DIGITAL DATA CASSETTE RECORDING SYSTEM

Ernest A. Dahl
Naval Ship Weapon Systems
Engineering Station
Port Hueneme, California

Michael Shields
Sony Technology Laboratory
Palo Alto, California

ABSTRACT

The Digital Data Recording System employs digital encoding and time-compression combined to provide a DC-to-1MHz data channel. And two audio channels with bandwidth of 50 to 10KC on a commercially available Beta-format video cassette.

INTRODUCTION

In recording telemetry data during missile flights and various airborne vehicle test programs a requirement developed for a small, inexpensive data recorder capable of recording radio receiver outputs which may have modulation from DC to 1MHz using FM/FM, PAM, or PCM data formats. The system (Figures 1 and 2) described fulfills these requirements.

THE SYSTEM

A common problem in the area of instrumentation (telemetry) recording has been the bulky size of the tape and the tape transports. The requirement for long recording times at high data rates has resulted in the use of a large quantity of tape. This problem was solved at an early point in video recording with the use of rotary heads, which gave high writing speeds with much more efficient use of tape area. Several hours of video may now be stored on a cassette the size of a paperback book, using a relatively small transport. Unfortunately, this progress has been slow in finding its way into instrumentation recording because the picture video information is naturally segmented into lines and frames as the rotary head passes across the width of the tape. Instrumentation data is usually one long continuous track. The solution to this problem is time-compression, made possible by the evolution of low-cost digital conversion stored briefly in memory, and put on tape in bursts. The operation is reversed during playback, resulting in continuous data with no head-switching holes. An additional benefit of digitizing the signal for recording is the ability to record DC in the signal.

A telemetry recording system incorporating these methods has been developed and demonstrated by the Sony Technology Center (Palo Alto, CA) in cooperation with the U.S. Navy's NSWSES group, represented by Ernest Dahl. The system consists of a modified Betamax industrial video recorder and an adapter for data conversion and formatting. The primary data channel records DC to 1MHz, and two auxiliary channels are provided for voice or time-code. Recording time is 30 minutes with a commercially-available L-500HG Beta video cassette, or 45 minutes with an L-750HG cassette.

THE RECORDER

The system consists of two units, the first of which is the Recorder/Reproducer (Figure 3). This unit (Figure 4) is a highly modified industrial Betamax video recorder, using the standard Betamax scanner and transport which includes a brushless motor, but running at twice normal scan rate resulting in a writing speed of 550 ips. The record and reproduce electronics have been replaced with wideband circuits to allow recording of digital data at 27.5 Mbits per second. The two standard auxiliary channels have been retained for recording of voice or time-code. Meters and level controls are provided. All standard remote control functions are also retained, including remote tape index display and auto-search. Standard heads (Figure 5) are used, with an expected useful life of approximately 1000 hours.

THE ENCODER

The second part of the system is the Encoder/Decoder (Figure 6). This unit digitizes the signal to be recorded and formats the digital data in blocks for the recorder (Figure 7). The input signal is sharply filtered at 1MHz, sampled at 2.6 MHz, and converted to eight-bit digital words. The input circuit is direct-coupled, DC information in the signal can be encoded and recorded.

At this point, a problem arises due to the nature of rotary-head recorders. Although the data is sampled continuously, it must be sent to the recorder in bursts corresponding to the time when the rotating head is in contact with the tape, and allowing for gaps when switching between the two heads. For this reason, the data travels through a FIFO (first-in-first-out) memory buffer, entering continuously and exiting in bursts. This time-compression process is reversed in playback, when bursts are read from tape and data is continuously converted back to analog. The FIFO buffer performs the additional task of removing all tape flutter from the off-tape signal. The data signal to the recorder consists of a single serial line with a rate of 27.5 Mbits per second. For optimum recording, it is desirable that this signal have no DC component, which would cause level shifts in the record circuits of the recorder and in the decoding circuit of the encoder/decoder. For this

reason, each eight-bit data sample is translated into a ten-bit binary word having five ones and five zeros. When this ten-bit data is serialized, there will be no DC component.

THE TAPE

The limiting factor in the system performance is the tape. Magnetic tape is still an art and not a fixed process. Any tape problems such as scratches, dirt, surface finish imperfections, or non-uniform distribution of particles will result in errors of omission of data. Therefore the highest quality tape is necessary to ensure optimum performance.

WORD ERROR COUNTER

A word error counter has been developed for use in system operation testing and for evaluating tape dropout content. This device generates a digital test signal to be recorded and then monitors the playback of this signal. Word errors are accumulated and a continuous display is provided of errors per million words. This device is powered by the encoder unit and is approximately the size of a tape cassette.

AUTO SEARCH/REMOTE CONTROL UNIT

A standard search and remote control assembly is available that reads out tape position and permits, with contained keyboard, the selection of any tape position for either record or playback. The same unit can be used for remote control-record/play operation. The size of this unit is 3 1/2" by 1 1/2" by 7 inches.

DIGITAL DATA RECORDER/REPRODUCER PRELIMINARY SPECIFICATIONS

The Digital Data Recorder combines a high density digital data channel with two general purpose analog channels on a commercially-available Beta-format video cassette. The input data rate may be up to 27.5 Mbits/sec. Data must be in a DC-free form with allowance for a head switching rate of 120 Hz. Such a format is provided by the SONY Data Encoder.

SPECIFICATIONS

Digital Data Channel (input and output)

Signal level	$0.5V_{pp}$, AC (75 ohm load)
Maximum bit rate	27.5 MHz
Recording system	Two-head helical scan

Packing density	50.0 KBits/inch
Writing speed	550 ips

Analog Channels (two)

Frequency response	50 to 10,000 Hz
Signal-to-noise	45 dB

Sync Signal (input and output)

Level	TTL
Frequency	120 Hz (head switch)

General

Tape	SONY HG Beta cassette or equiv.
Record time	30 min (L-500 tape)
	45 min (L-750 tape)
Dimensions	15.5 x 5.9 x 14.4 inches (w/h/d)
Weight	28 pounds
Power Consumption	70W, 120Vac, 50/60Hz

DIGITAL DATA ENCODER/DECODER
PRELIMINARY SPECIFICATIONS

The Digital Data Encoder makes possible the digital recording of a DC-to-1MHz analog signal when used with a helical-scan digital data recorder such as the SONY Data Recorder. The encoder digitizes a DC-to-1MHz analog signal, formats it for serial (single track) digital recording, and performs the corresponding playback functions. The data output format is a DC-free “8/10 block” serial code with interspersed sync information. Allowance is made for head switching at a 120 Hz rate.

SPECIFICATIONS

Data Conversion

Analog signal level	±1V (75 ohm load)
Signal bandwidth	DC to 1 MHz (-3dB at 1 MHz)
Signal-to-noise	48dB
Sampling rate	2.619 MHz
Quantization	8 bits

Recorder Signal (input and output)

Level	$0.5V_{pp}$, AC (75 ohm load)
Bit rate	27.5 MHz

Sync Signal (output)	
Level	TTL
Frequency	120 Hz (head switch)
General	
Dimensions	15.5 x 3 x 14.375 inches (w/h/d)
Weight	15 pounds
Power Consumption	35W, 120Vac, 50/60Hz

FIGURE 1. DIGITAL DATA RECORDING SYSTEM, FRONT VIEW.

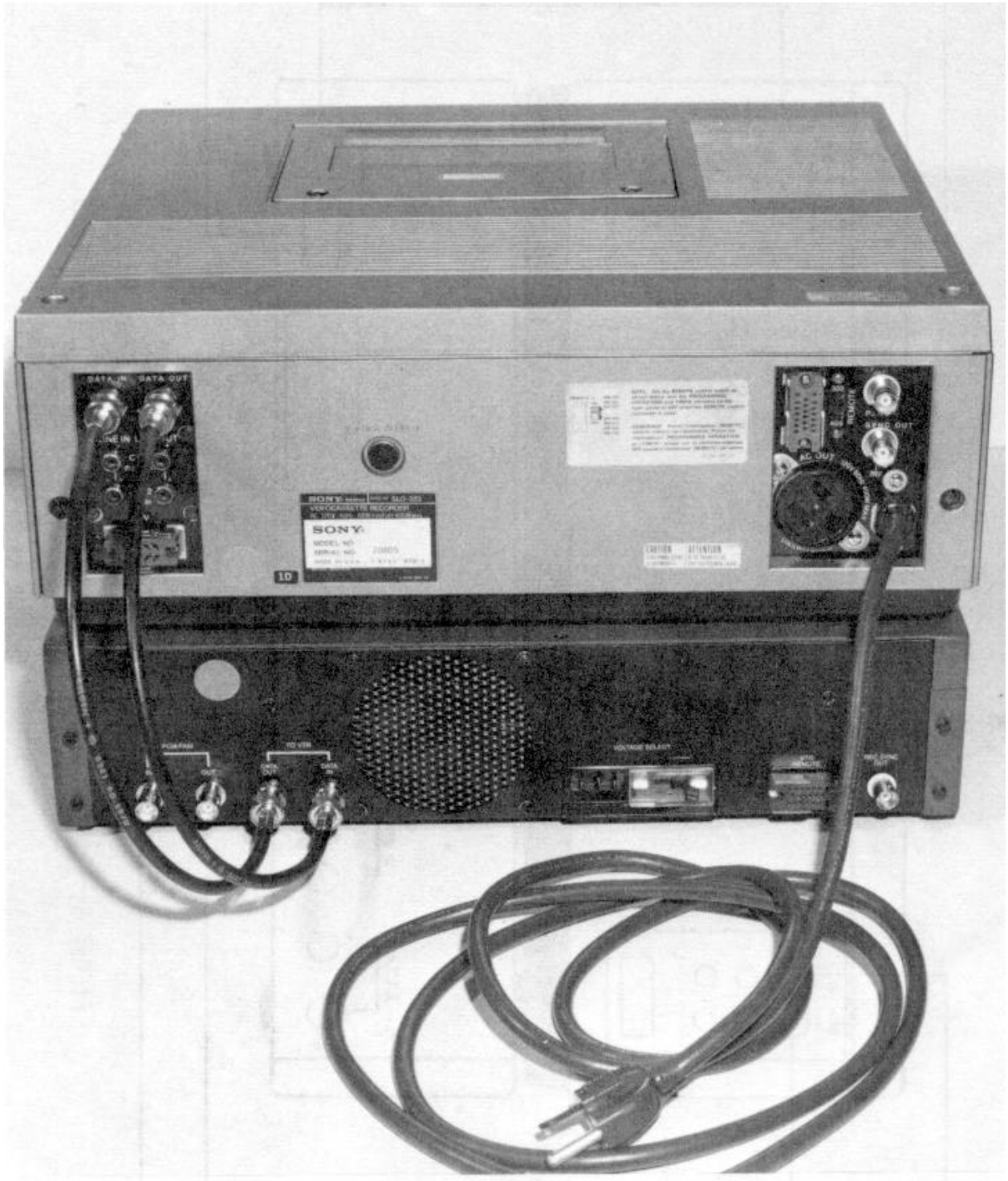

FIGURE 2. DIGITAL DATA RECORDING SYSTEM, REAR VIEW.

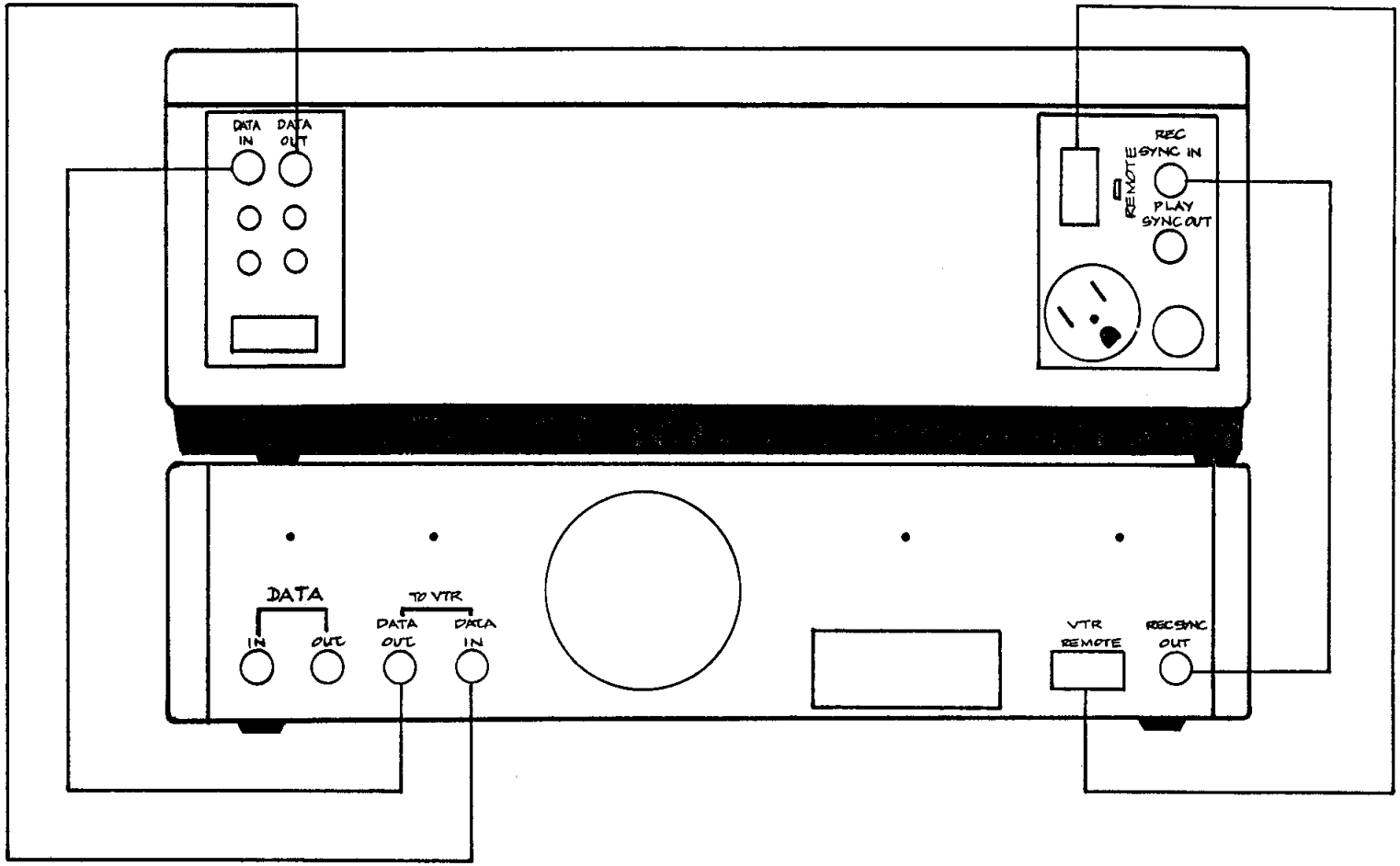

FIGURE 3. DIGITAL DATA RECORDING SYSTEM, SYSTEM INTERCONNECT.

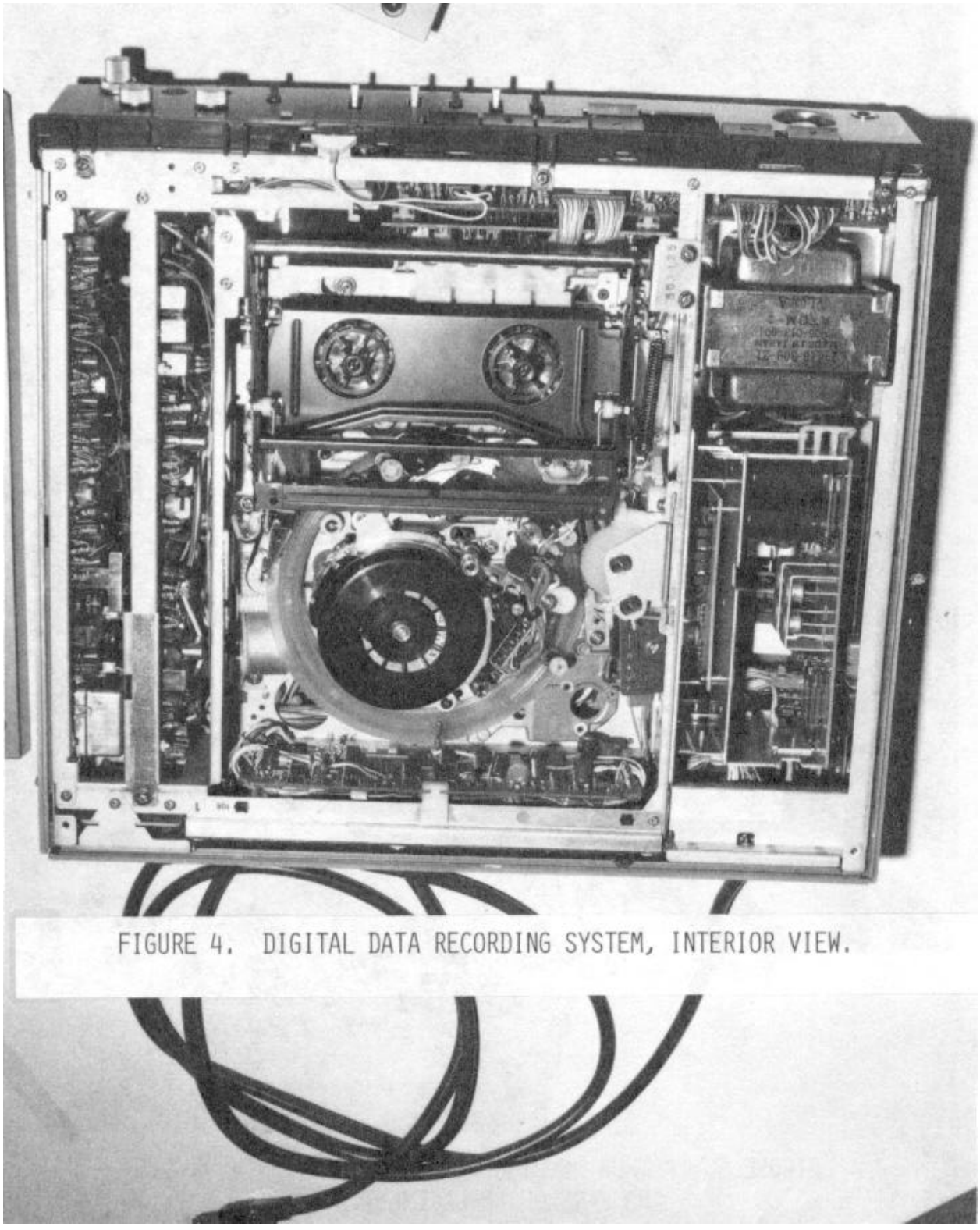

FIGURE 4. DIGITAL DATA RECORDING SYSTEM, INTERIOR VIEW.

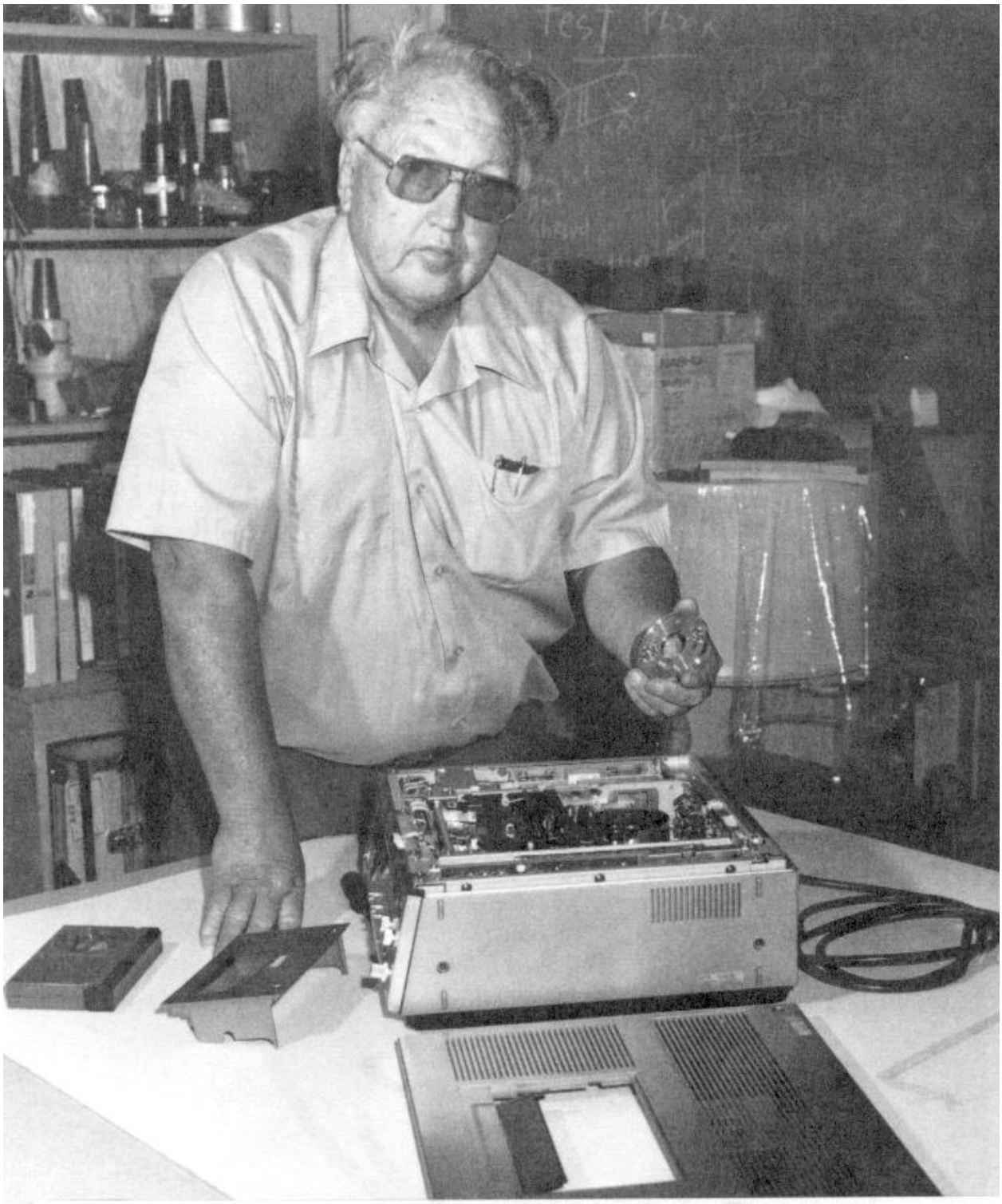

FIGURE 5. AUTHOR HOLDING HEAD ASSEMBLY, SHOWING SIZE AND EASE OF REPLACEMENT.

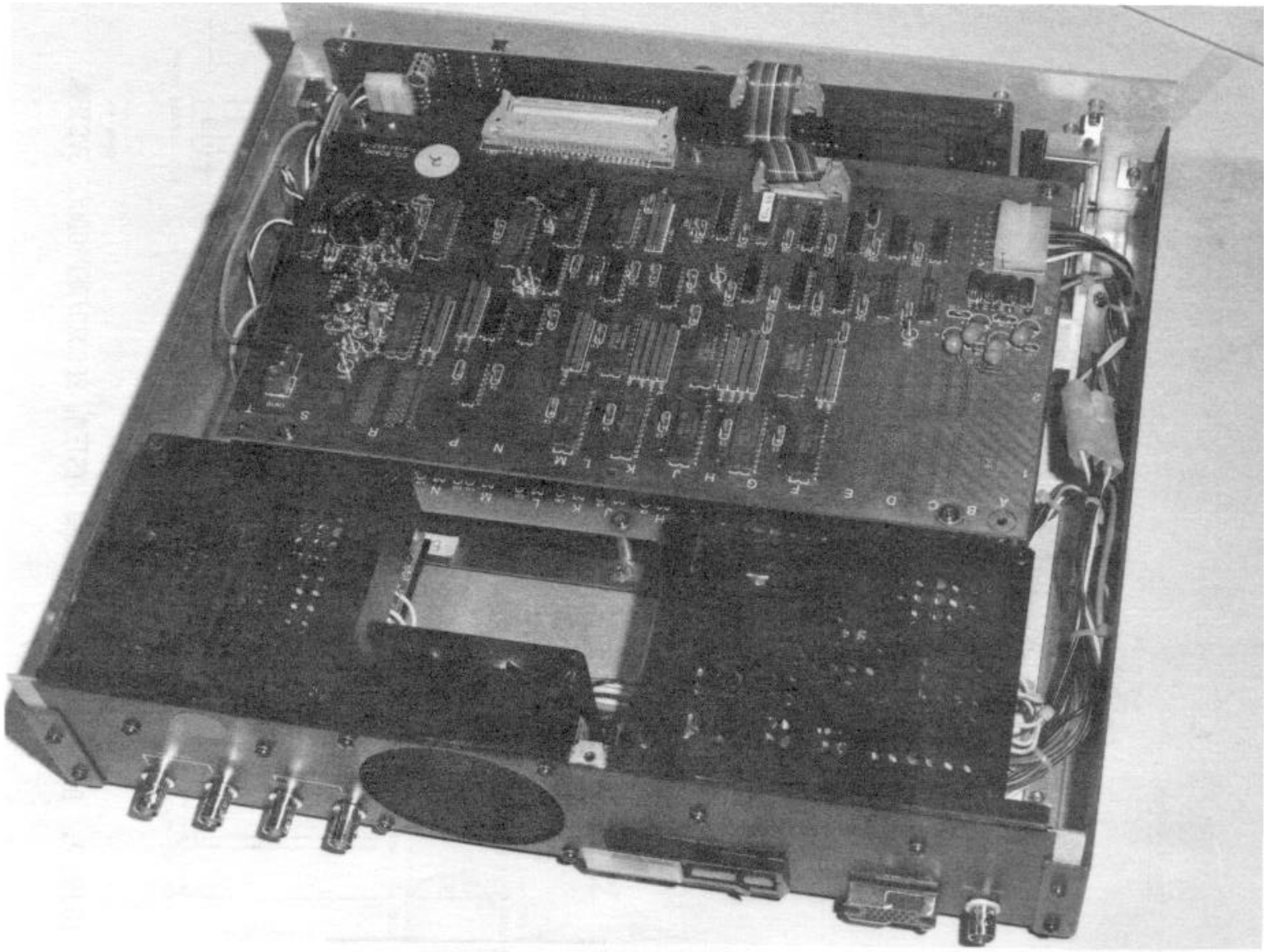

FIGURE 6. BASIC BOARD, DATA CONVERSION/TLM ADAPTER.

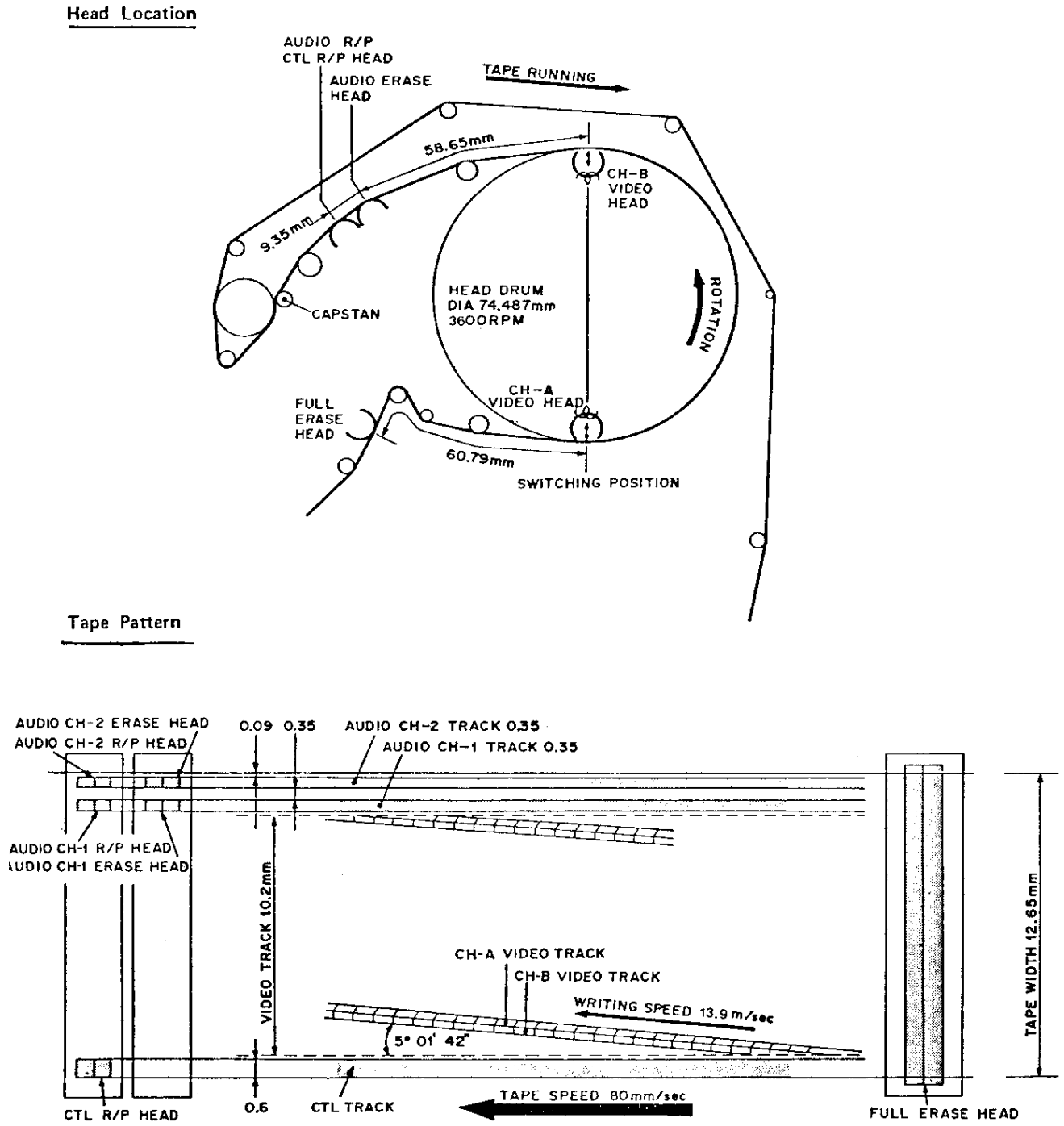

FIGURE 7. DIGITAL DATA RECORDING SYSTEM, RECORD/REPRODUCE SYSTEM.