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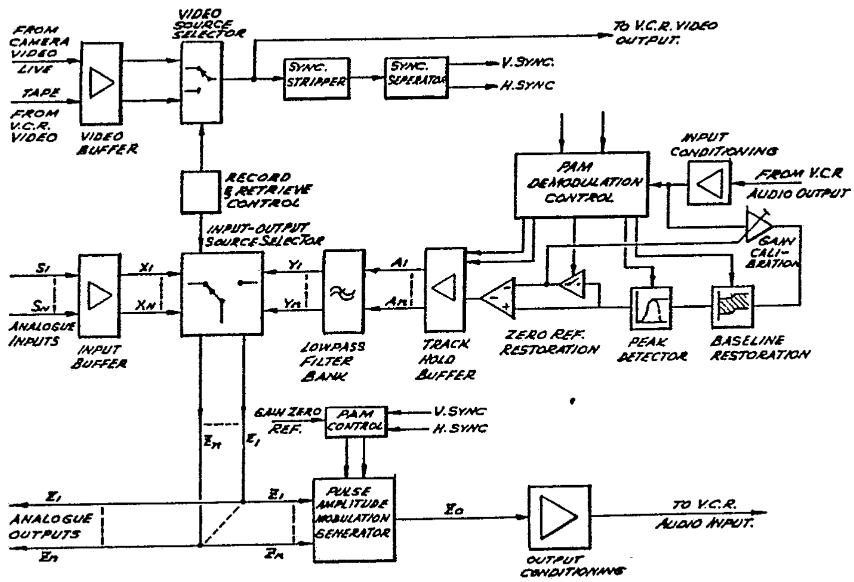

(57) Abstract

A method and apparatus for recording/playback of low frequency analogue data signals together with a video signal on a single video recording medium, for example a video tape. The low frequency analogue signals are formatted into a single high frequency signal compatible with the bandwidth and dynamic range of the audio track of said medium and recorded synchronously with said video signal. An audio signal may also be recorded. On playback the data signals and video signal may be displayed simultaneously on single display means.

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TITLE: SYNCHRONOUS, MULTIPLE CHANNEL ANALOGUE AND AUDIO-VISUAL RECORD AND PLAYBACK UNIT

TECHNICAL FIELD

This invention relates to a method and means by which electronic and mechanical components are combined in order to acquire and format low frequency analogue data signals, in conjunction with associated video and audio signals, in such a way as to permit the simultaneous and synchronous recording of both analogue and audio-visual signals on a single video tape. Likewise, the specification describes the means and method for reconstructing, with acceptable accuracy, the original analogue data signals from a previously formatted video tape without loss of synchronism with the audio-visual information.

BACKGROUND OF THE INVENTION

Over the years, many facets of science have required the simultaneous recording of a number of electronic signals derived from a myriad of transducers and sensors. Traditionally, these signals have been recorded on various forms of paper printout, thereby permitting the 'capture' of the signals for later study.

With the introduction of multi-channel magnetic tape recorders, the signals of interest were recorded on magnetic tape of varying width, length, and density. This gave the scientist the ability to replay the recorded signals any number of times and, thereby, enable more effective study of the information contained within the signals.

Often, the electronic signals of interest convey only part of the total information available to the scientist. There are a large number of situations where the visual and/or audible attributes of the item under observation are of crucial importance to the interpretation of the information contained in the electronic signals being recorded. It is, therefore, desirable in these instances to be able to record both audio-visual and electronic signals simultaneously, and synchronously.

Until recently, audio-visual and analogue data were recorded separately on different media. For example, the advent of the video tape recorder (VTR) enabled a convenient means of recording the audio-visual information, while the analogue data was still recorded on either paper or multi channel reel-to-reel tape recorders.

The use of the VTR in conjunction with the standard analogue recording apparatus provides useful advantages over the previous methods. However, the inconvenience and clumsiness of separate recording media produce a number of drawbacks when trying to analyse the information 'off-line'.

For off-line analysis of the recorded information, all elements of the data must remain stable relevant to each other. That is, synchronisation must be maintained. This is extremely difficult and cumbersome with separate recording media. The problems of archiving, editing, and handling separate media also make this form of recording less attractive.

In order to solve the problems associated with separate recording media, engineers devised ways of recording both audio-visual and analogue data on a single medium. The most convenient medium is that of video tape because it accommodates both wide bandwidth and dynamic range. Various means, either the audio or video tracks, or a combination of these, were used to hold the analogue data, together with a video image and sound track.

SUMMARY OF THE INVENTION

The invention, in one aspect, relates to a new and improved method and means by which better synchronisation and more analogue information, by way of improved dynamic range, bandwidth, and increased number of channels, can be accommodated on a single video recording medium, for example a video tape.

The method according to a first aspect of the invention takes advantage of the higher bandwidth available on the audio tracks of an HiFi Video Cassette Recorder (HiFi-VCR), and the fact that the video sync pulses read from the tape can be used to eliminate the effects of timebase error generated by tape stretch and cueing inaccuracies.

According to the first aspect, the present invention provides a method of recording a plurality of analogue signals, together with a video or audio visual signal, on a single video recording medium comprising the steps of

a. reducing a plurality of low frequency analogue input signals, together with a reference signal, to a single high frequency signal compatible with the bandwidth and dynamic range of the audio tracks of the video recording medium,

b. recording said high frequency signal on one or both of the audio tracks of said video recording medium in synchronism with a video image signal being recorded on the video track of said video recording medium.

If an audio signal is also required to be recorded the spare audio track may be used.

According to a second aspect, the invention provides a method of reconstructing a plurality of analogue signals and a video or audio-visual signal recorded on a single video recording medium in accordance with the abovementioned method comprising the steps of

a. replaying the recorded video medium to recover the high frequency signal, the video signal or audio-visual signal,

b. processing said high frequency signal to reconstruct said plurality of low frequency analogue input signals.

The invention also provides apparatus comprising means for performing the functional steps of the above methods.

The method utilises basic electronic building blocks in order to reduce multi-channel low frequency analogue input signals to a single high frequency signal compatible with the bandwidth and dynamic range of the video recording medium audio tracks.

For preference a number of analogue signals of designated bandwidth are formatted together to produce a train of pulses of fixed duty cycle and modulated amplitude. This fixed duty cycle, Pulse Amplitude Modulated (PAM) waveform is preferably generated by triggering the pulse formation with the horizontal sync (HSYNC) signal from the associated composite video signal. In this way, pulse position and pulse amplitude define any given channel, whilst maintaining synchronisation with the video image.

Having formatted the input signals into a PAM waveform, the PAM signal is recorded on one or both of the audio tracks of an HiFi-VCR, while the video image is recorded on the video track.

During playback of the recorded video medium, the formatted 'audio' signal from the audio track(s) is fed to the decoder section of the record/playback unit where it is 'broken' into its component parts and distributed, in appropriate order, to the output conditioning circuitry, and, finally, to the outputs of the unit.

In the playback (reconstruction) phase, the data pulse train itself is used to generate synchronous clocking signals so as to correctly and accurately locate and retrieve each channel's signal information. The said clocking signals are used to trigger baseline restoration, and peak detection circuitry used to capture the data required to reconstruct the original signal for each channel. Reconstruction of the reference signal encoded along with the channel signals enables accurate recalibration of each channel's analogue data. Further steering circuitry, also synchronised by the self generating clocking signals, enables distribution of the signal data to the appropriate output channel.

Each output channel comprises fundamental track-and-hold and filtering circuits in order to provide accurate signal reconstruction in accordance with the Nyquist sampling theory.

In order to provide accurate reproduction of the original signals from either first, second or later generations of the original recorded data, the output of the reconstruction circuitry is re-routed (during playback) through to the input of the PAM waveform generator (in place of the 'live' inputs). Hence, edited copies of the original video medium can be made using freshly formatted 'audio' signals, thereby eliminating contamination of the analogue signals by timebase errors induced by the video recording/playback apparatus.

According to a third aspect, the invention relates to a method and means by which electronic and mechanical components are combined in order to acquire and format a plurality of channels of biological electrical activity from a subject at a remote distance from the main recording and analysis hardware.

In the Neurological and Neurophysiological fields of medicine there is an ongoing need to study the electrical activity of the brain and the central nervous system.

Brain activity has traditionally been monitored and recorded using a specially adapted multi-channel paper chart recorder, referred to as an EEG machine. The electrical activity of the brain, the electroencephalogram (EEG), is recorded from electrodes placed at well defined positions on the scalp, overlying prominent parts of the brain.

The activity occurring at each electrode site and between electrode sites is recorded by 'montaging' pairs of electrode signals through a bank of differential amplifiers. Further amplification of the differential outputs is performed, followed by outputting to a suitable paper recorder.

Traditionally, the patient to be tested is brought to the EEG machine, and is subjected to a number of testing protocols using various montages. The total time required for the test can typically vary between twenty minutes and an hour.

Throughout the testing period the patient is placed in a chair near the EEG machine. Due to the large number of wires and heavy cabling between the patient and the EEG machine, patient mobility is restricted to the chair only.

This text describes a new and improved means by which the patient EEG signals are acquired and transferred to the EEG machine or similar recording device. This new apparatus permits greater patient mobility, and eliminates the need for long testing protocols by permitting montage changes during off-line analysis of the signals.

The apparatus consists of two major components: the patient 'headbox'; and, the control unit.

The patient 'headbox' is a small lightweight box worn by the patient. This box contains the necessary electronic components required for pre-amplification and calibration of the biological signals, and componentry and software required for the transfer of these signals to the master control unit.

The control unit consists of electronic components and software required to receive the biological signals and for montaging of these signals in the requested way.

BRIEF DESCRIPTION OF DRAWINGS

Preferred embodiments of the various aspects of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1. shows a schematic block circuit diagram of the multiple channel analogue and audio visual record and playback unit according to the first aspect of the invention;

Figures 2a, 2b and 2c show waveform diagrams of the individual pulse amplitude modulation timing and pulse train formation ;

Figure 3 shows a schematic block circuit diagram of the functional blocks within the patient 'headbox';

Figure 4 outlines the functional blocks within the control unit;

Figures 5a, 5b and 5c show the bi-directional serial transmission of the serial bit stream sequence, data word format and command word format respectively; and

Figures 6a, 6b and c show waveform diagrams of a standard scanning pattern, the trace reproduction without interpolation and trace reproduction with interpolation respectively.

DESCRIPTION OF PREFERRED EMBODIMENTS

Two basic criteria define the properties of any signal: dynamic range and, bandwidth. In any electronic system, the circuitry must be able to the accommodate these two criteria in order to adequately analyse the signals of interest. Likewise, any recording device must be capable of recording and reproducing the signals with adequate dynamic range and bandwidth so as to allow accurate analysis at a later date.

If we consider the capabilities of the audio system within an HiFi-VCR we see that the bandwidth available is typically from 20Hz to 20kHz, and the dynamic range typically approaches 90dB. This is more than adequate to record audio signals.

For the vast majority of analogue signals recorded in the scientific community, a bandwidth from DC to 500Hz is required. The dynamic range of the signals of interest usually vary between 48dB and 100dB.

The apparatus according to the preferred embodiment described herein is designed to convert signals whose bandwidth extends down to DC into a form that lies within the band limits of the VCR audio tracks. The upper bandwidth limitation of the signals to be recorded is dependent on the number of channels to be accommodated. For example, the device may accommodate a single channel of bandwidth DC to 3.9kHz, or, alternately, sixteen channels of bandwidth from DC to 244Hz. as defined below:

$$\text{CHANNEL BANDWIDTH, BW} = \frac{f_s}{4 \times N}$$

where f_s is the scanning frequency, (15.625 kHZ for 625 line video system) and, N is the number of channels to be recorded.

The device operates by forming a fixed duty cycle, pulse train that is synchronised with the video scan rate, and modulated in amplitude by the analogue signals to be recorded. Demodulation of the pulse train amplitude during playback yields the original signals.

During both record and playback of the data, the signal to be recorded on the audio track is synchronised to the video scanning rate by selecting the appropriate video source ('live' or 'off-tape') and stripping the synchronisation pulses from the composite video signal (see Fig. 1.).

The composite SYNC pulse signal stripped from the video signal is then broken into its elemental parts of horizontal and vertical synchronisation pulses, HSYNC and VSYNC, respectively. The timing signals HSYNC and VSYNCare then routed to the control logic used for generation and demodulation of the Pulse Amplitude Modulated (PAM) waveform.

The analogue signals to be recorded are inputted to the device at $S_1 - S_n$ (see Fig. 1.), where the interface buffers couple the inputs to the internal circuitry via signals $X_1 - X_n$. In the RECORD mode, these signals are looped through to the corresponding output signal lines $Z_1 - Z_n$ via a multi-pole, two-position analogue selector circuit. During PLAYBACK, the analogue selector circuit loops the demodulated signals $Y_1 - Y_n$ through to the outputs $Z_1 - Z_n$.

During both RECORD and PLAYBACK, the outputs $Z_1 - Z_n$ are presented to the input of the Pulse Amplitude Modulation (PAM) Generator (see Fig. 1). Hence, original and pre recorded analogue signals will be formatted for recording. In this way both original videotape and edited copies will record 'clean' analogue information.

Through electronic circuitry, the PAM Control module directs the PAM Generator to sequentially select signals $Z_1 - Z_n$. Each signal, Z, in turn is selected for a period equal to the video line scan period, i.e. the period of HSYNC. The signal Z is then voltage limited, inverted, and the offset by a fixed calibration voltage (see Fig. 2a). For a pre-determined portion of this interval (T_p), the selected signal Z, is sampled, and the sampled value is directed to the output conditioning circuitry. Hence, a pulse, Z_o of fixed timing and whose amplitude varies proportionately to signal Z around a reference voltage is generated.

By sequentially selecting one or more of the input signals, a pulse train, synchronised to the video scanning, is produced (see Fig. 2b). This pulse train exhibits fixed timing parameters but varying pulse amplitude. The amplitude of each pulse is dependent on and proportional to the corresponding input signal in the sequence.

By electronically assigning numbers to each horizontal scan period, each pulse is uniquely defined by its position in the pulse train. Hence, the demodulation of the pulses into the original signals is accommodated by pulse position and amplitude detection circuitry. By electronic insertion of a 'missing' pulse (see Fig. 2b) the start of the pulse train can be defined. Hence, a pulse train will consist of a (missing) SYNC pulse, N pulses for the channel data, and a REFERENCE pulse (see Fig. 2c).

The fundamental frequency of the pulse train is equal to that of the horizontal scanning frequency (typically 15.625kHz or 15.7kHz), while harmonics of the PAM signal occur at multiples of the scanning frequency. Since the high frequency cut-off point for the HiFi-VCR is 20kHz, only the fundamental component of the PAM waveform will be recorded by the video tape. However, the amplitude of the fundamental is proportional to the amplitude of the overall waveform. Hence, peak detection and calibration during playback enables signal reconstruction.

The dynamic range and signal-to-noise ratio of the HiFi-VCR and videotape determine the guaranteed dynamic range and quality of the recorded signal. Output conditioning circuitry ensures no noise interference is recorded, and that the PAM signal has maximum peak-peak amplitude compatible with the HiFi-VCR.

During PLAYBACK, the PAM signal previously recorded on the videotape is passed to the demodulation circuitry via an input conditioning amplifier (see Fig. 1).

Due to the AC coupling ($f_o \approx 20Hz$) and head switching aspects of the VCR, the zero volt baseline of the original pulse train will fluctuate from zero volts in accordance with the RMS value of the waveform. Hence, baseline restoration is performed so that a common reference voltage (GND) can be used to determine the absolute amplitude of each pulse.

The pulse amplitude is sampled under precise timing constraints in synchronism with the data rate so that the peak amplitude only is detected. This peak value is sampled and held for distribution by a bank of track-and-hold buffers. The output of these buffers are lowpass filtered to remove sampling distortion and then passed to the input/output selector for routing to the output of the unit, as well as to the PAM Generator for re-formatting for editing purposes.

Referring to Fig. 3, the biological signals are inputted to the unit at the 'electrode inputs'. The signals, with respect to a common reference, are pre-amplified to a convenient level by 'biological' differential amplifiers. Hence, the outputs of the pre-amplifier stage, E_1 - E_n, reflect electrical activity at each electrode site, rather than the montaged electrical activity of traditional EEG machines.

The electrode signals are passed through bandpass filters specific to EEG recording before being passed to the analogue to digital conversion section. All analogue circuitry used to this point can be calibrated on command through the use of the Electrode Test (ET), CAL, and, OFFSET Null modules.

Analogue-to-digital conversion is performed sequentially and at a rate at least four times the highest frequency of interest, and with a highly accurate 12-bit conversion. Final stage gain and offset control is performed before conversion, with the offset value for each channel being taken from a preset memory file that can be updated at any time.

The conversion word is fed (synchronously) to a serialisation circuit ready for transfer to the master control unit. All conversion words are transferred sequentially, by a single, high speed, bi-directional digital data link. Channel identification and separation is achieved at the control unit by synchronous detection of the start of the sequence.

The 'headbox' functions for CAL, ET, and, OFFSET Null are controlled by command transfer to the headbox from the master control unit. Data/command transfer time via the data link is proportioned such that two bytes of command are transferred to the headbox after every sequence of data channels is received from the headbox (see Fig. 3). When no command is issued, the No Operation (NOP) command is continually sent.

Referring to Figure 4, we see that the master control unit comprises two sub-sections: receiver/transmitter, and montaging.

The receiver/transmitter stage monitors the serial link and subsequently decodes the data stream from the headbox into parallel words for signal reconstruction, and inserts command words into the serial stream for passage to the headbox.

Signal reconstruction proceeds via digital-to-analogue conversion, and distribution to a bank of track-and-hold amplifiers. The outputs, $A_1 - A_n$, of the track-and hold amplifiers are routed through appropriate filters to remove sampling distortion before the reconstructed signals, $Z_1 - Z_n$, are passed to the output connector of the unit.

The signals $Z_1 - Z_n$, presented to the output connector are a direct representation of the electrical activity occurring at each electrode site. All signals are presented with reference to a common (non-ground) value. These (electrode) signals are available for recording for later analysis.

The electrode signals are passed back into the control unit (from 'off-tape' or 'live') via buffers to produce signals $Y_1 - Y_n$. These buffered signals are processed by the montaging subsection.

Via appropriate software, montaging is achieved by taking digital samples of each electrode signal, $Y_1 - Y_n$, and arithmetically determining the difference between pairs of signals, e.g.$Y_2 - Y_1$. The common reference for each signal is removed through the subtraction process, leaving an inter-electrode differential value. The difference value for each pair is outputted through digital-to-analogue conversion and filters to provide the 'montaged' signal, $M_1 - M_n$.

Sixteen 'montaged' signals (including NO SIGNAL) can be formed at any particular time by entry of the appropriate differencing equations through a keyboard. Non-volatile memory enables the retention and updating of commonly used montages.

The ability to record the electrode signals, with respect to a common reference, rather than the montaged signals, enables all montaging protocols to be performed off-line, any number of times, without the need for the patient to be present. Video recording of the patient activity completes the capture of all relevant patient data.

The graphical data produced by the abovementioned systems, such as analogue signals, may be mixed with a standard video camera signal for display on a conventional black and white, or colour, video monitor. In particular, the following description outlines a preferred method and means by which raw analogue signals may be superimposed onto a background video picture so as to use a single video monitor as a multi-channel analogue display device.

Until recently, the usual method for displaying analogue signals was by means of an oscilloscope or by various types of paper printout.

The inherent problems of oscilloscopes are primarily the short persistence of the screen phosphors, the relatively small display area, and a small number of display channels. The oscilloscope is, therefore, best suited to the display of one or two channels, at high rates, in contrast to a multitude of slowly varying signals.

Paper printouts are available in many formats, ranging from single to as many as twenty four channels, and, will reliably print signals from DC to 100Hz or more. The primary disadvantage of paper printers is their ongoing paper and maintenance costs.

When video and analogue signals are both important to the analysis of events of interest, oscilloscopes and paper printouts are cumbersome in adequately displaying both at the same time. Hence, the simultaneous display of the analogue signals on the same monitor as the video picture became a convenient and worthwhile alternative.

This text describes a preferred means and method for the display of the analogue signals in a superimposed mode, in contrast to the split screen method traditionally used.

The fundamental principle underlying the use of a video monitor as a signal display device lies in an understanding of the scanning system used by conventional video monitors.

All video monitors and televisions form a visual image by scanning the phosphor(s) of the screen area with an electron beam. The intensity and scanning pattern of the beam determine the picture resolution and quality.

Conventional video monitors use horizontal raster scanning for picture formation, and use three phosphors for colour picture production. Black and white monitors use the same scanning pattern but require only one phosphor.

The scanning pattern comprises a number of horizontal scan lines which are 'written' from left to right (see Fig. 6a). The total number of scan lines N, used depends on the standard employed, but typically varies between 260 and 350 lines per field. One field is the total number of lines required to write from top to bottom of the screen area.

In this unit, the scan lines are electronically numbered from 0 to N as they proceed down the screen, starting from the top of the visible area. Likewise, each scan line is broken, horizontally, into a minimum of 512 precise elements (H), called dots. Hence, a matrix of dots (H & N) is formed.

The dots are addressable by means of suitable electronics and software. When correctly addressed at the right time, a dot may be 'enabled' for display. An enabled dot will produce a spot on the video picture at an intensity between black and full white, depending on the

TRACE INTENSITY setting. This dot is seen in place of the picture element at that point, giving the appearance of superimposition.

The dot position of any point in an analogue waveform that needs to be displayed is determined by the digital values recorded for contiguous points in the waveform. By reading the recorded values sequentially as each line is scanned and comparing the stored values with the current line number, a dot is formed whenever a match occurs, i.e. when the stored value and line number are equal. In this way, a line of dots in the shape of the waveform will be seen on the screen (see Fig. 6b).

Interpolation of the values that lie between two consecutive points enables all vertically aligned dots between two 'equal' dots to be enabled as well. This is done by not only testing for equality on each stored value but, also, for 'greater than' or 'less than' results. That is, if a stored value lies between the 'equality line' of the previous stored value and the 'equality line' for the present stored value, then it should be enabled.

Comparison of two consecutive results in a scan line will indicate if the present point in the display lies between two previous dots. If so, this dot is enabled also. Hence, all contiguous dots are linked to produce a smooth waveform on the screen (see Fig. 6c).

Since the elemental dots of the waveform actually take the place of the picture at those points, the waveform is seen at its own intensity between real picture elements. The TRACE INTENSITY facility permits the trace to be seen as black through to white independently of the picture intensity. Hence, the traces can be displayed with any background, black, white, or varying.

By assigning only a portion of the screen height to the display of each trace, a number of traces of relatively high resolution can be displayed. For example, the CCIR scanning system allows up to 288 visible lines to be used. By assigning 64 lines per trace, a total of four traces can be accommodated without overlap.

Provision for 50% overlap increases the number of traces to eight vertically. Furthermore, by taking advantage of the interlaced scanning system, the resolution of the traces is doubled without affecting the area occupied by the trace.

Due to the, often, large horizontal viewing area of most monitors, it is also possible to split the horizontal display into two sections without greatly diminishing the view of the traces. Hence, it is easy to accommodate up to sixteen traces on the screen without cluttering the display, or impairing the view of the underlying video picture.

Suitable electronic hardware and software permit the flexible manipulation of the video and trace information so that various display formats, and signal sweep rates can be used to view the data.

By using the display memory as a 'ring buffer', the traces can be made to sweep from left to right in a refresh mode or from right to left in the chart recorder 'scroll' style.

Cursors, timescale graticules, and the ability to blank traces and/or the background video also enhance the display and greatly ease the task of data analysis.

It will be appreciated by those skilled in the art, that further embodiments of the invention are possible without departing from the spirit or scope of the invention described.

CLAIMS:-

1. A method of recording a plurality of analogue signals together with a video or audio-visual signal on a single video recording medium comprising the steps of

a. reducing a plurality of low frequency analogue input signals, together with a reference signal, to a single high frequency signal compatible with the bandwidth and dynamic range of the audio tracks of the video recording medium,

b. recording said high frequency signal on one or both of the audio tracks of said video recording medium in synchronism with a video image signal being recorded on the video track of said video recording medium.

2. A method of recording according to claim 1 wherein a number of said analogue signals of a designated bandwidth are formatted together to produce a train of pulses of fixed duty cycle and modulated amplitude.

3. A method of recording according to claim 2 wherein said train of pulses are generated by triggering the pulse formation with a horizontal sync (HSYNC) signal derived from the associated composite video image signal.

4. A method of reconstructing a plurality of analogue signals and a video or audio-visual signal recorded on a single video recording medium in accordance with the method of claim 1 comprising the steps of

a. replaying the recorded video medium to recover the high frequency signal, the video signal or audio-visual signal,

b. processing said high frequency signal to reconstruct said plurality of low frequency analogue input signals.

5. A method of reconstructing according to claim 4 including displaying said reconstructed analogue signals simultaneously with said video signal on the same monitor.

6. Apparatus for recording a plurality of analogue signals together with a video or audio-visual signal on a single video recording medium comprising,

a. means for reducing a plurality of low frequency analogue input signals, together with a reference signal, to a single high frequency signal compatible with the bandwidth and dynamic range of the audio tracks of the video recording medium,

b. means for recording said high frequency signal on one or both of the audio tracks of said video recording medium in synchronism with a video image signal being recorded on the video track of said video recording medium.

7. Apparatus according to claim 6 including means for formatting together a number of said analogue signals of a designated bandwidth to produce a train of pulses of fixed duty cycle and modulated amplitude.

8. Apparatus according to claim 6 wherein said means for formatting includes means for generating said train of pulses by triggering the pulse formation with a horizontal sync (HSYNC) signal derived from the associated composite video image signal.

9. Apparatus for reconstructing a plurality of analogue signals recorded using the apparatus of anyone of claims 6 to 8 including

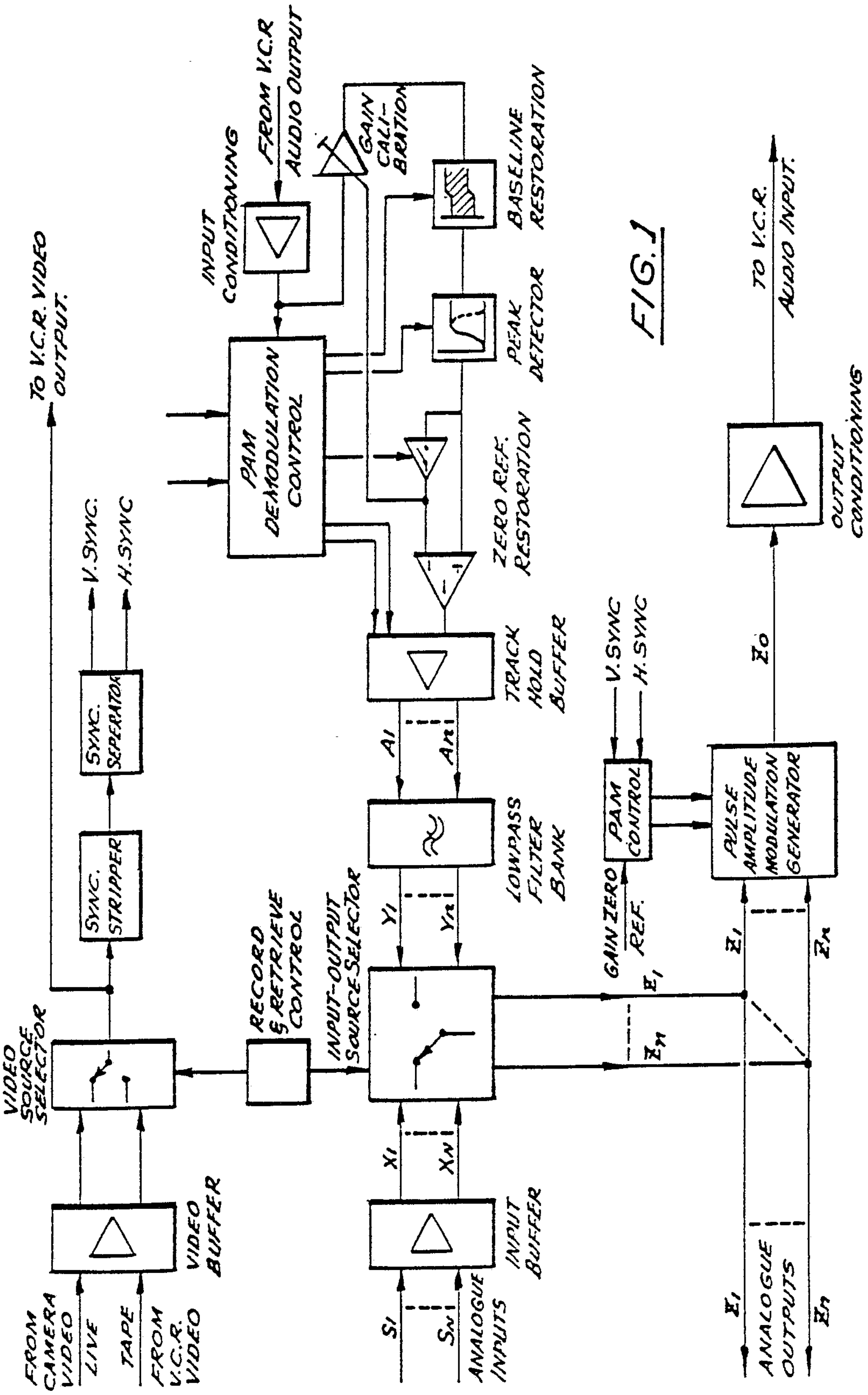
a. means for replaying the recorded video medium to recover the high frequency signal, the video signal or audio-visual signal,

b. means for processing said high frequency signal to reconstruct said plurality of low frequency analogue input signals.

10. Apparatus for reconstructing a plurality of analogue signals according to claim 9, wherein said processing means includes means for generating synchronous clocking signals from said data pulse train, said clocking signals triggering baseline restoration circuit means and peak detection circuit means to capture said analogue signals.

11. Apparatus according to claim 10 wherin said processing means further includes means for recovering said reference signal, said reference signal being used to recalibrate each of said reconstructed analogue signals.

12. Apparatus according to claims 9, 10 or 11 including display means for simultaneously displaying said analogue signals and said video signal on the same monitor.


FROM CAMERA VIDEO
LIVE
TAPE
FROM V.C.R. VIDEO
VIDEO BUFFER
VIDEO SOURCE SELECTOR
SYNC. STRIPPER
SYNC. SEPERATOR
V. SYNC
H. SYNC
TO V.C.R. VIDEO OUTPUT.
RECORD & RETRIEVE CONTROL
S1
SN
ANALOGUE INPUTS
INPUT BUFFER
X1
XN
INPUT-OUTPUT SOURCE SELECTOR
Y1
Yn
LOWPASS FILTER BANK
A1
An
TRACK HOLD BUFFER
ZERO REF. RESTORATION
PAM DEMODULATION CONTROL
INPUT CONDITIONING
FROM V.C.R AUDIO OUTPUT
GAIN CALI-BRATION
PEAK DETECTOR
BASELINE RESTORATION
GAIN ZERO REF.
PAM CONTROL
V.SYNC
H.SYNC
PULSE AMPLITUDE MODULATION GENERATOR
OUTPUT CONDITIONING
TO V.C.R. AUDIO INPUT.
Z1
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ANALOGUE OUTPUTS

FIG.1

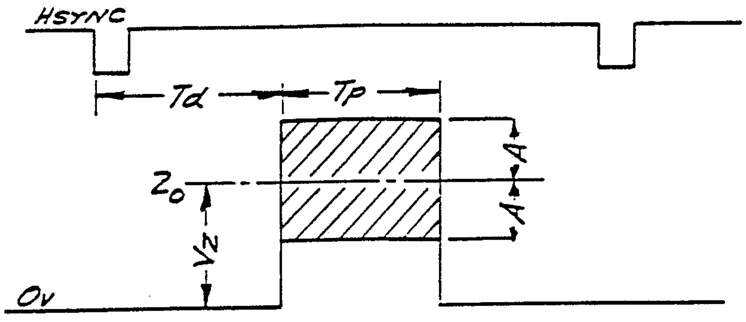

FIG. 2a

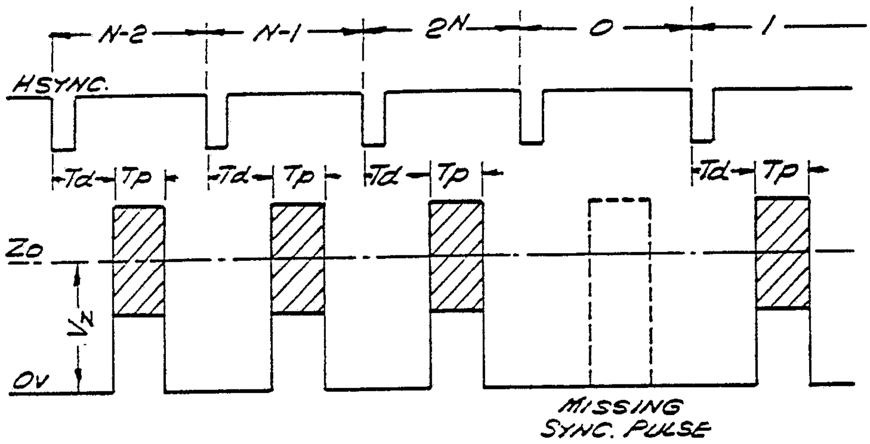

FIG. 2b

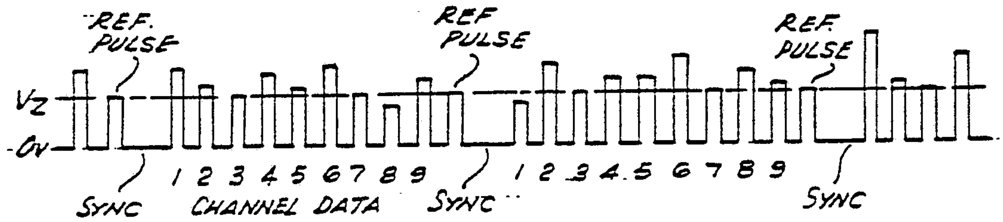

FIG. 2C

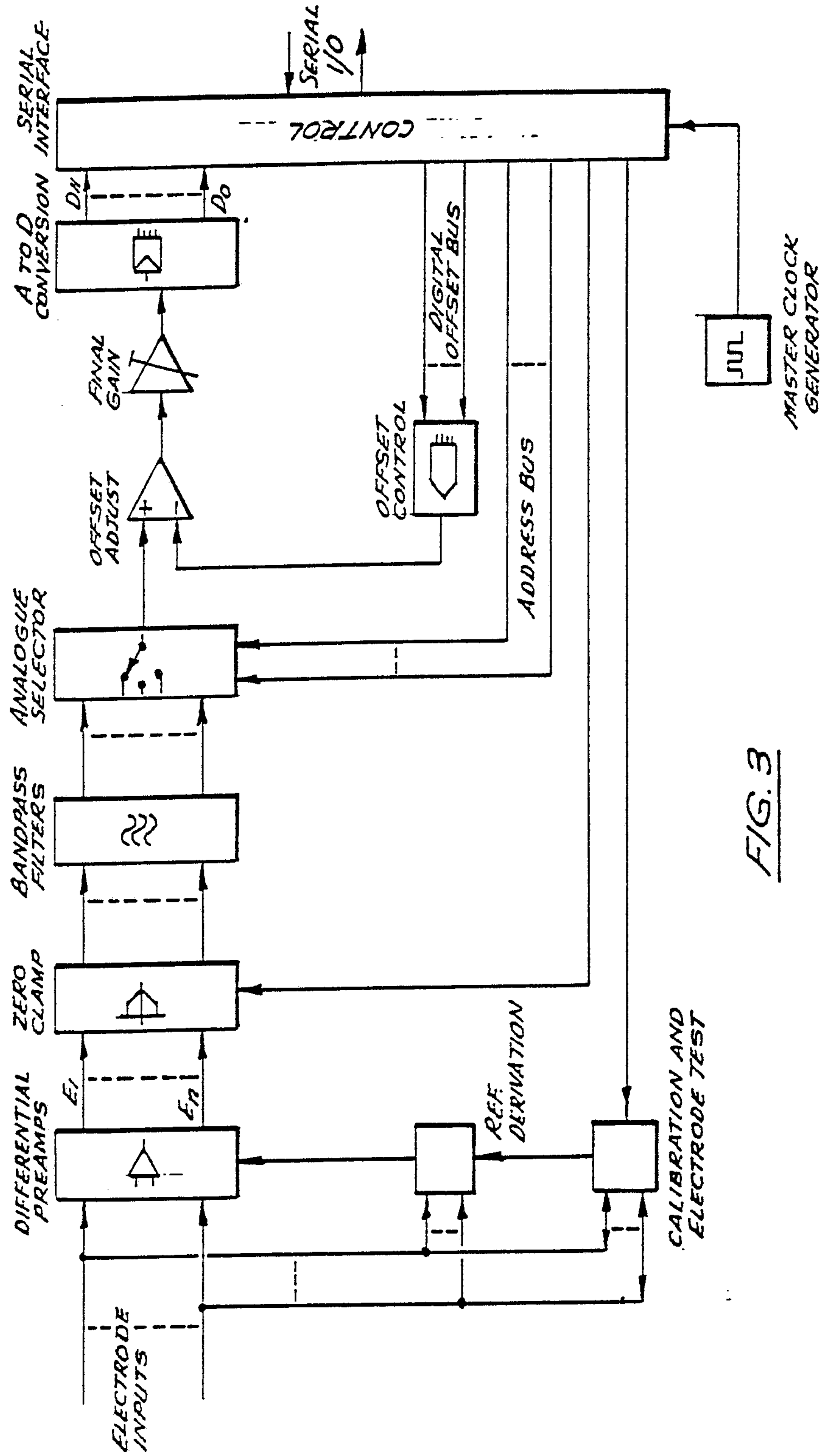
SERIAL INTERFACE
SERIAL I/O
CONTROL
A TO D CONVERSION
Dn
Do
DIGITAL OFFSET BUS
FINAL GAIN
OFFSET CONTROL
OFFSET ADJUST
ADDRESS BUS
MASTER CLOCK GENERATOR
ANALOGUE SELECTOR
BANDPASS FILTERS
ZERO CLAMP
DIFFERENTIAL PREAMPS
E1
En
REF. DERIVATION
CALIBRATION AND ELECTRODE TEST
ELECTRODE INPUTS

FIG. 3

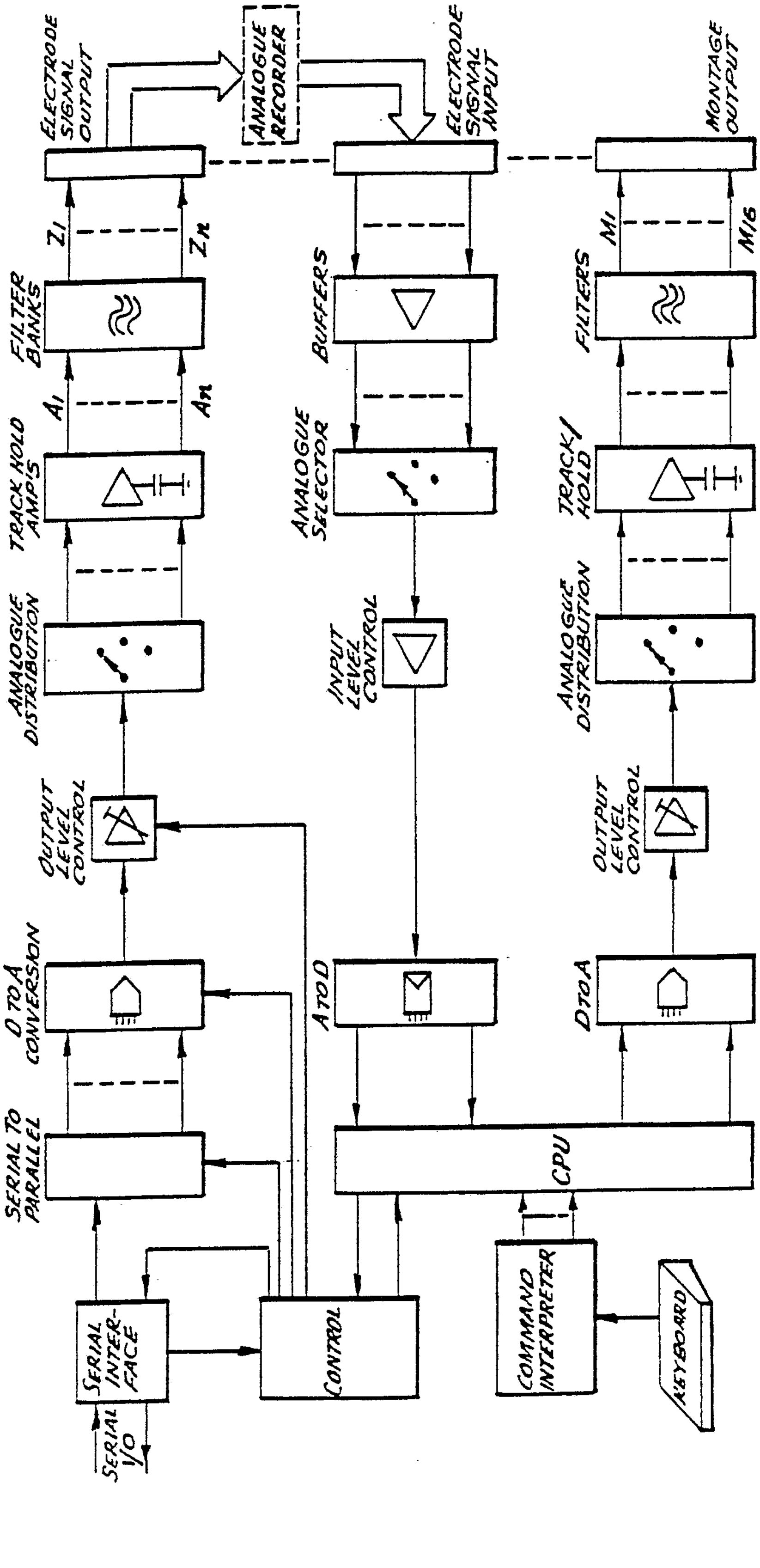
ELECTRODE SIGNAL OUTPUT
ANALOGUE RECORDER
ELECTRODE SIGNAL INPUT
MONTAGE OUTPUT
Z1
Zn
M1
M16
FILTER BANKS
BUFFERS
FILTERS
A1
An
TRACK HOLD AMPS
ANALOGUE SELECTOR
TRACK/ HOLD
ANALOGUE DISTRIBUTION
INPUT LEVEL CONTROL
ANALOGUE DISTRIBUTION
OUTPUT LEVEL CONTROL
OUTPUT LEVEL CONTROL
D TO A CONVERSION
A TO D
D TO A
SERIAL TO PARALLEL
CPU
SERIAL INTER-FACE
CONTROL
COMMAND INTERPRETER
KEYBOARD
SERIAL I/O

FIG.4

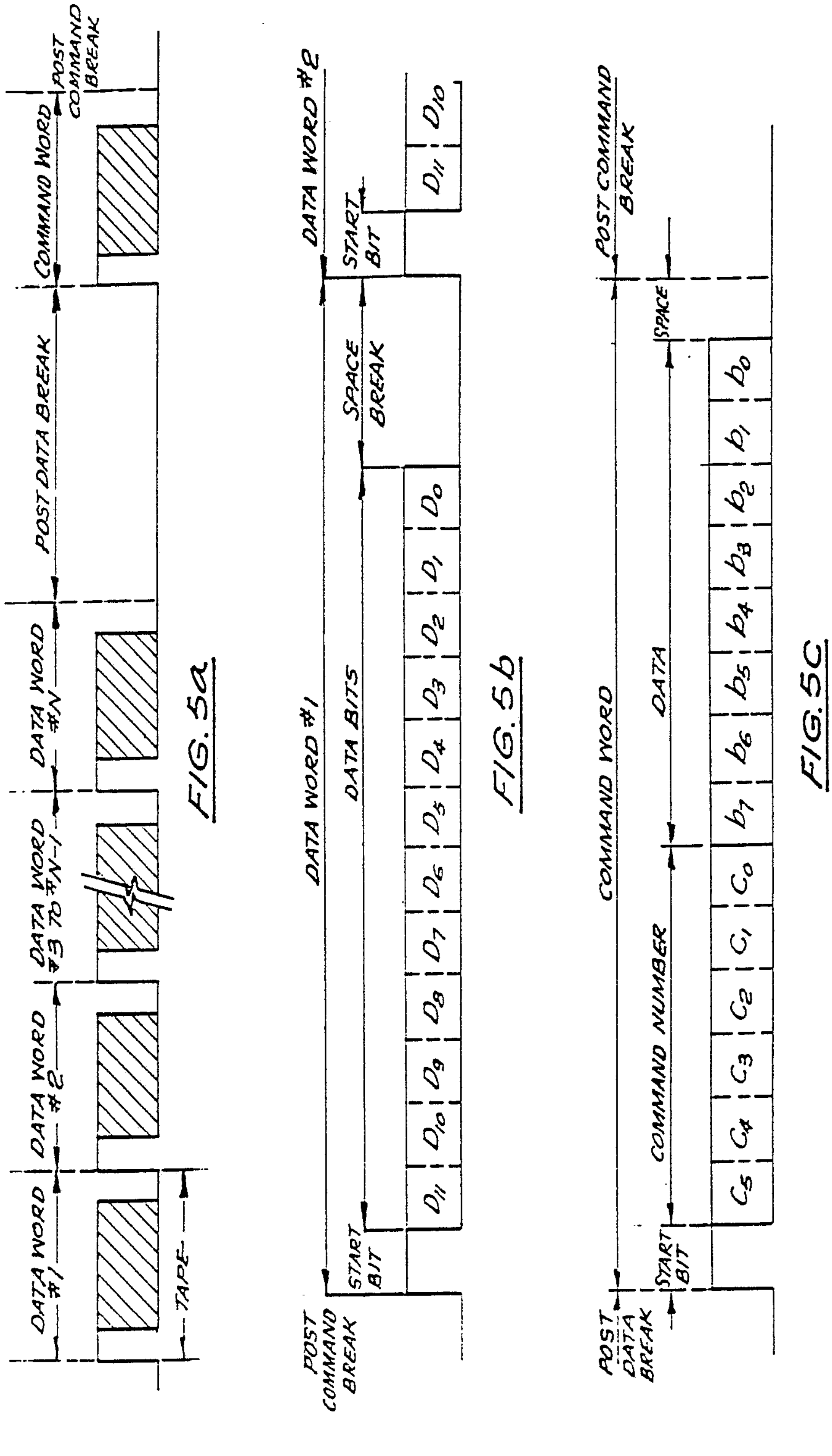

FIG. 5a

FIG. 5b

FIG. 5C

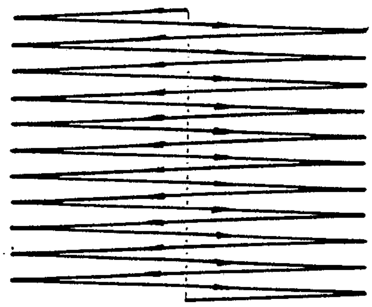

FIG. 6a

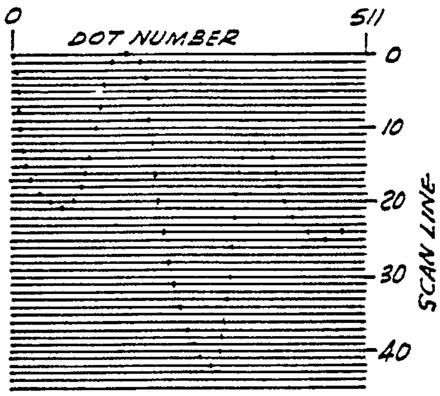

FIG. 6b

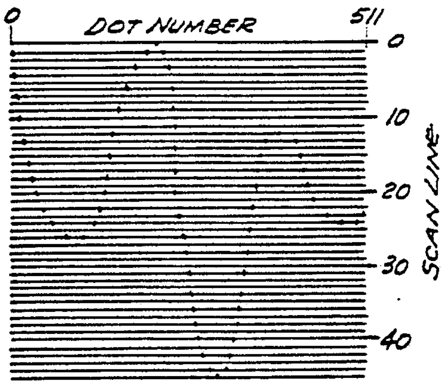

FIG. 6c

INTERNATIONAL SEARCH REPORT

International Application No PCT/AU 89/00052

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int. Cl.[4] G11B 20/02

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC	G11B 5/027, 20/02, 20/08

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

AU : IPC as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	AU,A, 62396/86 (ROYAL CHILDREN'S HOSPITAL) 12 March 1987 (12.03.87)	
A	US,A, 4216492 (SCHMALZ) 5 August 1980 (05.08.80)	
A	US,A, 4191969 (BRIAND et al) 4 March 1980 (04.03.80)	
A	US,A, 4045815 (GRIFFITH et al) 30 August 1977 (30.08.77)	
A	US,A, 4028733 (ULICKI) 7 June 1977 (07.06.77)	
A	US,A, 4018986 (WILK) 19 April 1977 (19.04.77)	
A	US,A, 3900887 (SOGA et al) 19 August 1975 (19.08.75)	
A	US,A, 3848082 (SUMMERS) 12 November 1974 (12.11.74)	

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
17 April 1989 (17.04.89)	26 APRIL 1989 26.04.89
International Searching Authority	**Signature of Authorized Officer**
Australian Patent Office	A J Evans A.J. EVANS

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 89/00052

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Members		
AU 62396/86	EP 215604	JP 62076378	
US 4216492	BE 865948 NL 7804117	DE 2717090	JP 53129915
US 4191969	CA 1127752 FR 2389290 NL 7803789	DE 2818704 GB 1562381 SE 7804770	ES 467786 JP 53135509
US 4018986	DE 2436674 GB 1512803	DK 2916/75 IT 1039901	FR 2281022 NL 7505948
US 3848082	DE 2400889	JP 49106220	

END OF ANNEX