroom timer is built in two parts: chassis (left) housing relays, gas triode, transformer and timing capacitor, and (right) phototube scanning head.

Charging the capacitor

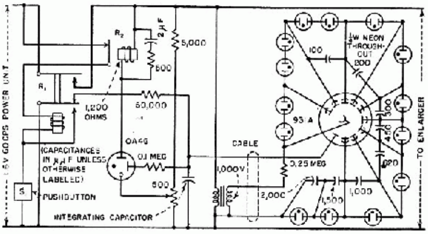
Two neon lamps are used between the last dynode and the anode of the photomultiplier tube to assure a constant (fairly saturated) high signal current and to provide enough voltage so that the firing voltage of the thyratron, which terminates the timing period, can be chosen at a value for which the derivative of the capacitor charging curve is still large. The integrating capacitor should have low leakage. Electrolytic capacitors, which have high leakage and change capacitance, cannot be used.

Different contrasts, grades and surfaces of paper will require different exposures. With the dynode voltages fixed, the exposure interval can be changed by switching capacitors or changing apertures in front of the phototube. Capacitances of the order of magnitude of one microfarad were found proper.

Timers of this sort can be of two types. In the more common type, an initially discharged capacitor is abruptly charged at the beginning of the timing cycle and then allowed to discharge slowly until the capacitor voltage falls to a pre-determined value and activates the circuit. In the other type, the capacitor is momentarily shorted and then charged slowly until its voltage rises to the assigned value. This latter arrangement is preferable because the average voltage across the capacitor during the timing cycle is lower than in the first arrangement and hence the leakage current is smaller. In the first type circuit, leakage tends to make the interval too short; in the second, it tends to make it too long, but the error is less.

Timing operations.

The foregoing considerations form the basis for the complete circuit shown in the diagram. To understand the functions of the components, let us follow a timing cycle. Depressing pushbutton S_1 causes relay R_1 to close and, because one set of its contacts is across S_1, to remain closed even after S_1 is released. Another set of contacts on R_1 turn on the enlarger and supply to the photomultiplier transformer. The intergrating capacitor charges slowly from the current passed by the phototube, making the control element of the 0A4G tube increasingly negative with respect to its cathode. When the potential difference between these two electrodes becomes high enough, a pilot discharge takes place that partially ionizes the tube. On the next half cycle, the anode of the 0A4G becomes positive, the tube breaks down, and relay R_2 is energized, thus releasing R_1. In dropping back, R_1 turns off the enlarger and the power to the phototube and also connects a 50,000-ohm resistor across the intergrating capacitor, thus discharging it in preparation for another cycle. Between timing cycles the equipment draws no power and thus can be left permanently connected. It has no warmup delay, so to operate it for the next cycle all that is necessary is to push the button again.



Circuit of timer shows parts built on chassis to left of cable and, at right, multiplier phototube and its neon-bulb regulator built in pickup head.

The type 0A4G tube was chosen not only for its heaterless construction, but for other advantages. Before the control electrode breaks down there is very little leakage through the tube because the cathode is cold. Also, because of the construction of this tube, the voltage at which the control electrode fires is a very slowly varying function of the anode potential. No regulation of the anode supply is necessary. In the circuit shown the cathode of the 0A4G is returned through a voltage divider so that a variable positive bias can be introduced as a fine control for the timing interval. This bias controls the intergrating capacitor voltage at which the tube fires.

Because the cathode bias is an alternating voltage, it tends to fire the tube only during a positive half cycle. However, the control electrode might break down during a negative half cycle and discharge the integrating capacitor to the extinction voltage before the positive half cycle arrives. Hence a 0.1-megohm resistor is used to limit the discharge current to a value that will still ignite the anode circuit but will not discharge the integrating capacitor too rapidly. This resistor also protects the tube by limiting the discharge current.

By using a 110-volt a.c. lockin relay for R_1, its size and capacity are not limited by the ability of a tube to pass large currents, as in some timers. The lockin action also makes the timing interval independent of the way in which the button is pushed. Even at short intervals, the action of the two relays of this circuit is quite regular.

The phototube used has an S4 blue-sensitive surface (response peaked at 4,200 Angstroms) and thus should not see light coming through a reasonably good safelight filter. (The dark current to the integrating capacitor is below 0.1 microampere.) However, if spurious currents flow due to the safelight, a relay can be arranged that will turn the safelight off when the enlarger goes on.

Photomultiplier pickup head

The phototube is mounted in a light-tight housing with an aperture aimed down at a small angle toward the enlarger easel. However, the angle from the vertical should not be less than about 10 degrees because specular reflections from the paper might then give erratic results as the enlarger head is moved. The housing is mounted on the enlarger head and adjusted so that the phototube sees a suitable portion of the print. As the enlarger head is raised or lowered the phototube will see a larger or smaller portion of the easel but will be further from or closer to it so the light reaching the phototube will be independent of its height. The timing is thus independent of the degree of enlargement.

With the usual subjects, the pickup head can be set to scan the middle of the print. However, for certain subjects, such as a portrait against a black background or another against a white background, the field of view of the pickup should be limited only to the region of primary interest. A small lamp could be installed in the pickup head to project a beam of light onto the field of view to facilitate aiming the pickup.

Although the field of view of the pickup head can be controlled solely by stops or diaphragms, the same result can be obtained with much better light-gathering power by using a lens to cast an image of the working area of the easel on to a diaphragm in front of the phototube. This lens need not be of good quality as a sharp image is undesirable, but it should have a short focal length. The diaphragm in front of the phototube can be a ground glass masked to accept the desired field of view. The image should not be formed directly on the photocathode because it may be nonuniform.

To test the reliability of this timer, prints were made with the enlarger lens at f4.5 and at f 16 and with the line voltage at 115 and at 105 volts. The four prints were processed identically thereafter and compared. They were indistinguishable from each other. However, because of the change in colour of the enlarger light with line voltage, some enlargers may not give compensation to this degree. The magnitude of the effect will be determined by how well the photocell colour characteristic curve matches that of the paper being used. Because of its cascade action, and consequent extreme voltage sensitivity, this timer may be inadequate for exacting colour work unless the line voltage is stablized. A constant-voltage transformer is a simple solution to such a problem.

Valves in "Clusters" Increase Power for Television

(Reprinted from Radio Age, by courtesy of the Radio Corporation of America.)

A new method of combining transmitting valves in groups or "clusters", which materially increases the power of television stations operating on ultra-high frequencies (300 to 3000 megacycles), has been developed at RCA Laboratories. The new method makes it possible to handle the normal band of frequencies involved in television transmission with greater signal strength than has heretofore been attained. G. H. Brown, W. C. Morrison, W. L. Behrend, and J. G. Reddick of the Laboratories staff collaborated in the preparation of a paper describing the system which Mr. Brown read before the Institute of Radio Engineers.

In the RCA method, two transmitter valves—or two complete transmitters—are teamed through a special network called a duplexer, which permits the combined outputs of the valves to be fed into the same antenna, thereby doubling the effective power output without narrowing the width of the frequency band transmitted. Since the output of the duplexer with the combined power of two valves acts as a single unit, it is possible to combine two or more duplexers to multiply the output proportionately. This process can be continued to any extent desired.

Miniature Valves in War and Peace

By N. H. GREEN.*

Reprinted from RCA Review by courtesy of the Radio Corporation of America.

SUMMARY—*In 1939 a new line of miniature valves was made available for use in small personal-type receivers. Since that time, the use of miniatures has been extended into electronic equipment of almost every type. This paper describes the design features which account for the versatility and lower cost of the miniature valve and cites several varied applications of miniatures in both military and commercial equipment.*

Introduction.

Each basic receiving valve enclosure has features which make it particularly suitable for specific fields of application. The miniature valve enclosure incorporates most of the desirable features of the other enclosures. It was first introduced by RCA in a line of battery-type tubes in 1939 and has since shown a versatility unmatched by any other of the basic enclosures. The miniature valve design was achieved principally through the elimination of non-essential parts. The high standards of performance, low cost, versatility, and small size of valves incorporating this design are attributable to a large degree to the simplicity of the construction.

In World War 2 miniature valves were first used in war applications to provide more compact equipment and to make available high-frequency valves which would be mass-produced. Before the end of the war, however, over 50 million of these valves had been used in nearly every field of electronic application.

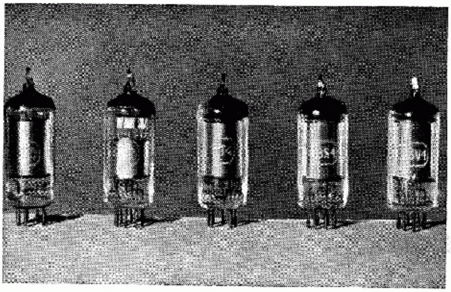
Engineering developments and mass-production techniques are now directed intensively toward many peacetime products. The application of miniature valves to wartime equipment provided a good proving ground to test their performance and dependability, and the promise held for their widespread commercial use is now being fulfilled.

The purpose of this paper is to describe the miniature valve development and the history of its rapid extension to military and commercial use.

Development of the miniature valve.

The development of a battery-operated, personal-type receiver having the general size of the average camera and capable of being produced at reasonable cost was begun in 1938. Smaller valves of high efficiency and low cost were among the first requirements. To provide such valves, the development of a small valve enclosure was started.

As a result of this work, four filamentary-type valves in the new miniature envelope were made available in 1939 for use in a personal-type radio receiver. These valves were the 1T4 radio-frequency pentode, 1R5 converter, 1S5 diode pentode, and 1S4 output pentode. All of the valves used a 1.4-volt filament with low current drain suitable for small dry-battery operation. The receiver space required for the four valves was only about one-fifth of the space required for the equivalent valve complement in glass tubular (GT) bulbs.



Range of miniature battery valves, 1R5, 1S5, 1T4, 3S4 and 3V4.

Although several types of small valves had previously been available, the new miniature valves had one very important advantage. The reduction in size was accomplished almost entirely by the elimination or redesign of auxiliary parts, while components of the electrode assembly, or mount cage, were comparable in size to those of the larger receiving valves. Consequently, the manufacturing techniques for parts and assembly of the mount cage, where the bulk of the labor for valve making is required, were essentially unchanged and high-speed methods developed for standard types were directly applicable to the miniatures. This feature played an important part in the speed with which mass-production of miniature valves was achieved in World War 2.

The reduction in valve size was effected principally by two design features. First, the conventional base was eliminated on the miniature valve by extending the lead wires from the electrodes through the glass seal to serve as base connections. The temper of the external lead wires was carefully adjusted to provide sufficient stiffness for easy insertion into a socket, yet the leads were kept flexible enough so that severe strains were not placed on the glass seal through misalignment of the pins and socket lugs.

---

* Tube Department, RCA, Victor Division,
Harrison, N.J.

Secondly, the conventional press-seal stem used in the larger valves was replaced by a flat button stem with the seven lead wires positioned in a circle and sealed in the same plane as the glass seal between the bulb and stem. This arrangement provided shorter connections to the electrodes, improved the high-frequency performance and the heat conduction through the lead wires in the seal was increased by the circular lead arrangement which reduced the possibility of electrical leakage and minimized the capacitance between lead wires. A wider spacing between pins one and seven gave a positive index for insertion of the valves in sockets.

Compared to the equivalent GT valves, the miniatures provided a reduction in diameter from $1\frac{5}{16}$ inches to $\frac{3}{4}$ inch maximum and a reduction in overall length from $3\frac{5}{16}$ to $2\frac{1}{8}$ inches maximum. The fact that the miniatures do not have a conventional base removed a source of dielectric losses and a costly operation in manufacture. At standard broadcast frequencies, the two types were comparable in performance but the miniatures gave promise of superior performance at higher frequencies.

Miniature valves in war.

With the advent of war, the trend toward more compact, lighter-weight equipment was greatly accelerated. Portable transceivers of smaller size were needed for the infantry. Compact, lightweight units were required for aircraft communication receivers and radar equipment. Balloon transmitters for weather forecasting, detection and trigger equipment for water mines, emergency transmitters for life rafts, and radio controls for guided missiles were but a few of the many applications requiring smaller valves.

A further war need was for valves which would operate satisfactorily at higher frequencies. Few GT types are efficient above 100 megacycles, but the military requirements demanded that equipment be made to operate at a frequency of several hundred megacycles.

Anticipating these requirements, work was started in 1940 to develop heater-cathode valves as well as additional filamentary types in miniature enclosures. Other types of small valves which were then available required slow, precise assembly by highly skilled operators and could not possibly meet the expected demands.

The most urgent needs in heater-cathode types were for a radio-frequency amplifier, a local oscillator, and a mixer for the conversion of the high carrier frequencies to an intermediate frequency which could be handled by conventional valves. An early solution to this problem was found by transferring to the miniature enclosure the mount cages of the acorn types 954, 955 and 956, which had already been proven for high-frequency operation. The new miniature heater-cathode types were introduced in 1941 as the 9001, 9002 and 9003, to provide a complement consisting of a mixer, local oscillator, and radio-frequency amplifier. In laboratory tests on the miniature equivalents of the acorn types, some sacrifice in top frequency was observed, but the results were better than predicted. It was evident that small valves suitable for high-speed manufacture could be made for operation at frequencies of several hundred megacycles.

Using types 9002 and 9003, an Army communications receiver (SCR-522-A) was designed and placed in production for aircraft service. Operating on a frequency band of 100 to 156 megacycles, this transmitter-receiver unit had a working range of 180 miles at an altitude of 20,000 feet. It was used extensively for aircraft and vehicular communications throughout the war.

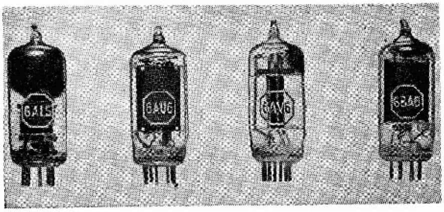
As the use of high-frequency miniatures was rapidly extended to other equipments, the advantages of their small size became more evident and the development of other miniatures was undertaken for use at frequencies which could be handled by conventional types if space were not a consideration. Additional features, not anticipated originally, became evident with expanding field use. Under climatic conditions of high humidity, the basing cement on conventional types deteriorated, moisture was absorbed by the base, and high electrical leakage resulted. Also, salt water spray during shipboard operation took its toll in corroding external metal parts of conventional valves. The baseless miniature valve, however, did not absorb moisture, and the nickel external pins and glass enclosure, which were the only surfaces exposed, were practically impervious to corrosion. A further advantage disclosed by field use was that while the miniatures on casual inspection appeared less sturdy than the larger valves, the lower mass of the miniatures actually gave better shock-resistant qualities to withstand the impact of gun-fire, the high acceleration of units enclosed in missiles, and the rough usage encountered in mobile service.

One question unanswered at the start of the war was whether heater-cathode types with appreciable wattage input could be made to operate with satisfactory life in the smaller miniature enclosures. Since the size of the electrodes was not reduced appreciably and the short lead connections provided good heat conduction to the socket, the possibilities for higher dissipations appeared favourable except for limitation of increased bulb temperatures, resulting from the greatly reduced radiating area of the miniature enclosure. If higher dissipations could be tolerated, miniature types having better transconductance and higher peak currents could be designed.

In answer to this, the 6C4 oscillator, introduced in 1942, was found to be capable, in Class C oscillator service, of dissipating five watts in the plate with approximately one watt cathode input. At 150 megacycles, the average power output obtainable was 2.5 watts. As a result, this miniature triode found wide use in both local-oscillator service and pulse-modulator applications where higher dissipations were required. One model of aircraft interrogation equipment (AN/AP-2), for example, used nineteen miniature 6C4 valves out of a total complement of forty-four valves, of which all but three were miniatures.

With the knowledge that higher wattages were practical in miniature valves, work was concentrated on the design of a mixer valve and an intermediate-frequency amplifier to complete a high-frequency miniature complement having transconductances of the same values as the comparable larger receiving types. These types were made available during the latter half of 1942 as the 6J6, a twin triode mixer-oscillator with a transconductance of 5300 micromhos at 8.5 milliamperes. The 6J6 was used in pulse-oscillator service at frequencies as high as 450 megacycles and the 6AG5, although used principally in 30-megacycle intermediate-frequency amplifiers, was employed in some applications at frequencies as high as 200 megacycles.

It was soon found that many equipment designers were using the 6J6 connected as a diode for a second detector to conserve space and gain higher perveance than could be obtained with standard types specifically intended for detector use. To provide for this service, the high-perveance, miniature twin diode 6AL5, was introduced in 1944. This valve has a voltage drop in each section comparable to a diode-connected 6J6. For narrow band applications requiring less perveance, the twin-diode high-mu triode 6AQ6 was introduced during the same year.



Some 6.3 volt a.c. miniature valves from the Radiotron Recommended Range.

The introduction of these valves gave receiver designers a complete miniature complement of heater-cathode types through the second-detector stage for equipment operating up to 400 megacycles. In 1943, the 6AK6 output pentode was introduced to complete the receiver complement.

The rapid development of heater-cathode type miniatures was paralled by a similar programme to provide filament-type miniatures for dry-battery, portable communications equipment for the infantry. The original miniatures introduced for the personal receiver formed the nucleus for a receiver complement, but there were no existing types suitable for a transmitter. In the early part of 1942, the 3A5 twin triode giving 2 watts output at 40 megacycles with a filament input of only 0.3 watt, was introduced. A radio-frequency power pentode type 3A4 was also made available for class C transmitting service. The 1L4 sharp-cutoff pentode and the 1A3 diode for frequency modulation detection use completed a working complement of filamentary miniatures for portable transceiver applications.

With these new types and the personal-receiver valves developed before the war, a "walkie-talkie" frequency-modulation transceiver, SCR-300-A, was developed and became the first radio field telephone which was truly portable. With the necessity for telephone lines eliminated, the "walkie-talkie" made possible the maintenance of communications between fast-moving combat units and proved to be one of the most important tactical weapons of the war. The "walkie-talkie" contained eighteen miniature valves in a unit 5 by 11 by 17 inches with total weight, including batteries, of thirty-eight pounds. Operating at a signal frequency of 40 to 48 megacycles, the quick-heating miniatures gave instant switch-on service and a working radius of three miles.

The first large-scale test of the filament-type miniature valves was provided by the SCR-300-A in the invasion of Sicily. The records of valves replaced in equipment used by combat divisions during this campaign showed that despite the rough usage of battle service the valve replacements for all reasons were less than three per cent. of the total number in service. The results firmly established the ruggedness and dependability of the miniature valves.

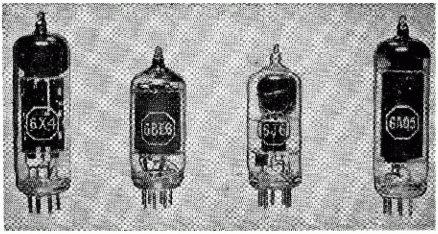
A still smaller transceiver of lighter weight, the "handy-talkie" SCR-536, was employed in the Pacific during the latter months of the war. Using a total complement of five miniatures and weighing less than six pounds, this unit was only 4 by 6 by 16 inches in size and could be held conveniently in one hand during operation.

The applications of miniature valves to war equipment were so many and so varied that only a few can be cited. The best indication of their contribution to the war effort can probably be given by production figures. Although RCA was the only manufacturer of miniature valves in 1939, the end of the war found all the seven principal suppliers of receiving valves producing miniatures in large quantities. Figures available from the War Production Board record from September, 1943, to July, 1945, show that over the twenty-three month period a total of more than 50 million miniature valves were produced by the industry for military use. The monthly production rate for all companies increased from a total of 800,000 valves in September, 1943, to over 3,500,000 valves in May, 1945.

Miniature valves in peace.

The promise of widespread commercial use of miniatures was evident at the end of the war. The shift in frequency allocations to establish frequency modulation in the band of 88 to 108 megacycles, the higher-frequency requirements for television, and a general trend toward more compact ac/dc and battery-portable receivers all indicated that miniature valves would eventually carry the bulk of peacetime production load for the new designs of broadcast receivers.

In September, 1945, a complete miniature complement of valves for ac/dc receivers were made available. These valves included the 12BA6 radio-frequency pentode, 12BE6 converter, 12AT6 twin-diode-triode, 50B5 output pentode, and the 35W4 rectifier. This complement is comparable in performance and cost to the valve complements used for pre-war ac/dc receivers. Their use has made possible the more compact receivers now available. Coincident with the ac/dc line, the 6.3 volt equivalents 6BA6, 6BE6 and 6AT6, were introduced, together with a sharp-cutoff radio-frequency pentode, the 6AU6.



Some 6.3 volt a.c. miniature valves from the Radiotron Recommended Range.

In order to provide for operation at both amplitude- and frequency-modulation frequencies, the miniature radio-frequency amplifier and the converter were designed to have higher gain and improved high-frequency characteristics as compared with the pre-war equivalent larger types intended for the lower frequency only. As a result, the combination amplitude-and frequency-modulation receivers now in production are using the same miniature valves for both bands. In addition to the savings in receiver cost, a lower unit cost for valves is made possible by the resulting concentration on fewer valve types.

In December, 1945, the new miniature rectifier 117Z3 provided, with existing filamentary types, a complete miniature complement for portable ac/dc battery receivers. A miniature line for automobile receivers was also provided for with the availability of the 6X4 rectifier, the 6BF6 twin diode medium-mu triode, and the 6AQ5 beam power amplifier. High-frequency types 12AW6 radio-frequency pentode and the 12AL5 twin-diode detector are recent additions designed for use in ac/dc receivers for frequency-modulation reception.

In the television field the space saving and performance afforded by miniatures are particularly desirable because of the large number of valves required for each receiver and the high frequencies of operation. The current RCA 10-inch table-model television receiver uses 15 miniatures out of a total complement of 30 valves.

In addition to their use in the field of broadcast entertainment, miniatures are rapidly being extended into industrial applications. The 2D21 thyratron, 0A2 voltage regulator, and 1654 high-voltage rectifier are employed in many industrial applications where their small size and ruggedness are of advantage. Recently, a nine-pin miniature twin-triode, 12AU7, was made available in a slightly larger envelope for industrial applications as well as for home-receiver use. Although intended primarily to provide the additional pin connections required for multi-unit valves, the nine-pin miniature envelope also open up possibilities for higher-wattage types to supplement the seven-pin miniature line, since bulb temperatures are the present limiting factor in the extension of seven-pin types.

(Ed. Note. To date, approximately 14 specialised 9-pin types are in current use of which half are twin-triodes. As against this, nearly 200 types of 7-pin miniatures are now available, thus emphasising the trend to accommodate valves on the 7-pin construction wherever practicable.)

Conclusion.

The four miniature valves first introduced in 1939 were designed to fill the need for valves which could be produced in quantities and at reasonable cost for a compact personal-type receiver. In the intervening years, however, the practical experience with miniatures has shown them to be adaptable for general receiving valve use with an exceptional range of capabilities. The versatility of miniatures holds promise for higher performance and lower costs in electronic equipment of the future.

NEW RATINGS FOR X61M

Life tests on the new Radiotron X61M converter now show that it is perfectly satisfactory to operate this valve with 250 volts plate supply, 100 volts screen supply, and −2 volts control grid bias. Previously the screen voltage was limited to 85 with this bias. This new condition permits a saving in components as all screens can now be run from the same dropping resistor. Full operating data will be published in the next issue of Radiotronics.

BACK NUMBERS

The following issues of Radiotronics are no longer available:—117, 118, 121, 122, 123, 124, 125, 126, 127, 128 and 129.

Simplifying the Calculation of Transmitting Triode Performance

By E. E. SPITZER

(Reprinted from Ham Tips, by courtesy of the Radio Corporation of America.)

Simple methods of calculating transmitting triode performance are presented in this article which give results very close to published data. They are applicable to class C amplifiers both modulated and unmodulated and also to class B audio amplifiers.

Published data on transmitting valves show many typical operating conditions which are excellent guides for the operation of the valves. Conditions sometimes arise, however, which make other operating conditions desirable or necessary.

Many amateurs would probably like to calculate new valve operating conditions but are deterred by the apparently formidable mathematics involved. In this article, the mathematics for the calculations of class C amplifiers are very much reduced by eliminating one variable, the length of the plate-current pulse. For our calculations, this variable is assumed to be 140 degrees of a r-f cycle. 140 degrees is a representative value for class C amplifiers. With this assumption, five simple formulas permit calculation of power output, plate loss grid bias, grid current, and driving power.[1] The same method of calculation is extended to class B audio amplifiers by using a plate pulse of 180°. Several examples are worked out to show clearly how the methods are used.

In the method described here, the calculations are based on the instantaneous values of grid and plate current at the peak of the plate-current pulse. It is well known that this peak occurs when the grid voltage is at its peak positive excursion and the plate voltage is at its peak negative excursion. When these two voltages are equal, the valve has very nearly its optimum performance. This important fact is recognized in the valve characteristic curves by the inclusion of a curve labelled $E_c = E_b$. The 812-A characteristic curves shown in Figure 1 include this limiting curve. If we choose a point such as

---

[1] For a derivation of these formulas, refer to "Simplified Methods for Computing Performance of Transmitting Tubes", W. G. Wagener, Proc. IRE., Vol. 25, No. 1; January 1937, pp 47-77.

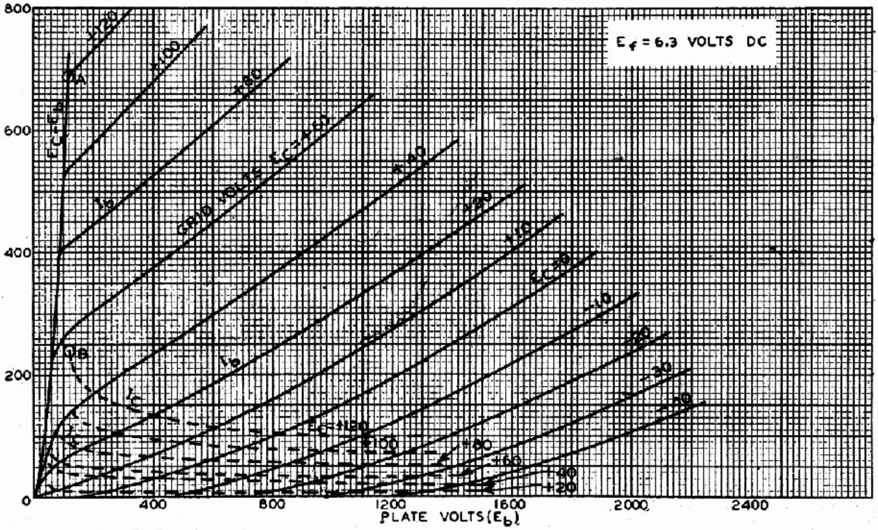


Figure 1. The 812-A characteristic curves.

"A" on the $E_b = E_c$ curve in Figure 1, we can read directly the instantaneous plate current, the required plate and grid voltages, and then, by dropping down to point "B" on the I_c family, we can also read the instantaneous grid current for the same grid voltage. All calculations are then made using these values.

Class C operation (telegraphy and telephony)

It is assumed that we have data on the valve including the plate-characteristics curves. It is also assumed that we want to operate at a certain value of d.c. plate voltage, E_b, and with a certain average plate current, I_b. We want to know power output, P_o, grid bias, E_c, d.c. grid current, I_c, and driving power, P_d.

First we find the peak plate current. This value is 4 times the average plate current, I_b. Then, we go to the plate-characteristics curves and on the curve $E_c = E_b$, we find the instantaneous plate voltage e_b, and the instantaneous grid voltage e_c, at which we get the plate current of 4 I_b. With these values, together with the amplification factor, μ, obtained from the valve data, we then apply the following formulas.

Power output

$$P_o = 0.86\ (E_b - e_b)\ I_b\ \text{(watts)} \qquad (1)$$

Plate loss

$$P_p = E_b\ I_b - P_o\ \text{(watts)} \qquad (2)$$

Grid bias

$$E_c = \left[\frac{E_b}{\mu} + 0.52\ \frac{(\mu + 1)}{(\ \mu\ )}\ e_b\right] \text{(volts)} \quad (3)$$

Peak r-f driving voltage

$$e_g = E_c + e_c\ \text{(volts)} \qquad (4)$$

To get the d.c. grid current, I_c, we first have to calculate $\frac{E_c}{e_g}$ the ratio of the grid bias to the peak r-f driving voltage and then from Figure 2 get $\frac{I_c}{i_c}$ the ratio of average grid current to the instantaneous grid current at $E_c = E_b$. The instantaneous grid current is obtained from the characteristic curves.

Then, the average grid current,

$$I_c = i_c \times \left(\text{ratio } \frac{I_c}{i_c} \text{ from Figure 2}\right), \text{(amp.)} \quad (5)$$

and driving power

$$P_d = 0.9 \times e_g \times I_c\ \text{(watts)} \qquad (6)$$

The calculated power output figure as well as the published typical power output values are theoretical values of valve output which include both useful output and r-f losses in the valve, in the tank circuit, and associated wiring. Useful r-f power obtainable, therefore, will depend on the efficiency of the circuit and in turn upon the quality of components and circuit layout used.

The calculated value of driving power includes only the actual power input to the grid plus the power lost in the bias supply. It does not include r-f losses that occur in the driver-stage tank circuit, in coupling from the driver stage, in the socket and wiring or losses in valves caused by transit-time loading. The driver stage power output, therefore, should be substantially greater than the calculated value of driving power in order to provide an adequate range of adjustment for optimum transmitter performance.

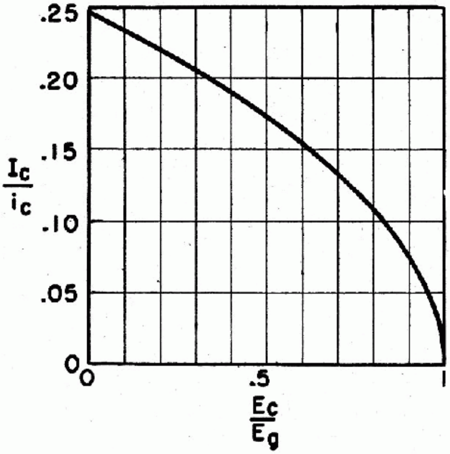


Figure 2.

Curve from which ratio I_c/i_c is obtained.

Example

As a check, this method may be applied to the 1500-volt ICAS Telegraphy condition given in the published data for the 812-A. The given conditions are $E_b = 1500$ volts, $I_b = 173$ mA, $\mu = 29$. The peak plate current is $4 \times 173 = 692$ mA. This value of current can be obtained at $e_c = e_b = 120$ volts, as given in the plate characteristics, Figure 1, at point A.

Power output

$$P_o = 0.86\ (1500 - 120)\ 0.173 = 205 \text{ watts}$$

Plate loss $P_p = 1500 \times 0.173 - 205$

$$= 259 - 205 = 54 \text{ watts}$$

Grid bias

$$E_c = -\left[\frac{1500}{29} + 0.52\ \frac{(30)}{(29)}\ 120\right]$$

$$= -116 \text{ volts}$$

Peak r-f driving voltage

$$e_g = 116 + 120 = 236 \text{ volts}$$

$$\text{and } \frac{E_c}{e_g} = \frac{116}{236} = 0.49$$

$$\text{From Figure 2, } \frac{I_c}{i_c} = 0.175.$$

From the characteristic curves (Figure 1) for $e_c = e_b = 120$ volts, $i_c = 220$ mA or 0.220 amp. at point "B". Therefore, the average grid current

$$I_c = 0.220 \times 0.175 = 0.038 \text{ amperes}$$

and the driving power

$$P_d = 0.9 \times 236 \times 0.038 = 8.0 \text{ watts}$$

A comparison between these calculated values and the published data for the 812-A is shown in Table 1 below.

It can be seen from this comparison that for practical purposes there is a satisfactory agreement between published and calculated values.

Class B operation (audio frequency)

For class B audio operation it may be assumed E_b and I_b are given. In this case, I_b is the plate current for both valves of the push-pull amplifier.

Table 1—(Class C).

	Calculated Values	Published Data
D.C. Plate Voltage (E_b)	1500	1500 volts
D.C. Grid Voltage (E_c) ..	–116	–120 volts
Peak R-F Grid Voltage (e_g)	236	240 volts
D.C. Plate Current (I_b)	173	173 mA
D.C. Grid Current (I_c)	38	30 mA
Driving Power (P_d)	8.0	6.5 watts
Power Output (P_o)	205	190 watts

Then, peak plate current for two valves

$$i_b = 1.57\, I_b \tag{7}$$

At the value of i_b given by (7) we determine the peak grid voltage e_c and the peak plate voltage e_b on the $E_c = E_b$ curve.

The following formulas apply:

Power output for two valves,

$$P_o = 0.78\ (E_b - e_b)\ I_b \text{ (watts)} \tag{8}$$

Plate loss per valve,

$$P_p = \tfrac{1}{2}\ (E_b\, I_b - P_o) \text{ (watts)} \tag{9}$$

The grid bias should be chosen so that at E_b, a zero-signal current flows which produces a plate dissipation of about $\frac{1}{3}$ the rated dissipation. Thus, if each valve is rated to dissipate P'_p watts,

Zero-signal plate current for two valves

$$= I'_b = \frac{2P'_p}{3E_b} \text{ (amperes)} \tag{10}$$

The bias required for this plate current can be found from the characteristic curves. The peak grid drive per valve is then the sum of the bias and e_c ($= e_b$) which was determined for equation (8).

Peak grid-to-grid driving voltage

$$= e_g = 2\ (e_c + E_c) \text{ (volts)} \tag{11}$$

The required plate-to-plate load resistance

$$R_L = \frac{2.6\ (E_b - e_b)}{I_b} \text{ (ohms)} \tag{12}$$

The maximum-signal driving power for two valves,

$$W_d = \frac{i_c\, e_g}{4} \text{ (watts)} \tag{13}$$

where i_c is the grid current in amperes at the point found for equation (8).

Example

Again consider the typical operating conditions given in the published data for the 812-A as a class B a-f power amplifier in ICAS service. The data given are $E_b = 1500$V, $I_b = 310$ mA, or 0.310 amperes (2 valves).

Then the peak plate current $i_b = 1.57 \times 310 = 487$ mA.

From the $E_c = E_b$ curve in Figure 1 we get 487 mA at $e_c = 90$ volts and $e_b = 90$ volts.

Then from equations (8), (9), and (10), power output for two valves $P_o = 0.78\ (1500 - 90)\ 0.310 = 340$ watts. Plate loss per valve $P_p = \frac{1}{2}\ (1500 \times 0.310 - 340) = 62.5$ watts. Zero-signal plate current for two valves

$$I'_b = \frac{2 \times 65}{3 \times 1500} = 0.029 \text{ amperes.}$$

The required bias for a plate current (per valve) of 14.5 mA at 1500 volts can be found from Figure 1 and is about –48 volts.

Then from equation (11),

Peak grid-to-grid driving voltage

$$e_g = 2\ (90 + 48) = 276 \text{ volts.}$$

From equation (12), plate-to-plate load resistance

$$R_L = \frac{2.6 \times (1500 - 90)}{0.310} = 11{,}800 \text{ ohms}$$

To get the driving power, we first need the peak grid current at $e_c = e_b = 90$ volts. This value is obtained from Figure 1 and is 130 mA or 0.130 amperes. Then, driving power for two valves

$$P_d = \frac{0.130 \times 276}{4} = 9 \text{ watts.}$$

The calculated values may now be compared with the 812-A published data, as shown in Table 2 below.

Table 2—(Class B Audio).

	Calculated Values	Published Data
D.C. Plate Voltage (E_b) ..	1500	1500 volts
D.C. Grid Voltage (E_c)	–48	–48 volts
Peak A-F Grid-to-Grid Voltage (e_g)	276	270 volts
Zero-Signal D.C. Plate Current (I'_b)	29	28 mA
Max.-Signal D.C. Plate Current (I_b)	310	310 mA
Effective Load Resistance (Plate to Plate) (R_L) .	11,800	13,200 ohms
Max.-Signal Driving Power (P_d)	9	5 watts
Max.-Signal Power Output (P_o)	340	340 watts

Again, the approximate calculations give results in good agreement with the published data.

Radiotron Type 5763

V-H-F Beam Power Amplifier

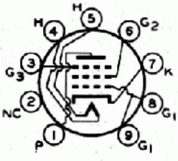
Reprinted by courtesy of the Radio Corporation of America.

Data contained herein is published for general information. No stocks of these valves are at present held in Australia.

The 5763 is a transmitting beam power amplifier of the heater-cathode type intended for use in compact, low-power mobile transmitters and in the low-power stages of larger fixed station transmitters. It has a maximum plate dissipation of 12 watts. Because of its high transconductance, and a plate characteristic favorable to the generation of a high harmonic output, the 5763 is particularly useful in the doubler and tripler stages of transmitters and can be operated with full input up to 175 Mc/s.

The 5763 features heavy control-grid support rods and two control-grid base-pin connections which provide for cooler grid operation. Its 6-volt heater can be conveniently operated from a storage battery in mobile or emergency-communications equipment. The exceptional efficiency of the 5763 as a frequency multiplier is made possible by the large cathode area which supplies the high peak currents necessary for multiplier service.

SOCKET CONNECTIONS
Bottom View



PIN 1 – PLATE
PIN 2 – NO CONNECTION
PIN 3 – GRID No. 3
PIN 4 – HEATER
PIN 5 – HEATER
PIN 6 – GRID No. 2
PIN 7 – CATHODE
PIN 8 – GRID No. 1
PIN 9 – GRID No. 1

GENERAL DATA

Electrical:

Heater, for Unipotential Cathode:		
Voltage (a.c. or d.c.)	6.0 ± 10%	volts
Current	0.75	ampere
Transconductance for plate current of 45 mA	7000	μmhos
Mu-Factor, Grid No. 2 to Grid No. 1	16.0	
Direct Interelectrode Capacitance (No external shield):		
Grid No. 1 to Plate	0.3 max.	μμF
Input	9.5	μμF
Output	4.5	μμF

Mechanical:

Mounting Position	Any
Maximum Overall Length	2-5/8"
Maximum Seated Length	2-3/8"
Length from Base Seat to Bulb Top (excluding tip)	2" ± 3/32"
Maximum Diameter	7/8"
Bulb	T-6-1/2
Base	Small-Button Noval 9-Pin

R-F POWER AMPLIFIER & OSC.—
Class C Telegraphy■
AND R-F POWER AMPLIFIER—
Class C F-M Telephony

Maximum CCS• Ratings, *Absolute Values:*

D.C. Plate Voltage	300 max.	volts
D.C. Grid-No. 3 (Suppressor) Voltage	0 max.	volts
D.C. Grid-No. 2 (Screen) Voltage	250 max.	volts
D.C. Grid-No. 1 (Control-Grid) Voltage	−125 max.	volts
D.C. Plate Current	50 max.	mA
D.C. Grid-No. 2 Current	15 max.	mA
D.C. Grid-No. 1 Current	5 max.	mA
Plate Input	15 max.	watts
Grid-No. 2 Input	2 max.	watts
Plate Dissipation	12 max.	watts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts
Bulb Temperature at Hottest Point on Bulb Surface	250 max.	°C

Typical Operation:

	At 50 Mc/s	
D.C. Plate Voltage	300	volts
Grid No. 3	Tied to cathode at socket	
D.C. Grid-No. 2 Voltage	250	volts
D.C. Grid-No. 1 Voltage	−60	volts
From a grid resistor of	22000	ohms
Peak R-F Grid-No. 1 Voltage	80	volts
D.C. Plate Current	50	mA
D.C. Grid-No. 2 Current	5	mA
D.C. Grid-No. 1 Current (approx.)	3	mA
Driving Power (Approx.)	0.35	watt
Power Output (Approx.)°	8	watts

FREQUENCY MULTIPLIER

Maximum CCS● Ratings,

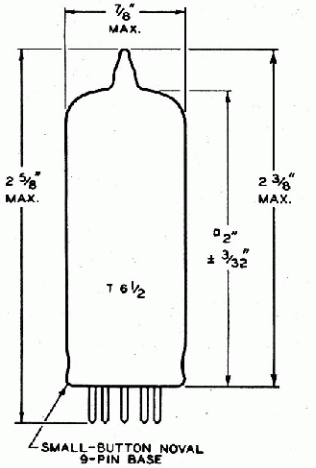
Absolute Values:

D.C. Plate Voltage	300 max.	volts
D.C. Grid-No. 3 (Suppressor) Voltage	0 max.	volts
D.C. Grid-No. 2 (Screen) Voltage ..	250 max.	volts
D.C. Grid-No. 1 (Control-Grid) Voltage	−125 max.	volts
D.C. Plate Current	50 max.	mA
D.C. Grid-No. 2 Current	15 max.	mA
D.C. Grid-No. 1 Current	5 max.	mA
Plate Input	15 max.	watts
Grid-No. 2 Input	2 max.	watts
Plate Dissipation	12 max.	watts
Peak Heater-Cathode Voltage:		
Heater negative with respect to cathode	100 max.	volts
Heater positive with respect to cathode	100 max.	volts
Bulb Temperature at Hottest Point on Bulb Surface	250 max.	°C

Typical Operation:

	Doubler to 175 Mc/s	*Tripler to 175 Mc/s*	
D.C. Plate Voltage	300	300	volts
Grid No. 3	Tied to cathode at socket		
D.C. Grid-No. 2 Voltage	*	*	volts
D.C. Grid-No. 1 Voltage	−75	−100	volts
From a grid-No. 1 resistor of	75000	100000	ohms
Peak R-F Grid-No. 1 Voltage	95	120	volts
D.C. Plate Current	40	35	mA
D.C. Grid-No. 2 Current ...	4.0	5.0	mA
D.C. Grid-No. 1 Current (Approx.)	1.0	1.0	mA
Driving Power (Approx.) ..	0.6	0.6	watt
Power Output (Approx.)♯ ..	3.6	2.8	watts

DIMENSIONAL OUTLINE



□ MEASURED FROM BASE SEAT TO BULB-TOP LINE AS DETERMINED BY RING GAUGE OF 7/16" I.D.

Maximum Circuit Values
(for maximum rated conditions):

Grid No. 1-Circuit Resistance .... 0.1 max. megohm

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	*Min.*	*Max.*	
Heater Current	1	0.69	0.81	ampere
Grid No. 1 to Plate Capacitance♦	—	—	0.3	μμF
Input Capacitance♦	—	8	11	μμF
Output Capacitance♦ ..	—	3.8	5.2	μμF

Note 1: With 6 volts a.c. on heater.

■ Key-down conditions per valve without amplitude modulation. Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115 per cent. of the carrier conditions.

● Continuous Commercial Service.

○ The useful power output is approximately 7 watts.

* Obtained from plate supply voltage of 300 volts through a series resistor of 12500 ohms.

♯ Useful power output is approximately 2.1 watts for doubler service and 1.3 watts for tripler service.

♦ With no external shield.

Installation and application

The base pins of the 5763 fit the noval 9-pin socket. The socket may be mounted to hold the valve in any position.

If the 5763 is to be used in aircraft transmitters at high altitudes, it is recommended that the socket clip of pin No. 2 be removed. Removal of this clip will help to insulate the plate (pin No. 1), from grid No. 3 (pin No. 3) and thus prevent any flashover.

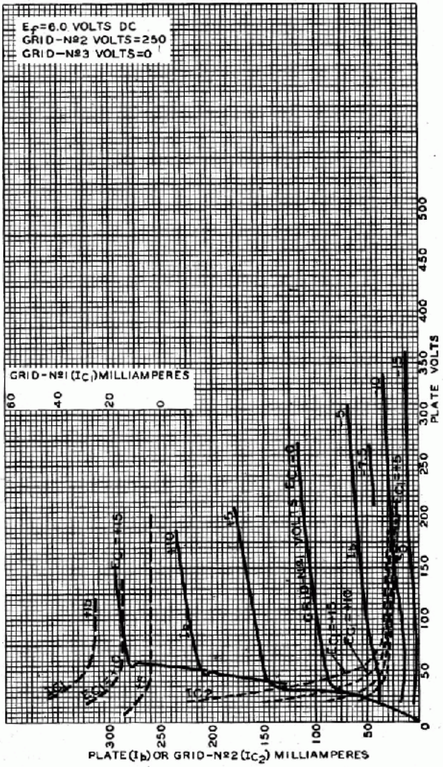
The bulb becomes hot during continuous operation and, therefore, free circulation of air around the valve should be provided. If a valve shield is used, it is advisable to paint the inside and outside surface of the shield a matte black, and to provide ventilation slots in order to prevent the temperature at the hottest point on the bulb surface from exceeding 250° Centigrade.

Grid No. 1 of the 5763 is designed with heavy support rods, and has 2 pin connections (pins 8 and 9) to permit cooler grid operation. In operating the 5763, it is essential that both grid No. 1 pins be connected into the circuit.

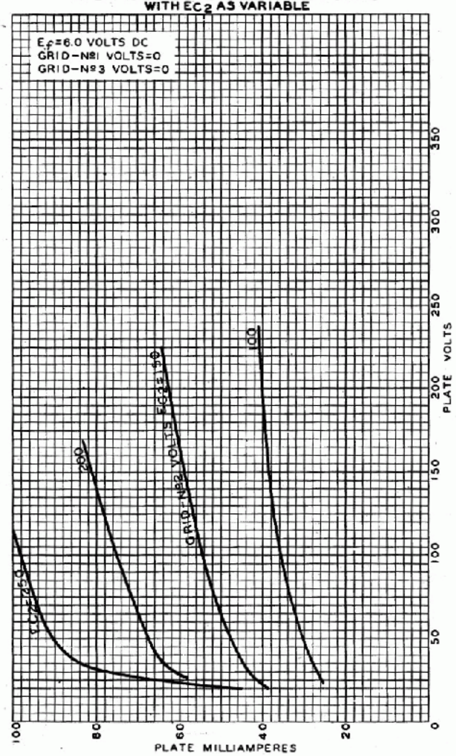
The maximum ratings are limiting values above which the serviceability of the 5763 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual conditions of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

In class C r-f telegraph and class C F-M telephony service, the 5763 should be operated with grid bias obtained from a fixed supply or from a grid resistor. The use of a grid resistor is preferred because the bias is automatically adjusted as the load on the

AVERAGE CHARACTERISTICS



AVERAGE PLATE CHARACTERISTICS
WITH EC2 AS VARIABLE



circuit varies. Because of the high amplification factor of the 5763, a small cathode resistor of 68 ohms can furnish sufficient voltage to protect the valve in the event of excitation failure and resultant loss in developed bias. The cathode bias of 3 volts required for protection is sufficiently small to make the d.c. plate power loss an unimportant factor.

In class C service, the grid current and driving power required to obtain the desired power output will vary with the plate loading. If the plate circuit presents a relatively low resistance to the valve, the desired output can be obtained with relatively low grid current and driving power, but plate-circuit efficiency is sacrificed. Conversely, if the valve operates into a relatively high load resistance, relatively high grid current and driving power are required to obtain the desired output and the plate-circuit efficiency will be high. In practice, a compromise must be made between these extremes. The typical operating conditions given in the tabulated data represent compromise conditions which give good plate-circuit efficiency with reasonable driving power.

In order to permit considerable range of adjustment, and also to provide for losses in the grid circuit and the coupling circuits, the driver stage should have considerably more output capability than the typical driving power shown in the tabulated data. This recommendation is particularly important near the maximum rated frequency where there are other losses of driving power, such as radiation losses and transit-time losses.

Circuit considerations pertaining to the operation of the 5763 are given in the following paragraphs.

The 5763 can be operated at full input up to 175 megacycles. It is recommended that it be used as a frequency multiplier rather than as a straight-through amplifier at frequencies above 135 megacycles, in order to avoid excessive driving power due to high-frequency input loading.

Highest operating efficiency in high-frequency service, and therefore maximum power output, will be obtained when the 5763 is operated under load conditions such that maximum rated plate current flows at the plate voltage which will give maximum rated input.

When more radio-frequency power is required than can be obtained from a single valve, push-pull or parallel circuit arrangements may be used. Two valves in parallel or push-pull will give approximately twice the power output of one valve. The parallel connection requires no increase in exciting voltage necessary to drive the valve. With either connection, the driving power required is approximately twice that for a single valve. The push-pull arrangement has the advantage of simplifying the balancing of high-frequency circuits.

Because of the relatively large high-frequency currents carried by the grid and plate terminals, heavy conductors should be used to make the circuit connections.

When two or more valves are used in the circuit, precautions should be taken so that the plate current drawn by each valve is the same.

RADIOTRON 6AU6 TRIODE CHARACTERISTICS

AMPLIFIER — Class A_1

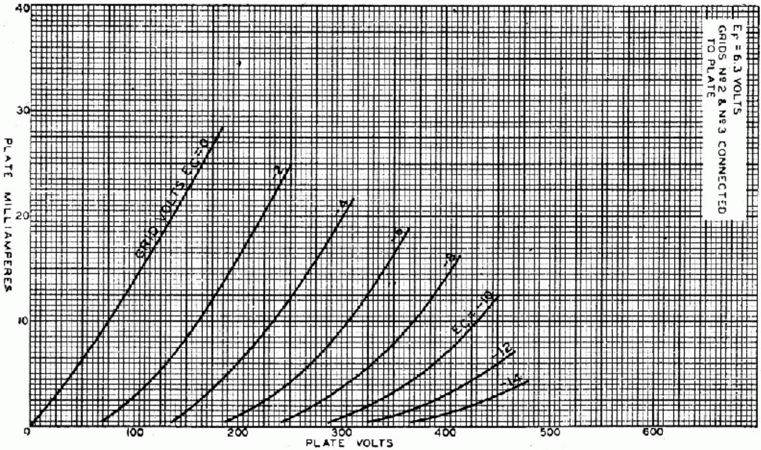
Triode Connection — Grids No. 2 and No. 3 tied to Plate.

MAXIMUM RATINGS, Design-Centre Values:

Plate Voltage	250 max. volts
Plate Dissipation (Total)	3.2 max. watts
Peak Heater-Cathode Voltage:	
Heater negative with respect to cathode	90 max. volts
Heater positive with respect to cathode	90 max. volts

TYPICAL OPERATION AND CHARACTERISTICS:

Plate Voltage	250	volts
Grid — No. 1 Voltage	−4	volts
Amplification Factor	36	
Plate Resistance (Approx.)	7500	ohms
Transconductance	4800	µmhos
Plate Current (Total)	12.2	mA



Average plate characteristics for 6AU6.
(Triode connection.)

Mixer-Oscillator Circuit for F-M and A-M Using Radiotron-6J6 or Radiotron-19J6

RCA application note AN-138 reprinted by courtesy of the Radio Corporation of America.

The 6J6 and 19J6 are twin-triode valves designed to operate efficiently as oscillators and mixers at high frequencies, including the F-M and television bands. These types are identical except for heater voltage and current ratings. This Note describes the application of the 6J6 or the 19J6 in an A-M/F-M circuit in which one section of the valve is used as a mixer and the other section as the local oscillator. In addition, the operating characteristics of one section of type 6J6 or 19J6 in mixer service are discussed in detail.

Triode mixer considerations

The principal advantage of a triode mixer is its low level of valve noise. The advantage is especially important at the higher frequencies at which most of the loading of the resonant circuits comes from the valves. In the case of a pentode or a pentagrid converter, the major part of the output noise results from division of current between the plate and the screen circuits. In the A-M broadcast band it is practical to use circuits of high enough impedance so that the noise from a pentagrid converter is less than the thermal-agitation noise from the input circuit. In the F-M band, however, the advantage of lower noise from a triode can be fully utilized.

The local-oscillator voltage for a triode mixer may be applied at the control grid by inductive or capacitive coupling between the local-oscillator circuit and the control-grid circuit, or it may be introduced between cathode and ground. The control-grid bias must be sufficient to limit the grid current to a small value in order to prevent excessive loading of the input circuit. This bias may be obtained by use of a cathode resistor, or by use of a grid resistor of several megohms. In the latter case, the bias is obtained from the grid current caused by the oscillator voltage.

The output resistance of a triode mixer is substantially lower than that of a pentode mixer or a pentagrid converter. Consequently, the gain realized from the triode is generally lower. The lower output impedance of the triode must also be taken into account in the design of the i-f transformer.

Characteristics

The curves of Fig. 1 show the conversion transconductance, plate current, and plate resistance obtained from one section of type 6J6 or 19J6 as functions of the control-grid bias, when this bias is obtained by varying the local-oscillator voltage supplied to the control grid. These curves apply for a plate supply voltage of 100 volts. The maximum value of conversion transconductance, 1700 micromhos, is obtained with a bias of 3 volts developed from a peak oscillator voltage of approximately 2.5 volts. The plate resistance per section of either valve for this condition is about 16000 ohms and the plate current is 3.6 milliamperes. It is evident from the curves that lower values of oscillator voltage will reduce the plate resistance as well as lower the conversion transconductance. Higher values of oscillator voltage can be tolerated, but are objectionable because of increased radiation, particularly in receivers not using an r-f stage.

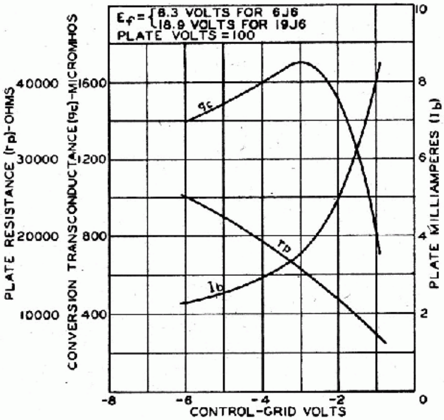


Fig. 1—Operation Characteristics in Mixer Service.

Fig. 2 shows the variation of conversion transconductance with control-grid bias when additional bias is supplied from an a.v.c. system, the oscillator voltage being held constant. This operation characteristic is obtained with type 19J6 in an a.c./d.c. receiver. In a receiver in which higher voltages are available, the cutoff voltage of the triode can be extended to larger negative values by obtaining the plate voltage through a series resistor.

Design of intermediate-frequency transformer

The intermediate-frequency transformer between the mixer plate and the grid of the first i-f stage must be designed to give satisfactory gain and selectivity when it is loaded on the primary side with an impedance of 16000 ohms from the plate of the mixer valve. For the A-M broadcast band, because it is desirable that the first i-f circuit shall not be loaded too much by the plate resistance of the valve, a low-impedance connection to the transformer primary is suggested. This connection may be conveniently obtained by using a winding similar to one used with a high-impedance valve (pentode or pentagrid converter) but with a tap located so as to present the desired impedance to the triode plate. If it is desired to obtain the same selectivity as would be obtained from a high-impedance valve, the voltage ratio between this tap and the high-potential side of the winding must be equal to the square root of the ratio of the plate resistance of the high-impedance valve to that of the triode. Thus, if the plate-resistance values compared are one megohm and 16000 ohms, the voltage ratio should be approximately 8 to 1.

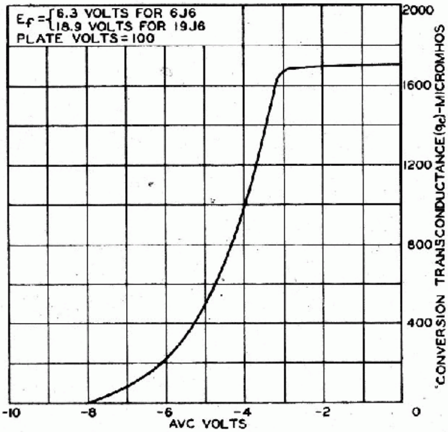


Fig. 2—Operation Characteristics Obtained When Additional Bias is Supplied from A.V.C. System.

A similar result can be obtained by using a low L/C ratio in the i-f transformer primary. If the Q of the low-inductance winding is the same as that of the high-inductance winding for which it is substituted, the ratio of capacitances required for valves with high and low values of plate resistance is the reciprocal of the ratio of output resistances. Thus, if the valve with a 1-megohm plate resistance requires a capacitance of 120 $\mu\mu$F, a valve with a 16000-ohm plate resistance would require a capacitance of 7500 $\mu\mu$F for the same selectivity. Such a capacitor, however, is likely to be rather bulky.

Selectivity may be sacrificed for amplification by the use of a higher tap position or of a higher L/C ratio than the values suggested above. In the F-M band, it is common practice to use a primary circuit impedance several times higher than the valve plate resistance, so that the amplification obtained approaches the maximum possible value for the mixer valve.

Input conductance and feedback considerations

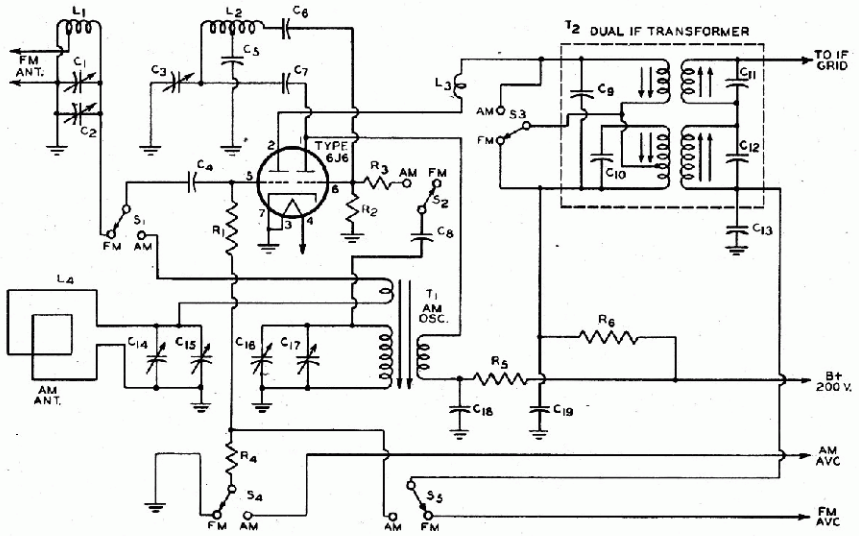
In the A-M band, the short-circuit input conductance of the 6J6 mixer is determined by the signal-grid current. For a bias of 3 volts and a resistance of 6 megohms this current is 0.5 microampere. The corresponding conductance in micromhos is of the order of ten times this current value; that is, 5 micromhos, or a resistance of 200,000 ohms. A resistance of this value would load the input circuit considerably. When a tapped i-f transformer is used, however, the leakage inductance at the tap in conjunction with the plate-to-grid capacitance of the valve results in some negative conductance. At 1600 kilocycles, an inductance of 12.5 microhenries in the plate circuit would produce a negative conductance of 5 micromhos. The value of conductance will be highest at the high-frequency end of the broadcast band which is desirable because the effect of the circuit loading is also greater at higher frequencies.

In the F-M band, the transit-time effect and the feedback produced by the inductance of the cathode lead result in grid-circuit loading. In addition, because the i-f transformer presents capacitive reactance to the signal frequencies, additional loading results should the i-f transformer comprise the whole of the plate impedance. It is desirable, therefore, to include series inductance in the plate circuit of the valve to produce enough regeneration to partially counteract these input loading effects. The inductance may take the form of a long lead, or a small, single-turn coil. At 100 megacycles, an inductance of 0.03 microhenry produces a negative conductance of 50 micromhos. Because the short-circuit input conductance of type 6J6 used as a mixer at 100 megacycles is in the order of 50 micromhos, a higher value of plate inductance would cause oscillation at the signal frequency.

Circuit considerations

The circuit diagram, Fig. 3, shows a 6J6 valve employed as an oscillator and mixer with plate supply voltages derived from a 200-volt supply through series resistors. For type 19J6 with a 100-volt supply, as in an a.c./d.c. receiver, the series resistors are omitted or reduced to lower values if it is desired to retain them as r-f filters.

Triode section 2 (plate pin 1, grid pin 6) of the 6J6 or 19J6 should be used as the oscillator section. The other triode section has a getter support attached to its plate and, therefore, would be more susceptible to microphonic disturbances if used as an oscillator. The heater should be at the same r-f potential as the cathode to avoid heater-cathode microphonics. This requirement presents no problem



C1: Antenna Tuning Capacitor, 7 – 25 μμf (FM)
C2: Trimmer Capacitor, 2 – 17 μμf (FM)
C3: Oscillator Tuning Capacitor, 7.5 – 22.5 μμf (FM)
C4: 1500 μμf, mica
C5: 56 μμf, mica
C6: 15 μμf, mica
C7: 68 μμf, mica
C8: 150 μμf, mica
C9: 33 μμf, mica
C10: 160 μμf, mica
C11: 3 μμf, mica
C12: 160 μμf, mica
C13: 0.01 μf, paper, 50 volts
C14: Antenna Tuning Capacitor, 11 – 408 μμf (AM)
C15: Trimmer Capacitor, 2 – 17 μμf (AM)

C16: Oscillator Tuning Capacitor, 9 – 180 μμf (AM)
C17: Trimmer Capacitor, 2 – 17 μμf (AM)
C18: 0.01 μf, paper, 250 volts
C19: 0.01 μf, paper, 250 volts
L1: RF Coil (FM)
L2: Oscillator Coil (FM)
L3: See Text
L4: Loop Antenna, 550 – 1600 kc (AM)
R1: 3.9 megohms, 0.5 watt
R2: 22000 ohms, 0.5 watt
R3: 100 ohms, 0.5 watt
R4: 2.2 megohms, 0.5 watt
R5: 18000 ohms, 1 watt
R6: 27000 ohms, 0.5 watt
S1 S2 S3 S4 S5: Ganged Five-Section Switch
T1: Oscillator Transformer (AM)
T2: Dual IF Transformer (AM and FM)

Fig. 3. Mixer Oscillator Circuit for A-M/F-M Receiver.

in the circuit of Fig. 3 because the cathode and one side of the heater are grounded.

Inductive coupling is used between the oscillator coil (L_2) and the r-f coil (L_1) to obtain the desired oscillator voltage at the mixer grid. In the particular layout used, sufficient coupling is obtained when the two coils are separated by about 2 inches. The oscillator coil (L_2) has a total of $4\frac{3}{4}$ turns: $2\frac{1}{2}$ turns between the plate end and the tap, and $1\frac{1}{4}$ turns between the tap and the grid end. The r-f coil (L_1) has $1\frac{3}{4}$ turns, tapped at $\frac{1}{2}$ turn from the grounded end for the antenna connection. The switching arrangement used requires only one connection between the oscillator circuit and the switch. The switch is open for the F-M position. The 100-ohm resistor (R_3) is used to prevent oscillation at the F-M frequency when the switch is in the A-M position.

The transformer (T_1) for the A-M oscillator includes an extra winding to supply oscillator voltage to the mixer section of the valve. Because this winding is connected between the mixer grid and the high-potential side of the A-M circuit, the capacitance between this winding and the other windings should be small.

The bias developed at the mixer grid is approximately 2.8 volts in the A-M band and 2.5 volts in the F-M band. For the F-M band, the total resistance between grid and ground is about 6 megohms. In the A-M band, a.v.c. voltage is applied to the mixer triode through resistors R_1 and R_4.

A dual i-f transformer is used. The A-M primary is tapped; the F-M primary is designed to operate with a capacitance consisting of a 33-μμF capacitor plus the output capacitance of the valve. Both windings are tuned with movable iron cores. When one band is used, the unused primary winding of the other is short-circuited.

Performance

In the A-M band, the conversion gain between mixer grid and first i-f grid is about 26. The i-f selectivity, the image rejection ratio, and the i-f rejection ratio are nearly the same as the values usually obtained with pentagrid converter valves. Only four per cent. of the noise output appears to come from the mixer valve, the balance being thermal-agitation noise from the input circuit.

In the F-M band, the gain measured from the terminals of the signal generator to the grid of the first i-f stage is 18 to 26. A 300-ohm dummy antenna is connected between the signal generator and the antenna input circuit when this measurement is made. The signal input required to obtain a signal-to-noise ratio of 20 db (signal deviation: 22.5 kc/s at a 400-cycle modulation frequency is 5.5 to 10 microvolts).

New RCA Release

Radiotron 811-A—power triode

The new 811-A power triode—an improved version of the popular 811—utilizes a modified construction featuring a zirconium-coated plate having radiating fins to give greater dissipation capability, grid and plate leads designed to have low r-f loss, and a greatly strengthened top-cap assembly with ceramic collar. The greater dissipation capability permits increased ratings for plate current and plate input.

Because of its high perveance, the 811-A operates at high efficiency and with low driving power. For example, a pair of 811-A's in class B a-f service with a plate input of 470 watts (ICAS) requires a driving power of only 4.4 watts and can modulate 100 per cent. a r-f amplifier having an input of 680 watts.

In unmodulated class C service under ICAS conditions, two 811-A's operated with a plate input of 520 watts require a driving power at the valves of only about 14 watts. Operation with maximum ratings is permissable up to 30 megacycles, and with reduced ratings to 100 megacycles.

TELEVISION TRANSMISSION STANDARDS

Presented below are the proposed Australian TV standards so far announced. For comparison, the current U.K. and U.S. standards are also shown.

	U.K.	**U.S.A.**	**Aust.**
Carrier frequencies Mc/s	41.5–61.75	54–216	178–200
Bandwidth Mc/s	2.7	6	7
Number of lines	405	525	625
A-M video polarity	Positive	Negative	Negative
Sound modulation	A-M	F-M	F-M
Transmission polarisation	Vertical	Horizontal	Horizontal
Vestigial sideband transmission	Not at present	Yes	Yes
Pictures per second	25	30	25
Aspect ratio	5 to 4	4 to 3	4 to 3

The similarity of the U.S. and proposed local standards is immediately obvious. For this reason, descriptions of American equipment and technique being published in Radiotronics will be of particular interest to Australian manufacturers.

RADIOTRON DESIGNER'S HANDBOOK

Enquiries and orders for the Radiotron Designer's Handbook continue to reach us, not only from Australia but from New Zealand, India, South Africa and other widely separated countries and it is felt that progress reports should be released in connection with the forthcoming publication.

The fourth edition will include over 1000 pages (octavo) of valuable information on all phases of radio receiver design, both theoretical and practical, making it the most comprehensive book which has ever been published on this subject in any country.

It is hoped to pass the copy to the printer in January, 1950, and that the deliveries of the book will commence several months later. The price has not yet been determined.

Any enquiries received in relation to the Radiotron Designer's Handbook are not only acknowledged but are noted on our reminder files and subsequent advice will be mailed just as soon as more definite information becomes available.

Radiotron Type Z77

MINIATURE TELEVISION AMPLIFIER PENTODE.

GENERAL DATA

Electrical

Heater, for unipotential cathode:

Voltage (a.c. or d.c.)	6.3 volts
Current	0.3 ampere

Direct Interelectrode Capacitances*

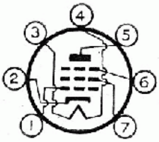
	Cold	Hot•	
Grid No. 1 to plate	0.009	—	μμF
Input	7.4	10.0	μμF
Output	3.1	3.0	μμF
Heater to Cathode	—	4.0	μμF

Mechanical

Mounting position	any
Shielding	No internal or external shielding is fitted. An external shield should be used.
Ventilation	The valve and shield should be mounted with as much free air circulation as possible.
Microphony	This type is free from microphony in most applications, but checks should be made under maximum gain conditions of the equipment.
Maximum overall length	$2\frac{11}{64}''$
Maximum seated height	$1\frac{15}{16}''$
Maximum diameter	$\frac{3}{4}''$
Bulb	T – $5\frac{1}{2}''$
Base	Miniature Button 7-pin B7G

Basing Designation

Pin 1	Grid No. 1
Pin 2	Cathode
Pin 3	Heater
Pin 4	Heater
Pin 5	Plate
Pin 6	Grid No. 3
Pin 7	Grid No. 2



TRIODE CONNECTION

(Grid No. 2 tied to plate and Grid No. 3 tied to cathode)

Maximum Ratings

Plate Voltage	250 volts
Plate (plus screen) dissipation	3.3 watts
Cathode Current	30 mA

Typical Operating Data

Class A Amplifier

Plate Voltage	250 volts
Grid No. 1 (Control) Voltage	–2 approx. volts
Cathode-Bias Resistor	160 ohms
Amplification Factor	75
Transconductance	7500 micromhos
Plate Resistance	10000 ohms
Cathode Current	12.5 mA

PENTODE CONNECTION

Maximum Ratings

Plate Voltage	250 volts
Grid No. 2 (Screen) Voltage	250 volts
Plate Dissipation	2.5 watts
Grid No. 2 (Screen) Dissipation	0.8 watts
Peak Heater-Cathode Voltage	150 volts

Typical Operating Data

Class A Amplifier

Plate Voltage	250 volts
Grid No. 3 (Suppressor) Voltage	0 volts
Grid No. 2 (Screen) Voltage	250 volts
Grid No. 1 (Control) Voltage	–2 approx. volts
Cathode-Bias Resistor	160 ohms
Plate Resistance	0.3 megohms
Transconductance	7500 micromhos
Plate Current	10 mA
Grid No. 2 (Screen) Current	2.5 mA
Input Resistance (at 45 Mc/s.)	9000 ohms
Equivalent Noise Resistance	1000 ohms

Mixer (with series injection to Grid No. 1)

Plate Voltage	250 volts
Grid No. 3 (Suppressor) Voltage	0 volts
Grid No. 2 (Screen) Voltage	250 volts
Grid No. 1 (Control) Voltage	–4 approx. volts
Cathode-Bias Resistor	680 ohms
Conversion Conductance	2700 micromhos
Peak Oscillator Voltage	4.5 volts
Plate Current	4.5 mA
Grid No. 2 (Screen) Current	1.5 mA

Class A Amplifier (Low voltage operation)

Plate Voltage	28 volts
Grid No. 3 (Suppressor) Voltage	28 volts
Grid No. 2 (Screen) Voltage†	8 volts
Grid No. 1 (Control) Voltage	–2 volts
Cathode-Bias Resistor	2200 ohms
Load Resistor	22000 ohms
Stage Gain	30 db
Plate Current	0.75 mA
Grid No. 2 (Screen) Current	0.15 mA

* With external shield.

• At E_b=250V E_{c_2}=250V E_{c_3}=0V I_b=10 mA.

† Wherever possible, a voltage divider supply should be used for Grid No. 2.

General

With maximum plate and screen wattage, the effective external resistance between Grid No. 1 and Cathode should not exceed 0.5 megohm with self-bias, or 0.1 megohm with fixed bias. This valve is the equivalent of the 6AM6.