Hi Fi TRANSISTOR MICROPHONE

By H. E. OWENS

A Hi Fi Microphone that can be used with 100ft of cable without electrostatic or magnetic interference

Crystal microphones are generally viewed with scorn in the hi-fi fraternity, an image well deserved by the majority. For while some of the more carefully designed examples are capable of natural, wide range reproduction and, price for price, can be superior to dynamic types, there remains one serious disadvantage: the capacitative nature of the crystal element limits the length of the output lead to a maximum of about 10ft. More than this will progressively attenuate the signal.

Also, a very high input impedance is required of the associated amplifier to achieve full bass response, and because of this the circuit becomes sensitive to electrostatic hum pick-up and cable-handling noises. To add to our difficulties, the better the acoustic quality of the microphone, the lower will be its output!

F.E.T. PRE-AMPLIFIER

This article describes the construction of a low-noise f.e.t. pre-amplifier designed to do justice to the wide response of a specified crystal microphone insert, and physically small enough to be mounted as an integral unit with the insert and battery in a convenient metal tube.

Used in this way, it completely overcomes hum pick-up and permits the use of a long output cable, but it can alternatively be housed in a larger case and equipped with an input socket for use as a general purpose audio booster having a voltage gain of at least 25 (28dB), suitable for feeding valve or transistor equipment. It will handle inputs of up to 50mV and the frequency response is flat from 10Hz to 100kHz.

CIRCUIT DESCRIPTION

The circuit (Fig. 1) consists of a common-source f.e.t. stage, TR1, having an input impedance of around 5 megohms (recommended value for the insert used), direct coupled to an emitter follower, TR2. This has a voltage "gain" of slightly less than unity but, because of 100 per cent negative feedback, reduces the signal impedance to less than 2 kilohms.

The input series resistor R1, in conjunction with the gate-to-source capacitance of the f.e.t., forms an r.f. stopper. This was found to be necessary when using the prototype next door to a radio taxi base station, when broadcasts persisted in breaking through despite the excellent linearity of the f.e.t. and the screening properties of the tube.

With this potential source of trouble overcome, the microphone is immune to all forms of interference—both electrostatic and magnetic. To prove the point, the prototype has been tested alongside a high-power radio transmitter, sitting on top of a transformer carrying 500W, and feeding a tape recorder through 100ft of unscreened flex.

BATTERY SUPPLY

Current drain is less than 0·5mA and the circuit will operate consistently to a supply end-point of 15V, thus obtaining good service life from the 22½V battery. Resistor R5 provides a charging path for C2.

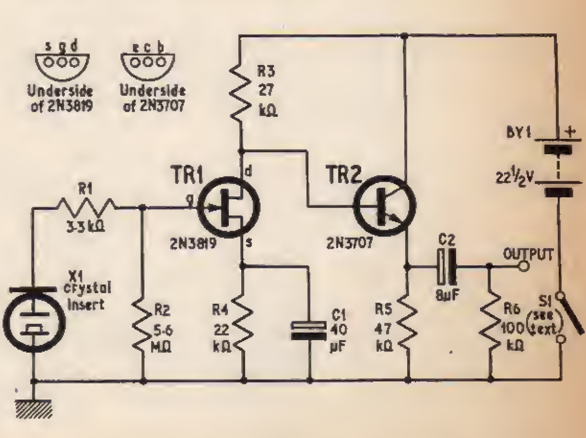


Fig. 1. Circuit diagram of the transistor-amplified microphone. The source, gate and drain of the f.e.t. (TR1) correspond functionally to the emitter, base and collector, respectively, of conventional bipolar transistors

COMPONENTS . . .

Resistors

R1	3·3kΩ	R4	22kΩ
R2	5·6MΩ	*R5	47kΩ
*R3	27kΩ	R6	100kΩ

All 10%, $\frac{1}{8}$W carbon. *R3 and R5 should be low noise types

Capacitors

C1 40μF 6V elect.
C2 8μF 12V elect.

Transistors

2N3819 n-channel field effect transistor } Texas Instruments.
2N3707 npn silicon } Texas Instruments.

Insert

X1 Acos 39/1 crystal (Henry's Radio)

Miscellaneous

Tube: brass, copper or brass-clad steel, $\frac{7}{8}$in bore × approx. 4$\frac{1}{2}$in long. Steel strip, approx. 8in long × $\frac{1}{4}$in wide. Cartridge-type connector. Polyshrink tube No. 50 if required (black or white, sold in multiples of 1ft), Home Radio. Piece of Veroboard, 1$\frac{1}{4}$in × $\frac{3}{4}$in. 4B.A. solder tag. Thin p.v.c. flex.

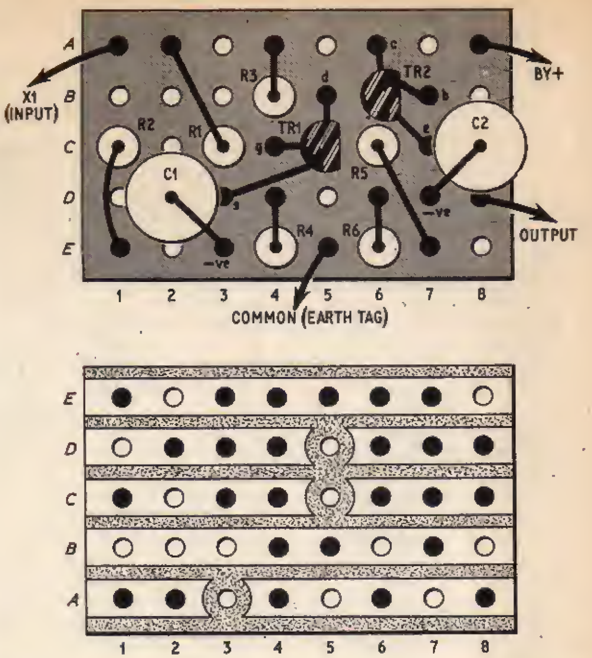


Fig. 2. Component layout and underside of the board with connection details to other components.

From the stability point of view, no capacitor is required across BY1. But as a safeguard against the occasional battery that causes frying noises as it nears the end of its life, a 10μF 25V electrolytic could be connected between holes *A7* and *E8* on the circuit board (see Fig. 2), with the positive end taken to *A7*. This measure was found to be necessary with only one of the large number of batteries that died prematurely while voltage and current adjustments were being made to the prototype, and was therefore omitted.

AMPLIFIER CONSTRUCTION

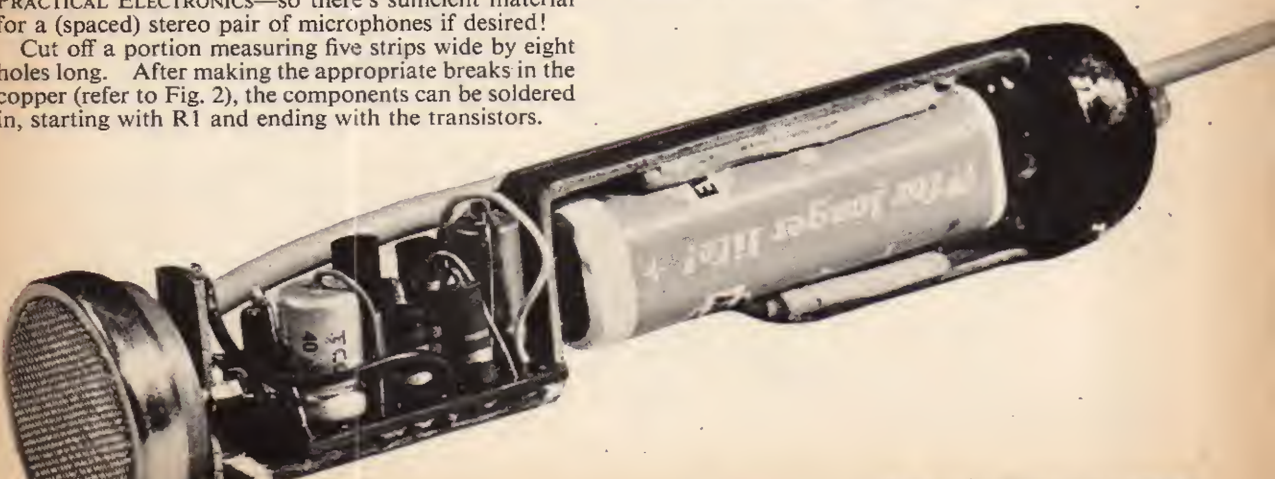
The amplifier occupies exactly half the length of the Veroboard presented with last month's issue of Practical Electronics—so there's sufficient material for a (spaced) stereo pair of microphones if desired!

Cut off a portion measuring five strips wide by eight holes long. After making the appropriate breaks in the copper (refer to Fig. 2), the components can be soldered in, starting with R1 and ending with the transistors.

To ensure the finished assembly will go into the tube, all component leads must be cut to the absolute minimum and solder blobs, rough ends, etc. should be filed away from the underside of the board.

It is important that the amplifier board be insulated from the S-shaped sub-frame, this prevents the copper strip on the underside of the board from being shorted out. This is best accomplished by cutting out a piece of cardboard, or any plastics material, the same size as the wiring board and glueing it between the underside of the wiring board and sub-assembly chassis.

If the amplifier is to be tested before making up the rest of the microphone, use an earthed tobacco tin or something similar to screen the input.



View of the completed transistor microphone prior to insertion in the metal tube. It is important to insulate the amplifier board from the metal sub-assembly.

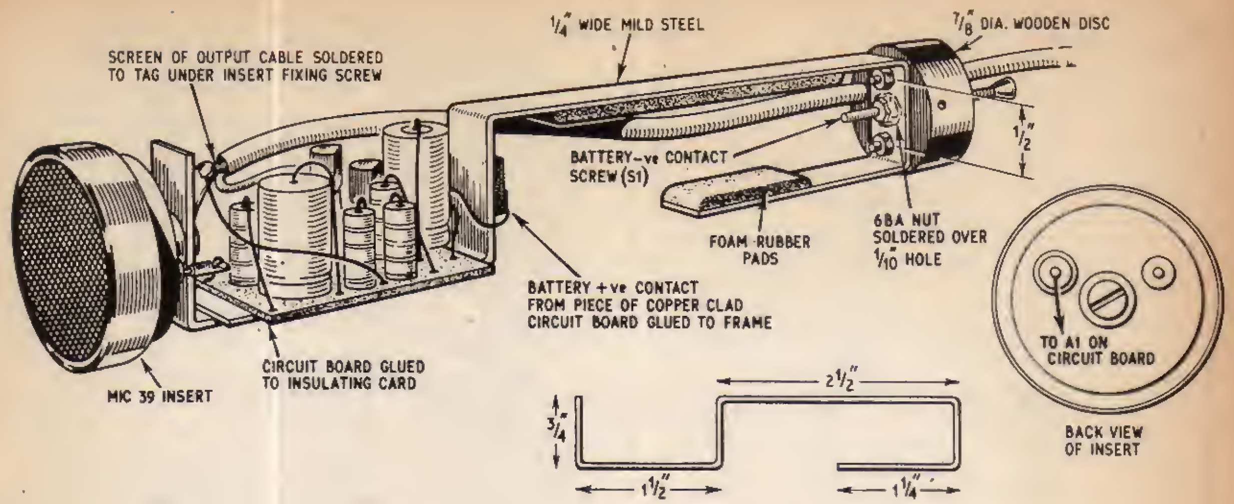


Fig. 3. Construction of the transistor microphone, with battery and metal cover removed

MECHANICAL CONSTRUCTION

The drawings (Figs. 2 and 3) and photographs give most of the constructional information necessary. The amplifier and battery are mounted on an S-shaped sub-frame of mild steel, carrying the microphone insert at one end and a circular block of wood plus a made-up on/off "switch" at the other (Fig. 3). The case is a $\frac{7}{8}$in i.d. thin-walled steel or copper tube (it must of course be metallic) secured by two screws into the wood block. The tube is grounded by contact with the rim of the insert.

The length of the sub-frame, and the quantity of strip needed to make it, is a little unpredictable because the radius of the bends will vary from one constructor to the next. Start with slightly more strip than necessary and cut off the excess after making the final bend. After drilling the appropriate holes and attaching the insert and wood disc, the assembly can be measured and the tubular case trimmed to size.

The wood disc in the prototype was cut with a hacksaw from a piece of whitewood $\frac{3}{4}$in thick and filed to shape, but constructors who take pride in their carpentry or who own a lathe will no doubt use their own methods.

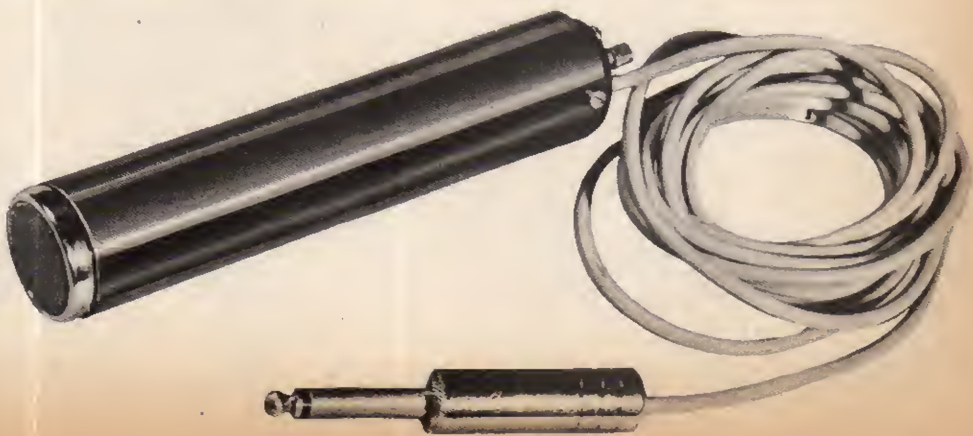
FITTING THE INSERT

When connecting the amplifier to the insert on no account make a direct soldered connection, because the heat will immediately dissolve the crystal. Use a gramophone cartridge type connector, or trap the lead under a piece of plastic sleeve pushed over the "live" post. Note that the "earth" pole is integral with the case and need not be used, as continuity is achieved via the central fixing screw and 4B.A. tag.

FINAL FINISH

Various finishes are possible. The tube can be given a "satin" finish by twisting it in a wad of wire wool and protecting with a couple of coats of clear lacquer, or it can be painted.

For the sake of trying a new material, the prototype was sheathed in black "Polyshrink" (available from Home Radio), which is a soft plastics tubing that shrinks dramatically when heated. The correct size is No. 50, suitable for covering objects of 0·8in to 1·25in diameter. A particular advantage of the material is its ability to damp handling noises.



View of the completed transistor microphone

USING THE MICROPHONE

Before setting up the completed unit for trial one most important point must be noted. The amplifier will not function until the contact adhesive used to attach it to the sub-frame is completely dry. The prototype produced a terrifying rumbling noise caused by leakage through the damp glue from the supply line to the high impedance input, and had to be left overnight for the noise to subside.

The specified insert is "pressure operated" and therefore non-directional over most of the frequency range. At higher frequencies however, it has a greater sensitivity to sounds arriving directly on axis, which can be useful in balancing the "presence" of individual voices or instruments.

Average male speech at a distance of 12in from the microphone produces a peak level of about 70mV at the amplifier output, and at 3ft an upright piano (played forté) produces 400mV, so that normally the microphone will be used in the line, or radio, socket of a recorder or amplifier.

Fig. 4 shows a simple attenuator to prevent overloading the first stage of tape recorders having only a microphone socket. Without the attenuator, the output is sufficient to feed a simple passive mixer.

Although the output impedance of the microphone is effectively 2 kilohms so far as immunity to electrostatic hum pick-up on the line is concerned, it should not be operated into a load of much less than 5 kilohms. Doing so will cause distortion on peaks and bass loss through C2.

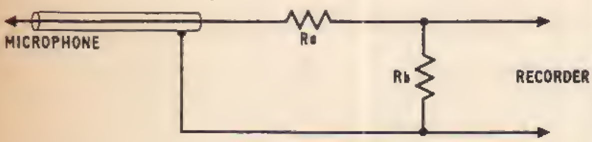


Fig. 4. An attenuator to prevent overloading of recorders that have only a low-level microphone socket. With Rb = 2·7kΩ, Ra should be around 22kΩ for valve recorders and 220kΩ for transistor models. Components should be at the recorder end of the microphone output cable, and can probably be mounted inside the plug

PERFORMANCE DETAILS

Judged subjectively the microphone has a most satisfactory performance, with a noise level far lower than could be achieved with the same insert feeding a typical valve pre-amplifier. The maker's literature for the 39/1 insert quotes a frequency response flat from 40Hz to 15,000Hz, with a broad peak of 5dB at about 8·5kHz. Played through wide-range equipment, the peak is noticeable as a slightly metallic quality on orchestral instruments, but this is the only clue to the "economy" nature of the device.

The battery should last at least six months, used for an hour every day or for eight hours each weekend. Expressed another way, 3s worth of energy will allow recording of 120 7in reels of l.p. tape at 7½in/sec. The complete transistor microphone with battery and flex costs less than £2 10s.

★

UNLIMITED!

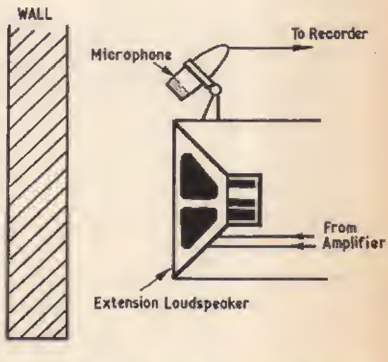
A selection of readers' suggested circuits. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

This is YOUR page and any idea published will be awarded payment according to its merit.

PHASE SPEAKER

After reading the article in Practical Electronics on Musical Phase, September issue, I thought my method of making phased recordings may be of interest.

The signal to be phased is amplified in the normal way, but the output is fed into an extension speaker with the microphone of a tape recorder mounted as shown in the diagram below.



With the selected programme playing and the tape recorder on record the speaker and microphone are moved towards and away from a sound reflecting surface.

When the speaker and microphone are one foot away from a wall the microphone picks up sound from the speaker only. But when the two are moved closer to the wall, sound reflected off the wall, which is out of phase, is also picked up.

The only problem with this system is that the recording level on the tape recorder has to be decreased as the gap between the wall and speaker/microphone diminishes.

G. Stratton,
Dawlish, Devon.