RADIOTRONICS

AMALGAMATED WIRELESS VALVE CO. PTY. LTD.

BOX No. 2516 BB G.P.O., SYDNEY

TECHNICAL BULLETIN No. 82 15th DECEMBER, 1937

THIS being the December issue, the Management and Staff of Amalgamated Wireless Valve Co. Pty. Ltd. take the opportunity of conveying to the wide circle of *Radiotronics* readers good wishes for a Happy Xmas and prosperous New Year.

Thanks are also extended to readers for the many expressions of appreciation concerning the high standard of the technical articles appearing in our monthly releases.

The value of this service and resulting good-will is reflected in the gratifying support given to Radiotrons during the past year and it might well be said that readers have given literal expression to the philosophy that:—

> *"Value given — for value received*
> *Is a rule that everyone ought to heed;*
> *For whatever we get we've got to earn*
> *By giving an equal share in return."*

In this issue:—

THE PROBLEM OF VARIABLE SELECTIVITY

A single tuned circuit in the plate load of a valve has the well-known frequency characteristic shown in fig. 1. At the resonant frequency, where the reactance becomes zero, there is a peak of response, and the gain falls off on either side. The curve may be plotted graphically by the construction of fig. 2. The ratio of gain at resonance, to the gain at any frequency off tune may be termed the attenuation function of the stage, and may be plotted as a vector quantity, having magnitude and phase. As the frequency is varied, it may be shown that the vector OP in fig. 2 rotates about its origin, O, and that its extremity traces out a linear path, P_0P. At resonance, the ratio m_0/m is unity, and has its least value. If OP_0 is the vector representing the condition of resonance it will be perpendicular to the line P_0P. The distance P_0P for any frequency is equal to $Q(f/f_0 - f_0/f)$, and is seen to be governed by the Q factor as well as the frequency. Where f is nearly equal to f_0, the resonant frequency, P_0P may be taken as $2Q\Delta f/f_0$ where $\Delta f = (f - f_0)$. Thus the length P_0P is very nearly proportional to the amount of detuning close to resonance.

If the selectivity of a single circuit is to be satisfactory, that is, if it is to suppress signals on adjacent channels sufficiently, its Q factor would be impossibly great, and it would tend to attenuate high modulation frequencies when used for broadcast reception. The use of two or more circuits improves the response, but the attenuation of remote side-bands is still too great for fidelity reception.

It is found that when two identical tuned circuits are coupled, either by some common reactance component in the circuit or by mutual magnetic coupling, the locus of the end of the radius vector OP becomes a parabola (see fig. 3), instead of a straight line. The form of the parabola is seen to depend upon the Q factor of the coils, and the coupling co-efficient K. The distance OT is the criterion of form and may be expressed $2/\sqrt{1 + K^2Q^2}$. It is found that where $OT < \sqrt{2}$, there are two frequencies of maximum gain, corresponding to the vectors OP^1, OP^1 in fig. 3. If the attenuation is plotted against Δf, as in fig. 4, it is clear that a much flatter top may be attained by using coupled pairs of circuits than could ever be

THE PROBLEM OF VARIABLE SELECTIVITY — *continued*

realised with single isolated tuners. Fig. 4 serves also to show the variation in band width with variations of OT (that is, changes of KQ). It should be noted that the form of the *skirt* of the curve remains practically similar for all values of KQ.

If the variable bandwidth is to be of value, it must expand symmetrically about some resonant frequency. When the coupling component is a common condenser in series with both the tuners, there is an assymmetrical expansion as shown in fig. 5a. The mean frequency tends to rise as the coupling reactance is increased. Where a common parallel condenser is used, as in fig. 5b, the mean frequency tends to be reduced as the coupling is tightened. Such variations are due to changes in the total reactance in the circuit, and may be avoided by adopting mutual inductive (magnetic) coupling as in fig. 5c.

To vary the mutual inductance of the coils, their relative positions may be changed, or some variable linking device may be used. If the latter course is taken it is found difficult not to change the total inductance as the coupling is altered. Where one coil is moved, care should be taken to make certain that its change of position, relative to the screening, does not alter its self-inductance, and that no change of capacity occurs. Capacity coupling should be reduced to a minimum by taking every precaution. If the two tuning condensers are not located at the opposite ends of the cans, they should be screened from each other. One of the better arrangements appears to be that of mounting the coils along a common axis and varying the axial distance between coils. The capacities of the trimmers must be as constant as possible, and they should, where possible, have air dielectrics. The mechanical flexing of the two leads to the movable coil presents a problem, and where Litz wire is used, it must be understood that a break of one strand may cause sufficient alteration in the Q factor of one coil to destroy the symmetry of the whole filter.

Perhaps a better and safer method of coupling is a combination of both "top" or "bottom" capacity coupling, as in fig. 6. The variable coupling condenser, C_c, is of the special design shown. The symmetry of circuit depends on the adjustment of the common capacitance C_m, and is best carried out with a frequency modulated oscillator and oscillograph. The coils must be screened from each other with extreme care, but extra capacitive coupling should not be harmful.

Even with pairs of coupled circuits the response in the "pass band" is not necessarily flat since with increased coupling a "trough" appears in the centre. By introducing a single tuned circuit, electronically coupled to the reactively coupled pair, the trough may be eliminated as shown in fig. 7. In fig. 7a the Q factor of the coil in the single tuned circuit is taken to be equal to that of the coils of the coupled circuits. The centre peak is obviously too pronounced, resulting in an overall response with a centre peak. (fig. 7a). When a coil having half the Q of those in the coupled circuits is used, the effect (fig. 7b) is to give the pass band three equal peaks. Such an adjustment is desirable. If a poorer coil were used, as in fig. 7c, its effect is not sufficient to fill the "trough."

Unfortunately, the maximum selectivity attainable with three coils is not sufficient for ordinary use, an attenuation of 30 times being usual at frequencies of 10K.C. off resonance. This is not regarded as being sufficiently selective for all requirements, from which it may be seen that two such filters are required. To reduce the required number of valves, the two pairs of coupled coils may be loosely coupled to each other, and the whole variably coupled four coil filter placed between the converter plate and first I.F. grid. To avoid "Miller effect" input impedance ratios, the first I.F. valve may best be employed as an I.F. buffer, having a tuned plate circuit with extremely low selectivity (low Q). The two single coils, when coupled very loosely, approach nearly enough to isolated coils so that they may be used to couple the last I.F. stage to the detector. Maximum transfer of power occurs when loads are matched, and it is wise to match the single coils to their loads, thus halving their effective Q factors. All except the buffer coil thus have the same values of Q, though the dynamic resistances $\left(\frac{L}{CR}\right)$ of the last two coils must be equal to their respective loads—the A.V.C. diode and R_p of the last I.F. stage, and the detector diode loading the secondary.

References:—

Wheeler & Johnson: "Proc. I.R.E.," June, '35.

Cocking: "Wireless Engineer," Mar., Apr., May, '36.

Erickson: "Radio Engineering," March, '37.

Howe (Editorials): "Wireless Engineer," June, July, '37.

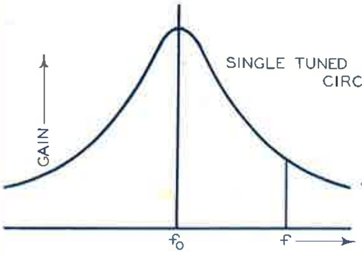


FIG. 1

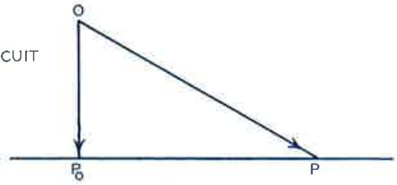


FIG. 2

$OP_0 = 1$

$OP = \frac{m_0}{m}$

$P_0P = Q\left[\frac{f}{f_0} - \frac{f_0}{f}\right]$

WHERE m_0 = GAIN AT RESONANCE
m = GAIN AT f
f_0 = RESONANT FREQUENCY
$Q = \frac{2\pi f_0 L}{R}$
$y = \left[\frac{f}{f_0} - \frac{f_0}{f}\right]$
k = COEFFICIENT OF COUPLING.

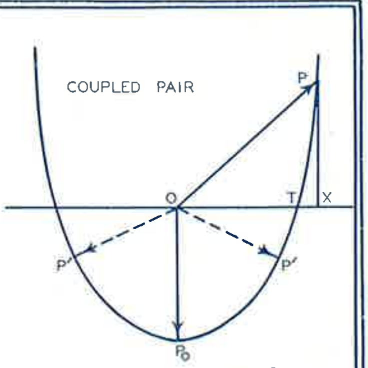


FIG. 3

$OP_0 = 1$

$OP = \frac{m_0}{m}$

$OX = \frac{2Qy}{1+k^2Q^2}$

$XP = 1 - \frac{Q^2y^2}{1+k^2Q^2}$

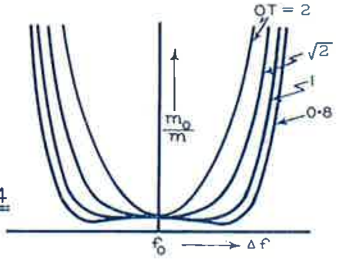
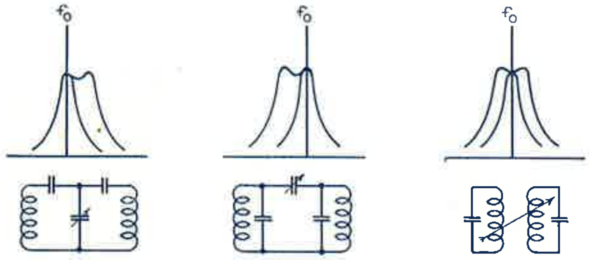


FIG. 4



A B C

FIG. 5

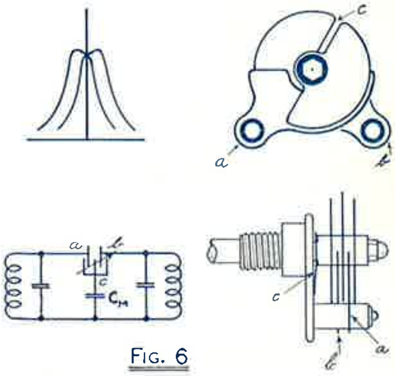


FIG. 6

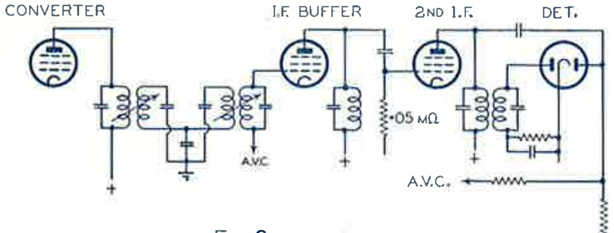


FIG. 8

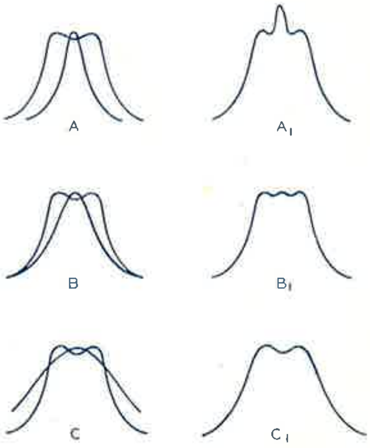


FIG. 7

N.W.

T.R.F. RECEIVER

High Power Quality Output

The problem of the design of a fidelity receiver is a very difficult one. The audio amplifier is very much more simple than the radio tuner, and in recent issues of *Radiotronics* there have been described several amplifiers giving a high quality output and which could well be applied to a radio receiver giving a correspondingly high quality output.

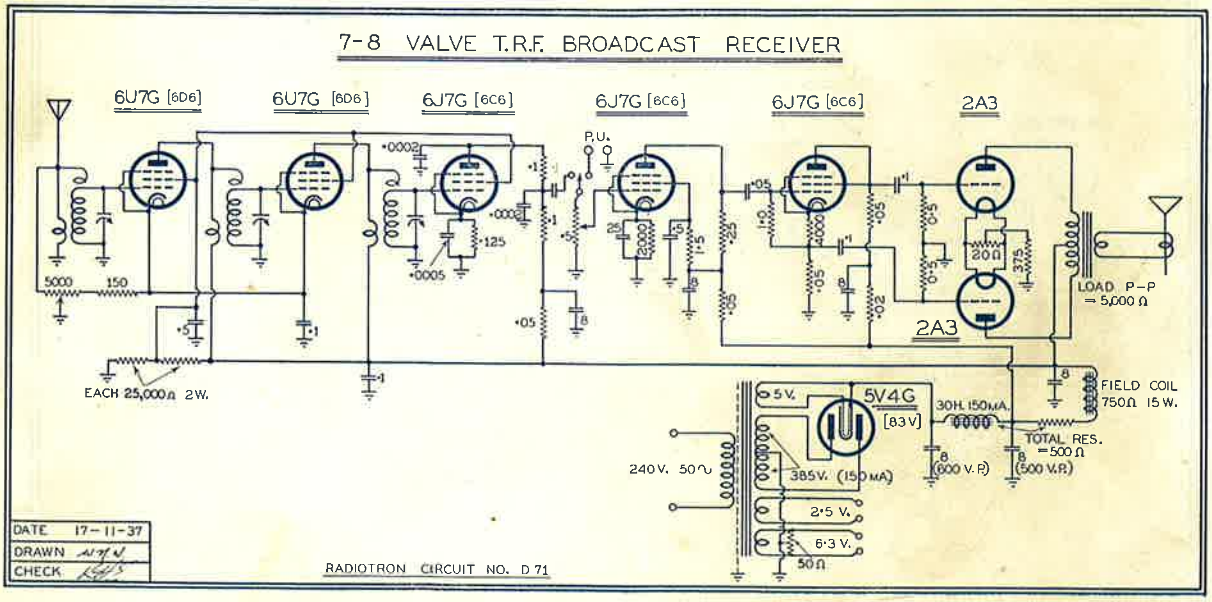
The principal difficulties as regards quality in a radio tuner are, firstly, the reduction of harmonic distortion and, secondly, the reduction of side band attenuation. This second problem is related to the selectivity of the receiver and a very serious problem is thereby introduced. In another part of this Bulletin "the problem of variable selectivity" is discussed somewhat briefly, but sufficiently to show that the response given by ordinary tuned circuits is not the best type of response for a combination of good audio frequency response and good selectivity.

The simplest form of quality receiver is obviously the "Tuned Radio Frequency" type. Many attempts have been made at producing fidelity receivers of this type and satisfactory results may be obtained with a simple construction. At the same time, it must be realised that the results given by a receiver of this type are not by any means ideal since the response at the higher frequencies is unavoidably attenuated and since the selectivity is extremely poor.

It must be realised that a receiver of this nature, although sufficiently sensitive to give good reception of interstate stations, is not selective enough to prevent interference even in some cases between local stations of equal strength. If a design of this type is used it may be necessary to employ a wave trap in the aerial circuit so as to reduce the strength of the strongest local stations to a more satisfactory level. Even with this addition there are cases when a receiver of this type will not give sufficient selectivity to separate local stations. The application of such a receiver is therefore limited to localities in which the problem of selectivity is not acute.

On the other hand, there are localities where a receiver of this type may be employed to give reasonably satisfactory reception from local stations, together with good quality. At some later date it is hoped to describe a superheterodyne receiver employing an improved form of "flat top" response with good selectivity. A receiver of this type is necessarily expensive, but the contrast with the T.R.F. type is an interesting one and the problems involved are of interest to all.

Two stages of T.R.F. were decided upon for this receiver, since less than this number would not provide sufficient selectivity and more would add to the cost and necessitate a 4-gang tuning condenser. One advantage of this type of re-


7-8 VALVE T.R.F. BROADCAST RECEIVER

RADIOTRON CIRCUIT NO. D 71

ceiver is that there should be no whistles on any part of the band. A difficulty with this type of receiver is that the sensitivity and selectivity tend to vary very considerably over the band, so that the selectivity on the higher frequencies is not sufficient for many requirements and the sensitivity at the low frequency end of the band is poor. A distinct improvement in these conditions may be made by the employment of high impedance primary coils together with a suitably small capacity coupling as employed in a number of the best R.F. coils. By the use of coils of this nature, a reasonably constant selectivity and sensitivity may be obtained over the broadcast band.

In order to improve the selectivity of the tuner a high impedance "reflex detector" was chosen in preference to a diode detector. The distortion given by this form of detection is very small indeed, and for most purposes it may be completely neglected.

A reflex detector is really an ordinary anode bend detector in which degeneration is applied to reduce the harmonic distortion. The degree of degeneration can be controlled by the arrangement of load in the cathode or plate circuits. With complete degeneration a gain of less than unity is obtained, but with the constants as given in this circuit, a useful gain is obtained while still keeping the distortion to a very low factor. The reflex detector has the advantages of the anode bend detector in a high input resistance and the capability of handling a reasonably high grid swing. This form of detection cannot be used with A.V.C. unless the A.V.C. is obtained from an entirely separate valve.

We thus have a tuner consisting of two R.F. stages each using Radiotron type 6U7G and a reflex detector using type 6J7G. The coils required will be one aerial coil and two standard R.F. coils of the types mentioned. The details of the receiver are shown in the circuit diagram.

Although a number of audio amplifiers could be employed with this tuner, it was decided to combine the tuner with the 7 watt push pull 2A3 amplifier (Radiotron Circuit A115) described first in *Radiotronics* 77. This amplifier is sufficiently sensitive to operate from a pick-up and provides sufficient output for a reasonable margin of power from any loudspeaker operating under home conditions. The quality of the amplifier is extremely high and the whole receiver gives distortion which, when checked on a cathode-ray oscillograph, is barely noticeable under any conditions. It may therefore be regarded as a receiver of good quality as regards harmonic distortion.

The fequency response of this tuner drops by 6 db. at 10,000~ due to sideband attenuation, although due to the rising response of the loudspeaker at the higher audio frequencies, the overall response is still above zero reference level up to 5,000~. The high frequency response may therefore be regarded as quite satisfactory, although not quite so good as would be obtained by a "flat top" resonance curve. The bandwidth is 170 K.C. at 1,000 times and the sensitivity 30μV. at a frequency of 1,000 K.C.

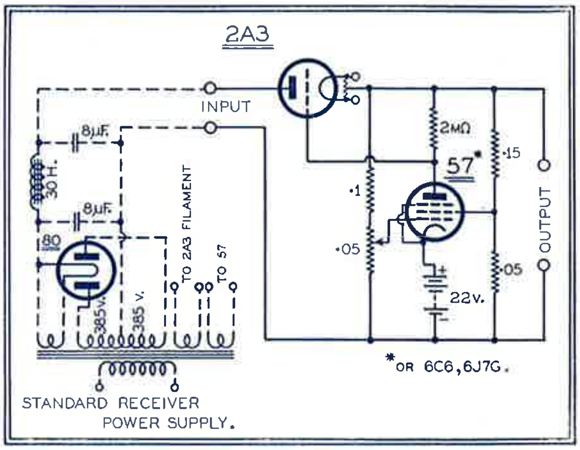
The construction of this receiver is very simple indeed, and it should supply the demand for a local station receiver at cheap cost. It is not regarded as being in any way a receiver suitable for the reception of more than a few of the stronger local stations.

No A.V.C. has been adopted in this receiver since its inclusion would increase the cost without conferring any appreciable advantages. It would also seriously affect the selectivity of the receiver since with the "reflex detector" the impedance is very high, while with a diode used either for signal rectification or for A.V.C., the damping would be sufficiently serious to necessitate an additional R.F. stage to be used to obtain reasonable selectivity. Due to the omission of A.V.C. it is necessary to have two gain controls. The first of these takes the form of a variable cathode resistor for the two R.F. stages and this should be adjusted so that the input to the reflex detector is sufficiently high to reduce the distortion while, at the same time, not sufficiently high to cause overloading. It should be controlled according to the strength of the station being received, and its setting bears no relation whatever to the volume provided by the loudspeaker. In other words, this R.F. control replaces A.V.C. and it should be adjusted so that the output from each station is as nearly as possible at the optimum level for the reflex detector. This introduces one of the difficulties of such a receiver and the responsibility for its correct adjustment must rest with the user.

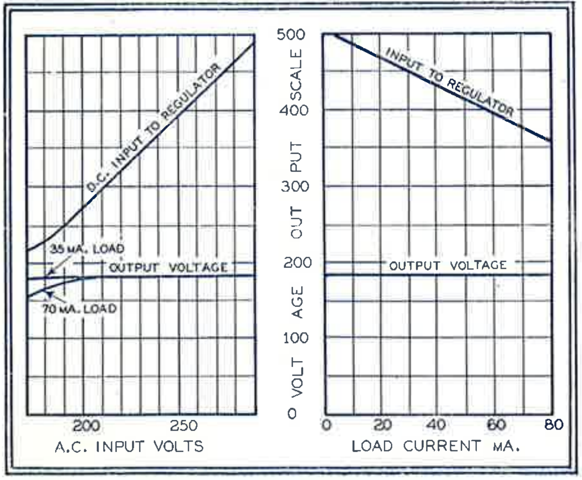
A second gain control is in the grid circuit of the first audio stage and may also be used when the amplifier is used with a pick-up. This audio control should be adjusted to suit the audio level required from the loudspeaker. There are these two controls to be adjusted, the R.F. control being in accordance with the strength of carrier being received and the audio control in accordance with the volume required from the loudspeaker. A correct adjustment of these two in relation to each other and to the conditions of reception will be well repaid.

VOLTAGE REGULATOR

Stable D.C. Voltage for Oscillators



For many test purposes it is essential to have available a supply of D.C. voltage which remains constant irrespective of any fluctuations of the mains. Owing to the difficulty of obtaining sufficiently good regulation from the mains, much test equipment has been built, using battery supply for the plate circuit. This is not altogether satisfactory owing to the high cost of batteries and to their gradual dropping voltage. Any method which can be evolved and which will provide a steady D.C. voltage under all conditions is much to be desired. Various methods have been used and are more or less successful, but the arrangement to be described in this article will be found to provide regulation superior to all of the simple types of regulators. At the same time, its construction is essentially simple and no difficulty should be experienced in its application. The performance given by this regulator is shown in the measured curves and will be seen to be extremely good. Other methods of obtaining good regulation have been tried out in our laboratory and have not been found to give regulation of comparable excellence, even though the curves shown for the alternative equipment appear attractive at first sight. As will be seen from the circuit diagram the regulator incorporates only two valves, these being Radiotrons 2A3 and 57. The input to the regulator is normally 240 volts A.C. and the output remains constant at 180 volts D.C. for a current drain up to 80*m*A. maximum. Not only does the voltage remain constant with extreme variations in D.C. drain, which in many cases is relatively unimportant, but also when the A.C. supply fluctuates the voltage still remains constant with ± 1.0 volt. With the constants used in the circuit diagram the A.C. voltage may vary between 200 and 290 volts A.C., with a load of 70*m*A. and between 160 and 290 volts A.C. with a load of 35*m*A. before the D.C. voltage is appreciably affected. It will therefore be seen that this arrangement provides for fluctuations either in the A.C. supply or in the D.C. load. Within the limits of its operation it is therefore equal in every respect to battery supply and superior to battery supply in its permanent nature and reliability.



Its application is particularly for the operation of test equipment such as oscillators, but it may be applied to other services within its capabilities. Although its application is not a very wide one, it should prove interesting to anyone concerned in accurate measurements.

RADIOTRON MANUAL

R.C.13

This publication has been prepared specially to assist those who work or experiment with radio valves and circuits and the present edition of almost 200 pages provides information on individual Radiotrons from types 00A and 01A up to the new series which will be equipment in 1938 broadcast receivers.

Theoretical considerations are presented in an easily understood manner covering thirty-five pages. Circuit diagrams and charts occupy sixteen pages, in addition a section is devoted to "G" types and recent additions to the Radiotron range.

Write now for your copy of this valuable publication, which may be obtained through Radiotron distributors or direct from Amalgamated Wireless Valve Co. Pty. Ltd., Box 2516 BB, G.P.O., Sydney, the price being 1/8, post paid.

VOLTAGE DIVIDERS AND DROPPING RESISTORS

Which Should be Used?

In the R.F. and I.F. stages of a receiver, it is possible to use either a voltage divider or dropping resistors as means for providing the correct voltages on the screen grids of the valves. There are advantages in both methods for certain applications and no general rule can be made to cover all circumstances. In the case of an R.F. amplifier it is preferable that the screen voltage should be obtained from a voltage divider in order that the screen voltage shall remain constant under all conditions. This will give the most effective A.V.C. action and thereby will prevent overloading and distortion in the I.F. amplifier. In the case of a battery receiver the voltage may be obtained from a tapping on the B battery, or if no suitable tapping point is available to give the exact voltage required the lowest tapping point above the required voltage should be used and a small dropping resistor used to decrease the voltage to the desired value. In both A.C. and battery cases it is possible to use a common dropping resistor for the R.F. and converter valves and this will have the effect of providing a fairly constant voltage under all conditions, particularly if the converter valve operates on fixed bias, since the screen current of the converter valve is generally higher than the screen current of the R.F. valve. It is therefore satisfactory to employ either a voltage divider or a dropping resistor in common with the converter screen.

The screen of the converter valve may be supplied either from a dropping resistor or from a voltage divider, there being no advantage in either particular arrangement. In the case of a battery receiver using Radiotron 1C6 or 1C7G under the recommended conditions it is essential to use a screen dropping resistor. The anode grid circuit of a converter valve should include a dropping resistor of approximately 20,000 ohms for a voltage of 250 volts. Radiotron 1C6 or 1C7G should be operated with an anode grid dropping resistor of 50,000 ohms for the broadcast band and 20,000 ohms for the short wave band.

The screen of an I.F. amplifier should preferably have its supply from an individual dropping resistor. The reason for this is that if A.V.C. is used on this stage the screen voltage will increase as the grid is made more negative, with the result that the valve gives less distortion on strong signals than would otherwise be the case. This applies particularly to valves having a short grid base such as the 1A4, 1D5G, 1C4 or 1M5G in the battery series. It is also desirable with Radiotron 6B7S or 6G8G when used as an I.F. amplifier. It is not necessary although it may be desirable in the case of Radiotron 6D6 or 6U7G. In a receiver having an R.F. stage and with A.V.C. applied to three stages in all, the effect of using a dropping resistor on the I.F. stage is not to cause any appreciable loss in the efficacy of the A.V.C. system. If no R.F. stage is used a compromise is necessary and it will generally be desirable to supply the screen of the I.F. amplifier with a constant voltage such as would be obtained either from a voltage divider or from a dropping resistor common with the converter valve in order that the A.V.C. may be fully effective.

In a Magic Eye Tuning Indicator the plate supply may be obtained from any point having a potential of approximately 250 volts, the exact voltage not being critical. On the other hand the voltage applied to the target is critical and should not, under any circumstances, exceed 250 volts. It is strongly desirable to obtain this voltage by means of the correct value of dropping resistor rather than from a voltage divider, in order that more consistent operation may be obtained. The dropping resistor gives a considerable self-regulating effect which is most valuable in this application in cases where the supply voltage is above 250 volts. In order that long life may be obtained from the Magic Eye it is preferable to maintain the target voltage below 250 volts, from 200 to 230 volts being recommended. This may be accomplished by the use of a 10,000 ohm dropping resistor from 250 volts supply, or a higher resistor in the case of higher voltages. This resistor need not be by-passed.

In resistance coupled audio amplifier pentodes, the screen supply should always be obtained from a dropping resistor. The correct values of dropping resistors are given in the table on Page 41 of *Radiotronics* 76 as well as in the loose leaf Data Book, and these values should rigorously be adhered to. In the case of the 6B7S or 6G8G a dropping resistor is not generally satisfactory and it is preferable to use a special voltage divider consisting of a 1.0 megohm and a 0.25 megohm resistor in series as explained in the table.

RESISTORS FOR AIR CELLS

In air cell receivers it is essential to employ the correct value of resistance so as to reduce the voltage of the air cell, which is considerably above 2 volts, to a voltage which is low enough to be safe to apply to the filaments of the valves while at the same time not being so low as to cause loss of emission from the filaments. Since the voltage of the air cell during its life drops steadily but slightly, it is necessary to arrange so that the voltage on the filaments is maintained between optimum limits during the life of the air cell. With the co-operation of the Ever Ready Company, in conjunction with tests made in our own laboratory, we have been able to determine the optimum values of resistors for use in this application. The table shown below incorporates the results of the laboratory investigation and it is strongly recommended that these values of resistances should be employed in all air cell receivers using Radiotron valves. It may be noticed that the values given differ noticeably from certain other published figures, but the differences are due to factors which have been fully considered in this determination. While it is possible to vary these resistances to some extent without apparent effect, the best results both from the air cell and from the valves will be obtained when these values are used. The resistances are given in terms of filament current, and it is only necessary to tabulate the types of valves used in the receiver, to insert the filament current of each type and to add these together so as to obtain a total current which can then be applied to the table. The use of these resistors will give a voltage on the filaments of the valves which is slightly over 2 volts for the first portion of the life of the air cell, but which remains between 2 volts and 1.95 volts for a long period. The voltage is maintained sufficiently high to give excellent results from all the valves in the receiver until the point is reached at which the voltage of the air-cell begins to drop very rapidly, beyond which point no appreciable advantage would be obtained in using a lower resistance value.

RESISTORS FOR USE WITH AIR CELLS

Nominal Drain.	Series Resistor (including lead resistance).
600 milliamps	.595 ohms.
540 ,,	.685 ,,
480 ,,	.81 ,,
420 ,,	.96 ,,
360 ,,	1.10 ,,

CATHODE RAY TUBES

Radiotrons 1800, 1801 and 914

Radiotrons 1800 and 1801 are *Kinescope* types particular suitable for amateurs, experimenters, laboratories and technical schools for television picture reception. Radiotron 1800 is a nine-inch tube and 1801 is a five-inch tube. Both types are of the electromagnetic-deflection type and employ viewing screens on which the picture appears with a yellowish hue. In making the announcement of these *Kinescopes,* it is emphasised that these cathode ray tubes are being made available for the convenience of experimenters and that their release does not constitute a general commercial announcement by RCA of television apparatus intended for sale to the public.

Radiotron 914 is a nine-inch high-vacuum cathode ray tube of the electrostatic type employing a medium-persistence screen and intended for oscillographic use. Limited stocks are expected in Australia early in the New Year.

NEW RADIOTRON VALVE RELEASES

Tentative Data

6ZY5G:—*Full wave rectifier* with low drain cathode (6.3V. 0.3A) employing two heaters each drawing 0.15A. internally connected in parallel. It is intended particularly for use with non-synchronous vibrators for battery or automobile receivers, where the low heater current is of advantage.

6AC5G:—*Single high-mu triode for Class B output* in large A.C. receivers. The heater rating is 6.3V. 0.4A. and the electrode structure is arranged with two grids internally connected so as to provide a high amplification factor.

1612:—*Pentagrid amplifier* similar to Radiotron 6L7 but intended particularly for use in amplifier applications where valves having especially low values of noise, hum and microphonics are required. These three types are not yet available from stock but are expected to be available in the near future.