Fairlight Music

Ray Hammond

ALTHOUGH microcomputers are particularly good at music making, the first microcomputer package dedicated solely to music production did not appear until 1980. It was developed in Sydney, Australia, and was named 'The Fairlight'—after a hydrofoil that skims its way across Sydney harbour.

There are now about ten systems manufactured in the world which might reasonably be described as dedicated music computers. The Fairlight has now been surpassed in some areas, but the system, in common with all 'soft' packages, is under constant revision and it has certainly become the most widely-played computer musical instrument (CMI) in the world. As a result, there is now a considerable amount of user feedback available.

POLYPHONIC SYSTEM

The Fairlight was the end product of five years of research by Peter Vogel, Kim Ryrie and Tony Furse. Vogel and Ryrie were, and still are, precocious young Australian designers with a talent for electronics and a love of music. Furse was a computer engineer of 20 years' standing who in 1974 brought to the partnership a monster machine, already capable of producing digital music. The team then developed a system called the Qasar M8 which was an eight channel polyphonic system. The unusual element in this machine was the 'dual processing' carried out by two microprocessors working in tandem. Whilst one controlled information exchange with the human users, the other saw to it that the hardware did what was necessary. The Qasar was a large expensive system and as improved microchips became available, the team redesigned the package making it both smaller and cheaper.

The Fairlight is a 'digital ear' on the world of sound. It is markedly different to most other musical instruments in that it is capable of 'listening' to the external world, storing what it hears and reproducing that sound as music. The symphony of windows breaking is a reality with the Fairlight. This ability was developed from Tony Furse's original system of digital music production. Rather than opting for FM index synthesis, or any of the other methods of sound production, he worked with digitally produced waveforms, a system that later allowed information to be entered from the outside world.

The Fairlight is larger (in total RAM terms) than most microcomputers. Its total RAM of 208K—coupled with dual processing capacity—almost brings it up to the minicomputer, although *processor* RAM (excluding that used for waveform storage) is currently the regular 64K. The concept, successfully developed in the Qasar, of running two microprocessors as independent but linked central processing units, became a central part of the Fairlight design. There have long been problems in running two, linked microprocessors and gaining maximum speed from both—one tends to take on capacity work leaving the other partly idle. The Qasar development provided the answer.

Software may reliably be regarded as the really clever part of dedicated computer design and the Fairlight system contains the end product of six years of solid work by several programmers. The present program, in 'assembler language', occupies over 300K of memory space and understandably the team are now

Computer

looking to move towards a high level language, such as 'C', now that major improvements in hardware memory capacity are on the horizon.

HARDWARE

Despite this insistence on the importance of good software, it is fair to say that the Fairlight incorporates some very dedicated hardware indeed. The system arrives with one or two musical keyboards (at the purchaser's option), the VDU housing the central CPUs and the eight voice modules, a dual disc drive and the main operating software language stored on an 8 inch disc. The VDU is fitted with another Furse development, a 'light pen' to assist in graphics work. It was the team's intention to display musical sounds and wave shapes. The monitor was built to the Fairlight company's own design because commercially available units didn't have sufficiently high resolution graphics. Some of the electronic components in the circuit have been deliberately overrated in an attempt to offer the user some protection against mains fluctuation—a phenomenon that has been known to occur on concert stages from time to time. The twin floppy disc storage system operates on DMA (direct memory access), a refined high-speed information retrieval system. Disc systems found with most home computers and many professional machines, operate under the control of the CPU (central processing unit) which requires an interruption in the task in hand for the CPU to monitor the disc system during loading. The DMA system requires a signal from the CPU when information is required but thereafter the transfer takes place without CPU involvement, until the CPU senses the end of the information load. In practical terms this allows the musician to program a piece of music which calls for voices to vary during the performance, and the CPU will cue the disc to load the required voices when necessary without being interrupted in its task of controlling pitch, waveshape or any other parameters.

The disc drives are unimportant to the theoretical system design, but are vital in practice. Despite the expense of a Fairlight system and its relative bulk and complexity, the makers are certain that the Fairlight will become a fully-fledged transportable instrument. Several world tours have been undertaken with the system being shipped from concert to concert—in most cases without any provision for back-up, spares or systems being made—and the system has performed without trouble.

Fairlight financed their seemingly insane decision to build a dedicated music computer by producing business computers that Remington Office Machines of Australia shipped out as business machines under their own brand label. The hostile business environment showed up the weaknesses of available disc drive systems and the company heaved a sigh of relief when, shortly before the first Fairlight was produced, a Japanese company marketed a drive significantly more reliable than anything previously available.

A Fairlight (along with some of the other dedicated instruments mentioned later) represents the most flexible and powerful type of musical instrument available to mankind. But it has no sound of its own. When it arrives the memory spaces are empty and at no stage will a characteristic 'Fairlight sound' develop.

Fairlight Instruments provide a starting disc on which a wide variety of digitally-stored sounds are pre-recorded. These may be loaded into the Fairlight by inserting the disc into the right-hand disc drive and issuing the appropriate command via the alphanumeric keyboard—the left-hand drive contains the system disc. The sounds may also be loaded into RAM via the calculator-type keypad on the musical keyboard and via the light pen and screen. After loading, any one of the sounds is instantly available under the musical keyboard and can be played in real-time, i.e. the response time of the Fairlight is rapid enough to allow instant recall of sound when a key is depressed.

VISUAL INFORMATION

The operating software of the Fairlight is 'menu-driven' throughout. On powering up and loading the system disc containing the operating software, and a disc containing sounds, an index appears on the screen. This index lists a total of 12 pages (menus) that the user may go to and several new pages are due to be added. Page 1 is the index itself. Page 2 is Disc Control, a menu for the store of voices and for the disc-control system which will create space for a new voice or file. Page 3 is Keyboard Control and this menu allows the playing parameters to be set, such as tuning, scale, etc. Page 4 is Harmonic Envelopes which will allow the user to draw envelopes on the screen and hear the result, and so on.

While using any of the pages except Page C (Composition) described later, the user may request 'Help'. This command clears the screen temporarily and lists operating instructions which should solve the user's problem. The page currently in hand is restored when the help page is no longer needed.

The musician selects the page required—perhaps Page 2—to load a voice or an 'instrument' (an instrument is a generic name for a set of keyboard controls). The musician may then start to work with these. Page 2 is also the page that allows the storage of new voices or instruments to take place and the transfer of information, e.g. from one disc to another. It is the disc control page.

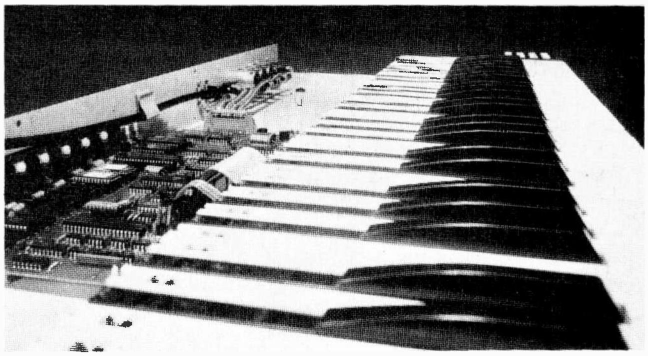
At any time during the user's work on a voice, a sequence or during the creation of a sound, the user may call up any of the pages necessary and issue the next command without the risk of losing any work completed.

Most users I have spoken with say that although the system seems daunting initially, basic understanding arrives after two days of experimentation, and fluency develops after a few weeks. All, however, complain that the operating manual is inadequate and poorly written, although like all aspects of the Fairlight, this is (and will remain) under constant revision.

CONCEPT

The concept of the Fairlight is—as a soft instrument the owner will never have to replace the system, the company has promised that it will never produce a Mark II which makes the Mark I obsolete. Improvements in software will be supplied on disc, and improvements in hardware will be supplied as plug-in cards for the user to fit. Kim Ryrie, Fairlight's Managing Director, estimates that the cost to the Fairlight owner of keeping a system up to date would be 'one thousand dollars a year'.

The keyboard unit in the Fairlight package is itself 'intelligent'. A microprocessor is installed in the keyboard unit and this pre-processes key-strokes and control information. External controls such as pedals may be plugged into this unit and in a performance situation the VDU can be replaced by a 16 button control panel and small alphanumeric display which interfaces with the keyboard. The input commands are simplified using these buttons and long strings of pre-programmed sounds can be accessed in a shorthand form through this separate keypad. This adapts the unwieldy Fairlight package to a format as close to performance requirements as possible.



The master keyboard with its own processor can calculate the velocity of any key depression

OPTIONS

Performance is an area that the Fairlight engineers are currently studying. Plans are afoot to provide the instrument with several new performance aids. Amongst these will be dynamic pitch-bend controls and other analog-type controls. Bob Moog—the father of modern analog synthesis, is working on a new keyboard for the company which will be pressure sensitive. It will be an expensive optional extra. It is also possible that the Fairlight will become the first dedicated music computer to offer input from a guitar-type instrument. At the time of writing a London company working in association with Fairlight, was developing a guitar-type instrument that could replace the musical keyboard. This type of input device would open up the world of the real-time music computer to the millions of guitarists who can't play a note on a keyboard.

The Fairlight CMI is an expensive musical tool. The price at the time of publication was hovering around £18,000 in the UK, plus or minus £3,000 depending on options purchased. This market position is unlikely to change. As micro-power becomes cheaper, Fairlight will opt to improve the package, rather than reduce the price of the existing system.

The eight voice modules installed in a standard Fairlight allow eight-voice polyphony or simultaneous playing of up to eight sounds. Sound can be inserted into the Fairlight's memory banks in several ways. The pre-recorded sounds may be loaded from disc. Most users with whom I have discussed the subject agree that the pre-set sounds are useful at the beginning, but are rapidly replaced by sounds created by the user. Another method of creating a sound for the Fairlight is to sample an external sound—the Fairlight has an input line which will accept signals from a microphone, mixer or any other line carrying sound signals. Inside the hardware an A to D converter changes the sound into digital form which is stored for later use.

The A to D converter in the Fairlight samples sound waves at a rate determined by the user up to a maximum of 32K. In practice the optimum rate will depend on the nature of the sound to be recorded. The duration of sample that the Fairlight is capable of taking is one area where the system has been surpassed by its rivals (although any disadvantage in this fast-moving field is likely to be temporary). The duration depends on the frequency of the sound to be sampled. A bass drum may be sampled for about four seconds, whereas a high harmonic spectrum sound will be sampled for about one second. To overcome the shortage of sample, the waveform is looped so that it may be sustained indefinitely. Some of the pitfalls of this sampling system may be overcome by setting internal high and low-pass filters to narrow the frequency bandwidth that the computer has to sample. The limitation with this system is that some fidelity of reproduction is lost, particularly at high frequencies. The reason for this is logical—the higher the frequency, the more rapid the soundwave and the more information there is to be measured.

COMPARISONS

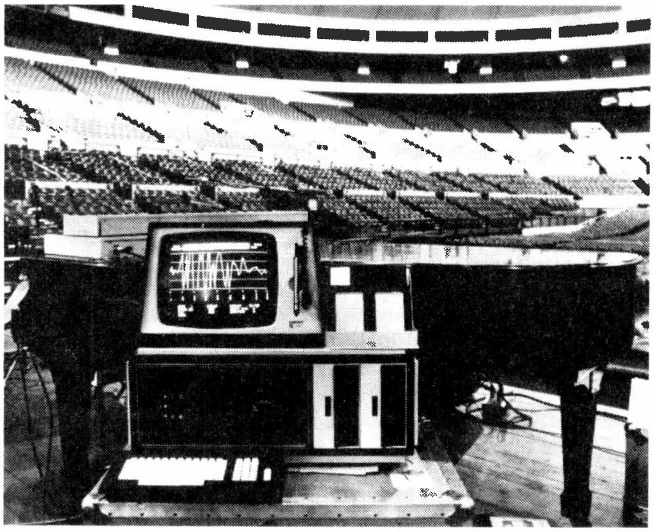
If a middle C from a Steinway grand piano is captured using a high quality microphone and the note is sampled by the Fairlight, the sound may be stored on a disc as a voice. The voice may be recalled (from Page 2), stored in the 16K RAM voice modules and reproduced at will by the user. In raw terms the user may choose the sound to be reproduced at middle C and the 'piano' sound that is reproduced is virtually indistinguishable from the original acoustic instrument. Any alteration to the sound will come from loudspeakers and their enclosures, but remember that if recording is the goal, the acoustic will suffer equally when a recording of it is replayed through loudspeakers.

Without any further modification the user may then play the grand piano sound back at any pitch, using the musical keyboard. In raw terms, the digits representing the timbre and envelope of the middle C remain unchanged, but the digits governing frequency are those of upper C. Thus a sound like a top C is produced but it doesn't sound like a grand piano. The reason is that the envelope and amplitude of the top C on the piano changes as well as the frequency, but the digital store did not have this information.

One answer available is to take several samples from the grand piano keyboard, from top to bottom. The Fairlight has eight voices, each may receive a sample from the grand piano. Now the computer has a store of information from a range of sounds. This store may be organized so that the nearest appropriate sample may be used to generate the piano note required. Thus A above middle C would draw its envelope and amplitude from the sample of C above middle C—its nearest sample source. This is far more accurate, and for some purposes will produce a sound acceptably close to the grand. But in filling up all eight voices with separate samples, the polyphony has been used up and thus the object is defeated.

A better option would be to take the eight samples and then ask the computer to work out what percentage of which sample should be applied to the note called for. Software changes are now becoming available which will compute these changes but the reduction in polyphony still remains directly proportionate to the number of samples taken.

I have deliberately picked the piano as an example as it is one of the few instrument sounds that the Fairlight, and its rivals, find impossible to reproduce accurately. It is important to say that no musician would use a computer to reproduce a piano, it would be far better to use the original instrument. In a survey of users, Fairlight discovered that the single most important feature on the instrument was its ability to capture natural sounds and place them on the music keyboard, the computer's ability to reproduce conventional instrument sounds was rated as a low priority.



Entire musical scores can be fed into the computer via the VDU's alphanumeric keyboard

CPU UPDATE

However, the problem of inaccurate reproduction should be solved when the promised new hardware is available for the Fairlight. This is scheduled to appear towards the end of 1983. Although this new hardware will fit all Fairlights, it is quite a major revision. The central 6800 CPU is to be replaced with the new (but related) 6809 which works internally as a 16-bit processor and offers a RAM of 256K as opposed to the existing 64K. This major jump, accompanied by similar upward leaps in individual voice card RAM capacity, will end most of the limitations now affecting the Fairlight. Sampling rate will go up to around 40K and this will make possible every kind of natural sound sampling. Currently the Fairlight has difficulty sampling long sounds, such as running water, because of limited RAM storage in voice channels. With the new capacity, quite long sounds—six seconds for example—may be captured. The bandwidth will jump from its present low-ceiling cut-off to the point where almost perfect fidelity will be possible. With this combination of new hardware and software the eight voices from the grand piano discussed in our hypothetical example will be stored in just one of the eight voices available. Accurate sound and full polyphony will be the result.

The Fairlight software offers the user absolute control over the musical scale in use—this is accessed from Page 3, Keyboard Control. The default setting that the software specifies is the equal-tempered scale, and a few key strokes alters this scale at the user's will. The grand piano can become perfectly tuned for the first time in its life.

It must be pointed out that although the perfect reproduction of a grand piano or any conventional instrument is a highly useful tool, particularly for recording and composing, to use the Fairlight exclusively for this purpose would be to miss a major advantage.

All sound produced by conventional musical instruments is artificial. The only reasonable definition of musical sound is sound which is pleasing and the Fairlight, and some others in its class, allows the composer and artist to use sounds from our environment in a musical way. Thus a sample of a chain saw, a canary's song or an explosion, may be taken at its naturally-occurring frequency and stored digitally, allowing the mighty-micro control of all its elements.

Much of the music that is now produced with computer aid still 'apes' conventional instruments, but this is changing. The composer is required to shake free from mental prejudice about musical sounds and start experimenting with sound itself all over again.

ABSTRACT COMPOSITION

Experimentation with the essence of sound is at the centre of the philosophy that is behind the design of the third system for entering sound into the Fairlight's memory banks. This system allows the user to create sound by a variety of abstract methods. The best known of these is additive harmonic synthesis which is based on Fourier transforms, which are a series of formulae creating a bridge between the dimensionally complex relationships of frequency and time. The human ear hears sound and the mind notes the frequency, but when stored the time elapsed must also be recorded and stored. The Fourier mathematical principle shows that all repeating waveforms can be resolved into sine-wave components, consisting of a fundamental and a series of harmonics at multiples of the frequency.

In use, additive synthesis allows sounds to be built up one harmonic layer at a time. Arbitrary waveform synthesis is also possible, demanding the maximum from the user, and a system unique to Fairlight allows sounds to be drawn on the screen with a light pen.

This last method of creating abstract synthesis is particularly intriguing. The light pen may be used to draw harmonic envelopes or actual waveforms on the VDU—from Page 4 (Harmonic Envelopes). The light pen is also able to adjust index information on the screen and a total of 128 waveforms may be created and loaded in the waveform memory of each voice module.

When shaping harmonic envelopes with the light pen, up to eight may be shown at a time, the fundamental harmonic being shown in bold, although recent software revisions allow the 'energy' and 'duration' profiles to be displayed bringing the total envelopes that may be shown on the screen at one time up to 34. The desired harmonic number is selected by the light pen and the pen may then be used to modify an existing envelope or draw a new one.

An alternative method of abstract sound creation is offered from Page 5, Waveform Generation. Here the musician is presented with a graphic representation of 32 'faders' such as might be found on a mixing desk. These faders each represent a harmonic in a sound. A light point on each represents the level of volume in each harmonic. This level may be altered by the light pen or by using the alphanumeric keyboard. A voice must be either loaded from disc or newly created before this page can operate. On 'start-up' this page displays the appropriate amplitude plot of the voice held in RAM. This voice may be modified as described and then saved.

Page 6, Waveform Drawing, allows sound to be created by drawing waveforms. As might be expected, sounds are saved via the control page, Page 2. With this facility, waveforms are put directly into waveform memory by drawing waveshapes on the screen. A plot function ensures the light pen is followed no matter how complex the route, and 'Join' allows the user to input dots at various stages on the wave, the Fairlight computes the gaps and joins them up. The main advantage this method has over methods such as additive synthesis is that the harmonics involved are automatically computed as the wave shape changes. Joining up separate wave shapes is also made easy, with the Fairlight guessing the correct bridging shapes under the 'Merge' function.

Page 7, the control page, is loaded whenever a voice is loaded into RAM. This page allows the musician to specify the limits of such events as sustain, level, filters, attack and vibrato depth etc—the sort of controls found for voice-shaping on an analog synth. A new software modification will marry this page into individual voice files.

Sound samping is controlled from Page 8 and the sequencer section of the Fairlight is accessed from Page 9. The sequencer is programmed by playing the music keyboard in real-time. Key velocity information and foot pedal movements etc are automatically recorded. Sequence lengths are limited by the space available on the disc—an empty disc will store about 50,000 notes. Discs are the subject of much research in Sydney—the hard disc, an advanced version of the floppy disc, allows huge amounts of information to be stored and retrieved rapidly, typically two or three million bytes against 500,000 on a standard 8 in. floppy—but the systems are too fragile for road use and Fairlight's declared policy of making the Fairlight 'performance proof' currently excludes their great storage power.

Up to eight separate parts may be overdubbed, each having its own voice. Page 9 requires control decisions such as a name for the sequence and speed for playback. A sequence is recorded by using the light-pen to select 'record'; the part is then played. To play back the sequence, the musician uses the light pen to select 'replay'. The speed of replay must also be selected. Parts using the same voice may be merged and all settings may be stored on disc along with the sequence.

Page L is the Disc Library. This allows the updating of a list of files, voices, control, instrument files, etc. Whenever a new voice or other file is saved it can be added to the library list.

LANGUAGE

Page C loads the Music Composition Language that Fairlight have developed to aid composers and provide musicians who cannot play keyboards with a way to play their compositions on the Fairlight. It is also true that someone who cannot play 'any' musical instrument but who understands the theory of music can compose and play with this system. This software opens up the world of music to those with imagination and a little theoretical knowledge but who have not mastered the discipline of a musical instrument—singers for example. This is likely to prove a very exciting development. The Fairlight survey also revealed that 70% of users who 'can' play a keyboard still choose to use MCL for some purposes.

John Lewis, a London film-music and jingle writer, at his Fairlight CMI

Fairlight describe MCL as being a tree-structured language operating on several levels of hierarchy. Top of the tree is the 'Piece', followed by the 'Part' and finally the 'Sequence'. These are all terms musicians are familiar with and throughout MCL, musical language is adopted wherever possible.

A piece consists of up to eight parts to be played simultaneously and each part consists of up to 32 sequences which are played sequentially—although a larger number of sequences may be written and the overflow stored on disc. Fairlight suggest the analogy of parts representing independent musicians, each playing their own instruments through written sequences. Each part is independent although capable of playing at the same time.

Continuing Fairlight's imagery; the piece is the conductor, instructing each part when to come in. The system has the power to allow chords inside each individual part, and each part may be played by a different voice. Each sequence may be between 1 and 2,000 notes long and individual sequences may be used by individual parts independently.

To the question 'what's the longest piece of music I can compose and have played back at one time?' Fairlight respond, 'that depends'. The final answer is that it is adequate for most purposes. Certainly piece lengths of 30 minutes or an hour usually present no problem.

In use, the composer has to write a program for his music. It is this hurdle that some manufacturers believe musicians are unwilling to try. Substantial sales of the Fairlight over the last few years indicate that some musicians are prepared to learn a simple programming language, but Fairlight also think that this requirement is a barrier to expression for some users and have just produced a software revision which adds a new option to the system 'page R', described later.

It takes a little time to learn the Music Composition Language and like any learning task in life, success depends upon motivation. The motivation appears to be intense when absolute control over music is the goal.

The MCL program includes a 'debugger', a self-diagnostic device that tells the user if any errors have occurred during the writing of the program. Writing programs can be tedious and it is all too easy to misspell a command. The usual result is that the program execution stops, or 'hiccups' over the command. In the MCL program, the software locates the line written incorrectly and prints it on the screen for the user to amend.

WRITING MUSIC

To write a piece of music into the Fairlight the composer opens a 'piece file' (top of the tree) and specifies how many parts there will be: part A, part B, etc. The composer then opens one of the 'Part Files'—Part A for example—and specifies how and what the sequences will play: sequence One will play keyboard area number One and sequences Two and Three will play keyboard areas number Two and Three etc.

The composer then opens the first sequence file. It is here the user starts to write musical notation. Although the sequence of events calls for a specification of numbers of parts and sequence allocation before getting down to writing the dots, these decisions may be altered endlessly during composition.

Typically a composer might always start by deciding to write four parts, each of four sequences and all sequences to play on one keyboard. That might be considered the composer's 'default' setting. Only as the part progresses might the composer decide to add more parts or to change around the allocation of sequences to different voices. The composer can go back and do this at any stage.

Working with a computer means endless decision making and the first notation decisions the Fairlight composer has to make are as follows—BEAT: this is the number of sub-divisions within each time unit. Setting a value of 16, means each beat has a sub-division of 16 available. The GAP specifies the time between the end of the current note and the start of the next note and it is calculated in beat units. OCTAVE specifies in which keyboard octave the note falls. TRANSPOSITION adds an offset to the note requested; e.g. a note which is a specified number of keys up or down is played instead of the original note.

VELOCITY specifies the key velocity used when playing the note and the data is used exactly as if it had come from an actual keystroke on the musical keyboard. KEY SELECTION allows the key to be set, i.e. amount of sharps, flats and naturals. Most of these control options have default values and the composer will be able to settle for these on many occasions.

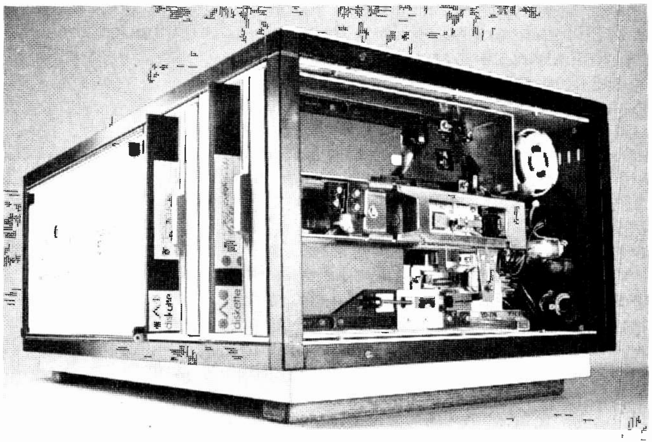
Once these parameters are established the entering of the notation may begin. Each note may be fully specified by Pitch, Velocity, Time and Gap. For Pitch the name of the note is typed in: A, D or F for example. Any accidentals may precede it, overriding the key signature set up in the sequence specification.

Each individual note may have its own velocity specified and each note will have its time expressed in the number of beats. The gap, between the conceptual 'key release' and the start of the next note, will also be set. In practice the pitch of the note must always be set, in other instances the controls for Time, Velocity and Gap may be default settings taken from the information entered when the sequence controls were specified. Rests may be entered by an 'R'. Notes to be played together as chords are grouped in brackets.

In this way, and with quite a few other control specifications, music may be entered. The procedure becomes rapid with practice and several composers insist it is a very efficient way of writing music.

PROGRAMMING MADE EASY

Fairlight have produced Page R so that musicians may compose on the Fairlight without having to learn MCL. Kim Ryrie describes this system as 'working rather like a Linn drum machine, but with the ability to add melody and expression' and the system allows the composer to build bars which constantly repeat. The composer can play notes in real-time which are read by the Fairlight and appear as notation on the screen. Adding another few bars builds up a sequence. Instruments may then be added to that polyphonically. Each pattern created can be linked together and the Fairlight user has up to 250 patterns to link together. Any eight patterns can be linked together to form up to 26 sections (labelled from A to Z). Patterns and sections can be mixed during linking to create a complete piece.



The all-important high quality disc unit

Software is being developed to make Page R and Page 9 (the real-time sequencers) act as real-time input sources for MCL. The music created through these pages in real-time will write itself as MCL in the Fairlight memory. For editing the musician can then refer to the MCL read-out and edit through this language—a precise and easy-to-use system. With the new high-level language that has been created in these software updates, Fairlight have overcome the requirement for the musician to learn programming techniques. As microprocessor memory capacity increases, so the demands made upon the musician's non-musical abilities will further diminish.

The ultimate goal for the Fairlight team is to develop the CMI so that it is totally software based. Such a system would have an analog-to-digital converter at one end, a massive amount of RAM and some super-high-speed processors in the middle and a few A to D converters at the output end. This system will arrive within a few years. Once this happens, hardware development is effectively at an end and the software teams will then have no limit to the programs they can write.

With its ability to 'listen' to the sounds of the outside world and then place them under the musician's control, the Fairlight represents the current 'state of the art' in commercial computer musical instruments. ★

Ray Hammond has recently completed a book which takes an in-depth look at music electronics, entitled 'The Musician and the Micro'. It is published by Blandford Press at £4.95 (paperback).