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EMT FRANZ GMBH

# EMT 251

## Digital Reverberation System

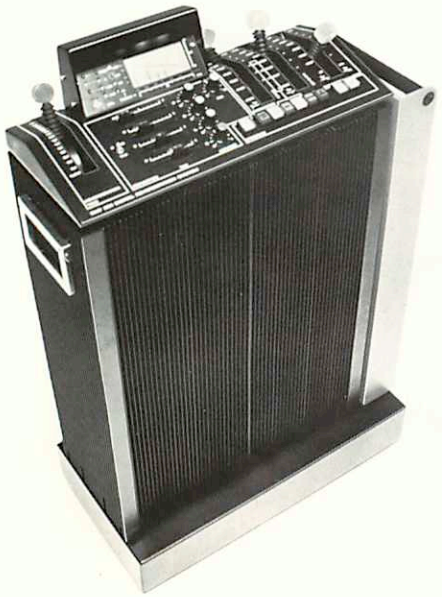
**Microprocessor controlled with graphic display of reverberation parameters**

**Five years have passed since EMT introduced the EMT 250 Electronic Reverberator Unit, the first and, for a long time, only unit of its kind in the world. Since then, many new developments have been made in the field of semiconductor technology, particularly in Large Scale Integration. It has therefore become appropriate to replace the discrete processor of the EMT 250 with an integrated configuration. The advantages: more natural reverberation with nine adjustable discrete reflections and a full audio bandwidth, as well as new sound effect programs by higher clock frequency and larger memory capacity.**

# EMT 251

# Digital Reverberation System

## Microprocessor controlled with graphic display of reverberation parameters



Although modern microprocessors afford high-capacity performance, their operating speed is about ten times too slow for audio signal processing. A single microprocessor is therefore not capable of satisfying the requirements placed on a reverberation unit.

A solution to the problem is provided by a program architecture based on the use of a number of microprocessors. Computations which would be conducted serially by a single microprocessor in slow control applications are distributed here among a group of processors. This technique results in a system which not only is faster than its predecessor but also enables more versatile programs to be included. It also has been possible to raise the sampling frequency, significantly increasing the transmission bandwidth. New, highly integrated components allow the use of a 16 bit digital language for the analog/digital conversion processes in both directions. A substantial improvement in the signal-to-noise ratio is thereby achieved.

The result of these developments is a digital reverberation unit with technical specifications which greatly exceed those of its predecessor, and with an expanded reverberation program.

### Block Diagram

The unit executes all programs according to the block diagram of Fig. 1.

The audio input is balanced and exhibits conventional studio characteristics. Following the input stage, a low-pass filter prevents frequency products from forming between components of the input signal and the sampling fre-

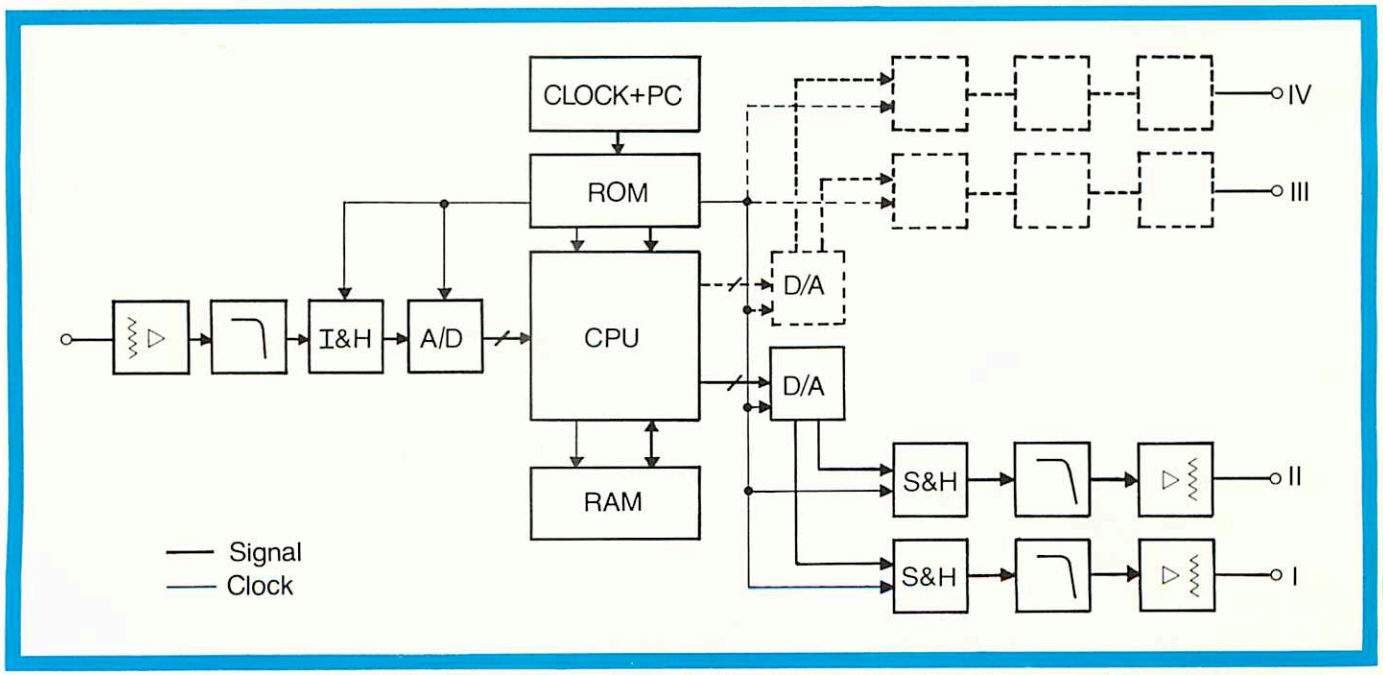



**Fig. 1 Block diagram of the EMT 251 Digital Reverberation System**

quency. An integrate-and-hold circuit and the analog/digital converter are arranged after the filter. According to the sampling theorem, the sampling frequency must be at least twice as high as the highest frequency to be transmitted. In the EMT 251, therefore, a frequency of 32.75 kHz is employed. The program signal, now converted into a uniform 16 bit code, is routed to the processor itself.

The type and sequence of operations is determined by the Read Only Memory (ROM). Intermediate results are stored in a Random Access Memory (RAM). The processor is followed by a digital/analog converter, from which two non-correlated signals appear. These are conducted through sample-and-hold circuits and low-pass filters to the line output amplifiers. The four-channel version, available as an option, contains a second D/A converter with corresponding sample-and-hold circuits, low-pass filters, and output amplifiers.

## Data Integrity

Data integrity and error recognition are achieved in the EMT 251 using so-called CCRC's (Cyclic Redundant Check Codes). Check bits are added to data blocks of a certain length, enabling errors to be recognized and corrected. The effectiveness of the data-checking procedure is expressed by the Hamming distance. (The concept of Hamming distance is explained in the "EMT Courier" No. 32, May 1977, page 5.) A Hamming distance of 4 has been realized in the EMT 251 Digital Reverberation System; that is, any single bit error within a data block can be located and corrected. If two errors occur, they will be signaled but not corrected.

An error signal is indicated by an LED on the operating panel.

The error-detection capability also allows the localization of an error and thus the indication of defective chips in the RAM memory. Replacement of a defective chip eliminates the source of recurrent errors.

## The Reverberation Program

The total storage time of the EMT 251 Digital Reverberation System has been increased to allow the production of a number of discrete reflections with a combined length of up to 120 ms in addition to the pure reverberation. Three of the reflections may be individually adjusted for time and amplitude. One each is assigned to the right and left channels, while the third can be routed to either channel through a panorama potentiometer. The delay times are selected with individual linear potentiometers, the amplitudes with rotary controls.

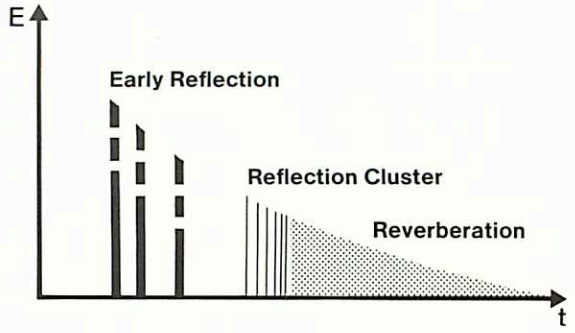



**Fig. 2**
**Distribution of reflections as a function of time with the EMT 251**

A fourth linear potentiometer controls the delay of a group of reflections with fixed relationships to one another, known as a reflection cluster, and determines the initiation of the reverberation program in time. The cluster consists of six individual reflections with decaying amplitude and fixed temporal relationships that determine the transition of discrete reflections to reverberation. The corresponding amplitude control potentiometer determines the proportion of direct to reverberative sound at the beginning of reverberation, thereby establishing the reverberation. radius. This capability thus enables the control of an essential recording parameter which previously had remained fixed.

A time diagram can be produced for the entirety of reflection amplitudes that very nearly approximates the conditions encountered in natural rooms.

The reverberation time itself can be adjusted between 0.4 and 4.5 seconds. In addition, the magnitude of the reverberation time can be varied over a wide range as a function of frequency, expressed as a factor of the basic reverberation time:

for bass frequencies (300 Hz), a factor of 0.5 to 2;

for midrange frequencies (4 kHz), a factor of 0.2 to 0.85;

for treble frequencies (8 kHz), a factor of 0 to 0.85.


**Fig. 3**
**The selected frequency response of the reverberation time and the amplitude/time distribution of the first reflections are identifiable at a glance on the display of the EMT 251.**

## Display

An additional new feature is the comprehensive indication of all selected parameters on a liquid crystal display.

The frequency response of the reverberation time as well as the amplitude-time distributions of the first reflections are indicated simultaneously by two curves. The user can therefore inform himself of the selected values at a glance.

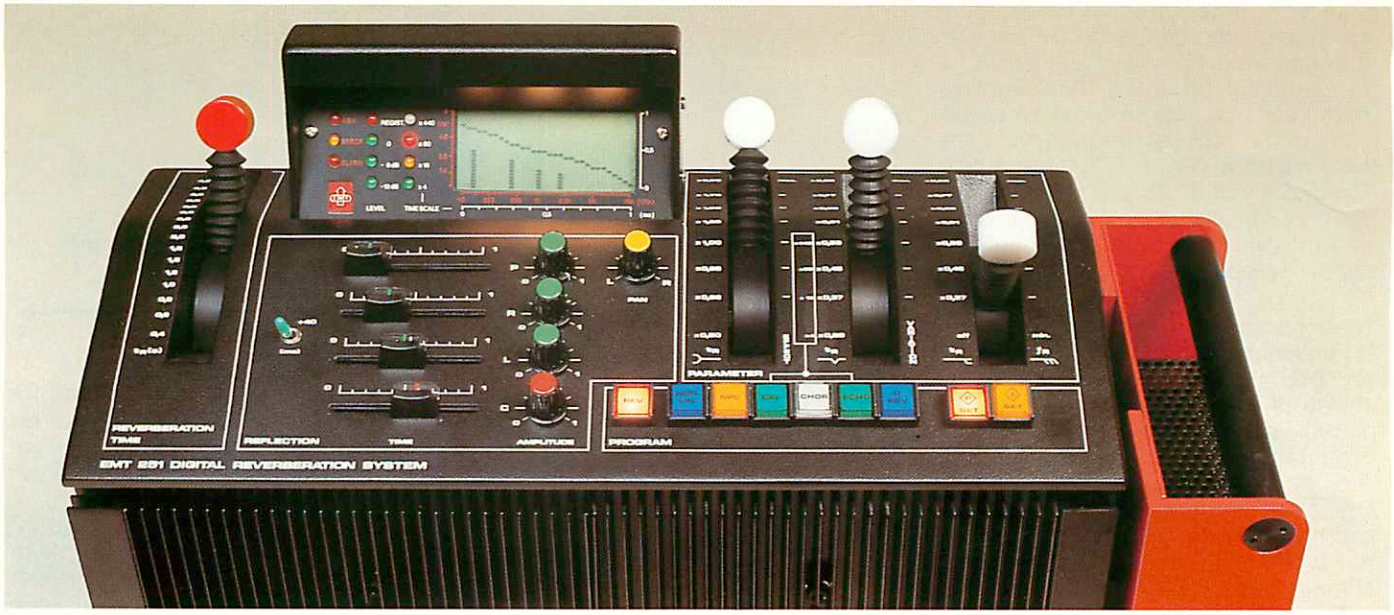



Fig. 4 The control panel of the EMT 251

## Special Programs

In addition to the reverberation program itself, the EMT 251 is provided with a considerable number of special programs for the production of particular effects.

## Chorus

This program produces a multiplicity of voices or instruments. The effect is based on the recognition that the impression of a large sound source is partially due to individual sound signals with different propagation times. Even when all the musicians of Fig. 5 play at the same time with the microphone placement shown, the sound waves from their instruments reach the microphone at different moments because of the various distances necessary in positioning the musicians. In addition, small relative differences occur in pitch and beat. These effects, together with natural differences in propagation times, produce the impression of a large sound source. The block diagram of Fig. 6 depicts the electronic simulation of these processes in the Chorus program. The signal is conducted through four delay circuits with the various delay times $t_1 ... t_4$, which are continuously altered by four random signal generators $k_1 ... k_4$. The subsequent level controls $A_1 ... A_4$ allow the delayed signal to be mixed in such a way that the levels fall with increasing delay time.

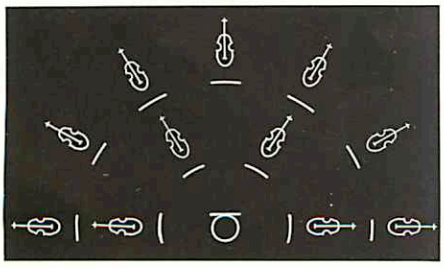


Fig. 5
**The individual sound sources lie at different distances from the microphone, resulting in different propagation times.**

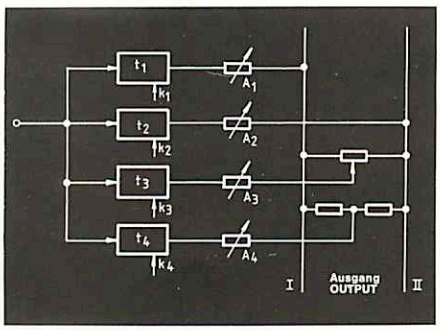



Fig. 6
**Block diagram of the Chorus program**

The provision of the required level controls represents a significant advantage over the EMT 250 predecessor. With that unit, it was necessary to occupy four inputs of the mixing console to realize the same control function.

## Non-Lin

If an acoustical event is repeated within a very certain range of time, the ear does not detect the repitition but rather perceives an increase in loudness because of the increased energy content. This effect is preferred for compressing audio signals. In driving power amplifiers and radio transmitters, however, it also affords the advantage of increasing the volume without raising the required power. Previously, the necessary signal delay was accomplished with a fixed propagation time. This method, known as Automated Double Tracking (ADT), has the disadvantage that the processed audio signal sounds somewhat unnatural. The Non-Lin program of the EMT 251 avoids this difficulty by employing statistically distributed delay times, i.e., reverberation. By combining two reverberation processes, the reverberation is barely diminished over an interval of 0.5 seconds; afterwards, it decays rapidly. In this manner, the impression of excessive and thus disturbing reverberation is prevented.

## Delay Program

The original signal appears at both outputs with as many as nine separate delay times. Three of the delayed signals may be individually controlled for time and amplitude and are assigned to the left or right channel or to the pan pot for stereo positioning. The remaining delayed signals comprise the cluster which is also used in the reverberation program.

The maximum delay time is 480 ms: the amplitudes may be varied between 0 and 100 %.

## Doppler-Reverb

With this program, the pitch of the perceived reverberation signal can be appreciably changed. An illusion is thereby created that the reverberated sound is moving within the room. The impression of shifting images is produced by utilizing the Doppler effect.

## Space

This sound effects program affords a reverberation time of maximally 18 seconds. The high-frequency control may be used to alter the frequency response and coloration. Such long reverberation times do not occur in our natural environment, and since the program is often used for science fiction productions, it has been named "Space".

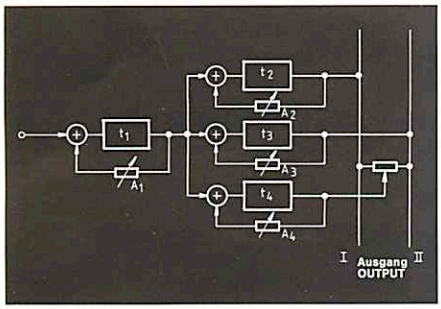



**Fig. 7 Block diagram of the Echo program**

## Echo

The Echo program is implemented by loops which are variable in time between 0 and 440 ms and are adjustable for 0 to 60 dB attenuation per reflection. A main loop is followed by three auxiliary loops, thus enabling different effects to be selected for each of the two channels.

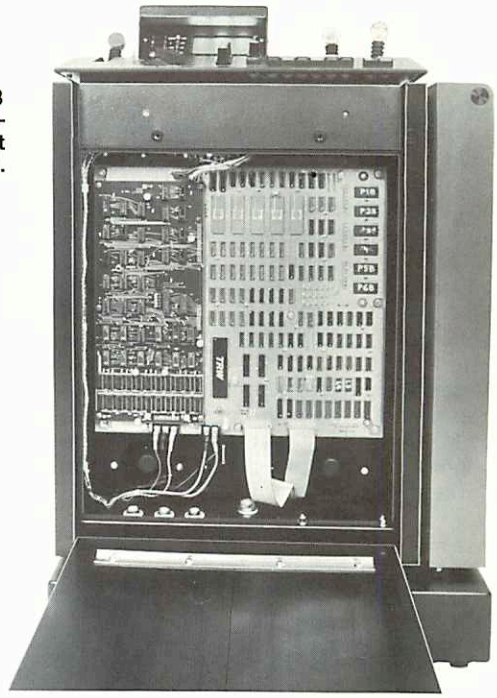


**Fig. 8**
**The digital board is located behind the front panel of the unit.**

## Constructional Details

The appearance differs little from that of the predecessor. The form of a free-standing unit with switching levers has proven to be extremely practical, as has the arrangement of system components (Fig. 8). The power supply is located in a chassis at the bottom of the unit and is shielded to prevent disturbances of the sensitive electronics. The analog and digital sections are mounted in the center of the unit and separated from each other by an internal partition. Both side panels may be opened, affording good accessiblity to all components (Fig. 8 and 9). The external panels are made of black anodized aluminum for dissipating heat from the interior of the unit. On the narrow right-hand side, the heat sink for the control circuitry is located together with the operating controls. The EMT 251 Digital Reverberation System is provided with a mains filter and with filters at the audio inputs and outputs – as are all new digital units from EMT.

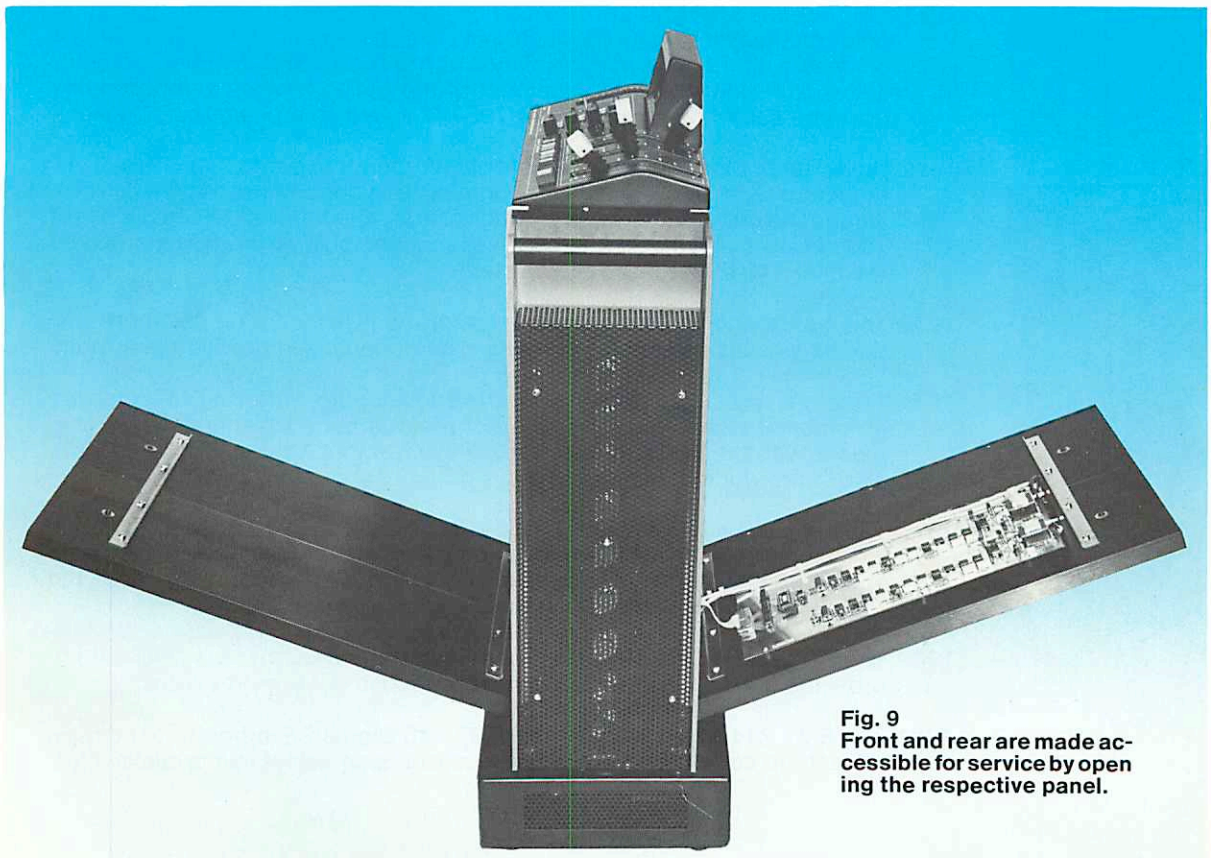


**Fig. 9**
**Front and rear are made accessible for service by opening the respective panel.**

## Remote Control and Remote Indication

All programs and the reverberation parameters of the unit are not only selectable by remote control, but they can also be stored as preset values in a potentiometer array. In this manner, optimum adjustments for a particular application can be recalled by push-button. The DISPLAY lines also appear on a multiple connector, allowing an additional indicator to be located anywhere in the control room. The selected parameters can be stored in a computer or recorded on tape through a dc interface. The unit can then be controlled from the computer or tape during mixdown.

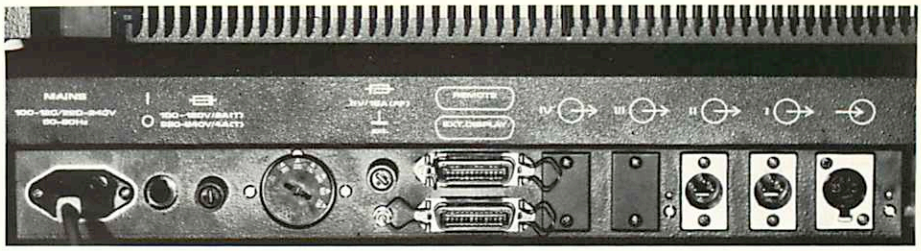


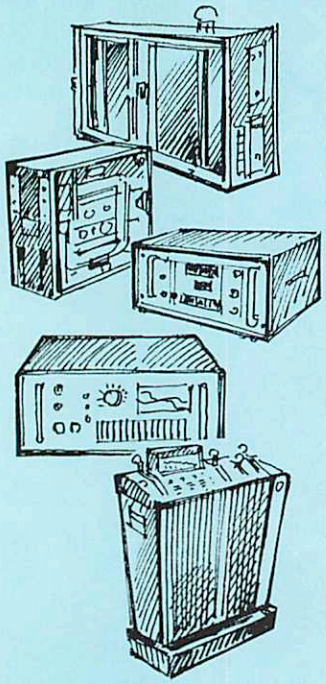
**Fig. 10 The connector board of the EMT 251 with remote control and remote display**

**Literature**


**(1) Bellis, F.A., "A Stereo Digital Sound Recorder"; BBC Research Development Report PH-97, 1972.**

**(2) Nakajima, H., and T. Dol, Y. Tsuchiya, A. Iga, "A New PCM Audio System as an Adapter of Video Tape Recorders"; Preprint 1352 (E-11), 60th AES Convention, 1978, Los Angeles.**


# A Brief Chronicle of EMT Artificial Reverberation



Before the development of reverberation units, it was possible to obtain additional reverberation only by using an appropriate chamber.

1957 EMT introduced the EMT 140 Reverberation Unit, which was developed in close cooperation with Dr. W. Kuhl and the Institute for Radio Technology (IRT) in Hamburg. The unit employed a steel plate 2 $m^2$ in area and 0.5 mm thick on which bending waves were produced by a dynamic transducer. This was to remain the only reverberation unit of studio quality in the world for the next ten years.

1961 The EMT 140 Reverberation Unit was equipped with two microphone systems, enabling two largely uncorrelated signals to be obtained. The reverberation became stereophonic.

1971 EMT delivered the EMT 240 Reverb Foil. The surface of the vibrating 0.02 mm gold foil measured only 30 × 30 cm. The foil was contained in a double enclosure affording very high isolation from airborne and solid-borne disturbances, sufficient to allow placement of the EMT 240 even in mobile units or – at a sound pressure level of 105 dB – next to monitor loudspeakers.

1972 Digital technology entered the field of reverberation production. Previously, magnetic tape loops which were unreliable in continuous duty had represented the only way to produce artificial first reflections between the direct sound waves and reverberation. This function could now be discharged by the EMT 440 Electronic Delay System.

1973 The quadrophonic EMT 140 Q Reverberation Unit with four pickup transducers was introduced for creating a homogenous impression of a room.

1975 After four years of computer-supported development efforts, EMT achieved an ambitious goal: the production of reverberation by entirely electronic means with the EMT 250 Electronic Reverberation Unit, the first unit of its kind in the world.

1978 The EMT 440 was followed by the EMT 444 Electronic Audio Delay System, which featured a greater dynamic range and longer delay time. In the same year, a smaller and simplified version of the EMT 250 was first produced, the EMT 244 Digital Reverberation Unit.

1980 The EMT 251 Digital Reverberation System represented a significant improvement over the EMT 250. It is described in detail in this issue.

1981 The EMT 244 is replaced by the EMT 245 Digital Reverberator. The main advantage compared with its predecessor is an adjustable predelay time.

**Disc-type audio storage units afford the advantage of rapid access times, regardless of the method of recording. When an appropriate data drive system is employed as the storage device, access times are reduced to inaudibly small values, enabling electronic editing to be accomplished with a single unit.**

# The EMT 450 Digiphon Records Audio Signals on Digital Storage Disc Units

**Fig. 1**
**The prototype of the EMT 450 Digiphon consists of three component units. At the right, the CDC Disc Drive; to the left, the computer. The control unit is shown on page 4.**

The recording of audio signals onto magnetic tape by digital means has been treated extensively in the literature (1) (2). Considerably improved signal-to-noise ratios, better channel separation, and negligible wow and flutter are achieved in comparison with conventional methods of storage. The quality of reproduction is determined almost entirely by the level of complexity characterizing the analog/digital conversion process. As soon as the signal exists in digital form, it can be processed indefinitely without a loss in tonal quality. This property is of particular value in contemporary studio practice, in which multi-track recordings are redubbed many times during the mixdown process for creating a two-channel signal for record cutting or stereo broadcasting.

EMT has gone a step farther in the development of the EMT 450 Digiphon by employing a disc storage unit rather than a tape recorder for information storage. This method affords additional advantages for particular professional applications. The extremely rapid access time of 50 milliseconds to any desired point in the recorded material is of particular significance. This capability predestines the unit for applications in which sound and word inserts are required, such as for special effects in theatrical productions and for station identification melodies in radio and television.

The unit is also suited as a sound effects generator. A further advantage of disc storage is realized in this application: it is possible to form automatic loops in which departure from the end of a sound sequence is followed by a return to the beginning of the sound. Continuous effects may thus be produced from short sequences.

The audio information is recorded by the EMT 450 Digiphon using a standard computer disc storage unit. The CDC BK 6 XX Disc Drive employed in the system utilizes a stack of eleven 14" magnetic discs, which rotate at 3600 rpm and afford a storage capacity of 300 million bytes. With the 16 bit linear code selected for the digital language and a sampling frequency of 32 kHz, a dynamic range of 80 dB and an upper transmission frequency of 15 kHz have been attained.

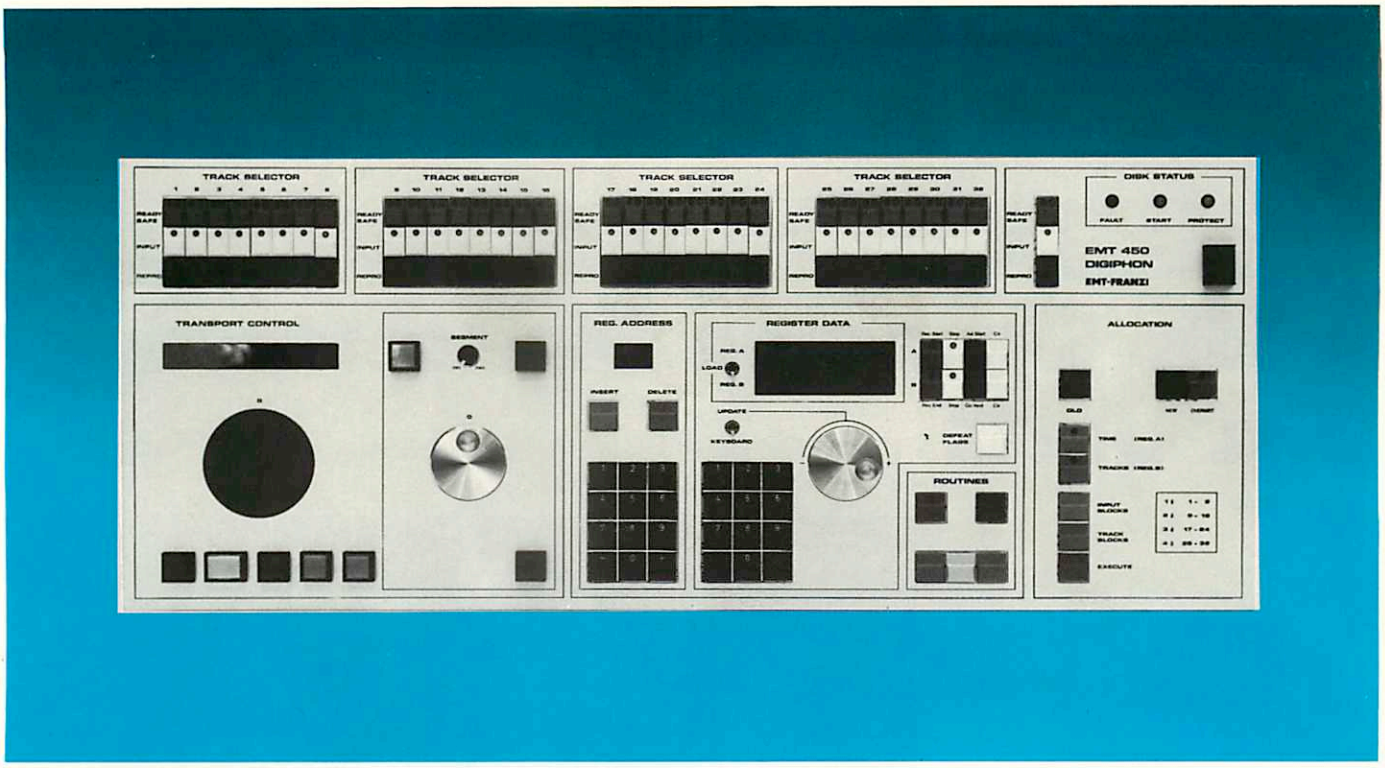



**Fig. 2 Control unit of the EMT 450 Digiphon**

The digital resolution and the sampling frequency determine the possible recording time for a given storage capacity. When the redundant check bits necessary for data integrity are included, a recording time of 35 minutes for stereo or 70 minutes for mono is possible with the EMT 450 Digiphon.

Located in a separate cabinet, the high speed computer converts the stereo program signal into a code suitable for digital processing. A very important prerequisite for developing this subsystem was the extensive experience gathered by EMT in digital processing of audio signals.

The third component of the first prototype is the control unit. The operating controls of the Digiphon are similar to those of a conventional analog tape recorder. The usual buttons for recording and playback as well as for fast transport in either direction are provided. A time display fulfills the same function as the tape counter of reel-to-reel machines, enabling the location of any point in the recorded material. An autolocator capability is also provided for predetermination of initially ten return or departure points that can be selected by pushbutton. Reproduction of the corresponding recorded sequences then proceeds after, of course, the access time of 50 ms, but without any special search interval.

**Fig. 3**
**The disc stack of the CDC BK 6XX contains eleven discs with a diameter of 14" (35.6 cm). Concentric tracks are located on the upper surface of each disc, over which the magnetic heads glide without contact or friction on a cushion of air.**



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