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# PRACTICAL CIRCUITS MANUAL

by E. NEWBOLD

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## RECEIVERS

1. *Series Capacitor Heater Feeding.*—With the overall increased cost of domestic electricity, and the added winter charges, it pays to investigate any method whereby receiver consumption can be reduced without affecting efficiency. In small and midget receivers for A.C. operation where the valve heaters are connected in series and fed directly from the mains through a barretter or dropping resistor, a considerable saving in power is obtained by substituting a series capacitor for the dropping resistor.

Two circuits are shown in Figs. 1A and 1B.

To understand how the capacitor functions in Fig. 1B it is necessary to remember the behaviour of a capacitor when fed with A.C. If a capacitor is connected to any type of supply source, a current flows into the capacitor to charge up the

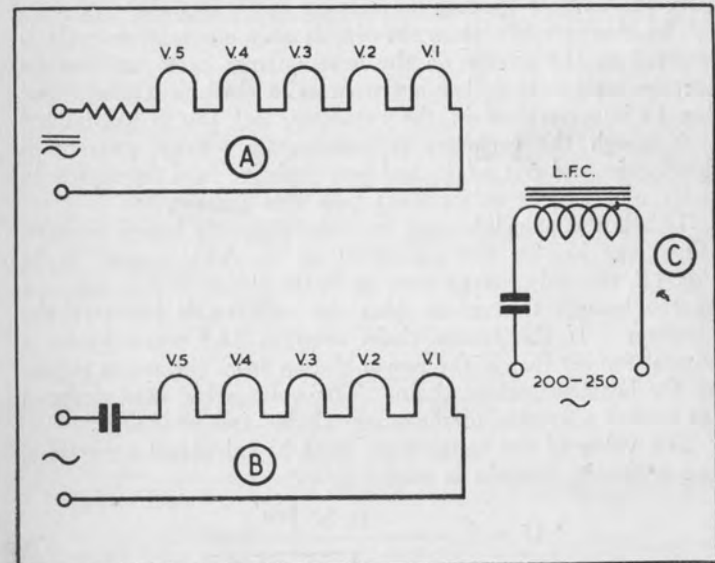


Fig. 1. A. Series resistance heater supply. B. Series capacitor heater supply. C. Capacitor check circuit.

plates. In the first instant of current flow, the potential across the plates is zero, although the current flow is then greatest; as the current flow continues the potential across the plates rises and the current flow diminishes.

On an A.C. source of supply, current flows into a capacitor while the voltage is rising, so that over the parts of an A.C. cycle where the voltage is increasing from zero to maximum the capacitor is charging. When the voltage falls from its peak value back to zero, however, the capacitor loses its charge, the current flowing from it back into circuit. Since at the instant of greatest current flow into the capacitor the potential across the plates is zero, it is apparent that when a capacitor is connected across an A.C. supply the greatest current flow into, and out of, the capacitor occurs when the voltage is passing through the zero points of a cycle. The capacitor charges as the voltage rises and loses its charge as the voltage falls, the current leading the voltage by 90 degrees.

The charge taken from the circuit over one quarter cycle is restored to the circuit on the next quarter cycle, so that on average no power is lost. (In practice there is a slight loss due to imperfections in the capacitor, but this is negligible.)

Although the capacitor is wasting no energy, current is flowing in and out of it, and any resistive load connected in series with the capacitor must pass this current.

This is the principle used in series capacitor heater circuits. When the heaters are connected to an A.C. supply, as in Fig. 1B, the only energy used up in the circuit is that required by the heaters themselves, plus the very small losses in the capacitor. If the heater chain requires 14.5 watts (quite a normal figure) that is the power drawn from the mains supply by the heater-capacitor chain. The voltage has been dropped for correct operation of the heater chain 'free of charge.'

The value of the capacitance must be calculated accurately, and a simple formula is used:

$$C = \frac{I_h \times 10^6}{2\pi f \sqrt{V_s^2 - V_h^2}}$$

where  $C$  is the capacitance in microfarads,  $I_h$  is the current

required by the heater chain (0.2 amp. for most British valves designed for series operation),  $2\pi f$  is 314 for 50 cycles mains,  $V_s$  is the supply voltage and  $V_h$  is the voltage dropped across the heater chain. An example will clearly show the use of the formula.

Assume that capacitor heater feeding is to be applied to a small receiver with a valve line-up as follows:

V1.	Frequency Changer,	CCH35.	Heater :	7	volts,	0.2	amp.
V2.	I.F. amplifier,	EF39.	Heater :	6.3	"	0.2	"
V3.	Det. A.V.C. 1st audio,	EBC33.	Heater :	6.3	"	0.2	"
V4.	Output,	CL33.	Heater :	33	"	0.2	"
V5.	Rectifier,	CY31.	Heater :	20	"	0.2	"
	Dial Lamp,			6.3	"	0.3	"
			Total	78.9	volts	0.2	amp.

Note particularly that the type of dial lamp is shown as 0.3 amp. rather than 0.2 amp. This is dealt with later.

The total voltage across the heater chain,  $V_h$  in the formula, is therefore 78.9—say 79 volts.  $I_h$  is 0.2 amp. and so, for a mains voltage of 230 volts, the formula can be written:

$$C = \frac{0.2 \times 10^6}{314 \sqrt{(230 \times 230) - (79 \times 79)}}$$

*N.B.—The expression  $10^6$  is merely a convenient way of writing 1 million.*

Simplifying, we have

$$C = \frac{200,000}{314 \sqrt{46659}}$$

The value of  $314 \sqrt{46659}$  is 216, so the formula is

$$C = \frac{200,000}{216} \quad \text{and} \quad C = 2.94 \text{ mfd.}$$

The regulation of a capacitor-fed circuit is surprisingly good, provided the voltage required across the heater chain is not more than 100 volts for 0.2 amp. valves, or 50 to 75 volts for

0.3 amp. valves. The heater chain described with a voltage across its ends of 79 volts, is thus very satisfactory for capacitance feeding. At the same time despite this good regulation, the capacitance value should be within 5 per cent. of the calculated figure, so that a 3 mfd. capacitor could just be used with safety for C above, although it would be preferable to obtain a 2.94 or 2.95 mfd. component.

This may be done by building up the capacitance from smaller units. A 2 mfd. capacitor could be bridge checked (by a good radio store if the constructor is not equipped for the work) and its exact value found; then a series of 1 mfd. capacitors could be bridged until a component is found with the necessary value to make up the extra capacitance.

The capacitors must be new, and must, of course, be of the paper type, with working voltages at least 500 volts and preferably 1,000 volts. The capacitors must be checked as shown in Fig. 1C before being used in the circuit.

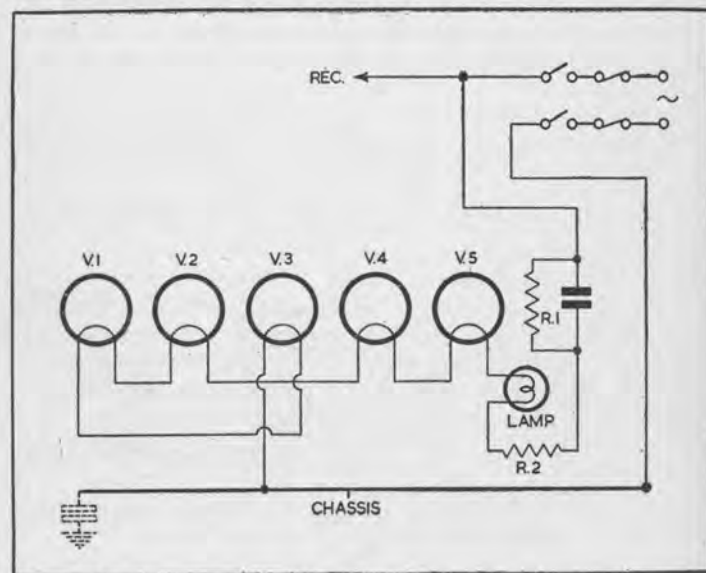


Fig. 2. Practical Series Capacitor heater circuit.

If these points are neglected both the capacitor and the valves may be damaged; if an electrolytic capacitor is used the valves will, of course, be ruined immediately.

The check circuit shown in Fig. 1C consists of placing the chosen capacitor (or capacitors in parallel) in series with a good choke across the A.C. mains supply. This imposes a high working A.C. voltage across the capacitors; the voltage will depend upon the choke's impedance to A.C., but if a 10 Henrys choke is used a voltage of the order of 60 volts will appear across the capacitor.

The choke will heat up, and the check should not be run for too long—a minute or two is sufficient.

Capacitors which stand up to this test are suitable for use in the series heater circuit and should the capacitor break down, the choke takes the load until the power is switched off. Not too small a choke should be used. The current carrying capacity should be of the order of at least 100 m/As. and preferably 200 m/As. or more. A short test does the choke no damage, however.

The final circuit to be used is shown in Fig. 2 where the whole heater circuit of the receiver is shown. Remember that the detector-first audio valve must be the valve with one side of its heater 'earthed' to the chassis or negative line for hum prevention. As with other series-fed heater receivers, no direct earth is permissible. If an earth connection other than that provided by the mains is required it must be made through an 0.01 mfd. 750 v.wg. capacitor.

Note the resistor R1 across the capacitor. This should have a value of 1 megohm and plays no part in feeding the heater chain but discharges the capacitor should the set be switched off on a part of a cycle which would leave the capacitor charged.

The dial lamp in series with the heater chain should be of the 0.3 amp. type. An 0.2 amp. lamp will break down rapidly, because, at the moment of switching on, there may be a momentary high current surge. The inertia of the valve heaters protects them from harm, but the inertia of the dial lamp is too small to serve as protection.

The dial lamp acts as a fuse in the event of a breakdown in the capacitor; but fuses on the mains side of the circuit should

also be incorporated. Their value must depend to some degree on the H.T. and rectifier system, but 1 amp. fuses should generally be satisfactory.

The economy obtained from this type of heater feeding must be regarded as having effect over a period, for the first cost of a suitable capacitor is generally higher than the cost of a series resistor or barretter; but apart from the power saved, there is the added advantage of cool running—for the capacitor runs cold, unlike a resistive voltage dropper. This method of heater feed is excellent for receivers built into very small cabinets where adequate ventilation is difficult.

Only accurate, tested and adequately rated capacitors of the paper type may be used in this circuit, and capacitor feed can be used only on A.C. circuits. For D.C. fed receivers a resistor or barretter must still be used.

An excellent capacitor is the T.C.C. Type 92 Tropical Paper Capacitor, which is supplied by the manufacturer as being suitable for 330 volts R.M.S. operation at power frequencies, and does not therefore require further testing. Values which range between 0.1 mfd. and 10 mfd. allow any required capacitance to be built up.

**Heater Protection.**—The current surge which may occur when first switching on, has already been mentioned. The surge value depends to a great extent on the instantaneous value of the A.C. wave when the switch makes contact. Correspondence has appeared in the technical press about valve breakdowns due to this cause; the author has, perhaps, been fortunate in not having had this trouble so far. It is possible to guard against surges of this nature by introducing a Brimistor, which is a resistive element with an exact resistance depending on operating temperature. This component is indicated in Fig. 3 by R2.

The Brimistor presents a high resistance as the receiver is switched on, the resistance falling rapidly to an operating level as current flow warms the thermistor material.

A suitable Brimistor for 0.2 amp. circuits is the type CZ2; for 0.3 amp. circuits the CZ1 should be used. Brimistors should be mounted with a clear half-inch or more of their end wires left free before a soldered joint, and no mechanical strain must be placed on them. They must also be clear of other

components to permit adequate ventilation.

As the inclusion of a Brimistor is left to the discretion of the constructor, no compensation for its operating resistance has been made in the calculations. Curves supplied by the manufacturers show that the resistance of a CZ2 at 0.2 amp. may be taken as about 63 ohms, so that across this type of Brimistor there would be a voltage drop of roughly 12.6 volts. This may be added to the heater chain voltage and it will then be found that the required capacitance is much nearer still to an exact 3 mfd.—it is slightly above 3 mfd. The circuit regulation will compensate any slight discrepancies in the final Brimistor operating resistance.

The resistance of the CZ1 Brimistor at an operating current of 0.3 amp. may be taken as 44 ohms.

The position of the Brimistor as shown in Fig. 3 is correct for any type of series heater circuit. This component should always be placed between the main voltage dropper (whether barretter, resistor or capacitor) and the rectifier heater; or between the main voltage dropper and the dial lamp, when one is used.

**2. A Simple F.M. Tuning Unit.**—Constructors of super-regenerative receivers may know that F.M. stations can be heard on these sets as clearly as normal A.M. stations; but a super-regenerative receiver of the simplest type is not suitable for F.M. reception because of the very serious interference and re-radiation caused. If the super-regenerative receiver is slightly changed in form, however, and made into an I.F. amplifier-detector of a quite simple superhet. circuit, the advantages of a super-regenerative circuit (tremendous gain and quite good A.V.C. and noise discrimination) can be enjoyed without the disadvantages.

Constructors and experimenters in the service areas of the B.B.C. main F.M. station and experimental stations can build up a three-valve F.M. tuner to feed into the pick-up terminals of the home broadcast receiver, or into a gramophone amplifier, with excellent results.

The normal F.M. receiver must include a high gain I.F. amplifier with a limiter and discriminator detector. If a ratio detector is used, the limiting stage or stages need not be included; but the F.M. receiver is still fairly complicated and



costly to build and, further, is by no means simple to align.

Alignment on the circuit shown in Fig. 3, however, is a very simple matter.

The valves are chosen for their ready availability, the two types used often being found in war surplus gear. If required, the first two valves may be combined, and a normal frequency changer used, such as the ECH35; but for the high frequencies a separate oscillator is to be preferred.

V1 is tuned to the F.M. station carrier frequency—about 90 to 95 mcs. for British stations—and is arranged to act as a bias detector with grid injection of oscillator energy from V2. This method of operation produces the required I.F. signal in the anode load of V1. V1 tunes broadly, and so is well adapted for F.M. reception. An EF50 is used.

V2, a simple triode oscillator using the EC52, is not coupled directly to the EF50; sufficient oscillator energy is introduced into the mixer circuit by stray coupling, though a very low capacitance between the triode plate and the pentode grid may be placed in circuit if the injection seems poor. The tests conducted by the author would appear to be unnecessary; if a capacitance is used it should be of the order of 1 or 2 pFd.

With the EF50 tuned to the F.M. carrier on, say, 90 mcs., the EC52 is tuned to 59 mcs. to produce an I.F. of 31 mcs. This I.F. is chosen so that the super-regenerative I.F. and detector stage, V3, another EC52, works efficiently and outside any amateur or broadcasting band to prevent stray signal pickup.

The coupling between V1 and V3 is via a tuned transformer, and all circuits may be trimmer tuned since it is assumed that the unit will be set to the nearest F.M. transmitter.

The F.M. signals are detected or demodulated in the V3 stage by tuning the super-regenerative detector so that the frequency modulated I.F. carrier falls on one side of broad response of the detector curve. There are, therefore, two tuning points to which the V3 circuit may be set, one on each side of a quiet spot. With the detector tuned in this way the frequency modulation shifts the I.F. carrier up and down the side of the curve, thus giving a varied audio output for a shift in frequency. The principle is that used by amateur transmitting stations when receiving a narrow band F.M. amateur

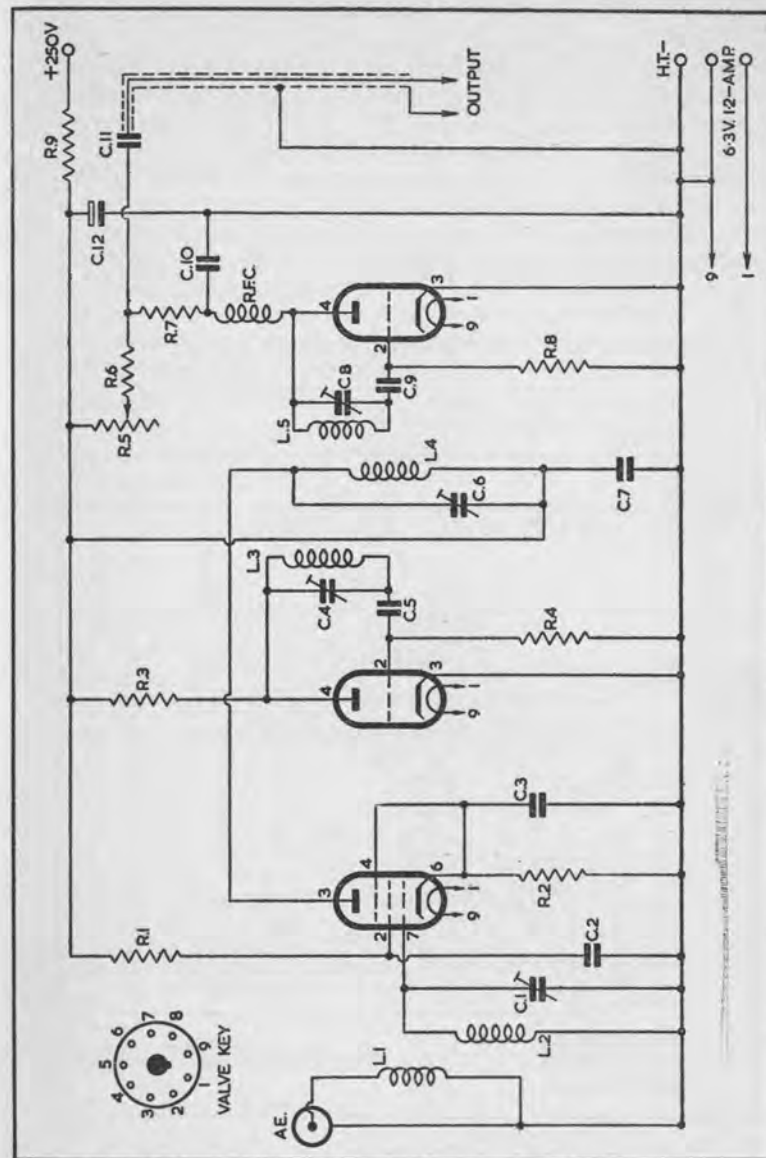


Fig. 3. A simple FM tuner.



station on the selectivity curve of a communications receiver. The N.B.F.M. signal is received on a very selective tuned circuit by setting the tuning slightly to one side of the carrier rather than tuning exactly to the central frequency.

A suggested layout and wiring diagram, with chassis drilling details, are shown in Figs. 4 and 5.

**Construction.**—The chassis is drilled and cut to shape as shown in Fig. 4, and the components are mounted and wired as in Fig. 5. Note that all the trimmers are held firmly in place by bolts which secure them to the chassis, although the trimmers are not bolted down on the chassis but are supported

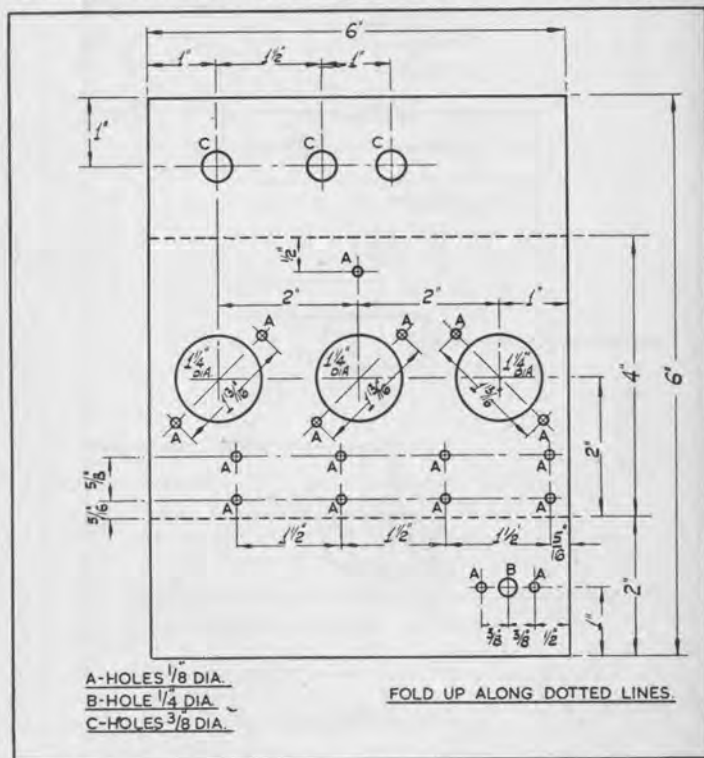


Fig. 4. Chassis drilling dimensions for the FM tuner.

$\frac{1}{2}$  in. from its surface. 1-in. bolts should be used for this purpose, each bolt having 3 nuts (6 B.A. bolts should be used).

At each trimmer position 2 bolts are passed down through the chassis and secured by a nut run down the bolt and clamping the chassis. A further nut is then run down the bolt to a distance of  $\frac{1}{2}$  in. from the chassis, the trimmer dropped on to its two bolts, and the last nut run down each bolt to grip the trimmer. Spring washers should be used. The capacitors are then held firmly and can be used as anchoring points for the coil ends.

The H.T. and heater supply leads, which are taken to the receiver or amplifier used with the tuning unit, may terminate in a socket on the unit chassis, or may be taken to a plug for connection to a power socket on the receiver or amplifier chassis. Power requirements are about 10 m/As. at 250 volts and 1.2 amps. at 6.3 volts.

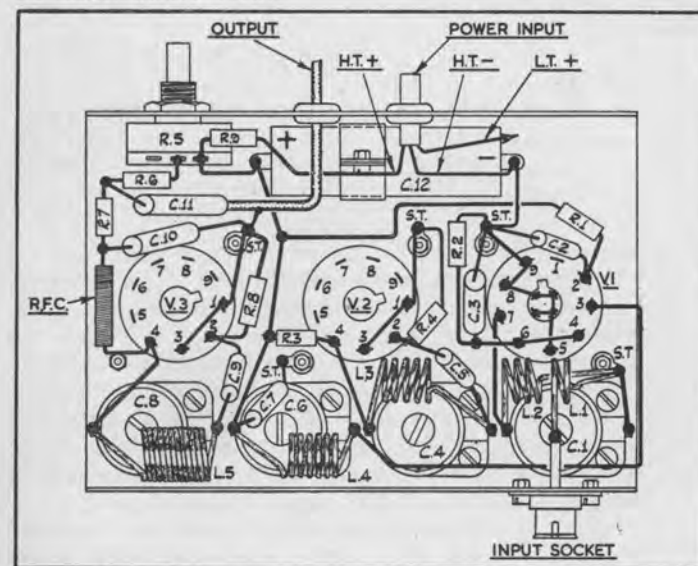


Fig. 5. Under chassis view of the FM tuner. ST denotes chassis connection via soldering tag.

## COMPONENTS LIST, FIG. 4

R1-4	...	...	100,000 ohms.
R2-7	...	...	10,000 ohms.
R3	...	...	22,000 ohms.
R5	...	...	0.5 megohm potentiometer.
R6	...	...	47,000 ohms.
R8	...	...	220,000 ohms, $\frac{1}{2}$ watt.
R9	...	...	10,000 ohms, 1 watt.
C1-4-8	...	...	6-70 pFd. ceramic trimmer. T.C.C. CVS31
C2-3-11	...	...	0.01 mfd. 350 v.wg. Tubular. T.C.C. 346.
C5-9	...	...	100 pFd. Mica. 350 v.wg. T.C.C. CM20N.
C6	...	...	10-100 pFd. ceramic trimmer. T.C.C. CVS31.
C7	...	...	0.001 mfd. Mica. 350 v.wg. T.C.C. CM20N.
C10	...	...	0.003 mfd. Mica. 350 v.wg. T.C.C. M3N.
C12	...	...	8 mfd. 350 v.wg. Electrolytic. T.C.C. CE11L.
R.F.C.	...	...	60 turns 30 S.W.G. enam. close wound on 1 meg. resistor, or $\frac{1}{2}$ in. diam. former.
V1	...	...	Mullard EF50. 3 B9G valveholders.
V2-3	...	...	Mullard EC52.
Aerial socket (for co-axial feeder), Belling Lee L604/S with plug L604/P.			
Chassis (Fig. 4), 6in. x 4in. x 2in. Aluminium.			
L1	...	...	1 $\frac{1}{2}$ turns 18 S.W.G. $\frac{1}{2}$ in. diam. spaced $\frac{1}{4}$ in. from L2.
L2	...	...	3 turns 18 S.W.G. $\frac{1}{2}$ in. diam. spaced own diam.
L3	...	...	5 turns 18 S.W.G. $\frac{1}{2}$ in. diam. spaced own diam.
L4	...	...	6 turns 18 S.W.G. enam. $\frac{1}{2}$ in. diam. close wound.
L5	...	...	14 turns 18 S.W.G. enam. $\frac{1}{2}$ in. diam. close wound In line with L4 and separated from L4 by $\frac{1}{4}$ in.

*Alignment.*—To align the receiver a signal generator with a high frequency range is a considerable help. If a generator cannot be employed it will be necessary to align on a signal.

First insert V3, after checking the wiring, and when the valve has warmed up check that super-regeneration is obtained. A fairly loud hiss should be heard through the amplifier speaker.

Set the signal generator to 31 mcs. and feed a signal into L4. Rotate C8 until the signal is heard; the hiss should diminish considerably. By varying R5 set the detector to its most sensitive condition for best signal with no hiss.

Insert V1 and feed the 31 mcs. signal from the generator into its grid. With the valve warmed up and operating, rotate C6 to tune to 31 mcs. Again the signal should be heard at good strength with no hiss. Correct the spacing between L4 and L5 if necessary. For this test a better signal is obtained

if L2 and C1 are disconnected from the grid of V1. Remake this connection, and, if possible, feed in a 90 mcs. signal to the aerial socket, and insert V2. If the signal generator will not tune as high as 90 mcs. the sub-harmonic 45 mcs. may be fed in, though care must then be taken over the tuning of C4. Alternatively the rest of the trimming can be performed on an F.M. signal.

Rotate C4 until the 90 mcs. signal fed into the aerial socket is heard, and peak up on C1 for best volume. Finally trim C6 and C8 slightly to one side of the signal, choosing the best position for results, judged audibly.

Both capacitors must be tuned to the same side of the signal, i.e., both must go a little high or a little low in value, not one high and the other low.

The aerial system must depend on the reception location. If near an F.M. station an indoor wire will suffice, but when the receiver is to be operated at some distance from the station a vertical dipole, possibly with a reflector, should be used. For a 90 mcs. signal both halves of the dipole should be constructed of  $\frac{1}{2}$ -inch tubing (copper, dural or aluminium tubing are suitable), each half being cut to a length of 31 in. For slightly different frequencies this size of aerial should still prove effective. A 70 or 80 ohms co-axial line connects the centre of the dipole to the tuning unit, the core of the cable being connected to one half dipole and the outer covering to the other half. A  $\frac{1}{2}$ -in. or  $\frac{3}{4}$ -in. gap at the centre of the aerial allows the cable connections to be made conveniently.

3. *A Modern Crystal Receiver.*—Crystal receivers can still be useful as standby and 'late night' sets and are ideal for children who want a radio of their own and who are too young to be trusted with a mains or battery receiver.

A crystal set must be fed from a good aerial and earth system and there must be adequate field strength at the receiving location to supply a good signal to the headphones; crystal receivers should not be considered other than 'local station' sets. They are useless in poor reception areas; but in good reception areas, however, a simple circuit using a radar type crystal can give excellent results with no troublesome crystal adjustments.

Two types of radar crystal are available: the silicon crystal such as the B.T.H. CS7A (often obtainable in surplus gear or from surplus stock, when it bears the service number CV253); and the germanium crystal such as the B.T.H. CG 1-C. Both crystals are very small; but the germanium type is easier to handle as it is tubular and has wire ends.

Two crystal receiver circuits are available, the first being the normal parallel-tuned combination, and the second a series-tuned circuit with the crystal tapped down the coil to obtain a better match from the tuned circuit into the crystal impedance. The first circuit is shown in Fig. 6A, and tests indicate that this type of receiver is more suited to the germanium crystal.

A Wearite PA2 coil tuned by a 500 pFd. variable capacitor, with a 0.002 mfd. capacitor across the headphones, are the only components required. An aerial coupling capacitor between 100 and 500 pFds. can be used for direct coupling of the aerial

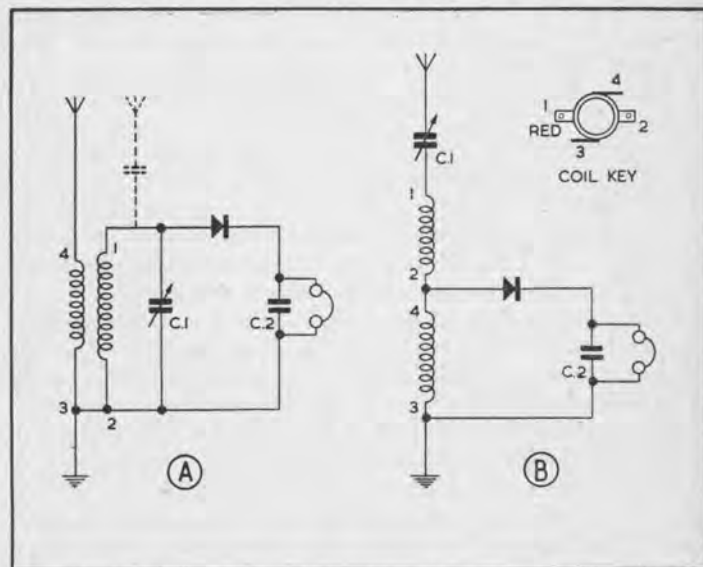


Fig. 6. Radar Crystal Receivers. C.1=500 pFds variable condenser. C.2=0.002 mfd.

to the tuning coil (as shown by a dotted line), for tighter coupling than that provided by the aerial coil.

The headphones used with either circuit should be of the high resistance type, 2,000 or 4,000 ohms being suitable values. Low resistance phones cannot be used and cannot be transformer-coupled into these receivers.

The second circuit is shown in Fig. 6B where the coil and capacitor are series-connected with the aerial. The tuning range depends on the aerial capacitance to some degree, but a Wearite PA7 coil may be used in this circuit, the two windings being connected in series to provide the crystal tapping. Should it be desired to make a series of tests on the circuit, a special coil can be wound, consisting of up to 120 turns of 30 S.W.G. on a 3-inch former and tapped experimentally for best results.

Both circuits are for medium wave reception; for long wave tuning the coil of Fig. 6A may be changed for a Wearite PA1; but in Fig. 6B quite a large coil is necessary for long wave reception, and to maintain efficiency honeycomb or wave winding is necessary. It is difficult to wind such a coil by hand. One way of obtaining the required inductance would be to use a pi-wound short wave choke of between 4 and 5 millihenrys inductance, making the connecting wire between the last two pins at the earthy end of the crystal tapping point.

If first tests on either circuit indicate that good results will be obtained, it is possible to miniaturise either receiver by using a padder type capacitor in place of the bulky air-spaced tuner and the crystal can be mounted within the coil former, the capacitor being held across the end of the coil.

The silicon type crystal must be held and connected up by small clamps or clips shaped to fit its ends. The germanium crystal should be protected from heat during soldering by gripping its leads between the body of the crystal and the joint with broad-nosed pliers.

4. *Improving the T.R.F. Receiver.*—The T.R.F. receiver or tuning unit is still favoured by quality enthusiasts by reason of its relatively broad response curve compared with that of the superheterodyne. The curve permits reasonably unattenuated reception of the whole carrier and sidebands without high frequency cutting, so that full advantage is taken of the full modulation width of the received station.



Such a tuning characteristic means, however, that the receiver must be less selective than a superhet. or other sharply tuned set, with the result that in many reception areas there is trouble from overlapping and interference. One method of avoiding this trouble, to some degree at least, is by using a very small aerial, but then reception other than from the local station becomes unsatisfactory. High quality reception of distant and foreign stations is not really practicable, and the circuit of Fig. 7 shows how the detector of a T.R.F. tuner or receiver can be adapted for quality or distant reception at the turn of a switch.

Fig. 7A shows a typical R.F. detector stage circuit before conversion. The stages are coupled by an R.F. transformer and grid leak detection is used. In Fig. 7B the same detector coil is directly coupled to the R.F. stage, and the secondary or anode coil is now used to provide a degree of regeneration over the detector stage. The circuit allows the detector to be run past the critical point and into oscillation, the regeneration control being the potentiometer in the screen supply circuit to the detector valve. When the detector is switched to "Quality" this control becomes a highly effective volume control.

By extending the idea it is possible to add a short wave tuning range to the receiver, when the rather limited quality tuner becomes a high gain all-wave set at the turn of a switch.

#### COMPONENTS LIST, FIG. 7A-B

R1	...	100,000 ohms.	R2	...	330 ohms.
R2	...	330 ohms.			
R3	...	10,000 ohms variable.			
R4-9	...	10,000 ohms.			
R5-8	...	1 megohm.			
R6	...	330,000 ohms.			
R7	...	33,000 ohms.			
R10	...	1.5 megohm.			
R11	...	0.5 megohm potentiometer.			
L1	...	PA2 Wearite.	L2	...	PHF2 Wearite.
L2	...	PHF2 Wearite.			
C1-2	...	2 x 500 pFd. gang condenser.			
C3-4	...	6-70 pFd. trimmer. T.C.C. CVS31.			
C5-6-7-8	...	0.1 mfd. T.C.C. 346.			
C9	...	0.01 mfd. T.C.C. 346.			
C10	...	8 mfd. Electrolytic. T.C.C. CE11L.			
C11-13	...	100 pFd. T.C.C. CM20N.			
C12	...	50 pFd. T.C.C. M.W.N.			
S1	...	S.P.S.T. switch.			
VI-2	...	EF 37A MULLARD, or OM5A COSSOR.			

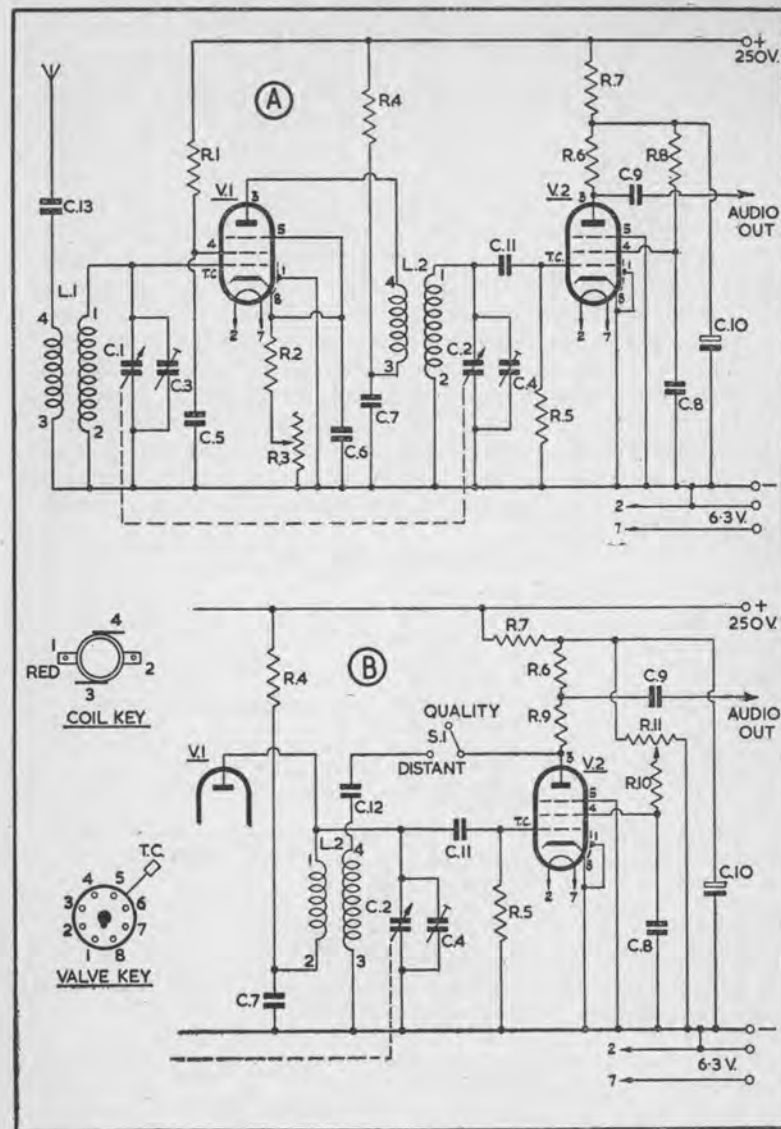


Fig. 7. A. RF and Detector stages of typical TRF receiver. B. The same circuit modified for "Quality-Distant" reception.

The quality receiver often has an infinite impedance detector in place of the grid leak detector shown in Figs. 7A-B. Conversion to give a regenerative detector for sharper tuning and distant station reception is still possible; but in this case it is better to employ a second detector valve and circuit which can be switched in for types of reception other than high quality.

A new detector circuit is preferred since it is highly desirable to maintain the transformer coupling to the infinite impedance detector whilst the new detector will require a direct coupling to the R.F. stage if normal two-winding coils are to be used. There is no reason why the new detector valve should take up extra space, however, and the proposed circuit is shown in Fig. 8 where the triode (or strapped pentode) used as the impedance detector is replaced by a double triode, one half of which works as an impedance detector for quality reception and the other half becomes a regenerative detector for distant or selective reception.

#### COMPONENTS LIST, FIG. 8

R1	...	...	330 ohms.
R2	...	...	10,000 ohms variable.
R3	...	...	100,000 ohms.
R4-6-11	...	...	10,000 ohms.
R5	...	...	1 megohm.
R7-10	...	...	47,000 ohms.
R8	...	...	33,000 ohms.
R9	...	...	39,000 ohms.
S1-2-3-4	...	...	4-pole 2-way rotary wafer switch.
V1	...	...	EF37A.
V2	...	...	ECC32.
C1-2	...	...	2 x 500 pFd. gang condenser.
C3-4-7	...	...	6-70 pFd. trimmer. T.C.C. CVS31.
C5-6	...	...	0.1 mfd. T.C.C. 346.
C8	...	...	300 pFd. variable.
C9	...	...	100 pFd. T.C.C. CM20N.
C10	...	...	0.5 mfd. T.C.C. 343.
C11	...	...	500 pFd. T.C.C. CM20N.
C12	...	...	200 pFd. T.C.C. CM20N.
C13	...	...	0.01 mfd. T.C.C. 346.
C14	...	...	8 mfd. Electrolytic. T.C.C. CE11L.
L1	...	...	PA2 Wearite.
L2-3	...	...	PHF2 Wearite.

In all T.R.F. conversions some care with the switch wiring and coil placing is essential to avoid any chance of instability, but if the two sets of coils are separated by the chassis deck

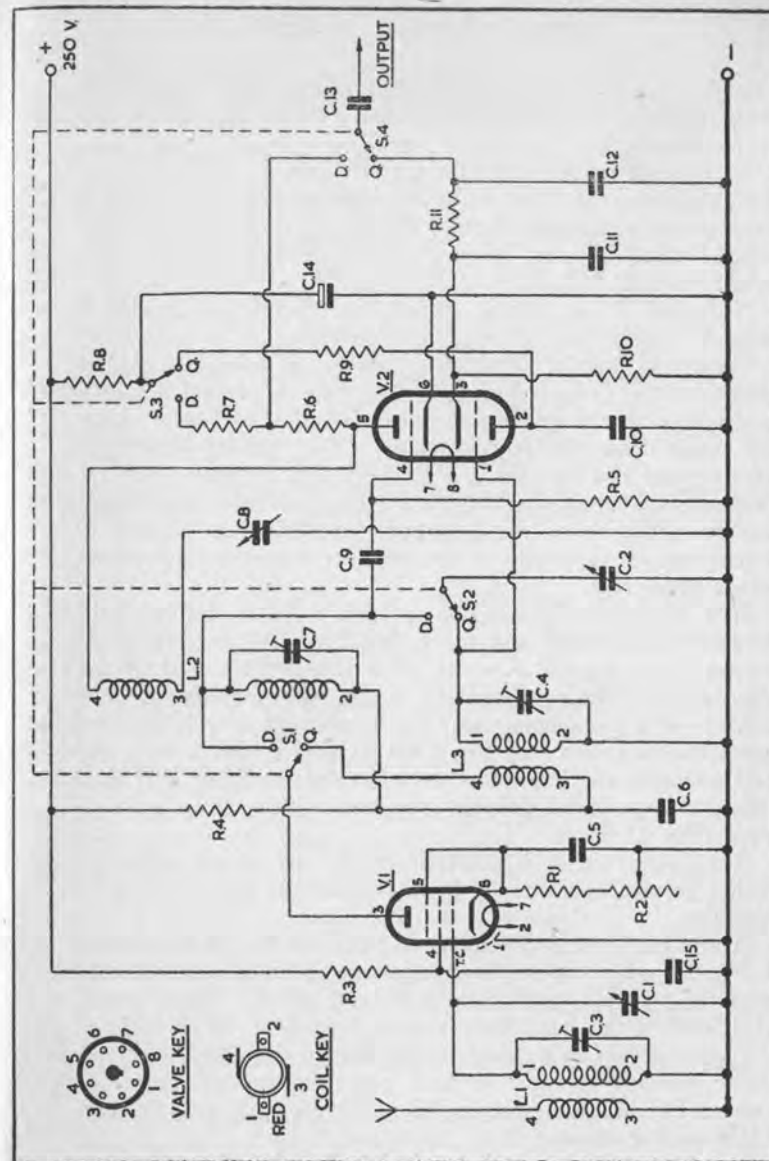


Fig. 8. TRF receiver with Infinite impedance detector for local reception and regenerative leaky grid detector for distant reception.

(the R.F. stage coils being above and the detector coils below the chassis), this is usually sufficient to ensure that there will be no inter-action.

In a direct coupled detector the circuit is more likely to be unstable since the R.F. valve is, after all, connected into a tuned-anode tuned-grid circuit; but any sign of instability can invariably be adjusted by a reduction in the R.F. pentode screen voltage.

Neat and direct wiring should be sufficient to provide a perfectly stable circuit.

When the infinite impedance detector is used for quality reception, the audio output from the stage is often fed into a quality amplifier to which the tuner is attached and from which the tuner draws its power supply. The infinite impedance detector can also be used in a straight T.R.F. receiver with a further audio amplifying stage and a single-ended output stage; but the difficulty of the first audio amplifier can sometimes become acute, especially if the receiver is to be compressed into a small case.

If a sensitive output valve is used, a great deal of gain between the detector and the output stage is unnecessary—if the set has a good R.F. stage, as it should have to feed the impedance detector adequately, a pentode amplifier is not needed—and the simplest way out of the difficulty is again to use a double triode. In Fig. 9 an ECC32 is shown with one half acting as the impedance detector and the other half as a resistance-capacitance coupled amplifier with a stage gain of more than 25 times.

A volume control is incorporated in the circuit, although such a control may already be in the cathode line of the R.F. amplifier.

A straightforward development from the last idea is shown in Fig. 10, where the amplifier following the impedance detector is of the push-pull type with an output, for the valves shown, of 8 watts with a total distortion of 1 per cent. The detector is again one half of a double triode, but in this case the second triode operates as a concertina phase splitter feeding into another ECC32 push-pull amplifier which in turn feeds the two EL33 output valves.

If a tone control stage is required it should be fitted between

the detector and the phase splitter, and in this type of circuit the tone control stage should have a valve incorporated to give

#### COMPONENTS LIST, FIG. 9

R1	...	47,000 ohms.
R2	...	39,000 ohms.
R3	...	33,000 ohms.
R4	...	220,000 ohms.
R5	...	10,000 ohms.
R6	...	0.5 megohm potentiometer.
R7	...	3,900 ohms.
L1	...	PHF2 Wearite.
C1	...	6-70 pFd. trimmer. T.C.C. CV531.
C2	...	part of ganged tuning condenser.
C3	...	200 pFd. T.C.C. CM20N.
C4.5	...	0.01 mfd. T.C.C. 346.
C6	...	8 mfd. Electrolytic. T.C.C. CE11L.
C7	...	25 mfd. 12 v. T.C.C. CE31B.
C8	...	0.5 mfd. T.C.C. 345.
C9	...	500 pFd. T.C.C. CM20N.
V1	...	ECC32 MULLARD.

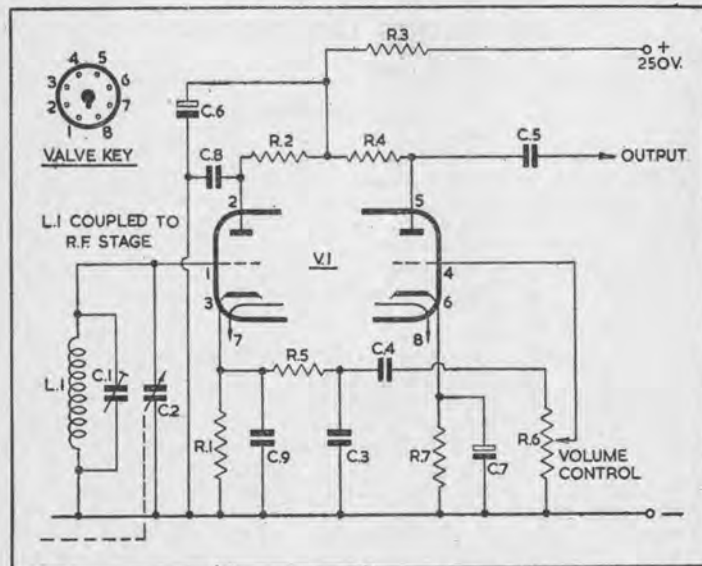


Fig. 9. Double triode as Infinite impedance detector and first audio stage.



sufficient amplification to overcome the losses caused by the tone controlling circuits.

The circuit shown has negative feedback included over the output stage and penultimate stage, so that good quality can be maintained. The feedback is taken from the voice coil winding of the output transformer and applied to the cathodes of the push-pull triodes, and it must be noted that the proper connections to the output transformer must be found by experiment. If the circuit howls when first switched on, the connections to the output winding must be changed over, when the sense will be correct and the feedback applied in the proper phase.

The application of negative feedback causes some loss of sensitivity over the amplifier; but if a little more gain and a little less feedback is required, the resistors between the voice coil winding and the triodes' cathode circuits can be increased experimentally. These two resistors must always have equal values.

#### COMPONENTS LIST, FIG. 10

R1	...	47,000 ohms.
R2	...	10,000 ohms.
R3	...	0.5 megohm potentiometer.
R4	...	39,000 ohms.
R5-8-15-16	...	100,000 ohms.
R6-17	...	33,000 ohms.
R7	...	4,700 ohms.
R9-10	...	100 ohms.
R11-12	...	1,000 ohms.
R13-14	...	1 megohm.
R18-19-20	...	390,000 ohms.
R21-22	...	47 ohms.
R23-4	...	470 ohms.
R25	...	140 ohms, 1 watt.
V1-2	...	ECC32 MULLARD.
V3-4	...	EL33 MULLARD.
C1	...	6-70 pFd. trimmer. T.C.C. CVS31.
C2	...	part of ganged tuning condenser.
C3	...	500 pFd. T.C.C. CM20N.
C4	...	200 pFd. T.C.C. CM20N.
C5-6-7-8-11-12	...	0.01 mfd. T.C.C. 346.
C9-10	...	8 mfd. Electrolytic. T.C.C. CE11L.
T1	...	Output transformer to match speech coil to 10,000 ohms load. The secondary winding is centre tapped.

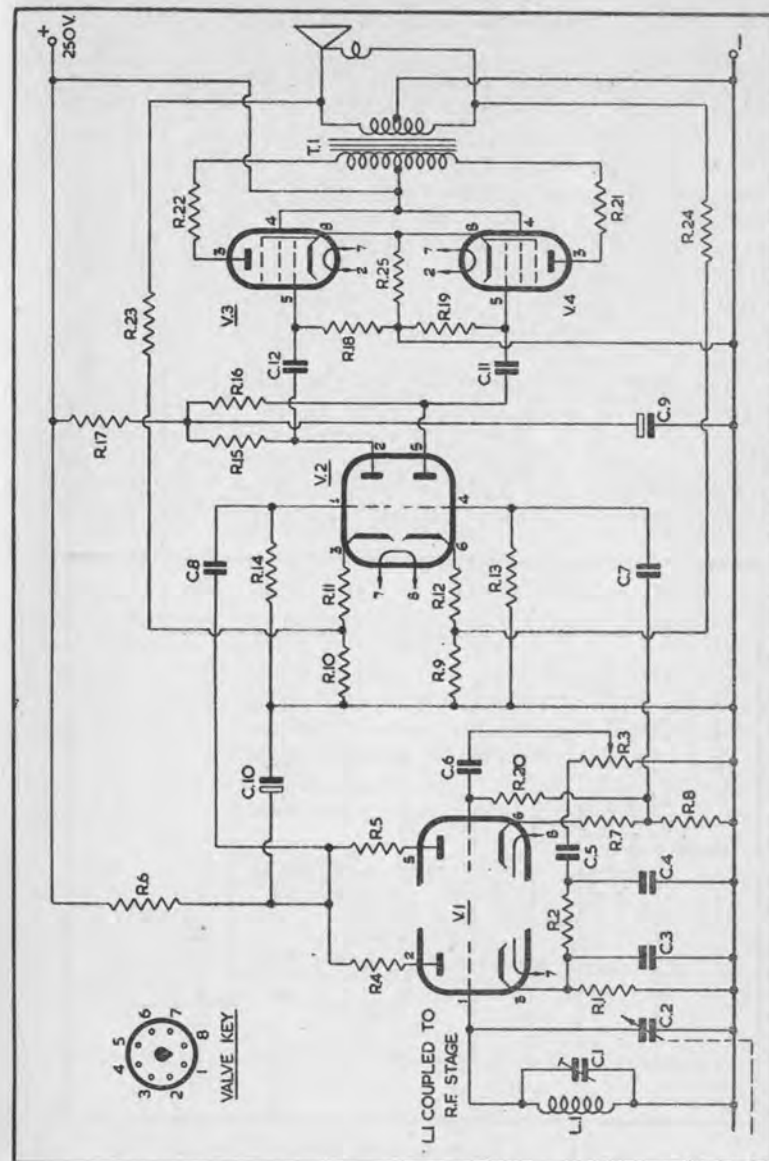


Fig. 10. An Infinite impedance detector followed by a high quality audio amplifier.

5. *A Versatile Tone Control Stage.*—A tone control stage which can be fitted between a detector and following audio and output stages in a receiver, or between the first and following stages of an amplifier, is shown in Fig. 11. The tone control covers a wide range and allows a variety of settings since the output from the valve is fed to 3 output potentiometers in parallel, one of which deals with the high frequencies, another with the middle frequencies and the other with the low frequencies. It is, therefore, possible to feed into the following stages whatever proportions of the 3 tonal ranges are found desirable.

The upper potentiometer, R4, has the full output from the valve set up as audio voltages across it, but the lead to the following circuit is taken to the variable contact on the potentiometer through a small capacitance, so that only the high frequencies pass with little or no attenuation. Middle and low frequencies are very strongly attenuated. The second

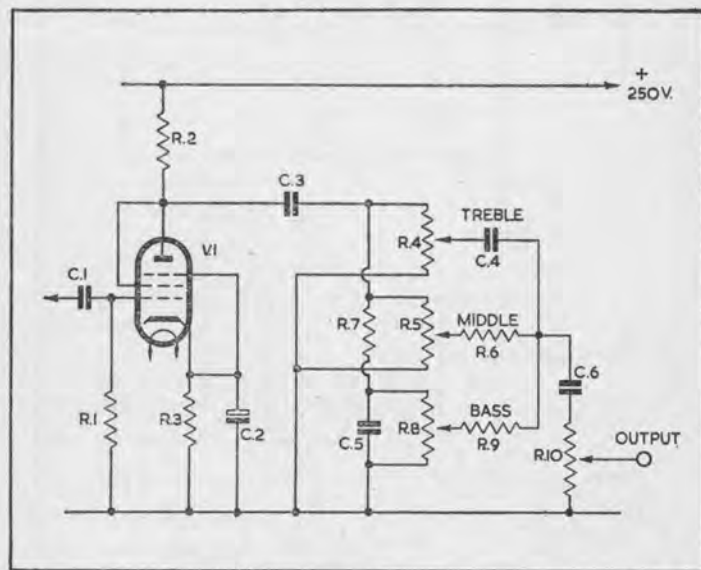


Fig. 11. A versatile tone control circuit.

potentiometer, R5, also carries the full output from the valve and the following circuits are connected to the variable contact via a resistance which serves to isolate the control circuit so that its effect is not nullified by the positions of the sliders on the other potentiometers.

The third potentiometer is connected to the valve through a treble attenuating circuit, since R7 is in series with the potentiometer, R8, and the potentiometer is also shunted by a fairly high capacitance which bypasses to earth all but the low frequencies. A further isolating resistance, R9, feeds the following circuits from the variable contact.

This type of control circuit should be fed from a triode valve; or an R.F. pentode triode connected, which for the majority of pentodes (including the EF37A which acts well in audio stages either as a pentode or triode connected) means that the screening grid, G3, should be connected to the anode, and the suppressor grid, G3, should be connected to the cathode.

This tone control may also be made into a remote control device, for, by setting the controls well down their ranges, volume as well as tone can be varied. The valve should be on the receiver or amplifier chassis in the usual manner for remote control, but the three potentiometers can be built into a metal or metal-lined wooden box or case, the input and output circuits being carried to the control case through screened two-core cable, the screen acting as the earth return and the cores as the input and output leads respectively.

The length of cable permissible between a receiver or amplifier and a remote tone control box is limited by the hum

#### COMPONENTS LIST, FIG. 11

R1	...	...	470,000 ohms.
R2	...	...	47,000 ohms.
R3	...	...	470 ohms.
R4-5-8-10	...	...	0.5 megohm potentiometer.
R6-9	...	...	330,000 ohms.
R7	...	...	150,000 ohms.
V1	...	...	EF37A Mullard. Z63 M.O.V.
C1-3-6	...	...	0.1 mfd. T.C.C. 345.
C2	...	...	25 mfd. 12 v. T.C.C. CE31B.
C4	...	...	200 pFd. T.C.C. CM20N.
C5	...	...	0.005 mfd. T.C.C. 545.

pick-up, and also by the cable capacitance which causes a certain high frequency loss; but it has been found possible to use a cable 3 yards long without noticeable effect. Separate volume control is provided by taking the joint output lead from the three tone controls via C6 to R10. If this control is not required the output may be taken from the junction of C6 and R6, 9 and C4.

6. *A Cathode-Coupled R.F. Pre-amplifier.*—Communications and amateur receivers, especially those designed before the advent of modern high gain and miniature valves, often leave much to be desired on the 30 mcs. band, although their performance is satisfactory on the lower bands.

To improve the high frequency performance a pre-amplifier (as distinct from a carefully tuned and selective pre-selector) can be connected between the aerial and the receiver to give extra R.F. amplification. See Fig. 12.

Several points in this arrangement may be new to some

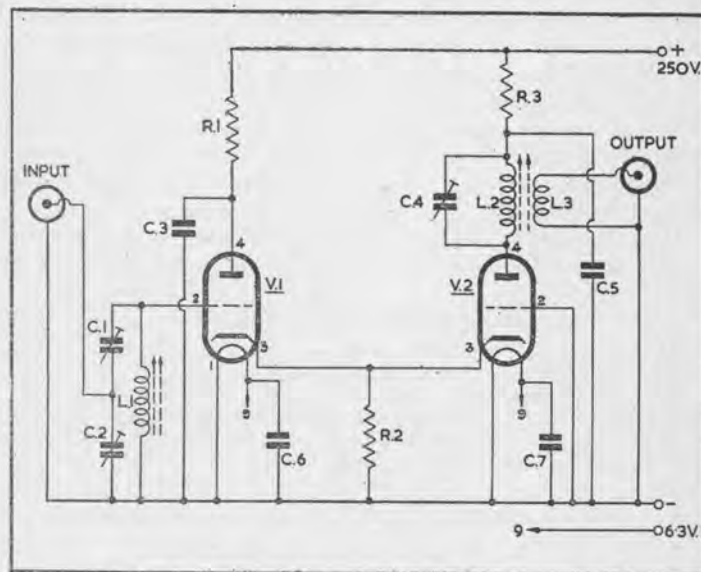


Fig. 12. *A cathode-coupled RF pre-amplifier.*

constructors, including the two-capacitor aerial coupling circuit where the aerial feeder is led in directly across a capacitor. Adjusting the two capacitances by trial and error gives a close and accurate match of the aerial or feeder impedance into the first tuned circuit, while at the same time the energy transfer is good.

The signal appears across the common cathode resistor of the two valves, and as the grid of V2 is earthed to the chassis, this valve acts as an earthed grid amplifier. Possibly better results could be obtained by using a Mullard EC91 for V2, which is designed as a grounded grid amplifier, or a Mullard ECC91 double triode could be used in place of the two EC52 valves.

The output appears across L2, which is tuned by C4, and the receiver is coupled to the pre-amplifier via L3. If the receiver lacks selectivity it is advisable to make C4 a variable capacitor which may be tuned from the front panel or chassis wall of the pre-amplifier; but under the conditions in which the circuit was tested this was not required and so both the input and the output tuned circuits were treated as band-tuned, and adjusted to give results over the 28.5-30 mcs. band.

#### COMPONENTS LIST, FIG. 12

R1	...	...	10,000 ohms.
R2	...	...	470 ohms.
R3	...	...	4.700 ohms.
C1-2	...	...	5.40 pFd. ceramic double trimmer. T.C.C. CVS12.
C3-5-6-7	...	...	0.001 mfd. Mica. T.C.C. CM20N.
C4	...	...	5.40 pFd. ceramic trimmer. T.C.C. CVS11.
V1-2	...	...	Mullard EC52. 2 B9G holders.
Chassis (Fig. 14), 4in. x 3in. x 2in. Aluminium.			
2 Co-axial sockets, Belling-Lee, L604/S with plugs L604/P.			
Co-axial output lead, and feeder.			
L1	...	...	15 turns 26 S.W.G. enam. close wound.
L2	...	...	12 turns 22 S.W.G. enam. close wound.
L3	...	...	3 turns 22 S.W.G. enam. close wound over earthy end of L2.

All coils on Aladdin dust cored formers,  $\frac{1}{2}$ in. diameter.

These coils are for 28-30 mcs. operation, and if it is desired to use the pre-amplifier on 14 mcs. (20 metres), the turns on L1 and L2 should be doubled. L3 remains the same size.



**Construction.**—The small chassis is cut and drilled to the dimensions shown in Fig. 13A. If an ECC91 valve is used, an even smaller chassis might be used. A screening partition divides the underside of the chassis into two compartments (to prevent feedback from L2 to L1), and three grommeted holes in this partition allow the passage of leads linking the valveholders together.

Fig. 13B shows the under chassis layout.

The valveholders and trimmers should be mounted. As much wiring as possible should be carried out before the coils are fitted, because these mask the valveholders to some extent. The coils are held in  $\frac{1}{4}$  in. diameter holes in the rear chassis wall through which the coil necks are passed; a nick must be filed at the edge of both holes to take the locating pip on each coil neck. The coils are held in place by speed-nuts passed over the necks and pressed down to the chassis wall.

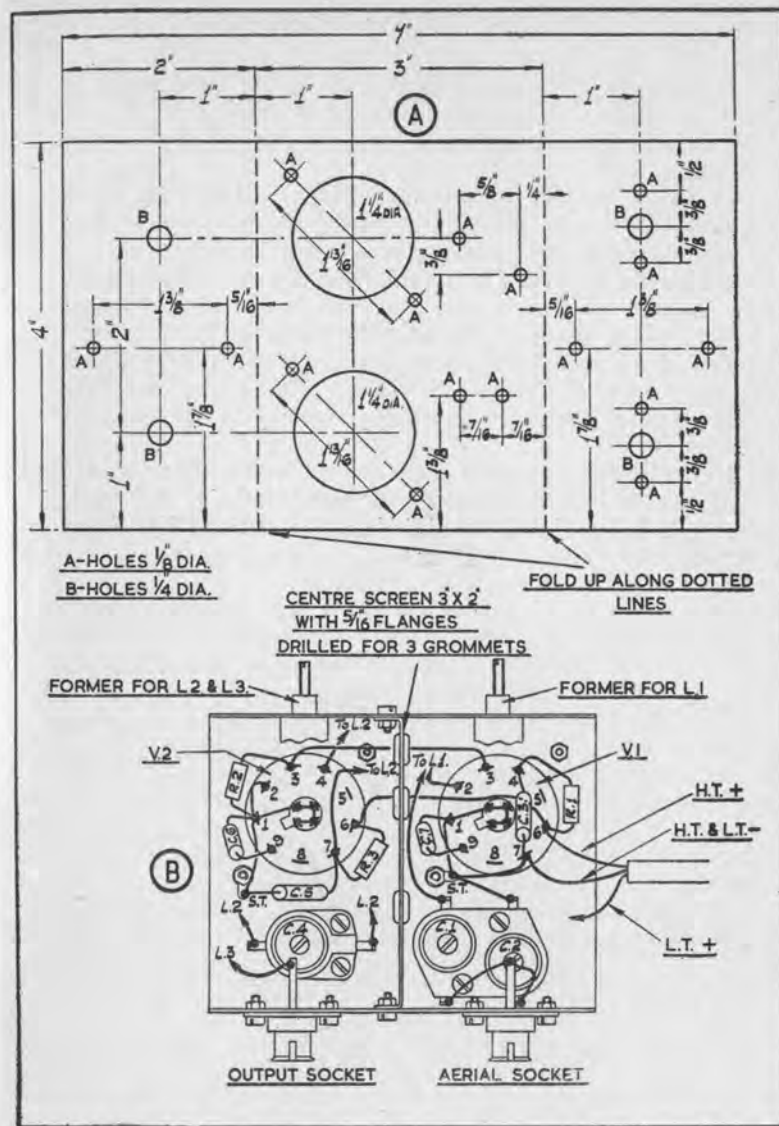
The coil core-adjusting screws are thus accessible from the rear of the chassis.

If EC91 or ECC91 valves are used the H.T. should be cut to 150 volts.

**Alignment.**—With the pre-amplifier coupled to the receiver, tune the set to the centre of the band and adjust C4 and the core of L2 for resonance, which will be indicated by an increase in noise level. This increase in noise should be only slight, since the main advantage of the cathode-coupled pre-amplifier lies in its high signal noise ratio. It is usually most convenient to set C4 to about one-third full capacitance, completing the tuning by adjusting the core of L2.

The aerial is coupled into the input socket and a number of different settings of C1 and C2 tested for results, the first tuned circuit being peaker up, for each different setting of the capacitors, by adjusting the core of L1. A good starting point is to make C1 rather lower in capacitance than C2, but if C1 is too low in value—or C2 too high—there is a chance of instability and oscillation.

The receiver should be tuned over the band, when the pre-amplifier is correctly adjusted, to check for coverage. If amplification drops at or towards the band edges, tighter coupling between the aerial and input circuit is required, and C1 should be increased a little in value.



If coverage still appears inadequate at the band edges, it may be beneficial to switch over to variable tuning of L2, and this certainly should be done if the main receiver shows image reception.

If L2 is variably tuned, the settings will not be found critical—C4 may be advanced in steps as the main receiver dial is turned, and finally peaked up on a desired signal.

When this pre-amplifier is used at an amateur station where the aerial is coupled in (for reception) by the same resonant feeders that are used for transmission, it may be found in some cases that a correct loading and adjustment of the input circuit of the pre-amplifier cannot be made. This occurs only with some resonant feeders: non-resonant feeders do not show the effect.

If the loading cannot be made correctly, the feeders should be terminated in a small tank circuit tuned to the 30 mcs. band, the tank being linked coupled into the pre-amplifier input circuit.

## Section 2

### TEST GEAR

7. *A Simple Signal Tracer.*—Although a signal tracer can be a most useful piece of testgear (showing up a faulty receiver or amplifier stage in a matter of seconds once its correct application is understood), a good signal tracer of the normal type can be very expensive to build. It should have a diode or pentode probe—a high gain amplifier consisting generally of two R.F. pentodes used as audio amplifying stages—an output stage with loudspeaker and a magic-eye stage for visual indication on unmodulated R.F. circuits, together with a power pack to drive the apparatus. The signal tracer is thus bulky as well as costly.

It is possible, however, to change the method of signal tracing round, so that the set or amplifier under test becomes the indicator, the signal tracer itself taking the form of a generator which can feed either audio or R.F. signals into the faulty circuit.

Tracing then starts at the loudspeaker and moves back towards the aerial, a signal being injected into each stage in turn until one stage refuses to pass on the signal. This stage must be the one at fault.

A generator which will supply both A.F. and R.F. signals

without switching, can take the form of a multivibrator working on a fundamental frequency of about 1,000 c.p.s. It is well known that the output from a multivibrator is very rich in harmonics, and besides the 1,000 cycles note, the generator gives a series of radio carriers, modulated at the same frequency, each carrier being separated from the next by 1,000 cycles. The effect on a receiver is that a signal is heard wherever the tuning of the set may be adjusted, and the harmonics reach well into the short wave bands.

A double triode or two separate triodes may be used in a multivibrator circuit, and whilst practically any valve or valves will work well, a particularly interesting form of multivibrator is shown in Fig. 14A. The circuit is normal but the use of an ECC91 miniature triode allows the 'tracer' proper to be built up into a probe made of copper or brass tubing, the power pack being separate with an interconnecting cord between it and the tracing probe.

The circuit could be further simplified by using an A.C./D.C. type of power pack; but for complete safety the pack as shown should be constructed, the probe then being completely isolated from the supply mains.

#### COMPONENTS LIST, FIG. 14A

R1-2-3-4	...	47,000 ohms.
R5	...	1,000 ohms.
R6	...	10,000 ohms, 2 watts.
C1	...	0.001 mfd. Mica. T.C.C. CM20N.
C2-3-4	...	0.01 mfd. T.C.C. 346.
C5-6	...	8 plus 8 mfd. 450 vw. Electrolytic. T.C.C. CE34P.
T1	...	Primary to suit mains. Secondary 250 volts, 30 m/As. 5v. 2A. 6.3v. 2A.
V1	...	Mullard ECC91.
V2	...	Mullard EY91.
2 B7G holders.		
Probe material, 1in. diameter copper or brass tubing, with round end discs.		
S1a, b, 2-pole mains on-off switch.		
Small chassis or case for power pack.		
3 core cable for power lead.		
Grommet, 14 S.W.G. wire for probe point, bolts, nuts, etc.		

**Construction.**—The power pack can be built up in any convenient form—a small chassis to carry the transformer,

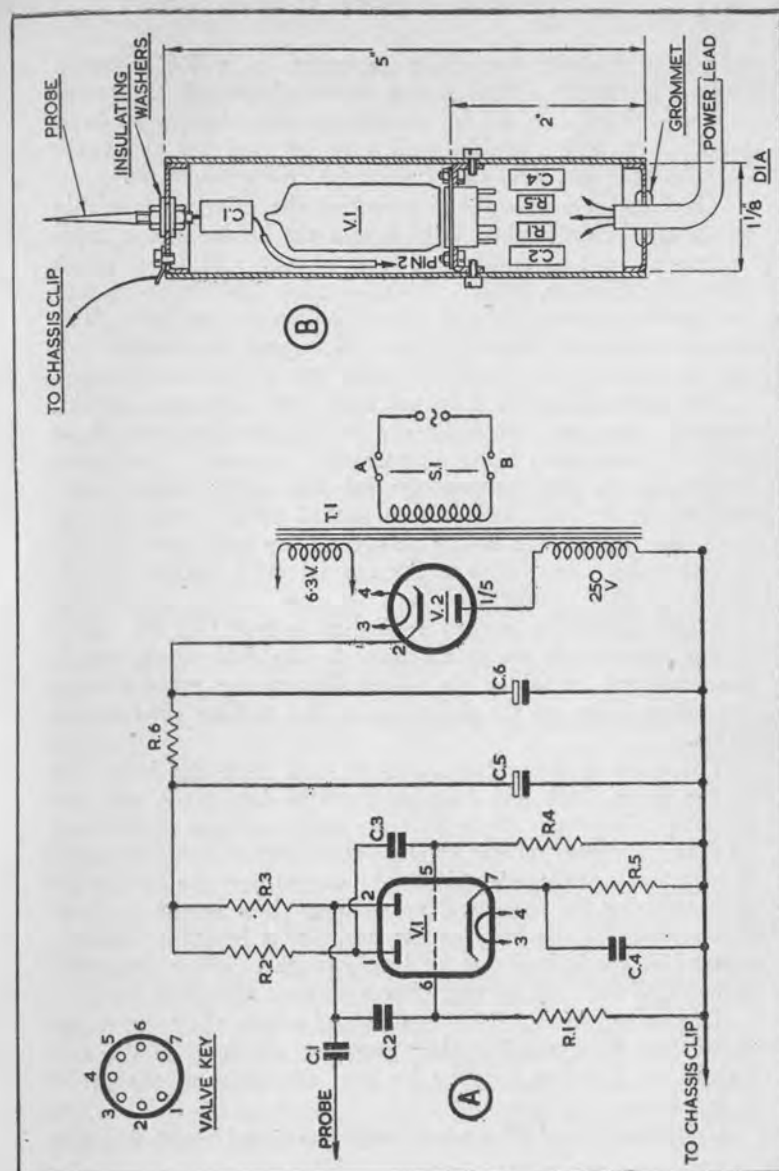


Fig. 14. A. The simple signal tracer. B. Section through the Probe unit.



valve and reservoir-smoothing capacitor, with R6 mounted across the capacitor lugs makes a neat job—and the tracer proper is fitted into a 1-in. diameter probe. Copper or brass tubing with a fairly thin wall may be used for the probe housing, with end discs of the same material sweated on.

There are several ways of mounting the valvholder within the probe. One method is to mount the holder into a small 'carriage' bent up from sheet brass or copper of a size which allows the carriage, holder, valve and associated components to be slipped into the probe and secured with a nut and bolt. The mounting method shown in Fig. 14B is both simple and neat, though possibly a little more troublesome as regards soldering.

The probe tubing is 5 inches long. At a distance of 2in. from the rear end two holes are drilled through the wall at point A, these holes being diametrically opposite. The valvholder has all the components and the power supply cable soldered to its lugs, and is then pushed up the probe tubing until the tips of the holder mounting are positioned in the drilled holes. In this way the normal B7G holder will fit across a 1-in. diameter tube.

A spot of Fluxite is then applied to each end of the valvholder mounting through the holes in the probe wall, and a hot iron used to solder the valvholder to the probe tubing, the solder filling up the drilled holes and making good strong joints.

The valve is then placed into position from the front end of the probe, both end discs are sweated into place, and the probe is completed. Note that the probe point is made from 14 S.W.G. copper wire with one end pointed with emery cloth. A length of systoflex should then be slipped over the bare probe point, leaving the sharp end protruding. The earthing clip is also sweated to the body of the probe by a length of rubber-covered flex which should be long enough to allow the probe to move all over the average chassis without distorting the clip.

The probe rod and point can be held within the front probe cover disc by a small rubber grommet which grips the rod tightly, or a socket may be let into the disc and the probe plugged in.

*Using the Signal Tracer.*—To use the signal tracer first test

it on a receiver in perfect working order. Switch on the set and switch on the signal tracer power pack, allowing both to reach operating temperature.

Clip the tracer earthing clip on to the receiver chassis (taking care to avoid shock if the set is of the A.C./D.C. type) and apply the probe point to the aerial terminal. No matter to what point or waveband the receiver is tuned a strong signal should be heard.

Now apply the probe point to the gram. socket of the receiver; if there are no pickup sockets, apply the probe to the grid tag of the output valve holder. In either case a signal should be heard in the receiver's loudspeaker before contact with the probe point is made—presenting the probe near to a grid pin should give sufficient pickup for an audible loudspeaker signal.

If these results are not obtained the tracer is faulty in some way and must be inspected.

To use the tracer on a faulty receiver, first inspect the power pack of the set, correcting any faults and replacing any broken down components. This is necessary with any type of signal tracer. Next check the receiver for short circuits which could damage the power pack, and when this section of the receiver is in order, switch on.

Commence the tracing operations at the loudspeaker. Clip the earthing clip to one side of the output transformer primary and apply the probe point to the other side of the primary winding of the output transformer. This checks the output transformer on both sides, the loudspeaker voice coil and the inter-connecting wiring. If no signal is heard in the speaker, suspect first the voice coil and its connections, then the transformer primary. Invariably a signal will be heard with this test and the check may continue.

Disconnect the clip from the output transformer and clip it on to the receiver chassis, where it remains for the rest of the tests. Approach the probe to the grid terminal of the output valve—a signal should be heard. Approach the probe to the anode of the first audio amplifier—a double diode triode in the majority of superhets. Again a signal should be heard. Approach the probe to the grid of the double diode triode, and,

if the signal is heard there, transfer the connection to the detector diode where again the signal should be heard.

In this simple way the whole audio section of the receiver is tested. If the signal is lost at any point, the fault must lie between that point and the point where the signal was last heard. Make a very careful check of coupling capacitors if the signal is lost in the audio section, gently pulling the end wires of such components or lightly tapping the capacitor bodies with a pencil. In several cases a lost or weak signal will be found due to a broken down coupling capacitor, and very often a slight mechanical shock will suddenly restore the signal to full volume.

Assuming that the audio section of the receiver is in order, the tests are continued over the I.F. stage. First take the probe point to the anode of the I.F. valve, then to its grid—here again it will probably be sufficient to approach the probe to the electrode contact to give a signal. Continue by approaching the probe to the anode of the frequency changer. If the signal is lost over the I.F. stage carefully check the I.F. transformers; there may be a broken winding, very often in the primary windings which carry H.T., rather than in the secondary or grid windings.

If the signal is still heard with the probe at the frequency changer anode, transfer the connection to the probe point to the control grid of the valve. If no signal, or a weak signal, is obtained, suspect the oscillator section of the valve, and check by inserting a new frequency changer of the correct type, preferably checking H.T. and heater voltages first.

In the majority of cases the fault will have been found by this time, but if a strong response is still obtained, connect the probe point to the top or 'hot' end of each aerial winding, to test the main tuning coils and the coupling, switching the wavechange selector through each band as the test is made, and finally transferring the probe point to the aerial socket of the receiver.

The whole circuit is rapidly checked over in this short series of tests, and in many cases the use of the tracer will carry the fault finding down to the point where, as in the case of a faulty coupling capacitor, the component responsible for the trouble is clearly indicated.

Very careful checking is required to clear up intermittent troubles in a receiver, and again especial care should be taken to check coupling capacitors, which are very often the cause of this type of fault.

Amplifiers are tested in the same way as receivers. First check the output transformer and receiver, then run the probe down the whole valve line-up, starting at the anode of the output valve or valves and moving the probe from anode to grid until the whole circuit from loudspeaker to input sockets has been tested.

The only disadvantage of this type of signal tracer is that it is liable to overload a sensitive stage. When testing high gain amplifiers and audio stages, approach the probe point to the grid terminal slowly—if the probe is connected up directly, a stage thought to be causing distortion is in fact working correctly but is overloaded by the tracer output.

8. *A Quantum Box.*—When the serviceman is of the opinion that the distortion in his faulty receiver is caused by an open-circuit smoothing capacitor, and clips in a new 8 mfd. smoother across the old capacitor as a remedy, he is well on the way to using a quantum box. A quantum box can really be used in two ways. First, as a collection of resistors and capacitors (and possibly chokes and transformers), any one of which can be brought out to a pair of test leads and so introduced into a circuit in place of a faulty component used. Secondly, as a type of 'standard' box, which can be clipped into a circuit from which a faulty component has been removed to test the effects of different values of resistance or capacitance so that the most effective value can be replaced.

A quantum box can be quite small, containing a few resistors and capacitors; or it can be fairly large and ambitious, even including a spare loudspeaker and output transformer. A quantum box is not illustrated, since its form must depend on the constructor's knowledge of the parts most often replaced in broken-down receivers. The box should certainly contain an 8 mfd. capacitor of high working voltage and a 50 mfd. bias electrolytic rated at 25 or 50 working volts. Also there should be a selection of mica capacitors rated at 350 volts working from 50 pFd. through 100, 200, 300 and 500 pFd. up to 0.001 mfd., and paper tubular capacitors rated at 500

volts, covering the values 0.005, 0.01, 0.05 and 0.1 mfd. All these capacitors should have one lead common—the negative lead of the electrolytics—and the other lead of each capacitor should be taken to a single pole selector switch.

A second selector switch should have its points taken to a number of resistors. Values of 100, 220 and 330 ohms should be on the first switch points as suitable resistors for bias circuits, and other values might well include 10,000 ohms, 22,000 ohms, 33,000 ohms, 47,000 ohms, 100,000 ohms, 220,000 ohms and 0.47 and 1 megohm. Again the resistors (all of  $\frac{1}{2}$  watt rating) may have one lead common.

One end contact of a 1 megohm variable potentiometer should be taken to the common lead, and the other end contact and variable arm should be brought out to two sockets on the box panel.

The common leads of the resistor and capacitor combinations are all brought out to one socket on the box, and the selector switch arms should be taken to a further selector switch whose arm is brought out to a second socket placed beside the first. Thus by operating the switches any resistance or any capacitance can be brought out across one pair of sockets.

A pair of rubber leads terminated in clips at one end and plugs at the other, should be provided to connect the sockets on the box into any circuit.

The main selector switch, besides switching either resistance or capacitance across the two main sockets, may have further contacts which connect in other components. A 10 or 12 Henries choke might be included in the box, one lead going to the common socket and the other to a selector switch contact, and a small speaker and output transformer could be switched across the sockets for tests on receivers and circuits where the loudspeaker is found to be damaged or inoperative. Another useful component which can be included in the quantum box is a dial lamp, or a set of dial lamps; these are suggested chiefly because sometimes they are the components most easily forgotten on outside repair work when the spare parts kit is being packed.

The quantum box can also contain one or two simple pieces of test gear. A small buzzer with a series battery can be switched across the main sockets for continuity tests and short-

circuit checks, and a voltmeter with one or two switched multipliers is often an advantage even if a multi-meter is carried. It is often desirable to make checks simultaneously on voltage and current, rather than making one measurement after the other.

It should be remembered that if a loudspeaker and output transformer are fitted in the box they can take the place of a microphone for amplifier testing.

A neon bulb of the small disc and ring type which strike at about 80 or 90 volts is also useful. The bulb is easily mounted and can just protrude through the quantum box panel, being mounted in a rubber grommet which grips the bulb firmly. This bulb, connected in series with a suspected capacitor and a source of about 100 volts or so, which can be drawn from the receiver or gear under test, will indicate quite clearly the state of the capacitor (although the test is most suited to mica and paper capacitors and is not recommended for electrolytics). If the capacitor is large there will be a flash as it charges up and if there are flashes succeeding fairly rapidly the capacitor is leaky. A continual glow indicates, naturally, an internal short-circuit. Small capacitances give little or no charging flash, though leaks and short-circuits are still indicated.

9. *A Tuning Wand.*—Although a tuning wand is easily made and easily used and can be of considerable assistance in the lining up of tuned circuits, it is an item of testgear which seems to be employed by few constructors and experimenters. A typical tuning wand consists of a non-metallic rod or tube which has at one end an iron-dust core and at the opposite end a brass slug. A suitable length for the wand is about 6 in.

In using the wand, the circuits to be checked are trimmed up as accurately as possible using a signal generator or known station as a signal source, and the iron-dust core is then introduced into each coil in turn. The effect on the coil is to increase the inductance and so lower the frequency to which the coil, together with its associated trimmer and tuning capacitor section, is tuned. If the volume of the receiver is increased (or gives a higher reading of the output meter if one is used in place of the loudspeaker) it shows that the coil under test should be tuned to a slightly lower frequency, and accordingly the trimmer across that coil should be tightened up



to increase capacitance.

If the signal strength is reduced, the wand is reversed and the brass slug is introduced into the coil. The effect of the brass slug is to make the coil, with its associated capacitors, tune to a higher frequency, since the coil inductance is lowered slightly. If, therefore, the volume or metered output of the receiver is improved, the trimmer across the coil under test should be slackened off to reduce its capacitance.

If the coil is correctly tuned to the required frequency, the increase or decrease of inductance caused by the introduction of the iron or brass ends of the wand respectively causes a loss in volume, so that when either end of the wand produces lower volume or output the coil is correctly trimmed.

The iron-dust core may be obtained from an old I.F. transformer or from an unused coil former of the Aladdin type. The brass slug is obtained from a volume control with a long spindle: it is often necessary to trim off a half-inch or so from the volume control spindle of a newly constructed receiver, and this length of  $\frac{1}{4}$  in. or  $\frac{3}{8}$  in. diameter brass is suitable.

For the body of the wand a piece of  $\frac{3}{8}$  in. paxolin tube may be used, the two cores being cemented or fixed with wax at either end of the tube; often it will be found that one core will fit snugly into the tube but the other is too large. In this case the body of the wand can be made from gummed paper strip, which is thoroughly dampened and then wound up spirally to form a tube with a suitable inside diameter.

A tuning wand is particularly suitable for correcting the tracking of home-constructed superhet. receivers. The oscillator tuned circuits should be inspected at three points over their range, the first tuning point near the high frequency end of the scale, the second at mid scale and the third near the low frequency end of the scale. The best compromise for perfect tracking at these three points is small and careful adjustments of the trimmers and padders.

10. *Grid-Dip Oscillator.*—The grid-dip oscillator is a piece of testgear which is still not so widely used as it might be. Its chief user is, perhaps, the amateur transmitter; but the oscillator can also be of considerable use to the experimenter and the short wave listener.

The circuit of a typical grid-dip oscillator is shown in

Fig. 15A, and this model is particularly suited for short wave experiments.

A triode valve is connected as a Colpitts oscillator and a single coil is tuned by a split stator capacitor. Under oscillating conditions the valve is self-biased by grid current through R2, and the grid current flows through a moving coil instrument, M, which may have a sensitivity of between 100 microamps and 1 m/A. full scale deflection. In most cases a 1 m/A. instrument is most readily obtained, when R2 may have a value of 47,000 ohms.

The grid current indicated by the meter depends on the amplitude of oscillation; anything which reduces the amplitude of oscillation will reduce the grid current and thus will cause the meter reading to fall.

If, therefore, the coil L is coupled into a tuned circuit and the tuning capacitor of the oscillator is rotated, at some point where the resonant frequency of L and C1 correspond with the frequency of the external tuned circuit, power will be lost

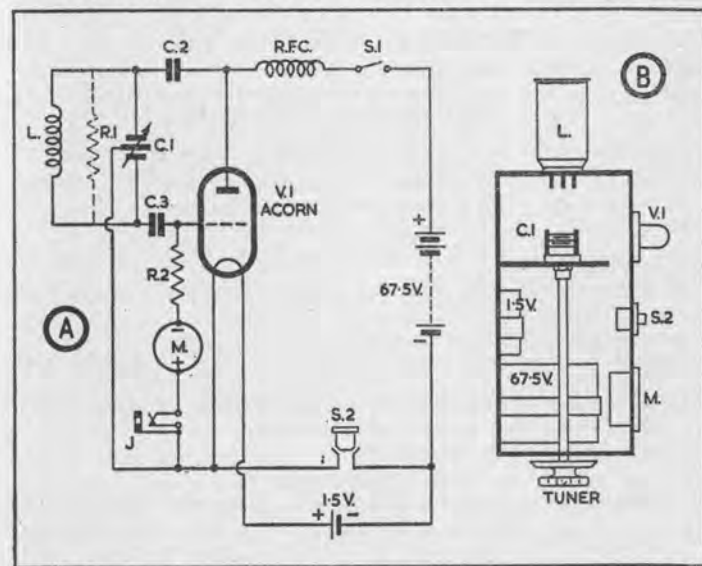


Fig. 15. Grid-dip oscillator with suggested layout.



through the coupling to the external circuit, and the amplitude of oscillation at that point will be reduced. As C1 is rotated, the grid meter will show a correspondingly sharp dip in its reading, hence the name of grid-dip oscillator.

The component values are by no means rigid. Any triode or triode-connected pentode which will oscillate well at the high frequencies may be used for V1, first choice being the Acorn type 957 which requires only 1.5 volts for the filament. These valves are often obtainable from a good supply house. A DL92 or its equivalent can also be used, with its screen strapped to the anode, and should be operated with the two halves of the filament in parallel for 1.5 volt working. The base connections would be:

Filament, positive Pins Nos. 1 and 7, strapped.  
 Filament, negative Pin No. 5  
 Grid ... Pin No. 3.  
 Anode ... Pins Nos. 2, 4 and 6, strapped.

R2 should be chosen by experiment to suit the moving coil instrument used.

#### COMPONENTS LIST, FIG. 15A

R1	...	See text.
R2	...	47,000 to 100,000 ohms, to suit meter.
C1	...	Split stator tuner, 34 pFd. each half, Eddystone 584.
C2,3	...	100 pFd. Mica. T.C.C. CM20N.
R.F.C.	...	Short wave choke, Eddystone 1010.
S1	...	S.P. on-off switch.
S2	...	Press-switch. (Press for 'on.')
V1	...	957, DL92, 3S4, N17 or 1P10.
Holder for V1, to suit.		
67.5 volt H.T. battery, Ever-Ready Minimax.		
1.5 volt cell, Type U2 or similar.		
Small wooden chassis or containing case.		
Flexible coupler and extension rod for tuner, if used, Eddystone 1008 and 529.		
Direct drive 2in. tuning knob, marked 0—100°, Eddystone 595.		
J, closed circuit jack socket, with jack plug.		
1 coilholder, Eddystone, type 964.		

#### COIL TABLE, 'L'

3.5 Mcs.	55 turns 26 S.W.G. enam. closewound $1\frac{1}{2}$ in. diameter.
7 Mcs.	30 turns 22 S.W.G. enam. closewound $1\frac{1}{2}$ in. diameter.
14 & 21 Mcs.	13 turns 22 S.W.G. enam. in adjacent slots of former.
28 Mcs.	7 turns 22 S.W.G. enam. in alternate slots of former.
60 Mcs.	3 turns 22 S.W.G. enam. in alternate slots of former.

The 3.5 and 7 mcs. coils are wound on Eddystone type 537 formers, unslotted, and the 14-60 mcs. coils on Eddystone type 538 formers, slotted.

Wind each coil at the top of the former for easy coupling to external circuits.

R1 may or may not be required. The grid current will be found to vary with different coils inserted in the holder, and R1 can be fitted across each coil, if desired, to reduce the amplitude of oscillation to make all coils give substantially the same grid current as that flowing with the highest frequency coil in place.

R1 must be found experimentally, and can be situated within the coil former.

*Construction.*—The grid-dip oscillator is best-constructed to the form shown in Fig. 15B (which is not drawn to scale). The containing case is best made of wood so that when the coil is presented to an external tuned circuit there is no metallic mass which might have an adverse effect on results or cause detuning of the external circuit.

C1, the tuning capacitor, should be mounted close to the coil holder and driven from the dial via an extension spindle. The valve may be placed at any convenient point, though short leads between the valve and the tuned circuit are very necessary; the batteries can be clamped to the base of the container as shown. The meter and jack may be mounted in the container top, or beside the dial on the front panel.

The press-button switch, S2, should be mounted in such a position that it can be held down with a finger of the hand supporting the grid-dip oscillator. For this purpose it is best placed on the container top, and a handle should be built on to the side of the box which will enable the unit to be held and switched on and off with one hand, leaving the other hand free for tuning and making circuit changes in the external circuit under test.

The grid-dip oscillator must be calibrated from a reliable receiver; a good communications receiver of known accuracy is ideal for the purpose. Care must be taken to distinguish between the fundamental carrier of the oscillator and its harmonics, but this should not be found difficult.

The calibration is best made as a chart for each tuning coil,

the frequency tuned being plotted against the dial readings from 0 to 100.

The coils should be of sturdy construction and handled with care to avoid any change in calibration.

*Using the Grid-Dip Oscillator.*—Before the uses of the grid-dip oscillator are described, it must be pointed out that the circuit shown in Fig. 15 has two features not usually found in this type of apparatus. S1, a switch in the anode supply line, allows the H.T. to be cut off from the valve while the filament is still operating, when the instrument works as an absorption wavemeter without grid current readings, except when coupled to high power gear, and this function is also coupled with the closed circuit jack, J. If headphones are inserted into this socket, the valve without anode current flowing, acts as a diode rectifier, and if the coil and capacitor are tuned to the tank frequency of a phone transmitter the grid-dip oscillator, in a non-oscillating condition, acts as a useful phone monitor.

If a C.W. transmitter is to be monitored, it is only necessary to close S1 and to tune the grid-dip oscillator to produce a beat note against the transmitter frequency, when the code will be heard in phones plugged into J.

A grid-dip oscillator can be of great value when first setting up a newly built transmitter—indeed it is safe to say that if the valves are inserted into the transmitter and supplied with heater power the transmitter can be lined-up by the grid-dip oscillator without anode power being applied to the transmitter stages.

The oscillator can be coupled into any tuned circuit by placing the coil on the unit close to the external coil. The oscillator tuning capacitor is then rotated until the dip in grid current is indicated, when the frequency of the external tuned circuit can be read off from the appropriate oscillator chart, by reference to the capacitor setting. For greater ease in coupling the oscillator to external circuits, a link coil of a few turns of wire may be wound over each oscillator coil and coupled to a link temporarily wound over the external coil or, alternatively, to a 'search' link, a single turn of wire at the end of a length of Twinlead feeder or twisted two-wire line.

It is possible to measure inductance and capacitance with

the grid-dip oscillator by the following methods.

*Inductance Measurements.*—The unknown inductance is connected across a 100 pFd. mica capacitor of reasonably good accuracy; it is a simple matter to obtain capacitors with a marked accuracy of 2 per cent. at a fair price; the author has a selection of 'standard' capacitors which were carefully removed from unused surplus gear which were found sufficiently accurate for this type of work.

The oscillator coil is then presented, or coupled via a link, to the unknown coil, and the oscillator tuner rotated to give the characteristic dip. The coil to be used in the oscillator should be chosen by inspection; if the dip cannot be obtained the oscillator coil should be changed for the next in the range. When the dip is found, reduce the coupling between the coils to the loosest which will still give a visible indication, and correct the oscillator tuning as may be necessary. Read off the dial setting of the oscillator and convert this to megacycles, then calculate the unknown inductance by using the formula

$$L = \frac{25,300}{C \times f^2}$$

where L is the unknown inductance in microhenries, C is the capacitance of the mica capacitor used as a standard (100 pFd. as stated, though other values may be used) and expressed in pFd. and  $f^2$  is the square of the frequency in mcs. to which the oscillator is tuned.

*Capacitance Measurements.*—To measure capacitance with the grid-dip oscillator, a calibrated variable capacitor is required. It is possible to calibrate a good variable capacitor from the oscillator in the following manner.

With a suitable coil in the oscillator coupled to a second coil of any suitable size, connect an accurate 50 pFd. capacitor across the external coil and tune the oscillator for grid dip. Remove the 50 pFd. capacitor and connect across the coil the variable capacitor to be calibrated, which should be mounted on a panel or stand and fitted with a pointer knob and dial.

Without touching the oscillator, rotate the variable capacitor until grid-dip is observed. This means that the external circuit is now tuned as it was with the 50 pFd. capacitor across the

coil, therefore the variable capacitor must be set at 50 pFd. Mark its dial accordingly.

Disconnect the variable and now connect across the coil a 100 pFd. standard capacitor. Rotate the oscillator tuner until grid dip is observed, then remove the 100 pFd. capacitor, connect the variable capacitor across the external coil and, without touching the oscillator, tune the external variable capacitor until grid dip is again observed. The variable capacitor must now be tuned to 100 pFd. and its dial may be marked with the 100 pFd. point. By using a selection of standard capacitors, and connecting them across the coil singly or in series and parallel combinations, the variable capacitor can be calibrated quite finely. For most applications it is quite sufficient to calibrate the 50, 100, 150, 200, 250, 300, 350, 400, 450, 500 pFd. points. The value of the capacitor at its minimum setting will be found stated reasonably accurately in the manufacturer's list.

The calibrated variable capacitor may now be used to measure any value of capacitance smaller than its own. (It is useful to connect the two sections of a two gang capacitor in parallel for calibration, thus obtaining a calibrated variable capacitor with a maximum capacitance of 0.001 mfd. rather than 500 pFd.)

Take the calibrated capacitor, set it at 450 pFd. or any convenient high reading, connect it across a coil of suitable size, and then measure the frequency with the grid-dip oscillator.

Now connect across the coil and variable capacitor the unknown capacitance. This increases the tuning capacitance across the external circuit, and the oscillator is restored to the grid-dip condition by rotating the calibrated capacitor to a lower setting. The value of the unknown capacitance is then equal to the difference between the two settings of the calibrated capacitor. If the first setting was 450 pFd., and, to restore the grid-dip condition, the capacitor had to be rotated to 250 pFd. with the unknown capacitance connected into the external circuit, the value of the unknown capacitance is obviously 200 pFd.

11. *Measuring Capacitance with the Multi-meter.*—Many home constructors and experimenters have good multi-meters which measure volts and current over several ranges of A.C.

and D.C. together with ohms, over quite wide ranges, but have no means of measuring capacitance. The grid-dip oscillator method of measuring capacitance just described, has obvious limitations and capacitance measurements are not required often enough to warrant the construction of a capacitance bridge. In these circumstances it is quite possible to use the multi-meter for capacitance measurements, using the circuit shown in Fig. 16.

It is necessary to stress that the measurements are made with the greatest care to avoid damage to the instrument, which is only commonsense.

Note that electrolytic capacitors must NOT, in any circumstances, be measured in this way. The method is suitable for mica and paper capacitors only, and these should be checked previously to ensure that they are in good condition, i.e., without leaks or short-circuits which might damage the multi-meter.

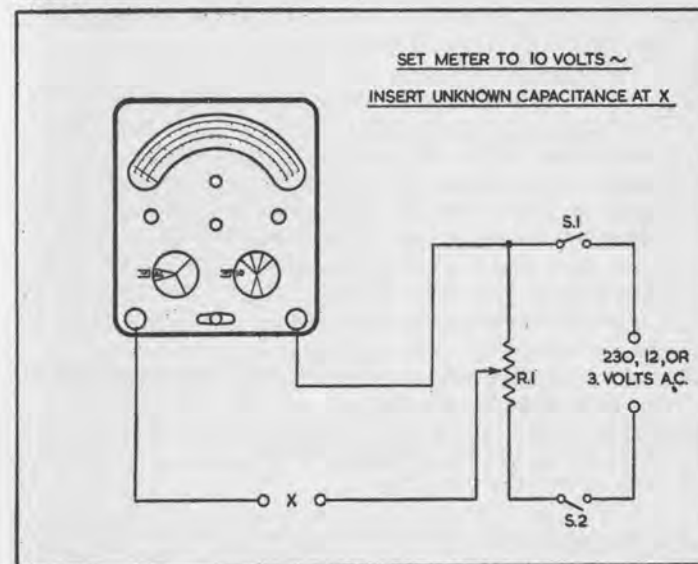


Fig. 16. Measuring capacitance with a multi-meter. The unknown capacity is connected across points X.

Few components are required for the extra test circuit. A pair of terminals across which the unknown capacitor is connected, a good variable potentiometer (R1) of 100,000 ohms resistance (preferably wirewound), a pair of voltage input terminals and a double pole on-off switch, S1-2, are all that are necessary. The unit can be made up on a small chassis or 'breadboard.'

Before the method of calibrating and the use of the circuit are described it is necessary to give the sequence of operations, which are as follows:

1. Ensure that the potentiometer is turned right over to the off position. This means that the potentiometer sliding arm must be at the top end of the resistance. See Fig. 16.
2. Connect the unknown capacitance to its terminals.
3. Check that S1-2 is off.
4. Check that the multi-meter is set to the 10 volts A.C. range.
5. Connect into the supply terminals of the unit a suitable voltage, 230, 12 or 3 volts A.C.
6. Switch on S1-2.
7. Slowly rotate the potentiometer arm right round to full, watching the multi-meter reading. If the pointer approaches full scale before the potentiometer is turned right up, too high a voltage has been selected. The next lower voltage must be used. Reverse the steps so far described to connect up to the lower voltage source.
8. Assuming that the voltage is correct, turn up the potentiometer to the full position, and read the capacitance from the multi-meter scale, using a conversion chart to be described.
9. The reading made, slowly turn back the potentiometer to the right-off position.
10. Open S1-2.
11. Disconnect the A.C. voltage source.
12. Disconnect the capacitance.

Any change in this sequence may lead to surges of current which would damage the multi-meter rectifier and/or instrument.

The capacitance is read in terms of current flowing through

the capacitor, and the voltage source is chosen to give a suitable current through the unknown.

It should be noted that the exact voltage connected to the voltage input terminals is of little importance *so long as the voltage is the same for each test*. The 230 volts shown in the diagram can be any mains supply voltage from 200-250 volts, so long as the voltage used to calibrate the capacitance scale is duplicated in following tests, though a fluctuation of 10 volts or so in 230 volts makes little difference to results.

The 12 volts A.C. can be obtained from a small mains transformer with two 6 volt windings connected in series, and the 3 volts A.C. can be obtained across the end and the centre tap of one of these 6 volt windings.

With 230 volts fed in, the range of capacitance measured is about 100 pFd. to 0.02 mfd. An exact range cannot be given since this finally depends on the sensitivity of the multi-meter in ohms per volt. The range covered with 12 volts fed in is about 0.02 mfd. to 0.1 mfd. or more, and with 3 volts fed in the range is about 0.1 or 0.2 up to about 4 mfd.

It must be realised that the meter does not give a full scale reading, but must be calibrated. On the range using a 230 volts input for example, 100 pFd. in the unknown position will give only a slight indication on the meter scale. 200 pFd. will cause the meter to travel a little further up scale, 500 pFd. will give a higher reading still, and so on. It is necessary, therefore, to calibrate the unit and multi-meter when first built, with a series of reasonably accurate capacitors, starting at 100 pFd. and running up through 200, 300, 400, 500 pFd., etc., noting the meter reading obtained with each capacitor and calibrating by making a conversion chart—a straight line drawn to scale with the A.C. volts readings marked out on one side of the line and the corresponding capacitance values on the other side. It is not possible to show a specimen chart since the readings will vary with different multi-meters to quite an extent.

When the meter reaches nearly to full scale with, say, 0.01 mfd. capacitance across the 'unknown' terminals, the voltage supply source is changed to reduce sensitivity and the calibration recommences on a new range.

With the three ranges calibrated as conversion charts, any



unknown capacitance can be connected in, the correct voltage chosen by judgment or trial, the meter reading noted and the capacitance value read off from the conversion chart for that input voltage.

Always rotate the potentiometer slowly, in case too high a voltage has been chosen in error.

## Section 3

### TRANSMITTERS

12. *The Simplest Phone Monitor.*—To monitor a phone transmission in the shortest possible time, or as a substitute for a broken-down monitor, connect a pair of headphones across a low power neon bulb. This idea is so old that it seems in danger of being forgotten.

With the phones on, place the neon bulb within the field of the tank coil or beside the feeders, and speak into the microphone—the ionisation current through the bulb allows the signal to be heard.

It is important to observe all the normal precautions, for, on no account must the bulb be allowed to touch the tank or the feeders, as the result might be a very serious shock.

13. *R.F. Chokes.*—The author's nearest radio store is 10 miles away, so when components are lacking in experimental

work it is often necessary to press substitutes into use. Good medium-wave coils, either air cored or iron-dust cored, make excellent transmitter chokes, and it has been found possible to cure low frequency parasitics in small transmitters by removing a normal R.F. choke from either a grid or anode circuit and replacing it by an iron-dust cored coil of the Atkins type. The choke inductance can be varied by adjusting the core, and the parasitic can sometimes be 'tuned' out.

The use of these coils seems to have no detrimental effect on the working of transmitter stages—measurements of anode voltage, anode and grid voltage, and power output into a dummy load all remain constant.

14. *Checking for Parasitics.*—During the design of new transmitters, whether of low or high power, a very careful check for parasitics should be kept, as not only trouble at or near the transmitter frequency will be caused, but also very serious broadcast interference to neighbouring receivers.

During the tuning-up stages listen to the signal in a phone monitor placed beside the transmitter, when the presence of parasitics is shown, either by hissing or whistling, as soon as they arise. Very often this allows the stage causing the trouble to be identified immediately.

The parasitic is then inspected by the use of a neon bulb, a method which will work well on gear of the smallest power. The bulb is touched to the tank circuit of the stage where trouble arises—generally the final—and the bulb colour denotes the type of parasitic. An orange glow in the neon bulb shows that the parasitic is a low frequency oscillation, probably caused by T.G.T.P. operation, the R.F. chokes being tuned by coupling and stray capacitances to form a low frequency oscillator stage; but this form of parasitic is not met with so frequently as may be supposed. Very often the neon bulb glows a vivid violet or blue, indicating very high frequency parasitic oscillation.

The cure must depend on the type of parasitic, and a method often found efficacious for low frequency oscillation, is shown in Fig. 17A. Here the R.F. choke between the valve grid and the grid leak is removed and its place taken by a small resistance (of a value determined by trial, although 330 ohms (R1) is usually satisfactory), the junction of this resistor and

the grid leak being by-passed to earth by an 0.01 mfd. capacitor (C1).

Low frequency parasitics are more likely to arise in balanced tuning circuits. In single ended stages the normal by-passing capacitances in the anode circuit are greater in value than those in the grid circuit, with the result that the frequency tuned by the R.F. choke and by-pass capacitors is much lower in the anode circuit of a single ended stage than in the grid circuit. This condition is not conducive to low frequency oscillation, since the anode of a T.P.T.G. oscillator must be tuned to a frequency higher than that of the grid circuit.

In balanced tuned circuits, however, the parasitic circuit is very different, and the split stator tank capacitor is, in effect, connected directly across the ends of the choke. It is advisable in this type of output tank (or grid tank, if the final stage is driven from a balanced tuned circuit coupled to the buffer or

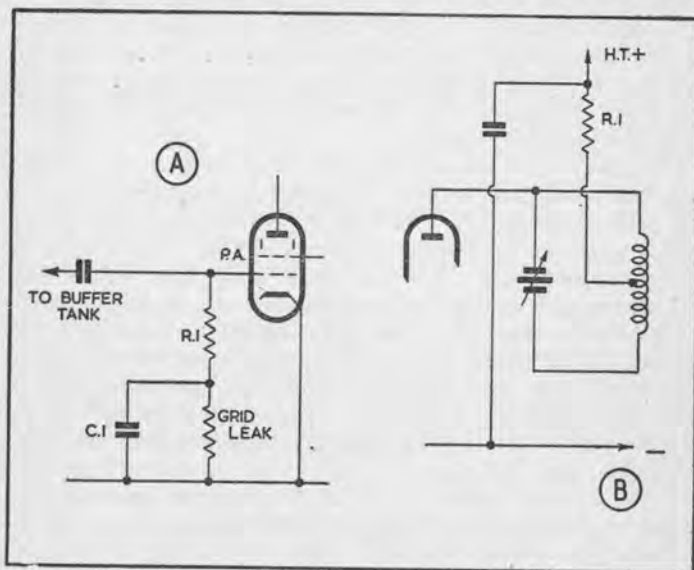


Fig. 17. Prevention of LF parasitics. A. In single ended stages. B. In balanced tuned circuits.

driving stage), to eliminate the centre tap-connected choke by replacing it by a small resistance (R1). A 100 ohms resistor rated at 1 watt is usually effective. The circuit is shown in Fig. 17B.

Very high frequency parasitics are invariably caused by the inductance of the leads to the grid and anode of a valve being tuned by by-pass or coupling capacitors to a frequency often between 100 and 150 mcs. A common method of suppressing such parasitics is to use a very low resistance in series with the valve screening grid and the screen supply and by-pass circuit; but the introduction of even a few ohms at this point in the circuit adversely affects the grid to anode isolation of a tetrode or pentode. A better method of suppressing V.H.F. parasitics is to employ small stopping chokes in the grid and anode circuits of the affected valve, these chokes being placed right at the valveholder pins and/or valve top cap.

The grid choke should be made first, and a winding of 15 turns of 26 S.W.G. enamelled wire on a  $\frac{1}{4}$  in. diameter former, spaced their own diameter, is generally satisfactory. The former may be made of a ceramic 1 megohm resistor with wire ends, the ends of the chokes being sweated to the resistor ends for anchorage. The choke required in the anode lead can be found experimentally; a size of choke—i.e. an inductance—is required which will tune the anode parasitic circuit to a lower frequency than that in the grid circuit, thus upsetting the T.P.T.G. oscillator circuit.

To find the length of wire needed in the anode choke, increase the length of the lead from the valve anode connector to the anode tank circuit, checking for parasitic oscillation meanwhile. A length of lead will be found which will prevent the trouble, and this length of wire should be wound up on to a second  $\frac{1}{4}$  in. former and used as the anode V.H.F. choke.

Many types of valve will not need this treatment, but in circuits using the 807 or Mullard QV05-25, chokes made in this way have been found extremely effective.

15. *Balancing R.F. Amplifying Stages.*—Fig. 18A shows a very effective driving circuit where a single-ended buffer stage is capacitively coupled to one end of a push-pull grid tank. All too often, however, this circuit is left unbalanced. The valve capacitance of the buffer stage is coupled between the

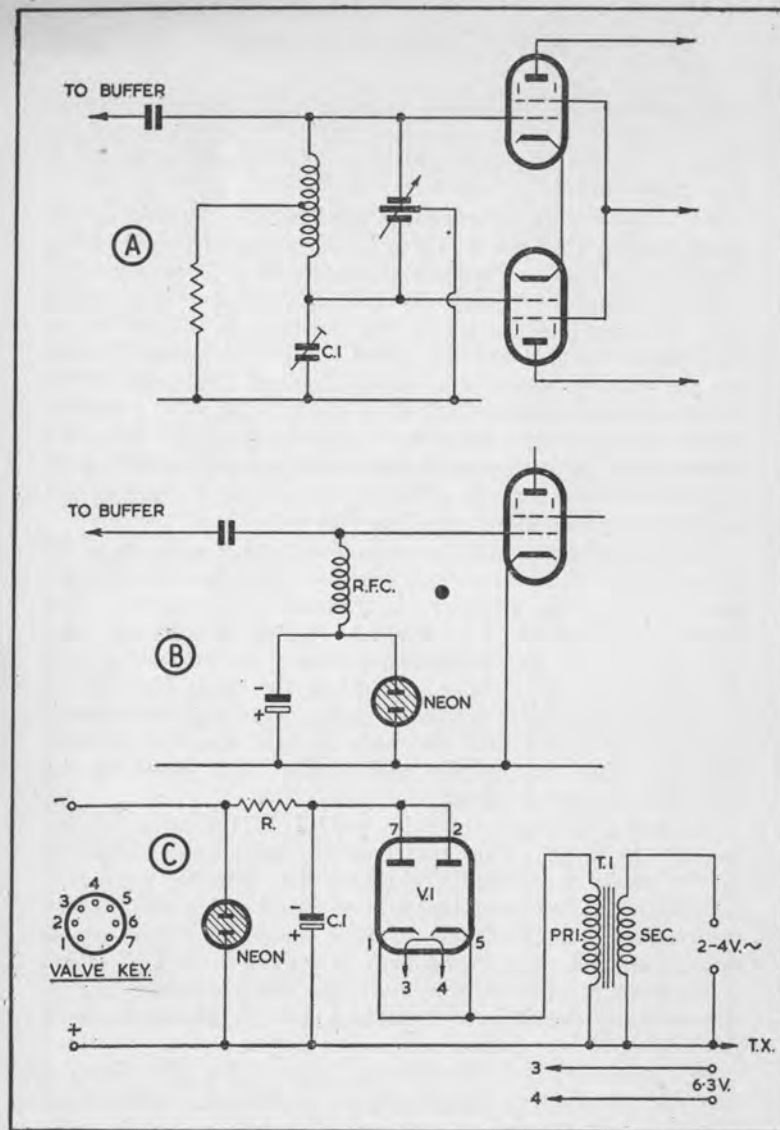


Fig. 18. A. Balancing a Push-Pull RF amplifier. B. A simple biasing method. C. A simple bias supply. Connection TX should be connected to the transmitter chassis.

top of the p-p grid tank and earth; but in many transmitters no equivalent capacitance is coupled from the other end of the tank to earth, since the constructor has the mistaken idea that the amount of unbalance so introduced is small and needs no correction.

This is by no means the case as will be discovered by the amateur who includes a balancing capacitor shown in Fig. 18A. When the capacitance is adjusted it will be found quite a delicate operation and the setting must be chosen as carefully as for a neutralising capacitor.

C1 may be a 10 pFd. trimmer which will cover the requirements of most circuits, though if large valves are in use in the buffer stage it may be desirable to use a larger capacitance. One of the most useful types of trimmer for this job is the Mullard-Phillips concentric type, which takes up very little space, is easily adjusted, and has a steady and smooth increase of capacitance.

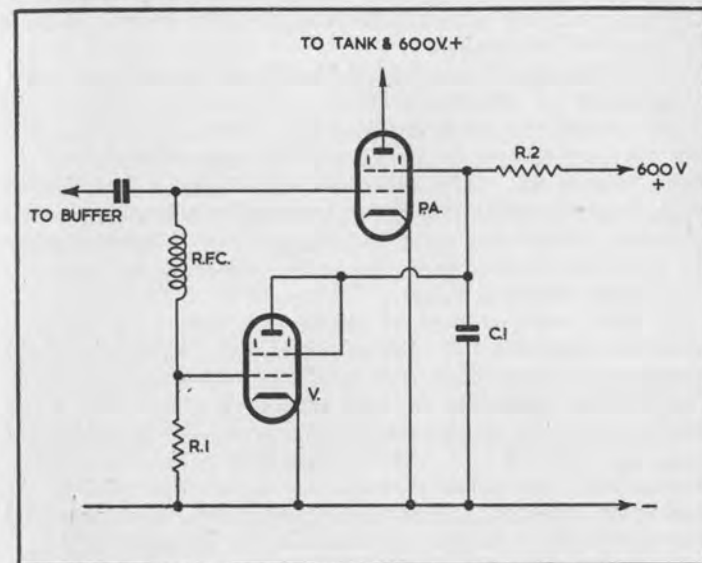


Fig. 19. Screen protection for the PA stage.  
 $R.1 = 12,800$  ohms, 1 watt.  $R.2 = 50,000$  ohms, 20 watt.  
 $C.1 = 0.002$  mfd.  $V = 6V6$  or  $6L6$ .

The capacitor must be trimmed to suit the circuit against indications either of equal grid current, cathode current or anode current in the two valves, and one very convenient method is to temporarily break the common grid leak from the centre of the grid tank coil, and use in its place a separate resistor from each grid to earth. These resistors should have twice the resistance of the common leak, and should be identical in value.

Both grid currents should then be metered, and the new trimmer adjusted, the tank being re-tuned as necessary until both valves draw the same grid current.

Cathode current checks are not possible in double valves where the cathode is brought out as a common connection; but quite a rapid and satisfactory check can be made without disturbing the grid circuit by touching a low power neon bulb to either end of the anode tank coil. A brighter glow will be obtained from one end, and the new balancing trimmer is adjusted until the same brilliance in the bulb is obtained from either end of the tank.

**16. A Simple Biasing Method.**—When operating a C.W. transmitter for break-in working it is necessary to key the whole transmitter, or to cut feed from all stages, in order that the receiver may work at the required sensitivity during the key-up conditions. This necessitates fixed bias, at least for the P.A. stage, in order that the valve may be held at a suitable operating point when no drive is applied. It is often possible to use cathode bias on the buffer stages, but this is not generally desirable in the final stages.

A very simple method of obtaining a fixed bias supply is shown in Fig. 18B. In place of a grid leak a neon tube of the stabilisor type is used, shunted by a high value capacitor. When drive is first applied to the final stage, grid current flows and ignites the tube, setting up a voltage across it, while the capacitor charges up. When drive is removed the tube is extinguished, but across the capacitor a potential equal to the extinction potential of the neon tube is left. This potential biases back the P.A. grid and the valve is therefore held in a safe working condition until drive is again applied. The capacitor should have a value of 32 mfd.

The neon tube used in the circuit must have a burning

voltage equal to the required grid bias, so that in some cases it will be necessary to experiment with various neon tubes unless a bias voltage equivalent to the burning potential of standard tubes is required. The tube must be rated to pass the grid current of the stage. The Mullard 13201A neon stabilisor, burning at about 95 volts and passing between 15 and 200 m/As. should suit a wide range of final stages.

The capacitor may be an electrolytic, rated at well above the potential across the tube. Note the polarity of the capacitor connections.

When commencing to operate, drive should be applied to the final stage before the final H.T. is applied, which is the standard practice.

**17. A Simple Fixed Bias Supply.**—For low power transmitters the neon bias source may prove unsuitable, and it may be necessary to build up a fixed bias source. Bias is often taken from the main H.T. transformer at a high potential and dropped to the required potential through heavy duty resistors; but a more convenient source (which can also be used for large audio amplifiers needing fixed bias) is shown in Fig. 18C. The rectifier VI is a miniature double-diode, the Mullard EB91, is used for this purpose. This valve can deliver 18 m/As. with both anodes strapped, and can have up to 150 volts applied. The power is drawn from a small output transformer (T1), used as a power transformer, with between 2 and 4 volts applied to the voice coil winding. Cheap transformers will work quite well in this way and give a high potential output from the primary winding which depends, naturally, on the transformer ratio.

The driving voltage is conveniently obtained from the centre-tap and one side of a 6 volt winding on the main power transformer; with 3 volts into the voice coil winding a 25 : 1 output transformer will give 75 volts output, provided that not too high a current is demanded.

The reservoir capacitor C1 should have a capacity of 8 mfd. and the output from the rectifier is fed through a resistor R to a neon bulb N which acts as a stabilisor. Both R and N must be chosen to suit the bias voltage required, and the neon bulb should pass only one or two m/As. If the bulb passes 2 m/As. this leaves 16 m/As. for the bias supply. The source



cannot therefore be used with a valve or valves requiring more than 16 m/As. grid current, which should be ample for many types.

A small NE15 or 20 bulb, sometimes obtainable from American war surplus equipment, is often ideal for the stabilisor; other bulbs may be chosen by experiment. The Mullard 7475 is suitable for many applications, drawing from 1 to 8 m/As. and burning at about 95 volts.

18. *Screen Protection for P.A. Stages.*—Although the previously described bias sources will protect a transmitter P.A. valve from over-running with the biasing drive cut off, when the oscillator and buffer stages of the transmitter are keyed for C.W. break-in operation, a different type of P.A. protection is becoming increasingly popular, which calls for no fixed bias source of any kind.

When the drive is cut from the grid of a self-biased transmitter stage, so that bias is lost, the valve passes a heavy anode current and is therefore overloaded—the anode dissipation is too high. If, however, the screen voltage of the affected valve could be reduced to a low value as the drive is cut off from the grid, the reduction in screen potential would also cause a great reduction in anode current so that the valve, although still operating, would be far from the overload point and the anode dissipation would be within the rated limits of the valve.

There is a further advantage to be obtained from this type of operation: the output voltage from the transmitter power pack is liable to swing between very wide limits when the whole transmitter is keyed, causing chirrup and frequency changes at the moment of make and break. This can be obviated to some extent by the use of a heavy duty bleeder, but there is a serious power wastage. If, on the other hand, the P.A. valve draws some current with the key up, the wide voltage swing across the power pack is reduced and the bleeder resistance can be higher for the same effect.

The screen voltage to the P.A. valve can be controlled in the desired manner by connecting in a further valve as shown in Fig. 19. For small transmitters a 6V6 is ideal as the control valve, and since this will suit an 807 output stage the circuit as shown will serve for many transmitters with a C.W. output of up to 40 watts.

Larger P.A. stages can be controlled through a larger valve, a 6L6 being satisfactory for the majority of larger transmitters.

The 6V6 grid is biased along with the P.A. grid and the 6V6 screen and anode are strapped together for triode working. The anode is then connected to the screen of the P.A. stage, and the common line so formed is fed through the normal P.A. screen resistor.

With the key down both valves are biased. When the P.A. is an 807, about 3.5 or 4 m/As. grid current will be flowing through R1, a grid resistor of 12,800 ohms, to give a bias of about 45 volts. The 6V6 will cut off when biased to about 40 volts, so that under key down conditions the P.A. is correctly biased and the 6V6 is cut off with no anode current flowing. The P.A. valve thus draws its normal current through the screen resistor to give a normal voltage drop.

With the key up both valves are unbiased, and the 6V6 therefore becomes conducting. Its anode current must flow through the screen resistor of the P.A. stage, and therefore a fairly heavy voltage drop occurs across this resistor, leaving only about 70 volts on the P.A. screen. Under these conditions the P.A. passes less anode current than when working under normal drive conditions, and so is held at a perfectly safe working level.

Note that the values shown in Fig. 19 are suited to an 807 output stage, and must be changed for other valves.

19. *A C.R. Tube Modulation Monitor.*—Although a phone monitor will enable many checks to be made on the speech transmitter, the normal monitor, or the receiver 'juggled' to pick up the transmitter output, will not give a satisfactory indication of over-modulation which causes splatter, distortion and, often, B.C. interference; nor is it possible to get a clear indication of under-modulation until the level has dropped seriously. A cathode ray tube connected in a simple circuit will give visual modulation checks from the transmitter tank circuit, will show up under- and over-modulation, and will show up the presence of R.F. harmonics. This circuit is, moreover, cheap to build if a surplus C.R. tube of the VC139 type is obtained.

The circuit of the monitor is shown in Fig. 20, and in Fig. 21 a desk-type case is shown into which the monitor can

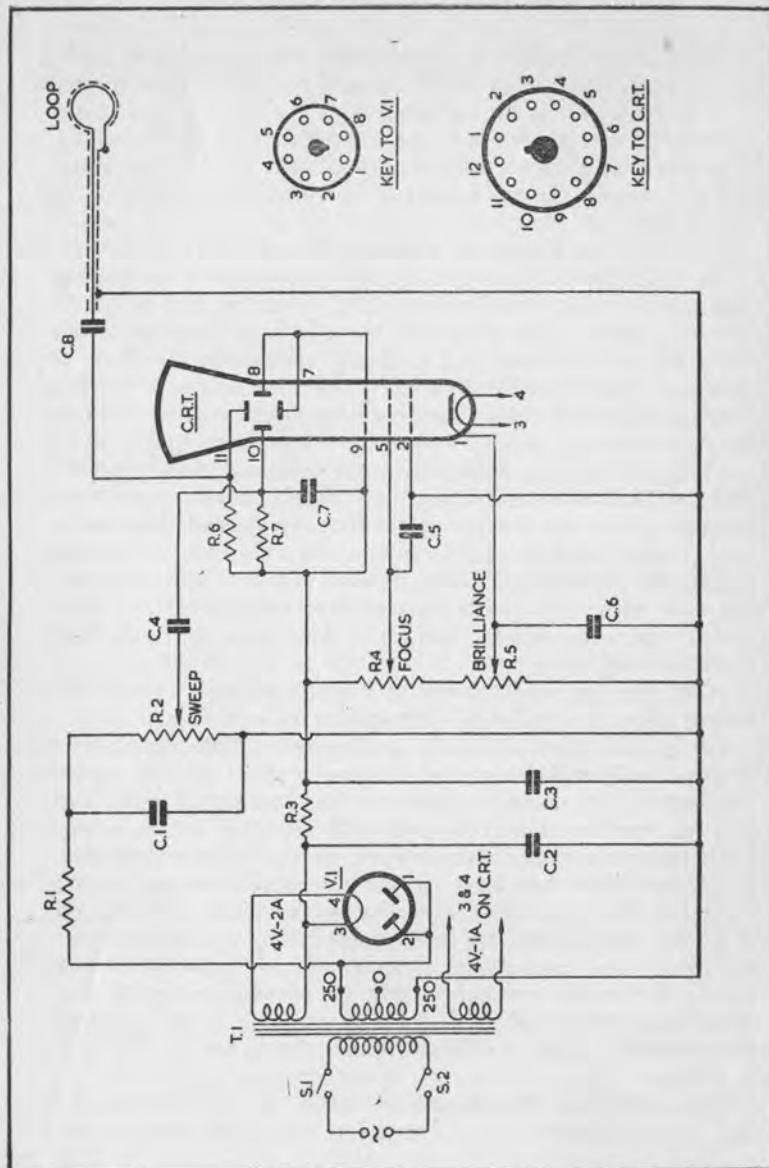


Fig. 20. The Modulation Monitor.

be built, with self-contained power pack. It is possible to draw the monitor H.T. voltages from the power pack of a transmitter with an H.T. line running at 600 volts or more, whilst the VC139 tube will work on an anode potential as low as 350 volts; but as the monitor shown was to operate with various transmitters, a self-contained power pack was necessary.

A valve rectifier is shown in the circuit; the UU5 can handle a 500 volts input from a 250-0-250 volts transformer and the final output voltage is 600 volts or more which is ample for a bright picture on the C.R.T. screen. A copper oxide or barrier rectifier could be used; but since a transformer is in any case necessary if only to supply the heater power to the tube, it is convenient to employ valve rectification.

The horizontal sweep voltage is drawn from the transformer secondary, a 50 cycles sweep thus being provided. This frequency is suitable as a time base for speech.

A pick-up loop made of co-axial cable is placed in or beside the transmitter tank circuit, and this supplies sufficient R.F. energy to give a good Y deflection. As a result, a band of

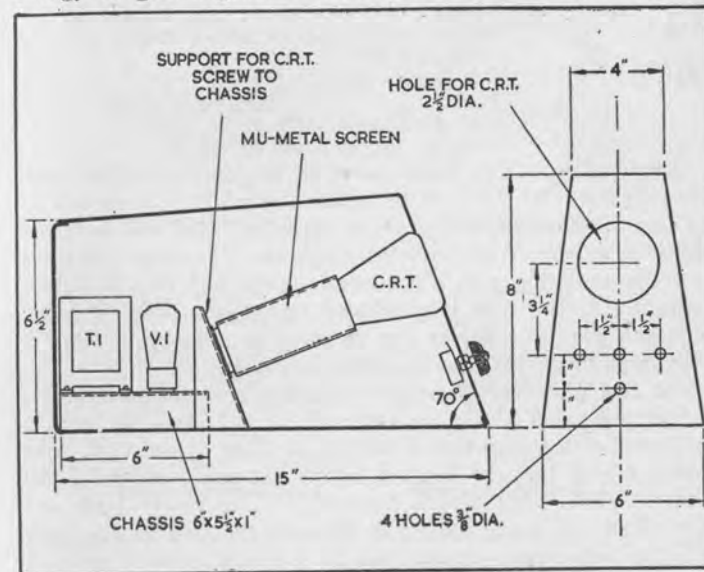


Fig. 21. Suggested layout for the monitor.

light representing the carrier is drawn on the tube screen, the length of the band depending on the setting of the sweep control and the height of the band depending on the R.F. pickup voltage presented to the Y plates by the loop. When modulation is fed to the transmitter the broad band breaks into a typical modulated carrier trace, as shown in Fig. 21.

#### COMPONENTS LIST, FIG. 20

R1	...	47,000 ohms, 1 watt.
R2-4	...	1 megohm potentiometer.
R3	...	33,000 ohms, $\frac{1}{2}$ watt.
R5	...	100,000 ohms potentiometer.
R6-7	...	2.2 megohms.
C1	...	0.1 mfd. 750 v.w. Tubular. T.C.C. 743.
C2-3	...	1 mfd. 750 v.wg. Paper. T.C.C. 92.
C4	...	0.01 mfd. 750 v.wg. Tubular. T.C.C. 743.
C5-6-7	...	0.001 mfd. 350 v.wg. Mica. T.C.C. CM20N.
C8	...	50 pFd. 750 v.wg. Mica. T.C.C. M2U.
T1	...	250-0-250 v. 60 m/As. secondary, primary to suit supply.
V1	...	4v. 2A. 4v. 1A.
V1	...	Mazda UU5, with Mazda octal holder.
C.R.T.	...	VC139 with holder, or similar surplus type, or Mullard ECR30.
S1-2	...	3 control knobs.

D.P. on-off switch.

Co-axial cable for loop.

Small case, as shown in Fig. 21.

**Construction.**—The chief point to be observed when constructing the instrument, is to mount the power transformer to the rear of the tube, so that stray magnetic fields will have the minimum influence on the electron beam. Surplus tubes are generally available with a mu-metal screen, and this should be retained. If the tube is purchased unscreened it is advisable to screen the tube before the monitor is assembled, using a cylindrical tin if there is no better material.

The case used for the original monitor is shown in Fig. 21. A tapering panel set at an angle of 70 degrees gives both a decorative appearance and a convenient view of the C.R. tube screen, which has the control knobs mounted below it, the sweep control being placed centrally. The power lead and pickup loop cable are led away through the side of the case.

The pickup loop is made from good rubber covered co-axial

cable so that insulation is perfect and the loop may be placed between the turns of the transmitter tank coil with perfect safety. The loop is formed by baring the end of the cable core wire, and soldering this to the outer screen which is bared at one point. The joint is then insulated with tape, or it may be covered with several layers of good rubber cement, each layer being allowed to dry before applying the next.

The screen can be covered with a viewing hood if the monitor is placed in a brightly lighted position, although screen brilliance is good.

When first testing the monitor before putting it into use, turn down the sweep control to zero, the brilliance control being well turned back to ensure that a single spot can be obtained. If the spot is distorted into a line or loop of any shape there is hum modulation on the tube due to stray fields from the transformer, and this should be investigated and the transformer turned round or shrouded to minimise or clear the effect.

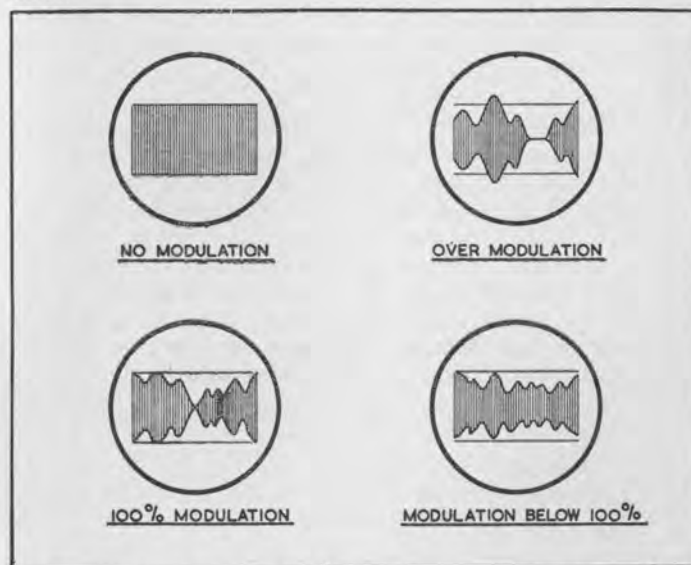


Fig. 22. Modulation pattern on the monitor screen.

With the sweep control turned up there should be a single bright line across the tube, clearly focused and of adequate brilliance.

Now couple the loop into the transmitter tank, with the transmitter switched on. The bright line across the screen should expand, as in the first diagram of Fig. 22, to give a broad band of light across the screen. Any bright lines running horizontally through this band indicate R.F. harmonics, and the loop should be tried at different points in the tank circuit to get a trace free of this defect. If the harmonic lines cannot be cleared this indicates that the tank constants are incorrect for efficient working; the L/C ratio, perhaps, being too high.

When a clear band of light corresponding to the carrier with no modulation is obtained, modulate the transmitter either by voice or, in the first instance, by feeding in a signal from an audio oscillator to the speech amplifier. The modulation will appear along the carrier as in the other diagrams of Fig. 22, 100 per cent. modulation being indicated by the meeting of valleys at the centre line of the band. If vertical bands of light appear over the modulated image the sweep voltage has harmonics affecting the timebase, and C1 in Fig. 20 may be increased to clear the effect.

Over-modulation is very clearly indicated by the valleys of the modulated envelope meeting and overlapping to produce a very bright trace along the centre line of the screen.

A tipped or distorted picture on the screen indicates that either R.F. is affecting the sweep plates of the tube, when C7 might be increased, or there is a hum pickup on the loop. The latter effect can also cause the appearance of ellipses at the top or bottom of the trace, and an investigation must be made to discover whether the hum pickup is on the loop from an A.C. source or whether the transmitter is hum-modulated.

## Section 4

### MISCELLANEOUS

20. *Chassis Supports*.—Useful chassis supports, to hold or prop the chassis in any position for servicing, can be made of odd shaped pieces of wood. If the longest side of each piece is used as a base and covered with a strip of felt glued to the wood, the supports will not slip on the bench.

One or two pieces should have a deep saw cut to grip the edges of a chassis.

21. *Soldered Joints*.—Wind up a few spirals of tinned copped wire of various gauges on differing diameters of formers—screwdriver spindles, nails, etc., and store them with the soldering tags. These spirals of wire are of great assistance when several leads have to be brought into one joint—all the leads are packed into one of the spirals and the whole joint well soldered. This is particularly useful in experimental gear where it is likely that changes of resistance and capacitance will be made after tests. Twisting the leads into a joint is not only clumsy but weakens the wire ends of components so that they break after being used once or twice.

22. *Stripping Insulation*.—Soldering enamelled wires is always a tiresome job. Fine wires should be cleansed by being immersed in methylated spirit for a minute or so; the enamel



is then wiped off. The enamel from rather stouter wires may be burnt off by the flame of a match, the wire then being rubbed clean.

To strip off enamel from thick wires and to strip silk and cotton insulation, make up a stripper from a strong sprung clothes peg with its jaws covered with emery cloth glued down to the wood. Clamp the peg over the wire to be cleaned, and pull the wire through, giving a twist. The emery will clean off the insulation and leave a bright surface ready for soldering. It is advisable to have pegs with fine and coarse grades of emery cloth.

23. *Broken Heaters in A.C./D.C. Receivers.*—A broken heater in a universal receiver is sometimes difficult to trace without removing all the valves and testing them individually. A quick test is to connect a low power neon bulb across the heater pins of each valveholder in turn, the universal receiver being switched on. The neon bulb glows when connected across the broken heater.

24. *Cutting Sheet Aluminium.*—It is economical to buy aluminium in large sheets, size 6ft. x 3ft., for chassis construction; but cutting a small chassis from a large sheet can be difficult with a normal sized hacksaw.

Aluminium can be cut, however, with an ordinary handsaw, although the process is extremely noisy; a large sheet of aluminium can soon be ripped into smaller sheets by the use of such a tool and wastage is by no means serious if some care is taken in choosing the cutting sizes.

An old saw should be used, since the teeth will be ruined for woodwork; but a discarded saw seems to cut the metal as well as a new one.

25. *A Photoelectric Cell Relay Operator.*—The experimenter working with photoelectric cells will find the circuit shown in Fig. 23 of interest, as this shows an arrangement designed to operate a sensitive relay from a photoelectric cell with the minimum of parts and low power consumption. The circuit can be used for opening doors, counting, model switching by light beams, shop window displays and many other applications.

The cell is directly coupled to a triode or triode connected pentode of the 1.5 volt filament type. In the diagram the

connections for a DL92 are shown, but if the relay is sufficiently sensitive a valve with a lower power consumption can be used, when the filament current is likely to be only 50 m/As in place of the 100 m/As required by the DL92. Either a 67.5 volts battery or a 90 volts battery may be used for H.T., depending on the valve. The DL92 should have no more than 67.5 volts on the screen. The majority of small cells are designed to take 90 volts or less on the anode, so that the direct coupling shown is permissible.

S1 controls the filament circuit, and the valve is back-biased over R2, which sets the bias between the filament and grid and thus the current passed by the valve with no light falling on the cell. By means of R2 quite a sensitive setting can be made, the current flowing through the relay being almost sufficient to close the contacts, so that the cell requires only a very low power illumination to trip the relay.

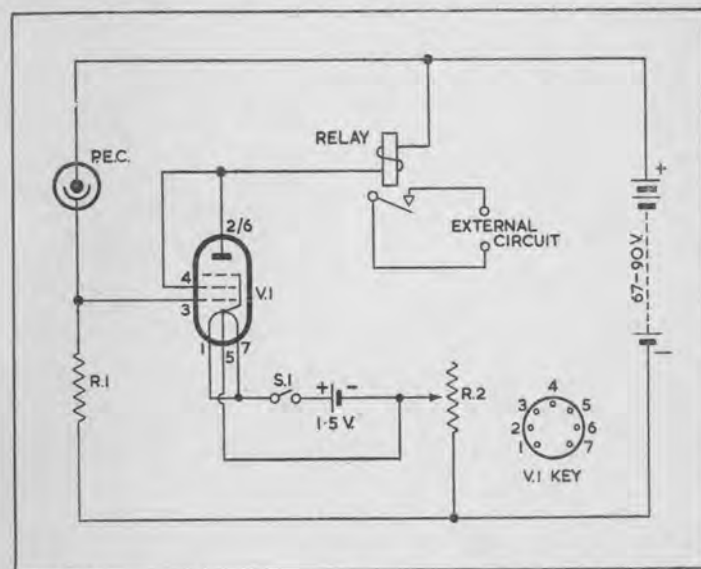


Fig. 23. The Photo-electric cell relay operator.  
R.1 = 4.7 megohm. R.2 = 10,000 ohms variable. V.1 = DL92.

With the circuit as shown the relay closes and thus activates the external circuit when light falls upon the cell; but the relay contacts can be changed, or a closed-contact relay can be used, to switch off on external circuit when the cell is illuminated.

In shop window displays it is generally required to switch on the external circuit when the cell is darkened—the cell is usually mounted behind the window in a small box, the aperture of which can be darkened by the hand. In this case a relay is needed where the contacts are held open whilst the cell is illuminated, closing when the cell is darkened and the anode current through the valve falls.

The cell should be mounted so that light passes the anode ring or wire and falls on the cathode, and the cell may be masked with insulating tape, leaving a slit bare, to prevent extraneous light operating the circuit.

The whole unit may be mounted in a light-tight box with an aperture left over the cell for illumination of the electrodes. The leads between the cell and the valve should be short.

The resistance of the relay used is not of great importance and generally the main requirement is for it to operate on low current.