Apparatus (12) for delivering recorded messages to a person called on a telephone, for recording responses by the called person on magnetic tape and for moving a magnetic tape to a particular location to deliver a further recorded message, if necessary. The location of a previously vocalized message is known to a processor (54) via a digitally recorded tape track parallel to the vocal track. Apparatus (50) is disclosed for recording digital data on an audio tape recorder. Specifically, digital data is accurately recorded on tape by trilevel recording in which a signal being recorded returns to a datum level after each data word is communicated to the recorder. This prevents tape recorder drift to a high or low binary level at the end of such a data word.
### FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

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AUTOMATED CONVERSATION SYSTEM

BACKGROUND OF THE INVENTION

The present invention in its various aspects relates to a system by which a machine can communicate with a human and record the person's responses. The invention also relates to techniques for recording digital information on tape.

There are various applications in which it would be convenient to have a system with a facility for carrying on a "conversation" with a person. For example, such a system is particularly useful for telephonic banking. In such application, the cost of the system must be justified. Yet, it must also be very reliable - particularly in such operations as banking transactions.

In carrying on a conversation, the system must be able to give different vocalizations in response to various conditions. If the system asks a question to the banking customer and receives an answer, the system should determine whether the transaction is complete, and if not, ask the next intelligent question. However, if the response from the customer is inaudible or subject to some other infirmity, the system must remedy this problem by reasking the question or by advising the customer of the nature of the problem and then asking him to repeat his response. Hence, the system must have a facility for determining whether the "conversation" is proceeding properly, and must further be able to give vocalizations, whether in the form of responses or questions, depending on various conditions. It is therefore an object of the present invention to provide such a system.

As will be described below, the present invention uses tape recorders to carry on and record the "conversation." The system is faced with the further problem of keeping an accurate record of where various responses or questions or other vocalizations are...
prerecorded on a tape. As will be explained in further
detail below, another aspect of the invention is to use
two tracks of recording, one track having the audio
calizations prerecorded thereon, and the other track
having digital data recorded thereon which cor-
responds to the audio information. The system can select
a vocalization to articulate by playing back the tape
recorder and by means of the digital data recorded on
the tape, can move the tape to the proper starting
point for the selected vocalization.

Although audio tape recorders are well adapted
for recording signals such as voice that have a zero
DC component, they are not well-suited to recording dig-
tal data. Digital data can easily include a substan-
tial DC component, such as a string of high logic
signals which will degrade to a zero or middle level if
it is presented to the audio tape recorder for recording.
This results in a loss of data.

The simplest, least expensive way to write
digital data on an audio tape recorder requires a start-
up period. Basically, a bit coming off a processor,
port can be coupled to the audio input of the recorder.
The computer or processor can use a modulation scheme
using square waves to signify the logic states. However,
when the processor stops modulating the square wave
signal, its voltage level is at one of the two extremes,
high or low. This causes the electronics of the tape
recorder to drift up to or down to that level. The, when
new information is applied to the recorder for recording,
the recorder electronics requires between one-half and
one second to recover the reference or datum level. In
other words, the reference level is lost at the term-
ination of an ordinary square wave and unless it is
restored by a subsequent procedure, the next data that
are written will not be reliably recorded. In various
applications where a given response is needed from the system, such as where the system "converses" with a person, the time required for a subsequent proceeding is not available.

It is therefore another object of the present invention to provide a method and apparatus for reliably recording digital data using an audio tape recorder.

It is further object to provide an inexpensive method and apparatus for recording digital data with an audio tape recorder.

**SUMMARY OF THE INVENTION**

According to one aspect of the invention, a system is provided for communicating with a person on a predetermined subject. The system includes a first audio tape recorder equipped with a tape having two tracks. One one track, a set of vocalizations relevant to the predetermined subject has been prerecorded. This may be done in a sound studio as is well known to the art. The tape has a second track on which are prerecorded a set of digital, machine-readable signals. Such signals correspond to the vocalization set, and the two tracks are played in time registration so that the system knows the locations on the tape of various vocalizations.

The systems uses a second audio tape recorder for recording the vocalizations of the person communicating with the system. A processor controls the activation of both the first and the second tape recorder. It determines whether the information is being safely recorded and can be programed to evaluate data presented by the person communicating with the system. For example, the person may communicate his bank account number to the system by pressing the numbers identifying his account on a Touch-Tone telephone or by dialing his
account number on a dial type telephone.

In response to certain determinations by the processor, the processor will cause the first tape recorder to move its tape to a position at which an appropriate prerecorded vocalization begins, and then to replay the vocalization to the person. At an appropriate time the second audio tape recorder will record incoming information from the person communicating with the system or may record both incoming and outgoing information for a complete record of the communication.

The present invention in another of its aspects relates to a system for communicating with two or more people on a certain subject. The system is similar to the one described immediately above and includes a set of first audio tape recorders each having a tape with two tracks. The first track of each tape includes a set of vocalizations relevant to the predetermined subject and the second track contains a set of digital information. The system also includes a set of second audio tape recorders each having a tape for recording information from a person communicating with the system. A central processor is provided for housekeeping operations and assigns one of the first tape recorders and one of the second tape recorders to a communication with a person.

The central processor which does the "housekeeping" may be assisted by peripheral processors each corresponding to one tape recorder. The peripheral processor has control over the recorder and can cause it to play one or both tracks, record, move tape, rewind, go to a particular tape position, and do other functions as requested by the central processing unit. This greatly alleviates the burden on the central processor.
According to another aspect of the invention, in communicating a data word to be recorded on the tape track, signals representing the data word are generated by a tri-level coupler and inputted to the recorder for recording. As the end of each data word, the signal outputted by the tri-level coupler returns to a datum or reference level which is intermediate the high and low logic state voltages (illustratively).

In the method practiced by the illustrated coupler, a logic circuit receives data to be recorded and emits on a first output a first signal directly corresponding to the data. A second signal corresponding inversely to the data is emitted on a second output of the logic circuit. The second signal is then inverted so that each of the two outputs corresponds directly to the data. These outputs are coupled by a voltage divider to a circuit point which is capacitively coupled to the input of the audio recorder.

After the data are thus communicated, the logic circuit causes its two outputs to have the same voltage (or logic state). Due to the inversion of one output and the voltage divider, the circuit point will have a voltage level which is intermediate the voltage levels corresponding to the high and low logic states.

The consequence of this is that the audio recorder electronics will have a reference level at the end of each data word. The first bit of the next data word will have a voltage level departure from the reference level and will be reliably recorded.

**BRIEF DESCRIPTION OF THE DRAWINGS**

In describing a preferred embodiment of the present invention, reference is made to the accompanying
drawings wherein:

Figure 1 is a set of representative wave diagrams illustrating digital data to be recorded (Fig. 1A), a tri-level representation of such data modulated according to one modulation scheme (Fig. 1B), and signals generated in the apparatus below described (Fig's. 1C and 1D); which is useful in understanding the present invention;

Figure 2 is a circuit diagram illustrating a tri-level recording apparatus according to the present invention.

Figure 3 is a set of representative wave diagrams illustrating a second modulation scheme for modulating data;

Figures 4 and 5 and diagrams illustrating apparatus for demodulating the modulation scheme of Figure 3.

Figure 6 illustrates a system for telephone banking (by one person at a time) according to the present invention; and

Figure 7 illustrates a system for telephone banking (by a group of people at a time) according to the present invention.

DESCRIPTION OF A PREFERRED EMBODIMENT

The aspect of the invention relating to recording digital data on tape will first be described. Figure 1A schematically illustrates an arbitrary eight-bit binary word plotted against time and voltage. A logical high state is represented by a certain positive
voltage level 10; and a logic low state is represented by a zero voltage level 12. The first and last bits of the illustrated eight-bit word of Figure 1A are at a high level. If this word is impressed on line coupled to the input of an audio tape recorder, after the conclusion of the word, the recorder electronics will drift towards the positive voltage representing the high voltage level at the end of the last bit. When the next data word is communicated to the recorder, the first bit can easily be lost to the lost reference level occasioned by this drift in the recorder electronics.

According to the method of the present invention, however, at the end of communicating a certain quantity of information, illustratively an eight-bit word, the voltage level is returned to some particular voltage level. Figure 1B illustrates the data of Figure 1A modulated according to one modulation technique described below, but having a voltage level 14 intermediate the high and low levels 10 and 12. Returning to level 14 will preserve the datum level of the audio recorder electronics, so that the next data word to be recorded can begin from reference level 14 and record information reliably. Thus, the first bit of Figure 1B starts at level 14.

Figure 2 shows illustrative apparatus for practicing the method of Figure 1B. Digital data to be recorded is applied to a microprocessor 20 in eight-bit parallel format. Microprocessor 20 itself or with the assistance of a parallel to serial converter (not shown) converts the data to serial format and outputs corresponding signals on two output leads 22 and 24. As a complex circuit environment may require more port capability than the microprocessor has, a latch 26 can be used to couple the output ports of microprocessor 20 and thereby expand the port capability.

Output 22 is applied to the input of an inverter 30. The output of inverter 30 is coupled by a resistor 32 to a circuit point 34.
The output 24 from microprocessor 20 is coupled to inverters 36 and 38 connected in series. These two inverters in series convert the zero to three volt swing of TTL logic of the microprocessor to CMOS voltage levels so that the voltage swing between the high and low logic states is about five volts. The output of inverter 38 is coupled by a resister 40, matched to resistor 32, to circuit point 34. A roll-off capacitor 42 couples point 34 to ground, and a capacitor 44 couples circuit point 34 to the input of an audio tape recorder, illustratively the "line" input.

The microprocessor can use a variety of modulation techniques, such as the so-called "Kansas City standard." According to that modulation scheme as heretofore known, a modulator (i.e. microprocessor 20) outputs two cycles of a two kilohertz signal to indicate one binary logic state, and outputs one cycle of a one kilohertz signal to indicate the other binary signal. That scheme is modified to begin with and return to an intermediate voltage level 14, as shown in Figure 1B. It will be understood that other signals may be inserted between the two instances of the voltage level 14, such as training signals in a preamble, or a parity bit, or others as are conventional in the art.

When the microprocessor 20 is not communicating a data word, it causes its output signals to be in parity, that is, both at the same state. It can be seen that when the signals on leads 22 and 24 are the same, opposite polarity but equal amplitude voltage levels will be outputted by inverters 30 and 38. These voltage levels are coupled by the voltage divider formed by matched resistors 32 and 40 to circuit point 34 which therefore will be at a voltage level precisely at the mean of the high and low voltage states.
To communicate a logic high state, the outputs of inverters 30 and 38 are both caused to be high, illustratively. In this case, the voltage level of lead 22 must be low, whereas the voltage level of lead 24 must be high. Figures 1C and 1D show the voltage levels on leads 22 and 24 corresponding to the data word of Figure 1A. Thus, the conditions for generating a high logic level for the first bit are that \( V_{22} \) is low and \( V_{24} \) is high, as illustrated. Conversely, to output a logical low state for the second bit of Figure 1A, the voltage on lead 22 must be high and the voltage on lead 24 must be low. These voltage levels are determined by microprocessor 20. It will be seen that the voltage \( V_{24} \) but for the voltage levels at the beginning and end of the eight-bit word, corresponds to the data word of Figure 1A. It will also be noted that the voltage \( V_{22} \) shown in Figure 1C corresponds inversely to the Figure 1A data word.

At the end of the last bit, the voltage on each of leads 22 and 24 drops to or remains, illustratively, low. The low level of lead 22 will be inverted by inverter 30 to present a high voltage of one magnitude at circuit point 34. The low voltage on lead 24 will be inverted and then reinverted and presented to circuit point 34 as a voltage level of equal amplitude to that voltage derived through inverter 30 but of opposite polarity. Consequently, when the voltages \( V_{22} \) and \( V_{24} \) drop to low, the reference level of 2.5 volts, illustratively, will result at circuit point 34 and be communicated to the tape recorder by capacitor 44.

Another modulation scheme which can be used is a new modification of the well-known Manchester bi-phase technique. This new modification is a doubled, fully redundant, balanced, bipolar, Manchester bi-phase technique. This modification is a short-term balanced, highly noise resistant code. As illustrated below, it uses the tri-level recording, although it need not.
Referring to Figures 3A and 3B respectively, in a standard Manchester code, a level change from a low state 12 to high state 10 represents a logical "high" or "1" bit, and a change from high state 10 to low 12 is a "low" or "0" bit. (Shaded areas 45 represent indeterminate, irrelevant states). The data signals may be concatenated in various combinations. Figure 3C shows the standard Manchester concatenation of bits "0011." It can be seen that such a concatenation is not short term balanced. This causes problems in recording on an audio recorder.

The modified code gives the data both a low duty cycle and a high duty cycle. Figure 3D illustrates a "0011" word according to the modification, which doubles each standard Manchester representation and then concatenates the sequence. In Figure 3C, the set of separate voltage levels of various durations is represented by the set a, b, c, d, e, f and g. In the modified code shown in Figure 3D, this set is shown primed as a', b', c', d', e', f' and g'.

The remaining sketches in Figure 3 illustrate other concatenations in the modified code and include other features. Thus, Figure 3E shows the word "0110010" preceded by a preamble period for defining a period 3T against which a demodulator will compare subsequent periods of 2T or 4T. Figure 3E also shows a parity bit following the eight bits of data. This parity bit is used in determining the reliability of data transmission in manners well-known to those skilled in the art.

Figure 3F illustrates the word "11111111"; Figure 3G illustrates the word "00000000"; and Figure 3H illustrates the word "10101010", each having respective preamble and parity bits.
Figure 4 represents an illustrative system showing binary data inputted to the binary to tri-level coupler 50 of Figure 2. The tri-level signal is recorded on tape by audio recorder 52. To retrieve the data from tape, a microprocessor central processing unit (CPU) 54 can command recorder 52 via a command control connection 56 to replay. The outputted signals thereof are then coupled to a device such as a hysteresis comparator 58 which gives symbol recognition with good noise immunity. Comparator 58 will not be triggered by the intermediate level 14 and will pass binary signals to a transition detector 60 and to a period counter 62, (Figure 5 shows an illustrative transition detector 60.) The output of detector 60 interrupts CPU 54 from whatever it might be going and signals that the voltage level of the data signal has changed. The period counter measures the time between changes and communicates this data to CPU 54 on an eight line bus. It will be appreciated that CPU 54 could handle the functions of detector 60 and 62, but to free it for other activity, it is preferred to use the detector 60 and counter 62 combination. CPU 54 can discard alternate cycles and use standard Manchester decoding techniques to decode the data.

Figure 6 is a block diagram representing a system for telephone banking with one customer at a time. The customer telephones on a line 60. The call is electronically coupled to the system by an interface unit 62. A recorded message, on one track of tape in a Recorder A, answering the telephone call is played under control of a CPU 64. When it is an appropriate time for the customer to respond, a Recorder B is directed by CPU 64 to record the information inputted on line 60, whether the information is spoken word or electronic signals. If the latter, interface 60 may operate on the signals to generate representative signals which are recorded by Recorder B.
The CPU 64 may cause Recorder A to move the tape to any position to give a selected prerecorded vocalization in response to a corresponding occurrence. When the communication is complete, the telephone link will be released.

Figure 7 illustrates a similar system but with greater capability. Several customers may call on respective telephone lines 60'. The CPU 64 will determine whether a pair of recorders is available and, if so, will assign them to the call. If not, a "busy signal" will be given.

It is to be understood that any individual aspect of the present invention will be applicable to specific applications other than telephone banking. For example, the tri-level data recording method and/or apparatus is well suited to use with any computer system, especially low-cost systems used by home consumers or hobbyists.

It will be apparent to those who are skilled in the art that several modifications or alterations may be made to the embodiment of the tri-level recording apparatus described herein and other apparatus may be devised to practice the invented method. It is therefore to be preferred that this specification be taken in an illustrative sense and that the scope of protection afforded be determined by the appended claims.
I CLAIM:

1. A machine-implemented method for coupling binary digital information to be recorded to an analog recorder comprising:
   generating and coupling to the recorder a sequence of first and second voltage levels, the sequence corresponding to the data to be recorded;
   then forming and coupling a third voltage level to the recorder.

2. The method according to claim 1 wherein said third level is intermediate said first and second levels.

3. The method of claim 1 or 2 wherein said generating and coupling a sequence of first and second voltage levels comprises:
   generating a first sequence of voltage levels corresponding directly to the data to be recorded;
   generating a second sequence of voltage levels corresponding inversely to the data to be recorded;
   inverting a selected one off said first and second sequences;
   combining said first and second sequences in time registration to provide an output sequence of voltage levels; and
   coupling said output sequence to the input of said recorder.

4. The method of claim 3 wherein said forming and coupling a third voltage level comprises controlling the voltage level of each of said first and second sequences to be equal.
5. Apparatus for facilitating recording of digital information on an analog recorder comprising: a logic circuit receiving the data to be recorded and outputting on first and second outputs signals related to the data to be recorded; means coupled to said first logic circuit output for inverting said first outputs with respect to second output; means coupling the output of said inverting means to a circuit point of said apparatus; means coupling said second output of said logic circuit to said circuit point, whereby when both of the outputs of said logic circuits are at the same voltage level, said circuit point will be at a voltage point intermediate the voltage levels corresponding to high and low logic states; said logic circuit outputting signals on said first output of said logic circuit being inversely related to signals on said second output.

6. The apparatus of claim 5 further comprising a latch coupling said logic circuit to said inverter.

7. The apparatus of claim 5 further comprising a pair of series connected inverters coupling said second output of said logic circuit to the second named coupling means.

8. The apparatus according to claim 5, 6 or 7 further comprising a roll-off capacitor coupling said circuit point to ground, and further including a coupling capacitor coupling said circuit point to the input of the analog recorder.
9. A tape system for recording both essentially non-digital signals and digital signals on the same tape comprising:

an audio tape recorder having first and second recording tracks, said recorder being coupled to receive and record the essentially non-digital signals on said first track;

coupling means for receiving and generating signals representative of the digital signals to be recorded, said representative signals initiating and concluding with a reference voltage level applied to said audio tape recorder;

said audio tape recorder being coupled to receive and record said representative signals on said second track.

10. The system of claim 9 wherein said coupling means modulates the digital data so that said representative signals include modulated digital signals between said reference voltage level at the initiation and conclusion of said representative signals.

11. A system for communicating with a person on a predetermined subject comprising:

a first audio tape recorder having a first tape on a first track of which a set of vocalizations relevant to said predetermined subject has been prerecorded and on a second track of which a set of digital, machine-readable signals corresponding to said vocalization set;

a second audio tape recorder having a second tape for recording vocalizations of the person communicating with the system;

processor means for causing said first audio tape recorder to play a selected vocalization by commanding said first recorder to move said first tape to a position at which said selected vocalization begins.
said processor means determining said position via said set of digital, machine-readable signals,

said processor means also causing the said second recorder to record on said second tape said vocalizations of the person to communicating with the system.

12. A system for communication with two persons on a predetermined subject comprising:

a set of first audio tape recorders each having a respective tape on a first track of which a set of vocalizations relevant to said predetermined subject has been prerecorded and on a second track of which a set of digital, machine-readable signals corresponding to said vocalization set has been prerecorded;

a set of second audio tape recorders each having a respective tape for recording vocalizations of one of the persons communicating with the system;

central processor means for assigning a selected one of said first recorders, and a selected one of said second recorders to a person communicating with the system and for causing the selected first recorder to play a selected vocalization by commanding said selected recorder to move its tape to a position at which said selected vocalization begins, said processor means determining said position via said set of digital, machine-readable signals,

said central processor means also causing the selected second recorder to record on its tape the vocalizations of said person,
INTERNATIONAL SEARCH REPORT

International Application No PCT/US80/01753

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) *

- According to International Patent Classification (IPC) or to both National Classification and IPC
- IRC: G11B 5/09, 15/48
- USCL: 360/40, 74.4

II. FIELDS SEARCHED

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*Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.*

III. DOCUMENTS CONSIDERED TO BE RELEVANT **

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<td>US, A, 3,804,993 Published 16 April 1974 Harrold et al</td>
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** Special categories of cited documents:**
- "A" document defining the general state of the art
- "E" earlier document but published on or after the international filing date
- "L" document cited for special reason other than those referred to in the other categories
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but on or after the priority date claimed
- "T" later document published on or 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

IV. CERTIFICATION

Date of the Actual Completion of the International Search **

20 March 1981

International Searching Authority **

ISA/US

Date of Mailing of this International Search Report **

02 APR 1981

Signature of Authorized Officer **

[Signature]

Form PCT/ISA/210 (second sheet) (October 1977)
V. OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE 10

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claim numbers ......... because they relate to subject matter 10 not required to be searched by this Authority, namely:

2. Claim numbers ......... because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out 10, specifically:

VI. OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING 11

This International Searching Authority found multiple inventions in this international application as follows:

I. Claims 1-10
II. Claims 11-12

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.

2. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:

3. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest:

☐ The additional search fees were accompanied by applicant’s protest.
☒ No protest accompanied the payment of additional search fees.