laughter, a[illegible]y found they were unable to carry on in front of the class or me. Depression set in and the idea of the piece was endlessly discussed and almost abandoned. Finally they came to me to ask for help which, as it was to be an examination piece, I declined to supply, except to suggest they borrow a copy of Berio's *Visage* to listen to. The following day they returned the record telling me that they didn't like it and could not see much point in it. They still wanted to go ahead with their piece so in desperation, after another attempt had broken down, I told them to take the recording equipment to a vacant office and not return until the piece was complete. Half an hour later the composition was finished. As I was not present at the session I was very interested to find out how the piece was finally taped. Various words were stressed in different ways, syllables were accented, echo was used to produce not only echo, but also feedback, the recording speed was changed abruptly and the psaltery was plucked on suitable occasions. I find the piece very satisfying considering the traumas that surrounded its composition. It shows imagination and a grasp of aural awareness on the part of the recording engineer. In spite of the fact that they assured me they did not like *Visage* I find the piece full of Berio's influence. It is a piece for which the bare minimum of equipment was needed. No expensive electronics were involved, just a three-headed stereo tape machine, two microphones and a great deal of imagination (*Cassette example 5.7*).

ELECTRONIC MUSIC IN SCHOOLS ORTON, (ed.)

6 Simple equipment for electronic music making.

ANDREW BENTLEY

The advice and information given in this chapter is intended to serve as a form of 'survival kit' for the first weeks of electronic music making in the classroom. It presumes that only the most modest equipment is available: the classroom hi-fi, an additional tape recorder or two, perhaps augmented by a few cassette recorders brought from home. This chapter does not presume a great deal in the way of previous skills or know-how, and an attempt has been made to go into as much detail as possible about how to apply the techniques suggested, leaving as little as possible to chance. This approach has its dangers, of course, since our aim first and foremost is to make music, or at least to experiment with sound in a musically meaningful way. The technical and rather matter-of-fact slant of this contribution is thus principally intended to provide some ways and means to that goal.

It is also presumed that the reader has no access to a synthesiser. The techniques discussed here go more than a little way to fill the gap, and at the same time cost virtually nothing. What is still better is that they lose none of their value or impact if a synthesiser is available, and can be used to augment and complement its facilities in the same way as such techniques often do in professional studios. Most important of all, they are in many ways explanatory of what is happening inside the synthesiser, which in view of the black-box nature of this instrument can be rather helpful in itself. The primitiveness of simple techniques such as these tends to cheapen their validity – I am not ashamed to admit that I have used each and every one of them at some time in my own compositional work even though I am lucky enough to work in a studio costing many tens of thousands of pounds.

If one's first aim is to make music, the practicalities of classroom electronic music can seem a little tiresome. Certain skills are essential: the ability to record on to a tape recorder successfully, to put together the right leads in order to connect one tape recorder to another for copying and manipulating the material during the transfer process and to edit tapes (described in detail in Chapter 1). Once the art of making connecting leads has been mastered it is only a small step to being able to construct some simple electrical hardware suitable for insertion in the leads between the tape recorders. This is often a matter of using an electrical device where previously an instrument was operated manually. While what I suggest may appear unorthodox, nothing here will cause damage provided the cautions are heeded. It is to be hoped that ingenuity will lead to the discovery of new techniques, and it

will soon become evident that lateral thinking and the will to explore new and even wildly strange ideas, when coupled with a thorough understanding of how things work on technical and musical levels, are the two most useful attributes of the electronic music composer-to-be.

As a final word of introduction, it should be said that even though all the material found in this chapter has been tried and tested in the field, problems may arise from time to time which result from the particular characteristics of the equipment available to you. Do not be disheartened if something that you try does not work, either in the technical domain, or the musical. With a technical failure it is simpler to blame your own incompetence first, try again from scratch, and if it does not work the second time blame the equipment. This is the correct course to take, since you lose virtually nothing from failures except time, and usually you gain greatly in knowledge in the process. With failures on a musical level (when you try a particular technique with a certain type of sound material, for example, and nothing spectacular seems to take place) you are experiencing a process of learning the correct matching of materials against techniques which is central to the successful creation of electronic sound compositions. Each case is so specific in this regard that no one would attempt to offer advice designed to cover all eventualities. Each composer builds up a repertoire where techniques are matrixed against musical goals, and he or she should be constantly striving to extend it through varied and preferably reasonably systematic forms of experiment.

Let us turn first of all to the resources nearest at hand. Among those resources most commonly and readily available to us is the tape recorder. It is evident that whatever sounds we are recording with it, we should do so efficiently and effectively. This means, in a technical sense, that we want to record to the highest quality allowed by the equipment. In a musical sense it means not wasting too much time and tape, and not accumulating grossly wasteful and unmanageable quantities of material, because editing then becomes a heavy chore rather than a creative activity, and tape is one of the most difficult media of storage from which to find something when you need it, however many notes you have made about what you have recorded on what piece of tape. Good quality recordings can be obtained by following the practical guidelines outlined here.

Recording materials

Recording is a skill and there are several things one should know in order to do it well.

(1) Use the recording meter, observing that the loudest parts of the sound send the needle just into the red area on the scale.
(2) Use manual rather than automatic, if there is a choice, since the automatic level control tends to make strange changes to the level and the result is usually a continuous *forte* with a lot of 'pumping'.

(3) Record quiet sounds in quiet places.
(4) If you are trying to record sounds from a single object, place the microphone as close to it as possible.

On the other hand rules are made to be broken, and one should explore as many different ideas as possible.

(1) Record with the needle right into the red and against the end-stop: this produces *distortion* which can be used to good effect in the right context.
(2) Try different kinds of microphone if they are available: contact microphones pick up sounds through materials; guitar pick-ups work electromagnetically and respond to vibrations in metal; carbon telephone mouthpieces have the strange advantage of being rather bad quality; old gramophone cartridges are very sensitive to small vibrations and a facility is often provided on tape recorders to accommodate them; normal 'air' microphones are very cheap if you buy the crystal type, enabling you to afford several should you need them.
(3) You can do strange things by 'fooling' the automatic level control when re-recording many sharply attacking sounds in succession.
(4) Neither the microphone nor the sound you are recording need stay still, and if you have the possibility of recording in stereo, you might try to move the sound in the stereo space: moving the microphone also allows you to either mix or sample sounds that are happening simultaneously in the same space.
(5) Some tape recorders offer a built-in facility for mixing microphones, and if yours is not one of this type, if may be worth investing in a cheap little microphone mixer. Record sounds using microphones located at more than one place around the object making the sound, and experiment with mixing them in different ways. Use different types of microphone mixed together. With stereo tape recorders, record with different microphone types on each track. This will allow you to mix them together at a later stage.

Recording successfully in a musical sense demands experimentation and forethought. It is not always practical or spontaneous to rehearse what you are to record but it is to be highly recommended where it suits the musical needs of your activity, be it the recording of some water swishing in a pan or several sound events to be recorded as a combination all in one take, where several pairs of hands are involved. When something does not succeed it is better to wipe it out than accumulate rubbish.

Looking for sound materials

Good sounds are to be found in abundance from very simple bits and pieces around us in everyday life. If you have any sense of history or reverence for the early pioneers of electronic music, you may wish to exploit these real live 'concrete' sound sources for their changing qualities which are nearly impossible to replace with synthetic sounds. From a practical point of view two alternatives exist: either the tape recorder can be taken to the sounds, which is necessary if you are

recording environmental sounds and for which purpose a cassette recorder is ideally suited, or the sounds must be brought to the tape recorder, which in the noisy classrooom environment can have problems. There is no shortage of sound-making materials, starting with your own voices, but if your minds need jogging this list will help you:

wood	plastic	glass
metal	cardboard	cloth

These materials appear in many forms:

sheets	netting	balls	utensils
springs	blocks	foil	
plates	grating	tubes	

Gather some of these materials around a tape recorder and start experimenting with ways of exciting them into vibration in order to get sound from them. School rulers were made to be twanged, and doing this is not unlike the way a square-wave generator works in a synthesiser. All serrated and ribbed surfaces (combs, washboards, a pile of envelopes) are sources of regular waves and thus musical pitches. If blowing, stroking, beating, bowing, shouting or rubbing with wet fingers does not excite the material into making a suitably interesting sound you may want to turn, disgruntled, towards electronic means to make it for you.

Simple electronic sources

It tends to be difficult to control the pitch of most recorded sounds as precisely as one can control the pitch of musical instruments, though the abstract, indefinable qualities of the former are often highly desirable. An electronic sound source, though it will be far simpler timbrally than many 'concrete' sounds, can offer a more versatile raw material whose pitch can be controlled at the time of recording. For this purpose an electronic organ can be used, or one of the many similar but far cheaper types of instrument now finding their way into toy shops. Besides the evergreen *Stylophone*, one especially interesting example is the *Compute-a-Tune*, which will remember the tunes you have entered into it via its two-octave keyboard, and which also has an output socket for connection to your tape recorder or amplifier.

There is a certain fascination and satisfaction in conjuring sounds out of 'thin air'. An impromptu oscillator can be formed by connecting a microphone to an amplifier (such combinations also exist as toys) or to a tape recorder if it is capable of sending the amplified sound directly to the loudspeaker when the record button is depressed. The feedback caused by doing this can be controlled easily if the microphone is turned to face away from the loudspeaker: among the possibilities offered by this technique is that of rapid fluctuations in volume caused by swinging the microphone around on its cable (but tape the cable to the microphone case to prevent damage to the connections), which can even produce

beautiful bird-like twittering. Experiment by putting your mouth around the end of the microphone which allows you to alter the pitch of the feedback according to how wide you open your mouth.

One extremely rich source of often very beautiful electronic sounds is a short-wave radio. If this kind of radio is not available you can try the extremities of the shorter wave bands of a medium-wave receiver, and in either case you should investigate those regions in between stations where atmospheric interference and modulation effects are strongest. These sounds are excellent material when played at lower tape speeds where the rapid high-pitched patterns are extended in duration. For how to obtain *electronic noise* as source material, see later in this chapter (p. 120).

'Musical numbers'

With the aid of two common items of domestic electronic equipment – a pocket calculator and a transistor radio – we are set to explore a rather unusual and fascinating method for producing pitched and other types of electronic sound.
The calculator should be placed in very close vicinity to the radio's internal aerial while tuning in to the medium and long wavebands, or alternatively to the telescopic metal rod aerial when using FM or short wave. Tune through the bands searching for a very strong steady tone which obliterates all other radio signals.
It is likely that you have found the calculator operating-clock frequency, or possibly the frequency which is used to scan its display. This may appear on any or all of the radio's tuning bands. When you have a good signal level, press each of the calculator keys, numbers and functions, and observe their musical effect.
Pressing several keys simultaneously in various combinations will produce different sounds, and each type of calculator is unique in this respect so it is a good idea to try all the calculators you can lay your hands on! Not all calculators use the same frequency, and there may be more than one place on the radio dial where sounds will be produced without the steady tone being present. It is just these places, hard to find as they are, which are likely to give the most interesting musical results – glissandi, various types of noise, different musical pitches and 'chord-like' sounds. More sophisticated calculators can give more varied results, but this is not always the case. If a programmable calculator is near at hand, try out programmes which use repeating calculation sequences and loops as these are likely to be the most promising. It is very difficult to offer more detailed advice because of the great variety of calculators on the market.
Once the effects have been discovered, it is very easy to 'notate' them by writing down the relevant keys that you have pressed, allowing you to return to them later. If the radio you are using has a built in cassette recorder, this can be used for recording the sounds directly on to cassette.

Developing recording techniques (one tape recorder)

If you are in command of recording techniques, you may wish to experiment with

some methods where the tape recorder's facilities can themselves play a role in the musical results which you are seeking. The tape recorder is not unlike a musical instrument in many ways: it has a facility for varying the pitch (the speed control), loudness (the microphone or line input control or in playback the volume control) and, to a limited extent, the timbre (tone control). With a little ingenuity one can extend the musical characteristics of this very versatile machine even further, even if you have only one tape recorder at your disposal.

Sampling

Your machine may have a pause control designed to stop the tape momentarily by lifting the pinch wheel away from the capstan. Cassette recorders have such a facility which is remote-operable from the microphone switch and which works in exactly the same way in playback mode too. A special lead can be made with a switch wired across the terminals of a 2.5 mm jack plug if you want to control this from a distance. You may use this switching provision to take short recorded samples of sounds occurring over a long and sustained period. This sometimes has a strange by-product (which can either be considered a drawback or something worth experimenting with in its own right) in that a rapid glissando downwards in pitch occurs as the tape gathers speed while recording. When switched in playback mode the glissando is heard to go upwards. A tape recorded in this way, manipulated in the same way during playback, will give glissandi in both directions.

Glissandi and octaves

Manipulation of the speed-change control in either record or playback mode (check with the instruction manual as this is not advisable on some tape recorders) will also produce glissando effects of a longer duration than that offered by the pause control. Using the fixed speeds of the machine, related to one another in octaves in musical terms, is extremely useful: doubling the speed, while raising the pitch of the material an octave, also halves the duration, which means that superb virtuosity is possible if the situation allows you to make the sounds at a lower pitch than you eventually intend them to be heard and you do this at as fast a tempo as you can.

Completely variable pitch

You can also record on to the tape, or play back from it, while hand winding the tape from the reels. Remove the head cover, slip the tape round the back of the capstan (rather than between the pinch wheel and capstan where it usually passes) and keep the tape taut while you hand wind it (Fig. 6.1). Hand winding backwards while you are in record mode will erase parts previously recorded, which if done knowledgeably and with care can result in an interesting telescoping of the musical events as they come into the tape recorder from the microphone or line inputs.

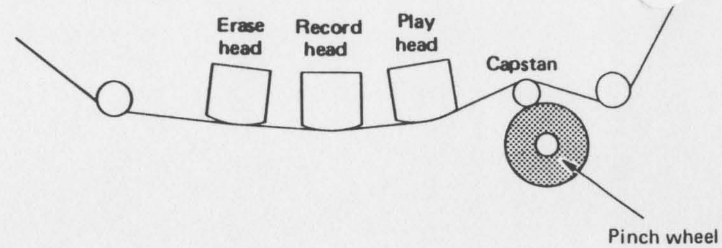


Fig. 6.1 Threading a tape recorder for hand winding

Vibrato

Because the capstan has been ground to be very precisely round, the tape will normally be driven along without any noticeable fluctuations in speed. Wrapping a short piece of sticky tape (masking tape is far preferable to clear adhesive tape in that it does not leave any sticky residue behind when you remove it) around the capstan will therefore provide a splendid vibrato on any material recorded or played back (or both for double the effect). Folding the end of the masking tape over to create a bump will intensify the effect. Vibrato will clearly be far more noticeable on pitched material than on more amorphous sound masses.

Creating textures and masses

Tape recorders are so designed as to erase the tape when something new is being recorded on to it. This happens at the erase head over which the tape passes before it reaches the recording head. If we prevent the tape from touching the erase head, which is a simple matter of bending a small piece of thick cardboard to fit snuggly round the front face of the head, it becomes possible to record a second, third or even fourth layer of sound on to the same stretch of tape, thereby thickening the texture of whatever is being recorded, even to the point of achieving a thick mass of sound when the nature of the material allows it. The last layer to be recorded will always be the loudest when the tape is played back and this is in the nature of things; if you want all the layers to mix equally in level it is necessary to lower the recording level with each successive pass over the same section of tape. Winding back the tape to the beginning is not necessary if all you require is a short piece of material, since the tape can be spliced into a loop (see Chapter 2, p.33), on to which sounds can be recorded continuously with the texture thickened on each full cycle of the loop past the heads.

Acoustic modifications (two or more tape recorders)

While the above mentioned techniques can all be performed using only one open-reel tape recorder, and some of them (sampling, layering, vibrato) even on cassette

recorders a little extra effort, more than one tape recorder enables us to copy from one machine to another via the built-in loudspeaker and microphone. This is not to be recommended for the purpose of making a good copy, but rather for allowing you to make modifications to the sound as it passes from the playback machine's loudspeaker to the microphone plugged into the recording machine.

Reverberation

Reverberation can be added to already recorded sounds by putting the playback tape recorder behind the soundboard of an upright piano and hanging the recording microphone in amongst the strings. Use of the piano's sustain pedal serves to turn the reverberation on and off. Damping upper or lower strings will lend different sound qualities to the reverberation. If you wish to avoid the motor noise from the playback machine finding its way on to the rerecording it is wise to plug an extension speaker into the speaker socket, enabling you to move the tape recorder itself away from the piano. You will in any case need to employ as much level from the loudspeaker as it will reasonably give without distortion, to combat surrounding noises and to stimulate the piano into resonating effectively. If the material is played back and correspondingly recorded at a higher speed than the one at which it was originally recorded, the length of the reverberation will be doubled.

Changing the tone quality

Many ways can be found to colour the sound on its way between the loudspeaker and microphone ranging from use of the acoustics of the room you are in (as Alvin Lucier employed in his composition *I am sitting in a room*, in *Source*, No. 7, 1970) to putting a loudspeaker unit in a bucket, a sock, an empty milk bottle, a guitar or virtually anything that comes to hand. Passing the sound more than once through the object will, of course, serve to intensify the effect which it has on the sound (Lucier went on passing the sound through the room until none of the sound of his voice was left, merely the resonances of the room). Tubes of all sorts and sizes are excellent for this purpose because they are 'tuned', like organ pipes, to a certain frequency. They will resonate at this frequency like a drum (drums can in fact be used too) if they are 'hit' with a short sharp sound from a loudspeaker. Putting one tube inside another like a telescope allows the length of the tube, and thereby the frequency, to be varied while recording is in progress, but this can make undesirable noises. Lateral thinking provides us with an alternative solution if a stereo tape recorder is available, whereby the effective length of the tube can be altered. Record your material on to one track of the tape and play this back through the extension speaker placed at one end of the tube. Record from the microphone, situated at the opposite end of the tube, on to the second track, using the hand-winding method described above (Completely variable pitch p.112). With the tape wound slowly forwards the effective resonance of the tube will turn out to have a higher pitch when the tape is played back; when run more quickly it will appear to be lower in pitch. The fact that this only becomes

apparent when the tape is subsequently played back means that it ther difficult to estimate what the effect will be. One has to 'listen upside down' and make a guess!

One is not restricted to passing sounds through the air; fixing a loudspeaker down on to some object or material in order to pick it up at the other end with a contact microphone proves to be an interesting alternative. Wood or glass work satisfactorily for this purpose, and if metal is used a guitar pick-up can be employed in place of the contact microphone. A large metal plate can act as a reverberation device in this fashion, though an impromptu rig-up such as this will not be the equal of the professional type of reverberation plate described elsewhere (Chapter 1, p.17).

The mouth tube

A variation on the acoustic methods of filtering just described, and equivalent to the band-pass filter often found on synthesisers, is the mouth tube. A glance at the diagram (Fig. 6.2) should explain all. A funnel large enough to cover the loudspeaker on the tape recorder or cassette recorder is stuck in the end of a piece of hosepipe about a metre in length. It is then taped down over the loudspeaker with masking tape to effect a well-sealed join. The end of the tube is placed in

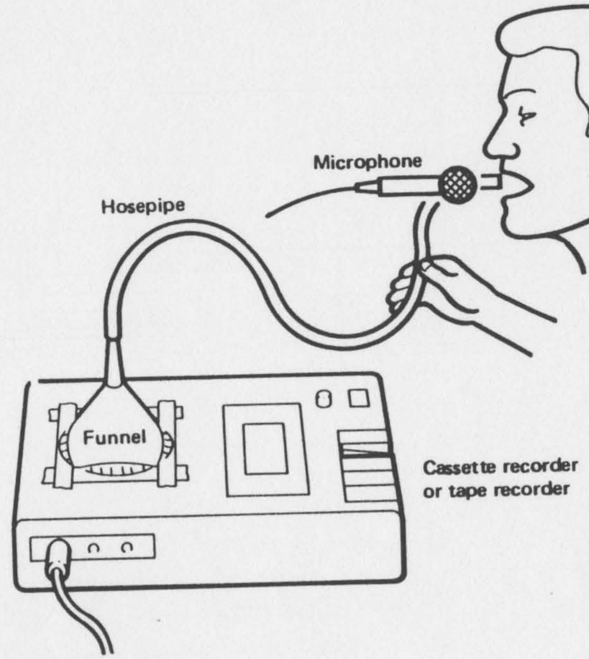


Fig. 6.2 The mouth tube

your mouth with the recording microphone as near to your mouth opening as possible. Opening and closing your mouth around the tube will alter the filtering frequency in the same way as it changed the pitch of the feedback 'oscillator' described earlier (p.111), and in the best of cases the sound material can be made to 'talk'. Tuning your mouth sharply to a resonant frequency can be difficult to do well in the first place but improves rapidly with practice. This is, in a sense, a type of acoustic *vocoder*. All the tone-colouring techniques described here are the acoustic analogy of what is happening in electrical filters, where a 'tuned circuit' is used to replace the tube's role in colouring the sound.

Making leads

The advantages we have seen from using two tape recorders can be exploited far more effectively if we have the possibility of copying from machine to machine using a direct electrical connection. In order to do this it is necessary to buy or make the appropriate leads. The price of ready-made leads and the demands of different situations are usually reasons enough to make it worthwhile learning the gentle art of lead-making.

The tools you will need for making leads are as follows: a pair of side cutters, pliers, some tool with a sharp point (the smallest of a set of watchmaker's screw-drivers or a filed-down paper clip), a soldering iron with a reasonably fine bit, and solder. A vice is very handy to hold the plugs while you are soldering on to them, and a multimeter is a boon for checking that good connections have been made and that there are no shorts from the signal wires to earth, but these are not altogether essential.

Audio leads should be made from single-screened cable. Double screened cable may be used for connections between stereo devices, but in most cases two separate leads will prove handier. In order to solder the lead on to the plug, the plug should be dismantled and the lead passed through the plug cover. You will need to pare away the outer covering of the cable, using the side cutters, to expose about 2 cm of the screen braiding underneath. Your sharp point now comes in handy for separating the plaits in the braiding starting from the tip of the cable. Twist the braiding together and tin it with solder, applying the solder and iron simultaneously (this is the golden rule of soldering). A few millimetres should be pared off the plastic covering of the signal wire which has now been exposed from under the braiding. The signal wires are twisted and tinned as before and then soldered on to the appropriate pin on the plug. Information on which pin is which can be gleaned from Fig. 6.3. The screen braiding is soldered on to the earth pin, and the plug reassembled.

If you plan to build your own equipment at some later stage it may be wise to standardise on a certain plug and socket combination where it is possible to do so, e.g. mono jack plugs or the smaller and cheaper alternative the 3.5 mm jack plug. At the tape recorder and amplifier end you are unfortunately stuck with what you are given.

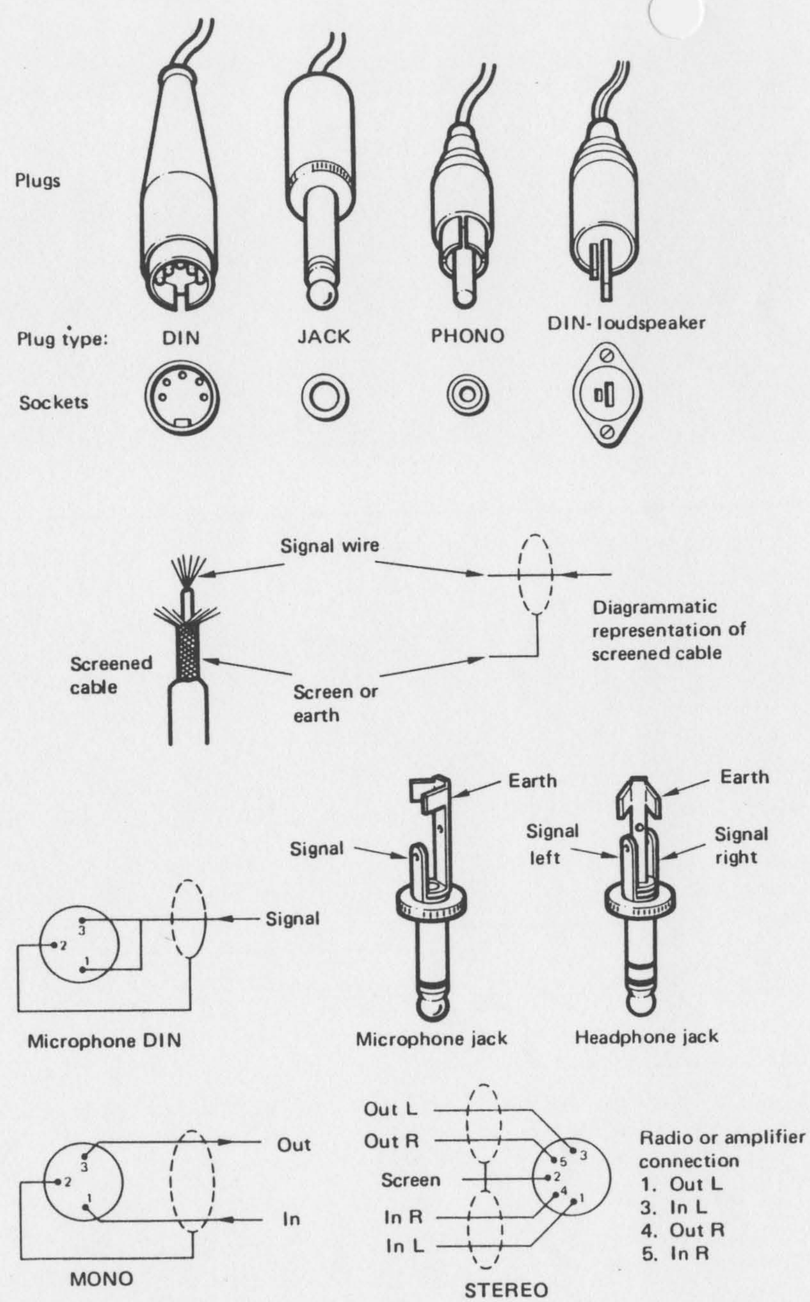


Fig. 6.3 Tape recorder inputs and outputs

Amplifier		*Terminology used*
Inputs	– from record deck	PHONO, PICK-UP, X-TAL MAGNETIC
	– from tape recorder	TAPE, REPLAY, RADIO, AUX, LINE-IN
	– from tuner or radio	TUNER, RADIO, AUX
Outputs	– to tape recorder	TAPE, RECORD, AUX OUTPUT, LINE-OUT
	– to loudspeakers	LS, LOUDSPEAKER, MAIN, REMOTE, 8Ω/4Ω
Tape recorder		
Inputs	– from radio, amplifier or tape recorder	RADIO, AUX, LINE-IN, DIODE
	– from record deck	PHONO, PICK-UP
Outputs	– to amplifier or tape recorder	RADIO, AUX, LINE-OUT, PRE-AMP
Cassette		
Inputs	– from microphone	MIC (microphone remote control – REMOTE)
	– from cassette recorder	MIC (only from EAR when no other choice is available)
	– from radio or amplifier	AUX
Outputs	– to cassette recorder	EAR (only to MIC), AUX
	– to amplifier	AUX

Symbols used

- to or from tape recorder
- from record deck
- from radio
- from microphone
- to headphones
- to loudspeaker

Fig. 6.4 Connections between equipment

Whether you choose to make leads or buy them, it is still necessary to know which plugs (and, in the case of DIN plugs, which pins on each plug) and which sockets should be connected together to ensure a successful transfer of the signal from device to device. This can be tried out by experiment but the combinations are often many, and not all are equally successful. Those readers who have heard such terms as 'impedance matching' and 'balanced lines' should rest easy because these problems rarely raise their ugly heads when dealing with domestic equipment. It is usually a question of finding combinations of inputs and outputs which

suit one another in terms of signal level, or 'sensitivity' as it is usually unhelpfully described in instruction manuals. The table of connection terminology (Fig. 6.4) should be your guide. If your equipment uses sign language on the sockets, the key to the symbols will clarify matters. A bad combination of output and input will be evident if the sound quality deteriorates or if a hum is induced on the inputs. Look for alternatives too if you find that the signal level arriving at the input is too low and that you therefore have to use more than half the level available at the input level control. With suitable leads available for connecting the tape recorders together it becomes possible to try some techniques which work most effectively when the sound material is being played back and copied on to a second tape recorder. Listening on headphones to what is arriving at the second machine's input allows you to monitor what is happening to the sound. The techniques which we applied when recording sounds on to the tape, such as sampling, layering, octave changing and hand winding, are equally applicable here, but in addition to these we may try the following.

Distortion

Distortion, which in electric guitar players' terminology is flatteringly called 'fuzz', can be obtained electronically by overloading the inputs of the tape recorder, which is not generally considered to be good practice. The alternative is overloading the tape itself by recording very heavily into the red on the recording meter. This will not do any damage but is likely to render the tape less usable for recording thereafter. The simpler and purer the sounds recorded (a suitable candidate being the mouth feedback described above), the more effective the distortion for making them timbrally interesting: thicker textures usually sound distasteful when distorted. If the distortion is recorded at a quieter dynamic level in the final musical product, it is likely to sound more as if it was intended as a timbral decoration than a mistake. This is a characteristic of perception rather than an electronic phenomenon. Later in this chapter you will find a very simple electrical circuit for obtaining fuzz and controlling it more effectively. Electric fuzz has the strange characteristic of sounding more pleasant than the gross overmodulation of the tape described above. The 'harmonics' produced by these two methods are related in different ways to the original sound.

Bending the pitch

Once the sound has been recorded on the tape it becomes possible, by holding the tape at two carefully chosen points with the fingers and thumbs and stretching it slightly, to make small downward bends in pitch. This, needless to say, renders the tape completely unusable afterwards but its artistic merit may justify this expense. The stretched sections can be edited out of the tape before it is used again. However, there can be no equivalent way of making the sound bend up.

Tremolo and fluctuating dynamics

There are several ways of creating variations in the dynamics of the recorded

material when it is copied on to a second tape recorder. Taking a blunt and non-metallic instrument, or your finger if it is small enough, and using it to bounce the tape on and off the head as it is playing is a technique which can be performed at various tape speeds. When the material is copied at a lower speed than that at which it was recorded, the fluctuations can be made to occur at a faster rate than your own dexterity would otherwise allow. The variations in dynamic are accompanied by drops in the high frequencies as the tape wavers away from the surface of the head. With tape recorders that are equipped with pressure pads to keep the tape in contact with the head it usually suffices just to waddle this backwards and forwards.

If an electronic organ with built-in Leslie loudspeaker (this is a type of loud-speaker which rotates) happens to be available, it is sometimes possible to plug the output of the tape recorder into its preamplifier (usually a jack or phono socket is provided for this purpose somewhere under the keyboard) and the various speeds of tremolo can then be rerecorded on to the second tape recorder using a micro-phone placed near the Leslie. The technique for doubling the speed of fluctuation is just as effective in this case also.

It is not out of the question to build your own rotating loudspeakers. The most difficult problem in this regard is getting the signal to the loudspeaker when it is turning round. Wires simply will not do, since they get wrapped in knots after a few revolutions. The solution I came up with was to use a jack plug and socket combination, fixed vertically to act as a kind of bearing on which the loudspeaker could rotate. This will not take the weight of a large loudspeaker, nor will it last indefinitely, but it does work.

Electronic noise

This is a useful source material for creating percussive effects and lends itself admirably to tube filtering and dynamic modifications. No expensive noise generator is actually needed to obtain it, since by plugging in a tape recorder output to another recorder's input and turning up the input level to maximum it is possible to record nothing – nothing, that is, except noise. If this does not give enough noise level, play the tape you have recorded on the first machine and repeat the operation until the level is satisfactory.

Dynamic shapes

This is an extension of the technique described in Chapter 2 under 'Rhythmic templates' (p. 32). A little fancy work with the scissors and the low speeds available on domestic tape recorders work effectively together as a way of changing the dynamics of sounds by cutting the tape at acute angles. If two tape recorders are available we are not restricted to the tiresome process of cutting up each individual sound recorded on the tape, but we may cut empty tape into the dynamic shapes that we want and record the material, where it happens to be fairly continuous stuff, on to the readily cut sections. These shapes, made from bits of tape with leader tape for the silences, can be formed into a loop for convenience (Fig. 6.5).

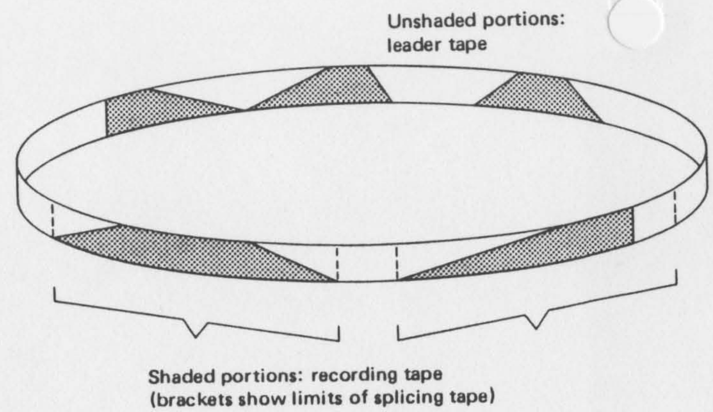


Fig. 6.5 A chopping loop for making dynamic shapes

When the sound has been recorded on to the loop it is then replayed and recorded on the first tape recorder, or a third should it be conveniently available, for storage in its new form. The loop can then be re-used for another sound. With tape recorders equipped with three heads, it is possible to 'pass the sound through' the chopping loop on to a third recorder all in one operation. Mono tape recorders work best for this technique. With stereo tape recorders the sound appears to move in space, unless the two outputs are mixed into mono.

Painting the tape

'Painting' is meant here in only a figurative sense. The idea is that by stroking the tape with a demagnetiser, it is feasible to record the 50 Hz mains frequency on to the tape, thus producing tones whose pitches depend on the speed that the de-magnetiser is guided along the tape. Some demagnetisers do not produce this effect; instead they erase the tape entirely, which is something which can quite equally be used for causing changes in dynamic if the demagnetiser is not allowed to come into close contact with the tape. With a stereo tape, erasing one side of the tape rather than the other causes the sound to wander. Those demagnetisers which pro-duce tones can also be used to make rather pretty modifications to material which has previously been recorded on the tape, including spectacular sweeping sounds. It is wise to experiment with some unimportant materials at first, and to keep the demagnetiser away from any important tapes while you are working with it, for reasons which should be obvious. This means that one should cut out the parts of the tape to be treated in this way and replace them afterwards.

As a final word on tape recorders it may be worth noting that the reel of tape is not the only method of storing recorded sound material. One entertaining alternative is the Mapophone.

Mapophone

This is the name I have given to a realisation of the idea suggested by the American composer Jon Hassell in his compositions *Map 1* and *Map 2* (*Source*, No. 5, 1969). Strips of empty or prerecorded tape are glued down, with the oxide coating (the side normally touching the heads) uppermost, on to a sheet of cardboard or plastic to form a rectangular area on which the sounds are to be recorded. If you are lucky you will be able to appropriate some 2 or 1 in tape which will make the job of laying down the strips much easier and which will also last much longer in use, owing to there being fewer adjoining edges. A record head, or record/playback head must be obtained, either surplus or from a component firm, and connected to your tape recorder's record/playback head terminals. This should be done with extreme care so as not to dislodge the leads that are already there. It should be connected with a cable that has two signal wires for the connections between the head terminals and a screen which should be attached, as shown in Fig. 6.6(b), either to the central tap on the tape recorder's head or to the machine's chassis. Not doing this will result in hums or the cable acting as a radio aerial. It is wise then to wrap the tape head in insulative material so that only the front face is to be seen, which prevents your hands from touching the cover. This helps to prevent hums. Put the tape recorder in record mode and record the sounds at the input of the tape recorder on to the map surface in any and all directions, keeping the head as upright as you can, using fairly swift and even strokes of the head. Playback is done in a similar manner, with the machine in play mode, with the added freedom to explore different regions and directions of the map using your artistic licence. Tilting the head slightly results in the higher frequencies becoming fainter, and a mellowing of the sound.

A more recent use of unusual tape and tape recorder head mountings was demonstrated by another American, Laurie Anderson, in his *Violin Tape Bow*. This

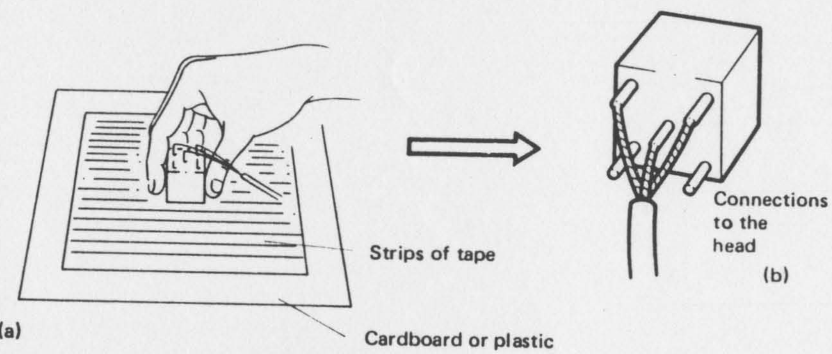


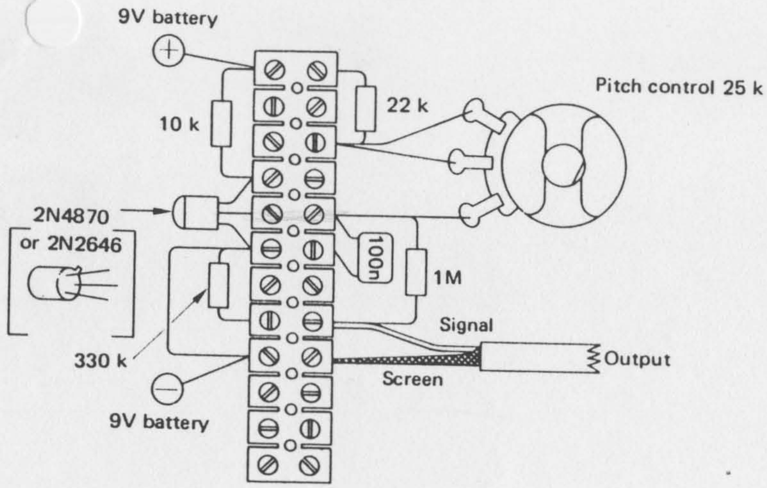
Fig. 6.6 (a) The Mapophone
(b) Tape recorder head and screened cable

comprises a tape head fixed to a violin, and the hair of the bow is replaced by a length of prerecorded tape. As with the *Mapophone*, the prerecorded sounds can be played at any speed, with the possibility of enormous speed changes and rapid changes of direction between forwards and backwards.

The poor man's synthesiser

The tape recorder has so far gone a long way towards providing us with many techniques for the origination and manipulation of sounds which we would normally expect from a synthesiser: sources of oscillation, vibrato, pitch-bending, changing of the tone quality by filtering, creation of dynamic shapes or 'envelopes' and reverberation to give an impression of acoustic space. The tape recorder's only drawback, as can rapidly be deduced from the techniques described above, is that it can rarely do more than one of these things at a time. If build-up of noise from many generations of tape is inclined to be a problem, however, and you really know what it is that you want in advance, it may be worth rationalising your procedures a little to see just how much you can manage to do in one operation.

With the tape recorder thoroughly explored, and some confidence gained from making leads and connecting equipment, the time may be ripe to employ your constructional skills in building small devices which can cut a few corners in an operational sense and at the same time overcome some of the problems of performing techniques with machinery not really designed to do the job. The circuits to be described below are logical extensions of the techniques which are already familiar from working with the tape recorder, and are whittled down to the most minimal versions which will still work with reasonable quality. They are simple enough for the pupils themselves to assemble on terminal blocks. The more adventurous can transfer the units that have been tried and tested for their musical usefulness on to 0.15 Verostrip or Veroboard for permanent use. Verostrip (0.15 in. matrix) is a rather close equivalent to terminal blocks. As they stand, these projects do not demand any soldering skills other than the attaching of leads to the potentiometers to enable them to be screwed into the block. This could be done by the teacher. No tools other than those which were used for lead-making are necessary. You can lay the components out and insert them into the blocks using the diagrams shown in Figs. 6.7 – 6.11 as a guide. Lists of components are given to make ordering or buying easier. With everything connected together properly they should work first time, but the terminal block arrangement does mean that you have to be careful not to let wires touch each other unless they are connected to the same hole. Observe the polarities of such things as diodes and capacitors, and be careful to insert the transistors in the way shown on the diagram. None of the components is terribly vulnerable and should not be suspected first if the device does not work. To connect these units to tape recorders or other equipment you will need three or more cables with bare ends to insert into the terminal block and plugs to suit the equipment at the other end. These too could be provided ready-made by



Component list

10 k	resistor
22 k	resistor
330 k	resistor
1 M	resistor
100 n	capacitor
(= 0.1 μ),	polyester radial
2N4870	transistor or 2N2646
25 k	potentiometer
9 V	battery
	battery connector

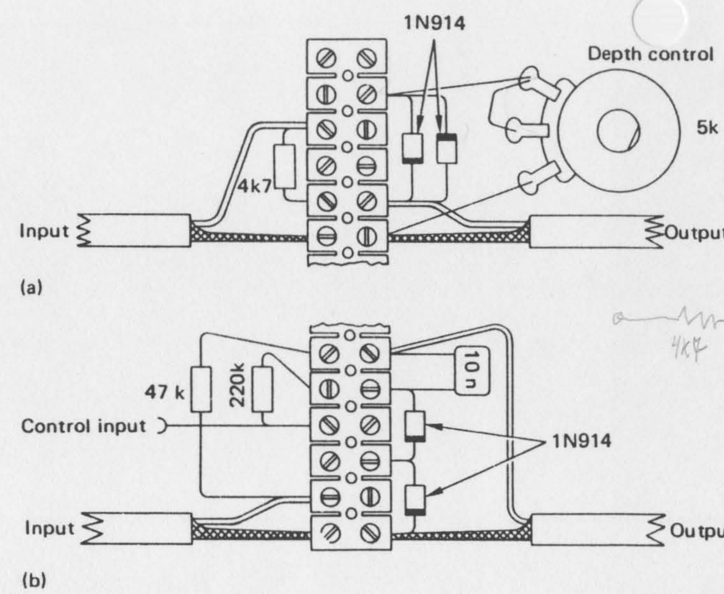
resistor colour codes

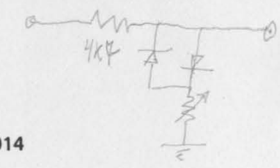
10 k	brown	black	orange
22 k	red	red	orange
330 k	orange	orange	yellow
1 M	brown	black	green

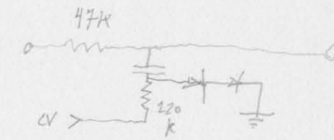
Fig. 6.7 The oscillator

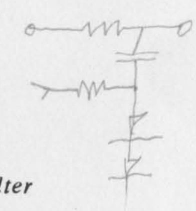
the teacher. If you suspect that the inputs and outputs of your equipment may not be adequately protected ('decoupled') against DC voltages from the outside world, you should insert a 0.1 μ (100 n) capacitor in the signal lead of each of these cables for safety's sake. This will prove to be a wise precaution in any case.

The oscillator *(Fig. 6.7)*
Though many electrical oscillators work in a way which is analogous to the teacher. If you suspect that the inputs and outputs of your equipment may even simpler. It is a *unijunction relaxation oscillator* built around a unijunction transistor, and its frequency is controlled by a voltage applied to the fifth terminal from the top via a potentiometer. This potentiometer could be replaced by a set of keyboard contacts separated by a chain of resistors or preset potentiometers if the need were felt. This way one would be able to obtain discrete intervals of pitch. The voltage could equally well be derived from some other source.









Component list

Distortion:	
2 x 1N914	diode
5 k	potentiometer
4 k7	resistor
Filter:	
47 k	resistor
220 k	resistor
10 n	capacitor, polyester radial
2 x 1N914	diode

resistor colour codes

4k7	yellow	purple	red
47 k	yellow	purple	orange
220 k	red	red	yellow

Fig. 6.8 (a) Distortion and fuzz circuit (b) Voltage-controlled filter

The fuzz unit *Fig. 6.8(a)*
This unit will distort the sound passed through it by symmetrically clipping the tops and bottoms off the wave-form peaks. It is entirely passive, i.e. it needs no battery power to work. The potentiometer controls the amount of distortion. It is possible that signals of too low a level will not be distored by this circuit, but normal tape recorder outputs should work quite happily.

The voltage-controlled filter *Fig. 6.8(b)*
This is a passive low-pass filter of the RC (resistor-capacitor) type. It needs to be supplied with varying voltage at the control input from some source, which might be a similar arrangement to that used in the oscillator. This control voltage can also be supplied by the output of the attack-decay generator or the envelope follower,

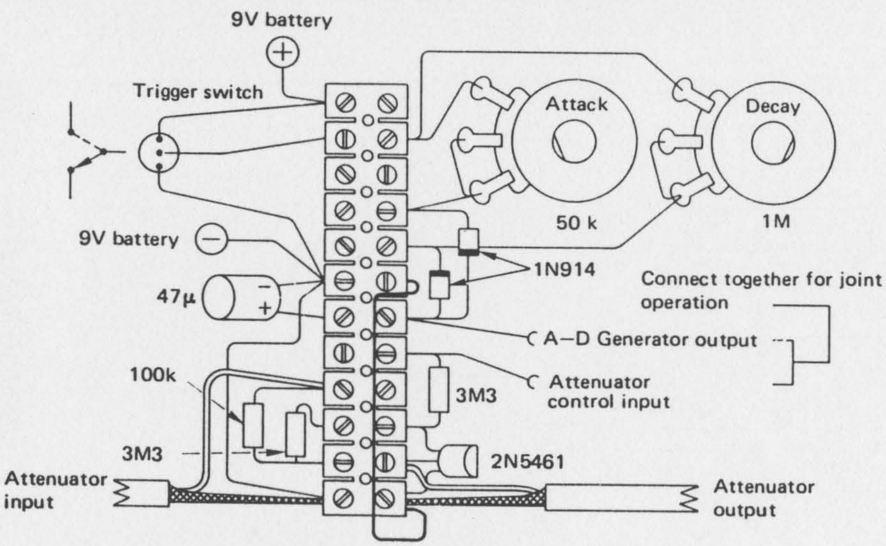
described below. The higher the voltage (up to 9V) supplied to this terminal, the lower the frequency of cut-off and the more treble is removed from the sound being passed through.

***The voltage-controlled attenuator** (Fig. 6.9)*

This is for controlling the dynamic shapes of sounds and works in conjunction with the attack–decay generator or envelope follower, either of which will provide a voltage to vary the amount of the signal which is allowed through the device. It uses the variable resistance of a P-FET transistor to sap away larger or smaller amounts of level from the signal.

***The attack–decay generator** (Fig. 6.9)*

This is a very simple form of envelope generator, capable of supplying an upward-going ramp of voltage for the attack portion and a descending ramp



Component list	
47µ	capacitor, electrolytic
2 x 1N914	diode
50 k	potentiometer
1 M	potentiometer
9 V	battery
	push-button SPDT changeover switch
100k	resistor
2 x 3M3	resistor
2N5461 [or 2N5460]	transistor P–FET

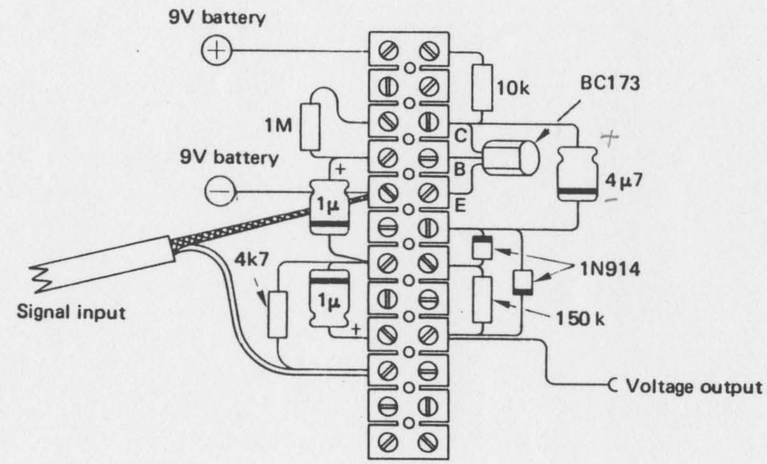
resistor colour code			
100k	brown	black	yellow
3M3	orange	orange	green

Fig. 6.9 Attack-decay generator and voltage-controlled attenuator

for the decay portion, achieved by charging and discharging the capacitor. The durations of the attack and decay can be altered using the potentiometers: the push-button switch, which should normally be resting with the centre terminal connected to earth (battery negative terminal) should be pressed for as long as the attack portion of the wave form lasts if it is intended that the sound reach full volume.

***The envelope follower** (Fig. 6.10)*

This is a handy device which follows the dynamic shape (envelope) of the input signal and produces a varying voltage which traces it. With its output connected to the control input of the voltage-controlled attenuator, the level of the signal passed through the attenuator will vary in exact correspondence with the dynamic of the sound connected to the follower's input. Thus new material can be synchronised with previously recorded sounds, and rhythmic materials created. The output of



Component list	
4k7	resistor
10 k	resistor
150k	resistor
1 M	resistor
2 x 1µ	capacitor, electrolytic
4µ7	capacitor, electrolytic
BC173	NPN transistor or BC182
2 x 1N914	diode
9V battery and connector	

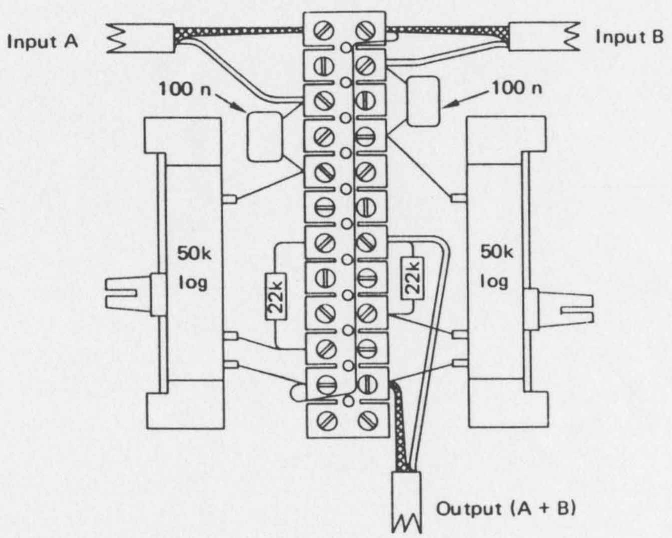
resistor colour codes			
4k7	yellow	purple	red
10 k	brown	black	orange
150k	brown	green	yellow
1 M	brown	black	green

Fig. 6.10 Envelope follower

the foll(can also be applied to the voltage-controlled filter's control input, causing the filter to dip in frequency as the input to the follower grows in dynamic; when the signal present at the follower input is mixed with the filter output, the two sounds will appear to alternate. When connecting any of the above devices together, it is essential to use either a common battery or common earth connections, which entails connecting all the battery negative terminals together.

***The mixer** (Fig. 6.11)*

Suitable for use with the signals from the above devices, and of great help in other more general tasks, is the mixer built from passive circuitry shown in Fig. 6.11. Although, in the form described here, it is laid out in the same way as the previous projects on a terminal block, this is a rather ineffective method of constructing it. Its general usefulness will make it worthwhile to transfer the connections on to 0.1 in Verostrip, the holes of which very conveniently match up with the pins on slider-type potentiometers, thus making the job very much easier to accomplish. Suitable sockets might then be mounted on to the strip, or attached to an angle bracket fixed to the strip, enabling the mixer to be plugged in where and when required. Contrary to what is often said about the 'loading effects' of passive



Component list	
2 x 100 n	capacitor, polyester radial
2 x 22 k	resistor
2 x 50 k	log potentiometer

resistor colour code
22 k red red orange

Fig. 6.11 Mixer

mixers, this one works very satisfactorily in the great majority of   s. If an active two-input mixer is preferred, a very simple Josty Kit is available, but the passive mixer works out much cheaper and adds no distortion or noise to the signal !

Ready-made alternatives

Comparable in many ways to the little construction projects just described, but designed and constructed to better specifications and boxed for permanence, are the effects accessories which guitarists often use for processing the sound from their instruments. These are excellent devices for classroom experimentation and, though not cripplingly expensive if bought singly, they can usually be borrowed from some willing person to enable you to try them out for a few days. The *fuzz box* has an effect similar to the circuit described above, with the added advantage that its active circuitry guarantees good distortion in all cases. The *wah-wah pedal*, a foot-operated low-pass filter with a resonating peak approaching that of a band-pass filter, will give a sharper filtering effect than the passive unit described above. Other units include *sustain*, which gradually increases the dynamic on a new sound being inputted in order to compensate for the decay inherent in plucked guitar sounds, and the *octave divider* (hiding under many different pseudonyms such as 'sub-octave generator' or 'blue box') which provides a square-wave signal of a pitch one or two octaves below the input frequency. It is only able to follow fairly pure tones with any accuracy, but responds excellently to voice sounds and makes a fair mess of anything complex in character. The *phaser* causes a sweeping effect to be added to the sound not unlike the variations in a jet engine sound of an aeroplane flying overhead.

Building equipment

Even though the music lesson may not be the time or place to engage in serious electronics construction, some words of advice and encouragement may be welcome to those who would like to try this in their spare time or initiate such a project as part of school science activities. Electronics teaching is becoming a more familiar phenomenon in British schools, due in part to the impetus and excellent literature provided by the Schools Council Science Project, and volunteers for experimenting with electronic music circuits may well be found in your own class or school. Use them: home-made electronics are very cheap and, if constructed from a well-known published design, can be quite the equal of commercially available equipment. Try construction yourself: it is certainly not as frightening a prospect as it seems, but a rather relaxing and satisfying activity. If you are able to solder leads together you are halfway there; any further know-how that is necessary revolves around the components– identifying them, making sure that they are put into the circuit the right way round and assessing which of them may be causing problems if the circuit does not work. Excellent literature is available to cover all these aspects.

Start [illegible] kit; the simpler the better. Kits are child's play to assemble in most cases, and the suppliers often include copious notes to accompany them. Some even offer to put the matter right if you do not succeed in getting the circuit to work under your own steam. There are firms which specialise in kits for electronic music modules (see Appendix V), many of which are taken from articles published from time to time in the popular electronics magazines. Kits have many advantages over homebrew construction: professionally made, printed circuit boards are included, almost guaranteeing the success of the project by itself, since alternatives such as using matrix boards of the Veroboard type are more fiddly and it is relatively easy to make mistakes or leave some connection out. Making your own printed circuit boards is a messy business involving etching acids and home-made boards rarely come out to the same standards as the professional ones supplied in kits, which often have diagrams printed on their upper face to show where the components are to be inserted. All the components are supplied in one package, simplifying ordering immensely, and the total cost rarely works out more expensively than 'shopping around'.

Surprisingly, electronics construction usually involves more metalwork and woodwork than it does electronics, since when the printed circuit board has been furnished with its components, soldered and tested – which may take one hour – the problem still remains of how to house the device you have built, involving the drilling of holes to accommodate potentiometers, switches, plugs and sockets. Not only is this more time-consuming than the electronics assembly but these components and the box will often cost several times the price of the electronics inside. Boxes are one area where great savings can be made if you do-it-yourself in the school metalwork shop. Compatibility of electronic music modules from different sources can sometimes be a problem. This applies less to audio signal levels, though some synthesisers work on so-called 'hot' levels of a few volts' swing, and others on lower levels more closely matching those found in domestic audio equipment. Sadly, information in kits or constructional articles far too rarely give clues to these and other problems, nor to the nature of the required control voltages and their polarity. An oscillator's frequency, for example, might be controlled by a voltage which rises either linearly, 1V per 1000 Hz, which is musically less useful, or exponentially at 1V per octave which is a widely accepted standard among professional manufacturers. This voltage can be rising for an increase in frequency, or falling, and furthermore it may be positive with respect to earth, around earth, or negative going. These systems are not necessarily compatible with one another and the best policy is therefore not to mix circuits from one synthesiser design with those of another if you are in doubt.

Access to further information for the beginner

Whether you are merely experimenting with tape recorders or are adventurous enough to try out the constructional ideas presented here, many questions will be

raised which require answering. If access to equipment proves to be [illegible]oblem, then access to information, tools and know-how can prove often to be a far more serious matter. If ideas or information are what you are lacking, look near to home: there is always an expert near you. The list of university studios in Appendix VI may be of help – you can contact the studio director for advice, arrange a studio visit, or ask for a willing composer to bring a synthesiser to school and discuss what you are doing, even arranging an impromptu concert-demonstration if there is enough interest. A resident technician may be available in some cases to answer your technical queries. Books are plentiful but are often too general to cover specific problems relating to your equipment. Magazines tend conversely to be rather too specialised, demanding specific technical knowledge of the reader. Summer courses can be a rich source of inspiration but are inevitably too short, and regrettably few societies exist to promote these kinds of activities. The answer lies, in the final analysis, in exploiting the best of all these sources, some guidance to which will be found in the appendices to this book.

Musical goals

No quantity of tape recorders, synthesisers or techniques for applying this equipment can ever replace the combined cooperation, endeavour and imagination of a class of thirty pupils. Although the activities described in this chapter are inevitably destined for small-group activity, there are many simpler activities which can be used in the first instance to gain familiarity with the equipment and involve the whole class: some of them, such as collecting sounds from the environment, lead naturally into investigating recording techniques and developing a strong sense of appreciation for sound materials and a responsibility towards their creative application in improvisation and composition. Aural games, in which the tape recorder can take part as a storage medium for sounds, help to sharpen the ear towards different aspects of the living sound. Building instruments, including electroacoustic instruments, helps to gather the threads of how sound is made in a physical sense while providing ideal material for the techniques described in this chapter.

All these resources must be turned into music, and in guiding pupils in the kind of activities described here it is wise to lay extra emphasis on the musical significance of what is being done in order to counterbalance the technical nature of its execution: use musical terminology rather than technical terms where you have a choice; quiz your pupils on what it is they are trying to achieve on a musical level. Draw attention to the way that the sound has been transformed from its original state to its present one, and encourage the use of material from all stages of the transformation process. In this way musical similarities and differences, processes and coincidences, conscious execution and discovery, can all play their part in whatever turns out to be the musical product. In this sense this chapter can only hope to help you in your technical survival: the rest is up to you.