Ames

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for
Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3,549,799

Government or Corporate Employee : Government

Supplementary Corporate Source (if applicable) : NA

NASA Patent Case No. : ARC-10003-1

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes ☐ No ☑

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

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Enclosure
Copy of Patent cited above

FACILITY FORM 602

N71-25866 (ACCESSION NUMBER)
7 (PAGES)
(NASA CR OR TMX OR AD NUMBER)
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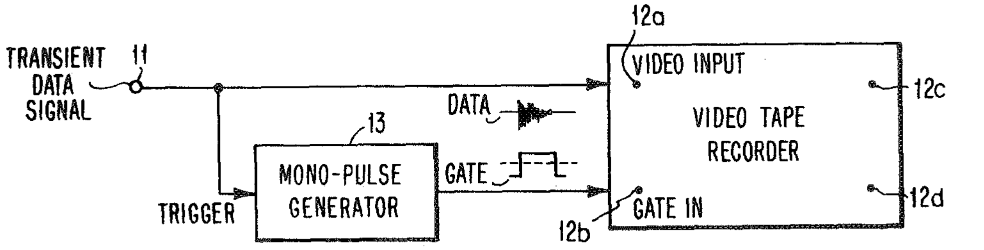

FIG. 1

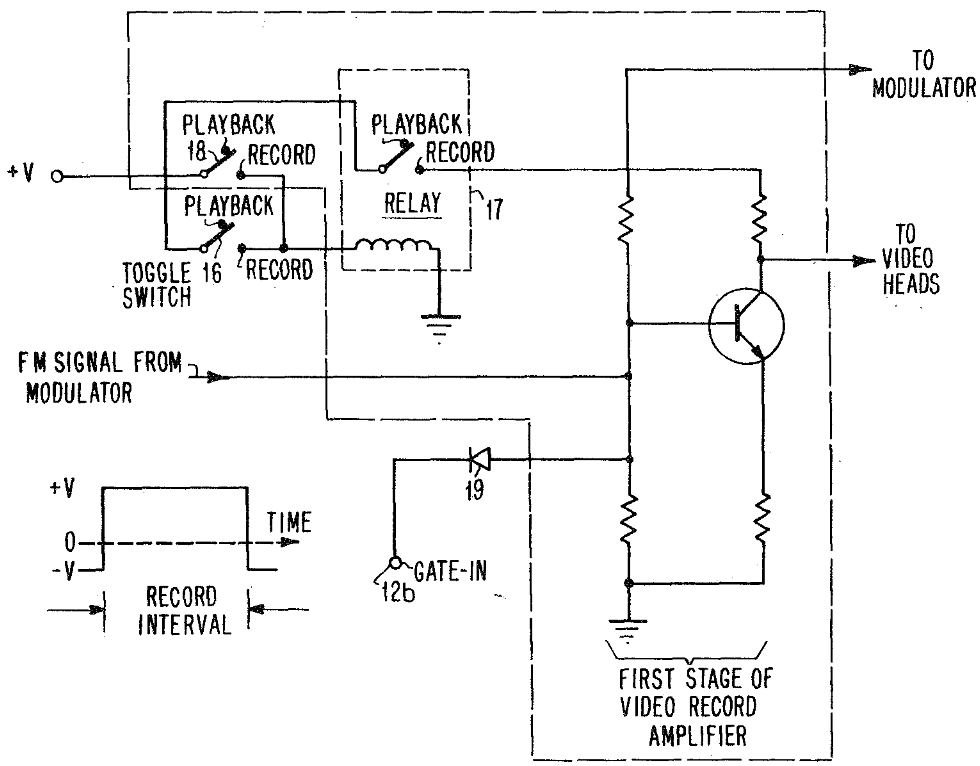

FIG. 2

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PATENTED DEC 22 1970

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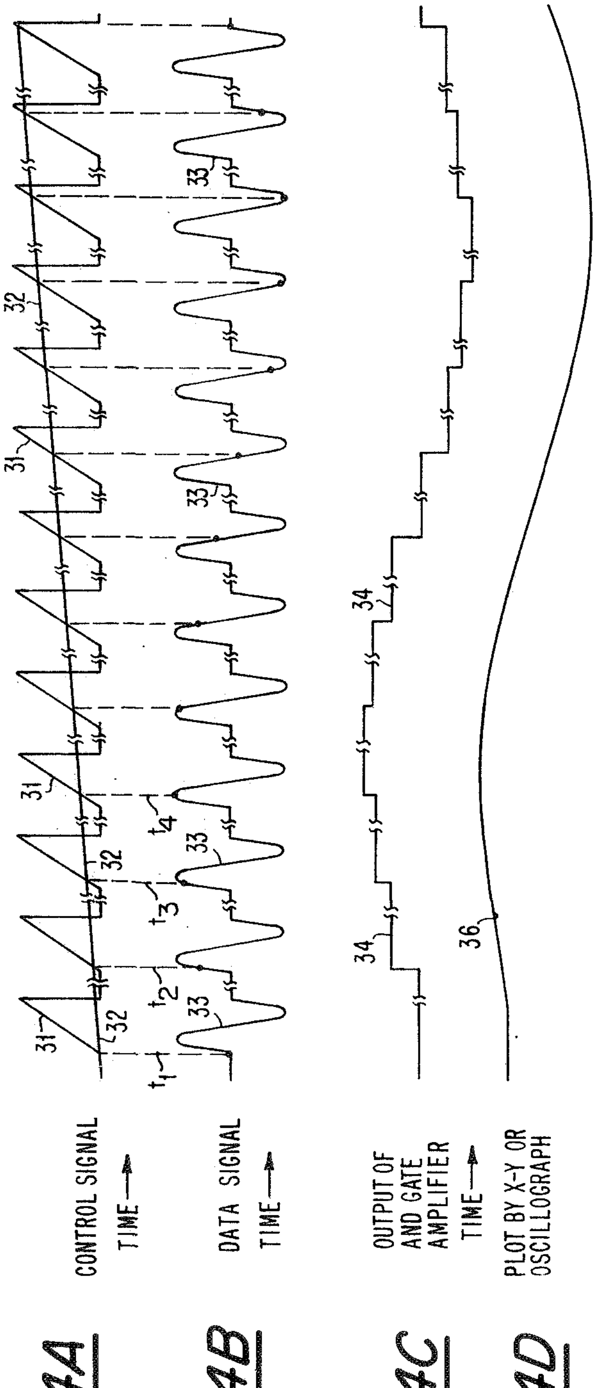

FIG.4A

FIG.4B

FIG.4C

FIG.4D

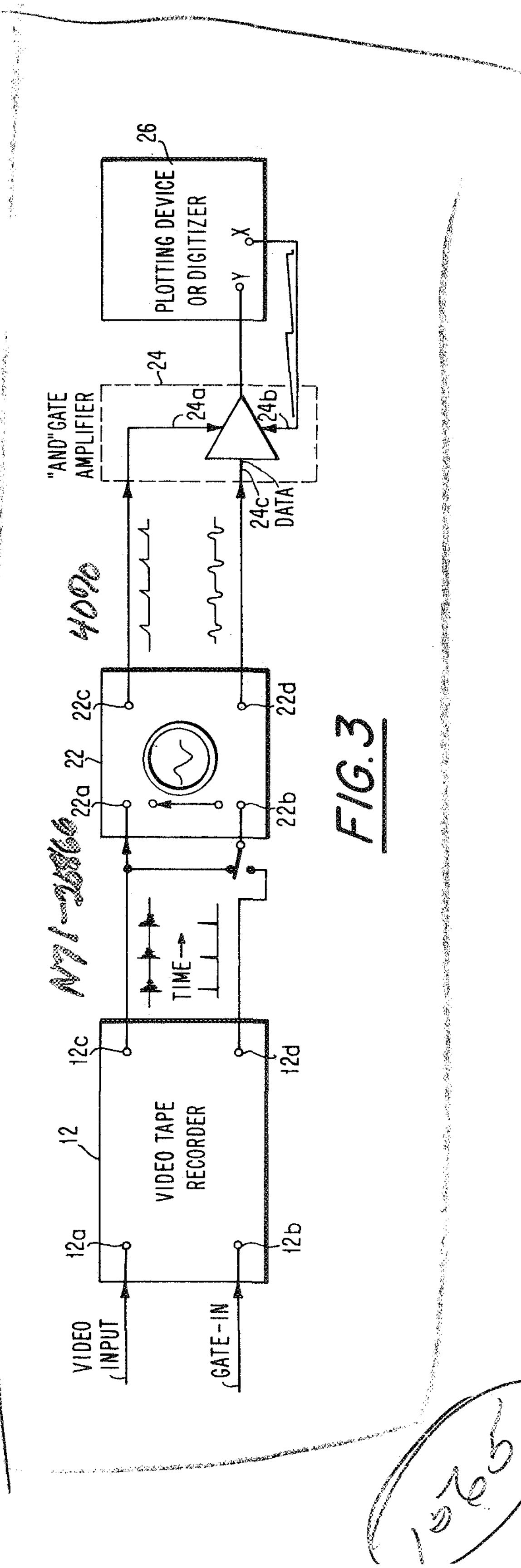

FIG.3

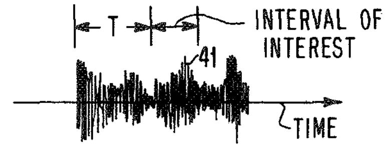

FIG. 5A

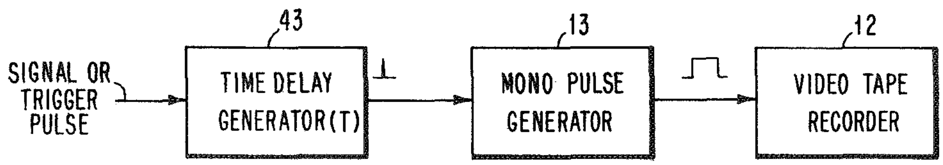

FIG. 5B

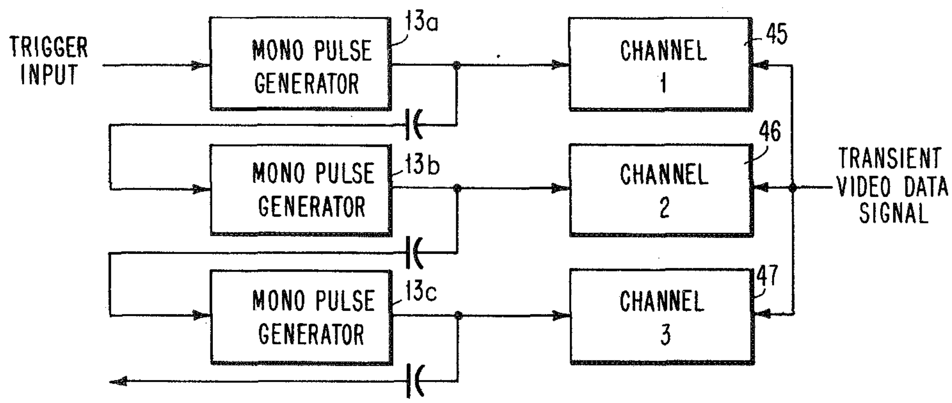

FIG. 6

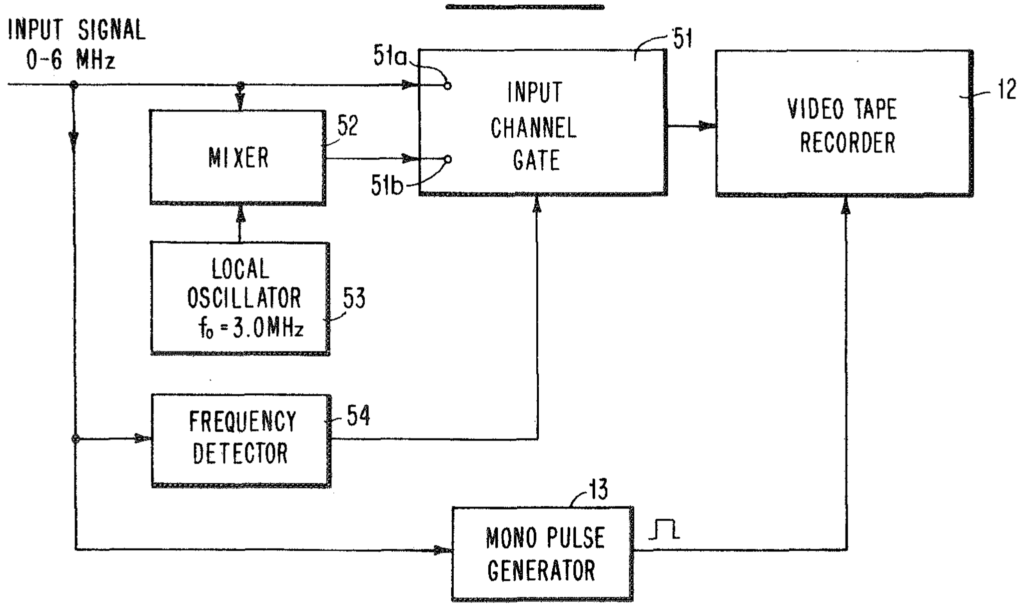

FIG. 7

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,549,799 Dated December 22, 1970

Inventor(s) Ronald C. Sander and Ronald J. Hruby

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover page at [54] and Column 1, lines 1 and 2, "DECOMPRESSION DEVICE FOR INTERNAL COMBUSTION ENGINE" should read -- TRANSIENT VIDEO SIGNAL RECORDING WITH EXPANDED PLAYBACK -- .

Signed and sealed this 6th day of April 1971.

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

Attest:

Attesting Officer

United States Patent

[11] 3,549,799

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Ronald J. Hruby, Campbell, Calif.

[21] Appl. No. 717,822
[22] Filed Apr. 1, 1968
[45] Patented Dec. 22, 1970
[73] Assignee to the United States of America as represented by the Administrator of the National Aeronautics and Space Administration

[54] ~~DECOMPRESSION DEVICE FOR INTERNAL COMBUSTION ENGINE~~ See attached Certificate of Correction

5 Claims, 11 Drawing Figs.

[52] U.S. Cl. 178/66; 179/100.2
[51] Int. Cl. H04n 1/28, G11b 27/36
[50] Field of Search 178/6.6A, 6.6FSS; 179/100.2T, 100.2MI, 15.55; 179/100.2B

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Primary Examiner—Bernard Konick
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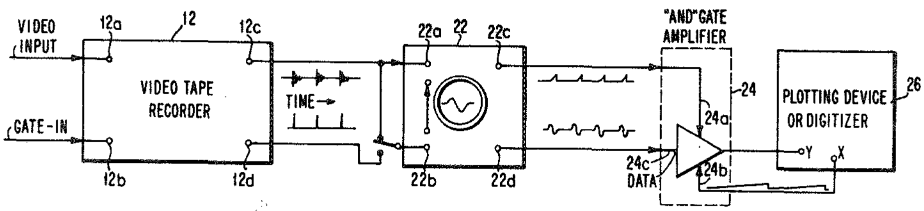
ABSTRACT: A transient video signal is recorded on a video recorder by triggering the recording circuits upon appearance of the transient and when the recorder is in the "stop-motion" mode. The recorded signal, or a selected portion thereof, is subsequently reproduced for display on a cathode ray tube and for reproduction on an expanded time scale for a plotting device and/or an analog to digital converter.



~~DECOMPRESSION DEVICE FOR INTERNAL COMBUSTION ENGINE~~ See attached Certificate of Correction

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates in general to transient recording and playback systems, and relates more particularly to such systems for recording high frequency transients and for producing playback on an expanded time scale.

2. Description of the Prior Art

There is considerable need in the art for systems to record transient video frequency signals and to provide for playback of these recorded signals, or portions thereof, to such devices as relatively low-speed, low bandwidth plotting devices and/or to analogue to digital conversion devices. A number of different systems have been proposed for such applications, but none of them have provided the desired degree of reliability, simplicity of operation and low cost.

SUMMARY OF THE INVENTION

In accordance with the present invention, there is provided such a system utilizing conventional electronic equipment with slight modifications thereto. The invention utilizes a conventional video tape recorder to which the transient to be recorded is applied. For recording, the recorder is operated in the stop-motion mode, in which the same portion of the video tape is repetitively scanned by the rotating video recording and reproducing heads. The occurrence of the transient triggers a pulse generator which is connected to the video recording control circuits to produce recording of the transient on the recorder.

For playback, the recorder again operates in the stop-motion mode in which the recorded transient is repeatedly reproduced on a cyclic basis from the recorder and supplied to a cathode ray tube display device. The transient signal, or selected portion thereof, which is thus displayed is also available for expanded playback through the use of a conventional AND gate amplifier. The transient signal from the display device is supplied as the data input to such an amplifier, while the horizontal sweep signal from the display device is supplied as one of the control inputs to the amplifier. The other control input is provided by the sawtooth voltage generated within the amplifier, and by properly selecting the ratios of these sawtooth voltages, an expanded playback of the transient of any suitable time scale is available at the output of the amplifier. This expanded output may be supplied to a low speed, low bandwidth plotting device to provide a permanent record of the transient or selected portion thereof. Also, this expanded output may be supplied to an analogue to digital converter device for recording on magnetic tape for subsequent analysis of the transient on a digital computer.

It is therefore an object of this invention to provide an improved system for the recording and playback of high frequency, short duration transient electrical signals.

It is a further object of the present invention to provide a system for recording transient electrical signals and producing a playback of the recorded signals on an expanded time scale.

It is an additional object of this invention to provide a system for recording in a compact and undistorted form a transient video signal and reproducing the recorded signal upon demand on an expanded time scale for use by printing or recording devices having a low bandwidth and low speed.

It is a further object of the present invention to provide a system for recording and reproducing transient video signals utilizing conventional equipment with a minimum of modifications thereto.

Objects and advantages other than those set forth above will be apparent from the following description when read in connection with the accompanying drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of the recording circuitry involved in the present invention;

FIG. 2 is a schematic diagram showing the modifications to a conventional video tape recorder to carry out recording in accordance with the present invention;

FIG. 3 is a block diagram showing the system for playing back the recorded transient on an expanded scale;

FIG. 4A, 4B, 4C and 4D are graphs showing output signals involve involved in various portions of the playback apparatus;

FIG. 5A is a graph showing a transient video signal having a particular interval of interest therein;

FIG. 5B is a block diagram of circuitry for recording the interval of interest shown in FIG. 5A;

FIG. 6 is a block diagram of an alternate embodiment of the invention for recording transient signals whose duration exceeds the recording interval for one diagonal track of the video recorder; and

FIG. 7 is a block diagram of an alternate embodiment of the invention for recording transient signals whose frequency range exceeds the frequency range of the video recorder.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Recording

Referring to FIG. 1, there is shown a block diagram illustrating the circuitry for recording the transient video signal. The transient signal appears at a terminal 11 and may have the following characteristics. It only occurs once, has a duration of less than one-sixtieth of a second, has a dynamic amplitude range of at least 35—40 db., and has a frequency content as high as 3 MHz. Such signals are common in a number of applications, such as ballistic measurements and reflectometer work.

The transient signal is applied to the video input terminal 12*a* of a conventional video tape recorder 12, and is also supplied as the input to a monopulse generator 13. Generator 13, when triggered by the occurrence of the transient signal on terminal 11, generates a pulse of predetermined duration, and this pulse is supplied to a special input terminal 12*b* of recorder 12. This terminal, labeled the "gate-in" terminal, represents a modification of a conventional video tape recorder.

As is well-known in the art, conventional video tape recorders achieve a bandwidth of 3.5 MHz by helically driving a slowly-moving length of magnetic tape around a synchronously driven disc or drum containing the video and record and playback heads. The video signal is thus recorded on the tape in the form of a parallel, slanted stripes of or tracks, with each track generally containing the signal for one video frame (one-sixtieth of a second). Single-frame or stop motion playback operation is achieved by stopping the tape, thus causing the rotating heads to repetitively scan the same track on the tape. Simple modifications of a conventional recorder permit it to function as a continuous loop recorder for purposes of this invention, with loop lengths of one-sixtieth of a second.

The modifications to a conventional video tape recorder required to record in accordance with this invention are shown in FIG. 2, where the regular components of recorder 12 are shown inside the dotted lines, while the modifications thereto are outside the lines. These modifications include the addition of a toggle switch 16 which when closed to the "record" position, energizes a relay 17 which is provided in the recorder by the manufacturer for selecting between the record and the playback mode. With switch 16 closed, relay 17 is energized to close its "record" contact to activate the modulator and video record amplifier of the recorder to prepare for recording when the transient occurs. It will be understood that since the recorder is placed in the stop-motion playback mode prior to recording in accordance with this invention, the normal switch 18 provided on the recorder for controlling record or playback will be placed in the "-playback" position and hence cannot be used to activate the modulator and video record amplifier.

Even though relay 17 is energized by closure of switch 16, recording does not occur until the transient appears, because of the action of generator 12. As indicated above, the output of generator 12 is supplied to input terminal 12*b* of recorder 12, and as shown in FIG. 2, this input is supplied through a diode 19 to the base of the first transistor in the video record amplifier. This input serves to maintain the recorder in either a record or nonrecord condition. Assuming that the recorder 12 uses NPN transistors, generator 12 may supply a negative output voltage, in the absence of a transient input on terminal 11, and this negative voltage forward biases diode 19 and back biases the base-emitter junctions of the transistors in the video record amplifier. Under these conditions, the amplifier is maintained in a nonrecord mode.

However, when a transient signal appears on terminal 11, generator 12 generates a positive output which back biases diode 19 to isolate this voltage from the video record transistors. The transistors own biasing circuits will then hold the amplifier in a record condition, so that the transient signal, which appears at input terminal 12*a* of the recorder, is recorded. Thus, when triggered by the beginning of the transient signal, the output of generator 12 switches from a negative to a positive level, and after slightly less than one-sixtieth of a second, it will switch its output back to a negative level, thus cutting off the record amplifier and stopping the recording.

Thus, the only modifications required to a conventional video tape recorder to record in accordance with this invention are the addition of the manually operated switch 16 to energize or deenergize relay 17, the addition of terminal 12*b* on the recorder chassis, and the connection of diode 19 between the base terminal of the record amplifier transistors and the input terminal 12*b*. Further, recording of the transient requires only setting the recorder for single frame or stop motion playback and closing switch 16 to energize relay 17 to activate the modulator and video record amplifier.

After the transient and gate pulse have occurred, the track of tape containing the recorded transient may be protected from further recording by resetting switch 16 to deenergize relay 17. This deactivates the modulator and video record circuits, and the mode of operation reverts to the conventional stop motion playback mode.

Playback

The system arrangement for playback is shown in block diagram form in FIG. 3, and includes recorder 12, a cathode ray tube oscilloscope 22, and AND gate amplifier 24 and suitable plotting and digitizing equipment represented by the block 26. After recording the transient and with switch 16 of FIG. open, recorder 12 is functioning in the stop motion playback mode, so that the recorded transient signal appears at the video output terminal 12*c* in FIG. 3 every time a rotating video playback head passes over the tape track containing the recorded signal. In the present example, this will occur 60 times per second. This signal is supplied to the vertical input terminal 22*a* of oscilloscope 22.

It is generally simple to locate in recorder 12 a moderately sharp pulse which is synchronized with the position of the rotating head on the track, since the rotating disc is driven by a synchronous motor which is locked to pulses produced by an ultrastable oscillator. Thus, such a sync pulse bears a fixed time relationship to the beginning of the data record and may be used to trigger external electronic equipment. By bringing such a sync pulse to an outside terminal 12*d* of recorder 12 through a small coupling capacitor or the like, it is available for use in oscilloscope 22 at input terminal 22*b*.

Oscilloscope 22 may be of any suitable type having sufficient bandwidth capacity to display the transient signal. The oscilloscope also preferably is provided with a time delay generator, so that the entire transient signal, or any selected portion thereof, may be selected an displayed using the appropriate sweep rates in conjunction with the time delay generator. The oscilloscope also preferably has output terminals on the front thereof, which are indirectly connected to the horizontal and vertical deflection plates of the device. Thus, that portion of the recorded transient signal which is displayed on the cathode ray tube is available at an output terminal 22*d*, and the synchronous sawtooth horizontal sweep voltage is available at a terminal 22*c*. These signals are utilized in AND gate amplifier 24 as described below.

The AND gate amplifier 24 may be of any suitable type which uses two sawtooth input control signals to produce a time-expanded replica of the signal applied to its data input terminal. One of the sawtooth signals is supplied from the horizontal sweep terminal 22*c* of oscilloscope 22 to form the first control signal at terminal 24*a*, while the other control signal is supplied to terminal 24*b* in the form of an ultralinear sawtooth signal generated within amplifier 24, as is well-known in the art.

As indicated above, the complete transient signal appears at the video output terminal 12*c* of recorder 12 once every sixtieth of a second, and this signal is supplied to the input terminal 2*a* of oscilloscope 22. With the appropriate time delay and horizontal sweep rate in oscilloscope 22, the selected portion of the transient signal will also appear on the face of the oscilloscope and at the oscilloscope vertical signal output terminal 22*d* once every sixtieth of a second. This signal is supplied to the data input terminal 24*c* of amplifier 24. The horizontal sawtooth signal from terminal 22*c* which is synchronous with the signal at terminal 22*d* is supplied to input terminal 24*a*.

As indicated above, an internally generated sawtooth signal is supplied to the second control terminal 24*b* of amplifier 24. In accordance with the usual practice, the length of this second sawtooth signal is adjusted to be 10,000—100,000 times longer than the length of the sawtooth sweep signal from oscilloscope 22 which is supplied to control terminal 24*a*. This ratio also determines the factor by which the signal displayed on the face of oscilloscope 22 is expanded in time by amplifier 24.

Amplifier 24 functions to compare the amplitudes of the two sawtooth control signals and when their amplitudes are equal, the amplitude of the data signal on terminal 24*c* is sampled and stored until the two sawtooth control signals again have equal amplitudes. This is shown graphically in the of FIGS. 4A, where the curve 31 represents the sawtooth control signal applied to terminal 24*a* from oscilloscope 22, while curve 32 represents the much frequency sawtooth control signal applied to terminal 24*b*. The amplitudes of these curves are compared within amplifier 24 to sample and store the data input when the amplitudes are equal. The data input signal is shown in the curve of FIG. 4B, where it is assumed that only a single cycle of the entire transient recorded on recorder 12 has been selected for display on oscilloscope 22 and for expanded playback.

The points at which the amplitudes of the compared sawtooth control signals are equal are indicated by the times t_1, t_2, t_3, etc., and the amplitude of the data signal of curve 33 is sampled and stored at each such time. This produces a progressive sampling the curve 33, as seen from FIG. 4B. The output from amplifier 24 for this sampling and storing operation is shown graphically in FIG. 4C, where it is seen that this output is in the form of a different output level for each successive sampling interval, with the levels of curve 34 corresponding, on an expanded time scale, to the levels of a single cycle of the transient of curve 33.

This form of output is very satisfactory for use in an analogue to digital converter to digitize the signal for recording on magnetic tape and subsequent analysis or data reduction on a digital computer. The signal of FIG. 4C is also quite suitable for use on X–Y plotters or oscillographic recorders because of its low bandwidth requirements and its relatively low speed of response requirements. With the signal of FIG. 4C and the second sawtooth control signal from terminal 24*b* applied to their Y and X inputs, respectively, such a plotter will plot a time-expanded replica of the portion of the transient signal selected for display on the oscilloscope. Since the limited frequency response of such plotters will filter out the steps in the signal of FIG. 4C, the final plot will appear as shown in FIG. 4D, where the curve 36 represents a smooth curve corresponding to curve 34 of FIG. 4C. It is significant to note that the effects of any nonlinearity in the horizontal sawtooth sweep voltage from oscilloscope 22 are removed by the time expansion technique and thus do not appear in the final plot of curve 36.

The number of times the data is sampled determines the degree of similarity between the curve plotted by the plotting devices and the selected portion of the transient appearing at the output of recorder 12. Any signal displayed on oscilloscope 22 may be sampled a maximum of 3,600 times because the recorder replays the data 60 times per second and the maximum length of the send second control sawtooth signal is 60 seconds. Obviously, greater fidelity of data expansion will be obtained by displaying smaller portions of the data on the oscilloscope. Hence, if a transient signal is split up into a number of slightly overlapping segments, the time-expanded plots may be matched up to each other to provide a complete and highly accurate time-expanded plot of the entire transient signal.

Any suitable type of components may be used in the present invention, provided they have the characteristics as listed for them. By way of example, and not as a limitation of the invention, we have found the following components to be highly satisfactory. Video recorder 12 was a Sony Model EV200, and the AND gate amplifier 24 was a Model 1001 CRT Display Converter manufactured by Pacific Measurements, Inc. of Palo Alto, Calif. Oscilloscope 22 was a Model 535 manufactured by Tektronix, Inc.

It will be apparent to those skilled in the art that various modifications may be made to the present invention, and that numerous alternate embodiments are possible. For example, if there is a particular interval of data of less than one-sixtieth of a second that occurs among other bursts of signal or noise, this interval alone may be recorded and expanded if the following two conditions are met. The time location of the start of this particular interval relative to the start of the burst of signal must be capable of being accurately predicted, and there must be a time delay generator available to delay the start of the gate pulse from generator 13 by the requisite amount.

This is shown in FIGS. 5A and 5B, where curve 41 of FIG. 5A represents the entire transient signal, with the interval of interest indicated thereon. The start of the transient causes a trigger pulse to be generated by a time delay generator 43, the time delay of this generator corresponding to the time T between the start of the transient and the beginning of the interval of interest within the transient. Thus, after the time interval T, generator 43 supplies a triggering pulse to monopulse generator 13 to initiate the recording of the transient on recorder 12 as described above.

If the interval of data to be recorded is longer than the duration of one track on recorder 12 (one-sixtieth of a second in the illustrated embodiment), a number of techniques are available. One such technique is shown in FIG. 6 and involves the use of as many video recording channels or recorders as is necessary to record the data, allowing one-sixtieth of a second for each channel or recorder. In FIG. 6, it is assumed that three such channels 45, 46, 47 are required, and each is provided with its own associated monopulse generator 13*a*, 13*b*, 13*c*, respectively. The trailing edge of the output pulse from generator 13*a* is supplied to trigger generator 13*b*, while the trailing edge of the output pulse from generator 13*b* triggers generator 13*c*. Generators 13*a*, 13*b*, 13*c* are thus sequentially fired over the duration of the transient to cause recording of different portions of the transient on the channels 45, 46, 47.

As an alternative approach, the data may be recorded with the video tape moving, using the recorder's normal record mode. The data may then be played back in the stop motion playback mode and the time expansion technique utilized on selected portions of the data. There may be about a 3—5 db loss of signal-to-noise ratio because the rotating video heads traverse slightly different tape paths on the moving tape in the record mode and on the stationary tape in the playback mode. However, this loss may be reduced or eliminated over small portions of the track if the tape is carefully positioned so that the record track and the playback track overlap in the region of interest.

As an additional approach to this problem, the connections of the synchronous motor driving the rotating disc may be varied to decrease its speed of rotation, thus increasing the recording time available in one track of the loop. Alternatively, the frequency of the audio oscillator which controls the synchronous drive motor may be varied to vary its speed of rotation to thus increase the available recording time on a given loop.

If the transient signal contains frequencies higher than the frequency capacity of the recorder (3.0 MHz in the illustrated examples), the following techniques may be employed. If the transient signal has a 3.0 Mhz or less information section located at some higher frequency, a mixer and local oscillator may be used to translate the information down into the recording frequency range of the recorder.

If the information bandwidth is larger than 3.0 MHz, a down frequency translation may be used on certain portions of the transient signal. This is illustrated in FIG. 7 for a transient signal having a frequency content up to 7 MHz. This system includes an input channel gate 51 having a first input terminal 51*a* and a second input terminal 51*b*. Terminal 51*a* receives its input directly from the signal to be recorded, while channel 51*b* receives its input from a mixer 52 which receives the transient input signal and a signal from a 3.0 MHz local oscillator 53.

Gate 51 is controlled by a frequency detector 54 which senses the frequency of the transient input signal and selects the appropriate channel of gate 51. When the frequency of the transient input is below 3.0 MHz, channel 51*a* is activated so that the signal is supplied directly to recorder 12. When the transient input signal frequency is above 3.0 MHz, detector 54 causes channel 51*a* to be deactivated and channel 51*b* to be activated. Thus, channel 51*b* receives the high frequency components of the input signal down-shifted by the 3.0 MHz action of mixer 52 and oscillator 53, so that the signal is still within the frequency range of recorder 12.

While the above detailed description has shown, described and pointed out the fundamental novel features of the invention as applied to various embodiments, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

We claim:

1. Apparatus for recording a transient electrical signal and playing such signal back on an expanded time scale, comprising:

recording means for recording said transient signal on a recording media;

trigger means connected to said recording means for turning on said recording means upon the appearance of said transient signal;

playback means for repetitively scanning said recording media and repetitively reproducing said transient signal;

sampling means connected to said recording means for repetitively sampling the amplitude of successive points of said reproduced transient signal to produce a plurality of amplitude level sample signals, one sample being taken each time the signal is reproduced;

said sampling means including an AND gate amplifier, a first sawtooth signal generator and a second sawtooth signal generator;

said first sawtooth signal being synchronized with said reproduced signals from said playback means;

said second sawtooth signal having a longer period than said first sawtooth signal;

said AND gate amplifier having a data input and two control inputs, said reproduced signals being coupled to said data input and said first and second sawtooth signals being coupled to said control inputs, respectively, said amplifier comparing the amplitudes of said first and second sawtooth signals and sampling the amplitude of said reproduced signal when said compared amplitudes are equal; and

output means connected to said amplitude level sample signals for producing a replication of said transient signal with an expanded time scale.

2. Apparatus for recording a transient electrical signal and playing such signal back on an expended time scale, comprising:

recording means for recording said transient signal on a stationary recording media, said recording means having a rotary recording head that is in motion before the appearance of said transient;

trigger means connected to said recording means for completely energizing said recording means upon the appearance of said transient signal and enabling said transient signal to be recorded upon said recording media;

playback means for repetitively scanning said recording media and repetitively reproducing said transient signal;

sampling means connected to said recording means for repetitively sampling the amplitude of successive points of said reproduced transient signal to produce a plurality of amplitude level sample signals, one sample being taken each time the transient signal is reproduced; and

output means connected to said sampling means and responsive to said amplitude level sample signals for producing a replication of said transient signal with an expended time scale.

3. Apparatus as claimed in claim 2 wherein said sampling means includes and AND gate amplifier, a first sawtooth signal generator and a second sawtooth signal generator,

said first sawtooth signal being synchronized with said reproduced signals from said playback means,

said second sawtooth signal having a longer period than said first sawtooth signal,

said AND gate amplifier having a data input and two control inputs, said reproduced signals being coupled to said data input and said first and second sawtooth signals being coupled to said control inputs, respectively, said amplifier comparing the amplitudes of said first and second sawtooth signals and sampling the amplitude of said reproduced signal when said compared amplitudes are equal.

4. Apparatus for recording a transient electrical signal and playing a selected portion of said signal back on an expanded time scale, comprising:

recording means for recording said transient signal on a recording media;

trigger means connected to said recording means for turning on said recording means upon the appearance of said transient signal;

playback means for repetitively scanning said recording media and repetitively reproducing said transient signal;

adjustable gating means connected to said playback means for blanking all of said reproduced transient signal except a selected portion;

sampling means connected to said recording means for repetitively sampling the amplitude of successive points of said remaining portion of said reproduced transient signal to produce a plurality of amplitude level sample signals, one sample being taken each time the selected portion of the signal is reproduced;

output means connected to said sampling means and responsive to said amplitude level sample signals for producing a replication of said selected portion of said transient signal with an expanded time scale.

5. Apparatus as claimed in claim 4 wherein said sampling means includes an AND gate amplifier, a first sawtooth signal generator and a second sawtooth signal generator,

said first sawtooth signal being synchronized with said reproduced signals from said playback means,

said second sawtooth signal having a longer period than said first sawtooth signal,

said AND gate amplifier having a data input and two control inputs, said reproduced signals being coupled to said data input and said first and second sawtooth signals being coupled to said control inputs, respectively, said amplifier comparing the amplitudes of said first and second sawtooth signals and sampling the amplitude of said reproduced signal when said compared amplitudes are equal.