

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.

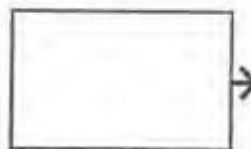
In order to use the SYNTHI intelligently, it is necessary to understand what the devices do, and how several devices may be connected to work in combination. In this section the general ideas will be explained, and in the sections following these ideas will be applied to examples that you can try on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

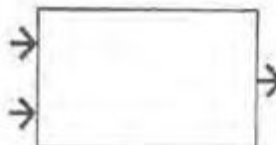
tions and specifications are provided with the devices themselves.

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.

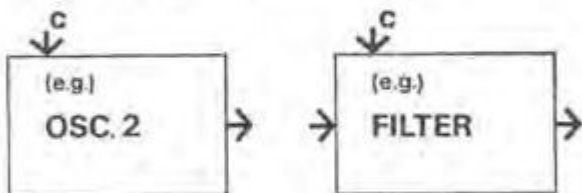
The third kind of device is an *output device*, and is the ultimate destination of the signal. We represent an output device diagrammatically by drawing a box with an arrow going into it:



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:

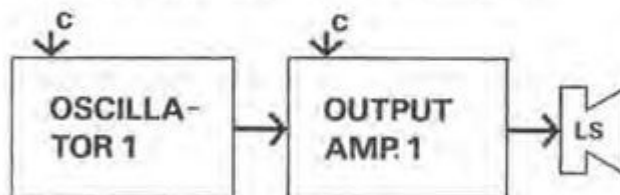


The control input is marked with a 'C' to distinguish it from a signal input. The left hand box represents an oscillator whose frequency is determined by a control voltage, and the one on the right shows a filter whose response is determined by a control voltage.

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.

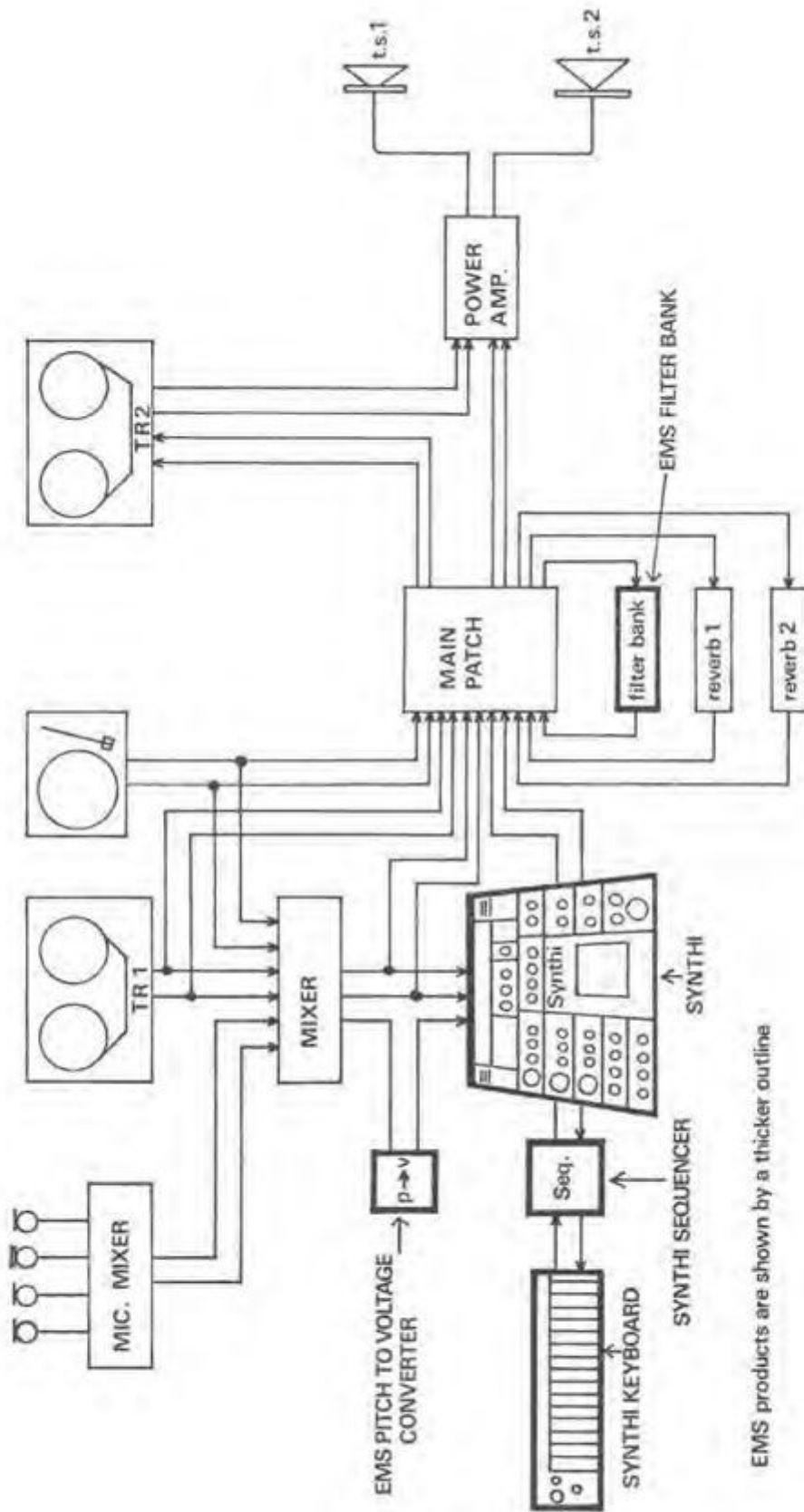
OCTAVE FILTER BANK — A bank of eight filters covering the musical spectrum and providing complete control of the tone colour of any signal.

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

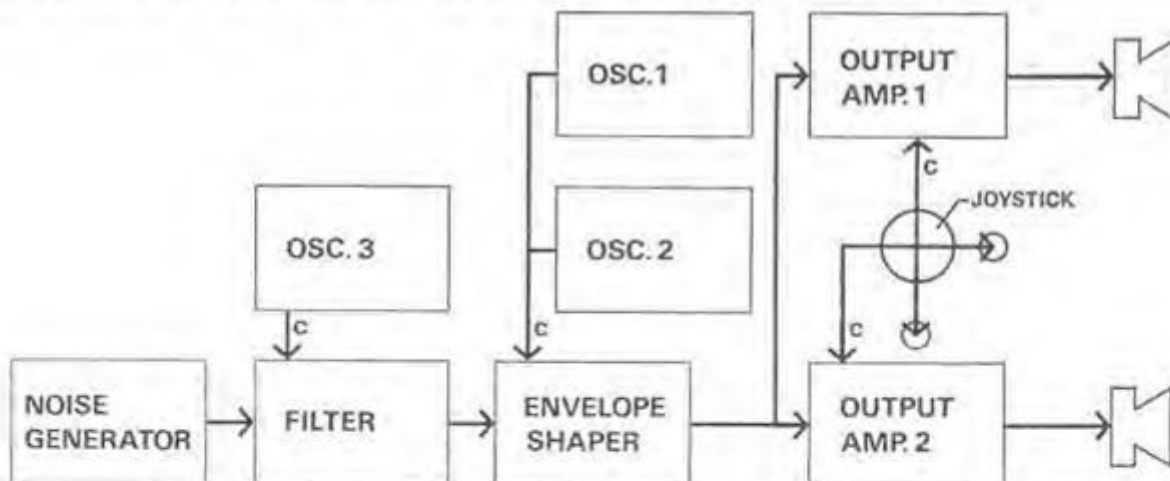
From this point in the manual onwards we will assume that you have a SYNTHI and that it is switched on, so the explanation will be conducted in terms of practical experiments.

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

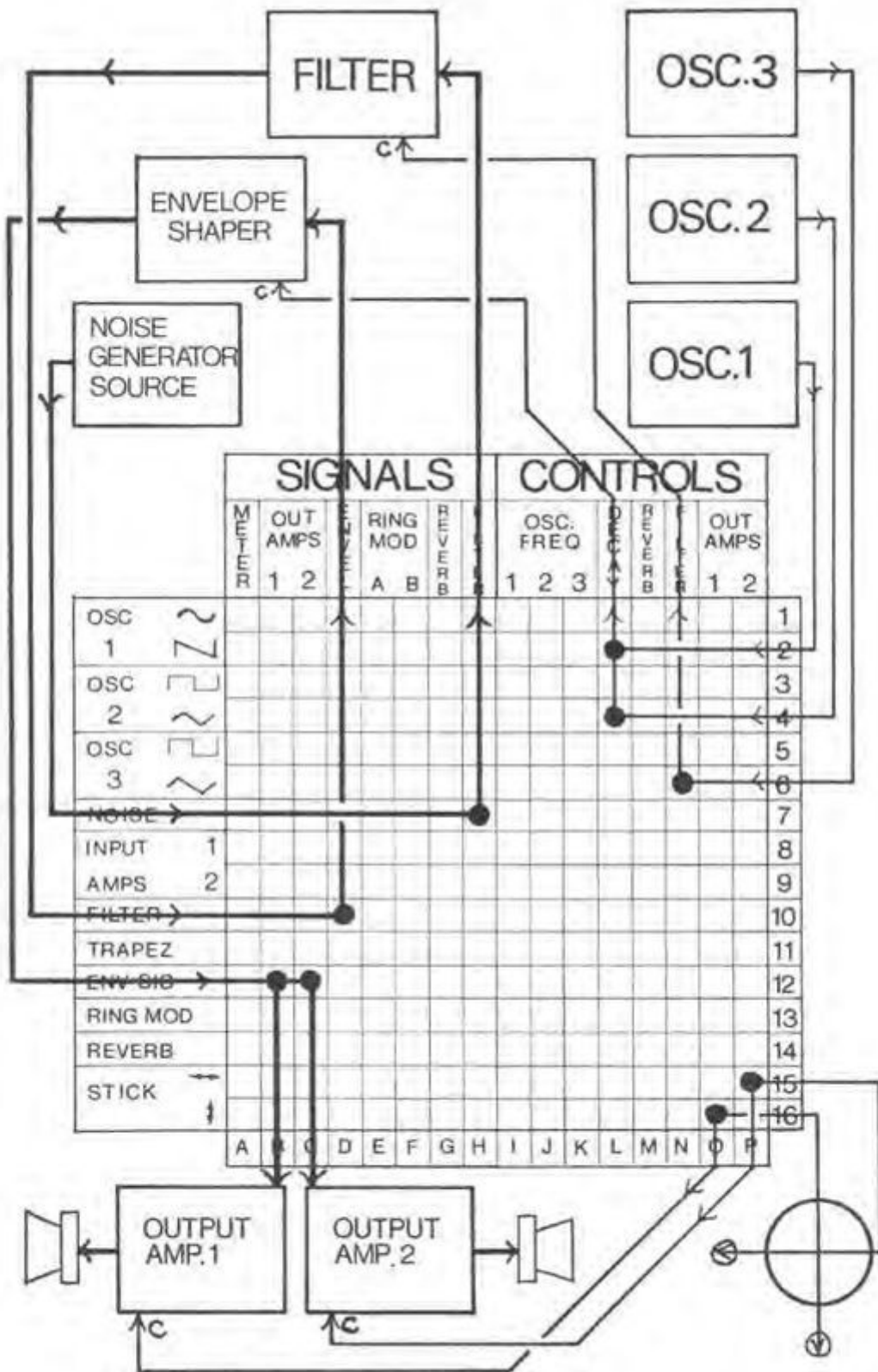
will refer to holes by the letters along the bottom of the patchboard and the numbers on the right of it — so you have put a pin in B1.

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.)

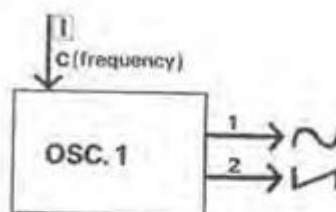
(The slot underneath the Patch Panel on the SYNTHI AX is for *preset patches*. When the SYNTHI is used in performance, there is often insufficient time to move the pins for a new patch, and of course there is always the risk of making a mistake. The preset patches are simply plugs which fit into the 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.

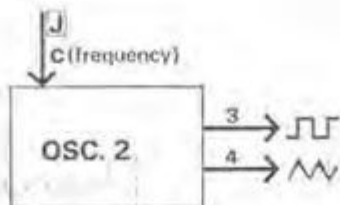
Sine Output Level:

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

Ramp 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.

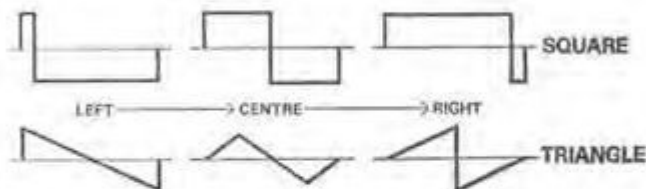
Controls

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.



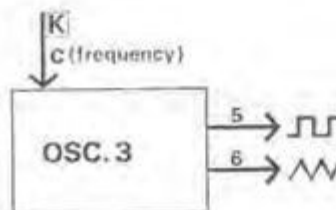
Square Output Level:

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.

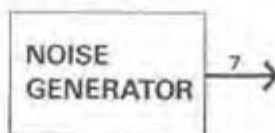
Square Output Level:

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.

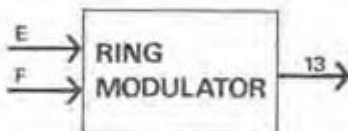
Level:

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.

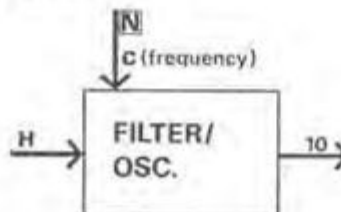
Put a pin at A1 and adjust the sine LEVEL of Oscillator 1 so that the Meter registers a signal level of 0.45. This is about 1.5V p-p and is the highest signal level that should be put into the ring modulator to avoid distortion. Turn the RESPONSE control on the Filter to 10 (this makes the filter oscillate) 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.

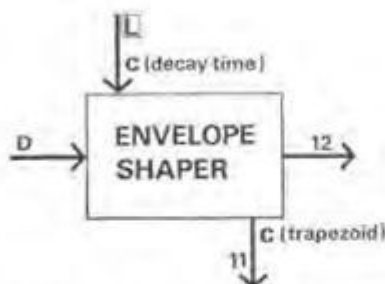
Response:

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

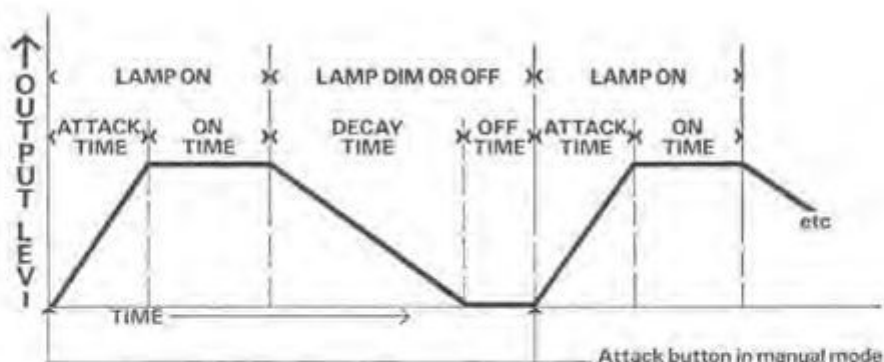
Level:

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.

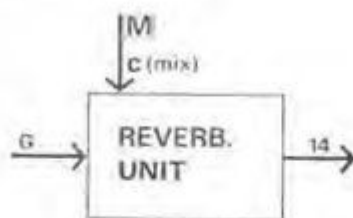
Envelope:

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 SYNTH, 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

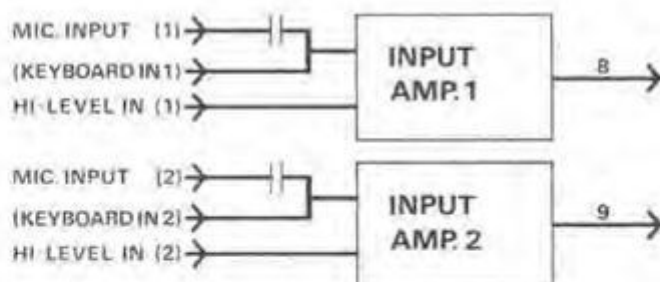
Mix:

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).

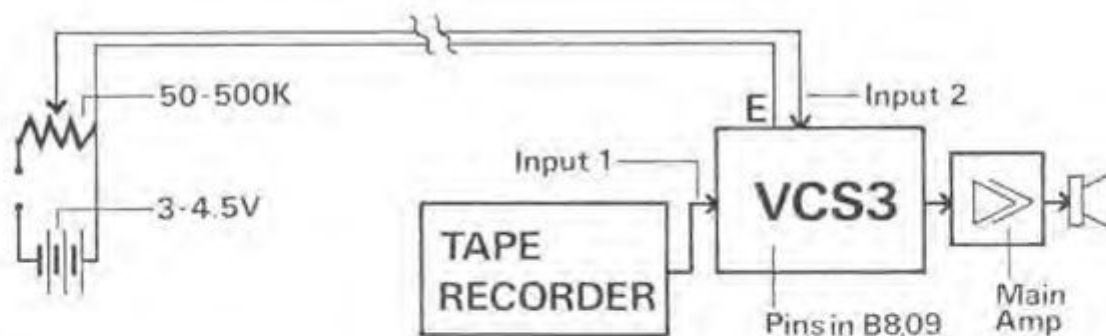
Microphones may be connected at the Microphone jacks. These are suitable for crystal microphones, but the high quality dynamic microphones (which provide a lower output) may require pre-amplifiers.

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.

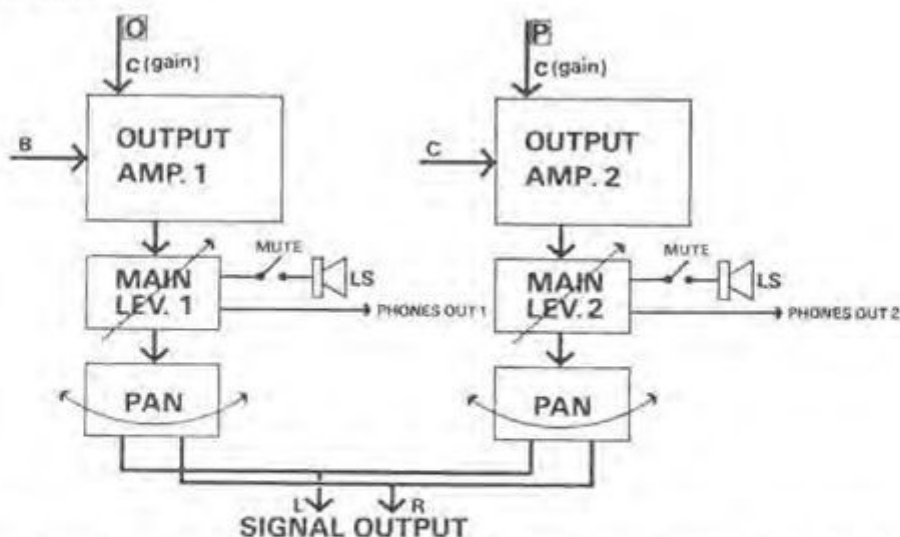
Main Level:

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.

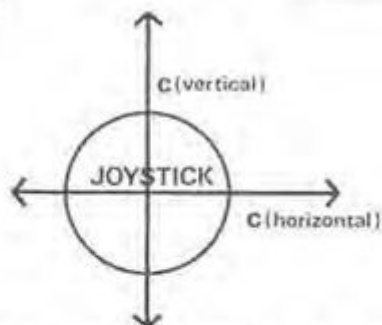
Each Amplifier contains a Filter which functions as a simple tone control; these should normally be left in the "flat" position (5 on the dial) and adjusted only when the other controls have been set. They are useful in live performance for "tuning" the SYNTHI to the acoustic environment.

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 5 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.

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.

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

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).