PE MINISONIC

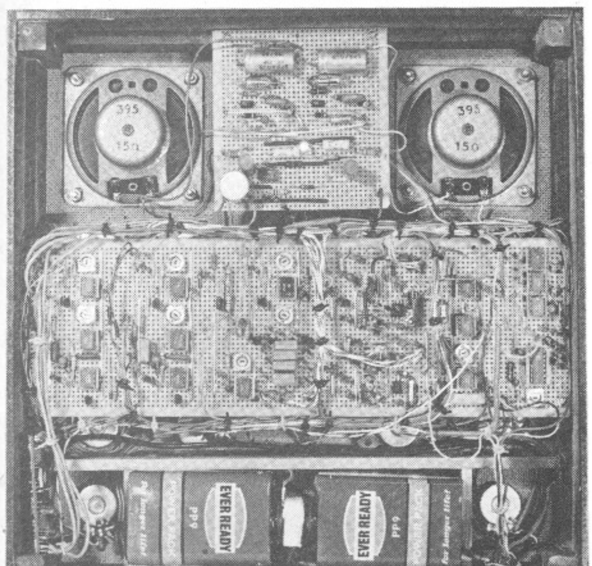
By G. D. SHAW

PART FOUR

- **Final Wiring and Setting Up**
- **Alternative Keyboards**
- **Optional Extras**

LAST month the electronics on the two Veroboard panels were described and so this month it only remains to connect the two boards with the controls on the front panel.

Many of our more ambitious constructors may wish to add their own conventional keyboards to the Minisonic thus making it into a more "playable" musical instrument. Four different keyboard options are therefore described.



The upper board has been extended since the photo was taken so the large board must be mounted so that its lower edge is flush with the top of the battery compartment

WIRING UP

Fig. 4.1. shows a diagram of the reverse side of the front panel. Controls have been grouped together by labelled boxes so as to indicate which part of the main Veroboard panels they are connected with. All interwiring on the front panel has been shown; interconnections from the front panel to the Veroboards are indicated by lettered designations which correspond with the letters on the Veropins on the Veroboard panels.

When wiring the main circuit board to the front panel it is preferable that the front panel be fitted into the case with all leads, equal in length to the diagonal of the case, attached.

The leads, which should be suitably colour coded, are bunch tied in groups and, ideally, should be wired to the circuit board from one side only. This will enable access to the underside of the circuit board in the event of problems.

After trimming the various leads to length they can be soldered to their respective pins and then tied off to form a neat harness.

No problems of signal induction were experienced with the prototype despite the fact that both signal and control leads were included within the same harness. The NOISE GENERATOR may possibly give rise to induced noise and for this reason the output lead to its volume control should be kept as short as possible and routed clear of other signal leads. When the NOISE GENERATOR is not in use its volume control should be kept at zero.

A DIN socket was mentioned in passing in Part 3 without any detailed description of its function. In fact its purpose is to enable external keyboards to be plugged in to the Minisonic.

Wiring to the DIN socket is shown in Fig. 4.2. The DIN socket is in fact mounted on the front wooden panel at the lower left-hand side and can be seen in the photographs.

The two Veroboard panels are mounted on the Minisonic as shown in the photograph, though the smaller panel has been enlarged somewhat thus necessitating the lowering of the larger board so that its lower edge comes flush with the top of the battery compartment.

FRONT PANEL INTERWIRING

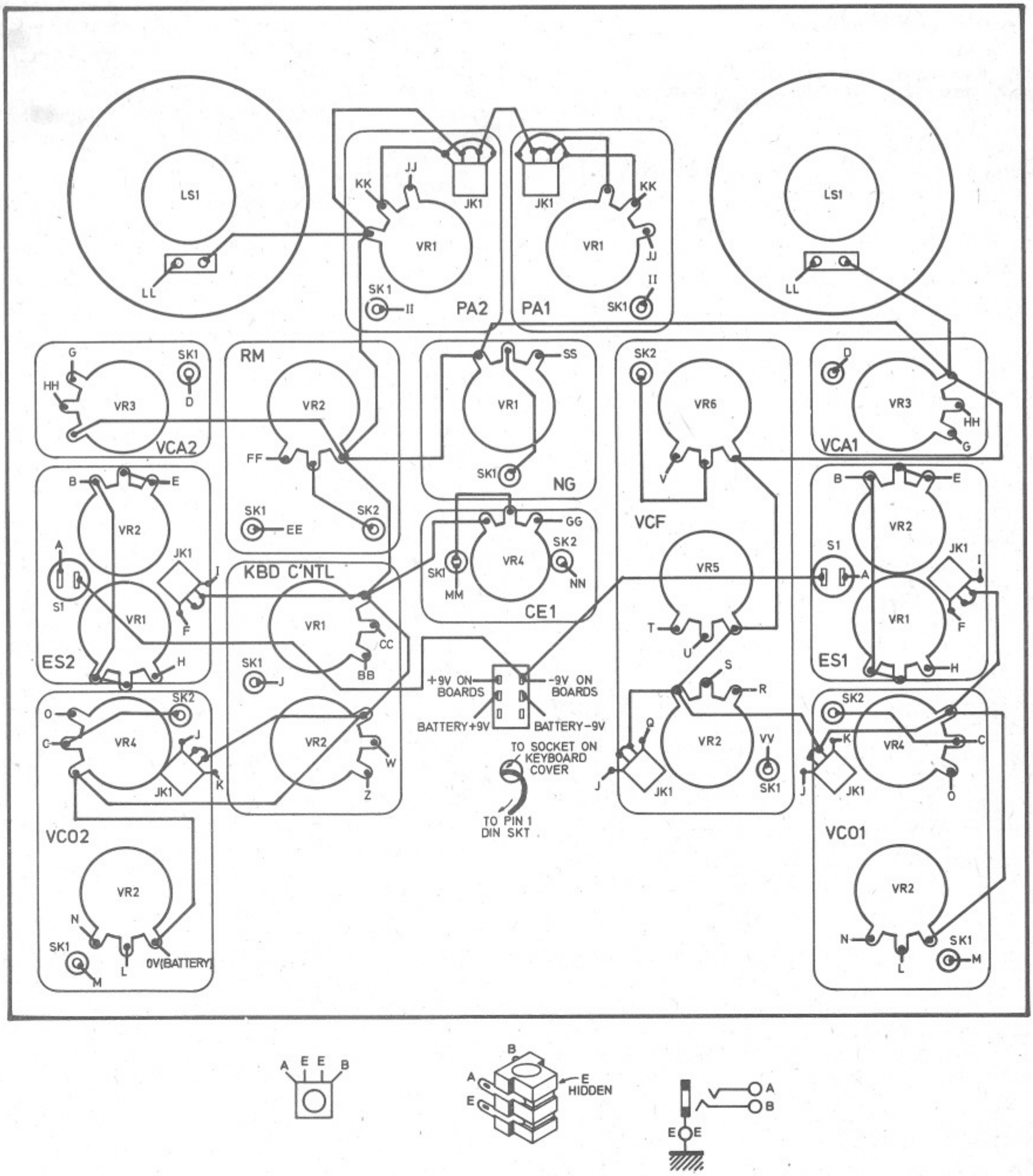


Fig. 4.1. The reverse side of the front panel. All interwiring on this panel has been shown; interconnections to the Veroboard panels are indicated by the lettered designations which correspond with letters on the Veroboards. The jack sockets are shown in detail to simplify wiring

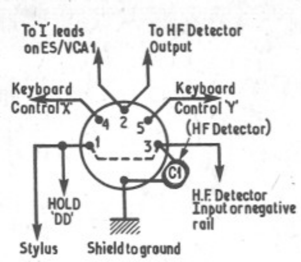


Fig. 4.2. Wiring of the DIN socket on the front panel. The link between pins 1 and 3 may not be necessary for some keyboard options—see text. The connection from pin 1 to the HOLD should go via a 20kΩ resistor (R7, Fig. 3.5)

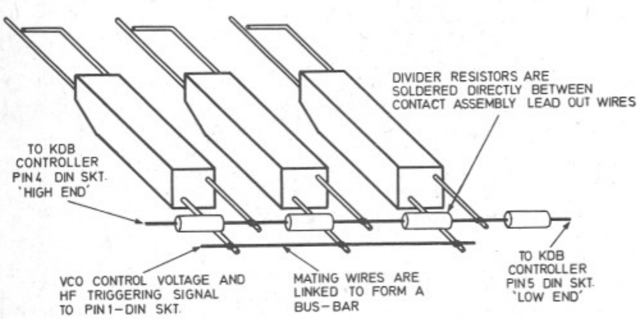


Fig. 4.3. The wiring of the single pole contact assemblies in a conventional keyboard. Only a three wire connection is necessary to the Minisonic. (Note: the normally closed contact wires have been omitted for clarity)

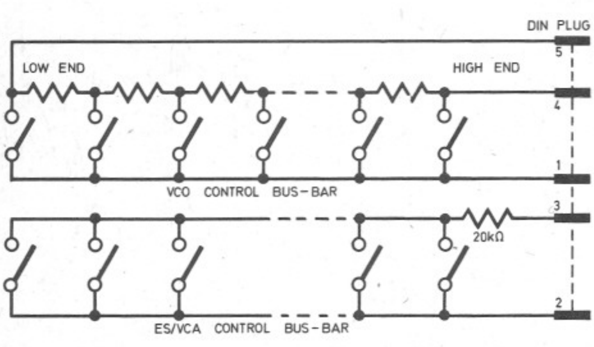


Fig. 4.4. Wiring arrangement for a conventional keyboard with double pole contact assemblies. In this case all five pins of the DIN plug and socket are necessary

KEYBOARD OPTIONS

1. Conventional Keyboard—single pole contact assemblies

The use of a keyboard of conventional style greatly improves the musical capabilities of the Minisonic and perhaps the simplest option here is to use a conventional style keyboard unit (the Kimber Allen type is recommended) which may be fitted with single pole changeover contacts of the Kimber-Allen G.J. type.

Wiring up is very easy and is illustrated in Fig. 4.3. After positioning the contacts such that the moving wires are central over their respective key actuators, connect up the moving wire lead-outs in the form of a busbar as shown. Divider resistors are now linked directly between the lead-outs on the normally-open contact wires.

Note that in Fig. 4.3 the normally-closed contact wires have been omitted for the sake of clarity.

Connection from the Minisonic to the keyboard unit in all cases is made via a DIN socket mounted on the front panel of the case. This has already been mentioned in the circuit diagrams of the HF DETECTOR last month. By simple changes in the wiring to this socket all the keyboard options to be described can be accommodated.

For this particular case a wire connection is made to each end of the divider chain and one to the busbar. All three wires are then taken to a DIN plug which mates with the DIN socket on the Minisonic. The "high" end of the divider chain goes to pin 4, the "low" end to pin 5, while the busbar goes to pin 1. The dotted link in Fig. 4.2 is required here.

If this option is adopted in addition to the printed circuit keyboard, then provision should be made to disconnect the latter keyboard divider when the external keyboard is in use.

2. Conventional Keyboard—double pole contact assemblies

With double pole contacts it is possible to trigger the Minisonic using the extra set of contacts rather than the HF OSCILLATOR signal superimposed on the VCO voltage input.

Referring to the DIN socket wiring, Fig. 4.2, disconnect the HF DETECTOR input and output from pins 3 and 2 respectively. Remove the link between pins 1 and 3 (shown dotted) and couple pin 3 to −9V via a 20kΩ resistor. VCO control voltages are brought to pin 1 as before while ES/VCA trigger pulses from the second set of contacts are brought into pin 2.

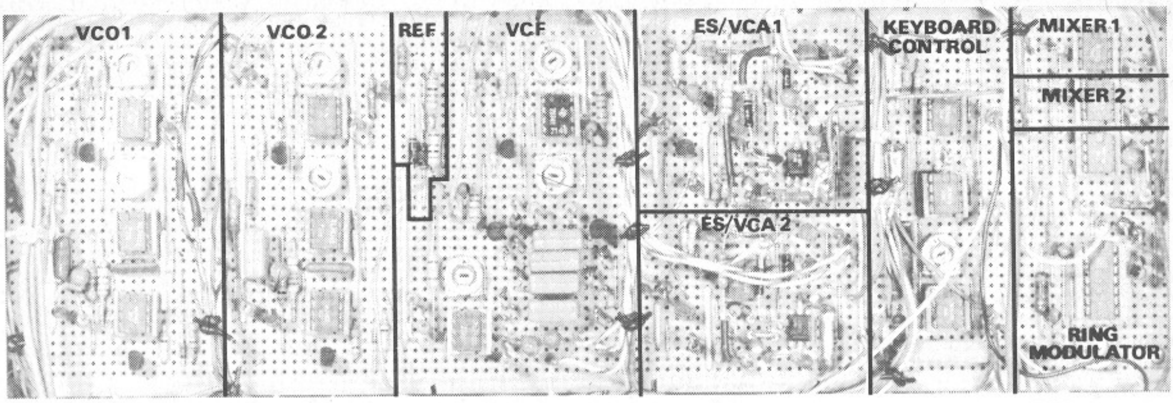
Fig. 4.4 shows a diagrammatic wiring arrangement. When this option is used the HF OSCILLATOR and DETECTOR may be omitted from the overall scheme. In any event the HF OSCILLATOR should be disconnected from the KBD CONTROLLER.

3. Existing Keyboard System—single pole contact assemblies

This option requires that the existing keyboard should offer negative control voltages and also that there should be a facility whereby the HF OSCILLATOR output may be evenly superimposed on the keyboard divider system. If these requirements can be met by the external unit then the procedure is as follows.

In Fig. 4.2 link pins 1 and 3. Disconnect the keyboard control voltages from pins 4 and 5. Disconnect the HF OSCILLATOR from the Minisonic KBD CONTROLLER and reconnect through a 1,000pF capacitor to either pin 4 or 5.

The mating DIN plug from the external unit will in this case require only two connecting wires: one carrying the HF signal to the external KBD CONTROLLER; the other bringing the VCO control voltage and the HF triggering signal to pin 1 as with the other options.



Photograph of complete board on which VCO's, VCF, Voltage Reference and ES/VCA's are mounted. (Note: some minor changes have been made to this layout)

4. Existing Keyboard System—double pole contact assemblies

With double pole contact assemblies the external unit will be supplying VCO and ES/VCA control voltages from its own resources. These voltages must be negative going. Pin 3 need not be connected to the negative rail.

It may possibly be necessary to include a resistor in series with pin 2 if the ES/VCA trigger pulse is in excess of −3V. For instance the *P.E. Sound Synthesiser* comes into this latter category, a 62kΩ resistor being necessary to attenuate the trigger pulse sufficiently.

FINAL SETTING UP

Assuming that all circuits have been constructed, bench tested and linked to the front panel controls as described, it now remains to get the instrument into action.

VCO BALANCING

The front panel controls should be set as follows:
AT MINIMUM ENVELOPE SHAPER attack and decay. VCF frequency. CE inverter.
AT MID POSITION VCO frequency, tune, span and VCF "Q."
AT MAXIMUM All level controls.

Switch on the power and apply the stylus—in the case of a conventional keyboard, press a key—around the midpoint of the keyboard. Both channels should be heard (the frequency is unimportant) almost instantaneously with the application of the stylus, with the sound dying away equally quickly when the stylus is removed.

Apply the stylus again and hold it in position. Tune one or other of the oscillators so that there is a slow beat between them. Advance the decay control to maximum and remove the stylus. The audio signal from the oscillators should now begin to die away over a period of about 16 seconds.

At this point however there will almost certainly be a change in oscillator frequency as the sound decays away. The problem is that the hold circuit requires to be finally balanced by means of VR4, Fig. 3.2a.

Without an oscilloscope it is unlikely that a very fine balance can be achieved but perhaps what is more important is that the instrument "sounds" right. Thus the stylus should be applied and removed with adjustment of VR4 being made during the decay period until finally there is no appreciable change in VCO frequency during the decay phase of the envelope. This operation requires some degree of patience since the closer the HOLD circuit is to balance the smaller will be the adjustments required.

SPAN CONTROL SETTING

Having balanced the HOLD circuit it now remains to set the KEYBOARD CONTROLLER span control such that the instrument can play an equal tempered scale. The situation is that the two VCO's are already tracking fairly closely with the tune and span controls in approximately their mid position. Tuning will be found easier however if only one oscillator is used.

Turn down the level control on one of the oscillators and advance the tune control to its maximum position. Run the stylus up and down the keyboard to ensure that the working oscillator frequency is within audible range at each extreme. If not adjust the oscillator frequency control accordingly. With the values given in the text of the series the equal temperament position will be found to be with the span control approximately in mid-rotation.

As with the HOLD circuit some patience may be required to get the tuning just right. Musicians with a sense of absolute pitch should not have too much difficulty in this respect but for the majority of constructors it will be a case of repeated adjustments and playing of octaves until the instrument sounds right.

An oscilloscope or frequency meter is a useful adjunct during these setting up procedures but is by no means essential. Having found the equal temperament position this should be carefully recorded since it is almost certain that the span control will be moved about again during the full evaluation phase of the instrument.

This completes the final setting up. Remaining checks on circuit performance may be made as follows:

VOLTAGE CONTROLLED FILTER

With the controls set as described, patch the output into a power amplifier external input. Turn both VCA level controls to minimum. Apply the stylus to the keyboard in about mid-position and check that no signal is present in the channel carrying the VCF output.

Advance the VCF frequency control to maximum. As this is done the VCO signal should become audible in the patched channel rising from a fairly bland sound to the full harsh bite of the sawtooth waveform as the frequency control of the VCF approaches its maximum setting.

Repeat this procedure with the *Q* control at both extremes. With *Q* at minimum the overall level of the sound should be somewhat greater than when it is at maximum but there will be less subjective change in the harmonic content of the resultant sound.

The next procedure is to check out the effect of automatically programming the VCF signal. Advance ES1 attack and decay controls to approximately one third of their rotation. Patch the output of the control envelope inverter into the control input of the VCF (jack socket). Set the CONTROL ENVELOPE level about halfway.

Application of the stylus to the keyboard will now result in a slow rise in audibility of the sound together with a distinct change in harmonic content as the sound becomes louder.

Try various settings of the attack, decay and envelope level controls to achieve a typical synthesiser "waa-waa" effect.

N.B. Remember that VCO2 is permanently linked into the audio input of the filter. The level control of VCO2 should therefore be at maximum for these latter checks.

RING MODULATOR

Remove the patch cords from the previous tests and patch the output of VCO2 into the uncommitted input of the RING MODULATOR. Patch the output of the RING MODULATOR into one of the POWER AMPLIFIER inputs and with both VCO level controls and the RING MODULATOR level control at maximum a resultant sound comprising the sum and difference of the input frequencies should be heard.

Try varying one or other of the VCO frequencies and note how the composite signal from the RING MODULATOR contains both rising and falling frequencies at the same time.

Removal of the patch cord from VCO2 should result in the complete loss of output signal from the RING MODULATOR. If this is not the case then VR1, Fig. 3.7, will require further adjustment.

NOISE GENERATOR

Patching the output of the NOISE GENERATOR into the POWER AMPLIFIER input should result in the immediate sound of white noise, a harsh, uneven rushing sound.

Having established that the main functions of the Minisonic are operating as described the constructor may now wish to make further investigation into the performance of the instrument.

Tracking of the oscillators at both extremes of the audio spectrum is a useful exercise particularly if the instrument is to be used for any kind of serious musical purpose. So far the checks on tracking have been limited to the measurement of current through the current generators. If this has been done with care there will be found to be very few problems with the audible trackability. Any measurement with a meter however is liable to error if fundamental precautions, such as ensuring good contact between the probe and measuring point, are not taken.

AUDIO TRACKING

Audio tracking should be carried out using the keyboard to supply the reference voltages to both oscillators. With the stylus at about mid-position on the keyboard, set the VCO's so that there is a slow beat between them, say around 2 to 3Hz. Now move the stylus to the top contact and, in this position, if the beat has increased so as to introduce a noticeable discord, then some adjustment will be necessary to VR3, Fig. 2.1, on one of the VCO's.

It should be borne in mind that this latter adjustment should be very small and also that it will change the frequency setting at mid-keyboard. Consequently after such adjustment the stylus should be moved back to the original contact and the manual frequency controls on one or both VCO's adjusted to achieve the slow beat again.

Do remember that with the law controls *exactly* matched any beat between VCO's is as the result of differences in bias on the control node induced either by the manual frequency controls or by the bias preset or by a combination of the two.

Such a difference in bias will result in a minute variation between the currents through the constant current generators which will increase as the overall bias increases. Thus a slow beat at say 250Hz fundamental will be rather more rapid at 1kHz fundamental but should not be so rapid as to cause a discord.

The constructor should not therefore try to iron out the beats completely since although this is a theoretically possible exercise it is also one which is calculated to try one's patience to the limit.

Another useful check is to measure the timing of the attack and decay phases of the envelope shaper as far as is possible in order to gain some idea of the effects induced by various settings of the respective controls.

TEMPERATURE STABILITY

The greatest problem experienced with constant current generators utilising a single, uncompensated transistor is that the current is anything but constant. Minor variations in ambient temperature can cause quite significant changes in V_{be} and thus in current through the transistor.

For this reason it was decided to offer, as an optional extra, the possibility of incorporating temperature stabilisation to the VCO's and VCF. The additional cost will be something under £2 (excluding Veroboard or PCB) and as such represents a good investment if the Minisonic is to be used for multi-tracking or more serious musical purposes.

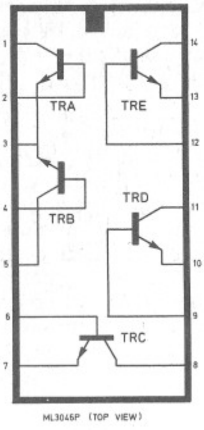
During a twelve-hour soak test on a Minisonic VCO the oscillator demonstrated a stability better than 0·2% per hour, a figure which would compare pretty favourably with most of the less expensive commercially available synthesisers.

STABILISER CIRCUIT

(Subject to Patent Application)

A full circuit of the stabiliser is given in Fig. 4.5.

TRA and TRB comprise part of a transistor array, the ML3046P. TRA is connected directly across the



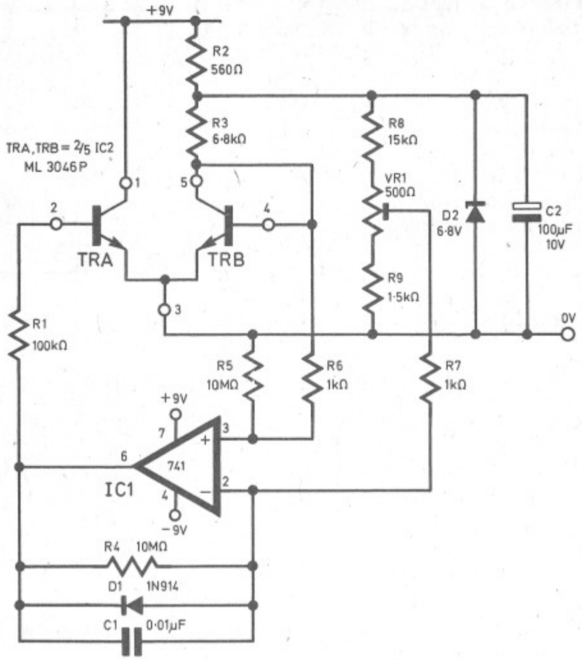


Fig. 4.5. Circuit of the optional stabiliser circuit

+9 and 0V rails and acts as a heater, the current through this transistor being limited by its own base current, which is, in turn, limited by R1. TRB is connected as a diode which is passing 1mA.

The V_{be} of TRB is compared by IC1 with a reference voltage set by R8, VR1, R9 which is nominally 660mV. IC1 is connected as a bounded integrator having a gain of about 10,000.

CIRCUIT ACTION

When power is first applied the transistor array is cold and thus the V_{be} of TRB will be greater than the reference voltage. The output of IC1 will therefore go rapidly positive turning on TRA which, with the output of IC1 at +8V, will pass about 7mA.

The effect is to heat up the transistor array which, in turn, causes the V_{be} of TRB to fall. The tendency will be for the V_{be} to fall to a point below the reference voltage at which time the output of the integrator will try to go negative. As soon as less current passes through TRA however the V_{be} of TRB will tend to rise again thereby signalling the requirement for more heating current to the integrator. In practice the circuit settles in about 30 seconds to a stable condition in which the V_{be} of TRB is maintained equal to the reference voltage.

In this situation the transistor array is kept at a constant temperature where the heat loss from the array is balanced by the heating effect of the current through TRA. Changes in ambient temperature will alter the heat balance of the system and thus cause a greater or lesser current to be passed through TRA. Similarly current passing through the other transistors on the array will also cause changes in the heat balance with the same effect.

SETTING UP

Setting up the so-called transistor oven is very simple. With a high impedance voltmeter connected to the output of IC1 and switched to the 10V range, set VR1 so that the wiper voltage is 670mV and apply power.

The voltmeter will indicate that IC1 has an output of +8V although this will begin to fall almost immediately and will settle, depending on ambient temperature, to a point between +2 and +4V. Gradually adjust VR1 until its wiper potential reads 660mV and again check the output of IC1 which, at this time, should be about +6V.

The criterion here is that TRA must, under cold conditions, pass a current which is at least equal to the maximum combined currents of all the other transistors on the array. If this were not the case then stabilisation would fall off in a situation where the remaining transistors were all passing their maximum currents (not a common situation in practice).

USING THE OVEN IN THE MINISONIC

The oven may be incorporated into the Minisonic scheme by removing the current generating transistors from the VCO and VCF circuits and linking in TRC, TRD and TRE respectively using three wires per transistor in order to prevent any problems which might possibly arise due to a circuitous negative rail return.

The control voltage/current relationship will have altered in the sense that higher currents will be passed for a given control voltage due to the fact that the array temperature is significantly above ambient. This may be compensated for by a proportional adjustment to VR1 in all control nodes so that the current levels are similar to those shown in Fig. 2.2.

The actual "law" is unlikely to have changed significantly and thus it should not be necessary to reset VR3 in any of the control nodes.

The maximum current drain of the "oven" will be about 11mA with a mean drain of about 7mA.

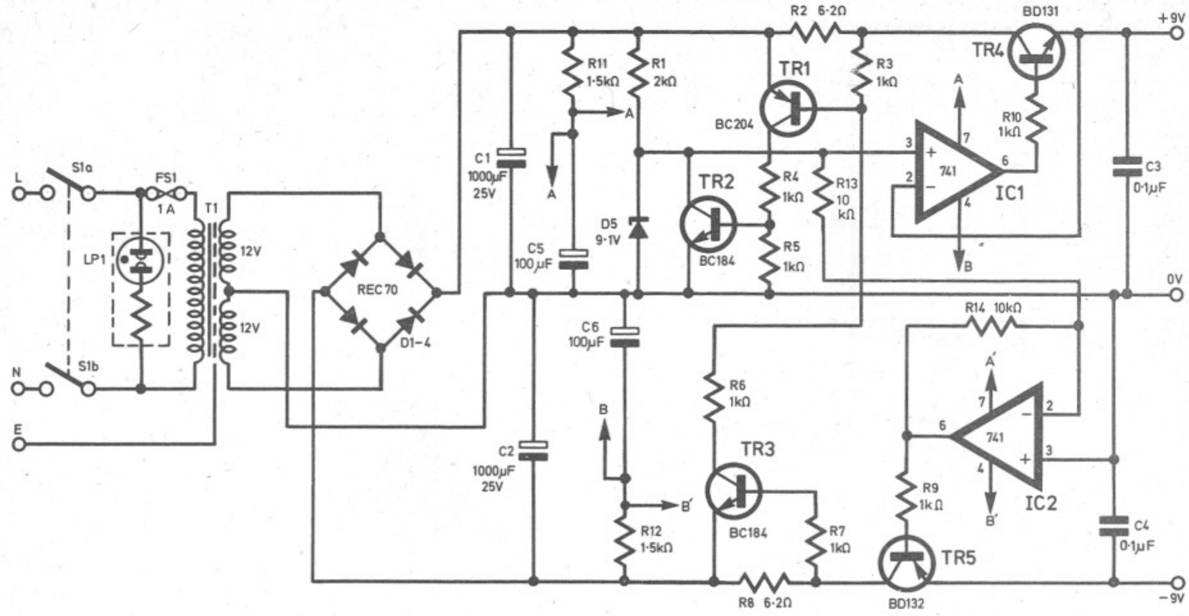


Fig. 4.6. Circuit of a battery eliminator for the Minisonic

POWER SUPPLY UNIT

The Minisonic was designed initially with the younger constructor in mind but it is a fact that, for the more serious experimenter, battery operation is not the ideal. Consequently a fairly simple stabilised power supply has been designed for incorporation into the instrument and is shown in Fig. 4.6.

CIRCUIT ACTION

Positive and negative rails are developed using a dual secondary or centre tapped transformer, a bridge rectifier and two electrolytic reservoir capacitors. D5 is a 9·1V Zener providing a reference voltage to the non-inverting input of IC1 which, in turn, provides drive to the series pass transistor TR4 which is operating as an emitter follower.

IC2 takes its reference from the same Zener diode as IC1 and provides drive to TR5, a complementary version of TR4. The arrangement of TR1, TR2 and TR3 provide short-circuit protection and current limiting.

Under normal conditions there is a minimal voltage drop across R2 and R8 and thus TR1 and TR3 are biased off. In this situation TR2 is also off.

If a short circuit occurs, say between the positive rail and ground, the voltage across R2 will rise rapidly thereby turning on TR1 and TR2.

The effect is to short out the Zener diode and pull down the outputs of IC1 and IC2 to zero volts. The power supply is thus effectively switched off. A similar action takes place if the short circuit occurs between the negative rail and ground or if the positive and negative rails are shorted together.

The values of R2 and R8 are chosen such that current limiting occurs when the demand is in excess of 100mA.

It should be pointed out that, at the time of writing, the performance of the power supply has not been fully evaluated and it may be necessary to make some adjustment to R2 and R8 in order that current limiting commences at the specified demand. In general it is better to have R2 and R8 larger rather than smaller in relation to the specified value in order that limiting starts earlier. The specified series pass transistors are capable of handling up to 3A so it is unlikely that they would be too unhappy in the event of a short term overload particularly if the recommended transformer rated at 3VA per winding is employed.

PRINTED CIRCUIT BOARD

As mentioned last month, the author has now developed a printed circuit which carries all the Minisonic electronics thus replacing the two Veroboard panels.

This will be available through certain of the advertisers in P.E. including Eaton Audio.

Next month: Making the most of the Minisonic

The completed Minisonic showing the DIN socket mounted on the front wooden panel