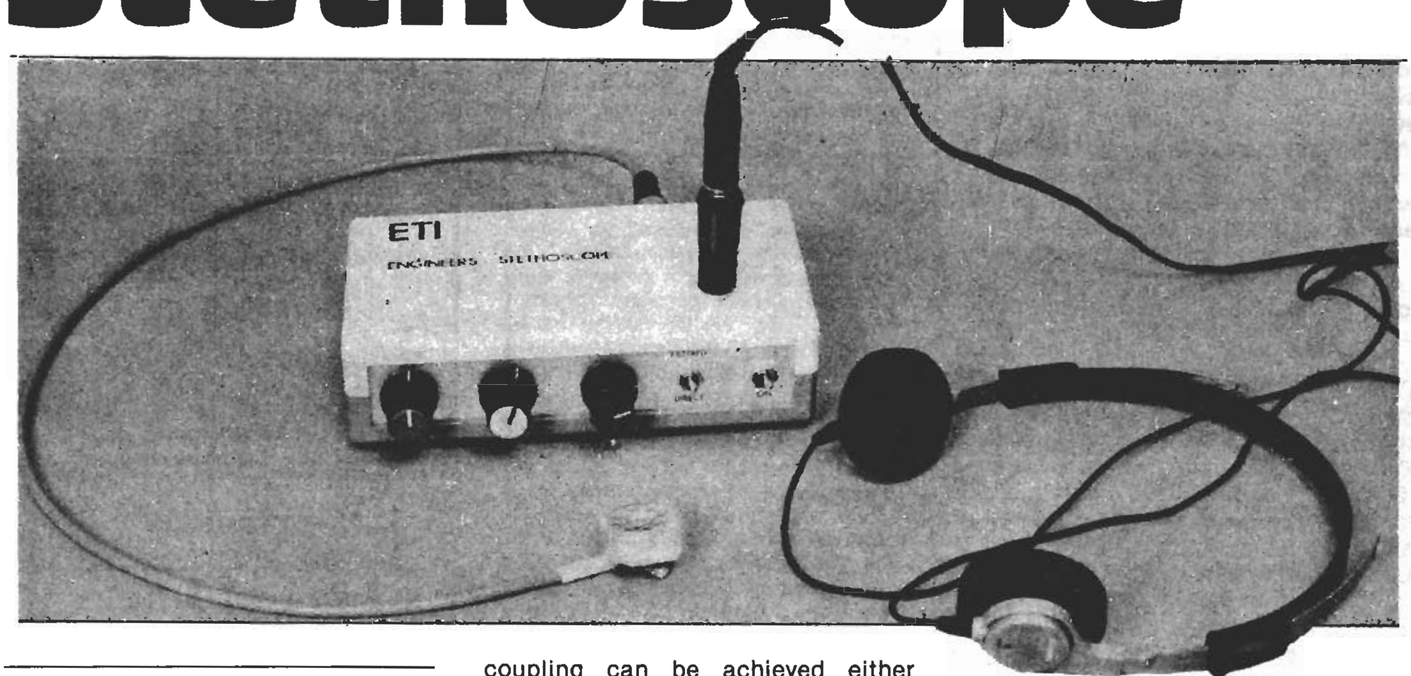
Engineer's Stethoscope



This unusual device lets you locate or listen to internal engine sounds, such as the rumble of bearings or the rattle of valves. An essential project for the DIY nut.

THIS VERY UNUSUAL project enables you to effectively and effortlessly get right inside an engine and listen to, or locate, all of its internally-generated sounds, such as the noises of bearings, pistons, valves, etc. The device is fitted with a double filter network that can be used to pick out one set of sounds (such as those of the bearings or the valves, etc.) from all others, thus facilitating fault-finding on engines.

The Stethoscope project comprises an acoustic probe unit, a 'box-of-tricks' and a pair of conventional headphones. The headphones help muffle ambient sounds, so that you can concentrate on the sounds of the stethoscope even in a very noisy environment. The probe unit is used to make mechanical contact with the engine or mechanism under test and is coupled to the 'box-of-tricks' by flexible leads.

The probe unit relies on mechanical coupling or contact between itself and the engine (or whatever) for acoustic pick-up. The coupling can be achieved either directly or by a metal rod. The rod can take any one of a variety of forms eg a screwdriver or a needle. If a needle probe is used, the stethoscope can even be used to listen to the sounds of individual jewelled bearings in a watch mechanism.

Operating Principles

The stethoscope operation relies on the simple fact that what is commonly called sound is a series of mechanical vibrations transmitted through a medium of some sort — air, water, metal etc. Thus, all the internally-generated sounds of a gas (or any other) engine, such as the sounds of valves, pistons, bearings, etc, are transmitted throughout the engine block and can readily be further transmitted down a metal rod (or screwdriver, etc) to the body of an acoustic pick-up device such as a microphone.

Our stethoscope relies on this mechanical coupling principle. We use a crystal mike as the pick-up device, with all of its air holes blocked off (to exclude dirt) and with the coupling made to its body either directly or by some kind of metal rod. The use of rod coupling enables the source of a given sound to be precisely located within (say) an engine block, by simply probing to find the position of maximum noise. If a needle probe is used, the sound source can be located with pin-point accuracy.

Construction

The Stethoscope circuit is fairly simple and construction should present very few problems. Wire up the PCB first, noting the use of 20 Veropins to facilitate interwiring, as shown in the component overlay. When wiring up RV1 and RV2 take special care to connect the two halves of each component in the same phase, so that the resistances increase or decrease together.

On our prototype we've fitted the two 9V batteries into the top half of the case, secured by double-sided tape. We've fitted a small jack socket to the case top to facilitate connection to the external low-impedance headphones and have used a 3-pin socket for connecting the probe unit.

Finally, to complete construction, wire up the probe circuit as shown in the circuit diagram, taking care to fit Q1 and R1 as near as possible to the crystal mike terminals and connect the assembly to a suitable plug and lead.

At this stage, give the unit a simple functional test by placing the head against the speaker of a small radio. Check that tone quality and volume can be varied with the three

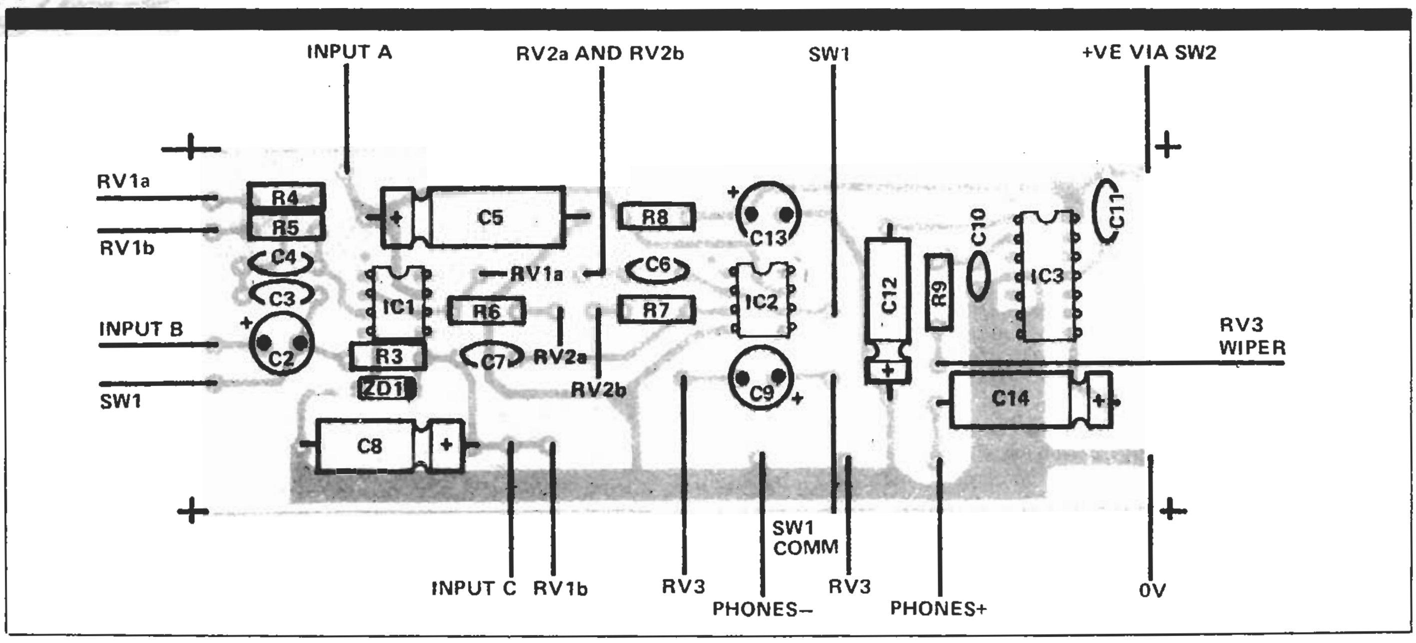


Fig. 1. Component overlay.

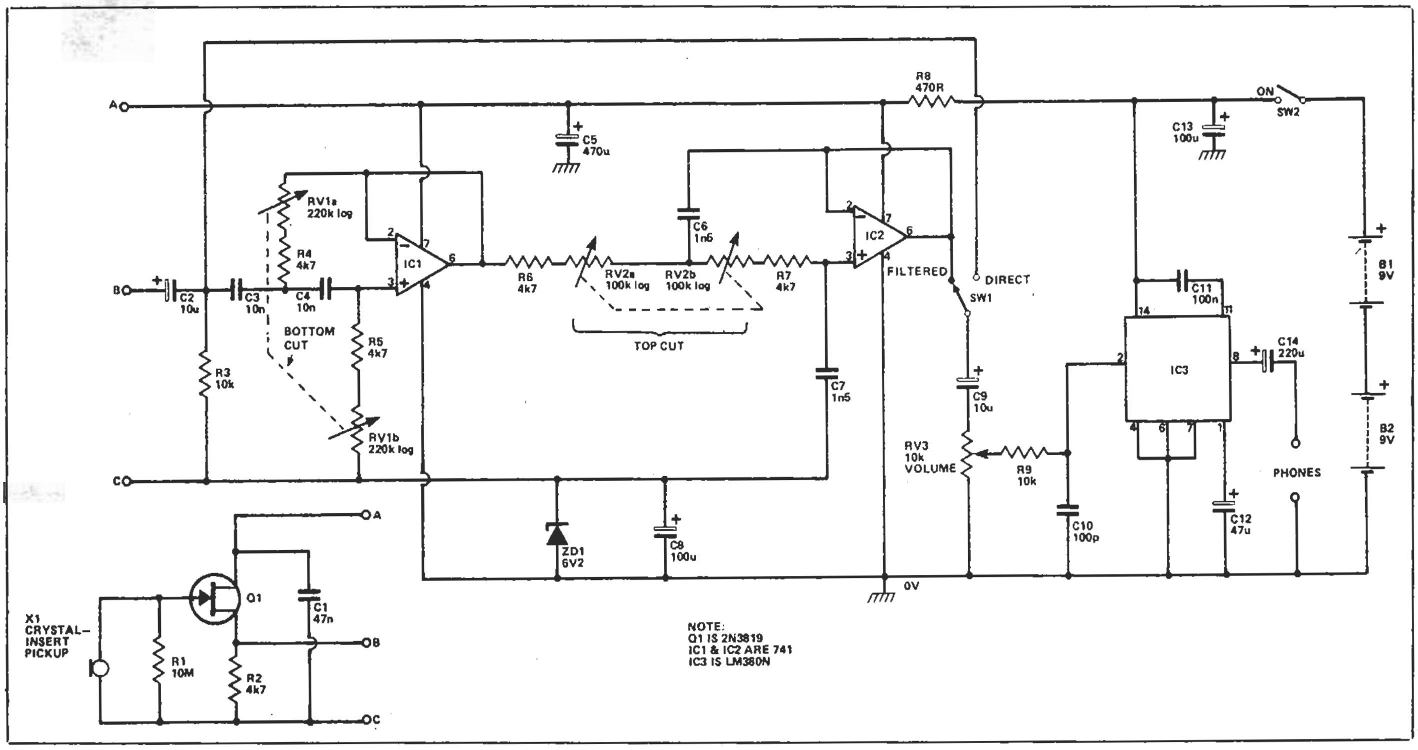
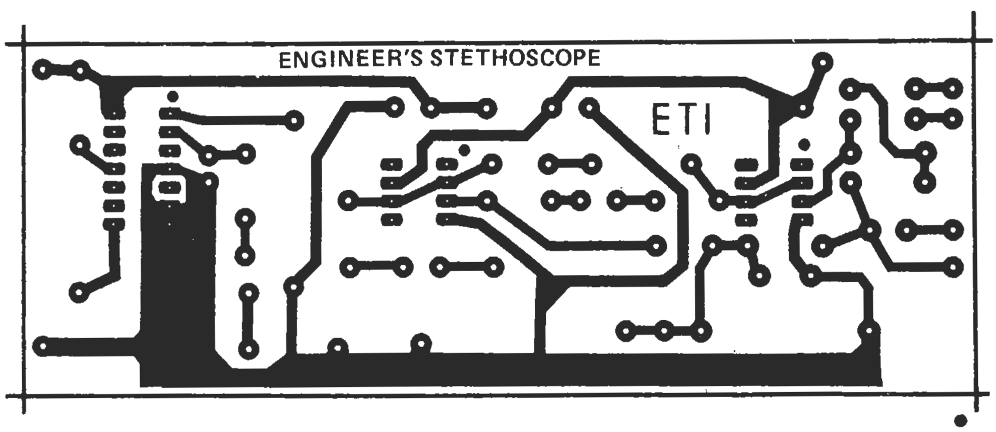


Fig. 2. Circuit diagram.

controls. When the above test is satisfactory, complete the probe construction by blanking off (with tape) air holes in the insert (to exclude dirt and oil) and encapsulate the electronics in wax or resin. On the completed circuit the probe can work as it stands or can be epoxied to a screw terminal or clip (or both) that can be used to make connections to a variety of probe types (metal rods, a screwdriver, etc). The Stethoscope is intended for use with a pair of headphones of not less than 8R0 impedance.

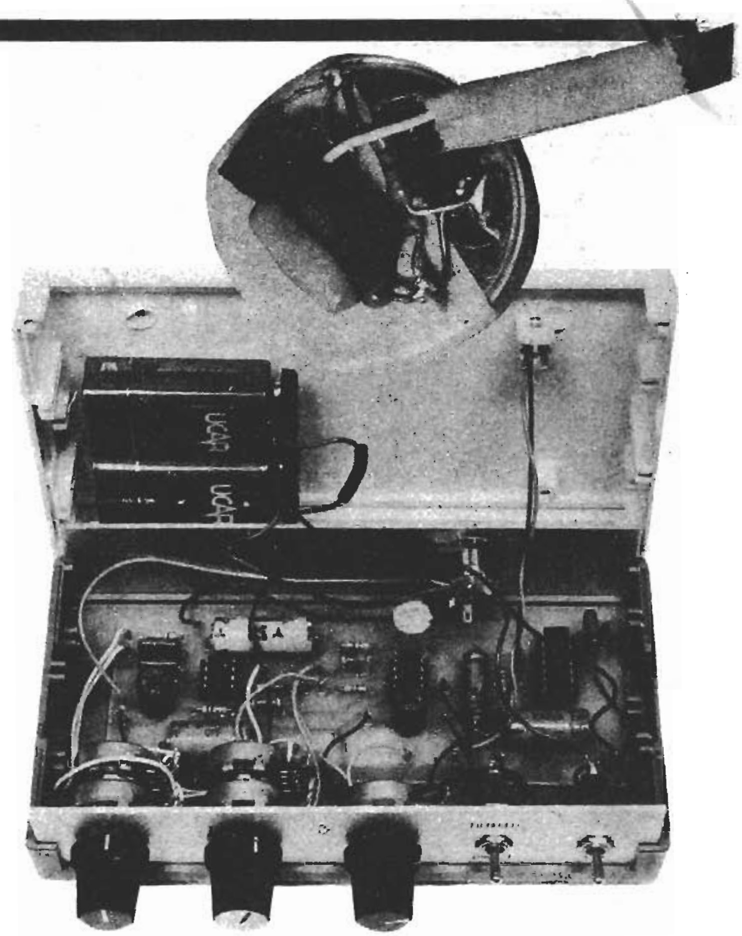


How It Works

A common crystal mike is used as the pick-up device, with the external mechanical sound vibrations being fed to its body either directly or by a metal rod from the engine (or whatever) under test. FET source follower Q1 is wired directly to the output of the pick-up device, to give a low-inpedance output from the resulting probe. The output of the probe circuit is then fed, either directly or through a double filter network, to a power amplifier stage (IC3) and then on to a pair of headphones.

When the stethoscope is used in the filtered mode, the output of the probe circuit is first passed through high-pass (bottom-cut) filter IC1 and then on to the power amplifier via low-pass(top cut) filter IC2. both of these filters are second-order variable types. The IC1 filter can be used to reject signals below roll-off frequencies that are variable from 80 Hz to 3 kHz via RV1 and the IC2 filter can be used to reject signals above roll-off frequencies that are variable from 700 Hz to 15 kHz via RV2. These two filters can be used to pick out specific sounds, such as the low-frequency rumble of bearings or the high-frequency rattle of valves, from the broad spectrum of sounds that are generated by an engine.

The complete stethoscope is powered by a pair of 9 V batteries and typically consumes about 15 mA when driving a pair of 8R0 headphones. The split power supplies to the IC1-IC2 op-amp filters are generated with the aid of ZD1 and C8.



R1, R2, C1, and Q1 are wired directly across the mic. insert. We fixed our batteries to the top half of the case.

Parts List

Resistors All ¼W 10%

R1	10M
R2,4,5,6,7	4k7
R3,9	10k
R8	470R
Potentiometers	
RV1a,b	220k dual logarithmic
RV2a,b	100k dual logarithmic
RV3	10k logarithmic
Capacitors	
C1	47n polycarbonate
C2,9	10u 63 V electrolytic, PCB type
C3,4	10n polyester
C5	470u 25 V axial elec
C6,7	1n5 polycarbonate
C8,13	100u 25 V axial electrolytic
C10	100p ceramic
C11	100n polyester
C12	47u 25 V axial electrolytic
C14	220u 25 V axial electrolytic
Semiconductors	
IC1,2	741
IC3	LM380
Q1	2N3819
Miscellaneous	
SW1,2	DPST miniature toggle
SK1	3-pin socket
SK2	3.5mm jack socket
Case	Vero No. 202-21040

3 off knobs to suit
Crystal mike