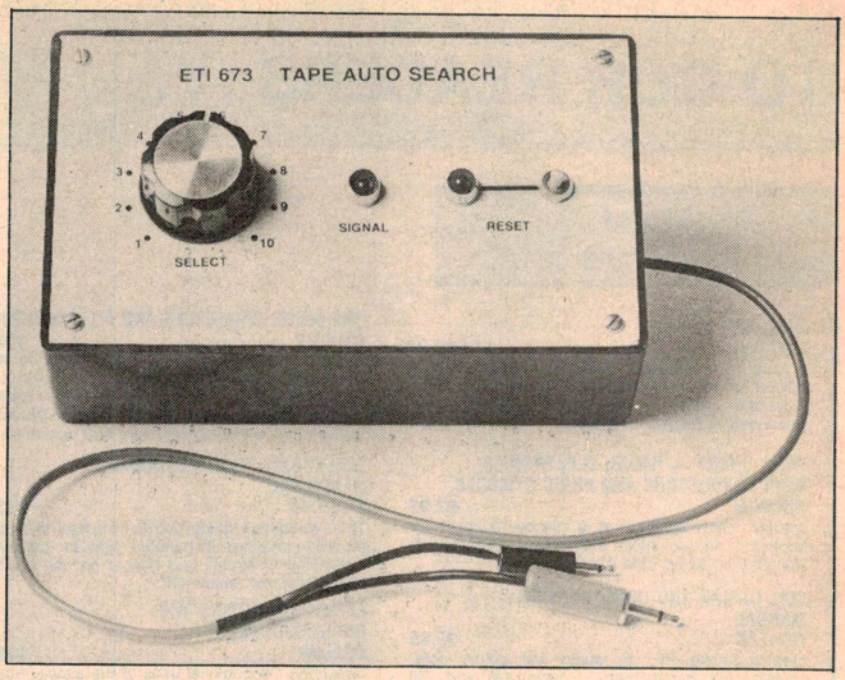
Project 693

TAPE AUTO-SEARCH



THE CASSETTE is probably the most cost effective means of information storage in use today. Capable of storing whole symphonies, dozens of computer programs, or anything that can be converted to an electrical signal, the cassette is surely the most widely used form of data storage.

However, the major difficulty with the cassette is accessing information on it. It usually seems to happen that the section you want is somewhere at the end, and it can often take longer to find the selection than to play it out.

Many tape recorders come equipped with search facilities, which will fast forward to the desired track, stop, and then enter the play mode. Marvellous, if you have one, even better if you can commandeer it for your exclusive use to help find the computer program you know is somewhere about half-way along the cassette.

The ETI-693 is a simple add-on device that can be plugged into a suitable portable cassette player, and which can then be used to find any one of 10 selections in a very short time. It uses a player that can cue in search mode, like the National RQ-2133, or other players with modifications.

The principle of operation is to count the gaps between each track, and to then stop when the right number of gaps have been passed. This means that the play head must be in contact with the tape when the tape player is in its fast forward (or even rewind) modes. One difficulty, of course, occurs when the information on the cassette is analogue such as music or speech, and when quiet sections (or pauses in speech) occur. The search system registers these pauses as a gap, and you end up in confusion. However, with judicious selection of components and time periods between each selection on the cassette, even this problem can be overcome. In general, the unit will work best with digital data, but I have used it for both purposes with great success.

The 'hardware'

Before discussing the auto-search unit, it is better to first attend to the requirements of the cassette player. Depending on the brand of player some modifications, either electrical or mechanical, may be required. I have successfully integrated the unit with two totally different types of players, and have checked various others for their suitability.

The main mechanical requirement is that, when the player is in its fast forward mode, the play head be in light contact with the cassette tape. As it happens, some cassette players have this facility already, actuated by pressing both the PLAY and FAST FORWARD (sometimes called the CUE) keys. The idea is to listen to the sound as it passes rapidly past the play head, and to mentally count the gaps.

Many National brand cassette players have this feature, in particular the National Model RQ-2133. This particular unit is ideal for the auto-search, as only very minor electrical modifications are required to adapt it for use. These modifications are described later in this article, so if you own one of these tape players, or intend buying one, then you can proceed happily to building the electronics.

If you decide to try to adapt another type of tape recorder, like the one the kids used to use until they took over the hi-fi, first determine if it can be suitably modified. Many Sony tape recorders cannot be modified, but other types, particularly those with a single rotary switch arrangement can be. It is impossible to describe a general technique, due to the differing arrangements employed. I can only give general requirements, the best will be up to your mechanical ability.

In general, the tape head should advance towards the tape, when in fast forward mode, slightly less than it does when in the play mode. If it is too far forward it will slow the tape transport system, and if not enough, it will not allow a signal to be generated by the head. An easy method of determining if the head position is correct is to listen to the result through the player's speaker.

The correct position is when the loudest sound occurs, without the transport slowing down. Naturally, the erase head, often just a permanent magnet, should not be allowed near the tape, as you'll lose everything. Often, just bending a lug here and there is sufficient, so don't be surprised if the modifications turn out to be easier than you thought.

Electrical modifications

In order to make the auto-search unit as simple as possible, I decided to make the tape recorder supply the power to the unit. The power requirements are very low, around 10 to 20 mA, because of CMOS and diode logic. This means, however, that the circuit has to be able to cope with either polarity of earth associated with the tape player.

The pc board layout accommodates both types of polarity, with very minor differences occurring between the two. The circuit can operate with differing voltages, with 6 V being the most typical voltage available from the player. The National RQ-2133 uses a negative earth at 6 V but if you are adapting another player, determine the polarity first.

In order that the auto-search can integrate with the player, use is made of the phono sockets generally present somewhere on the side of the player. The sockets used are the so called MONITOR (or earphone) socket, and the REMOTE socket. The REMOTE socket is generally next to the MIC socket. The principle of the auto-search is to replace this switch with a transistor that is in turn operated on by the electronics within the auto-search.

This project requires some electrical modifications to the tape recorder. If you don't feel confident about these we advise you not to try this one.

Now you can load several programs on a single cassette and find a particular one quickly and easily. The ETI-693 auto-search will also find a track on an audio cassette.

Peter Phillips

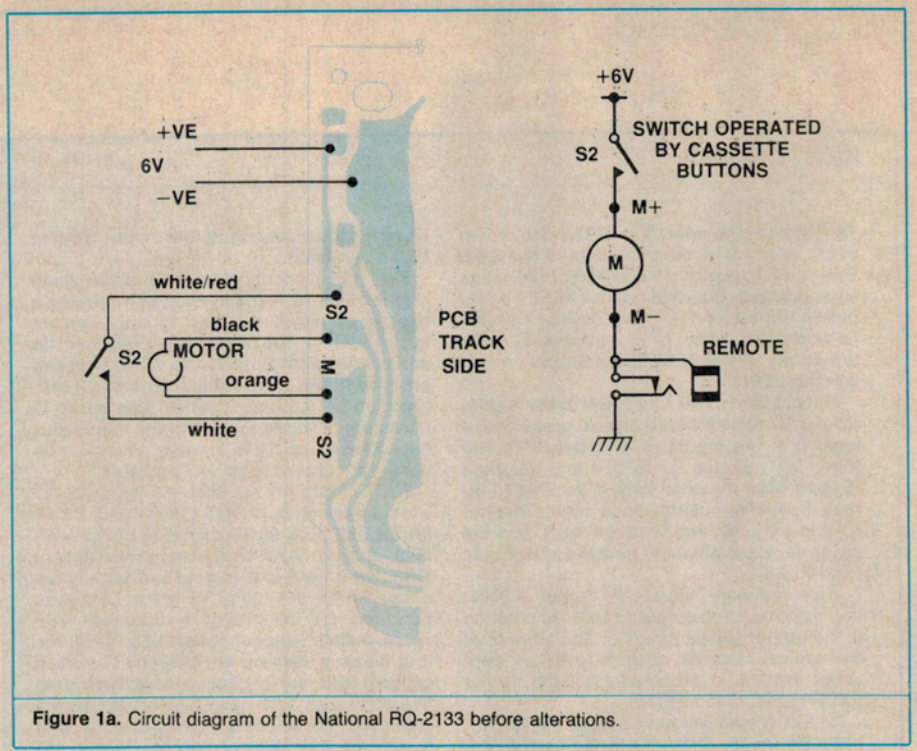


Figure 1a. Circuit diagram of the National RQ-2133 before alterations.

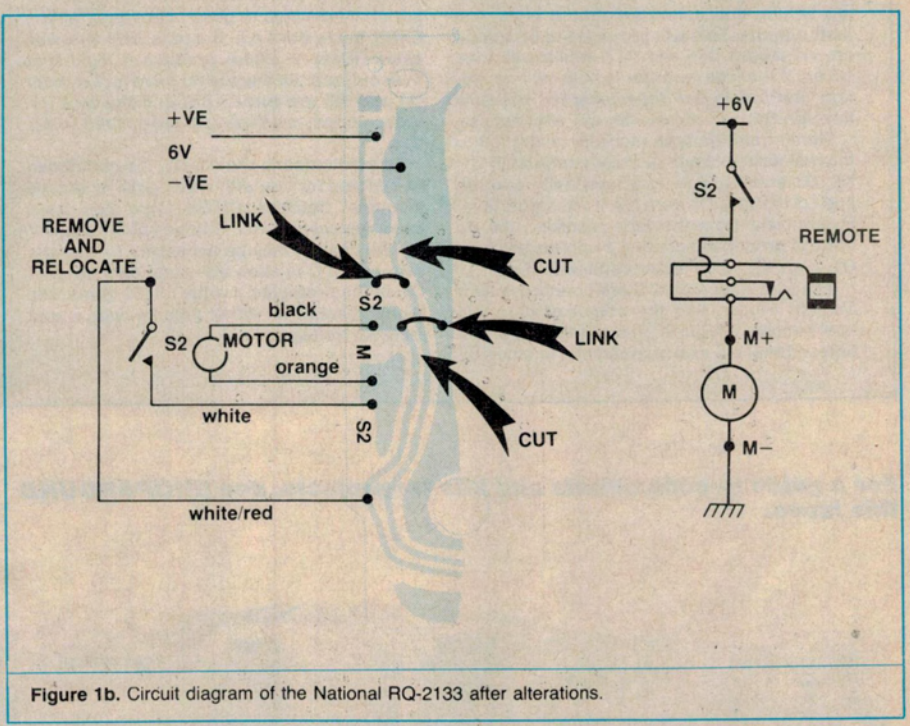


Figure 1b. Circuit diagram of the National RQ-2133 after alterations.

As already mentioned, it may also be necessary to modify the tape recorder electronically. Because the auto-search not only derives its power from the tape recorder, but also controls the power to the tape recorder, the electrical relationship between the player's power supply, remote socket, and the player's electronics and motor must be as shown in Figure 1b. The differences between Figure 1a and 1b are that in 1a, the remote socket is wired between the motor/electronics and earth, while in 1b, the remote socket has been moved between the supply rail and the motor/electronics. Figure 1 shows how to modify the National RQ-2133 tape recorder.

The procedure for the RQ-2133 is farily simple. Firstly, remove the five screws holding the back cover, including the one in the battery housing. Remove the single red screw holding the tone/volume control assembly, and lift this assembly clear. Remove the three screws holding the pc board in place to gain access to the track side. Cut the tracks as shown in Figure 1b, and connect the two links. Finally, relocate the wire that originally connected S2 to the point shown in Figure 1b. This completes the modifications, and allows the player to work normally, as well as allowing it to now interface with the auto-search.

Other tape players may already be electrically correct, but this point needs to be determined, and, if necessary, corrected.

Electronic modifications

With the tape player now ready, construction of the auto-search electronics can proceed. Start by mounting all the passive components, then mount the transistors and ICs. Note the wire link to the left of IC1. Also note that all diodes, except D1, are placed the same way, with the cathode towards the bottom of the pc board.

All the ICs are also orientated the same way, with pin 1 facing the top of the pc board. When you come to mount transistors Q4 and Q5, follow the layout for the particular polarity of tape recorder. The overlay diagram shows the layout for a negative earth system, such as the RQ-2133 with the necessary modifications for positive earth separately detailed. The differences are the orientation of Q4, the type of transistor for Q5, (NPN for positive earth) and the position of the two links in between these two transistors.

With the pc board completed, connect the LEDs, and switches SW1 and PB1, allowing about 140 mm lead length. When wiring SW1, note that pin 1 of the switch is not connected. The layout shows the view for SW1 with the connecting terminals facing towards you. The use of rainbow cable is recommended, to facilitate correct connection of SW1 to the pc board.

Normally, a 2.5 mm phono plug is required for the remote socket, and a 3 mm plug for the monitor socket. In the prototype, I squeezed four wires into an 800 mm ▶

HOW IT WORKS

To consider the operation of the circuit, assume selection 6 on a cassette is required. SW1 is set to position 6 and RESET (PB1) has been pressed. Operation of the RESET pushbutton will cause IC3, a dual decade counter, to be set to 0, which in turn causes Q2 to be turned off, allowing Q3 to be turned on and lighting LED 2.

The position of SW1 (at 6) will cause diodes D6 and D7 to be forward biased, presenting a logic 0 at the inputs of inverters IC1a and IC1c. SW1, diodes D4 to D14 and inverters IC1a to IC1d together form a decimal to binary converter, using diode logic. Inverter IC1a is the LSB, and IC1d the MSB, and the range of output numbers from the inverters is from 0 to 9.

Thus, position 1 causes an output of 0000, and position 10 an output of 1001. At position 6, the output will be binary 5. The outputs of the counter, and the decimal to binary converter are fed, in bit parallel fashion, to the EXOR gates, IC4a to IC4d.

An EXOR gate will have a logic 1 at its output if its inputs differ, so in the case under discussion, gates IC4a and IC4c have differing inputs, and hence produce a logic 1 at their outputs. This will cause Q4 to be turned on, via diodes D15 and D17, which will drive Q5 on. If the tape recorder is now set into motion, current to the tape recorder will flow through Q5, and the search will commence.

Signal from the tape recorder is applied to the half-wave voltage doubler comprising C1, C2, D1 and D2. RV1 is a sensitivity control, and D3 isolates C3 from C2. If the signal level is sufficient from the tape recorder, the dc voltage produced across C2 will forward bias Q1, causing its collector voltage to drop.

Inverters IC1e and IC1f are connected as a Schmitt trigger, and the output of IC1e will now become a logic 1. This allows IC2, a '555 timer connected as a monostable, to time out, and then to set its output (pin 3) low, lighting LED 1 (SIGNAL).

The '555 timer is present to allow small bursts of signal that may be present during a gap to go unnoticed, and to thus prevent false counting. The delay of the timer must be sufficiently short however, to allow intended short sections of data (such as a small program) to be recognized when tape speed is maximum, towards the end of the tape. Altering either R7 or C4 to a lower value may be necessary under these circumstances.

When a gap on the cassette appears, Q1 will turn off when C3 has discharged. C3 allows small gaps in the signal to be ignored, such as may occur in analogue information. Thus, the output of IC1e goes low, setting the output of the '555 high. The signal LED goes out, and the counter will increment one count, extinguishing the reset LED. Thus, the first block of data on the cassette has been passed, and the sequence continues until five blocks of data have passed. When the gap before the selected block is reached, that is, after the fifth block of data, the counter will increment to binary 5. As this equals the output of the decimal to binary converter, all the EXOR gates have equal inputs, and all these gates (IC4a) to (IC4d) produce a logic 0 at their outputs. As there is no drive for Q4, both Q4 and Q5 are turned off, and the tape recorder stops, cued ready at the desired selection.

As mentioned in the article, the circuit can be adapted for use with either polarity of tape recorder. Because CMOS logic has been used, typical cassette voltages of 6 V and 9 V can be used. It may be necessary to alter the value of R17, to allow adequate saturation of Q5. In the prototype a value of 330 ohms was found suitable, for either polarity, with a tape recorder voltage of 6 V.

PARTS LIST — ETI-693

Resistors ..... all ¼ W, 5%
- R1 ..... 470R
- R2, 14 ..... 10k
- R3 ..... 100k
- R4 ..... 2k2
- R5 ..... 22k
- R6 ..... 47k
- R7 ..... 82k
- R8, 13 ..... 560R
- R9, 10, 11, 12 ..... 100k
- R15, 16 ..... 4k7
- R17 ..... 330R* see text
- RV1 ..... 25k trimpot (large vertical)

Capacitors ..... all 16 V tantalum
- C1 ..... 6.8µ
- C2, 3 ..... 22µ
- C4 ..... 15µ
- C5 ..... 33µ

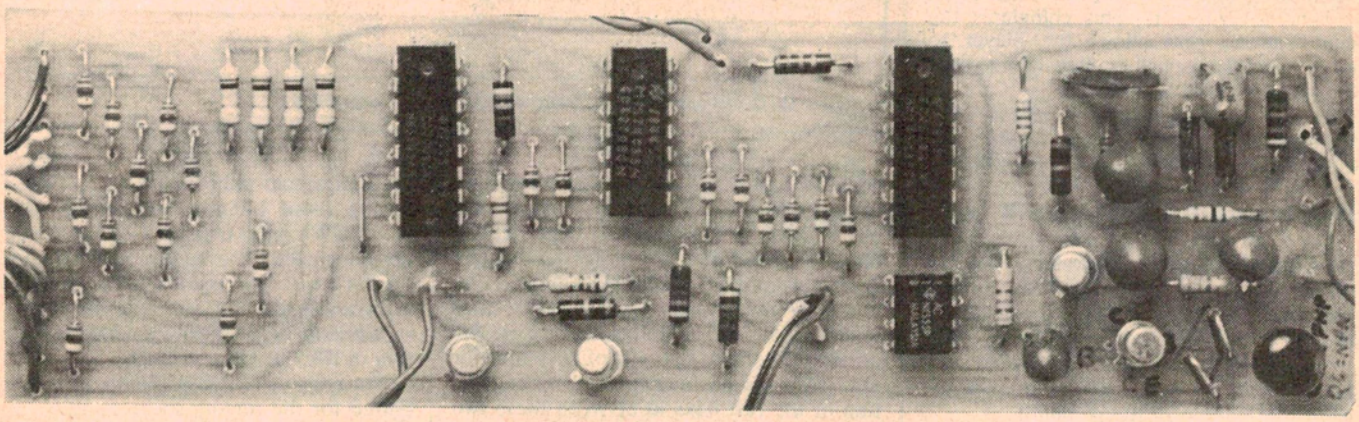
Semiconductors
- D1, 2 ..... 0A90
- D3-D22 ..... 1N914
- LED1 ..... 5 mm red
- LED2 ..... 5 mm green
- Q1, 2, 3, 4 ..... BC548 or equiv.
- Q5 ..... 2N3641 or equiv. (for +ve earth tape recorder) 2N3645 or equiv. (for −ve earth tape recorder)
- IC1 ..... 4049 or equiv.
- IC2 ..... '555
- IC3 4518
- IC4 ..... 4070 or equiv.

Miscellaneous
- SW1 ..... single pole, 10 (or 12) position
- PB1 ..... SPDT ultra miniature push button

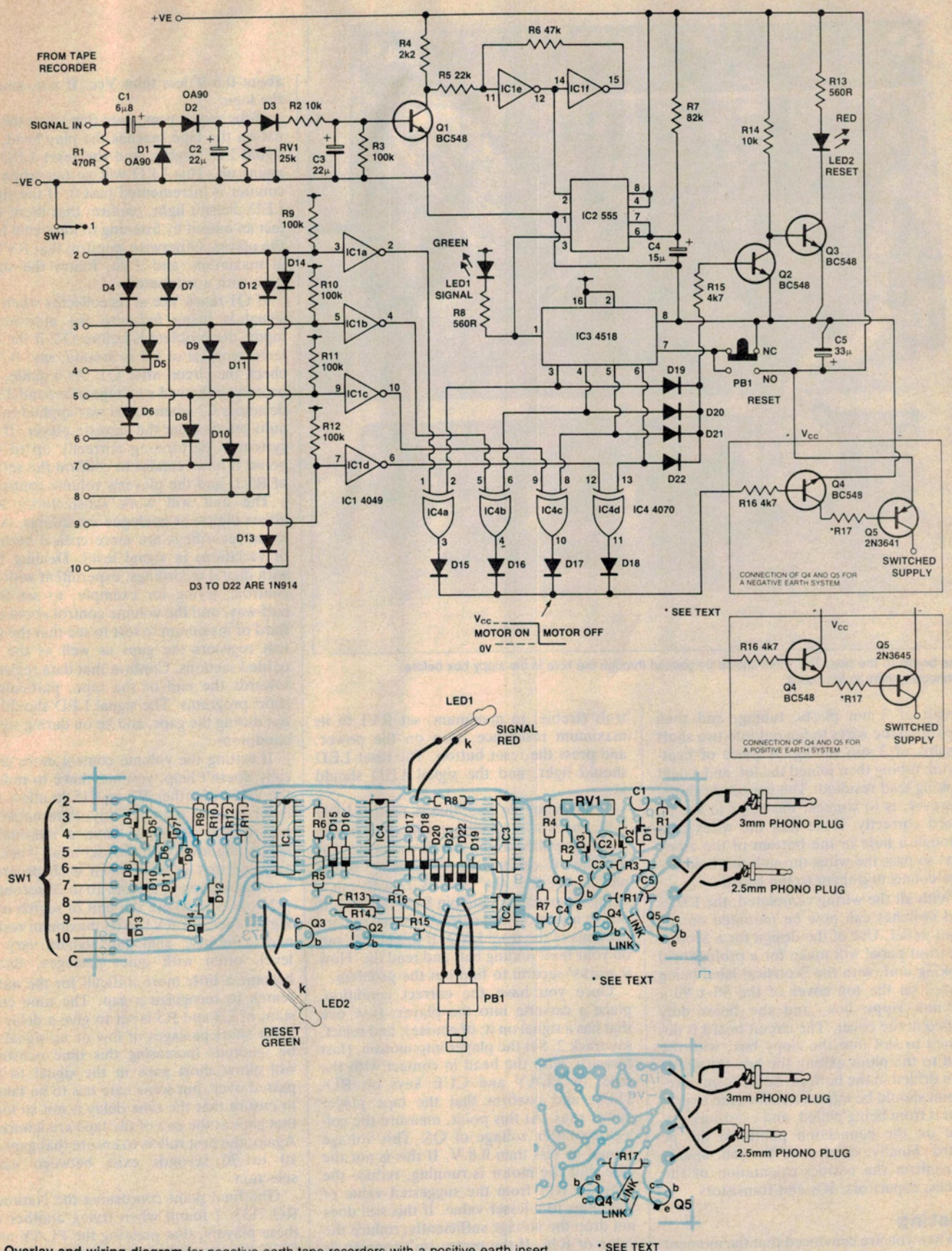
ETI-693 pc board; Scotchcal front panel; knob; mounting bezels for LEDS; zippy box (50 x 90 x 150 mm); 2 phono plugs 2.5 mm and 3.5 mm (or plugs to suit tape recorder); 150 mm length of rainbow cable; 800 mm length of suitable plastic sleeving to house 4 connecting wires between unit and tape recorder.

Price estimate: $30-$35
(not including tape recorder)

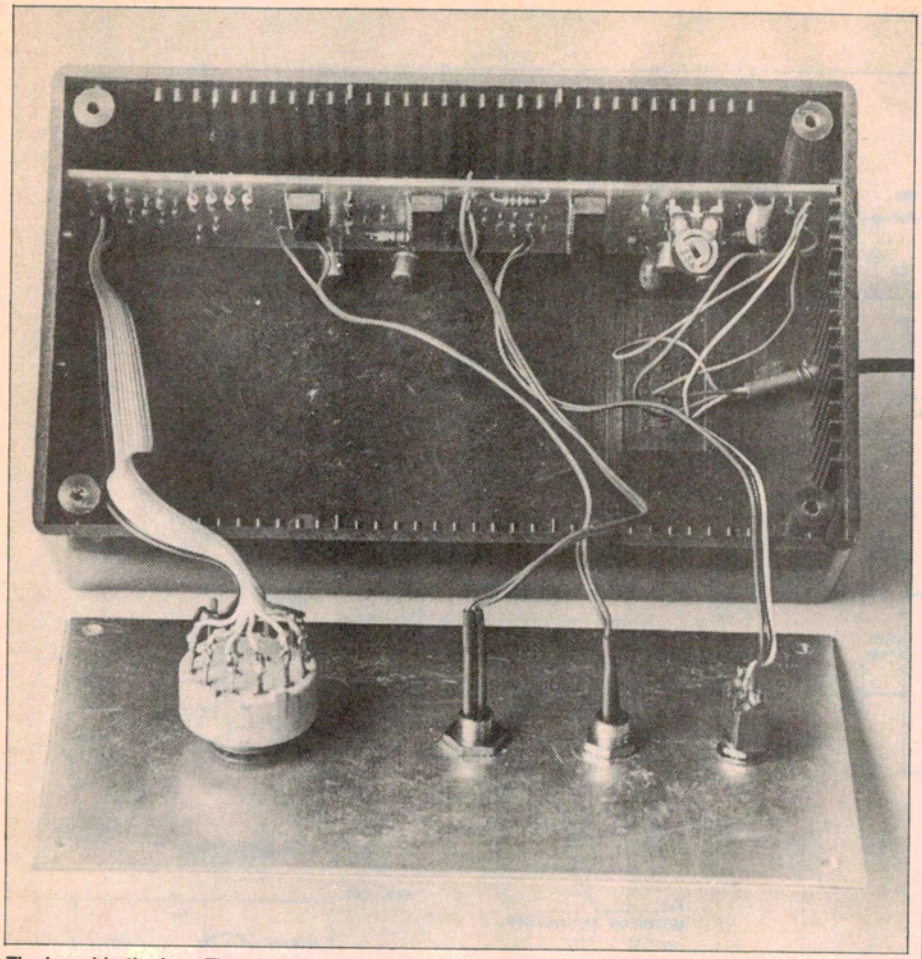
For a guide to components and kits for projects, see SHOPAROUND this issue.



The pc board. Check the polarity of the tape recorder before mounting transistors.



Overlay and wiring diagram for negative earth tape recorders with a positive earth insert. All diodes except D1 are oriented the same way.



The board in the box. The wires should be passed through the hole in the zippy box before connecting them to the board.

length of 3 mm plastic tubing, and then separated the wires to fan out into two short lenghts of 2 mm tubing. A piece of heat-shrink tubing then joined the lot, and a neat looking lead resulted. The important thing, however, is to connect the plugs to the pc board correctly. Note that the wires pass through a hole in the bottom of the zippy box, so pass the wires through this hole before connecting them to the board.

With all the wiring completed, the LEDs and switches can now be mounted on the front panel. Use of the design for a Scotchcal front panel will make for a professional looking unit, with the Scotchcal label being placed on the top cover of the 50 x 90 x 150 mm zippy box, and the holes duly drilled in the cover. The circuit board is designed to slot into the zippy box, with the lead to the plugs exiting the box through a hole drilled in the bottom. Some form of restraint should be attached to the lead to prevent it from being pulled, and exerting pressure on the connection points to the pc board. Finally, check over the job, mainly to confirm the correct orientation of the diodes, capacitors, ICs and transistors.

Testing

When you are convinced that the moment of truth has arrived, plug the unit into the tape recorder, set the volume and tone controls (treble) to maximum, set RV1 to its maximum resistance, turn on the power, and press the reset button. The reset LED should light, and the signal LED should not.

If this is not the case, that is, neither LED is lit, check with a voltmeter to see if power is being applied to the circuit correctly, if at all. This is easily done by looking across pins 1 and 8 of the '555, IC2, with pin 1 being the negative, and pin 8 the positive. If power is present and correct, check the connections of the reset LED. If this is OK, put on your fault finding hat, and read the 'How it works' section to find out the problem.

Once you have the correct condition, place a cassette into the player, (use one that has a signal on it, of course), and select, say track 2. Set the player into motion, (fast forward, with the head in contact with the tape, or PLAY and CUE keys on RQ-2133), and confirm that the tape player motor runs. At this point, measure the collector-emitter voltage of Q5. This voltage should be less than 0.8 V. If this is not the case, but the motor is running, reduce the value of R17 from the suggested value of 330 ohms to a lesser value. If this still does not drop the voltage sufficiently, reduce the value of R16. If the motor isn't running at all, determine why. Check, for example, that the voltage on the diode side of R16 is about 0.6 V less than Vcc. If not, suspect the logic.

If the motor runs, note that when the signal on the tape reaches the play head, the signal LED lights, and the reset LED remains on. This LED will go out when the counter is incremented past 0. If the signal LED doesn't light, confirm that there is in fact an output by listening to the signal from the player. Otherwise, confirm that RV12 is at maximum, and if so, follow the signal path with a voltmeter.

If Q1 reads Vcc at its collector when the signal is being fed into the auto-search input, the problem is before Q1; if the collector voltage of Q1 is around, say, 0.5 V, check the circuit after Q1. As a guide, the prototype showed a voltage of around 2.5 V dc across C2 when signal was applied to the auto-search from the cassette player. If the system is performing correctly up to this point, it now remains to confirm the setting of RV1, and the player's volume control.

The unit will work satisfactorily with either digital or analogue recordings. Analogue recordings are more critical because of variations in signal level. Dealing first with digital recordings, experiment with the controls, trying for example, to set RV1 half-way, and the volume control about one third of maximum to test to see that the system registers the gaps as well as the recorded sections. Confirm that data registers towards the end of the tape, particularly short programs. The signal LED should go out during the gaps, and be on during signal conditions.

If setting the volume control more critically doesn't help, you may have to reduce the value of either R7 or C15 to allow the timer to reset more quickly. Alternatively, ensure that programs have a reasonable length, made up with a leader tone, if necessary, or that gaps between each program have a duration of around 10 to 20 seconds.

If you wish to use the unit to search analogue tapes, set RV1 to its maximum resistance. Because analogue signals vary in level, often with quiet passages, things become a little more difficult for the auto-search to recognize a gap. The time constant of C3 and R3 is set to give a delay to allow short passages of low or no signal to be ignored. Increasing this time constant will allow short gaps in the signal to be passed over, but some care has to be taken to ensure that the time delay is not so long that gaps at the end of the tape are ignored. Again, the best rule is to ensure that gaps of 10 to 20 seconds exist between each selection.

One final point concerning the National RQ-2133. I found when trying another of these players, that pressing the PLAY and CUE keys to their locked position caused the play head to not be in sufficient contact with the tape to allow adequate output. By

bending or filing a stop lug associated with the mechanism, this problem was fixed. If you are buying one for the purpose of this article, listen to the particular unit with the keys actually locked down, rather than just held down, and buy the one that gives the best output. Otherwise, gently disassemble the mechanism, and modify the stop lug.

This tape recorder also allows for searching in reverse, by pressing the PLAY and REVIEW keys together. Again, you may have to fiddle with the mechanics if you want this feature.

Pressing the reset button after 10 selections have been passed resets the counter to 0. It is possible to have as many items on the cassette as you wish by repressing reset, and adding 10 each time. If you are adventurous, this simple system can be upgraded to allow modifications to permit, for example, the inclusion of a switch to transfer the signal to the computer, using the cassette player to play out the program without having to unplug the auto-search. This switch could even be electronic, actuated by the output of diodes D15 to D18, (taking advantage of the fact that this output level is a logic 0 when the cueing has taken place). Other possibilities could include interfacing the cassette to the computer and providing the mechanics can be suitably modified, using the cassette player under software control. ●

ETI 673 TAPE AUTO SEARCH