RADIOTRONICS

Technical Editor
F. Langford-Smith, B.Sc., B.E.

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RADIOTRON RECEIVER RC53

IMPROVED 6 VALVE A.C. DUAL-WAVE

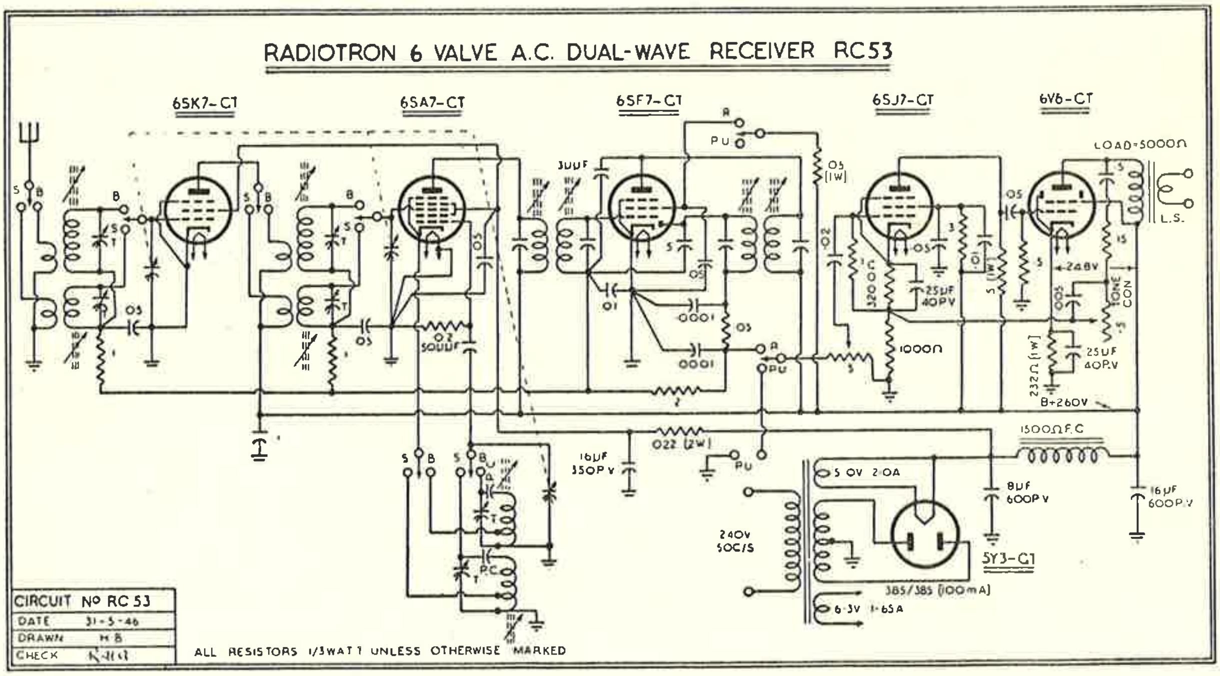
In Radiotronics 117 there was described a 6 valve receiver using the single-ended GT valves, which had excellent performance in every respect except for the frequency shift which occurred with strong input signals, which was more than is regarded as good practice. Subsequent investigation has shown that the amount of frequency shift can be reduced from the previous value of 12.0 Kc/s to 4.6 Kc/s for a change of input signal between 1 microvolt and 100 millivolts, through the use of an improved system of neutralizing the i-f amplifier.

A still further improvement in frequency stability with changing input signal voltage can be achieved by removing a.v.c. from the converter valve and substituting fixed bias. Under these conditions the frequency shift was reduced to the altogether negligible amount of 1.4 Kc/s. It is very doubtful whether the use of fixed bias is justified for an ordinary broadcast receiver, although it might be desirable in a communication type of receiver with very sharp selectivity and with accurate dial calibration.

In the improved version of this receiver it was decided to retain a.v.c. on the converter valve, since the frequency shift likely to occur with any ordinary degree of fading would be less than about 2 Kc/s, which is regarded as being reasonably satisfactory for this class of receiver.

The alteration to the circuit diagram RC52 published in Radiotronics 117 involves only the addition of a second neutralizing condenser from the diode, which is returned to the same common point as the plate neutralizing condenser. As a result of the interaction of these two neutralizing condensers, the value of the one from the plate has been changed to 3 $\mu\mu$F. while the one from the diode is 5 $\mu\mu$F. Neither of these values is critical, but the correct adjustment on a pilot model should be made in accordance with the method described in detail elsewhere in this issue under the title "Neutralization in circuits employing a valve as a combined intermediate frequency voltage amplifier and diode detector."

With the exception of the amount of frequency shift, the characteristics and test results of RC53 are the same as for the original circuit RC52, to which reference should be made.



1.—RADIOTRON RECEIVER CIRCUIT RC53

This circuit diagram includes an improved method for neutralizing the i-f amplifier, resulting in better i-f stability and better oscillator frequency stability with changes in input signal level.

The electrodynamic speaker may be replaced by a "permag." speaker provided that a filter choke (having an inductance of 14 Henries at 60 mA., and a resistance of 520 ohms) is added and that the transformer secondary voltage is reduced to 315/315 volts, or additional resistance is provided to give the correct d.c. voltage.

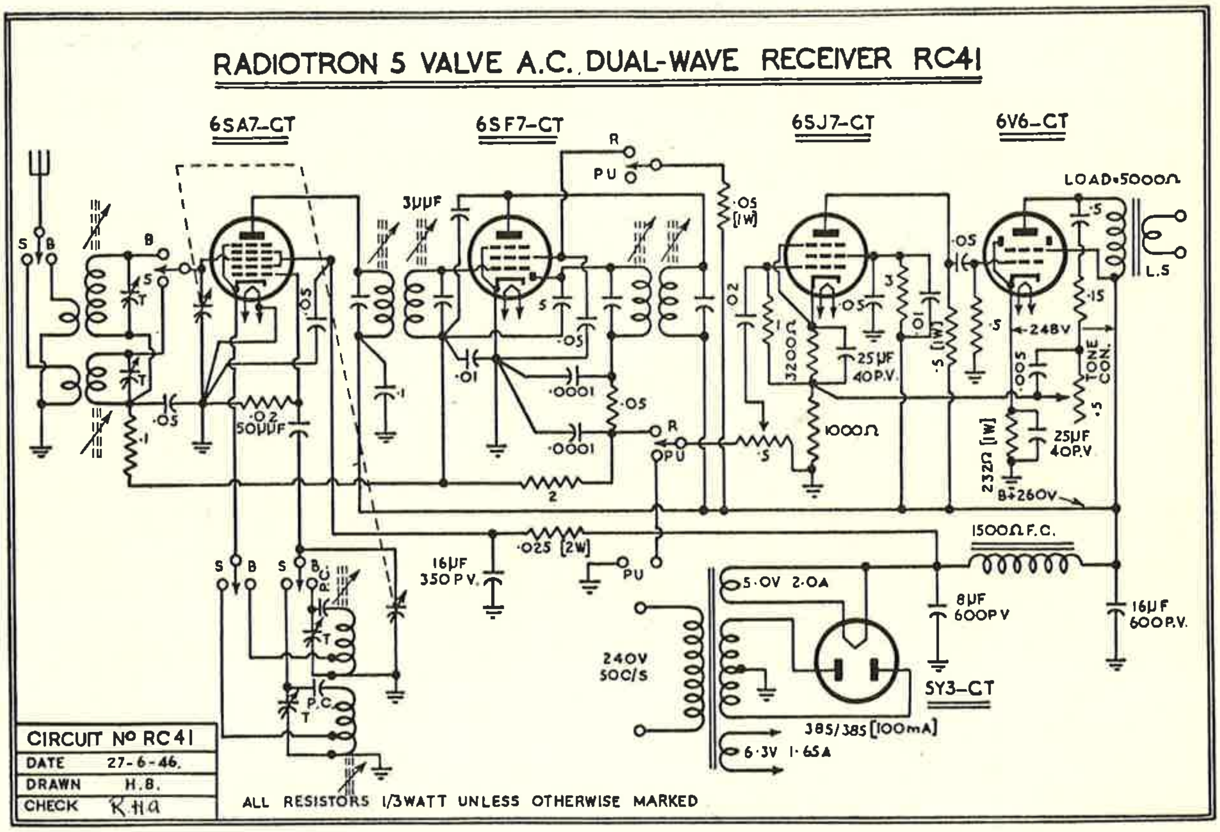
The variation of frequency shift with input signal voltage for circuit RC53 is tabulated below.

Input Signal	Frequency Shift	Input Signal	Frequency Shift
1µV	0	1mV	+2.4
10	0	3	+3
30	+0.4 Kc/s	10	+3.5
100	+1.0	30	+4.1
300	+1.7	100	+4.6

RADIOTRON RECEIVERS RC41 AND RC42

5 VALVE A.C. CIRCUITS USING SINGLE-ENDED GT VALVES

To extend the range of receiver designs using the new single-ended A.C. valves, a 5 valve receiver was developed. We present here two versions, both very similar to the 6 valve receiver which was described in Radiotronics 117, and also to Circuit RC53 published elsewhere in this issue. Apart from the obvious deletion of the r-f stage, the principal design changes centre around the neutralization of the 6SF7-GT i-f amplifier. This improved arrangement is described in some detail elsewhere in this issue.



2.—RADIOTRON RECEIVER CIRCUIT RC41

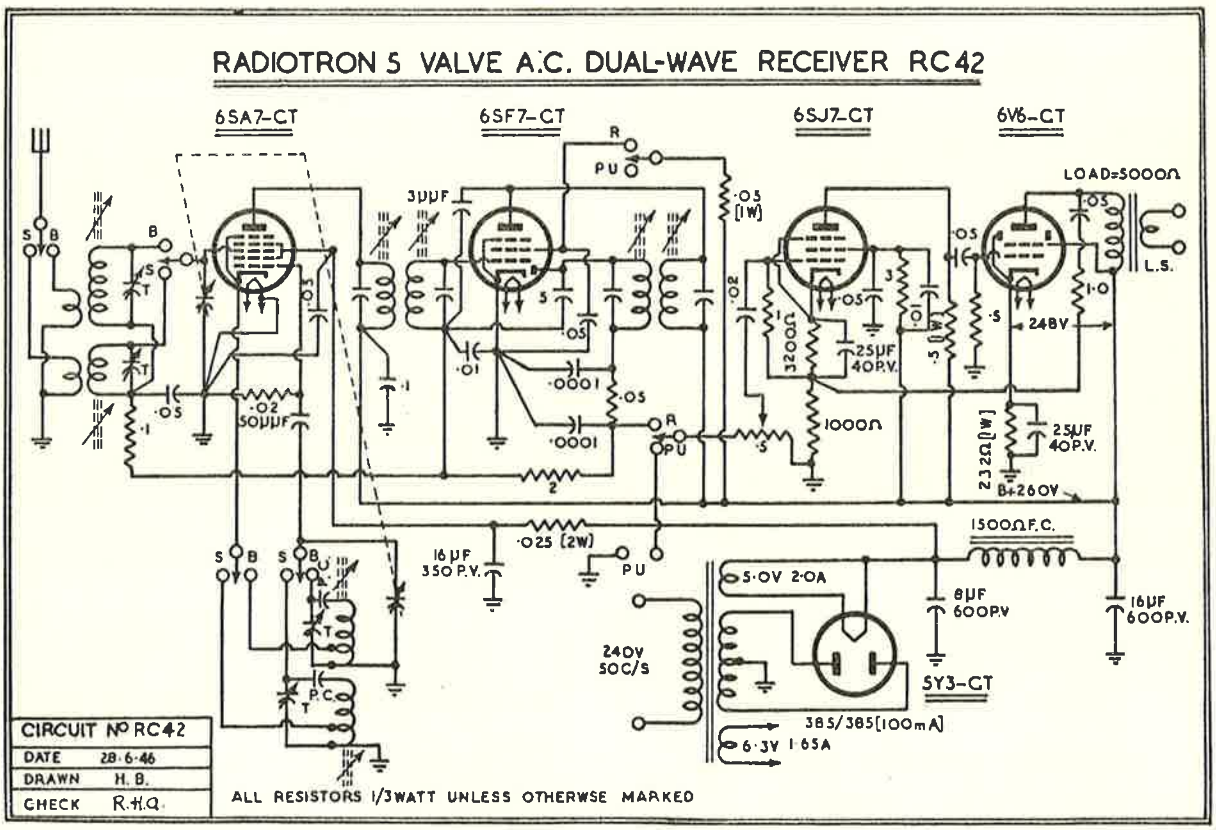
This circuit diagram is very similar to the 6 valve circuit RC53 and incorporates the same i-f neutralization system. It has a very low oscillator frequency shift with changes in input signal level. The audio frequency amplifier includes a very good bass-boost tone-control, with a very high degree of negative feedback. The a-f gain is necessarily reduced but this is no serious detriment under most conditions of operation. The a-f gain is sufficient for operation from an ordinary high-level crystal pickup. If the utmost in r-f sensitivity is required, or if gramophone reproduction is desired from a not-too-sensitive pickup, circuit RC42 is recommended.

As a direct result of the stabilisation of the i-f amplifier, detuning effects resulting from varying strength of short-wave signals is very much reduced. Furthermore, the signal voltage appearing at the input of the converter valve is much less without an r-f stage. Thus, for both receivers RC41 and RC42, the maximum frequency shift resulting from an extreme variation in strength of an 18 Mc/s signal can cause only 1.4 Kc/s change in oscillator frequency. It should be noted that in normal operation, such severe fading would never be encountered. Therefore, these 5 valve receivers can be regarded as completely satisfactory from the point of view of short-wave oscillator frequency stability with respect to fading signals.

The receiver RC41 retains the audio circuit used in RC53 which has the very desirable characteristics of high input resistance and true bass boost tone control. However, to secure the rise in gain at low frequencies due to the automatic reduction of negative feedback, the total feedback for middle frequencies is rather higher than usual. As a result, the audio gain is lower than might be required in some applications. For example the majority of gramophone pick-ups do not deliver enough output to drive the amplifier to full output. Alternatively, it might be desired to increase the overall sensitivity. In cases where the increased audio gain is considered to be of more importance than superior audio quality, the alternative arrangement RC42 may be used. In this receiver the negative feedback tone control system has been replaced by a moderate degree of feedback of conventional form. The useful effects are an increase in audio control gain of 14.5 db and an increase in overall sensitivity (for 50 mW. output) by a factor of 2.63. Thus, a pick-up with the normal output of 0.25V. can fully drive the audio amplifier to its full output of 4.5 watts, and there is some reserve of sensitivity for difficult reception areas.

The input resistance to the amplifier is still high enough to cause low detection distortion, as it is 5.6 megohms. The distortion caused by the a.v.c. loading on the detector remains unaltered.

The overall 400 c/s distortion figures might be misleading in that there appears to be a reduction of distortion with very large inputs. It should be realised that the measured distortion includes about



3.—RADIOTRON RECEIVER CIRCUIT RC42

This circuit diagram is identical with circuit RC41 except for the audio frequency amplifier, which does not incorporate bass-boost tone control, and hence has a higher gain. This enables the a-f amplifier to operate from any ordinary pickup, and gives higher overall sensitivity.

6% signal generator distortion which can either add to or subtract from the receiver distortion. Apparently, in this case, the phases are such that there is a reduction in resultant harmonics at large input voltages. This is quite a random effect and should not be relied upon to reduce broadcast station distortion.

Although the circuit diagrams show electromagnetic speakers, it is quite possible to use "permag" speakers with a suitable filter choke, provided that the transformer secondary voltage is reduced to a suitable figure. With a 14 Henry 60 mA. choke having a d.c. resistance of 520 ohms, the transformer voltage should be reduced to 315/315 volts, or suitable resistance should be added to produce the required d.c. voltage.

The Aegis broadcast band aerial coils were slightly modified by increasing the top coupling to give more constant gain over the band.

Apart from the changes outlined above, the general circuit design follows very closely to that of the 6 valve receiver RC52 described in the preceding issue of Radiotronics (No. 117). Reference should be made to the article in that issue for further information relevant to the use of the single-ended GT valves.

TEST RESULTS

(both receivers RC41 and RC42)

Oscillator.

Frequency	6.5 Mc/s.	11.0 Mc/s.	18.2 Mc/s.
e_k (RMS)	1.4	2.5	3.7 V.
e_o (RMS)	9.2	13.2	16.0 V.
ic_1	0.27	0.48	0.55 mA.
Frequency	600 Kc/s.	1000 Kc/s.	1500 Kc/s.
e_k (RMS)	1.5	2.44	1.44 V.
e_o (RMS)	20.0	17.2	15.0 V.
ic_1	0.42	0.52	0.52 mA.

Frequency Shift.

Input	10	100	1,000	10,000	100,000 µV.
Frequency shift	—	+0.4	+0.9	+0.6	+1.4 Kc/s.

Selectivity	Times down	Bandwidth
—	3	6.7 Kc/s.
—	10	10.7
—	30	15.0
—	100	19.3
—	300	25.0
—	1,000	32.0
—	10,000	41.0

A.V.C. and Distortion

Input	db (O=0.6W)	Distortion % (50mW)*	A.V.C. Volts
1µV.	—	—	—
3	—	—	—
10	— 15	16 (12mW)	—
30	— 2.5	6.5 (50mW)	0.8
100	+ 6.2	5.5	3.0
300	+ 9.5	5.5	5.0
1mV.	+12.0	5.6	7.0
3	+14.0	6.0	9.3
10	+16.8	6.4	13.2
30	+18.0	6.6	17.2
100	+20.0	6.2	21.0
300	+22.0	4.5	25.5
1V.	+25.3	2.15	32.5

*including noise and signal generator distortion.

Test Results—RC41

For output of 50 milliwatts (absolute)

Input to	Frequency	Input	Ratio	ENSI	Image
6SJ7-GT control grid	400 c/s	0.142 V	—		
6SF7-GT diode	455 Kc/s	690mV	—		
6SF7-GT control grid	455 Kc/s	3.1mV	—		
6SA7-GT signal grid	455 Kc/s	50 µV	62		
	600 Kc/s	62 µV	50	2.7	
	1000 Kc/s	60 µV	52	2.6	
	1400 Kc/s	58 µV	53.5	2.4	
	6.5 Mc/s	68 µV	45.5	2.9	
	11.0 Mc/s	58 µV	53.5	2.5	
	17.0 Mc/s	48 µV	64.5	2.1	
Aerial	600 Kc/s	11.5 µV	5.4	0.52	
	1000 Kc/s	11.7 µV	5.3	0.53	
	1400 Kc/s	11.6 µV	5.0	0.57	
	6.5 Mc/s	35 µV	1.94	1.7	15.4
	11.0 Mc/s	27 µV	2.15	1.3	7.8
	17.0 Mc/s	25 µV	1.92	1.2	3.35

Test Results—RC42

For output of 50 milliwatts (absolute)

Input to	Frequency	Input	Ratio	ENSI	Image
6SJ7-GT control grid	400 c/s	0.026 V	—		
6SF7-GT diode	455 Kc/s	262mV	—		
6SF7-GT control grid	455 Kc/s	1.18mV	—		
6SA7-GT signal grid	455 Kc/s	19 µV	62		
	600 Kc/s	23.6 µV	50	2.7	
	1000 Kc/s	22.8 µV	52	2.6	
	1400 Kc/s	22 µV	53.5	2.4	
	6.5 Mc/s	25.8 µV	46	2.9	
	11.0 Mc/s	22 µV	53.5	2.5	
	17.0 Mc/s	18.2 µV	64.5	2.1	
Aerial	600 Kc/s	4.4 µV	5.4	0.52	
	1000 Kc/s	4.45 µV	5.3	0.53	
	1400 Kc/s	4.4 µV	5.0	0.57	
	6.5 Mc/s	13.3 µV	1.94	1.7	15.4
	11.0 Mc/s	10.2 µV	2.15	1.3	7.8
	17.0 Mc/s	9.5 µV	1.92	1.2	3.35

Frequency Response—RC42 Only

Frequency (c/s)	Output (db)
20	—18
30	— 8
50	— 2
100	— 0.5
400	0
1000	0
3000	0
5000	— 1
10000	— 4
13000	— 7

RADIO RECEIVER DESIGN

(The second article of this series)

In the previous issue of Radiotronics some advice was given on the mechanical features involved in the design of radio receivers. The article in this issue deals with other general features of design preliminary to the detailed consideration of individual stages which will commence in the next issue.

Engineering Design Versus Experimental Hook-up.

There is a big difference between an experimental hook-up which may work perfectly satisfactorily in all respects, and a satisfactory design from an engineering point of view, having in mind the production of a number of receivers with equivalent performance. In an experimental hook-up the experimenter often fails to pay careful attention to the exact values of resistors, condensers or valve characteristics, since its performance may be arrived at either by a hit-and-miss process or by measurement of important features such as the plate and screen currents of valves and the voltages at important points in the circuit. A laboratory model is developed by an entirely different procedure, with careful attention to all features, and the results obtained by good design will be better than those obtained from the short-cut methods used in an experimental hook-up; it is still, however, only a single piece of equipment.

It is not until we come to the necessity for duplicating the results of a "pilot model" that we have to consider such matters as tolerances in valves and components, standardisation, specifications and tooling up. These will be considered in detail below.

Tolerances in Valves and Components.

No component, whether resistor, capacitor, inductor or valve, can be depended upon to have exactly the characteristics in accordance with its label. It is frequently possible to purchase resistors, for example, with different values of tolerances above and below the nominal value, the price usually increasing as the accuracy is made greater. In laboratory work it is frequently desirable to adopt components having characteristics within a very close tolerance of the nominal value, and they may even be branded with their precise values. This practice is, of course, impossible in production design, and it is generally regarded as good engineering design to arrange the circuit so that the majority of components in the receiver may be of the widest commercial tolerances. In most ordinary receiver and amplifier circuits the majority of resistors and capacitors will not affect the performance more than very slightly with a tolerance of plus or minus 10%, and even greater tolerances may be permitted in many cases. There may be a few especial components which require a higher degree of accuracy, such as a fixed padder condenser, and these would require individual consideration in each case.

The tolerances in valves are, in general, even wider than those in the other components. For example there are variations in plate and screen currents, transconductance, plate resistance, capacitances, overall length and diameter. Some of these are of little consequence—for example, the capacitances are of negligible importance in an audio frequency amplifier, while the plate resistance of a pentode is usually so high that the lowest value of any individual valve would still be high enough for its purpose. Other characteristics may have a more important effect on the performance, those requiring most careful attention being usually the transconductance, capacitances and plate and screen currents. In most stages the gain is approximately proportional to the transconductance, but is not so seriously affected by the other variables. The plate current is usually only of direct importance in the power amplifier stage, where it has an effect on the maximum power output. The screen current has a more general effect but only when the screen is supplied through a dropping resistor. For this reason, it is good practice to avoid the use of a screen dropping resistor in beam power amplifier valves because the screen current is extremely variable owing to the design of the valve, and may be anything between zero and double the published value.

The capacitance from grid to plate is principally important through its tendency to cause instability in i-f amplifiers, and these should be tested with a wide enough selection of valves to ensure that stability is attained under all conditions. The input capacitance has an effect on the tuned circuits of the r-f, converter, oscillator and i-f stages, while the output capacitance has a similar effect on the tuning of the converter and i-f valves which are followed by double-tuned i-f transformers.

As a result of the varying tolerances in all types of components, individual receivers manufactured in accordance with quantity production methods will have their performance varying within fairly wide limits. Two of the most serious of these are the overall sensitivity of the receiver and the maximum audio power output. It is suggested that the correct design procedure is to test each individual stage with the most extreme tolerance of valves and other components in order to ascertain whether or not this stage is stable and performs satisfactorily, even though with slightly higher or lower gain as brought about by the tolerances. Particular attention should be paid to instability in i-f amplifiers and to the grid currents of oscillators in superheterodyne receivers, which are liable to cease oscillation under the combined effects of low oscillation transconductance, low tolerance oscillator coil, and low supply voltage.

After the designer has satisfied himself that each stage is satisfactory, it is then desirable to insert, in each socket, valves having average characteristics, and then to measure the performance under these conditions. Tests should later be carried out with a large number of valves having normal commercial tolerances and all results recorded. From these results it is possible to lay down a satisfactory design specification for overall performance.

Standardisation.

The fundamental basis of quantity production is the standardisation of design and components. It is necessary for the receiver to be constructed so that any component may be replaced by another of its kind in accordance with a published list of component values, and for the latter to give satisfactory performance provided that the replacement component is within the specified tolerances.

It is also necessary for the manufacturer to prepare and distribute sufficient data to allow the receiver to be serviced with the minimum of difficulty. Such data require to give the complete circuit diagram, the list of component parts with tolerances, the list of valve types, the frequency ranges covered, the intermediate frequency, the tracking frequencies and the supply voltages and frequencies. If changes in design are made from time to time there should preferably be a change of model number, or else a reference may be made to the serial numbers of the chassis affected by the change. The notification regarding the modification should be in such clear language that it can readily be understood by all servicemen while, if it is merely a slight modification, it could with advantage be printed in such a way that the servicemen can paste it on to his original service data sheet and have it always available for reference in the right place.

Continuity of Supply of Components.

In quantity production it is essential to use components which will be in continuous supply and will not experience any serious changes in characteristics

SINGLE-ENDED "GT" TYPES

6SQ7-GT

6V6-GT

6X5-GT

5Y3-GT

likely to affect the performance of the receiver. Resistors and capacitors should be capable of being replaced by those of another make having the same nominal values and tolerances, but some of these may require more space than the ones originally used, and provision may have to be made for the installation of those styles having exposed metal ends. For this reason, it is usually desirable not to cramp the components too much, so as to allow for any contingencies. The position regarding other components is more difficult, this applying to loud speakers, gang condensers, chokes, coils and i-f transformers. Some manufacturers endeavour to produce the greater part of their own components so as to be independent of other suppliers and hence able to protect themselves from design changes at short notice. Those manufacturers who do not possess these facilities must therefore be prepared to introduce alternative designs without any serious change in the design or performance of the receiver.

Power transformers have different amounts of leakage flux resulting in different degrees of hum, this being particularly noticeable between vertical and horizontal types of transformers. Some designs of receivers which are quite satisfactory with the vertical mounting transformer are satisfactory with one make of transformer but not with another of the same mounting type. It is therefore important to design so as to be able to use at least one alternative type in an emergency.

Tooling Up.

Even apart from the production of component parts a considerable amount of tooling is required for the quantity production of a radio receiver. The degree of such tooling-up is affected by the quantity to be produced and the facilities for quantity manufacture. It is obvious that the cost of tooling-up must be spread over the total number of receivers produced. This addition to the cost needs to be balanced against the saving in cost per unit due to quantity production. Considerable economy may be exercised through the use of tooled parts for more than one design. For example, it may be possible to use one chassis for several models of receivers either during the current season or successive seasons, while many of the smaller tooled parts may be used for a very wide range of receivers and need not necessarily be outdated for some years to come.

Field Design.

When a pilot model has been produced and has passed through its initial testing for performance in the screened room, it is ready for what may be called developmental field testing. This is an opportunity for the receiver designer to try out his design under all anticipated conditions of operation and location. Special attention should be paid to such matters as selectivity, cross-modulation and overloading on strong signals, hum, quality of reproduction, tonal balance, "joeys" and second spots. During this test it is desirable to operate the receiver with a mains voltage plus and minus 20% for periods of about two hours and half an hour respectively, in order to ensure that no deleterious effects occur. These tests should be carried out in the normal cabinet and with the normal amount of ventilation. Battery receivers require special attention to the effects of high and low battery voltage, and this subject will be considered in detail in a later issue.

At this stage it is also desirable to look at the pilot receiver from the point of view of the serviceman, the ease of removing valves, chassis, speaker and the whole chassis from the cabinet.

When the receiver has completed its developmental field test, it will then be advisable to incorporate such modifications as were shown to be desirable. A second field test may then be desirable, and after its completion the performance of the receiver should be entirely satisfactory in all respects. The receiver will then be ready for developmental production to commence, but a series of production field tests are equally necessary and should be carried out on the first batch of receivers put through the production line. Some of these production tests should be carried out by experienced agents, dealers or servicemen under as wide a selection of operating conditions as is practicable. Reports received from these various observers may necessitate some slight changes to be made in the final design, and provision should be made for these before proceeding to quantity production.

Design to Fit Known Conditions.

A particular design of receiver is required to give good performance under certain fixed conditions. It is not satisfactory merely to design a range of 4 valve broadcast, 5 valve broadcast 5 valve dual-wave, 6 valve dual-wave, etc., but to look on each from the point of view of the class of listener and the service which it is required to perform. There is not always need to get the utmost in sensitivity from a particular type of receiver, and appreciable economies may be made, for example, by the use of less selective and lower gain i-f transformers, or the use of a cheaper type of converter valve. A small local station receiver intended for operation in areas of high field-strength need not have very high sensitivity, since the latter not only increases cost but brings in unnecessary background noise when tuning between stations, and may cause more interference from man-made static and power line interference.

RADIOTRON RECEIVER RC52

ADDITIONAL INFORMATION

Tests carried out subsequently to the preparation of the article in Radiotronics 117 have shown that a large part of the frequency shift which occurred on strong signals could be avoided by an improved i-f neutralization system. An article on this subject appears elsewhere in this issue and the description of the improved receiver incorporating the new i-f neutralization is given under the title "Radiotron Receiver RC53".

Neutralization in Circuits Employing a Valve as a Combined Intermediate Frequency Voltage Amplifier and Diode Detector

INTRODUCTION.

The general principles applied to the neutralization of ordinary types of i-f amplifiers are well known. Conditions for the neutralization of this type of amplifier, where the valve also incorporates a diode, do not appear to have been examined in any detail. In the circuit to be discussed the pentode section of the valve performs the ordinary function of i-f voltage amplifier, and a single diode acts as a combined detector and variable bias supply for the a.v.c. system. It is the purpose of this article to examine the conditions required for neutralization, and to give simple formulae which check reasonably accurately with practical results. A description of a practical method for obtaining neutralization is included.

Figure 1 shows a typical arrangement, employing a type 6SF7-GT valve, in which the various capacitances are indicated by the dotted lines. All the capacitances shown may be taken to include stray capacitance as well as direct interelectrode capacitance. As an example the capacitance Cst due to the i-f transformer could be included with the diode-to-plate capacitance Cdp.

The condition normally required for neutralization in this type of circuit is that no energy be fed back from networks in the output circuit into the grid circuit. That is, the valve and its associated circuits should act as a true unilateral network, transferring energy efficiently in one direction and preventing energy transfer in the reverse direction. The required conditions can be substantially achieved if the points marked G and X can be brought to the same potential as regards undesired feedback.

From an examination of the circuit of figure 1, it will be seen that there are two possible ways in which regenerative voltages may be fed back from the output circuits to the grid. The first path is provided by the capacitance between plate and grid (Cgp), and the second path is due to the diode-grid capacitance Cgd. Several simplifying assumptions are made to help in the analysis. The effects of the screen grid have been ignored, while the capacitance Cdk between diode and cathode may be regarded as being substantially in shunt with the capacitance C_2 tuning of the i-f transformer secondary.

Suppose now, that it is desired, first of all, to neutralize the effects of the diode-to-grid capacitance, and assume for the time being that there is no effect due to the presence of the grid-to-plate capacitance and C_{N_1}. We can then draw the capacitance bridge as shown in figure 2.

The values of Cdp, Cst, etc., clearly have no effect on the potential difference between G and X when there is no connection between G and P, except in the desired direction. This may readily be seen from an examination of figure 1.

From figure 2, the conditions required for a balance are that

$$\frac{C_{N_2}}{Cgd} = \frac{C}{Cgk}$$

$$\text{or } C_{N_2} = \frac{Cgd\ C}{Cgk}$$

where C_{N_2} is the required neutralizing capacitance, under this particular set of conditions. This value will require modification, as will be shown later, but the procedure indicates the method required for neutralization, and the approximate value of capacitance required. Stray capacitances must, of course, be included in all the values of capacitance used if a reasonably accurate indication is required, and this will usually have most effect on the value of Cgk, which will have a total capacitance of the order of 10$\mu\mu$F.

If the case is now considered where the effect of the diode-to-grid capacitance can be ignored and, of course, C_{N_2} is not present, we obtain the bridge circuit shown in figure 3. This is seen to be the usual circuit when the diode is not contained in the same valve. The conditions required for zero potential difference between G and X are now seen to be

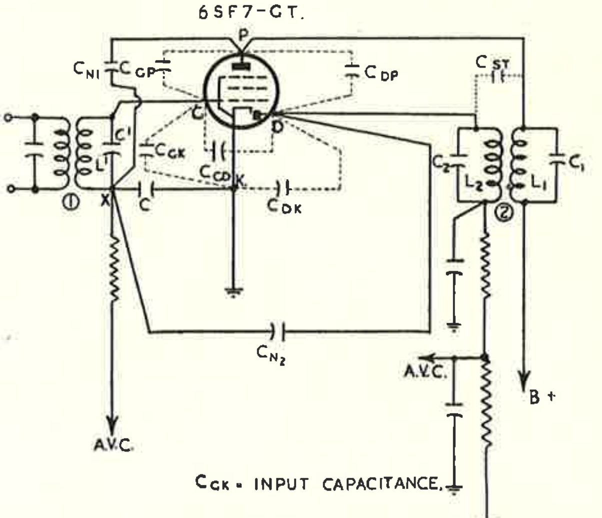


FIG. 1.

$$\frac{C_{N_1}}{C_{gp}} = \frac{C}{C_{gk}}$$

$$\therefore C_{N_1} = \frac{C.C_{gp}}{C_{gk}}$$

(note that C_{N_1} will be modified in the complete circuit as shown below.)

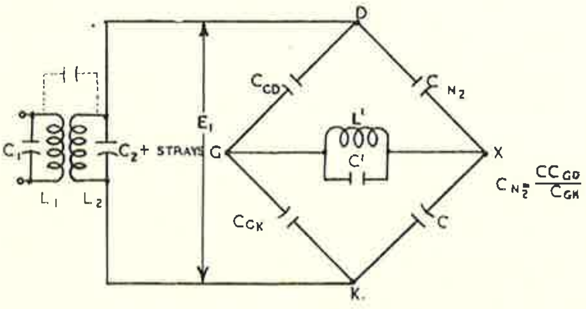


FIG. 2.

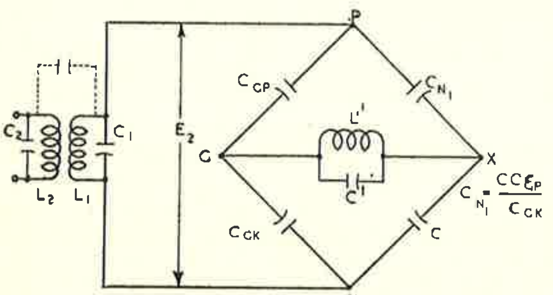


FIG. 3.

From the considerations above it may be seen that the two effects, if considered independently, will prevent excessive regenerative voltages from appearing across the grid input circuit. The conditions are, of course, even for these simplified conditions, only approximate, since complex impedances may exist in place of the simple capacitances shown, but the analysis can be extended to include these if desired; however, it offers difficulties, particularly in regard to obtaining an easy practical solution to the problem.

The next important factor to be considered, is as to what occurs in the complete circuit when the simplifying assumption that the circuits are independent no longer holds. Consider first the plate-to-diode capacitance; the effect of this should be small since it can have only an indirect effect on the potential difference between the points G and X. To substantiate this conclusion, tests were made by artificially increasing this capacitance and the changes required in the values of neutralizing capacitances noted. It was found that an increase of up to 10μμF. in the total capacitance had a negligible effect on the settings, although for obvious reasons the i-f transformer had to be realigned in each case.

The next effect to be considered is a change in the value of either Cgp or Cgd. Clearly, if either of these components is altered, the potential at the point G alters, and it becomes necessary to reset both of the neutralizing capacitances. The same must apply if Cgk is altered.

If the value of C_{N_1} or C_{N_2} is altered, then the potential at point X alters, and a resetting of the other unaltered neutralizing capacitor becomes necessary. Changes in C also upset both balancing arrangements.

From the considerations above it is clear that the settings of C_{N_1} and C_{N_2} are never completely independent of each other. The process of obtaining neutralization is not particularly complicated, however, and a suggested method is given at the end of this article.

It is found that once approximate settings for C_{N_1} and C_{N_2} have been obtained the values are not particularly critical, and fixed capacitors, of the approximate values required, may be used without any serious effect on the conditions for neutralization. This is, of course, advantageous in receiver production since it is only necessary to set the capacitance values required for neutralization in the developmental model, and then to use fixed capacitors in quantity production.

To show how the analysis of operation checks with the practical values obtained for C_{N_1} and C_{N_2}, the following example is appended.

For the interelectrode capacitances of the type 6SF7-GT the following average values have been measured:—

Cgp = .004 μμF.
Cgd = .003 μμF.
Cgk = 5.5 μμF.
C (A.V.C. bypass condenser) = .01 μF.

Taking the total value of capacitance from grid to cathode as 10 μμF. made up from 5.5 μμF. + strays (the strays being mainly from the grid end of the i-f transformer to ground) we have

$$C_{N_1} = \frac{.01 \times 10^6 \times .004}{10} = 4\ \mu\mu F.$$

$$C_{N_2} = \frac{.01 \times 10^6 \times .003}{10} = 3\ \mu\mu F.$$

The actual values obtained in the circuit were C_{N_1} = 4μμF. and C_{N_2} = 7μμF. When the wiring was rearranged in an effort to reduce stray capacitance the values became C_{N_1} = 3μμF. and C_{N_2} = 5μμF., so that the method of analysis yields results which give a close indication for the practical conditions.

METHOD OF PROCEDURE FOR NEUTRALIZATION OF I.F. AMPLIFIERS

A method of procedure for obtaining neutralization in a circuit of the type shown in figure 1, is given below. The general set-up of the equipment necessitates the use of a high gain audio amplifier, connected to the receiver output, to obtain sufficient voltage to give a sensitive indication as to when neutralization is obtained. An amplifier gain of about 1,000 times will give approximately 30 volts output wth ordinary types of receivers. In the particular arrangement used the horizontal and vertical amplifiers in a cathode ray oscillograph were connected in series, and the conditions for neutralization observed on the oscillograph screen. The use of a 400 c/s filter, connected between the receiver output and the amplifier input, is also advantageous as it minimizes the effects of undesired interference, such as hum.

The actual operations required with this arrangement are as follows:

1. Bias the control grid of the valve sufficiently negative to make the stage gain so low that regeneration does not occur. A suitable arrangement is to use a 45V. "B" battery, and connect it in series with the a.v.c. filter circuit, to the stage being neutralized, and ground. This bias must of course only be applied to the one stage and not to the other stages in the receiver through the common a.v.c. line.
2. Apply the output from a signal generator to the grid of the preceding stage and align the i.f. transformers at the required frequency.. Once this alignment is complete the adjustment of the first transformer should not be altered during the subsequent operations.
3. Disconnect the screen grid voltage.
4. Increase the negative bias on the control grid until plate current cut-off occurs.
5. The input from the signal generator should then be increased up to about 0.1 volt until sufficient indication is given on the output measuring equipment.

The output indicator may be a voltmeter, a cathode ray oscillograph or some other suitable device. The oscillograph is preferable, since large variations in output voltage during neutralization are not so likely to damage the measuring equipment.

6. Detune the primary of the second i.f. transformer.
7. Tune the secondary of the second i.f. transformer through resonance so as to obtain maximum output.
8. Adjust CN_2 to give minimum output. Again tune the secondary of the transformer and readjust CN_2.
9. Retune the primary of the second i.f. transformer to resonance.
10. Adjust CN_1 for minimum output.
11. The receiver can now be returned to the normal operating conditions.
12. For the best results the above procedure should be repeated.

TRIODES VERSUS BEAM POWER AMPLIFIERS

THE ANSWER TO A PROTRACTED CONTROVERSY

Ever since the introduction of negative feed-back with pentode and beam power valves, there has been a succession of arguments between those who prefer triode valves and those who use the more modern valve types with negative feed-back. It has been realised for some time that the ordinary methods for measuring harmonic distortion do not give a complete picture, and that it is also necessary to carry out tests on the intermodulation distortion. (2) The question has now been resolved by J. K. Hilliard (1) who has confirmed the fact that properly designed beam power amplifiers with negative feed-back are at least as good as, and, in some cases, better than triodes nearly giving equivalent power output. These measured results were checked by listening tests which confirmed the results obtained. A resumé of the article is given below for its general interest.

Negative feed-back does not necessarily give good results, particularly when it is used for compensating low- and high-frequency cut-off, or for frequency compensation. Under these circumstances, the full degree of negative feed-back is not available at extremely low or high frequencies where it is needed for good performance. Some apparatus also uses negative feed-back from the secondary of the output transformer, thereby introducing phase shift which frequently results in instability at very low- or high-frequencies, and in other cases to a reduction in the effectiveness of the feed-back at the extreme frequencies. In order to carry out tests which could not be challenged on technical grounds, J. K. Hilliard designed four push-pull amplifiers which incorporated good practice throughout. Two of these were in the 10 to 15 watt class and the other two of considerably higher power. The smaller triode amplifier included push-pull 2A3 valves with cathode bias, giving an output of 10 watts, while its competitor used 6L6 valves, giving an output of 15 watts. In the latter amplifier, feed-back was introduced from the secondary of the output transformer to the cathode of the first stage (6SJ7 r-c pentode) which was coupled to a phase splitter (6SJ7 connected as a triode) and then capacity coupled to the final stage. It was interesting to note that the method of phase splitting for this very high fidelity amplifier is the type used in many Radiotron amplifiers on account of its extremely low harmonic distortion. Special attention was paid to the design of the output transformer in order to give a very high inductance primary, accurate balance between windings, a high co-efficient of coupling to reduce leakage, and a very low distributed capacity. This transformer gives its maximum output power within 1db from 40 to 10,000 c/s.

The intermodulation tests were carried out with two signals of frequencies 60 and 1,000 c/s, the latter being 12db below the former. The negative feed-back 6L6 amplifier gave 1.3% intermodulation distortion at an output of 10 watts compared with 7.5% for the 2A3 amplifier. Even at an output of 12 watts, the intermodulation distortion was less than 2%, while at 14 watts it was 3.1%. At lower outputs, the improvement continued, and for an output of 6 watts the negative feed-back amplifier gave 0.4% as compared with 2.9% of the 2A3 valves; at an output of 2 watts the negative feed-back amplifier gave distortion below 0.1%, while the 2A3 amplifier gave over 2%.

These results were confirmed by listening tests, the reproducer being a special two-way loud-speaker system as designed for high-quality high-power reproduction (3). Quoting from the article—"All of the listening group stated that the beam power tube amplifiers were at least equal to the triodes and some observers favoured the beam power tubes slightly over triode type amplifiers."

Similar tests were made on the high-power amplifiers, these including a 40 watt push-pull 807 amplifier and a push-pull type 845 triode amplifier. The same general circuit arrangement was adopted for the 40 watt 807 amplifier and the frequency characteristic showed a drop of —0.5db at 20 c/s and —0.9db at 20,000 c/s when tested at 3db below rated power. Both the measured intermodulation distortion and the listening tests showed similar general results as for the smaller amplifiers, indicating that the negative feed-back amplifier was preferable.

Features which may have led to the listeners favouring the beam power valves were firstly that the output hum was approximately 15 db lower than for the triode valves for the same net gain, and, secondly, that the intermodulation distortion is less in the negative feed-back amplifiers than with the triodes.

In both casts, the negative feed-back amplifiers were designed to give the same measured output resistance as the competitive triode amplifier, so that this did not affect the result of the test. In any case, this would have had very little effect, since the type of loud-speaker used had so much internal damping that the output resistance of the amplifier had a negligible effect.

SUMMARY OF RESULTS:

1. Beam power valves can deliver the same audio power as triodes with the same or less distortion.
2. A high overall power efficiency could be obtained by using relatively low plate voltages and inexpensive valves.
3. The circuit of the beam power valves need not be complicated.
4. The signal-to-noise ratio is improved since indirectly heated cathodes are used in the beam valves.
5. The intermodulation method of testing compares favourably with the listening tests.
6. Excellent output transformers are required.

(1) J. K. Hilliard "Intermodulation Tests for Comparison of Beam and Triode Tubes used to drive Loudspeakers". Communications 26.2 (February, 1946) 15.

(2) J. K. Hilliard "Distortion Tests by the Intermodulation Method". PROC. I.R.E. 29.12 (December, 1941) 614.

(3) "Motion Picture Sound Engineering"—pages 97 to 115. D. Van Nostrand Company, Inc.

PHOTOTUBES AND LAMPS.

How to Calculate the Illumination on Phototubes and their Electrical Output.

Radio Engineers are frequently unfamiliar with the units used in connection with lamps and illumination, and are often hazy regarding the proper approach to the design of equipment incorporating a phototube. This article will assist in approaching the design with the minimum of wasted energy.

Illumination is the application of light for a particular purpose. The light may be sunlight, or more often artificial light usually from an electric lamp. It is necessary to measure light intensity and **the unit of light intensity** is the "candle." For instance, an electric lamp may be classified as a "50 candle-power lamp."

The unit of illumination is the "foot-candle" which is the illumination on a surface one foot distant from a lamp having a light intensity of one candle-power. This unit of illumination is used in connection with the determination of satisfactory lighting in offices and factories, and minimum values of illumination have been specified for particular purposes, such as general office work, general factory illumination, illumination for fine and delicate work, etc., all these being specified in terms of foot-candles.

The unit of light flux is the "lumen" which is the flux over the surface of 1 sq. foot when it is illuminated at the level of one foot-candle. Light flux can be regarded as being the light emitted by a lamp, and the total flux is constant irrespective of the distance from the lamp.

The total flux emitted by a lamp of one candle power is therefore 4π lumens, since the surface area of a sphere is $4\pi r^2$. We may therefore put down the following relationships for ready reference.

A point source of one candle power emits a flux of 4π lumens, 1 foot-candle is the illumination intensity of 1 lumen per square foot.

Lamps.

The flux emitted by electric lamps depends on many factors including the type of lamp, the size and the voltage. Ordinary 240 volt lamps of the coiled-coil variety have approximately * the following characteristics:—

Watts	Lumens	Lumens/Watt
40	415	10.4
60	700	11.7
100	1340	13.4

*There are slight differences between the published figures of lamp manufacturers.

The column "watts" indicates the electrical power consumed by the lamp. The column "lumens" indicates the total light flux emitted by the lamp, while the "lumens/watt" column gives an indication of the efficiency, which is shown to increase with the size of the lamp.

If a small object (such as the cathode of a phototube) is placed so as to intercept some of the light flux, the flux which will fall on it is given the expression.

$$\frac{A}{4\pi D^2} \times F$$

where A = area of object in square feet.

D = distance from lamp to object in feet,

and F = light flux in lumens emitted by the source.

As an example take as the "object" a phototube type 922 with a window area of 0.4 sq. inch, placed 2 feet from a 100 watt lamp.

A = 0.4/144 sq. ft.

D = 2 feet.

F = 1340 lumens.

The flux which will fall on the cathode is therefore

$$\frac{0.4 \times 1340}{4 \times \pi \times 4 \times 144} = 0.074 \text{ lumen.}$$

The following table will be found useful in connection with lamps and phototubes. It holds for 240-volt coiled-coil lamps, and the phototube is assumed to have a window area of 0.4 square inch. The flux on larger or smaller cathodes will be in proportion to the window area:—

Distance from Lamp (feet)	LAMP 40 watts 415 lumens	60 watts 700 lumens	100 watts 1340 lumens
	Light flux intercepted by phototube (0.4 in².)		
1	0.092	0.156	0.296
2	0.023	0.039	0.074
4	0.0057	0.0097	0.018
8	0.0014	0.0024	0.0046
12	0.00064	0.0011	0.0021
16	0.00036	0.0006	0.0012
24	0.00016	0.00027	0.0005
32	0.00009	0.00015	0.0003

If a lens is used to focus the light on to the cathode of the phototube, the area of the lens should be used in the calculation instead of the area of the cathode (it being assumed that none of the light focused by the lens is lost).

VACUUM PHOTOTUBES.

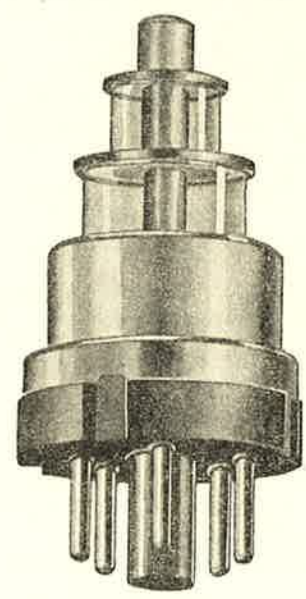
The current which will be passed by a vacuum phototube without any resistance in the circuit is given by the light flux in lumens multiplied by the luminous sensitivity. In this case type 922 has a luminous sensitivity of 20 μA/lumen so that the current will be 20 × 0.74 = 14.8 μA. This current is not appreciably affected by the voltage applied to the phototube, provided that this is not less than 50 volts.

When a load resistance is inserted in series with a vacuum phototube, it has very little effect on the cathode current provided that the anode-cathode voltage does not fall below about 50 volts. This differs considerably from the effects with gas-filled phototubes, as will be described below.

GAS-FILLED PHOTOTUBES.

Gas-filled phototubes have characteristics which vary considerably with the applied voltage, load resistance, and illumination. In general, gas-filled phototubes should always be used with a load resistance of the specified minimum value in order to protect them from excessive current.

In the application of gas-filled phototubes it is necessary to refer in each instance to the curves "Average Anode Characteristics," on which the loadline corresponding to the desired value of load resistance has been drawn. The static anode current for any value of light flux can then be determined directly from the curves. The variation between maximum and minimum values of light flux can also be converted to a variation in anode current and/or voltage.



RADIOTRON LIGHTHOUSE VALVE.

For description see page 42.

deleted - See Sept/Oct - Page 106.

NEW RMA TYPE DESIGNATION SYSTEM

For some years past the RMA type designation system (e.g., 6D6) has been used for receiving types of valves and cathode ray tubes, but transmitting types have generally had a numerical type designation. As from October 11th, 1945, a modified form of this same type designation has been used for electron tubes and devices other than radio receiving valves and cathode ray tubes. The full RMA standards proposal No. 168 is quoted below, and it will be seen that it incorporates three basic symbols, the first being a number symbol indicating the cathode power, the second a letter symbol indicating the structure and the final number symbol which is purely a serial symbol commencing with the number 21.

As an example, type 2C21 would indicate a cathode power not more than 10 watts, a triode, and serial number 21 under this system.

It is possible to differentiate between receiving valve types under the old RMA system and other than receiving types under this modified system, by the fact that the latter all have the final number 21 or more. There is, therefore, no danger of confusion between the two systems.

The full RMA standards proposal, as adopted, is given below.

FOR TRANSMITTING AND SPECIAL PURPOSE TUBES:

The type designation shall comprise three distinctive symbols. These will be, in their regular order, a number symbol, a letter symbol, and a number symbol; the significances of which are given below:

1. **The first number symbol** will indicate the cathode power required for normal operation in accordance with the following schedule:

Designation.	Range of Filament or Heater Power.	
1.	-	Zero Watts
2.	In excess of zero watts and up to and including	10 „
3.	In excess of 10 watts and up to and including	20 „
4.	In excess of 20 watts and up to and including	50 „
5.	In excess of 50 watts and up to and including	100 „
6.	In excess of 100 watts and up to and including	200 „
7.	In excess of 200 watts and up to and including	500 „
8.	In excess of 500 watts and up to and including	1000 „
9.	In excess of 1000 watts.	

2. **The letter symbol** will indicate the structure in accordance with the following schedule:

A. Monodes—Such as ballast tubes and vacuum-sealed resistors.

B. Diodes—Including full-wave as well as half-wave rectifiers, protective tubes, spark gaps, voltage regulators, etc.

C. Triodes—Including thyratrons, cold-cathode three-electrode control tubes, etc.

D. Tetrodes—Including thyratrons, cold-cathode four-electrode control tubes, etc.

E. Pentodes.

F. Hexodes.

G. Heptodes.

H. Octodes.

L. Vacuum-sealed types of capacitors.

N. Crystal detectors and crystal rectifiers.

P. Photo-emissive, vacuum-sealed devices; photo-tubes, photo-multipliers, pick-up tubes, etc.

R. Mercury pool types, inclusive.

S. Vacuum-sealed contactor-type switches.

3. **The second number symbol** will be a serial designation and in no case shall be less than 21.

Use of Suffix Letter for Type Designations

(Standards Proposal No. 144)

It shall be standard to use the same type designation for both the prototype and the improved version where complete interchangeability exists between the two types, and to assign different type designations in accordance with the appropriate standard to tube types that are not completely interchangeable except that it shall be standard to permit the assignment of a suffix letter in alphabetical order, beginning with A. to the type designation of a prototype to identify the improved version where both:

A. Unilateral interchangeability exists between the improved version and the prototype; i.e., where the improved version may serve to replace the prototype in all known, important applications but not vice-versa, and,

B. The improved version is intended to displace completely the prototype.

TYPICAL TYPE DESIGNATIONS

1C23, 1N35, 2C53, 3C44, 6D25, 1P39.

ALTERNATIVE GT AND METAL VALVES

Receiver manufacturers are strongly recommended to make provision for the use of either GT (glass) or metal valves in new designs of a-c receivers. both for new epuipments and for replacements. Although there is no present indication of any shortage of GT types, except for type 6SF7-GT which is not yet manufactured in U.S.A., some receivers may be exported or taken overseas. For this reason it is desirable to provide for the use of either of the alternative forms in which these valves are manufactured.

The metal and GT single-ended valves are very similar in both their electrical characteristics and dimensions, and shielding is generally unnecessary even for the GT types. The principal differences are in the capacitances—and these only affect types 6SK7-GT, 6SA7-GT and 6SF7-GT. In general, the input and output capacitances differ only slightly, and the variation may be adjusted by re-aligning, and even this would not be necessary in many cases. The oscillator input capacitance of types 6SA7 and 6SA7-GT differ only by about 1 $\mu\mu$F., so that the effect of a change from glass to metal valve is very slight.

There is a larger difference between the grid-to-plate capacitances of the two versions of type 6SK7-GT, which is only of importance in the i-f amplifier. Whether or not neutralization is used, it is quite in order to design (and neutralize if desired) on the basis of the GT valve, and then to replace by either glass or metal version. On the other hand, owing to the higher grid-to-plate capacitance of the GT valve, instability might result if the set were designed around the metal valve and later used with a glass valve.

In the case of type 6SF7-GT, the input and output capacitances are the same as for the metal version, but the capacitances tending to cause instability when it is used as an i-f amplifier are greater in the glass version. Here again it is satisfactory to design around the GT version, preferably neutralized, and a metal valve may then be used as a replacement.

Once again we wish to stress the importance of earthing No. 1 pin of the octal sockets, which in the metal valves are connected to the envelope, and in the GT valves to the metal shell around the base.

3V4 REPLACES 3Q4

FOR AUSTRALIAN PRODUCTION

It is understood that type 3Q4 has not been approved by the American underwriters, on account of the danger of its insertion into the wrong socket, owing to its twin plate leads. It has consequently been decided to cancel the Australian production of type 3Q4 and to substitute type 3V4, which is free from these objections. Radiotron type 3V4 is similar to type 3Q4 except for the pin connections.

Pin No.	3Q4	3V4
1	Filament —	Filament —
2	Plate	Plate
3	Grid	Screen
4	Screen	No connection
5	Filament tap	Filament tap
6	Plate	Grid
7	Filament +	Filament +

RADIOTRON 2E26

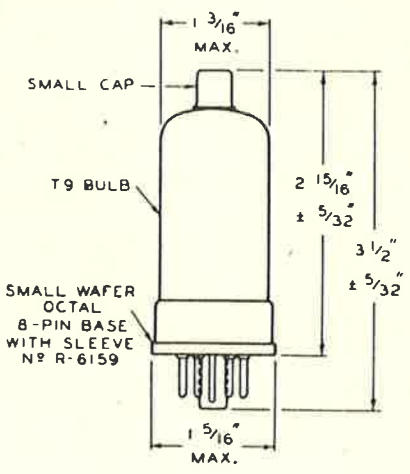
V-H-F BEAM POWER AMPLIFIER

Radiotron type 2E26 is a beam power amplifier intended primarily for use in FM transmitters, either in low power driver stages, or in the output stage when only low power output is required. It is also useful in a-f power and modulator service.

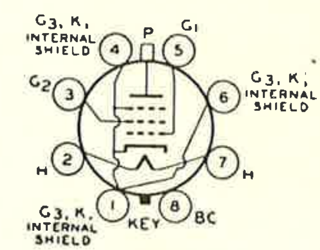
Having high power sensitivity and high efficiency, the 2E26 can be operated at relatively low plate voltage to give large power-output with small driving power. Furthermore, it can be operated with full input to 125 megacycles.

TYPE 2E26

DIMENSIONAL OUTLINE



SOCKET CONNECTIONS
Bottom View



7CK

PIN 1. CATHODE, GRID NO.3, INTERNAL SHIELD
PIN 2: HEATER
PIN 3: GRID No.2
PIN 4: SAME AS PIN 1
PIN 5: GRID NO. 1
PIN 6: SAME AS PIN 1
PIN 7: HEATER
PIN 8: BASE SLEEVE
CAP: PLATE

RADIOTRON 2E26 (Continued)

Small in size for its power-output capability, the 2E26 features rugged button-stem construction with short internal leads, and an octal base with short metal sleeve which shields the input to the valve so completely that no other external shielding is required. Separation of input and output circuits is accomplished by bringing the plate lead out of the bulb to a cap opposite the base.

General Data

Electrical:

Heater, for Unipotential Cathode:		
Voltage (AC or DC)	6.3	Volts
Current	0.8	Ampere
Transconductance for plate current of 20 milliamperes	3500	Micromhos
Grid-Screen Mu-Factor	6.5	
Direct Interelectrode Capacitances:°		
Grid to Plate	0.20 max.	μμf
Input	13	μμf
Output	7	μμf

° With no external shielding and base sleeve connected to ground.

Mechanical:

Mounting Position	Any
Overall Length	3-1/2" ± 5/32"
Seated Length	2-15/16" ± 5/32"
Maximum Diameter	1-5/16"
Bulb	T-9
Cap	Small
Base	Small Wafer Octal 8-Pin with Sleeve No. R-6159

AF Power Amplifier and Modulator —Class A1

Maximum Ratings, *Absolute Values*:

	CCS†	
DC PLATE VOLTAGE	300 max.	Volts
DC GRID-No. 2 (SCREEN) VOLTAGE	200 max.	Volts
PLATE DISSIPATION	10 max.	Watts
GRID-No. 2 INPUT	2.5 max.	Watts
PEAK HEATER-CATHODE VOLTAGE:		
Heater negative with respect to cathode	100 max.	Volts
Heater positive with respect to cathode	100 max.	Volts

Typical Operation:

DC Plate Voltage	250	Volts
DC Grid-No. 2 Voltage	160	Volts
DC Grid-No. 1 (Control Grid) Voltage	−12	Volts
Peak AF Grid-No. 1 Voltage	12	Volts
Zero-Signal DC Plate Current	35	Ma.
Max.-Signal DC Plate Current	42	Ma.
Zero-Signal DC Grid-No. 2 Current	7	Ma.
Max.-Signal DC Grid-No. 2 Current	10	Ma.
Load Resistance	5500	Ohms
Total Harmonic Distortion	10	Per cent
Power Output	5.3	Watts

Maximum Circuit Values:

Grid-No. 1-Circuit Resistance	30000 max.	Ohms

Push-Pull AF Power Amplifier and Modulator—Class AB_2*

Values are for two valves

Maximum Ratings, *Absolute Values*:

	CCS†	ICAS†	
DC PLATE VOLTAGE	400 max.	500 max.	Volts
DC GRID-No. 2 (SCREEN) VOLTAGE	200 max.	200 max.	Volts
MAX.-SIGNAL DC PLATE CURRENT**	150 max.	150 max.	Ma.
MAX.-SIGNAL PLATE INPUT**	60 max.	75 max.	Watts
MAX.-SIGNAL GRID-No. 2 INPUT**	5.0 max.	5.0 max.	Watts
PLATE DISSIPATION**	20 max.	25 max.	Watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	Volts
Heater positive with respect to cathode	100 max.	100 max.	Volts

Typical Operation:

DC Plate Voltage	400	500	Volts
DC Grid-No. 2 Voltage ▲‡	125	125	Volts
DC Grid-No. 1 Voltage (Fixed Bias)	−15	−15	Volts
Peak AF Grid-No. 1-to-Grid-No. 1 Voltage	60	60	Volts
Zero-Signal DC Plate Current	20	22	Ma.
Max.-Signal DC Plate Current	150	150	Ma.
Max.-Signal DC Grid-No. 2 Current	32	32	Ma.
Effective Load Resistance (Plate to plate)	6200	8000	Ohms
Max.-Signal Driving Power (Approx.) ♦	0.36	0.36	Watt
Max.-Signal Power Output (Approx.)	42	54	Watts

Plate-Modulated RF Power Amplifier —Class C Telephony

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

Maximum Ratings, *Absolute Values*:

	CCS†	ICAS†	
DC PLATE VOLTAGE	400 max.	500 max.	Volts
DC GRID-No. 2 (SCREEN) VOLTAGE	200 max.	200 max.	Volts
DC GRID-No. 1 (CONTROL GRID) VOLTAGE	−175 max.	−175 max.	Volts
DC PLATE CURRENT	60 max.	60 max.	Ma.
DC GRID-No. 1 CURRENT	3.5 max.	3.5 max.	Ma.
PLATE INPUT	20 max.	27 max.	Watts
GRID-No. 2 INPUT	1.7 max.	2.3 max.	Watts
PLATE DISSIPATION	6.7 max.	9 max.	Watts
PEAK HEATER-CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	Volts
Heater positive with respect to cathode	100 max.	100 max.	Volts

Typical Operation:

DC Plate Voltage	400	500	Volts
DC Grid-No. 2 Voltage‡	160	180	Volts
	32000	35500	Ohms
DC Grid-No. 1 Voltage●	−50	−50	Volts
	20000	20000	Ohms
Peak RF Grid-No. 1 Voltage	60	60	Volts
DC Plate Current	50	54	Ma.
DC Grid-No. 2 Current	7.5	9	Ma.
DC Grid-No. 1 Current (Approx.)	2.5	2.5	Ma.
Driving Power (Approx.)	0.15	0.15	Watt
Power Output (Approx.)	13.5	18	Watts

Maximum Circuit Values:

Grid-No. 1-Circuit Res.●●	30000 max.	30000 max.	Ohms

RF Power Amplifier and Oscillator —Class C Telegraphy

Key-down conditions per valve without modulations‡‡

Maximum Ratings, *Absolute Values*:

	CCS†	ICAS†	
DC PLATE VOLTAGE	500 max.	600 max.	Volts
DC GRID–No. 2 (SCREEN) VOLTAGE	200 max.	200 max.	Volts
DC GRID–No. 1 (CONTROL GRID) VOLTAGE	–175 max.	–175 max.	Volts
DC PLATE CURRENT	75 max.	75 max.	Ma.
DC GRID–No. 1 CURRENT	3.5 max.	3.5 max.	Ma.
PLATE INPUT	30 max.	40 max.	Watts
GRID–No. 2 INPUT	2.5 max.	2.5 max.	Watts
PLATE DISSIPATION	10 max.	13.5 max.	Watts
PEAK HEATER–CATHODE VOLTAGE:			
Heater negative with respect to cathode	100 max.	100 max.	Volts
Heater positive with respect to cathode	100 max.	100 max.	Volts

Typical Operation:

DC Plate Voltage	400	500	600	Volts
DC Grid–No. 2 Voltage□	190	185	185	Volts
	19000	28500	41500	Ohms
DC Grid–No. 1 Voltage δ	–30	–40	–45	Volts
	10000	13500	15000	Ohms
Peak RF Grid–No. 1 Volt	41	50	57	Volts
DC Plate Current	75	60	66	Ma.
DC Grid–No. 2 Current .	11	11	10	Ma.
DC Grid–No. 1 Current (Approx.)	3	3	3	Ma.
Driving Power (Approx.)	0.12	0.15	0.17	Watt
Power Output (Approx.)	20	20	27	Watts

Maximum Circuit Values:

Grid–No. 1–Circuit Res.••	30000 max.	30000 max.	Ohms

* Subscript 2 indicates that grid current flows during some part of input cycle.

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

▲ Preferably obtained from a separate source, or from the plate-voltage supply with a voltage divider.

‡ In applications requiring the use of screen voltages above 135 volts, provision should be made for the adjustment of grid–No. 1 bias for each valve separately.
The necessity for this adjustment at the lower screen voltages depends on the distortion requirements and on whether the plate-dissipation rating is exceeded at zero-signal plate current.

♦ Driver stage should be capable of supplying the No. 1 grids of the class AB_2 stage with the specified driving power at low distortion. The effective resistance per No. 1 grid circuit of the class AB_2 stage should be kept below 500 ohms and the effective impedance at the highest desired response frequency should not exceed 700 ohms.

♯ Obtained preferably from a separate source modulated with the plate supply, or from the modulated plate-supply through series resistor of the value shown.

• Obtained from grid resistor of value shown or by partial self-bias methods.

•• Any additional bias required must be supplied by a cathode resistor or a fixed supply.

♯♯ Modulation essentially negative may be used if the positive peak of the audio-frequency envelope does not exceed 115% of the carrier conditions.

□ Obtained preferably from a separate source, or from the plate-voltage supply with a voltage divider, or through a series resistor of the value shown. The grid–No. 2 voltage must not exceed 600 volts under key-up conditions.

δ Obtained from fixed supply, or by grid–No. 1 resistor of value shown.

† CCS = Continuous Commercial Service: ICAS = Intermittent Commercial and Amateur Service.

REVISED CHARACTERISTICS

TYPE 9C21

Water and Forced-air Cooled Transmitting Triode.

The highest operating frequency for maximum rated plate voltage and plate input has been increased from 5 to 15 Mc/s., after thorough testing to ensure satisfactory performance. The reduced ratings for operation at 25 Mc/s. remain unchanged, but new ratings have been introduced for a frequency of 20 Mc/s.

TYPE 813

Transmitting Beam Power Amplifier.

Ratings for the operation of type 813 at frequencies up to 120 Mc/s. have recently been added. At the latter frequency type 813 may be operated with a maximum rated plate voltage and plate input of 76 % for class B, class C grid or suppressor modulation, and 50% for class C telegraphy and class C plate modulation conditions. The lower frequency ratings remain unchanged.

TYPE 931-A

Multiplier Phototube.
9 Stage Electrostatically Focused Type.
Blue Sensitive.

The maximum ratings for anode current and dissipation have been reduced from 2.5 mA. and 0.5 watt to 1.0 mA. and 0.25 watt respectively. The ambient temperature rating has been increased from 50°C. to 75°C. and the typical operation characteristics have been modified. Full characteristics are shown below. Types 1P21, 1P22, 1P28, and 931-A have similar outlines, socket connections and circuits. Reference should be made to the article on type 1P22 elsewhere in this section.

RADIOTRON 931-A

General:

Spectral Response	S–4
Wavelength of Max. Response	3750 Angstroms
Cathode:	
Minimum Projected Length*	15/16"
Minimum Projected Width*	5/16"
Direct Interelectrode Capacitances (Approx.):	
Anode to Dynode No. 9 ...... 4	μμF
Anode to All Other Electrodes .. 6.5	μμF
Maximum Overall Length	3–11/16"
Maximum Seated Length	3–1/8"
Length from Base Seat to Centre of Useful Cathode Area ...	1–15/16" ± 3/32"
Maximum Diameter	1–5/16"
Bulb	T-8
Mounting Position	Any
Base	Small Shell Submagnal 11-Pin
Basing Designation	11K

Pin 1—Dynode No. 1	Pin 7—Dynode No. 7
Pin 2—Dynode No. 2	Pin 8—Dynode No. 8
Pin 3—Dynode No. 3	Pin 9—Dynode No. 9
Pin 4—Dynode No. 4	Pin 10—Anode
Pin 5—Dynode No. 5	Pin 11—Cathode
Pin 6—Dynode No. 6	

(Continued on page 47)

RADIOTRON LIGHTHOUSE VALVES

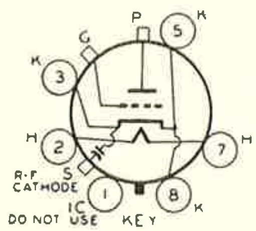
TYPES 2C40, 2C43 AND 559

These three valve types have been called "lighthouse" valves because of their distinctive appearance which results from their design features. These features are of vital importance in their u-h-f performance. and include

1. Very close interelectrode spacing combined with low interelectrode capacitances.
2. R-f and mutual d.c. cathode connections.
3. A unique arrangement in connections to the grid and plate.
4. A structural shape facilitating their use in concentric line circuits.

Types 2C40, 2C43.

Bottom View of Socket Connections



PIN 1: INTERNAL CONNECTION, DO NOT USE
PIN 2: HEATER
PIN 3: CATHODE
PIN 5: CATHODE
PIN 7: HEATER
PIN 8: CATHODE
POST & DISC TERMINAL: PLATE
DISC TERMINAL: GRID
SHELL: CATHODE RF TERMINAL

Radiotron types 2C40 and 2C43 are triodes for use in r-f amplifier and oscillator service at frequencies up to approximately 3,000 Mc/s. Both types have low frequency drift with variations in heater and plate voltages. In addition, they are held to close electrical and mechanical tolerances to meet the exacting requirements of u-h-f- circuit design.

Radiotron type 559 is a diode for operation in half wave rectifier services.

Brief mention was made of these three lighthouse valves in Radiotronics 117 but the full characteristics are given below for reference. on P.24.

Types 2C40 and 2C43

General:

	2C40	2C43	
Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3 ±5%‡	6.3 ±5%	Volts
Current	0.75	0.9	Ampere
Direct Interelectrode Capacitances (Approx.):			
Grid to Plate*	1.3	1.7	μμF
Grid to Cathode*	2.1	2.8	μμF
Plate to Cathode*△	0.02	0.02	μμF
Cathode to Shell	100	100	μμF
DC Heater-Cathode Voltage	100 max.	100 max.	Volts
Seal Temperature	200 max.	200 max.	°C
Dimensions and Terminals	See *Out.ine Drawings*		
Base	Small H-Wafer Octal 6-Pin		
Mounting Position	Any		

Characteristics, *Class A Amplifier*.

	2C40	2C43	
DC Plate Voltage	250	250	Volts
DC Grid Voltage: *from a cathode resistor of***	200	100	Ohms
Amplification Factor	36	48	
Plate Resistance	7500	6000	Ohms
Transconductance	4800	8000	Micromhos
Plate Current	16.5	20	mA.

(Continued on page 43)

(See photograph on page 37)

Radiotron 2C40

Radiotron 2C43

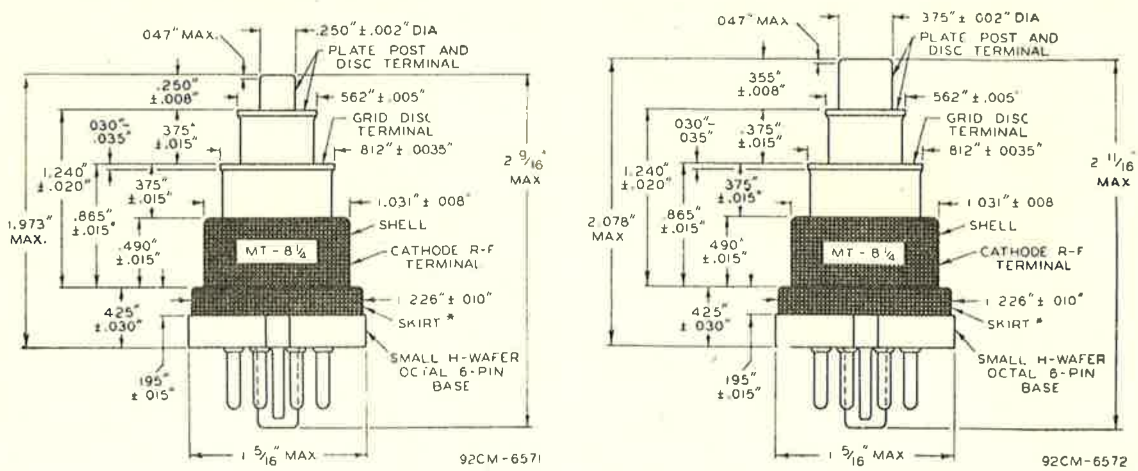


PLATE POST, GRID DISC TERMINAL, AND CATHODE RF TERMINAL ARE CONCENTRIC WITH RESPECT TO EACH OTHER WITHIN 1/64".

* NOT TO BE USED FOR RF CONTACT IN NEW EQUIPMENT DESIGNS

RADIOTRON 1P22 MULTIPLIER PHOTOTUBE

9-Stage Electrostatically Focussed Type

[NOTE: Types 1P21, 1P22, 1P28, and 931-A have similar outlines, socket connections, and circuits. The information in this article may be applied to any of these types, with the exception of Spectral Response.]

Radiotron 1P22 is a high-vacuum multiplier phototube having a spectral response covering the visible range from about 4,000 to 7,000 angstroms. Maximum sensitivity occurs at approximately 4,200 angstroms. The 1P22, therefore, has high sensitivity, to green-and blue-rich light. Its sensitivity to incandescent light depends on the color temperature of the source. When a Wratten No. 101 filter is used with the 1P22, the response is approximately equivalent to that of the eye. Because

the photocurrent produced at its light-sensitive cathode is multiplied many times by secondary emission occurring at successive dynodes, the 1P22 is capable of multiplying feeble currents produced under weak illumination by an average value of 200,000 times when operated at 100 volts per stage. The resultant output current is a linear function of the exciting illumination under normal operating conditions. Since secondary emission occurs instantaneously, frequency response of the 1P22 is flat up to frequencies at which transit time becomes a limiting factor.

(Continued on page 44)

RF AMPLIFIER & OSCILLATOR—Class C Telegraphy

Maximum Ratings, *Absolute Values*:

DC PLATE VOLTAGE ..	500 max.	500 max.	Volts
DC PLATE CURRENT ..	25 max.	40 max.	mA.
PLATE DISSIPATION ...	6.5 max.	12 max.	Watts

* With cathode connected directly to shell.
** Fixed bias is not recommended.
‡ Type 2C40 may be operated at 6.3 volts ±10% in some applications.
△ With shield having diameter of 2–3/8" in plane of grid disc terminal.

The *cathode* of each type is brought out to three base pins in order to make possible the reduction of circuit inductance. In addition, a capacitor of approximately 70 μμF. is connected between the cathode and the metal shell. Connection to the shell provides a low-impedance path for u-h-f currents to the cathode.

Type 559

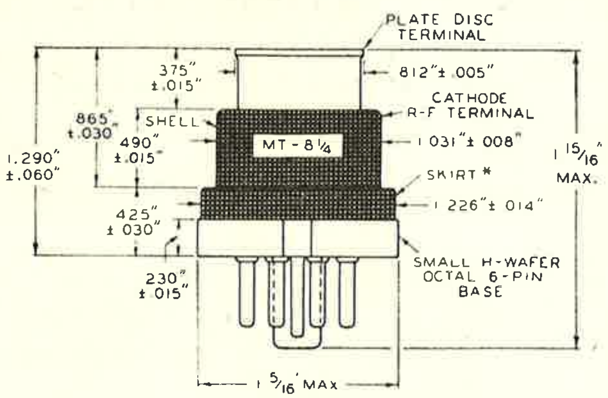
General:

Heater, for Unipotential Cathode:			
Voltage (AC or DC)	6.3 ±5%		Volts
Current	0.75	..	Ampere
Direct Interelectrode Capacitance (Approx.):			
Plate to Cathode	2.70	..	μμF
Valve DC Voltage Drop (Approx.), for a dc plate current of 24 ma.	5	..	Volts
Dimensions and Terminals	See *Outline Drawing*		
Base	Small H-Wafer Octal 6-Pin		
Mounting Position	Any		

Maximum Ratings, *Absolute Values*:

PEAK PLATE VOLTAGE	100 max.	Volts
PEAK PLATE CURRENT	200 max.	mA.
AVERAGE PLATE CURRENT	30 max.	mA
DC HEATER-CATHODE POTENTIAL	100 max.	Volts
SEAL TEMPERATURE	200 max.	°C

Radiotron 559

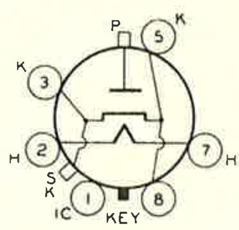


MAXIMUM ECCENTRICITY OF ℄ (AXIS) OF THE FOLLOWING ITEMS WITH RESPECT TO ℄ OF SHELL AS REFERENCE IS:

PLATE DISC TERMINAL: 0.020"
SKIRT: 0.035"

* NOT TO BE USED FOR CATHODE RF CONTACT IN NEW EQUIPMENT DESIGN.

Bottom View of Socket Connections



PIN 1. INTERNAL CONNECTION - DO NOT USE
PIN 2: HEATER
PIN 3: CATHODE
PIN 5: CATHODE
PIN 7: HEATER
PIN 8: CATHODE
SHELL: CATHODE RF TERMINAL
DISC: PLATE

RADIOTRON 1P22 (Continued)

Having small size, rugged construction, enormous sensitivity, low noise level, low dark current, freedom from distortion, and a spectral response covering the same range as that of the eye, the 1P22 is specially useful in colorimetry and spectroscopy. It also finds application in light-operated relays, in sound reproduction from films, in facsimile transmission,. and in scientific research involving low light levels.

Tentative Data

General:

Spectral Response	S-8
Wavelength of Maximum Response	4200 Angstroms
Cathode:	
Minimum Projected Length*	15/16"
Minimum Projected Width*	5/16"
Direct Interlectrode Capacitances (Approx.):	
Anode to Dynode No. 9	4 μμF
Anode to All Other Electrodes	6.5 μμF
Maximum Overall Length	3-11/16"
Maximum Seated Length	3-1/8"
Length from Base Seat to Centre of Useful Cathode Area	1-15/16" ± 3/32"
Maximum Diameter	1-5/16"
Bulb	T-9
Base	Small Shell Submagnal 11-Pin
Mounting Position	Any

Maximum Ratings, *Absolute Values*:

ANODE-SUPPLY VOLTAGE (DC or Peak AC)■	1250 max.	Volts
SUPPLY-VOLTAGE BETWEEN DYNODE No. 9 AND ANODE	250 max.	Volts
ANODE CURRENT	1.0 max.	Milliampere
ANODE DISSIPATION	0.25 max.	Watt
AMBIENT TEMPERATURE	50 max.	°C

Characteristics:

Voltage between Dynode No. 9 & Anode	50	50	Volts
Voltage per Stage	75	100	Volts
Max. Anode Dark Current	—	0.25	Microampere
Sensitivity:			
At 4200 Angstroms	55	370	Microamp./μwatt
Luminous**▲	0.09	0.6	Ampere/lumen
Current Amplification**▲▲	30000	200000	

* On plane perpendicular to indicated direction of incident light normal to axis of tube.

■ Referred to cathode.

** On basis of lighted cathode area approximately 0.2" X 0.8".

▲ For conditions where a Mazda projection lamp operated at a filament color temperature of 2870°K is used as a light source. A light flux of 10 microlumens and a 0.01-megohm load were used.

▲▲ Ratio of anode sensitivity to cathode sensitivity.

Multiplier Phototube Considerations

An *electron multiplier* is a vacuum tube which utilizes the phenomenon of secondary emission to amplify signals composed of electron streams. In the multiplier phototube, represented in Fig. 1, the electrons emitted from the illuminated cathode are directed by fixed electrostatic fields along curved paths to the first dynode (secondary emitter). The electrons impinging on the dynode surface produce many other electrons, the number depending on the energy of the impinging electrons. These secondary electrons are then directed to a second dynode and knock out more new electrons. This multiplying process is repeated in each successive stage, with an ever-increasing stream of electrons until those emitted from the last dynode (dynode No. 9) are collected by the anode and constitute the current utilized in the output circuit.

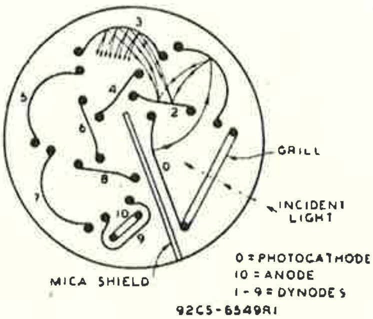


Fig. 1.—Schematic arrangement of type 1P22 structure.

Dynode No 9 is so shaped as to enclose partially the anode and to serve as a shield for it, in order to prevent the fluctuating potential of the anode from interfering with electron focusing in the inter-dynode region. Acually the anode consists of a grid which allows the electrons from dynode No. 8 to pass through it to dynode No. 9. Spacing between dynode No. 9 and anode creates a collecting field such that all the electrons it emits are collected by the anode. Hence, the output current is substantially independent of the instantaneous positive anode potential over a wide range. As a result of this characteristic, the 1P22 can be coupled to any practical load impedance.

The *mica shield* which extends between the photocathode and the anode shields the photocathode from the anode and prevents ion feedback If positive ions produced in the high current region near the anode were allowed to reach the photocathode or the initial dynode stages, they would cause the emission of spurious electrons which after multiplication would produce undesirable and often uncontrollable regeneration.

The *grill* through which the incident light reaches the photocathode, is connected to the photocathode and serves as an electrostatic shield for the open side of the electrode structure.

The *successive stages* of the 1P22 are operated at voltages increasing in equal steps from the photocathode to the 9th dynode, and are generally chosen as 75 to 100 volts per stage. The voltage between dynode No. 9 and the anode should be kept as low as will permit of operation at a point just giving anode-current saturation. This point on the anode characteristic curves corresponds to a voltage of about 50 volts. Low operating voltage between dynode No. 9 and anode reduces the dark current due to leakage paths and also reduces the ion bombardment of the dynodes. As a result, the operating stability of the 1P22 is greatly improved without sacrifice in sensitivity. It is to be noted that the supply voltage required to give an operating voltage of 50 volts between dynode No. 9 and anode will, of course, be contingent on the load impedance used and the desired signal output voltage.

Control of the *amplification* of the 1P22 can be obtained conveniently with slight sacrifice in sensitivity through defocusing the electron paths by making the voltage step of one dynode unequal to that of the others.

The *sensitivity* values for the 1P22 are *average* values. These values are representative of this type when operated with low values of anode current. At high values of anode current, a drop in sensitivity below the values shown may be expected. The extent of the drop is affected by the nature and severity of the operating conditions to which the 1P22 is subjected. After a period of idleness, the 1P22 usually recovers a substantial percentage of such loss in sensitivity.

Installation and Application

The *base* pins of the 1P22 require a special 11-pin socket designed for a pin-circle diameter of 0.75 inch. The socket may be mounted to hold the tube in any position but the incident light must fall on the same side of the tube as pins No. 1 and No. 11.

Magnetic shielding of the 1P22 may be necessary if it is operated in the presence of strong magnetic fields. Whenever frequency response is important, the leads from the 1P22 to the amplifier should be made short so as to minimize capacitance shunting of the phototube load. Because of the tremendous sensitivity of the tube, adequate light shielding is obviously essential.

The *maximum ambient temperature* rating of the tube should not be exceeded because too high a bulb temperature may cause the volatile cathode emitter surface to evaporate with consequent decrease in the life and sensitivity of the tube.

The use of a *refrigerant,* such as dry ice or liquid air, to cool the 1P22 is recommended in those applications where maximum gain with unusually low dark current is required.

The *dc supply voltages* for the electrodes can be obtained conveniently from a high-voltage rectifier. The voltage for each dynode and for the anode can be supplied by equally spaced taps on a voltage divider across the rectified power supply. The bleeder current will depend on the voltage regulation required by the application. In general, the current in the divider should be about ten times the maximum output of the multiplier phototube. Such a value will prevent variations of the dynode potentials by the signal currents. Because of the relatively large bleeder current required for good voltage regulation, the use of a rectifier of the full-wave type is recommended. Sufficient filtering will ordinarily be provided by a well-designed two-section filter of the condenser-input type. A choke-input filter may be desirable for certain applications to provide better regulation. Due to critical dependence of the gain of the 1P22 on voltage, rapid changes in the voltage resulting from insufficient filtering of the power supply will introduce hum modulation; and slow shifts in the line voltage due to poor regulation will cause a change in the level of the output.

The high voltages at which the 1P22 is operated are very dangerous. Great care should be taken in the design of apparatus to prevent the operator from coming in contact with these high voltages. Precautions should include the enclosure of high-potential terminals and the use of interlock switches to break the primary circuit of the high-voltage power supply when access to the apparatus is required.

In most applications, it is recommended that the positive high-voltage terminal be grounded rather than the negative terminal. With this method, which places the photocathode at a high negative potential with respect to ground, the dangerous voltages can more easily be made inaccessible.

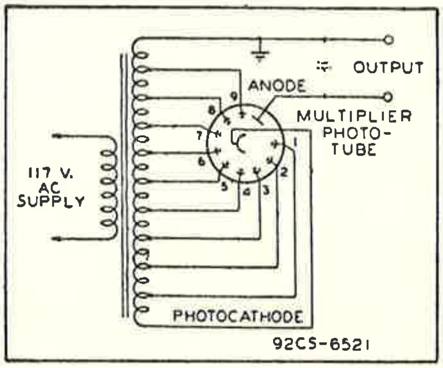


Fig. 2.—Ac power-supply circuit with uniformly tapped transformer for use with type 1P22.

In the use of the 1P22, as with other tubes requiring high voltages, it should always be remembered that these high voltages may appear at points in the circuit which are normally at low potential, due to defective circuit parts or to incorrect circuit connections. Therefore, before any part of the circuit is touched, the power-supply switch should be turned off and both terminals of any charged condensers grounded. Also, the use of a protective resistor having a minimum value of 10,000 ohms in the output circuit is recommended as a desirable procedure to prevent possible damage to component parts during adjustment.

A typical circuit for the 1P22 with a.c. power

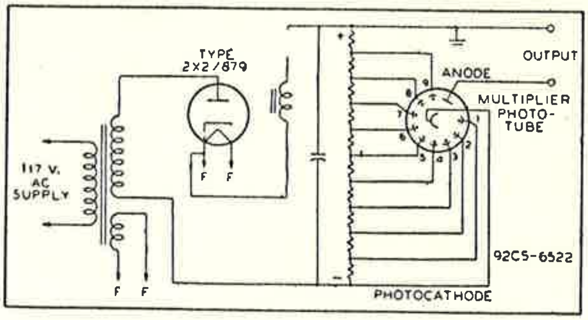
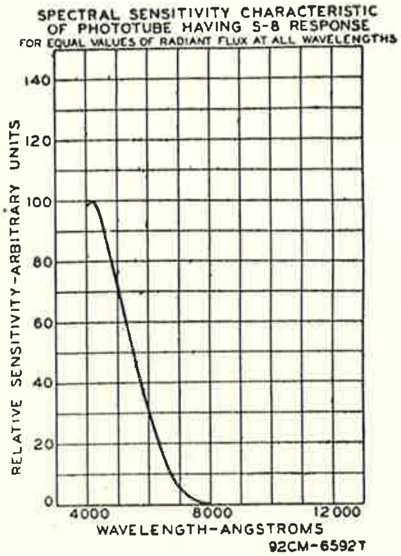
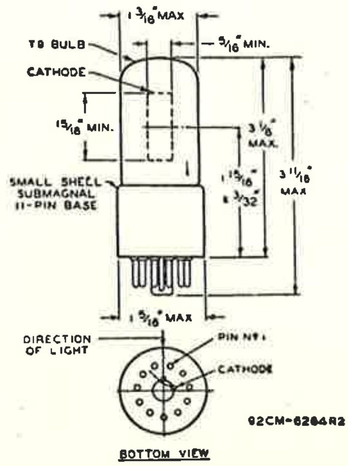


Fig. 3.—Simple half-wave rectifier power-supply circuit with bleeder for supplying dc voltages to type 1P22.

1P22

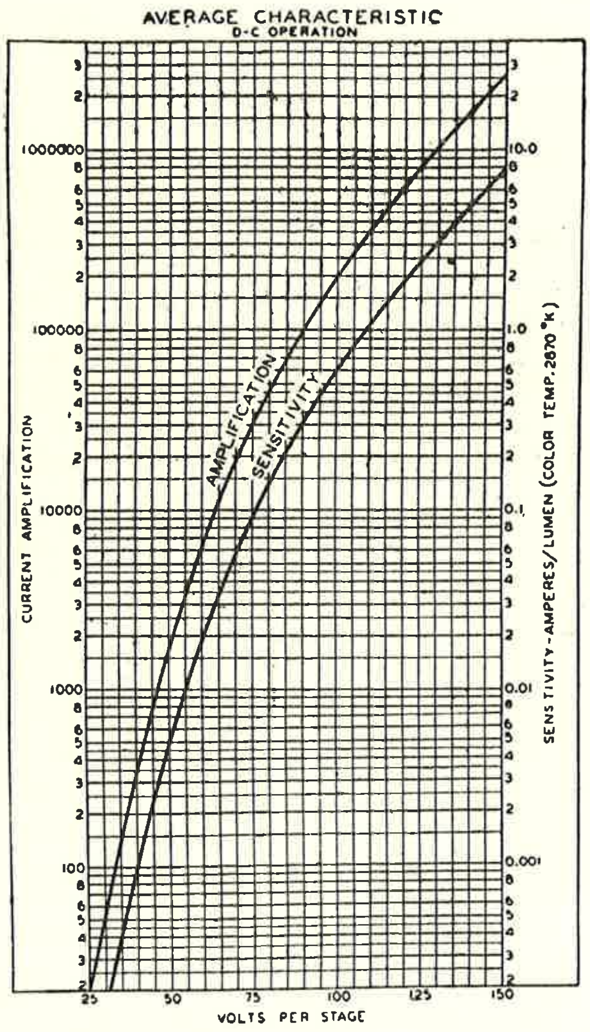


1P22



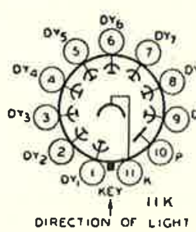
℄ OF BULB WILL NOT DEVIATE MORE THAN 2° IN ANY DIRECTION FROM THE PERPENDICULAR ERECTED AT CENTER OF BOTTOM OF BASE.

1P22



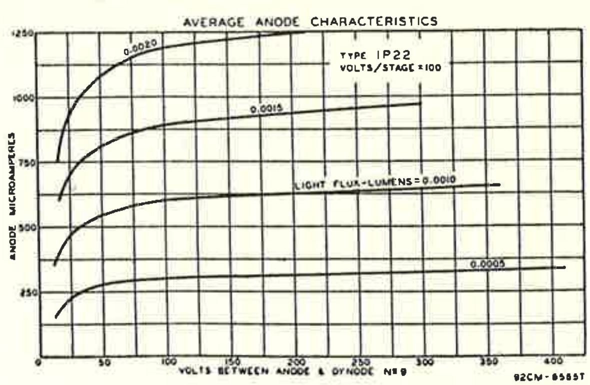
1P22

Bottom View of Socket Connections



DY_1 TO DY_9: DYNODE No. 1 TO DYNODE No. 9
P: ANODE
K: CATHODE

1P22



supply is shown in Fig. 2. Since the 1P22 has approximately equal sensitivity for a.c. and d.c. voltages having the same r.m.s. value, this circuit is particularly suitable for relay operation.

For sensitive measurements and in applications where high signal-to-noise ratio is important, the circuits in Fig. 3 and Fig. 4 are useful. The circuit

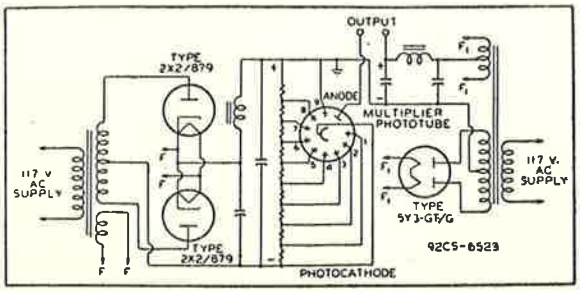


Fig. 4.—Full-wave power-supply circuit with bleeder for supplying dc voltages to dynodes No. 1 to No. 9 and separate dc voltage supply for the anode stage.

in Fig. 3 utilizes a half-wave rectifier to provide the d.c. power for the 1P22. A choke-input filter is employed to improve regulation. In applications where excellent regulation, particularly for wide variation in output current of the 1P22, is required and where minimum hum modulation is essential, the circuit in Fig. 4 may be used. In this circuit, the d.c. power supply is arranged so that the dynode voltages are furnished by the 2X2/879 rectifiers while the anode-stage voltage is supplied by the 5Y3-GT/G rectifier.

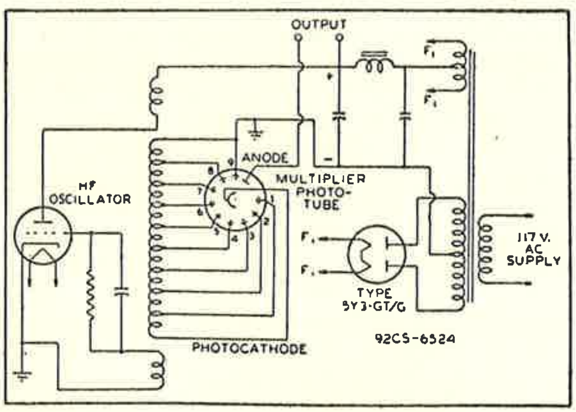


Fig. 5.—Circuit utilizing hf oscillator for supplying ac voltages to dynodes No. 1 to No. 9 and separate dc voltage supply for the anode stage.

In certain audio-frequency applications, such as sound-track reproduction, the circuit in Fig. 5 is of special interest. In this circuit, the dynodes are supplied with a.c. voltage from an oscillator at a frequency considerably higher than the uppermost signal frequency. The anode voltage is most economically obtained from a separate low-voltage d.c. source. Under these conditions, the output of the 1P22 consists of a series of rectified pulses occurring during the positive halves of the cycles. Each voltage pulse produces tremendous gain as its instantaneous values near its peak value. Because of this tremendous increase in gain, the a.c. sensitivity is nearly equal to the d.c. sensitivity for the same r.m.s. values.

References

E. A. Boettner and G. P. Brewington, "The Application of Multiplier Photo-Tubes to Quantitative Spectrochemical Analysis," Journal of the Optical Society of America, Vol. 34, pp. 6-11, January, 1944.

G. H. Dieke and H. M. Crosswhite, "Direct Intensity Measurement of Spectrum Lines with Photo-Multiplier Tubes," Journal of the Optical Society of America, Vol. 35, pp. 471-480, July, 1945.

A. M. Glover, "A Review of the Development of Sensitive Phototubes," Proc. I.R.E., Vol. 29, pp. 413-423, August, 1941.

M. F. Hasler and H. W. Dietert, "Direct Reading Instrument for Spectrochemical Analysis," Journal of the Optical Society of America, Vol. 34, pp. 751-758, December, 1944.

R. B. Janes and A. M. Glover, "Recent Developments in Phototubes," RCA Review, Vol. 6, No. 1, pp. 43-54, July, 1941.

J. A. Rajchman and R. L. Snyder, "An Electrically Focused Multiplier Phototube," Electronics, Vol. 13, pp. 20-23, December, 1940.

D. H. Rank, R. J. Pfister, and P. D. Coleman, "Photoelectric Detection and Intensity Measurement in Raman Spectra," Journal of the Optical Society of America, Vol. 32, pp. 390-396, July, 1942.

D. H. Rank, R. J. Pfister, and H. H. Grimm, "A Method for Determining Depolarization Factors in Raman Spectra," Journal of the Optical Society of America, Vol. 33, pp. 31-35, January, 1943.

O. H. Schade, "Radio-Frequency Operated High-Voltage Supplies for Cathode-Ray Tubes," Proc. I.R.E., Vol. 31, pp. 158-163, April, 1943.

V. K. Zworykin and J. A. Rajchman, "The Electrostatic Electron Multiplier," Proc. I.R.E., Vol. 27, pp. 558-566, September, 1939.

(Continued from page 41)

Maximum Ratings, Absolute Values:

Anode-Supply Voltage (DC or Peak AC)†	1250	max.	volts
Supply Voltage between Dynode No. 9 & Anode	250	max.	volts
Anode Current	1.0	max.	mA.
Anode Dissipation	0.25	max.	watt
Ambient Temperature	75	max.	°C

Characteristics:

Voltage between Anode & Dynode No. 9	50	50	volts
Voltage per Stage	75	100	volts
Max. Anode Dark Current	—	0.25	μamp.
Sensitivity:			
At 3750 Angstroms ..	1350	9000	μamp./μwatt
Luminous**▲	1.5	10	amp./lumen
Current Amplification**▲▲	150000	1000000	

* On plane perpendicular to indicated direction of incident light.

† Referred to cathode.

** On basis of lighted cathode area approximately 0.2" x 0.8".

▲ For conditions where a Mazda projection lamp operated at a filament color temperature of 2870°K is used as a light source. A light flux of 10 microlumens and a 0.01-megohm load were used.

▲▲ Ratio of anode sensitivity to cathode sensitivity.

TYPES DISCONTINUED BY R.C.A.

Type 5FP7 has been superseded by type 5FP7-A as indicated under New R.C.A. Releases.

Type 48 has been inactive for several years and is no longer available, and is now considered obsolete.

Type 832 has been superseded by type 832-A and, although both types have been available concurrently during the war, type 832 has now been discontinued in favour of the improved type 832-A.

Type 958 has been superseded by type 958-A. For some time past, both types have been available, but type 958-A has been selling at a higher price than type 958.

Improved manufacturing techniques have resulted in cost reduction so that the price of type 958-A has recently been reduced to that of the 958.

Type 8012 has been replaced by type 8012-A. See remarks under New R.C.A. Releases.

Type 8025 has been replaced by type 8025-A. See remarks under New R.C.A. Releases.

Type 1899 has been replaced by type 2F21. See remarks under New R.C.A. Releases.

NEW R.C.A. RELEASES

Radiotron type 5FP7-A is an improved type of cathode ray tube which supersedes and replaces type 5FP7. Type 5FP7-A utilises a limiting-aperture construction to give greater effective resolution and also has increased voltage ratings to permit greater brilliance to be obtained. The new valve type shows improved spot shape and focus under the scanning experienced in equipment.

Radiotron type 8012-A is a u-h-f transmitting triode superseding and replacing the earlier type 8012, both types having a maximum plate dissipation of 40 watts and being capable of operation on maximum ratings up to 500 Mc/s. Type 8012-A differs from the earlier type 8012 in that it is made without visible getter deposit on the bulb. Type 8012-A can be operated at higher plate voltages than its predecessor on a frequency of 600 Mc/s., the percentage of maximum permissible plate voltage being 80% for class B, class C grid modulated, or class C suppressor modulated operation and 70% for class C telegraphy and class C plate modulated operaton.

Radiotron type 8025-A is a u-h-f transmitting triode superseding and replacing type 8025. The same remarks apply as for type 8012-A. Types 8012-A and 8025-A are electrically identical and differ in that the former has its twin plate leads and twin grid leads brought out through the sides of the bulb, and filament leads brought out at the bottom of the valve, while type 8025-A is fitted with two plate caps and two grids caps situated on the sides of the bulb and a small 4-pin base through which the filament is connected.

Radiotron type 1P37 is a gas phototube of the blue-sensitive type designed particularly for use in sound reproduction from a dye-image sound-track. It is also useful in measurement and colour-control applications. It has negligible sensitivity to infra-red radiation. When used on the dye-image sound-track, masking of the dye-image modulation by infra-red transmitted through the film is avoided and the modulation is reproduced essentially to its full degree. The luminous sensitivity, anode characteristics and structure of type 1P37 are comparable with the same properties of types 868 and 918 so that the new type may be used without circuit modification in motion picture equipment designed for either of the older two types.

Radiotron type 1P39 is a blue-sensitive phototube having negligible response to red radiation, and electrical and mechanical dimensions similar to those of type 929. It employs a non-hygroscopic base which ensures a value of resistance between anode and cathode pins about 10 times higher than conventional bases under adverse operating conditions of high humidity.

Radiotron type 1P40 is a gas phototube having high response to red and near infra-red radiation. Its electrical characteristics and mechanical dimensions are similar to those of type 930. It also is fitted with the same non-hygroscopic base as for type 1P39.

Radiotron type 1U4 is a 1.4 volt miniature sharp cut-off r-f pentode having a filament current of .05 ampere. The screen may be operated at the same voltage as the plate, thus avoiding the need for a screen dropping resistor. With 90 volts on both plate and screen its draws a plate current of 1.6 mA., a screen current of 0.45 mA., and has a transconductance of 900 μmhos.. with a plate resistance of 1.5 megohm.

Radiotron type 2F21 is a monoscope of the 5″ magnetic deflection type superseding the earlier type 1899. It is approximately 1½″ shorter than type 1899 and has slightly modified characteristics.

Radiotron type 575-A is a half-wave mercury-vapour rectifier with ratings intermediate between those of types 872A/872 and 869-B. The filament is rated at 5 volts 10 amps., and for a condensed mercury temperature range of 25°C. to 55°C., the maximum peak inverse anode voltage is 10,000 volts, the average anode current 1.75 amps. and the peak anode current 7 amps. It may be used with a peak inverse anode voltage of 15,000 volts provided that the condensed mercury temperature is within the range of 25°C. to 50°C., and that the plate current does not exceed 1.5 amps., and the peak plate current 6 amps. It is fitted with the jumbo 4-pin bayonet base. Type 575-A has a rolled edge anode so shaped as to reduce arc-back and confine the glow discharge with minimum bulb bombardment and bulb deposit, the anode being coated with zirconium to increase its radiation. It uses a coated filament of a special alloy material to ensure a large reserve of emission.

Radiotron type 673 is a mercury-vapour rectifier similar in all respects to type 575-A except that it is fitted with the super-jumbo 4-pin bayonet base.