For tennis players — an electronic 'let' caller

This low cost, simple to build project detects when a ball 'tips' the net cord as it passes over — no more disputes about whether it did or it didn't! No false alarms either.

Geoff Nicholls

TENNIS IS a popular outdoor sport, particularly in summer. But a 'friendly' game can be spoilt by bad feelings arising from a dispute — particularly where a 'let' call is involved, where the ball is seen to 'tip' the net cord wire as it passes from one side of the court to the other. This little project will solve such disputes and is safe from 'human fallibility', provided it is correctly set up — a simple procedure.

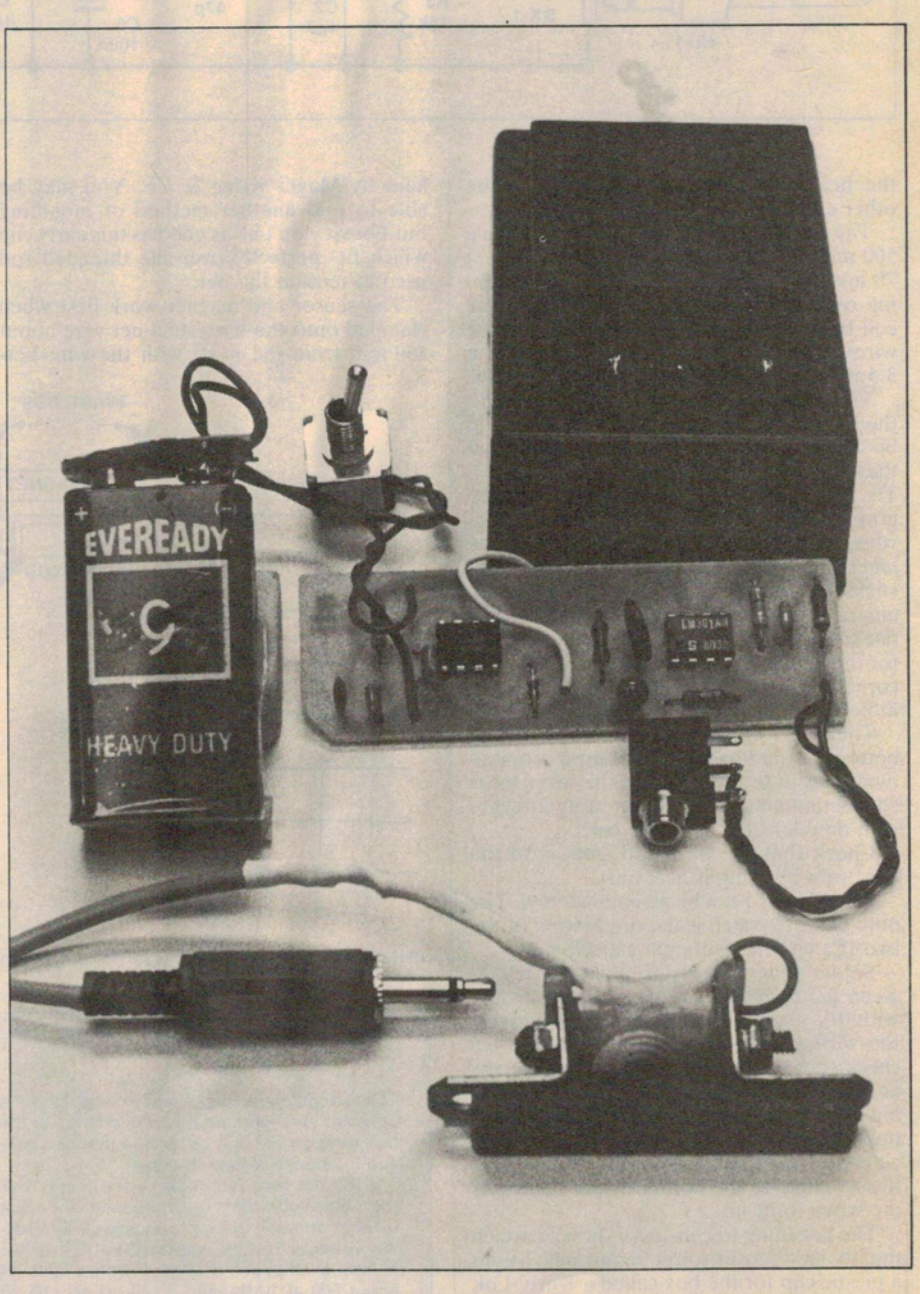
When I first thought of this project, I realised some sort of sensor and detection system that was free from false alarms would be necessary. This ruled out using a microphone attached to the net cord. As net cords are (usually) steel, I hit upon the idea of using some sort of magnetic sensor. It was obvious that trying to slip a coil over the net cord was out of the question, so some other scheme had to be devised. Then again, winding coils is tedious, so a ready-wound coil of some description was necessary. Casting around for something suitable we discovered reed relay coils were cheap and readily available, so I did some experiments to see if one could be pressed into service. It worked!

Thus, the sensor consists of, simply, a reed relay coil, a few brackets and a small bar magnet. This assembly is attached to the steel net cord, as shown in the accompanying diagram. When the ball strikes the net cord, a travelling wave moves out from the point struck by the ball, toward the net cord supports. The movement of the steel net cord in the magnetic field in the vicinity of the sensor coil causes a small variation in the magnetic field, inducing a voltage across the ends of the coil. This voltage pulse is detected and an alarm is sounded.

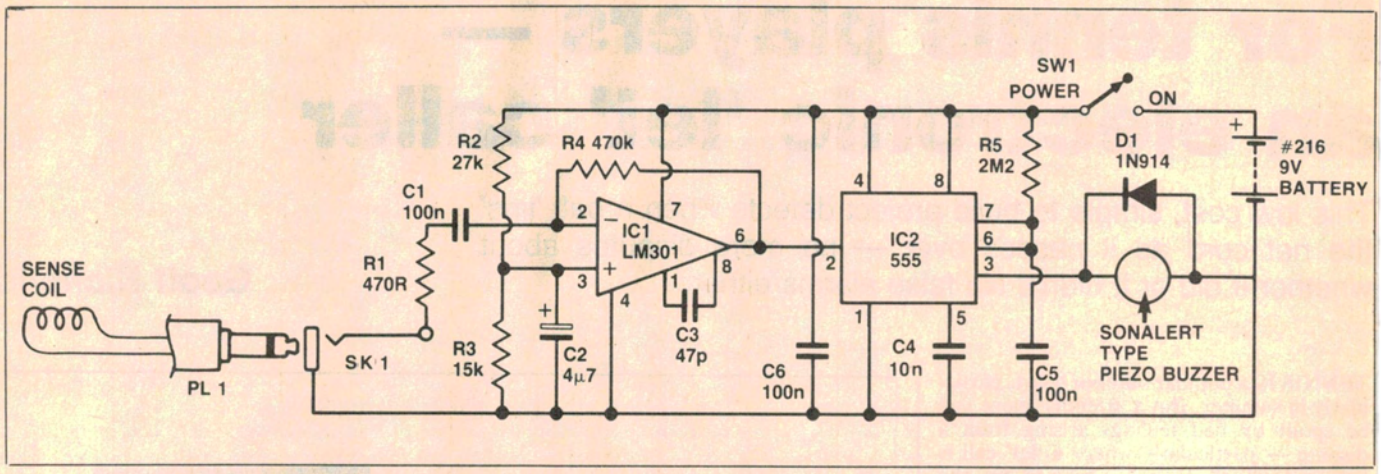
Construction

Everything except the sensor mounts in a small plastic box, the printed circuit board slots in to the grooves on the walls of the box with the 9 V battery on one side and space for the switch and sensor socket on the other side. The front panel is dressed up with a Scotchcal label.

The only unusual part of the project is the sensor, so I'll start with it. The heart of it is a reed relay coil, with a ⅛" (3 mm) steel screw down the middle clamping a small right angle steel bracket to each end. (See the accompanying photo). To create a good magnetic circuit I screwed two nuts up to



Neat and simple. All the bits for the Let Caller. There's not much to it, but it's certainly effective. The sensor coil is shown in the foreground. It mounts on the net cord (see diagram next page). ▶



the head end and put three nuts on the other end.

The sensor connects to the main unit via a 500 mm length of shielded cable, with a 70 mm length of 4 mm dia. heat-shrink tubing over the join. Secure the cable to the coil body with tape to relieve stress on the wires. Complete the sensor by soldering a 3.5 mm plug to the other end of the cable.

The Scotchcal label can be attached to the box lid now, the corner markers should be a few mm outside the lid area, so that they won't show when the label is trimmed. To get a good finish with a white background label I usually spray the lid with flat white paint and let it dry before sticking the label down. Once the label touches the lid it sticks fast, so it is important to carefully align it beforehand. Rub any trapped air pockets toward the edges and drill the holes for the switch and socket, then trim the four corner holes and lid edges with a sharp knife.

The piezo buzzer mounts on the plastic bottom of the box; the one I used required two holes in the box to pass the wires to its connecting pins. The buzzer easily attaches with double-sided adhesive tape.

Check that the pc board slots onto the box, trim by filing if necessary.

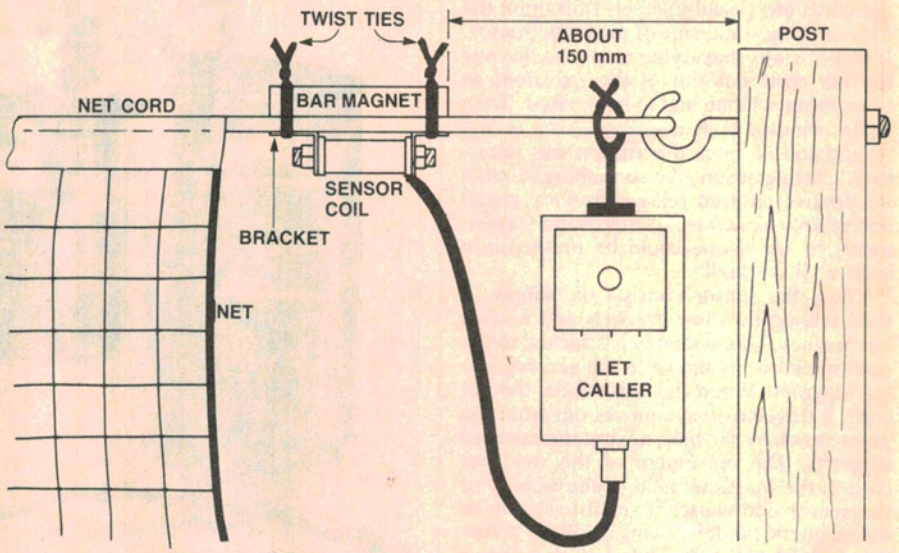
The pc board can be assembled now. The only point to watch is the orientation of the two ICs and the tantalum capacitor.

Solder a twisted pair of hookup wire between the pc board and the 3.5 mm socket, with 0 V going to the shield side. Complete the wiring to the battery and switch, then check that everything goes together. If the lid won't fit it is probably due to wires passing over the pc board. There are two solutions to this; either solder the offending wires to the copper side of the pc board or file an angle at the corner of the board for the wires to fit in.

The last thing to consider is how to attach the box and sensor to the tennis net. I used a plastic clip for the box called a Kurly-Lok On Base, Richco part no. KLB-750A. It is 40 mm high, has an adhesive base about 12 x 25 mm and is made by Richco, distributed here by Mayer Krieg & Co. You may be able to find another method of mounting but I bet it won't be as good as this curly clip which fits perfectly over the threaded rod used to tension the net.

The sensor and magnet work best when clamped onto the bare steel net wire about 150 mm from the post, with the wire between the two. I used wire ties as supplied with loaves of bread, although a clothes peg may be adapted to make it easier to attach.

The sensitivity is directly related to the strength of the magnetic field at the sensor coil. A small bar magnet is adequate, an old speaker magnet is superlative! (but probably 'overkill').



Installation. It's simple. Tie the sensor coil and magnet on the net cord about 150 mm from the post and hang the box near the post.

HOW IT WORKS — ETI-273

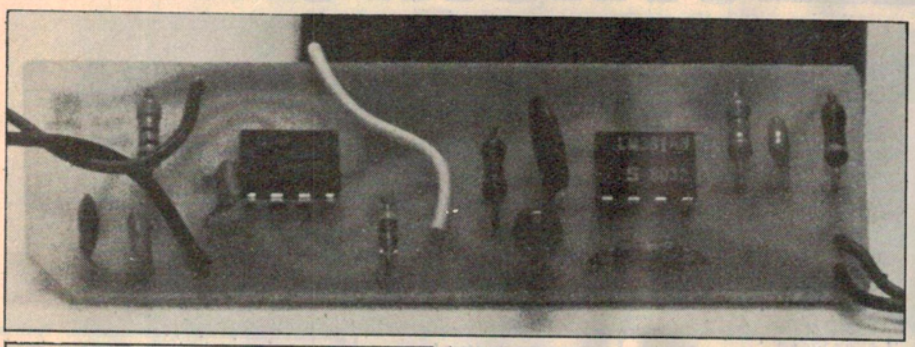
The sense coil is magnetically coupled to the net cord steel wire so that any change in the flux through the coil causes an induced voltage to appear across thd coil.

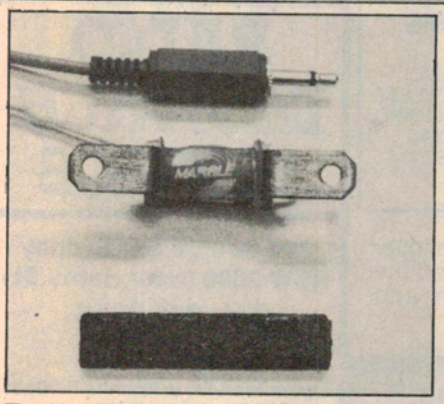
If the net wire is struck by the tennis ball the vibrations set up modulate the flux through the coil, thus producing an alternating voltage. This is amplified by IC1, an ac inverting amplifier designed with a gain of about 500 at 1 kHz, and a roll off of −20 dB per decade each side of that frequency.

Resistors R2 and R3 bias the amplifier's output to just over one-third of the supply voltage, C3 filters that bias voltage. IC2 is a 555 timer configured as a monostable multivibrator or one-shot with an interval of a quarter of a second.

When the voltage at the trigger input (pin 2) is less than one-third of the supply voltage, a timing interval is initiated, which sounds the piezoelectric buzzer. So any slight disturbance in the flux in the sense coil will cause the voltage at pin 2 of IC2 to drop below one third of the supply and activate the buzzer.

Diode D1 clamps any reverse voltage spikes from the buzzer, preventing false triggering.





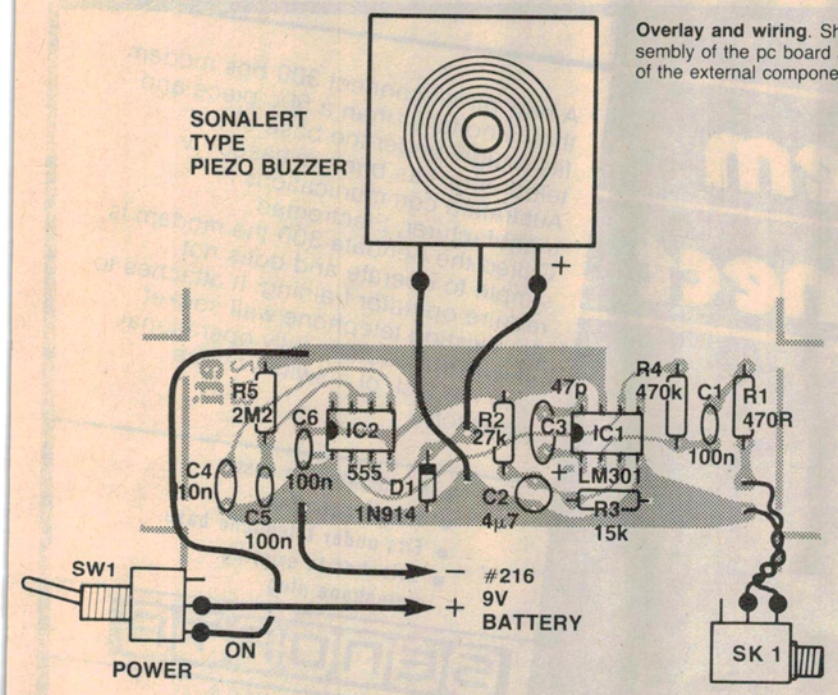
The bits. Above is a view of the completed pc board, below is a view of the completed sensor coil assembly.

Using it

The Let Caller will beep once on power up, and may beep continuously if the sensor is not plugged in.

Since it responds to high frequency vibrations, a very slow serve may not 'twang' the net cord enough to trigger the unit, although I have used it for several hours and it never missed one. The wind doesn't seem to affect it either, and balls hit into the bottom of the net won't always trigger it. This confirms the validity of the sensor design and its superiority to a microphone-based system.

Having dispensed with the umpire, have a happy tennis game! ●



Overlay and wiring. Showing assembly of the pc board and wiring of the external components.

Board and panel. The pc board artwork is at left, panel artwork on the right. Both are shown full-size.

OTHER USES

The pc board could be used for a number of other purposes besides a Let Caller. For instance, the sense coil may be replaced by most transducers, as long as R4 was adjusted to suit the particular unit. The pulse length from IC2 can be increased by replacing C5 with a higher value tantalum capacitor. You could experiment and come up with a motor-bike alarm etc. The 555 IC can easily drive relays, so a high power load could be switched. The power supply can be anything up to 15 Vdc, so experimenters, go to it!

PARTS LIST — ETI-273

Resistors.....all ¼W, 5%
- R1.....470R
- R2.....27k
- R3.....15k
- R4.....470k
- R5.....2M2

Capacitors
- C1, C5, C6.....100n ceramic
- C2.....4µ7/35 V tant.
- C3.....47p disc ceramic
- C4.....10n ceramic or greencap

Semiconductors
- IC1.....µA301, LM301, µA308, LM308
- IC2.....555 timer

Miscellaneous

ETI-273 pc board; Scotchcal front panel label; plastic 'zippy' box 80 x 50 x 30 mm; piezoelectric buzzer — Sonalert, Murata or similar; reedy relay coil — D.S.E. cat. no. S-1948 or similar; 3.5 mm plug and socket (optional); 500 mm shielded cable; type 216 9 V battery and snap connector; single-pole single-throw (SPST) miniature toggle switch;m two right angle steel brackets 12 x 12 mm; ⅛" x 2" Whitworth (3 mm x 50 mm) steel bolt and five nuts; curly-clip — Richco KLB750A or similar; 50 mm long bar magnet; double-sided stick tape; hookup wire etc.

Price estimate: $20-$24