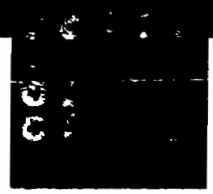
PE Sound Synthesiser 9

VOLTAGE CONTROLLED & DIFFERENTIAL AMPLIFIERS

By G.D.SHAW



THIS part describes the construction and operation of the Voltage Controlled Amplifiers, the Differential Amplifier and finalises the interconnection details outlined in Part 1 of the series.

OUTPUT AMPLIFIERS

The heart of each of the Voltage Controlled Amplifiers is the Motorola MFC6040 electronic attenuator which was described in Part 7 of the series and which, by means of an externally derived voltage, enables the input signal to be attenuated by 77dB or amplified by 13dB.

Two Output Amplifiers are employed, each having two stages, and arranged to be operated in parallel with cross-coupling between the final stages by means of panning controls. The general arrangement is shown in block form in Fig. 9.1. The first stage consists of a two input resistive mixer at the front end of the MFC6040 which has, for each channel, a separate control amplifier. Output from the first stage is led to a pan-pot which can route the signal to either of the output stages direct or to both channels at a range of intermediate levels.

Fig. 9.2 shows the theoretical circuit of the left channel Output Amplifier in which IC1 provides the variable gain input mixer, IC2/TR1 the control amplifier and IC3 the final output stage. The right channel is identical in design except that the 'a' side of the pan-pot is coupled to IC3 of the left channel instead of direct to the right channel output stage. This is so that clockwise rotation of the pan-pots will route signals to the right channel and anticlockwise rotation to the left.

PAN-POTS

The pan-pots themselves are designed to allow the smoothest possible transition when swinging the signal from one channel to the other and in such a way that equal increments of rotation of the pot give approximately equal incremental changes in the level of the signal.

The pots consist of two tracks ganged together and wired back-to-back so that as the output of one track increases the output of the other decreases by a similar amount. The ideal arrangement is when one of the tracks follows a logarithmic law with the other being anti-logarithmic. Unfortunately the manufacture of accurately matched tracks of this type is difficult and purpose built pots having the desired characteristics are not easily available and generally expensive.

The pan-pots in the Synthesiser represent a compromise in that they utilise linear tracks which, for most practical purposes, are made logarithmic in action by the addition of a relatively low value load resistor (R11 and R12 in Fig. 9.2).

PRACTICAL PROBLEMS

On completion of the module and having checked that each channel's performance characteristics are similar for a given input signal the following procedure should be adopted for determining the electrical centre of rotation of the pan-pots. Set both pots to approximately the mid-point of rotation and apply a signal of about 250mV to the input of one channel only. The remaining inputs should be grounded.

With the gain on the appropriate channel turned full up monitor the output stages of both amplifiers and adjust the appropriate pan-pot until the output signals are exactly equal. With a well matched pot the electrical centre should be quite close to the

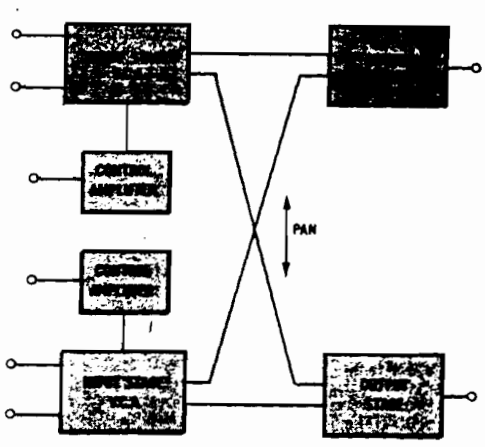


Fig. 9.1. General arrangement of voltage controlled Output Amplifiers

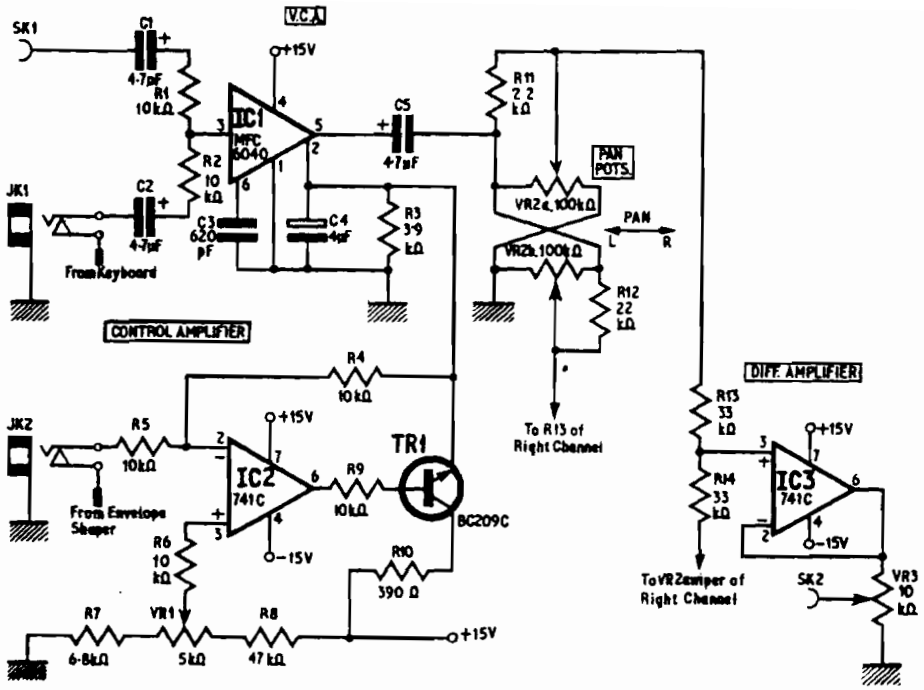


Fig. 9.2. Output Amplifier for left channel, right channel is identical. Note that if the Envelope Shaper is not connected by prewired link or if auto-programming of gain is not required JK2 must carry a grounded jack plug in order that full range of attenuation gain is achieved

COMPONENTS . . .

OUTPUT AMPLIFIERS (Left and right channels)

Resistors

R1–R2	10k Ω (4 off)
R3	3·9k Ω (2 off)
R4–R6	10k Ω (6 off)
R7	6·8k Ω (2 off)
R8	47k Ω (2 off)
R9	10k Ω (2 off)
R10	390 Ω (2 off)
R11–R12	22k Ω (4 off)
R13–R14	33k Ω (4 off)

All 5% ¼ watt carbon

Capacitors

C1–C2	4·7uF tantalum 35V (4 off)
C3	620pF (2 off)
C4	4uF elect. 18V (2 off)
C5	4·7uF tantalum 35V (2 off)

Potentiometers

VR1	5k Ω midget linear carbon (2 off)
VR2	100k Ω ganged midget linear carbon (2 off)
VR3	10k Ω midget linear carbon (2 off)

Integrated Circuits

IC1	MFC 6040 (2 off)
IC2–IC3	741C (4 off)

Transistors

TR1	BC209C (2 off)

Sockets

SK1–SK2	2mm miniature sockets (4 off)
JK1, JK2	3·5mm jack sockets (4 off)

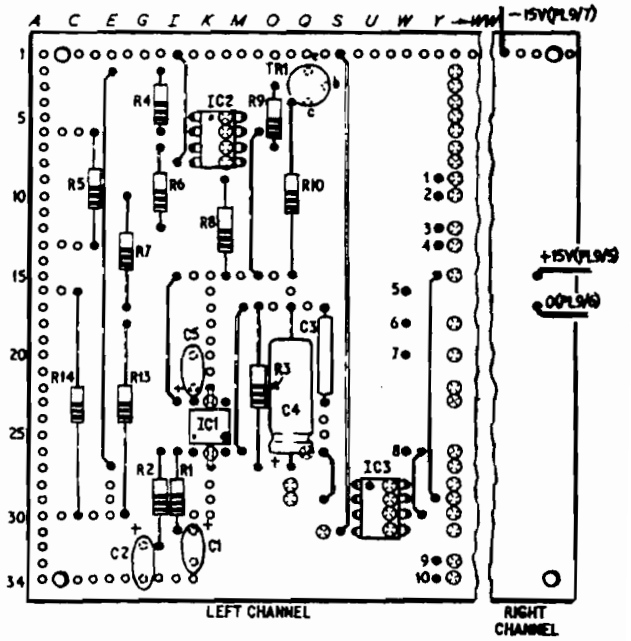


Fig. 9.3. Component layout for Output Amplifiers. As both channels are identical only the left hand is shown

mechanical centre. If there is more than say 10 to 15 per cent rotation between the two points it may be worth considering the empirical adjustment of one of the loading resistors in order to obtain a better balance or, alternatively, replacing the pot.

Both channels should be checked out in a similar manner and the electrical centres, when satisfactorily determined, marked on the front panel for reference.

CONTROL AMPLIFIER

In Part 7 of this series the action of the MFC6040 was described and it was shown that the full range of attenuation/gain could be obtained by varying the control voltage applied to pin 2 of the device. Maximum attenuation is associated with a control of +6V whilst maximum gain is obtained when the control falls to +3·5V.

As in the Reverberation Amplifier the control voltages are supplied by a separate amplifier, IC2 in this case, which is operating in the differential mode. Signals normally arrive at the control amplifier, via R5, from the envelope shaper to which it is permanently linked by means of a pre-wired interconnection. This means that R5 is effectively grounded since it is looking into a low impedance whatever the setting of the envelope shaper level control.

The non-inverting input of IC2 is provided with a reference voltage supplied via the divider R8, VR1, R7, which is variable between +1·75V and +3V and which, since the feedback around IC2 is halved due to the coupling on R5, results in the amplifier having an output swing ranging between +3·5V and +6V.

TR1 acts as a follower/current amplifier to ensure that the current sink at the MFC6040 control input has no effect on the output voltage of IC2.

Fig. 9.3 shows the recommended board layout of the output amplifiers.

If the output amplifiers are tested out before making the necessary pre-wired interconnections it is essential to insert a grounded jack plug into the control socket, or otherwise ground the input end of R5, in order to ensure the correct functioning of the circuit.

ENVELOPE COMPARISON

The rapidity with which the MFC6040 responds to changes in control voltage depends very largely on the value of C4 which has been chosen to present a time constant as close as possible to the fastest rate of attack/decay set by the envelope shaper. However it is prudent to compare the signal envelope at the output of the v.c.a. with the control envelope produced by the envelope shaper.

Fig. 9.4 gives a typical example of such a comparison. The slight rounding off at the corners of the signal envelope is due to the buffering action of C4 and is perfectly acceptable. If the rounding off is too pronounced there is a case for reducing the value of C4 to the next lowest preferred value but it is not recommended that the capacitor be removed entirely.

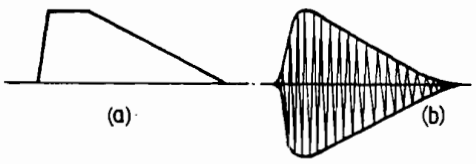


Fig. 9.4. (a) Control envelope—positive going (b) audio signal envelope with rounded edges

DIFFERENTIAL AMPLIFIER

In common with the voltage inverter appearing in Part 3 there is little which need be said concerning the Differential Amplifier which is of the simplest kind. Despite its simplicity however the Differential Amplifier can be made to perform many useful functions in the Synthesiser particularly in connection with the mixing of complex programming waveforms.

Fig. 9.5 gives the circuit diagram of the differential amplifier, while Fig. 9.6 shows the recommended board layout. The front panel component layout and wiring is shown in Fig. 9.7.

MODULE CONSTRUCTION

Construction of the module should generally follow the pattern already established in the series, that is, with the assembly and wiring of the components to the front panel before the panel itself is mounted to the circuit board support plate.

Wiring from the front panel components should be formed into two harnesses, one containing all leads to the output amplifiers passing out at the top of the front panel to the circuit board which is mounted in the position adjacent to the McMurdo plug. Leads to the differential amplifier should pass direct to the circuit board which is mounted in the lower postion adjacent to the front panel.

The board size for this latter circuit should not exceed 17 ways in depth otherwise there may be some difficulty in clearing the ganged pan-pots.

USING THE MODULE

As was explained last month the Voltage Controlled Amplifiers are principally intended for use with the Envelope Shaper in order that signals passing through them can be amplitude modulated in a variety of ways. However, only the left channel v.c.a. is permanently linked to the Envelope Shaper while the right channel control input is open circuit, that is, it requires a grounded jack plug inserted if control over signal amplitude is to be exercised.

With a jack plug in position the input level control may be operated in a similar fashion to a normal volume control, the characteristics of which were illustrated in graphical form in Part 7.

It is worth bearing in mind that the input level potentiometer is linear and thus the greatest degree of change in volume of the audio signal will occur within the last 30 degrees or so of rotation of the control. Alternatively, the control socket of the right channel may be linked by means of a patch-cord with the positive going envelope socket in order that both channels may be programmed by the envelope shaper. This latter procedure in no way compromises the audio signal and, in fact, with the pan-pots in the full left and right positions respectively the separation between channels is almost perfect.

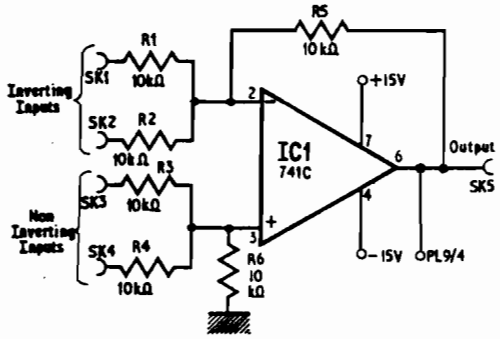


Fig. 9.5. Differential Amplifier circuit

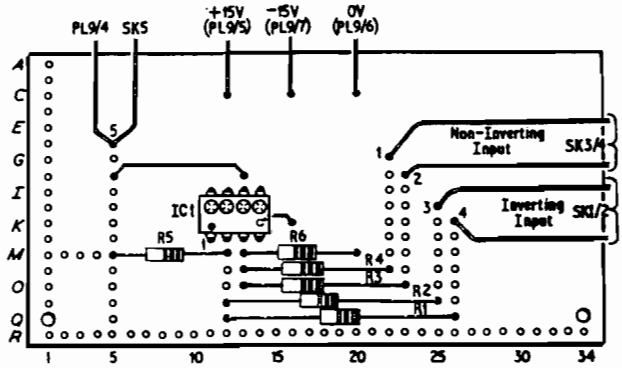


Fig. 9.6. Board layout for Differential Amplifier components

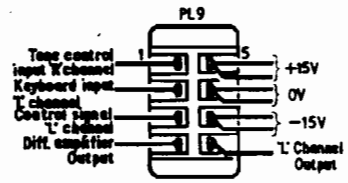
COMPONENTS . . .

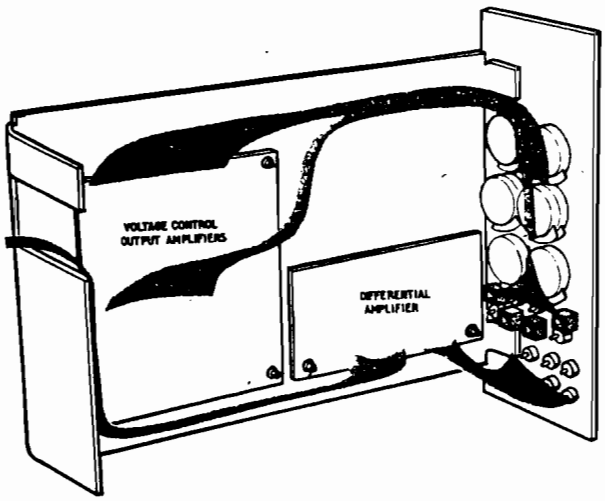
DIFFERENTIAL AMPLIFIER

Resistors
R1–R6 10k Ω (6 off)

Integrated Circuit
IC1 741C

Sockets
SK1–SK5 2mm miniature sockets (5 off)





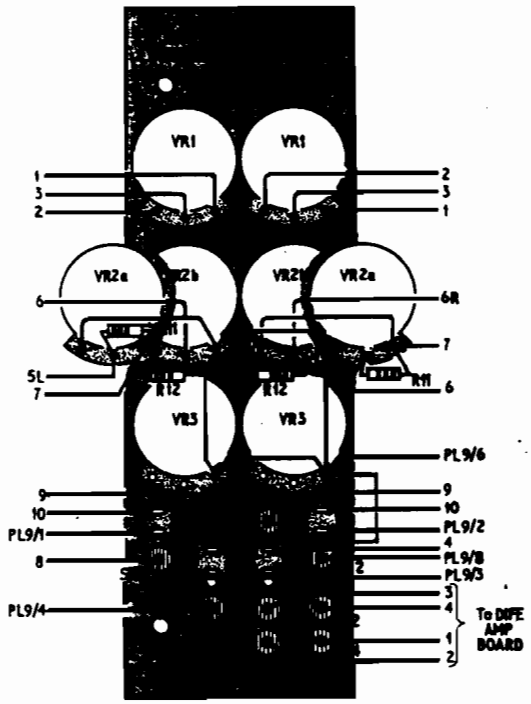


Fig. 9.7. Front panel wiring and inter-board connections. Note: Leads from VR3 as follows: wipers to SK2, unconnected tags to pin 8 on output amplifier board. Board positioning on the module is shown on the left with the McMurdo plug connections above

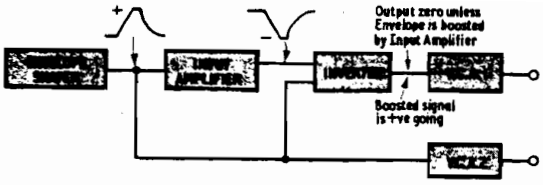


Fig. 9.8. Showing a method of obtaining a differential in envelope level

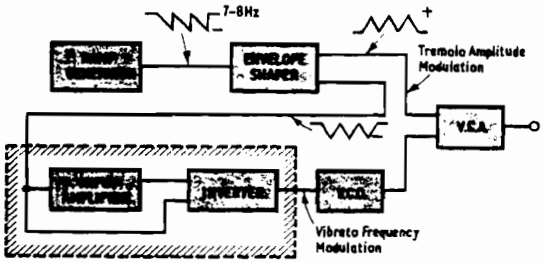


Fig. 9.9. Arrangement for combining tremolo and vibrato modulation

INPUT LEVEL

The total audio input signal level to the MFC6040 should not exceed 500mV and it is worthwhile ensuring that, if two signals are to be mixed in the v.c.a., each signal does not exceed 250mV peak. The penalty for neglecting this precaution lies in the possibility of damage to the device. The mean output level of the final stages will depend very much on the settings of the pan-pots. However, with 500mV input to the v.c.a. and with the pan-pots in mid-position, the maximum output is unlikely to exceed 2·2V. Output level controls are provided so that the output may be tailored to suit a range of input levels required by external apparatus such as tape recorders, power amplifiers and so on.

When the Envelope Shaper is programming the amplitude of the audio signal it is normal to set the input level control to zero if the full 90dB range of the v.c.a. is to be used. An alternative method is to adjust the input level so that, with a zero level envelope, the signal is just audible. The provision of an envelope under these conditions will serve to emphasise parts of the continuing signal. This technique is useful when one channel is carrying a repetitive rhythm which is to be mixed with another signal derived from, say, the keyboard. In these circumstances it is sometimes possible for the rhythm to be swamped by the keyboard signal unless the former signal is boosted.

If it is required to provide a differential level of positive going envelope for the latter purpose a suitable method is illustrated in Fig. 9.8. Set the envelope shaper signal level to provide the lowest amplitude response required between the two channels. Route the positive-going envelope to an input amplifier set to unity gain and also to the inverter. The output of the input amplifier should similarly be routed to the inverter. Since the inputs to the inverter are now of equal level and opposite polarity, the net output will be zero. Advancing the

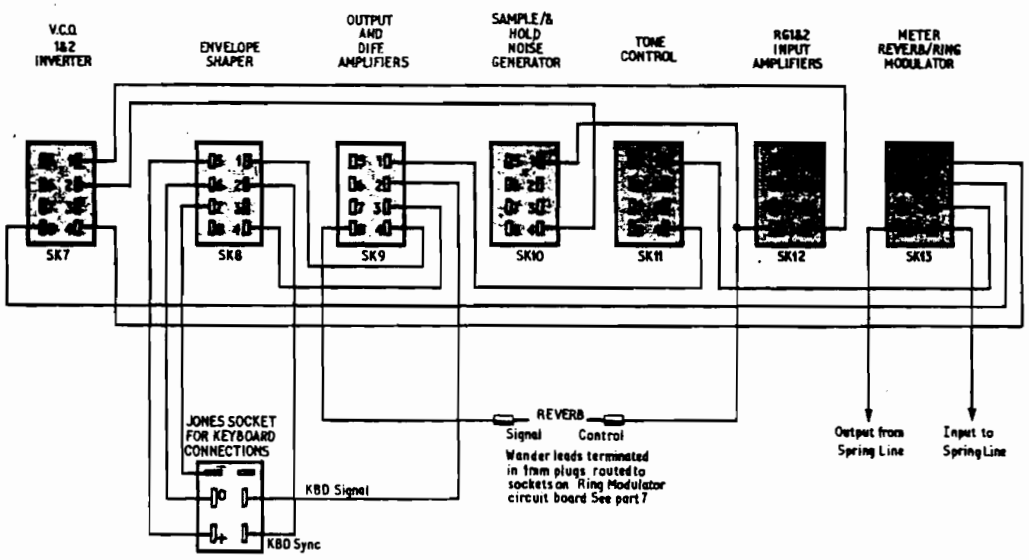


Fig. 9.10. Socket arrangement and wiring on connector mounting rails. Prewired interconnections are shown only

Table 1: Prewired Connections

Terminal Number	SK7 V.C.O. 1 & 2 Inverter	SK8 Envelope Shaper	SK9 Output Amplifiers Diff. Amp.	SK10 Sample/ Hold Noise Gen.	SK11 Tone Control	SK12 Ramp Gens. 1 & 2 Input Amps.	SK13 Meter Reverb. Ring Mod.
	Connect to	Connect to	Connect to	Connect to	Connect to	Connect to	Connect to
1	SK12 (4)	SK9 (4)	SK11 (4)	SK12 (8)	SK13 (3)	NC	SK7 (4)
2	SK10 (4)	Jones Skt. kbd. conn. sync.	Jones Skt. kbd. conn. signal	NC	NC	NC	SK7 (8)
3	NC	NC	SK8 (4)	NC	NC	NC	SK11 (1)
4	SK13 (1)	SK9 (3)	SK8 (1)	SK7 (2)	SK 9 (1)	SK7 (1)	Input to Spring Line
5	V+	V+	V+	V+	V+	V+	V+
6	O	O	O	O	O	O	O
7	V–	V–	V–	V–	V–	V–	V–
8	SK13 (2)	NC	Wandering lead	NC	NC	SK10 (1) Wandering lead	Output from Spring Line

gain control of the input amplifier will have the effect of providing a positive going envelope which may be adjusted to suit the requirements of the so-far unprogrammed output channel.

TREMOLO EFFECTS

An interesting experiment lies in the investigation of tremolo effects. Set a ramp generator to about 7–8Hz programming the envelope shaper direct. Adjust the attack and decay controls so that the resultant envelope is triangular in form and adjust the envelope level so that it provides peak modulation to a v.c.a. Couple a v.c.o. running at about 300Hz to the audio signal input of the same v.c.a. and adjust the input level control so that the sound does not die away completely at zero envelope level. The resultant pulsating sound is known as tremelo modulation.

The next stage is to take the negative going envelope and couple it to the same series of modules described in the previous example. The output of the inverter should be led to the v.c.o. providing the 300Hz signal. If the input level control to the v.c.a. is now turned to maximum and the input amplifier gain carefully increased the resultant sound is known as vibrato or, perhaps more suitably, frequency modulation. Variation of input amplifier gain, in conjunction with v.c.a. input level, can provide an interesting range of sounds in which tremelo and vibrato modulations are mixed. The schematic arrangement of modules for the above experiment is shown in Fig. 9.9.

Further interest may be provided by variation in the triggering rate of the envelope shaper and variation in the mark-space ratio of the envelope by careful adjustment of the ratio control.

PRE-WIRED INTERCONNECTIONS

This article concludes with some notes on interconnections which was outlined in Part 1.

Permanently connected interwiring is advocated to reduce the problems associated with external patch cords which, besides being possible sources of hum-pick-up, can often render the front panel controls difficult to operate particularly if a complicated patch is in use.

Table 1 gives the scheme of interconnection, whilst Fig. 9.10 gives a wiring layout based on the original illustration shown in Part 2 of the series. The socket numbers shown correspond to the socket numbers on that illustration which is a view from behind, as it were, of the front panel also depicted in that issue. Those constructors who have changed the arrangement of modules from that shown in Part 2 should note that the wiring on the McMurdo sockets will have been re-routed accordingly and would, perhaps, be well advised to use the table of connections as a guide.

There are two minor changes in the interwiring differing from the block diagram depicted in Part 1. These are:

(a) V.c.o. 1 is no longer programmed direct from the envelope shaper since the range of sounds which could be produced was not considered wide enough to merit a permanent connection.

(b) The Envelope Shaper programming of reverberation depth has been replaced by R.G.2 to gain the benefit of the wholly opposite type of effect resulting from the use of negative-going programming signals. At the same time the R.G.2 connection to the envelope shaper has been replaced by a connection from the differential amplifier since it has been found, in practice, to be the more useful of the two.

Note: See Points Arising this month.

Next Month: Commencement of the Keyboard Unit. This is an independent instrument that can be used for live performance apart from the main Synthesiser.