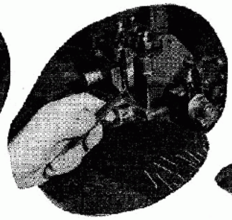
Radiotronics

NUMBER 137 · MAY-JUNE 1949

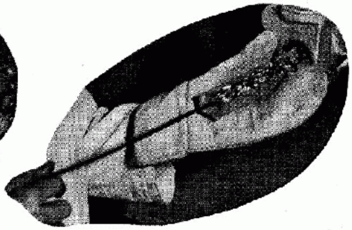
MINIATURE VALVE PRODUCTION FLOW

METAL STRIP IS PRESSED INTO CYLINDRICAL PLATES

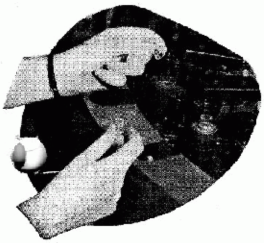
WIRE IS WOUND INTO ACCURATELY GAUGED GRIDS



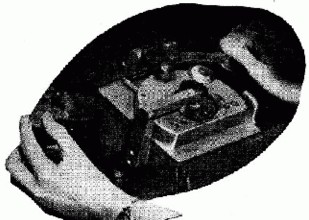
COATED FILAMENT WIRE IS CUT TO EXACT LENGTHS



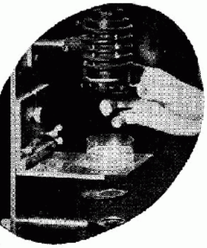
COMPLETED PARTS ARE TREATED IN HYDROGEN FURNACES



WIRE LEADS AND GLASS ARE FUSED TO MAKE STEMS

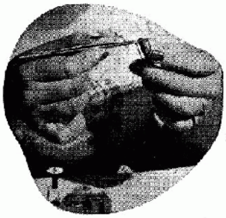


STEM LEADS ARE TRIMMED AND FORMED INTO POSITION

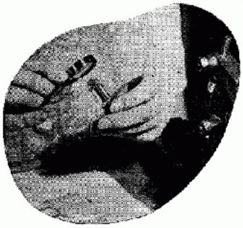


COMPLETED GLASS STEMS ARE EXAMINED UNDER POLARISED LIGHT

SPACING WASHERS ARE STAMPED FROM SHEETS OF MICA

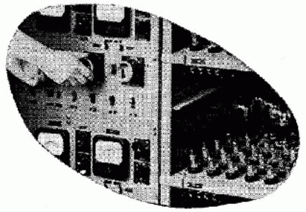


COMPONENTS ARE ASSEMBLED IN THE FORM OF CAGES

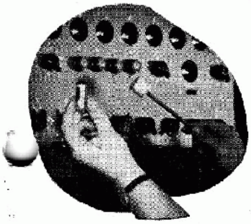


CAGES AND STEMS ARE WELDED TOGETHER ELECTRICALLY

COMPLETE MOUNT IS SEALED IN GLASS AND AIR EXHAUSTED

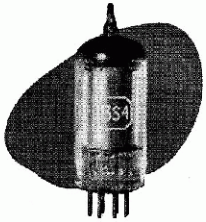


RACKS OF FINISHED VALVES UNDERGO THE AGEING TREATMENT



EVERY VALVE MUST PASS RIGID AND THOROUGH TESTS

RADIOTRON VALVES ARE INDIVIDUALLY PACKED IN SPECIALLY DESIGNED CARTONS TO ENSURE SAFE TRANSPORT



A GRAPHIC PRESENTATION OF SOME OF THE PROCESSES INVOLVED IN THE PRODUCTION OF AN AUSTRALIAN MADE RADIOTRON MINIATURE

R. Gill

Miniature Valve Production Flow

(Cover illustration)

Of paramount importance in the organisation of a factory is the smooth flow of production from raw materials to the finished article complete in its package. Radiotron valves are no exception to this general aim, and though necessarily passing through many intricate stages, their progressive construction is graphically presented on the cover of this issue of Radiotronics.

Although a number of the operations are performed on modern machinery, it devolves upon keen perception and deft fingers to achieve and maintain the high standards of quality so essential to ensure uniform characteristics.

Commencing with acceptance tests upon raw materials (glass, wire, metal strip, mica and so on), the fabrication of valve parts is constantly accompanied by rigid checks and minute inspections. Polarised light reveals flaws and strains present in glass; weight is applied to ascertain the breaking point of exhaust tube seals; immersion in boiling water provides ample proof that the bulb can withstand extremes of temperature. These are but a few of the many tests applied in the process of valve manufacture.

Here in this Australian factory approximately twenty million valves have been produced during the seventeen years since its inception in 1932, and to-day thousands of Radiotrons are produced daily to meet the ever-expanding needs of the electronic industry.

The extremely close tolerances to which the component parts of a valve are made and assembled are already widely known, and the successful establishment of so highly skilled an industry within such a comparatively brief period speaks volumes for Australian craftsmanship. Much of the automatic mass production machinery has been built in Sydney, whilst a number of intricate operations are carried out on equipment devised and constructed by the Company's own engineers.

As an example of the progressive policy of the Valve Company, the Australian made miniature valve is now available to set manufacturers as initial factory equipment for personal portables, car radios, F-M equipment of the mobile kind and for short-wave work. Both the battery (1.4 volt filaments) and a.c. (6.3 volt filaments) are now in production, and performance reports rate them as equal to or better than overseas products.

With the increasing interest in miniature type valves being evidenced as design engineers pay greater attention to very high frequencies, the planning side of valve production must be more and more concerned with the all-glass construction of the Tom Thumb" Radiotron—a midget in size, but a giant in performance.

Radiotronics

NUMBER 137 **MAY-JUNE, 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 IRE

Asst. Tech. Editor
I. C. Hansen, Member IRE

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

Reducing the Harmonic Power Output of Amateur Transmitters

By JOHN L. REINARTZ

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

Although it is not generally realized, most amateur transmitters using but one tuned circuit in the final output stage cannot meet the International regulation with regard to the reduction of the radiation of harmonic frequencies to not less than 40 db below the output of fundamental frequency.

This article on harmonic reduction will present some practical methods of minimizing TVI* at the source.

Reason for harmonics

All valves generate harmonic components when operated under class C conditions. Each time the grid of the valve is driven positive, a current pulse flows in the plate circuit of the valve. The current value for each of the harmonics produced depends on the angle of plate-current flow. For example, for a plate-current-flow angle of 140° the harmonic relationships[1] are given in Table I.

TABLE I

Component	Current % of fundamental	Equivalent power level referred to fundamental (db)
Fundamental	100	0
Second harmonic ..	69.4	− 3.2
Third harmonic ...	30.8	− 10.3
Fourth harmonic ..	4.6	− 25.8

The voltages produced across the output circuit by these harmonic components are dependent on the magnitude of the impedances presented to each harmonic component by the tuned circuit and are dependent to a large degree on the Q of the tuned circuit.

The performance of any amplifier in a transmitter is determined by both the characteristics of the associated tuned circuit and the valve. The choice of the valve has been made easy for us by the manufacturer who has supplied us with the necessary valve characteristics and operating values. It is, therefore, only necessary to consider the r-f circuit constants that should be used. C, L, and R can be of various values within rather large limits, and, if frequency were the only consideration, the capacitance could be made small and the inductance large or vice versa. The action of the reflected load resistance on the tuned tank circuit is to decrease the sharpness of tuning as its shunt value is made smaller. In actual practice, however, there is a compromise value for the three components which results in high efficiency and good harmonic suppression.

Now, the larger the value of the tuning capacitor, the smaller the impedance it presents to the harmonic components in the plate-current pulse. Consequently, the harmonic voltage produced across this capacitor is smaller. In addition, there is a larger circulating current in a larger capacitance for a given power output. It is this ratio, called Q, of the circulating volt-amperes (r-f voltage times circulating current), to the power output, that determines the harmonic power that can be passed on. The harmonic power is higher for low Q and lower for high Q circuits.

Harmonics are suppressed to a considerable extent even by a simple tuned circuit.[2] For example, if the tuned tank circuit is as shown in Figure 1 where R_a and C_a are the antenna resistance and capacitance, then the db reduction of harmonics in the antenna due to the Q of the tank circuit is given in Table II.

TABLE II

Harmonic reduction in db due to a single-tuned circuit referred to fundamental-frequency power

Q	Second harmonic	Third harmonic	Fourth harmonic
5	−23.5	−32.0	−37.5
10	−29.6	−38.1	−43.5
15	−33.0	−41.6	−47.0
20	−35.6	−44.1	−49.6

adding these values to those given in Table I gives—

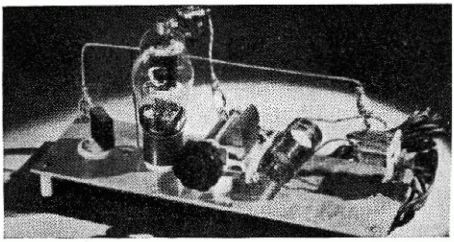
TABLE III

Harmonic power output in db of valve and single-tuned circuit referred to fundamental-frequency power.

Q	Second harmonic	Third harmonic	Fourth harmonic
5	−26.7	−42.3	−63.3
10	−32.8	−48.4	−69.3
15	−36.2	−51.9	−72.8
20	−38.8	−54.4	−75.4

We see from these tabulations that every time we double the Q of the tuned circuit the harmonic level goes down by 6db. For the second harmonic, how-

* TVI—Television Interference.



This one-stage rig was designed to reduce harmonic radiation and resultant television interference. Although it is not the unit described, it utilizes the same practical method discussed.

ever, this reduction is still insufficient to comply with the International rule of −40db even when the Q of the tuned circuit is 20.

Harmonic suppression in double-tuned circuit

If the circuit is doubly tuned as in Figure 2, there is an even greater reduction in harmonics as shown in Table IV.

TABLE IV

Harmonic reduction in db due to two coupled circuits referred to fundamental-frequency power.

Q	Second harmonic	Third harmonic	Fourth harmonic
5	−38.2	−54.4	−76.8
10	−50.2	−67.4	−88.8
15	−57.3	−75.1	−96.2
20	−62.3	−79.4	−100.8

It can be seen from this tabulation that whenever the value of Q is doubled the harmonics are all reduced by 12 db. Another important fact that can be deduced from these tables is that it is better to have a Q of say 10 in each tuned circuit of Figure 2 than to have a Q of 20 in the single tuned circuit of Figure 1. Now we can meet the International rule of −40db for harmonic radiation if we use a Q of 10 or better in each of the tuned circuits. This −40db value represents 0.01 watt for an amateur station radiating 100 watts at the fundamental frequency.

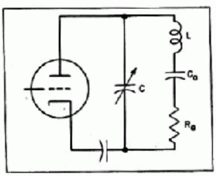


Figure 1.
A single-tuned circuit.

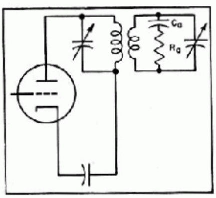


Figure 2.
A double-tuned circuit.

Field-strength considerations

Let us consider the field strength produced by an antenna. The field strength produced by a horizontal half-wave dipole[3] is

$$E = 23\sqrt{P/d} \text{ volts per metre,}$$

where P is the radiated power in watts and d is the distance in feet from the radiator to the point where E is measured. This value can be considered an average value. Actually, the field strength varies with distance between a lower and higher value because of subtraction and addition of the wave reflected from the ground and the direct wave, and also because the configuration of the lobes changes with the effective length of the transmitting antenna for any particular harmonic. The formula is useful for distances up to about 650 feet. Since the amateur is concerned with distances within this value down to say 50 feet, the above formula for field strength applies. Inversion of the formula will give the power required to produce a given field strength.

$$P = 1880\ (Ed)^2 \text{ microwatts,}$$

where E is in volts/metre and d is in feet.

The limiting field strength for the service area of a television transmitter is considered by the FCC in U.S.A. to be 500 microvolts per metre in residential and rural areas. It has been determined that an interfering signal of 1/100 this value is not objectionable. The amateur, therefore, should not produce an interfering field greater than 5 microvolts/metre for such a service area.

Let us now find the power required to produce such a field at 500 feet.

$P = 1880\ (5 \times 10^{-6} \times 500)^2 = 0.012$ microwatts.

Compare this 0.012-microwatt value with the 0.01 watt (10000 microwatts) which the present International rulings allow for harmonic radiation when the radiated fundamental output is 100 watts. A 0.01-microwatt value represents a power ratio of harmonic to fundamental values of 10^{-10} or −100db when the power radiated at the fundamental is 100 watts. This changes to 10^{-11} or −110db when the fundamental power is 1000 watts. These values are far more severe than the −40db level currently required, but are what the amateur must attain if he wants to stay on good terms with the general public.

Other methods of reducing TVI

Because even two tuned tank circuits may fail to reduce an interfering signal to the −100 or −110db level, other means must be found. Several good articles on the subject have appeared in amateur magazines. Mack Seybold has shown in the August 1947 issue of QST that the addition of trap circuits in the plate lead of the final class C stage will reduce the harmonic level some 40 to 50db and if considered along with two tuned tank circuits may reach the desired −100 or −110db level.

Harmonic suppression

In cases where even the processes outlined above fail to reduce the interference to television reception at distances shorter than 500 feet it will be found advantageous to resort to additional grounded trap circuits tuned to the interfering harmonic. These trap circuits should be closely coupled to the hot end of each plate tank circuit of every stage in the transmitter. Such a system, devised by the writer, was found capable of apparently completely cancelling a harmonic. Because every r-f stage in a transmitter amplifies the harmonic components present in its grid excitation voltage, the first place to get rid of the harmonic is at the crystal oscillator plate-tank circuit. What may be left can be taken care of in subsequent stages at their respective plate tank circuits.

To prove the effectiveness of this system, a 2E26 oscillator-doubler, controlled by a 7 Mc/s crystal, followed by an 813 final was built having the shunt traps roughly tuned to 28 Mc/s and the grounded traps (tuned to the offending harmonic, approx. 28 Mc/s) coupled closely to each plate tank circuit.

In some cases, it may be necessary to tune one or more of these traps to the third harmonic, to obtain greater reduction of interference.

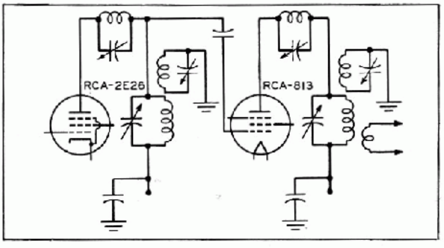
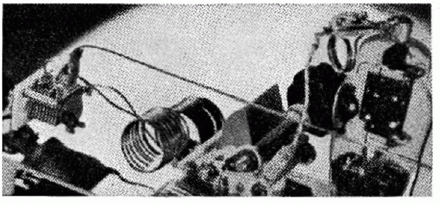


Figure 3. Schematic of method devised to cancel transmitter harmonics.

The essentials of this circuit are shown in Figure 3. A television receiver was set up ten feet away and connected to a standard 90″ folded-dipole antenna through 100″ of 300-ohm, twin-lead transmission line. The antenna for the transmitter was strung within 8 feet of the TVR antenna. With normal excitation to the 813 valve in the 20-metre band and with the TVR tuned to channel 2, it was possible to operate the transmitter with 100% 60-cycle modulation without undue interference to the TVR even though the transmitter was incompletely shielded in that the entire top cover of the transmitter cabinet was removed. The measured output from the 813 was adjusted to 150 watts as a convenient value for testing purposes.

A cathode-ray oscilloscope was connected to the grid of the receiver kinescope to allow further visual indication of the interference caused by the transmitter when the closely coupled grounded-trap circuits were detuned. Under such conditions the pattern on the kinescope was a maze of interference and the oscilloscope showed a pattern with both r-f and 60-cycle components present at the grid of the kinescope. All these patterns disappeared when the grounded plate traps were properly tuned. The shunt traps in series with the plate circuits of the two valves needed only to be tuned to the inductive side of resonance of the unwanted harmonic. This tuning was not critical. To obtain the results described, the grounded-trap coil should be located at the hot end of the tank coil and wound on the same form and in the same direction. Ground the trap coil at the far end, away from the tank coil.



Component details which were found essential for reducing harmonic output are shown in this close-up. A plate shunt trap, upper right, reduces harmonic pulses generated at the plate of the 807. An absorption trap coil, centre, tunes to the harmonic and changes the phase relation to the plate tank tuning system. Cancellation of stray harmonic currents traversing the chassis is accomplished by means of a cancellation wire shown running parallel with chassis.

It is realized that a complete test requires that the TVR be tuned to a television station signal in order to determine if any interference may still be present that could not be detected under the test conditions outlined above. Such tests will be discussed later.

Previously it was shown that the generation of harmonics in a class C stage is natural and must be expected. In fact, it is this harmonic generation that makes doubler and tripler stages possible. However, if the radiated power capable of causing interference must be kept to less than 0.01 microwatt, even such high order harmonics as the 8th or 16th from fundamental operation at 7 or 3.5 Mc/s may cause television interference. Even more trouble can be expected from stages operating at 14 and 28 Mc/s where the harmonic order that can cause interference is much lower and the amplitude much higher. The problem then is — what to do about these harmonic radiations that cause TVI.

Earlier, it was pointed out that previous investigators advocated the use of complete shielding along with the installation of parallel-tuned series-inserted traps(4) and other by-passing devices which must also be shielded. The writer, however, has had considerable success with another method of reducing harmonic radiation which does not depend upon shielding for its efficacy. This method involves the use of the tank-coil traps described but with one additional and important refinement in the method of connecting the traps together and grounding them. These tank-coil traps operate by absorbing the unwanted harmonics and cancelling them out by means of tuned feedback circuits. But more of this later. Our first problem is to locate the offending harmonics.

Locating the harmonic

In order to use this method, we must first locate the offending harmonic and utilize some method of measuring its relative amplitude. For this purpose an old standby, the universally used absorption-type wavemeter, comes into play.

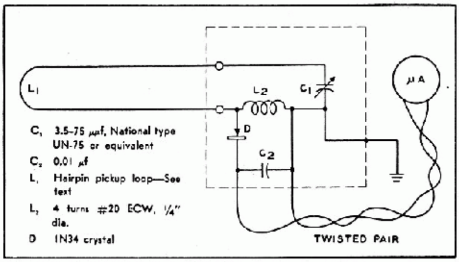
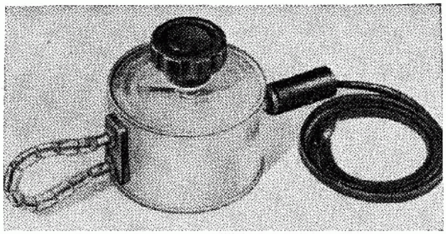


Figure 4. Wavemeter schematic.

A modified wavemeter that has proved extremely sensitive was devised by the writer. This unit, diagrammed in Figure 4, consists of a resonant circuit (L_1C_1) for the frequencies under discussion, a 4-turn, $\frac{1}{4}''$ diameter coil of No. 20 B & S enamelled insulated wire (L_2) in series with the resonant circuit, a 1N34(*) crystal and microammeter in series connected across the 4-turn coil, and a capacitor (C_2) connected across the meter. The microammeter is connected to the tuned circuit by means of a flexible two-wire cord of any desired length. This arrangement allows the operator to get much closer to circuits suspected of harmonic radiation than would be the case if the resonant circuit and the meter were in one container. The absorption meter may be built into a small metal can into which the pick-up loop for the particular frequency range desired can be plugged. A photograph of the wavemeter is shown on this page. When a variable capacitor of 3.5 to 75 μμF is used together with a pickup loop 2" long, consisting of a single hairpin turn, the tuning range extends from 50 to 150 megacycles.

The hairpin pickup loop should be threaded with



This easily built but extremely sensitive absorption type wavemeter is essential for tracking down offending harmonic radiation in transmitters.

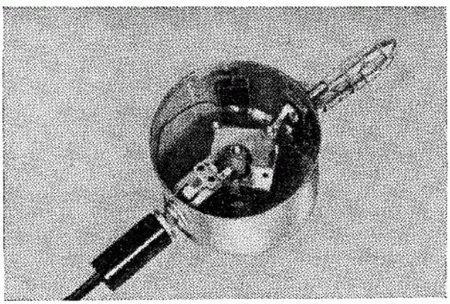
glass or porcelain beads or with some other insulating material so that when the wave-meter is used to probe near high-voltage points, direct contact will be prevented. An additional, but very worthwhile precaution is to connect a flexible grounding wire between the wavemeter can and ground.

Because the 4-turn coil is inside the can, it picks up very little energy from the fundamental frequency when the wavemeter hairpin is held close to a tank circuit.

Preliminary checking

The next thing to do is to make a preliminary check with the wave-meter to determine which harmonics are prevalent in the transmitter and where they are most prominent. A good place to check is near the plate connection of each valve. Caution must be exercised when high-voltage points are checked in order to prevent any accidental contact.

As the check for harmonics progresses, make a note of the location and relative value of the harmonics for future reference. Don't be surprised if harmonic indications are noted in the heater leads of heater-cathode-type valves or at that end of a plate-tuning-capacitor frame which is not by-



An interior view of the wavemeter shows placement of components. The rotor plates of the variable capacitor may be trimmed in order to make the frequency response of the unit more linear at the high-frequency end.

* English equivalent CG1.

passed for r-f ground. In order to cut down the harmonics at these points, connect a by-pass capacitor of 0.001 μF and the proper voltage rating between the plate-tuning capacitor frame and ground. Between the heater lead and ground use a 0.01 μF capacitor. A further check with the wavemeter at these points will in all probability show a substantial reduction in the harmonic amplitude. Any long lead under a chassis may also show harmonic voltages and should be similarly by-passed at readily accessible points.

Tuned-plate traps

After adequate by-passing is accomplished, the first step is to insert parallel-tuned trap circuits in series with the plate leads of each class C stage. See Figure 5. These traps may be made readily with ten turns of No. 20 B & S enamel coated wire, wound with a ½-inch inside diameter and shunted with a 3- to 30-μμF trimmer capacitor for tuning. It will be found that the tuning range of this trap extends from 25 to 80 Mc/s.

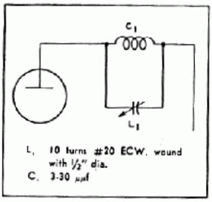


Figure 5.
A parallel-tuned trap circuit.

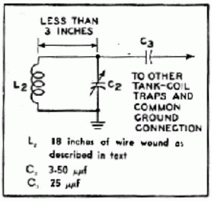


Figure 6.
A tank-coil trap circuit.

Tank-coil traps

The next step, which is something new in TVI reduction, is to utilize the previously mentioned tank-coil traps which absorb and cancel through negative feedback the unwanted frequencies. These traps are positioned about ¼" from the hot end of the plate coil at each stage. Each trap (see Figure 6) is made by winding a coil of as many turns as can be made from 18 inches of wire in the same direction and of the same diameter as the tank coil.

Wire comparable in size to that of the tank coil should be used although it is not necessary to use wire larger than No. 10 B & S. The coil is then shunted with a 3- to 50-μμF tuning capacitor. The hot end of the coil is connected to the stator plate. This capacitor is mounted adjacent to but not more than 2" to 3" from the coil in such a manner as to be tunable from the front panel by means of an extension shaft. The rotor side of the variable capacitor is then grounded. Similar traps are mounted at the hot ends of the other plate tanks and the antenna coil as shown in Figure 7. Each trap is then coupled by means of a 25 μμF fixed capacitor to a common line which is grounded at a point approximately half way between any pair of 25 μμF fixed capacitors.

Connecting the grounding wire

A final connection completes the hookup. This connection is made to the trap in the tank circuit of the final and consists of a grounding wire approximately ten inches long connected between the ungrounded side of the variable tuning capacitor and any convenient point of the chassis. Some experimentation may be necessary to locate the optimum grounding point necessary to produce maximum harmonic attenuation.

In push-pull stages only one tank-coil trap is required. If either a centre-tapped antenna tuning unit or a split tank circuit is used, the tank-coil trap may be located at either end.

Shielding considerations

Although the operation of this system of reducing harmonic interference does not specifically require shielding, it is advantageous to use a metal front panel in addition to the usual metal chassis. The metal front panel minimizes the detuning effects of hand and body capacitances when the several air capacitors are adjusted.

Tune up

The tune-up procedure is quite simple. The absorption-type wavemeter is tuned to the lowest harmonic causing TVI. It is then brought in close proximity to the tank circuit of the first stage in the equipment and the series-inserted plate trap is tuned to reduce the offending harmonic to a minimum. It will be found that several minimums will be noted as the 3- to 30 μμF trimmer capacitor is adjusted from minimum capacitance to maximum capacitance. In the doubler and final stages, however, care must be taken to avoid tuning to the output frequency so that the 3- to 30 μμF capacitor will not tend to arc over and burn up. After testing over the entire range with the wavemeter, choose the setting at which all harmonics, even and odd, above and including the offending harmonic are reduced to a minimum. The tank-coil trap is then tuned for still further harmonic reduction. The process is repeated for each stage, in order, ending with the antenna-tuning stage. A further check is made at the antenna feeders to make sure that no harmonic emission is detectable. The final, and most important check of course, should be made on the nearest television receiver.

Field tests

In several rigorous field tests, this system of reducing TVI gave excellent results. One test was made at the writer's home station in Lancaster, Pa. The regular 20-metre folded dipole 45 feet high was located within 50 feet of the television antenna also

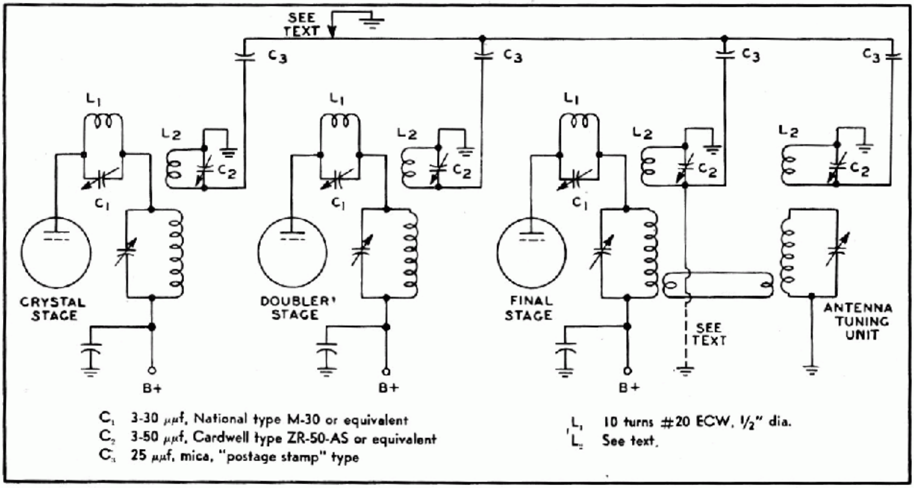


Figure 7. Partial schematic of transmitter showing manner in which harmonic-cancelling traps are placed in circuit.

45 feet high. The transmitter was operated with 300 watts input and caused no interference on channels 3 and 6 originating in Philadelphia 65 miles away. For these tests the TV screen was viewed at a distance of approximately 40 inches in order to obtain the standard 4-to-1 viewing ratio for a 10-inch kinescope.

For a more strenuous test, the transmitter was then taken to Harrison, N.J., where it was operated in the same room with a commercial television receiver. All 6 channels in the New York area were sampled and were clear of transmitter interference to a degree considered unattainable before the tests began.

In Lancaster, the system was tried and is still in use on a Collins 32V transmitter operating on 10 metres with equally satisfactory results.

Although this system has worked remarkably well in every transmitter the author has modified, it should be recognized that each case of TVI presents special problems and requires experimentation.

[1] Radio Engineers Handbook, F. E. Terman, Fig. 86.

[2] "Labus and Roder", Proc. I.R.E., Vol. 19, pp. 949-962, 1931.

[3] RMA publication R4-2860-A (July, 1948) by W. T. Wintringham.

[4] Mack Seybold "Curing Interference to Television Reception", QST, August, 1947, Vol. XXXI, No. 8, pp. 19-23.

The following is a list of U.S. television channel numbers and their corresponding frequency allocations.

TV Channel Number	Channel Freq. Mc/s
1	44–50
2	54–60
3	60–66
4	66–72
5	76–82
6	82–88
7	174–180
8	180–186
9	186–192
10	192–198
11	198–204
12	204–210
13	210–216

Radiotron Type 5786 Power Triode

Reprinted by courtesy of the Radio Corporation of America

The 5786 is an improved version of Type 6C24, which is a Radiotron preferred transmitting type. No stocks of either valve are at present held in Australia.

The 5786 is a compact, forced-air-cooled power triode intended primarily for industrial applications, but useful in broadcast service. In unmodulated class C service, it has a maximum plate input of 1500 watts and a maximum plate dissipation of 600 watts. Full ratings may be used at frequencies up to 160 megacycles.

Contributing to the exceptionally good high-frequency performance of the 5786 is its small size, its centre-tapped filament to permit minimizing the effect of filament–lead inductance low inter-electrode capacitances, and its efficient radiator to provide ample cooling with a low-cost blower.

GENERAL DATA

Electrical:

Filament, Thoriated Tungsten:

Voltage (a.c. or d.c.)	11 ± 0.6	volts
Current	12.5	amperes

Starting current—The filament current must never exceed, even momentarily, a value of 50 amperes.

Cold Resistance	0.13	ohm
Amplification Factor	30	
Direct Interelectrode Capacitances:		
Grid to Plate	5.3	μμF
Grid to Filament	4.2	μμF
Plate to Filament	3.4	μμF

Mechanical:

Mounting Position	Vertical, grid end up or down
Overall Length	9-3/4″ ± 1/4″
Maximum Diameter	2.895″
Terminal Connections	See Outline Drawing
Radiator	Integral part of valve
Air Flow to Radiator and Seals for Max. Rated Conditions	140 min. cfm

Sufficient air must be delivered by a blower to the radiator and seals so that the maximum radiator and seal temperatures will not be exceeded. Air flow must start before the application of any voltages. Filament power, plate power, and air may be removed simultaneously.

Incoming Air Temperature	45 °C max.
Radiator Temperature (see text for making measurement)	180 °C max.
Seal Temperature:	
Grid and Plate	165 °C max.
Filament	220 °C max.

A-F POWER AMPLIFIER AND MODULATOR—Class B

Maximum CCS* Ratings, Absolute Values:

D.C. Plate Voltage	3000 max.	volts
Max. –Signal D.C. Plate Current†	400 max.	mA
Max. –Signal Plate Input†	1200 max.	watts
Plate Dissipation†	600 max.	watts

Typical Operation:

Values are for 2 valves

D.C. Plate Voltage	3000	volts
D.C. Grid Voltage‡	–95	volts
Peak A-F Grid-to-Grid Voltage	470	volts
Zero-Signal D.C. Plate Current	75	mA
Max. –Signal D.C. Plate Current	800	mA
Effective Load Resistance (Plate to plate)	8600	ohms
Max. –Signal Driving Power (Approx.)	30	watts
Max. –Signal Power Output (Approx.)	1640	watts

PLATE-MODULATED R-F POWER AMP.—Class C Telephony

Carrier conditions per valve for use with a max. modulation factor of 1.0

Maximum CCS* Ratings, Absolute Values:

D.C. Plate Voltage	2500 max.	volts
D.C. Grid Voltage	–500 max.	volts
D.C. Plate Current	400 max.	mA
D.C. Grid Current	150 max.	mA
Plate Input	1000 max.	watts
Plate Dissipation	400 max.	watts

Typical Operation:

D.C. Plate Voltage	2500	volts
D.C. Grid Voltage:		
From a fixed supply of	–350	volts
From a grid resistor of	2600	ohms
Peak R-F Grid Voltage	620	volts
D.C. Plate Current	400	mA
D.C. Grid Current (Approx.)	135	mA
Driving Power (Approx.)	75	watts
Power Output (Approx.)	810	watts

* Continuous Commercial Service.

† Averaged over any audio-frequency cycle of sine-wave form.

‡ Grid Voltage is given with respect to mid-point of filament operated on a.c. or d.c.

R-F POWER AMPLIFIER AND OSC.— Class C Telegraphy

Key-down conditions per valve without amplitude modulation §

Maximum CCS* Ratings, Absolute Values:

D.C. Plate Voltage	3000 max. volts
D.C. Grid Voltage	−500 max. volts
D.C. Plate Current	500 max. mA
D.C. Plate Current	500 max. mA
D.C. Grid Current	150 max. mA
Plate Input	1500 max. watts
Plate Dissipation	600 max. watts

Typical Operation as R-F Power Amplifier:

D.C. Plate Voltage	3000 ... volts
D.C. Grid Voltage:	
From a fixed supply of	−200 ... volts
From a grid resistor of	2200 ... ohms
From a cathode resistor of	330 ... ohms
Peak R-F Grid Voltage	450 ... volts
D.C. Plate Current	500 ... mA
D.C. Grid Current (Approx.)	90 ... mA
Driving Power (Approx.)	36 ... watts
Power Output (Approx.)	1000 ... watts

Typical Operation as Oscillator at 160 Mc/s.

D.C. Plate Voltage	3000 ... volts
D.C. Grid Voltage	−225 ... volts
From a grid resistor of	2000 ... ohms
From a cathode resistor of	380 ... ohms
Peak R-F Grid Voltage	475 ... volts
D.C. Plate Current	500 ... mA
D.C. Grid Current (Approx.)	90 ... mA
Power Output (Approx.)	1000 ... watts
Useful Power Output (Approx.)— 85% circuit efficiency	850 ... watts

SELF-RECTIFYING OSCILLATOR OR AMPLIFIER—Class C

Maximum CCS* Ratings, Absolute Values:

A.C. Plate Voltage (rms)	4250 max. volts
D.C. Grid Voltage	−300 max. volts
D.C. Plate Current	320 max. mA
D.C. Grid Current	85 max mA
Plate Input	1500 max. watts
Plate Dissipation	600 max. watts

Typical Operation:

A.C. Plate Voltage (rms)	4250 ... volts
D.C. Grid Voltage	−115 ... volts
From a grid resistor of	1500 ... ohms
D.C. Plate Current	320 ... mA
D.C. Grid Current (Approx.)	77 ... mA
Driving Power (Approx.)**	46 ... watts
Power Output (Approx.)	1050 ... watts

AMPLIFIER OR OSCILLATOR—Class C

With Separate, Rectified, Unfiltered, Single-Phase, Full-Wave Plate Supply.

Maximum CCS* Ratings, Absolute Values:

D.C. Plate Voltage	2700 max. volts
D.C. Grid Voltage	−300 max. volts
D.C. Plate Current	450 max. mA
D.C. Grid Current	120 max. mA
Plate Input	1500 max. watts
Plate Dissipation	600 max. watts

Typical Operation:

D.C. Plate Voltage	2700 ... volts
D.C. Grid Voltage	−180 ... volts
From a grid resistor of	1530 ... ohms
D.C. Plate Current	450 ... mA
D.C. Grid Current (Approx.)	118 ... mA
Driving Power (Approx.)††	57 ... watts
Power Output (Approx.)	1150 ... watts

CHARACTERISTICS RANGE VALUES FOR EQUIPMENT DESIGN

	Note	Min.	Max.	
Filament Current	1	11.7	13.3	amp
Amplification Factor	1, 2	27	33	
Grid-Plate Capacitance	–	4.8	5.8	μμF
Grid-Filament Capacitance	–	3.6	4.8	μμF
Plate-Filament Capacitance	–	2.8	4.0	μμF
Plate Voltage	1, 3	1030	1350	volts
Plate Voltage	1, 4	2400	3000	volts
Grid Voltage	1, 5	–	−130	volts
Peak Cathode Current	1, 6	6	–	amp
Useful Power Output	1, 7	800	–	watts

Note 1: With 11 volts a.c. on filament.

Note 2: With d.c. grid voltage of −25 volts, and plate voltage adjusted to give d.c. plate current of 200 mA.

Note 3: With d.c. grid voltage of 0 volts, and plate voltage adjusted to give d.c. plate current of 200 mA.

Note 4: With d.c. grid voltage of −50 volts, and plate voltage adjusted to give d.c. plate current of 200 mA.

Note 5: With d.c. plate voltage of 3000 volts, and grid voltage adjusted to give a d.c. plate current of 1 mA.

Note 6: Represents the maximum usable cathode current (plate current and grid current) for the valve under any condition of operation.

Note 7: With d.c. plate voltage of 3000 volts, d.c. plate current of 500 mA, d.c. grid current of 80 to 120 mA., grid resistor of 2000 ± 10% ohms, and frequency of 160 Mc/s.

Installation

In transportation and storage of the 5786, care should be taken to protect the valve from rough handling that would damage the metal-to glass seals or other parts. Each valve is suspended within its shipping carton so that it will not come in contact with the sides of the carton during shipment. The valve should preferably be stored in a vertical position in the carton and should be protected from moisture and extreme temperature changes. The weight of the valve is approximately 1½ pounds.

§ Modulation essentially negative may be used if the positive peak of the a-f envelope does not exceed 115% of the carrier conditions.

** From a self-rectifying driver.

†† From a driver with a rectified, unfiltered, single-phase, full-wave plate supply.

It is recommended that the valve be tested upon receipt in the equipment in which it is to be used. Before the valve is placed in operation, any foreign material clinging to the valve should be removed.

The mounting for the 5786 requires a clamp support for the radiator (plate connection), a connector for the grid terminal, and three connectors for the filament leads. A suggested mounting device is shown in Fig. 1. This illustration also shows the relative positions of the air duct and the air deflector described below.

The valve should be supported in a vertical position with either the filament or the grid end up. If the valve is subjected to considerable vibration or shock in service, it is advisable to support the mounting by means of a spring suspension. The installation of all wires and connections must be made so that they will not be close to or touch the glass parts.

Connections to the grid and filament terminals must be kept flexible in order not to put strain on the glass-to-metal seals. These terminals should not be used to support circuit parts.

Cooling of the 5786 is accomplished by supplying an adequate amount of air to the radiator, the plate seals, the grid seal, and the filament seal. The use of a suitable air filter is recommended in the air supply. Care should be given to cleaning or replacing the filter at intervals in order that accumulated dirt will not obstruct the required flow of air.

The quantity of air necessary for adequate cooling will depend on the power input to the valve, as well as on the efficiency and frequency at which the valve is operated. When the 5786 is operated with full power input at the maximum rated frequency of 106 megacycles, and with the circuit adjusted for valve operation at the maximum plate-dissipation rating, sufficient cooling will be provided by a blower such as the Fasco No. 50749. This blower is made by F. A. Smith Mfg. Co., Inc., Rochester 2, N.Y., U.S.A. It has an outlet area of approximately 6.25 square inches and is capable of supplying 140 cubic feet of air per minute, free delivery.

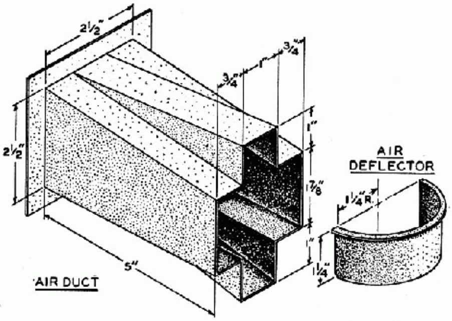
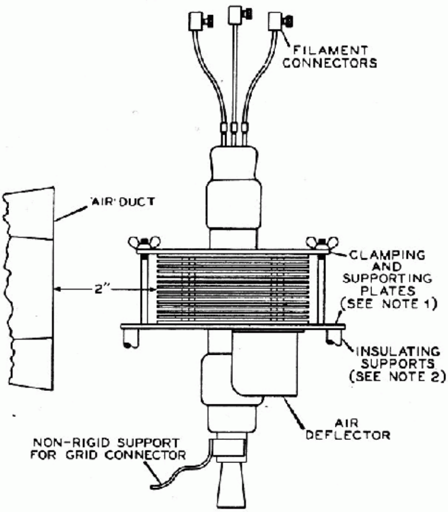


Fig. 2 — Details of suitable air duct and air deflector for use with Type 5786.

Provision must be made to direct part of the air from the blower to the filament and grid seals. For this purpose, a blower duct similar to that shown in Fig. 2 is suggested. Also sketched in Fig. 2 is a semi-circular air deflector which is useful in providing adequate cooling to the side of the grid seal away from the in-coming air stream.

Depending on the type of application in which the 5786 is used, the required quantity of cooling air and the method employed for directing this air to the radiator and seals will vary considerably. It is recommended, therefore, that operating temperatures be measured in each application to make certain that maximum temperature ratings are not exceeded.

The maximum seal temperatures and the maximum radiator temperature as shown in the tabulated data are valve ratings which are to be observed in the same manner as other ratings. The temperature of the radiator should be measured near the core. Temperature measurements should be made at a sufficient number of places on the valve to insure that ratings are not exceeded. The measurements may be made with thermocouples or with temperature-sensitive paint such as Tempilaq. The latter is made by the Tempil Corporation, 132 West 22nd Street, New York 11, N.Y., U.S.A., in the form of liquid and stick and is stated by the maker to have an accuracy of 1%.



Note 1: Supporting plate and clamping plate have holes large enough to permit passage of the glass bulbs of the valve.

Note 2: Two or more insulators may be used. Insulators must be placed so as to not interfere with air flow onto grid terminal.

Fig. 1 — Suggested mounting for Type 5786.

The cooling system should be properly installed to insure safe operation of the valve under all conditions, and for this reason should be electrically interconnected with the filament and plate power supplies. This arrangement is necessary to make sure that the valve is supplied with air before any voltages are applied. Air pressure interlocks which open the power transformer primaries are desirable for protecting the valve when the air flow is insufficient or ceases.

The filament of the 5786 is of the thoriated-tungsten type and should be maintained at the rated voltage within ± 0.6 volt. It is recommended that, in intermittent service where the standby periods are no longer than 15 minutes, the filament voltage should be reduced to 80% of normal during standbys; for longer periods, the filament voltage should be shut off.

The filament is centre-tapped in order to minimize the effect of filament-lead inductance, and not to permit operation of the two sections in parallel. At the higher frequencies, all three filament leads should be connected in parallel by means of r-f by-pass capacitors. The centre lead should then be used as the r-f return to the filament.

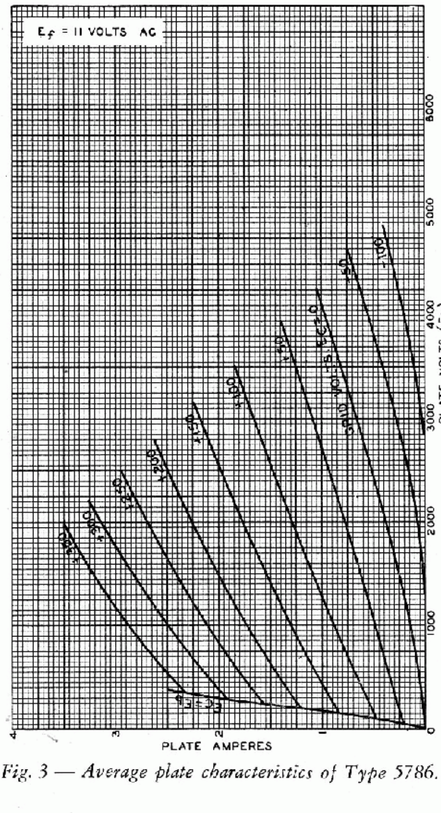


Fig. 3 — Average plate characteristics of Type 5786.

Having a maximum value of starting current 4 times higher than the normal operating value, the filament can be operated without a filament starter provided the filament transformer is designed with adequate secondary impedance to limit the starting current to 50 amperes. Otherwise, some form of current-limiting device will be required to prevent the starting current from exceeding, even momentarily, the maximum value of 50 amperes.

Overheating of the 5786 by severe overload may decrease the filament emission. The filament activity can sometimes be restored by operating the filament at rated voltage for ten minutes or more with no voltage on the plate or grid. This process may be accelerated by raising the filament voltage to 13 volts (not higher) for a few minutes.

The plate circuit should be provided with a time-delay relay which will prevent the application of plate voltage before the filament has reached normal operating temperature.

A protective device, such as a high-voltage fuse, should be used to protect the plate against overloads, it should remove the high voltage when the average value of plate current reaches a value 50% above normal.

The rated plate voltage of this valve is high enough to be dangerous to the user. Great care should be taken during the adjustment of circuits, especially when exposed circuit parts are at high potential.

Application.

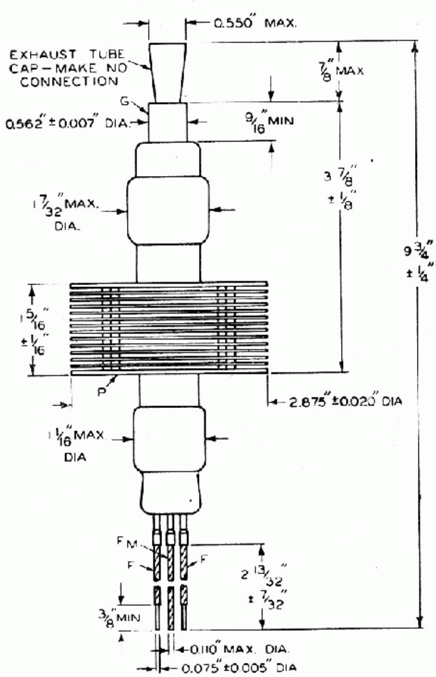
The maximum ratings shown in the tabulated data are limiting valves above which the serviceability of the 5786 may be impaired from the viewpoint of life and satisfactory performance. Therefore, in order not to exceed these absolute ratings, the equipment designer has the responsibility of determining an average design value for each rating below the absolute value of that rating by an amount such that the absolute values will never be exceeded under any usual condition of supply-voltage variation, load variation, or manufacturing variation in the equipment itself.

In class B a-f modulator service, the 5786 should be operated with grid bias obtained from a battery or other source of d.c. voltage of good regulation. It should not be obtained from a high-resistance source such as a grid resistor, nor from a rectifier-filter type of d.c. power supply unless the supply has exceptionally good voltage regulation. Each grid circuit should be provided with a separate bias adjustment to balance the grid and plate currents.

In plate-modulated class C r-f amplifier service, the 5786 should be supplied with bias from a grid resistor, or from a suitable combination of grid resistor and fixed supply or grid resistor and cathode resistor. The cathode resistor should be by-passed for both audio and radio frequencies. The combination method of grid resistor and fixed supply has the advantage of not only protecting the valve from damage through loss of excitation, but also of minimizing distortion by bias-supply voltage compensation. Grid-bias voltage is not particularly critical, so that correct adjustment may be obtained with valves differing widely from the calculated values.

In class C r-f telegraph service, the 5786 may be supplied with bias by any convenient method. When the valve is used in the final amplifier or a preceding stage of a transmitter designed for break-in operation and oscillator keying, a small amount of fixed bias must be used to maintain the plate current and, therefore, the plate dissipation at a safe value. If the 5786 is operated at the maximum plate voltage of 3000 volts, a fixed bias of at least −90 volts should be used.

DIMENSIONAL OUTLINE



When the 5786 is used in either class C telephony or telegraphy 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 will give good plate-circuit efficiency with reasonable driving power.

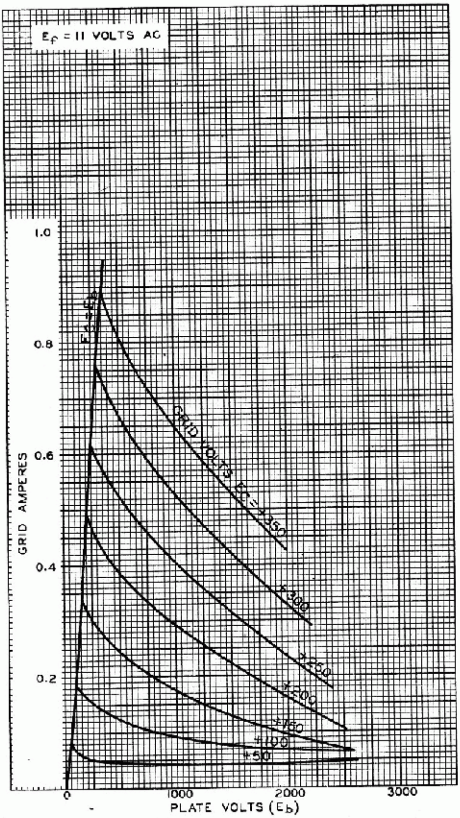


Fig. 4—Typical grid characteristics of Type 5786.

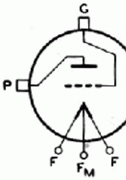
In order to permit considerable range of adjustment, and also to provide for losses in the grid circuit and the coupling circuits, the driver stage should have considerably more output capability than the typical driving power shown in the tabulated data. This recommendation is particularly important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

When operated as a self-rectifying amplifier or oscillator with a separate, rectified, single-phase, full-wave plate supply without a filter, the 5786 can be biased by any convenient method. However, the use of a grid resistor is preferred because the bias is automatically adjusted as the load on the circuit varies. In those applications, such as are encountered in electronic heating equipment, where grid voltage may vary widely because of fluctuating loads, it is important to design equipment so that the maximum grid-current and grid-voltage ratings are never exceeded for any load. An approximate rule is to adjust the grid-current and grid-voltage values at full load to one-half of the corresponding maximum values. This operating condition permits grid-current and grid-voltage values to rise from zero load to twice their full-load values, and usually provides adequate leeway.

Circuit considerations pertaining to operation of the 5786 are given in the following paragraphs:

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.

TERMINAL CONNECTIONS



F: FILAMENT
F_M: FILAMENT MID-TAP
G: GRID
P: RADIATOR-COOLED PLATE

The 5786 may be operated at maximum ratings in all classes of service at frequencies as high as 160 megacycles.

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 a single 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. When two or more valves are used in the circuit, precautions should be taken to balance the plate currents.

If parasitic oscillations occur in the parallel or push-pull circuits, non-inductive resistors of about 10 to 100 ohms connected in series with each grid lead as close to the valve terminals as possible will often prevent the oscillations.

CALCULATIONS INVOLVING DECIBELS PER OCTAVE

The rate of attenuation, or of boosting, is usually given in the form of so many decibels per octave. In some cases the frequencies at which readings are taken do not conveniently cover an exact number of octaves. In such a case the procedure below may be adopted.

(a) To convert db/specified frequency ratio to db/octave.

Frequency ratio	Multiply db/specified ratio by factor to give db/octave.
1.2:1	6.02
1.25:1	3.10
1.33:1	2.43
1.5:1	1.71
2:1	1.00
3:1	0.63
4:1	0.50
5:1	0.43
6:1	0.39
7:1	0.36
8:1	0.33
10:1	0.30

Example: A change of 0.7 db occurs with an increase of frequency from 1000 to 1250 c/s. What is the rate of change in db/octave?

Rate of change = 0.7 × 3.10 = 2.17 db/octave.

(b) To convert db/octave to db/specified frequency ratio.

Frequency ratio	Multiply db/octave by factor to give db/specified frequency ratio.
1.2:1	0.263
1.25:1	0.322
1.33:1	0.412
1.5:1	0.585
2:1	1.00
3:1	1.59
4:1	2.00
5:1	2.33
6:1	2.59
7:1	2.81
8:1	3.00
10:1	3.33

Example: What is the change in level for a frequency ratio of 1.5 to 1 when the rate of change is 6 db per octave?

Change in level = 0.585 × 6 = 3.51 db.

Correction Radiotronics 136

In the first paragraph of Oscillator Coil Details, page 19, R5 should read R15. Also in the Oscillator Grid Current tabulation, page 19, R8 should read R15.

Low-Noise Broad-Band Preamplifier Designed for 2-Metre Receivers

By E. M. BROWN, J. T. BLAKE

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

In the two-metre band, one of the best ways to improve receiver sensitivity is to add a properly designed preamplifier. The one described in this article will increase the signal strength two to three points of the "S" meter of a receiver and has such a high signal-to-noise ratio, that its performance is limited only by antenna noise.

The preamplifier is inserted in a 300-ohm feeder, between the antenna and the regular two-metre receiver. The unit has a broad-band response so that only an occasional touch-up of the tuning is necessary.

Design considerations

On the low-frequency bands, the limit of useful receiver gain is set by interference, man-made or natural. Signal-to-noise ratio is of minor significance and the features usually considered for determining the merit of a low-frequency receiver include such factors as bandwidth of i-f stages, audio response, ease of tuning, and image rejection.

On the v-h-f bands, atmospheric noise is practically non-existent. Man-made noise may be troublesome, but in most locations it is a minor problem. The noise which limits the performance of an ideal v-h-f receiver, however, is the thermal noise generated by the antenna. The thermal noise across a 300-ohm input line is equivalent to about 0.2 microvolts in a good communications-type receiver having an i-f band-pass of 10 kilocycles. If a gain of 5 can be obtained from a "quiet" r-f preamplifier, the 0.2 microvolts of thermal noise can be detected by a receiving system including the preamplifier and a receiver capable of detecting a one-microvolt signal.

Circuit selection

If the proper circuit is chosen, considerable reduction in valve noise generated within the amplifier stage can be achieved. Since triodes generate less noise than pentodes, it is well to consider utilizing a triode in the r-f stage. Triodes in push-pull were selected for the pre-amplifier because such a circuit permits the use of a step-up antenna transformer and takes advantage of the full gain of the triode stage.

Of course, the triodes have to be neutralized but the new miniature valves and components that are now available permit such compact circuit layouts that nearly perfect neutralization is easy to achieve. The push-pull connection reduces the input capacitance by 50% which makes for a broadly resonant, high-inductance circuit.

The RCA-6J6 twin triode was selected for this preamplifier chiefly because of one feature — it has only one cathode, and one cathode lead. In a push-pull class A circuit, no r-f current flows through the cathode lead, and, consequently, degeneration due to cathode lead inductance is eliminated. As a result, the grids of a properly neutralized 6J6 present an input load of better than 10,000 ohms at 144 megacycles. By way of comparison, the 6AK5 r-f pentode has an input resistance of approximately 3,000 ohms, a value less than one-third that of the 6J6.

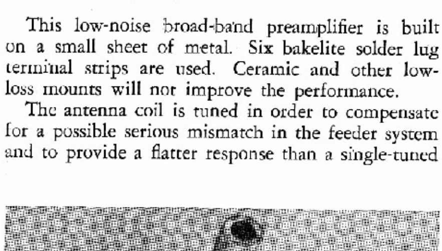
The low interelectrode capacitance of the 6J6 also aids in making the amplifier broad band. A voltage gain of 8 to 10 can be obtained over the entire 144-148 megacycle band with this valve.

The valve noise of an amplifier stage containing a 6J6 should be, theoretically, about 1.5 to 2 times the thermal noise. The corresponding value for a 6AK5 is about 3 times the thermal noise. This difference may often be enough to bring some weak signals up out of the noise level so that they may be copied.

Construction details

This low-noise broad-band preamplifier is built on a small sheet of metal. Six bakelite solder lug terminal strips are used. Ceramic and other low-loss mounts will not improve the performance.

The antenna coil is tuned in order to compensate for a possible serious mismatch in the feeder system and to provide a flatter response than a single-tuned



This easily-built preamplifier unit greatly increases signal strength and improves receiver sensitivity on the 2 metre band.

circuit provides. The coil requires a tuning capacitance of about 20 to 30 $\mu\mu F$ which can be well provided by a mica compression-type trimmer capacitor. Mica trimmers introduce small losses at low capacitance settings, their leads are short, their stray capacitances are nearly balanced to ground, and they are not expensive.

Electrostatic shield

An electrostatic shield is used between the antenna coil and the grid coil. At first glance, this shield may seem superfluous, but when the possibility of the long feeders picking up noise or signals from powerful local stations is considered, it seems wisest to be on the safe side and include an electrostatic shield.

The shield can be made as follows: Fold a piece of plastic about 2″ × 4″ × $\frac{1}{32}$″ into a 2″ × 2″ square. Then, wind a flat coil of cotton- or silk-insulated copper wire (approximately No. 22 B & S) along most of the length of this flat form. Sandpaper the insulation off one side of the coil and lay a piece of heavy tinned copper bus wire along the edge. Solder each turn of the flat coil to the bus wire, *but be very careful not to melt or ignite the plastic.* Coat one side of the assembly liberally with house-hold cement or coil dope. After it is thoroughly dry, cut the uncoated side away with a pair of tin snips. When completed, the shield looks like a "picket fence" of copper wires with the tips of the pickets all insulated from each other, and the bottoms all soldered to the heavy bus wire.

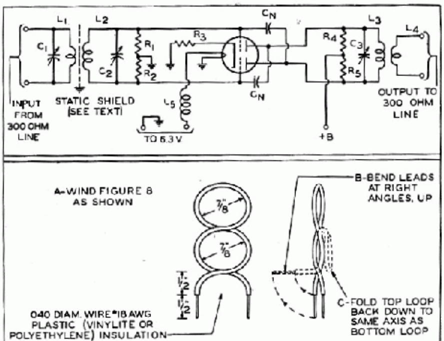
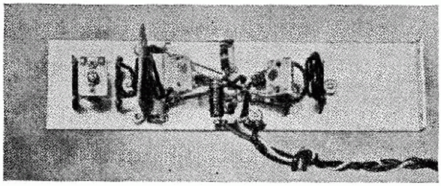


Figure 1. Schematic drawing of the preamplifier, and a pictorial sketch showing how the "figure-eight" grid coil is made.

Grid coil construction

The grid coil is of the "figure eight" variety made from solid plastic-insulated wire. This type of coil has balanced stray capacitances to ground and can be backed right up to the electrostatic shield without becoming unbalanced. Figure 1 shows the development of this winding. Some slight spreading or squeezing may be required to permit tuning the coil with the lowest possible value of grid-tuning capacitance.



Simplicity and low cost components do not detract from the effectiveness of the 2 metre preamplifier.

The connection between the terminal strip on which the grid coil is mounted and the grid terminals of the valve socket (No. 5 and No. 6) are made with thin tubing, not wire. These tubes can be brass or copper with a bore of about 1/16 of an inch, or they can be made by rolling a strip of soft copper foil into a tubular cylinder. The socket connections are soldered so that the holes in the ends of the connection tubes are exposed and accessible.

The grid coil is tuned by means of a 1- to 20 $\mu\mu F$ compression-type mica capacitor. In practice, this trimmer is run almost wide open.

The neutralizing "capacitors" are short lengths of plastic-insulated No. 18 B & S wire inserted about $\frac{1}{2}$ inch into the grid-connecting cylinders. Some slack in the wires should be left for adjustment.

The r-f plate tank is identical with the r-f grid tank. No by-pass capacitors or plate chokes are needed. On the assumption that the output line will be coupled tightly to a tuned circuit in the next stage, the output coil is not tuned.

Adjustment and test

For the adjustment of this preamplifier, no special test equipment is needed. The procedure is as follows: Tune in a strong local signal near the middle of the band on your regular station receiver. Insert the preamplifier in the antenna feed line. It is well to mount the unit at a point two or three feet from the receiver, especially if the receiver is not fully shielded.

Turn on the heater voltage of the 6J6 but not the plate voltage. The signal should still be present, but weak. Then, peak up the trimmers for minimum signal. Next, with a fibre screwdriver work the neutralizing leads in and out of the tubular grid connectors. A definite signal null point should be encountered. A very great reduction in feed-through signal can be obtained when optimum neutralization is reached.

Properly neutralized, the 6J6 will not oscillate even though it is lightly loaded. From a standpoint of signal-to-noise ratio and bandwidth, however, it is best to use tight coupling in both plate and grid coils. Push the coils together and at the same time trim the tuning adjustments for greatest gain in the centre of the band until the point of maximum gain is reached *and passed*. The unit should be operated with the coils over-coupled.

If everything has been done correctly thus far, turn on the plate voltage and the preamplifier is ready to operate.

Parts list

C1	30 μμF (at mid-range) mica-sandwich trimmer
C2 C3	1.5 μμF to 25 μμF mica-sandwich trimmer
L1 L4	1 full turn No. 18 B & S plastic-insulated solid wire ⅞″ int. dia.
L2 L3	See Figure 1, and text
L5	2-metre r-f choke (20 inches, approximately, of No. 24 enamelled wire, wound on ¼″ dia. form.)
R1 R2	560,000 ohms, carbon, ¼-watt
R3	56 ohms, carbon, ½-watt
R4 R5	47,000 ohms, carbon, 1-watt

GETTING THE MAXIMUM FROM MINIATURES

The advent of the Australian-made Radiotron miniature series of valves affords an unrivalled opportunity for local radio engineers to pause and review their existing approach to receiver design.

Small size and outstanding performance are two of the major factors which have already won immediate acceptance of miniatures in overseas radio manufacturing circles.

Whilst considering suitable circuits to obtain maximum results, the designer must also give some thought to the mechanical problems involved in securing good contact between the small diameter valve pins and the socket contacts.

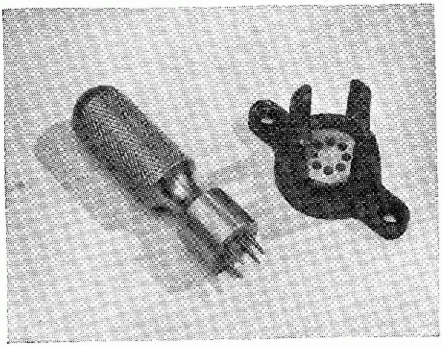
After passing through a number of hands, or as the result of a fall, the valve pins may be bent out of their correct factory alignment. The normal method of straightening, by using a pair of pliers, is seldom successful and usually results in a glass fracture, either immediately or later, when an effort is made to force the valve into its socket.

A pin straightener, into which all valves can be inserted prior to fitting into their respective receiver sockets, is now available designed specifically to obviate the difficulty of bent pins.

Displacement of the valve socket contacts because of strains imposed by rigid wiring, bending lugs down to the chassis for earthing, or wiring heavy components with stiff leads directly to the socket lugs, will make valve insertion and removal without breakage difficult or impossible.

A solution to this trouble is the use of the wiring jigs illustrated, which are plugged into the valve sockets prior to the wiring operation. These jigs ensure proper contact location. Defective valves are sometimes used for this purpose, but are not very satisfactory, as with constant handling the pin spacings are soon outside dimensional limits.

In a compact receiver chassis it is sometimes difficult to secure a good grasp of the small glass envelope to withdraw it from the socket, as the valve is usually hemmed in by other components. A special valve removing tool will soon be obtainable from A.W.V. Company.



Illustrated here are the wiring jig and pin straightener.

Both the pin straightener and wiring jig which are exempt from Sales Tax will shortly be available in quantity at 12/6 and 12/- respectively. All users of miniature valves — manufacturers, dealers and servicemen — will find these tools a very considerable asset that will quickly pay dividends by minimising valve breakages.

Characteristics of Pentodes and Triodes in Mixer Service

RCA application note AN–139; reprinted by courtesy of the Radio Corporation of America.

This Note gives mixer information, including typical operating conditions and approximate characteristics, for a number of pentode and triode types.

The characteristics of a valve used as a mixer may be derived from the amplifier characteristics of that valve by application of Fourier analysis. Detailed analysis reveals, however, that satisfactory approximations of the mixer characteristics can be obtained by assuming simple proportionality relationships between the mixer characteristics and the amplifier characteristics which apply to the peak of the local-oscillator cycle.

In the preparation of the data given in the tabulations of mixer characteristics (Tables I, II, III, and IV), the following conditions were considered:

1. Pentode grid-No. 2 voltages and triode plate voltages are chosen to permit the use of moderate oscillator injection voltages and, of course, to provide operating conditions within valve ratings.
2. The data are derived for peak values of oscillator voltage one volt less than the control-grid bias voltages. This condition may cause a small amount of grid current in some valves, but the additional input conductance caused by the grid current is not important except at low frequencies. The majority of applications for pentode and triode mixers, at the present time, are at frequencies above forty megacycles.
3. For sharp-cutoff pentodes and triodes, the control-grid bias is chosen so that the plate current for zero oscillator voltage is reduced to about one-tenth the value observed at one-volt bias.
4. For remote-cutoff pentodes, the control-grid bias is chosen so that the transconductance for zero oscillator voltage is reduced to about one-quarter the value observed at one-volt bias.

The proportionality factors applicable under the given conditions are tabled at the foot of this page.

Use of the tables

The operating conditions chosen for the valves give approximately the maximum values of conversion transconductance obtainable with the stated grid-No. 2 or plate voltage. Consequently, the values of conversion transconductance and input conductance shown may be used in the same manner as the transconductance and input-conductance data for r-f amplifiers in calculating the stage gain, provided the required oscillator voltage is applied. The input conductance values, which are given for a frequency of 100 megacycles, may be assumed to vary directly with the square of the frequency. The average transconductance values may be used to calculate the gain with an i-f signal applied to the control grid, provided such a test can be made without materially changing the oscillator amplitude. The values of plate current and grid-No. 2 current are useful for indicating when the correct oscillator voltage has been obtained.

The cathode resistor values listed will give approximately the indicated bias voltages when the oscillator voltage is applied. Deviations of ± 10 per cent. from these values can be tolerated; they will have little effect on valve performance.

In cases where difficulty is experienced in obtaining the required oscillator voltage, it is usually preferable to operate the pentode or triode mixer with reduced grid-No. 2 or plate voltage. With high grid-No. 2 or plate voltage and low oscillator voltage, the ratio of average transconductance to conversion transconductance is higher than necessary, with the result that plate or grid-No. 2 current is also high with respect to the conversion transconductance

Mixer Characteristic	Derived from Amplifier Characteristic	Proportionality Factor* Sharp-Cutoff Triodes & Pentodes	Remote-Cutoff Pentodes
Plate Current (i_b)	Peak Plate Current	0.30	0.45
Grid-No. 2 Current (i_{c2})	Peak Grid-No. 2 Current	0.30	0.45
Plate conductance (g_p)	Peak Plate Conductance	0.40	0.40
Input Conductance (g_{in})	Peak Input Conductance	0.40	0.40
Average Transconductance (g_m)	Peak Transconductance	0.40	0.40
Conversion Transconductance (g_c)	Peak Transconductance	0.27	0.23

$$* \text{ Proportionality Factor} = \frac{\text{Mixer Characteristic}}{\text{Amplifier Characteristic}}$$

obtained. This condition leads to excessive input conductance and excessive noise. When the available oscillator voltage is limited, the grid-No. 2 or plate voltage for sharp-cutoff valves should be chosen so that as the oscillator voltage swings from its peak value to zero, the plate current varies over a range of 10 to 1. On the other hand, when the oscillator voltage is higher than the optimum value there is generally only a small loss in conversion transconductance.

Table I—Characteristics and Typical Operating Conditions for Remote-Cutoff Pentodes used as Mixer Valves.

	Valve Type					
	6SK7	6SG7	6BA6	6BJ6	9003	
Plate Voltage	250	250	250	250	250	volts
Grid-No. 2 Voltage	100	150	125	125	100	volts
Grid-No. 1 Voltage	−8.5	−4.5	−4.5	−4.5	−6.0	volts
Plate Current	6.1	7.4	7.6	6.1	5.0	mA
Grid-No. 2 Current	1.2	2.7	2.9	2.2	2.0	mA
Cathode Resistor	1200	470	470	560	820	ohms
Peak Oscillator Voltage	7.5	3.5	3.5	3.5	5.0	volts
Input Conductance (100 Mc/s)	240	340	300	150	32	µmhos
Average Transconductance	980	2000	2000	1700	1000	µmhos
Conversion Transconductance	560	1150	1150	1000	580	µmhos

Table II—Characteristics and Typical Operating Conditions for Sharp-Cutoff Pentodes used as Mixer Valves.

	Valve Type									
	6SJ7	6SH7	6AC7	6AU6	6BH6	6AG5	12AW6	6AK5	9001	
Plate Voltage	250	250	250	250	250	250	250	180	250	volts
Grid–No. 2 Voltage	125	150	150	150	150	150	150	120	100	volts
Grid–No. 1 Voltage	−6.5	−4.0	−3.5	−3.5	−3.5	−3.5	−3.5	−4.0	−4.5	volts
Plate Current	2.9	3.3	6.3	3.2	2.2	3.3	3.3	4.1	1.6	mA
Grid–No. 2 Current	0.8	1.2	1.5	1.3	0.9	0.9	0.9	1.3	0.6	mA
Cathode Resistor	1800	1000	470	810	1000	810	810	810	2200	ohms
Peak Oscillator Voltage	5.5	3.0	2.5	2.5	2.5	2.5	2.5	3.0	3.5	volts
Input Conductance (100 Mc/s)	300	260	1040	300	140	140	160	80	32	µmhos
Average Transconductance	1000	1960	5400	2100	1800	2100	2100	2900	800	µmhos
Conversion Transconductance	680	1300	3600	1400	1240	1430	1430	1940	540	µmhos

Table III—Characteristics and Typical Operating Conditions for Sharp-Cutoff Pentodes, Triode Connected used as Mixer Valves.

	Valve Type									
	6SJ7	6SH7	6AC7	6AU6	6BH6	6AG5	12AW6	6AK5	9001	
Plate and Grid–No. 2 Voltage	125	150	150	150	150	150	150	120	100	volts
Grid No. 1 Voltage	−6.5	−4.0	−3.5	−3.5	−3.5	3.5	−3.5	−4.0	−4.5	volts
Plate and Grid–No. 2 Current	3.7	4.5	7.8	4.5	3.1	4.2	4.2	5.4	2.2	mA
Cathode Resistor	1800	1000	470	810	1000	810	810	810	2200	ohms
Peak Oscillator Voltage	5.5	3.0	2.5	2.5	2.5	2.5	2.5	3.0	2.5	volts
Input Conductance (100 Mc/s)	300	260	1040	300	140	140	160	80	32	µmhos
Output Conductance (low freq.)	67	70	150	78	45	60	60	150	55	µmhos
Average Transconductance	1280	2670	6700	2800	2500	2700	2700	3800	1100	µmhos
Conversion Transconductance	880	1770	4500	1950	1730	1820	1820	2540	740	µmhos

Table IV—Characteristics and Typical Operating Conditions for Triodes used as Mixer Valves.

	Valve Type						
	6C4	12AU7	12AT7	6J6	6J4	9002	
Plate Voltage	150	150	250	150	150	150	volts
Grid–No. 1 Voltage	−7.5	−7.5	−5.0	−4.0	−3.5	−6.0	volts
Plate Current	5.0	5.0	5.0	4.8	6.6	3.5	mA
Cathode Resistor	1500	1500	1000	810	560	1800	ohms
Peak Oscillator Voltage	6.5	6.5	4.0	3.0	2.5	5.0	volts
Input Conductance (100 Mc/s)	76	76	132	96	—	—	µmhos
Output Conductance (low freq.)	72	72	65	98	96	40	µmhos
Average Transconductance	1300	1300	3300	2800	5300	1100	µmhos
Conversion Transconductance	880	880	2200	1900	3560	740	µmhos

New RCA Releases

Radiotron type 3KP11—is a 3" cathode-ray tube, similar to the 3KP1, except for its screen characteristics. It is intended particularly for photographic recording of electrical phenomena. The blue radiation of its flourescent screen is highly actinic, and has sufficiently short persistance for moving-film recording without blurring except where the film moves at high speed.

The 3KP11 is also quite satisfactory for visual observation of phenomena, because it utilizes an improved phosphor having unusually high brightness for a blue screen.

This type has electrostatic focus, electrostatic deflection, high deflection sensitivity, and a "zero-current first-anode" gun. This electron gun has a grid No. 2 operating at anode No. 2 potential, so that the beam current and grid No. 1 cutoff voltage are not affected by focusing adjustment. The spot can be sharply focused on the screen, both at the centre and at the edges, and remains sharp when beam current is varied over a wide range.

Having a separate base-pin connection for each of the four deflecting electrodes, the 3KP11 is especially suitable for use in balanced electrostatic-deflection circuits, and when so used gives best definition. However, the 3KP11 may be used with unbalanced deflection because of design features which minimize spot and pattern distortion usually characteristic of such operation.

Radiotron type 3RP1—is a 3"cathode–ray valve only 9⅜" long, yet it has high deflection sensitivity. It is capable of providing high light intensity when operated with an anode No. 2 voltage near the maximum of 2,500 volts and good brilliance at relatively low anode No. 2 voltages.

Utilizing electrostatic deflection and electrostatic focus, the 3RP1 is intended for general oscillographic applications. Its screen has medium persistence, green fluorescence, and high contrast.

Because of features incorporated in the "zero-current first-anode" gun the beam current and grid No. 1 cutoff voltage are not affected by focusing adjustment. The spot can be sharply focused on the screen, both at the centre and at the edges, and remains sharp when beam current is varied over a wide range.

The 3RP1 has the same electron gun, operating voltages, and basing arrangement as the 2-inch types 2BP1 and 2BP11. Since these three types are electrically interchangeable, only size difference needs to be considered in equipment design to permit interchangeability of these types and thus enhance the versatility of the equipment. Under the same operating conditions, these types will have pattern deflections proportional to their respective screen diameters.

Radiotron type 5794—is a fixed-tuned u-h-f oscillator triode for radiosonde transmitters at 1680 Mc/s, with a useful power output in the order of 500 mW.

It has two integral resonators, one of which is fixed-tuned and attached between grid and cathode and the other tunable over a narrow range centreing at 1680 Mc/s and attached between grid and plate. The latter resonator is loop-coupled to a coaxial r-f output terminal.

Features contributing to the usefulness of the 5794 in radiosonde service include its compact metal construction, low battery drain, small frequency drift and high efficiency.

TYPE KT61—POWER TETRODE

A new addition to the Radiotron range is the KT61 power tetrode. It is intended for use in the output stage of a.c. receivers or audio amplifiers. The designer of a receiver using 6.3 volt octal base valves has now available a high sensitivity power valve of the same heater voltage and base. Its sensitivity makes it particularly suitable for operation directly from a diode detector. The mutual conductance is 10.5 mA/volt and with 250 volts on plate and a screen a power output of 4.3 watts can be obtained with a plate current of 40 mA. An application note on the KT61 will be published in the next issue of Radiotronics, No. 138. Large stocks of this type will be available later in the year.

DISCONTINUED RCA TYPES

Type 2J41—Obsolete.
Type 9C27—Power triode. Replaced by type 5771.
Type 812—Obsolete. Replaced by 812A.

OBSOLETE VALVES

Radiotron type 1B5/25S is now obsolete. No further stocks will become available. Stocks of 1H6-G are held, and this type is recommended as an exact electrical substitute for type 1B5/25S, with a socket change. When present stocks are exhausted, type 1H6-G will also become obsolete, with no future availability.