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NOAA Technical Memorandum ERL PMEL-11

CONVERSION FROM FILM TO MAGNETIC CASSETTE RECORDING FOR THE GEODYNE 102 CURRENT METER

Alex I. Nakamura
Robert R. Harvey

Pacific Marine Environmental Laboratory
Seattle, Washington
April 1978

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CONVERSION FROM FILM TO MAGNETIC CASSETTE RECORDING FOR THE GEODYNE 102 CURRENT METER

A. Nakamura[1] and R. R. Harvey[2]

Joint Institute for Marine and Atmospheric Research (JIMAR)

This report describes a conversion of the Geodyne 102 current meter, which recorded its data on film, to digital cassette tape recording. Sufficient information is included to enable the reader to implement this modification.

1. INTRODUCTION

The original Geodyne 102 current meter contained sensors for current speed (savonius rotor), meter azimuth, current direction, and meter tilt. The modifications described here chiefly concern the recording scheme, where the above sensors are little affected.

The Geodyne 102 current meter was first produced in the mid-1960's following the design of Richardson et al. (1963). This instrument became a workhorse of oceanographic current measurement and was used extensively by the military, industry, and research until it was superceded by digital magnetic tape recording units.

2. PHYSICAL MODIFICATIONS

The original film recording instrument is schematically depicted in Figure 1, along with its modified version. We will discuss the modification, beginning at the top and working downwards.

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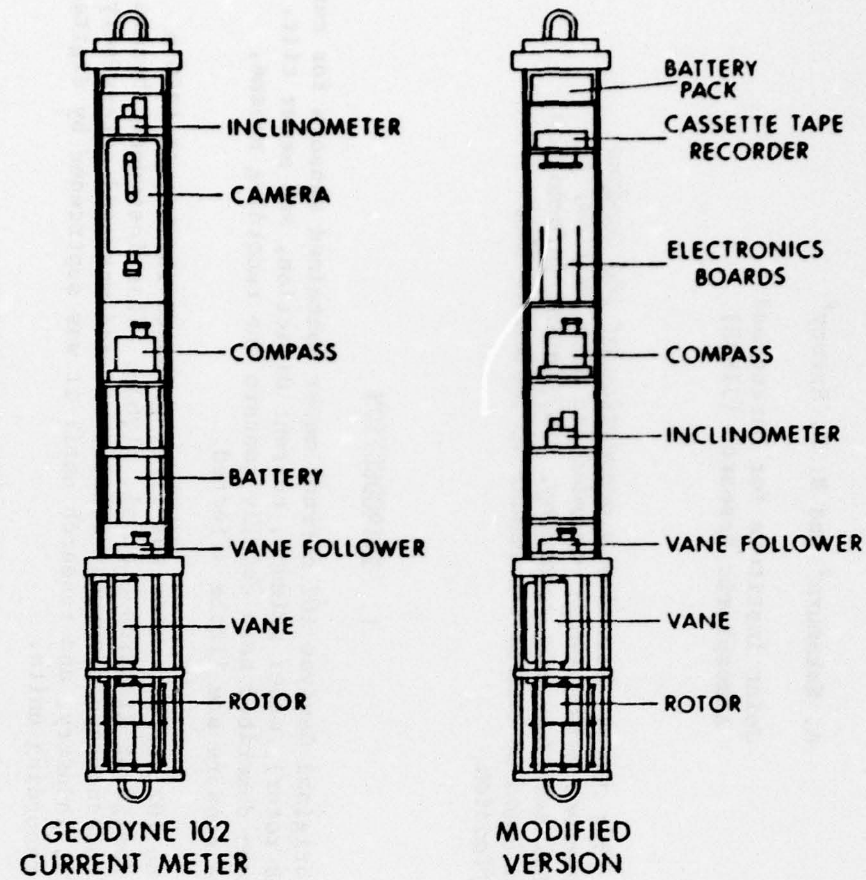

Figure 1. Schematic views of the Geodyne 102 current meter - original and modified versions.

The battery pack consists of nine alkaline "D" cells. Eight of these in series provide 12-volt power for the electronics and tape recorder. The ninth powers a quartz crystal oscillator circuit which serves as a time base for sampling.

Beneath the battery pack lies a Memodyne Inc., Model 201, digital cassette recorder. This recorder is an incremental stepping type which writes with a density of 615 bits per inch. The write/step electronics are located on a printed circuit board, mounted below the stepping motor.

All other electronics are wire-wrapped on three general purpose boards which mount vertically beneath the recorder. These boards measure 4 1/2 X 5 inches and are designated A100, A200 and A300.

The optical encoding scheme for both the compass and vane follower remains unchanged except for replacing the fragile and expensive glass fiber optics with single element plastic fibers. To convert the light coded signals to logic level signals, the light pipes lead to holes in an opaque lucite block, screwed to the tops of the compass and vane follower. Photodarlington transistors recessed into the opposite sides of the blocks then receive the light pulses and pass the signals electronically to the data registers.

The inclinometer is a sealed unit consisting of eight concentric circles of wire suspended above a pool of mercury. The dimensions are arranged such that contact between the mercury and each successive wire corresponds to 5^{o} of tilt.

The vane and rotor are unchanged except for the bearings. Since we intended to use these instruments for deep ocean current measurement, the original threshold current of 2.5 cm/sec was too high. Thus we adapted a design from Sessions (1975) which consists of a .0938" carballoy shaft, inserted into a teflon bushing and resting on a 3/16" dia. synthetic ruby sapphire sphere. These bearings result in a reduction of threshold speed to about 0.5 cm/sec. The approximate cost of modifying one Geodyne 102 current meter as described here is $1000 in materials and one man-month of labor. Neglecting the original cost of the Geodyne 102 meter, this represents a considerable cost saving compared to comparable, commercially available instruments.

3. DATA FORMAT

Data recorded for each sample include day count, hour count, inclination, compass direction, vane follower position, and rotor counts consisting of 7, 5, 8, 7, 7, and 10 bits, respectively. Two bit gaps separate consecutive parameters except for the day and hour counts, which are treated as one data word. A sixteen bit end-of-file gap frames each sample to permit synchronization when reading the tape.

Data is recorded at 615 bits per inch, each bit requiring one step of the capstan drive motor. A total of 70 bits (including gaps) comprise a single sample. A 450 foot cassette tape is capable of recording forty-seven thousand samples, which translates to 32 days at a one minute sampling interval.

4. POWER REQUIREMENTS

During the sampling process, the lamps and cassette recorder draw an average of 100 milliamperes for 0.85 seconds, corresponding to about 300 microwatt-hours of energy from the 12 volt battery pack.

Fourteen watt-hours of energy are required to fill one 450 foot cassette. Eight, 10 ampere-hour capacity, alkaline "D" cells connected in series are sufficient to power the system even if battery capacity is reduced by typical ocean-bottom near freezing temperatures.

The time base oscillator draws only 40 microamperes from a 1.5 volt alkaline "D" cell. For all practical purposes, this circuit can run continuously for the shelf life of the battery, so no ON/OFF switch is provided.

5. ELECTRONICS DESCRIPTION

A block diagram of the current meter (Figure 2) shows the general recording scheme. Primary data from the vane, compass, inclinometer, rotation counter, and clock feed in parallel to a data register, consisting of a string of parallel load, serial shift registers. A sample command is initiated by the clock and sample rate generator. This command sequentially flashes the vane and compass lamps, loads data into the data register, clears the rotation counter, serially shifts the data to and steps the digital cassette recorder.

The sequence of events is graphically displayed in the timing diagram, Figure 3. The circuit details for individual circuit boards are shown in Figures 4, 5 and 6, where the interconnections appear in Figure 7. The photodarlington transistor array interconnection is

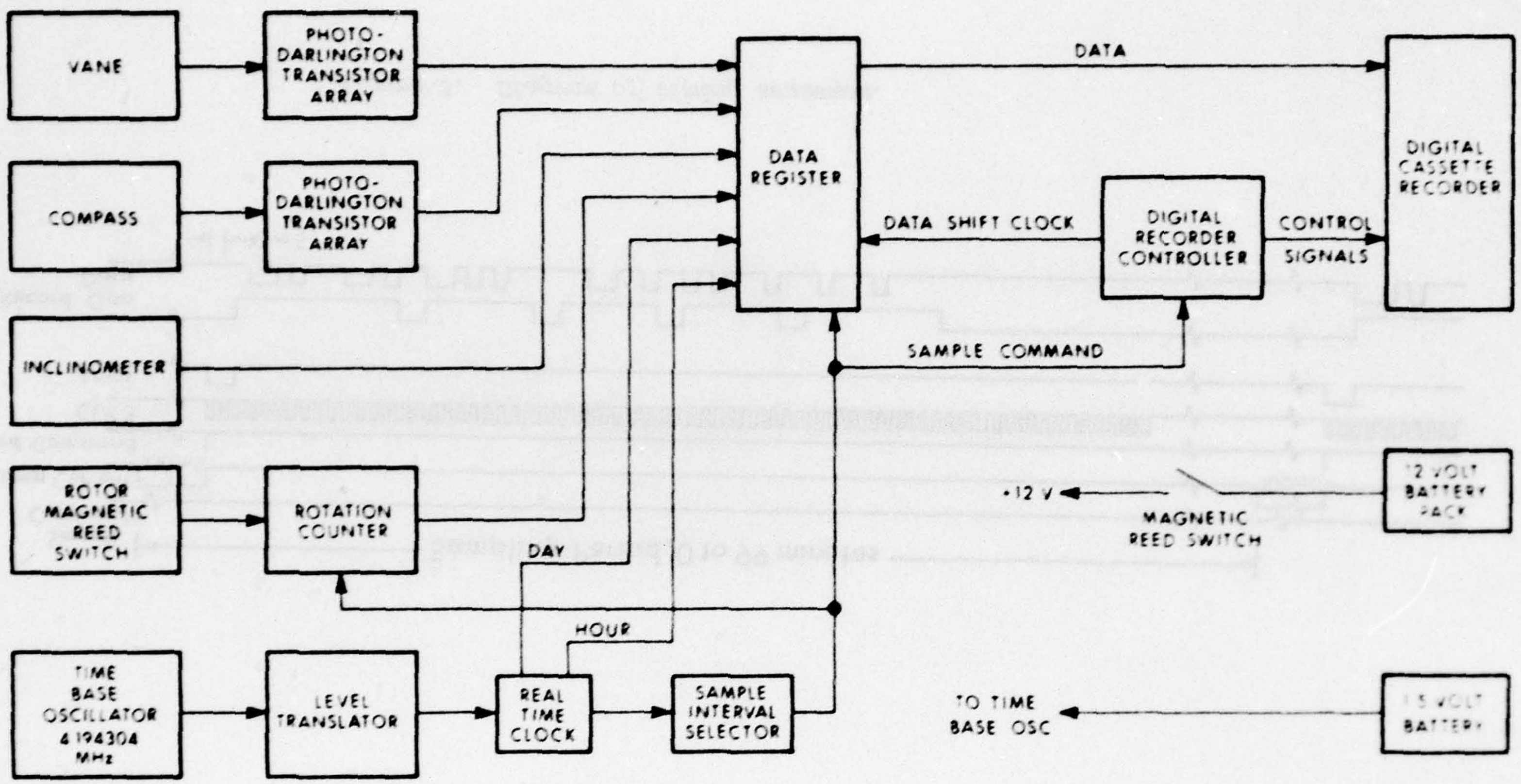

Figure 2. Block diagram of modified Geodyne 102 current meter.

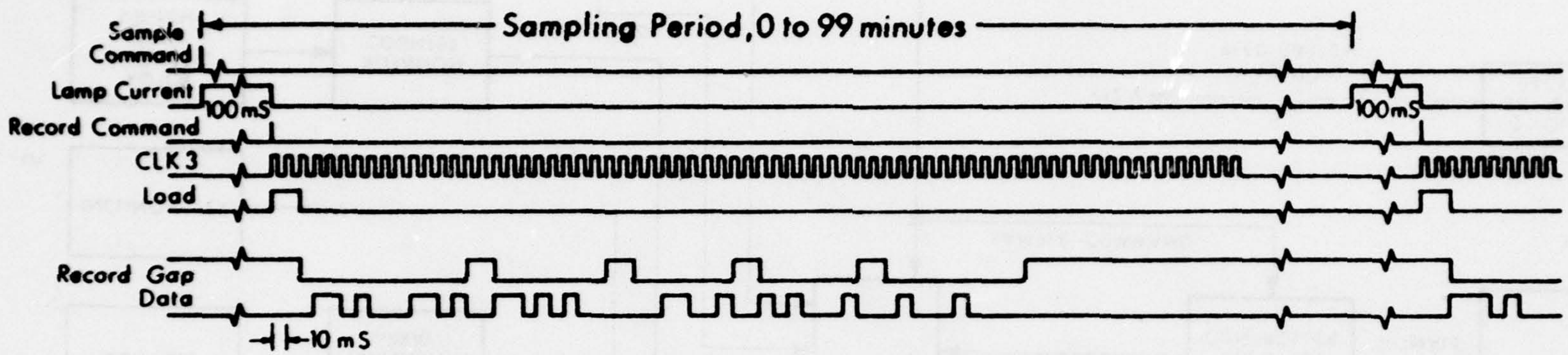

Figure 3. Diagram of timing sequence.

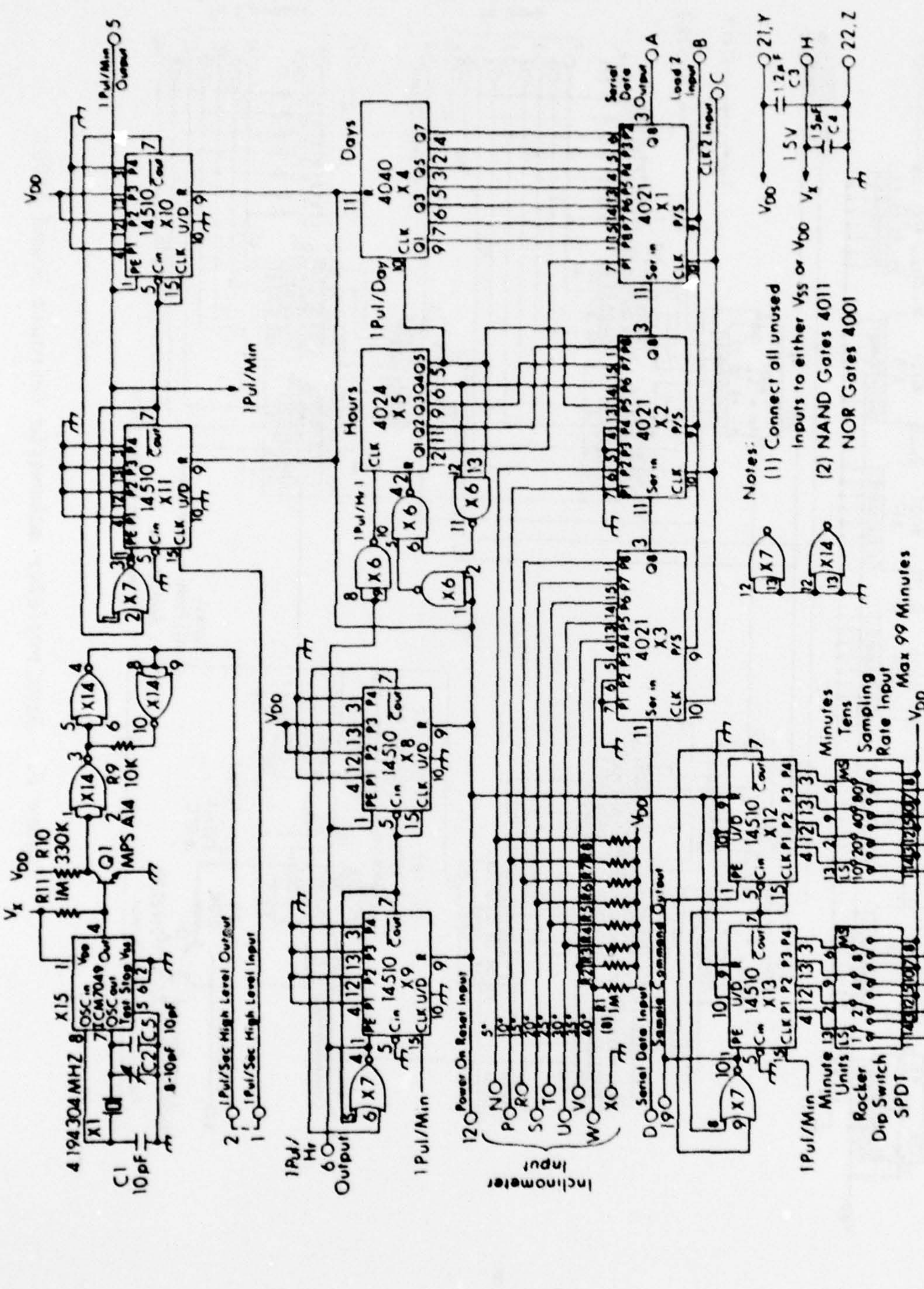

Figure 4. Clock timer schematic (circuit board A100).

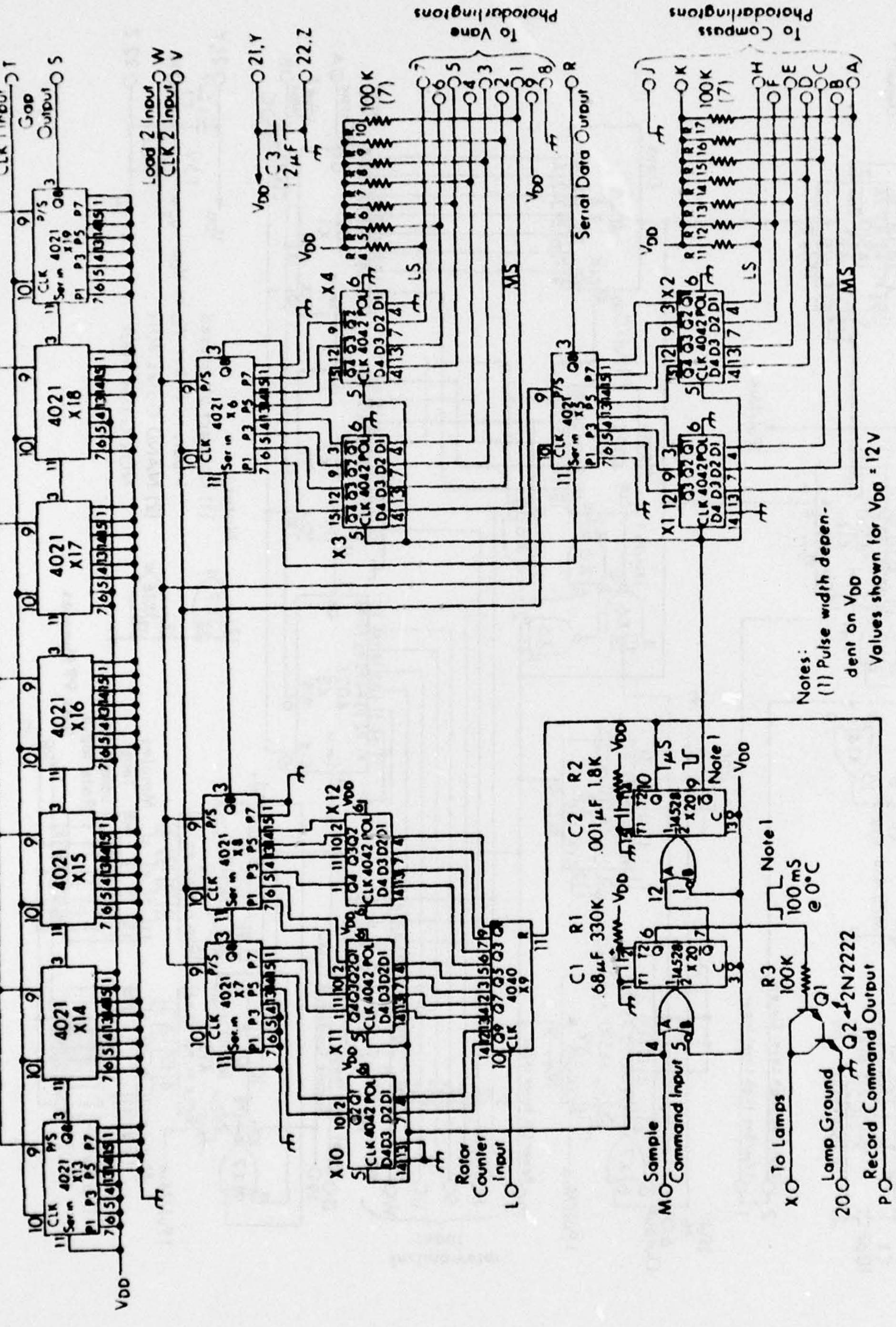

Figure 5. Data register schematic (circuit board A200).

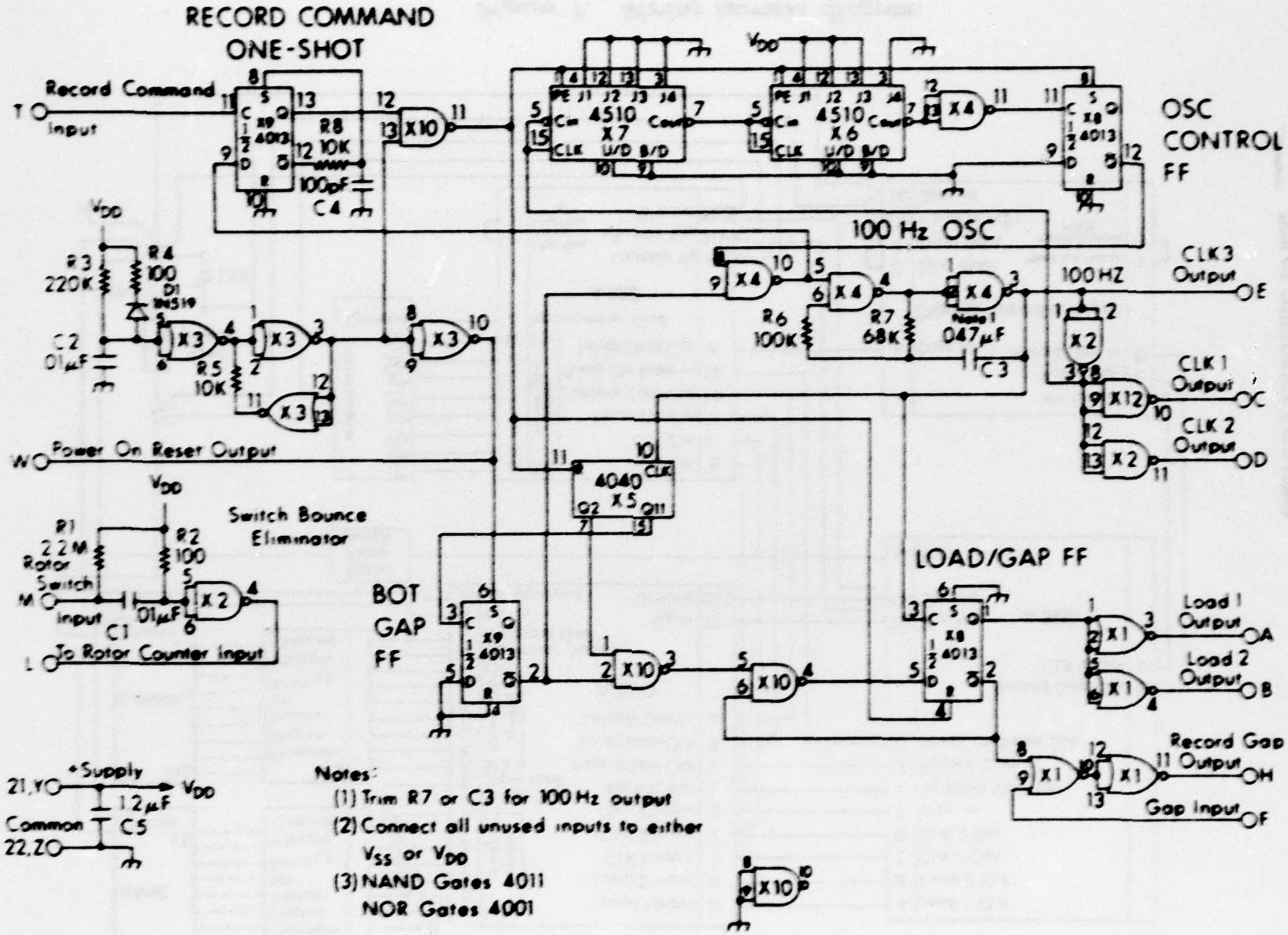

Figure 6. Record controller schematic (circuit board A300).

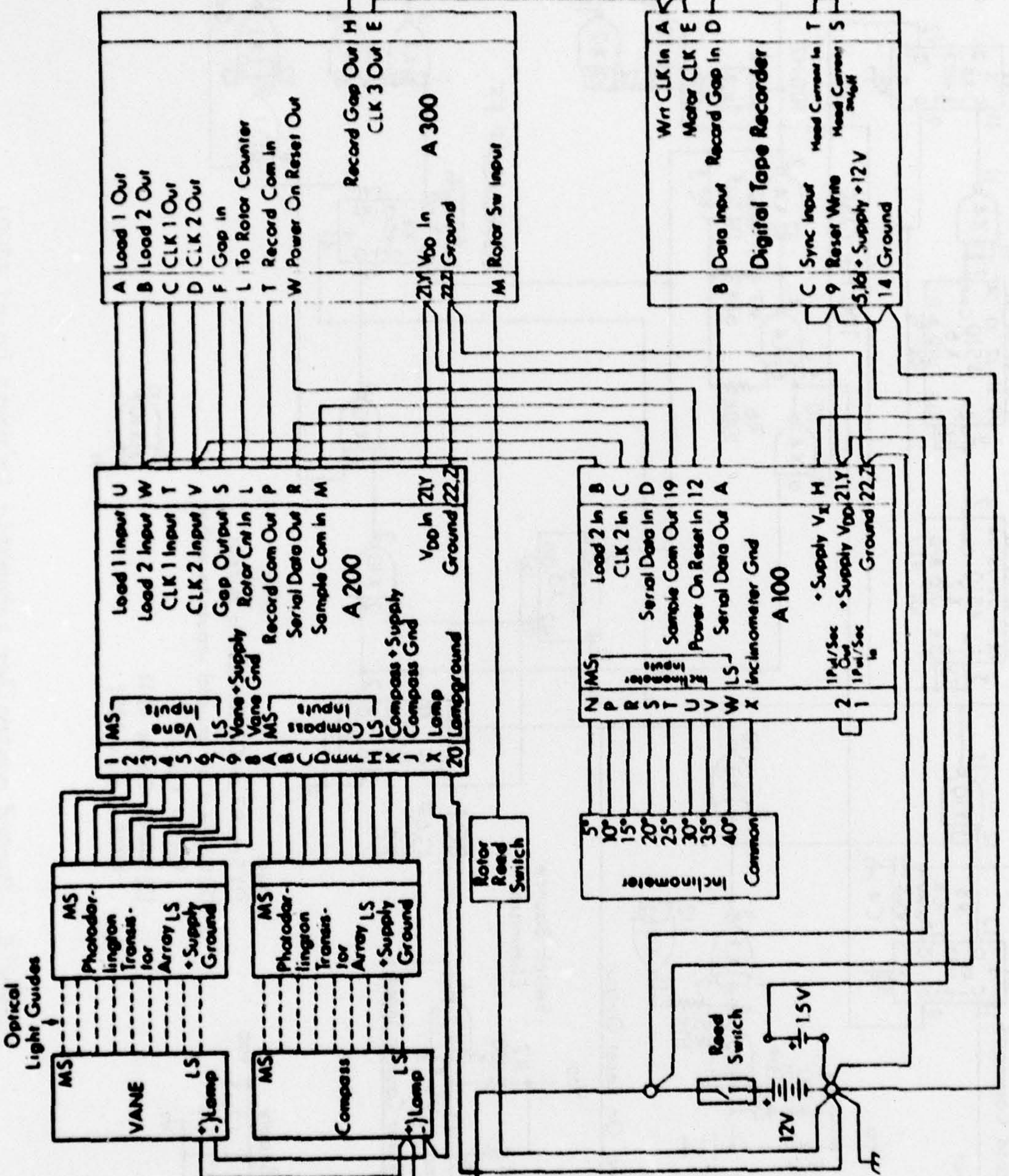

Figure 7. Wiring harness diagram.

shown in Figure 8. Circuit components are labelled by a code referring to the board number and component number, for example, X309 denotes the integrated circuit (IC) X9 on circuit board A300.

An oscillator containing a 4.194304 MHz crystal and X115 forms the current meter's time base. This circuit operates from a single 1.5 volt alkaline "D" cell and draws so little current (40 μa) that it is allowed to run continuously. The output level of X115 is boosted to the 12-volt logic level of the remaining circuitry by darlington transistor Q101 and resistor R110.

NOR gates in X114 form a Schmitt trigger which decreases the rise time of the output of Q101. The 1 Hz output from X114 feeds a divide-by-sixty counter (X110, X111, X107) to produce one pulse/min. at X107-3. This frequency is again divided by sixty (X108, X109, X107) to generate one pulse/hour. The once-per-hour pulses are inverted by X106 and fed to a 24-hour counter, X105, whose output is accumulated by a day counter, X104.

The once-per-minute signal from X107-3 also feeds the programmable sampling rate counter (X112, X113, X107) which can be set to sample from one to 99 minutes by the SPDT DIP switches below X112 and X113 in Figure 4. The "sample command" signal from X107-10 starts the recording cycle as shown in Figure 3.

Current speed is sensed by a Savonius rotor with two magnets attached. Upon rotation of the rotor, the magnets activate a reed switch whose closure is "debounced" by X302, R301, R302 and C301. The number of switch closures, proportional to rotor counts, then accumulates in counter X209.

Upon receipt of the sample command signal, the circuit simultaneously samples the accumulated rotor counts and the instantaneous vane and compass positions. The data from rotation counter X209 are loaded into data latches X210, X211, and X212. The first one-shot in X220 turns on transistors Q201 and Q202, lighting the vane and compass lamps. These are activated for 100 ms. to allow them to reach maximum brightness. The trailing edge of the 100 ms "lamps on" pulse triggers the second one-shot in X220, generating a 1 μs record command pulse. This clears rotation counter X209 and initiates writing of the data onto tape.

The record command pulse from X220-10 triggers the record command one-shot, X309. This parallel loads the digital recorder step counters, X306 and X307, sets oscillator control flip-flop X308, clears counter X305, and resets load/gap flip-flop, X308. Note that both the oscillator

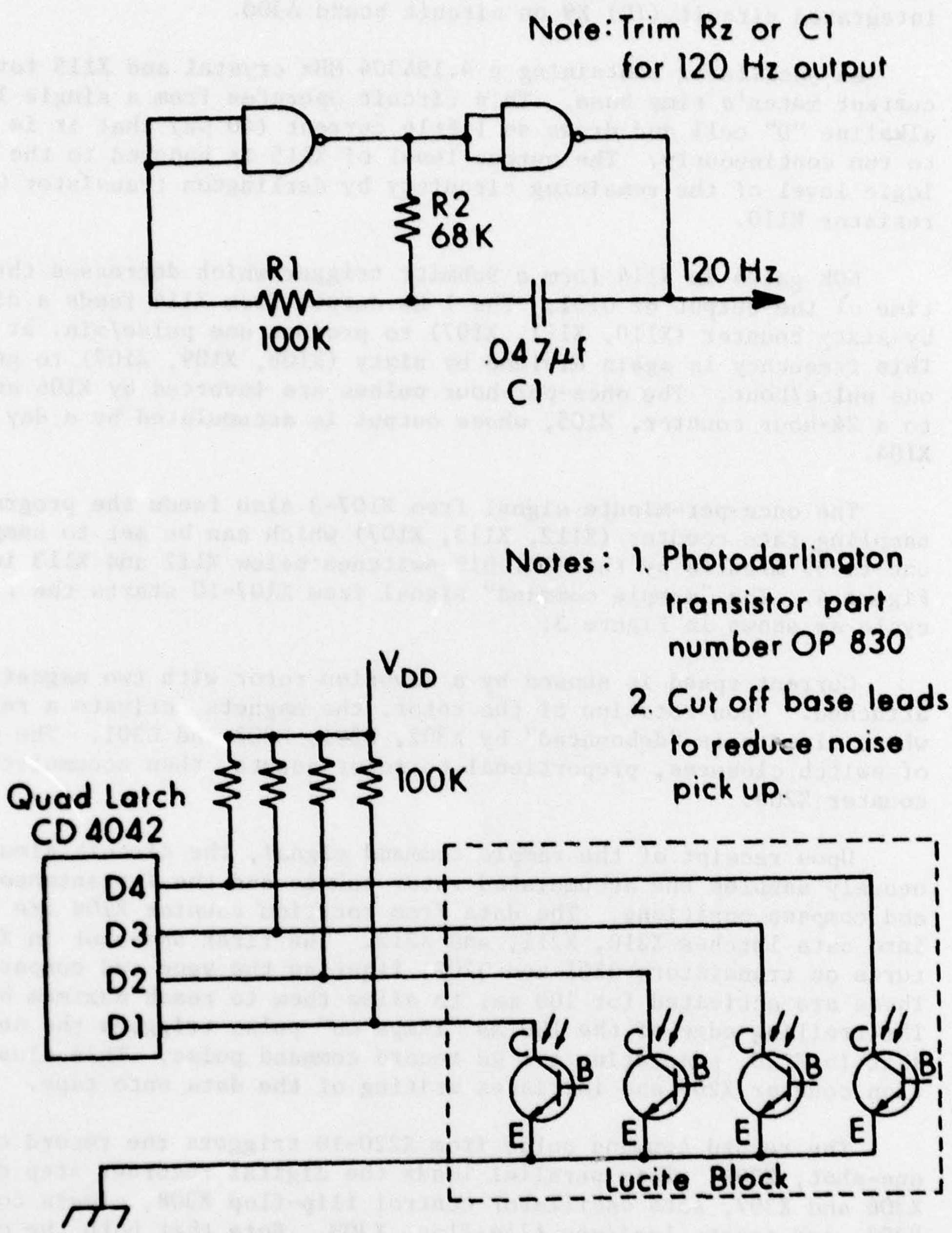

Figure 8. Test oscillator and photodarlington array schematics

control flip-flop, X308, and beginning of tape gap (BOT) flip-flop, X309, must be in the reset state in order to trigger the record command one-shot. This interlock scheme ensures that one write cycle is completed before another can begin.

Setting the oscillator control flip-flop enables the 100 Hz oscillator causing clock pulses to appear at CLK3, CLK1, and CLK2, (see the timing diagram, Figure 3).

The first two steps of the recorder (one step per clock pulse) represent a gap, since the load/gap flip-flop, X308, is in the reset state. During this time the load outputs, LOAD 1 and LOAD 2, are at a high level, causing the data to be loaded into parallel-to-serial converters X101 - X103, X213 - X219 and X205 - X208. Upon the high-low transition of the second clock pulse, counter X305-7 goes high, causing a high level to appear at input D of the load/gap flip-flop, X308. At the low-high transition of the third clock pulse, X308-2 drops the load and gap signals to low level. At this point, subsequent clock pulses write the data onto tape, since the gap signal to the recorder is low. The load/gap flip-flop, X308, is maintained in the set state for the rest of the cycle by feedback from X310-4.

Data words are written with two-bit gaps, generated by a string of shift registers (parallel-to-serial converters X213-X219). "1" bits correspond to gaps and "0" bits to data positions. The data shift registers, X101 - X103, X205 - X208, and gap shift registers, X213 - X219, are shifted out in parallel, with the gap output feeding the record gap input and the data output feeding the data input of the cassette recorder.

6. POWER ON SEQUENCE

The current meter is activated by removing a magnet external to the pressure case. This closes a magnetic reed switch and applies power to the circuits. Application of power to X303 generates a reset pulse; the Schmitt trigger formed by X303 and R305 holds the output of X303-3 low for about 1.5 ms; it then rises sharply and remains high. This power on reset initializes all counters and flip-flops.

The reset pulse clears counter X305, resets load/gap flip-flop X308, and sets flip-flop X309, causing a 1024 step gap to be written at the beginning of the tape cassette. This gap is subsequently used as a starting point for reading the tape. The low level at X309-2 causes a high output on X304-10, enabling the 100 Hz oscillator, composed of X304, R306, R307, and C303. Clock pulses at CLK3 cause the recorder to increment one step per pulse.

As long as X309-2 remains low and X308-2 remains high, the "record gap" output is high and the recorder writes only gaps. When counter X305 accumulates 1024 counts, X305-15 goes high. This clocks flip-flop X309 disabling the 100 Hz oscillator and stopping the recorder. Beginning of tape (BOT) flip-flop, X309, then remains in the reset state for the rest of the mission.

7. TEST CIRCUIT

It is frequently desirable to accelerate the sampling rate in order to test or troubleshoot the circuitry efficiently. Accordingly, we use the circuit shown in Figure 8 to effect this option. With the sampling switch set at two minutes and the test circuit applied, samples are written at one Hz. The 12-volt D.C. and ground jacks are connected to power pins on any one of the circuit boards. The 120 Hz output connects to pin 1 on the printed circuit board connector for board A100, after removing the jumper between pins 1 and 2.

8. ACKNOWLEDGEMENTS

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