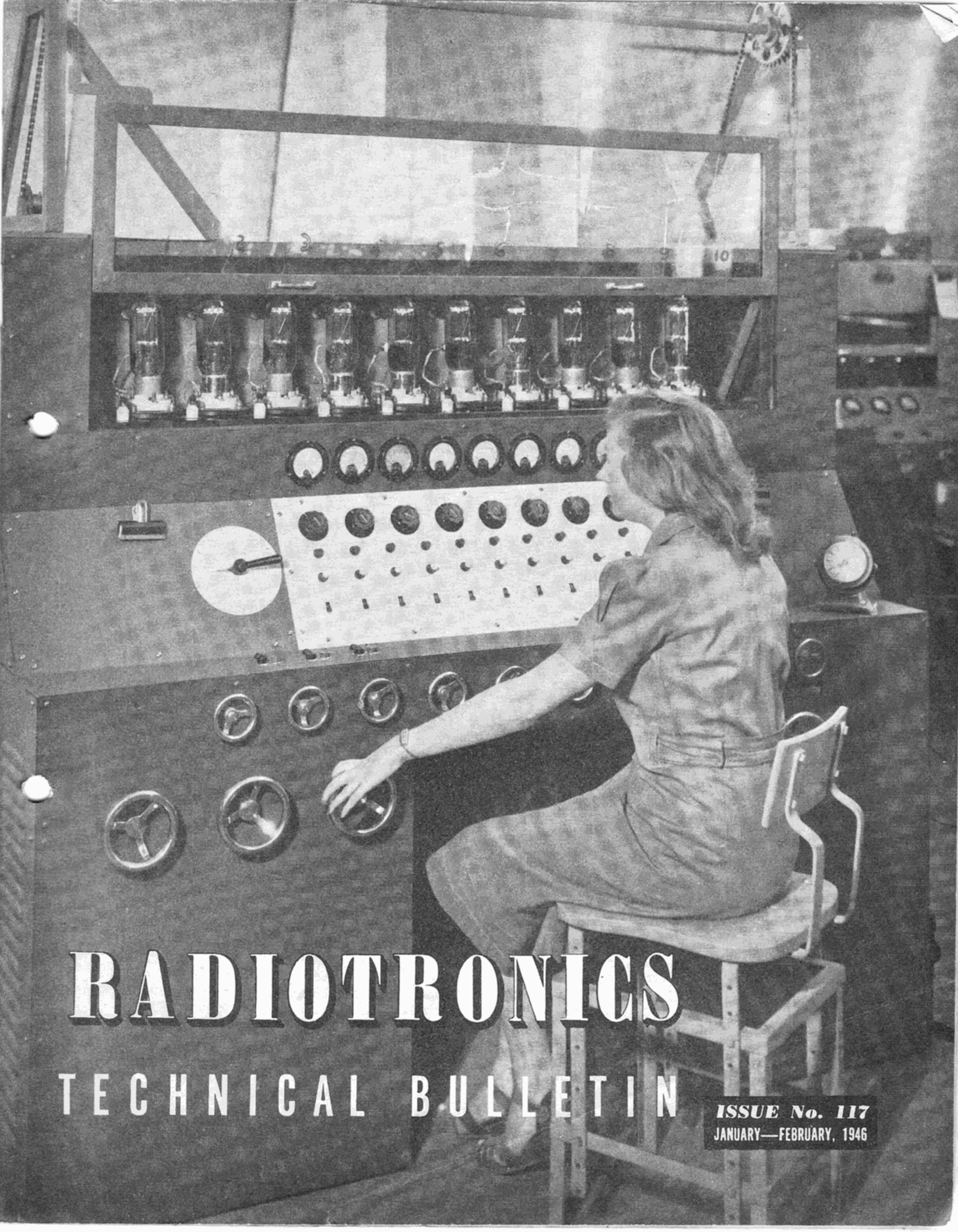

RADIOTRONICS

TECHNICAL BULLETIN

ISSUE No. 117
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RADIOTRONICS

Number 117 ★ TECHNICAL BULLETIN ★ Jan./Feb., 1946.

The last issue of Radiotronics was in September/October, 1941, but we are happy once more to greet our readers and hope that from now on the issues of Radiotronics will continue regularly and will prove even more interesting.

During the past few months, pending the re-introduction of Radiotronics in its proper form, four issues of a small four-page "Radiotronics Digest" have been made. Some technical data were given in addition to matters of general sales interest, but these were only intended to bridge the gap until circumstances permitted the resumption of publication of Radiotronics.

Opportunity has been taken to rearrange the material in Radiotronics so as to assist the reader in finding the items which interest him most. In the normal issue there will be a **Design Section,** which will deal with the detailed design of receivers and amplifiers, giving reasons for the choice of circuit constants, and curves showing the detailed performance.

This will be followed by a **Circuit Section** in which (except for this issue) will appear the circuit diagram and such explanatory notes as are needed by the ordinary person who may not be interested in the full technical details of design. These will be arranged with one circuit on each page so that they may be reprinted in leaflet form to meet subsequent inquiries.

The third section deals with **General Theory,** and as far as possible the material will be arranged to include both elementary and advanced articles, including items of general interest.

The final section will deal with **Valve Data** and will give information on new valve types and particular points in connection with existing types of valves which may not otherwise be available.

In each issue of Radiotronics it is planned to insert a loose supplement in the form of Radiotron Service Digest which will include such matters as the availability, prices and announcements of valve types, sales aids and advertising, followed by a section for Servicemen covering valve testing, faults and their identification, and the replacement of types in short supply by the nearest Australian equivalents.

Information in Radiotronics may be republished without restriction provided that due acknowledgment is given to Radiotronics.

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DESIGN SECTION

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RADIOTRON RECEIVER RC52.

6 VALVE DUAL WAVE RECEIVER USING NEW SINGLE-ENDED A.C. VALVES

As a guide to receiver designers, work has been carried out on the development of a six valve receiver of fairly conventional design, using the new single-ended A.C. valves. These give the opportunity of introducing certain modifications as compared with earlier Radiotron circuits using the G valve types, notable among these being the higher gain obtainable from the r-f and i-f stages together with the possibility of omitting shield-cans from the valves.

All these single-ended GT valves intended for operation at radio- or intermediate-frequencies are fitted with metal sleeve wafer-type bases in which the metal sleeve is directly connected to pin No. 1 for earthing purposes. **Although this earthing is not shown on the circuit diagram, it should be taken for granted in all cases that pin No. 1 is earthed.** Our experience indicates that shielding is unnecessary owing to the fairly extensive internal shielding combined with the metal sleeve, and that even the i-f amplifier is stable with a reasonable layout. However, in order to make certain that no instability will occur in the i-f amplifier, it was decided to adopt neutralisation as a general principle in all future receivers. This addition means that there is a satisfactory margin of safety with varying components, valves and layouts. The small cost involved is probably less than that of the cost of a shield-can, and the addition appears to be highly desirable.

The first design undertaken was that of a six valve set with an r-f stage and single i-f stage, using type 6SK7-GT r-f amplifier, 6SA7-GT converter, 6SF7-GT i-f amplifier followed by its own diode detector and a.v.c., with type 6SJ7-GT audio voltage amplifier and 6V6-GT power amplifier, with negative feed-back of an improved type as described below.

Type 5Y3-GT was selected as the rectifier since this type has been adopted as standard in place of the larger type 5Y3-G which will shortly be unobtainable, its manufacture having already been discontinued in U.S.A.

An alternative valve type arrangement would be the use of type 6SK7-GT as an i-f amplifier followed by type 6SF7-GT as diode detector and pentode audio frequency voltage amplifier. This would present difficulties in the application of the type of negative feedback circuit adopted in the present design, while the curved characteristics would be less desirable in the so-called "series feedback" circuit, owing to the heavy plate load shunting and higher distortion which would result therefrom in the first a-f stage. A third alternative would be the substitution of type 6SQ7-GT as the diode detector and triode voltage amplifier but this would not permit of any appreciable degree of negative feed-back without reducing the gain to a low figure and, although satisfactory for a cheaper type of receiver, would be less satisfactory for a high quality set.

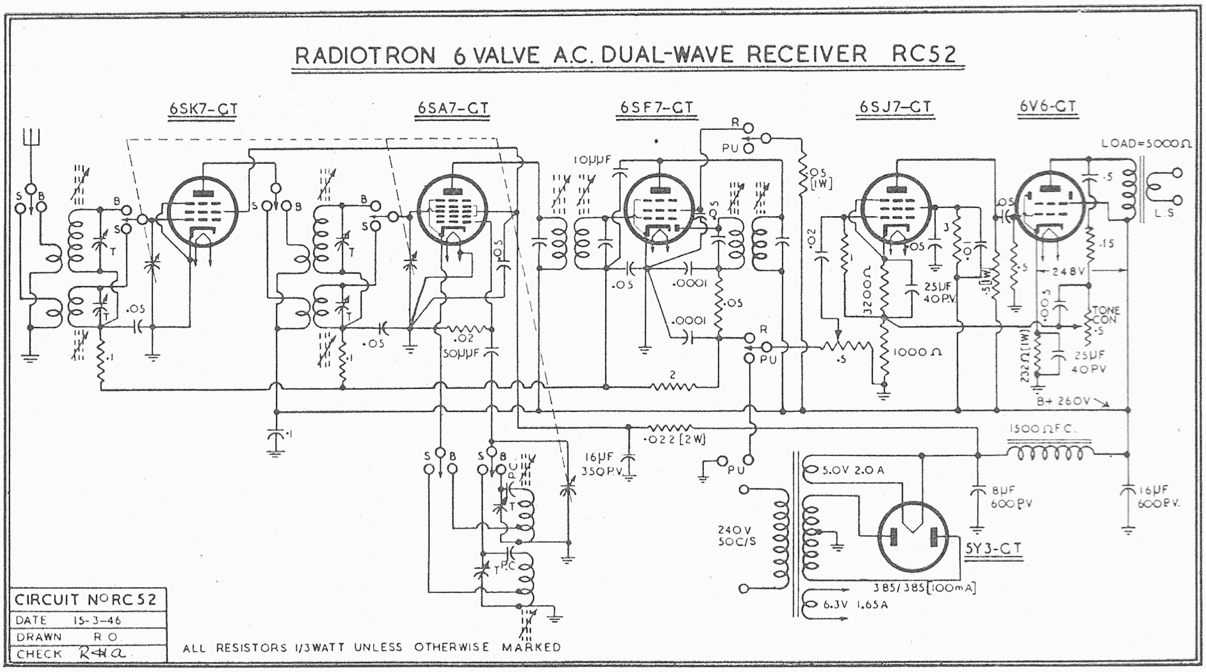
The gain with type 6SF7-GT as an i-f amplifier is almost identical to that obtainable with type 6SK7-GT, so that the choice may be made between the two types merely on the question of convenience and circuit arrangement. In either case the overall gain of the whole receiver is so high that steps may be taken to reduce the gain and thereby avoid the high noise level which would otherwise appear when tuning between stations. The neutralisation adopted in this particular receiver has an effect in reducing the gain, although some receiver designers might prefer to reduce it still further by other means. Some of the major problems associated with the design of a large receiver are functions of the high gain—for example, the avoidance of overloading on strong signals, the reduction of regeneration and the limitation of noise between stations. The stage in which the gain may most usefully be reduced is the i-f amplifier, since any serious reduction in gain in the r-f amplifier will result in a decrease of the signal-to-noise ratio. The gain of the i-f amplifier may most conveniently be controlled by the type of i-f transformer adopted. Very high gain i-f transformers, which would necessarily have high selectivity, are inclined to be troublesome on account of the selectivity being sufficient to cut the higher audio frequencies, as well as making the tuning and the i-f alignment extremely critical. A communications type of receiver requires very high selectivity, but the ordinary broadcast receiver usually has an intermediate degree of selectivity so as to give a reasonable compromise between good tone and separation of stations. Owing to the higher gain given by type 6SK7-GT as compared with earlier types of i-f amplifiers, it would be quite possible to use cheaper types of i-f transformers and still obtain the same overall gain as previously.

A receiver with a radio-frequency stage is more inclined to overload on very strong signals than one without an r-f stage, at any rate unless special precautions are taken to reduce the overloading on a strong signal, which may be of the order of two volts on the aerial terminal in some cases. In order to reduce these effects to a minimum, the first two stages were arranged to operate with nearly constant screen voltage (through a common screen dropping resistor for types 6SK7-GT and 6SA7-GT) and the i-f amplifier was given an extended grid base through the use of a 260 volt supply to the screen dropping resistor. Since the screen currents of the first two stages vary in opposite directions as the grids are made negative, the screen voltage remains fairly constant; on the other hand the i-f amplifier is provided with a much more extended grid base, thereby reducing the modulation rise in this stage, which is operating at the highest input level of all three stages and is therefore the most likely to overload.

A limitation of type 6SF7-GT is that it has only one diode and it is therefore necessary, unless special arrangements are made, to use simple a.v.c. In the interests of simplicity of design it was decided to adopt the common American practice of earthing the cathodes of the three valves controlled by a.v.c. This not only avoids the use of cathode bias resistors and by-pass condensers but also simplifies the detector arrangement and makes the wiring easier.

CONVERTER STAGE

Type 6SA7-GT is a converter which has proved very popular in U.S.A., and it undoubtedly has good features. Its use, normally, involves the use of tapped coils and the return of the cathode to the tapping point instead of using two separate windings for the oscillator coil. Although the tapping point is not actually critical, there is an optimum for any given conditions. It is generally better to err on the side of under-excitation than to have over-coupling, since the latter condition tends to result in the flow of positive grid current in the signal grid circuit and so to damping and loss of gain. This would not be so important if the converter stage itself were not controlled by a.v.c., but this latter is necessary to avoid overloading the i-f amplifier. As a general rule, with type 6SA7-GT the cathode tapping should be taken to a point approximately 9% from the earthed end of the coil, on the broadcast band.


RADIOTRON 6 VALVE A.C. DUAL-WAVE RECEIVER RC52

Radiotron type 6SA7-GT valve gives a considerably better performance when used as a mixer than as a combined converter, but this application is obviously ruled out for five or six valve receivers, although it is well worth consideration in larger receivers, including those of the communications type, and especially when operating at higher frequencies than those of the usual short-wave channels.

SHORT-WAVE DESIGN

It is desirable to have the full gain of the receiver available for short-wave operation and this is one of the reasons why the i-f gain was maintained at a fairly high figure. Over-loading is most unlikely in short-wave reception, so that the special difficulties associated with a high-gain amplifier are absent. The higher gain given by type 6SK7-GT as an r-f amplifier is particularly beneficial on the short-wave band, while type 6SA7-GT as a converter operates with a negative input resistance and therefore improves both the r-f selectivity and gain.

COILS

The aerial and r-f coils used for the broadcast band are Aegis "Permaclad" having a slug for inductance adjustments, and high impedance primaries. The Q (at 1,000 Kc/s) of the aerial coil is 97 and that of the r-f coil 93. The resonant frequency of the primary of the r-f transformer was measured by us as 320 Kc/s. Any other good design of coil could have been adopted, and we propose to use other makes and types of coils in other receivers so as to make our designs closely applicable to existing components.

All the short-wave coils, as well as the oscillator for the broadcast band, were specially designed for this receiver. Type 6SA7-GT converter requires a tapped oscillator coil which is not yet standard in Australia, and our design attempts to achieve a satisfactory compromise between the different factors affecting the operation of the converter valve. We have not yet had the opportunity to test large numbers of type 6SA7-GT valves with this proposed coil design but submit the design as a tentative standard, subject to possible slight modification at some future date.

It is important to have a very high insulation resistance between the primary and secondary of the r-f transformer, since a resistance of even 500 megohms has a serious effect on the a.v.c. voltage at low signal levels. We therefore specify a double thread for the grooving of the former so that the primary may be wound exactly midway between the secondary turns. The whole coil should be satisfactorily impregnated so as to withstand any heat and humidity conditions likely to be experienced. These remarks apply, of course, irrespective of the type of converter valve.

FREQUENCY COVERAGE OF COILS

The broadcast band coverage extends from 540 to 1,600 Kc/s in accordance with the recommendation given elsewhere in this issue, and the short-wave band from 6 to 18.2 Mc/s for a similar reason.

COIL SPECIFICATIONS.

Broadcast Band

Aerial & R.F. Coils Aegis "Permaclad"

Oscillator

Former	¾in. diameter.
Winding	75 turns 38 SWG. S.S.E. tapped 6.9 turns from bottom. Winding length ½in . Tuning slug 7/16in. diameter x ½in. long.
Shield Can	1 5/16in. inside diameter x 2⅛in. long aluminium.
Padder	535μμF.
Tracking Points	600, 900, 1,400 Kc/s.

Shortwave Band

All formers ¾in. diameter, grooved double 16 T.P.I. (except oscillator), coils unshielded. All S.W. coils tuned with slugs ⅜in. diameter x ¼in. long.

Aerial Coil

Primary	1.8 turns 34 B. & S. interwound from bottom end of secondary.
Secondary	8 turns 24 S.W.G. enam. wound in groove 16 T.P.I.

R.F. Coil

Primary	5.8 turns 34 B & S. interwound from bottom end of secondary.
Secondary	As aerial coil.

Oscillator

Total Coil	7.5 turns 24 SWG enam. tapped 1.2 turns from bottom.

Padder	.005 μF.
Tracking Points	6.5, 11.0. 17.0 Mc/s.
Gang Condenser	A.W.A.

Frequency Coverage

Broadcast Band	540-1600 Kc/s.
S.W. Band	6-18.2 Mc/s.

I.F. TRANSFORMERS.

The i-f transformers used in this receiver were Aegis, which use fixed capacitors with iron-core tuning. The selectivity is shown in detail in the tabulated data and it will be seen that it is extremely selective—in our opinion too much so for a normal radio broadcast receiver. We would prefer to use i-f transformers giving a reasonably broad top so as to reduce side band attenuation and permit a reasonable degree of frequency drift in the oscillator without losing sensitivity. This applies particularly to the short-wave band where a certain amount of oscillator frequency drift is inevitable, not only during the warming up period, but also with changes in line voltage and signal strength. A further reason for a fairly broad top on the selectivity characteristic is the misalignment which so frequently occurs during the life of a receiver and which is more noticeable with sharply peaked i-f transformers.

Our preference is therefore for the widest possible top on the selectivity characteristic subject to having sufficient selectivity to provide reasonable separation of stations on the broadcast band. This is a question which every receiver designer has to decide for himself, but our impression is that there has been a tendency towards slightly broader selectivity, particularly in dual-wave receivers.

OVERALL SELECTIVITY

I.F. Transformers:—Aegis.
Frequency:—455 Kc/s.
Dynamic resistance i-f transformer:—
0.23 megohm *
Q = 125 (each winding) **
Tuning capacitances—100 μμF. **

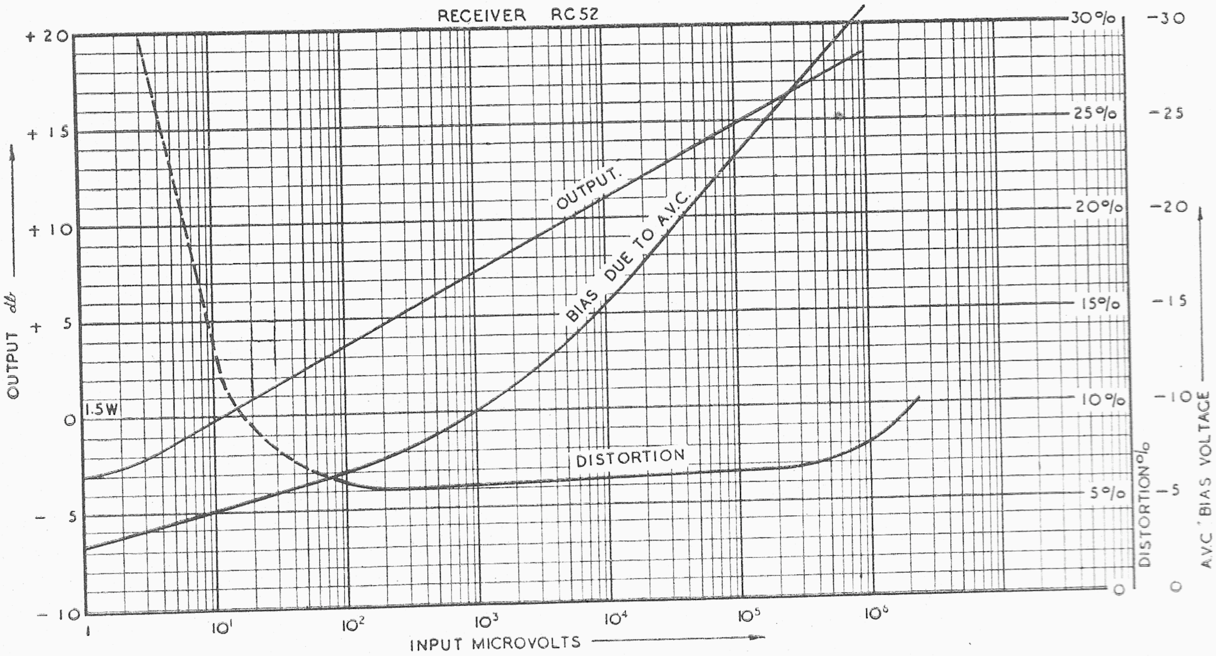
Selectivity characteristic:—

Times down.	**Total bandwidth (Kc/s).**
3	3.3
10	6.7
30	9.85
100	14.1
300	17.4
1000	22.3
3000	26.8
10000	33.2
30000	39.6
100000	49.4

* as measured by us.
** as stated by manufacturer.

NEUTRALISATION.

The i-f neutralisation circuit adopted in this receiver is one previously described in Radiotronics, but we are not entirely satisfied with the results obtained and propose to investigate the matter and publish an article on this subject in Radiotronics. As a general principle, neutralisation should not be relied upon to overcome faulty layout or wiring. It is also highly desirable to orient the 6SF7-GT valve so that the grid (pin 2) is directly opposite the first i-f transformer and the plate (pin 6) opposite the



second i-f transformer. The screen by-pass condenser may be connected across the valve socket (from pin 4 to pin 1) in order to form a screen between grid and plate. The a.v.c. decoupling resistor should be located as close to the diode pin as possible, while the .05 μF bypass condenser in the a.v.c. circuit should be as close as possible to the bottom end of the i-f transformer, and the lead from the condenser to cathode should be short. The best layout is to have the two i-f transformers exactly on opposite sides of the valve, and in our particular lay-out they were placed ½in. away from the valve envelope.

The capacitance of the neutralising condenser adopted for this receiver was 10 μμF, based on the symmetry of the selectivity curve.

SENSITIVITY AND NOISE.

As a result of the high gain of the 6SK7-GT valves and the i-f transformers, the overall sensitivity is high, in fact too high on the broadcast band where the noise level prevents the full gain of the receiver from being utilised. On the broadcast band the sensitivity varies from 0.19 to 0.57 microvolt but for equal noise and signal outputs the useful sensitivity is slightly over 1 microvolt. With an input of 5 microvolts the noise-to-signal voltage ratio is 22.7% at 600 Kc/s.

On the short-wave band for the test frequencies 6.5 to 17 Mc/s, the sensitivity is from 4.6 to 1.4 microvolts with a satisfactory low noise level, so that the full sensitivity may be used.

The excessive sensitivity on the broadcast band, although it causes noise when tuning between stations with no signal input, does not affect the noise level when tuned to a carrier under normal conditions of listening. Under these conditions the noise level is quite low, as would be expected from the high gain r-f stage ahead of the converter. In any case, the full sensitivity of the receiver is rarely reached, owing to the close spacing of the stations on the broadcast band and the operation of the a.v.c., which commences to operate considerably off resonance with any powerful station.

A.V.C. CHARACTERISTIC.

In spite of the lack of a delay voltage in the a.v.c. system, the characteristic is reasonably satisfactory, owing primarily to the use of an r-f stage and the high gain from the grid of the r-f stage to the diode. With zero signal the a.v.c. voltage is approximately -0.75 volt, but on the very small signal of 0.5 microvolt it reaches -2.7 volts, rising to -3.25 volts at 1 microvolt and 31 volts with an input of 1 volt to the aerial terminal. This is considerably less than the cut-off voltage of the 6SF7-GT i-f amplifier, so that the overload point is far from being reached. A marked improvement in the a.v.c. characteristic and reduction in overload distortion was brought about through the use of a nearly fixed voltage on the screens of the first two stages and the "sliding voltage" on the screen of the i-f amplifier brought about by the screen dropping resistor.

The output of the receiver changes by 6.3 db between 10 microvolts and 1 millivolt, by 4.5 db from 1 to 10 millivolts, by 3.3db from 10 to 100 millivolts and by a further 4.2db from 100 millivolts to 1 volt.

The "distortion" has a minimum of 6.1% at 300 microvolts input, but this figure is the reading of the combined total distortion of the signal generator and receiver. At lower input voltages the increase in the readings is due almost entirely to noise, while at higher input voltages the distortion commences to rise appreciably in the region of 1 volt input; however even with 1.4 volts at the aerial terminal the distortion is only 11.2% for both units combined. This is a considerably better figure than has been obtained in other receivers which we have tested, and it is an important feature since strong local stations give voltages of this order with a fairly large aerial.

TRACKING.

The tracking points on the broadcast band were 600, 900, and 1,400 Kc/s, and the loss caused through incorrect tracking was as under:—

550 Kc/s	-2.5 db
800	-1.5
1200	-2.8
1500	-1.5
1600	-7.0

FLUTTER.

It was found necessary, in order to avoid flutter on strong shortwave stations, to decouple the screen supply for the converter and r-f amplifier. The source of voltage was the filament of the rectifier valve, the dropping resistor and bypass condenser providing sufficient decoupling for the purpose.

FREQUENCY SHIFT.

All converter valves suffer from oscillator frequency shift with the voltage applied to the signal grid, although there are considerable variations between one type and another. The use of a separate oscillator reduces the frequency shift to negligible proportions, while type 6J8-G, as a typical triode heptode, is almost equally good in this respect. Type 6K8-G, which has two indepedent electron streams, is also quite good.

All pentagrid converters, such as type 6A8-G, have a large degree of frequency shift, which requires special attention in receiver design in order to give good performance on short-waves. Type 6SA7-GT is basically a pentagrid, although it has no anode-grid and incorporates some novel features which reduce the degree of frequency shift.

Tests carried out on this receiver showed a frequency shift versus signal input voltage characteristic, at a frequency of 18 Mc/s, as under:—

Input.	**Developed a.v.c. Bias**	**Frequency Shift.**
1μV	-3.25V	0 Kc/s
10	-5.2	2.6
100	-6.9	5.3
1mV	-9.8	7.9
10	-15.3	10.8
100	-22.5	12.2

This frequency shift for shortwave operation is too large to be accepted as good design; on the other hand, the shift on the broadcast band is negligible. The fault is evident during serious fading of a strong shortwave station, and results in detuning which makes the fading appear worse than it actually is. The shift is larger than it would be in a receiver without an r-f stage, owing to the higher amplification and consequent higher a.v.c. voltage. The bad effects of the frequency shift may be made less evident through the use of broad, or flat-topped, i-f transformers, although there are limits beyond which this method cannot go.

In this receiver design there appear to be several alternatives:—

1. To limit the receiver to the broadcast band only, on which its performance is excellent.
2. To leave the frequency shift on shortwaves as it is—this is not recommended.

SENSITIVITY AND NOISE LEVEL FOR 50 mW. ABSOLUTE OUTPUT.

(All measurements were made with correct tracking)

Position	Frequency	Input	Ratio	E.N.S.I. (μV)	Image Ratio
6SJ7-GT control grid	400 c/s	0.142 V			
6SF7-GT diode	455 Kc/s	680 mV*			
6SF7-GT control grid	455 Kc/s	3.8 mV			
6SA7-GT signal grid	455 Kc/s	51 μV	74.5		
	600 „	61 „	62.5	2.0	
	1000 „	54 „	70.5	2.0	
	1500 „	51 „	74.5	2.0	
	6.5 Mc/s	65 „	59.0	3.6	
	11.0 „	62 „	61.0	3.0	
	17.0 „	51 „	74.5	2.4	
6SK7-GT control grid	600 K/s	1.2 „	51	0.43	
	1000 „	1.5 „	36	0.43	
	1500 „	2.0 „	25.5	0.49	
	6.5 Mc/s	8.0 „	8.1	0.85	
	11.0 „	4.2 „	14.8	0.7	
	17.0 „	3.42 „	14.9	0.49	
aerial	600 Kc/s	0.19 „	6.5	0.34	
	1000 „	0.38 „	4.05	0.34	
	1500 „	0.57 „	3.5	0.37	
	6.5 Mc/s	4.6 „	1.74	0.5	435
	11.0 „	1.9 „	2.2	0.34	142
	17.0 „	1.4 „	2.44	0.23	41.5

* Signal Generator inserted in series with the .0001μF filter condenser with the secondary of the

3. To change over to a triode-heptode converter. Type 6J8-G is a very satisfactory type for short-wave operation, while an improved triode-heptode valve is now in the early stages of development in our factory.
4. To use type 6SA7-GT as a mixer with a separate oscillator (6SJ7-GT). This is an arrangement which we hope to describe in detail in a future issue
5. To reduce the amount of the frequency shift by a circuit re-arrangement which will balance a shift in a positive direction by a nearly-equal shift in a negative direction. Several methods for achieving this result are now being investigated and will be described in the next issue.

Oscillator

f	600	1000	1500	Kc/s
ek	1.6	1.36	1.34	VRMS
eo	19.0	16.4	14.0	VRMS
Ic1	0.42	0.53	0.525	mA.

f	6	11	18.2	Mc/s
ek	1.4	2.65	4.1	VRMS
Ic1	0.27	0.49	0.56	mA.

Current Consumption

Total "B" Current zero signal — 77 mA.
„ „ 100mV „ — 70 mA.

RADIOTRON CIRCUIT RC52

AUDIO FREQUENCY AMPLIFIER

Although many radio receiver designers seem to regard the audio frequency amplifier as being completely standardised and incapable of any appreciable improvement, in reality the position is far different. After a careful review of the whole position we have come to the conclusion that improvements are required in the way of an improved tone control, very largely increased input resistance, and lower hum. We have assumed that some satisfactory form of negative feedback is used to reduce distortion, and to provide a levelling effect on the frequency response of the loudspeaker.

Tone Control:

In circuits not using negative feedback, the usual type of tone control is the resistance-capacitance network from the plate of the power valve to earth. This is not satisfactory when using negative feedback, as the action of the feedback is to resist changes in gain due to such causes, and therefore a very high capacitance has to be used in order to get any noticeable change of tone. In any case, the overall effect is merely to cut the very high audio frequencies without giving any degree of bass boosting with regard to the middle frequencies. It seems quite evident that the public desires bass boosting rather than attenuation of the treble which is already severely attenuated by the tuning circuits, but with existing receivers they are unable to satisfy their desires. The weird tonal effects brought about through extreme use of the old type of tone control is the result of their attempts to get bass boosting with a control which is incapable of providing it.

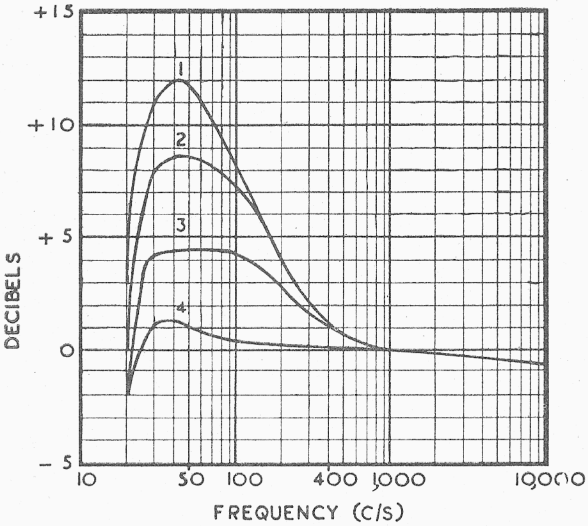
When negative feedback is used, bass boosting may be provided by one of two methods. Either it may be entirely outside the feedback network (such as ahead of the first a-f amplifier) or it may be incorporated in the negative feedback system itself. The latter is the one which we prefer, but many systems purporting to provide this type of control do not give a satisfactory overall frequency response. Careful investigation was, therefore, made of various systems which can be used to give true bass boosting, i.e., a rise in the bass which is not accompanied by any serious drop in the level of the middle frequencies; so that varying the control causes no apparent change in the overall volume level.

The method finally adopted is to feed back from the plate of the power valves through a resistance-capacitance network with an adjustable element, to the cathode circuit of the first a-f amplifier stage. This has the additional advantage, in the form here adopted, of increasing the input impedance of the amplifier, as will be described in detail below. Portion of the cathode bias resistor of the first a-f amplifier is unbypassed so that the voltage which is fed back is able to combine with the input voltage in phase opposition as is necessary for negative feedback. Incidentally, even without the tone control, this method of feedback has considerable advantages over the "series feedback" arrangements used in many Radiotron circuits during past years. It is capable of handling a higher degree of negative feedback and also gives better hum reduction, while, in addition, it does not result in a heavy load on the plate of the first a-f amplifier.

One of the problems in the design was to select values of capacitors and resistors which would give the required degree of bass boosting, an effective degree of negative feedback under all conditions, and avoid any tendency towards instability at very high (supersonic) audio frequencies. The values finally selected provide a satisfactory combination for the purposes of a typical high class radio receiver with console cabinet and a good quality loud speaker. They are obviously unsuited for a table-model cabinet or small speaker.

The maximum degree of bass boosting is at a frequency below 50 c/s. in all cases, when tested with a typical loudspeaker and transformer (12/42). The graphs shown in figure were taken at a low level so as to avoid any overloading effect on the very low frequencies such as would occur as the result of the highly reactive load of the loudspeaker at frequencies below its bass resonance and with the heavy reactive shunt caused by the primary of the transformer. For most purposes, the lowest frequency of any real interest is about 70 c/s., but the good response at lower frequences may be used for special cases where it is desired.

Although listening tests have been carried out with a view to determining the optimum values of the capacitance and resistance in the tone control portion of the feedback circuit, these are capable of minor adjustment to suit any particular need. The 0.005 μF. condenser is the one controlling the frequency at which the bass boosting become operative and this may therefore be varied to obtain any desired result. The 0.5 μF. condenser, directly conected to the plate of the 6V6-GT valve, is merely the blocking condenser, but it is required to be sufficiently large in capacitance to avoid any appreciable phase shift at low audio frequencies. The 0.15 megohm resistor is the one which largely controls the degree of negative feedback and hence the gain and the distortion of the amplifier. If for any reason it is desired to increase the gain of the amplifier, this resistor may be increased in resistance to a value such as 0.2 megohm or higher, but this is undesirable since it has a deleterious effect on the overall performance of the amplifier and on the degree of bass boost which is possible to achieve.



BASS BOOSTING CHARACTERISTICS
RADIOTRON CIRCUIT RC52.

Condition.	Position of Tone Control.
1	Maximum resistance
2	$\frac{3}{4}$,,
3	$\frac{1}{2}$,,
4	Zero ,,

N.B. The curves have been super-imposed to coincide at 1,000 c/s.

Input Resistance:

With this type of feedback and an unbypassed cathode resistor for the first a-f stage, it is permissible to return the grid resistor to the top end of the unbypassed cathode resistor and so obtain a considerable increase in the input resistance of the amplifier. This is highly desirable as it reduces the harmonic [illegible] arising in the dode detector circuit on receiver, with an input resistance of the order of 1 megohm, the volume control may only be taken part way above minimum before the distortion becomes severe. This may not be serious when the audio frequency gain is very high, but the latter tends to cause trouble through hum and adds to the cost of the receiver. By the simple expedient of increasing the input resistance to more than 10 megohms, it is possible to operate the volume control at full setting with no appreciable increase in this type of distortion. It will be seen that the total impedance shunting the 0.5 megohm load resistor of the diode is 2 megohms in the a.v.c. line, and at least 10 megohms in the input resistance of the amplifier.

The actual measured input resistance of the amplifier is 20.3 megohms for all frequencies with the tone control at minimum, the same figure for all frequencies above 400 c/s. with the tone control at maximum, and falling to a value of 10 megohms at 70 c/s. with the maximum amount of bass boosting.

It will be seen that this has considerable advantages over the method of grid leak bias using a grid resistor of the order of 10 megohms and an input resistance of about 5 megohms. In any case, we hesitate to recommend this latter arrangement owing to some difficulties which have been experienced in extensive field tests.

Hum:

With any form of bass boosting it is essential to reduce the residual hum to a very low level. Some methods of negative feedback result in increased hum or make it difficult to use any method to reduce the hum through filtering. In the development of this circuit we adopted an arrangement originally described in Radiotronics No. 90, page 153, known as "Hum Neutralisation." Use is made of the fact that the screen and plate of the pentode valve are out of phase with one another with regard to hum, and the hum voltage in the output of the amplifier may be reduced very considerably through a suitable choice of capacitance from B+ to screen. With a 3 megohm screen dropping resistor for type 6SJ7-GT and an 0.05 μF. bypass, it was found that a considerable degree of hum neutralisation could be achieved by adding an 0.01 μF. condenser directly across the screen dropping resistor. Even better results were obtained through the selection of a capacitance to give complete neutralisation but, in actual practice, it is necessary to use normal tolerances for all components and in any case the need for complete neutralisation does not exist.

Tests indicated 11 db reduction of hum with a commercial tolerance condenser as compared with the ordinary condition without such condenser.

General Comments on A-F Amplifier:

The plate load resistor for type 6SJ7-GT was selected as 0.5 megohm in order to increase the stage gain and thereby permit an increased percentage of negative feedback. The deterioration in frequency response which would occur without feedback is immaterial, and the response obtained at 10,000 c/s.

In other respects the amplifier is conventional and very similar to previous amplifiers used in Radiotronics circuits. It is capable of a maximum power output of 4.5 watts under the voltage conditions shown.

Pick-up:

The circuit provides for the connection of a gramophone pick-up and for the necessary switching to allow this to be inserted. We have also added a screen open-circuiting switch to ensure that no signal can come through the receiver when the pick-up is in use, but it might be possible to omit this refinement in a commercial receiver design.

Loud-Speaker:

In a good quality receiver we believe that provision should be made for the connection of an extension loud-speaker. An article on this subject is being prepared for future publication, but the conventional arrangement is to provide a terminal or plug on the chassis so that a second speaker, which must be a permag. type, may be connected in parallel with the existing speaker. With the degree of negative feed-back used in this receiver the affect on output level of connecting the extension loud-speaker is very small, although the maximum power output is obviously reduced owing to the non-optimum loading on the valve and the division of power between the two speakers. We believe that a generally acceptable compromise is to have an extension loud-speaker with a load impedance approximately 50% greater than that of the main speaker, thus reducing the mismatching which would occur with two speakers of equal impedance, and providing higher power in the main speaker than in the extention speaker. If it is desired to switch off the main speaker entirely and to use the extension speaker only, it is obviously necessary to use the same impedance for both.

Although the circuit shows an electro-magnetic speaker, it could be used equally well with a permag. speaker provided that the transformer voltage is reduced and the field coil replaced by a suitable choke.

Power Pack:

The power pack is quite conventional with a 385/385 volt transformer and type 5Y3-GT rectifier. A 1,500 ohm field coil is specified, and this will have a dissipation of about 9 watts at no signal; this being suitable for most light 12-inch speakers.

If it is desired to use a permanent magnet speaker, this may be done by using a good choke coil in place of the field coil and reducing the transformer voltage sufficiently to give an output voltage of 260 volts across the second electrolytic condenser.

RADIO-FREQUENCY HIGH-VOLTAGE SOURCES

High-voltage, low-current power supplies such as are required for C.R. tube operation normally employ 50 c/s step-up transformers. There are obvious advantages in using a higher supply frequency, particularly with respect to a reduction in the size and cost of the transformer and filter capacitors. These advantages are so substantial that it may be more economical to use a valve oscillator to generate high frequency alternating current which is then transformed, rectified, and filtered.

For the supply of the voltages less than 2KV., the simpler 50 c/s system is preferable. Above this potential the advantages of the r-f operated high voltage source become increasingly apparent. Some of these advantages are summarised in the following article:

The usual 50 c/s high voltage supply system is capable of supplying far more current than is required, simply because it is not practicable to wind the transformer secondary with thinner wire. Further, as the voltage step-up is solely a function of the turns-ratio of primary and secondary (with the minimum primary turns limited by maximum core magnetising currents) the transformer is necessarily bulky, heavy and expensive. Capacitors necessary to filter 50 c/s have a value of the order of 0.5 μF. to 4 μF.; for voltages in excess of 2KV their cost is very high.

Contrasted to the 50 c/s case, r-f high voltage supplies employ transformers and filter capacitors which are extremely small, light and economical. As the energy stored in the low capacitance filter system is small, and the total power is limited by the oscillator output, a high frequency power source offers a greatly increased safety factor for the user.

This consideration alone would justify the use of the r-f method, particularly as present indications are towards higher voltages for cathode ray tube work. The accelerator-anode types, for example, require potentials of the order of 4KV., while 10KV is quite a moderate value of high voltage supply for home television receivers.

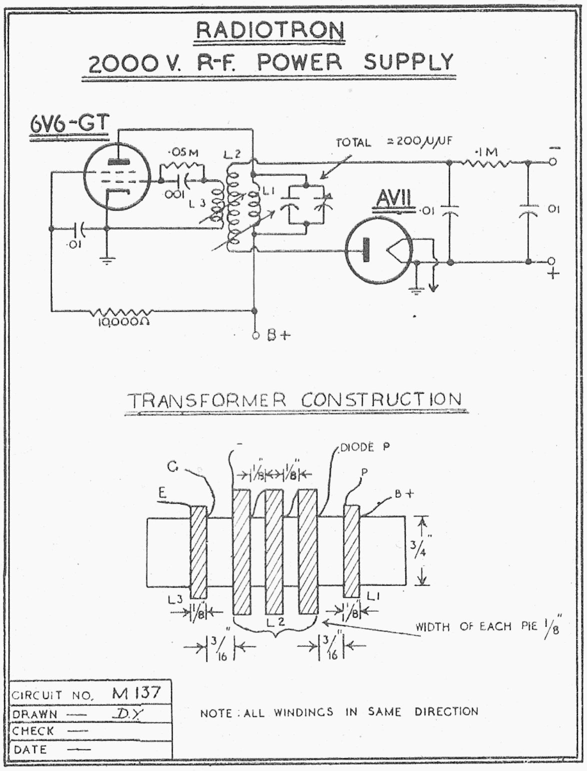
Magntic shielding of the transformer is no problem at all. A standard coil shield is quite sufficient to confine the field so that the unit may be mounted in almost any position with respect to the cathode ray tube, but complete shielding is necessary to prevent interference with receivers.

The output voltage can conveniently be controlled over quite a wide range by the oscillator tuning capacitor. With automatic control of oscillator output, an improved regulation characteristic with respect to mains supply variation could be secured. A further possibility lies in the use of the r-f high-voltage supply for battery-operated portable equipment.

It should be noted that the power available cannot exceed the output of the oscillator—thus, for 2KV, or so, the current is limited to the order of a few milliamps.

PRACTICAL CONSTRUCTION.

An experimental high-voltage supply was set up in the A.W.V. Application Laboratory to form the basis of a typical practical design embodying the fore-



going principles. As described, it would be quite suitable for supplying H.T. to a 5in. cathode ray tube, or with slightly reduced oscillator screen voltage, a 3in. or 2in. tube. It is hoped later to modify the arrangement to provide 4KV if there is a popular demand for C.R. tubes requiring this potential.

The design of an r-f operated high voltage supply centres around the tuned step-up transformer which is, therefore, a good place to commence. The voltage output is a function of the oscillator voltage developed across Z_{L1} and the ratio Z_{L2}/Z_{L1}, where Z_{L2} is the dynamic impedance of L_2 and its associated capacitance shunted by half the d.c. load resistance, and Z_{L1} is the dynamic impedance of L_1 shunted by the reflected plate load. Thus the transformer design should aim at producing the highest possible impedance for Z_{L2} since the oscillator plate load is Z_{L2} divided by the square of the voltage step-up ratio.

The frequency of operation is determined by the inductance of L_2 tuned by its self capacitance and stray circuit capacitance. As the dynamic impedance is L_2/RC_2, with C_2 more or less fixed, a large value of L_2 and a high Q_2 are desirable; this indicates a fairly low operating frequency. On the other hand, economy of filter capacitance demands a high frequency. A reasonable compromise would seem to be between 100 Kc/s and 1 Mc/s. Plate and grid feedback windings are placed at opposite ends of L_2 to give a more stable tuning characteristic. All coils are wound with 9/44 Litz. wire to minimise eddy-current losses.

It should be noted, that although this unit looks like a familiar coil, it operates at very high voltages and should be treated with due respect. To this end, a winding form embodying a well-spaced multi-pie construction is necessary to avoid high potentials between adjacent turns. The coil itself should be spaced at least ½in. from nearby conductors. For the wiring carrying high voltages, sharp bends and points should be avoided to reduce tendencies towards corona formation.

The oscillator circuit is of a conventional tuned-plate type, which is stable and gives high output.

An outline of the method for designing the transformer is given below*, but for further detailed information the reader should consult the reference quoted.

From the circuit it will be seen that the transformer is a special case of a radio-frequency coupled circuit with tuned primary and secondary. In order to obtain reasonably high efficiency, good voltage regulation and stability, it is necessary to use coupling greater than critical and it is recommended that the value chosen be at least 20 times the value required to give critical coupling. The frequency of operation will be determined by the natural resonant frequency of the transformer secondary circuit, the coil L_2 being tuned by the various stray capacitances present due to the diode, coil, wiring, etc.

A suitable value for L_2 may be found from the expression $L_2 \leqq \dfrac{0.05R_L}{\omega}$

where $R_L = R/2$ for half wave rectifiers

and R = direct current load resistance offered to supply system.

$$= \frac{\text{D.C. Current output}}{\text{D.C. Voltage output}}$$

ω = angular frequency of operation.

Having found L_2 it is possible to fix a value for L_1, this being given by

$$L_1 \leqq \frac{0.1\ R_p}{\omega}$$

where R_p = load reflected into primary

$$= \frac{(\hat{E}_p)^2}{2\ \text{P.O.}}$$

$\hat{E}_p$ = oscillator peak voltage swing,

P.O. = Total oscillator power output,

and ω = Angular frequency of operation.

High values of Q are recommended since the overcoupled condition is then more readily obtained, values of the order of 100 being suitable for L_1 and 200 for L_2. The maximum coefficient of coupling that can be employed is usually limited by the insulation requirements of the windings, and the high Q values allow the requirements to be met with values of K which are of the order of 25%. Two peaks can be obtained due to the overcoupled condition; the frequency of operation will be correct when the usual connections are made to the oscillator coil. Reversal of these connections will give the higher frquency peak, but operation is recommended at the lower frequency.

The output voltage can be adjusted approximately by means of the screen dropping resistor and the final adjustment can be made with the tuning capacitor.

In conventional C.R.O. applications, the positive side of the high voltage supply is earthed and the rectifier is usually a half wave diode in the negative lead. This requires a heater supply for the rectifier which is insulated from the ground, to the full extent of high voltage. R-F. high-voltage supplies have been developed which successfully derive heater current from a single turn of heavy gauge wire around the transformer. However, for the usual types 879 and AV11 the power required is about 4.4 watts, which is a considerable part of the total power available. In the experimental model described, a departure is made from conventional practice. The rectifier is placed at the earthy end of L_2, with a polarity which makes this the positive output. **Thus, with the diode heater earthed, the power for it can be supplied from the main 50 c/s power transformer.**

The d.c. load resistance, which is the potential divider for the C.R. tube, was selected as 2 megohms in this design. Considering the small currents drawn by the various elements of the C.R. tube, the bleed current of 1mA. should be adequate.

OPERATING CONDITIONS.
CIRCUIT M137.

Plate voltage of 6V6-GT	250 volts
Screen voltage of 6V6-GT	192 volts
Plate current of 6V6-GT	23 mA.
Grid bias of 6V6-GT	—39 volts
D.C. resistance of load (— +)	2 megohms
Output voltage (— +)	2000 volts
Frequency (approx.)	1 Mc/s.

TRANSFORMER DETAILS.

All windings are 9/44 Litz.

L1	60 turns
L2	500 turns
L3	60 turns

For dimensions see drawing.

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* Schade, O. H. "Radio-Frequency-Operated High Voltage Supplies for Cathode Ray Tubes," Proc. I.R.E., 31.4 (April, 1943), 158.

RADIO RECEIVER DESIGN

This is the first of a series of articles on Radio Receiver Design. The subject is a very extensive one and it is impossible in a single article to cover the whole field at all adequately. By covering the subject in a number of articles, of which the subsequent ones will appear in later issues of Radiotronics, it is hoped to assist Receiver Designers in some of the problems associated with design, particularly those having direct or indirect relationship to the valves.

(I) GENERAL FEATURES OF DESIGN.

(a) Mechanical Features.

It is found convenient to discuss under this heading such matters as the layout of components, the wiring, the chassis design, cabinet design, temperature rise and accessibility for servicing. Some of these are of course associated with other sections and will be mentioned also in later articles.

LAYOUT.

The first mechanical problem is concerned with the layout of the components on the chassis. A good layout is most desirable for the production of a satisfactory receiver, and an unsatisfactory layout may cause serious troubles which may affect the performance of the receiver, or may bring about service troubles or short life of the valves or other components.

The purpose of good layout is to so arrange the components that those connections which are most critical are kept short and direct, and leads carrying voltages likely to result in feed-back should be isolated from the part of the circuit most sensitive to them. It is complicated by the necessity for ensuring adequate ventilation, particularly in smaller sets. Even in larger sets it is most important to place the converter valve, the power valve, the rectifier and the power transformer where they are adequately ventilated.

The reason for placing the converter valve in a well ventilated position is in order to avoid frequency drift which occurs as the valve and its socket become heated. This is most serious in short-wave receivers and every endeavour should be made to keep the converter valve on the coolest portion of the chassis. The power valve and rectifier may be kept a reasonable distance apart (preferably 1½in. to 2in. between bulbs) and should not be too close to the power transformer, since otherwise there will be a mutual heating effect between them.

The oscillator coil is also subject to frequency drift through temperature rise, and it should be mounted in as cool a position as possible.

The electrolytic condensers should be kept some distance away from the rectifier valve, power valve or power transformer, since they tend to dry out early in life if placed in such a position that they are appreciably warm.

The power transformer should be kept away from iron cored audio transformers or inductances and, in particular, from the oscillator coil. It is desirable to keep all valves some distance away from the power transformer since many of these have iron electrodes and even those having nickel electrodes are partially magnetic. Many types of hum are the result of poor layout with regard to the power transformer. If a filter choke is used, it also should be kept as far as possible away from the critical parts of the circuit. A vertical mounting transformer is preferable to a horizontal one, since its field is kept away from the chassis and the effects of the leakage field are very much reduced as a consequence.

In table model receivers it is also necessary to keep the field coil (if any) away from the amplifying valves, since stray electro-magnetic coupling may result in hum difficulties.

It is desirable to have good ventilation with a current of air from underneath the chassis, through the chassis, and then upwards and outwards. The pilot lamps should also have good ventilation if they are to have long life, and the effect of placing a pilot lamp in a small enclosed space is to expedite its decease.

Holes for ventilation in the chassis should be small enough, or covered with metal gauze, to keep out mice.

In general, any coupling should be avoided between stages or points tuned to the same frequency. This coupling may be either inductive or capacitive. In particular, it is desirable to avoid long plate or grid leads such as to wave-change switches. The length of lead between the plate of the converter valve and the primary of the first i-f transformer should be kept very short, since oscillator frequencies are present in the plate circuit.

Long leads should also be avoided in the audio frequency end of the receiver, particularly when carrying a.f. voltage in a high impedance circuit. In such a case shielding with copper braided flex will attenuate the high audio frequencies while it may not be entirely effective as a screen. If the second-detector valve is mounted at the back of the chassis it is preferable to arrange the volume control in close proximity to the valve, and to operate the control through a long shaft or other mechanical link.

The second-detector valve should be kept some distance apart from its neighbouring components so as to avoid the crowding of components which frequently occurs around this stage. This may be reduced by the use of small components (such as resistors and condensers) in the second-detector circuit.

Attention should be paid to vibration of the oscillator section of the gang condenser, since this can cause severe microphonic troubles, particularly on the short-wave band. In console sets it is desirable to keep the speaker as far as possible from the chassis and to use non-microphonic mounting both for the chassis and for the gang condenser itself. This difficulty is more pronounced in table models having a short-wave band and particular attention must be paid to it in these models. One possibility, in addition to those usually adopted, is the use of a sound-absorbing dust-cover over the gang condenser, which will prevent the air waves from causing direct vibration of the condenser plates.

THE CHASSIS.

In console receivers it is desirable to make the chassis of large size so as to give ample space for all components, adequate ventilation and ready accessibility. The chassis may be of heavy-gauge metal, preferably of plated steel. Fixed metal ends are desirable so as to strengthen the chassis and minimise flexing.

One of the best ways of mounting the chassis is by means of lugs on the lower part of the chassis ends which will take four bolts for mounting. These bolts should go through grommets, which should preferably be attached to the chassis so that they cannot be lost when the receiver is removed from the cabinet.

It is desirable to arrange for solder lugs to be pressed into the chassis at suitable points, rather than to solder to lugs mounted on bolts.

Lock washers are desirable under all nuts so as to reduce troubles caused from loose nuts. Although self tapping screws may be used on parts which do not need to be removed, they are undesirable for holding those components which may have to be removed by a serviceman. Apart from the danger of becoming loose through removal and replacement, there is the further difficulty that many servicemen do not have spare self-tapping screws to use in case they should lose the original.

WIRING.

Do not use No. 1 pin on any valve socket as a convenient anchor. In the single-ended GT valves this must be earthed and even in other cases it should only be used for this purpose.

A single earth point should be used for all by-pass condensers for a single stage. They should not be returned to different points owing to the impedance which may exist between them, and which may result in unsatisfactory operation particularly on the short-wave band.

The heater wiring may be with twin leads which are preferably twisted for any long lengths. With any method of heater wiring it is important to keep the two leads close together and avoid making a large loop which will result in inductance which may cause hum or other troubles. If the heater transformer is not centre-tapped, it is desirable to use a 20 ohm resistor across the heater circuit with the centre-tap earthed, or to earth one side of the heater circuit.

The r-f wiring should be kept as short as possible and directly from point to point and not in close proximity to the chassis. Those leads which affect the tuning or the alignment of the receiver (e.g., oscillator and i-f transformers) should be rigidly mounted so that the tuning is not affected by moving the wiring. Ordinary shielded wire (copper braided) should not be used in the r-f wiring unless it is adopted purposely to increase the losses and capacitance. In most cases where instability is experienced, there are better methods for correcting the fault without introducing other troubles; this will be dealt with in a later article on radio frequency amplifiers.

While there are diverse opinions regarding the mounting for components, our preference is for components mounted in the most convenient position, close to the valve sockets. This facilitates servicing, particularly by servicemen who do not have complete service details of the receiver. It also facilitates the replacement of faulty components.

Resistors and condensers may be mounted as far as possible in one plane at about the same level below the chassis, care being taken to avoid one component being hidden by another. They should also be located so as to give convenient access to the valve socket terminals both for a soldering-iron and for voltmeter prods. These features are important since service charges are based on the time required to change a component.

In console receivers, and in table model receivers in which the speaker is directly mounted on to the cabinet, the speaker should be connected to the chassis by means of a plug.

DIAL.

The dial driving mechanism should be mechanically robust and if a cord drive is used the cord should not be taken around too sharp a curvature since this has a very detrimental effect on its life. The shafts of the various controls should be long enough to allow for the knobs to be conveniently removed and replaced, with due allowance for slight movement of the chassis after servicing, and should be fitted with flats.

The holes in the cabinet should be large enough to give good clearance for the shafts of the controls.

The dial lamps should be accessible so that they may readily be replaced, but the ventilation of the lamps is of the greatest importance if they are to have a satisfactorily long life.

CABINET DESIGN.

In console receivers the conventional arrangement with the chassis on a shelf above the loud speaker has many good features and is probably the best possible. The cabinet itself should be of robust construction and the shelf should be of thick timber, supported only on the two extremes so as to reduce vibration from the loud speaker. Ventilation is highly desirable and this may be arranged either through apertures at the bottom of the chassis or by lifting the chassis slightly above the shelf. The back of the cabinet should not be closed in, or if it is desired to have a back on it this should be well ventilated with a large number of holes. These holes should be arranged from the extreme low level of the chassis right to the top of the cabinet, so as to avoid a pocket of hot air in the top of the cabinet.

There are noticeable advantages gained through closing in the back of the speaker section of the cabinet in console receivers. This avoids some of the short-wave microphony trouble arising on the short-wave band through vibration of the plates of the gang condenser. It also avoids the effect of reflection from a wall at the back of a receiver and thereby can be made to give better fidelity. Cheap console receivers will undoubtedly continue to be made with an open back but for better quality there seems to be much to recommend the use of a "vented baffle"* which also provides improved accoustic bass response from the loudspeaker.

In table models the heat dissipation is a very serious problem and this must be reduced in proportion to the size of the cabinet. Ample provision should be made for air circulation, and one suggested arrangement is to raise the cabinet on four rubber feet and to provide apertures in the bottom of the cabinet.

Another problem is the provision of a reasonably free outlet for sound from the loudspeaker so as to avoid the boxed-in effects which frequently mar the re-production from such receivers. This may be improved through a suitable layout, and the avoidance of large components immediately behind the loudspeaker.

In most table models the speaker is mounted directly on the chassis and no plug is used for the connection of the loudspeaker. For ease in servicing it is desirable to arrange for the dial to be removed with the chassis, although in some designs this may not be practicable. In table models the accessibility of pilot lamps and the easy removal of the chassis become very important problems.

In all receivers, particularly having in mind table models, the valves should be removable without removing the chassis and without requiring any special tool for the process.

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* Smith, F. W. "Resonant loudspeaker enclosure design," Communications, 25.8 (August, 1945), p. 35. Hoekstra, C. E. "Vented speaker enclosure" Electronics, 13.3 (March, 1940) p. 34.

A HEARING-AID AMPLIFIER USING MINIATURE WAVES

We reprint below R.C.A. Application Note No. 107 describing a Hearing-Aid Amplifier using miniature 1.4 volt valve types 1S5 and 1T4. This should prove of general interest from the point of view of audio amplifier design and the ideas incorporated in it may be adapted for other applications.

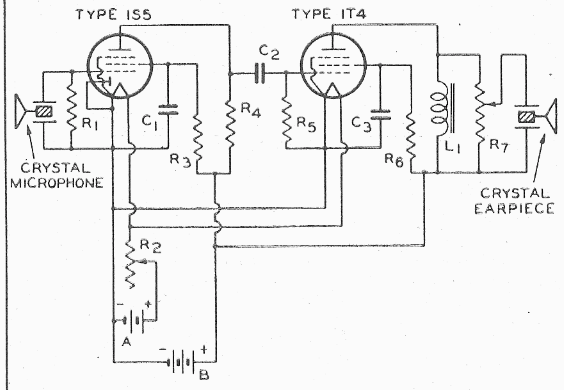
APPLICATION NOTE ON A MINIATURE-TUBE HEARING-AID AMPLIFIER FOR USE WITH AN AIR-CONDUCTION EARPIECE.

For use in hearing-aid amplifiers, the miniature tubes have the advantages that they are small, operate well at low plate and screen voltages, and employ commercially available sockets which are very small. The miniature tubes are especially well suited for use in a hearing-aid amplifier which employs an air-conduction earpiece; sufficient gain and power output for such a unit can be provided by two miniature voltage-amplifier tubes drawing a total filament current of 100 mA.

Tests have shown that the best miniature-tube complement for an air-conduction hearing-aid is a 1S5 followed by a 1T4. The 1T4 is desirable for use in the second stage because it can provide more power output than the 1S5; the 1S5 is desirable in the first stage because it can provide more gain than the 1T4. A circuit using this tube complement is shown in Fig. 1.

It was found desirable to use choke coupling, rather than resistance coupling, for the output of the 1T4

HEARING-AID CIRCUIT



C_1 = 0.02 μf
C_2 = 0.002 μf
C_3 = 0.03 μf
L_1 = 500-HENRY CHOKE, 6000 OHMS D-C RESISTANCE, SMALL LIGHT-WEIGHT DESIGN
R_1 = 10 MEGOHMS
R_2 = 100 OHMS FILAMENT RHEOSTAT
R_3 = 3 MEGOHMS
R_4 = 1 MEGOHM
R_5 = 10 MEGOHMS
R_6 = 0.15 MEGOHM
R_7 = 1 MEGOHM, VOLUME CONTROL

FIG. 1

92C-6168

OPERATION CHARACTERISTICS OF HEARING-AID CIRCUIT SHOWN IN FIG. 1

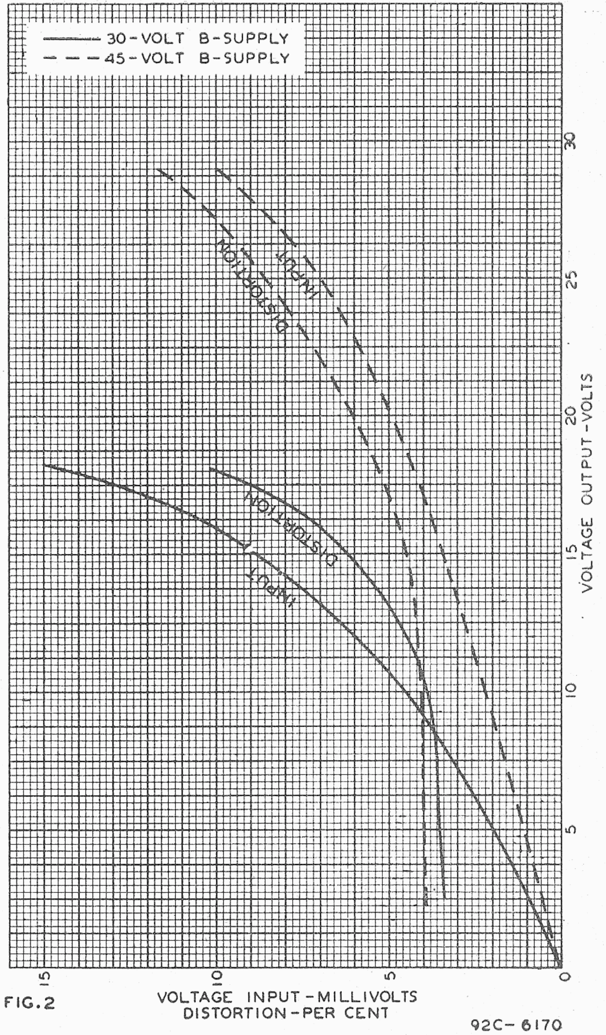


FIG. 2

92C-6170

in this circuit. With resistance coupling, the voltage at the plate of the 1T4 was so low that the gain and output of the 1T4 were inadequate. Suitable chokes, small enough and light enough for use in a wearable hearing-aid, are commercially available.

The filament rheostat R2 is the "battery saver" frequently used in hearing-aids. This rheostat should be set so that filament current is at the lowest value providing adequate signal output. It is possible to use the rheostat as the volume control and thus to eliminate potentiometer R7. However, volume can be controlled more smoothly by means of R7 than by means of R2. It is not advisable to insert a volume-control potentiometer in place of R1 or R5 because suitable potentiometers having a resistance as high as 10 megohms are not generally available. A resistance of less than 10 megohms for R1 or R5 would reduce the circuit's sensitivity.

Fig. 2 shows the performance of the circuit with a 45-volt, and with a 30-volt B-supply. These curves were measured at a signal frequency of 420 cycles. The capacitance of the earpiece was 0.0015 μf. It can be seen from Fig. 2 that, with a 45-volt supply, a 5-millivolt signal from the microphone produces an output voltage of 20 volts across the earpiece with 6% distortion. This output voltage is large enough for most people who use an air-conduction unit. With a 30-volt supply, a 5-millivolt signal produces approximately 10 volts output with 4% distortion. This output voltage is large enough for many people whose hearing loss is not severe. The total plate and screen current drawn by the circuit from a 45-volt supply is approximately 0.6 mA.; from a 30-volt supply, the drain is approximately 0.4 mA. At these low drains, good life can be obtained from a very small B-battery.

THEORY SECTION

STANDARD FREQUENCY RANGES

It is highly desirable to distinguish between the various frequency ranges, particularly the frequencies above 30 Mc/s, which are often loosely called "ultra-high-frequencies." This matter has been considered at length by the Standards Committee of the Institute of Radio Engineers (U.S.A.) which has adopted, as a standard, the "wavelength-range" and "frequency-range" designations shown in the following table.* These designations will be used in all future references in Radiotronics, and we take the opportunity of recommending their use by all radio engineers.

Range. Number N.	Frequency Range. Lower Limit (exclusive)	Frequency Range. Upper Limit (inclusive)	Wavelength Range. Lower Limit (inclusive)	Wavelength Range. Upper Limit (exclusive)	Wavelength Range Designations.	Frequency Range Designations.
0	0.3C	3C				
1	3C	30C				
2	30C	300C				
3	300C	3,000C				
4	3Kc	30Kc	10,000m	100,000m	Ten-kilometre	Very-low-frequency (v-l-f)
5	30Kc	300Kc	1,000m	10,000m	Kilometre	Low-frequency (l-f)
6	300Kc	3,000Kc	100m	1,000m	Hectometre	Medium-frequency (m-f)
7	3Mc	30Mc	10m	100m	Dekametre	High-frequency (h-f)
8	30Mc	300Mc	1m	10m	Metre	Very-high-frequency (v-h-f)
9	300Mc	3,000Mc	0.1m	1m	Decimetre	Ultra-high-frequency (u-h-f)
10	3,000Mc	30,000Mc	1cm	10cm	Centimetre	Super-high-frequency (s-h-f)
11	30,000Mc	300,000Mc	1mm	10mm	Millimetre	

* Proc. I.R.E. 33.8 (Aug. 1945) p.548.

EXTENSION OF BROADCAST FREQUENCY BAND

We understand that the Postmaster General's Department has officially specified the band from 550 to 1600 Kc/s as the broadcast frequency band, although no station licenses have yet been issued between 1500 and 1600 Kc/s. There is the possibility of slight extension in the opposite direction, namely to 540 Kc/s, although no official decision has yet been made regarding this frequency. In U.S.A. the 540 Kc/s frequency has been allocated to broadcasting stations and it would seem quite logical for this frequency also to be used in Australia, owing to its very good daylight coverage and its suitability for high-power broadcasting. . In view of these developments, we recommend that all radio receiver designers should arrange for their receivers to cover the band from at lease 540 to 1600 Kc/s. In most cases this could be done without serious difficulty, and it will then mean that receivers will be capable of receiving the new wave lengths when allocated.

STANDARD INTERMEDIATE FREQUENCY

Once again we remind our readers that the frequency 455 Kc/s has been kept as a clear channel purposely to enable superhetrodyne receivers to use this as their intermediate frequency without interference. Altogether apart from the advantages of the clear channel, there are other advantages arising from the standardisation of intermediate frequency, particularly in connection with the servicing of receivers and the manufacture of component parts. We intend to use 455 Kc/s in all normal Radiotron receiver circuits and would urge the same upon all receiver and component manufacturers.

NEW DRAWING STANDARDS

A welcome step towards standardisation of the graphical symbols in radio and electronic circuits has been made by the American Standards Association which, during 1944, standardised these symbols in U.S.A. The two standards which are of interest to Radio and Electronic Engineers are Z32-5-1944 "American Standard Grapical Symbols for Telephone, Telegraph and Radio Use" approved October 24, 1944 and Z32-10-1944 "American Standards for Graphical Symbols for Electronic Devices" approved April 11, 1944.

In an effort to achieve international standardisation, it has been decided to adopt (with only slight amendments) these American Standards for Graphical Symbols in all new circuits published in Radiotronics. The changes that will be noticed are very few and their meaning will be obvious. The principal changes affect condensers, antennae and loudspeakers. Condensers are shown by one straight line and one curved line, the curved element representing the outside electrode in fixed paper-dieletrics and ceramic-dielectric capacitors, the negative electrode in electrolytic capacitors and the moving element in variable and adjustable capacitors. Trimmer capacitors are identified by a small letter T.

Modifications to Circuit Diagrams.

A proposal has been made in England, which we deem worthy of support, to make all circuit returns to a common point where this can be done. For example, all returns to the cathode of a valve should be made to the one point in proximity to the cathode and not to two or more points situated at varying distances along the lead connected to the cathode. In practice this amounts to the use of only one common contact point in any lead between two circuit elements. This has the advantages of directing the eye to the common point and of encouraging those with limited knowledge in wiring to return all leads to such a common point, which is frequently the solder lug of the socket.

TONAL-RANGE AND SOUND-INTENSITY PREFERENCES OF BROADCAST LISTENERS

An article with this title by H. A. Chinn and P. Eisenberg was published in the Proceedings of the I.R.E. (U.S.A.) September, 1945, which deserves careful study by all Radio Engineers. This is the most extensive test so far carried out on large numbers of listeners in connection with their preference of tonal (frequency) range and sound intensity. The tests were carried out very carefully and there seems to be no doubt but that the results of the test are reliable as an indication of public preference under the conditions obtaining. So far as tonal range is concerned, the listeners were asked to state their preference for one of three frequency ranges as under:—

Narrow	140 — 4,500 c/s
Medium	65 — 7,500 c/s
Wide	35 — 10,000 c/s

(these frequency ranges are for an attenuation of 5 db below that at 1,000 c/s.)

A cross section of the listeners showed that only 12% preferred the wide range on classical music and 21% on male speech; the remainder had no preference or were divided between narrow and medium, and the exact proportion of narrow and medium was shown to depend upon various factors. It will be seen that 88% of the listeners preferred a frequency range extending no more than from 65 to 7,500 c/s; there is no need, therefore, for the frequency range in a normal receiver to cover more than from 65 to 7,500 c/s, with a provision for limitation by means of a tone control. This tonal-range is only possible in console receivers, and is considerably better than most console receivers sold at the present time.

It therefore appears that there is scope for three types of receivers to suit the listening public:—

1. A narrow tonal range, as is given by all table models and the poorer type of console.
2. The medium tonal range which can be provided listeners prefer a wide tonal range if this can be provided without introducing noise or distortion.

The tests also indicate that the claims of frequency modulation proponents regarding improved fidelity are not based on fact so far as the majority of the listeners is concerned. Only some 12% of the public appear to appreciate a tonal range as wide as 10,000 c/s, and an even smaller percentage would prefer it to be extended beyond 10,000 c/s.

One of the most interesting features of the results is that a number of owners of frequency modulation receivers who had been listening on these receivers locally for at least one year, showed a preference for narrow over-wide tonal range. When they were informed of the fact that they were listening to the wide tonal range, they changed their preference to wide range when listening to classical music. A clear inference from these results is that they changed their opinions on account of the preference they had for the name "wide range" rather than for the actual musical preference. This reversal of opinion did not occur with any other class of listener. It may therefore be concluded that the result arose from the high-pressure selling tactics of those marketing F-M receivers in U.S.A.

At the same time it is important to remember that there is a percentage, even though a small one, which definitely and undeniably prefers wide tonal range, and something should be done to give these people what they want if it can be done at a reasonable cost.

SOUND INTENSITY PREFERENCE.

Tests were made at three levels of sound intensity (namely 50, 60, and 70 db above the reference level of 10-16 watt per sq. centimeter). The preferences appear to be for a sound level something between 60 and 70 db above the accoustical reference level, the precise intensity varying for the type of music. The conclusion of those who carried out the tests

EXTRA-TERRESTRIAL RELAYS

There is an interesting article by Mr. A. C. Clarke on the subject of "Extra-Terrestrial Relays—Can Rocket Stations Give World-Wide Radio Coverage" in the Wireless World for October, 1945. Although at first sight the idea of having broadcasting stations many miles above the earth's atmosphere may seem somewhat akin to Jules Verne, this article points out that there is no known reason why such cannot be constructed in the near future. The problems of high-speed rockets have been largely overcome and only a comparatively small future step is necessary to enable one or more rockets to be sent up to such a height above the earth's surface that they will continue revolving indefinitely without either returning to the earth or going away from it. The plan is to arrange for a rocket to have a velocity such that it will rotate with the same angular velocity as the earth, and it will therefore continue to be over the same point on the earth's surface.

This may be used for the purpose of relaying the programmes for broadcasting to one or more countries without any limitations such as exist at present regarding the optical range of about 50 miles. It is still too early to make any definite announcement regarding such a move, but there is at least a possibility that it will provide a much cheaper and more effective way of giving radio coverage for ultra-high-frequency broadcasting, and especially for television.

It will therefore be an alternative to the very expensive network of ultra-high-frequency radio links or co-axial cables which would be the only other ways of obtaining continent-wide coverage for television. It will make us hesitate before committing ourselves to extremely heavy expense with existing methods of broadcasting F-M or television.

An alternative proposal, which is likely to have a more immediate application, has been put forward by C. E. Nobles of Westinghouse Electric Corporation which uses a succession of aeroplanes remaining at a height of 30,000 feet for eight hours each, using a power of approximately 1KW to give the same signal over a distance of 200 miles as would be obtained from a ground station having a power of 50KW. Thus the cost of operating the aeroplanes will be more than offset by the saving in ground installations and the arrangement appears to be economically practicable and capable of early operation. If the rocket idea is practicable, it may be adopted as a cheaper alternative at some later date.

POST-WAR RADIOS

As the result of statements made by certain people, a section of the public appears to expect post-war radio receivers to be something outstandingly better than pre-war. There is no advantage to be gained by the radio trade as a whole through the propagation of such a statement, and it is advisable for an authoritative statement to be made to the effect that no revolutionary inventions made during the war may be expected to have any appreciable effect on the design or performance of post-war broadcast receivers.

The great majority of war-time developments in both radar and radio communication are incapable of being usefully applied to our existing system of radio broadcasting. No outstanding improvements have occurred, and no fundamental changes in valve theory or design, which are able to be incorporated with any benefit to the broadcast listener. The only important war-time development is the increase in popularity of the very small (miniature) valves, but this had already been brought to the production stage before the war began, and the war merely served to expedite the development which had already been made. There is no doubt that these miniature valves will have an important future in equipment in which light-weight and small-size are the predominant factors. They will therefore be used in light-weight portables, walkie-talkies and any similar equipment, but their characteristics are no better, on the whole, than those of the larger valves, and they offer no operating advantages in large equipments where space and weight are of no consequence.

Both F-M and television were in use overseas before the war began and there is no doubt that they will be used in the more densely populated industrialised countries of North America and Europe. Both are unfortunately expensive and the cost factor is one of the most serious which has to be considered in a country such as Australia with a small population and a limited market for local manufacture. Until the economic question of cost has been considered, it is too early to make any detailed comments. The position is that an F-M receiver will cost from 50% to 100% more than the ordinary (amplitude-modulated) receiver as used at the present time. Furthermore, 90% of the listeners could not discern the difference between the two systems. The remaining 10% of listeners may get improved reception as the result of frequency modulation and suitable location of transmitting stations, but the question to be faced is whether this improvement is worth while at such a high cost. F-M will also enable those listeners who can afford a really high fidelity set (e.g. one with dual or triple loud-speakers and selling at prices in excess of £100) to obtain really good reception.

It is a moot point whether nearly all the advantages given by F-M cannot be obtained through a better arrangement of our present A-M stations as regards wave-lengths and permissible power. From the point of view of the whole community, it would be cheaper to increase the power of all important broadcast stations by 5 or 10 times so that a number of the most important stations would have powers of 50 KW. It would enable them to overcome some of the present interference and would permit the design of receivers having lower sensitivity and therefore less expensive to produce and less likely to give trouble during their useful life.

The question of **television** is a far more difficult one, and the final cost is enormous. There seems

VALVE DATA SECTION

to be no hope of a continent-wide television service being established in Australia under present conditions unless the greater part of this cost is carried by the Government. Whether this is likely to be popular in view of the anticipated small percentage of the population prepared to take the trouble to watch a television screen waits to be proved. Both in England and America respectively, observers have pointed out the very small percentage of television receivers to total population in areas served by television broadcasting stations. There is also the further difficulty that television is still in the stage of being developed to a higher standard of performance and this stage of development will probably not be complete for several years. It therefore seems undesirable for Australia to be over-impetuous when we can learn very readily from mistakes made overseas. It will be time enough to consider the Australian television services when some standardisation is arranged in both England and America.

As regards both F-M and television there is the further suggestion elsewhere in this issue that this may be provided by high-flying aeroplanes or by a rocket relay station high above the earth's atmosphere, which would simultaneously provide a solution to most of these problems. By waiting a few years we may save ourselves considerable expense and disappointment.

In view of these remarks, it seems highly desirable to inform the public through every possible means that no good purpose will be served by delaying the purchase of a receiver "until F-M and television come in".

RADIOTRON 879

Australian-made High Voltage Half-wave Rectifier for use with Cathode Ray Tubes.

The Australian-made type 879 is a war-time product which, owing to the special circumstances then obtaining, differs in its characteristics and ratings from both the original American type 879 and the newer type 2X2/879. The Australian-made type 879 is intermediate in its maximum voltage ratings between the older American type 879 and type 2X2/879.

The characteristics of the Australian-made Radiotron type 879 are given below.

Heater.	Coated Unipotential Cathode.	
Voltage	2.5 ± 5%	a-c. volts.
Current	2.0	amperes.
Overall Length	4-9/32 in. to 4-17/32 in.	
Seated Height	3-21/32 in. to 3-29/32 in.	
Maximum Diameter	1-9/[illegible]6 in.	
Bulb	ST-12	
Cap	Small Metal	
Base	Small 4-Pin	

Pin 1—Filament.
Pin 2—No connection.
Pin 3—No connection.
Pin 4—Filament.
Cap—Plate.

Mounting Position .... Any
Maximum Ratings are Absolute Values.

Maximum Ratings.

A-C Plate Voltage (RMS)	2650	3000	max. volts.
Peak Inverse Plate Voltage	7500	8500	max. volts.
Peak Plate Current	100	100	max. mA.
D-C Output Current	7.5	6.0	max. mA.
Total Effec. Plate Supply Impedance	0	0	min. ohms.

HIGH VOLTAGE RECTIFIERS

For convenient reference, a table is given below setting out the most important characteristics of a selection of Radiotron high-voltage rectifiers having comparatively low plate current. These are suitable for use in cathode-ray oscilloscopes, high-voltage testing and many other purposes requiring high-voltage at a low power level.

Type	Fil. volts	Fil. amps	Peak Inverse plate voltage	Peak plate Current	Average plate Current	Base	Top Cap	Max. Overall Length
2V3-G	2.5	5.0	16,500	12mA	2mA	Octal	Plate	4-15/32"
2X2/879	2.5	1.75	12,500	100	7.5	4-pin	Plate	4-17/32"
AWV879*	2.5	2.0	8,500	100	6.0	4-pin	Plate	4-17/32"
AV11**	2.5	1.75	12,500	200	20	4-pin	Plate	5-3/4"
878	2.5	5.0	20,000	—	5	4-pin	Plate	7-5/8"
8013	2.5	5.0	40,000	150	20	4-pin	Plate	6-1/16"
1654	1.4	0.05	7,000	6	1	Min. 7-pin	Plate	2-7/16"

** See article entitled "Radiotron 879" elsewhere in this section.

* * See article entitled "Radiotron Type AV11" elsewhere in this section.

RADIOTRON TYPE AV11 HIGH-VOLTAGE RECTIFIER

Radiotron-type AV11 is a special war-time emergency type of high-voltage rectifier with higher current carrying capacity than any other in its group. Although its manufacture has been discontinued, large stocks are at present held and various uses may be found for it in special laboratory equipment. An article appears elsewhere in this issue on Radio-Frequency High-Voltage Sources, and a practical example is given on the use of type AV11 as the rectifier in conjunction with the radio frequency oscillator. This is only one of the many applications suited to this type of rectifier valve.

The characteristics of type AV11 are tabulated below.

Revised Ratings as from 6/4/45.

Filament Voltage	2.5 ± 5%	volts.
Current	1.75	amps.
Maximum Overall Length	5¾ in.	
Maximum Diameter	2-1/16 in.	
Bulb	ST16.	
Cap	Small Metal.	
Base	Medium 4-Pin.	
Pin 1—Filament.	Pin 3—No connection.	
Pin 2—No connection.	Pin 4—Filament.	
	Cap — Plate.	

Maximum Ratings:

Peak Inverse voltage	12,500	volts.
Peak Plate current	200	mA.
Average plate current (D.C.)	20	mA.

Radiotron Type 7193 (2C22)

RADIOTRON CATHODE RAY TUBE CHARACTERISTIC CHART.

A Characteristic Chart showing the most important data on Radiotron Cathode Ray Tubes has been prepared, and a copy is enclosed as a supplement to this issue.

Any additional data on individual types will gladly be supplied on request.

RADIOTRON TRANSMITTING VALVES FOR V-H-F AND U-H-F.

A tabulation of Radiotron transmitting valves for operation at frequencies above 30 Mc/s is available free on request. This shows the valve type number, maximum plate dissipation and input, and maximum frequency of operation at (1) maximum and (2) reduced ratings.

RADIOTRON 7193 (2C22)*

A Versatile Australian-made V.H.F. Triode

Radiotron type 7193 (2C22) is a triode valve in the standard T9 envelope as used for all "GT" valves, and fitted with a standard octal base, but it is capable of being used as an oscillator or amplifier at frequencies up to about 300 Mc/s. In point of size it is slightly smaller than type 1A7-GT, but it may be used on plate voltages of 300 volts (CCS) and 500 volts (ICAS), with a plate dissipation of 3.3 watts on both ratings. A useful output may be obtained up to about 250 Mc/s, while the resonant frequency of the input circuit is 335 Mc/s.

In order to obtain this performance, it was necessary to bring both grid and plate to caps on the top of the bulb, the angle between the axes of these caps being 28°. The octal base is therefore only required to make connections to the heater and cathode. This arrangement makes possible very short leads to the tuned circuits for both conventional and special u-h-f-tuning arrangements.

One suggested application of type 7193 (2C22) is an oscillator driving type 807 in amateur transmitters. Type 7193 (2C22) is not recommended for use at audio frequencies, since conventional types (6J5-GT, 6SJ7-GT etc.) have approximately equal performance and the two top caps make its use somewhat awkward. Its performance is only shown to advantage on high radio frequencies.

* Type 7193 was originally introduced as a special type for defence purposes, but its electrical characteristics are identical to those of the commercial type 2C22. Individual valves may be branded either 2C22 or 7193.

(Continued on next page.)

RADIOTRON 7193 (2C22)

V-H-F TRIODE

Heater *	Coated Unipotential Cathode.	
Voltage	6.3	a-c. or d-c. volts.
Current	0.3	amp.
Direct Interelectrode Capacitances: †		
Grid to Plate	3.6	μμF.
Grid to Cathode	2.2	μμF.
Plate to Cathode	0.7	μμF.
Overall Length		3$\frac{1}{8}$″ ± $\frac{1}{8}$″
Seated Height		2-9/16″ ± $\frac{1}{8}$″
Maximum Diameter		1-5/16″
Bulb		T9.
Caps (two)		Skirted Miniature.
Base	Intermediate Shell Octal 8-Pin.	

Pin 1—No Connection.
Pin 2—Heater.
Pin 3—No Connection.
Pin 4—No Connection.
Pin 5—No Connection.
Pin 6—No Connection.
Pin 7—Heater.
Pin 8—Cathode
Cap above pins 1 and 8—Plate.
Cap above pins 4 and 5—Grid.

Mounting Position .... Any

Maximum Ratings are Design-Centre Values.

AMPLIFIER

Plate Voltage §	300	max. volts.
Plate Dissipation	3.3	max. volts.
Characteristics—Class A1 Amplifier:		
Plate Voltage	300	volts.
Grid Voltage ‡	– 10.5	volts.
Amplification Factor	20	
Plate Resistance	6600	ohms.
Transconductance	3000	μmhos.
Plate Current	11	mA.

* In circuits where the cathode is not directly connected to the heater, the potential difference between heater and cathode should be kept as low as possible.

† With no external shield.

§ This value is for continuous Commercial Service (CCS). In intermittent Commercial and Amateur Service (ICAS), the plate voltage may be as high as 500 volts maximum, but the maximum plate dissipation remains unchanged.

‡ Under maximum rated conditions, the resistance in the grid circuit should not exceed 1.0 megohm.

The approximate resonant frequency of the input (grid-cathode) circuit is 335 megacycles.

RADIOTRON TYPE 6AC7/1852

HIGH-SLOPE R-F PENTODE

Radiotron type 6AC7/1852 is a high-slope r-f pentode superseding the earlier type 1852. It has a metal envelope and is single-ended in construction. Under normal working conditions it has a transconductance of 9,000 micromhos and is particularly suitable for use as a wide band amplifier or mixer at very high frequencies. It should not be used as a general rule as an i-f amplifier at frequencies in the region of 465 Kc/s as its high gain and high capacitance from grid to plate tend to cause instability.

This type probably has the highest stage gain of all types as a converter in the region of 60 to 150 Mc/s. It may be operated either as a pentode or, with screen connected to plate, as a triode.

Large stocks of type 6AC7/1852 are held in this country.

SUPPRESSION OF PARASITIC OSCILLATION

TYPE 807 VALVES.

It has been found that type 807, which is somewhat inclined to give trouble with parasitic oscillation under certain conditions, may be made to give satisfactory operation by the incorporation of a small resistor and by-pass condenser in the screen circuit, in the form of a suppressor resistance.

A resistance of 100 ohms has been found satisfactory when connected directly to the screen terminal of the valve, with a by-pass condenser having a capacitance of 0.01 μF. taken from the end of the suppressor resistance remote from the screen, directly to earth. The resistor should be non-inductive, and I.R.C. type F with a maximum dissipation of 2 watts has been found satisfactory. The by-pass condenser should be of the mica type.

NEW GUN FOR CATHODE RAY TUBES.

In a paper entitled "An improved Electron Gun for Cathode Ray Tubes" appearing on page 122 of the March, 1945 issue of Electronics, Mr. L. E. Swedlund of the R.C.A. Engineering Department discussed basic design factors for Cathode Ray Tubes, and traced the development leading up to the design of the new "zero-first-anode-current" gun. This improved gun, which is used in the list of Cathode Ray Tubes shown elsewhere on this page identified by suffix "-A", simplifies both the design and operation of oscillograph equipment.

Earlier cathode-ray guns employing a long first-anode structure with masking apertures drew currents which were often larger than those taken by the second anode. The large flow of current to the apertures not only necessitated the use of heavy bleeder currents and expensive power supplies but also caused interaction between brightness and focusing controls.

Mr. Swedlund points out that in the "zero-first-anode-current" gun the accelerating electrode has been lengthened to carry the masking aperture and that the first anode has been shortened and is used only for focusing. With this construction, the first anode no longer masks the electron stream and, consequently, draws practically zero current from the focusing tap on the power-supply bleeder. This feature provides better focusing characteristics, and may permit appreciable economies in the power-supply design.

A tube with the "zero-first-anode-current" gun can be operated with a beam current anywhere between zero bias and cutoff without variation in the bleeder current affecting the focusing voltage. This characteristic simplifies operation of an oscillagraph in that it is not necessary to readjust the focusing control for every change in the intensity control.

Along with the gun change, design refinements have been introduced which provide a more nearly round, smaller spot with less increase of spot size with deflection.

MODIFICATIONS TO RADIOTRON TYPES 6U7-G AND 6D6 VALVES

As indicated on the data sheet for type 6U7-G (sheet 1 dated December, 1944) the internal screen in type 6U7-G is connected to pin 5 to which is also connected the suppressor. This arrangement was adopted purposely in order to enable this type of valve to be used in certain circuits in which the cathode is above earth potential. No effect is found in normal usage since the suppressor is usually connected to the cathode at the socket and the internal screen is therefore at the same potential as both cathode and suppressor.

Type 6U7-G valves supplied against Army, Air Force or Navy Orders, are tested to JAN-1A specifications which call for connection of the internal screen to the cathode. There is, therefore, a difference between the commercial 6U7-G valves and those supplied to the services and branded JAN.

Commercial type 6D6 valves will have the same connections as type 6U7-G and the data sheet for this type (dated October, 1940) will shortly be amended to agree with this change.

INTERPRETATION OF VALVE RATINGS.

On receiving valves a question sometimes arises regarding the interpretation of the maximum plate and screen dissipation ratings. These are quite clear and definite with regard to a valve having plate and screen currents equal to the published valves, but what happens when a valve has higher than the published value of plate or screen current? Is it safe to use it under the published typical operating voltages, or must the currents be reduced by overbiasing until the dissipation comes within the maximum rating?

The answer is that the ratings are so arranged as to make allowance for the increased dissipation arising from high plate and screen currents. In other words, it is sufficient for the designer to design his set or amplifier so that, when tested with valves having published characteristics, the dissipation ratings are not exceeded. The consequences arising from higher currents which may occur with some valves are the responsibility of the valve designer and not the equipment designer.

Another question which has arisen is in connection with a pentagrid converter valve (such as type 6A8-G) in which the screen current may increase as the control grid is made more negative. This increase in screen dissipation is also covered automatically, and it is sufficient for the receiver designer to check with a valve having published characteristics at minimum bias. No increase in dissipation at more negative voltages need be considered.

A further question, which has previously been explained in Radiotronics, is regarding the screen voltages of R.F. pentodes. One of these valves may have a maximum screen supply voltage of 300 volts. In such a case it is permissible to design the equipment so as to have a screen voltage of 100 volts under minimum bias conditions, and the rise in screen voltage which occurs as the control grid is made more negative is automatically covered by the method of rating.

RADIOTRON TYPE 6V6-GT AS OSCILLATOR, R-F AMPLIFIER AND DOUBLER

Although Radiotron type 6V6-G or 6V6-GT valve is principally used as an audio frequency power amplifier, it may also be used quite successfully as an oscillator, r-f power amplifier or doubler within the limits of its frequency ratings. It may be used both for test purposes and in small transmitters, and is particularly suitable for use in the earlier stages of amateur transmitters. For a number of years it has been very successfully used as an oscillator, and for most purposes its output power is ample, so that it is quite unnecessary to use any larger or more expensive type such as 6L6-G or 807.

As an r-f power amplifier, type 6V6-GT is capable of a maximum power output in excess of 20 watts, and it makes a very satisfactory buffer provided that it is neutralised, since the grid-to-plate capacitance is too high to permit of its operation as a buffer without instability. Neutralisation is not necessary when it is used as a frequency doubler, or for this purpose it appears to be an ideal type.

The maximum ratings in regard to plate voltage, screen voltage, plate dissipation and screen dissipation are the same as for class A1 or class AB1 operation, these being given below for reference:—

Maximum Plate Voltage	315 volts.
Maximum Screen Voltage	285 volts
Maximum Plate Dissipation ..	12 watts
Maximum Screen Dissipation .	2 watts

For the maximum screen voltage of 285 volts, the control grid cut-off occurs at about — 40 volts, so that optimum grid bias for class C operation is somewhere about — 80 volts, although the precise value will depend upon the operating conditions.

As with other beam tetrode valves, care should be taken to avoid the application of full grid excitation when the plate circuit is unloaded, since under these conditions there will be extremely high voltages developed in the plate circuit which will probably result in the break-down of insulation either in the base or in the stem-press of the valve; in addition, the screen current goes up very rapidly when the plate circuit is detuned. Like other receiving valves, it does not have the margin of safety in insulation on the plate such as exists with type 807 or larger valves. Under normal operating conditions these high voltages do not develop, and the valve thus gives quite satisfactory operation.

RECENT R.C.A. RELEASES

Radiotron type OA2 is a miniature voltage regulator with characteristics somewhat similar to those of the larger type VR150/30. It maintains a d-c operating voltage of approximately 150 volts over a current range from 5 to 30 mA.

Radiotron type 2E24 is a v-h-f transmitting beam power amplifier with a quick-heating filmament designed for mobile and emergency-communications equipment. It may be operated at maximum plate input of 30 watts (CCS) or 40 watts (ICAS) in Class C telegraph service up to 125 Mc/s. and at 71% ratings up to 175 Mc/s. It can deliver an output of 20 watts (CCS) on a plate voltage of 400, or 27 watts (ICAS) on 600 volts, with a driving power of 0.2 watt. The filmament is of the coated type, operating at 6.3 volts ± 10%, and is ready for operation in less than 2 seconds after the power is turned on. It has a button stem and a T9 bulb, and is fitted with an octal base with a new short metal sleeve which provides all the screening required. The plate lead is brought out to a top cap.

Radiotron type 2E26 is a v-h-f transmitting beam power amplifier intended primarily for use in FM transmitters, although it may also be used in a-f power amplifiers and modulators. It may be operated at full input up to 125 Mc/s, and can deliver an output of 20 watts (CCS) on a plate voltage of 400 volts, or 27 watts (ICAS) on 600 volts, with a driving power of 0.2 watt. It has a button-stem and a T9 bulb, and is fitted with an octal base with a new short metal sleeve which provides all the screening required. The plate lead is brought out to a top-cap.

Radiotron type 6AK5 is a miniature r-f pentode with a sharp cut-off characteristic and a transconductance of 5,100 micromhos. Its plate dissipation is limited to 1.7 watts but, having low input and output capacitances, it is useful as an r-f amplifier up to about 400 Mc/s and may be used as a high frequency, intermediate amplifier, especially in compact lightweight equipment.

Radiotron type 6AT6 is a 6.3 volt miniature duplex-diode high-mu triode with characteristics similar to those of type 6Q7, and differing only slightly from those of type 6SQ7-GT.

Radiotron type 6AU6 is a 6.3 volt miniature sharp-cutoff r-f pentode with a transconductance of 5,200 micromhos. It is the miniature equivalent to the metal type 6SH7.

Radiotron type 6BA6 is a 6.3 volt miniature remote-cutoff r-f pentode with a transconductance of 4,400 micromhos. It is the miniature equivalent to the metal type 6SG7.

Radiotron type 6BE6 is a 6.3 volt miniature pentagrid converter with characteristics similar to those of type 6SA7-GT.

Radiotron type 6C24 is a v-h-f transmitting triode of the radiator type for use with forced-air cooling, which may be operated at 160 Mc/s to deliver an output of 1100 watts in Class C telegraphy. The plate is cooled by means of a fin-type radiator under 1.906in. diameter and 1.33in. in length; the grid is brought out to a cap at one end, while the three flexible filament leads are brought out at the other end. The maximum plate dissipation is 600 watts, and plate voltages 3000 volts, while the filament rating is 11.0 volts 12.1 amperes, thoriated tungsten.

Radiotron type 6SZ7 is a single-ended metal duplex-diode high-mu triode with a 6.3 volt 0.15 ampere heater. It has an amplification factor of 70, plate resistance 58,000 ohms and transconductance 1,200 micromhos, and is especially suitable for use in series-heater circuits.

Radiotron type 7C24 is a forced-air-cooled transmitting triode with a plate dissipation of 2 kilowatts and a maximum plate voltage of 5,000 volts at frequencies up to 110 Mc/s. It has complete shielding between filmament leads and plate, low grid to plate capacitance, and is particularly suitable for use in grounded-grid circuits. The filmament is centre-tapped, and of thoriated tungsten, while the grid supports are designed to reduce their inductance to a minimum.

Radiotron type 12AT6 is a 12.6 volt miniature duplex-diode high-mu triode, corresponding with the 6.3 volt type 6AT6.

Radiotron type 12BA6 is a 12.6 volt miniature remote-cutoff r-f pentode with a transconductance of 4,400 micromhos, corresponding with the 6.3 volt type 6BA6.

Radiotron 6AS7-G is a very low-mu twin power triode which is particularly suitable for use in regulated a.c. power supply units. It has an ST16 bulb with octal base, 6.3 volt heaters, a maximum plate voltage of 250 volts, max. plate current 125 mA per unit and max. plate dissipation 13 watts per unit. The amplification factor is 2.1 and transconductance 7,500 micromhos per unit.

Radiotron 6SB7-Y is a high-slope metal pentagrid converter intended particularly for operation in the 100 Mc/s. region. It operates on the same principles as type 6SA7, but has a conversion conductance of 950 micromhos, and a micanol wafer base.

Radiotron 117Z3 is a miniature indirectly heated high-vacuum rectifier intended for use in 117 volt ac/dc/battery-operated portable receivers. The heater current is 0.04 ampere and the maximum d.c. output current 90 mA.

Radiotron type 12BE6 is a 12.6 volt miniature pentagrid converter, corresponding with the 6.3 volt type 6BE6.

Radiotron type 26A7-GT is a single-ended twin beam power amplifier with a common cathode. It is intended especially for use in the output stage of equipment where it is desired to operate plate, screen, and heater from a 12 cell accumulator. Under these conditions it is capable of delivering an output of 200 milliwatts per unit, as a class A1 amplifier.

Radiotron type 35W4 is a miniature half-wave high vacuum rectifier intended for use in ac/dc receivers, with characteristics similar to those of type 35Z5-GT.

Radiotron type 50B5 is a miniature beam power amplifier with a maximum power output of 1.9 watts, intended for use in AC/DC receivers, with characteristics similar to those of type 50L6-GT, although not capable of such a large power output as the latter.

Radiotron type 1654 is a miniature half-wave high vacuum rectifier intended for high-voltage, low-current operation. The filament is rated at 1.4 volts, 0.05 ampere, the peak inverse plate voltage is 7,000 volts, the peak plate current 6 mA. and the average plate current 1mA. The plate is brought out to a terminal at the top of the valve.

LIGHTHOUSE VALVES.

Radiotron type 2C40 and 2C43 are triodes from whose design features their family name "lighthouse valves" is derived. These features, of great value in high frequency applications as amplifiers and oscillators, include very close inter-electrode spacing combined with low-electrode capacitances, r-f. and multiple d.c. cathode connections, and unique arrangements for connections to the plate and grid. The design of these valves is such as to facilitate their use in concentric-line circuits. An important consideration is their low frequency drift with variations in heater and plate voltages.

Radiotron type 2C40 is similar to the older lighthouse types 446-A and 446-B, which it supersedes in military equipment. In comparison with these types, the 2C40 has a slightly lower amplification factor and plate resistance, and consequently higher transconductance and plate current. As an r-f. amplifier and oscillator it is limited to a plate voltage of 500 volts, a plate current of 25 mA and a plate dissipation of 6.5 wats. As a class A amplifier operating with a plate voltage of 250 volts it has an amplification factor of 36, plate resistance 7,500 ohms, transconductance 4,800 micromhos and plate current 16.5 mA.

Radiotron type 2C43 has the same design features as type 2C40, but it has increased maximum ratings. It may be used with a maximum plate current of 40 mA and plate dissipation 12 watts while its amplification factor is 48, plate resistance 6,000 ohms, transconductance 8,000 micromhos and plate current 20 mA. Both types have 6.3 volt heaters.

Radiotron type 559 is a u-h-f diode of the "lighthouse" series. It has a 6.3 volt heater, direct inter-electrode capacitance 2.7 $\mu\mu$F. peak plate voltage 100 volts, peak plate current 200 mA. and average plate current 30 m.A maximum.

NEW CATHODE RAY TUBES.

Modifications have been made to a number of cathode ray tubes which have recently been fitted with an improved gun, known as a "zero-first-anode-current" gun which is described elsewhere in this issue. On account of the difference in the characteristics, the new versions are distinguished by a suffix –A after the former designation. These –A suffix types will supersede the earlier types when they become available, and are usuable in equipment designed for the earlier types without any modification.

The types are:—**Radiotron** 2 AP1–A, 3 AP1–A, 3 BP1–A, 5 CP1–A, 5 HP1–A, 902–A, 905–A, 908–A.

In addition to these modifications of older types of cathode ray tubes, there have also been released some new types which are described below:—

Radiotron type 3DP1–A is a 3in. radial deflection tube having a medium-persistence screen with electrostatic deflection and focus. It has an absolute maximum anode No. 2 voltage of 2,200 volts and its maximum overall length is 10¾in.

Radiotron type 3DP1S2–A is identical with type 3DP1–A except for the addition of an external scale to the screen end of the tube.

Radiotron type 3FP7–A is a 3in. tube with electrostatic focus, electrostatic deflection, and a combination of long and short persistence screens. The trace fluoresces a blue-white colour which subsides immediately leaving a yellow long-persistence phosphorescence. Its brightness, while much lower than that of the fluorescence, is considerably higher than that of screens previously available. The difference in the colours of the fluorescence and the phosphorescence permits the use, by means of colour filters, of the tube in applications requiring either a short- or long-persistence characteristic. This tube has a supplementary high-voltage anode with an absolute maximum voltage of 4,400 volts, which permits increasing the brightness of the fluorescent spot.

Radiotron type 3JP1 is a 3in. tube with electrostatic focus and electrostatic deflection and medium-persistence screen. It is fitted with a third anode having an absolute maximum voltage of 4,400 volts.

Radiotron type 5CP7–A is a 5in. tube with electroctatic focus, electrostatic deflection and a combination long- and short-persistence screen. It is fitted with a third anode which has an absolute maximum voltage of 4 400 volts. Comments for the screen material are the same as for type 3FP7-A.

NEW PHOTOTUBES

Radiotron type 1P22 is a 9 stage electrostatically focused multiplier phototube which is sensitive in the blue-green-red region (spectral response S8). Its maximum senstitivity occurs at approximately 4,200 angstroms. When it is used with Wratten No. 101 filter the response is approximately equivalent to that of the eye. It has a maximum sensitivity of 370 microamps. per microwatt, and a luminous senstitivity of 0.6 ampere per lumen. It has a current amplification of 200,000 times.