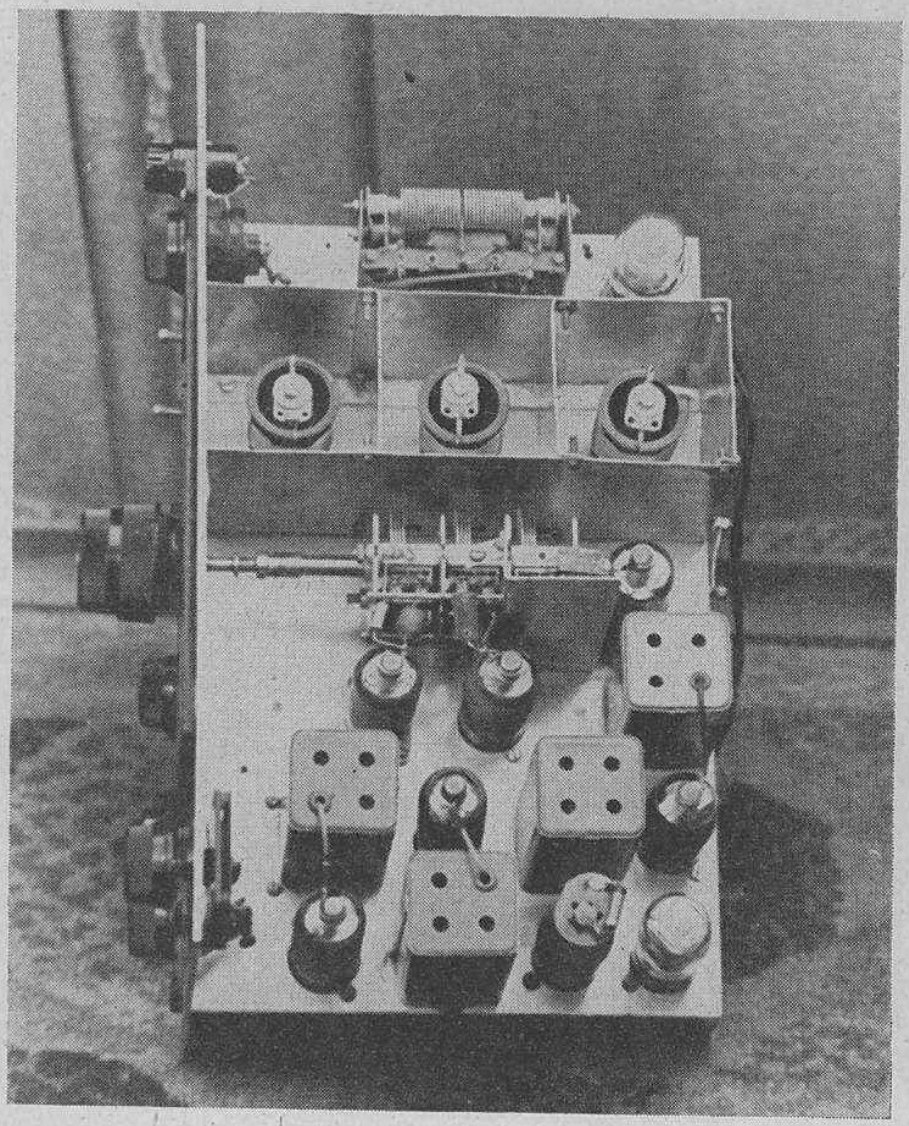
The R 109

Rebuilding for the Amateur Bands

By

A. Hitchcock



Introduction.

AS the army 109 receiver can now be obtained for around £7 from surplus stores, the writer thought that one would form the basis of a good battery communications receiver. Prime consideration was given to battery operation as the writer has no mains. The original receiver was considered unsuitable in its existing condition for several reasons. Firstly the wave lengths covered are only 35—160 metres, thus omitting the most interesting part of the bands from 10—35 metres. Also the output obtainable from the speaker fitted was very mediocre. Due to feeding the valve filaments from the same battery as the vibrator H.T. unit, a large amount of "hash" was introduced and this made the noise level very high when the volume was turned up. Lastly, the receiver had no refinements such as RF gain control, AVC switch and tone control. Due to these reasons it was decided to completely rebuild the whole receiver on a different chassis, fitting plug-in coils, pentode output, and a power pack suitable for either mains or batteries.

Circuit.

The circuit of the modified receiver is roughly the same as before, but with many minor changes. Since by careful design it is possible to obtain a 2.1 tuning ratio with a 160$\mu\mu$F tuning capacitor, the variable capacitor was stripped of all but four of its moving vanes, thus reducing its capacitance to the required value. This operation is easily performed by levering the vanes out with a screwdriver. As no suitable commercial ones are available the coils are home wound on standard 4-pin formers.

Starting at the RF end of the set, provision is made for input from either an end-on or dipole aerial. The RF gain control varies the screen voltage of the valve, as the bias is obtained from the AVC line. Although decreasing the screen voltage is not usually recommended since it reduces the signal handling capacity of the valve, no trouble from cross-modulation has been experienced. The mixer is coupled to the RF valve by RF transformer coupling. This gives better selectivity and signal-to-noise ratio than the original tuned anode coupling. Due to

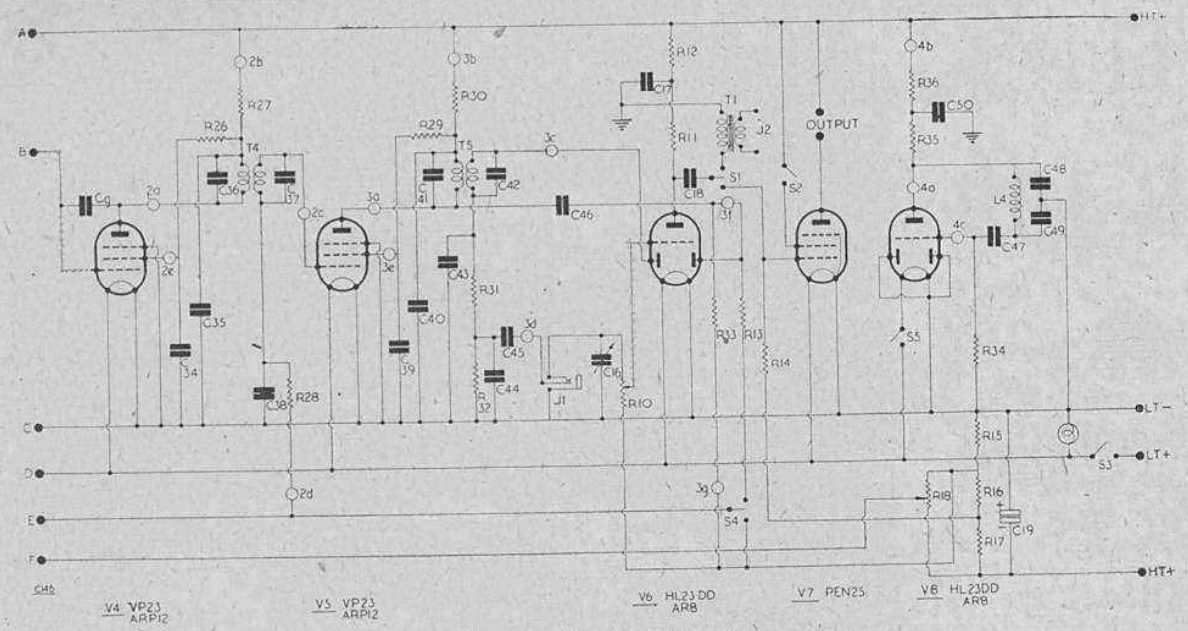


Fig. 1. Original Circuit.

tracking errors inevitable in home made coils, a small variable trimmer is inserted in parallel with the main tuning capacitor. Such a refinement was not found necessary in the RF stage as the aerial damps the circuit and it tunes comparatively flatly. The local oscillator is a parallel fed tuned grid circuit, this being found most satisfactory after much experimenting. The suppressor grid of the mixer is fed through a small capacitor from the anode of the oscillator. If it is fed from the grid, severe pulling will occur, it being possible to tune the oscillator with the mixer trimmer.

The IF stages are the same except that the anode and screen resistors are reduced to the values shown to obtain increased gain. This is also done in the mixer stage, the original 250 K Ω resistor in the anode circuit being removed. Controlled regeneration is introduced into the first IF valve as this gives greatly enhanced selectivity. By careful adjustjment of this, results equal to those of a crystal filter are easily obtainable.

The AVC diode is fed from the anode of the second IF stage as double the signal is obtainable here. The detector diode is fed from the secondary as before. In this circuit however are inserted a pick-up jack, and tone control. The latter is a 500$\mu\mu$F bakelite variable capacitor. The anode of the triode feeds either the phones, or the output valve and speaker. Audio volume at this point is ample for phone reception and the noise level is less. Parallel feeding ensures less noise and hum. Since low impedance phones were used by the writer, a matching transformer was obtained, but if high impedance ones are used, this transformer is not necessary.

The output valve is a Mazda PEN 25, which is very economical, and gives adequate output for normal purposes. The anode is taken to a four pin valve holder at the rear of the chassis, and the external speaker is plugged in here. No output transformer is fitted in the set, as this is contained with the speaker.

The BFO circuit is exactly the same as before,

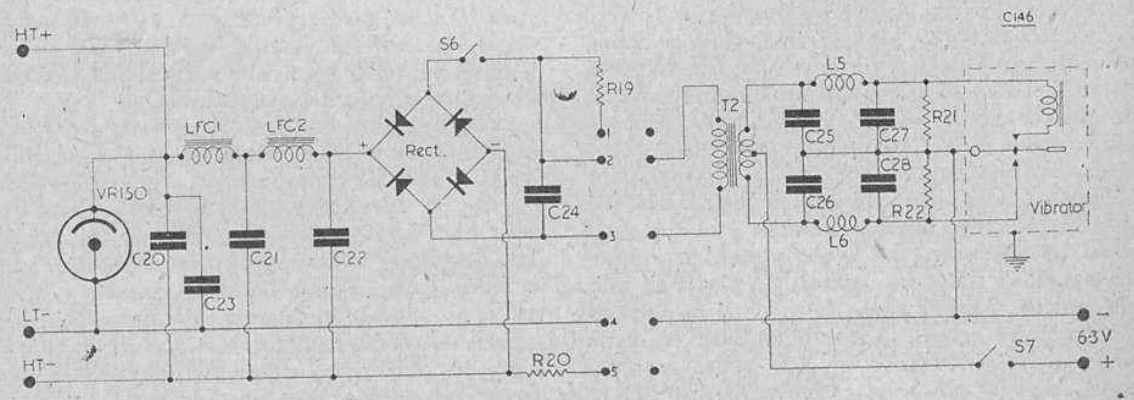


Fig. 3. The power pack.

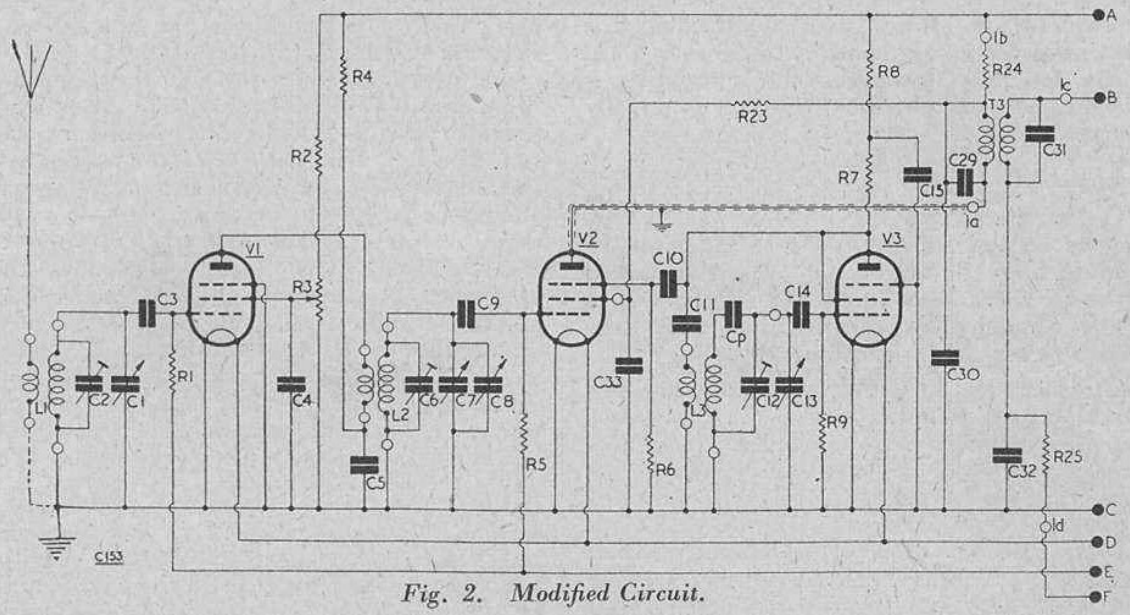


Fig. 2. Modified Circuit.

COMBINED COMPONENT LIST.

Capacitors.

C1, 8, 13.	160$\mu\mu$F variable.
C2, 6, 12.	15-40$\mu\mu$F trimmer.
C3.	300$\mu\mu$F mica.
C4, 5, 15, 30, 32, 33, 34, 35, 38, 39, 40, 50.	.01μF tubular.
C7.	15$\mu\mu$F variable.
C9, 11, 29, 36, 41.	150$\mu\mu$F mica.
C10.	50$\mu\mu$F mica.
C14, 43, 44, 47.	100 $\mu\mu$F mica.
C16.	500$\mu\mu$F variable bakelite.
C17.	2μF electrolytic.
C18, 23, 25, 26, 27, 28.	.1μF tubular.
C19.	25μF electrolytic.
C20.	8μF electrolytic.
C21, 22.	4μF electrolytic.
C24.	.025μF tubular.
C31, 37, 42.	160$\mu\mu$F mica.
C45, 49.	.002μF tubular.
C46.	200$\mu\mu$F mica.
C48.	.0022μF mica.

Resistors.

R1, 5, 13, 25, 28, 32, 33.	1M Ω
R2, 31.	100K Ω
R3.	250K Ω potr.
R4, 12.	5K Ω
R6.	50K Ω
R7.	27K Ω
R8, 20.	1K Ω
R9, 11.	47K Ω
R10.	1M Ω potr.
R14.	500K Ω
R15, 16.	100 Ω
R17.	200 Ω
R19.	1.5K Ω 2 watt.
R18.	50K Ω potr.
R21, 22.	150 Ω
R23, 26, 29.	150K Ω
R24, 27, 30.	2.7K Ω

Inductors.

L1.	Aerial coil.
L2.	HF coil.
L3.	Oscillator coil.
L4.	BFO coil
L5.	Vib. chokes
L6.	Vib. chokes.
T1.	Phone transformer.
T2.	Vibrator transformer
T3, 4, 5.	IF transformers.

Miscellaneous.

J1, 2.	Closed circuit jacks.
S1, 4.	S.P.D.T.
S2.	Closed by LS plug.
S3, 5, 6, 7.	S.P.S.T.

1 chassis 15″ x 9″ x 2″.
1 front panel 16″ x 9″.
1 Wilkins and Wright Utility Microdial.
9 Mazda octal valve holders.
1 international octal valve holders.
5 knobs 1″ diam.
1 pilot lamp and holder.
$\frac{1}{4}$″ diam. rod for extension spindles.
2 $\frac{3}{8}$″ brass collars for same.
5 valves type ARP 12 or VP 23.
2 ,, ,, AR 8 or HL 23/DD.
1 ,, ,, Pen 25.
1 ,, ,, VR 150/30.
Quantity 4 and 6 B.A. nuts and bolts.

but no coupling was found necessary. The noise limiter was omitted as it was not effective.

Of the power pack, the rectifier and smoothing arrangements are built on the receiver chassis, and the vibrator unit is built in a separate metal box. When used on mains, the latter are connected to the rectifier through a resistor. When on batteries, the vibrator is connected to the rectifier. These connections are made through a power socket at the rear. A separate

accumulator is always used for feeding the filaments whether on mains or batteries. When on the former, however, a voltage stabiliser is brought into circuit, but this is not really essential.

Construction.

The original receiver is first completely stripped, all resistors and capacitors being removed from the tag boards. Those contained in the IF transformers are left however, as this greatly simplifies wiring. Some of these have later to be replaced as seen above.

After stripping, the IF transformers are opened and the replacements performed. The leads that originally connect to the test panel are also removed. It will be found that in the last transformer the secondary winding is connected to a small coil wound near the primary. This is to overcouple the windings and provide broader selectivity. This is removed to increase the selectivity. On the other two transformers this winding is brought out to a tag. so the connecting wires are removed and only the secondary connected up.

After this has been done, construction can be commenced. The writer used a chassis 15″ x 9″ x 2″, but any of about the same size will serve. The front panel was obtained ready cut from an ironmonger. Thin sheet aluminium for the coil boxes was also obtained from the latter source. Since the chassis as obtained will be very easily marked, it is first given a matt finish by gently rubbing it with steel wool.

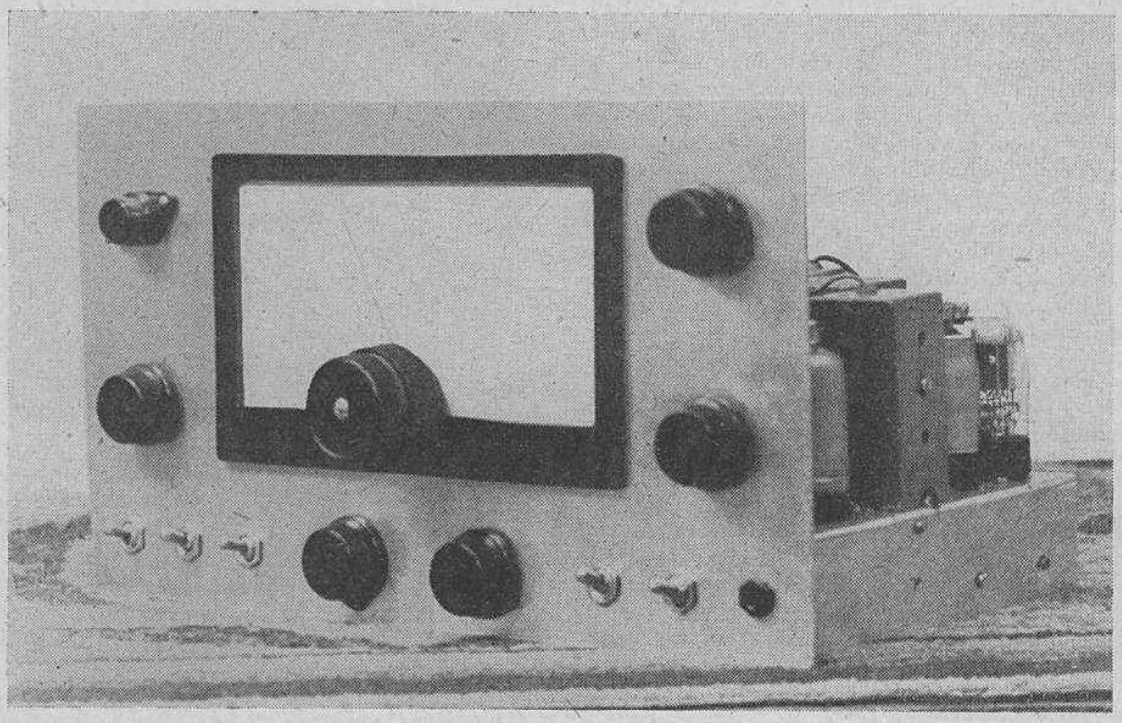
The method of construction can be left to the *reader, but it is best to start by cutting out all the valve holder holes. These are all 1⅛″ diameter and are easily cut with one of the many* cutters on the market. These are followed by the IF transformer holes, etc. The coil boxes may then be made to suitable dimensions, bending being easily accomplished on a vice. After all the valve holders, IF transformers and coil boxes have been fixed, the holes in the front of the chassis for switches are drilled. These can be widened with a tapering bit. The front panel can then be drilled with the corresponding holes, and affixed to the chassis by mounting the switches and phone jack. All the major components such as the rectifier, chokes, and potentiometers can then be fixed. The tuning capacitor is fitted with the extension spindle, and mounted on brackets of suitable height to align the end of the spindle with the hole in the front panel. The end of the spindle is held by a collar. The mixer trimmer is mounted on a piece of the thin aluminium, and an extension spindle fitted to coincide with the hole in the panel.

Wiring can then be commenced. It is best to wire all cold leads first such as power supplies, and to keep these near the chassis. The hot leads can then be kept away from the chassis. 22 swg tinned copper wire is used for all wiring except that of the RF section which is carried out with bare 18 swg tinned copper. The grid capacitors and leaks for the first three valves are mounted as closely to the top caps as possibly. The capacitance for the IF regeneration is formed by twisting a lead from the anode of the first IF valve round the grid lead.

The vibrator is built in a lighter fuel tin which *can be easily obtained from a tobacconist. The* vibrator holder is mounted on the bracket used originally to hold the spare vibrator.

By using suitable pins on the power input *socket, the rectifier is connected straight to the vibrator transformer, or through the resistor to the mains. When used on mains, the pins 4 and 5* are shorted by a wire in the plug. This connects R20 across the bias resistors and compensates for the current taken by the voltage stabiliser.

Pin.	ARP 12.	AR 8.	Pen 25.	VR 150.
1	Filament & E.	Filament & E.	Filament & E.	—
2	—	—	—	Cathode.
3	Anode.	Anode.	Anode.	—
4	Screen.	—	Screen.	—
5	Suppressor.	Diode 1.	Control grid.	Anode.
6	Metallisation.	Metallisation.	—	—
7	—	Diode 2.	—	—
8	Filament.	Filament.	Filament.	—
TC.	Control grid.	Control grid.	—	—



Front view of the modified reeeiver. Along the bottom, reading left to right, the switches are Filament on/off, HT on/off, BFO on/off, AVC on/off, Phone/speaker switch. At the extreme right is the phone jack—the speaker plug being situated at rear. The two lower knobs are for Mixer Trimmer and IF gain. The left-hand side control is RF gain, with the pilot indicator above it. On the right-hand side is the Tone control (top) with the audio gain below it.

COIL DATA

The Coils have been so designed that the amateur bands fall at the HF end of each range. This ensures maximum performance at these frequencies. The coils for the first three ranges are home wound on standard formers, while for the two low frequency ranges, commercially made coils are used.

	Aerial and HF.		Oscillator.	
	Grid.	Coupling.	Grid.	Coupling.
Range 1. 10—20 metres.	3¾ turns,	2⅜ inter.	3⅝ turns.	2½ Inter.
,, 2. 18—40 ,,	6⅞ ,,	4 turns.	6¼ ,,	4 close.
,, 3. 36—80 ,,	16½ ,,	9¼ ,,	15½ ,,	8 close.
,, 4. 75—155 ,,	Wearite	PA6, PHF6.	Wearite.	PO6.
,, 5. 190—370 ,,	,,	PA2, PHF2.	,,	PO2.

On the first two ranges, no padding capacitors are used. The values for the other ranges are:—

Range 3. 0.0014 F mica.
,, 4. 900$\mu\mu$F.
,, 5. 450$\mu\mu$F.

For the last two ranges the coils used are Wearite P type mounted in bases from discarded four pin valves. The coils themselves can be fixed through the unused centre pin hole.

All grid windings are wound with 20 swg. tinned copper wire. The coupling coils for the aerial and HF coils are wound with 26 swg. wire in the normal thread, while for the oscillator, the winding is of 26 swg. interwound in the case of range 1 and 36 swg. close wound for the other two.

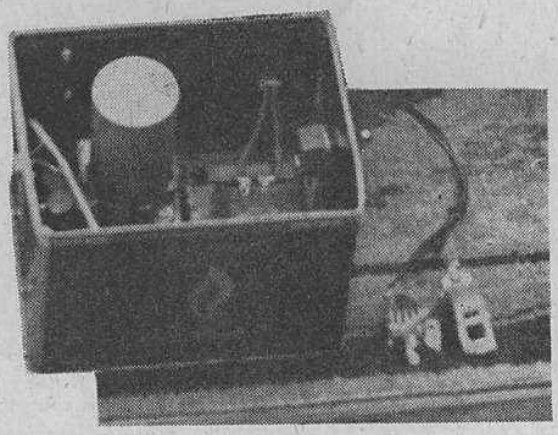
The dial is made by cutting out a piece of $\frac{1}{8}$" thick aluminium. This can be accomplished with a fretsaw—and a little patience! This is then enamelled black, and bolted to the front panel with the dial for calibration held underneath. The slow motion drive is a utility "Microdial" with the original pointer removed and replaced by a piece of steel wire hammered flat to make it as narrow as possible. This wire is soldered to the large brass nut at the rear of the drive. The writer has found this simple dial sufficient, but readers may like to construct a better one.

As yet no cabinet has been made for this receiver, but one can easily be made from sheet aluminium or wood. The former material is very easy to work, and is easily bent in the jaws of a vice. Metal about $\frac{1}{8}$" thick would be suitable.

Due to many of the resistors and capacitators being contained in the IF transformer cans, the external connections to these transformers have been shown with a circle drawn on the wires, with a number to indicate the transformer it belongs to.

Notes on operation.

It is strongly advised that the IF transformers be accurately lined up with a signal generator. As they will already be roughly so, it will be sufficient to inject a modulated 465 kcs. signal into the mixer grid, and tune the transformers by adjusting the iron cores until an output meter connected across the primary of the speaker transformer gives maximum reading. The signal circuits can then be lined up for each range by adjusting the trimmers for maximum output. A detailed account of lining up is not necessary here as it can be found in many textbooks.



A view showing how the vibrator unit was built into a discarded lighter fuel container.

The IF regeneration lead has to be adjusted in length and coupling until the stage oscillates with the IF gain control almost at maximum. If oscillation is erratic, detuning the grid and anode IF circuits slightly will cure it. Normally the gain is kept near the minimum position, but when QRM is present, increasing it to the point of oscillation will result in razor-edge selectivity.

RSGB RADIO EXHIBITION.

Just to remind readers that the RSBG Exhibition will be opened by Dr. R. L. Smith-Rose at 2.30 p.m. on Wednesday, November 17th. On the next three days, it will be open from 11 a.m. to 9 p.m. Admission is by catalogue, issued free to RSGB members. Non-members may purchase catalogues at the door, price 1s. Last year's exhibition was visited by almost 6,000 amateurs and this year the show will be even bigger.

The exhibition will be held at the Royal Hotel, Woburn Place, London.