Project 576

The electromyogram — part 2.

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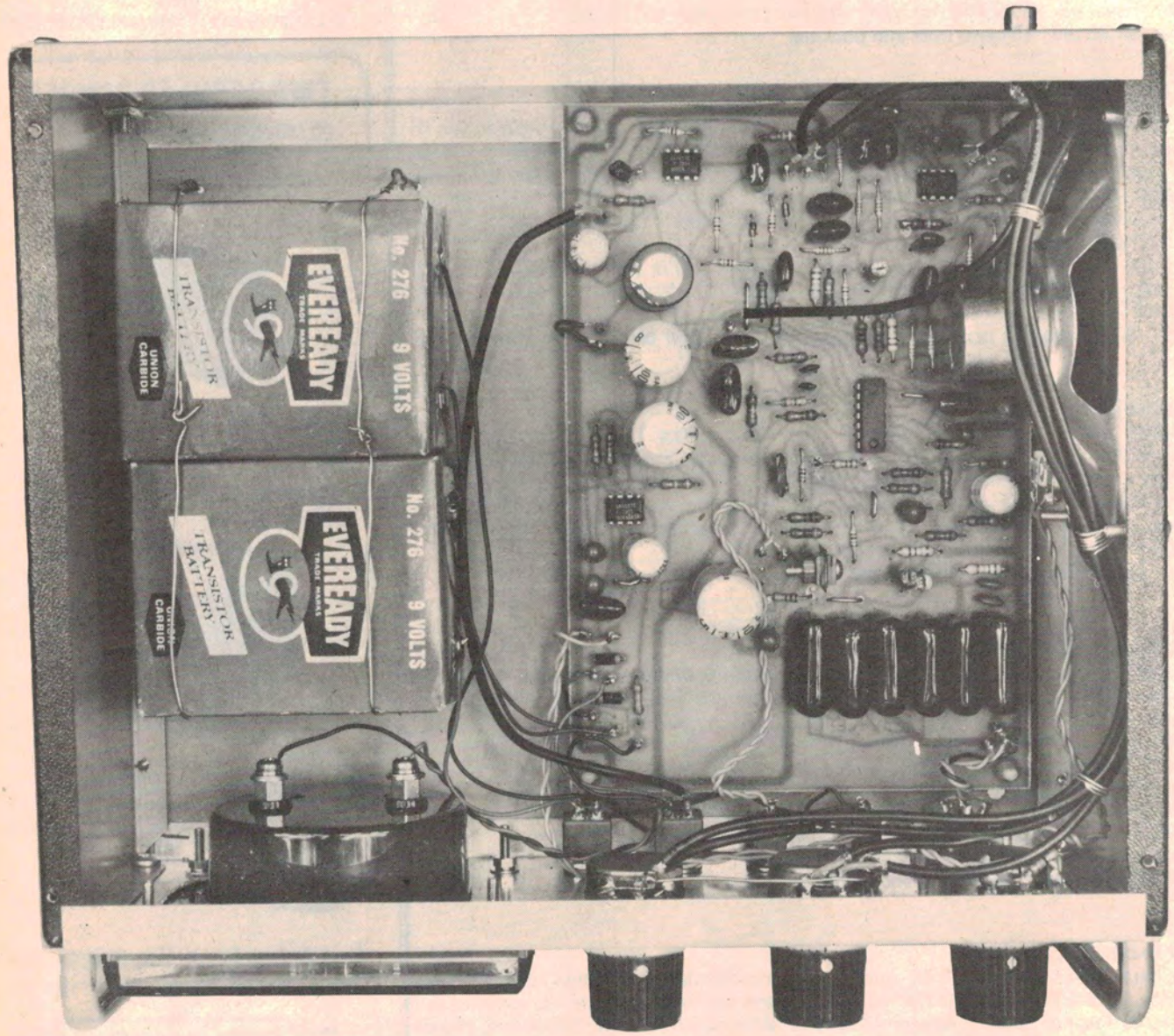
This month we present construction details and some suggestions on using the instrument



OUR PROTOTYPE was housed in a Horwood instrument case measuring 254 mm wide by 203 mm deep by 102 mm high. These are available from quite a few component suppliers but any box with similar dimensions should suffice. The advantage of this particular case is that it is supplied with steel top, bottom and side panels which provide better shielding from stray hum fields than does aluminium.

Construction is best commenced with the pc board. This method of construction is recommended as layout of the various stages is critical to avoid feedback or interaction between stages as one LM3900 package does sterling service in several parts of the circuit!

Assembly of the pc board should start with the resistors and capacitors. I found it easier to leave the six 1 uF input capacitors until the input transistors (Q1-Q4) were mounted. Be sure to check the polarity of the electrolytic and tantalum capacitors.

Finish loading the pc board by inserting the diodes, transistors and ICs. The input transistor pair, Q1 and Q2, must be mounted so that their flat faces are touching to provide thermal coupling. The best way to do this, to avoid straining anything, is to solder only the collectors and emitters of Q1 and Q2 at first. Smear some thermal paste on the two flats and then tie the two transistors together using a link of enamelled (coil) wire – this prevents the possibility of shorts to the transistor leads should the loop slip off at some time. Tighten the loop by taking the ends in a pair of pliers and twisting until the transistors are held tightly together. Once this is done, solder the base leads.

The two BD140s, Q3 and Q4, also need to be mounted together. As they are in TO-126 packages they may be bolted together. It is necessary to use an insulating washer between them to prevent the collector contacts touching. Use thermal paste to improve the thermal coupling.

Once these devices are mounted, six 1 uF input capacitors may be soldered into place.

If you use pc board pins, the external connections to the board may be made after it is mounted in the case, otherwise, now is the time to attach all the leads going to the externally-mounted components.

As high gain stages are used in several places, the circuit is sensitive to noise or signals radiated from other parts of the board. The 555 VCO output can be especially troublesome, so use shielded cable to connect the output of the 555 to the volume control. The only resistor not mounted on the pc board (R50) is mounted between the wiper terminal of the volume control and one of the loudspeaker terminals.

There are a number of other connections that should be made with shielded cable and these are shown in the wiring diagram.

There is sufficient room inside the cabinet to accommodate a variety of 9 V batteries. The type of connection to the battery will depend on the particular style of battery used.

The speaker is mounted on one side of the cabinet and the monitor output (and RCA coax socket) is mounted on the back.

On the front panel, the switches should be mounted first, followed by the pots and the meter. Juggle the pc board into the case last.

Electrode construction

Although the common mode rejection of the input is better than 100 dB this will be degraded drastically if the contact to the skin is not good enough. To enable the input stage CMRR to effectively reduce 50 Hz hum it is necessary to ensure that the hum is exactly the same level on both inputs. For this reason the construction of the electrodes is very important.

The diagram on page 65 shows the electrodes we built. Three lengths of shielded cable were used (RG174 coax). The two input leads are made by soldering the centre conductor of the shielded cable to small metal discs about the size of 5c pieces. Cut the earth braid back enough so that it cannot touch the electrode. The braids of the two input cables are connected to pin 2 of the five-pin DIN plug (the grounded pin). This pin is also connected to the shield of the third cable which becomes the ground electrode. The centre conductor of this cable is not used and the other end of the braid is soldered to another metal disc. Use a slightly larger disc (about the size of a 10c piece) as this helps to ensure a good ground connection to the body.

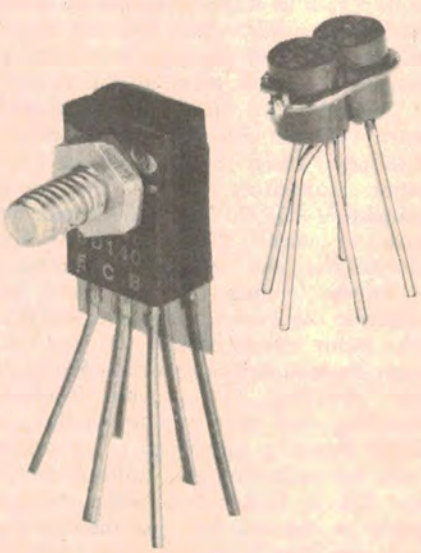
How to use it

Before powering up, check the pc board. Check the orientation of all the polarised components – electrolytic and tantalum capacitors, transistors, ICs and diodes. If everything is all right, switch the unit on with the battery switch in the test position. With 9 V batteries the meter should read about 9. If the battery switch is now switched off the meter should immediately fall to zero provided the gain control is turned fully down. If the volume control is turned to full on a slow clicking should be heard. Now, measure the voltage (with respect to earth) at the test point (TP1) at the output IC1a (pin 4). With the x10 switch in the x1 position adjust the preset pot to obtain zero volts.

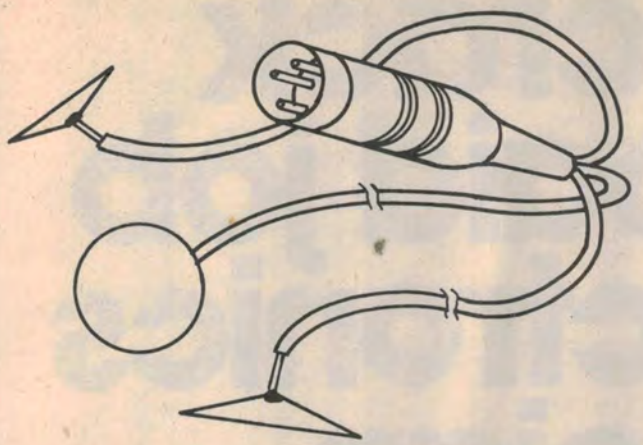
If the gain control is now increased, the meter reading will move along with the frequency of the clicks.

Now, advance the threshold control and the meter reading and click frequency should decrease. This threshold control works by varying the minimum signal required to cause a meter response. The higher the threshold control is set, the higher the input signal must be to cause a meter response. The threshold can be set just above the noise level so that even a very small input signal can be detected.

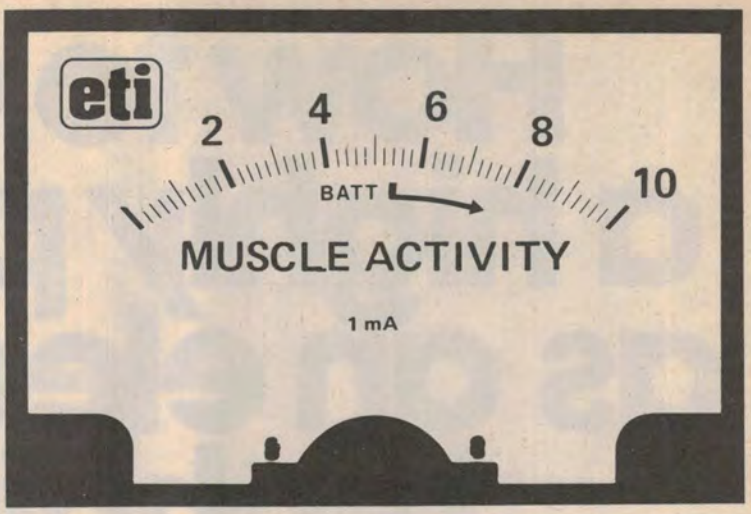
The electrodes can now be connected to the body and plugged in. The ideal way to secure the electrodes to your skin is to use a band of Velcro (Tm) tape, although we found Bandaids okay. If all three electrodes are placed reasonably close to each other along the inside of the arm (earth between the others) they can be secured in place all



Thermal stabilisation is achieved by mounting the input transistors together as shown and described in the text. Note the insulating piece between the BD140s.



The three electrodes.



Full size reproduction of the meter scale.

at once with a single wide band of Velcro wrapped right around the arm. Some electrode paste may be used between the electrodes and the skin to improve the contact. This is available from some distributing chemists and medical suppliers, although it is relatively expensive. We found moistening the electrode to be a good alternative.

Once the electrodes are attached to the arm and plugged into the EMG monitor a reading should be easily obtained. Start with the gain and threshold controls set fully anti-clockwise, the gain switch in the X1 position and the integrate switch off.

If the arm is tensed the meter should indicate muscle activity readily. With these settings the EMG is really acting as a strength meter. Relaxing the arm, the gain switch can be switched to the x10 position and the gain control slowly increased. With each gain increase, the threshold can be increased slightly to cancel any increase in noise that may have occured, although don't overdo the use of the threshold control until you are familiar with the unit as it is easy to cover up muscle activity as well as noise.

Eventually you should reach a stage such that the gain control can be set at maximum but with muscle activity held so low that the meter reads about 2 to 3.

This isn't easy! In fact the only person who has been able to do this so far has been Tom Benjamin, the author of our article on biofeedback, and quite a few of us have tried!

Some experimentation with electrode placement will indicate how to get good results on particular muscles.

For some background reading on EMG instruments, an article in the March/April issue of "Physiotherapy Canada" (published by the Canadian Physiotherapy Association) on EMG biofeedback, pages 65 to 72, gives an overview and a very comprehensive list of references. ●

PARTS LIST - ETI 576

Resistors all ½ watt, 5%

R1, R2 . . . . . 220k
R3 . . . . . 4k7
R4 . . . . . 100R
R5, R6 . . . . . 2M2
R7 . . . . . 4k7
R8 . . . . . 1M
R9 . . . . . 4k7
R10, R11 . . . 1M
R12. . . . . 1k
R13. . . . . 8k2
R14–R17 . . . 47k
R18. . . . . 220k
R19. . . . . 270k
R20. . . . . 10k
R21. . . . . 100k
R22, R23 . . . 1M
R24. . . . . 10k
R25, R26 . . . 100R
R27–R30 . . . 47k
R31. . . . . 220k
R32. . . . . 270k
R33. . . . . 10k
R34. . . . . 330k
R35. . . . . 560k
R36. . . . . 5M6
R37. . . . . 3M3
R38, R39 . . . 10k
R40, R41 . . . 1M
R42. . . . . 10k
R43. . . . . 390k
R44. . . . . 470k
R45. . . . . 1k
R46. . . . . 680R
R47. . . . . 10k
R48. . . . . 2k7
R49. . . . . 18k
R50. . . . . 27R (mounted on volume pot)

Capacitors

C1–C6 . . . . . 1µ greencap
C7, C8 . . . . . 1n greencap
C9, C10 . . . . 33µ 16V tantalum
C11. . . . . 100µ 25V electro
C12. . . . . 33µ 16V tantalum
C13. . . . . 100n greencap
C14–C17 . . . 68n greencap
C18. . . . . 22n greencap
C19, C20. . . . 33µ 16V tantalum
C21. . . . . 100n greencap
C22. . . . . 1000µ 25V electro
C23. . . . . 33µ 16V tantalum
C24–C27 . . . 68n greencap
C28. . . . . 47n greencap
C29, C30. . . . 1n greencap
C31. . . . . 100n greencap
C32. . . . . 220n greencap
C33. . . . . 150n greencap
C34. . . . . 100n greencap
C35. . . . . 33µ 16V tantalum
C36. . . . . 100µ 25V electro
C37. . . . . 470µ 25V electro
C38. . . . . 47µ 25V electro
C39, C40. . . . 1000µ 25V electro
C41. . . . . 33µ 16V tantalum

Semiconductors

D1, D2 . . . . . IN914 or sim
D3, D4 . . . . . EM401, EM4001, IN4004 or sim

Q1, Q2 . . . . . BC559, BC179, DS559
Q3, Q4 . . . . . BD140
Q5–Q7. . . . . BC549, BC109, DS549

IC1 . . . . . LM3900
IC2, IC3 741
IC4 555

Potentiometers

RV1 . . . . . 1M linear
RV2 . . . . . 5k linear
RV3 . . . . . 1k linear
RV4 . . . . . 1k vertical mounting trim pot

Switches

SW1, SW2 . . . SPST miniature toggle
SW3, SW4 . . . DPDT miniature toggle

Miscellaneous

M1 . . . . . 1mA meter, 100 mm x 80 mm, square face MRA 65B or similar; 5-pin DIN socket; 8 ohm small speaker; panel mounting RCA socket; two 9V batteries type 276 or 2364; knobs, instrument case Horwood 203 x 102 x 254 mm or similar; power cord and plug.