THE TAPE RECORDER SHUTDOWN ALARM

Jacob C. Hahn
Member Technical Staff M/S DA-37
Rockwell International
12214 Lakewood Boulevard
Downey, California 90241

ABSTRACT

Data from the Space Shuttle is recorded on magnetic tape during manufacture, during pre-flight tests and during flight. Thus a permanent record is obtained for all tests. When a tape recorder suddenly stops before the end of its run, some data will not be recorded. Tape recorders run silently and make no sound when they stop. A tape recorder that is not running is easily observed, but constant visual monitoring is impractical. Yet it is important that personnel become aware of the problem at once. An audio alarm that sounds when a tape recorder stops before the end of its run will alert personnel. An alarm in use at Rockwell's Flight Systems Laboratories not only sounds when a tape recorder stops before it is supposed to, but it turns on a standby recorder in less than two seconds.

INTRODUCTION

Very few tests are conducted that involve the Space Shuttle where data is not recorded on magnetic tape. The tape provides a permanent record of data that can be processed later. In the event of an anomaly, it can be played back repeatedly while the data is examined for clues. Tape recorders, of course, have their own anomalies, one of which is that they can suddenly stop while recording. When they stop it is essential that the fact becomes known at once. An audio alarm will alert personnel as to what has happened. It should be loud enough to be heard by those who have left the recording area to perform duties elsewhere. A description of such an alarm, how it works and how it is used, is given in the following pages.

THE RECORDING SET-UP

A block diagram of the set-up used to record test data at the plant in Downey is shown in Figure #1. The tape recorders are equipped with end-of-tape sensing circuits that enable the recorders to stop just short of where the tape would unwind from the reel. This feature is extremely important during the time when the tape is being rewound because of the high

speed that is used. If the tape was not stopped, it would come off the reel in a heap and be mangled. The tape speed is gradually reduced until the tape stops, because a sudden stop at high speed would cause the tape to break.

The end-of-tape sensing circuit provides an additional service. When end-of-tape is sensed, a discrete “start-up” signal is sent to the other recorder via the switchover cable and it starts to record. A built-in delay enables the first recorder to keep recording for about one minute before it stops. Thus an overlap of data is provided for the short period when both recorders are recording. A tape recorder that is merely playing back and not recording will not send a start-up signal to the other recorder when it senses end-of-tape.

After a switchover has occurred and one recorder has stopped, its tape is rewound and removed. The heads are cleaned and a new reel of tape is installed. When the other tape recorder nears the end of its tape, it will send a start-up signal to the first recorder. As long as the reels are changed the action is automatic and continuous. The recording is halted only when the STOP button is depressed on the recorder in operation at the time.

CAUSES OF TAPE RECORDER SHUTDOWN

It might be felt that a discussion of this kind belongs in a separate paper. The author does not think so. A complete knowledge of what can happen and why, led directly to the design of the Tape Recorder Shutdown Alarm. The design, breadboarding and construction were completed in two days. It is hoped that the discussion which follows will provide the impetus for the installation of the alarm wherever instrumentation tape recorders are used. Little can be done to prevent a tape recorder or any electronic device from failing. The difficult task is to explain why the failure was not detected immediately. An audio alarm provides immediate detection.

COMPONENT FAILURE

The Capstan Motor and the reel motors have a finite life expectancy. The same is true of the electronic circuits that control these motors. The solid state components might last indefinitely, but the electrolytic capacitors will not. With present day technology the time between failures might be several years, but all devices fail eventually.

FAILURE TO SWITCHOVER

If the first recorder reaches the end of its run and stops and the other recorder has not started to record, then we have a “failure to switchover”. This is a case where a tape recorder has not stopped before the end of its run. A tape recorder has failed to start when it is supposed to. The definition of the need for an audio alarm must be broadened. An

audio alarm is needed to alert personnel that the recording process has stopped. The Tape Recorder Shutdown Alarm described here fulfills this need.

The failure to switchover can be the result of the failure of the first recorder to provide the start-up signal or the failure of the second recorder to respond.

FAILURE TO PROVIDE START-UP SIGNAL

The end-of-tape sensing utilizes two incandescent lamps whose beams are permitted to fall on sensors when the end of the tape is near. These lamps will stop the tape in either direction. If the upper lamp has burned out or its sensor has failed, then an end-of-tape signal will not be provided nor the start-up signal to the other recorder. The tape movement will stop when all the tape has left the top reel. Both recorders will be stopped and no data will be recorded. An alarm is necessary to alert personnel.

FAILURE TO RESPOND TO START-UP SIGNAL

Inside the tape recorders are incandescent lamps that help provide constant tape tension. The lamps are mounted on arms that move in response to changes in tape tension. The amount of light that falls on a receptor generates a proportional voltage that is used to control the power furnished to the upper and lower reel motors. These incandescent lamps can burn out. (Later model tape recorders use Light Emitting Diodes whose life expectancy greatly exceeds that of incandescent lamps.) If the upper lamp has burned out, the tape recorder will not start in the forward direction. If the lower lamp has burned out, the tape cannot be rewound. (Tape recorder will not run in the reverse mode.)

A number of relays in both recorders are involved in the switch-over function. Their outright failure or inability to open or close on time can also result in a failure to switch-over.

DESIGN CONSIDERATIONS

A decision was made to use one of the data signals recorded on the tape. The reproduced output would be monitored. Its absence would set off an alarm; its presence would prevent the alarm from sounding. Analog and PCM data of various types are recorded, and equipment designed to use one of these signals would work only if that signal was being recorded. A servo reference frequency is recorded on all tapes recorded at the Flight Systems Laboratories in Downey. The Tape Recorder Shutdown Alarm was designed to utilize this signal.

THE TAPE RECORDER SHUTDOWN ALARM

A block diagram of the first prototype is shown in Figure #2. The connection to two tape recorders is shown in Figure #3.

A sinewave servo frequency from a recorder is applied to a diode detector. The detected envelope is a D.C. voltage. The one volt RMS input voltage produces an output voltage of from 0.5 to 1.0 VDC. A voltage comparator is used to convert this to the 5 volt level required to operate integrated circuits. An audio frequency generator produces a 256 HZ square wave output which is applied to a NAND gate. A servo frequency at either input will produce a D.C. voltage output from the detector. This in turn produces a 5 volt output from the voltage comparator. A 5 volt level at either input to the NOR gate will produce a zero level at its output. Since a 5 volt level is required to enable the audio signal to pass through the NAND gate, the alarm will not sound.

If both recorders are stopped, no servo frequency is applied to the diode detector and their output is zero. The voltage comparator outputs are also zero. This causes the NOR gate output to go high, which enables the NAND gate and the square wave to pass through. The alarm has sounded!

The prototype was built and it worked. It enabled personnel to build cables and electronic equipment while data was being recorded. Every two hours a switchover would take place and the tapes would have to be changed. If the alarm went off, the standby recorder was manually placed in the record mode. This took about 5 to 10 seconds. Five to ten seconds of data was lost. If personnel were working two aisles over or in the next room, then 30 seconds of data would be lost. This was unacceptable. It was decided that the alarm should be used to turn on a standby recorder. Tape recorder switchover is initiated by the closure of two relay contacts which made the task an easy one. The process would be automatic and require no operator assistance.

A second prototype was built and is shown in Figure #4. Connections to tape recorders are shown in Figure #5. The circuit works as follows. The high level at the output of the NOR gate that sets off the alarm is used to trigger the one shot multivibrator whose one second duration output pulse energizes the relay (K1) just long enough to close the contacts and send a start-up signal to the standby recorder.

In Figure #6 a recording arrangement that uses four tape recorders is shown. The recorders are connected to operate in pairs. At any one time the same data is being recorded on two machines. The failure of one recorder will not result in loss of data. In addition, data loss due to circuit failure while recorder continues to run will affect one machine only. Another advantage of this arrangement is that where tapes record for two hours, the second pair of

recorders can be started one hour later. This is a useful feature when the data run of interest is located on two tapes, it may also be found on one tape from the other pair of recorders. This is useful during playback. The arrangement is fine and no standby recorder is required. The audio alarm is still needed.

A third prototype (which has not been built) is shown in Figure #7. Four tape recorders are shown connected in Figure #8 and a standby recorder. The failure of any one of the four recorders will set off the alarm. This prototype can be used for two, three, four or five recorder operations and is therefore the most useful design.

USE OF SQUARE WAVE SERVO REFERENCE

The usual servo reference signal generated by a tape recorder is not a sinewave but a square wave. This is easily converted to a sinewave by placing a band pass filter in the alarm just before the diode detector.

USE OF ALARM WHEN A SERVO REFERENCE SIGNAL IS NOT USED

Some tape recorders are purchased without the servo option. A block diagram shown in Figure #9 shows the equipment which must be added. Suppose a 128 kilobit PCM signal is being recorded. A 5 KHZ sinewave signal 20 db below the PCM signal in amplitude is mixed with the PCM data before it is recorded. This is shown in Figure #9 . In Figure #10, the set-up required for playback is shown. A high pass filter removes the 5 KHZ signal from the PCM wave-train and a band pass filter recovers the 5 KHZ sinewave which is then amplified 20 db to a level required by the alarm.

SUMMARY

The Tape Recorder Shutdown Alarm alerts personnel that the recording process has stopped because the recorders have stopped. It provides no alarm in cases where the recorders continue to run even though no data is being recorded due to a malfunction of electronic circuitry. This type of failure can be detected only by monitoring the reproduced outputs of all tracks. In installations where four recorders are often employed in redundant recording, the third prototype should be built.

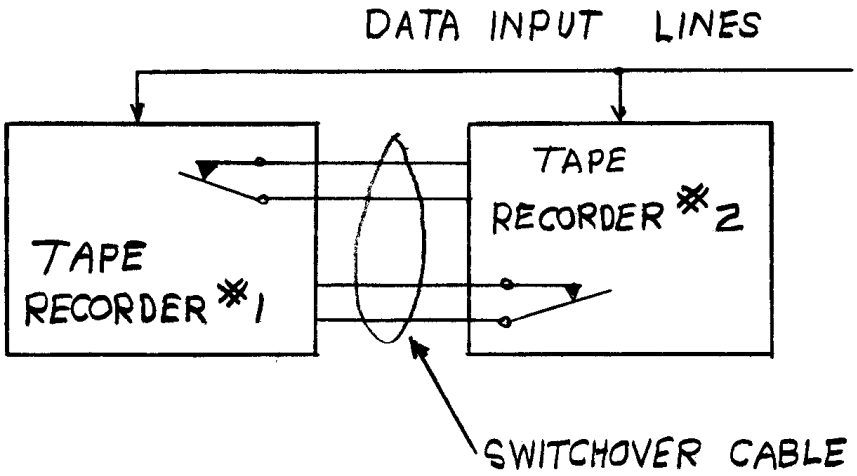

FIGURE #1 - TAPE RECORDERS CABLED TO SWITCHOVER AT END OF RUN

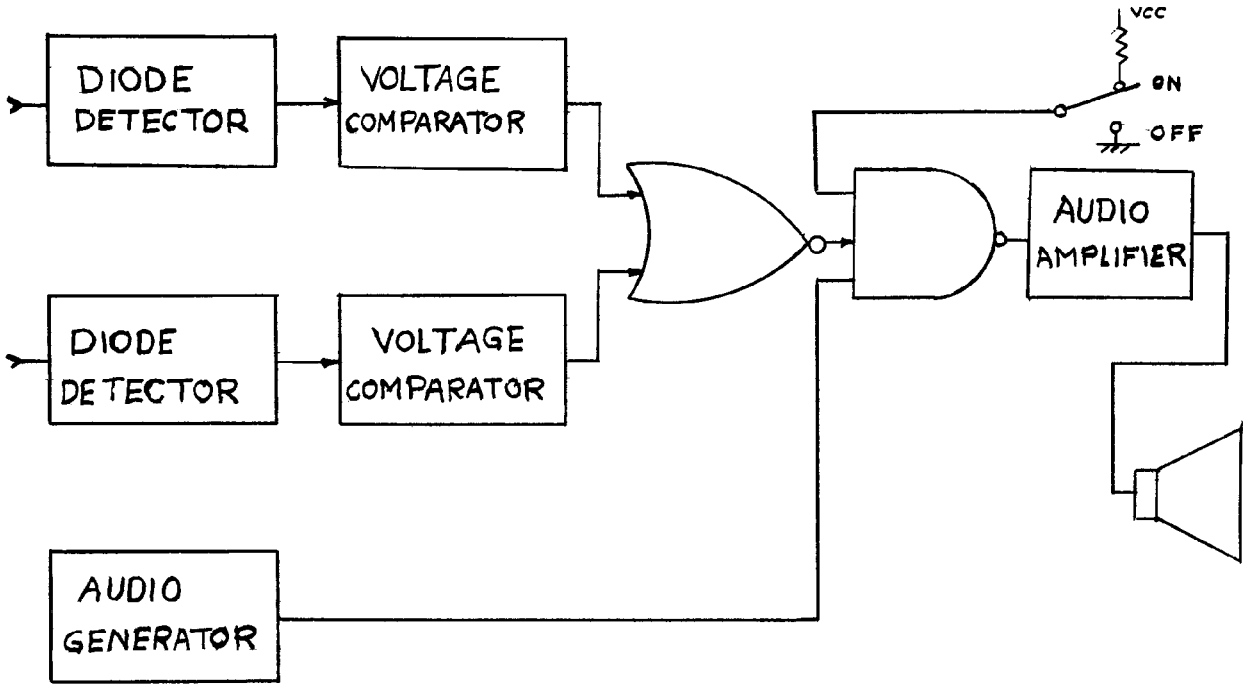

FIGURE #2 - TAPE RECORDER SHUTDOWN ALARM

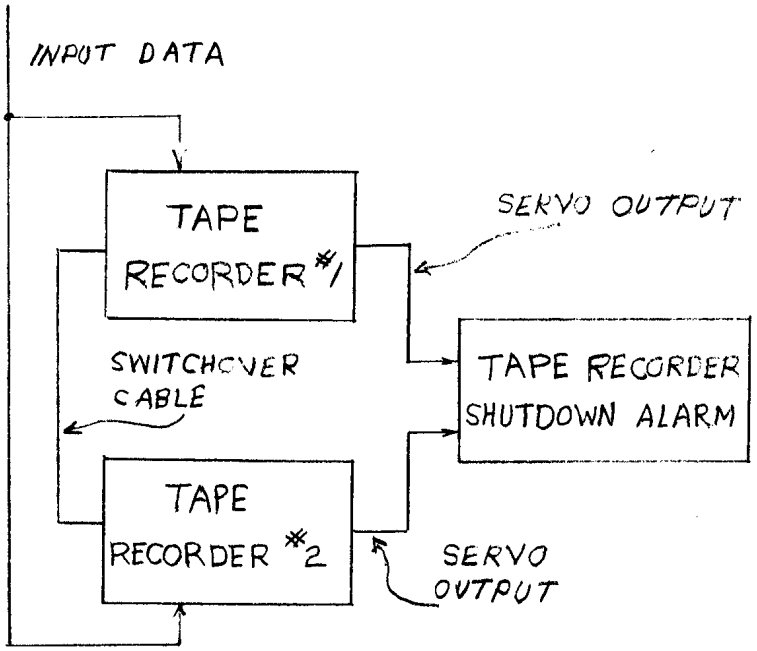

FIGURE #3 - ALARM CONNECTED TO TWO RECORDERS

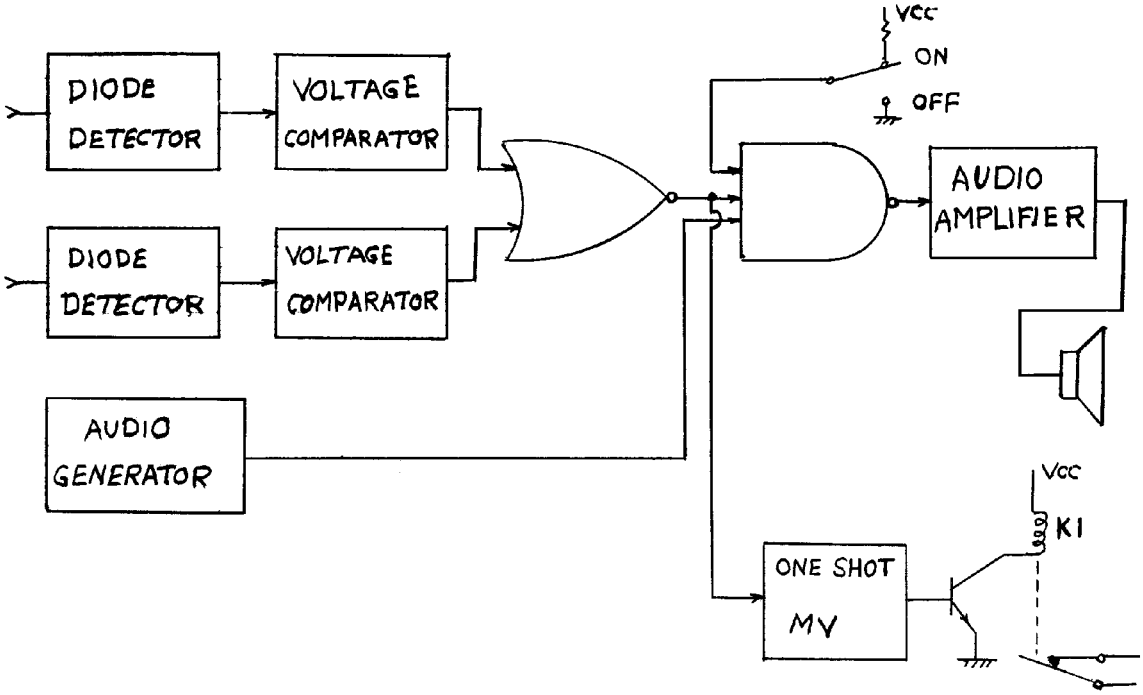

FIGURE #4 TAPE RECORDER SHUTDOWN ALARM EQUIPPED TO START STANDBY RECORDER

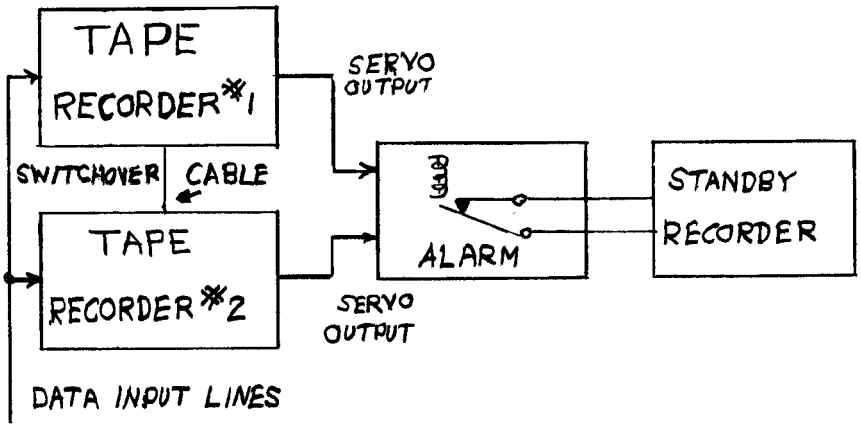

FIGURE #5 - ALARM CONNECTED TO STANDBY RECORDER

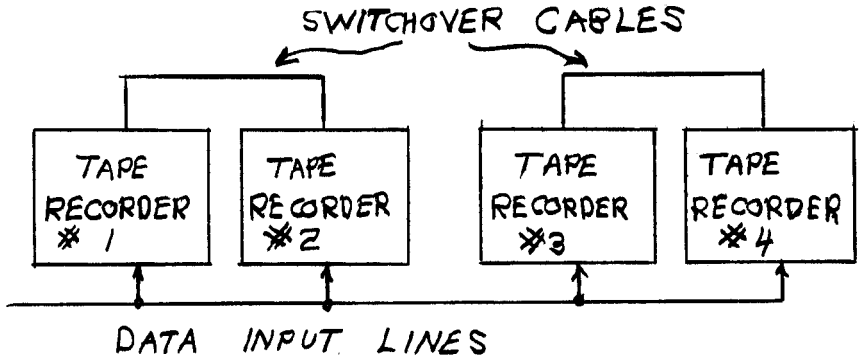

FIGURE #6 - USE OF REDUNDANT RECORDING TO PREVENT DATA LOSS

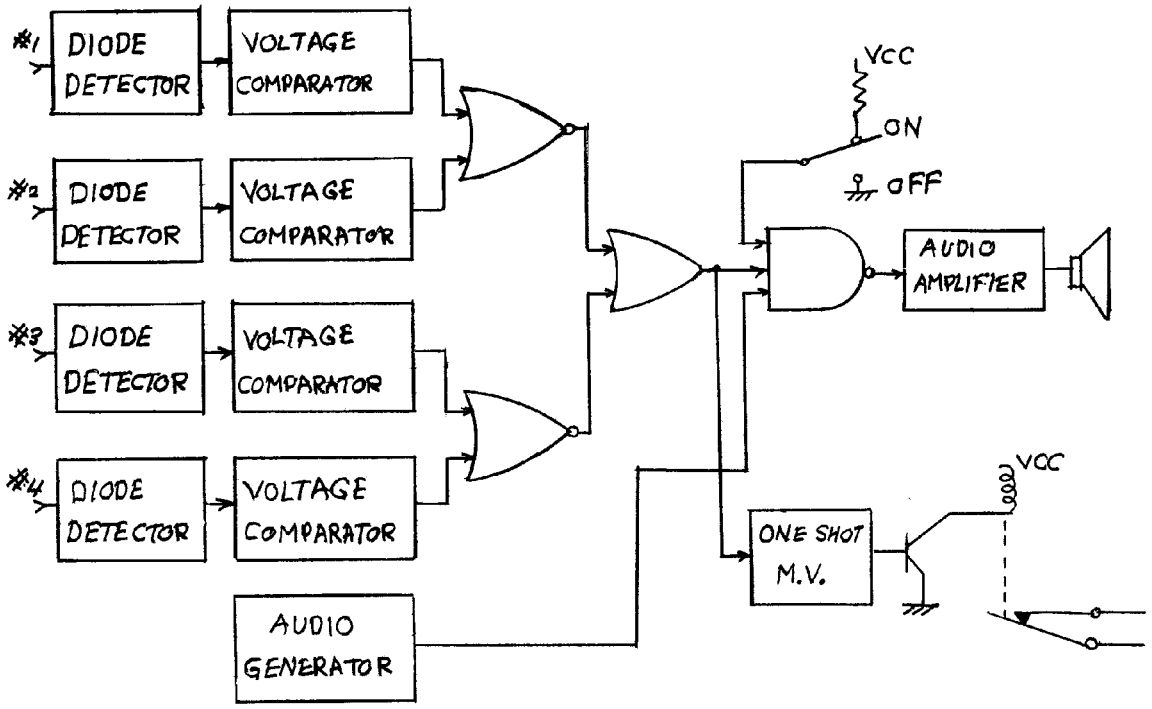

FIGURE #7 - ALARM FOR USE WITH FOUR RECORDERS

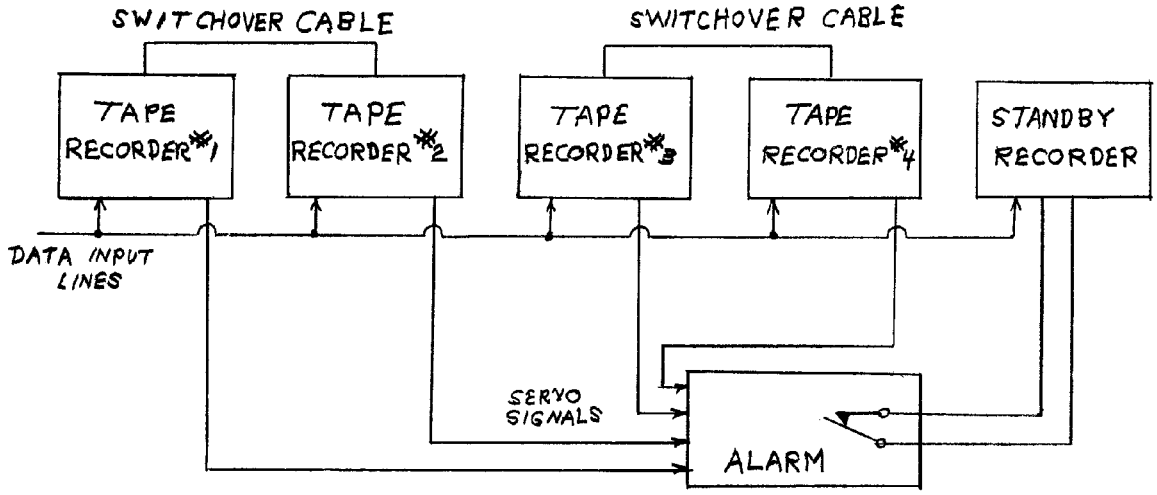

FIGURE #8 ALARM CONNECTED TO STANDBY RECORDER FOR REDUNDANT RECORDER SET UP

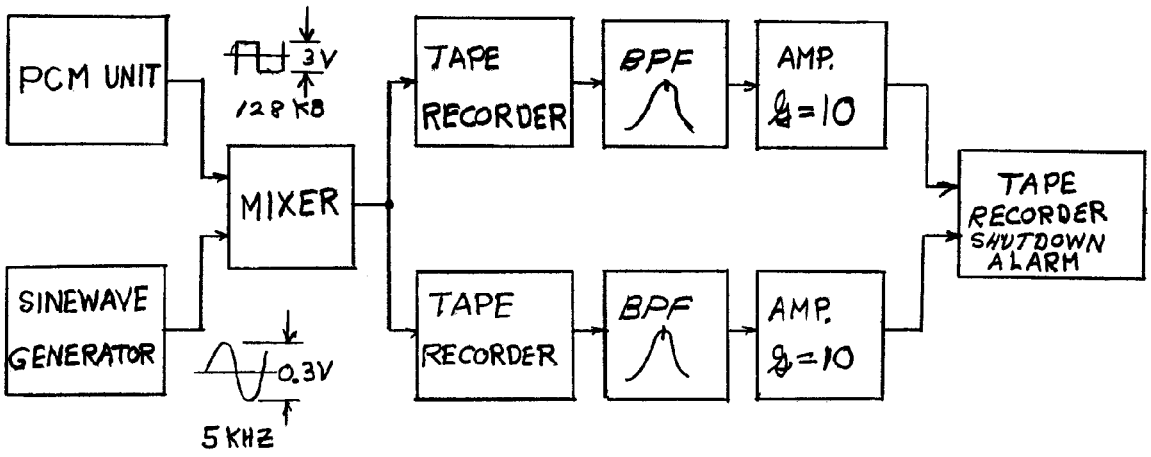

FIGURE #9 - ALARM USED WITH TAPE RECORDERS THAT DO NOT RECORD SERVO SIGNALS

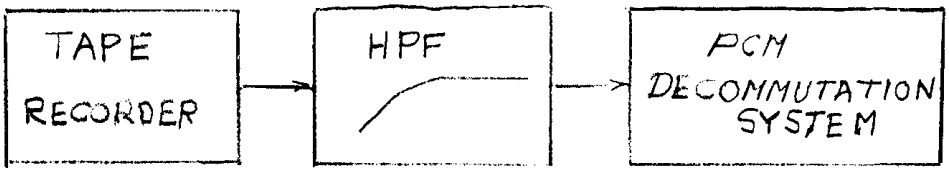

FIGURE #10 PLAYBACK OF PCM DATA MIXED WITH ALARM SIGNAL