RADIOTRONICS

AMALGAMATED WIRELESS VALVE COMPANY LIMITED

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

TECHNICAL BULLETIN No. 75 **30th APRIL, 1937**

In this issue:—

ITEMS OF GENERAL INTEREST.

Radiotrons for Air Cell Receivers:

The use of Air Cells necessitates the use of valves drawing very light filament current. While the superior performance of the Radiotron "120 milliamp" series makes these valves ideally suited to applications in which the filament current is not severely limited, there are other Radiotron valves ideally suited to Air-Cell operation. An 8 valve receiver using Radiotron valves throughout draws a filament current as low as 0.54 ampere. The performance of such a set is of an extremely high standard, and the limitation of filament current does not impair its operation in any way. Smaller sets may also be built around Radiotron Valves—a 4 valve set drawing 0.36 ampere and a 5 valve set drawing only 0.42 ampere are two excellent examples.

In addition to the well known Radiotrons 1B5, 1C4, 1C6, 1K4, 1K6, 19 and 30 there are two lesser known types now available in limited quantities. Type 1A4 is an R.F. Pentode, while type 1F4 is a power pentode. Radiotron 1A4 is somewhat similar to the familiar 34 except that it is fitted in a smaller bulb, has a short grid-base and is slightly more sensitive. Radiotron 1F4 is generally similar to the 1D4 except that the filament current is only 0.12 ampere and the plate current for the same power output is approximately 33% higher.

Radiotrons 1A4 and 1F4.

For receivers using Air Cells. Radiotron types 1A4 (Super Control R.F. Pentode) and 1F4 (Power Pentode) are now available from stock. Further information on their application is given elsewhere in this Bulletin. The Australian price of each of these types is 18/-.

Radiotron 6L6G:

This new valve may be used as a direct replacement for type 6L6, and has similar characteristics except that it is mounted in a glass envelope. The maximum overall dimensions are 5 5-16 in. x 2 1-16 in. Both types 6L6 and 6L6G are now available from stock.

The Australian price of Radiotron 6L6G is tentatively 21/-.

Transmitting Valves:

Full technical information with curves, dimensions and advice regarding the application of Radiotron Transmitting Valves is given in the Handbook No. 464 and supplement. These handbooks are available to licensed experimenters at 1/-, post free, for the two. Some experimenters may already have available the "R.C.A. de Forest Amateur Transmitting Types" Handbook No. 464, in which case the supplement only may be obtained at a cost of sixpence, post free. No amateur transmitter should be without these two publications.

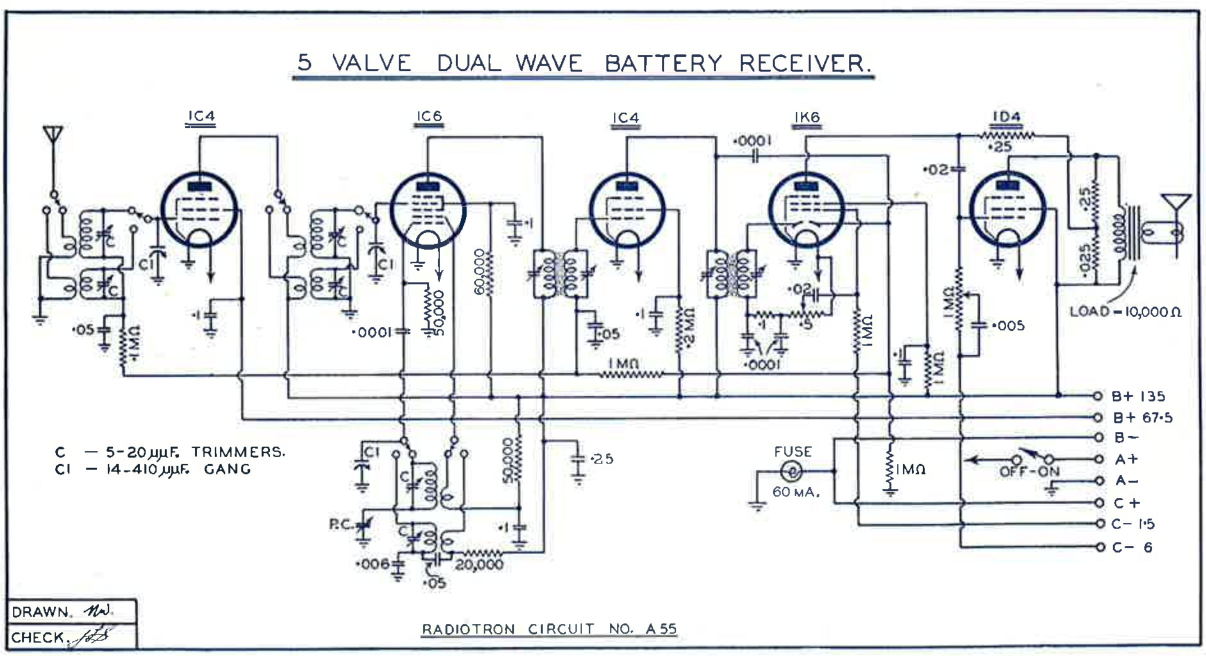
FOR THE RADIO ENGINEER

5 VALVE BATTERY CIRCUIT. ½ WATT OUTPUT WITH LOW BATTERY DRAIN.

The 5 valve circuit is undoubtedly the most popular arrangement for battery receivers. The most obvious deficiency in these sets is due to the use of a small power pentode valve which does not deliver the same power output as a Class B stage. Due to the development of the Australian-designed Radiotron 1K6 in conjunction with the Series Inverse Feedback Circuit (described in Radiotronics No. 74, Page 18) it is possible to obtain an output of ½ watt with fairly low distortion when using 135 volt B batteries and Radiotron 1D4. With a vibrator developing a voltage higher than 135 volts an even greater power output is obtainable. In order to obtain this higher output it is essential to over-bias the 1D4 —6 volts bias being required for 135 volts B supply and —7.5 volts bias for 150 volts B supply. This bias must be steady and should be obtained from a C battery. A poorly regulated bias supply such as "back bias" causes a fluctuating grid voltage and a loss of power output.

These features have been incorporated in the dual wave Radiotron Circuit A55 (shown below) which combines reasonably good selectivity and sensitivity together with a very satisfying audio output. A tone control is included in the grid circuit of the 1D4 since it cannot be applied effectively in the plate circuit with inverse feedback. This tone control is only intended to be used on the short-wave band since the tone with inverse feedback is not at all strident. Attention is drawn to the improved oscillator circuit of the 1C6 which gives more uniform performance over the short-wave band. A switch and 60 mA. fuse are shown in positions where the least possible damage would be done to the valves in the case of a short circuit.

The coils used in this circuit are those described in Radiotronics No. 63, Page 3. The A.V.C. circuit arrangement which has been adopted has been found to avoid overloading in the I.F. amplifier, and is recommended in preference to either the use of a reduced A.V.C. voltage (by means of a tapped diode load resistor) or the more usual method whereby the A.V.C. voltage is obtained from the secondary of the I.F. transformer (either "simple" A.V.C. or by means of capacity coupling between the two diodes). This circuit also provides better fidelity than the other methods mentioned since the shunting on the diode load resistance is reduced.



FOR THE RADIO ENGINEER

RADIOTRON VALVE COMBINATIONS

For Use with Air Cells

Total Valves	R.F.	Converter	1st I.F.	2nd I.F.	2nd Det.	Audio	Power Amp.	Total Fil. Current
4	—	1C6	1C4	—	1K6	—	1D4	0.60
—	—	1C6	1C4	—	1K6	—	1F4	0.48
—	—	1C6	1A4	—	1K6	—	1F4	0.42
—	—	1C6	1A4	—	1B5	—	1F4	0.36
5	1C4	1C6	1C4	—	1K6	—	1F4	0.60
—	1A4	1C6	1A4	—	1K6	—	1F4	0.48
—	1A4	1C6	1A4	—	1B5	—	1F4	0.42
—	—	1C6	1A4	—	1B5	30	19	0.56
—	—	1C6	1A4	—	1B5	1K4	19	0.62
6	1A4	1C6	1A4	1A4	1K6	—	1F4	0.54
—	1A4	1C6	1A4	1A4	1B5	—	1F4	0.48
—	—	1C6	1A4	1A4	1B5	30	19	0.62
—	—	1C6	1A4	—	1B5	30	30+30	0.42
—	—	1C6	1A4	—	1K6	30	30+30	0.48
—	—	1C6	1A4	—	1K6	1K4	30+30	0.54
—	—	1C6	1C4	—	1K6	1K4	30+30	0.60
7	—	1C6	1A4	1A4	1B5	30	30+30	0.48
—	1A4	1C6	1A4	—	1B5	30	30+30	0.48
—	—	1C6	1A4	1A4	1K6	30	30+30	0.54
—	—	1C6	1A4	1A4	1K6	1K4	30+30	0.60
—	1A4	1C6	1A4	—	1K6	30	30+30	0.54
—	1A4	1C6	1A4	—	1K6	1K4	30+30	0.60
8	1A4	1C6	1A4	1A4	1B5	30	30+30	0.54
—	1A4	1C6	1A4	1A4	1K6	30	30+30	0.60

MULTISTAGE AMPLIFIERS

Recent research in the laboratory of Amalgamated Wireless Valve Co. Ltd. has shown that high plate resistance pentodes such as types 1K4 and 6C6 possess considerable advantages over triode valves for the early stages of audio amplifiers. A single pentode stage has very much higher gain than a general purpose triode, and from two to three times the gain of a high plate resistance triode, thereby making possible a reduction in the number of stages. But not the least important feature of the pentode amplifier is that it is capable of giving greater fidelity than a corresponding amplifier using triode valves. This improved fidelity means less harmonic distortion and a wider band of uniform frequency response extending both to lower and to higher audio frequencies. An additional advantage in the use of pentode amplifiers is that a considerably greater output voltage is obtainable from any given supply voltage.

These good features of pentode amplifiers only hold with resistance-capacity-coupled arrangements, and do not apply to a power amplifier with loudspeaker load. In such a case a power triode valve is much to be preferred for fidelity. The reason for this choice is that a pentode valve is critical regarding its load impedance, while a triode valve is not at all critical in this regard. A loudspeaker presents a load of varying impedance and varying power factor, which can be handled quite well by the triode but which causes severe distortion in a pentode power amplifier. The ideal amplifier therefore combines resistance coupled pentode stages and a triode power stage.

The application of resistance coupled pentodes involves certain factors which are more apparent than with triodes and certain precautions are necessary as a consequence.

Hum Injection:

Hum injection includes any hum caused through capacity or other stray couplings between the A.C. or Rectified A.C. supply and an early portion of the circuit.

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MULTISTAGE AMPLIFIERS — (Continued)

Consider the circuit for a resistance coupled stage, Fig. 1A. It may be redrawn (neglecting D.C.) in a quiescent state as in B. The source (A.C.) may be A.C., Rectified A.C. from the unfiltered supply, or a combination of both. The capacities C_{s1} and C_{s2} represent the stray capacity between wiring and the A.C. leads.

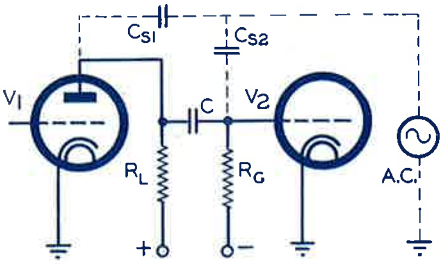


Fig. 1A.

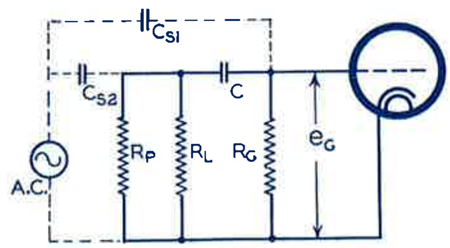


Fig. 1B.

The voltage developed across Rg depends on the A.C. voltage and the capacities C_{s1} and C_{s2} as well as the resistances Rg, R_L, Rp in shunt. If the bass response is good, the coupling condenser C has a small reactance compared with Rg. The resistors may thus be considered to be tied in parallel.

The reactances of C_{s1} and C_{s2} should always be much greater than $1/(1/Rp + 1/R_L + 1/Rg)$ so that the ratio of eg/e_{AC} varies almost directly as the shunt resistance. In triode valves, especially those of the medium plate resistance type (56, 76, 6C6 triode), the shunt resistance is lower than is the case with pentode stages and the hum injection is likely to be less than with pentodes. The plate resistance of a pentode valve is considerably higher even than that of a high mu triode valve and the amount of hum injection will consequently be greater due to the loss of the shunting effect through the plate resistance of the valve. As the reactances of C_{s1} and C_{s2} are lower at high frequencies, the harmonics of 50 cycles, generated in rectification, are injected with greater amplitude than the fundamental. For that reason, the hum has a characteristic singing note, usually termed "induction hum".

By careful layout and by earthing to a short bus bar so as to reduce inductive reactance along the earth line the hum level may be kept within reasonable limits.

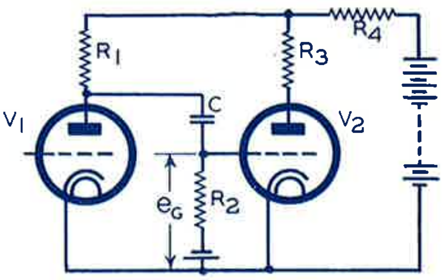
Hum from Poor Filtering:

Hum is frequently caused through inadequate filtering, but in the voltage amplifier stages there is no difficulty in securing sufficient smoothing by means of a dropping resistor and condenser. This method should only be necessary in the case of amplifiers having more than one high gain stage and it is generally applied only to the first stage of a multistage amplifier. As in the case of hum injection this effect is more pronounced with pentodes than with triodes.

Decoupling:

Consider the two stages in the circuit of Fig. 2. The B supply internal resistance is shown as R4.

Fig. 2.



It can be shown that across R4 there is developed, a voltage equal to $-eg\mu R4/(Rp + R3 + R4)$, where Rp is the plate resistance of V2. Of this voltage, a portion equal to

$$\frac{1}{R_1\sqrt{\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_P}\right)^2+\left[\left(\frac{1}{R_1}+\frac{1}{R_p}\right)^2\Big/(R_2\omega C)^2\right]}}$$

of the voltage across R4 may be applied to the grid of V2. It may be observed that the fed back voltage is nearly 180° out of phase with the original voltage e.g., by virtue of the phase reversal in the valve, V2, the other discrepancy being due to the reactive effect of the condenser C. Further, the valve V2 would usually be a triode or output pentode, and the stage gain from the grid to the fed back voltage would be much less than unity.

Thus it may be seen that a simple two stage amplifier should be stable even with the most poorly regulated power supplies.

Although gains as high as 42 db may be realised with a single 6C6 pentode stage, there are applications sometimes requiring more gain. The intro-

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MULTISTAGE AMPLIFIERS — (Continued)

duction of a third stage reverses the phase again, and the voltage fed back from the B supply to the second stage grid may be sufficient to keep the whole amplifier in a state of oscillation (motor boating).

In Fig. 3 is shown the outline circuit of a three stage amplifier. The feed back from the plate to

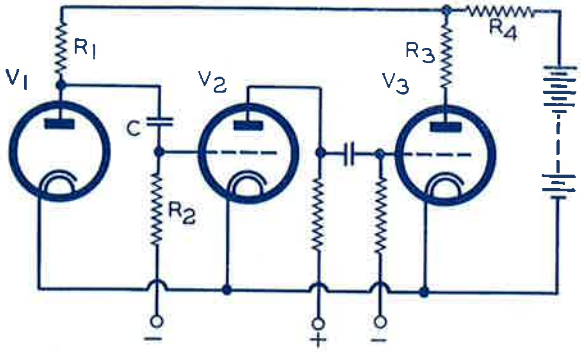


Fig. 3.

the grid of valve V3 is small and negative and has therefore been neglected. The gain from the grid of V2 to the Resistor R4 is

$$\frac{m\mu_3 R_4}{(R_{p3} + R_3 + R_4)}$$

where μ_3 is the amplification factor of V3 and m is the gain from the grid of V2 to the grid of V3.

Now the attenuation of the voltage fed back from R4 to the grid of V2 is

$$\frac{1}{R_1\sqrt{\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_{p1}}\right)^2+\left[\left(\frac{1}{R_1}+\frac{1}{R_p}\right)^2\Big/(R_2\omega C)^2\right]}}$$

It is obvious that the stability of the amplifier is determined by the ratio of the fed back voltage to the input voltage. This may be expressed as

$$\frac{m\mu_3 R_4}{R_1(R_{p3}+R_3+R_4)\sqrt{\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_{p1}}\right)^2+\left[\left(\frac{1}{R_1}+\frac{1}{R_{p1}}\right)^2\Big/(R_2\omega C)^2\right]}}$$

If this expression is greater than unity the amplifier will be unstable, and a high degree of stability is indicated by a value considerably less than unity.

A three stage resistance coupled amplifier may therefore be unstable and care should be taken to reduce the fed back voltage by suitable means.

Two examples of three stage amplifiers are shown in Figures 4 and 5 in which decoupling is employed so as to give a high degree of stability. From the previous discussion it is obvious that there is no advantage in decoupling the second stage, and this may be paired with either the first or third stage.

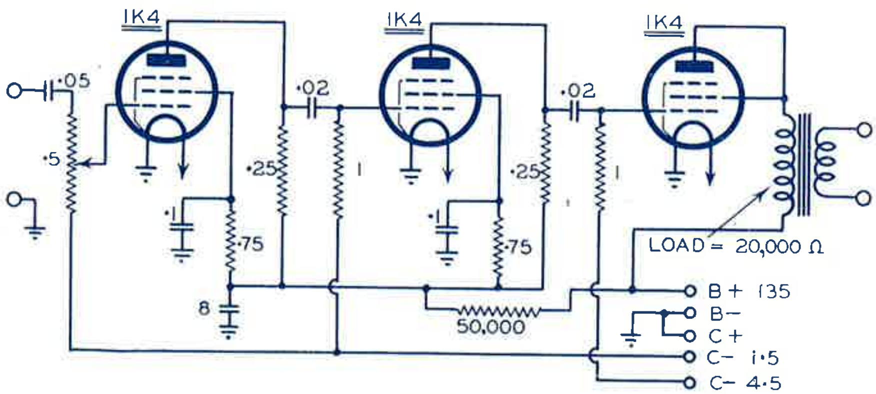


Fig. 4.

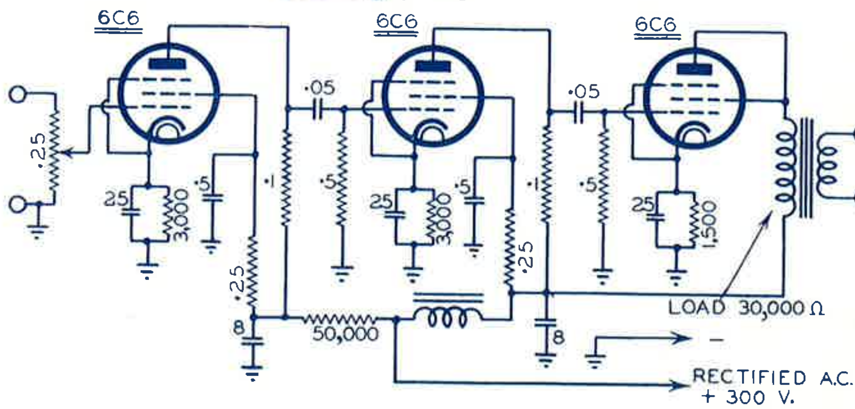


Fig. 5.

FOR THE EXPERIMENTER

RADIOTRON SENIOR AMATEUR RECEIVER:

The main requirements of a short-wave receiver for use on amateur bands are a high degree of selectivity, usable sensitivity (i.e., minimum noise level), good frequency stability, and ample band spread for selecting stations on the amateur frequencies. Selectivity requirements are achieved by the use of a crystal I.F. filter for C.W. and sometimes for 'phone reception. Low noise level is dependent largely on having ample gain ahead of the frequency converter valve, particularly in the aerial coupling coil. Band spread on amateur bands is obtained by using medium C tuning circuits, and a high-ratio dial, with four sets of plug-in coils.

General short-wave reception requires a good AVC characteristic to compensate for rapid fading and medium selectivity to compromise with fidelity. In general, quality is to be regarded as a secondary matter, so that where a compromise is necessary, audio distortion or poor frequency response is tolerated.

The circuit and receiver here described are built around Radiotron valves and constitute a first-class arrangement for amateur communication purposes covering the wave range 9—120 metres with four sets of plug-in coils. Extension to high wavelengths may easily be accomplished with additional coils. The receiver is provided with extra controls such as crystal filter and variable crystal selectivity, etc., to enable reception of weak signals under conditions of bad interference, by skilled manipulation of the various controls.

The general valve arrangement of the receiver is as follows:—

Radiotron	956	R.F. amplifier
Radiotron	6L7	Mixer
Radiotron	6D6	H.F. oscillator
Radiotron	6L7	Noise silencer
Radiotron	6C6	Noise amplifier
Radiotron	6H6	Noise rectifier
Radiotron	6D6	1st I.F. amplifier
Radiotron	6B7S	2nd I.F. amplifier, diode detector and BFO mixer
Radiotron	6J7	Beat frequency oscillator (for C.W.)
Radiotron	75	AVC diode, audio amplifier
Radiotron	42	Power output
Radiotron	6G5	Magic eye tuning indicator
Radiotron	80	Power rectifier

R.F. Amplifier:

The function of the R.F. stage in a superheterodyne receiver is to provide image suppression and improve the signal to noise ratio. Ample gain is available in the remainder of the receiver, so that the R.F. stages should be considered only in relation to these two factors. The signal-noise ratio is the limiting factor in the reception of weak signals. Inherent receiver noise is generated in the plate circuit of each valve due to "shot" effect and in the grid circuit impedance of each valve due to "thermal agitation". "Shot" effect is exceptionally high in the converter valve due to the relatively high peak currents flowing. These noise voltages modulate the signal carrier and produce noise outputs proportional to the band width of the receiver. This noise factor is reduced by limiting the I.F. band width, particularly when using the crystal filter.

It is thus desirable to have as much R.F. stage gain ahead of the converter as possible to reduce the "Equivalent Noise Voltage" at the aerial terminal to the smallest figure possible.

The valve chosen for this position is the 956 which gives the highest gain of any R.F. pentode valve available, the gain of the aerial coupling coil at high frequencies being further enhanced by its high input impedance at these frequencies. Provided the stage gain of the R.F. valve itself is greater than 10, approximately 85% of the E.N.V. at the grid of the R.F. Amplifier is generated in the tuned circuit itself. The aerial coil gain rather than the R.F. valve gain then becomes the more important factor in reducing E.N.V. at the aerial terminal.

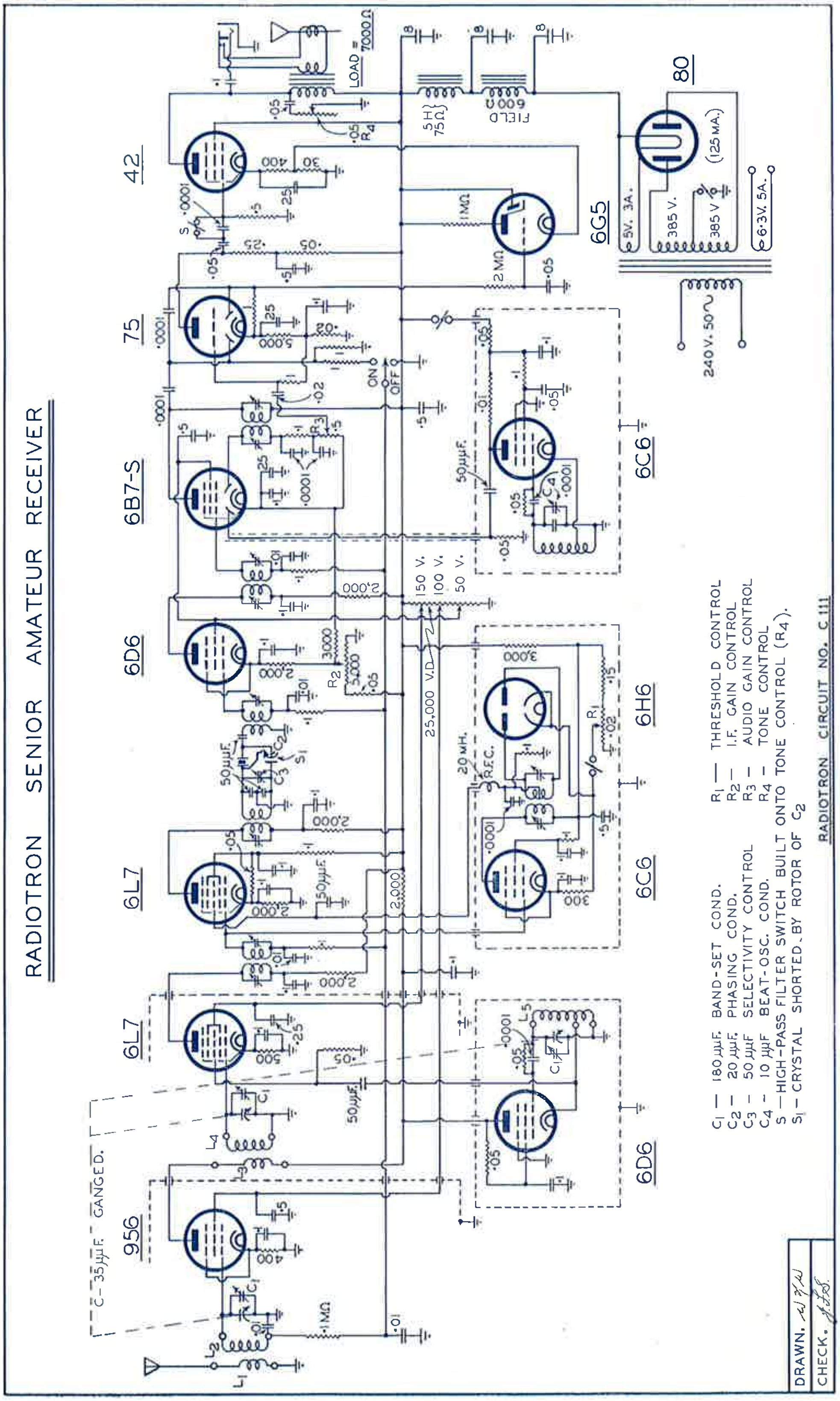
In order to obtain maximum gain in the R.F. amplifier, some loss in image suppression is incurred, due to increased capacity coupling in the R.F. coils. This is not considered serious.

Coils:

The coil ranges specified are designed to give optimum band spread on the amateur wave-bands 28, 14, 7, 3.5 MC. Interwound coupling gives the highest gain, the degree of interwinding being important in obtaining the optimum gain. The B voltage should be switched off before removing the coils.

The valve selected for the first detector socket is the 6L7 which was especially designed for this purpose, its main features being the lack of interaction between oscillator and signal-grid circuits due to reduced capacity and space-charge coupling within the valve.

FOR THE EXPERIMENTER



Note: 6C6 Beat Frequency Oscillator was replaced by a 6J7 in order to make a compact screened unit.

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The H.F. oscillator is a 6D6 electron-coupled, its output being fed to the outer grid (No. 3) of the 6L7 mixer. The D.C. grid current through the 50,000 ohm grid leak should exceed 80 microamps at all positions of the tuning condenser, in order to obtain maximum converter stage gain. The H.F. oscillator is particularly stable, the frequency drift due to warming up amounting to only 1.5 KC at 14 MC.

I.F. Amplifier and Crystal Bridge Circuit:

Two stages of I.F. amplification at 465 K.C. (besides the noise-silencer stage) are used to obtain selectivity. To reduce the I.F. gain and at the same time obtain improved selectivity by reduced valve damping on the tuned circuits, and a more level AVC characteristic, the screens of these valves operate at 50 volts, and minimum grid biases are —4 volts for the 6B7S and —8 volts for the 6D6. These circuits provide a band-width of 22 KC at 1000 times ratio.

For C.W. reception, to reduce noise level and to provide selectivity to meet the crowded amateur bands, a crystal filter is included in the I.F. amplifier. A crystal is equivalent to the circuit shown (Fig. 6) having a particularly high ratio of

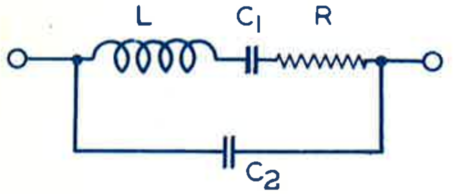
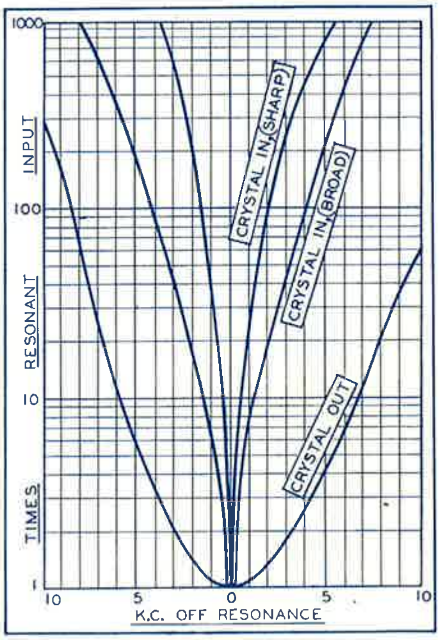


Fig. 6.

L to C (high Q) and having both series and parallel resonances, the parallel resonance being slightly higher in frequency than the series. The normal application of the crystal is as a series element providing low impedance (approx. 20,000 ohms), at its series resonant frequency and extremely high impedance to frequencies off resonance. In practical operation the capacity of the crystal holder plus the equivalent capacity of the crystal (C_2) must be balanced out by the neutralising condenser to reduce the off-resonance gain. When the neutralising condenser is adjusted to this condition, band-width and hence background noise is a minimum, and the parellel resonant frequency is very close to the series. The neutralising condenser provides a means of varying the parallel resonant frequency above and below the series. This enables an interfering signal removed a few KC from the desired signal, to be attenuated by phasing the crystal parallel resonance to the interfering frequency and particularly enables rejection of the beat oscillator image frequency. Adjustment to this condition is at the expense of some increase of background noise and reduced selectivity on the opposite side of the desired signal resonance.

Some control of crystal filter band width is obtained by tuning the input tuned circuit which is in series with the crystal. Under conditions of bad interference on a telephone signal it is desirable to make use of the high degree of selectivity obtainable from the crystal. When the circuit LC is tuned to the series resonant frequency, it acts as a pure resistance adding to the equivalent crystal resistance, increasing the damping on the crystal and resulting in the broad selectivity curve shown. When tuned off resonance the sharp selectivity curve shown in Fig. 7 results. This latter condition is used for high selectivity in CW reception.

Fig. 7.



Beat Frequency Oscillator:

The beat frequency oscillator uses a 6J7 as pentode in an electron-coupled circuit. The plate circuit output is resistance-capacity coupled to the second diode of the 6B7S. The small capacity between diodes provides weak coupling to the detector diode. The coupling obtained is sufficient to give optimum beat note output on weak signals. A variable tuning control is provided on the panel for adjustment of the beat note. This pitch control can be used with the crystal phasing condenser, to obtain signal selection in the presence of interfering stations.

Manual and Automatic Volume Controls — Tuning Indicator:

Two manual volume controls are provided, one the diode load resistor as audio volume control, and an I.F. gain control for use when AVC is off. No manual volume control operates on the R.F. stage, in order that noise level shall be a minimum for all settings.

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The diodes of the 75 first audio amplifier are used respectively as AVC diode and tuning indicator diode. The AVC control diode in order to improve the AVC characteristic is delay-biased approximately —6 volts, and is fed directly from the plate of the 6B7S I.F. amplifier.

A 6G5 tuning indicator is fed with D.C. proportional to the signal strength at the detector, and may be used as an approximate indication of the strength of incoming signals.

The time constant of the AVC system is extremely low (0.055 sec.) so that a good level of reception may be maintained on phone signals under varying fading conditions.

The AVC characteristic is maintained level within 5 D.B. from 100 to 100000 μV., and is maintained to a signal level of 30 μV. Below this signal the output falls quickly. This is considered not altogether a disadvantage in that bad distortion occurs if a strong signal is fading to this level. A.V.C. should normally not be used on C.W. A front panel on-off switch for AVC is provided.

Noise-Silencer:

A noise silencer is included between the frequency converter and I.F. Amplifier.

The 6L7 noise-silencer valve is fitted as a straight I.F. amplifier whose outer control-grid G3 is used for blocking the receiver during the period of sharp noise impulses. In order to reduce the value of D.C. control voltage required at this grid the screen voltage of this 6L7 is reduced to 50 volts, limiting the stage gain of the valve to 2 or 3 times.

The noise amplifier (6C6) is fed from the same I.F. circuit as the 6L7. Output from the 6C6 noise amplifier is rectified in the push-pull diode 6H6, and the resulting D.C. is fed to the silencer-grid (G3) of the 6L7, through a filter to remove the I.F. component. It should be noted that the voltage appearing on G3 is the modulation envelope of incoming signals including noise impulses. The noise amplifier rectifier circuit must operate instantaneously so that during periods in which noise peaks produce a D.C. voltage at G3 exceeding cut-off, the amplifier is blocked out.

The location of the noise-silencer in the receiver circuit is important. It should be noted that the silencer is only useful in filtering noise pulses of very short duration, as any noises having a long time period will block-out the amplifier for a period long enough to render the signal unintelligible.

The effect of peaked noise pulses on the crystal is to set it into oscillation at its own frequency, extending the period of the pulse, and rendering such noise more objectionable. It is desirable to have the crystal operate at a low signal level, and essential that the silencer be placed ahead of the crystal filter, to prevent these sharp pulses acting on it in the manner described. For this reason the silencer follows the converter valve and the crystal filter follows immediately after.

The coupling transformer feeding the noise rectifier diode should have a broad characteristic to pass the noise impulse in its original form. Two closely-coupled tuned circuits are used in this transformer.

Audio Amplifier and Output:

The audio preamplifier valve is type 75, and the output valve a 42. Headphone reception is provided by condenser coupling to the primary of the loud-speaker transformer.

A tone-control consisting of a 0.05 μF condenser and 50000 ohm resistor is connected across the output valve. In its maximum cut-off position it operates a switch placing a small .0001 μF coupling condenser in the grid of the 42. This reduces low-frequency noises for C.W. reception of the 1000 ~ note.

The overall sensitivity of the receiver is a fractional microvolt, and is limited only by the "equivalent noise voltage" at the aerial terminal. It is considered that a signal remains readable if the signal output is equal to the noise output of the receiver. The E.N.V. is then the value of a signal which is readable. The values of E.N.V. are obtained by comparison with a 5 μV. signal modulated 30% at 400 ~. For C.W. reception, the E.N.V. should be multiplied by the modulation factor 0.3, which means that a signal of approximately 0.45 microvolt is readable on C.W. with 50% noise (voltage ratio).

Radiotron Junior Amateur Receiver:

The circuit C71 shows a smaller type of superheterodyne receiver which has all the desirable features of an amateur receiver which can be included at moderate cost. The receiver uses in all 8 valves (including rectifier) as follows:—

- 6D6 R.F. Amplifier
- 6L7 Mixer
- 6D6 H.F. Oscillator
- 6D6 465 KC. I.F. Amplifier
- 6C6 2nd Detector
- 6C6 Beat Frequency Oscillator
- 42 Power Output
- 80 Power Rectifier

The R.F. stage uses a 6D6 which gives sufficient gain to limit the Converter noise to a very low figure. The 6L7 and 6D6 mixer oscillator combination is used, with the exception that regeneration is applied to the 6L7, increasing the stage gain from 30 times to approximately 150 times, thereby rendering ineffective the "shot effect" noise in the converter valve. However, grid noise is in-

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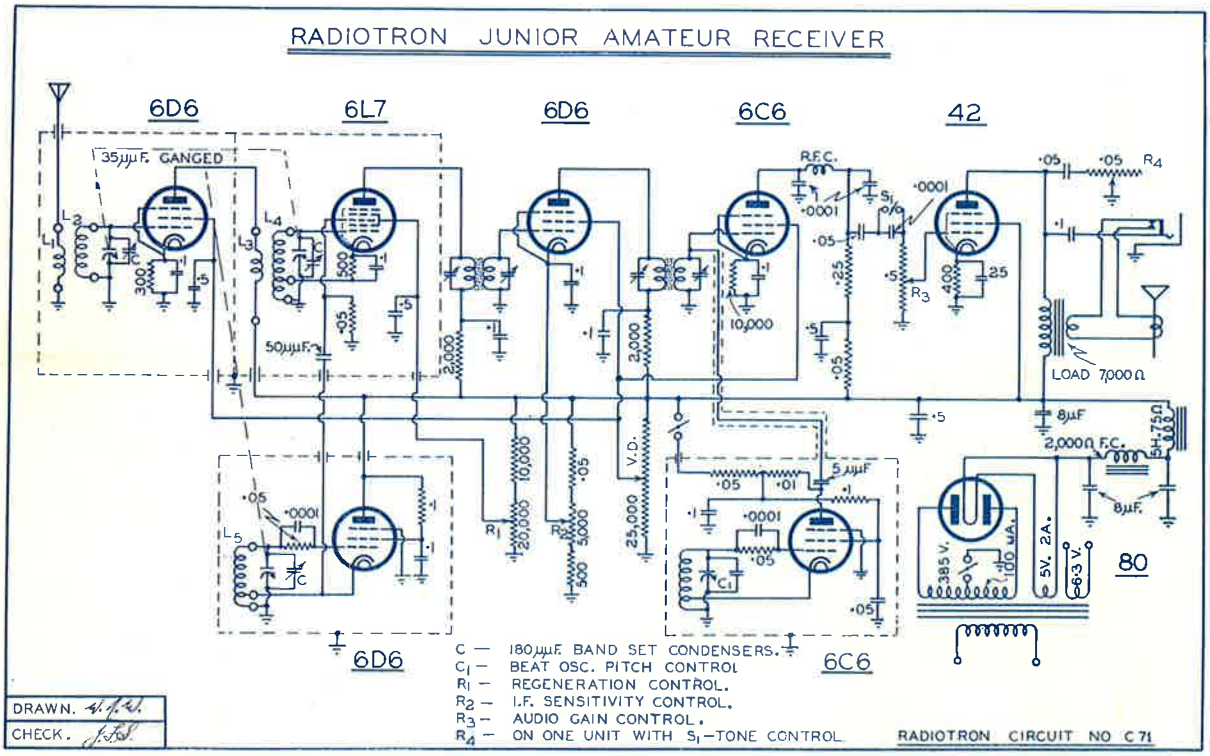
creased, and the overall result is that the equivalent noise voltage remains practically the same. Regeneration is controlled by a variable screen voltage. The signal circuit coil design is similar to that used in the Senior receiver, with the addition of a cathode tap for regeneration on the 6L7 input coil.

Only one I.F. Amplifier stage at 465 Kc is used, the maximum selectivity being obtained by using iron-cored I.F. transformers, and coupling the output to an anode-bend detector (6C6), which does not damp the I.F. circuits as in the case of a diode detector. A band width of 32 Kc is obtained at 1000 times ratio.

The B.F.O. (a 6C6) is coupled through a small condenser consisting of 2 or 3 inches of twisted wire to the grid of the second detector. No A.V.C. is used, but two manual volume controls are included, one in the audio amplifier, and one in the I.F. amplifier. The anode-bend 6C6 detector is resistance coupled to the output valve (42).

The overall sensitivity of the receiver is very high and it is necessary to limit the I.F. gain by over-biasing the 6D6, thereby assisting the improvement in selectivity. The "equivalent noise voltage" at the aerial terminal is approximately 0.75 microvolt.

Reference should be made to the discussion of the remaining features under the "Senior Amateur Receiver", which is similar in many respects.



COIL WINDING TABLE

AERIAL			R.F.			OSCILLATOR	
Band	L1	L2	L3	L4	L4 Cathode Tap*	L5	Tap
I	9(a)	33(b)	25(a)	33(b)	1½(e)	36(b)	10(e)
II	5½(a)	15¼(c)	11(a)	15(c)	1(e)	15½(c)	4¾(e)
III	2½(a)	5¾(d)	4½(a)	5½(d)	¾(e)	6(d)	2½(e)
IV	1¾(a)	2⅞(d)	1¾(a)	2⅞(d)	⅝(e)	3⅛(d)	1½(e)

(a) 30g. SWG. DSC. wire interwound in secondary starting from the bottom. (b) 28g. SWG. Enamelled wire wound 32 T.P.I. (c) 20g. SWG. Tinned Copper wire wound 10 T.P.I. (d) 18g. SWG. Tinned Copper wire wound 6 T.P.I. (e) Tap on secondary counted from bottom. All coils wound on 1¼ inch diameter ribbed formers. * C71 only.

BAND COVERAGE and AMATEUR BAND SPREAD

Band	Frequency Range	Amateur Band Spread Degrees
I	2.35 MC—5.3 M.C.	280°
II	5.15 MC—12.1 M.C.	108°
III	10.9 MC—26 M.C.	90°
IV	14.2 MC—33 M.C.	84°

FOR THE EXPERIMENTER

RADIOTRON 913 OSCILLOGRAPH: SIMPLE TYPES FOR EXPERIMENTERS

An oscillograph is one of the most valuable instruments in radio work, whether for making tests on receivers, amplifiers or transmitters. In its complete form an oscillograph includes amplifiers for both vertical and horizontal plates and also a linear sweep circuit, and is therefore rather elaborate and expensive. Two models have been designed to satisfy the requirements of most experimenters, one a simple model and the other a more elaborate model, capable of much wider application. These both incorporate the new Radiotron 913 Metal-envelope cathode ray tube, and their low cost is due to this fact. Not only is the 913 very much lower priced than other cathode ray tubes, but the voltages required are so much lower that the other components in the oscillograph may be standard radio parts, readily obtainable at low cost.

The simpler oscillograph (Fig. 8) has only one valve (type 80 rectifier) in addition to the 913.

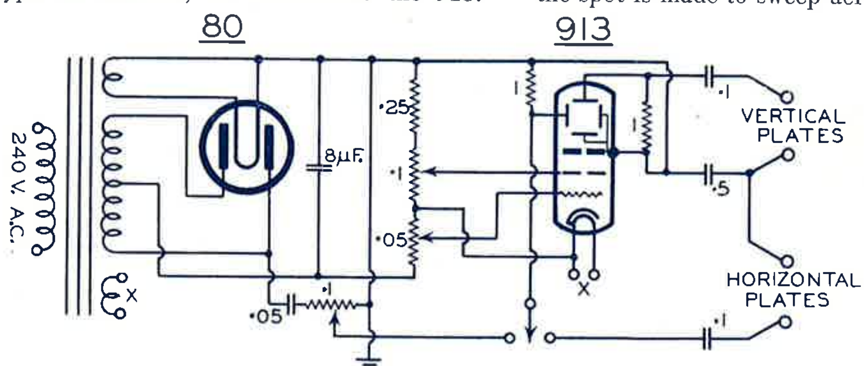


Fig. 8.

No amplifiers for the vertical or horizontal plates are provided, but for many purposes these are not necessary. A voltage of 50 volts R.M.S. applied to the vertical plates gives a very satisfactory indication, and considerably less than this voltage may be used for a readable deflection. Such a voltage is nearly always available, and no difficulty would be experienced in the application to a transmitter, modulator or the power output stage of an amplifier capable of operating a loudspeaker. It is necessary to "sweep" the screen horizontally so as to show the waveform, and in this model the sweep is accomplished by means of A.C. or audio frequency. Internal A.C. sweep is provided but by means of a switch it is possible to connect the horizontal plates to an external circuit. The power transformer may be a standard 385-385 volts radio type. The power output from this transformer is very low so that a small transformer is quite satisfactory.

Smoothing:

Because the current passed by the 913 is so small, being in the order of 250 μA, a relatively small condenser may act as a reactive short circuit to by-pass all A.C. A single 2 μF paper or 8 μF electrolytic condenser will generally be found sufficient to provide smoothing.

It will be seen that the metal envelope of the 913 is earthed, so that there is no danger of shock from the screen end, although care should be taken to prevent access to the socket connections or other live parts of the circuit without switching off the power.

For more extensive test work a linear sweep must be incorporated. The sweep voltage is provided by allowing a constant current to charge a condenser, which is suddenly discharged through a gas-filled tube at the end of the stroke. Thus the spot is made to sweep across the screen steadily and fly back rapidly, the sweep frequency being determined by the charging current and the capacity of the condenser. When a condenser is charged through a resistance, the current becomes less and less as the charge builds up. For a small period at the beginning of the charging time, however, the current is practically constant, and the grid bias of the 885 must be adjusted in order that the condenser may be discharged at a low voltage. The output is then limited, and an amplifier is necessary to make the sweep voltage great enough to cover the screen.

For examining the characteristics of small signals, it is found desirable to use another amplifier for the "vertical" or "Y" plates.

As the input voltages to the amplifiers must be applied between grid and earth, the cathodes are normally operated at earth potential together with the anodes of the 913. A second power supply is thus required. It may be obtained very con-

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veniently by using the scheme of Fig. 9, where one transformer secondary is used with two rectifiers. The 80 operates in the normal full-wave fashion to supply the sweep and amplifier circuits. The 1V is used as a half wave rectifier in the opposite sense, to provide a *negative* voltage for the cathode and grid of the 913.

There are eight controls:—

1. Intensity
2. Focus
3. Horizontal (X) gain
4. Vertical (Y) gain
5. Coarse sweep frequency
6. Fine sweep frequency
7. Switch for linear or external sweep (X amplifier).
8. Synchronizing.

The last mentioned enables one to "pull" the linear sweep frequency into some submultiple of the frequency of the wave under observation, so that the image remains steady on the screen. It applies a little of the "Y" voltage to the grid of the 885, allowing it to pass current only on peaks of the applied voltage.

The circuit Fig 9. forms the basis for the design of an oscillograph which may be used for almost any oscillographic test required in an experimenter's workshop or on a radio service bench.

Radiotron Transmitting Valve Data:

Your attention is drawn to the announcement on Page 1 regarding the Radiotron Handbook No. 464.

CORRECTION.

Radiotron Circuit D42:

In the circuit of Radiotron Circuit D42 published in Radiotronics 74 Page 19 the grid resistor of the 42 was not stated. The resistance should be 1 megohm.

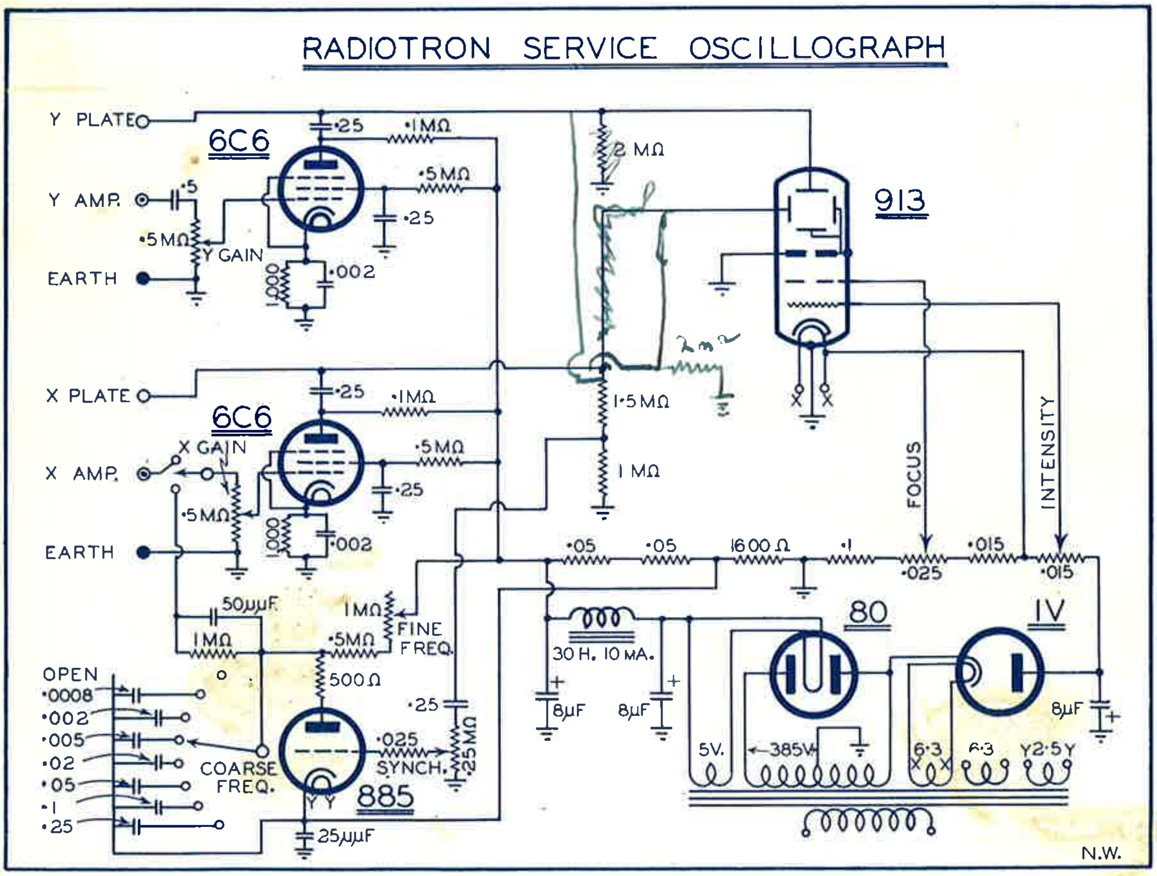

Fig. 9.