

Synthi Users Manual

EMMS

MANUAL

This manual describes the operation and maintenance of the SYNTHI VCS3, SYNTHI A, DK1 Keyboard and SYNTHI Keyboard, products of Electronic Music Studios (London) Limited.
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1. INTRODUCTION

The SYNTHI has a great variety of applications and it can be connected to many different kinds of electrical devices. It was designed with the following applications in mind:

As a live performance instrument, connected to power amplifiers, generating its own sounds and modifying sounds from microphones, guitars, etc.

As the main unit of an electronic music studio; one SYNTHI and two tape-recorders provide a flexible small studio, to which other devices can be added without difficulty.

As a teaching aid the SYNTHI can demonstrate most acoustics phenomena very easily. It can be operated without risk by students, and can be used with any convenient indicating or recording device.

The great flexibility of the SYNTHI comes from its basic design: unlike a television set or tape-recorder, in which the components are permanently connected to perform a specific function, the SYNTHI has about a dozen different devices which you connect together according to your particular need. The examples given in this Manual are intended to help you "get the feel" of the SYNTHI, and cover only a tiny fraction of its capabilities.

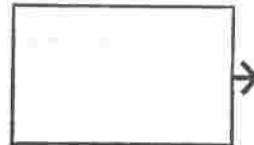
In order to use the SYNTHI intelligently, it is necessary to understand what the devices do, and how several devices may be connected to work in combination. In this section the general ideas will be explained, and in the sections following these ideas will be applied to examples that you can try on the SYNTHI.

This Manual describes the use of the SYNTHI VCS3 and the SYNTHI A and AX, the DK Keyboard and the SYNTHI Keyboard. The VCS3 and the SYNTHI A are very similar electrically, most of the differences being in the external design. The DK Keyboard has a similar finish to the VCS3 and the SYNTHI Keyboard is housed in a case matching the SYNTHI A for convenient transportation. The Keyboards are similar in concept but differ slightly in their controls: both are explained in Section 5.

It is possible to use the SYNTHI by itself, but you will probably want to use it as the basic unit of a more complex system. The SYNTHI is easily connected to almost all microphones, amplifiers, electric musical instruments and tape-recorders, and in addition there are special purpose peripherals made by E.M.S. These are described briefly in Section 6, and full instruc-

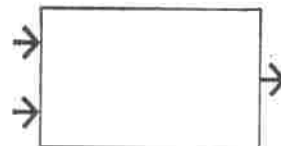
tions and specifications are provided with the devices themselves.

Devices in the SYNTHI are of three basic kinds. First there is the *source*, or *generator*; this produces a signal without requiring an input, and so we represent it diagrammatically with an arrow coming out of a box:



The SYNTHI has three Oscillators and a Noise Generator as its primary sources—the filter becomes a source when it is made to oscillate, and the Trapezoid output from the Envelope Shaper is also a source.

The next kind of device is a *treatment* or *process*. This modifies one or more signals that are put into it, and we represent it diagrammatically as a box with arrows going into it and an arrow coming out of it:



The Filter, Envelope Shaper, Ring Modulator, Reverberation Unit, and Amplifiers are all treatments on the SYNTHI. It is sometimes convenient to think of the Input Amplifiers as a "source" to the SYNTHI, but strictly they are treatments of the signal provided by a microphone, tape-recorders, etc.

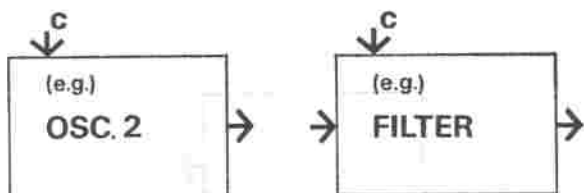
The third kind of device is an *output device*, and is the ultimate destination of the signal. We represent an output device diagrammatically by drawing a box with an arrow going into it:



In this manual we will assume that the output device is one of the loudspeakers built into the SYNTHI, or perhaps the meter. In practice, however, there are many output devices which

can be connected, such as power amplifiers, tape-recorders, other synthesizers, light-shows, etc.

All of these devices can be controlled by the knobs on the front of the SYNTHI. It is also possible to operate the controls electrically, and it is this fact which makes the SYNTHI so flexible. The devices themselves can turn the knobs, as it were. This is the principle of Voltage Control. We can include control voltages on the box drawings like this:

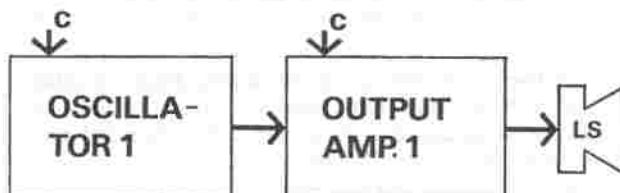


The control input is marked with a 'C' to distinguish it from a signal input. The left hand box represents an oscillator whose frequency is determined by a control voltage, and the one on the right shows a filter whose response is determined by a control voltage.

The SYNTHI does not distinguish Signal

Voltages and Control Voltages, but it is important that you do. Typically Control Voltages are of lower frequency than Signal Voltages. It is not possible to hear sounds of frequencies lower than about 25Hz (Hz means "oscillations per second") but a Control Voltage might be at a frequency of 8Hz (for a vibrato effect), or 1 oscillation per minute (for a slow fade), or 0Hz (i.e. constant) for a pitch determined from the keyboard.

Sounds are made by connecting the devices together. In order to listen to an oscillator, we connect it to an amplifier and a loudspeaker:



Although this is a very simple circuit (it requires only one pin on the patchboard of the SYNTHI) it is already capable of providing any audible pitch at a wide range of intensities—using manual control, since the Control Inputs are not connected yet.

2. CONNECTING THE SYNTHI

Power Supply

The SYNTHI is set to run from 245V AC; any other setting will be indicated by a label. *The SYNTHI must never be connected to a DC supply.* After checking the setting, attach a plug to the mains lead, and connect the studio to the mains. Turn the MAINS ON switch and the red light beside it; the other red lamp (on the Envelope Shaper) may also glow or flicker, and this does not matter.

Audio Equipment

Other devices (microphones, tape-recorders, amplifiers, or other SYNTHIs) may be connected via the jack sockets. The voltages required and produced by the SYNTHI are specified in the SPECIFICATIONS section. Note that the headphone socket is for a *stereo* jack plug — all others are mono. It is not advisable to use the 8-way Keyboard connector for equipment not specifically designed by EMS for use with the SYNTHI.

The SYNTHI has two inputs and two outputs. The actual sockets used depends on the nature of the device connected. Microphones should be plugged into the MICROPHONE sockets, and other input devices such as tape-recorders should be plugged into the HI LEVEL input. The SIGNAL OUTPUT sockets should be used unless the output is a Control Voltage destined for another SYNTHI, in which case the CONTROL OUTPUTS are used. The HEADPHONES socket provides the two outputs at a higher level through a jack of the kind normally connected to stereo headphones. The SCOPE socket is a distinct output (connected to the meter circuit) but with other applications which will be described later.

Many modern amplifiers have connections for a tape-recorder and a "SOURCE/TAPE" switch, and these will generally be suitable for use with the SYNTHI. Connect the "RECORD" terminals on the amplifier to the HI LEVEL sockets on the SYNTHI and the "PLAY" terminals to the SIGNAL OUTPUT sockets. If the amplifier is switched to SOURCE the SYNTHI is effectively disconnected; in the TAPE position, signals going into the amplifier (from a record-player or tuner) are routed through the SYNTHI, which can then be used to process them, or to produce its own sounds.

When connecting a device to the input sockets of the SYNTHI for the first time, always turn the Input Amplifier LEVEL controls to zero. Connect the Meter to an input by putting a pin at A8 or A9 (patching is described in the next section) and turn the level up slowly. If the needle goes over to the right as soon as you begin to turn the LEVEL control, the signal will have to be attenuated (reduced) before it is applied to the SYNTHI.

Peripherals

The tape-recorders, amplifiers, etc., which we can connect to the SYNTHI are called *peripherals*, regarding the SYNTHI as the most complex device and the centre of operations. E.M.S. manufacture some special devices for use in electronic music applications which are not available elsewhere. These currently include:

SYNTHI SEQUENCER — used with a SYNTHI and Keyboard, enabling short tunes (or, more generally, sequences of control voltages) to be stored and replayed.

PITCH TO VOLTAGE CONVERTER — this unit detects an input signal, sends a pulse to trigger the Envelope Shaper, extracts the fundamental frequency of the sound, and sends a proportional voltage, enabling the SYNTHI to accompany a performance in tune.

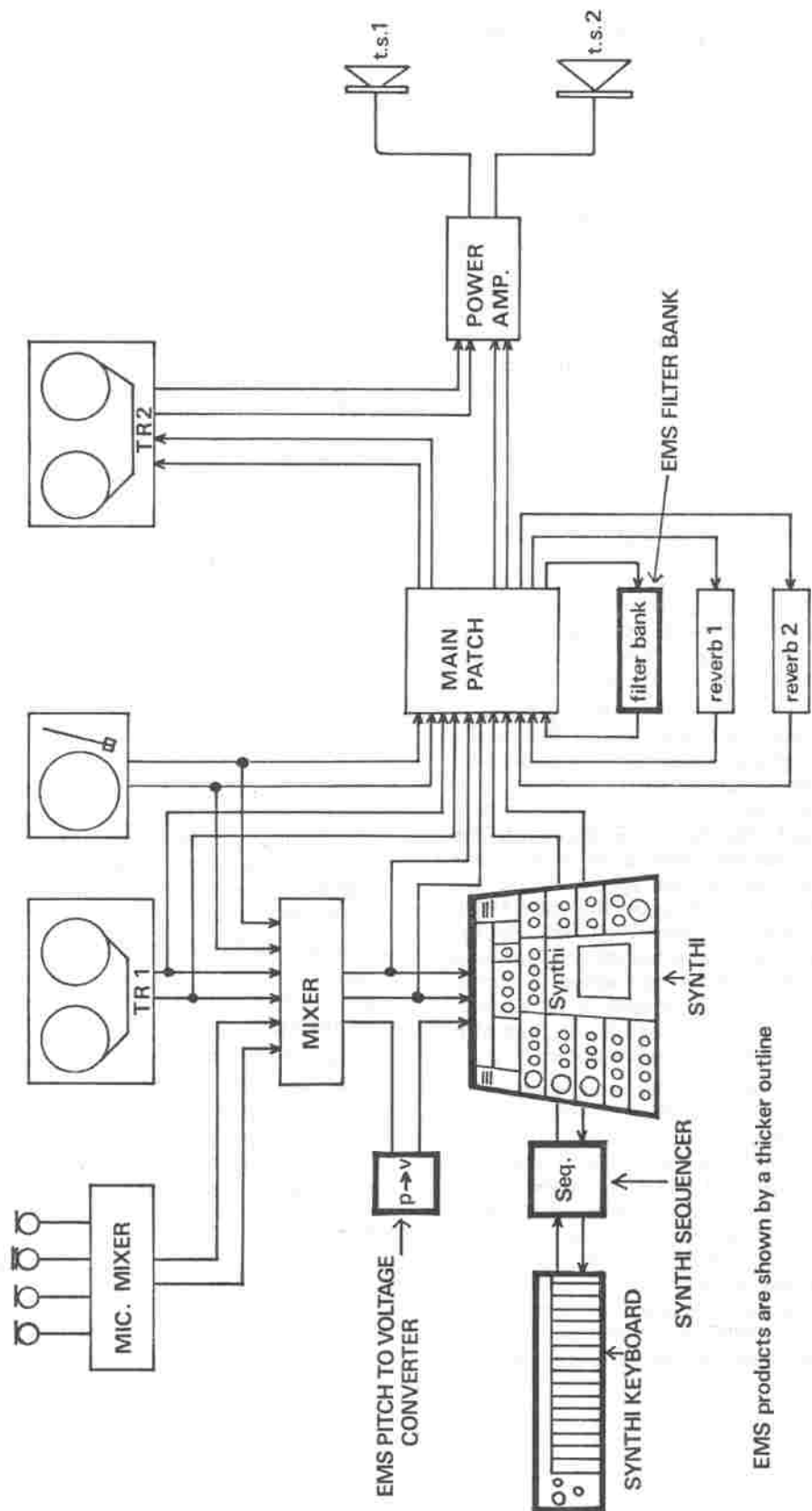
OCTAVE FILTER BANK — A bank of eight filters covering the musical spectrum and providing complete control of the tone colour of any signal.

SYNTHI BATTERY PACK — Another matching briefcase unit which enables the SYNTHI AX to be operated independently of the mains.

The SYNTHI can also be connected to another Synthesiser: most currently available synthesisers use similar control voltages, but you should check first. It is of course safe to connect it to another SYNTHI.

A small Electronic Music Studio organised around a SYNTHI and peripheral devices might look like this:

Diagram on page 4.



EMS products are shown by a thicker outline

3. USING THE MATRIX BOARD

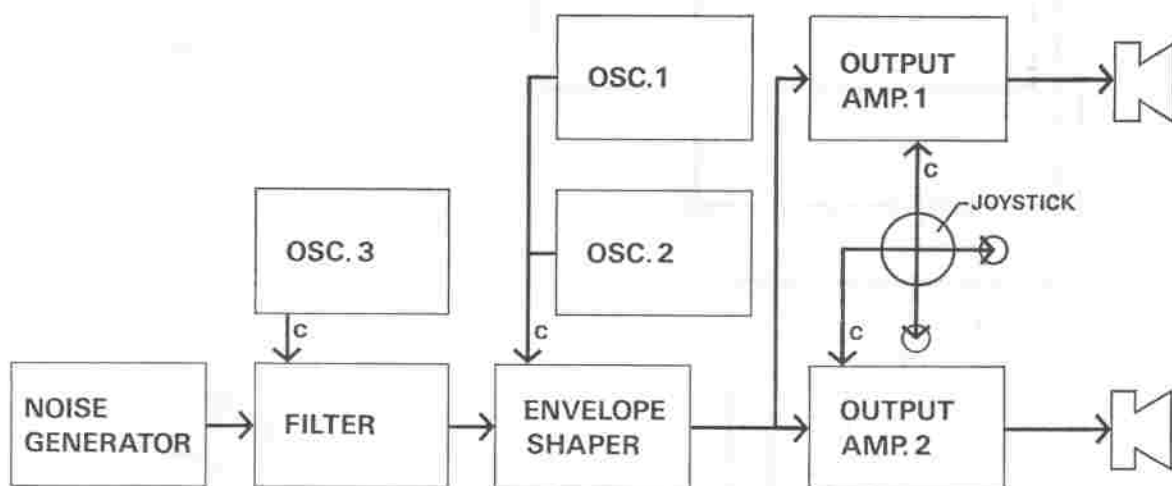
From this point in the manual onwards we will assume that you have a SYNTHI and that it is switched on, so the explanation will be conducted in terms of practical experiments.

The SYNTHI cannot produce a sound at all unless there are pins in the patchboard, and we will therefore describe the process of patching first. The principle of patching is very simple: each pin that is plugged into a hole on the patchboard connects one device to another. Examining the patchboard you will see that the *sources* (Oscillators, Input Amplifiers, Filter and Trapezoid) appear on the left, and below them are other outputs from treatments (Envelope Shaper, Ring Modulator and Reverberation). Imagine that each of these is producing a signal which is travelling across the board from left to right: at any point on its row, we can "tap" a signal and send it to one of the devices at the top of the board — if it is a Signal it will probably go to a device on the left hand half of the board, and if it is a control, to a device on the right hand half. Put a pin in the second hole of the top row, and you have connected Oscillator 1 to Amplifier 1, as shown in the last diagram of the Introduction. From now on, we

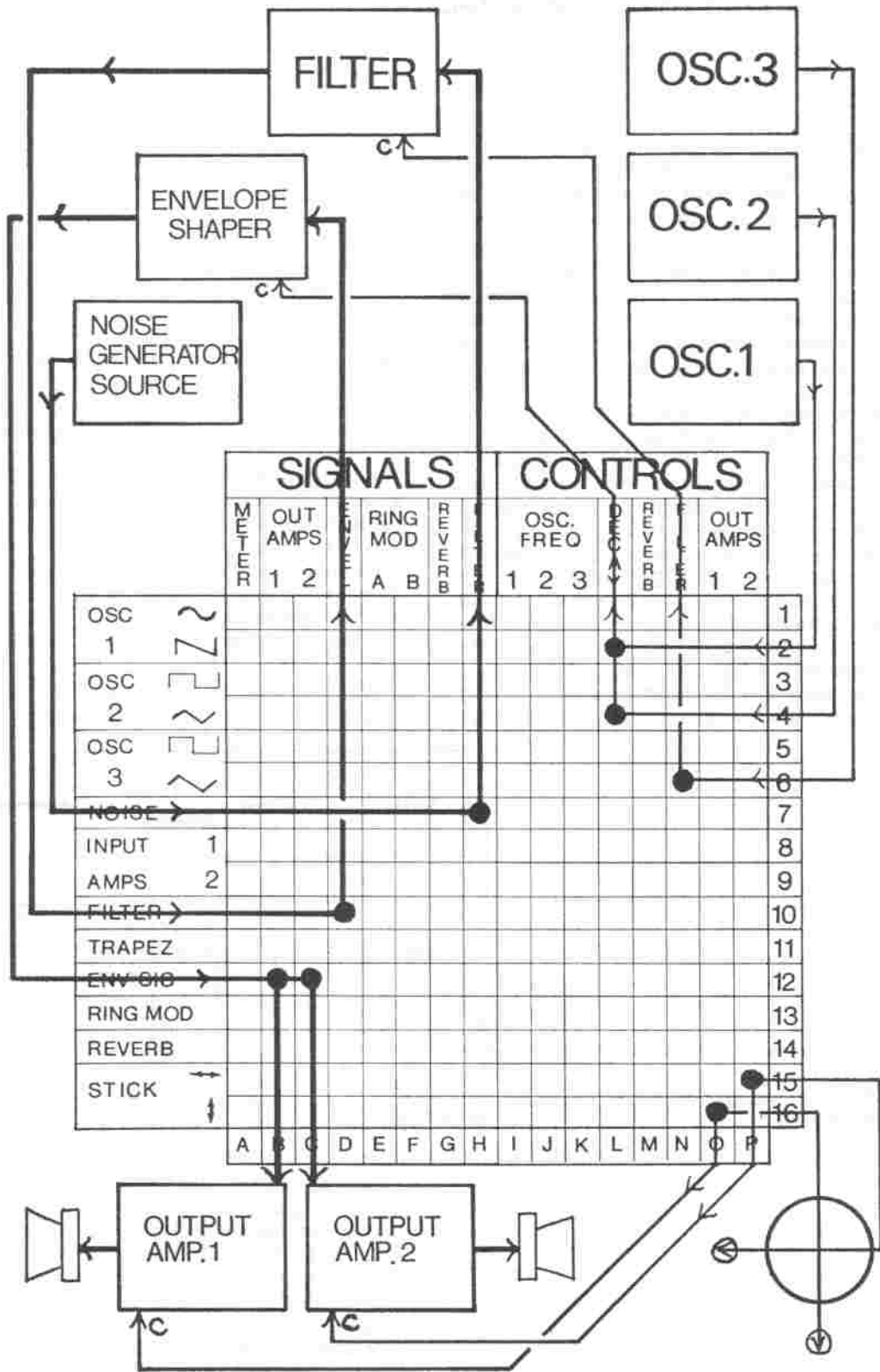
will refer to holes by the letters along the bottom of the patchboard and the numbers on the right of it — so you have put a pin in B1.

This patch does not necessarily produce a sound; to hear a sound (or to modify the sound you are hearing), turn the FREQUENCY control of Oscillator 1 to 5 and the LEVEL control to 7. Turn the LEVEL control for Output Amplifier 1 to about 7 as well, and if necessary turn off the muting switch for Amplifier 1. With this patch you can determine the frequency range of Oscillator 1, which will probably be inaudible at low frequencies (near 0) and very high pitched when the control is near 10. The SHAPE control affects the timbre of the sound, and both LEVEL controls affect the loudness. If the LEVEL controls are both set high, there will be distortion, which should be avoided although it will not damage the SYNTHI. Note that the PANNING controls on the Output Amplifiers have no effect if you are using the internal speakers of the SYNTHI, but will move the output signal from one loudspeaker to the other if a stereo amplifying system is connected.

We will now construct a more complicated sound, starting from a block diagram:



The source is the Noise Generator, and the signal is processed by the Filter and Envelope Shaper before being taken to both Output Amplifiers. Oscillator 3 controls the Filter, and Oscillators 1 and 2 control the Envelope Shaper; both Output Amplifiers are controlled by the joystick, which provides two Control Voltages. The effect of these controls will be described in the next section, here we are only concerned with the connections. Now consider this diagram:



Although the boxes have been moved around somewhat the connections are the same. The important addition is that we have incorporated the patchboard, and marked the pins with blobs on the signal routes. Considering the signal only, this patch was achieved along the following lines:

Connect Noise (row 7) to Filter (row H) with a pin at H7.

Connect Filter (row 10) to Envelope (row D) with a pin at D10.

Connect Envelope (row 12) to Output Amplifiers (rows B and C).

The other pins, for the Control Voltages, are worked out similarly. It is very important to remember that the Filter has a Signal input (Row H, here connected to Noise) and a Control input (Row N, here connected to Oscillator 3). This applies to the other devices as well.

The patchboard connections are associated with the knobs by the letters, and numbers by the knobs. Knobs with a number beside them control the amplitude of the Signal or Control voltage arriving at the patchboard. Letters on a round black ground (A—H) correspond to devices — for example, a pin in row H sends a signal to the filter — and letters in a square black ground

correspond to controls; in this case, a Control voltage has the same effect as turning the appropriate knob.

Suitable knob settings for this patch are given in the first specimen patch. Try altering these settings, and *understanding* the changes that occur. The next section explains the effect and use of each device and this will aid understanding. (If you try this patch immediately after turning on the SYNTHI there may be no sound since the Noise Generator takes 20-30 secs to warm up.)

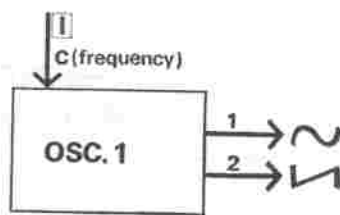
(The slot underneath the Patch Panel on the SYNTHI AX is for *preset patches*. When the SYNTHI is used in performance, there is often insufficient time to move the pins for a new patch, and of course there is always the risk of making a mistake. The preset patches are simply plugs which fit into the slot and make all the connections necessary for a patch. A preset patch can be added to (by putting pins in the Board in the normal way) but a preset pin cannot be removed. E.M.S. provide certain preset patches and will manufacture Presets for your patches. Remember that a preset patch can only establish pin settings — it can't set the knobs.)

4. THE DEVICES

We have already seen that the flexibility of the SYNTHI comes from its modularity: there are a number of devices which are connected by the user. This section explains the use of each device in detail, and indicates ways in which it might be connected to other devices. It is virtually impossible to damage the SYNTHI electrically by misuse of the controls and patchboard so do not hesitate to try to devise combinations not mentioned here.

The effect of all the controls for each device is explained. When settings are given it is important to remember that if the knob has a square letter (I-P) beside it, its effective setting can be altered electrically by a pin in rows I to P of the patchboard. For the most part, the controls are described qualitatively in this section, and for details of voltage, sensitivity, etc, you should refer to the Specifications section.

OSCILLATOR 1



This Oscillator will normally be used as an audible source since its frequency range covers the entire audio spectrum; it can also be used as a control since its range goes below 1Hz.

Put a pin in B1, turn the Oscillator 1 FREQUENCY control to mid-range, the sine LEVEL control to 6 and Output Amplifier 1 LEVEL to 5. The muting switch should be UP. Turn the SHAPE control on Oscillator 1 and note that the sound is "buzzy" at high or low settings but smoother at the centre. The buzziness is due to *harmonics*, extra sounds whose frequencies are multiples of the fundamental frequency, which is heard by itself in the control position.

Oscillator 1 can also produce a *sawtooth* or *ramp* waveform (the names are due to the appearance of a graph or oscilloscope trace of the signal) which can be heard by moving the pin to B2. By moving the pin from one hole to the other, check that the levels (loudness) of the two waveforms can be altered independently, but the pitch is the same for a given setting of the FREQUENCY control.

Controls

Frequency:

This control has a slow motion dial to make fine adjustment easier. Each major division of the dial corresponds to an interval of about 1.5 octaves.

Shape:

The Shape control affects the sine wave output only, and there is one position (near 5 on the dial) which produces a pure sine wave: on either side of this the shape changes as shown.

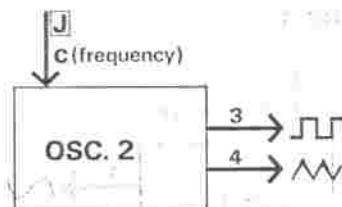
Sine Output Level:

This controls the signal level at row 1 of the patchboard.

Rampo Output Level:

This controls the signal level at row 2 of the patchboard.

OSCILLATOR 2



Oscillator 2 has the same frequency range as Oscillator 1, but the waveforms available are square and triangular.

Put a pin in B3 and turn the FREQUENCY, SHAPE and LEVEL controls to about half way. Note the 'rough' sound of the square wave, due to the presence of many overtones and find the symmetrical position on the SHAPE control where the sound is smoothest — at this point the even harmonics disappear. Move the pin to B4 and do the same with the triangular waveform.

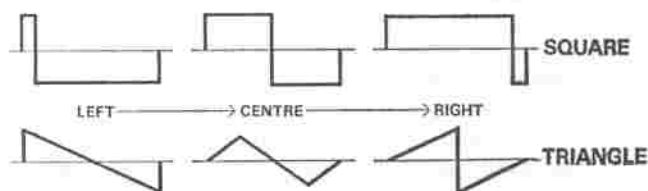
Controls

Frequency:

As for Oscillator 1.

Shape:

The Shape control affects both outputs, and the effect on the waveform is depicted below. At the extremes (0 and 10) the square output will become inaudible because the pulse is too narrow to be heard.



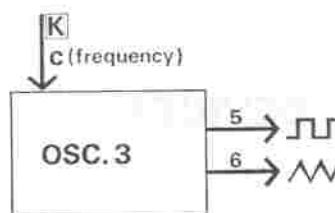
Square Output Level:

This controls the signal level at row 3 of the patchboard.

Triangle Output Level:

This controls the signal level at row 4 of the patchboard.

OSCILLATOR 3



This Oscillator is similar to Oscillator 2 in that it produces square and triangular waveforms, but its frequency range is much lower, approximately 0.025Hz (40 seconds per cycle) to 500Hz.

It is possible to listen to this oscillator in the same way as the others by putting a pin in B5 or B6 or both. However, at frequency settings below about 7 all that is heard is a series of clicks, and it is more instructive to put a pin in A5 and A6 and watch the output changing on the meter. (Set the meter switch to CONTROL VOLTAGE).

Controls

Frequency:

Slow-motion dial, range 0.025Hz to 500Hz. The period of the lowest frequency will vary from model to model.

Shape:

As for Oscillator 2.

Square Output Level:

Controls the level at row 5.

Triangle Output Level:

Controls the level at row 6.

NOISE GENERATOR



"Noise" is a sound of no particular frequency. Since white light consists of light of all wavelengths, noise which contains all audible frequencies is called "white" noise, and noise with more frequencies in one part of the audio spectrum than another is called "coloured" noise. The Noise Generator on the SYNTHI is not voltage controlled, but there is a manual COLOUR control which emphasizes low or high frequencies.

Noise occurs naturally in sounds such as the wind, the sea, or escaping steam, and in music it is produced by unpitched instruments such as cymbals, snare-drum and wood block.

To listen to the Noise Generator, put a pin at B7, and move the COLOUR control. Its applications will be described later, since noise is usually modified by other devices.

Controls

Colour:

"Dark" to the left, high and "light" to the right. A central setting gives pure white noise.

Level:

The amount of Noise available at row 7.

Special Note:

The Noise Generator requires 20 to 30 seconds to start after the SYNTHI is switched on.

RING MODULATOR



The Ring Modulator is a *treatment* device which requires two input signals and produces one output signal. The inputs are similar, and signals must be provided to both of them if an output is required.

Whereas a mixer (which also has two or more inputs and one output) *adds* the input signals, the Ring Modulator *multiplies* them. This is why both signals are necessary — multiplying by zero gives zero as a result. Musically, the effect is complex, since the frequencies in the output will only be musically related to the input frequencies in

special cases. In the simplest case, when the two inputs are pure sine waves, the output consists of two sine waves whose frequencies are the sum and difference of the input frequencies.

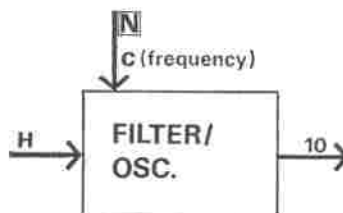
Put a pin at A1 and adjust the sine LEVEL of Oscillator 1 so that the Meter registers a signal level of 0.45. This is about 1.5V p-p and is the highest signal level that should be put into the ring modulator to avoid distortion. Turn the RESPONSE control on the Filter to 10 (this makes the filter oscillate) and move the pin to A10 to set the Filter LEVEL similarly. Then put pins at E1, F10 and B13. You are now listening to two sine tones ring-modulated, and by altering the input frequencies you can hear the sum and difference tones changing.

Control:

Output Level:

The level of the modulated signal at row 13.

FILTER/OSCILLATOR



The function of the Filter is to remove selected frequencies from the input signal, and present the remainder at the output. In addition, it can be made to resonate, producing a very pure sine tone which is a useful Source. The three principle functions of the SYNTHI Filter are:

1. Low Pass

If the RESPONSE control is set to zero, the Filter will pass low frequencies but stop high ones. The highest frequency passed is determined by the FREQUENCY control. Put pins at H2 and B110 and listen to the effect of filtering on a ramp waveform: set Oscillator 1 FREQUENCY to 5 and LEVEL to 5, Filter RESPONSE to zero and LEVEL to 7. By moving the FREQUENCY control on the Filter slowly from 0 to 10, you can listen to the waveform being "built-up" from its components as the Filter passes more harmonics.

2. Band Pass

When the RESPONSE control is turned higher, to 5 or 6, the Filter cuts out both low and high frequencies, and thus selects a *band* of frequencies whose position in the spectrum is controlled by the FREQUENCY knob. The effect of band-pass filtering on a complex sound is very

dramatic — it is in fact an exaggerated version of the “wah-wah” control used by guitarists. The Filter works most effectively when the incoming sound has a low level, but it should not be so low that noise is heard at the output.

3. Oscillator

If the RESPONSE control is turned up still more, to about 7, the Filter oscillates (remove the pin at H2 before doing this, to hear the effect more clearly). The point at which oscillation starts will vary slightly with the setting of the FREQUENCY control, and also from model to model.

Controls

Frequency:

This controls the cut-off frequency (or output frequency if the Filter is oscillating) over the whole audio range.

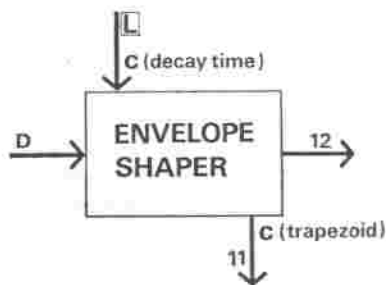
Response:

This selects the mode of the Filter — low-pass, band-pass or oscillatory.

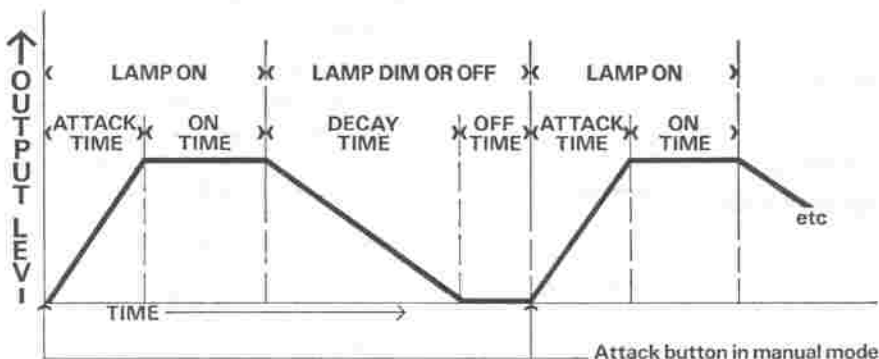
Level:

The signal output available at row 10.

ENVELOPE SHAPER



The Envelope Shaper is so called because its principle function is to control the *shape* of a sound. For example, the sound from a plucked string increases very rapidly in loudness at first, and almost immediately begins to die away. A bowed string increases in loudness more slowly at the start of the note as the bow accelerates over the string. The Envelope Shaper divides the duration of a note into four sections, and there is a control for each; these are the *attack time*, during which the sound increases in loudness, the *on time*, during which it remains at its loudest, the *decay time*, as it dies away, and the *off time*, which is the interval of silence before the next note. The red panel lamp is on during the *attack* and *on* parts of the note, and off or dim during the *decay* and *off* parts. The function of the Envelope Shaper is illustrated below.



Put pins at D1 and B12, so you are listening to Oscillator 1 through the Envelope Shaper. Adjust the LEVEL control to about 7 and experiment with the ATTACK, ON, DECAY and OFF controls. A setting of 0, 0, 6, 5 will produce a plucking sound; 1, 4, 4, 5 will produce an organ effect, in which the note is constant in intensity for most of its duration, and increasing the DECAY to 8 produces a sustained, gong-like sound. Low settings of the controls (try 2, 0, 5, 0) will produce a tremelo effect in which the individual cycles can barely be distinguished. If the OFF control is set to more than about 7, the note will not repeat, but a new note can be initiated manually by pressing the red button marked ATTACK. The decay phase will not start until the button is released, so for short notes it is necessary to practice a quick jabbing action.

The Envelope Shaper operates by generating a control voltage, and using it to control a voltage controlled amplifier. The control voltage appears on row 11 of the patchboard and its amplitude is controlled by the TRAPEZOID knob of the Envelope Shaper. Add a pin at I11 and you will find that the pitch of the output varies with the intensity. It is constructive to have a pin at A11 during this experiment so that the control voltage can be seen on the meter.

The decay time of the Envelope Shaper can be voltage controlled by a pin in row L. A pin at L6, for example, with Oscillator 3 set to a low frequency, will produce accelerandos and ritardandos, and it is possible with this simple patch to imitate a bouncing ball. (This effect is described more fully in Example 6 of Section 6.)

Controls

Attack:

The rate at which the note "grows" initially; variable from about 2ms to 1 sec.

On:

The time during which the note remains at its loudest; variable from 0 to 2.5 sec.

Decay:

The time required for the note to fade away; variable from 3ms to 15 sec.

Off:

The silence before the next note; variable from 10ms to 5 sec. At high settings of this control no note occurs until the ATTACK button is pressed.

Attack Button:

This button initiates a new cycle and holds the Envelope Shaper at ON until it is released.

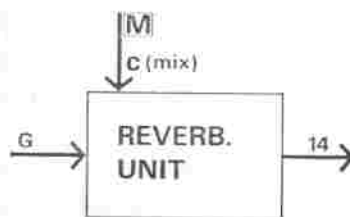
Envelope:

The level of the output signal at row 12.

Trapezoid:

The level of the control voltage at row 11.

REVERBERATION



The reverberation unit consists of a pair of lightly tensioned springs with transducers at either end to transform the electrical signal into a mechanical vibration and back again to a signal. Because a mechanical link is involved, the reverberation unit makes a slight noise which can be heard if the internal speakers are muted. It is also possible for the springs to pick up vibrations from other sources, such as knocks on the side of the cabinet and, more importantly, the internal loudspeakers. In fact, it is possible to induce acoustic feedback (howl) when using the internal loudspeakers, which is unavoidable in a small cabinet.

The basic function of Reverberation is to simulate electronically the effect of a room, or hall, in which sounds take a few seconds to die away but it can also be used for blending and distancing sounds. Reverberation is more effective when external amplifiers are connected to the SYNTHI, for the reasons given above. Set the MIX control to zero, and use Oscillator 1 and the Envelope Shaper to provide a short, crisp note, using pins at D2, G12 and B14. As the MIX control is tuned clockwise the sound becomes more sustained, as in a large bare room. At maximum, the reverberation time is about 2 seconds, equivalent to a small concert hall, but the sound is noticeably degraded. Small amounts of reverberation add an extra "richness" which is often used to avoid the rather dry quality of electronic sounds.

If the reverberated sound is severely distorted, the spring is probably overloaded; turn the level of the device feeding it down, and if necessary turn the reverberation level up.

Controls

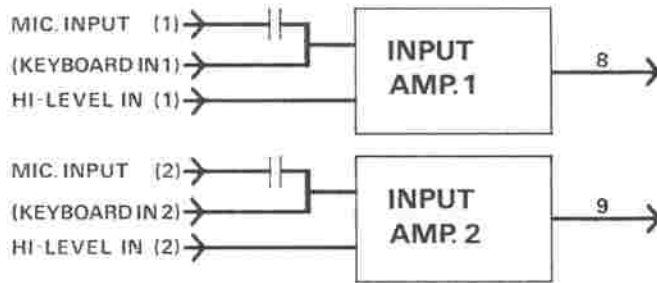
Mix:

The proportion of direct to reverberated output. At zero, there is no reverberation, and at 10 most of the signal is heard through the springs.

Level:

The amplitude of the signal at row 14.

INPUT AMPLIFIERS



These amplifiers are used when a signal or control voltage from another instrument is to be put in to the SYNTHI. Before connecting anything other than another EMS Device, you should make sure that the signals are electrically suitable. For a description of the procedure you should adopt when making connections, see the section **CONNECTING THE SYNTHI** above; for details of signal levels, see the **SPECIFICATIONS** section (page 19).

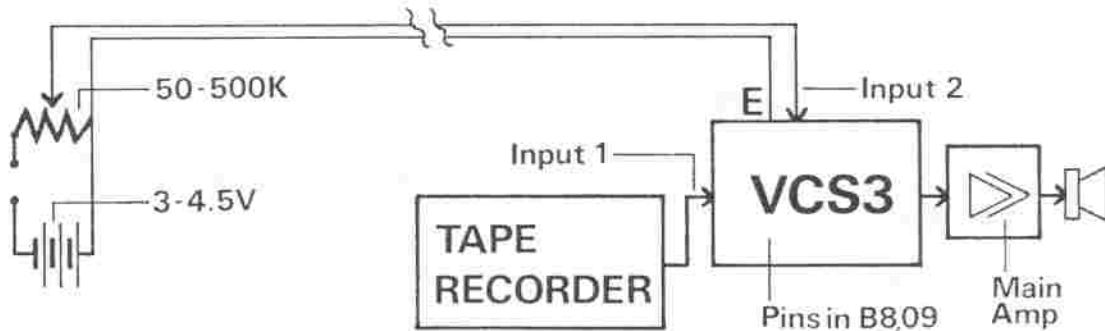
Microphones may be connected at the Microphone jacks. These are suitable for crystal microphones, but the high quality dynamic microphones (which provide a lower output) may require pre-amplifiers.

Musical instruments with an electrical output (guitars, organs) can be connected to the HI

LEVEL inputs; if the signal coming into the SYNTHI is inadequate, then connect them to the Microphone inputs.

EMS Devices use the special 8-way connector: these include the Keyboard and the Sequencer. It is best not to use this unless you are sure you understand the connections given in the Specifications section and their use.

The HI LEVEL inputs accept control voltages as well as signals. Two SYNTHIs may be connected, and one can control devices in the other, or, more simply, one SYNTHI can be used as a remote fader, as shown in the diagram. Using a control voltage to control loudness (or any other controllable function) has the advantage that long signal leads are not required and so the usual problems of hum and noise are absent.



Controls

Input Level:

One control for each channel determines the signal level at rows 8 and 9.

Filters:

Provide bass or treble attenuation with a central "flat" position.

Muting Switches:

Used to disconnect the monitoring

speakers when headphones or external amplifiers are being used.

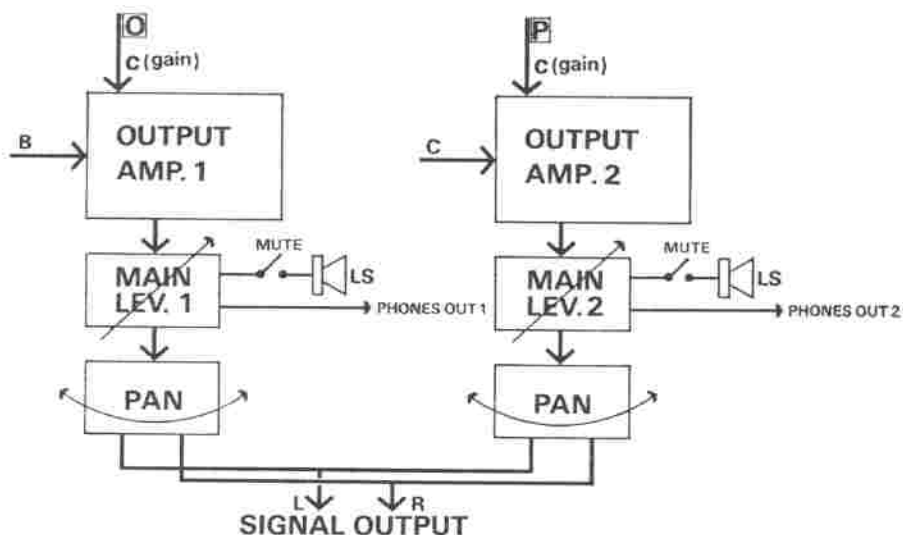
Main Level:

Control the level at the monitoring speakers and the output sockets.

Pan:

These pan the outputs available at the LOW LEVEL output sockets only.

OUTPUT AMPLIFIERS



These Amplifiers are used at the end of a chain of devices to send the signal to the internal loudspeakers, headphones, or to an external tape-recorder or amplifying system. Their inputs are rows B and C on the patchboard and all patches should have a pin in one or both of these rows.

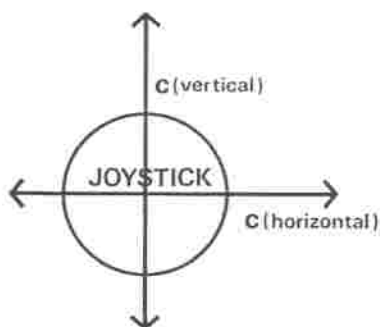
Each Amplifier contains a Filter which functions as a simple tone control; these should normally be left in the "flat" position (5 on the dial) and adjusted only when the other controls have been set. They are useful in live performance for "tuning" the SYNTHI to the acoustic environment.

The level of the output signal is controlled manually by the Output Level controls, and also by voltage control, using rows O and P on the

patchboard. Experiments 7, 18, 21, 26 and 27 in Section 6 show ways in which voltage control of the Output Amplifiers is useful. To use the internal speakers, turn the muting switches UP; these speakers are 5 inches in diameter and they are driven by 1 watt amplifiers: they are intended for monitoring only, and if you attempt to get a loud sound out of them they will distort. When external amplifiers are available, the internal amplifiers will generally be muted.

There are also two PANNING controls. When the SYNTHI is connected to a stereo amplifier, these control the position of the signal between the channels. As you can see from the diagram, neither the internal speakers nor the headphones are affected by the Panning controls.

JOYSTICK



The Joystick is a very useful device, enabling you to alter two control voltages simultaneously. These voltages appear on the patchboard at rows 15 and 16. Although the mounting is round, the Joystick moves in a square whose corners correspond to the extremes of each voltage. The voltage swing for a particular movement of the joystick can be controlled by the RANGE controls beside it.

Put pins at B1, B2, O15 and P16; the Joystick now controls both output channels and a fade can be made by moving it from top right to bottom left, or a pan by moving it from top left to bottom right. With pins at B1, O15 and I16, left and right movements of the Joystick control level, and up and down movements affect pitch.

The Joystick is often useful when a patch is being set up, to find out quickly the effect of a particular control, or of two controls in conjunction. When the optimum position is found, the Joystick pins can be removed and the position set manually. It should also be used as much as possible in performance, to minimise the risk of turning the wrong knob.

Controls

The RANGE controls determine the voltage swing obtainable from the Joystick.

METER

The Meter is used to check or monitor levels and it has two modes selected by the switch labelled CONTROL VOLTAGE and SIGNAL LEVEL. A control voltage or signal is measured by putting a pin in row A of the patchboard. If you put more than one pin in row A remember that as well as measuring the sum of the outputs you are linking two devices together.

Patch D1, B12 and A11; experiment with the Envelope Shaper controls and learn to associate the Meter movement with the sound, since this ability is useful in checking a patch noiselessly during performance. The switch should be set to CONTROL VOLTAGE for this experiment.

5. KEYBOARD

There are four important things to remember about an E.M.S. keyboard. These are:

1. It is monophonic (i.e. it does not play chords).
2. The output is a voltage that may be used to control anything, not just pitch.
3. The interval between any adjacent pair of notes is the same for each pair, but is not necessarily a semitone.
4. Each key is sensitive to the strength with which it is struck.

The first point is self-explanatory: if you want to play chords the best thing to do is buy a cheap electronic organ and plug it into the Input socket of the SYNTHI, or buy a harmonium and put a microphone inside it. The SYNTHI can then be used to alleviate the harsh tone, a task for which it is well-suited.

The keyboard can produce a tone whose pitch varies with the note struck, or a control voltage which depends on the note struck. If the second mode is used, the control voltage can be used to control filtering, reverberation, or amplitude as well as frequency. The range of this control voltage is adjustable, and determines the pitch range of the keyboard (assuming for the moment that it is pitch that we are adjusting). If two Cs are tuned to be an octave apart, then the keyboard will be tuned chromatically: if they are tuned to an augmented fourth (tritone) apart, then the keyboard will play a quarter tone scale.

Finally, when a key is played, a second control voltage which depends on the strength with which it was struck. (There are two contacts on

When using the Ring Modulator, set the switch to SIGNAL LEVEL and check that the inputs to the Ring Modulator indicate about 0.45 on the Meter scale, to prevent overloading.

If a complicated patch produces a noisy or distorted sound "trace" it with the Meter. Suppose you have patched Noise — Filter — Envelope Shaper — Reverberation — Output Amplifier 1; use one pin, and put it in A7, A10, A12, A14 in turn. Roughly speaking, the signal level should remain constant or increase slightly through the chain. If one stage has a particularly low output the next will have to amplify the signal considerably and this will degrade the final quality.

each key, and the circuit measures the time which elapses between their closing: so strictly speaking, it is the velocity of the key which is measured.) This voltage may be used to control volume (as a piano), timbre, or reverberation, for example. It can also be used to provide a fine frequency control, as on a clavichord (striking a note harder raises its pitch).

There are two kinds of E.M.S. Keyboard, the DK1 designed for use with the VCS3 and the SYNTHI Keyboard designed for use with the SYNTHI A. Electrically the keyboards are similar and each may be used with either machine, but the controls are slightly different. Each keyboard provides signals or control voltages at both Input Channels of the SYNTHI, and since there are three kinds of signal, switches are used to select the functions. The signals available are:

1. An Oscillator whose frequency depends on the key pressed and whose loudness depends on the strike rate.
2. A Control Voltage whose value depends on the key pressed.
3. A Control Voltage whose value depends on the strike rate. This facility is not included on the DK0.

On the DK1 Keyboard there is one switch for each Channel. The Channel 1 switch may be set to SIGNAL, as (1), or KEYBOARD VOLTAGE, as (2), and the Channel 2 switch can be set to KEYBOARD VOLTAGE, or DYNAMIC VOLTAGE, as (3). Since there is no point in having the KEYBOARD VOLTAGE coming to both inputs, there are three useful switch settings.

The SYNTHI Keyboard has only one switch, and

the Keyboard is divided into two 2-octave sections. With the switch at SIGNAL, the Keyboard is used as a single 4-octave unit providing a signal from the Oscillator on Channel 1 and a KEYBOARD VOLTAGE on Channel 2. With the switch in the CONTROL position, the Keyboard is divided in two, with the Upper two octaves providing a Keyboard Voltage and the Lower two octaves providing a Dynamic Voltage.

The keyboard is connected to the SYNTHI by a cable terminated with 8-way connectors. It provides a signal or a control voltage at Input 1 (row 8 on the patchboard) and a control voltage at Input 2 (row 9). The keyboard has four controls and two Switches, and the Input Amplifiers on the SYNTHI provide two further controls; additionally, each key has the same effect as the Attack Button, resetting the Envelope Shaper cycle.

Connect the keyboard, and patch Input 1 to the Envelope Shaper, and the Envelope Shaper to Output (D8, B12), and put the Input Ch. 1 switch on the Keyboard to SIGNAL. Turn the Keyboard Oscillator and Input Amplifier LEVEL controls to about 7 and you should hear a note when a key is depressed. The interval between notes is adjusted by the TUNING control, and the frequency of the whole keyboard may be moved up or down by the FREQUENCY control: Experiment with the Envelope Shaper timing controls; trying 0, 0, 0, 10 first (this gives an "organ" touch: the OFF time is set to 10 when the keyboard is in use so that the Envelope Shaper won't recycle automatically and give unwanted notes). Note that the loudness of the note depends on the striking rate, but that this is only effective in staccato playing. The touch sensitivity circuit and the Envelope Shaper are only activated by a note if the previous note was released first. With this patch the tone is relatively harsh: improve it by filtering.

With the INPUT CH1 switch set to KEYBOARD VOLTAGE, a control voltage rather than a signal is produced and you should start by patching Oscillator 1 to the Envelope Shaper (D1, B12) and using the keyboard to control the frequency of Oscillator 1 (I8). The tuning is now controlled by the Input Channel 1 control (on the SYNTHI) and the overall frequency by the Oscillator 1 FREQUENCY control. If the INPUT CH. 2 switch on the keyboard is turned to DYNAMIC VOLTAGE, the input to the SYNTHI and Channel 2 is the "touch" control, and its level depends both on the DYNAMIC RANGE control on the keyboard and the Input Channel 2 level control on the SYNTHI. Devise patches that use this voltage to control loudness, frequency, filtering, decay time and reverberation.

If Channel 1 is used for the SIGNAL output, Channel 2 provides the keyboard voltage, and this can be used to control another oscillator, or

to control another parameter (filtering, reverberation, etc.) which you want to be dependent on pitch.

Controls DK0 and DK1:

Frequency:

Centre frequency of keyboard.

Tuning Spread:

Pitch range of keyboard — in other words, musical interval between notes.

Level:

Output from keyboard oscillator.

Dynamic Range:

Output from strike-rate circuit.

Channel 1 Switch:

SIGNAL — Input Channel 1 connected to keyboard oscillator.

KEYBOARD VOLTAGE — Control voltage to Input Channel 1 depends on note pressed.

Channel 2 Switch:

KEYBOARD VOLTAGE — as above.

DYNAMIC VOLTAGE — Control voltage to Input Channel 2 depends on strike-rate. (Not on DK0.)

SYNTHI Keyboard

The SYNTHI Keyboard has similar functions for the knobs, but there is only one Switch.

SIGNAL — Oscillator signal at Channel 1.
Keyboard Voltage at Channel 2.

CONTROL — Keyboard Voltage at Channel 1 (upper 2 octaves).
Dynamic Voltage at Channel 2 (lower 2 octaves).

6. USING THE DEVICES TOGETHER

In this section we describe a number of experiments that you can perform with the SYNTHI. They are divided into four sections—Sound Effects, Music, Pop and Educational. Do not look only at the experiments in the Section in which you are most interested, because to use the SYNTHI well in any application it is useful to have a thorough knowledge of the many ways in which the devices can be used. In most cases the patches are given either by letters and numbers or by a dope-sheet, but the connections are also described: it is instructive to work out a patch from its description, and check that you have got it right from the codes given, since this is the way you will work out your own patches.

Many of the patches given in these experiments are very simple. After obtaining the sound or effect they are supposed to give, you should elaborate upon them, introducing new devices to enrich the sound.

Sound Effects

These are sound effects that may be used in films, plays, broadcasts, or simply for amusement. They are fairly simple patches, and a more complex sound for a specific application may be produced by adding to the patch or multi-tracking if a tape-recorder is available.

1. Coloured Noise

The first sound is given to show how the dope-sheets are used: it is the example given in Section 3. See Patch 1.

2. Irregular Clicks

Patch 2 does not make an interesting sound either, but it demonstrates that the Oscillators can be intercommunicated so as to produce a control voltage that is so complicated that it can be regarded as random. This sort of control voltage is useful for effects such as wind where randomness makes the effect more natural.

3. Wind

With white noise (use the Noise Generator with the COLOUR control at 5) and mid-range Filter FREQUENCY, a variety of wind noises are possible. Start with a simple patch (H7, B10) and elaborate by using slow-running oscillators to vary the filtering and amplitude (N4, N11, O6, etc.). The wind can be made to "whistle" by turning up the RESPONSE control on the Filter until it almost resonates.

4. Bells

Connect Oscillator 1 (Sine) and Oscillator 2 (Triangle) to the Ring Modulator and patch

through Filter, Envelope Shaper and Reverberation to Output (E1, F4, H13, D10, G12, B14, C14). By turning both Oscillators to fairly high frequencies (about 7.5 on the dial) and then filtering out the higher overtones, bell-like sounds can be produced. Bell sounds are characterised by the presence of overtones which are not harmonics, and such overtones are produced by ring-modulation.

5. Bird Song

There are a number of ways of simulating birds on the SYNTHI, of which this is one of the simplest. Use the three Oscillators (Osc. 1: Freq = 3, Sine = 5; Osc. 2: Freq = 5, Triangle = 5; Osc. 3: Freq = 7, Triangle = 5) to control the Filter Frequency (N1, N4, N6) with the manual control of Filter Frequency set high—about 8—and the RESPONSE at 10, so the Filter oscillates. Feed the Filter through the Envelope Shaper (D10, B12) adjusted to give short pulses (0, 1, 5, 2). Use the Joystick to control the Oscillators while experimenting (I15, J16, K15, L16). Bird songs consist of simple whistles, rapid glissandos and various vibratos, all of which can be produced by the SYNTHI.

6. Bounces

Connect Oscillator 1 (Sine) and Oscillator 2 (Square) to the Ring Modulator and add slight Reverberation. Use the same output of Oscillator 2 to control the Frequency of Oscillator 1 and set the manual control of Oscillator 1 to a high Frequency (10) and Oscillator 2 to a low Frequency (1.5). The patch is B14, C14, E3, F1, G13, I13. Adjust the levels to get a "bounce" sound; add a pin at J6 so that Oscillator 3 controls Oscillator 2, and adjust Oscillator 3 to a low frequency (4.5) and a Ramp Output (Shape = 10, Level = 5) and with careful manipulation of the controls you should be able to achieve a good imitation of a table-tennis ball bouncing on a hard surface.

7. Motor Sounds

A variety of motor sounds can be produced with the SYNTHI. Start by modifying a square wave in various ways, controlling the frequency with the Joystick. Patch 3 gives a simple example.

8. Battle

This is a very impressive demonstration patch (4), and to do it full justice powerful amplifiers and loudspeakers should be connected to the SYNTHI. The progress of the battle can be controlled by moving the Joystick and adjusting the SHAPE control of Oscillator 3. If you have a

Keyboard, move all the pins in rows 15 and 16 to rows 8 and 9, and "play" the battle on the Keyboard.

Musical Effects

These experiments suggest ways in which the SYNTHI might be used as a source of instrumental sounds for making up electronic music tapes, or as a performing instrument solo or in an ensemble. It is possible to produce fair imitations of various instruments with the SYNTHI, but we have chosen to illustrate novel sounds rather than imitations of familiar ones.

9. Pizzicato

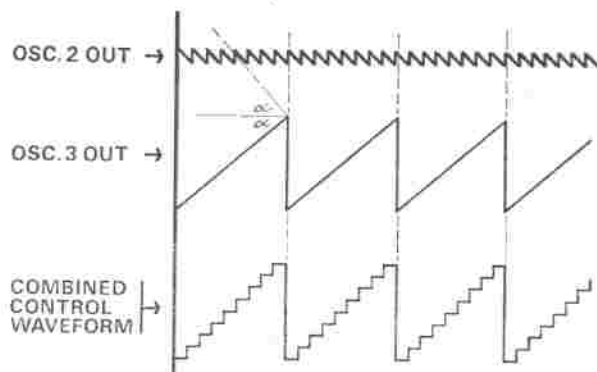
This very simple patch shows a different way of using the Keyboard: each note is very short and crisp, even if the keys are held down. Set the Keyboard Channel 1 switch to VOLTAGE CONTROL, and patch E1, F8, I8, B13; the effect is enhanced by adding slight reverberation.

10. Chords

Put pins in B1, C2, C3, B4, C5, B6. The result will be a three part chord whose component notes may be altered by the three FREQUENCY controls (remember that Oscillator 3 must be set to at least 8 if it is to be audible). Both loudspeakers produce the same chord, but the timbres are different in each channel, as can be shown by muting (with the Switches) or fading (with the LEVEL controls) each channel alternately.

11. Scales

If Oscillator 1 is controlled by Oscillators 2 and 3 (B1, I4, I6) scales will be played if the SHAPE controls are set in opposite senses (Osc. 2 SHAPE = 0, Osc. 3 SHAPE = 10 for ascending scales) and Oscillator 2 has a higher frequency than Oscillator 3. The effect is explained in the diagram: careful setting up is needed to make each note constant in pitch.



12. Bowing

This interesting effect makes use of the fact that the Ring Modulator "differentiates" the signals applied to it — which for the purpose of this experiment means simply that it gives no

output if one of the inputs is a constant voltage. Patch Oscillator 1 and the Joystick to the Ring Modulator and apply slight Reverberation (E1, F16, G13, B14) and control the FREQUENCY of Oscillator 1 from the Joystick as well (I15). The level of Oscillator 1 should be set so that there is no sound at all until the Joystick is moved. Adjust the Joystick RANGE controls for suitable amplitude (vertical movement) and pitch range (horizontal movement).

13. Melodies with Noise

Use the Keyboard to control the Filter Frequency, and connect Noise through the Filter to Output (N8, H7, D10, B12, C12). The Keyboard now controls the noise spectrum, and by gradually advancing the RESPONSE control while playing you can make a melody gradually emerge from the noise.

14. Timbre Changes

Patch Oscillator 1 and 2 into the Ring Modulator, and pass the signal through the Filter and Envelope Shaper. Use the Keyboard Voltage to control the Oscillator Frequencies and the Dynamic Voltage to control the Filter Frequency. The Keyboard now plays tunes (but note that the range is doubled by the Ring Modulator) and the timbre of a note depends on the strength with which it is struck. (E2, F4, H13, D10, B12, I8, J8, N9.)

15. Scales and Steam Noises

The last patch in this section (Dope Sheet 5) is a more complex one, and since all the devices are used, it is a useful test for the SYNTHI. When it is working correctly, you should hear pizzicato scales from the right Loudspeaker and steam-like noises from the left.

Pop Effects

These are simple patches demonstrating the versatility of the SYNTHI in modifying sounds made by live instruments. The ideas given use only one or two devices, and when you have tried each you should attempt more elaborate effects by combining the devices.

All of the patches assume that you have an instrument which can be plugged into the SYNTHI — an electric guitar or organ is suitable. Microphones can be used with singers, but be careful to avoid the howling due to feedback. In the patches we assume that the instrument is connected to Input Amplifier 1. A foot-pedal used with a battery (as in the diagram on page 12) can be used to provide a further control voltage at Input 2.

16. Filtering

To filter an incoming signal, patch H8, B10, C10. The most impressive results are obtained when the Filter Response is set fairly high (6-7) but not so high as to resonate. The FREQUENCY may be controlled automatically (N6 or N11) or

manually from the Joystick (N16). The characteristics of the SYNTHI Filter allow a drastic "wah-wah" effect to be obtained, and the voltage control pedal mentioned above becomes a wah-wah pedal (N9).

17. Panning

"Panning" means sweeping the signal from one side to the other by altering the signal levels. There are four simple ways of doing this on the SYNTHI when it is connected to external amplifiers:

- (i) Manually with the Pan controls.
- (ii) Manually with the Joystick — patch O15, P16.
- (iii) Automatically with the Envelope Shaper.

The basic patch for this is C8, D8, B12, P11. Channel 1 is controlled by the Envelope Shaper, and Channel 2 by the Trapezoid output from the Envelope Shaper which is an inverted signal, so that Channel 1 is soft when Channel 2 is loud and vice versa. The Envelope Shaper and Output Level controls have to be set carefully to achieve an even movement of sound.

- (iv) Automatically with an Oscillator.

This method of panning makes use of the fact that the Input Amplifiers invert a control voltage. You will need a short piece of screened lead with a jack plug at each end, and this is used to attach the Scope Output socket to Input 2 Hi Level. Patch B8 C8, A6, O6 and P9 and adjust the shape of Oscillator 3 to get a continuous movement of the sound. Moving the control pins from row 6 to row 5 results in the sound being switched from side to side abruptly.

18. Reverberation

The Reverberation unit on the SYNTHI is voltage-controlled and this enables it to be used in many ways which are not possible with normal reverberation units. For a very simple demonstration of this try "chopping" the reverberation with Oscillator 3 (C8, B14, C14, M5). Alternatively, by chopping the signal after reverberation an echo can be obtained (replace M5 by pins at O5, P5): the effect is best when a microphone is used.

19. Ring-Modulation

The Ring-Modulator provides a wide variety of effects, many of which may be used as "fuzz". Put pins at F8, B13, and C13, and move another pin up and down row E:

- E1 — ring-modulation with a sine wave provides entirely new frequencies. This is an interesting effect, but it may be difficult to play in tune.
- E5 — use a slow square wave to fragment the sound, giving a "struck" effect.
- E8 — ring-modulating the signal by itself doubles the original pitch. This is particularly effective at high frequencies.

E16 — the signal will only be heard when the Joystick is moved, and this may be used to "bow" any instrument.

Ring-modulation may produce harsh tones, which are due to the unusual overtones generated. These can be softened by appropriate filtering. If distortion occurs it is probably due to overloading — remember that the signals going to the Ring Modulator should never read more than 0.45 on the Meter.

20. Synthesised Percussion

The SYNTHI can make a number of different percussive sounds: the Noise Generator, Ring Modulator and Envelope Shaper are useful devices, and the square wave Oscillators can be used in conjunction to provide rhythmic patterns. Experiment with rhythmic control of noise (E3, E5, F7, B13), then try the more complicated patch — number 6 of the samples. This patch should really be set up bit by bit, so the various components work together successfully. You will need the Jack lead again to connect the Scope Output to Input Channel 1 Hi Level. Oscillator 2 provides the basic rhythm, switching the Filter so it produces a low sine-wave on the down-beat and a shrill noise on the up-beat. Oscillator 3 should be set to half the frequency of Oscillator 2 and adjusted to switch the sine tone from Oscillator 1 between the tonic and the dominant. The extra lead corrects the phase for the Reverberation control and also switches the output between the channels.

Educational Patches

The SYNTHI can be used to demonstrate a wide range of acoustic phenomena, both simple and complex. It immediately provides a source of simple oscillations of various pitches and waveforms which can be heard, displayed on an oscilloscope or meter, or used to control other apparatus. We describe some other experiments which can be carried out without any external equipment.

22. Beats

Connect the two sine wave sources to the same Output Channel (B1, B10) and adjust them to almost the same frequency so that beats are heard. If the two sounds are ring-modulated (E1, F10, C13) beats at twice the frequency are heard.

23. Harmonic Series

Connect a Ramp generator to the Filter (H2, B10) and set the Oscillator to a low frequency. By putting the Filter in bandpass mode (turn the RESPONSE control as high as it will go without the Filter resonating) and moving the FREQUENCY control, pick out the overtones from the Ramp signal. For best results, the ramp should be as low level as possible — about 2 on the dial.

24. Phasing

In the Section on Pop effects, we give four ways of making the sound appear to move from one channel to the other by changing the levels. Another way of doing this is to change the relative phases of the two signals between the speakers. Patch 7 shows how this is done on the SYNTHI. The two Oscillators should be tuned to be almost in unison before the control pins (I11, J11, I15, J16) are inserted.

25. Three Kinds of Modulation

When one signal affects another, it is said to *modulate* it. In this experiment the sinusoidal output of Oscillator 1 is modulated in three ways. Set Oscillator 1 Frequency to 6, Shape to 5, Level to 5; Oscillator 2 Frequency to 2, Shape to 5, Level to 5.

(i) Patch O1, B4. This is *amplitude modulation*

because the level of the output is being altered; the musical term is tremolo. If there are clicks, adjust the SHAPE of Oscillator 2 until they disappear.

(ii) Patch B1, I4. This is *frequency modulation*, or vibrato.

(iii) Patch E1, F4, B13. This is *ring-modulation*.

Now do the same experiments with the square wave output of Oscillator 2.

26. Mixing and Ring Modulation

Patch 8 can be used to show the difference between mixing two signals in the normal way (by addition) and ring-modulating them. The result of the mix is heard in the left hand loudspeaker and the ring-modulation products are heard on the right. The Envelope Shaper is used to select the sounds alternately.

7. SPECIFICATION AND MAINTENANCE

Power Supply: 220-245V AC or 105-115V AC at 50-60 Hz. The connection is by miniature 3-pin plug; earthing is advisable but not essential.

Fuse: 1A tubular type, mounted beside power socket.

SYNTHIs are set by the factory to 245V for Europe, and 110V for North America. To adjust the setting, remove the back panel and move the plug by the mains transformer.

The mains leads are connected as shown, viewed from the back of the plug:



If your Mains supply is likely to rise above 245V or drop below 220V we recommend that you use a constant voltage transformer to drive the SYNTHI.

Oscillators

The table below gives specifications for the three oscillators of the SYNTHI, and for the filter when it is used as a sine oscillator. The sensitivity given refers to voltage control of the frequency and is measured at the patchboard; it should be doubled for external control voltages since the input amplifiers have a gain of 2.

	Max. Output V p-p	Range		Sensitivity
		Min. (Hz)	Max. (KHz)	V/Octave
Oscillator 1	3 } 4 }	1	10	0.32
Oscillator 2	4 } 6 }			
Oscillator 3	4 } 6 }	0.025	0.5	0.26
Filter	5			

Noise Generator

Max. Output: 3 V p-p.

Ring Modulator

Max. Input Level: 1.5 V p-p at each input.

Max. Output Level: 6 V p-p.

Filter

Low Pass Filter: (RESPONSE control at 0).

Cut-off rate 12dB for first octave and 18dB/octave thereafter.

Resonator (Band Pass Filter — RESPONSE control at 6).

Maximum Q-factor: 20.

Envelope Shaper

Max. Repetition Rate: 60Hz.

Attack: min. 2 ms max. 1 sec

On: min. 0 sec max. 2 sec

Decay: min. 3 ms max. 15 sec

Off: min. 10 ms max. 5 sec
 Decay Time sensitivity: 0.4 V/octave.
 Control Voltage Output (Trapezoid):
 max. —3V (ON) to +4V (OFF).

Reverberation

Delay: 2 springs with delay times of 25 ms and 30 ms.

Reverberation Time: max. 2 sec.

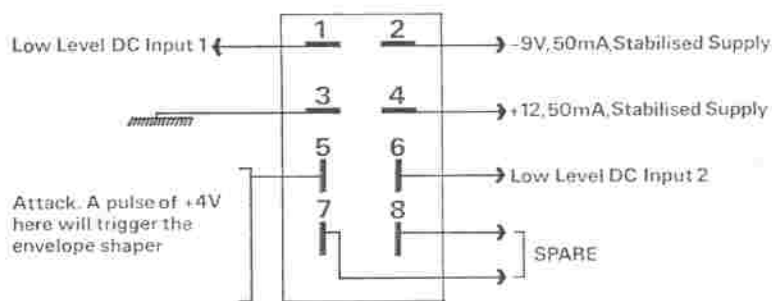
Mix control sensitivity: —2V no reverberation.
 +2V maximum reverberation.

Input Amplifiers

Microphone inputs: (2x) 5mV AC into 600 ohms.

High Level inputs: (2x) 1.8V AC (rms) or $\pm 2.5V$ DC into 50Kohms.

Keyboard Connections: See diagram (Fig. 24). The Low Level controls are 50 micro amps mm. A into 500 ohms.



Output Amplifiers

Signal Outputs: (2x) 2V p-p into 600 ohms.

Headphones: (2x) 10V p-p into 50 ohms.

DC (Control Voltage) Outputs: see device specifications. The impedance should not be less than 2Kohms.

Meter

Control Voltages: $\pm 1V$ DC centre zero.

Signal Voltages: 4V p-p.

Joystick

Control Voltage Output: $\pm 2V$ DC.

When the joystick is moved up and to the right, with the range controls at 10, both outputs are +2V.

Matrix Board

For all devices at the patchboard:

Input Impedance: 10 Kohms.

Input Sensitivity: 1.5V p-p.

Output Impedance: 300 ohms — 3 Kohms.

Output Level: 2V p-p average.

Keyboard

The Keyboard and certain other devices) are connected via an 8-way Jones socket.

Scope

The jack-socket labelled Scope is connected to the meter row on the patchboard.

A General Care and Maintenance

The VCS3 could hardly be easier to maintain, because the solid state circuitry is designed to run well within its capacity, even under conditions of electrical misuse, and there are no mechanical parts except the Joystick. But the following general points may be helpful:

1 **Jack Sockets.** These are of standard pattern, and extra jack plugs can easily be obtained. However there are some non-standard sizes on the market, and no plugs should be used if they are a very tight fit or on the contrary move too freely in the socket. They should push home with a firm click and have very little lateral play when in position.

2 **Joystick.** The grease in the control slots may eventually dry out, particularly if the studio is kept in a warm place. To service, remove the bottom panel, and take off the red cover plate of the joystick. Carefully clean the slots and ball joint, and re-lubricate with a *little* Vaseline or silicone grease. Do not allow any grease to touch the potentiometers, and take care not to cross-thread the self-tapping screws when replacing the cover.

3 **Knobs.** If knobs become loose, slacken off the set screw, reset at either maximum or minimum position, and tighten firmly. The spindles are nylon, and it is normal for the screw to bite in slightly for a firm fixing. If knobs are lost, we can supply more of the correct pattern, or in an emergency any knob suitable for a $\frac{1}{4}$ " spindle can be used. If knobs are wrenched so that the whole potentiometer becomes loose, attend to it at once before an internal wire is broken. Take off the back, hold the potentiometer from behind and tighten the nut firmly. If the wires

are already displaced check that none are broken and resolder if necessary.

Meter. If the pointer does not read zero when the studio is off, the zero can be adjusted with the small perspex screw at the bottom of the dial.

- 4 **Panels.** Avoid any abrasive cleaner, and *never* use strong solvents like acetone, trichlorethylene or petrol (gasoline, benzine, essence). The best cleaner is methylated spirits (alcohol), but paraffin (kerosene) or turpentine can be used, though they tend to leave an oily deposit and often an unpleasant smell. Use wax pencil to mark the panels if you wish to do so, rather than lead, particularly hard lead, pencil. Do not use ball point, which may leave a permanent indentation in the finish, or fibre-tipped pens, which often contain an indelible stain.

- 5 **Storage.** Solid state devices dislike sustained heat. Never leave the VCS3 in a sealed car in summer sun, or in a similar situation. For long term storage choose a cool, dry position. If it is not used for a very long time (a matter of years) there may be trouble with electrolytic capacitors when it is switched on again, and the best insurance against this is to run the studio for a few hours at least every few months.

DON'T connect unknown inputs with the input level controls wide open. Take particular care when connecting valve (tube) driven equipment to the VCS3.

DON'T overrun devices constantly for hours on end. If the outputs are not connected, this can happen without the user knowing. The safest course is to remove pins when the studio is finished with for the time being.

DON'T connect unknown mains supplies without checking.

DON'T interconnect jacks at the back of the studio without thinking carefully first. Particularly take care if you connect the Keyboard Jones Socket, because of the danger of short-circuiting the supply rails.

DON'T grossly overrun the internal speakers, which may be damaged and give unreliable results thereafter. For any audience application, connect to external power amplifiers and concert speakers.

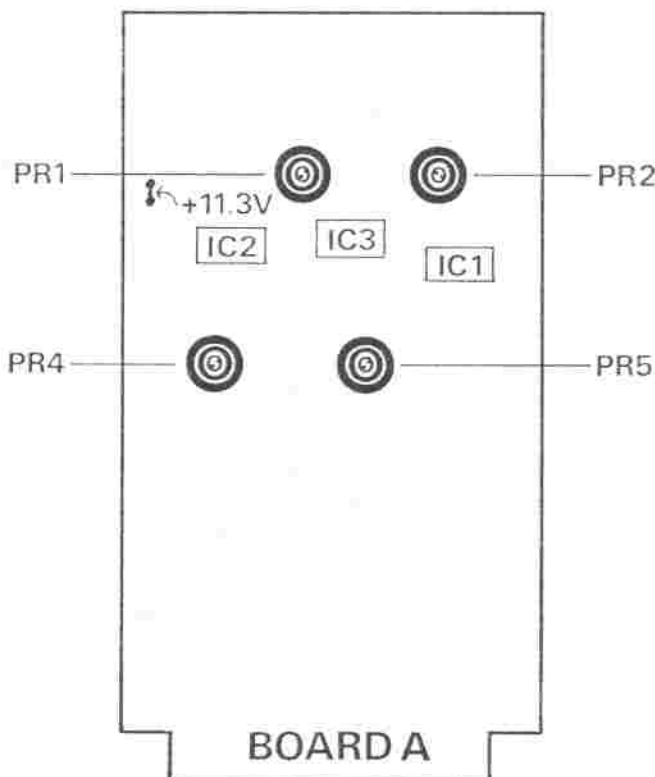
DON'T continue to use the studio if unexplained noises, heat or smells occur. Stop and investigate.

B Setting Up Preset Controls

The miniature preset potentiometers on the printed circuit boards are all carefully adjusted on initial setting up, and should not need further

attention. But in the event of components being replaced or accidental displacement of a preset, the following adjustments can be made, but only if proper measuring instruments are available. Adjustment to these small controls is best carried out with a plastic bladed screwdriver, but in any case be sure not to touch any other component except the preset you are adjusting. If you are doubtful consult an engineer, because rough handling can do a great deal of expensive damage in a very short time.

BOARD A (left hand looked at from back)



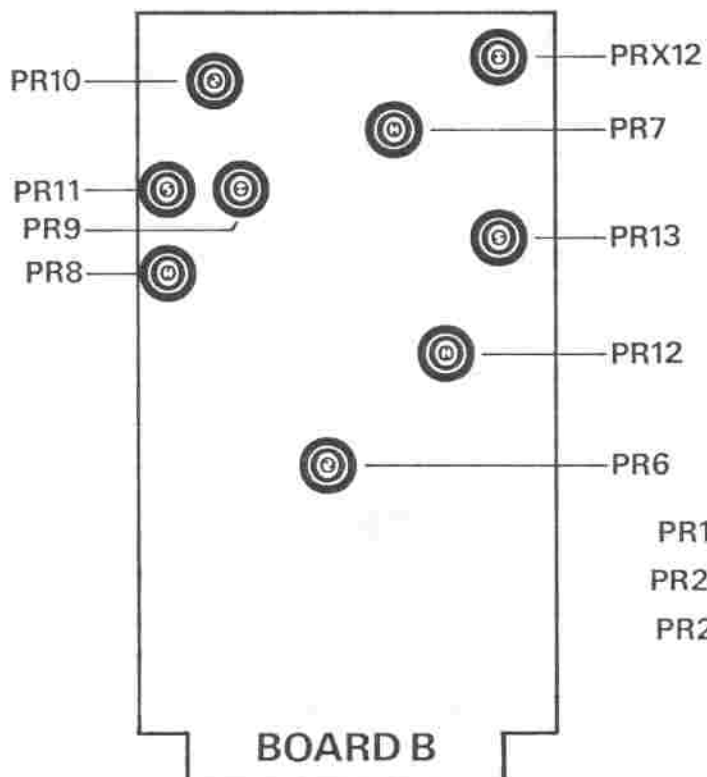
Board A contains: **Power Stabilisers**
Output Amplifiers
Reverberation Driver Amplifier

PR1 (10 Kohms) Negative stabiliser supply voltage. Adjust for -9 volts on negative power rail (ground to Keyboard socket 2).

PR2 (10 Kohms) Positive stabiliser supply voltage. Adjust for +12 volts on positive power rail (ground to Keyboard socket 4)

PR4 (2.5 Mohms) Output Channel 1 zero level. Adjust for -70dB with level control knob at zero.

PR5 (2.5 Mohms) Output Channel 2 ditto.

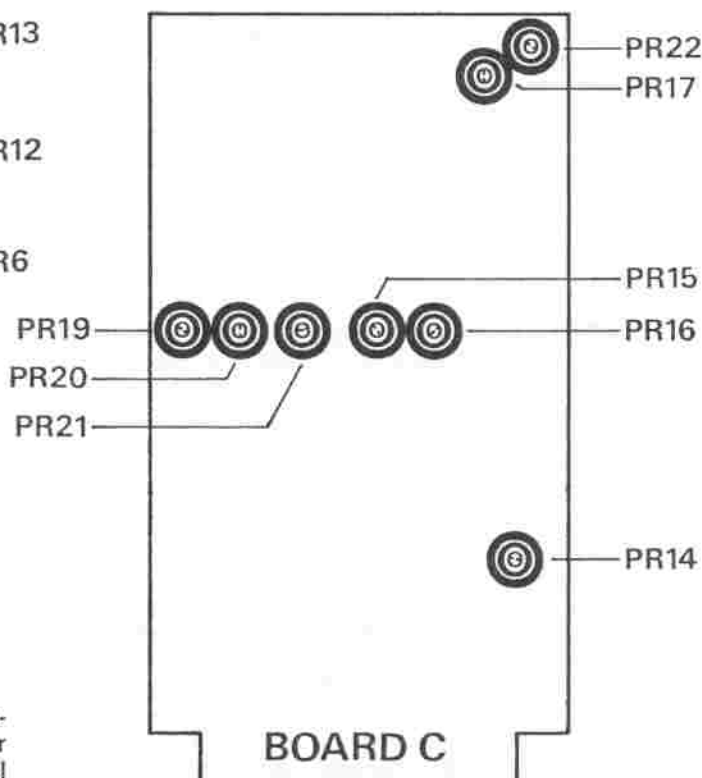


Board B contains: **Envelope Shaper
Filter/Oscillator
Ring Modulator
Input Amplifiers**

- PR6 (100 Kohms) Filter frequency adjustment. Adjust so that filter oscillates at 260 Hz with panel control at 5.
- PR7 (10 Kohms) Filter intrinsic gain control. Normally set fully counterclockwise.
- PR8 (100 Kohms) Ring modulator input B fundamental rejection. With a 1V p-p sine wave to input A, trim this control for minimum breakthrough fundamental.
- PR9 (100 Kohms) Ring modulator input A second harmonic rejection. With input as above to B, trim for zero break-through of second harmonic.
- PR10 (1 Kohm) Ring Mod. input A fundamental rejection.
- PR11 (2.5 Mohms) Ring Mod. input B second harm. rejection.
- PR12 (100 Kohms) Envelope shaper maximum decay rate. Adjust for decay time of 3ms with panel control at 0.
- PR12X (2.5 Mohms) Envelope shaper OFF level. Set PR13 clockwise, "OFF" panel control at 10, "DECAY" panel control at 10. Put large signal into

envelope shaper and adjust PR12X to just get zero output.

PR13 (2.5 Mohms) Envelope shaper "off" level. Having adjusted PR12X turn PR13 slowly counterclockwise until signal reappears, then back it off slightly.



Board C contains: **Noise Generator
Oscillator 1
Oscillator 2
Oscillator 3
Meter Amplifier**

- PR14 (10 Kohms) Meter amplifier DC zero. Ground the input to the meter amplifier, and trim so that meter reads 0.5 (half scale) when switched to Control Voltages.
 - PR15 (100 Kohms) Osc. 1 frequency offset. Set frequency dial at 6 and trim to obtain 261.6 Hz.
- NOTE:** Do not attempt frequency adjustments without an accurate frequency meter.
- PR16 (100 ohms) Osc. 1 frequency control sensitivity. Adjust to get precisely 1.5 octaves per major division on frequency dial. Calibration points are:
- | | | | |
|-----------|--------|---------|--------|
| Dial | 4 | 6 | 8 |
| Frequency | 32.7Hz | 261.6Hz | 2093Hz |

- PR17 (10 Kohms) Osc. 1 sine purity (flyback suppression). Adjust for purest sine wave at about 400 Hz.
- PR19 (100 Kohms) Osc. 2 frequency offset. Adjust as PR15.
- PR20 (100 ohms) Osc. 2 frequency control sensitivity. Having adjusted Osc. 1 (PR16), apply the same control to Oscs. 1 and 2 (e.g. from joystick) and adjust PR20 so that both oscillators track perfectly in unison (listen for zero beats).
- PR21 (100 Kohms) Osc. 3 frequency offset. Set frequency dial to 10 and adjust to 500 Hz.
- PR22 Noise level. Adjust for maximum undistorted noise.

HINTS AND SUGGESTIONS

If you set up a patch and there is no sound, check the following:

1. The power supply lamp is lit.
2. The speaker muting switches are up.
3. Levels on all devices, and the Output levels

are sufficiently high (typically 5-8 for Sources, 7-10 for Treatments, but there are no "rules"). Check Input Amplifier levels if using external devices.

4. Oscillators are not running subsonically. (Below Frequency setting 3 for Oscillators 1 or 2, or 6 for Oscillator 3.)
5. Noise Generator needs 20-30 seconds to start up.
6. Envelope Shaper Off Time may be set too high for automatic recycling (try pressing the Attack Button).
7. Check the patch by swapping pins: the pins are reliable but occasionally dirt in the holes of the matrix board can prevent contact or damage a pin.
8. The Output Amplifiers can be cut off altogether by a large control voltage in rows O and P.

If you have tried all these things with no success, ascertain which device (or devices) is not working, and remove the appropriate circuit board (the location of the devices is explained above). Send the board to E.M.S., and we will repair it or send a replacement board.