MINIATURE RADIO EQUIPMENT CONSTRUCTION MANUAL

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by EDWIN N. BRADLEY

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Preface

THE Miniature Radio Equipment Construction Manual describes in detail the building, operation and uses of a new range of radio gear. Included in the new designs are a Pocket Signal Tracer, a Pocket Signal Generator, an Emergency Transmitter for the licensed amateur, a new type of Converter, miniature Amplifers of totally original design, F.M. reception and other Short-Wave gear.

The author has been fortunate in having the assistance and co-operation of the foremost radio components manufacturers in the design and construction of this apparatus, and wishes to thank those firms, whose products are specified in the components lists, for their valuable assistance.

In view of the present supply difficulties all parts have been chosen with the utmost care to ensure that this gear can be duplicated by the home constructor, and it should be possible to purchase every component and part mentioned at a good radio house.

The construction of miniature radio equipment has an interest all its own, for apart from the building up of the circuit there is also the fascination of arranging the gear within a small compass, and the satisfaction which results from the compact and neat appearance of the finished job.

Miniaturisation for its own sake should, of course, be avoided for then it is no more than a fad and might well lead to inefficiencies in the equipment, but there are many instances where miniaturisation is both desirable and contributory to efficiency, either in circuit operation or the utilisation of the gear.

The equipment described in these pages has been designed and tested with the attainment of this added efficiency always well in view.

Ordinary broadcast receivers have found no place in this Manual, for Messrs. Bernards (Publishers) Ltd., have in preparation a manual devoted entirely to Midget Broadcast Receiver Construction.

Mention of the specified valves is desirable. The new Mullard U40 range, with 0.1 amp. heaters to fit B8A sockets should be available to the public through retailers now. These valves are already proving highly popular with commercial receiver manufacturers.

Of the Mullard E90 range, a triumph of valve design, it is at present only permissible to specify the EF91 R.F. pentode and the EB91 double-diode. When the rest of the E90 range becomes available through retailers, at some future date, the home constructor can look forward to building some really remarkable equipment.

The E90 valves, like the D90 battery valves, fit B7G sockets. The D90 valves are in good supply, and no difficulty should be encountered in obtaining them. They are, therefore, widely specified, and when used with the new miniature batteries (which the constructor may have to "look for," though these too are in quite good supply), they make possible a whole new range of pocket-sized apparatus.

THE "TRACETTE"

A Battery-Operated Pocket Signal Tracer

SIGNAL tracing is the modern method of fault finding in broken down or poorly working receivers, and, after a little experience with the tracer the service engineer or home repairman can discover the seat of a fault in, very often, no more than a matter of seconds.

Basically a signal tracer is a high gain amplifier which can deal with all types of signals—straight audio, modulated R.F., and I.F. signals, demodulating the signals if necessary and allowing the audio content to be heard through a loudspeaker. Not only modulated R.F. and I.F. signals can be detected, however, for it is possible to show the presence of an unmodulated carrier wave, such as is supplied by the local oscillator of a superhet, even though there is no sound to be heard in the loudspeaker.

In a mains driven signal tracer a Magic Eye indicator is used for this purpose, but in the battery-operated pocket tracer a small microammeter is plugged into a pair of sockets provided for its leads. When an unmodulated carrier is fed into the tracer the anode current of the first valve changes value, thus changing the potential on the valve's anode. The meter is connected, for the test, between the anode and a point selected on a potentiometer to give a zero reading when no signal is applied—in other words the meter is connected in a bridge circuit. Application of R.F. to the grid of the first valve upsets the balance of the bridge, the meter reads, and so the presence of R.F. is indicated.

In the "Tracette" the meter circuit is controlled by a switch which, when the meter is in operation, cuts out the main amplifier, leaving only the first valve and bridge circuit in operation, so that battery current is kept as low as possible.

Besides indicating R.F. the meter can also be used as an output meter for comparative readings, besides which the degree of pointer swing gives a rough indication of the amplitude of R.F. present on the R.F. tests.

The first valve of the tracer circuit is self-biased by being connected in to the set or apparatus under test via a grid capacitor and leak, the bias on the valve thus depending on the amplitude of the signal being traced. This means that not only does the first valve both detect and amplify the audio content of modulated R.F. and I.F. signals, but also that it is virtually

impossible to overload the tracer, a point of some importance for a clean and non-distorted output is needed in order that the instrument shall show up distortion in the receiver under test.

The first valve is mounted within a probe so that the leads to the grid circuit are about an inch in length—as a result the tracer causes no instability when connected into R.F. or tuned circuits, and the shunt capacitance of the whole probe is sufficiently small to cause very little detuning of such circuits.

A mains-operated signal tracer can be given such sensitivity that a reasonably good aerial, connected into its first circuit, will cause a jumble of stations to be heard in the loudspeaker. The sensitivity of the "Tracette" cannot, of course, be made as high as this—apart from the expense which would be incurred in providing the necessary chain of valves the drain on the midget batteries would be too great—but even so the instrument is surprisingly sensitive and in a good reception area the signal from the local station can be traced from the first tuned circuit onwards. It is more satisfactory, however, to provide a known signal to the receiver under test, and for this purpose the miniature signal generator described in the next chapter, was designed.

The actual method of making signal tracing tests is discussed after the description and building instructions for the "Tracette."

The theoretical circuit of the "Tracette" is shown in Fig. 1. The detecting/amplifying probe feeds either into the meter bridge, if the meter is connected in and the switch set to point 3, or into the main amplifier consisting of V2 and V3 if the switch is set to point 1, the whole circuit is off, and both batteries are disconnected.

The output valve is self-biased and bypassed for any R.F. which might escape the bypassing on V1 and be amplified by V2, and the stability of the circuit is notable.

The probe containing V1 can be entirely detached from the main amplifier since it is connected in by a 3 or 4 pin plug and socket—the probe cable can be as long as desired, since all the supplies are D.C. and there is no chance of picking up hum—and when it is realised that the whole of the main amplifier, complete with switching, bridge circuit, meter terminals, loudspeaker and batteries is contained within a case of only 7″ high by 3″ square it can be seen that this test instrument is certainly well adapted for portability and field service work.

COMPONENTS LIST FOR THE "TRACETTE"

Fig. 1.

R1,	10 megohms.	¼ watt.	Erie.
R2, R6,	100,000 ohms.	,,	,,
R3,	33,000 ohms.	,,	,,
R4,	20,000 ohms. variable.	Meter Zero Set.	
	Centralab midget.		
R5,	0.5 megohm. Volume control.	Centralab midget.	
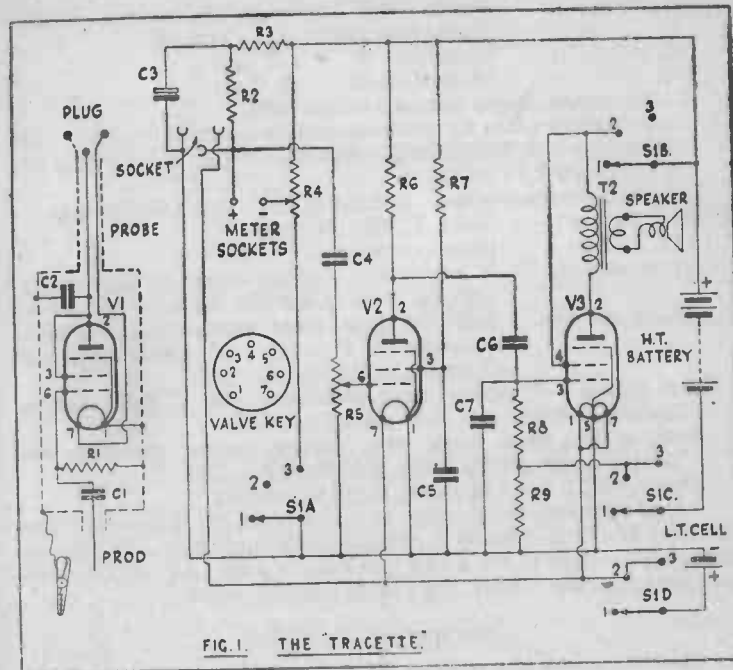
FIG. I.   THE "TRACETTE".

R7,	330,000 ohms.	¼ watt.	Erie.
R8,	470,000 ohms.	,,	,,
R9,	680 ohms.	,,	,,

See note below re resistors.

C1,	100 pfs. Mica.	T.C.C. Type M2U.
C2,	300 pfs. ,,	T.C.C. Type M2N.
C3,	8 mfds. 150 v.w. Electrolytic.	T.C.C. Type CE18F.
C4,C6,	0.01 mfd. 350 v.w. Tubular.	T.C.C. Type 346.
C5,	0.1 mfd. 200 v.w. Tubular.	T.C.C. Type 246.
C7,	0.001 mfd. Mica.	T.C.C. Type CM2ON.
Speaker with T1.	2½″ speaker with midget output transformer, to match to 5,000 ohms. anode load. Celestion, type P2V, with 40:1 transformer supplied separately, or Truvox "Wafer" 2½″ speaker, with separate transformer.	

S1,a,b,c,d,   4-pole 3-way rotary switch, midget, Messrs.
                   Walter Instruments, Ltd., Type "B.T."
V1, V2,   Mullard DF91. ← 1 T 4
V3,   Mullard DL92.   3 5 4
3 B7G ceramic chassis mounting valveholders.
3 Pin plug and socket for probe connections into main amplifier. Old
    valve base and 4-pin paxolin valveholder will serve, or Belling-Lee
    L525 plug and L1113 socket.
2 Sockets for Meter plugs. Belling-Lee L315, with L1021/3 plugs.
H.T. Battery :—   Vidor, L5500. 67.5 volts.
L.T. Cell :—   U2 cell, or similar.
Probe housing.   4" length of 1" diameter copper or brass tubing,
                   with end discs. Crocodile clip for earth return.
Instrument case.   Build up from sheet aluminium, to internal
                   dimensions of 7" × 3" × 3". Bottom and top.
                   3" square.
Sub chassis :—3" square, sheet aluminium, with ⅛" fixing flanges.
    Battery Partition 4⅛" × 3" sheet aluminium.
Paxolin strip, sheet brass, wire, sleeving, rubber grommets, etc.
    3 pointer type control knobs, Eddystone No. 1044.
Probe cable, 2 core with shield, length as required.
NOTE.—The resistors are given as *a* watt types, but in some localities
there may be a little difficulty in obtaining these small types. In this case
equal resistor values of the *a* watt type may be used. All resistor values
given are taken from Messrs. Erie's list of standard values.

CONSTRUCTION—THE PROBE

The B7G valveholder retaining V1 is fastened into the probe tube as
shown in Fig. 2. At two points diametrically opposite, 1¾" down the tube,
two small holes are bored through the tube walls and the valveholder located
with its fixing lugs visible and slightly protruding through these holes. The
valveholder is then sweated into place, its lugs being soldered to the tube
walls via the holes.

Before the valveholder is positioned, of course, the components C1, C2,
and R1 are soldered to the respective pins, together with the screen-anode
link, the anode lead and the positive filament lead, these two leads being the
two cores of the screened cable, the cable screening and covering being cut
back for about 3" to free the cores.

With the valveholder in place the earth lead from the negative filament
pin, the free end of R1 and the free end of C2 are all soldered firmly onto
the interior of the probe housing. The front disc is drilled centrally to take
a small rubber grommet and the free lead from C1 is taken through this
grommet to act as the probe prod. The front disc is sweated on to the tube,
to close the front end.

To keep the probe prod firm, it may have a short length of cycle valve
rubber slipped over it, to make a tight push fit through the grommet.

FIG. 2. SECTION THROUGH "TRACETTE" PROBE.
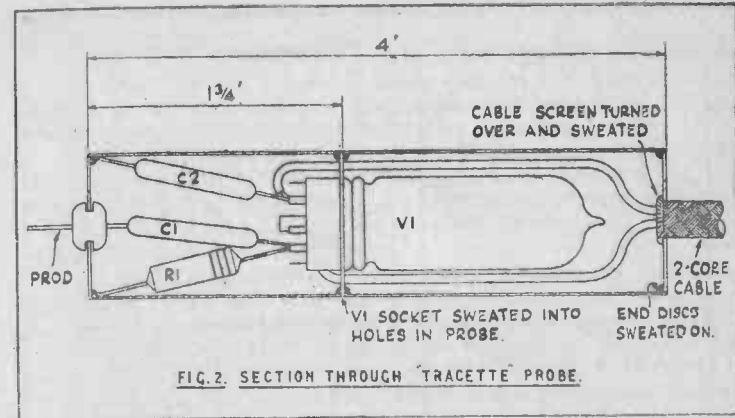
The back cover disc of the probe is drilled centrally to run over the
screened cable, slipped up to the probe housing and the screening of the
cable is unravelled for a ¼" or so and sweated down on to the interior face of
the back disc, thus providing both a firm cable anchorage and the earth return
between the probe and the main amplifier.

To the far end of the cable is attached the 3 pin plug. If an old valve
base is used this may be cut down to reduce the size a little, and the cable
sweated to the pins internally; this done, the valve base should be filled with
melted pitch or cobbler's wax to give a firm anchorage to the cable.

THE MAIN AMPLIFIER

Before any main constructional work is carried out on the main
amplifier, the loudspeaker and its output transformer should be measured
to ascertain whether the two can be mounted as shown in the sectional
diagrams of Fig. 3. This point is made for it is realised that many con-
structors will already have a 2½" speaker which they will wish to use, but if
this speaker should be rather deep then it will be a difficult matter to fit in the
output transformer beneath it.

The "Tracette" could, of course, be increased in height by the required
amount, but that should not be necessary.

A very small and neat output transformer can be obtained from Messrs.
Electro-Acoustic Industries, Stamford Works, Broad Lane, Tottenham,
N.15, the T18000, should a small component be required and not at hand,
whilst if a quite deep 2½" speaker is to be used a Wearite Type 207 output
transformer could be employed. This transformer, one of the "Hyperloy"
series, could be strapped to one wall of the "Tracette" case in much the same
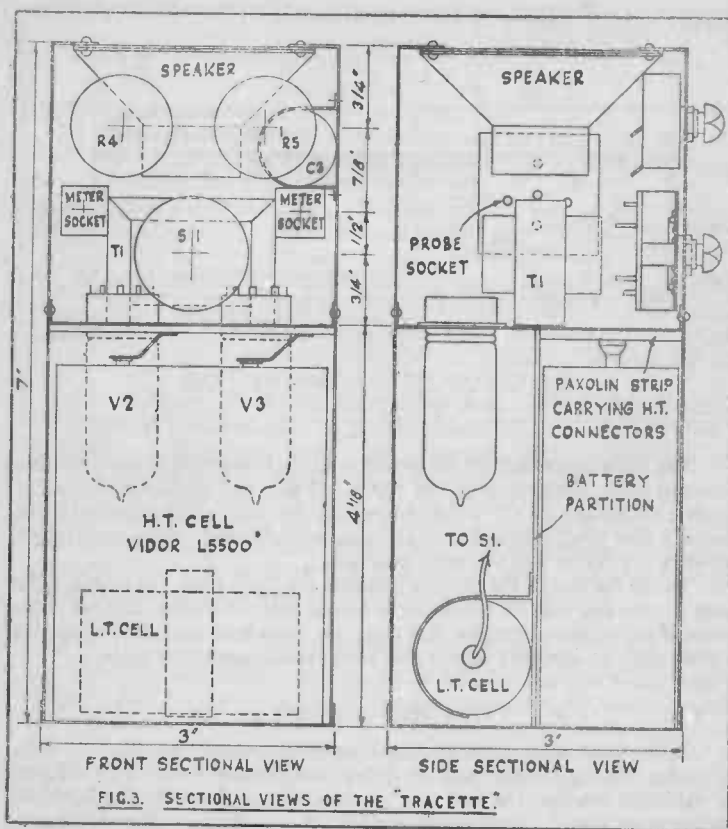way that C3 is mounted.

FIG.3.   SECTIONAL VIEWS OF THE "TRACETTE."

Generally speaking, however, it will be found that the 2½" speaker, with its output transformer, can be fitted neatly into the case without trouble.

The top of the case, 3" square with ¼" mounting flanges, should be drilled or punched with a 2" hole to act as the speaker opening.   To prevent injury to the speaker cone this hole is covered with fine mesh metal gauze—copper or brass gauze is easily obtainable—the gauze being clamped between the speaker frame and the top of the case by the speaker fixing screws.

The case itself may be built up from four pieces of sheet aluminium or from a single piece cut and bent to make the four sides; however the case is made the bottom should be a good push fit, with its fixing flanges

falling outside the case walls so that the bottom can be withdrawn for battery replacement, etc.

It is also advisable to have the back of the case removable in case service work is needed on the "Tracette."   If the back can be removed by withdrawing, say, four screws tapped into flanges on the sides of the case, the interior of the instrument becomes much more accessible.

It will be seen, from Fig. 4, that the valveholders and associated components are mounted on a subchassis fixed 4⅛" from the bottom of the case. Across the bottom of the subchassis is fastened a strip of good paxolin, on which are mounted two contacts, cut from springy brass strip, to connect with the terminals of the H.T. battery.

The metal of the subchassis is drilled away at the points where these contacts are bolted to the paxolin, and the bolts themselves then serve as insulated feed points for H.T. positive and negative.

The valves are mounted upside down—retainers can be fitted to the valveholders if these are thought desirable, but it was found that the valves were a tight fit in the holders and retainers were thus not needed on the original prototype.   The battery partition is mounted on to the subchassis to divide the case into two compartments; in one of these spaces slides the H.T. battery and the other contains both the valves and L.T. cell.   The cardboard case of the cell is slipped off and the cell clamped firmly in contact with the metal of the partition to provide the earth return.   The positive pole connection, from the rotary contact of the L.T. switch section, is soldered to the brass cap of the central pole of the L.T. cell—this connection should be made rapidly and the cell heated as little as possible when the joint is being made.

As can be seen from Fig. 3 the controls, R4, R5 and S1, are mounted on the front of the case, together with the metering sockets.

On the left-hand wall or side of the case is mounted the probe socket, and the bypass capacitor C3 is bolted to the right-hand side of the case, using a clamp cut from brass strip for the purpose.

The insulating cover round the T.C.C. capacitor should not be disturbed, and a proper earth connection must be made from the negative pole of the capacitor to the nearest earthed point—that is, the clamp itself.

The spindles of the two variable resistors, and possibly the switch spindle, will require cutting down to size.   A length of ½" protruding from the panel is sufficient, and the spindles can easily be cut with a hacksaw or even a fretsaw.

For convenience, in Fig. 4, all earth connections are shown as being made to the subchassis, but in the actual construction of the instrument each earth connection can be made to the nearest convenient earth point.   Remember to bolt down a soldering tag beneath one of the fixing bolts to each valveholder, etc., thus providing convenient earthing points.

Valveholder connections are shown in the theoretical plan, Fig. 1, by numbering the valve diagrams for comparison with a valve key illustration. The only note necessary concerns the DL92, i.e. V3. This valve has a double

FIG. 4. WIRING DIAGRAM OF "TRACETTE" SUB CHASSIS.

⊗ DENOTES EARTH CONNECTION.

MOUNT VALVEHOLDERS IN 5/8" DIA. HOLES.

filament which may be connected in series, for **3** volt operation, or parallel, for 1.5 volt operation. The parallel connections are needed for the "Tracette", of course, and so pins 1 and 7 on the holder of V3 are tied together, to form the positive side of the filament circuit, the negative side, pin 5, being taken direct to the earthed chassis.

With the instrument built, code the switch positions as:

Position 1.   OFF.

Position 2.   Modulated signals, audio.

Position 3.   R.F.-Meter.

USING THE "TRACETTE"

The sequence of signal tracing, with any type of tracer, is to work from the aerial terminal of the faulty receiver on to the output stage and loud-speaker—in direct contrast to fault finding with a multimeter or circuit analyser. The signal is thus followed on its normal course through the set, and the stage where the signal is lost, or where distortion is introduced, is discovered very rapidly.

To find faults by the use of a signal tracer, first check the faulty receiver for obvious breakdowns in the power pack and points where short circuits or low resistance circuits may occur—that is, broadly speaking, in the various stages where electrolytic capacitors are used for smoothing and bypassing. Ascertain that the receiver may be switched on without further damage, or, if necessary, make repairs to the power pack and so enable the set to be switched on, and either tune to the local station or, for preference when using the "Tracette", inject a signal from a signal generator into the aerial and earth terminals.

The following tests are described to cover conditions when a strong input signal from a signal generator can be applied to the receiver.

With the set working and tuned to the input signal—a note may not be heard at all in the loudspeaker, or there may be bad distortion or, again, the note may be intermittent, depending on the exact trouble in the faulty set—switch on the "Tracette" with the switch at position 2, and earth the probe by connecting the clip to the chassis of the receiver. As the "Tracette" is battery-operated it may be used with A.C., A.C./D.C. or battery sets without trouble.

Apply the prod to the signal or "hot" end of the aerial coil which is switched in, if necessary turning up the signal generator output for this test. The generator note should be heard—if not, it would appear that the first wave change switch section is faulty. Check by touching the prod direct to the aerial terminal, then to the set side of the aerial series capacitor if fitted. The signal should be heard at each point.

Transfer the prod to the "hot" or grid end of the first tuned circuit, and tune the set in and out of the generator signal. The signal should tune in just as when tuning the receiver, and should be louder, indicating tuned circuit gain. "No signal" here indicates a fault in the first tuned circuit

such as shorting capacitor vanes or a broken coilwinding—a rare place for a fault in modern receivers.

Switch the "Tracette" function switch to point 3 and plug in a 100 microamps meter to the R.F.-Meter sockets. Throw the switch before connecting in the meter. If such a sensitive meter is not available, then a 0—1 mA. instrument may be used, but the reading will be less marked.

NOTE.—Until the rough setting for zero on R4 is known, use a resistance in series with the indicating meter. If R4 is set far off zero there will be a relatively heavy current through the instrument, and although damage is unlikely, it could possibly occur.

When the "Tracette" is first built, therefore, code R4 with a dot or mark to show a rough zero setting, then remove the series resistance and set the meter to a final zero.

With the tracer switched to point 3 and the meter properly zero'd, apply the prod to the grid capacitor or anode of the local oscillator, or to points about the local oscillator circuit—the whole of this section of the tests assumes, of course, that the faulty receiver is a superheterodyne. A definite test point is not stated because the circuit of a local oscillator can vary widely from set to set; generally, however, it will be sufficient to connect the probe prod with the anode pin of the oscillator valve or valve section.

The loading of the "Tracette" should not be sufficient to stop the oscillator from working, no matter where the connection is made. If the oscillator is working correctly, the meter will read up the scale. It is worthwhile tuning the set round its various waveranges at this point to ensure that there are no dead spots where the oscillator goes out of action.

If no reading can be obtained, the oscillator is not working. A common cause of a dead oscillator is loss of emmission in the oscillator section of the frequency changer valve; if possible substitute a new valve of the same type as a check. Other faults are a loss of H.T.; a broken down anode bypass capacitor, a faulty grid capacitor (unlikely, especially if a mica component is used) and a faulty winding on the oscillator coils. Broken down or burnt out feed resistors to the oscillator anode are also found, sometimes, but in such a case a search for short circuits or other faults should be made, for the oscillator current would not be so high as to cause a resistor to burn out.

Broken coil wires, too, are not common unless the damage is mechanical, but in some areas—coastal districts, for example—corrosion and resulting wire failures are more often found than is normally the case, and this should be borne in mind.

With the oscillator checked and found to be in good condition remove the R.F. meter and switch back the "Tracette" to position 2.

Connect the prod to the final anode of the frequency changer, remembering to tune back the receiver to the local generator signal, which should be heard. Transfer the prod to the H.T. side of the I.F. transformer to check for hum on the H.T. line.

The prod capacitor has been specified as a 750 volts working mica

component, and so the probe may be contacted to points of H.T. with no fear of a breakdown. Remember, however, to keep your hand clear.

If no signal appears at the frequency changer anode, the most likely cause of the failure is either no H.T. feed because of an open H.T. line—unlikely, if the oscillator is working—or a broken winding in the I.F. transformer. If this is suspected, make a continuity check on the I.F.T. with a battery and meter.

Transfer the prod to the grid of the I.F. stage, where the signal should be heard, then to the I.F. valve's anode, where the signal should be quite powerful. Turn down the "Tracette" volume control if necessary. Carry on into the diode detector stage; if at any point the signal is lost, or becomes distorted, or intermittent, the fault must obviously lie between that point and the last point tested where the signal was properly heard.

From the diode the signal is traced into the grid of the first stage of audio amplification, then to the anode of the first audio amplifier, and so to the grid of the output valve.

If the signal is still present at the output valve anode it should by now be so strong that approaching the probe prod to the anode pin is sufficient to give a good output in the "Tracette" loudspeaker.

When a signal is traced thus far through a receiver and yet still no output is obtained from the receiver's own speaker, the test must proceed to the secondary of the output transformer and the speaker voice coil.

If the faulty receiver is of the T.R.F. type, then the tests are carried out in exactly the same way, the oscillator test of course being omitted. Audio amplifiers, too, can be tested by running the "Tracette" probe from the input terminals—an input from the audio section of the signal generator can be used, or a pickup and gramophone turntable can be employed—and a breakdown in a stage, or a point of introduction of distortion will soon be discovered.

Pickups can be tested by connecting them directly into the earth clip and prod of the "Tracette" probe, and even microphones can be tested in the same way provided that they are sufficiently sensitive; the "Tracette" really needs a little more gain to make it completely satisfactory as a microphone tester.

It will be seen, too, that the "Tracette" can be used to check various items of test gear, as well as receivers, amplifiers and the like. It will provide a ready means of ensuring that a constant output is being obtained round the tuning range of a signal generator, for example, by coupling in the generator with the "Tracette" switched to meter the R.F. output, and audio oscillators can be tested by using the "Tracette" in the ordinary way, monitoring the audio oscillator through the "Tracette" loudspeaker.

ALWAYS SWITCH OFF THE "TRACETTE" WHEN IT IS NOT IN USE—even between tests, if there is a pause in the work. It is ready to operate as soon as it is switched on, without warming up, and the H.T. consumption is a little heavy for the type of battery used—about 10 mAs. Nevertheless battery life is very good on intermittent service.

CHAPTER 2

THE "GENETTE"

A BATTERY-OPERATED POCKET SIGNAL GENERATOR

IT was stated in the preceding chapter that the "Tracette" could be used most efficiently when the faulty receiver under test was supplied with a check signal from a signal generator. The "Genette" was designed, as a companion to the "Tracette", to be carried about with the signal tracer as a simple and easily portable signal source giving both modulated and un-modulated R.F. as well as an audio signal for amplifier and output stage testing.

To make the signal generator small, with a low current consumption which would permit it to operate from a small battery, several refinements had to be omitted from the circuit. There are three tuning ranges, covering the basic requirements of the "all-wave" receiver, which permit operation over the bands

<div align="center">

16—47   metres,
250—750   ,,
700—2,000   ,,

</div>

and so the medium wave band, although starting at a rather high wave-length, covers the usual intermediate frequencies most often found.

A step attenuator was not necessary, as there are no arrangements for ensuring a constant output over each band—indeed, the output varies a little from top to bottom of each individual band—and so a plain potentio-meter type of output attenuator is used. At the same time some trouble was taken to ensure that switching the audio oscillator on and off caused no frequency shift between the modulated and unmodulated carrier—a point on which some commercial generators are open to criticism—and at the same time tuning over each band, and switching from band to band, causes no variation in the audio modulating note. This again represents a better performance than is sometimes found in a much more comprehen-sive and expensive generator.

There is, perhaps, one criticism which may be levelled at the "Genette," namely, the fact that a solid dielectric tuning capacitor is used. This was a necessary measure if the whole interior of the case was not to be filled with an air spaced tuning capacitor, and it may be said with confidence that a good solid dielectric capacitor, like the Jackson Bros. "Dilecon," is a great deal better than an inferior air-spaced component which may have end play and thus allow very serious changes in calibration, particularly as a slow motion drive is not used.

It will be seen, then, that the "Genette" does not pretend by any means to be a laboratory instrument, but it is capable of good service, provides an excellent signal, with harmonics at good strength should these be required for dealing with higher frequencies or the range between 47 and 250 metres, and is as easily portable as the "Tracette."

If the refinement of an artificial aerial is required, and this is often useful, it may be added in the form of a cable-mounted unit, like the "Tracette" probe head. This is shown in Fig. 8.

The theoretical circuit of the "Genette" is shown in Fig. 5. The three tuning coils are switched into the grid of the first valve, a DL92, with the screen providing the reaction through the secondaries of the coils. This leaves the anode free for the R.F. feed point, with the great advantage that a varying load presented to the anode is isolated from the oscillating circuits and so causes no de-tuning.

The output from the audio oscillator, a DF91, is fed into the grid circuit of the R.F. oscillator when a modulated signal is required, and the audio oscillator uses a transformer, in the usual way for regenerative inductances.

To reduce the "Genette" down to the size of the "Tracette" was found to be practically an impossibility, but the signal generator is only 1¼″ greater on one side, making it 7″ × 4¼″ × 3″ due to the size of the tuning coils and the audio oscillator transformer. Midget components were tested in the design, but operation was then found to be less efficient, and so the well known "P" type coils appear in the tuned circuit, with an ordinary 3:1 L.F. transformer in the audio oscillator. The transformer used in the original model was a Lissen "Hypernik," chosen chiefly because this type of inter-valve transformer is so often to be found in the "spares box."

Other transformers of about the same ratio will probably give results just as good; it may be necessary to experiment with the value of the resis-tance in series with the grid of the second valve and the Grid terminal of the transformer to obtain a satisfactory audio note.

The "Genette" has two main switches. One of these covers the tuning ranges in 3 positions; the other acts as the complete function switch and should be coded as

<div align="center">

Position 1.   OFF.
Position 2.   Modulated R.F.
Position 3.   Unmodulated R.F.
Position 4.   Audio Output.

</div>

The whole instrument is thus very easily controlled.

In the "Genette" the two valves are mounted in their B7G sockets on a small subchassis, raised to a height of 1″ and bolted to the back of the "Genette" case. The wiring diagram is shown in Fig. 6 and sectional views of the interior arrangement of the case are given in Fig. 7. The three controls, with the output socket, are mounted on the front panel of the case, whilst the main tuning capacitor is mounted at the top of the case, in the position occupied by the loudspeaker in the "Tracette."

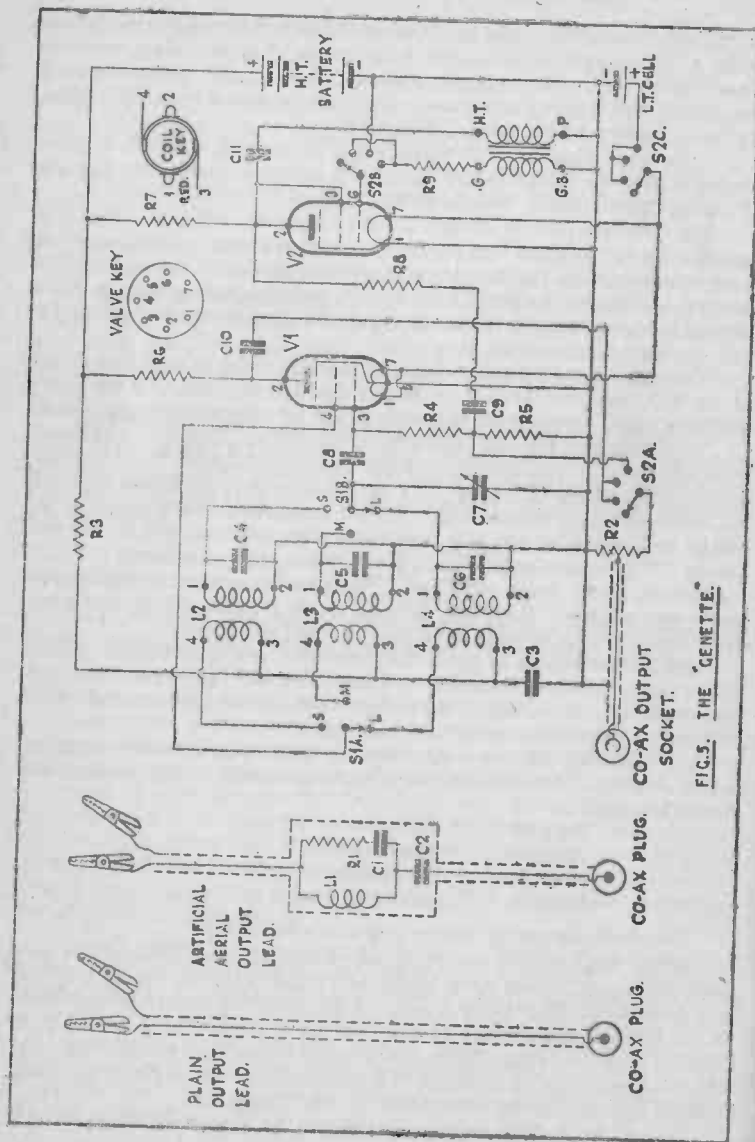This allows for full visibility of the dial, an Eddystone Type No. 62,

FIG.5. THE 'GENETTE.'

complete with pointer knob. This dial is divided into a 0—100 scale and the pointer knob permits quite fine setting—the accuracy attainable is perfectly sufficient for the work the "Genette" was designed to do. Calibration of the scale is made on a chart or graph, although one or two cardinal settings could be marked or the dial reading printed neatly on the blank half of the scale.

Suggested marked or noted points are 20 and 45 metres, for trimming and padding on the short wave band, 250 and 550 metres for trimming and padding on the medium wave band, 800 (or 1,000) and 1,750 metres for trimming and padding on the long wave band, and 465 kcs. (645 metres) for the usual I.F. adjustments.

COMPONENTS LIST FOR THE "GENETTE."

FIG. 5

L1,	60 turns 28 S.W.G. closewound to length of 1″ on a ½″ diameter paxolin former fitted into A.Æ. housing.
R1,	390 ohms, ¼ watt. Erie.
R2,	100,000 ohms variable, output control. Centralab midget.
R3, R6, R8,	10,000 ohms, ¼ watt. Erie.
R4, R5,	47,000 ohms, ¼ watt. ,,
R7,	68,000 ohms, ¼ watt. ,,
R9,	2.2 megohms, ¼ watt. ,,
C1,	0.0004 mfd. Mica. T.C.C. Type M2N.
C2,	0.0002 mfd. Mica. T.C.C. Type M3U.
C3, C9,	0.001 mfd. Mica. T.C.C. Type CM20N.
C4, C5, C6, C8,	50 pfs. Silver-mica. T.C.C. Type CM23N, 15%.
C7,	0.0005 mfd. Tuner. Jackson Bros. "Dilecon," Type No. 2093.
C10, C11,	0.0005 mfd. Mica. T.C.C. Type CM20N.
L2,	Wearite PHF3. 16—47 metres.
L3,	Wearite PHF7. 250—750 ,,
L4,	Wearite PHF1. 700—2,000 ,,
S1a, b,	2 pole 3 way wavechange switch. Messrs. Walter Instruments Type "B.T."
S2a, b, c,	3 pole 4 way Function switch. Messrs. Walter Instruments. Type "B.T."
T1,	3 : 1 Intervalve transformer, Lissen "Hypernik" or similar.
V1,	Mullard DL92. 3 S 4
V2,	Mullard DF91. 1 T 4

2 B7G chassis mounting valveholders.
1 Output socket (Co-ax type), Belling-Lee L604/S.
2 Output plugs, one for plain co-ax output lead, one for co-ax lead to artificial aerial, Belling-Lee L604/P.
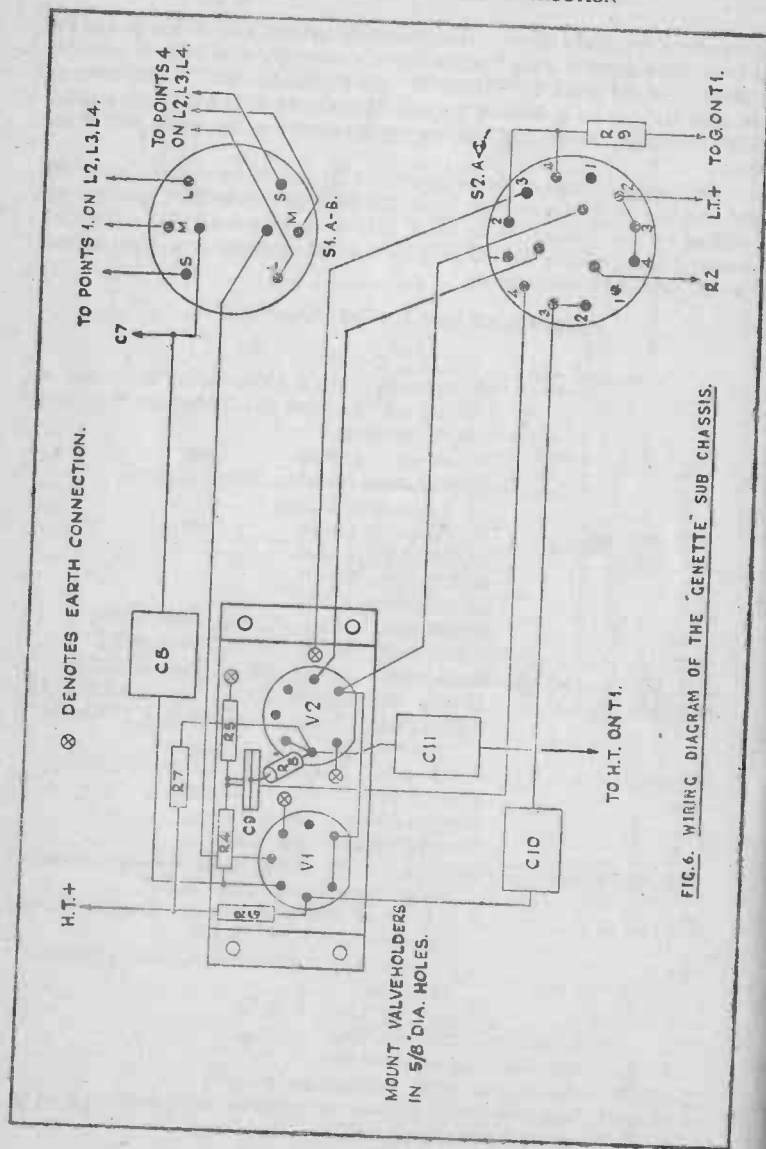
FIG. 6. WIRING DIAGRAM OF THE "GENETTE" SUB CHASSIS.

⊗ DENOTES EARTH CONNECTION.

Tuning knob and scale, Eddystone, No. 62.
3 Pointer type control knobs, Eddystone No. 1044.
H.T. Battery, Vidor, L5500.
L.T. Cell, U.2 or similar.

A.Æ. housing.   3″ length of 1″ diameter copper or brass tubing, with end discs. Crocodile clips for earth return, and feed connector.

Instrument case.   Build up from sheet aluminium to internal dimensions of 7″ × 4¼″ × 3″. Bottom and top. 4¼″ × 3″.

Sub-chassis,   2½″ × 1¼″, 1″ high with ¼″ fixing flanges.

Paxolin strip to hold battery contactors, brass strip for contactors and battery clamps.

Co-ax cable,   ¼″ diameter, Belling-Lee L.600, to lengths required for plain output lead and A.Æ. output lead.

Wire, sleeving, nuts, bolts, etc.

The internal arrangements of the "Genette" can be seen clearly from the two views of Fig. 7. The H.T. battery contactors are mounted on paxolin strip and, in the "Genette," the battery is flat on the bottom of the case. The instrument is stood up on end when in use, as with the "Tracette."

Battery retaining clips, bent from sheet brass, are riveted or bolted to the case so that the battery cannot move in the case when under shock or when the instrument is carried.

As with the "Tracette" it is only wise to make at least one side of the case removable to assist in the wiring and to give easy access should the generator require servicing at any time. "Prefabrication" is necessary when building completely shielded and self-contained miniature gear, as many parts of the circuit as possible being completed before the whole assembly is fitted into the case, and in the "Genette," for instance, the work is facilitated by sweating 6″ leads on to the switch contacts before mounting the switches whilst long leads can be left from the feed points on the sub chassis.

As already explained, one or more sides of the case can be made removable by bending flanges on the neighbouring walls, the removable side being fastened to these by 6 B.A. screws tapped into the flanges.

The "Genette" may be calibrated from an existing signal generator or from known radio stations, a good receiver being used as the indicator in either method. To calibrate the "Genette" from a second generator, couple both generators, via their artificial aerials, into the receiver, and, supposing the second generator and receiver to be mains driven, switch these on for 10 minutes or so to attain their operating temperatures. The "Genette" may be switched on a minute or so before calibrating.

Presuming that the medium wave range is under calibration, the standard generator will be tuned to 250 metres, 1,200 kcs., and the receiver tuned to bring in the standard generator note. The attenuator of this
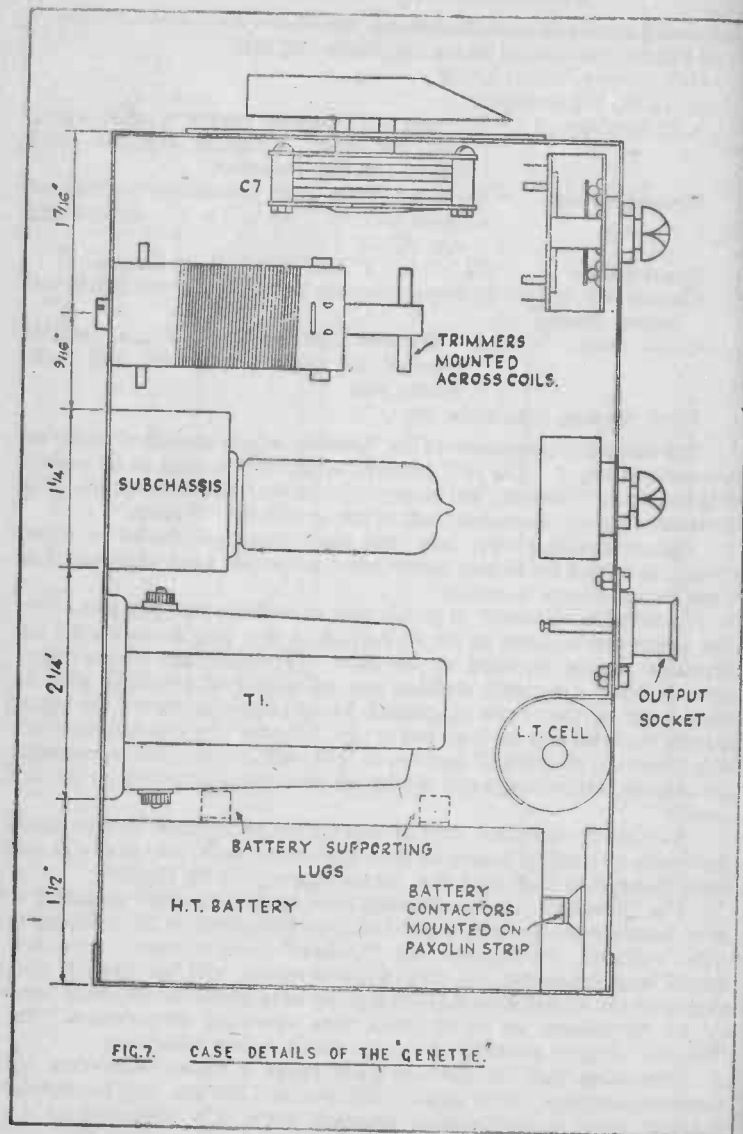
C7

TRIMMERS
MOUNTED
ACROSS COILS.

SUBCHASSIS

T I.

OUTPUT
SOCKET

L.T. CELL

BATTERY SUPPORTING
LUGS

H.T. BATTERY

BATTERY
CONTACTORS
MOUNTED ON
PAXOLIN STRIP

FIG.7.   CASE DETAILS OF THE "GENETTE."

generator may then be turned down till the signal is no stronger than is necessary for plain audibility, and the audio section of the standard generator switched out of action so that only a carrier is received.

The "Genette" is now switched to the medium wave range and the function switch turned to position 3 to give unmodulated R.F. As the tuning control of the "Genette" is rotated at the minimum capacitance end of the scale the output of the "Genette" will beat with the steady carrier supplied from the standard generator to give a beat note varying in pitch as the "Genette" is tuned. Rotate the tuning capacitor slowly so that the beat note *falls* in pitch right down to inaudibility; the two generators are then working on the same frequency and the "Genette" may be calibrated at that tuning point as 250 metres, 1,200 kcs.

The next required point may be 100 kcs. along the scale or, if fine calibration is not needed the next point might be 300 metres, 1,000 kcs. In either case tune the standard generator to this setting, switch on its audio oscillator, tune the receiver to bring in the note, switch off the audio section of the standard generator and again tune the "Genette" to give a falling beat note and, finally, inaudibility. Once gain the "Genette" is tuned to a known frequency and may be calibrated.
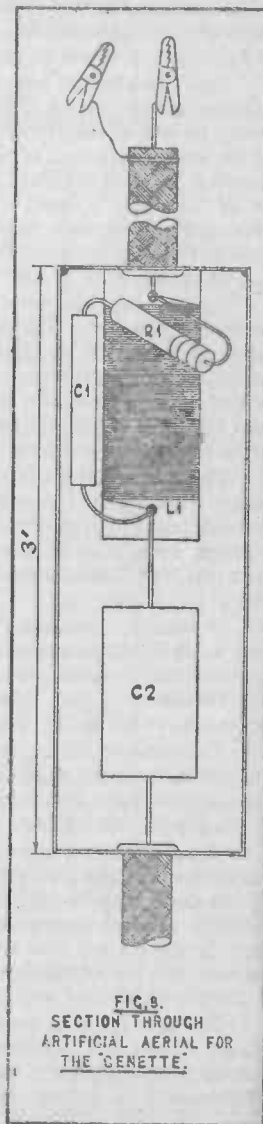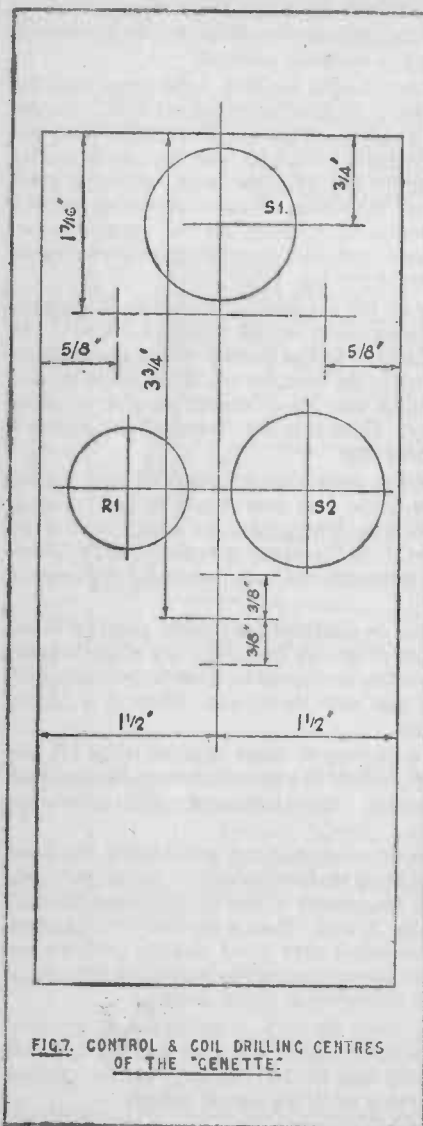
This procedure is carried out at each required point on each tuning range. The point of inaudibility of the beat note should be quite sharply defined, providing that the output from both generators is kept as small as possible, and cannot be missed for if the "Genette" is tuned to give a falling note and then tuned on through resonance the beat note will commence to rise in pitch.

If a standard generator cannot be obtained the receiver must be tuned to a series of broadcasting stations of known frequency, the stations being selected from a station list such as that published by Messrs. Bernards Ltd. The "Genette" is then tuned to beat with the station, when it is tuned, obviously, to the station frequency.

The audio oscillator, in this case, may be either switched on or off, but the indication is not so clear since instead of a plain carrier as the standard the station will give a modulated signal. Nevertheless quite good calibration is possible by this method.

The calibration curve may be drawn on ordinary graph paper, the three curves for the three tuning ranges being made separately. Along the Y axis of the curve may be plotted the frequencies of the range, whilst the dial readings will then appear along the X axis. Such a method of calibration may appear a good deal less convenient than direct reading from a slow motion dial, but a little experience shows that reading frequencies from such a chart is simple and very nearly as speedy as direct reading.

The battery life is excellent, since the H.T. consumption is approximately 4 mAs. L.T. consumption is, of course, 150 mAs. and the L.T. cell will need replacing more frequently than the H.T. battery, but the method of mounting the batteries make this a relatively simple matter.

FIG.7. CONTROL & COIL DRILLING CENTRES
OF THE "GENETTE."

FIG.9.
SECTION THROUGH
ARTIFICIAL AERIAL FOR
THE "GENETTE."

CHAPTER 3

THE "EMERTRAN"

A BATTERY-OPERATED EMERGENCY TRANSMITTER

DESPITE its miniature size and power the "Emertran" design is quite capable of putting up a good performance.

It was not desired to make the "Emertran" a 'walkie-talkie' transmitter, complete with receiving circuits; the design is definitely for an emergency transmitter intended to work, chiefly, on the 20 metre band and a 20 metre dipole aerial provides the correct load.

Emergency operation is less usual in this country than in others; in the first instance we are free, to a great extent, from natural calamities such as disastrous floods, hurricanes, whirlwinds, etc., but there is still no guaranteed freedom from widespread electricity cuts, transmitter failures and similar causes which can close-down an amateur station.

At the same time the "Emertran" can be used for short-distance contacts as between the members of a radio club, avoiding the use of the high powered gear (which, for short distance work, should be operated with a reduction in the modulation percentage) and a small transmitter offers many benefits to licenced training organisations which include signalling and communications in their curricula.

To judge from correspondence received from readers of the Bernards Radio Manuals, it is necessary to give a reminder, at this point, that no transmitting gear of any description may be used except by properly licenced and authorised amateurs and clubs.

Any emergency gear should be ready to operate at the throw of a switch, and this is a feature of the "Emertran." The oscillator is a push-pull circuit, as shown in Fig. 9, the tuning being accomplished by a trimmer capacitor, so that the transmitter can be set on a chosen frequency within the band when first tested and left at this frequency. The range of capacitance change over the trimmer also allows the transmitter to be operated in the 10 metre band, if required.

The original circuit was tested both with trimmer and normal variable capacitor tuning, and the trimmer tuning certainly showed up to advantage, the cause apparently being the reduced mass of metal connected to the inductance and the lower capacitance to earth of the trimmer capacitor. It can be seen in Fig. 10, that the trimmer is supported across the coil and thus held clear from the metal body of the "Emertran." The clearances between the

coil and the case are not great, but experiment showed that efficiencies with the tuned circuit both out of, and in, the metal case were practically the same.

The input to the oscillating circuit is of the order of 600 to 700 milliwatts, with a 67.5 volt battery, so that the output is small and not easily judged either by aerial feeder ammeters or a lamp, but the coupling between L1 and L2 can be adjusted when the transmitter is first built by including a milliameter in the H.T. -ve. lead, the oscillator current (V3 may be removed for the test) being brought up to 10 mAs. by adjusting the coupling between the two coils.

It can be seen from Fig. 10 that the coupling is close, L1 being inserted between the central turns of L2. In the original model the coils were correctly coupled when L1 was half-meshed with L2.

A pair of metering sockets could be provided on the instrument case to allow the H.T. current to be checked at will, and these sockets could also be used for keying the transmitter. These sockets are not shown in the diagrams as they were not needed on the prototype, but if it is desired to include them in the circuit it is only necessary to break the H.T. -ve lead at the point X in Fig. 9, the theoretical circuit diagram of the "Emertran."

At X the H.T. lead would come to one socket, the earth lead from the chassis being brought to a second socket. A shorting link would then allow the transmitter to be operated in the normal way; withdrawing the link would allow either a key or meter to be plugged in.

To keep both H.T. and L.T. consumption down it was desired to use a 50 mAs. filament valve as V3, the modulator, so various types were tested in this position, and it was found that a DAF91, triode connected, gave excellent modulation of the carrier. The diode of this diode-pentode is, of course, neglected—point 3 on the valveholder of V3 is earthed.

The microphone, of the G.P.O. type, is connected into the grid of V3 by a 60 : 1 midget transformer, and energised from the main L.T. supply. The microphone current averages at 50 mAs. so that L.T. drain is not too great, but a different type of microphone may require both a different transformer ratio and a different energising voltage. Ex-G.P.O. microphone buttons are, however, in good supply.

Choke coupled modulation is used, a low frequency choke being connected in as the anode load of V3. Many chokes with suitable electrical characteristics are made, but a search through manufacturers lists failed to show a choke sufficiently small which would still carry the 12 mAs. approximately which flow in this circuit. Various "trick" chokes were therefore tested, and found quite satisfactory; builders of this transmitter will almost certainly have a suitable inductance to hand.

Examples of suitable audio chokes are the 1,000 ohms coils, wound over iron formers, often found in ex-war gear and ex-G.P.O. gear; the primary of a midget intervalve transformer of the type often found in pre-war midget portable receivers; the coil from a relay or, if none of these are available, the double coil from an old earpiece, with the magnet removed, may be used.
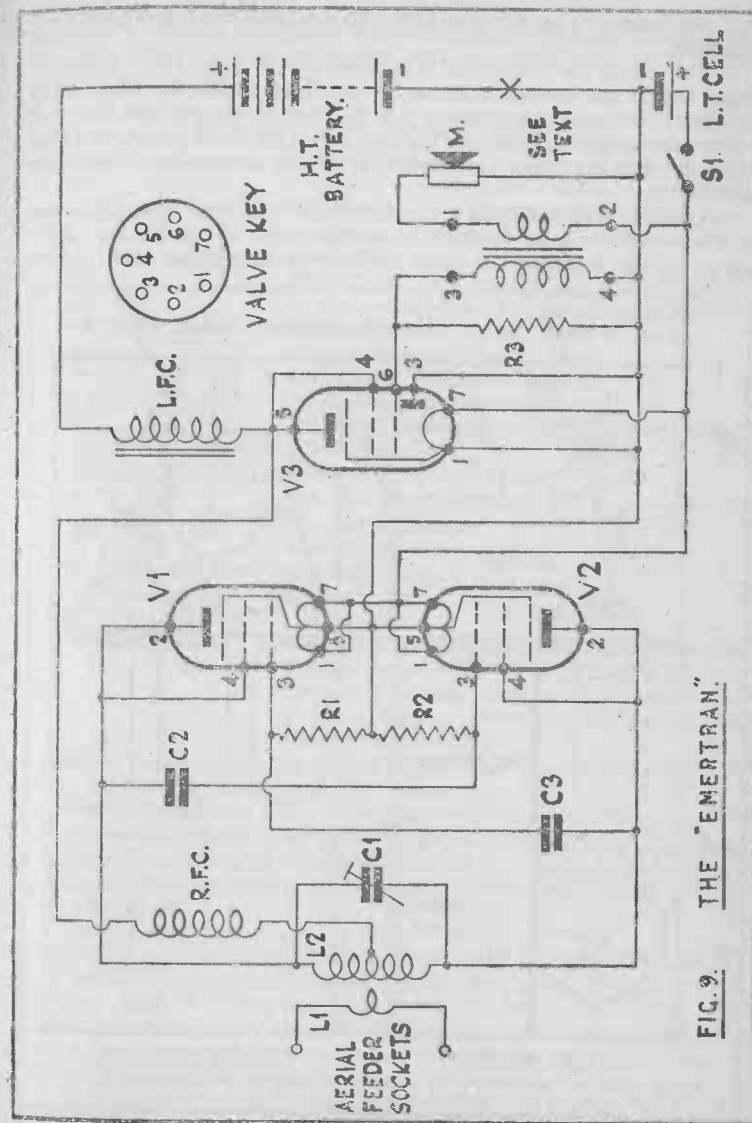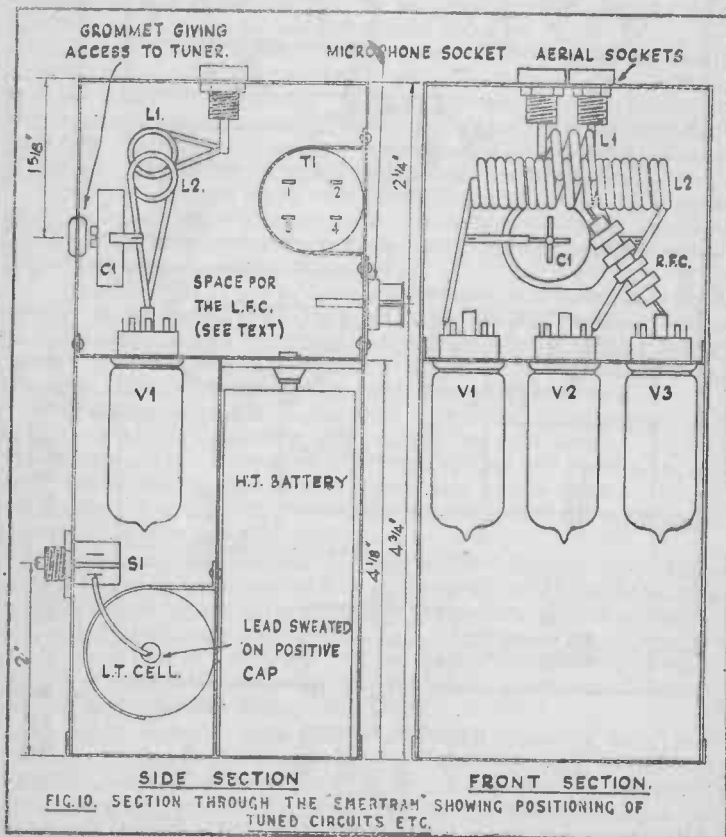
FIG. 9. THE "EMERTRAN."

An inductance as high as possible with a resistance as low as possible is required.

The case of the "Emertran" is modelled on the lines of the "Tracette" case, and to the same dimensions. A subchassis carries the valves in an inverted position—valve retainers may be fitted if desired—but only two controls are required on the case, the main switch, S1, and a grommetted hole through which any change to the setting of C1 may be made by a longbladed screwdriver.

This hole is drilled in the rear panel of the "Emertran" case, $1\frac{5}{8}''$ down and centrally across the width. On the front panel is mounted the microphone socket, a Belling-Lee co-ax L604/S, the microphone lead being a

SIDE SECTION   FRONT SECTION.
FIG.10. SECTION THROUGH THE "EMERTRAN" SHOWING POSITIONING OF TUNED CIRCUITS ETC.

length of L600 solid co-ax cable terminating in a Belling-Lee L604/P plug.

As neither side of the case carries any components, either or both may be made removable.

COMPONENTS LIST FOR THE "EMERTRAN"

FIG. 9

L1,	3 turns 16 S.W.G. enam. and D.C.C., $\frac{1}{2}''$ diam.
L2,	20 turns 16 S.W.G. enam. and D.C.C., close-wound, $\frac{1}{2}''$ diam. Mesh L1 centrally into L2 as in Fig. 10.
C1,	20—120 pfs. trimmer. T.C.C. Type TCK2012.
C2, C3,	49 pfs. ceramic disc. T.C.C. Type SCD6,20%.
R1, R2,	33,000 ohms, $\frac{1}{4}$ watt. Erie.
R3,	2.2 megohms, $\frac{1}{4}$ watt. Erie.
R.F.C.,	R.F. Choke, Eddystone No. 1010.
L.F.C.,	Audio choke, as described in text.
T1,	Microphone transformer, Wearite "Hyperloy," Type 207, 60:1.
M,	Microphone, G.P.O. Button.
S1,	S.P. On-Off switch, Bulgin S80.
V1, V2,	Mullard DL92.
V3,	Mullard DAF91. / S 5

3 B7G chassis mounting valveholders.

H.T. Battery, 67.5 volts, Vidor L5500.

L.T. Cell, 1.5 volts, U2 or similar.

"Emertran" case.   Cut and bend from sheet aluminium to internal dimensions of $7'' \times 3'' \times 3''$, with top and bottom 3" square. Subchassis, 3" square with $\frac{1}{4}''$ fixing flanges. Bottom a tight push fit, for battery replacements.

Aerial feeder sockets, mounted on top of case. 2 of Belling-Lee L315, with 2 of Belling-Lee L1021/3 plugs.

Feeder, Belling-Lee L336, unscreened twin feeder, 75 ohms.

Microphone socket, Belling-Lee L604/S, with 604/P plug.

Microphone cable, Belling-Lee L600 co-ax.

Spring brass for battery connectors, etc., Wire, sleeving, nuts, bolts. Grommet.

Thick paxolin strip.

Note that in the "Emertran" as distinct from the battery gear so far described, the H.T. neg. spring connector does not have to be isolated from the case, unless the meter-key sockets are included in the circuit. The positive connector is once again mounted on paxolin strip secured below the subchassis, the metal of the subchassis being drilled away to provide an insulating mounting for this connector.

The "Hyperloy" transformers are provided, by the manufacturers, with a mounting clamp, but a strip brass clip will be found more convenient as

FIG. II. WIRING DIAGRAM OF THE 'EMERTRAN' SUB CHASSIS.

M/c. SOCKET.

⊗ DENOTES EARTH CONNECTION.

MOUNT VALVEHOLDERS IN 5/8" DIA. HOLES.

LEGS OF L2.
L2, C1, & L1 NOT SHOWN.

TO CENTRE OF L2.

R.F.C.

H.T.−

R3

L.F.C. (SEE TEXT)

H.T.+

TO L.T. VIA S1.

V3   V2   V1

C3

R1   R2   C2

---

then the microphone transformer can be clamped tightly to the front panel. The L.T. cell, as before, is retained by a strong brass clip.

Working currents, using a 67.5 volts H.T. battery, may be taken as 12 to 13 mAs. H.T. and up to 300 mAs. or so L.T. The valves require 250 mAs. of L.T. current, the microphone drawing a further 50 mAs. or so. The L.T. battery life, therefore, is not over great whilst the H.T. drain is a little high for the small battery used. This type of transmitter is used for short periods only, however, so that there is plenty of recuperation time for the H.T. battery. Replacement of the L.T. cell is both simple and cheap.

CHAPTER 4
A FIXED-TUNE 10 METRES CONVERTER

OF the great number of surplus ex-service receivers now in use, few tune up to frequencies in the 30 Mcs. band. The common high frequency limit would appear to be about 18 Mcs.—for example the well known R107, BC348 and the R1155 all have high frequency limits of between 17.5 and 18.5 Mcs.—and so these excellent receivers cannot be used on the 10 metre band for amateur reception without a converter.

A converter is quite easily made—a single valve circuit, using a triode-hexode or similar frequency changer, can give very good results—but then the main receiver becomes a fixed tune I.F. amplifier, demodulator and output stage, and all the tuning is performed with the converter. This of course means that two tuned circuits in the converter itself, the R.F. and oscillator tuning circuits, must either be accurately ganged or separately controlled and the converter calibrated, whilst the existing accurate calibration of the receiver is "wasted." The converter gives a first I.F. output usually at a frequency of 5 to 10 Mcs., and the main receiver is tuned to this frequency and acts as a second frequency changer and I.F. circuit.

Really accurate calibration of the converter is by no means simple, and an altogether more satisfactory arrangement is to have a broad-band converter, using a fixed frequency oscillator, with a tuned I.F. amplifier. This is the manner in which the converter to be described operates.

To cover the 10 metre band the converter-receiver combination must respond over the range 27.5 to 30 Mcs. Using television technique the first tuned circuit can be made to cover this frequency band quite well; the tuned inductance may either be shunted with a resistance or be over-coupled to a second tuned circuit for its response band to be broadened. If the first tuned circuit feeds into an R.F. stage the band broadening may be performed by a resistance; the coupling between the R.F. stage and the frequency converter may be via over-coupled coils. So far, then, the R.F. circuits of the converter are tuned over the whole required band.

A pentode may be used as the frequency converter, the local oscillator being a separate circuit. The local oscillator also works on a fixed frequency and for convenience this should be chosen to be 20 Mcs. Thus an incoming signal on a frequency of 28.5 Mcs. (say) will beat with the local signal to

produce a first I.F. signal on a frequency of 8.5 Mcs. and if the main receiver is tuned to 8.5 Mcs. the signal will be heard. Similarly, a second signal, situated at, say, 29 Mcs., would be passing through the first broad-tuned circuit and beating with the local oscillator's carrier to give a final first I.F. signal on a frequency of 9 Mcs. This signal, therefore, would not be heard till the main receiver is tuned round to 9 Mcs. Tuning the converter simultaneously over the whole band does not, therefore, cause any interference; the only interference between signals which can exist is same-channel interference when more than one station is using the same frequency and in that case interference will occur on any type of receiver.

The calibration of the main receiver, moreover, holds good. If the local oscillator of the converter is working on 20 Mcs. for reception of the band from 27.5 to 30 Mcs., then, as already explained, the converter output will be over the range 7.5 to 10 Mcs. and the main receiver must be tuned over this range. The receiver's tuning dial may therefore be read and an imaginary 20 added to the dial figure—that is, the figure 2 is placed before the indicated reading. Thus, if, with the converter connected in, the main receiver is tuned to 8.34 Mcs., the true signal frequency is 28.34 Mcs. Similarly a signal received at 9.5 Mcs. on the dial has a true frequency of 29.5 Mcs.

When the receiver dial is tuned to 10 Mcs. the addition of 20 gives the true signal frequency of 30 Mcs.

To the advantage inherent in the fact that the converter has no tuning drive and dial is added the benefit of miniaturisation. The converter, once adjusted, can be situated behind or actually within the main receiver case, and as it is designed for use with existing sets it need have no power pack of its own. The low heater and H.T. demands can be supplied easily from the main receiver, unless its power pack is working with no reserves at all. The converter demand is 0.75 amp at 6.3 volts, heater current, and about 15 mAs. H.T. from a 250 volt line.

The converter circuit is shown in Fig 12.

The aerial is coupled in via L1 to L2, the first tuning coil. It will be seen that this coil, like L4 and L5, is iron cored and, like L4, is tuned only by the stray circuit capacitances. V2, the mixer or frequency converter, feeds into a coil tuned by a variable capacitor to a set frequency, whilst the local oscillator, V3 in an electron-coupled Hartley circuit, is also set to its permanent tuning point by a fixed and a variable capacitor in parallel. The oscillator circuit is therefore a "high C" circuit and so is stable—the tuning range is small, but this is of no importance so long as the correct working frequency is attained.

The circuit alignment and tuning details are given after the building instructions.

COMPONENT LIST FOR THE FIXED-TUNE CONVERTER.
FIG. 12

Coils.

L1,	3 turns 26 S.W.G. enam. closewound, ⅛" from L2.
L2,	14 „ „ „ „ „

Coils.

L3,	14 turns 26 S.W.G. enam. closewound ⅛" from L.2.
L4,	14 „ „ „ „ „ ⅛" from L3.
L5,	27 „ „ „ „ „
L6,	6 „ „ „ „ „ over L5.
L7,	10 „ 16 „ „ „ self-supporting, inside diameter ¼", tapped at 4 turns up.

All coils except L7 are wound on DENCO Iron cored formers, and the coil illustrations in Fig. 13 must be consulted before winding, together with text, below.

R1,	6,800 ohms,	½ watt.	Erie.
R2, R5, R9,	47,000 ohms,	„	„
R3,	200 ohms,	„	„
R4, R6,	4,700 ohms,	„	„
R7,	10,000 ohms,	„	„
R8,	100,000 ohms,	„	„
C1, C2, C3, C4, C5, C6,	0.001 mfd. Mica. T.C.C. Type CM20N.		
C7, C8,	75 pfs. Air trimmer. J.B. Type G801.		
C9, C10,	0.0001 mfd. Mica. T.C.C. Type CM20N.		
C11,	0.0005 mfd. Mica. T.C.C. Type CM20N.		
V1, V2,	Mullard EF91.		
V3,	9002 (American), or Mullard EAC91, if available.		

3 B7G chassis mounting holders.

Aerial input socket (For ¼" co-ax feeder, 80 ohms.) Belling-Lee L604/S. *See text.*

Signal output socket, Belling-Lee L604/S.

Aerial and signal output co-ax plugs, Belling-Lee 604/P.

Chassis, built up from sheet aluminium. *See text.*

3 Denco iron-cored coil formers.

4 core power cable, fitted at end with Belling-Lee plug L1258 to fit a power socket mounted on main receiver, Belling-Lee L331.

Wire, sleeving, nuts, bolts, etc., Grommets.

AERIAL INPUT

The details given concerning the aerial coupling socket and coil are based on the use of co-axial feeder from a dipole, the aerial circuit thus being matched to 80 ohms with the outer conductor of the feeder earthed to the converter chassis through the co-ax socket. It may well be, however, that a 300 ohms circuit is in use, consisting of a folded dipole and downlead made from 300 ohms twin feeder cable. In this case the co-ax input socket will hardly be suitable, and, instead, a double socket or a pair of feed-through terminals may be used as the connection at the converter for the feeder. The aerial coil will then be either earthed or unearthed, whichever gives best results; probably a balanced feeder with no connection from the aerial coil L1 to the chassis of the converter will be found best.

The present winding data for L1 matches an 80 ohms load into L2 and if a 300 ohms load is presented to the first stage L1 must be wound to suit
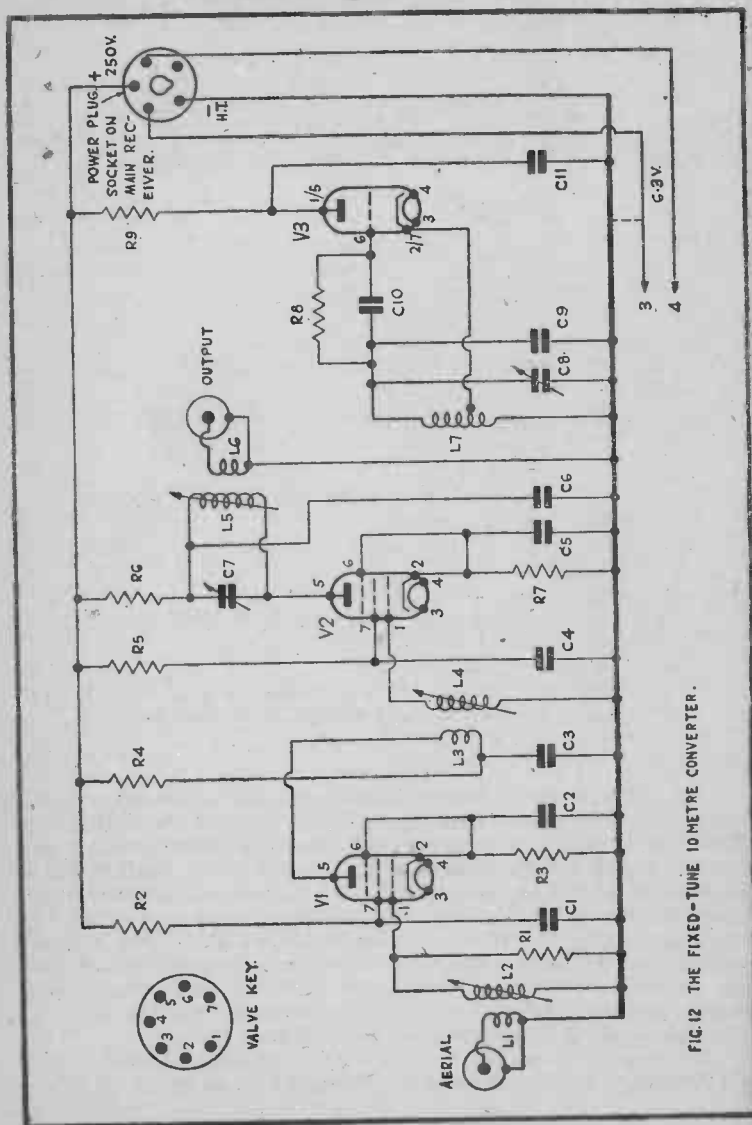
FIG. 12 THE FIXED-TUNE 10 METRE CONVERTER.

the new conditions. Dummy load tests show that L1 may then have 5 or 6 turns; in either case the coupling and loading of L1 on L2 assists in the broadening of the response of L2.

COIL WINDING

The coils are wound on Denco polystyrene formers, $\frac{1}{2}''$ in diameter, and if other iron-cored formers are used, they must have the same diameter if coil windings are not to need adjustment.

The coils must be positioned on the formers in such a way that the correct coil is tuned when the core is adjusted, whilst at the same time the core must have a full range of travel through this tuned coil, from fully out to fully in. In the coil groups the tuned coils are L2 in group L1, L2 and L4 in group L3, L4, and L5 in the final group although in this case L6 is wound over L5 and the main tuning is by a 75 pfs. capacitor.

The coils are therefore positioned on the formers as shown in Fig. 13, and in each case the core is shown fully retracted from the tuned coil.

L7, is not shown since this is a straightforward winding which is self-supporting, and mounted across the terminals of C8.

HEATER WIRING

In Fig. 12 the heaters are shown as connected to a double heater line and connections from each heater to earth are not shown. Such a connection, however, should exist; preferably one side of each heater should be connected to the chassis, the other side being connected, via a single heater line, to an earthed 6.3 volts source.

The final arrangement, however, must depend on the receiver with which the converter is to be used and so the heaters are shown isolated whilst the dotted line between the upper heater feed line and the negative or earth line of the converter will serve as a reminder that a connection, either in the converter or the main receiver, between the heaters and earth is desirable.

THE CHASSIS AND CONSTRUCTION DETAILS

A definite chassis size is not given in the parts list for the reason that many constructors will decide to fit this converter actually within their receivers, and so will be bound by the space they find available. In some
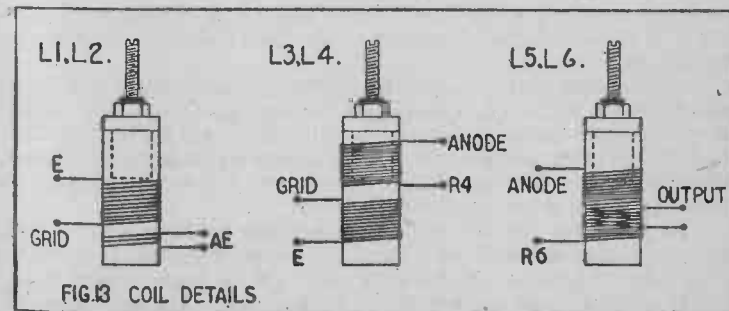

FIG. 13 COIL DETAILS.

surplus or ex-service receivers there is vacant room left on the chassis by the removal of a genemotor—the BC348 provides an example of this—and the converter could be fitted into such a position.

The circuit has been found very stable and it could probably be built up in a great many different ways; the recommended form of the layout and chassis is shown in Fig. 14 but there is plenty of room for personal ideas and trials.

No effort to obtain high gain has been made (in any case a high gain over the converter would be very difficult to achieve if the broad response band was to be maintained) and the reduction of screen voltages, together with separation of the chassis into screening compartments contribute materially to stability and ease of handling.

The layout diagram is self-explanatory and requires but few notes. The aerial input is on the left hand end of the chassis (the diagram shows the chassis viewed from the rear so that in Fig. 14 positions appear reversed) and the first screening compartment contains the R.F. stage. The coils wound on formers are mounted in each case on the front of the chassis; the Denco formers mount in a 0 B.A. hole and are clamped down by the top nut so that the core control screws protrude through the front of the chassis.

In the second screening compartment are found L3 and L4 on their formers and also L7 tuned by C8 and C9. The oscillator signal is injected into the mixer grid circuit by stray fields alone, there is no capacitive or direct inductive connection.

The third compartment contains the final tuned circuit and the output coil coupled to it.

The air-trimming capacitors chosen, Jackson Bros. C801, are self-insulating, and so C8 must have an earth connection to its moving vanes lug. The advantage of a self-insulating capacitor is found in the case of C7 where both sides of the component are above earth. The capacitors have 6 B.A. mounting pillars with centres 21/32" apart, and centrally between these fixing holes should be drilled a $\frac{3}{8}$" hole through which the control spindle passes without contacting the chassis.

Control both of C7 and C8 is by an end slot in the spindle, the capacitors being rotated by an insulated trimmer tool or a polystyrene or ebonite rod with a trimming blade fashioned at one end. Knobs are not fitted to the capacitor spindles.

The oscillator valve, V3, is mounted over the second compartment, so that the mixer, V2, is at the right-hand end of the chassis. As L3 and L4 are also mounted in the central compartment this means that the lead from L3 to the anode of V1 must pass through a grommetted hole in the first chassis screen whilst the lead from L4 to the grid of V2 must pass through a grommetted hole in the second chassis screen.

As is usual in high frequency gear, particular attention must be paid to the bypassing and earth leads, all of which must be as short as possible. Once again, mounting a soldering tag under a fixing screw of each valve-holder provides good and well-placed earthing lugs. The earth leads of

FIG 14. CHASSIS ARRANGEMENT AND MAIN COMPONENT DISPOSITION. THE FIXED TUNE CONVERTOR.
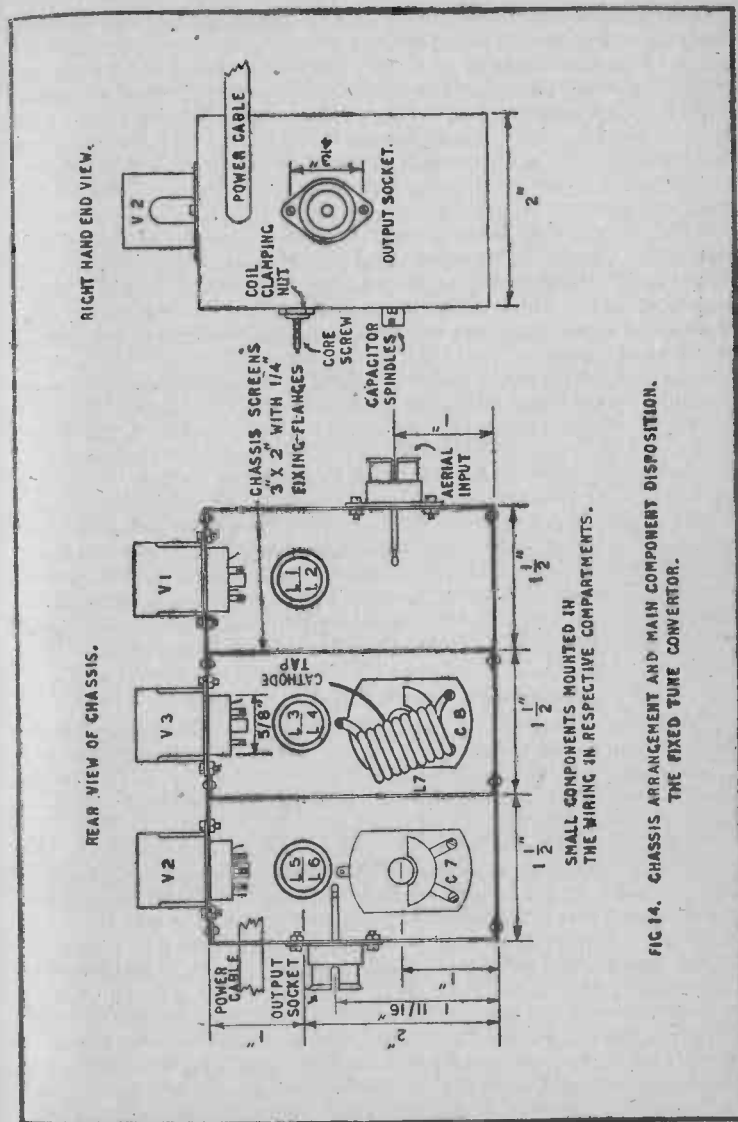
each stage should be contained within that stage's chassis compartment except in the case of L3 and L4, where it is necessary to have both C3 and the earth connection of L4 in the central or oscillator compartment.

The four core power cable leaves at the output or right hand end of the chassis. If the main receiver wiring permits, the power cable need only have 3 cores, one wire being common to H.T.-ve and to one side of the heater wiring. At the end of the cable is mounted a power plug, Belling-Lee L1258, and at a convenient point on the main receiver should be fitted a power socket, L331, to receive the plug.

The signal output socket is also mounted on the right-hand end of the chassis. Belling-Lee L600 co-ax cable should be used for the converter receiver link, the screen of the cable being earthed at each end to the chassis of the apparatus. This is achieved automatically at the converter by the use of the co-ax socket, but at the receiver the connections required will depend on the input circuit.

Earthing of the cable screen is necessary to avoid direct pickup of signals on the converter I.F. range of 7.5 to 10 Mcs.

The Oscillator Valve

A 9002 or Mullard EAC91 diode-triode should be used as V3, the oscillator. The triode of the latter is an excellent H.F. oscillator.

The 9002 works well in the circuit, and is widely obtainable but for those who have a selection of Acorns it may be of interest to mention that a 955 will also give good results in the V3 position using exactly the same circuit. The 955 is, perhaps, less easily mounted and its holder would have to be positioned on top of the chassis with the leads to the circuits taken through holes, but so far as performance is concerned there is little to choose between it and the 9002.

Tuning and Aligning the Converter

With the converter built, the wiring checked, and the first tests made, the circuit can be trimmed and set to work. The aerial should be connected in, the output from the converter coupled to the main receiver and the power supplies switched on and the gear left running for a few minutes to attain operating temperature.

First check the oscillator for correct working and frequency. V3 should oscillate with no trouble at all and lack of oscillation would indicate a circuit fault. The main receiver should be tuned to 20 Mcs., if possible; if not, a receiver capable of tuning accurately to this frequency should be employed. The oscillator tuner, C8, should be set about $\frac{1}{4}$ in.; then the receiver tuned to search for the carrier due to the oscillator of the converter, somewhere around the 20 Mcs. mark. Once the carrier is found C8 must be tuned carefully to set the oscillator exactly at 20 Mcs. At this stage care must be taken not to beat the convertor oscillator with the local oscillator in the main receiver. Assuming the receiver calibration is accurate this will usually be found at the dial frequency plus the receiver I.F. frequency and may be identified by a loud beat note similar to that produced by a

B.F.O. The required carrier is clear of any beat note and is similar to that produced by an unmodulated signal generator.

The oscillator should tune to 20 Mcs. without trouble, but if the frequency is high or low and cannot be brought right onto the correct frequency either more capacitance is needed, if the frequency is high, or a turn or so may be removed from the coil if the frequency is low.

An error here, however, would indicate that a mistake in the coil winding had been made, or that the tuning capacitance was incorrect for some reason.

With the oscillator working properly on 20 Mcs., retune the main receiver to 8.5 Mcs. and inject a 28.5 Mcs. signal, from a signal generator, into the input stage of the converter. It is generally sufficient to run the generator lead beside the input feeder, with the generator output turned well up: the converter is then correctly loaded by its aerial and a sufficiently strong signal is being received.

First tune L5, by means of its trimmer, C7, and its iron core, to give maximum output. If the first circuits of the converter are far off tune it may be difficult to find the signal, and in this case an 8.5 Mcs. signal may be injected into the grid of V2, C7 and L5 then being adjusted for maximum output.

If this is done, the generator must then be disconnected, tuned again to 28.5 Mcs., and the signal again fed into the input stage.

Next tune L4, by means of its core, to give maximum signal into the main receiver, and finally tune L2 for maximum signal. The response of the converter may now be tested over its range by tuning the signal generator to various points over the converter range—say 27.5 Mcs., 28 Mcs., 29 Mcs., 29.5 Mcs., etc., tuning the main receiver to 7.5, 8.9 and 9.5 Mcs. respectively.

If calibration is lost at any time through these tests, the oscillator section of the converter should be checked to ensure that it is still working on 20 Mcs.

The response band required is 2.5 Mcs. wide, and with the tuned circuits shown this is not so difficult to achieve as might be thought. Nevertheless, should there be any noted falling off in sensitivity at either end of the band for any reason the whole converter could be aligned to cover the range of frequencies which chiefly interest the constructor; the tests on this circuit showed, however, that coverage was very good and satisfactory working over the whole band was obtained.

Chapter 5
TWO MINIATURE AMPLIFIERS
A Push-Pull Battery Amplifier

WHILST the average town dweller probably never feels the need of a battery operated amplifier, the countryman, and particularly the music-loving countryman, often finds such a circuit almost a necessity. The ordinary mechanical gramophone cannot really give satisfactory reproduction of recorded music (this remark does not apply, of course, to carefully

designed and expensive mechanical reproducers) and besides the range of tone and volume control possible when using an amplifier, an electrical reproduction always appears to have a "life" or "sparkle" which is often lacking in mechanical reproduction.

The battery amplifier here described has been designed specially for this Manual, in the hope that it may fill an undoubted need.

Up to the present time the majority of battery amplifiers utilise Q.P.P. circuits, and consist of an input stage with or without tone control, a driver stage and a transformer coupled Q.P.P. valve, the output of the combination being of the order of 1 watt. The Q.P.P. valve economises to some extent on battery current but unless the whole circuit is very carefully balanced distortion can soon set in as the battery ages, and in any case a super-power 150 volt battery is needed. The Q.P.P. amplifier is also usually heavy on the L.T. supply, and a high capacity 2 volt accumulator is needed. As a result the whole amplifier is large and weighty and, considering the size of the power supplies, cannot easily be made portable.

The modern range of 1.4 volt filament valves make a push-pull amplifier with a resistance—capacitance coupled phase splitter practical, and therefore the centre-tapped input transformer needed with the Q.P.P. circuit can be omitted with a saving in weight and a probable improvement in quality, whilst the small-size of the valves themselves make it possible to build the whole amplifier on a very small chassis. The L.T. supply can be split up, each stage of the amplifier having its own 1.5 volt cell, and since a 90 volts battery is all that is needed for H.T., the whole amplifier can be made light and carried easily.

The push-pull circuit shown in Fig. 15 was designed to fit into a portable gramophone case along with the existing spring motor, hence the miniaturisation of the apparatus, but the amplifier could also be cabinet built and used as a fixture in the home.

Inspection of the circuit will show that it follows mains amplifiers technique, and when the circuit was first built and operated the output volume and tonal quality were truly worthy of a mains amplifier. The output power is something under a watt, but the effect, using an 8" speaker, was reminiscent of a single-ended Class A mains amplifier with a 4 watt output, whilst the completely silent and hum-free background made listening a delight. It was found that for straightforward reproduction tone controls were by no means necessary and so they were omitted from the final version of the original, nevertheless there is so much gain in hand that they can be added between the first stage and the phase splitter. The tone control circuit is shown in Fig. 16 in order that they may be fitted by the constructor who requires them.

Circuit analysis is conventional. The pickup feeds into a DAF91 diode pentode, the diode section of which is ignored, the pentode giving a voltage gain of approximately 50 when unbiased. A small bias is supplied to the stage from an automatic biasing circuit (another advantage over the Q.P.P. amplifier where it is practically essential to supply the bias from a battery).

The DAF91 was tested both with a high impedance input circuit, capacitance isolated from the pickup and volume control, and the ordinary input circuit shown; no advantage was apparent when the high impedance circuit was used.

The output from the first stage is fed either directly or via a treble and bass tone control into a DF91 which is triode connected and which acts as a "concertina" phase splitter. Once again it was found that a small bias voltage was desirable on the valve, and this is provided for in the filament-to-earth circuit. As readers will know, this type of phase splitter provides no gain—indeed there is a slight loss consequent upon its use—but a signal on the grid appears in the same phase on the cathode (i.e., in this circuit, at the negative end of the filament) with an out-of-phase signal on the anode, these two signals being equal in amplitude if the cathode and anode loads are equal.

By reason of the circuit the cathode of the valve is held well above earth potential—at about 40 volts in the present amplifier—and so the filament cannot be supplied from a common L.T. source. When 2 volt battery valves are in use this is sufficient to condemn the use of a resistance-capacitance phase splitter, but the DF91 can be fed from a single U.2 cell as only 50 mAs. are required.

The signals are fed from the anode and cathode of the valve (or, to be precise, from the negative end of the bias resistor in the cathode circuit) to the grids of the push-pull output valves, a pair of DL92's. These, and the first stage valve, are biased from a resistor through which the H.T. negative side of the battery is connected into the earth line, the current flow through the resistor giving a voltage drop and so providing a biasing voltage. Experiment showed that the bias on the DL92's, when they are used in push-pull, should be rather higher than the normal bias on a single valve (−7 volts) and this accounts for the rather high value of the bias resistance. As a result H.T. current consumption is cut, and with 90 volts on the H.T. supply line, the screens of the output valves being connected to the 67.5 volt battery tap, the H.T. current was at no time over 15 mAs. (The current fluctuates very slightly on heavy passages).

This is still a fairly heavy current, but not greater than that required by many modern battery receivers, and since an amplifier is not used to the same extent as a receiver it is felt that battery life should be very satisfactory.

To maintain both output and quality it is necessary to have a full 1.5 volts on the filament lines. Accordingly the output valves are supplied from a heavy capacity 1.5 volt cell and the first stage has its own L.T. cell as does the phase splitter. Bearing in mind that a new U.2 cell costs less than an accumulator charge, this is no extravagance. The switching must be arranged to cut all the separate L.T. circuits, but this only requires a multi-pole rotary switch in place of a single or double pole switch, whilst then the same switch can isolate the H.T. battery, a wise precaution as an electrolytic capacitor is connected across the supply lines.
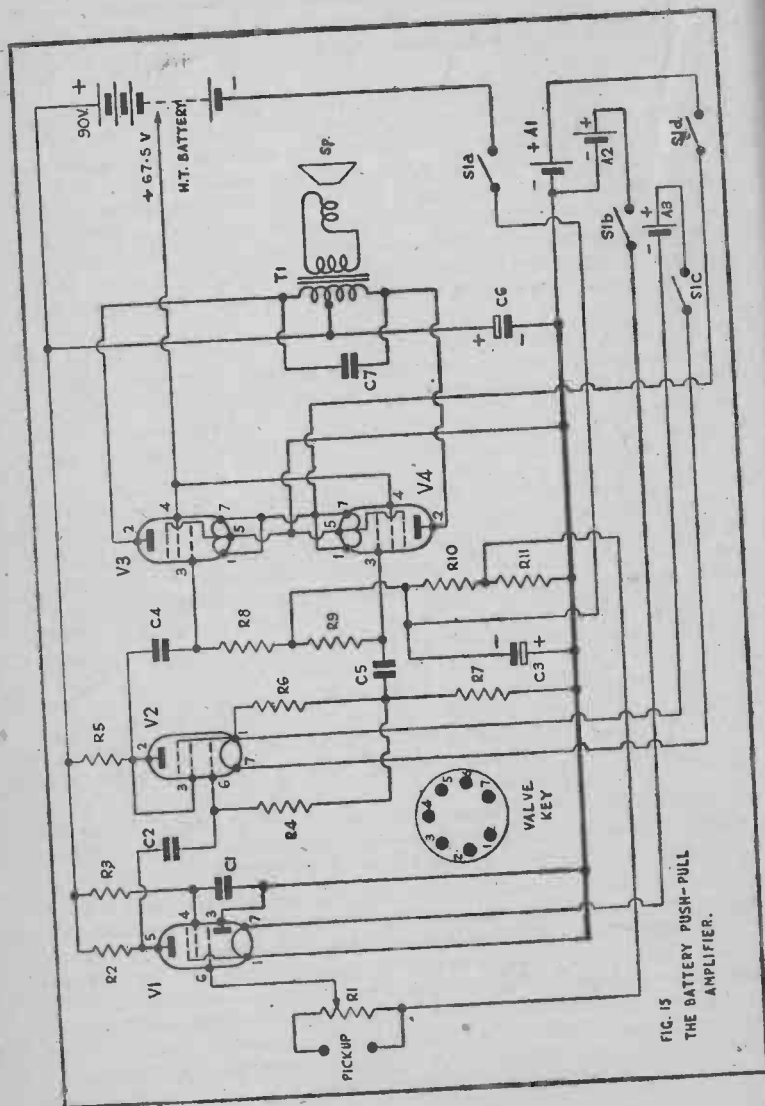
FIG. 15
THE BATTERY PUSH-PULL
AMPLIFIER.

COMPONENTS LIST FOR THE PUSH-PULL BATTERY AMPLIFIER
FIG. 15

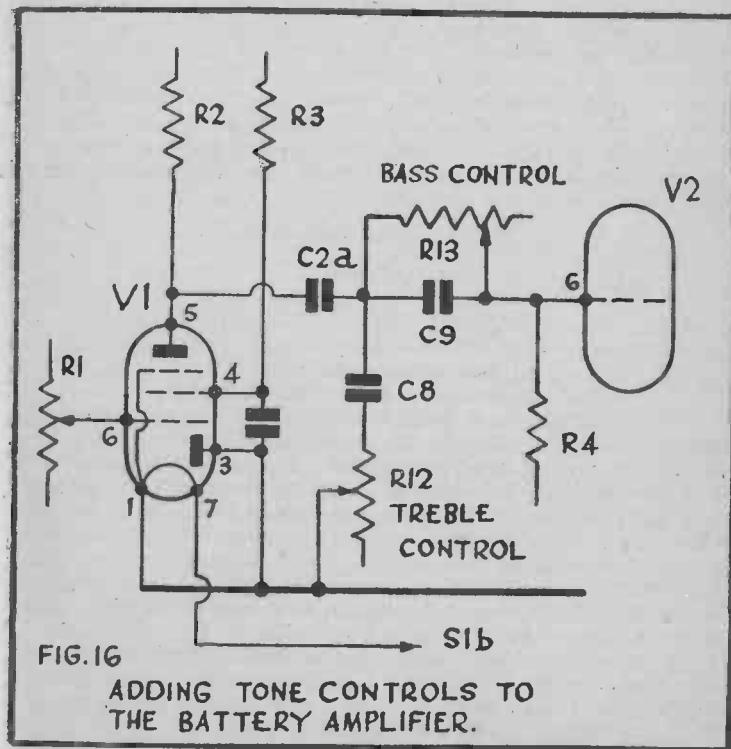| R1,	0.25 Meg. volume control.		Centralab midget.
R2, R4,	1 megohm,	¼ watt.	Erie.
R3,	3.3 megohms,	,,	,,
R5, R7,	100,000 ohms,	,,	,,
R6,	10,000 ohms,	,,	,,
R8, R9,	2.2 megohms,	,,	,,
R10, R11,	510 ohms,	,,	,,
C1,	0.1 mfd. 200 v.w.	T.C.C.	Type 246.
C2, C4, C5,	0.01 mfd. 350 v.w.	T.C.C.	Type 346.
C3,	25 mfds, 25 v.w.	T.C.C.	Type CE32C.
C6,	8 mfds. 150 v.w.	T.C.C.	Type CE18F.
C7,	0.001 mfd. Mica.	T.C.C.	Type CM20N.
V1,	Mullard DAF91.		

FIG. 16
ADDING TONE CONTROLS TO
THE BATTERY AMPLIFIER.

V2,   Mullard DF91.
V3, V4,   Mullard DL92.
4 B7G chassis mounting valveholders.
S1-ab,c,d,   4 pole single throw on-off switch.   Walter Instruments
                         Type "BT."
Sp.   Loudspeaker. *See text.*
T1,   Output transformer. To match speaker to 8,000 ohms
                         anode—anode load. *See text.*
A1,   High capacity 1.5 volt cell.   Vidor L.5049.
A2, A3,   1.5 volt cells, U.2 or similar types.
H.T. Battery. 90 volts.
2 control knobs, Eddystone No. 1044.
Chassis.   As original, 4" long, 2½" wide, 1½" high (*see Fig. 17*)
                         or as required.
Pickup.   S.H.E.F.I. Moving coil, with transformer, or as
                         required.
Wire, sleeving, nuts, bolts, screws, etc. Battery plugs.
Spring brass contactors for U.2 cells.
  If it is required to add the double tone control shown in Fig. 16, only
one component change is needed, whilst four further components are
required. The component change is an increase in the value of C2 which is
shown in Fig. 16 as C2a. The value must be raised from 0.01 mfd. to 0.1
mfd., using a T.C.C. Type 346 capacitor, 350 v.w. The extra components
are as follows:—

Tone Control Components
Fig. 16

C8,   0.02 mfd.   T.C.C. Type 543.
C9,   0.0005 mfd. mica.   T.C.C. Type CM20N.
R12,   100,000 ohms (Treble control), Centralab Midget.
R13,   0.5 meg. (Bass control),   "   "

The Loudspeaker and Output Transformer

  The loudspeaker must be chosen to suit the manner in which the
amplifier is built. If, as in the case of the original model, it is to be
incorporated into a portable gramophone case, then the loudspeaker must
be mounted in the lid of the case and the speaker size is finally dependent on
the lid depth available. Probably a depth of not more than 2½" will be found
in the majority of portable gramophone case lids, and so a 5" speaker will be
the largest which can be used.
  Whether the speaker can be mounted centrally in the lid or not will be
decided by the turntable arrangements; in same cases a centrally mounted
speaker will not permit the lid to be fully closed.
  At this point mention must be made of the Truvex "Wafer" range of
loudspeakers; if a 6½" "Wafer" is obtained this will mount centrally within
practically any case lid since it has an overall depth of no more than 1
17/32", and requires a baffle opening of 5¾" diameter.

  Whatever speaker is used the lid must have a suitable aperture cut out,
and the speaker mounted behind the opening. Between the lid and the
speaker must be mounted a circle or square of metal gauze to act as a
protective covering to the speaker diaphragm; cloth is not sufficiently strong
since the speaker aperture will be in a position where blows and knocks on
the case are most likely. Copper gauze is suitable and a good grade has
recently been obtainable in the household stores.
  The output transformer should be ordered with the speaker from the
manufacturers. If a 5" speaker is used, an ELAC is highly recommended;
this speaker is made by Messrs. Electro-Acoustic Industries, Ltd., Stamford
Works, Broad Lane, London, N.15.
  The transformer must have a centrally tapped primary, and match the
speaker voice coil into an 8,000 ohms anode to anode load. If the con-
structor has a small multi-ratio transformer to hand this may be used and it
may be said that there is room for experiment in the speaker matching.
The stated load, 8,000 ohms, was supplied to the valves in the original model
and gave excellent results, nevertheless a higher or lower loading might be
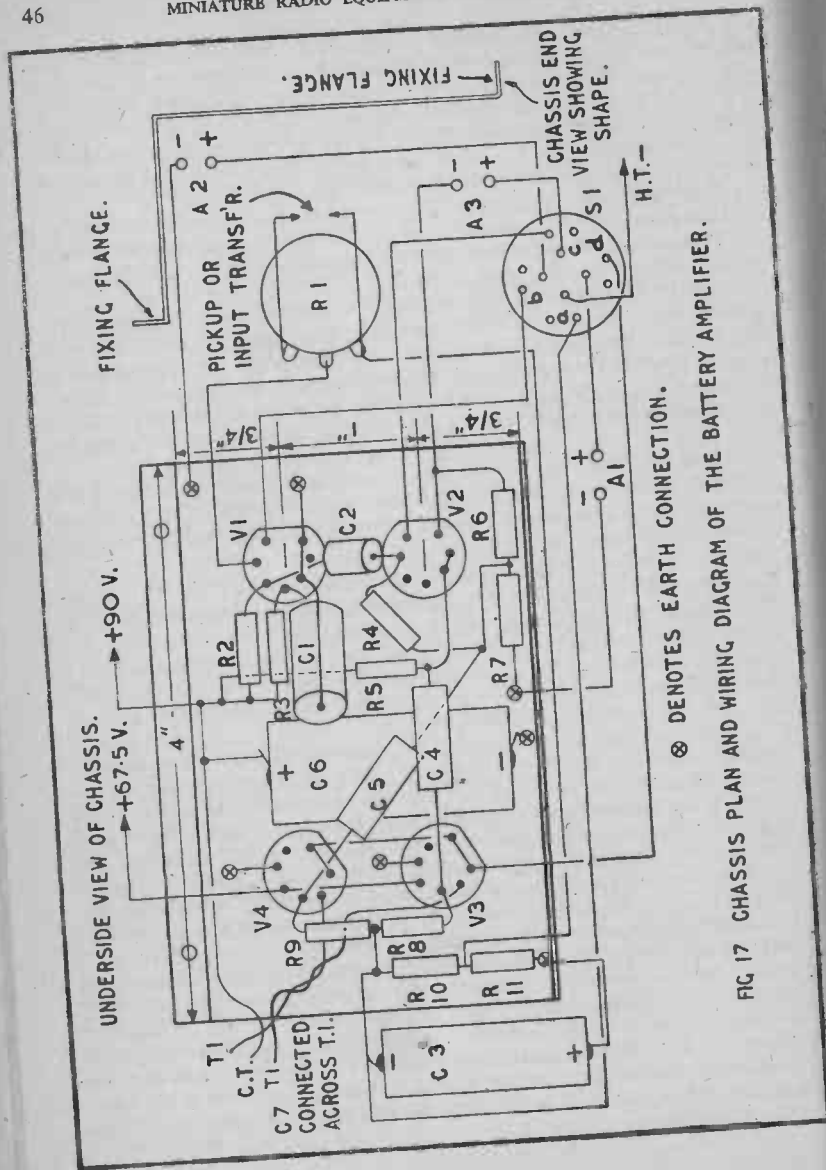tried.
  If the amplifier is to be used as a cabinet built fixture in the home the
output certainly warrants a larger loudspeaker than the 5" or 6½" types
mentioned as suitable for portable use. A good 8" speaker may be connected
in, such as the Rola Type 8 -Z.

Battery and Amplifier Mounting

  Within the main body of the gramophone case room must be found for
the amplifier, the input and output transformers (if the S.H.E.F.I. or a
similar pickup requiring an input transformer is used) and the batteries.
The only difficulty which may be encountered is with the H.T. battery which
may prove rather large for the space available. The transformer and L.T.
cells, like the amplifier, are easily fitted in.
  To prepare the gramophone case the motor board must first be removed
and the space around the motor noted. The tone arm can then be un-
screwed from the motor board and the "horn" or labyrinth which will be
found in the body of the case should then be stripped away. With luck
there will then be room at the rear of the case for the H.T. battery. The
arrangement of the parts in a typical gramophone case is shown in Fig. 18.
  The amplifier chassis proper is mounted on the wall of the case so that
the valves are in the upright position when the case is shut and standing on
the bottom wall; with the gramophone in use the valves are horizontal.
The position of the valves is much less important with battery types than with
mains types and tests have shown that the rather unusual valve mountings
described throughout this Manual—upside-down, as in the "Tracette"
and horizontally as in the "Genette" and the present amplifier—have no ill
effects. It must be remembered however that the same is not true of mains
valves which should be mounted vertically, with the base down, whenever
possible and, if mounted horizontally, should have the major axis of the
control grid vertical.

FIG 17 CHASSIS PLAN AND WIRING DIAGRAM OF THE BATTERY AMPLIFIER.

⊗ DENOTES EARTH CONNECTION.

UNDERSIDE VIEW OF CHASSIS.

This latter type of mounting is used in the amplifier, and attention must be paid to the disposition of the valveholders.

The two controls—or four controls, if the tone controls are added—are placed on the motor board. If the motor board is of metal or of thin wood it will only be necessary to drill holes to take the controls, but if thick wood is used then a section must be cut out and the controls mounted on a metal plate. This type of mounting is very effective if the plate is secured below the mounting board so that the knobs are recessed.

The H.T. battery is clamped into place with a strip of metal running round it from end to end and screwed to the case wall, the large 1.5 volt cell being similarly secured. The U.2 cells are mounted in clamps cut from sheet brass which both hold the cell firmly and provide good contact.

No shielding of any sort was found necessary with the original amplifier. Screened leads from the pickup to the input transformer were used, and this transformer was arranged to feed directly into the first stage with the volume control leads short and direct and screened.

The output and input transformers should be well separated, of course,

FIG. 18. ARRANGING THE BATTERY AMPLIFIER IN THE GRAMOPHONE CASE.
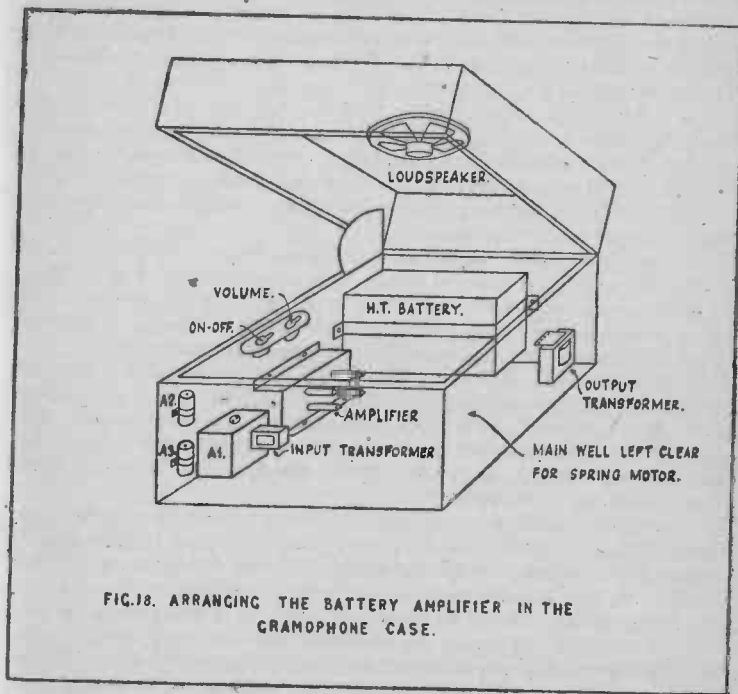
and have their cores at right angles to minimise the chance of stray field induction.

PICKUP MOUNTING

The pickup mounting and positioning will once again be governed by the dimensions of the gramophone case and motor board, and it is essential that the pickup be fastened into place to agree with the mounting chart provided with it. This point is of extreme importance, both as regards tone and record wear. If the pickup needle does not track properly over the record, wear will be increased seriously whilst at the same time the pickup cannot give its best results.

A Universal Mains Miniature Amplifier

The second miniature amplifier has been designed especially for the flat and apartment dweller who requires an electrical reproducer which will take up the minimum of space and give good output in a normal room without disturbing neighbours. The circuit shown in Fig. 19 develops an output power of approximately 4 watts and the output stage is given a small percentage of negative feedback, using a very simple circuit, to ensure satisfactory tone without the use of tone controls. The amplifier is thus quite straightforward and can be used either for gramophone or radio work, if a simple tuner is coupled into the input circuit.

As with the miniature battery amplifier, this circuit is intended for mounting within a small space, though some attention must be given to ventilation when using the mains amplifier. It could be mounted inside the body of a table gramophone or a playing desk could be built up with a turntable on the top, covered by a lid, the motor, amplifier and loudspeaker being mounted within the cabinet.

Where the motor and pickup are mounted in the same cabinet as a loud-speaker the whole motor board should be insulated for vibration. This is a simple matter and merely requires that the board be clamped down by long screws which have rubber stops both between their heads and the motor board and between the board and its supporting battens or ledges.

The valves used are small in size—the UAF42 has a maximum overall height of 55 mm. or something below 2¼″ and the UL41 a maximum height of 77 mm. or below 3″, both types having a maximum base diameter of 22 mm. (7/8″)—and economical in heater power since the heater current is 0.1 amp. Heater voltages vary, the UAF42 requiring 12.6 volts, the UL41 45 volts and the UY41 rectifier 31 volts.

The circuit, although conventional in having only two stages, has quite high gain since the UAF42 gives an amplification of almost 80 times and the output valve is sensitive, requiring an input of only 6 volts or so. It may therefore be said that for full output the input required is no more than approximately 0.1 volt and so practically any type of pickup may be used with the amplifier. A crystal pickup should have the input circuit recommended by the pickup manufacturer both to give the correct tone and input loading and also to reduce the input to the amplifier by some degree; a
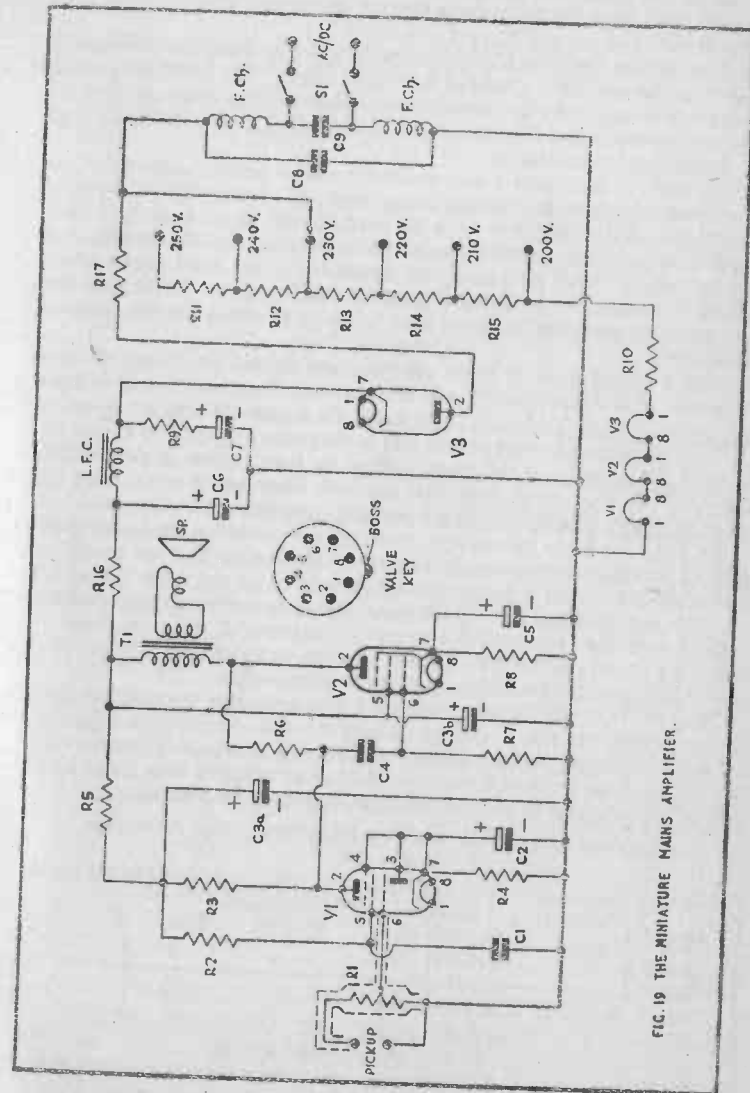
FIG. 19 THE MINIATURE MAINS AMPLIFIER.

crystal pickup connected straight into this circuit might well overload the amplifier and make R1, the volume control, useful over only the lower part of its travel.

The negative feedback is provided by R6 which is connected between the anode and the grid input circuit of the output stage. The feedback is therefore operative only over the second stage, but as the first stage can give the required voltage gain with a distortion of less than 2% total, feedback over the first stage is unnecessary.

In Fig. 19 the heater chain is shown with a comprehensive voltage adjustment, the dropping resistor being made up of a number of separate resistances. If the amplifier is to be used on one location, and so on a mains voltage which may be taken as fairly constant, the adjustments and tapping points can, of course, be omitted and the total heater chain resistance brought to the correct figure for that location. If the amplifier is to be made portable, however, then it is wise to retain the full range of adjustment.

The resistors used to make up the chain should be chosen to have tolerances of no more than 5% and if a selection of resisters can be bridged and correct values chosen, then so much the better. Universal valves of all types are generally very robust and a discrepancy of plus or minus 5% between the actual and the rated voltage on their heaters is permissible, but valve life and circuit operation are both improved if some pains are taken to ensure that the valves are properly supplied.

A final check can be made by metering the current in the heater chain with an accurate thermo-couple ammeter. Remember that the current is high when the voltage is first supplied, falling to its correct value in a matter of a few seconds, and so it is necessary either to use an ammeter with a higher range than the correct current (for example, a 0.5 amp. meter to measure a heater current of 0.1 amp.) or, better, to short-circuit the ammeter until the current has settled down to the working value.

On the H.T. side of the power pack two protective resistors are used, R9 preventing too heavy a surge current through the reservoir capacitor, C7, and R17 acting as a protective resistor in the input side of the rectifier. Mains noise and interference are blocked by a double filter choke and a pair of mica capacitors immediately following the on-off switch.
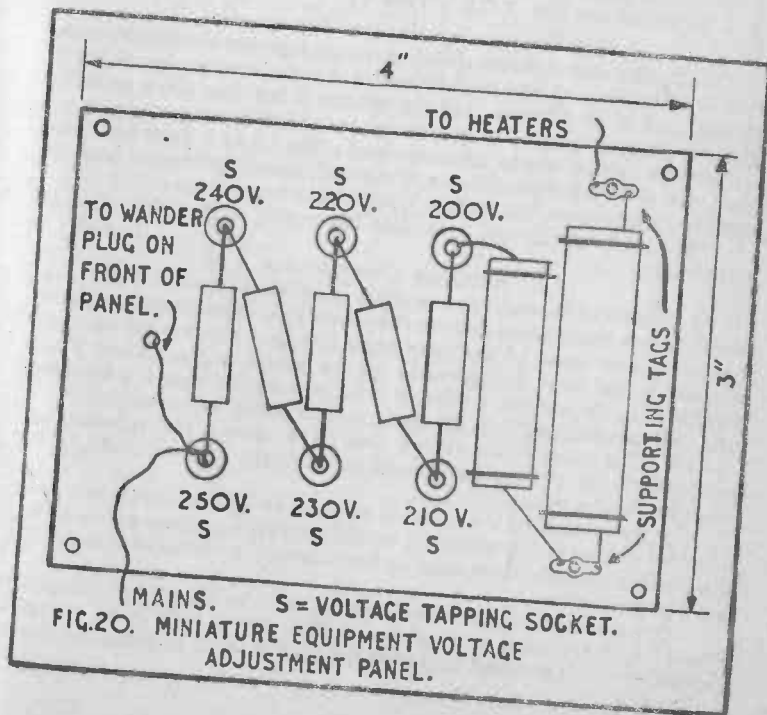
COMPONENTS LIST FOR THE UNIVERSAL MINIATURE AMPLIFIER
FIG. 19

R1,	0.25 meg. volume control, or as specified for pickup used.		Centralab.
	750,000 ohms,	½ watt.	Erie.
R2, R6,	220,000 ohms,	,, ,,	,,
R2, R3,	2,700 ohms,	,, ,,	,,
R4,	33,000 ohms,	,, ,,	,,
R5,	470,000 ohms,	,, ,,	,,
R7,	150 ohms,	1 ,,	,,
R8,	47 ohms,	1 ,,	,,
R9,			

R10,	1,110 ohms. Use two resistors in series, Erie standard values of 680 and 430 ohms, rated at 7 watts and 5 watts respectively.	
R11, R12, R13, R14, R15, R16,	} 100 ohms, 1 watts.	Erie.
R17,	1,000 ohms, 5 watt,	Erie.
C1,	100 ohms, 2 watts.	Erie.
C2, C5,	0.1 mfd. 350 v.w.	T.C.C. Type 346.
C3a, b,	50 mfds. 12 v.w.	T.C.C. Type CE32B.
C4,	8 plus 8 mfds 350 v.w.	Hunts Type J47.
C6, C7,	0.01 mfd. 750 v.w.	T.C.C. Type 645.
	16 plus 8 mfds. 450 v.w. C6 = 16 mfds.	
C8, C9,	0.001 mfd. Mica, 750 v.w.	T.C.C. Type CE28P.
V1,	Mullard UAF42.	T.C.C. Type M3U.
V2,	Mullard UL41.	

FIG.20. MINIATURE EQUIPMENT VOLTAGE ADJUSTMENT PANEL.

S = VOLTAGE TAPPING SOCKET.

V3,   Mullard UY41.
3 B8A chassis mounting valveholders. Belling-Lee L620.
Sp. with **T1.**   Loudspeaker with output transformer to match to
                              3,000 ohms anode load. *See text.*
L.F.C.,   22 Henries 120 mAs. Partridge, C22/120/VDL.
F.Ch.,   Mains Filter Choke, Weymouth, MSC3.
S1,   Two pole on-off switch, ganged with **R1.**
Chassis, cut and bend from sheet aluminium to size 6″ long, 2″ wide
    and 2″ high. Or as desired.
Voltage adjusting board, paxolin sheet, 4″ × 3″. (*See Fig.* 20).
6 Sockets for voltage adjusting panel. Belling-Lee, L315, with 1 plug,
    L1021/3.
Brass strip for capacitor clips.
Pickup, S.H.E.F.I. with transformer, or as required.
Screened cable for grid lead to V1. Rubber grommets.
Wire, sleeving, solder, soldering tags, nuts, bolts, screws.
1 control knob, Eddystone 1044.
1 Capacitor can clip, T.C.C. Type V3.

LOUDSPEAKER AND OUTPUT TRANSFORMER

The constructor probably already has a loudspeaker he will wish to use
with the amplifier; all that need be said is that the speaker should not be
smaller than 8″ in diameter, and the volume is sufficient for a good 10″
speaker. Unless a multi-ratio transformer is to hand a new component will
probably be needed here as the anode load of the UL41 is quite low, 3,000
ohms. A new output transformer, if required, should be ordered from the
speaker manufacturer, the speaker type number being quoted.

The transformer should be capable of carrying 60 m/A D.C. through
the primary.

AMPLIFIER CONSTRUCTION

A diagram of the main chassis of the amplifier is shown in Fig. 21, and
it will be seen immediately that the chassis does not carry all the component
parts, but only those of the main valve circuits. The smoothing choke
specified is too large for mounting on the chassis and so this is placed
separately in the cabinet, a pair of leads running through a grommetted
hole in the chassis wall from the choke to their anchoring points on C6, C7.

C6, C7 is mounted on the top deck of the chassis the capacitor lugs
protruding in the ordinary way through an octal hole. A can clip secures the
capacitor to the chassis.

C3, the other large capacitor, is mounted by a brass clip to one inner
side wall of the chassis, whilst the cathode bypass capacitors are mounted,
also by clips cut from brass strip, to the underside of the chassis top deck in
the positions shown.

R1, the volume control/on-off switch, should be mounted on the motor
board (or on the front panel of the amplifier if it is built into a separate
cabinet) with the screened lead from the control to V1 as short and direct
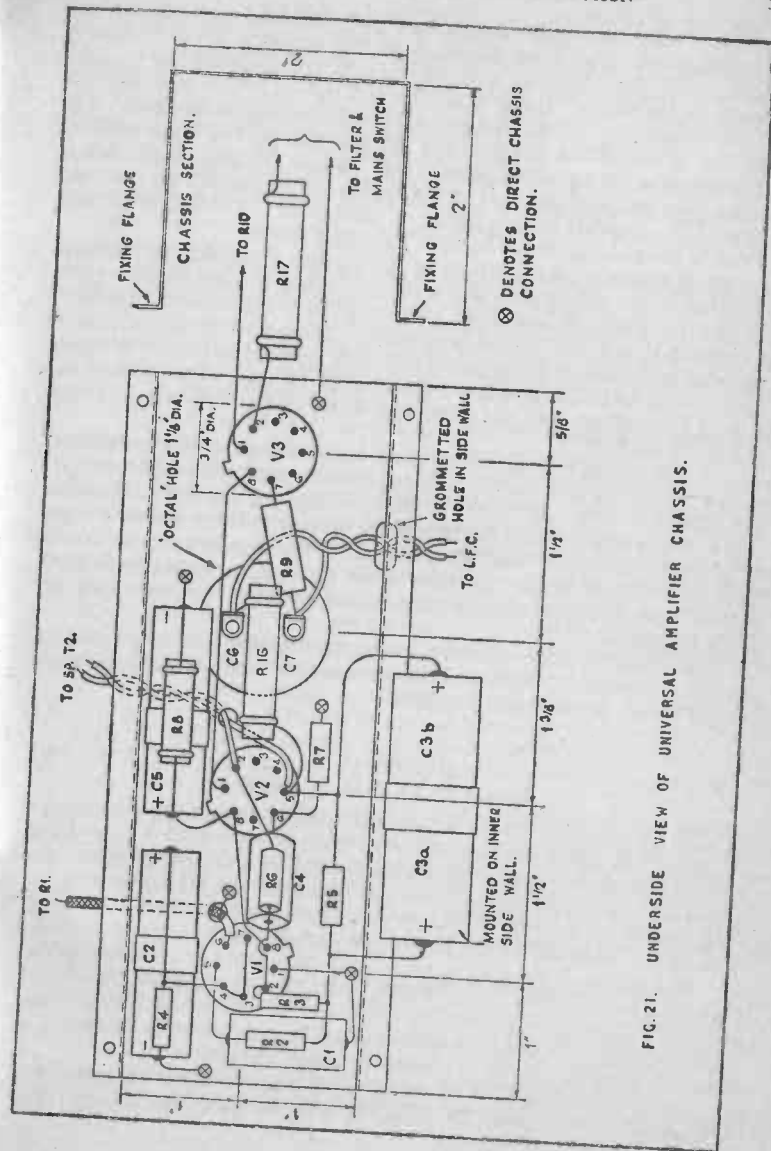as possible.

FIG. 21. UNDERSIDE VIEW OF UNIVERSAL AMPLIFIER CHASSIS.

The mains filter choke is also separately mounted, as is the voltage adjusting panel. This panel should be secured behind a $2\frac{1}{2}'' \times 3''$ cut-out in the rear of the cabinet or gramophone desk and positioned so that the sockets are accessible. The plug, at the end of a short flexible lead, can then be inserted into the correct socket and the heater voltage so adjusted. The rear view of the panel is shown in Fig. 20; note that the two heavy resistors are mounted at the top of the panel so that the heat dissipated from these is carried clear and does not heat up the smaller resistors which are mounted below. The specified sockets require $\frac{3}{8}''$ drill holes. A drill hole at each corner of the panel provides for four mounting screws.

To give ventilation the cabinet or playing desk containing the amplifier should be raised sufficiently high, on battens or feet, to allow for air to flow beneath the bottom of the cabinet, in which a few $\frac{1}{2}''$ holes should be drilled. A height of $\frac{1}{2}''$ or $\frac{3}{4}''$, for the feet, is sufficient. The rear of the cabinet should then also be drilled, or be made of a fretted or pierced sheet of ply or heavy card, as with the rear of a receiver, when air will be able to flow through the base of the cabinet, past the valves and dropping resistors, and out at the rear of the cabinet.

At least two of the ventilation holes should fall below the chassis itself, to give an air flow past the resistors and capacitors of the amplifier proper.

The B8A valves are located in their holders by a side boss which falls into a groove in the side of the holder, the valve then being locked in place by a circular wire clip. The holders require $\frac{3}{4}''$ diameter holes in the chassis through which the holder pins pass, whilst the securing bolts should have 6 B.A. holes drilled on diametrically opposite sides of this main hole, on fixing centres of $1.126''$.

As with B7G holders the B8A holder has a central tube which may be used as an anchoring point for earth connections—for clarity these tubes are not shown in the chassis diagrams.

CHAPTER 6

A MINIATURE F.M. TUNER

WITH the advent of regular F.M. broadcast transmissions in this country which will follow the completion of the new F.M. station now under construction, many experimenters and home builders are preparing for new signals by building special receivers and whilst, at the time of writing, no F.M. receiver has been announced by the manufacturers, doubtless a receiver or at least a tuner will shortly be put in an appearance on the market.

With prices at the present level, however, such a receiver cannot be cheap and a special F.M. receiver built by the home constructor can be quite a large undertaking unless specially simple circuits are utilised, such as those included, with more comprehensive circuits, in the Frequency Modulation Receivers Manual, No. 68 in Messrs. Bernards List, Price 2/6.

For these reasons F.M. converters—or, properly, F.M. tuning units— will probably be popular for some considerable time, and a simple but

efficient tuner, designed for use within the service area of the new F.M. station and subsequent stations, is shown in Fig. 22.

A comprehensive F.M. receiver consists, usually, of a preselecting stage, frequency mixer and oscillator, a high gain I.F. amplifier ending in a limiter, then the discriminator (the F.M. detector or demodulator) feeding into what should be a really first-class audio amplifier and output stage. The circuit of Fig. 22 does not contain all these stages.

V1 is the mixer or frequency changer. The first tuned circuit, into which the aerial is tapped, tunes the input of this stage to the signal frequency and whilst no final figure has yet been given the new F.M. station will almost certainly work at 90 Mcs. or so.

V2, the oscillator, injects a local signal into the L1C1 circuit inductively. The I.F. of the tuner is chosen to be 7.5 Mcs. so that the oscillator frequency must be separated by this amount from the signal frequency. The oscillator, therefore, can work at either 82.5 or 97.5 Mcs., assuming 90 Mcs. as the signal frequency. The usual working frequency of the oscillator is chosen to be the lower frequency, 82.5 Mcs.

The I.F. of 7.5 Mcs. appears in the anode circuit of V1 where a broad tuned circuit, R2, L2 and C3, acts as an impedance to the signal and so passes it, via C4, to the single I.F. amplifier, V3. In the anode circuit of V3 a primary tuned circuit couples the amplified signal into a secondary tuned circuit and this in turn is connected to a ratio detector.

It is very desirable that an F.M. receiver should be insensitive to changes in signal amplitude, whilst the tuned circuits must pass changes in signal frequency with as little attenuation over the broad signal as possible. It is for this reason that the conventional F.M. receiver has a high gain I.F. amplifier followed by a limiter—the limiter "cuts off" the signal peaks and so changes in amplitude of the modulated carrier or modulated I.F. signal do not pass to the discriminator which therefore responds only to frequency changes. Such an I.F. and limiter circuit might easily require 5 valves, however, and in a miniature tuner some simplification is very desirable. This is made possible by using a ratio detector; V4 with its associated components acts in this capacity.

The centre tapped secondary of the I.F. or discriminating transformer L4, L5, is so connected that a varying frequency signal in the primary will present varying I.F. voltages to the two diode sections of the double diode. Any signal on the diodes causes a current through R11 across which a corresponding voltage is set up, this voltage being smoothed by C16. A D.C. potential thus charges C14 and C15 to equal potentials, and the diodes are made non-conducting.

Now, when the I.F. signal changes in frequency the circuit conducts (as it will, also, for a constant frequency I.F.) and at any instant one diode has a greater potential across it than the other. The potentials across C14 and C15 are then forced to vary in the same ratio as the ratio between the I.F. voltages on the diodes; hence the name of ratio detector given to the circuits. The voltage set up across R11 varies with the signal. A strong signal

will set up a high voltage, a weak signal a low voltage, and so it is possible to tap A.V.C. from the detector circuit. In Fig. 22 A.V.C. is applied to the I.F. amplifier as this has the effect of broadening the response.

It will be seen that the ratio detector responds very poorly to changes in signal amplitude. The voltage across R11 and thus the potentials across the two capacitors will change for any change in signal amplitude, but the audio output depends entirely on the ratio of the potentials across C14 and C15. As a result amplitude modulation of the signal produces (theoretically) no audio signal in the output circuit, whether the amplitude modulation be caused by fluctuations in the F.M. signal, interference, fading or other causes. Impulsive interference, such as ignition noise, is also rejected by the circuit very strongly ; recent correspondence in the technical press shows that although it would seem that serious interference might charge up the smoothing capacitor C16 until the signal was cut-off or badly distorted, in actual fact there is a leakage effect which prevents this happening, and the ratio detector can work well under interference right up to the point where the interference is strong enough to ruin the signal in any case.

Practical tests on the ratio detector certainly bear out this fact.

R9 and C17, in the output circuit, have a double function. Not only do they act as an I.F. filter but they also make up a resistance capacitance combination with a time constant of about 50 micro-seconds, and acts as a treble attenuator.

This is necessary for the reason that the audio modulation of an F.M. carrier is given "emphasis", that is, the treble is accentuated. Reception of the higher frequencies, by F.M., causes an apparent increase in noise, heard as a hiss. By emphasising the treble at the transmitter it is possible to cut treble at the receiver—"de-emphasis"—and so cut the hiss, although the treble is still received, after de-emphasis, in the correct proportion.

The required degree of de-emphasis is stated in terms of the time constant of the correct resistor-capacitor combination where

$$T = RC.$$

T being the time constant in seconds, R the resistance in megohms and C the capacitance in microfarads.

R10 acts as an output volume control, and the audio signal is taken by a screened lead to the pickup terminals of a radio set or, preferably, to the input of a good amplifier capable of dealing with a wide frequency range.

The circuit has been miniaturised in order that it may be used conveniently with an ordinary receiver or amplifier into which it will feed the audio signal and from which it takes its power requirements. The drain has been kept as low as possible; the tuner needs 0.9 amp. at 6.3 volts for the heater supplies, and approximately 15 mAs. at 250 volts H.T. The receiver is set to the signal and then requires no further adjustment, consequently it can be placed behind or actually within the receiver or amplifier with which it is used.

If the volume control on the tuner is not required, volume adjustments being made on the main amplifier, it can of course be replaced by a fixed
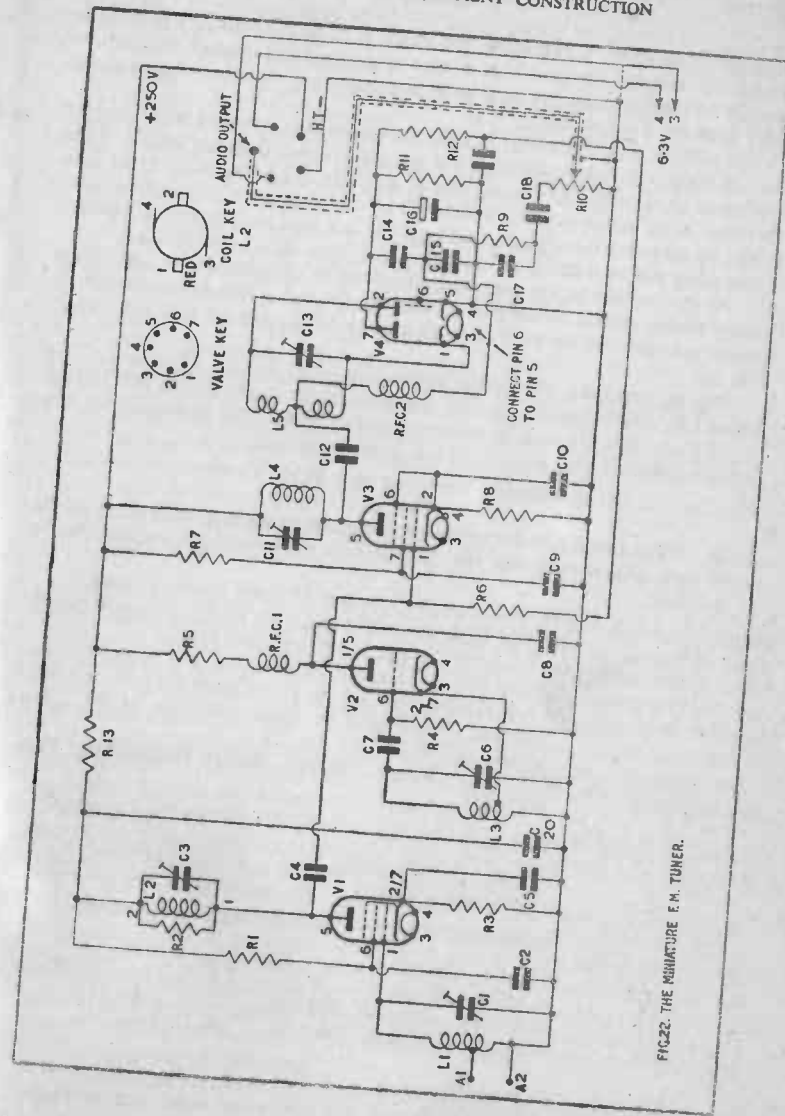
FIG.22. THE MINIATURE F.M. TUNER.

1 megohm resistor. If, however, the signal is to be fed into an amplifier in which the volume control is at a later stage then the control on the unit should be retained and set to a fixed position which gives adequate signal feed with no overloading.

It will be seen from Fig. 22 that the power supplies and audio output are all taken, via leads, through a 5 pin plug which contacts with a 5 pin socket to be mounted on the receiver or amplifier with which the tuner is to be used. The audio output lead should be run separately, however, so that it can be screened throughout its length; if this lead is included in a 5 core cable there will be a chance of hum pick-up from the heater wiring.

As in the case of the converter described in Chapter 4 one side of the heater wiring should be earthed to the chassis, and a dotted connection is shown between the heater lead to points 3 and the chassis H.T.-ve. line in Fig. 22.

Again, however, the actual connection will depend entirely on the method in which the main set or amplifier is wired, and it may well be that the H.T.-ve. line can also be common to one side of the heater supply, the heaters already being earthed in the main apparatus.

COMPONENTS LIST FOR THE F.M. TUNER
FIG. 22

Coils. (The tuned circuits have been designed to cover a wide band round 90 mcs. and should suit the final B.B.C. F.M. frequency when this is decided.

L1,	4 turns 16. S.W.G. enam. $\frac{3}{4}$″ diam, spaced $\frac{3}{4}$″ long.
L2,	Wearite PA5, main winding only used. (Upright tags).
L3,	As L1. Cathode tap, 1 turn up from earth.
L4,	35 turns 30 S.W.G. enam. closewound on $\frac{3}{8}$″ diam. former.
L5,	As L4, spaced from L4 by $\frac{1}{2}$″ on same former. Centre-tapped, and wound in same direction as L4. For details of L4, L5, *see* Fig. 23.

C1, C3, C6, C11, C13,	3—30 pfs. trimmer.	Messrs. Walter Instruments, Type M.S. 30.
C2, C4, C5, C17, C19,	0.001 mfd. Mica.	T.C.C. Type CM20N.
C7,	100 pf. Ceramic.	T.C.C. Type SCH1.
C8,	0.0005 mfd. Mica.	T.C.C. Type CM20N.
C9, C10, C14, C15,	0.005 mfd. Tubular, 500 v.w.	T.C.C. Type 543.
C12,	50 pfs. Ceramic.	T.C.C. Type SCD6.
C16,	8 mfds. 150 v.w.	T.C.C. Type CE18F.
C18,	0.05 mfd. Tubular, 500 v.w.	T.C.C. Type 543.
C20,	0.1 mfd. Tubular, 500 v.w.	T.C.C. Type 543.

R1,	1 megohm,	$\frac{1}{2}$ watt.	Erie.
R2,	68,000 ohms,	,,	,,
R3, R4,	10,000 ohms,	,,	,,
R5, R9,	47,000 ohms,	,,	,,

R6,	100,000 ohms.		
R7, R11,	33,000 ohms,	$\frac{1}{2}$ watt.	Erie.
R8,	180 ohms,	,,	,,
R10,	1 meg. volume control.	Centralab midget.	
R12,	220,000 ohms,	$\frac{1}{2}$ watt.	Erie.
R13,	22,000 ohms,		
R.F.C.1,	V.H.F. choke, Eddystone No. 1011, or 30 turns 30 S.W.G. enam. on $\frac{1}{4}$″ former, close-wound.		
R.F.C.2,	1.25 mH. Eddystone, No. 1010.		
V1,	9001 (American).		
V2,	9002 ,, or Mullard EAC91.		
V3,	Mullard EF91.		
V4,	Mullard EB91.		

4 B7G chassis mounting valveholders.
2 aerial input sockets, Belling-Lee L315 with two plugs, L1021/3.
1 Power plug, Belling-Lee L1258, with socket L331.
3 or 4 core power cable, screened output lead. Length as required.
Chassis. Cut and bend from sheet aluminium to size 7″ × 4″ × 2½″ or as desired. Screening panel 4″ × 2½″ with $\frac{1}{4}$″ fixing lugs. (under chassis screening partition).
1 control knob, Eddystone 1044.
Nuts, bolts, grommets, sleeving, etc.

COILS

The transformer L4, L5, is shown in Fig. 23. Each winding is put on in the same direction, and the coil ends should be anchored to lugs made by twisting heavy wire through a pair of drill holes at the correct points in the former, which may be of paxolin tube. The anchoring lugs must be strong enough to take the trimmer capacitors C11 and C13 which are directly connected across the coils. The centre tap of L5 may also be brought out to a wire lug (this will cause a gap in the centre of the coil; this gap must be kept as small as possible) to serve as a main centre tap connecting point and a support for one end of both C12 and R.F.C.2.

It can be seen in Fig. 24 that R2 and C3 are both mounted directly across the main (upright) tags of L2. The small secondary winding of the PA5 coil is not used, and the side lugs may be cut off.

The tuning trimmers C1 and C6 are mounted directly across their respective coils, the positions being shown by dotted outlines in Fig. 24.

The method of mounting the coils is also seen in this diagram. L1 and L3 are mounted directly to their respective valveholder lugs and the chassis, soldering tags being bolted down to take the ends of the coils, whilst L2, L4 and L5 are mounted on the chassis walls, equidistant from the chassis top and the bottom of the wall (i.e., the drill holes for these coils come 1¼″ up the chassis walls).

The cathode tap from L3 to V2 is taken directly by an inch or so of wire, whilst the grid capacitor of V2, C7, must be mounted directly between the

end of the coil and the grid pin on the valveholder so that this end of L3 is held rigidly.

The 1″ spacing between the coils must be maintained.

THE AERIAL AND AERIAL COUPLING

The aerial is tapped onto L1, one feeder going to earth and one to a tapping on the coil. This tapping must be determined experimentally to give best results with the aerial used.

A dipole or folded dipole aerial is recommended, and the outline of both systems is shown in Fig. 26a and b. At the time of writing it has not been stated whether the F.M. transmitter will have a vertically or horizontally polarised aerial but it is presumed that to obtain coverage the transmitter antenna system will be vertical. If this is so, then the receiving aerial must be vertical as well.

The aerials shown in Fig. 26 are shown horizontally, but they may be mounted vertically with no changes in characteristics.

The length shown—a total aerial length of 5 ft.—will be suitable for a band of frequencies round about 90 Mcs. but the length of the aerial may need some adjustment if the frequency differs from 90 Mcs. by an appreciable amount. The correct aerial length may be taken as

$$L = \frac{5610}{F}$$

where L is the overall dipole length in inches, and F is the station frequency in Mcs., assuming that the aerial is made of fairly thick wire but not tubing.

If a rod or tubing aerial is used—and this is preferable as the greater diameter of the aerial gives it a wide-band effect—and the tubing diameter is ½″, then the correct aerial length may be taken as

$$L = \frac{5492}{F}$$

the units being inches and Mcs. as before.

At the centre of the aerial a small gap allows for the connection of the feeder. If a simple dipole is used the feeder characteristic impedance must be 70—80 ohms, and Belling-Lee cable L600 is very suitable. The outer or screening conductor is the earthed line.

A folded dipole aerial can be made using 300 ohms double feeder which is reaching the market in increasing quantities. Cut a length of 300 ohms double line to the aerial length required, adding an inch at either end. Bare the ends of the wires for this inch, and at each end twist the two wires together and solder them. Cut the lower line dead centrally, and solder in a further length of 300 ohms feeder to act as the feeder proper, as shown in Fig. 26b.

In either case make the feeder as direct as possible from the aerial, so that line losses are cut to the minimum, although at the same time if the aerial is vertical the feeder should run away at right angles from its centre for about 1½ or 2 yards before bending and running down to the set.

The tap to L1 must be positioned to match the aerial/feeder impedance into the first stage. Start at one turn up the coil, and vary the position for best results, finally soldering the tap into place at the correct spot.
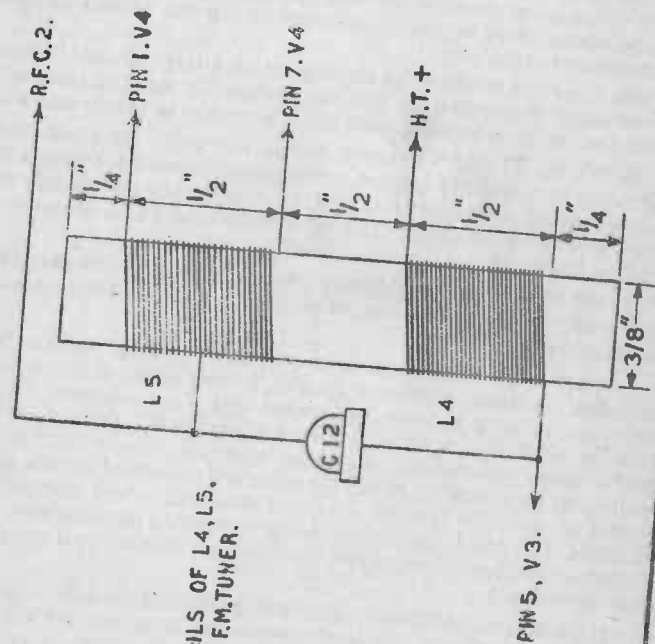
FIG. 23. DETAILS OF L4, L5. THE F.M. TUNER.

CONSTRUCTION

Little need be said concerning the construction of the F.M. tuner, the main details being shown in Fig. 24. Once again, as with all high frequency gear, the bypass and earth leads must be direct and short, and each bolted-down component can have a soldering tag under one of the bolt heads to provide plenty of earthing points.

The screen below the chassis divides the mixer from the I.F. amplifier components, and no trouble with feedback was encountered.

The leads through the screen are taken via grommetted holes. The heater wiring is not shown in the diagram to avoid confusion; in the usual way the heater wiring should be connected in first and pressed up against the chassis out of the way.

The tuner can of course be constructed on a larger chassis if desired, and the circuit is also suitable, with few changes, for use with other valves, should the experimenter have types which he wishes to test in such a unit.

EF50's for V1 and V3 should operate very well; R1 could then be 5,000 ohms or so with R3 dropped to 500 ohms, the oscillator voltage being injected into the suppressor grid of V1. by coupling this grid directly to the control grid of the oscillator. This valve could be an EC52, using the same circuit as in Fig. 22.

In the V3 circuit R7 could be dropped to 5,000 or 10,000 ohms, whilst the rest of the circuit would require no change, an EB34 being used as the double-diode ratio detector.

Probably the weakest point in any high frequency superhet is the oscillator. A circuit working at 80 Mcs. is more prone to frequency drift than one operating at lower frequencies, and if the oscillator frequency drifts the whole ensuing circuit is put out of alignment. Drift can be due to several causes—mechanical, where the coils and trimmers are not firm, heating, where expansion within the valve and associated circuits causes a change in electrode spacing, etc., and electrical, where fluctuations of oscillator H.T. and L.T. causes a change in working characteristics. (It is obvious that these causes cannot be separated, and are to a great extent inter-dependent.)

If C6 can be split into two capacitors, one a fixed capacitor with reverse temperature co-efficient, this is of considerable assistance and will correct for any frequency shift due to heating and capacitance changes. The required capacitor is not easily obtained however, and probably the simplest stabilizing method is to supply the oscillator H.T. from a neon stabilized source. The circuit is shown in Fig. 25; if the neon stabilizer is used the tuner chassis will require to be larger of course.

The only circuit change is to replace R5 by a 22,000 ohms 1 watt resistor, feeding both the oscillator and a neon stabilizer through this new resistor. The Mullard 7475 is recommended; and it fits an ordinary British 4-pin socket.
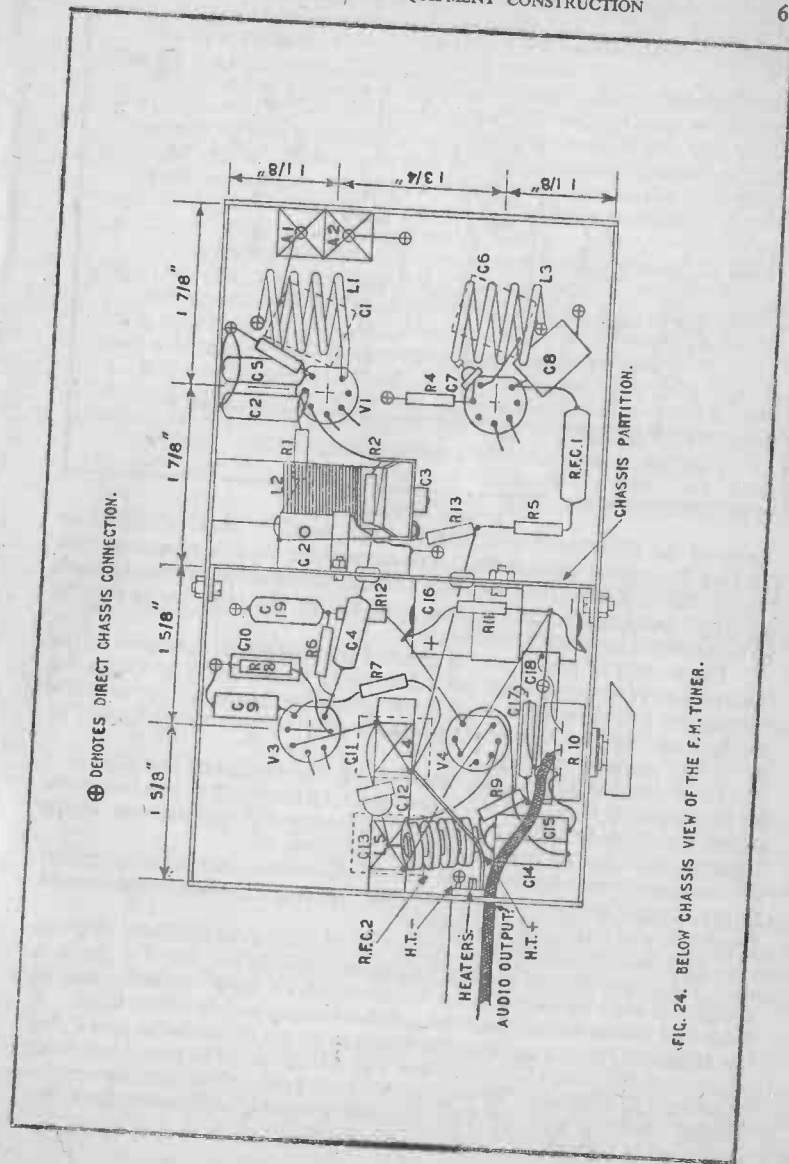
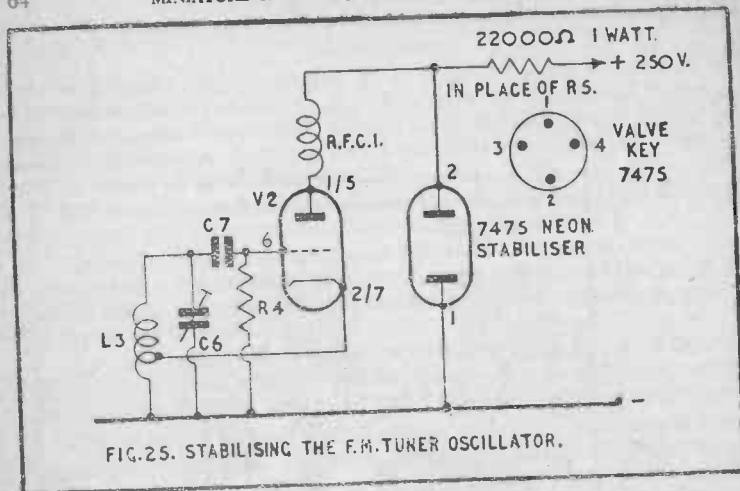FIG. 24. BELOW CHASSIS VIEW OF THE F.M. TUNER.

FIG.25. STABILISING THE F.M.TUNER OSCILLATOR.

CIRCUIT ALIGNMENT

With the F.M. tuner built, checked and tested, it must be aligned to working frequencies throughout. The output lead must be connected into an amplifier or receiver, and the tuner switched on for some minutes to reach operating temperature. Work must proceed with the tuner on its side, as all adjustments are made from below.

The process of tuning can be checked by listening to the signal in the loudspeaker of the amplifier, but adjustments are made by watching the reading on a high resistance or valve voltmeter connected between the junction of C19 and R12, and the chassis—that is, the tuner is aligned by the A.V.C. voltage readings.

First tune the I.F. stage. Remove V2, the oscillator, and feed in a 7.5 Mcs. signal to the grid of V1, adjusting C3, C11 and C13 to give maximum signal, searching with the generator if necessary and making only rough adjustments at first till the circuits come into line.

As adjustment improves and the A.V.C. voltage increases the output from the signal generator can be decreased; the A.V.C. voltage should not be allowed to rise much above 3 volts.

With these circuits aligned, replace V2 and allow the oscillator to warm up. The circuit should go into oscillation immediately, but if a check is needed the high resistance meter or, preferably, a valve voltmeter, can be connected across the grid leak R4, when a reading should be obtained. A low resistance meter may cause the circuit to go out of oscillation and if, for any reason, the circuit is troublesome and a fault has to be found it is more convenient to disconnect R4 temporarily from earth, connecting between its "earthy" end and earth a 0-1 m/Ammeter, a reading will then indicate that oscillation is present.

With the oscillator functioning properly the aerial may be connected in and, for the time being, tapped onto L1 one turn up.

A transmitter frequency signal is now needed; this may be presumed to be 90 Mcs., and probably the signal generator will not tune so high. If the F.M. transmitter is working that signal may be used; if not, then the signal generator may be set up to give a 30 Mcs. signal and its leads either run close to the feeder lead into the tuner, to give some capacitative pickup, or the generator output leads may have two lengths of wire connected to them and spread out into a very rough-and-ready dipole.

A normal signal generator should give a frequency of 30 Mcs., the third harmonic of which will act as a 90 Mcs. signal.

It is now necessary to tune both L1 and L3 to pick up the signal, and unless L3 can be tuned to 82.5 Mcs. by using a wavemeter or some similar device the rest of the alignment will require some patience.

If a v.h.f. receiver is in use, this could be employed as a wavemeter; alternatively the experimenter may have a calibrated absorption wavemeter. Setting L3, C6 to about the correct oscillator frequency is a great help.

With the oscillator on frequency it is only necessary to tune C1 to give the maximum A.V.C. voltage to have the tuner aligned. That done, the aerial tap on L1 can be checked, and C13 can be re-trimmed on an actual signal to give the best quality.

AERIALS FOR THE F.M.TUNER.

FIG 26 a.
SIMPLE DIPOLE.

FIG 26 b.
FOLDED DIPOLE.
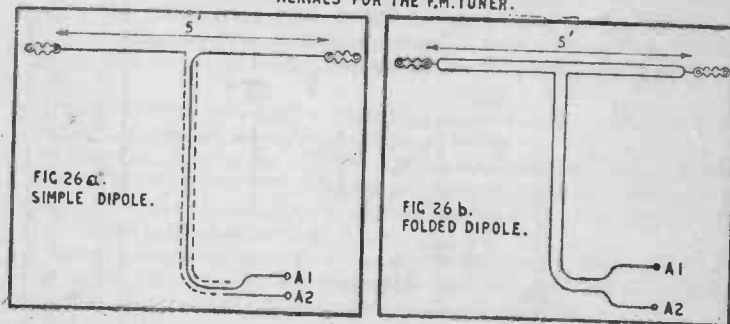
If, however, L3, C6 has to be tuned by a guess and without a wavemeter, then the oscillator and the mixer tuned circuits must be tuned over the band, first one and then the other, till the test or station signal is received, final adjustments then being made on each circuit for the greatest output and A.V.C. voltage.

AN AMPLIFIER AND POWER SUPPLY FOR THE F.M. TUNER

It is realised that some home constructors will wish to build the F.M. tuner and will also require an amplifier to use as its output stage. The circuit of Fig. 27 is accordingly given for their convenience.

FIG. 27. 8 WATT AMPLIFIER FOR F.M. TUNER AND GENERAL PURPOSE WORK.

The miniature mains amplifier cannot, of course, be used with the tuner as it has an A.C./D.C. feed and cannot supply the L.T. current for the tuner heaters; in any case a rather more ambitious circuit, with negative feedback, is desirable. The amplifier shown is not intended as a miniature circuit for standard valves and components are used throughout, but it will prove a curcuit which is useful for many more applications than solely that of working with the F.M. Tuner.

The output stage, a pair of EL33's, delivers 8 watts into a 10,000 ohms load with a total distortion, without feedback, of 3%. Feedback is taken from the secondary of the output transformer back to the input stage of the amplifier to reduce the overall gain; as a result the amplifier is sufficiently sensitive to work with practically any type of pickup but not too sensitive to work from the output of the F.M. tuner comfortably.

The input stage feeds into a phase splitter which in turn feeds the output stage; the H.T. line of the amplifier is maintained at 250 volts so that direct feeding into the tuner unit is possible and no voltage dropping is required. This is also an asset if the amplifier is required for use with another type of tuning units.

AMPLIFIER CONSTRUCTION

No special constructional details are necessary, and the layout of the amplifier components can be seen from Figs. 28 and 29. Group board building has not been advised for the miniature equipment described in this Manual for this type of apparatus is best made with the components built into the wiring and large capacitors clamped in their positions to the chassis or sidewalls, but group board construction of the amplifier is highly recommended.

Boards can be purchased or made from strip bakelite with soldering tags eyeletted, riveted or bolted along the board edges.

One side of the heater wiring is earthed, so that if this amplifier is used with the F.M. tuner or any other type of tuner or associated apparatus—a microphone preamplifier, for example—one lead can be common to the H.T.-ve and earthed heater line.

As the amplifier also has an input volume control, R10 in the F.M. Tuner can either be set to a convenient position and left, or a fixed 1 megohm resistor may be used in place of the potentiometer.

AMPLIFIER ADJUSTMENTS

Two adjustments are necessary when the amplifier is built and tested, the voltage on the H.T. line and the sense of the connections from the secondary of the output transformer to the chassis and the cathode circuit of V1.

A line voltage of 250 volts is required on the amplifier, although a 350 volts transformer is used. This allows for some drop through the smoothing choke, whilst a 4 mfds. reservoir capacitor in place of the usual 8 mfds. further reduces the voltage, but a final adjustment is possible through R19. This is an ordinary 0.2 amp. voltage dropper, as used in the heater lines of A.C./D.C. gear, with a maximum resistance of 1,000 ohms. When the amplifier is switched on for the first time the full resistance should be in

FIG. 28. TOP VIEW OF THE 8 WATTS AMPLIFIER CHASSIS.

circuit; the voltage on the H.T. line can then be metered through the power output socket by connecting a 1,000 ohms/volt meter between the appropriate pin and the chassis and the line voltage brought up to 250 by reducing the resistance in circuit.

To allow for current drain through the tuner the voltage may be taken to 260 if desired; the tuner's current will then cause a further drop to approximately the 250 volts required. If the tuner is to be used with the amplifier regularly, then, of course, the voltage may be adjusted with the tuner connected in.

The adjustment required to the feedback circuit is simply to connect the leads to the secondary of the output transformer experimentally to obtain feedback in the correct sense. If the leads are connected the "wrong way round" the whole amplifier will be unstable and will howl; to correct this it is necessary only to reverse the connections.

COMPONENTS LIST FOR THE 8 WATTS AMPLIFIER
FIG. 27

R1,	1 megohm volume control. Centralab.
R2, R11, R13,	33,000 ohms, ½ watt. Erie.
R3,	330,000 ohms, ,, ,,
R4,	3,900 ohms, ,, ,,
R5,	100 ohms, ,, ,,
R6,	820,000 ohms, ,, ,,
R7,	100,000 ohms, (treble control) Centralab.
R8,	0.5 megohm (bass control) ,,

FIG. 29. UNDERSIDE AND WIRING VIEW OF THE 8 WATT AMPLIFIER.

R9,	2.2 meg.	½ watt.	Erie.
R10,	22,000 ohms,	,,	,,
R12,	1,000 ohms,	,,	,,
R14, R15,	470,000 ohms,	,,	,,
R16,	150 ohms,	1 watt.	,,
R17, R18,	47 ohms,	½ watt.	,,

R19,   0.2 amp., 1,000 ohms adjustable voltage dropper. Dagole.

R20,	470 ohms,	½ watt.	Erie.

R21,   5 ohms, 2 watts. (2 × 10 ohms in parallel).

C1,   50 mfds. 12 v.w.   T.C.C. Type CE32B.

C2, C5,   0.1 mfd. Tubular.
500 v.w.   T.C.C. Type 543.

C3, C4,   8 plus 8 mfds. 350 v.w. T.C.C. Type CE35L.

C6,   0.02 mfd. Tubular.
500 v.w.   T.C.C. Type 543.

C7,   0.0005 mfd. Mica.   T.C.C. Type CM20N.

C8, C9,   0.05 mfd. Tubular.
500 v.w.   T.C.C. Type 543.

C10, C11,   8 plus 8 mfds. 450 v.w. T.C.C. Type CE27P.

C12,   4 mfds. 500 v.w.   T.C.C. Type CE13P.

T1,   4 and 15 ohms to 10,000 ohms, 12 watts, output transformer. Partridge PPO/2/VDL.

Sp.   Loudspeaker, 10", Hartley Turner 215.

T2,   350—0—350 volts, 80 mAs.
5v. 2a. 6.3v. 1a. 6.3v. 3a.
Partridge T/350/80/A/VDL.

L.F.C.   22 Henries, 120 mAs. 350 ohms. Partridge, C22/120/VDL.

V1, V2,   Mullard EF37.

V3, V4,   Mullard EL33.

V5,   5Y3G.

5 International octal chassis mounting valveholders.

Chassis,   14" × 9" × 2½" aluminium or steel.

S1,   Double pole On-Off. Bulgin S88.

F,   Double fuse holder, with 1 amp. fuses, Belling-Lee L.1033/C4.

Socket, power output and signal input, Belling-Lee L.331.
Socket, loudspeaker, Belling-Lee L.1286A with plug L.348.
3 control knobs. Eddystone 1044.
2 gridclips.
Screened cable, sleeving, wire, nuts, bolts, grommets, etc.

NOTE.—Should amplifier be switched on without loudspeaker plugged in, R21 is automatically connected as a load. When the L.348 plug is inserted *fully* R21 is switched out of circuit and the loudspeaker switched in. For the recommended (4 ohms) speaker the two secondaries of T1 are connected in parallel.

CHAPTER 7

A MINIATURE SHORT-WAVE RECEIVER

CORRESPONDENCE with readers of Bernards Publications shows that interest in short wave reception never wanes, and that circuits of reliable short wave receivers are still popular. There is, too, an undoubted trend towards smaller sets, and so this miniature short wave receiver, employing the new B8A valves, has been designed for the progressive constructor.

Basically the circuit is not new; an R.F. stage feeds via an inductive coupling to a regenerative detector which in turn passes the audio signal to an output stage. The treatment of the circuit is new, however, in that the complete set, with power supply and loudspeaker, is contained on a chassis 7" × 4" × 3" deep.

After some consideration it was decided to use commercially available coils in the original, both to save in space and to ensure efficiency. A single coil can be wound without trouble, but when coils are employed in pairs the commercial article is always more satisfactory.

The coils are of the plug-in type, chosen from the Denco range. The bases fit octal valveholders.

UAF42 valves are used in both the R.F. and detector stages, the diode anode in each case being connected to the cathode as it is not required. A variable cathode control in the R.F. stage permits of varying the input sensitivity of the set, so that the stage is not swamped by a local signal—an interesting point for the transmitting amateur, amongst others—whilst the regeneration control in the detector stage is of the screen-potentiometer type which gives a very smooth control. In addition to these two controls the output stage is supplied through a plain volume control so that the receiver is capable of dealing with practically any signal and any set of conditions.

The loudspeaker fitted to the set is admittedly small, and the design is intended to cater for the constructor who wishes to hear the station without being unduly concerned with quality. If better quality is required the receiver can be built onto a larger chassis and so have a larger speaker within the cabinet, or the speaker can, obviously, be separate from the receiver.

The speaker position is shown in the layout diagram of Fig. 31, but it should be noted that the loudspeaker is not "sunk" into the chassis. It is mounted either on the inside face of the cabinet, if the set is housed, or, if the set is to be used as a chassis receiver, the speaker must be mounted on either a small panel or a pair of brackets.

All the controls are mounted along the front edge and therefore a tuning dial of the ordinary type is not employed. The tuning drive and dial are of the Eddystone 597 type, in which a 2" dial rotates past an index strip, the dial being calibrated over 180 degrees of its edge with a 0—100 scale.
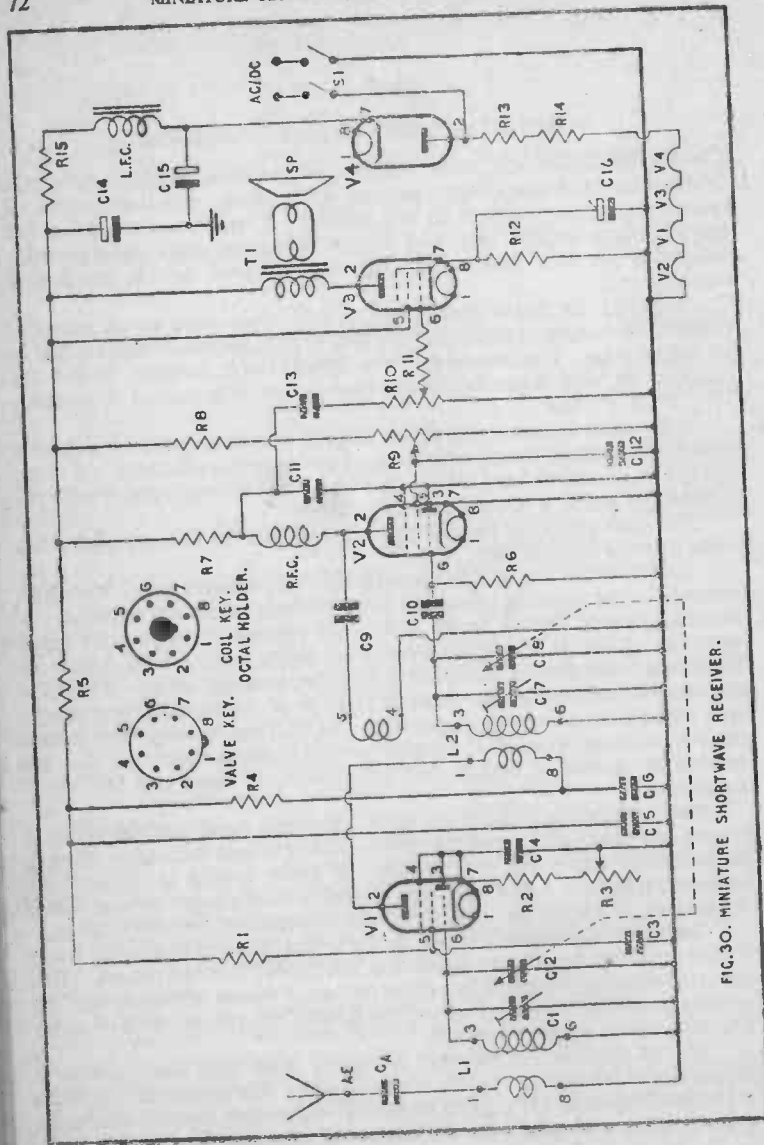
FIG. 30. MINIATURE SHORTWAVE RECEIVER.

Stations or frequencies can thus be charted or graphed against the dial reading.

As plug-in coils are used each set cannot be individually trimmed but the whole range of coils must be catered for by a trimmer connected permanently across each section of the two gang tuning capacitor. The coils have iron dust cores, however, and so the circuit stray capacitances can be balanced on the highest frequency range and the coils over all the ranges brought into alignment by core adjustment.

COMPONENTS LIST FOR THE MINIATURE SHORT-WAVE RECEIVER.—FIG. 30.

Coils.		
L1.		
Denco Blue 3P.	1.67— 5.3	Mcs.
Denco Blue 4P.	5—15	Mcs.
Denco Blue 5P.	10.5—31	Mcs.
L2.		
Denco Green 3P.	1.67— 5.3	Mcs.
Denco Green 4P.	5—15	Mcs.
Denco Green 5P.	10.5—31	Mcs.
Ca,	See text, "Choosing Ca". 0.01—0.0001 mfd.	
C1, C7,	4—30 pfs. Trimmers. Walter Instruments, Type MS30.	
C2, C8,	Midget 0.0003 mfds. Two-gang tuning capacitor. See text.	
C3, C4, C5, C6, C12,	0.1 mfd. Tubular. 500 v.w. T.C.C. Type 543.	
C9,	0.0005 mfd. Mica. T.C.C. Type CM20N.	
C10, C11,	100 pf. Ceramic. T.C.C. Type SCH1.	
C13,	0.05 mfd. Tubular. 500 v.w. T.C.C. Type 543.	
C14, C15,	8 mfds. Electrolytic. 450 v.w. T.C.C. Type CE19P.	
C16,	25 mfds. Electrolytic 25 v.w. T.C.C. CE32C.	
R1, R8,	47,000 ohms, ½ watt. Erie.	
R2,	330 ohms,	
R3,	10,000 ohms variable," sensitivity control. Centralab midget.	
R4,	4,700 ohms, ½ watt. Erie.	
R5,	10,000 ohms, " "	
R6,	1 megohm, " "	
R7,	100,000 ohms, " "	
R9,	100,000 ohms variable," regeneration control. Centralab midget.	
R10,	0.5 meg. variable, volume control. Centralab midget.	
R11,	3,300 ohms, ½ watt. Erie.	
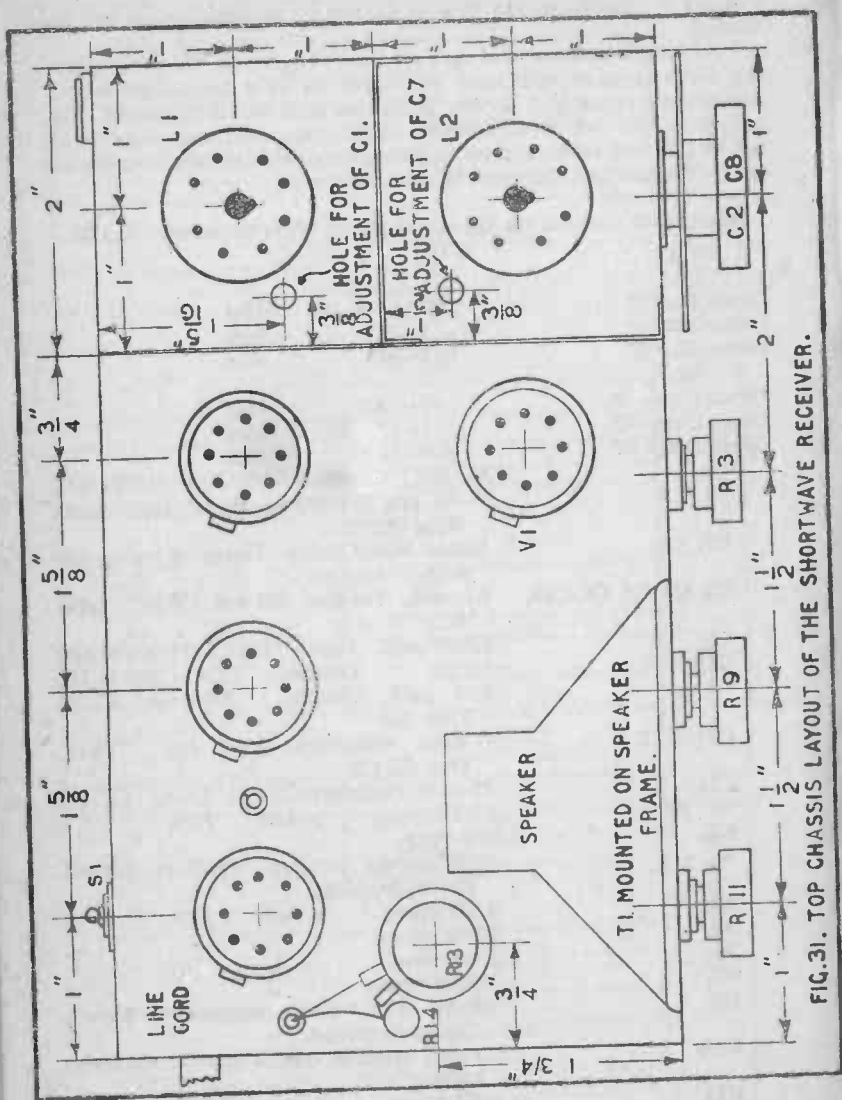
FIG. 31. TOP CHASSIS LAYOUT OF THE SHORTWAVE RECEIVER.

R12,	150 ohms, 1 watt. Erie.
R13,	1,000 ohms, 10 watts. Welwyn Electrical Co.
R14,	See text.
R15,	1,000 ohms, 5 watts. Erie.
T1, with Speaker,	2½″ or 3″ loudspeaker, with output transformer to match voice coil to 3,000 ohms.
L.F.C.	25 Henries, 60 mAs. 560 ohms. Partridge C25/60/VSE.
V1, V2,	Mullard UAF42.
V3,	Mullard UL41.
V4,	Mullard UY41.

4 B8A chassis mounting valveholders, Belling-Lee L.620.
2 International octal chassis mounting valveholders. (Coils).

S1,	D.P. On-Off. Bulgin S88.
R.F.C.	R.F. Choke, Eddystone 1010.
Aerial socket.	Belling-Lee L.315, with plug L.1021/3.
Chassis.	Cut and bend from sheet aluminium to 7″ × 4″ × 3″. Screening compartments round coils and coil holders, 2″ square, 2″ high above chassis, 3″ deep below chassis. *See diagrams and text.*
Tuning drive.	Eddystone 597.
3 Control knobs.	Eddystone 593.
Tuning coupler.	Eddystone 529.

Strip brass for capacitor clamps, wire, sleeving, grommets, nuts, bolts, soldering tags, etc., etc.

TUNING CAPACITOR

The tuned circuits were developed round the Jackson Bros. two-gang tuner type M.M., a particularly neat little component which, under a plastic dust cover, measures no more than $1\frac{11}{16}″ \times 1\frac{1}{16}″$ excluding the spindle. There are also several midget two-gang tuning capacitors of the correct value, 0.0003 mfd., on the surplus market—the Wingrove and Rogers model may be mentioned as one example. If a miniature two-gang capacitor of 0.0005 mfd. value is all that can be obtained, this may be used. The maximum capacitance of each section must be brought down to 0.0003 mfd. by connecting in series with each set of fixed plates and the appropriate coil pin a 0.001 mfd. mica capacitor of the T.C.C. CM20N type.

The fixing details with different tuning capacitors may require to be varied from these in the original set. Here the M.M. capacitor is fastened by means of the mounting holes in the two end plates; a pair of brass strip bars mounted between the coil screens carry the tuner by 4 B.A. bolts run into these fixing holes.

The position of C2, C8, is shown in Fig. 32 by a dotted outline. The spindle of the capacitor is connected by a coupler to the slow motion tuning

FLEXIBLE COUPLING.
FIG. 32. UNDERSIDE AND WIRING VIEW OF THE MINIATURE SHORT WAVE RECEIVER.

⊗ DENOTES DIRECT CHASSIS CONNECTION.
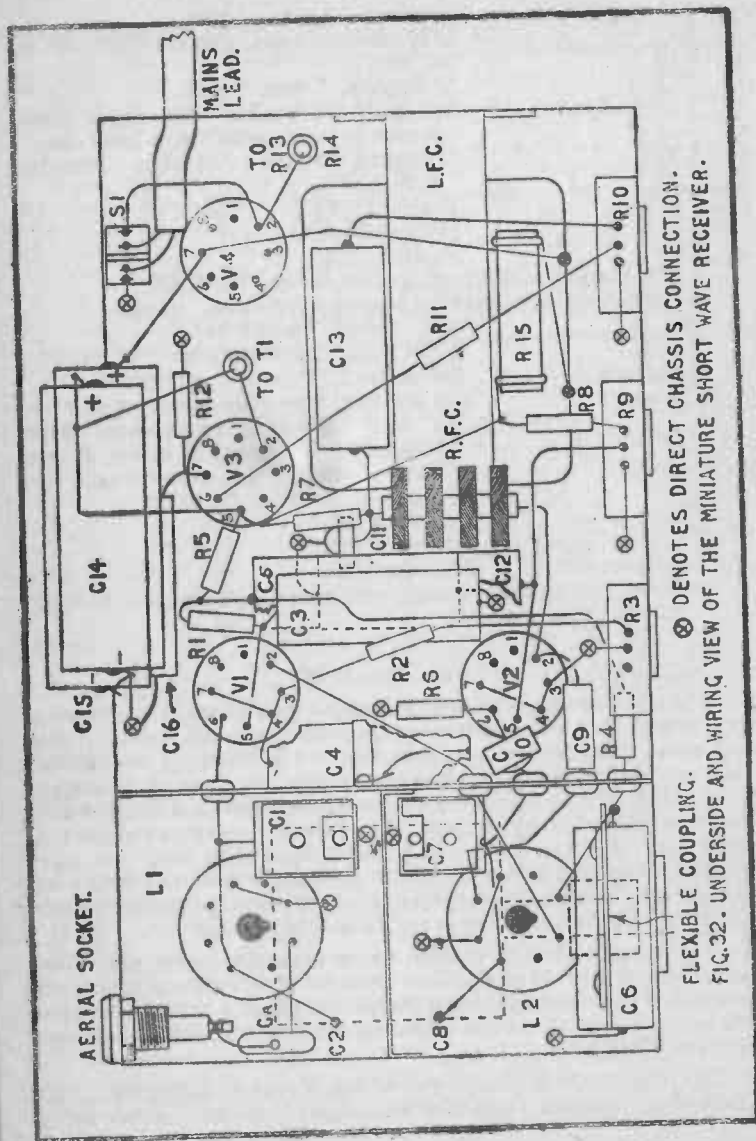
drive—this drive is mounted centrally in the depth of the chassis and the capacitor placement adjusted to bring the spindles in line.

C1 and C7 are mounted so that their adjusting screws are accessible to a screwdriver—or, better, a proper trimming tool—from the top deck of the chassis.

CONSTRUCTION

The coils on the chassis top deck are mounted within screening compartments and the coil holder leads below the chassis are similarly protected from interaction and feedback. These compartments are made from aluminium strip; the compartments on the chassis top are 2″ high but those below the chassis run down to the full depth of 3″ and the leads are carried through grommets in the compartment walls.

The central partition in the under-side compartments must be cut to fit round the frame of the tuning capacitor which is finally obtained. The frame of the capacitor may be bonded electrically to the screening partition, but if the joint is not perfectly made it is best to cut the partition to give a small clearance round the capacitor. If the partition and capacitor frame touch without being rigid and in perfect contact, scratching noises may be set up.

Placement of the larger tubular capacitors should be noted in the under chassis view of Fig. 32. C4, for example, is clamped by a strip of brass to the screening partition, whilst C3, C5 and C12 are mounted one above the other in another clamp fastened to the underside of the chassis floor. The chassis depth allows these capacitors to be mounted in this way; similarly the reservoir and smoothing capacitors, C14 and C15, are mounted one above the other on the rear wall of the chassis by a brass clamp.

These capacitor cans are substantially negative, but the negative connector must be wired firmly to the chassis as well.

In the figure these capacitors have been shown as overlapping the chassis wall for the sake of clarity; C3, C5 and C12 are shown overlapping and C4 is shown as broken for the same reason.

The set is A.C./D.C., and so no earth connection is required. When the mains plug is inserted to give least hum, then the chassis is earthed through the mains. This, of course, refers to A.C. circuits; on D.C. supplies the earth line should be the negative line and the set will only operate when the plug is correctly inserted.

If the mains earth introduces interference of any type and if it should be desirable to test the effect of a separate earth, the earth lead must only be connected to the receiver chassis through a capacitor rated as 0.01 mfd. at a working voltage of 750 or 1,000 volts. The T.C.C. "Metalpack" type is suitable.

HEATER LINE ADJUSTMENTS

The space available does not permit of a voltage adjusting panel such as that fitted to the miniature amplifier, and R13 with R14 are the heater dropping resistors.

The heater chain voltage is 101 volts, so that it may be said that on a 220 volt circuit 120 volts at 0.1 amp. must be dropped, on a 230 volt circuit 130 volts must be dropped and so on.

R13 is the main dropper, and 100 volts are lost across this resistor. The remainder of the drop is lost across R14 and so this resistor must be chosen to suit the mains supply and also the power lost in it.   If the mains voltage is 220, then a further 20 volts at 0.1 amp. must be dropped across R14; a 200 ohms 2 watt resistor will therefore be needed.   If the mains supply is 250 volts, then 50 volts must be lost across R14 which in that case must be a 500 ohms 5 watts resistor.

For intermediate voltages the resistance and wattage rating can be easily calculated from these examples of Ohms Law.

R14 is supported from the top connector of R13 and held rigid by the wiring from its base through the grommetted hole permitting the heater lead to pass through the chassis.

Headphone Operation

Many short-wave listeners prefer to "hunt stations" using headphones, switching on the loudspeaker when a required station or programme has been found.   When the set is of the universal type every precaution must be taken to ensure that the phones cannot become "live" to earth, and if it is required to use 'phones with this set the circuit of Fig. 33 is recommended.   This couples the headphones into the detector stage via C13, V3 being cut out of circuit automatically, and the chassis or earthy side of the 'phones is isolated from direct chassis connection through an 0.1 mfd. capacitor.

Many 'phones circuits use much greater values of coupling capacitors, but the values given are found perfectly adequate whilst the capacitors can be fitted in below the chassis.

The socket by means of which the 'phones are connected in can be mounted in the end wall of the chassis, especially if the mains lead is taken in beside S1 on the back wall.   With the double plug withdrawn C13 is connected in the usual way to the top of R10, and when the plug is half inserted this connection is still made whilst the 'phones are also connected across the input to V3.   When the plug is fully inserted into the socket, V3 is put out of action—its grid is still tied down through R10 so that the valve is working under the correct conditions—and the 'phones alone are coupled to the detector stage.

The components required for the headphones circuit of Fig. 33 are :—

Ca,   0.1 mfd. Tubular, T.C.C.   Type 543.
S.   Belling-Lee socket, L348.
P.   Belling-Lee plug, L1286/A.

Circuit Alignment

When the receiver has been built and checked, it must be trimmed and put into alignment.   The work is best performed using a signal generator which is coupled, through its artificial aerial, to the aerial socket and the chassis.   Allow the receiver and the generator to reach operating temperature.

Trim the circuit on the highest frequency range, plugging in the Blue 5 coil in the L1 holder and the Green 5 coil in the L2 holder.   Set the trimmers, C1 and C7, to about half capacitance, and the tuning dial to zero, this
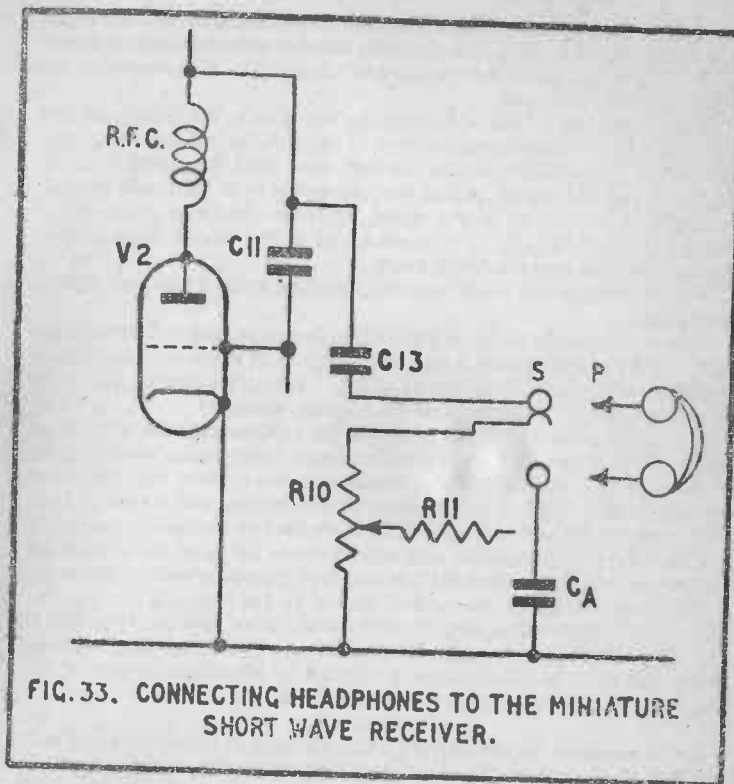
FIG. 33. CONNECTING HEADPHONES TO THE MINIATURE SHORT WAVE RECEIVER.

setting, of course, being made to correspond with minimum capacitance on C2, C8.

Tune the signal generator to 31 Mcs.—if the generator does not tune to a frequency higher than 30 Mcs. set the generator on 30 Mcs. and the tuning dial of the receiver to a reading of about 6 scale divisions instead of zero. Set R9 to nearly regeneration point, and R3 to minimum resistance.

Trim C7 to bring in the signal as well as possible, then trim C1 to improve the signal.   Check C7, reducing the generator's output as much as possible, and check C1.

The R.F. and detector circuits are now trimmed at the high frequency end of the scale, and the coils must be checked for alignment over the scale. Reset the generator, tuning to 12 Mcs., and tune the receiver over the band to bring in the signal—its harmonic should be heard at 24 Mcs. but tune on till the fundamental is reached.

Check for alignment by slightly varying the coil cores to see if the signal can be improved—if it can, adjust the cores and then retune set and generator to 31 or 30 Mcs. and check the trimming of C1 and C7. Continue until the circuits are nicely balanced.

Remove the No. 5 coils and insert the No. 4 coils, the Blue in L1 and the Green in L2. Tune the generator to 15 Mcs. and set the receiver tuning dial to zero. If necessary, adjust the coil cores until the signal is heard, then check over the range, tuning the generator to 6 Mcs. and rotating the receiver dial to bring in the signal. Results should be good, but if necessary readjust the coil cores at each end of the tuning range to give balanced reception over the whole range.

Repeat with the No. 3 coils inserted, checking at the 5 Mcs. and 2 Mcs. tuning points.

Now connect in the aerial, in place of the generator, and re-insert the No. 5 coils. Tune to a station on a high frequency—a 10 metre amateur station if possible—and check the trimming of C1. The aerial loading will in all probability make a readjustment of this trimmer necessary.

If a signal generator is not available the receiver must be aligned on stations. On each range choose a high frequency station and a low frequency station—that is, a station which is tuned with the receiver dial almost at zero, and another which is tuned almost at 100 degrees, and, on range 5, set the trimmers on the high and the coil cores on the low frequency station.

Check the other ranges for core adjustment in the same way, balancing reception once again between the low and high frequency ends of the scale.

The aerial used with the receiver should be the best that can be constructed, and it should run roughly north-south rather than east-west if it is about 20 yards long. A really long aerial can run in a more easterly-westerly direction; aerial direction is affected by the characteristics of the aerial, and the frequency which is being received.

Choosing Ca.

So far as results are concerned Ca may be omitted from the circuit, but in an A.C./D.C. receiver the aerial should be isolated from the receiver so that it cannot, under any circumstances, become "live." Where the aerial lead-in runs round a room, or is close to some used article in or out of doors (such as a clothes line) this point is of very considerable importance.

At the same time Ca can be used to reduce the aerial loading on the receiver, if a large aerial is in use, and so a final value for this capacitor is not given in the components list.

If a small aerial is all that can be managed then Ca may be an 0.01 mfd. capacitor, rated at 750 or 1,000 volts working, such as the T.C.C. Type 847 or the T.C.C. "Metalpack," but if the aerial is long then a smaller capacitance might improve the performance of the set. The capacitance should not be greater than 0.01 mfd.

Smaller capacitances may be of the mica type, and one or two values between 0.001 and 0.0001 mfd. should be tried. When the correct value for best results has been found, the capacitor should be chosen from the T.C.C. M2U or M3U ranges, which have working voltages of 750 volts rating.

BERNARDS RADIO BOOKS

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