FIND THAT bug

MICROBUG LOCATER

BY D. BOLLEN

THE widespread use of miniature electronic eavesdropping devices could be a cause of anxiety and embarrassment for the private citizen, as well as for those presiding in board-rooms. Unfortunately, the GPO cannot possibly be expected to track down every short-lived, unauthorised transmission, especially when the signal is weak and the range limited. Radio amateurs and radio control enthusiasts have been justly complaining for some time about the fly-by-night activities of pirate walkie-talkie operators and, if the trend continues, it may be gloomily predicted that anarchy of the air will overtake us in the future, when all the normal radio bands will be jammed solid by individual gibberish.

The tiny, transistorised, so called "bug" can be planted virtually anywhere, to relay private conversations 100ft or more, to a nearby house or parked car, and the National Press has already brought this threat to the attention of the public. The potentialities of its use by criminals are almost limitless.

Fortunately though, bugs are self-advertising, and the inverse square law of their radiation pattern favours the intended victim. A transmitter of only a few tens of milliwatts power will produce a strong r.f. field in its immediate vicinity, which is easily detected by a suitable instrument. Equipped with a Bug Locator, the private citizen can do much to discourage the use of such electronic pests. If he finds one he can throw it straight on the fire, or better still, take it to bits to use the components for some more rewarding project. Purchasers of bugs will soon find themselves very much out of pocket if their gadgets are always discovered.

The purpose here is to describe a fairly simple instrument which will detect a suspected "plant" and incidentally can be used also to locate numerous sources of troublesome electrical interference.

DETECTING TECHNIQUE

Although the favoured frequencies for "bugging" are in the 27–28Mc/s h.f. band, and the 85–100Mc/s v.h.f. band, such strict adherence to any particular set of frequencies, on the part of unlicensed operators, cannot be relied upon. Their choice will be largely determined by the receiver they intend to use. It is reasonable to assume that the practical upper limit, imposed by conventional components, will lie at about 200Mc/s. Since, at low frequencies, the ferrite rod will radiate effectively over room to room distances, doing away with the need for a long aerial, the lower limit might lie within the long wave band of a domestic receiver. Therefore, for the purposes of detection, the need is for an uncomplicated receiver covering, say, 100kc/s to 200Mc/s.

Few commercial receivers will cover this wide range, and those that do are bound to be cumbersome, complicated, and expensive. Sensitivity and selectivity are not of primary importance in this present application. If the bug is close to the receiver, acoustic feedback will occur by interaction between the concealed bug microphone and the loudspeaker of the receiver, and there will be no doubt as to the nature of the signal.

A simple alternative, avoiding knob-twiddling and band-changing, would be an untuned wide-band amplifier, capable of picking up any signal within the frequency range suggested above, and relying on the fact that this nearby signal will swamp all others and make tuning unnecessary.

Initially, tests were made with a simple point-contact diode detector and a.f. amplifier, to estimate the degree of sensitivity required, however when placed next to the output lead of a signal generator, results were unpromising. A stage of r.f. amplification ahead of the diode was tried. Even then, with a single transistor, RC coupled for wide band unselective coverage, the gain was disappointingly low. Finally, a two transistor cascode amplifier gave the desired sensitivity.

THE FINAL CIRCUIT

The complete circuit of the finalised microbug locator is given in Fig. 1.

The left-hand half of this diagram consists of the cascode amplifier TR1, TR2, the detector D1, and the coupling stage TR3.

A modulated r.f. signal is picked up and fed to the base of TR1, which operates as a common emitter amplifier, and is partially compensated by selective feedback resulting from C4 and R4, to offset fall of gain with increasing frequency. The collector of TR1 is directly coupled to the emitter of its companion transistor TR2. With base grounded to a.c. by capacitor C3, TR2 functions in the common base mode, with a good gain-frequency characteristic needing no compensation. It will be noticed that C3 is taken to the negative rail, the virtual earth of the *npn* pair. This arrangement gave the best results at critically high frequencies. R1, R2, R3 provide joint base biasing for both of the cascode stage transistors.

The combination R5, C5, D1, supplies a demodulated signal to the base of TR3 via C6, and the audio output is taken from R8. TR3 thus acts as an emitter follower.

A word or two about the types of transistors for the cascode stage. The BFY19 has been selected for TR1 because it has a cût-off frequency of 300Mc/s. In the common base mode, a BFY18 which has an f_T of 200Mc/s is quite acceptable for TR2. These particular transistors will give optimum performance. If, however, alternatives have to be used, those mentioned in the components list will be suitable—but with a slight limitation to the extreme high frequency response.

Almost any small transistor amplifier, whether transformer type, transformerless output, or complementary output, could be coupled to the emitter follower stage to supply the necessary drive for the locator loudspeaker.

The a.f. drive amplifier shown in the right-hand half of Fig. 1 is of a type that is fairly common and may, indeed, be bought complete as a commercial module, constructed from a kit, or it can even be sliced from the circuit panel of a defunct transistor radio!

To increase audio sensitivity in noisy surroundings, provision is made for low impedance headphone operation by means of jack socket JK1 mounted in the handle of the instrument.

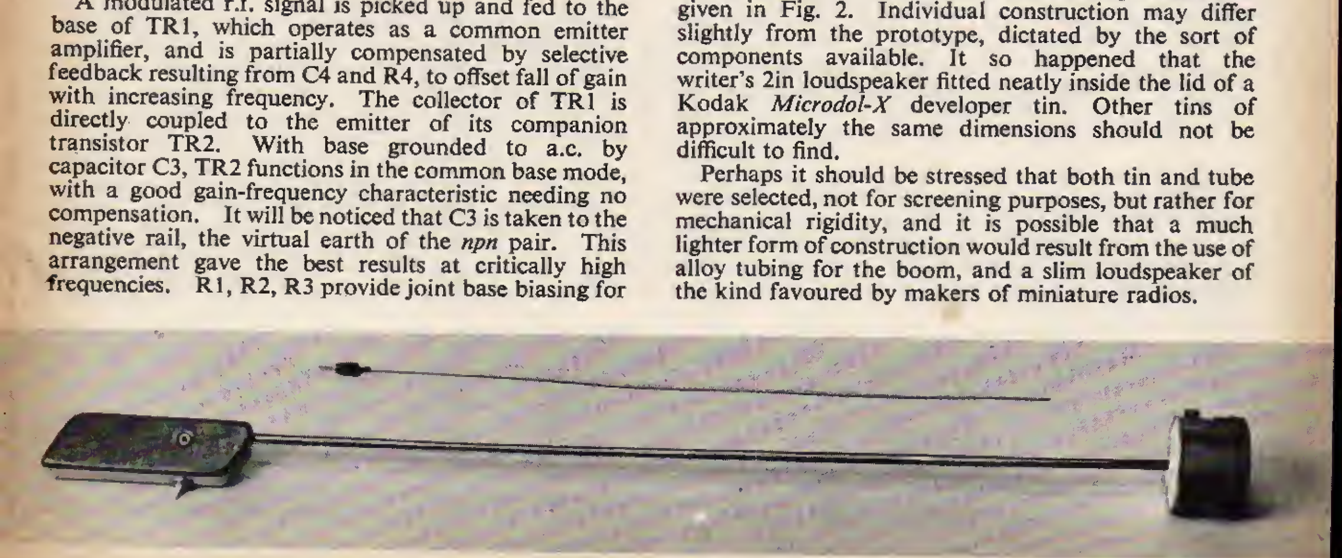
MECHANICAL DESIGN

Microbugs may be hidden in inaccessible places, behind high pelmet boards, inside ventilator gratings, behind or under furniture, to instance just a few hideouts. To reach high places, or under obstacles, the locator was constructed as a hand-held boom, with amplifiers, aerial, and loudspeaker at the business end, and battery, switch, and headphone socket in the wooden handle.

Another reason for this particular layout was that the wiring inside the boom tube would act as a counterpoise for the short whip aerial. To minimise strain on the wrist, weight must be kept low since considerable leverage results from a boom nearly a yard in length. To this end a lightweight, glued rather than screwed, compact method of construction was chosen.

General layout details of the microbug locator are given in Fig. 2. Individual construction may differ slightly from the prototype, dictated by the sort of components available. It so happened that the writer's 2in loudspeaker fitted neatly inside the lid of a Kodak *Microdol-X* developer tin. Other tins of approximately the same dimensions should not be difficult to find.

Perhaps it should be stressed that both tin and tube were selected, not for screening purposes, but rather for mechanical rigidity, and it is possible that a much lighter form of construction would result from the use of alloy tubing for the boom, and a slim loudspeaker of the kind favoured by makers of miniature radios.



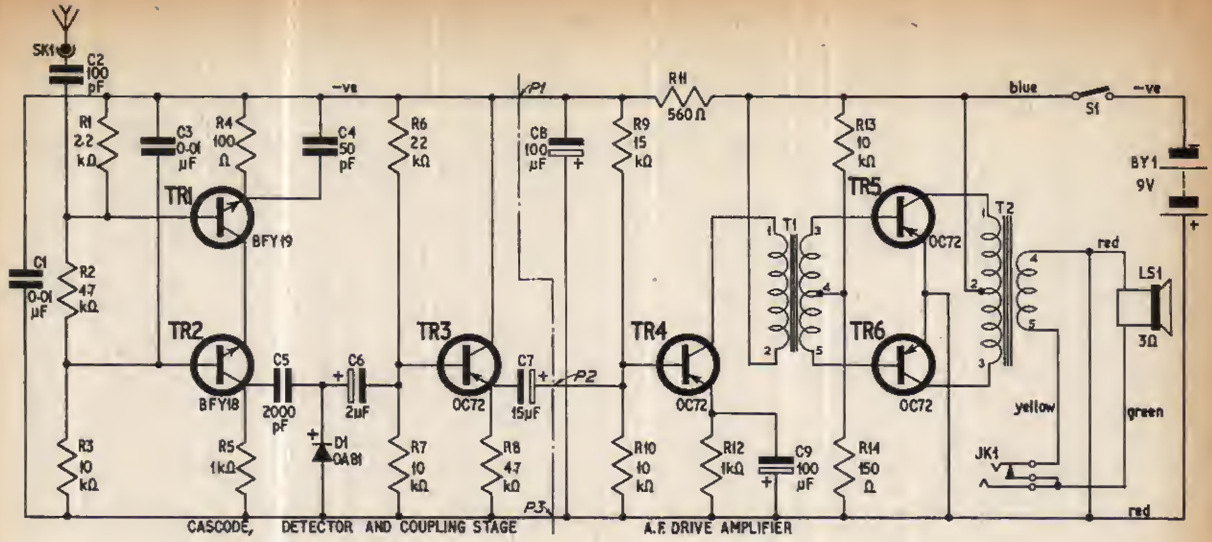


Fig. 1. Circuit diagram of the microbug locator

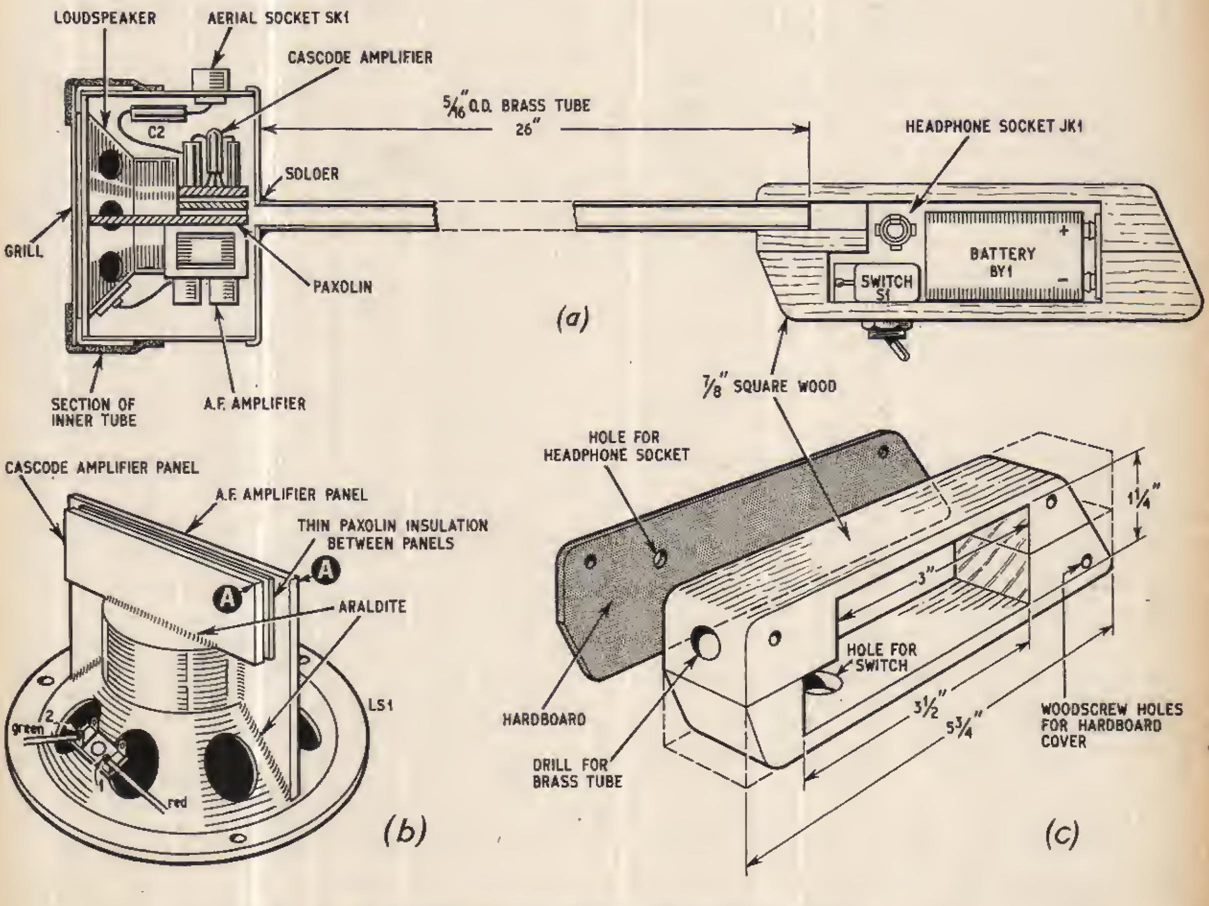


Fig. 2. General constructional details of the microbug locator.
(a) General assembly of the complete instrument
(b) The loudspeaker unit, showing how the two electronic sub assembly panels are mounted
(c) Details of the wooden handle

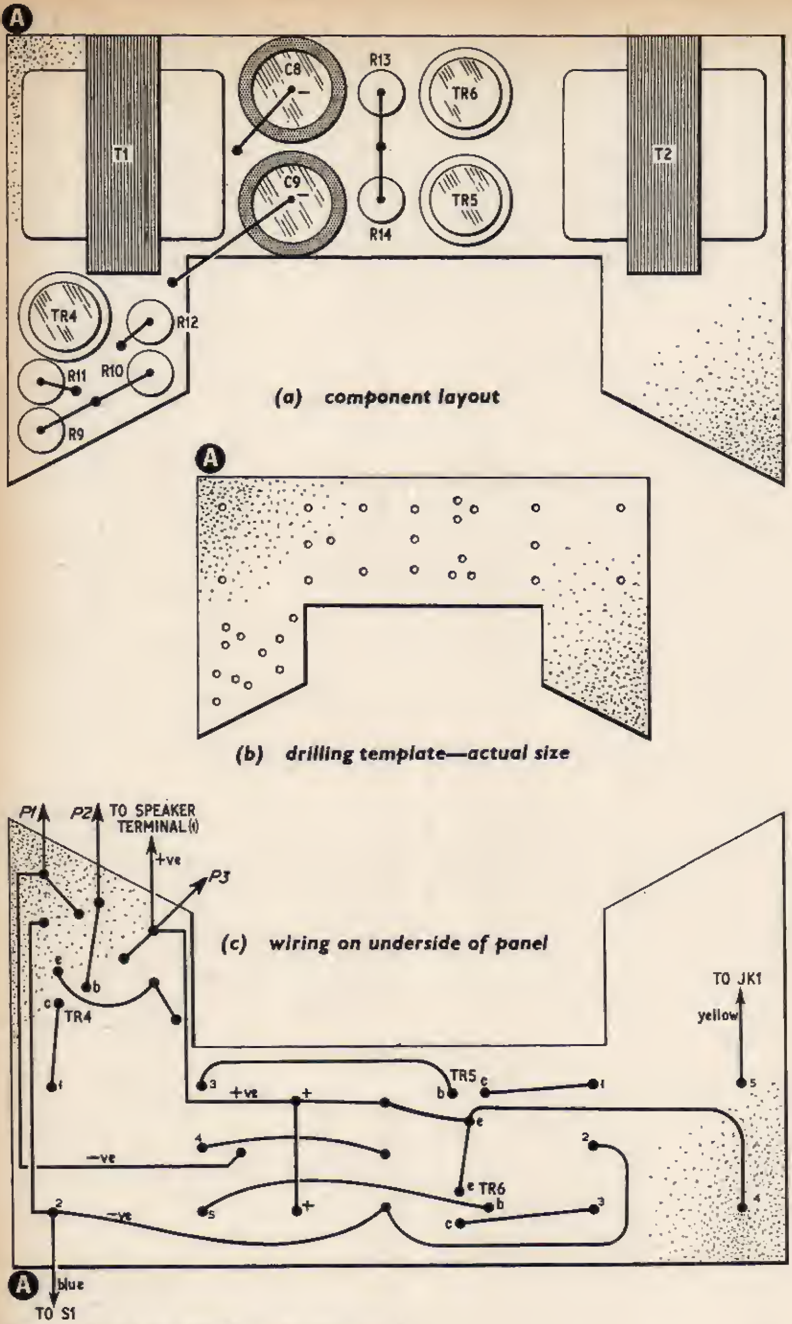


Fig. 3. The a.f. amplifier sub assembly

CIRCUIT ASSEMBLIES

Construction commences with the two sub-assemblies which carry the majority of the circuit components. These are shown *in situ* in Fig. 2a.

The a.f. drive amplifier is assembled on a piece of laminated plastics board, shaped to fit the loudspeaker magnet, shown in Fig. 3. The drawing given in Fig. 3b is full size and may be used as a drilling template. When all components have been mounted and the wiring on the reverse side of the panel completed, the unit should be tested. Short leads (about 2in long) should be soldered to points P1, P2 and P3 (see Fig. 3c). Note that this does not apply to the blue and yellow connections marked "to S1" and "to JK1", respectively. These leads are added at the final wiring-up stage.

After this the a.f. amplifier panel should be glued to the loudspeaker frame with Araldite and temporarily held secure with rubber bands. (To hasten setting of this epoxy glue, an assembly may be placed in a cool oven, at around 50 degrees C for a few hours.)

The cascode amplifier unit is built up on another, smaller, plastics board, details of which appear in Fig.4. Here again, a template is provided—see Fig. 4a. After testing this unit, the final assembly work can be tackled.

A considerable amount of care is required during this final assembly work. Place the cascode amplifier unit, wiring side uppermost, on the loudspeaker chassis so that ends "A" of both panels are facing the same direction. Solder the three flying leads to points P1, P2, and P3 on the cascode amplifier. Note that these leads must be of sufficient length to permit routing around the insulating panel which will be sandwiched between the two sub assemblies.

Place a piece of thin plastics board (approximately $2\frac{1}{4}$in × $\frac{11}{16}$in) against the underside of the a.f. amplifier panel, apply glue to the edge of the second sub assembly and fix this latter unit in position on the loudspeaker magnet. Secure the completed assembly with rubber bands until the glue has hardened.

For future repairs or component replacement the panels may be carefully prised away from the loudspeaker with a screwdriver, and afterwards re-glued.

HOUSING AND BOOM ASSEMBLY

The housing and boom assembly can now be dealt with.

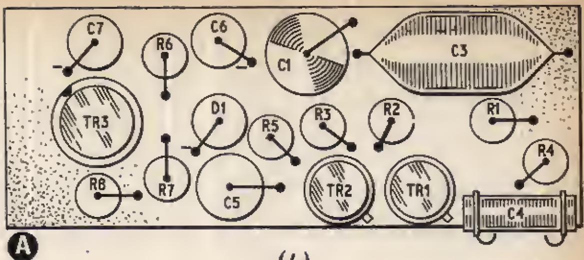
Cut a circular hole in the lid of the tin, leaving a narrow rim. Glue some plastic gauze to the outer surface of this rim. Fit the loudspeaker unit inside the lid. If the loudspeaker is a reasonably tight fit, a little glue will suffice to make this secure; otherwise it may be advisable to bolt the unit to the rim of the lid—this operation should, of course, be performed before the gauze is stuck in position.

Drill a hole in the side of the tin to suit the aerial socket SK1.

Next drill the base of the tin to suit the outside diameter of the brass tube and solder the tube to the tin. A large soldering iron is essential for this purpose.

Line the interior of the tin with cartridge paper or plastics material. Secure the aerial socket in position and solder one end of C2 to the socket.

(a)



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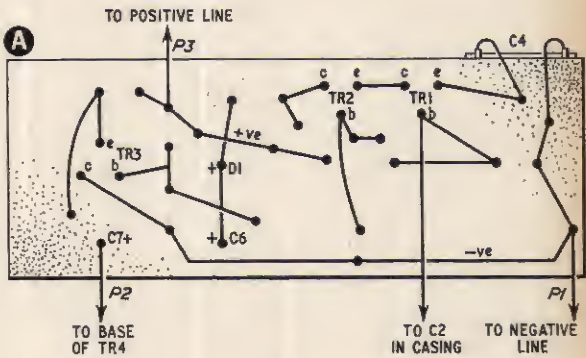


(c)

Fig. 4. The cascode amplifier sub assembly
- ***(a) drilling template—actual size***
- ***(b) component layout***
- ***(c) wiring on underside of panel***

COMPONENTS . . .

Resistors

R1	2·2kΩ	R8	4·7kΩ
R2	4·7kΩ	R9	15kΩ
R3	10kΩ	R10	10kΩ
R4	100Ω	R11	560Ω
R5	1kΩ	R12	1kΩ
R6	22kΩ	R13	10kΩ
R7	10kΩ	R14	150Ω

All 10%, $\frac{1}{4}$ watt carbon

Capacitors

C1 0·01µF paper
C2 100pF ceramic tubular
C3 0·01µF paper
C4 50pF ceramic tubular
C5 2,000pF plastic-paper
C6 2µF elect. 9V
C7 15µF elect. 9V
C8 100µF elect. 12V
C9 100µF elect. 12V
All are miniature types

Transformers

T1 Push-pull driver. Rex LT44
T2 Output. 3Ω secondary. Rex LT700 (Henrys Radio Ltd.)

Transistors

TR1 BFY19 } Suitable alternatives:
TR2 BFY18 } BSY27, BSY29, 2N753, 2N744
TR3-6 OC72 (4 off)

Diode

D1 OA81

Loudspeaker

LS1 2 in dia., 3Ω

Battery

BY1 9V layer type. PP3 or equivalent

Switch

S1 Single pole toggle on/off

Sockets

SK1 Wander plug and socket (Radiospares)
JK1 Miniature jack socket, with shorting contact

Miscellaneous

Circular tin $2\frac{3}{4}$in dia. × 2in high (see text). Brass tube $\frac{5}{16}$in outside dia., 26in long. Plastic speaker gauze. Laminated plastics board. Timber $\frac{7}{8}$in. square. Hardboard. 14 s.w.g. tinned copper wire. Connecting wire. Araldite glue.

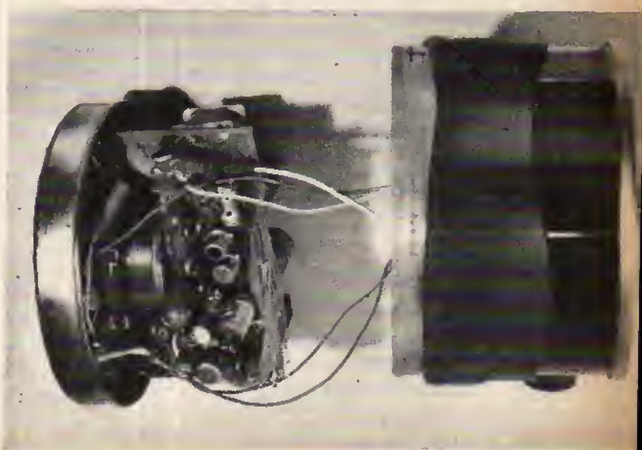
THE HANDLE

The handle is built up from two pieces of $\frac{7}{8}$in planed timber and two pieces of hardboard.

The cut outs should be fashioned with a tenon saw and chisel and the various holes drilled as indicated in Fig. 2c. Two hardboard panels, of identical size and shape, should be prepared—an additional hole for the headphone socket is needed in one panel. Assemble and glue together the two timber pieces and the hardboard side with the additional hole.

Push the brass tube into the hole at one end of the handle. Fit the jack socket, switch and battery into the handle housing. Pass four differently coloured connecting wires down the boom tube and connect these to the components as shown in Fig. 5.

Secure the handle lid with three woodscrews.



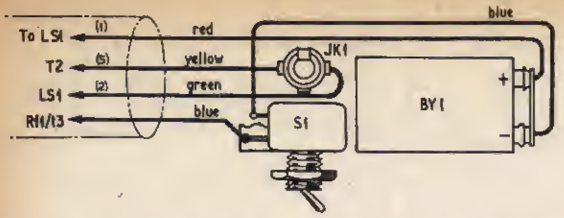


Fig. 5. Wiring diagram for the handle compartment. The four coloured leads pass through the boom tube and terminate at the points indicated on the loudspeaker assembly

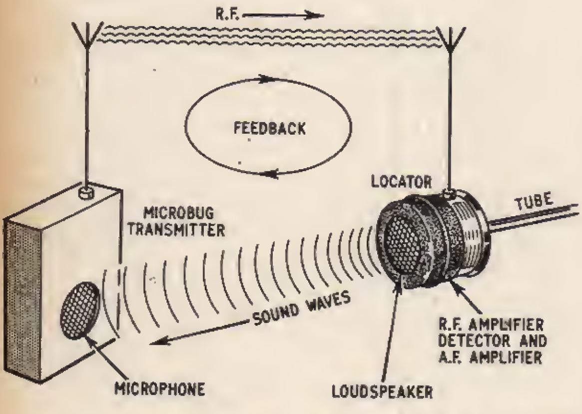


Fig. 6. This illustrates the technique used in detecting hidden radio microbugs. The hidden snooping device is activated by the operator whistling in a "suspect" area. This sound is transmitted by the bug, and received by the locator, the audio output of which is picked up by the bug, and so a self-sustaining feedback loop is created around the two devices. The intensity of the loudspeaker output will increase as the locator is brought closer to the concealed bug, whose hiding place is thus soon discovered

FINAL WIRING-UP

Returning now to the "business end", connect the four wires to the appropriate points on the loudspeaker/electronic assembly as indicated in Fig. 5. Connect the free end of C2 to the base of TR1 (see Fig. 4c). Carefully instal this assembly inside the tin, checking that the various wires are not strained or fouled in any way.

To hold the lid in place, and to protect against knocks and abrasions, a slice of bicycle inner tube can be stretched over and around the lid and tin, as shown in the illustrations.

The aerial consists of a 21in length of 14 s.w.g. tinned copper wire with a wander plug soldered to one end.

FIELD TESTS

It might be useful to mention some field tests carried out with the prototype locator.

At first, the tin and tube were earthed to the battery positive but this was found to attenuate response above about 50Mc/s, probably because of the additional capacitance thus introduced, so the connection was removed.

With a long outside aerial plugged in to the locator socket, just about every transmission within skip distance came in at fair volume, dominated by the local B.B.C. Home Service and Light Programme. Tests with a signal generator indicated that the limits of usable response were greater than 100kc/s to 180Mc/s. As for sensitivity, with headphones plugged in and a short whip aerial on the Locator, a 60mW radio control transmitter could be clearly detected at a distance of 25ft.

Another test was with a microphone and amplifier input to the modulation transformer of the signal generator. When the locator loudspeaker was brought close to the hook-up, acoustic feedback occurred—a distinctive warbling note. The onset of feedback could be initiated by a sharp whistle from the mouth or, better still, by using a toy whistle to jerk the system into oscillation.

"DEBUGGING" PROCEDURE

In use then, the mode of operation might be as follows. With headphones connected, the area to be "cleaned" is scanned while the operator emits a few strident whistles. If a bug is close at hand the operator will hear his whistles plus room echos reproduced in the headphones. Next, he will remove the headphones, unplug them from the locator and use the instrument like a feather duster, going round the room in a search for the source of the transmission he has picked up, while still whistling loudly. Sooner or later the warble note from the loudspeaker will give him a clue to the bug's exact whereabouts.

The microbug locator can, of course, be used for purposes other than that for which it was especially designed. It will effectively trace sources of electrical interference, check for mains borne r.f., serve as a zero beat detector where two close frequencies are to be compared, or it can be coupled to the i.f. output of a superhet receiver as a temporary detector and a.f. amplifier.

It only remains to wish would be Hemipterists, *happy Bug hunting!* ★