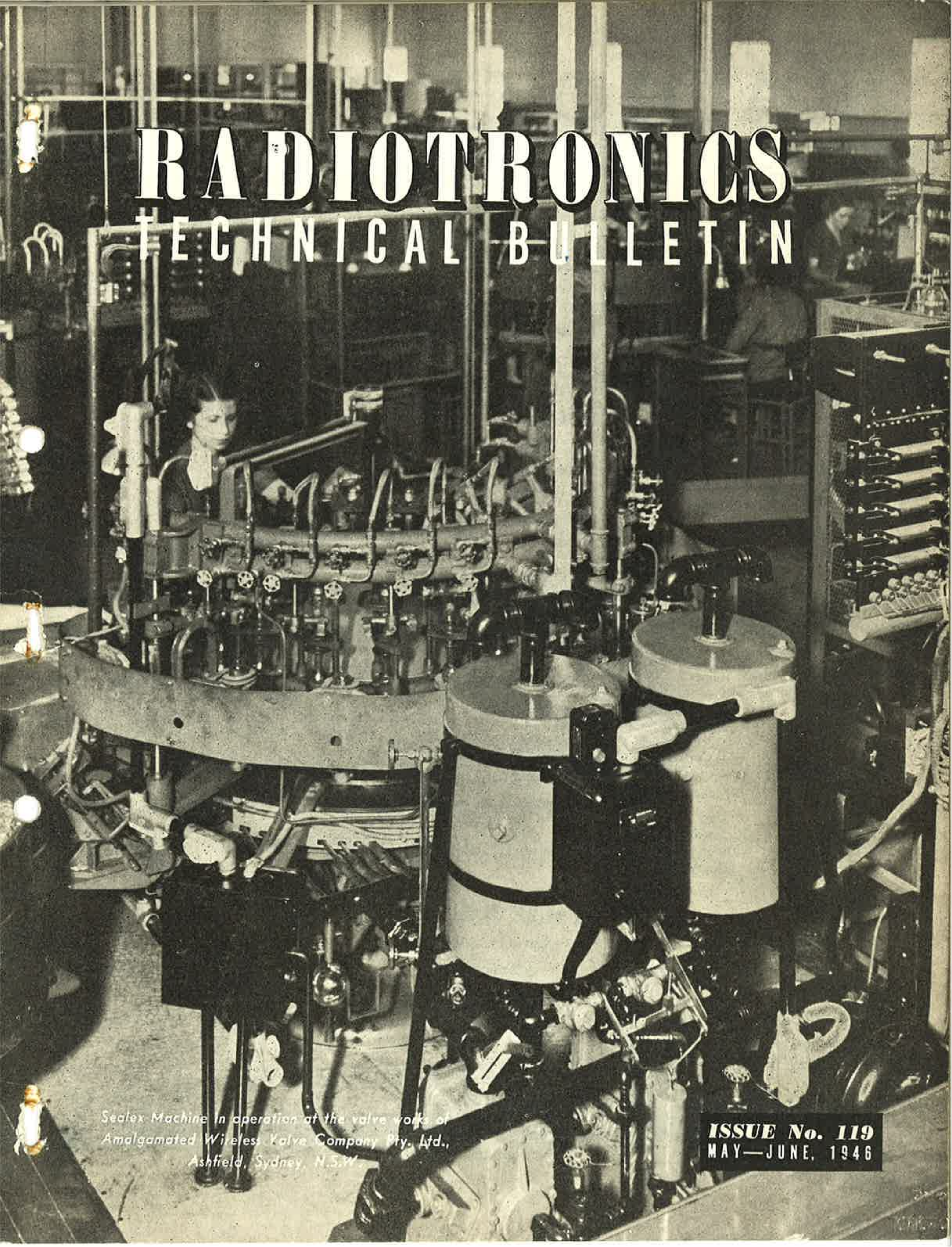
RADIOTRONICS

TECHNICAL BULLETIN



Sealex Machine in operation at the valve works of
Amalgamated Wireless Valve Company Pty. Ltd.,
Ashfield, Sydney, N.S.W.

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RADIOTRONICS

Editorial - - - - "Matters of moment"

The recent release of the report of the Parliamentary Standing Committee on Broadcasting has focussed attention on F-M, which has been further emphasized by the knowledge that experimental F-M transmitters were being erected in Sydney and Melbourne. It is important for all those engaged in radio receiver manufacture and sale, and also those engaged in broadcasting, to keep a balanced judgment, and not to become either panic-stricken or precipitate.

Like all new developments, F-M must come in gradually, but it will not supersede existing methods of broadcasting—it will add to them. So far as we can see ahead, there is no likelihood that existing medium-wave broadcasting will be discontinued, rather it may be used in due course to give better service to large areas of our great continent. Similarly short-wave A-M broadcasting is the only method so far developed to give world-wide coverage, so that it too must continue to be used, and increasingly so.

This issue of Radiotronics includes an introductory article on F-M in Australia, together with one on the choice of valve types for F-M. The following issue will cover certain aspects of F-M receiver design, including the i-f amplifier and ratio detector.

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Cover . . .

Our cover shows one of the Sealex Machines used at the Australian Radiotron factory. These machines seal the glass bulb on to the mount and then exhaust the envelope, induction heat the electrodes, drive off the getter, and finally seal off the exhaust tip.

Number 119 ★ May/June, 1946

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DESIGN SECTION:

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A Survey of F-M in Australia

It is understood that experimental F-M transmitters will shortly be operating in Melbourne and Sydney on frequencies between 88 and 108 Mc/s. These transmissions will be primarily for the purpose of enabling receiver manufacturers to carry out experiments in F-M reception which will assist them in completing the development of F-M receivers for quantity production. They are not intended, in the first stage, for general reception by the public, although anyone who owns an F-M receiver may listen in.

The two principal features of this system of transmission are the very high frequency and the method of modulation. A frequency of the order of 100 Mc/s has a normal range very little greater than the optical line-of-sight, say, about 50 miles radius. Special aerials are required, generally in the form of dipoles, which are normally erected in a suitable position outside the building. Special receivers are required, both on account of the high frequency and the method of modulation. These F-M receivers generally have more valves and other components than ordinary broadcast (A-M) receivers. The valve arrangement may include one r-f amplifier, converter, two i-f stages, limiter (not required with the ratio detector) and discriminator or ratio detector, followed by the usual audio frequency amplifier, power amplifier and rectifier.

The use of the ratio detector (described elsewhere in this issue) enables one valve to .be omitted for approximately the same performance when compared with the discriminator/limiter arrangement. Even so, a typical good F-M receiver incorporates 8 valves.

Owing to the higher frequency, and the flat-top on the i-f selectivity characteristic, the gain per stage is very much less than with an ordinary A-M broadcast receiver. A good 8 valve F-M receiver may actually be less sensitive (as measured in microvolts input to the aerial terminal) than a 5 valve A-M receiver on the medium wave-band. This reduced gain per stage would be even lower, only that high-slope r-f pentodes are used in the r-f and i-f stages, with a transconductance two or three times normal.

As described elsewhere in this issue, we have standardized on types 6BA6 (miniature r-f pentode) and 6BE6 (miniature converter) to cover the r-f and i-f stages of F-M receivers, and intend to manufacture them in Australia. With these valves a possible arrangement for an 8 valve F-M receiver would be:—

R.F. Amplifier	6BA6
Converter	6BE6
1st I.F. Amplifier	6BA6
2nd I.F. Amplifier	6BA6
Ratio Detector	6H6-GT
A.F. Amplifier	6SQ7-GT or equivalent
Power Amplifier	6V6-GT
Rectifier	5Y3-GT

A smaller and cheaper set might be made by omitting the r-f stage or one of the i-f stages—thus reducing the number of valves to seven. On present indications, it seems that 8 valves will be the minimum to give satisfactory reception over the whole optical-range area, while 7 valve sets might prove satisfactory under favourable conditions over a smaller area. At the present time, there is insufficient information available for any decision to be reached regarding the minimum number of valves which may be used in an F-M receiver to provide barely satisfactory reception in areas of high signal strength.

The Greatest Problem

The greatest problem facing us at the present time is not the design or manufacture of F-M receivers, but the combination of A-M and F-M in the one receiver with medium-wave, short-wave, and very-high-frequency ranges. There is no doubt that one very satisfactory arrangement would be the use of one dual-wave or all-wave receiver for A-M, and a second receiver for F-M. Even if the owner used his F-M receiver for all local reception (when all metropolitan stations are duplicating their transmissions on F-M), he would still require his A-M receiver to listen to international shortwave broadcasting. He might even use his medium-wave band for tuning in some distant A-M station as, for example, many Sydney people tune in to one of the powerful New Zealand stations when they are unable to listen to a local programme to their liking.

What amounts to almost the same thing, is a receiver with separate A-M (medium and short-wave) and F-M channels, in which the audio amplifier and loudspeaker are common to both channels. This would be cheaper to manufacture than two separate receivers, and would be the natural choice for a person not already owning an efficient A-M receiver. The better type of F-M receivers now sold in U.S.A. are of this type, and use up to 24 valves. Good results under Australian conditions would be given by 11 valves (8 for F-M plus an additional 3 for the A-M channel). With this separate channel arrangement, each channel may be designed for its own limited purpose, and the best results obtained from each. The switching is relatively simple, and service troubles should not be serious.

Trouble arises immediately an attempt is made to combine the two channels to save cost. The valve types for the r-f and i-f stages must be of the high-slope variety which are rather unsatisfactory on A-M. The high slope r-f amplifier may be beneficial on the short-wave band, but is likely to cause overloading of the converter on strong signals; this effect may be overcome by reducing the gain in the r-f transformer. In the i-f amplifier the gain is so high that it is completely unusable on A-M. Each valve has over twice the transconductance of type 6SK7-GT, and there are two or more stages. Various expedients may be adopted to reduce the i-f gain to a practicable figure—such as high loss transformers, heavy shunting, tapping-down, or a combination of two or more. The method adopted should be part of the i-f transformer so as to avoid additional switching. The screen should be supplied through a dropping resistor so as to avoid serious over-loading and modulation-rise.

It seems to be simpler to retain the ratio detector or discriminator for F-M and to use separate diodes for A-M detection and A.V.C., which may be part of a diode-triode or diode-pentode a-f amplifier. The switching must cover the aerial coil, r-f transformer, oscillator coil, i-f transformers, and small series and shunt capacitors in each section of the gang condenser.

It is still too early to say whether or not the limiter/discriminator has any important advantages over the ratio detector, but if it is adopted in the larger and more expensive receivers, this will mean the addition of at least one more valve.

If the full advantages of improved quality, or which F-M is capable, are to be obtained, the receiving set must have higher power output, less harmonic distortion, and wider audio frequency range than normal receivers. These are generally covered by the careful design of push-pull amplifiers with a high degree of negative feedback, possibly with two a-f channels, and multiple loudspeakers. At least two loudspeakers are required, with a suitable cross-over network, and the bass speaker or speakers should have high acoustic loading as provided by a low frequency horn, labyrinth or vented baffle—the last being the most likely to prove popular owing to its lower cost.

Alternatives Facing Receiver Manufacturers

Alternatives facing receiver manufacturers in the choice of models for production include:—

1. A-M medium band only.
2. A-M dual-wave.
3. A-M all-wave or multi-band.
4. F-M only.
5. F-M/A-M medium band only.
6. F-M/A-M dual wave.
7. F-M/A-M all-wave or multi-band.
8. F-M/A-M shortwave band only.
9. F-M/A-M multi short-wave bands only.

This formidable list is one to frighten any receiver manufacturer, and each will do his best to reduce the number. Fortunately, at this stage, it seems sufficient to restrict the power source to a.c. mains, since d.c. areas are rapidly being eliminated and dry-battery-operated F-M receivers are not yet in sight.

The only logical approach is to look at the whole position with an open mind, and weigh up the various possibilities.

After the first step of experimental F-M transmission, the second step will probably be the F-M duplication of existing metropolitan transmitters. A third step might mean the addition of F-M transmitters which do not transmit on A-M. A fourth step might involve the shutting down of metropolitan A-M transmitters and the transference of their licenses to rural areas.

Looking at these in turn, the experimental period may be passed over owing to the lack of F-M receivers. The duplication of existing transmitters would mean that either F-M or A-M reception would be possible, so that everybody would be happy. The addition of further F-M transmitters would not seriously affect owners of A-M receivers since they would have as many alternative stations as at present. No one is likely to disagree with any action up to this stage, but the shutting down of metropolitan A-M transmitters will undoubtedly cause such a storm of protest if there is any substantial percentage of the population still without F-M receivers, that it may be deferred for a further period until practically all the listening public have facilities for listening to F-M.

There appear to be two classes of receivers which, at the present time, cannot be duplicated by F-M receivers. The first of these is the small 4 valve table model receiver which, with our present knowledge of design, has no counterpart in F-M. Although these small cheap sets are largely used as second sets in the home, there seems good reason to believe that many families have no other form of receiver and they may be averse to purchasing a larger F-M receiver costing considerably more than the one they already own.

The second type of receiver in this group is the portable set which, at the present time, uses 1.4 volt valves of the miniature construction operating from dry batteries for both filaments and plates. No valves of this class have yet been manufactured suitable for use in portable F-M receivers, although it would be rash to make any statement regarding the future. It may therefore be some considerable time before portable F-M receivers are an accomplished fact. In the meantime, any shutting down on A-M Stations would cause portable sets to be made useless, and such a step would probably be deferred until some satisfactory substitute can be found.

As the result of the very gradual obsolescence of existing receivers and the fact that A-M receivers will undoubtedly be manufactured in considerable quantites even after the introduction of F-M, it seems that the final stage of shutting down A-M transmitters is likely to be deferred for at least 10 years and possibly more. With our present lack of knowledge, it would be foolish for anyone to attempt to prophesy what lies more than 10 years ahead. We can, however, see ahead for about 10 years and may assume, quite reasonably, that A-M transmission will be available in all areas as at present, for that period of time.

Accepting this as a substantial and logical argument, we now have to examine the choice of models for production. In weighing up the various points, it is necessary to remember that there will be a demand for A-M receivers for use in country towns and other areas with A.C. Supply Mains which will call for receivers not providing F-M reception.

Receivers covering the A-M medium band only are likely to be sold on account of their low cost, and possibly small size, in country towns and in metropolitan and closely settled areas. It seems likely that the demand for the small, cheaper table models will be much greater than for larger or console models.

Many country areas will call for A-M dual wave receivers as at present, and a higher percentage is likely to be in console cabinets than for the previous class.

There will also undoubtedly be some call for A-M all-wave or multi-band receivers for use in areas without F-M, but the quantity of this class will probably be less than that before the advent of F-M.

The demand for F-M receivers which are incapable of tuning in A-M stations is difficult to assess, but it is likely to be very limited until the number of F-M stations has increased sufficiently to provide adequate choice of programmes, and the purchaser may be prepared to sacrifice listening to international short-wave and medium-wave A-M stations.

F-M/A-M medium band receivers do not seem likely to be very popular since the A-M will merely duplicate the existing transmission of F-M. If an F-M/A-M receiver is to be manufactured, the additional cost of one short-wave band is not excessive, and most people would probably be prepared to pay the difference.

F-M/A-M dual-wave receivers will probably be popular since they may be used in any area throughout the country where a.c. power is available. They would enable the owners to tune to any type of transmission under any conditions likely to be encountered. This group would be in two main classes, the more expensive ones having two r-f/i-f channels and the cheaper ones a single channel with switching. The more expensive receivers might also include a better quality audio frequency amplifier and loudspeaker system, possibly also with a built-in turntable.

F-M/A-M all-wave or multi-band receivers will undoubtedly be less popular than the dual-wave class owing to their greater cost and complexity, but they would be the ideal from the point of view of those looking for the best type of set irrespective of price.

F-M/A-M short-wave band receivers are not likely to be popular in the early stages, but they may have a market at a later period even though limited to areas covered by F-M stations.

F-M/A-M multi-short-band receivers appear likely to be a specialty item which would have more limited sales than the preceding group and would definitely be in the high price class. Since the extra cost of adding the medium band is quite a small percentage of the total cost, there seems very little justification for bringing out receivers of this type.

Summing Up:

For the time being, it seems likely that A-M medium band table models will sell in large numbers, although their sales will undoubtedly decrease as F-M becomes more popular. Most large manufacturers will also probably manufacture either A-M dual-wave or multi-band receivers for use in areas not covered by F-M. These A-M receivers will all be much the same as existing models although possibly with minor improvements.

Receivers capable of reproducing F-M may be divided into two classes: the F-M receiver only, and the combined F-M/A-M type. It seems likely that the majority of the "combined" class will include the shortwave band or bands and substantial numbers also the medium band. Although this type of receiver is most desirable from all points of view other than cost, it seems likely that the cost factor will limit sales.

It is difficult to estimate the public's reaction to such combined receivers at fairly high prices, which will undoubtedly affect the proportion of sales in the various categories. Some manufacturers may prefer to restrict the number of types of receivers which they are prepared to produce. There seems to be no reason why every manufacturer should be called upon to produce a model for every conceivable combination of method of transmission, frequency and power supply. Just as no motor car manufacturer attempts to bring out a model for every class of customer, so there should be no necessity for every receiver manufacturer to cater for numerous small minor demands for special and limited application. There might be evolved an arrangement suited to Australian conditions, whereby some manufacturers specialize in a particular type of receiver, and other firms may limit their production to different types of receivers. This would be particularly helpful to the smaller manufacturers, but it might also be adopted in a modified form by the larger manufacturers.

Extract from F.C.C. Recommendations on F-M Engineering Practice

This extract covers some of the more general points recommended by the F.C.C. (U.S.A.) as standards for good engineering practice with frequency modulated equipment. Full details of the report are printed in "F.M. and Television" for October, 1945.

The frequency range recommended is from 88 to 108 Mc/s, which includes those frequencies allocated to non-commercial educational broadcasting. The first frequency allocation is 88.1 Mc/s with each successive allocation to follow in 200 Kc/s steps up to 107.9 Mc/s; the centre frequency of the transmitter must be within ± 2Kc/s of the assigned frequency. Objectionable interference is not considered to exist when the channel separation is 400 Kc/s or greater, so that F-M stations in the same area may be assigned channels 400 Kc/s apart.

A frequency swing of ± 75 Kc/s is recommended and this is defined arbitrarily as being 100% modulation. Percentage modulation on this basis, will be defined as the ratio of the actual frequency swing to the frequency swing defined as 100% modulation.

Horizontal polarization of the transmitted wave is recommended as standard, but vertical polarization may be authorized in circumstances which show it to be desirable.

The system is to be capable of transmitting a band of frequencies from 50 to 15,000 C/s, and pre-emphasis is to be in accordance with the frequency-impedance characteristic of a series inductance-resistance network having a time constant of 75 micro-seconds. Deviation of the system response must be between the two limits indicated on the standard pre-emphasis curve. Standards regarding maximum permissible distortion at various audio frequencies are also indicated.

The F.C.C. report is extensive and should be consulted by those requiring any further details.

INTERMEDIATE FREQUENCY

It has been proposed by the R.M.A. Standards Committee that an intermediate frequency of 10.7 Mc/s be adopted for use with v-h-f receivers.

The Ratio Detector

It had been intended to include in this issue an article on the "ratio detector," one of the most important developments in F-M receiver design. This has had to be deferred until the following issue, but opportunity will be taken to deal with it in greater detail than had originally been intended.

Those interested in the subject are referred to the following descriptions, although neither is complete:—

1. "A new F-M detector circuit," Q.S.T. January, 1946, p. 26.

2. Peters, R.F. "F-M ratio detectors," Communications November, 1945, p. 42.

Radiotron Type 1R5 Converter Operation

Radiotron type 1R5 is a pentagrid converter of the same general structure as type 6SA7-GT, having a suppressor grid to increase the plate resistance but without the "anode grid" as in type 6A8-G. By this means a fairly high conversion conductance is obtained with a plate resistance of 0.5 megohm or above. One of the principal advantages of this construction is that it enables the oscillator section of the valve to be designed with a high oscillator transconductance. This is particularly important in the case of a battery valve which is required to operate with a comparatively low nominal B-battery voltage, and to continue operating until the actual voltage drops to about half the nominal voltage.

Other types of converters may be used on the broadcast band but are difficult to handle on the shortwave band, particularly with battery voltages of 90 volts or less. Type 1R5 is capable of giving good operation both on the broadcast band and on the 6—18.2 Mc/s shortwave band with nominal B-battery voltages of 67.5 volts, dropping to 36 volts while at the same time the A-battery voltage drops from the nominal value of 1.4 volts to 1.1 volts. One complication arising from the omission of the "anode grid" is that the oscillator voltage appears on the screen and has the effect of reducing the conversion gain. The choice of oscillator coils is therefore important, since too low a value of oscillator voltage causes inefficient operation, while too high a value again results in a loss of gain through the effect just mentioned.

There are two principal methods of arranging the oscillator in type 1R5, the first being the tapped coil with the filament taken to the tapping point; the other the more usual type of double wound coil of which the primary is inserted in the common screen and plate return to B+.

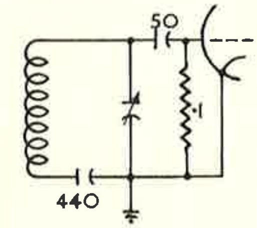

FIG. 1

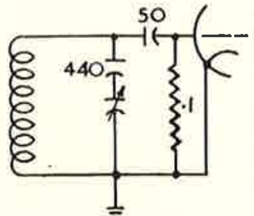

FIG. 2

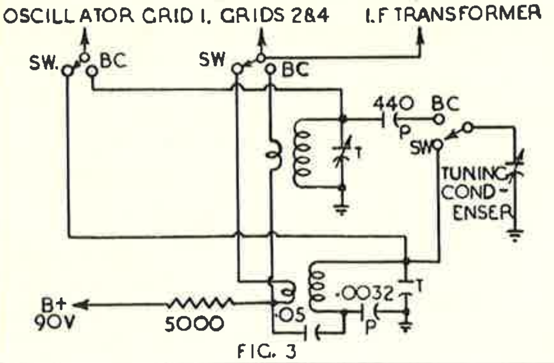

FIG. 3

The choice of coils was carefully investigated in our Applications Laboratory and satisfactory results achieved. Instead, however, of merely giving the final results in the form of recommendations, we give below the details of the approach to the problem and the results obtained with the various arrangements. Readers of Radiotronics will therefore be able to see for themselves why one particular design of coils has been adopted, and what results would be likely to be obtained from different forms of coils.

Experimental Development of Optimum Coil Design

Information given in the "Application Note on the R.C.A. Miniature Tubes" formed the basis for a design. The tapped oscillator coil, similar to the preferred circuit for type 6SA7-GT, seemed to offer advantages over the double-wound coil. The circuit itself is shown in circuit II of fig. 1 in the Applications Note and also on sheet 4 of type 1R5 in the Data Book.

Commencing with the broadcast band, a grid coil of 100 turns of 31 B & S.E. was wound on a $\frac{3}{4}''$ former and provision made to tune it with a 440 $\mu\mu$F. padder and a $\frac{3}{8}''$ diameter × $\frac{1}{2}''$ long iron slug. In conjunction with a standard condenser gang, the tuning range is 540 Kc/s. to 1600 Kc/s. A number of taps were brought out every two turns from 10 to 20 turns from the earthy end. The procedure was to vary the feed-back by the tap position, taking performance measurements for each degree of feedback. The choke for the A+ filament lead was $1\frac{7}{8}''$ winding length of 28 B & S.E. wound on $\frac{1}{2}''$ former. Measured at 2 Mc/s., this had an inductance of 43 μH. If the choke used in this position is low in reactance, it has a shunting effect on the feedback at lower frequencies; however, 43 μH. appears to be quite adequate at 540 Kc/s. even for high feedback tapping positions.

An arrangement which avoids the use of the choke consists of another winding directly over the feedback section of the tuning coil and having the same number of turns but insulated from it for a potential difference of 1.4 volts. F+ is supplied through this winding and F— through the tapped tuning coil. This would probably be less expensive to manufacture than the simpler coil plus choke. The oscillator performance is not affected by the choice between these two arrangements, assuming the potential drop in the filament supply to be neglible in each case.

Experiments indicated that best results would be obtained with the tap at 14 turns, giving a stage gain of the order of 19 times Oscillator voltage (e_o) on the oscillator grid (g_1) was 8.0 Vrms at 550 Kc/s and 13.4 Vrms at 1500 Kc/s, and the voltage (e_k) on the cathode 1.6 Vrms at 550 Kc/s and 1.8 Vrms at 1500 Kc/s. These results were obtained with new batteries, and there does not appear to be sufficient safety margin for the end-of-battery-life conditions.

Leaving the broadcast band, a similar procedure was followed for the shortwave band. Then, with a grid coil of 8.2 turns of 22 B & S.E., wound 16 T.P.I. on a ¾″ former with a slug ⅜″ diameter × ½″ long and a padder of 0.0032 μF., the best results were obtained with a tapping position of 2.0 turns from the earthy end. Results were:—

frequency	e_o	e_k	I_{c1} (Grid No. 1 Cur.)	M. (stage gain)
6.0Mc/s.	4.3Vrms.	1.6Vrms	22mA.	14.7
18.2Mc/s.	12.6Vrms.	4.6Vrms.	85mA.	12.1

The margin of reserve oscillator voltage here is far too small at the 6.0 Mc/s end of the band. A grid current of 20 μA. is the minimum desirable value, and this should be secured with batteries at the end of their useful life—in this case Ep = 36V. and E_F = 1.1V. It appears impossible to secure an adequate margin of grid current with this type of feedback. The maximum grid current resulted with the tap at 3.0 turns from the earthy end; even so I_{ci} at 6.0 Mc/s was only 25 μA. with new batteries and the stage gain was then only 7.7 times at 6.0 Mc/s and 4.05 at 18.2 Mc/s.

The arrangement set out in circuit I of fig. 1 of the application note and data book offers greater opportunity for securing increased coupling between plate and grid windings. The modification shown in circuit B of fig. 5 (Sheet 5 in the Data Book) was selected, with 67.5V applied to both plate and screen ($g_{2\&4}$). The improvement in conversion transconductance resulting from applying 90V to the plate does not seem to be worth the extra voltage dropping resistor and bypass condenser necessary. The same general procedure was followed as with the tapped coil feedback. The plate coil was varied to find the optimum—which is considered as a compromise between stage gain, minimum I_{c1} with low batteries, and band coverage. This latter is the factor on the shortwave band limiting the size of the feedback coil. Best results were obtained with a 3.8 turn feedback coil. Then I_{c1} at 6.0 Mc/s was 80 μA. At 18.2 Mc/s there was a tendency to squegg—even with a grid capacitor of 50 μμF. and grid leak of 0.1 megohm. Including a 15 ohm grid stopper resistor between the grid and its associated leak and capacitor cured this fault. As the value of 80 μA. is still less than optimum, padder feedback was added to increase I_{c1} at the low frequency end of the band, the results being:—

Frequency	I_{c1}	M.
6.0 Mc/s	100 μA	15.4
18.2 Mc/s	135 μA	37.0

The effect of a negative bias applied to the signal grid (g_3) was then investigated. From the conversion transconductance curves in the data book, it would seem desirable, for maximum gain, to operate the signal grid (g_3) with zero bias. However, it should be noted that these curves are drawn for zero oscillator potential on both filament and screen, and some modification may be necessary under operating conditions. Our experiments indicated a definite improvement resulting from the application of —3.0V. bias to the signal grid; the stage gain at 6.0 Mc/s being increased and the stability of the oscillator so improved at 18.2 Mc/s that the grid stopper was unnecessary. The stage gain at 18.2 Mc/s was slightly reduced, but as this appears to be artificially high in any case, the reduction is not a serious disadvantage.

With the signal generator coupled directly to the signal grid of the converter, there is no need for neutralisation. However, with the normal tuning circuit, neutralization is necessary, as pointed out in the data sheets. A very simple and effective indicator is a valve voltmeter connected between ground and the signal grid; then, in the absence of an input signal, any potential appearing here must be of oscillator frequency. The neutralizing condenser C_n can then be adjusted to minimize this potential. As an example of the order of magnitude, our circuit measured 6.0 Vrms. on g_3 with C_n = 0; this was reduced to 0.2 Vrms with C_n = 3.5 μμF.

The neutralising condenser should be connected in the circuit so that it is removed for broadcast band operation. It may even be desirable to substitute another neutralising condenser for this tuning range. With C_n = 5 μμF., the oscillator potential on g_3 at 1600 Kc/s was measured as 2.4 Vrms. Removing C_n reduced this to 0.88V., and adjusting C_n to 1.5 μμF. caused the potential to fall to 0.38V.

With the signal generator connected to g_3, and g_3 biased to —3.0V., with 67.5V. on the plate and grids 2 and 4, the following results were measured:—

Frequency	I_{c1}	e_0	e_2	M.
6.0 Mc/s.	72 μA.	10.3 Vrms.	6.0 Vrms.	19.8
9.0 Mc/s.	110 μA.	15.3 Vrms.	7.5 Vrms.	25.5
12.0 Mc/s.	140 μA.	19.0 Vrms.	9.2 Vrms.	24.2
15.0 Mc/s.	155 μA.	20.5 Vrms.	10.6 Vrms.	26.2
18.2 Mc/s.	145 μA.	19.8 Vrms.	11.3 Vrms.	27.0

The end of useful battery life I_{c1} was 25 μA. at 6.0 Mc/s. for an average valve.

The short-wave coil details are:—

Grid winding, 8.2 turns 22 B & S.E. wound 16 T.P.I.
Feedback winding 3.5 turns 44 SWG.DSC. interwound on earthy end.
Former ¾″ diameter.
Slug ⅜″ diameter × ½″ long, in grid end.
Padder 0.0032 μF.

Broadcast Band

For broadcast band operation, a tickler coil of 20 turns seemed likely to be optimum, but results were not good. This was due to the large variation in I_{c1} over the band which made it impossible to

(Continued on page 60)

Examination of Conditions which Give Rise to Hum Due to Heater-Grid Capacitance

This topic, which is apparently of general interest, has previously been treated in R.C.A. Application Note No. 88, reprinted in Radiotronics, No. 87.*

An examination is made below of the various conditions which may give rise to hum due to heater-grid capacitance. Derivations are included of formulae from which the magnitude of the hum voltage may be evaluated. These formulae are the same as those quoted in the Application Note, and it is shown that they are approximations only, but give results which are accurate enough for practical purposes.

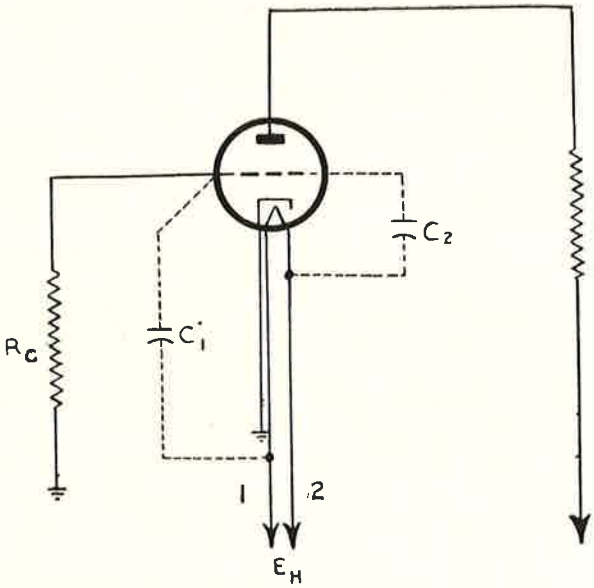

FIG. 1

Consider the circuit shown in figure 1 in which

E_h = heater voltage.
C_1 = capacitance between grid and heater lead 1,
C_2 = capacitance between grid and heater lead 2,
R_g = grid resistor.

Two cases may be treated as a first step—with heater lead 1 earthed, and then, as an alternative, with heater lead 2 earthed.

CASE 1—HEATER LEAD 1 EARTHED

The equivalent circuit for this condition is shown in figure 2.

Then $E_g = I_2R_g$ = hum voltage applied to grid.

$$\text{Write } Z_1 = \frac{1}{j\omega C_1}, \quad Z_2 = \frac{1}{j\omega C_2}.$$

Mesh 1.

$$I_1 (Z_1 + Z_2) - I_2Z_1 - E_h = 0.$$

Mesh 2.

$$-I_1Z_1 + I_2 (R_g + Z_1) = 0.$$

Solving these two equations simultaneously by determinants to find I_2:

$$\frac{-I_2}{\begin{vmatrix} Z_1 + Z_2 & -E_h \\ -Z_1 & 0 \end{vmatrix}} = \frac{1}{\begin{vmatrix} Z_1 + Z_2 & -Z_1 \\ -Z_1 & R_g + Z_1 \end{vmatrix}}$$

$$\therefore I_2 = \frac{E_h.Z_1}{Z_1.R_g + Z_2 (R_g + Z_1)}$$

but since $E_g = I_2.R_g$,

$$\therefore E_g = I_2R_g = \frac{E_h.Z_1.R_g}{Z_1.R_g + Z_2 (R_g + Z_1)}$$

Now for most practical cases,

$$Z_2 = \frac{1}{j\omega C_1} \gg R_g$$

$$Z_1 = \frac{1}{j\omega C_2} \gg R_g$$

$$\therefore E_g = \frac{E_h.Z_1 R_g}{Z_1.Z_2} \text{ approx.}$$

$$= \frac{E_h.R_g}{Z_2} \text{ approx.}$$

$$= jE_h.R_g.\omega C_2 \text{ approx.}$$

$$\text{and } |E_g| = |E_h|R_g\omega C_2 \text{ approx.} \quad \ldots\ldots\ldots\ldots \quad (1)$$

CASE 2—HEATER LEAD 2 EARTHED.

The equivalent circuit to be considered is shown in figure 3.

Again $E_g = I_2.R_g$ = hum voltage applied to grid

$$\text{and } Z_1 = \frac{1}{j\omega C_1}$$

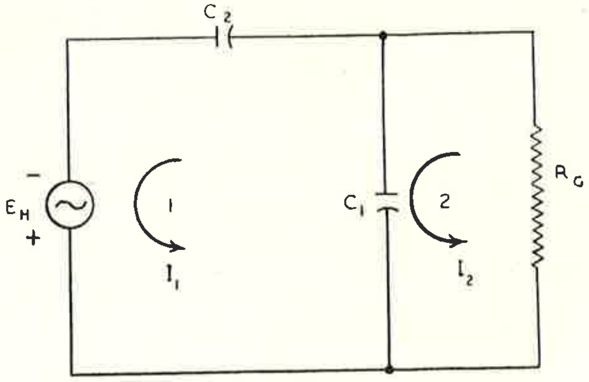

FIG.2

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* Now out of print.

$$Z_2 = \frac{1}{j\omega C_2}$$

Mesh 1.

$$I_1\ (Z_1 + Z_2) - I_2\ Z_1 + E_h = 0$$

Mesh 2

$$-I_1\ Z_1 + I_2\ (R_g + Z_1) - E_h = 0$$

Solving these two equations for I_2,

$$\frac{-I_2}{\begin{vmatrix} Z_1 + Z_2 & E_h \\ -Z_1 & -E_h \end{vmatrix}} = \frac{1}{\begin{vmatrix} Z_1 + Z_2 & -Z_1 \\ -Z_1 & R_g + Z_1 \end{vmatrix}}$$

$$\therefore\ I_2 = \frac{E_h\ (Z_1 + Z_2 - Z_1)}{Z_1.R_g + Z_2\ (R_g + Z_1)}$$

$$= \frac{E_h.Z_2}{Z_1.R_g + Z_2\ (R_g + Z_1)}$$

$$E_g = I_2R_g = \frac{E_h.Z_2.R_g}{Z_1.R_g + Z_2\ (R_g + Z_1)}$$

as before,

$$Z_1 \gg R_g$$

$$\text{and } Z_2 \gg R_g$$

$$\therefore\ E_g = \frac{E_h.Z_2.R_g}{Z_1.Z_2} \text{ approx.}$$

$$= \frac{E_h.R_g}{Z_1} \text{ approx.}$$

$$= jE_h.R_g\ \omega\ C_1 \text{ approx.}$$

$$\text{and } |E_g| = |E_h|\ R_g\ \omega\ C_1 \text{ approx.} \quad \ldots\ \ldots \quad (2)$$

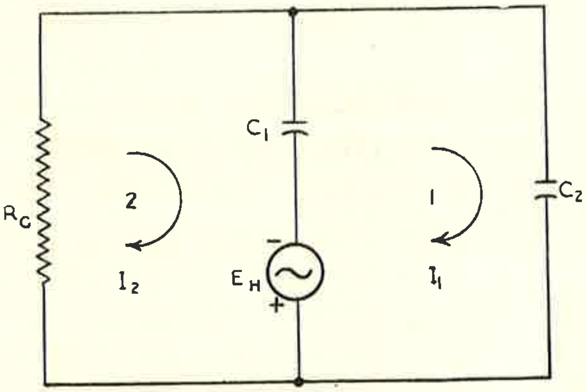


FIG. 3

From the results above, it becomes clear that earthing either lead 1 or lead 2 can give rise to different hum voltages on the grid of the valve being considered. Usually the values of C_1 and C_2 are nearly equal, so that it is often not very important which heater lead is earthed. It should be borne in mind, however, that a difference does exist and under certain circumstances it is possible to reduce hum due to these causes by interchanging the position of the heater-earth lead.

To obtain an idea of the order of the hum which may be present due to these effects take the solution for Case 1—Equation 1:

$$|E_g| = |E_h| R_g\ \omega\ C_2 \text{ approx.}$$

For a typical amplifier valve

$$|E_h| = 6.3\text{V.}$$

$$R_g = 1 \text{ megohm}$$

$$\omega = 2\pi f$$

$$= 2\pi \times 50$$

$$C_2 = 1\ \mu\mu\text{F.}$$

$$\text{Then } |E_g| = 6.3 \times 1 \times 10^6 \times 2\pi \times 50 \times 1 \times 10^{-12} = 1.98 \text{ millivolts approx.}$$

So that it is seen that this effect may be serious if a high gain amplifier is employed, particularly if care is not taken to keep to a minimum the stray capacitances shunting C_1 and C_2.

In many applications the hum may be excessive with either of these connections, and it is preferable to use the arrangement shown in figure 4. This utilizes a simple bridge arrangement for reducing to zero the hum voltage E_g due to E_h, across R_g.

The condition for balance in the circuit of figure 4 is:—

$$\frac{R_1}{R_2} = \frac{C_2}{C_1}$$

R_1 and R_2 may be set by using a variable resistance and adjusting for balance. Usually in practice C_2 and C_1 are very nearly equal, and it is sufficient to use an ordinary centre-tapped resistance, a suitable value being of the order of 50 ohms total.

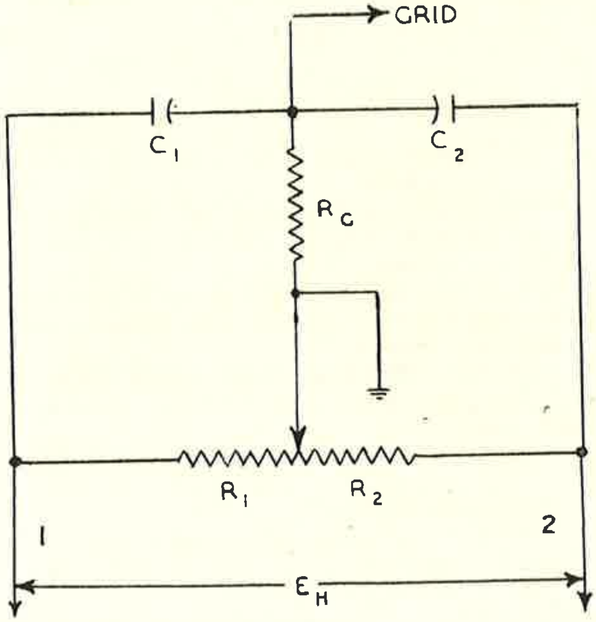


FIG.4

Pentode/Triode Characteristics

Procedure for Calculating One from the Other.

Frequently it is desired to learn the triode characteristics of a pentode valve, and the correct procedure is so simple that anyone can apply it directly.

When the cathode current of a valve is shared by two collecting electrodes (e.g. plate and screen) the mutual conductance of the whole cathode stream (i.e. the "triode g_m") is shared in the same proportion as is the current.

Let i_k = cathode current
i_{g2} = screen current
i_p = plate current
g_m = pentode transconductance (on the plate)
g_t = triode transconductance (with screen and plate tied together)
g_s = screen transconductance (with pentode operation)

Then $i_k = i_{g2} + i_p$ .... (1)
$g_t = g_m + g_s$ (by definition) .... (2)
and $g_m/g_t = i_p/i_k$ .... (3)

If it is desired to find the screen transconductance, this can be derived from the expression

$g_s/g_m = i_{g2}/i_p$ .... (4)
or $g_s/g_t = i_{g2}/i_k$ .... (5)

Examples of Transconductance Calculation

Example 1:—Type 6J7-G, as a pentode with 100 volts on both screen and plate, and with a grid bias of –3 volts, has the following characteristics:—

Transconductance	1185 micromhos
Plate Current	2.0 mA.
Screen Current	0.5 mA.

It is readily seen that the cathode current (see equation 1 above) is given by

$$i_k = 0.5 + 2.0 = 2.5 \text{ mA.}$$

The triode transconductance is calculated by inverting equation (3) above,

$$g_t/g_m = i_k/i_p$$
$$\therefore \; g_t/1185 = 2.5/2.0$$
$$\therefore \; g_t = 1482 \text{ micromhos.}$$

The example selected was purposely chosen so as to have equal plate and screen voltages. Under these conditions the method is exact, and the calculated triode mutual conductance applied to the same conditions of plate and grid voltages as for the pentode operation (in this example 100 volts and —3 volts respectively).

Example 2:—Type 6J7-G as a pentode with 250 volts on the plate, 100 volts on the screen, and –3 volts grid bias.

In this case a similar method may be used, but it is necessary to make an assumption which is only approximately correct. Its accuracy is generally good enough for most purposes, the error being within about 5% for most conditions.

The assumption (or approximation) which must be made is—*That the plate current of a pentode valve does not change as the plate voltage is increased from the same voltage as that of the screen up to the voltage for pentode operation.*

This assumption means, in essence, that the plate resistance is considered to be infinite—a reasonable approximation for most r-f pentodes, and not seriously in error for power pentodes and beam power valves.

In this typical example, we can take the published characteristics, and assume that the plate current and transconductance are the same for 100 as for 250 volts on the plate. From then on the procedure is exactly as in the previous example. It is important to note that the calculated triode characteristics only apply for a triode plate voltage of 100 volts and a grid bias of —3 volts.

Example 3:—To find the screen transconductance under the conditions of Example 1.

From equation (2) we may derive the expression—

$$g_s = g_t - g_m$$
$$= 1482 - 1185$$
$$= 297 \text{ micromhos.}$$

This could equally well have been derived from equation (4) or (5).

Triode Amplification Factor

The triode amplification factor (if not available from any other source) may be calculated by the following approximate method.

Let μ_t = triode amplification factor
$e_{c.o.}$ = negative grid voltage at which the plate current just cuts off
and e_{g2} = screen voltage
Then $\mu_t = e_{g2}/e_{c.o.}$ approx. .... (6)

For example, with type 6J7-G having a screen voltage of 100 volts, the grid bias for cutoff is indicated on the data sheet as being —7 volts approx. This is the normal grid bias for complete plate current cutoff, but it is not very suitable for our purpose since equation (6) is based on the assumption that the characteristic is straight, whereas it is severely curved as it approaches cutoff. The preferable procedure is to refer to the plate current-grid voltage characteristic, and to draw a straight line making a tangent to the curve at the working point—in this case with a screen voltage of 100 volts and grid bias —3 volts. When this is done, it will be seen that the tangent cuts the zero plate current line at about —5 volts grid bias. If this figure is used, as being much more accurate than the previous value of —7 volts, the triode amplification factor will be

$$\mu_t = 100/5 = 20$$

Alternatively, if only the plate characteristics are available, much the same result may be obtained by observing the grid bias for the lowest curve, which is generally very close to plate current cutoff.

In the case of remote cutoff (super-control) characteristics it is essential to adopt the tangent method, and the result will only apply to the particular point of operation, since the triode amplification varies along the curve.

The amplification factor of the screen grid in a pentode valve with respect to the control grid is the same as the triode amplification factor.

The amplification factor of the plate of a pentode valve with respect to its screen grid may be calculated from the expression—

$$\mu_{g1.p} = \mu_{g1.g2}\ \mu_{g2.p} \quad \ldots\ldots\ldots\ldots \quad (7)$$

where $\mu_{g1.p}$ = pentode amplification factor
$\mu_{g2.p}$ = screen grid-plate amplification factor.

This expression can only be used when the pentode amplification factor is known. If this is not published, it may be determined graphically by measuring the slope of the plate characteristic. This method is only very approximate in the case of sharp cutoff r-f pentodes, since the characteristics are nearly horizontal straight lines.

For example type 6J7-G, with a screen voltage of 100 volts and a grid bias of —3 volts, has a plate characteristic having a slope of about 0.1 mA. over a range of 400 volts on the plate (from 50 to 450 volts). The plate resistance is therefore, roughly,

$$r_p = (400/0.1) \times 1000 = 4 \text{ megohms.}$$

In this case, the screen grid to plate amplification factor may be determined from the expression

$$\begin{aligned} \mu &= g_m . r_p \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8) \\ &= 1185 \times 4 \\ &= 4740 \quad \text{very roughly..} \end{aligned}$$

Using this equation (1) we can find the screen to plate amplification factor=

$$\begin{aligned} \mu_{g2.p} &= \mu_{g1.p}/\mu_{g1.g2} \\ &= 4740/20 \\ &= 237 \end{aligned}$$

Plate Resistance

The "plate resistance" of each electrode (plate and screen) in the case of pentode operation, and the "triode plate resistance" when plate and screen are tied together, may be calculated from the corresponding values of μ and g_m in equation (8).

RADIOTRON TYPE 1R5 CONVERTER OPERATION.

(Continued from page 56)

secure optimum conversion transconductance except for a very small frequency range. Considering fig. 1, it is obvious that the potential applied to the grid is only a portion of the total potential across the coil. The ratio is proportional to the reactance of the tuning condenser with respect to the combined reactances of the tuning and padder capacitors in series. This causes the oscillator potential to fall off very seriously, at the low frequency end of the band; e.g., I_{c1} varied from 60 μA. to 249 μA., while the optimum I_{c1} is in the region of 160 μA. Changing to the arrangement shown in fig. 2 applied the whole of the coil potential to the grid. I_{c1} then varied from 165 μA. at 540 Kc/s to 220 μA. 1600 Kc/s. An extra set of contacts will be necessary to switch the grid input from broadcast to short-wave. This is a very small extra cost as there is normally room on the existing switch section devoted to the oscillator.

It can be seen from the circuit of fig. 3 that the bypass to ground of the i-f transformer primary is through the padder condenser of 0.0032 μF. There was no evidence of instability resulting from this arrangement. Broadcast band performance was measured as under:—

Frequency	I_{c1}	e_o	e_2	M.
540 Kc/s.	142 μA.	10.0 Vrms.	2.9 Vrms.	20.2
800 Kc/s.	170 μA.	16.0 Vrms.	3.4 Vrms.	20.6
1000 Kc/s.	180 μA.	18.0 Vrms.	3.7 Vrms.	21.0
1300 Kc/s.	192 μA.	21.0 Vrms.	5.0 Vrms.	20.2
1600 Kc/s.	190 μA.	23.0 Vrms.	7.2 Vrms.	19.8

Broadcast band coil details:—

Grid winding 100 urns 31 B & S.E.
Feedback winding 18 turns 34 B & S.E.
Former $\frac{3}{4}''$ diameter.
Slug $\frac{3}{8}''$ diameter $\frac{1}{2}''$ long in grid end.
Padder 445 $\mu\mu$F.

The voltage measurements of e_o and e_2 were made with an A.W.A. valve voltmeter type M8400. The loading on the oscillator when measuring e_2 was negligible; but when measuring e_o a correction has to be made which can be taken as the factor

$$\left\{ \frac{I_{c1} \text{ unloaded}}{I_{c1} \text{ loaded}} \right\} \times e_o \text{ measured.}$$

The stage gain is considered as the ratio of input to the i-f amplier valve compared with the input to the converter signal grid required to produce the standard test output. It is realised this is not an accurate measurement but it is a useful basis on which different converter valves can be compared. The order of accuracy in this receiver is improved by an i-f amplifier in which a high degree of stability has been achieved by means of neutralization.

Other forms of oscillator coils may be more convenient to manufacture and may be designed to give comparable results.

These notes are intended merely as a guide to indicate the sort of performance which can be expected under normal conditions.

Valves for F-M Receivers

After careful investigation of the whole position, we have decided to standardize on two types of miniature a.c. valves which are essential for the design and manufacture of F-M receivers. The first of these is **type 6BA6,** a high-slope r-f pentode which is suitable for use an an r-f or i-f amplifier. With a transconductance of 4,400 micromhos, it has over twice the gain of type 6SK7-GT under similar conditions and nearly three times the gain of type 6U7-G. It has exceptionally low grid-plate capacitance and does not require an external shield, so that it may be used in comparatively high gain amplifiers with very little instability resulting from grid-plate capacitance.

Radiotron type 6BE6 is a miniature pentagrid converter electrically similar to type 6SA7-GT and only differing in minor respects from the latter. When used on the broadcast band it may be used with the same coils as have been designed for type 6SA7-GT and, in fact, it is quite suitable for use in medium-wave broadcast receivers where its small size may make it desirable in preference to the larger GT type. It is proposed to manufacture both of these new a.c. types in the Australian Radiotron factory and in the meantime receiver designers are recommended to standardize on these two types for F-M receivers and in other equipment requiring such characteristics.

Type 6H6-GT, or its various equivalents, is recommended for use as the F-M detector, whether this be a ratio-detector or a discriminator. Stocks of type 6H6-GT are held in the country and this type is as effective as any other, since the intermediate frequency is comparatively low, namely, 10.7 Mc/s.

The main types of valves used in an F-M receiver may be the existing single-ended GT types such as 6SQ7-GT or 6SF7-GT a-f amplifier, type 6V6-GT power amplifier and type 5Y3-GT rectifier.

Data on types 6BA6 and 6BE6 are given below, but will be issued as early as possible in the form of loose-leaf valve data sheets.

Radiotron 6BA6

Miniature R-F Pentode

Radiotron 6BA6 is a miniature high-slope r-f amplifier with remote cutoff.

GENERAL DATA.

Electrical:

Heater for unipotential cathode:

Voltage	6.3	a.c. or d.c. volts
Current	0.3	amp.

Direct Interelectrode Capacitances:○

Grid No. 1 to plate	0.0035 max.	μμF.
Input	5.5.	μμF.
Output	5.0	μμF.

Mechanical:

Mounting Position	Any
Maximum Overall Length	2⅛"
Maximum Seated Length	1⅞"
Length from Base Seat to Bulb Top (excluding tip)	1½" ± 3/32"
Maximum Diameter	¾"
Bulb	T-5-½
Base	Miniature Button 7-Pin
Basing Designation	7BK1

Pin 1-Grid No 1
Pin 2-Grid No. 3, Internal Shield
Pin 3-Heater
Pin 4-Heater
Pin 5-Plate
Pin 6-Grid No. 2
Pin 7-Cathode

CLASS A_1 AMPLIFIER

Maximum Ratings, Design-Centre Values:

Plate Voltage	300 max. volts
Grid—No. 2 (screen) voltage	125 max.volts
Grid—No. 2 supply voltage	300 max. volts
Plate dissipation	3 max. watts
Grid—No. 2 dissipation	0.6 max. watt
Grid—No. 1 (control grid) voltage:	
Negative bias value	50 max. volts
Positive bias value	0 max. volts
Peak heater—Cathode voltage:	
Heater negative with respect to cathode	90 max. volts
Heater positive with respect to cathode	90 max. volts

Typical Operation and Characteristics:

Plate Voltage	100	250	volts
Grid No. 3 (suppressor)	Connected to cathode at socket		
Grid No. 2 Voltage	100	100	volts
Cathode-bias resistor	68	68	ohms
Plate Resistance (approx.)	0.25	1.5	megohms
Transconductance	4300	4400	μmhos
Grid—No. 1 bias (approx.) for transconductance of 50 μmhos	—20	—20	mA.
Plate current	10.8	11	mA.
Grid No. 2 current	4.4	4.2	mA.

○ With no external shield.

Radiotron 6BE6

Miniature Pentagrid Converter

Radiotron type 6BE6 is a miniature converter having characteristics closely resembling those of type 6SA7-GT.

GENERAL DATA.

Electrical:

Heater, for Unipotential Cathode:

Voltage	6.3	a.c. or d.c. volts
Current	0.3	amp.

Direct Interelectrode Capacitances:○

Grid No. 3 to all other electrodes (R-F input)	7.2	μμF.
Plate to all other electrodes (Mixer output)	8.6	μμF.
Grid No. 1 to all other electrodes (Osc. input)	5.5	μμF.
Grid No. 3 to plate	0.30 max.	μμF.
Grid No. 1 to grid No. 3	0.15 max.	μμF.
Grid No. 1 to plate	0.05 max.	μμF.

Grid No. 1 to all other electrodes except cathode	2.7	μμF.
Grid No. 1 to cathode	2.8	μμF.
Cathode to all other electrodes except grid No. 1	15	μμF.

Mechanical:

Mounting Position	Any
Maximum Overall Length	2⅛"
Maximum Seated Length	1⅞"
Length from Base Seat to Bulb Top (excluding tip)	1½" ± 3/32"
Maximum Diameter	¾"
Bulb	T-5-½
Base	Miniature button 7-pin
Basing designation	7CH

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

CONVERTER.

Maximum ratings, design-centre values:

Plate voltage	300 max. volts
Grids—No. 2 and No. 4 voltage	100 max. volts
Grids—No. 2 and No. 4 supply voltage	300 max. volts
Plate dissipation	1.0 max. watt
Grids—No. 2 and No. 4 dissipation	1.0 max. watt
Total cathode current	14 max. mA.
Grid—No. 3 voltage:	
Negative Bias value	50 max volts
Positive Bias value	0 max. volts
Peak heater—Cathode voltage:	
Heater negative with respect to cathode	90 max. volts
Heater positive with respect to cathode	90 max. volts

Characteristics—Separate excitation:*

Plate Voltage	100	250	volts
Grids—No. 2 and No. 4 (screen) voltage	100	100	volts
Grid—No. 3 (control grid) voltage	—1.5	—1.5	volts
Grid—No. 1 (Oscillator grid) resistor	20000	20000	ohms
Plate resistance (approx.)	0.5	1.0	megohm
Conversion transconductance	455	475	μmhos
Conversion transconductance (approx.)†	4	4	μmhos
Plate current	2.8	3.0	mA.
Grids—No. 2 & No. 4 current	7.3	7.1	mA.
Grid—No. 1 current	0.5	0.5	mA.
Total cathode current	10.6	10.6	mA.

NOTE: The transconductance between grid No. 1 and grids No. 2. and No. 4 connected to plate (not oscillating) is approximately 7250 micromhos under the following conditions: grids No. 1 and No. 3 at 0 volts; grids No. 2 and No. 4 and plate at 100 volts. Under the same conditions, the plate current is 25 milliamperes, and the amplification factor is 20.

* The characteristics shown with separate excitation correspond very closely with those obtained in a self-excited oscillator circuit operating with zero bias.

† With grid—No. 3 bias of —30 volts.

o With no external shield.

Radiotron 8D21

Push-Pull Power Tetrode

Water and Forced-Air Cooled

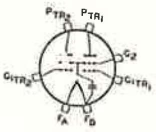
Radiotron type 8D21 is a water- and forced-air-cooled, high-power, twin tetrode of unique design intended for use as a class C, grid-modulated, r-f power amplifier in television transmitters. In such service, it has a maximum plate-voltage rating of 6000 volts, a maximum total plate input of 10,000 watts, and a maximum total plate dissipation of 6000 watts. It may be operated with maximum rated input up to 300 megacycles.

The 8D21 is unique in that high-power capability at very-high-frequency has been obtained by the use of a compact, high-current-density structure in which all electrodes are water cooled close to the active electrode areas.

RADIOTRON 8D21 (Continued)

For Terminal Connections, See Outline Drawing

F_A : FILAMENT
F_B : FILAMENT & MOUNTING FLANGE
$G_{1_{TR_1}}$: GRID NO.1 OF TETRODE UNIT NO.1
$G_{1_{TR_2}}$: GRID NO.1 OF TETRODE UNIT NO.2



G_2 : GRID NO.2 OF TETRODE UNITS NO.1 & NO.2
P_{TR_1} : PLATE OF TETRODE UNIT NO.1
P_{TR_2} : PLATE OF TETRODE UNIT NO.2

- 6 -

The structure features a thoria-coated, multi-strand filament; low interelectrode capacitances; excellent internal shielding between input and output circuits; internal neutralization of the small feedback capacitance to eliminate need for external neutralization internal by-passing of screen to filament to maintain the r-f potential of the screen at ground potential; and relatively short internal leads with consequent low inductances. The over-all length of the 8D21 is only about 12 inches and its maximum diameter is 5¾ inches.

Because of electron optical principles incorporated in its design, the 8D21 has high power sensitivity and thus its driving-power requirements are low.

GENERAL DATA

Electrical:

Filament, Thoria Coated:

Voltage (ac. or d.c.)	4.2	Volts
Current	135	Amperes

Starting Current: Must never exceed 220 amperes, even momentarily.

Grid-Screen Mu-Factor (each Unit)	5	

Direct Interelectrode Capacitances (each Unit):*

Grid No. 1 to Plate	0.15	μμF.
Input	24	μμF.
Output	6	μμF.
Grid—No. 2 By-Pass Capacitor (Internal) approx.	200	μμF.

Mechanical:

Mounting Position: Plane of grid No. 1 leads horizontal and below horizontal plane of plate leads

Maximum Overall Length	12-9/32″
Maximum Diameter	5-¾″
Terminal Connections	See Outline Drawing

Cooling: An air flow of at least 40 c.f/m should be directed at the glass end of the valve so as to cool the area between the plate seals as well as the sides of the glass envelope.

Water cooling of the filament block, the No. 1 grids, the No. 2 grids, and the plates is required. The water flow must start before application of any voltages and preferably should continue for several seconds after removal of all voltages. Interlocking of the water flow with all power supplies is recommended to prevent valve damage in case of failure of adequate water flow. A minimum water flow should be provided as follows for the:

Filament	0.2 min. gals./min.
Grid No. 1 of Each Unit	0.2 min. gals./min.
Grid No. 2	0.2 min. gals./min.
Plate of Each Unit	0.6 min. gals./min.

Water Pressure	{60 min. lbs./sq. in. {100 min. lbs./sq. in.	
Outlet Water Temperature	70 max.	°C.
Bulb and Seal Temperatures	150 max.	°C.

Grid-Modulated Push-Pull R-F Power Amplifier—Class C.

Unless otherwise specified, values are for both units.

Maximum Ratings, Absolute Values:

	CCS°	
D.C. Plate Voltage	6000 max.	Volts
D.C. Grid—No. 2 (screen) voltage	1000 max.	Volts
D.C. Grid—No. 1 (Control Grid) voltage	–1000 max.	Volts
D.C. Plate Current	2 max.	Amperes
Plate Input	10000 max.	Watts
Grid—No. 2 Input	400max.	Watts
Plate Dissipation	6000 max.	Watts
Grid—No. 1 Dissipation	50 max.	Watts

Typical Operation in Television Service up to 216 Mc/s.:

D.C. Plate Voltage	5000	Volts
D.C. Grid—No. 2 Voltage	800	Volts
D.C. Grid—No. 1 Voltage:		
Synchronising Level	–220	Volts
Black Level	–385	Volts
White Level	–875	Volts
Peak R-F Grid-No.-1-to-Grid-No. 1 Voltage	1300	Volts
D.C. Plate Current:		
Synchronizing Level	1.8	Amperes
Black Level	1.35	Amperes
D.C. Grid—No. 2 Current:		
Black Level	–0.025	Ampere
D.C. Grid—No. 1 Current:		
Synchronizing Level	0.050	Ampere
Black Level	0.010	Ampere
Driving Power approx.)**	5	Watts
Band Width	6	Mc/c.
Power Output:		
Synchronizing Level	5400	Watts
Black Level	3200	Watts

° Continuous Commercial Service.

* With no external shielding. Grid No.1-to-plate capacitance is internally neutralized by the valve structure.

** In practical, wide-band circuit design with swamping resistors, a driving power of about 500 watts is required to take care of the losses in the swamping resistors, the circuit losses, and the valve driving power.

TERMINAL CONNECTIONS

The two plate terminals are taken to the top of the valve. The two Grid No. 1 terminals, with their water inlet and outlet connections, are close together at the bottom right-hand corner of the photograph; the other connections at the lower end include the screen and filament, each with its own water inlet and outlet.

Radiotron 7C24

Power Triode, Grounded-Grid Type

Radiotron type 7C24 is a forced-air-cooled power triode designed for F-M, television, and industrial services. It is capable of operation with the maximum rated plate dissipation of two kilowatts at frequencies up to 110 megacycles.

The flanged-header grid terminal is a design feature of particular value when the 7C24 is used in grounded-grid circuits. In such circuits, this terminal when used with a large circular connector effectively isolates the filament from the plate circuit, and provides a direct low-inductance path to the grid. As a result, neutralization is generally unnecessary in grounded-grid service.

The design of the 7C24 includes three multiple-ribbon filament leads, one of which is a centre tap to facilitate the reduction of filament-lead inductance in high-frequency circuits. Within the valve, these leads are short and direct. An efficient external radiator provides for plate cooling by means of forced air. The conical grid support is structurally strong, serves to cool the grid, and effectively reduces grid-lead inductance.

These features, together with the ability of the valve to deliver a power output of four kilowatts in class C telegraph service at frequencies up to 110 megacycles, commend the 7C24 for use in high-frequency applications.

GENERAL DATA

Filament, Thoriated Tungsten:

Operating Current	29	Amperes
Voltage (a.c. or d.c.)	12.6	Volts

Starting Current: Filament current must never exceed 50 amperes, even momentarily.

Resistance, Cold	0.052	Ohm
Amplification Factor	25	

Direct Interelectrode Capacitances (approx.):

Grid to Plate	16	μμF.
Grid to Filament	19	μμF.
Plate to Filament	0.45	μμF.

Terminal Connections .... See Outline Drawing

Radiator .... Integral part of valve

Cooling: A minimum air flow of 275 c.f/m through the radiator is required at the maximum ambient temperature of 45°C so that the maximum rated radiator temperature of 180°C will not be exceeded at the maximum rated plate dissipation. In addition, an airflow of 10 c.f/m is required from a 1"-diameter nozzle directed into header and around the filament seals. Air flow must start before any voltages are applied.

Mounting Position .... Vertical only

A-F POWER AMPLIFIER & MODULATOR—Class B

Maximum Ratings, Absolute Values:

	CCS●	
D.C. Plate Voltage	5000 max.	Volts
Max.-Signal d.c. Plate Current*	1.4 max.	Amperes
Max.-Signal Plate Input*	5 max.	KW
Plate Dissipation*	2 max.	KW

Typical Operation:

Unless otherwise specified, values are for 2 valves.

D.C. Plate Voltage	5000	Volts
D.C. Grid Voltage	—200	Volts
Peak A-F Grid-to-Grid Voltage	760	Volts
Zero-Signal d.c. Plate Current	0.4	Ampere
Max.-Signal d.c. Plate Current	2.0	Amperes
Effective Load Resistance (plate to plate)	6000	Ohms
Max.-Signal Driving Power (approx.)	110	Watts
Max.-Signal Power Output (approx.)	7	KW

R-F POWER AMPLIFIER—Class B Telephony

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

Maximum Ratings, Absolute Values:

	CCS●	
D.C. Plate Voltage	5000 max.	Volts
D.C. Plate Current	1.0 max.	Ampere
Plate Input	3.0 max.	KW
Plate Dissipation	2.0 max.	KW

Typical Operation in Grounded-Filament Circuit:

D.C. Plate Voltage	5000	Volts
D.C. Grid Voltage	-200	Volts
Peak R-F Grid Voltage	190	Volts
D.C. Plate Current	0.6	Ampere
Driving Power (approx.)° ##	50	Watts
Power Output (approx.)	1.0	KW

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:—

Driving Power (approx.):

Carrier	100	Watts
Crest °	400	Watts
Power Output (approx.)	1.0	KW

PLATE-MODULATED R-F POWER AMPLIFIER—Class C Telephony

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

Maximum Ratings, Absolute Values:

	CCS●	
D.C. Plate Voltage	4000 max.	Volts
D.C. Grid Voltage	−1000 max.	Volts
D.C. Plate Current	1.0 max.	Ampere
D.C. Grid Current	0.3 max.	Ampere
Plate Input	3.3 max.	KW
Plate Dissipation	1.3 max.	KW

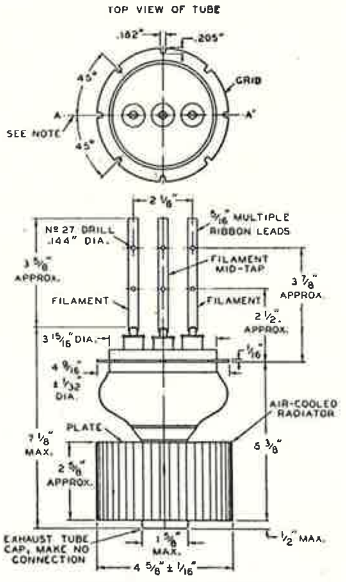
Typical Operation in Grounded-Filament Circuit:

D.C. Plate Voltage	4000	Volts
D.C. Grid Voltage:		
From a fixed supply of	−350	Volts
From a grid resistor of	1400	Ohms
Peak R-F Grid Voltage	570	Volts
D.C. Plate Current	0.8	Ampere
D.C. Grid Current (approx.) ##	0.25	Ampere
Driving Power (approx.) ##	130	Watts
Power Output (approx.)	2.6	KW

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:—

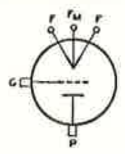
Driving Power (approx.) δ	525	Watts
Power Output (approx.)	3	KW



NOTE: PLANE OF FILAMENT LEADS WILL NOT DEVIATE MORE THAN 3-1/2° FROM PLANE PASSING THROUGH AA' NORMAL TO GRID FLANGE.

92CM-6606

TERMINAL CONNECTIONS



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

R-F POWER AMPLIFIER & OSCILLATOR—Class C Telegraphy

Key-down conditions per valve without amplitude modulation ☐

Maximum Ratings, Absolute Values:

	CCS●	
D.C. Plate Voltage	5000 max.	Volts
D.C. Grid Voltage	−1000 max.	Volts
DC. Plate Current	1.4 max.	Ampere
D.C. Grid Current	0.3 max.	Ampere
Plate Input	5.0 max.	KW
Plate Dissipation	2.0 max.	KW

Typical Operation in Grounded-Filament Circuit:

D.C. Plate Voltage	4000	5000	Volts
D.C. Grid Voltage:			
From a fixed supply of	−350	−400	Volts
From a grid resistor of	1250	1450	Ohms
From a cathode resistor of	230	310	Ohms
Peak R-F Grid Voltage	650	650	Volts
D.C. Plate Current	1.25	1.0	Amperes
D.C. Grid Current (approx.) ##	0.275	0.275	Ampere
Driving Power (approx.) ##	160	160	Watts
Power Output (approx.)	3.8	4	KW

Typical Operation in Grounded-Grid Circuit:

Same values as for Grounded-Filament Circuit with the following exceptions:—

Driving Power (approx.)	820	710	Watts
Power Output (approx.)	4.45	4.55	KW

R-F POWER AMPLIFIER—Class C F-M Telephony

Maximum Ratings, Absolute Values:

	CCS●	
D.C. Plate Voltage	5000 max.	Volts
D.C. Grid Voltage	−1000 max.	Volts
D.C. Plate Current	1.4 max.	Amperes
D.C. Grid Current	0.3 max.	Ampere
Plate Input	5.0 max.	KW
Plate Dissipation	2.0 max.	KW

Typical Operation in Grounded-Grid Circuit:

D.C. Plate Voltage	4000	5000	Volts
D.C. Grid Voltage			
From a fixed supply of	−350	−400	Volts
From a grid resistor of	1250	1450	Ohms
From a cathode resistor of	230	310	Ohms
Peak R-F Grid Voltage	650	650	Volts
D.C. Plate Current	1.25	1.0	Amperes
D.C. Grid Current (approx.) ##	0.275	0.275	Ampere
Driving Power (approx.)	820	710	Watts
Power Output (approx.)	4.45	4.55	KW

● CCS = Continuous Commercial Service.

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

Subject to wide variations depending on the impedance of the load circuit. High-impedance circuits require more grid current and driving power to obtain the desired output. Low-impedance circuits need less grid current and driving power, but plate-circuit efficiency is sacrificed. The driving stage should have a tank circuit of good regulation and should be capable of supplying considerably more than the required driving power.

o At crest of audio-frequency cycle with modulation factor of 1.0.

δ Carrier power or driver modulated 100%.

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

Radiotron Demonstration Triode Type AV25

This valve has been designed with characteristics similar to those of Westinghouse type WL787 so that only a socket change will be necessary when using type AV 25 to replace this type.

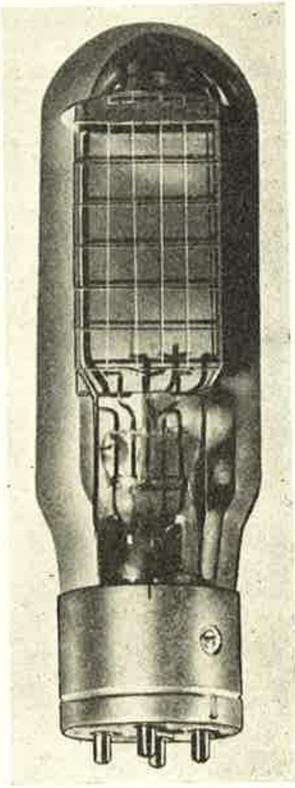
Radiotron type AV25 is an Australian-made Demonstration Triode intended for educational use. It has a plate situated on one side only of the filament, and the grid has an open ladder construction so that it does not obstruct the view of the plate, which is coated on this side with fluorescent material. When the grid is at about zero voltage, the fluorescence is nearly uniform over the area of the plate, while the bright area becomes steadily smaller as the grid is made more negative, forming a shadow of the grid. When the grid is made positive, the individual bright areas increase and finally overlap, thus demonstrating the curved electron paths under these conditions.

The Principal Characteristics are listed below:

Filament Voltage	6.0 volts a.c. or d.c.	
Filament Current	1.5 amps.	
Max. Overall Length	$8\frac{1}{2}$ inches	
Max. Diameter	$2\frac{5}{16}$ inches	
Bulb	T 18	
Base	Jumbo 4—Large Pin	
Plate Dimensions	$1\frac{1}{2}$ inches × $2\frac{3}{4}$ inches	
D.C. Plate Voltage	300	max. volts
D.C. Plate Current	100	max. mA.
Amplification Factor	2.5	(approx.)

Typical Operation as Demonstration Valve on D.C. Supply.

Plate Voltage	250	250	250	volts
Grid Voltage	—25	0	+25	volts
Plate Current	22	35	50	mA.



Radiotron 575-A, 673

Half-Wave Mercury-Vapour Rectifiers

Radiotron types 575-A and 673 are half-wave mercury-vapour rectifiers with ratings intermediate to those of type 872-A/872 and 869-B. Two of these valves can be used in a single-phase, full wave rectifier circuit to supply d.c. voltage of approximately 4800 volts at 3 amperes with good regulation.

The 575-A and 673 are alike except for their bases. The 575-A employs the jumbo 4-pin base while the 673 is fitted with the super-jumbo 4-pin base, a heavy-duty push type. The 673 is recommended for the design of new equipment.

These Radiotron types also feature: a rolled-edge, coated anode so shaped as to reduce arc-back and confine the glow discharge with minimization of bulb bombardment and bulb deposit; zirconium coating of the anode to increase its radiation; and a directly heated special-alloy, coated filament which is highly efficient and has a large reserve of emission.

GENERAL DATA

Electrical:

Filament, Coated:		
Voltage (A.C.)	5.0 ± 5%	Volts
Current	10.0	Amp
Heating Time	30	Secs.
Valve Voltage Drop (approx.)	10	Volts

Mechanical:

Mounting Position		Vertical, Base Down
Overall Length	575-A	9-¾"—11-1/16"
	673	10-1/16"—11-3/8"
Maximum Diameter		3-13/16"
Bulb		T-24
Cap		Medium, with Insulating Collar
Base	575-A	Jumbo 4-Pin, Bayonet
	673	Super-Jumbo 4–Pin, Bayonet

HALF-WAVE RECTIFIER

Maximum Ratings, Absolute Values:●

Cond.-Mercury Temperature Range▲	25 to 50	25 to 55		°C
Peak Inverse Anode Voltage	15000	10000	max.	volts
Peak Anode Current	6	7	max.	amp
Average Anode Current ☐	1.5	1.75	max.	amp
Surge Anode Current for Max. of 0.2 Second■	60	70	max.	amp

● For supply frequency up to 150 cycles per second.

☐ Averaged over any 20-sec. interval.

■ See definition of maximum surge current at end of text.

▲ Operation at 35° ± 5°C is recommended.

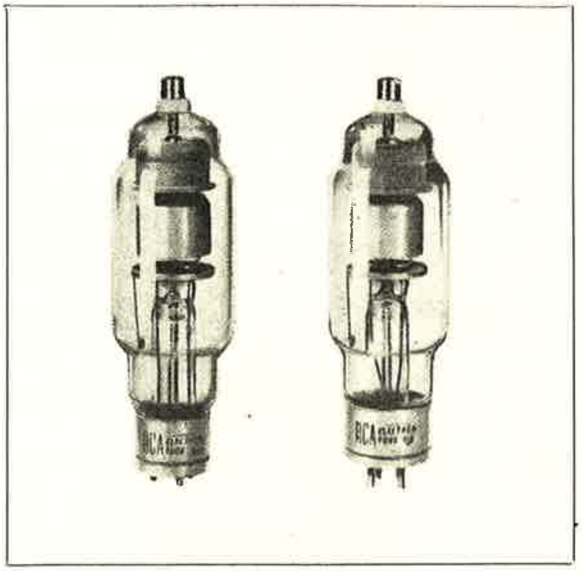
DEFINITIONS FOR RECTIFIERS

Maximum peak inverse anode voltage is the highest peak voltage that the rectifier valve can safely stand in the direction opposite to that in which it is desired to pass current. It is the safe arc-back limit with the valve operating within the specified temperature range. The relations between the peak inverse anode voltage, the d.c. output voltage, and the R.M.S. value of the a.c. input voltage, depend largely on the individual characteristics of the rectifier circuit and the power supply. The presence of line surges, keying surges, or any other transient or wave-form distortion may raise the actual peak voltage to a value higher than that calculated for sine-wave voltages. Therefore, the actual inverse voltage and not the calculated value should be such as not to exceed the rated maximum peak inverse anode voltage for the rectifier valve. A cathode-ray oscillograph or a spark gap connected across the valve is useful in determining the actual peak inverse anode voltage. In single-phase, full-wave circuits with sine-wave input, the peak inverse anode voltage on a rectifier valve is approximately 1.4 times the R.M.S. value of the plate-to-plate voltage applied to the valves. In single-phase, half-wave circuits with sine-wave input and with capacitor input to the filter, the peak inverse anode voltage may be as high as 2.8 times the R.M.S. value. In polyphase circuits, the peak inverse anode voltage must be calculated for the individual cases.

Maximum peak anode current is the highest peak current that a rectifier valve can safely stand in the direction in which it is designed to pass current. The safe value of this peak current in hot-cathode types of rectifiers is a function of the electron emission available and the duration of the pulsating flow from the rectifier valve during each half cycle. In a given circuit, the value of peak anode current is largely determined by the filter constants. If a large choke is used in the filter circuit next to the rectifier valves, the peak anode current is not much greater than the load current; but if a large capacitor is used in the filter next to the rectifier valve, the peak current is often many times the load current. In order to determine accurately the peak anode current in any circuit, the best procedure usually is to measure it with a peak-indicating meter or to use an oscillograph.

Maximum average anode current is the highest average current which should be allowed to flow through the valve. With a steady load, the current may be read directly on a d.c. meter. With a fluctuating load, the reading should be averaged over a period of 20 seconds.

Maximum surge anode current is the highest value of abnormal peak currents of short duration (0.2 second maximum for 575-A and 673) that should pass through the valve under the most adverse conditions of service. This value is intended to assist the equipment designer in a choice of circuit components, such that the valve will not be subjected to disastrous currents under abnormal service conditions approximating a short circuit. It is not intended for use under normal operating conditions because even a single surge current at the maximum value may impair valve life. Repeated surge currents will seriously reduce or even terminate valve life.



New R.C.A. Releases

✓ **Radiotron type 1P41**—is a small, gas-filled "head-on" type of phototube designed particularly for control purposes. It is highly sensitive to red and near infrared radiant energy, and is therefore suitable for use with an incandescent light source in light-operated relay applications such as the control of oil burners and animated signs. Type 1P41 is similar to type 924 except that it is fitted with a peewee 3-pin base which provides lower leakage and more reliable control.

In the design of new equipment, it is recommended that type 1P41 be used instead of type 924.

✓ **Radiotron type 2BP1**—is a 2" cathode ray tube with a medium persistence green-flourescence screen which has high deflection sensitivity, sharp focus, good screen contrast and other improved features commonly found only in large tubes.

Radiotron type 2BP11—is a 2″ cathode ray tube with the same features as type 2BP1 except that it has a short persistence bluish-fluorescence screen which provides a highly actinic fluorescent spot. It is particularly intended for use with photographic recording but is also quite satisfactory for visual observation because it utilises an improved phosphor having approximately twice the brightness of previously available P11 screens.

Radiotron type 2P23—is an Image Orthicon. This new television camera tube has extreme stability over a very wide range of light levels and approximates the seeing ability of the human eye. Because of these features, television cameras could be designed to televise practically any scene that the eye can see. The sensitivity of this Image Orthicon is approximately 100 times that of previous types of pick-up tubes, but this is accompanied by a signal-to-noise ratio appreciably poorer than that of less sensitive tubes. For this reason, type 2P23 is recommended for out-door pick-up use and for other applications where a wide sensitivity range is required to handle large fluctuations of light and shadow. The relatively small size of type 2P23 lends itself for use in comparatively light-weight, portable television cameras and facilitates the use of telephoto lenses with such cameras.

Radiotron type 3E22—is a small push-pull beam transmitting valve with Intermittent Mobile Service (I.M.S.) ratings intended to include applications such as in aircraft where minimum size, light-weight, and exceedingly high power output for short intervals are primary requirements, even though the average life expectancy of valves used in such transmitters is drastically reduced. Such use of valves under I.M.S. ratings, which are considerably higher than I.C.A.S. ratings, could be justified as economical practice in applications where high power is intermittently desired from small valves.

Under I.M.S. ratings type 3E22 may be used in class C telegraph service with a maximum plate voltage of 600 volts, a maximum plate input of 100 watts, and maximum plate dissipation of 35 watts. Under these conditions it is capable of delivering a power output of approximately 72 watts with a valve driving power of only 0.45 watt.

Radiotron type 3KP1—is a 3″ cathode ray tube with a "zero first-anode-current" electron gun having deflection sensitivities higher than those of other 3″ types and with other improvements giving this smaller tube many of the features generally incorporated in larger tubes.

Radiotron type 5TP4—is a 5″ projection kinescope with electrostatic focus and magnetic deflection, intended for use in television receivers. This is the first kinescope commercially available employing a thin metallic filament on the inner surface of the fluorescent screen. This development constitutes the latest of the many steps which have made practicable the projection of 18″ x 24″ television pictures in the home. Type 5TP4 is designed for use in a reflective optical system and has a very high light output with improved contrast and an optical-quality face plate with an accurately shaped spherical section which is, in fact, a part of the optical system.

Radiotron type 6X4—is a full-wave high-vacuum rectifier of the indirectly-heated type designed primarily for use in automobile radio receivers and also applicable to a.c. operated receivers. It is the miniature equivalent of type 6X5-GT.

Radiotron 7DP4—is a 7″ directly viewed kinescope with electrostatic focus and magnetic deflection. It has a high efficiency white-fluorescent screen which has almost twice the brightness and contrast of prewar types with an external conductive coating which, when grounded, acts as a filter capacitor and also serves as a shield against external electrostatic fields. It has provision for the elimination of ion-spot blemishes by means of an external ion-trap magnet. Type 7DP4 has a "zero first-anode-current" electron gun whose anode No. 1 draws no appreciable current.

Radiotron type 7GP4—is a 7″ directly viewed kinescope with electrostatic focus and electrostatic deflection and intended primarily for use in low-cost television receivers. It has high deflection sensitivity and exceptional brightness and resolution in comparison wth similar tubes operating at lower anode No. 2 voltage.

Radiotron type 8D21—is a push-pull transmitting tetrode with a maximum plate voltage rating of 6,000 volts, maximum total input 10,000 watts and maximum plate dissipation 6,000 watts as a class C, grid modulated, power amplifier in television service. It may be operated with maximum rated input up to 300 Mc/s. This high power capability at very high frequencies has been obtained by the use of a compact, high-current-density structure in which all electrodes are water-cooled close to the active electrode areas. Its overall length is about 12″ and maximum diameter 5¾″.

Radiotron type 10BP4—is a 10″ directly viewed kinescope with magnetic focus and magnetic deflection. This type has the same general features as type 7DP4, embodying the latest technical advances in the cathode-ray-tube art and the accumulated experience of the world's largest producer of cathode ray tubes during the war.

* * *

NEW AUSTRALIAN RELEASES.

Radiotron type AV25—is a demonstration triode intended for use in educational work. Full technical details are given elsewhere in this section.