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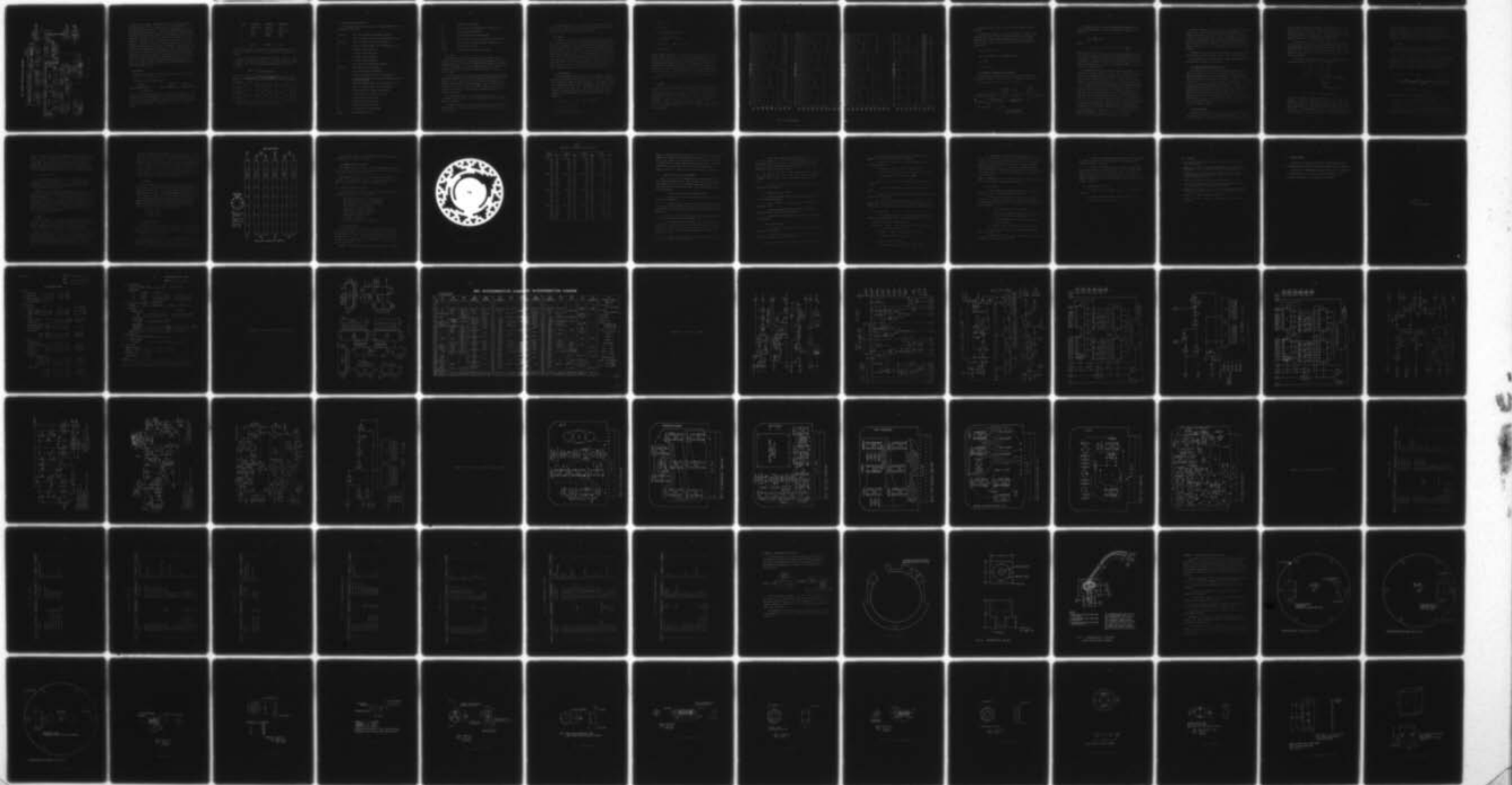
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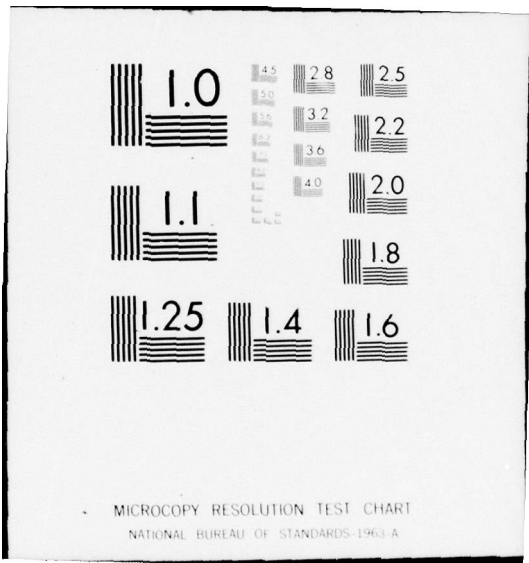
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COS/MOS 850 CURRENT METER REPORT

by

James R. Valdes

June 1977

TECHNICAL REPORT

Prepared for the Office of Naval Research
under Contract N00014-76-C-0197; NR 083-400
and for the National Science Foundation,
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COS/MOS 850 CURRENT METER REPORT

by

James R. Valdes

WOODS HOLE OCEANOGRAPHIC INSTITUTION
Woods Hole, Massachusetts 02543

June 1977

TECHNICAL REPORT

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Valentine Worthington
Valentine Worthington, Chairman
Department of Physical Oceanography

COS/MOS 850 CURRENT METER REPORT

Abstract

The COS/MOS 850 current meter is a burst sampling instrument designed to measure current speed, direction, and average water temperature. The instrument utilizes the major components of the Geodyne model 850 current meter; with most of the electronics replaced by COS/MOS integrated circuits. This report describes the operation and the maintenance requirements of the COS/MOS instrument.

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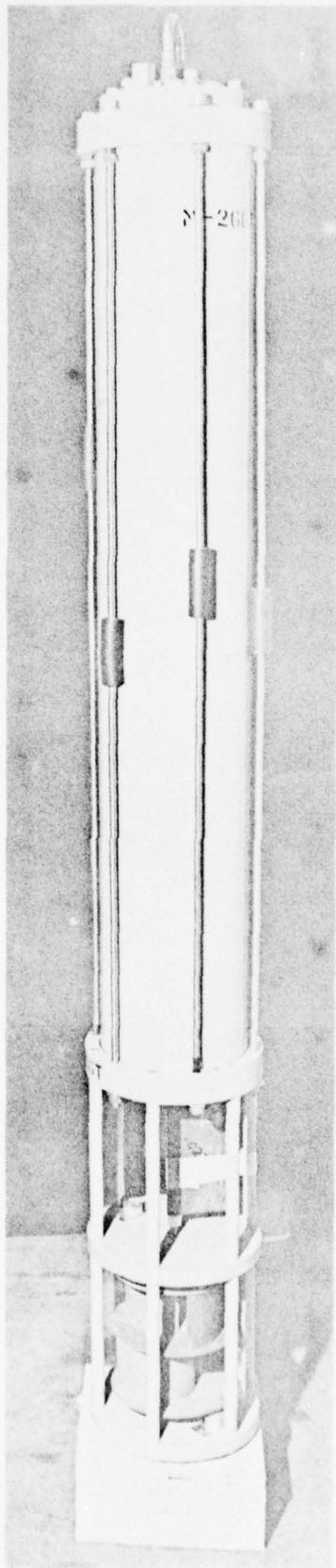
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I. INTRODUCTION

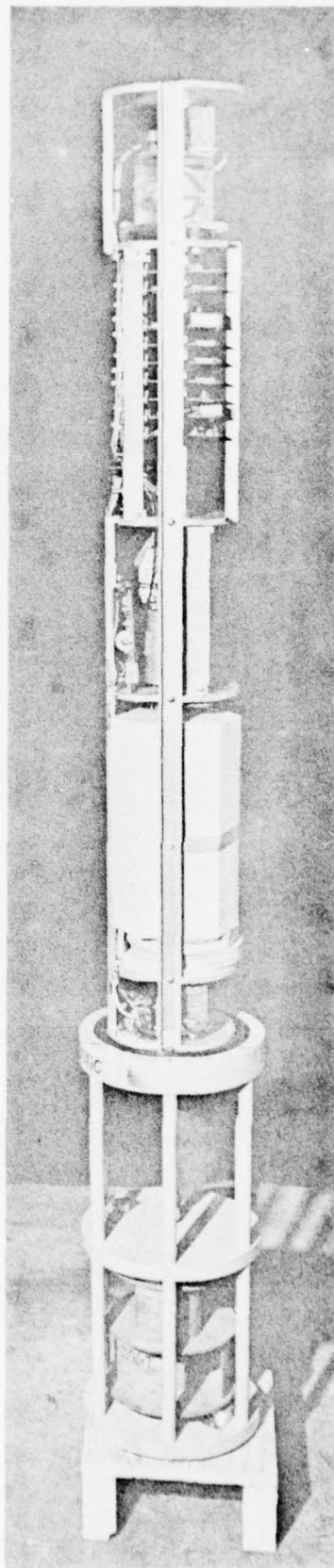
This manual is intended for use with the COS/MOS 850 current meter, the result of an on-going effort to upgrade instrument performance and provide for in-house maintenance of instrumentation. While the major components of the Geodyne instrument have been retained,¹ much of the electronics has been upgraded to COS/MOS (Complimentary-Symmetry/Metal-Oxide-Semiconductor) circuitry. The sampling technique is described by Webster², and yields one sample (temperature/speed and direction) every five seconds for the duration of the record interval. Interval times vary from seven and one-half minutes to one hour.

The configuration of the COS/MOS 850 has evolved since its initial deployment in POLYMODE I during 1974. The first multi-instrument deployment occurred during 1975 on POLYMODE Array II. Since this setting reliability work has continued, the electronics has been upgraded and the mechanical configuration has been improved.

The instrument is shown in Fig. 1. Water speed and direction sensors are located in a cage below the tubular pressure housing; a Savonius rotor is magnetically coupled to a reed switch producing sixteen pulses per revolution of the rotor. The vane position is magnetically coupled to a vane follower located in the lower electronics housing. Vane position and compass bearing are internally recorded and the vector sum used to compute current direction. The outputs from the compass and vane follower are in a seven-bit digital grey code with a 2.8° ($360^\circ/2^7$) resolution. Absolute temperature measurement has been incorporated into the instrument; the sensor is a thermistor mounted inside the lower pressure housing end cap. A voltage-to-frequency converter generates counts which are directly proportional to the temperature. A crystal controlled digital clock provides an accurate time reference and a time word in digital format.



A. Instrument Cased



B. Uncased

Fig. 1. COS/MOS 850 Current Meter

II. SPECIFICATIONS

Current Speed Sensor	Savonius Rotor
Threshold (Calibration Eq.)	1.8 cm/sec
Range	1.8-300 cm/sec
Rotor Constant, (K) ³	34.6 cm water/rev
Current Direction	Compass and Vane Follower (Geodyne)
Resolution	2.8°
Temperature Sensor	30,000 Ω (25° C) Thermistor
Accuracy	.01° C
Time Base	Crystal Oscillator
Stability	±1 sec/day
Tape Recorder	Digital Dual Channel
Type	Model 536-1A (Geodyne)
Mechanical	
Pressure housing	7075-T6 aluminum
Operational depth (standard)	5500 meters
Operational depth (high pressure)	6900 meters
Rotor/vane cage	6061-T6 aluminum
Hardware	316 stainless steel
Corrosion Protection	4 Zn Sacrificial Anodes
Weight (standard housing)	
Air	115 lbs (52.27 Kg)
Water	40 lbs (18.18 Kg)
Length	72 inches (1.83 meters)
Thru Housing Load Capacity	5000 lbs (2272 Kg)
Operational Life (Per Deployment)	Nominal 1 year

III. MECHANICAL CONFIGURATION

The rotor and vane cage is shown in Fig. 2. In converting the current meter the aluminum plates are modified to accept new bearings and anodes. The journal bearings are Delrin 150 with a tungsten carbide thrust plate in the rotor and lower vane; this bearing design has permitted us to improve the anodic protection. Figure 3 is a mechanical drawing of the cage assembly. Details of the cage modifications are given in the Appendix. Figure 1 shows the tubular pressure housing and the tie rods used to secure the pressure housing end plates; "O" rings are used to form water-tight seals.

For adequate preloading and to insure a water-tight seal, the instrument hardware is torqued to the values of Table 1.

Table 1. Torque Values

Cage rods	10 ft lbs (120 in lbs)
Tie rods	10 ft lbs (120 in lbs)
Upper bail plate	12 ft lbs (144 in lbs)
Upper vane bearing	10 to 12 in lbs
Center bearing locknut	15 to 20 in lbs
Lower pivot locknut	15 to 20 in lbs

IV. THEORY OF OPERATION

The block diagram for the COS/MOS 850 is shown in Fig. 4. A 74.5654 kHz oscillator is used to generate all timing functions, and is divided by binary counters to provide a 14-bit time word and other control pulses. At a pre-selected interval the clock start pulse sets the latch in the STA-9, this applies power to the switched bus lines, enables the control flip flop and momentarily resets the sequence counter on the program board. STA-9 outputs K_2 and \bar{K}_2 step the motor driver circuitry, while \bar{K}_1 clocks the sequence counter; its outputs are gated to generate most of the control pulses required by the instrument. The

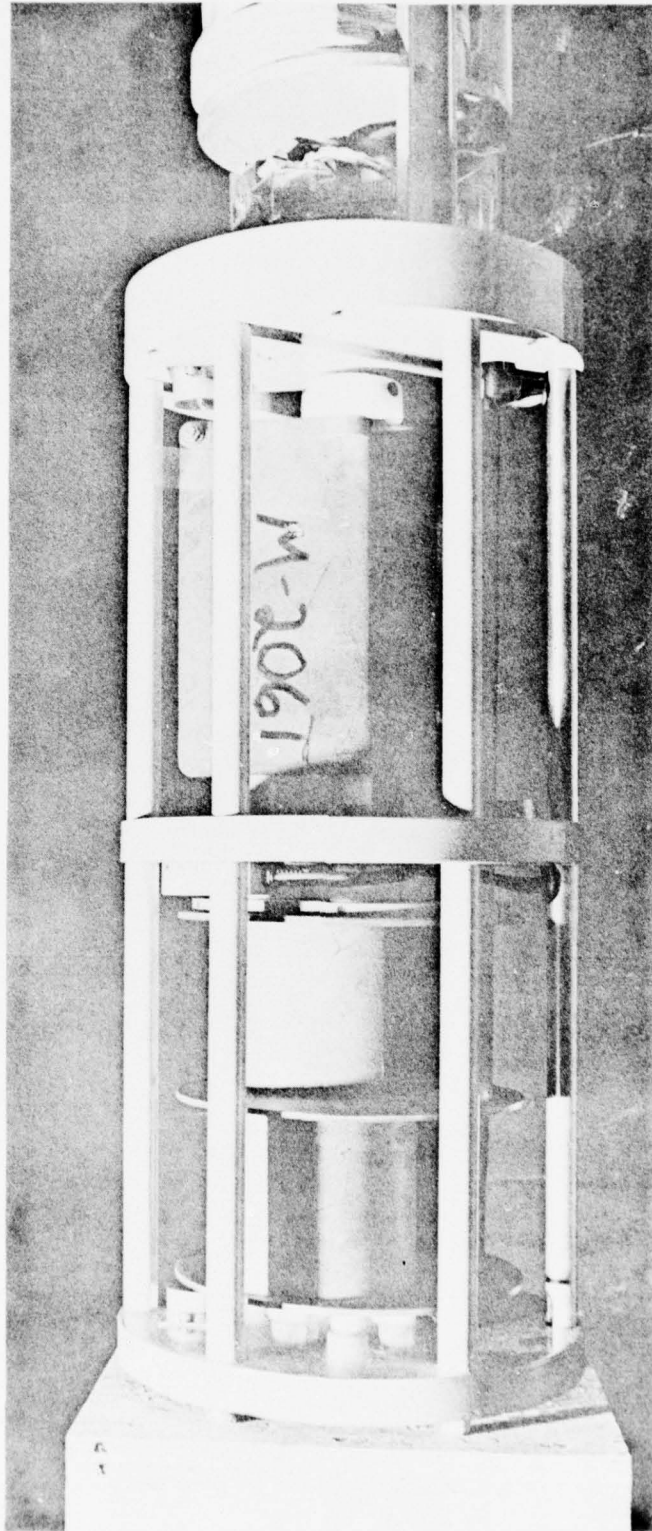


Fig. 2. Cage

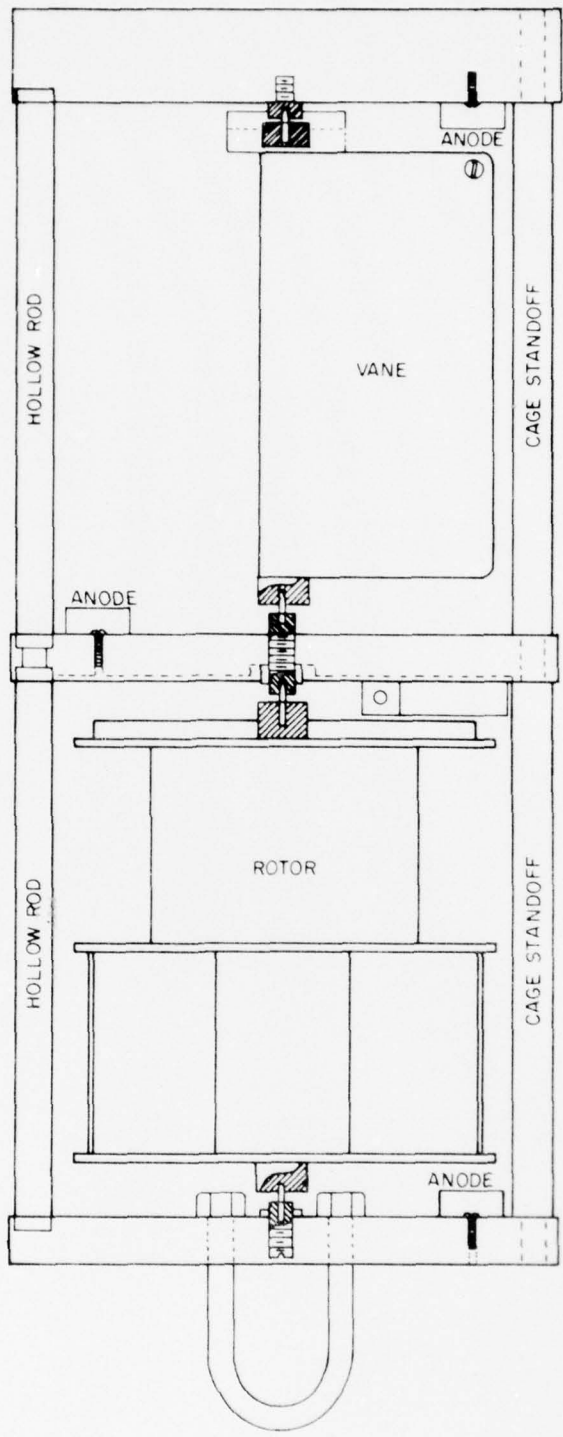


Fig. 3. Cage Diagram

850 CURRENT METER BLOCK DIAGRAM

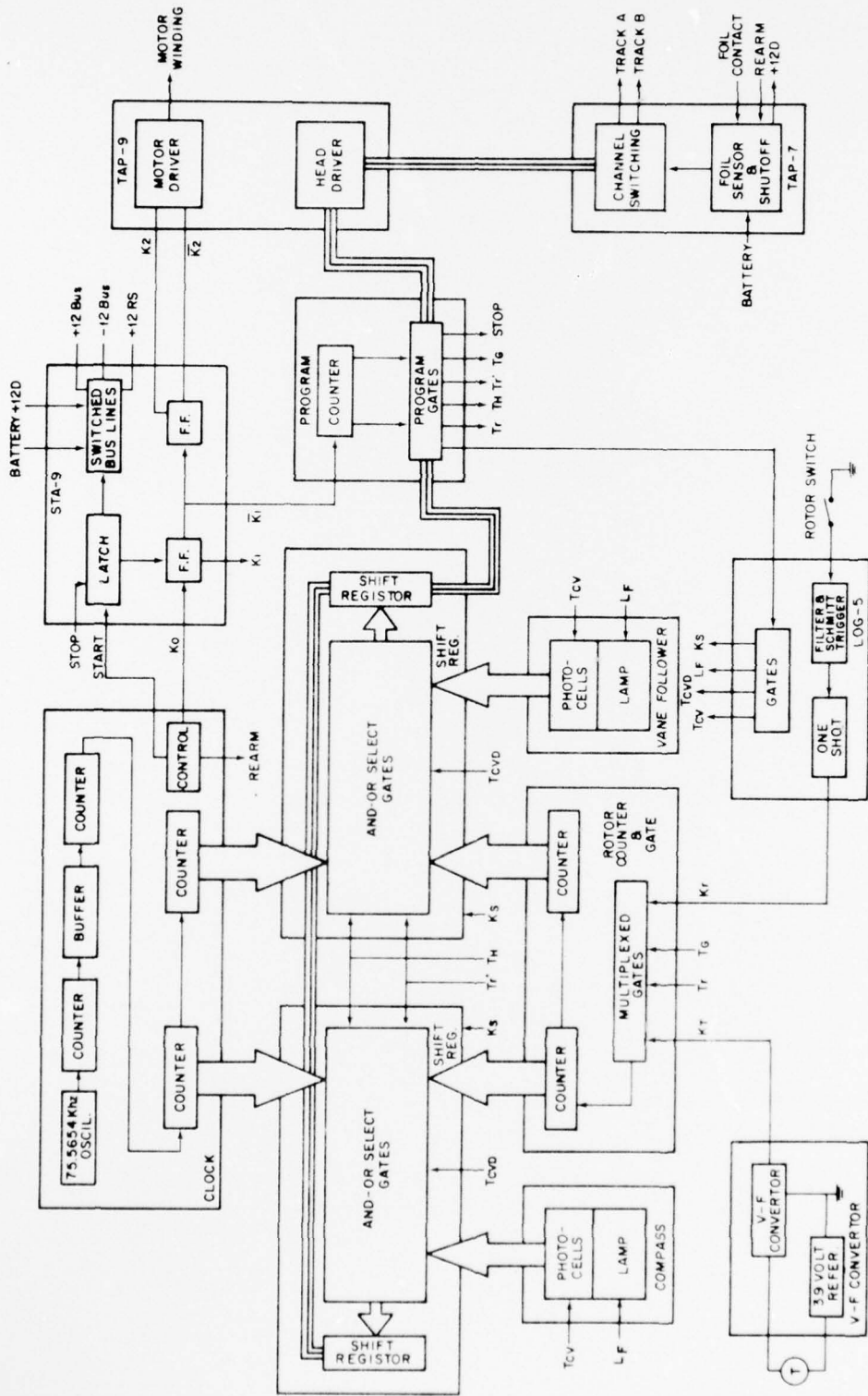


Fig. 4. Block Diagram

remaining control signals, lamp flash, and rotor counts are developed and processed by the LOG-5. Temperature counts are generated by a voltage-to-frequency converter. The rotor and temperature pulse trains are gated by the multiplexing circuitry on the rotor counter and temperature gate board into binary counters to be accumulated. At the end of each strobe the data is gated thru the and/or select gates to the shift registers. Operation of the shift registers is controlled by T_r , T_H , and T_{CVD} . The data is clocked out of the registers by K_s . While the rotor and temperature counts are being accumulated, compass and vane information is transferred thru the registers. The serial data train from the registers is buffered by the program board and used to toggle the head driver circuitry on the TAP-9. At the end of a preselected number of strobes, a stop pulse from the program board resets the latch on the STA-9. This action removes power from the switched bus lines and inhibits the control flip-flop. Channel switching and instrument shutoff are controlled by the Tap-7.

V. DATA FORMAT

The data are recorded in a sequence of strobes; each set of strobes is referred to as a data record.

A strobe has the following format:

Variable 1	Variable 2	Variable 3
xx 1 thru 14 bits	xx 1 thru 7 bits	8 thru 14 bits

xx = blank bits

Variable 1 contains fourteen bits, in the COS/MOS 850 temperature, time, and rotor data are multiplexed into this position by control pulses T_G , T_H , and T_r^O (see timing diagram). Variable 2 is compass data and Variable 3 is the vane information. A typical record of N strobes is shown below:

<u>Strobe</u>	<u>Variable 1</u>	<u>Variable 2</u>	<u>Variable 3</u>
1	Temperature	Compass	Vane
2	Time	Zero (239°)	Zero (239°)
3	Rotor	Compass	Vane
4	Rotor	Compass	Vane
.			
.			
.			
N	Rotor	Compass	Vane

Notice that on strobe 2, the binary bits in the compass and vane field are all zeros (239°), in all other cases they yield an instantaneous heading.

The data capacity for the COS/MOS 850 is shown in Table 2. This is dependent on the mode of operation, i.e., record interval and number of strobos. These are calculated values based upon a 390 ft data cartridge.

Table 2. Tape Capacity in Days

Mode	Record Interval				
	Continuous	1 Hr	30 Min	15 Min	7.5 Min
31 Strobos	9.23	-	-	-	-
23 Strobos	-	262	131	65.7	32.4
15 Strobos	-	394	197	98.5	49.2
7 Strobos	-	788	394	197	98.5

Note: This table applies to only the COS/MOS 850

VI. DETAILED CIRCUIT DESCRIPTION

The following terms are used in the circuit descriptions and tabulated here as a reference:

B_1 thru B_4	first four outputs of the sequence counter
B_1	output of program board, used to generate T_{CV} , T_{CVD}
E_1 thru E_6	last six outputs of the program counter
E_1	output of program board, used to generate T_{CV} , T_{CVD}
E_4	7 strobos output selection
E_5	15 strobos output selection
E_6	31 strobos output selection
23S	23 strobos output selection
C_i	output data train from shift registers
C_1 thru C_7	seven output bits from compass
D_T	data train applied to head driver
\overline{e}_i	output of program board, used to generate T_{CV}
\overline{e}_o	inhibits tape heads from writing for first five seconds of record interval
G_T	output of program board, used to generate T_{CV} , T_{CVD}
\overline{G}_T	output of program board, used to generate K_s
K_o	output from clock, primary clocking pulse
K_1	clocking pulse used to drive test box
\overline{K}_1	program board clocking pulse
K_2	stepping motor clocking pulse
\overline{K}_2	stepping motor clocking pulse
Lf	65 ms pulse which flashes lamps
M_1 - M_{14}	multiplexed data bits

T_G	temperature gate control
T_r^o	shift register (multiplexed data) transfer pulse
T_r	resets multiplexed counters
T_H	shift register (time) transfer pulse
T_{CVD}	applies voltage to cells in compass and vane follower
T_{CVD}	shift register (compass and vane) transfer pulse
$T_1 - T_{14}$	fourteen bit time word
$V_1 - V_7$	seven output bits from vane follower.

A. Clock

The digital clock provides an accurate time reference for the COS/MOS 850 and consists of a precision crystal oscillator and several ripple counters. The oscillator frequency (74.56540 kHz) is divided by 2^{40} which corresponds to a period of about 171 days. The time word is composed of the most significant fourteen bits from the counters (LSB = 15 min).

Q_1 and its associated circuitry form a regulated 7 VDC power supply which helps stabilize the oscillator frequency and limits the power consumption of IC1. Output Q_1 of IC1 (37.2827 kHz) is provided as a test point for adjusting the oscillator frequency. IC2 is a level shifter, raising the 7-volt logic high level of IC1 to that of the +12 C supply voltage. The output of IC2 drives ripple counters IC3 thru IC5 to develop the time word.

The instrument re-arm pulse is developed by Q_3 and Q_4 . IC6 and IC7A form a divide by three circuit to provide the 12 Hz (K_o) instrument clocking pulse.

The record interval is selected by wiring pin 8 to the appropriate counter output. For example, wiring pin 8 to pin 24 gives a one-hour record interval.

The instrument turn-on pulse is buffered by IC7B and its associated circuitry. When pin 7 is held low by the external on/off magnet, the turn-on signal is inhibited from output pin 6.

B. STA-9

K_0 from the clock drives pin 28 of the STA-9 clocking flip-flop IC2A. Output \bar{K}_1 of IC2A toggles IC2B generating the motor drive pulses (K_2, \bar{K}_2). The action of IC2A is governed by the level applied to pin 6 of the flip-flop, this is an inhibit signal from the latch (IC1B and IC1C). When pin 6 of the clock makes a low to high transition a one shot pulse is coupled to pin 8 of IC1C setting the latch. This applies a reset pulse to the program board, power to the switched bus line and also enables flip-flop IC2A. When the desired interval has been completed the output of the program board makes a high to low transition. This transition is inverted on the STA-9 by IC1A causing the latch to reset, removing power from the bus lines and inhibiting IC2A.

C. Program Board

The program board controls the sequence of operation. At the start of the record interval the sequence counter (IC1) is momentarily reset setting the counter to an all zero state. The sequence counter is a 12-stage ripple type which is advanced one count on the positive edge of the clocking signal (\bar{K}_1). The outputs of the counter are processed to provide many of the timing pulses required by the instrument. The Boolean expressions for the outputs of the program board are:

$$G_T = \bar{B}_2 \cdot \bar{B}_3 \cdot \bar{B}_4 \quad \text{and} \quad \overline{G_T} = \overline{\bar{B}_2 \cdot \bar{B}_3 \cdot \bar{B}_4}$$

$$T_r = \overline{G_T} \cdot \bar{K}_1 \cdot \bar{E}_1 \cdot B_1$$

$$\bar{e}_1 = \overline{\bar{E}_2 \cdot \bar{E}_3 \cdot \bar{E}_4 \cdot \bar{E}_5 \cdot \bar{E}_6}$$

$$T_H = e_1 \cdot T_r$$

$$T_r^O = \bar{e}_1 \cdot T_r$$

$$\bar{e}_O = \overline{E_2 \cdot E_3 \cdot E_4 \cdot E_5 \cdot E_6}$$

$$T_G = \overline{E_3 \cdot E_4 \cdot E_5 \cdot E_6}$$

$$D_T = \overline{G_T} \cdot C_1 \quad \text{and} \quad \bar{D}_T = \bar{G}_T \cdot C_1$$

$$23S = \overline{E_5 \cdot E_6}$$

Direct counter outputs B_1 , E_1 , E_4 , and E_5 are also available. Observe from the timing diagram (Fig. 5) that the program board outputs T_r , T_H , and T_r^O all occur during the same time frame. It is important to note the relationship between T_r^O and T_H , as this determines which data is multiplexed into the Variable 1 position. Note also the relationship between T_{CV} and T_H , when T_H occurs T_{CV} does not; this accounts for the all zeros condition on the second strobe in the compass and vane fields.

The data output (D_T) is gated by \bar{G}_T and controls the serial data train (C1).

D. LOG-5

Inputs \bar{e}_1 , B_1 , E_1 , and G_T are gated (IC1A and IC4A) to form T_{CV} . A pulse delay network consisting of IC4B, IC1B, IC3C, and IC3D are used to form T_{CVD} from T_{CV} . T_{CVD} is used to transfer the compass and vane information into the shift registers, and is delayed in order that the photocells will have time to respond to T_{CV} . L_F , an internally generated pulse, is used to gate the 65 ms L_F pulse. When L_F goes low, capacitor C_2 starts to charge, turning off Q_1 . When Q_1 is off, Q_2 and Q_3 are on allowing the lamps to flash. Q_4 is switched on when the +12R bus is activated.

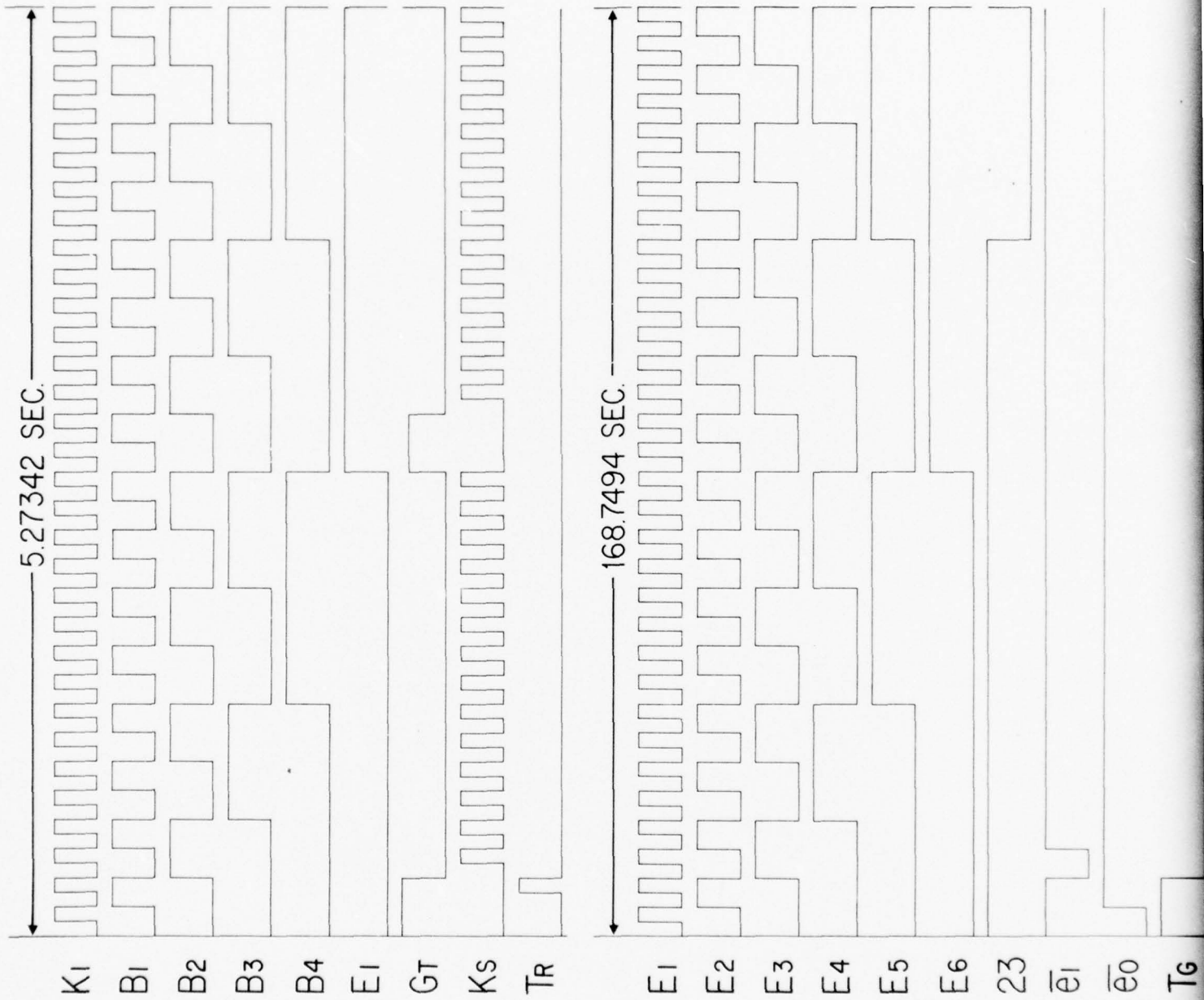
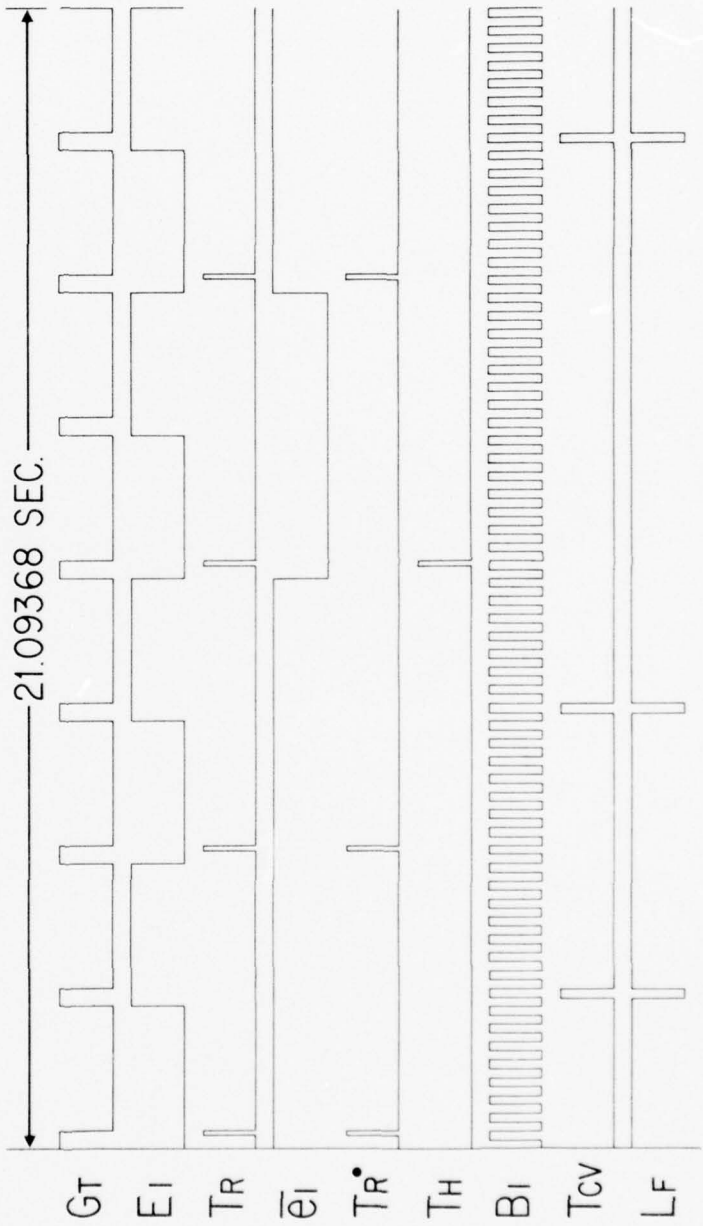
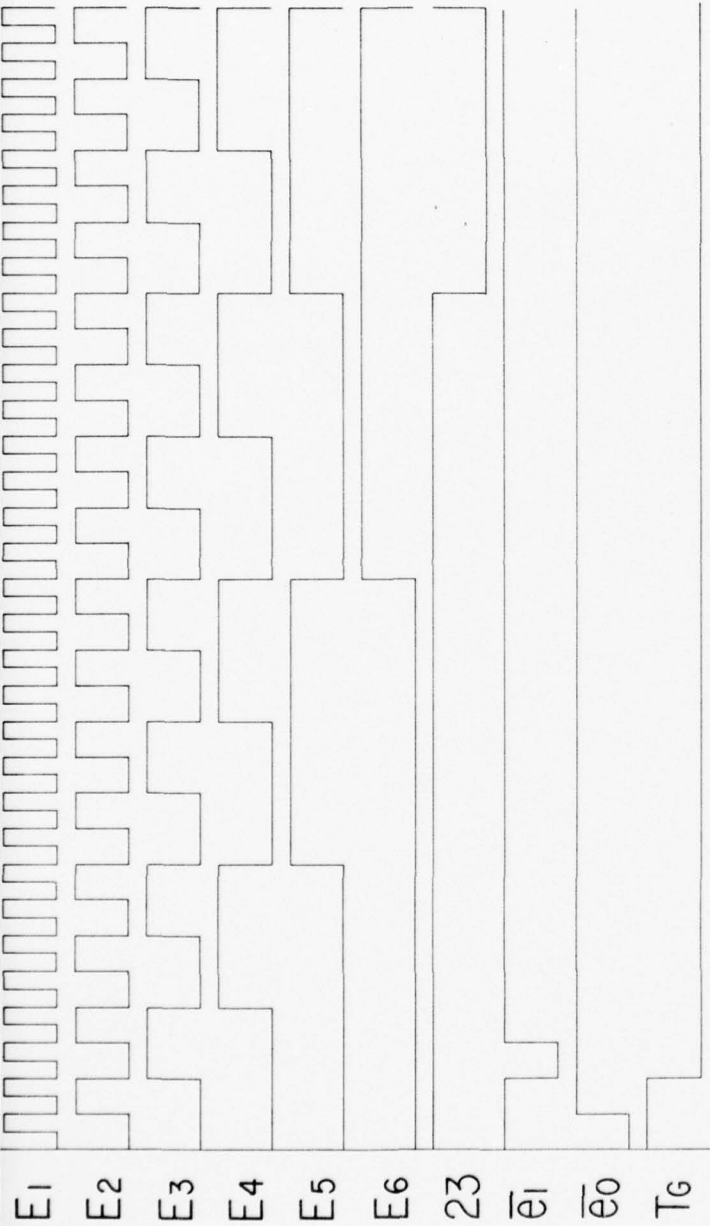


Fig. 5. Timing Diagram



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Inputs \bar{K}_1 and \bar{G}_T are gated to form the shift register clocking pulse K_S .

The reed switch signal is low pass filtered and inverted by IC2A to remove reed switch bounce, then used to drive a 1 ms one-shot (IC2C and IC2D). The resultant output pulse-train (K_r) is used to clock the rotor counter. The Boolean expressions for the output of the LOG-5 are:

$$T_{CV} = \bar{e}_1 \cdot B_1 \cdot E_1 \cdot G_T$$

$$T_{CVD} \approx T_{CV} \text{ (delayed by 4 propagation delays)}$$

$$L_F = \overline{T_{CV}}$$

$$K_S = \bar{K}_1 \cdot \bar{G}_T$$

E. Voltage to Frequency (F-F) Converter

The V-F converter forms an interface between the thermistor and the counters located on the rotor counter and temperature gate board.

A block diagram for the V-F is shown in Fig. 6.

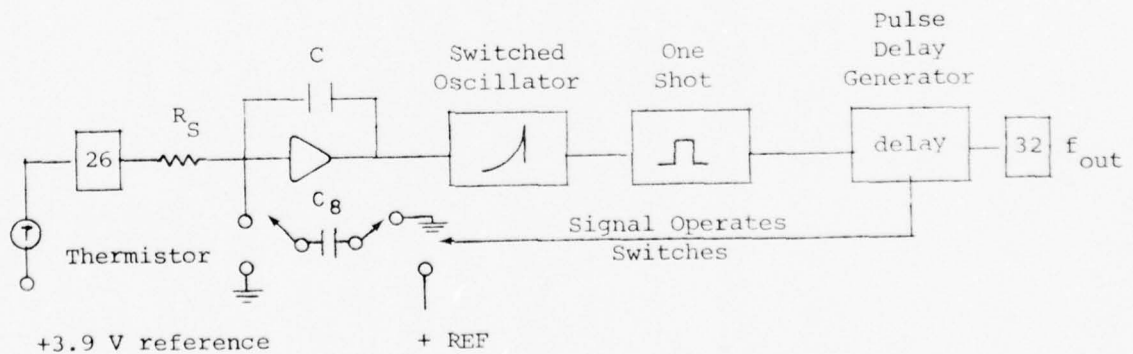


Fig. 6. V-F Block Diagram
(AMF⁶ DIAGRAM)

The output frequency varies inversely as the thermistor resistance (R) and therefore, directly as temperature according to the expression

$$f_{\text{out}} = \frac{E_{\text{in}}}{E_{\text{ref}}} (1/RC)$$

where,

$$C = C_8 + C_{13}, \quad R = R_2 + R_T, \quad \text{and} \quad \frac{E_{\text{in}}}{E_{\text{ref}}} \approx 1.$$

Assume a specific state for IC2, let Q be low, this makes A high and B low. Control signals A, B, and \bar{A} operate the FET switches ($Q_6, Q_7, Q_8, Q_9,$ and Q_{10}). A high on A causes Q_7 to be ON, effectively connecting one end of C_8 to ground. The low level on \bar{A} causes Q_{10} to be ON connecting the other end of C_8 to the 3.9 V reference supply. Q_8 is also ON due to the high level on A.

The temperature signal (+) drives the inverting input of IC1 resulting in a negative ramp at the output. Until the output of the integrator goes slightly negative, Q_1 remains OFF and Q_2 is ON. In this state the gate voltage of Q_4 (11.5 volts) is greater than the anode voltage (10.5 volts) and the PUT will not fire. When the ramp reaches -0.6 V, Q_1 turns ON, Q_2 turns OFF dropping the gate voltage allowing Q_4 to fire. When Q_4 fires, Q_5 turns on clocking IC2 causing Q to go high and \bar{Q} low. The pulse delay network at the inputs of IC3A and IC3B produces a make before break action. A goes low immediately when Q goes high, B is delayed from going high for 10 μ s. This action controls the switching of the FET's and results in C_8 being isolated for the 10 μ s R.C. time constant. When B goes high, Q_6 and Q_9 are switched ON connecting the negatively charged side of C_8 to the input of the integrator (IC1) and the other side to ground. The charge stored in C_8 is transferred to C_1 causing IC1 pin 6 to go positive and begin the negative ramp again. Capacitor C_9 forms a voltage divider with C_8 to limit the voltage applied to the Op Amp input.

Since the Q output of IC2 is a high, Q_3 is ON preventing Q_2 from changing state. When the anode voltage of the PUT reaches the gate voltage, the PUT will again fire causing IC2 to toggle. The period of the PUT is approximately 125 μ s which is determined by the 470K and 220 pf time constant. When IC2 toggles, Q_3 is switched off, B goes low and 10 μ s later A goes high. This returns C_8 to a charging position, allowing for a 10 μ s break before make at both ends of the capacitor.

The rate at which this sequence takes place is a function of the input resistance, lower resistance yields a higher output frequency.

The modifications required for adding temperature to a model 850 current meter are shown in the Appendix.

F. Rotor Counter and Temperature Gate

This board was part of the original temperature modifications made to the 850's, hence some minor component changes are required to make them compatible with the COS/MOS circuitry. Appendix B shows a circuit diagram with the necessary modification. A simplified version of this board (RC & GII) has been included in the Appendix; this board is directly interchangeable with the present design. Pulses T_G and T_r determine which data counts, temperature or rotor, are gated thru the multiplexing gates (IC1 and IC2) to the counters (IC4 and IC5). T_r functions as a count inhibitor and reset pulse. When T_r is high, IC3 prevents the data counts from clocking the counters. On the negative-going transition of T_r , Q_1 is momentarily turned on resetting IC4 and IC5. All multiplexed data bits ($M_1 - M_{14}$) are applied to the shift registers in parallel format.

G. Shift Register

There are two identical shift register boards in the COS/MOS 850, each handling seven data bits. All data are presented to the registers in parallel format. Control pulses T_r^O , T_H and T_{CVD} govern the sequence

in which data is transferred. Whenever any of these control pulses are high, they are gated thru the OR gates (IC1) to pin 9 of IC6 resulting in a parallel to serial shift. At T_{CV} time, when the compass and vane-follower are interrogated, the clocking pulse (Ks) is inhibited from clocking the shift register (IC6) by IC1C.

Recalling the discussion of the data format note that some of the multiplexing occurs on the shift register boards. The control pulses determine which sets of data are gated thru the AND-OR select gates (IC2, IC3, IC4, IC5) to the shift register (IC6). T_r^O transfers temperature and rotor data, T_H the time word, and T_{CVD} the compass and vane information.

The operation of the multiplexing gates can be best understood by considering only one section of the CD4019 (Fig. 7).

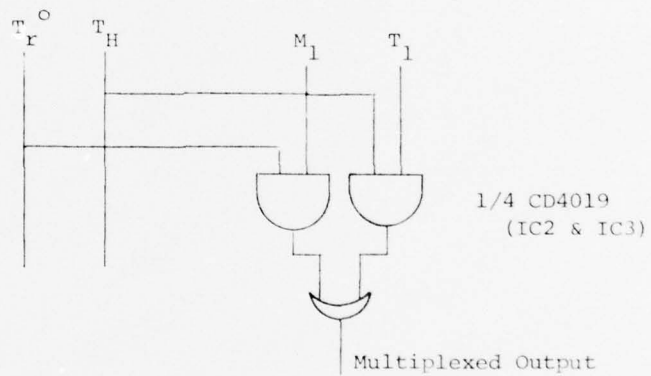


Fig. 7. Multiplexing Gates

It can be seen from the timing diagram that the control pulses are normally in a low state. Note that T_r and T_H do not go high at the same time. When T_r^O is a logical 1, all bits of data present at the multiplexed inputs ($M_1 - M_{14}$) are gated thru the CD4019 and appear at the output. In a similar manner when T_H is high the data appearing on the time inputs ($T_1 - T_{14}$) are gated thru. This multiplexed output

is again combined with the compass/vane information in the next CD4019. Controls signals T_{CVD} and the combined outputs of T_r^O and T_H (IC1B) determine which data bits are gated thru to the shift register. In this manner all data is presented to the shift registers in parallel format and converted into a serial data train.

H. TAP-9

The TAP-9 drives the tape heads and the recorder stepping motor. This is a Geodyne board with some modifications, the necessary circuit changes are outlined on the schematic diagram.

The head driver is divided into two sections, Q_1 and its associated circuitry for recording ones, and Q_2, Q_3 and the associated circuitry for recording zeros. The outputs from these sections are combined at pin 12 a test point. The collector circuitry serves as a pulse-shaping network, Fig. 8 shows a typical data train as recorded on tape.

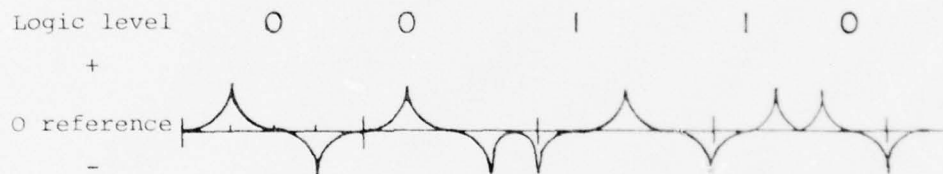


Fig. 8. Tape Head Waveforms

Observe the difference in waveshapes between a zero and a one:

Logical Zero - signal goes positive then negative

Logical One - signal goes negative then positive

The recorder clocking pulses (K_2, \bar{K}_2) are applied to pins 18 and 21. Since the drive circuits for the two windings of the stepping motor are similar, we will consider only one. When K_2 goes low, Q_5 is turned

off for a period of time until the charge across C_3 reaches approximately 1.2 volts. The time required for C_3 to charge to this voltage is dependent upon the values of C_3 , R_{14} , R_{14A} , and the voltage drop across CR23. Note also that the motor driving voltage (+12R) is separate from the logic voltage, the +12 bus. The general form for the voltage developed across a capacitor can be expressed as follows:

$$V_c = E(1 - e^{-t/RC})$$

This states that the time interval (t) required for a capacitor to charge to a specific voltage ($V_c = 1.2$ V) is dependent upon the voltage applied ($E = +12$ bus) and the time constant $R \cdot C$. Where $R = R_{14}$ in parallel with R_{14A} and $C = C_3$.

Therefore, as the battery voltage decreases the time required for V_c to reach a specific value must increase. This means that as the battery voltage drops Q_5 is Off longer. When Q_5 is Off, Q_6 and Q_7 are On causing the motor to stop. Because of this characteristic, the energy required to STEP the motor remains nearly constant and the motor torque is maintained as the voltage drops. This characteristic is set by the trim resistors (R_{14A} , R_{25A}). A procedure for selecting these values is outlined in Section VII-J.

I. TAP-7

The TAP-7 implements the channel switching and instrument turn-off functions. This is one of the original boards designed by Geodyne for the 850, some minor modifications have been made to increase the circuit reliability; these are shown in the schematic diagram.

When the instrument is turned on, the reset button is pressed returning all relays to a reset position. The first time the fail sensing head is shorted (at the end of channel A), Q_1 turns on pulling in K_1 causing K_2 to close effecting a channel switch. Note that the charge on C_4 has not been affected and the position of K_3 has not

changed. C_1 charges for approximately 150 ms after which Q_1 is turned off removing voltage from K_1 . After eight hours (allowing time for the foil to pass the sensing head) a re-arm pulse from the clock turns Q_2 ON causing K_1 to re-arm the instrument. At this time the ground reference is removed from the negative side of C_4 . The second time the foil is sensed (at the end of channel B) Q_1 turns on pulling in K_1 , applying ground to the negative side of C_4 turning Q_4 ON energizing K_3 . This removes the +12D and -12D voltages from the instrument and the recorder preventing an overwrite of earlier data.

J. Battery

The instrument requires a three section, 12-volt unregulated power source. The battery shown in Fig. 9 will power the instrument for a period of one year. The +12 logic supply consists of three parallel stacks of cells, each isolated by blocking diodes. The -12 logic supply is a single stack of cells, while the +12 motor supply is two parallel stacks of cells isolated by diodes. A suitable battery is available from Mallory⁴ as their part number 304191. Nominal currents drawn by the instrument averaged over one hour, for 23 strobos and a 1-hour record interval are:

+12 logic = 850 μ a

-12 logic = 350 μ a

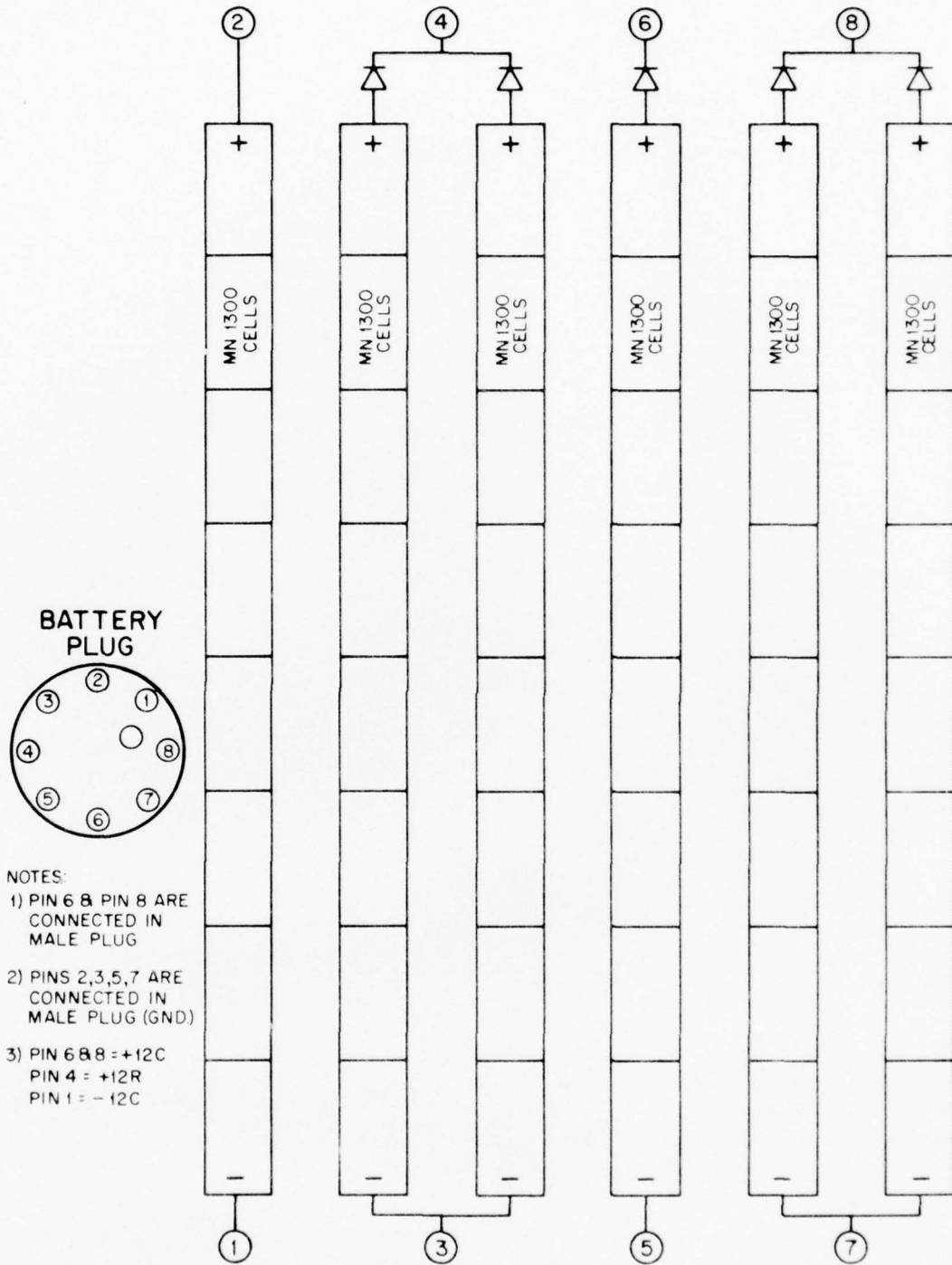
+12 motor = 800 μ a

K. Recorder and Tape

The COS/MOS 850 uses the original dual channel recorder supplied by Geodyne (Model 536-1A) and includes an internal foil sensing head. The stepping motor is controlled by the TAP-9 while the sensing head drives the control circuitry on the TAP-7.

Most problems with the recorder in the past have been traced to mechanical malfunctions such as incorrect anti-backlash gear adjustment, tape head misalignment, and grease causing excess drag on the gears. These areas are now routinely checked as part of the precruise tests.

850 BATTERY



- NOTES:
- 1) PIN 6 & PIN 8 ARE CONNECTED IN MALE PLUG
 - 2) PINS 2,3,5,7 ARE CONNECTED IN MALE PLUG (GND)
 - 3) PIN 6 & 8 = +12C
PIN 4 = +12R
PIN 1 = -12C

MALLORY PART NO. 304191

Fig. 9. Battery

The recorder requires a 394-ft endless loop cartridge available from Fidelipac, ^(R)5 number 65-140-394.

L. Compass and Vane-Follower

The compass and vane follower are the originals supplied by Geodyne. All compass and vane followers now in use are routinely adjusted for optimum coupling and minimum crosstalk.

The outputs of the devices are in a seven-bit digital gray code yielding a 2.8° resolution. Figure 10 is the gray coded disc and Table 3 is the Gray Binary to Degrees conversion table.

VII. TEST AND ALIGNMENT PROCEDURES

A. The following equipment or equivalent is required for proper alignment of the COS/MOS 850 current meter.

Electronic Counter/Timer - Systron Donner 6150
 Dual Channel Oscilloscope - Tektronix 564B
 VOM - Simpson 260 OR DVM - Fluke 8000A
 Current Probe - Tektronix P6042
 Power Supply - Lambda LPD-422A-FM
 Vishay Decode Resistor - Model 1303
 Torque Watch - Waters 651C-3
 Dial Gauge - Sarrett 645
 Digital Display Monitor - Geodyne/W.H.O.I.

B. Corrosion Control

Inspect cage and case assemblies to insure that there is no uncoated aluminum exposed. All corrosion product must be removed and the exposed metal cleaned. The piece is then treated in an aluminum chromate solution (1). All pits in the metal are filled with epoxy (2) and given a light sanding. The finished piece is then given two coats of Rustoleum ^(R) paint.

(Number in parenthesis refers to a note at the end of the section.)



Fig. 10. Gray Coded Disc

Note 1: Aluminum chromate solution is a 1 to 1-1/2 ounce of Alchrome #2 dissolved in a gallon of water and the pH adjusted to 1.5 to 2.0 with nitric acid. Immerse clean aluminum object to be coated in the solution and allow it to remain undisturbed for three minutes. Rinse with clean water. The part must be free of all surface contamination.

Note 2: Epoxy, B. F. Goodrich 2 part epoxy, #A 1177B or equivalent.

C. Rotor and Vane Bearing Adjustments

After all cage and case hardware has been corrosion treated, the cage should be assembled except for the bottom plate and all aluminum rods torqued to 120 in. lbs. The journal bearings and pivots in the rotor and vane must be secure and clean. Check vane magnet holder for proper orientation.

1. Install upper vane bearing without spacers.
2. Place vane in position and insert the center pivot into the lower vane bearing.
3. Place rotor into position and secure lower cage plate with two screws. Insert the lower rotor pivot into the rotor bearing. The rotor should now rotate freely. Locate and mark the "high spot" on the magnet ring.
4. Adjust the center bearing for .030" clearance between the reed switch and the high spot on the magnet ring.
5. Determine the lash in the vane. This can be done with a Starrett dial gauge or by the use of the bearing threads. The Delrin bearing has 24 turns per inch, therefore one turn is equal to .042". The spacer(s) required at the upper vane bearing will be equal to Total Lash - .030".
6. Remove the rotor, vane and all bearings; put Dow Corning 4 silicon compound on all plate threads.

7. Install upper vane bearings with appropriate spacers (C-5) and torque 10-12 in. lbs. Place vane in position, turn center bearing until there is no vane lash. Back center bearing out 3/4 of a turn (.030") and secure with nut torqued to 15-20 in. lbs. Check reed switch to rotor clearance (.030").

8. Install rotor and turn lower pivot until there is no rotor lash. Back lower pivot out 3/4 of a turn (.030"), secure with nut (torqued to 15-20 in. lbs.) and fill back side of bearing hole with DC4.

9. Recheck all clearances, and record on section A of pre-cruise sheet (see Appendix).

D. Preliminary Electronic Checks

1. Review instrument log and note any entries which may reflect instrument performance.

2. Place a $24.9K\Omega$, 1% resistor in place of thermistor (TB1 terminals 1 and 2).

3. Inspect instrument back plane wiring, circuit boards, compass and vane follower, and all connectors.

4. Verify that all modifications to the TAP-7 and TAP-9 have been completed.

E. Current Measurements

1. Set positive and negative supplies to 12 volts and connect power cable to instrument.

2. Using a Simpson 260, measure and record the currents indicated in section B-1 of the precruise sheet.

F. LOG-5 - An oscilloscope is required for the following checks.

1. Locate mark on rotor ring, monitor 0133 and record the number of pulses/revolution and the pulse amplitude.

2. Observe the output of IC2A (0129) and verify there is no reed switch bounce.

3. Measure and record the one-shot duration (0132).

4. Measure and record T_{CV} (0122) and T_{CVD} (0121) pulse widths.

5. Measure and record L_f (0106) pulse width.

G. Digital Clock - all tests are performed with shut-off magnet in place.

1. Using the counter measure and record the period at test point F.

2. Measure and record the period at 0431; this tests the operation of IC1, IC2, and IC3.

3. Speed-up clock by jumping 0404 to 0409, and T.P.F to 0431. Measure and record the period at 0412. This checks the operation of IC4 and IC5. Verify all 14 time bits go high and low. Remove jumpers.

H. Program Board

1. Utilizing the counter in a Start-Stop mode, measure and record the interval running times. The counter gating is set as follows:

Start (0223) positive going transition

Stop (0210) 7 strobes, (0209) 15 strobes, and (0212) 23 strobes, negative-going transition.

2. Measure and record the following pulse widths:

\bar{e}_o (0206), T_G (0213), and T_r (0222)

I. Voltage to Frequency Converter

1. Measure and record the reference voltage (1118).

2. Calibration. Monitor the V-F output period at 1132. Set the Vishay decode box at 64530Ω and connect between TBI terminals 1 and 2. Period at output should now be $552.275\ \mu\text{s}$. Set positive supply at 9 volts and measure output period. Differences between these two periods should be ± 0.1 counts, if not, adjust C7 (differential capacitor) for minimum period change with voltage variation. Set positive supply at 12 volts and complete table in section B-5 of the precruise sheet.

Note: If adjustment of C1 is required to meet the specifications then the 8°C period should be noted before adjusting.

J. Tape Recorder

1. Clean pinch wheel, capstan, and worm gear. Clean and degauss tape head. Lubricate worm gear with LPS-2.

2. Using the current probe and oscilloscope observe the stepping motor currents at 1029 and 1031. The pulse should remain in saturation for approximately 2 ms. This time is set by R14A and R25A as follows:

- a. Positive supplies are set at 12 volts.
- b. Probe is set to measure current at 1029 and R14A selected to meet the specification of 2 ms.
- c. In a similar manner, monitor 1031 and select R25A for 2 ms saturation.
- d. Complete table in section B-7 of precruise sheet.

3. With the torque watch measure and record the capstan torque at 12 and 9 volts.

4. Measure and record the positive and negative voltage peaks on channel A (0921) and channel B (0930).

5. Verify the channel switching function; with the instrument in channel A re-arm short the sensing head, the instrument should switch to channel B, no re-arm.

6. Verify the instrument shut-off function; after performing the channel switch test monitor 0420. Speed up clock until 0420 makes a high to low transition, instrument should now be in the channel B re-arm mode. Wait 15 seconds, short the sensing head, the recorder should stop and all indicator lamps should be off when the test button is depressed.

K. Cold Room Tests ($\approx 5^{\circ}$ C)

1. Adjust oscillator frequency (T.P.F) for $26.822090 \mu\text{s} \pm 0.000130 \mu\text{s}$.
2. Measure and record capstan torque at 12 and 9 volts.
3. Run test tapes as necessary.

VIII. REFERENCES

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3. McCullough, J. R. (1975). Vector Averaging Current Meter Speed Calibration and Recording Technique. W.H.O.I. Technical Report 75-44, unpublished manuscript.
4. Mallory, S. Broadway and Sunnyside Lane, Tarrytown, N. Y. 10591.
5. Fidelipac^(R) Tape Cartridge - available thru Continental Recording Co., 210 South Street, Boston, Massachusetts 02111.
6. AMF Electrical Products Division, 1025 North Royal Street, Alexandria, Virginia 22314. (Manufacturer of the Vector Averaging Current Meter.)
7. Delrin^(R) - A Dupont registered tradename.
8. Dean, J. P. (1976). VACM Notes. POLYMODE News #12, unpublished manuscript.

IX. ACKNOWLEDGMENTS

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X. APPENDIX A

850 Precruise Sheet

850 PRECRUISE SHEET

A. Cage

- 1) Vane Lash _____ in. .030 ± .005"
- 2) Rotor Lash _____ in. .030 ± .005"
- 3) Rotor Clearance _____ in. .030 ± .005"
- 4) Vane Alignment _____

B. Electronics

- | 1) Current | ON | OFF | OFF (MAGNET) |
|---------------|-----------|-----------|--------------|
| Tap-9 (+12R) | _____ ma. | _____ ma. | _____ ma. |
| +Logic (+12C) | _____ ma. | _____ ma. | _____ ma. |
| -Logic (-12C) | _____ ma. | _____ ma. | _____ ma. |
- 2) LOG-5
- | | | |
|---------------------------|--------------|----------------|
| Rotor Pulses/Rev (0133) | _____ pulses | 16 pulses/rev. |
| VP-P at 0133 | _____ volts | 12 volts |
| Reed Switch Bounce (0129) | _____ | |
| One Shot Duration (0132) | _____ ms. | 1 ± .1 ms. |
| Pulse Width | | |
| Tcv (0122) | _____ ms. | 164.79 ms. |
| Tcvd (0121) | _____ ms. | 164.79 ms. |
| Lf (0106) | _____ ms. | 65.0 ms. |
- 3) Clock
- | | | |
|-----------------------|------------|------------------------|
| Time Word Bits | _____ | |
| Period (test point F) | _____ μs. | 26.822090 ± .00013 μs. |
| Period (0431) | _____ sec. | 28.125 sec. |
| Fast Period (0412) | _____ sec. | 14.062 sec. |
- 4) Program
- Interval Running Times
- | | | |
|-------------------|------------|--------------|
| 7 Strokes (0210) | _____ sec. | 42.187 sec. |
| 15 Strokes (0209) | _____ sec. | 85.374 sec. |
| 23 Strokes (0212) | _____ sec. | 126.562 sec. |
- Pulse Width
- | | | |
|-----------------------|------------|-------------|
| \bar{e}_o (0206) | _____ sec. | 5.273 sec. |
| T _G (0213) | _____ sec. | 10.546 sec. |
| T _r (0222) | _____ sec. | 82.397 ms. |

Meter # _____

5) V-F Converter

Reference Voltage (1118) _____ volts 3.9 ± .2 volts

Calibration

T° C	R (K Ohms)	Period 12 V	9 V
0	94.98	_____ μs.	_____ μs.
8	64.53	_____ μs.	_____ μs.
30	24.27	_____ μs.	_____ μs.

6) Digital Display Monitor - Word Checks

Compass _____, Vane _____, Temperature _____, Time _____, Rotor _____

7) Recorder

Current Pulse	I _{p-p}	Width
1029	_____ ma.	_____ ms.
1031	_____ ma.	_____ ms.
Capstan Torque		
12 volts	_____ in. oz.	
9 volts	_____ in. oz.	
Head Voltage		
Channel A	_____ + volts	_____ - volts
Channel B	_____ + volts	_____ - volts
Channel Switching	_____	Shutoff _____

C. Cold Room (5° C)

1) Clock Period (test point F) _____ μs.

2) Capstan Torque

12 volts _____ in. oz., 9 volts _____ in. oz.

D. Test Tapes

Number of Records _____, _____, _____

Number of Errors _____, _____, _____

E. Thermistor No. _____

Date Installed _____

COMMENTS _____

APPENDIX B. 850 Interconnection Wiring Diagrams

850 INTERCONNECTION DIAGRAM

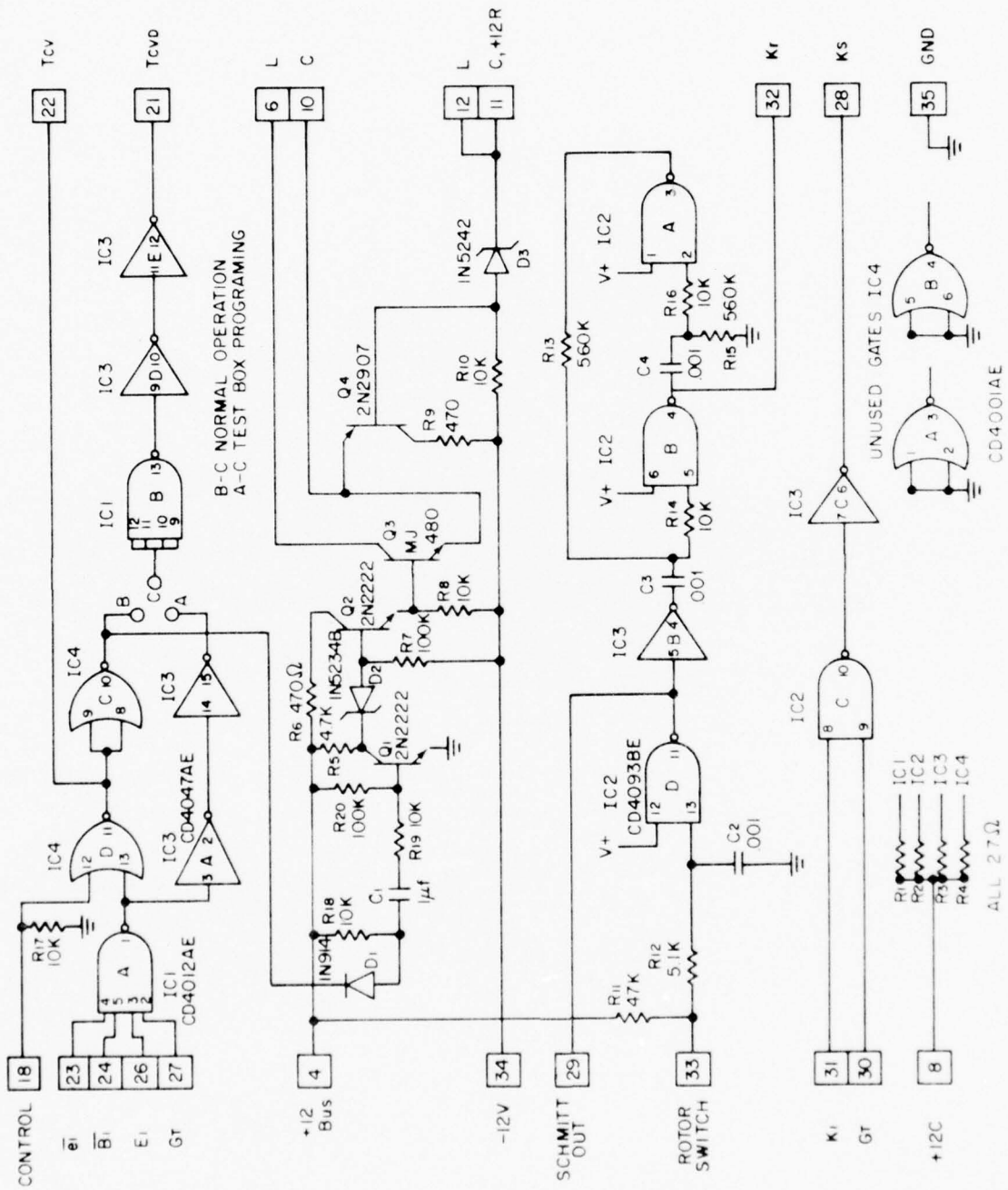
← WIRE FROM BOARD
→ WIRE INTO BOARD

PIN	01 LOG-5	02 PROGRAM	04 CLOCK	05 SHIFT REGISTER	06 ROTOR COUNTER	PIN	07 SHIFT REGISTER	08 STA-9	09 TAP-
1						1			
2						2			
3						3			
4	08-4	← ^{+12C} 01-8, 04-4	← ^{+12C} 02-4, 05-4	← ^{+12C} 04-4, 06-4	← ^{+12C} 05-4, 07-4	4	← ^{+12C} 06-4, 08-10	← ^{+12Bus} 01-4, 10-4	
5		← ^{B1} 01-23	← ^{12Hz} 08-28	← ^{CIN} 07-32	← ^{M1} 07-6	5	← ^{GND} 07-35		P- REARM
6	(N) LAMPS (C+V)	← ^{B0} 10-15	← ^{"TURN ON"} 08-14	← ^{Tr} 06-21	← ^{Tr} 02-22, 06-22	6	← ^{PROGRAM RESET} 06-5	← ^{PROGRAM RESET} 02-23	
7			MAG SWITCH		← ^{M2} 07-13	7			
8	← ^{+12C} 02-4		← ^(NOMINAL) 04-24	← ^{Tr} 02-14, 07-8	← ^{M3} 07-16	8	← ^{SHUTOFF} 05-8	← ^{SHUTOFF} 02-09/02-10/02-12	← ^{+12C} 08-11
9		← ^{OUTPUT} 15 STROBES	← ^{+7V (T.P.)}	← ^{Tr} 01-28, 07-9	← ^{M4} 05-28	9	← ^{Tr} 05-9		
10	← ^{5500μf CAP(-)}	← ^{OUTPUT} 7 STROBES	P-RESET SWITCH	← ^{COMPASS(B)}	← ^{M4} 07-19	10	← ^{+12C} VANE (B)	← ^{+12C} 07-4, 07-28	← ^{FOIL CO}
11	← ^{5500μf CAP(+), 08-24}			← ^{Tr} 02-15, 07-11	← ^{M11} 05-25	11	← ^{+12D} 05-11	← ^{+12D} 09-8	
12	(J) LAMPS (C+V)	← ^{OUTPUT} 23 STROBES	← ^{171 DAY} 05-30	← ^{Tr} 04-18	← ^{Tr} 02-13	12	← ^{Tr} 04-25	← ^{TEST POINT}	
13		← ^{Tg} 05-12	← ^{8.5 4 DAY} 05-27	← ^{Tr} 06-19	← ^{M12} 05-22	13	← ^{Tr} 06-7		
14		← ^{Tr} 05-8	← ^{42.7 DAY} 05-24	← ^{COMPASS(C)}		14	← ^{Tr} VANE (C)	← ^{Tr} 04-6	← ⁰⁴⁻³
15		← Th 05-11	← ^{21.3 DAY} 05-21	← ^{Tr} 04-17	← ^{M11} 05-19	15	← ^{Tr} 04-34		
16			← ^{10.7 DAY} 05-18	← ^{Tr} 06-17		16	← ^{Tr} 06-8	← ^{-12D} 09-26	
17			← ^{5.34 DAY} 05-15	← ^{COMPASS(E)}	← ^{M10} 05-16	17	← ^{Tr} VANE (E)		
18	← ^{Tr} 01-35	← ^{D1} 10-13	← ^{2.6 DAY} 05-12	← ^{Tr} 04-16		18	← ^{Tr} 04-23		
19			← ^{32 HR} 07-30	← ^{Tr} 06-15	← ^{M9} 05-13	19	← ^{Tr} 06-10	← ^{K2} 10-18	
20		← ^{D1} 10-6, P-T.P.	← ^{16 HR} 07-27	← ^{COMPASS(K)}	← ^{K1} 01-32	20	← ^{Tr} VANE (K)	← ^{K2} 10-21	← ^{TRAC}
21	← ^{Tcvd} 05-31	← ^{Tr} 05-32	← ^{8 HR} 07-24	← ^{Tr} 04-15	← ^{M8} 08-6	21	← ^{Tr} 04-22	← ^{K1} P-Kx, 10-7	← ^{TRAC}
22	← ^{Tcv} COMPASS & VANE (A)	← ^{Tr} 06-6	← ^{4 HR} 07-21	← ^{Tr} 06-13	← ^{Tr} 06-6	22	← ^{Tr} 06-27	← ^{+12R} ON/OFF SWITCH	← ¹⁰⁻¹
23	← ^{Tr} 02-5	← ^{Tr} 08-6	← ^{2 HR} 07-18	← ^{COMPASS(F)}	← ^{M7} 07-28	23	← ^{Tr} VANE (P)		← ^{P CHA (}
24	← ^{Tr} 02-25	← ^{Tr} 08-30, 01-31	← ^{1 HR} 04-8, 07-15	← ^{Tr} 04-14		24	← ^{Tr} 04-27	← ^{+12RS} 01-11, 10-26	← ^{P CH B (}
25		← ^{B1} 01-24	← ^{30 MIN} 07-12	← ^{Tr} 06-11	← ^{M6} 07-25	25	← ^{Tr} 06-25		
26	← ^{Tr} 02-34		← ^{15 MIN}	← ^{COMPASS(U)}		26	← ^{Tr} VANE (U)		← ⁰⁸⁻¹⁶
27	← ^{Tr} 02-30		← ^{7.5 MIN}	← ^{Tr} 04-13	← ^{M5} 07-22	27	← ^{Tr} 04-20		
28	← ^{Ks} 05-9		← ^{3.75 MIN}	← ^{Tr} 06-9		28	← ^{Tr} 06-23	← ^{Tr} 04-5	← ^{+12C} SWITCH
29	SCHMITT OUT		← ^{1.2 SEC}	← ^{COMPASS(S)}		29	← ^{Tr} VANE (S)		← ^{SWITC}
30	← ^{Tr} 02-32	← ^{G1} 01-27	← ^{56 SEC}	← ^{Tr} 04-12	← ^{Tr} 11-32	30	← ^{Tr} 04-19	← ^{K1} 08-24	← ^{+12D} 09-8, P.T
31	← ^{Tr} 02-24			← ^{Tr} 01-21, 07-31		31	← ^{Tr} 05-31		
32	← ^{Kr} 06-20	← ^{G1} 01-30	← ^{REARM} 09-14	← ^{COUT} 02, 21		32	← ^{COUT} 05-5		← ^{P RESET S}
33	← ^{REED SWITCH}		← ^{T.P.} 1.75 SEC			33			
34	← ^{-12 Bus} 04-34	← ^{E1} 01-26, P(T.P.)	← ^{-12 Bus} 01-34, 05-34	← ^{-12 Bus} 04-34, 06-34	← ^{-12 Bus} 05-34, 07-34	34	← ^{-12 Bus} 06-34, 08-34	← ^{-12 Bus} 07-34, 09-34	← ^{-12 Bus} 08-34
35	← ^{GND} 01-18, 02-35	← ^{GND} 01-35, 04-35	← ^{GND} 02-35, 05-35	← ^{GND} 04-35, 05-35	← ^{GND} 05-35, 07-35	35	← ^{GND} 06-35, 07-5, 08-35	← ^{GND} 07-35, 09-35	← ^{GND} 08-35

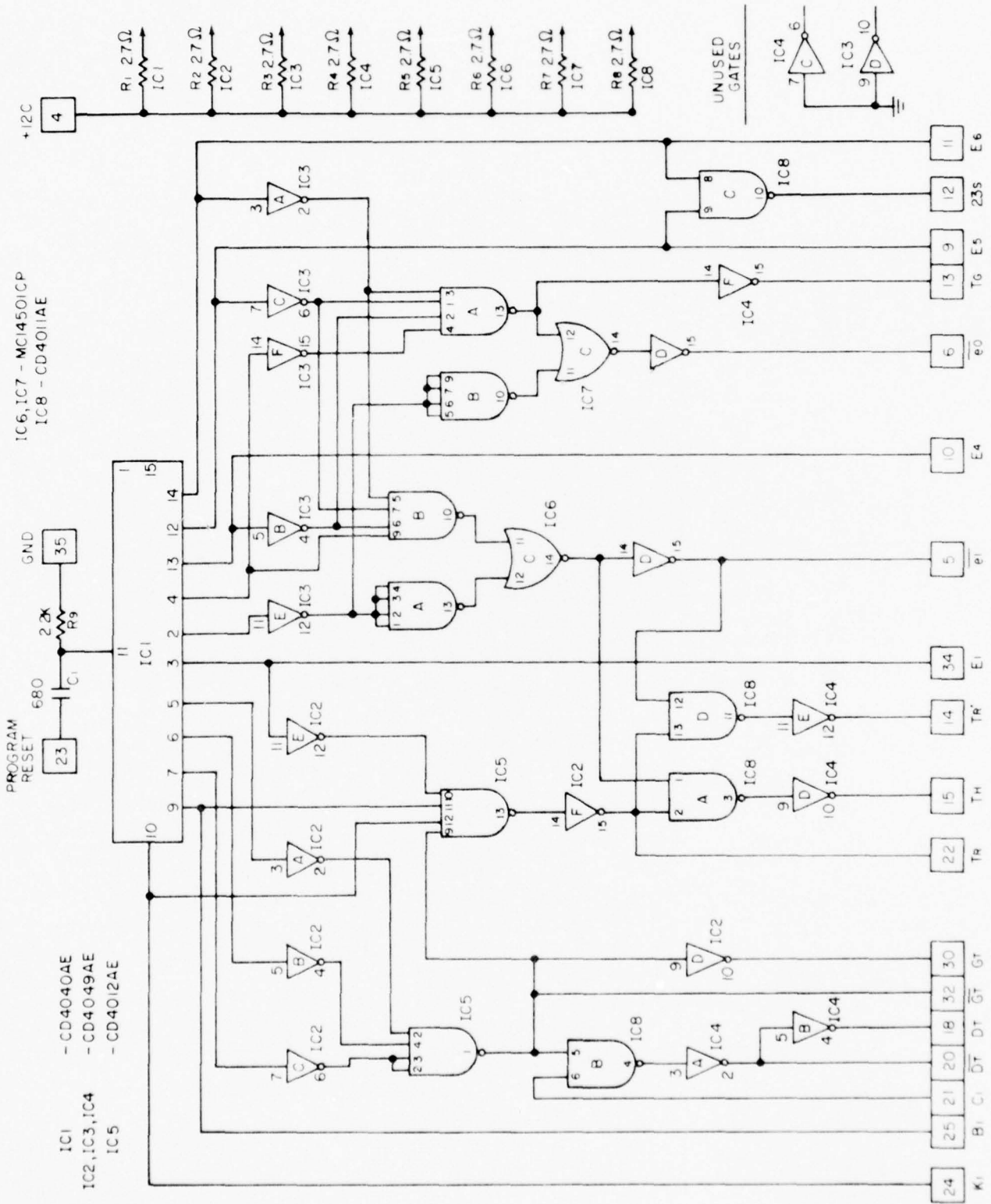
50 INTERCONNECTION DIAGRAM

T OR	06 ROTOR COUNTER	P I N	07 SHIFT REGISTER	08 STA-9	09 TAP-9	10 TAP-9	11 V-F CONVERTOR	P CONTROL PANEL
		1						<u>SWITCHES</u>
		2						TEST SWITCH:
		3						09-30, LIGHT COMMON
6-4	05-4 ^{+12C} , 07-4 ^{M1}	4	06-4 ^{+12C} , 08-10 ^{GND}	01-4 ^{+12Bus} , 10-4		08-4 ^{+12Bus} , 11-4	10-4 ^{+12Bus}	INS. RESET:
	07-6	5			P- REARM LAMP			09-32, CLOCK RESET (+)
	02-22 ^{Tr} , 06-22 ^{M2}	6	06-5	02-23 ^{PROGRAM RESET}		02-20		CLOCK RESET:
	07-13	7				08-21, 10-14		ON/OFF SWITCH B, 04-10
7-8	07-16 ^{M3}	8	05-8	02-09/02-10/02-12 ^{SHUTOFF}	08-11, 09-30 ^{+12D}	10-15		INS. RESET(+12C)
7-9	05-28 ^{M4}	9	05-9					ON/OFF SWITCH:
8(B)	07-19 ^{M4}	10	VANE (B)	07-4 ^{+12C} , 07-28 ^{+12D}	FOIL CONTACT			SIDE 1-
7-11	05-25 ^{M11}	11	05-11	09-8 ^{+12D}		09-22 ^{DATA OUT}		A) BATTERY (+12 B)
	02-13	12	04-25	TEST POINT				B) BATTERY (-12 B)
	05-22 ^{M12}	13	06-7			02-18		C) BATTERY (+12 R)
1(C)		14	VANE (C)	04-6	04-32	10-7		SIDE 2-
	05-19 ^{M11}	15	04-34			02-6, 10-8		A) CLOCK RESET (+12C)
		16	06-8	09-26 ^{-12D}				09-28 (+12C)
1(E)	05-16 ^{M10}	17	VANE (E)					B) 09-29 (-12C)
		18	04-23			08-19	3.9V (TP)	C) 08-22 (+12 RA)
	05-13 ^{M9}	19	06-10	10-18 ^{K2}				<u>TEST POINTS</u>
1(K)	01-32 ^{K1}	20	VANE (K)	10-21 ^{K2}	TRACK B			DATA 02-20
	08-6 ^{M8}	21	04-22	P-Kx ^{K1} , 10-7	TRACK A	08-20		Kx (x̄) 08-21
	06-6	22	06-27	ON/OFF SWITCH ^{+12R}	10-11		THERMISTOR	RESET (E1) 02-34
1(F)	07-28 ^{M7}	23	VANE (P)		P. CHA (LAMP)			GND CHASSIS
		24	04-27	01-11, 10-26 ^{+12RS}	P. CHB (LAMP)			<u>INDICATOR LIGHTS</u>
	07-25 ^{M6}	25	06-25					REARM 09-6, COMMON, SW.
1(U)		26	VANE (U)		08-16 ^{-12D}	08-24, CAP 2(+)	THERMISTOR	CHA 09-23, COMMON
	07-22 ^{M5}	27	04-20					CHB 09-24, COMMON
		28	06-23	04-5	SWITCH ^{+12C} , 08-10	MOTOR (YELLOW)		
1(S)		29	VANE (S)		SWITCH ^{-12C}	MOTOR (BLUE)		
	11-32	30	04-19	08-24 ^{K1}	09-8, P TEST SW ^{+12D}	MOTOR (ORANGE)		
1-31		31	05-31			MOTOR (BLACK)		
1(T)		32	05-5 ^{Cout}		INS P RESET SWITCH		06-30 ^{FREQ OUT K1}	
		33						
1-34	05-34 ^{-12Bus} , 07-34	34	06-34 ^{-12Bus} , 08-34	07-34 ^{-12Bus} , 09-34	08-34 ^{-12Bus} , 10-34	09-34 ^{-12Bus} , 11-34	10-34 ^{-12Bus}	
1-35	05-35, 07-35	35	06-35, 07-5, 08-35	07-35 ^{GND} , 09-35	08-35 ^{GND} , 10-35	09-35 ^{GND} , 11-35	10-35, 11-24, CHASSIS	

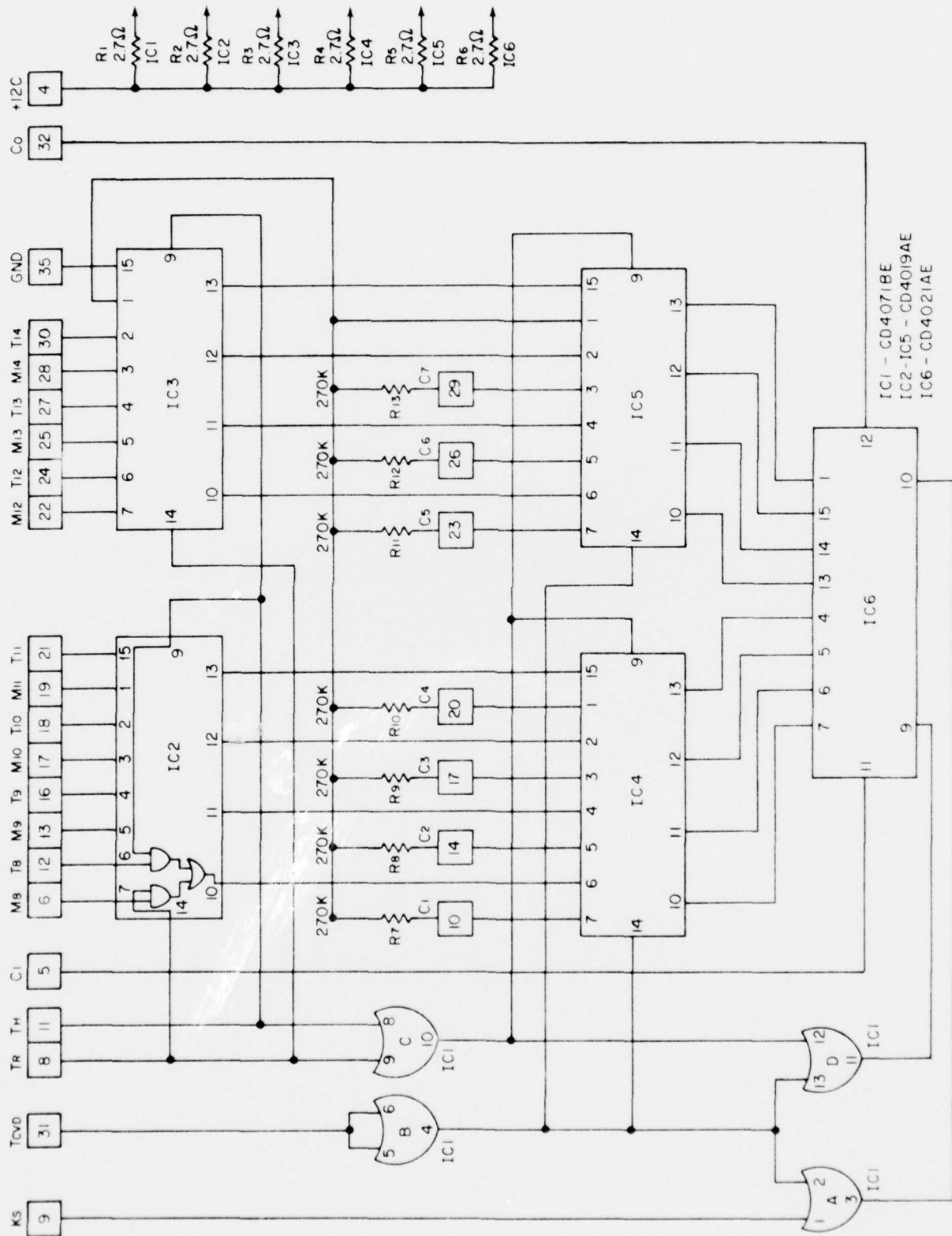
APPENDIX C. 850 Schematic Diagrams



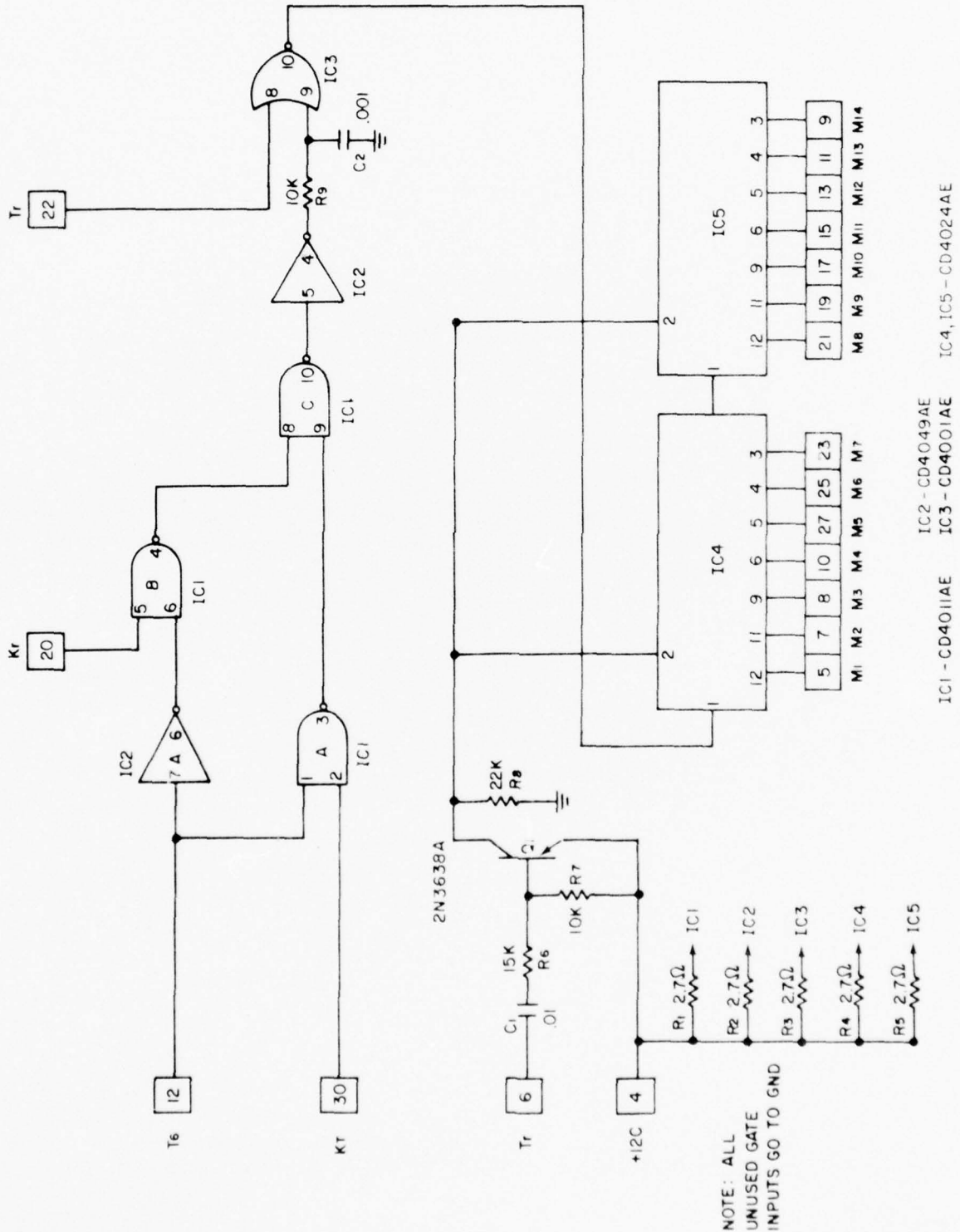
LOG-5



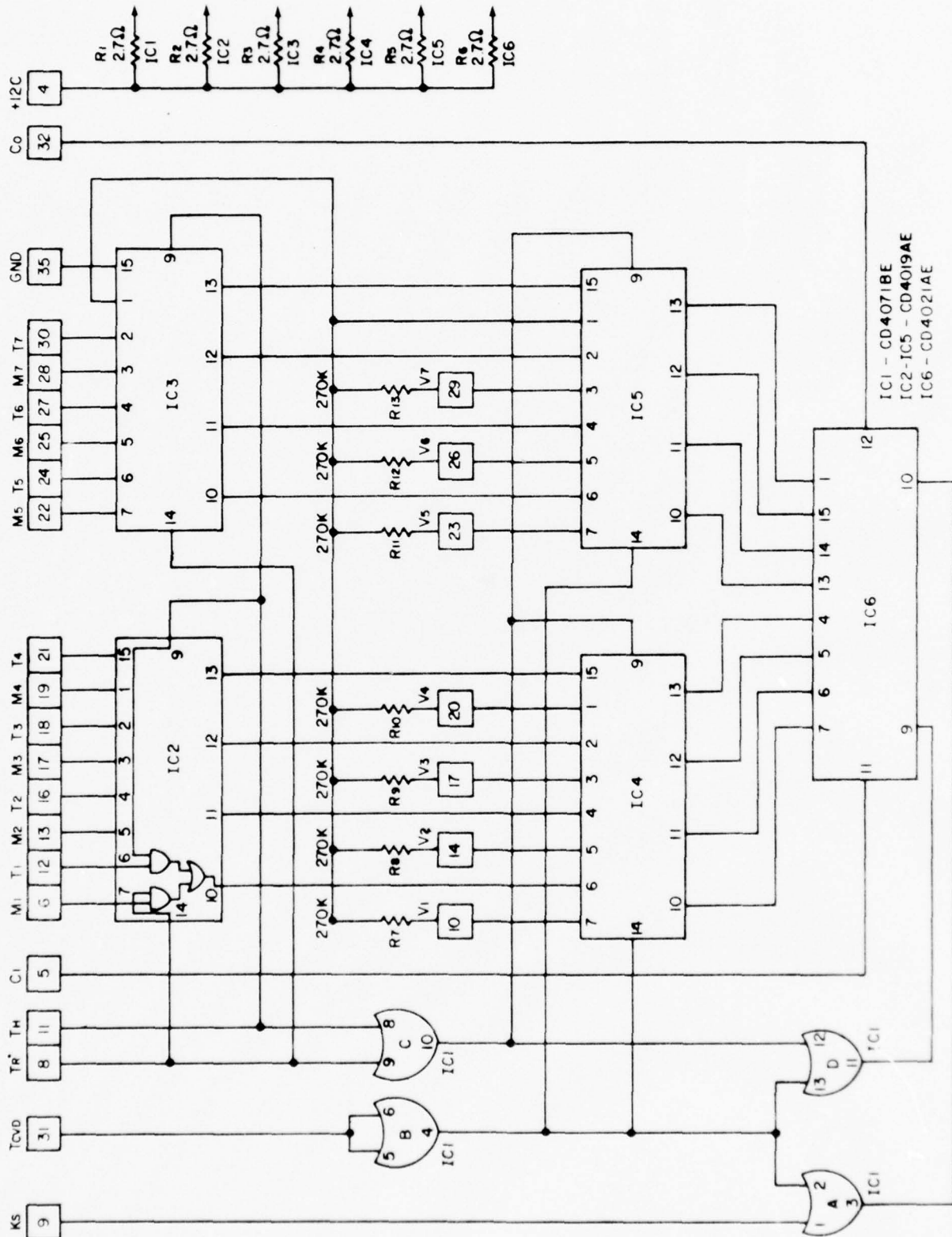
PROGRAM



SHIFT REGISTER

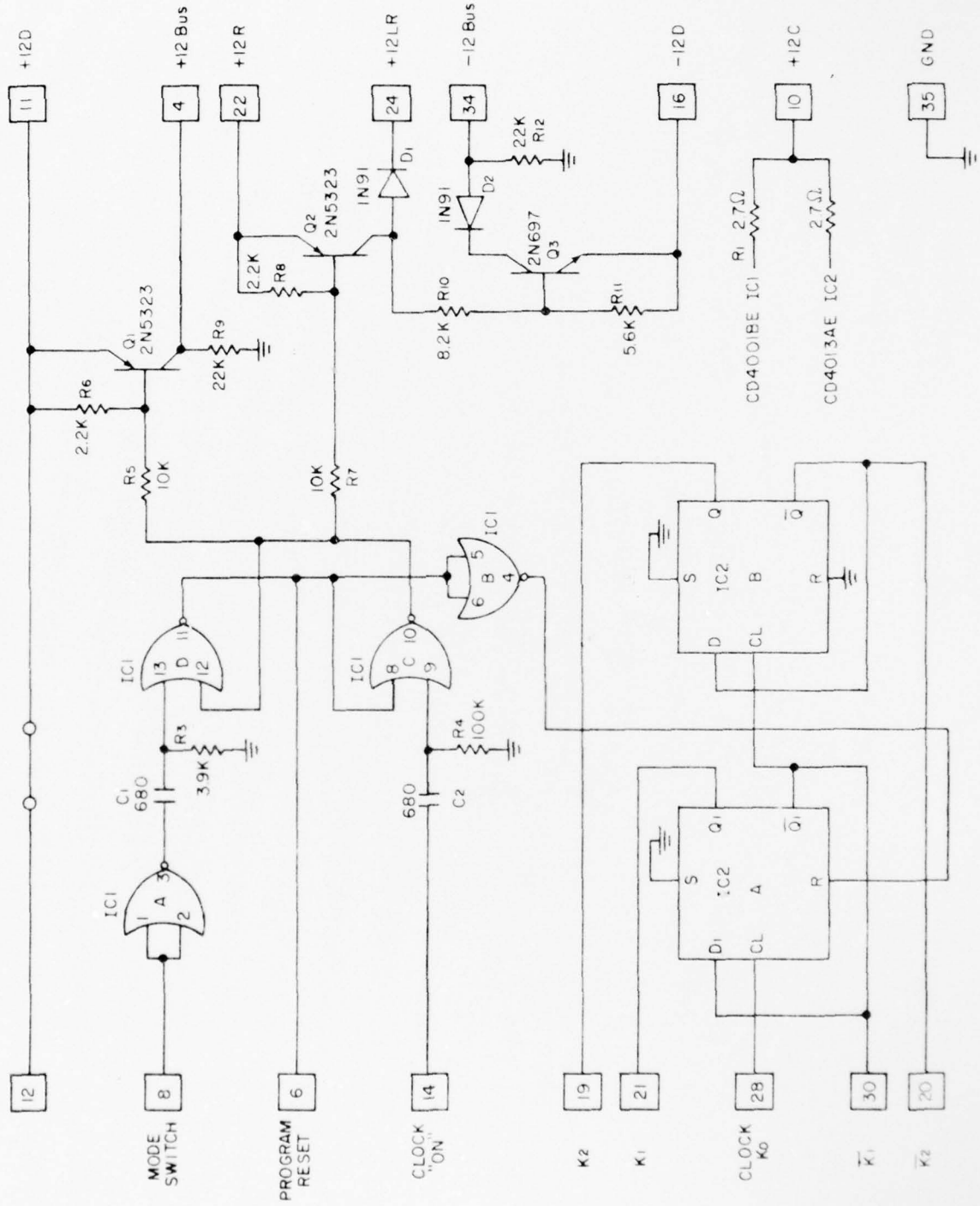


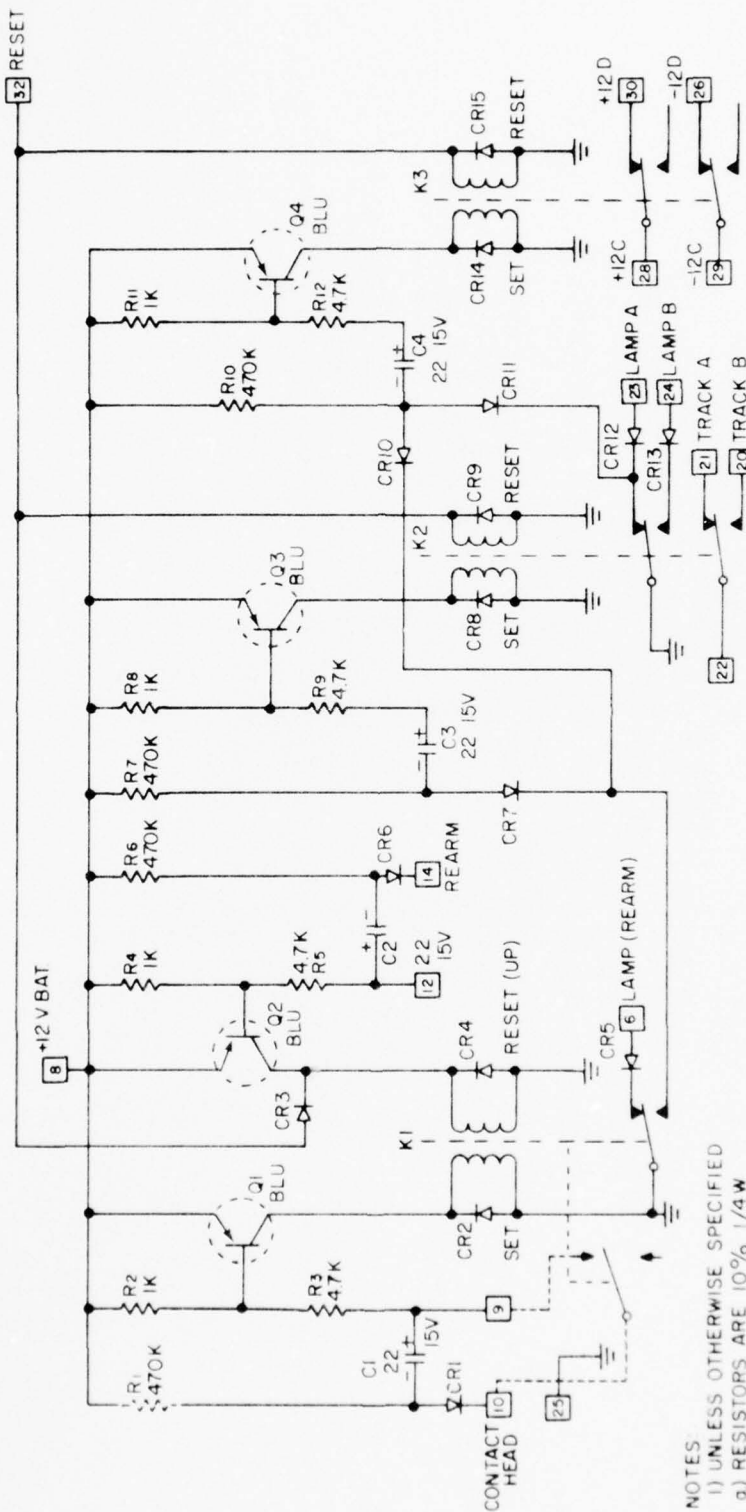
ROTOR COUNTER AND TEMPERATURE GATE



IC1 - CD4071BE
 IC2-IC5 - CD4019AE
 IC6 - CD4021AE

SHIFT REGISTER

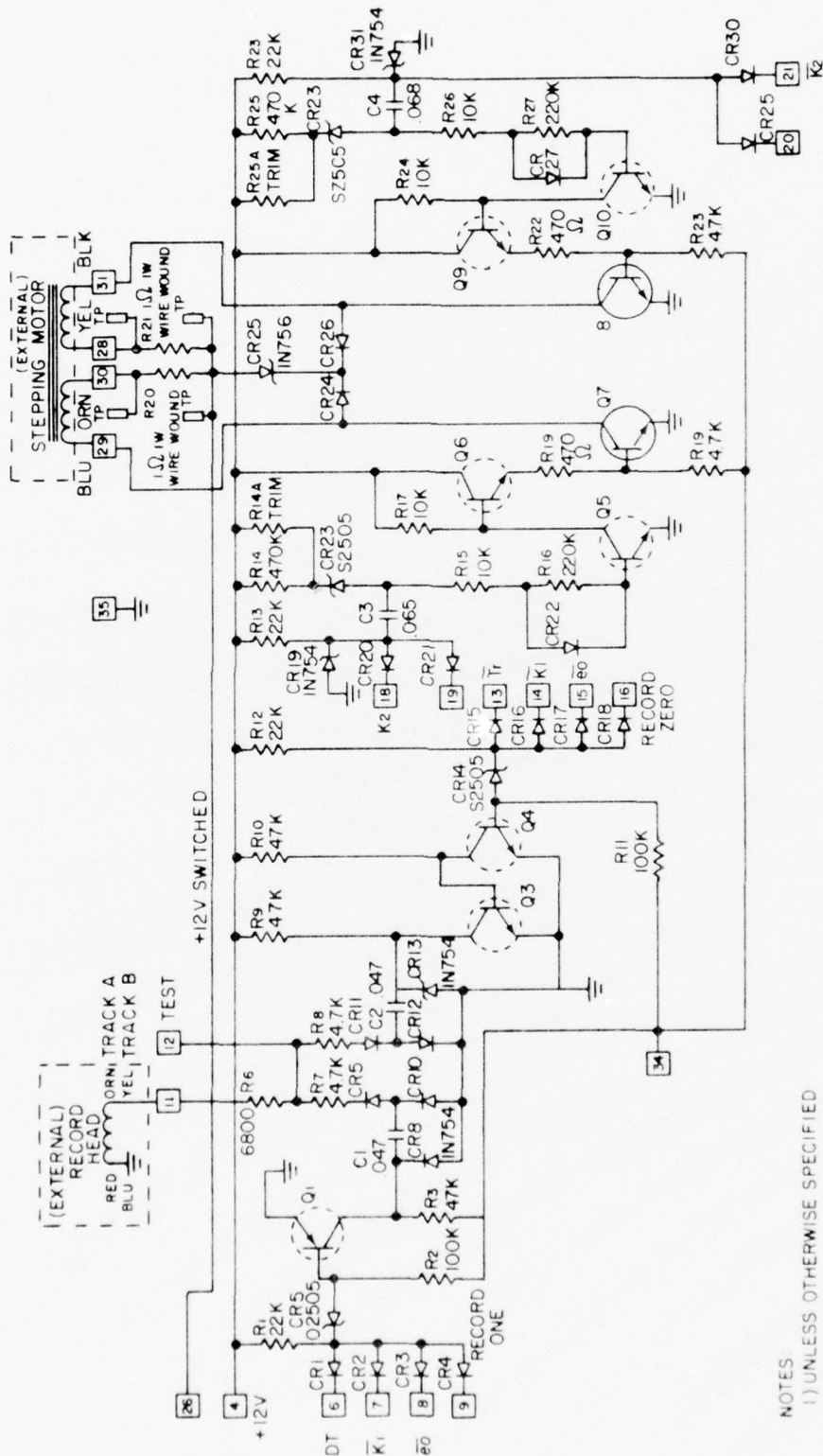




WHOLE CHANGES:
 1. Q1, Q2, Q3, Q4 REPLACED BY 2N2907
 2. REMOVE R1
 3. ADD WIRES (FROM [9] B [9]) AS SHOWN TO UNUSED K1 CONTACTS

- NOTES:
- 1) UNLESS OTHERWISE SPECIFIED
 - a) RESISTORS ARE 10% 1/4W
 - b) CAPACITORS ARE IN μ f SPRAGUE 1500
 - c) DIODES ARE IN914
 - d) TRANSISTORS ARE MM2003-2
 - 2) D.C. ASSY D-1659
 - 3) ALL RELAY CONTACTS ARE SHOWN IN RESET POSITION
 - 4) RELAYS, CLARE - LF2309 -600

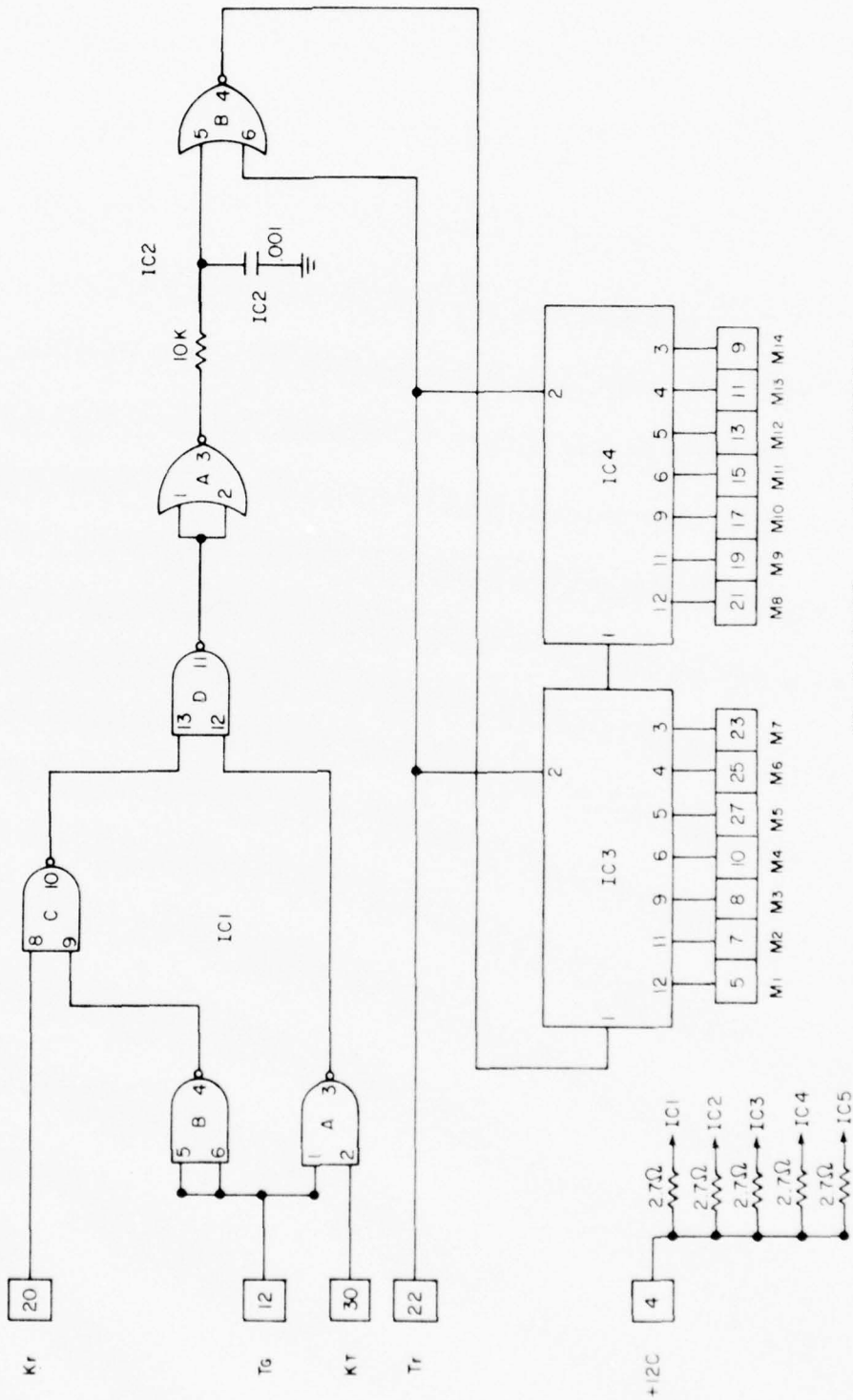
TAP-7



- NOTES:
- 1) UNLESS OTHERWISE SPECIFIED
 - a) RES. ARE 10% 1/4W
 - b) CAPS ARE IN μ F 100V ELEMENCO MYLAR
 - c) DIODES ARE IN914
 - d) TRANS ARE MM2000-2(YEL)
 - 2) USE TAP-9C FOR 20 Ω STEPPING MOTOR (0-25 STEPS/SEC)
 - 3) R/C ASSY IS D-1065 SHEET 2

WHOI CHANGES:

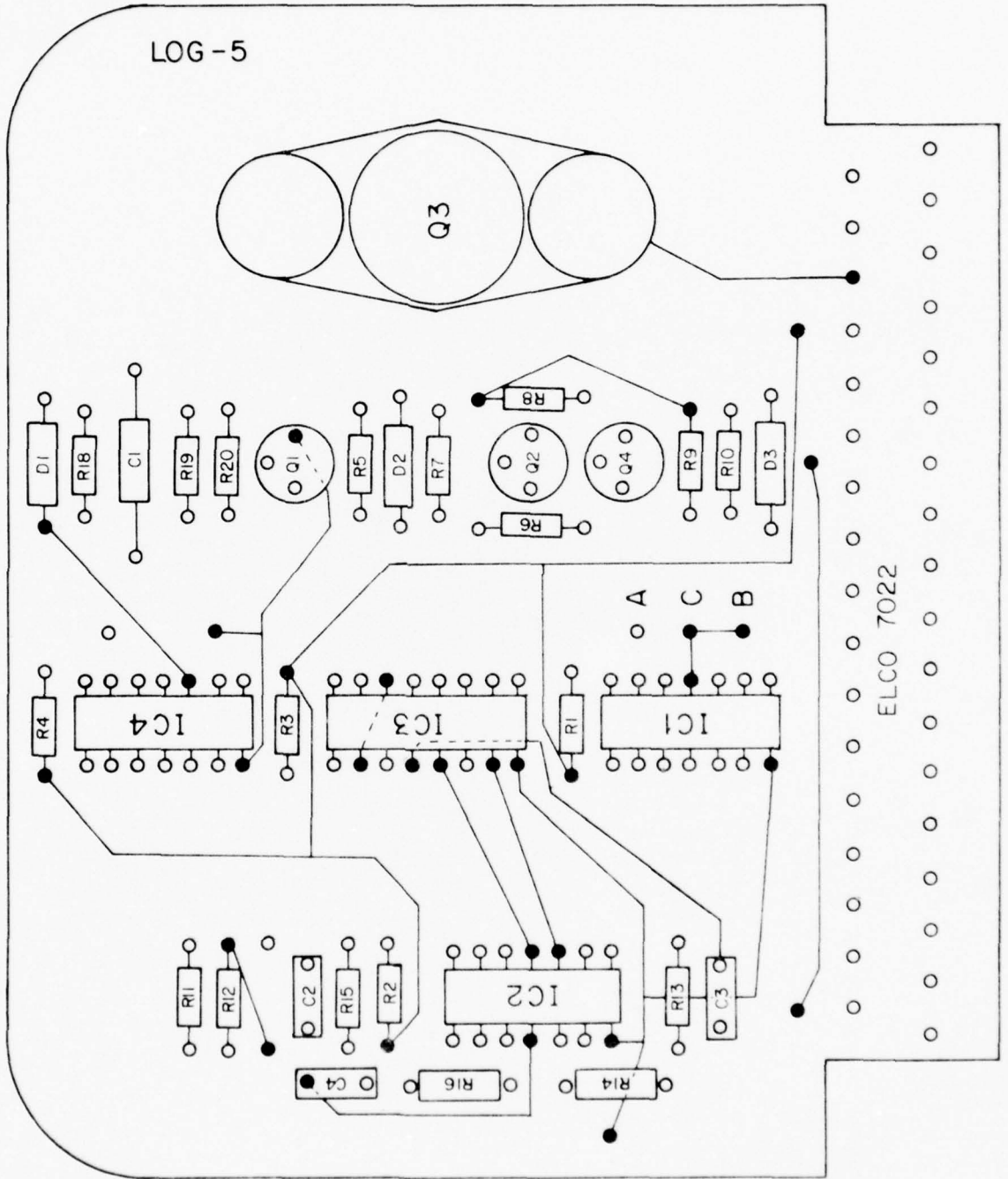
1. Q3, Q4, Q6, Q9 REPLACED BY 2N2222
2. Q5, Q10 REPLACED BY 2N5089
3. Q1 REPLACED BY 2N3638A



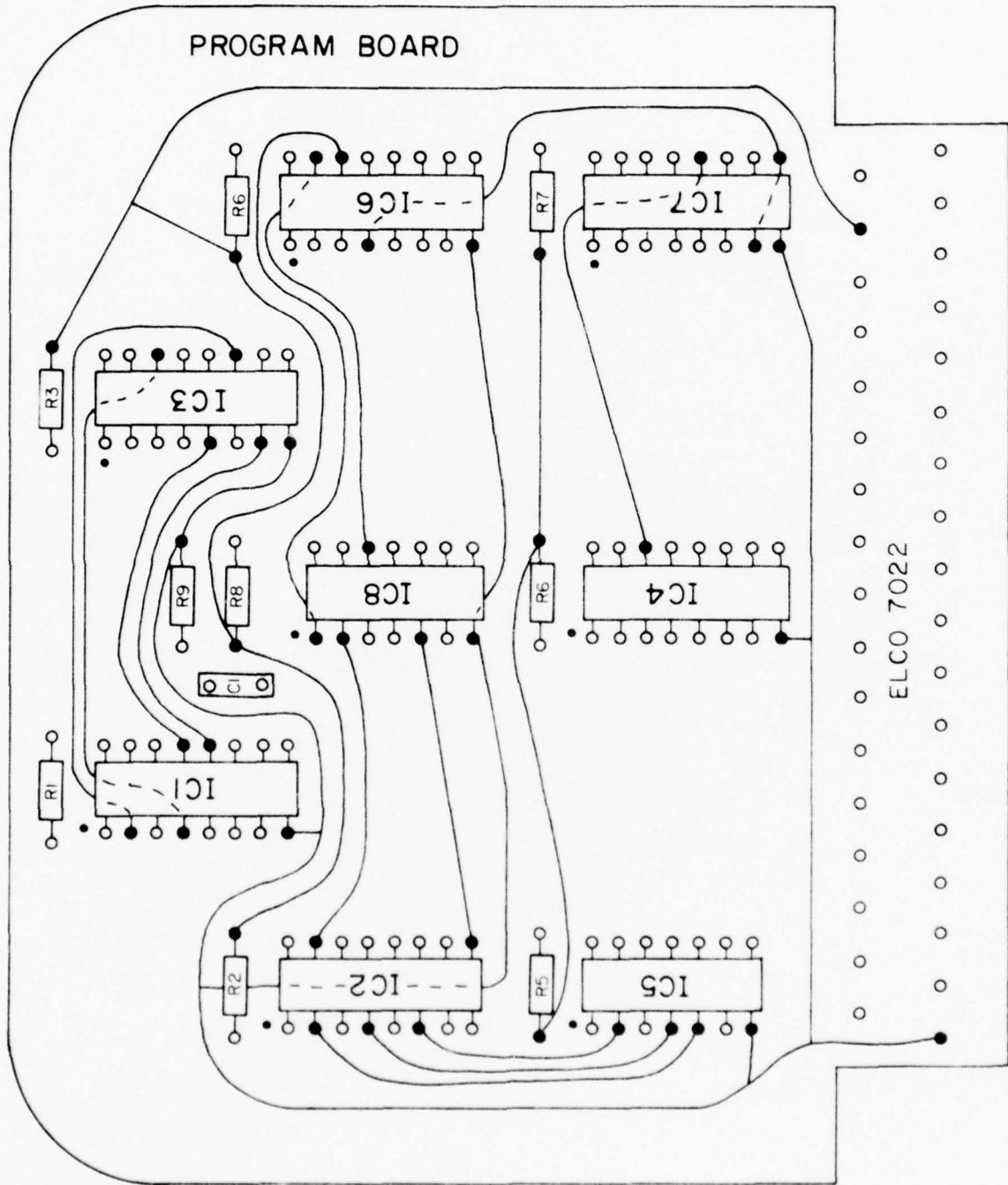
IC1 - CD4011AE IC3 - CD4024AE
 IC2 - CD4001AE IC4 - CD4024AE

NOTE: UNUSED INPUTS OF IC2 GO TO GND

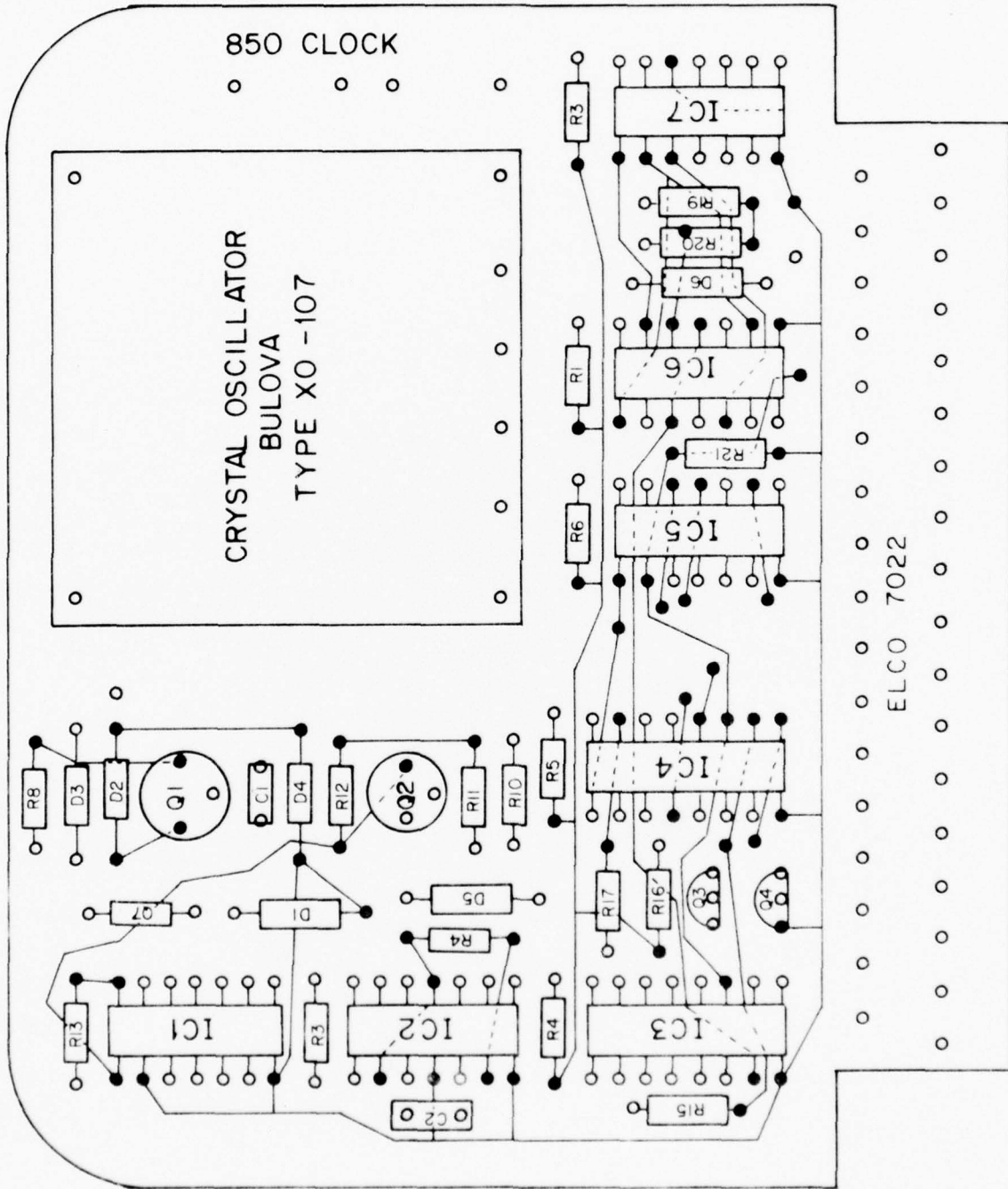
APPENDIX D. Printed Circuit Assembly Drawings (COS/MOS).



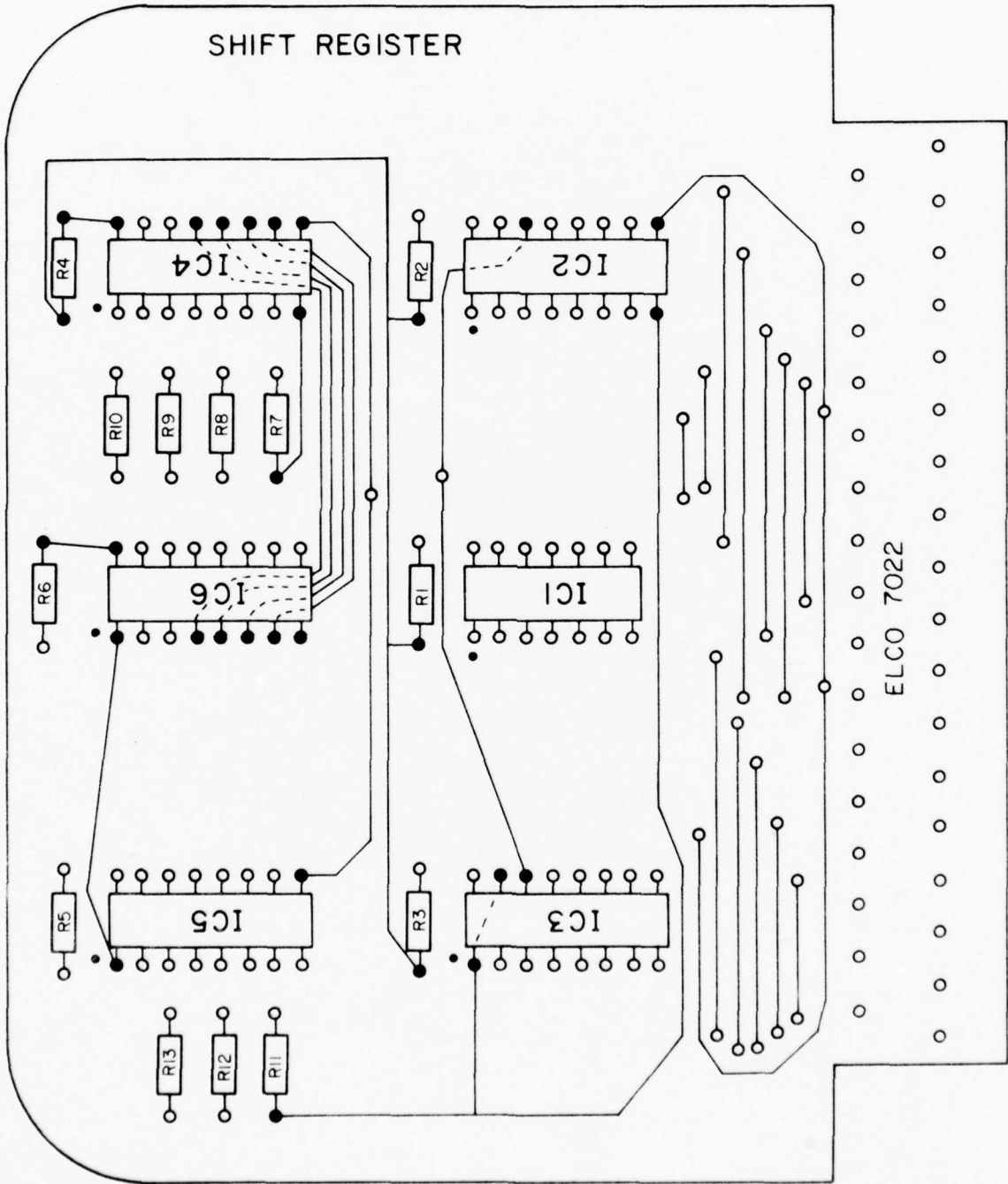
W.H.O.I. LOG-5 COMP SIDE



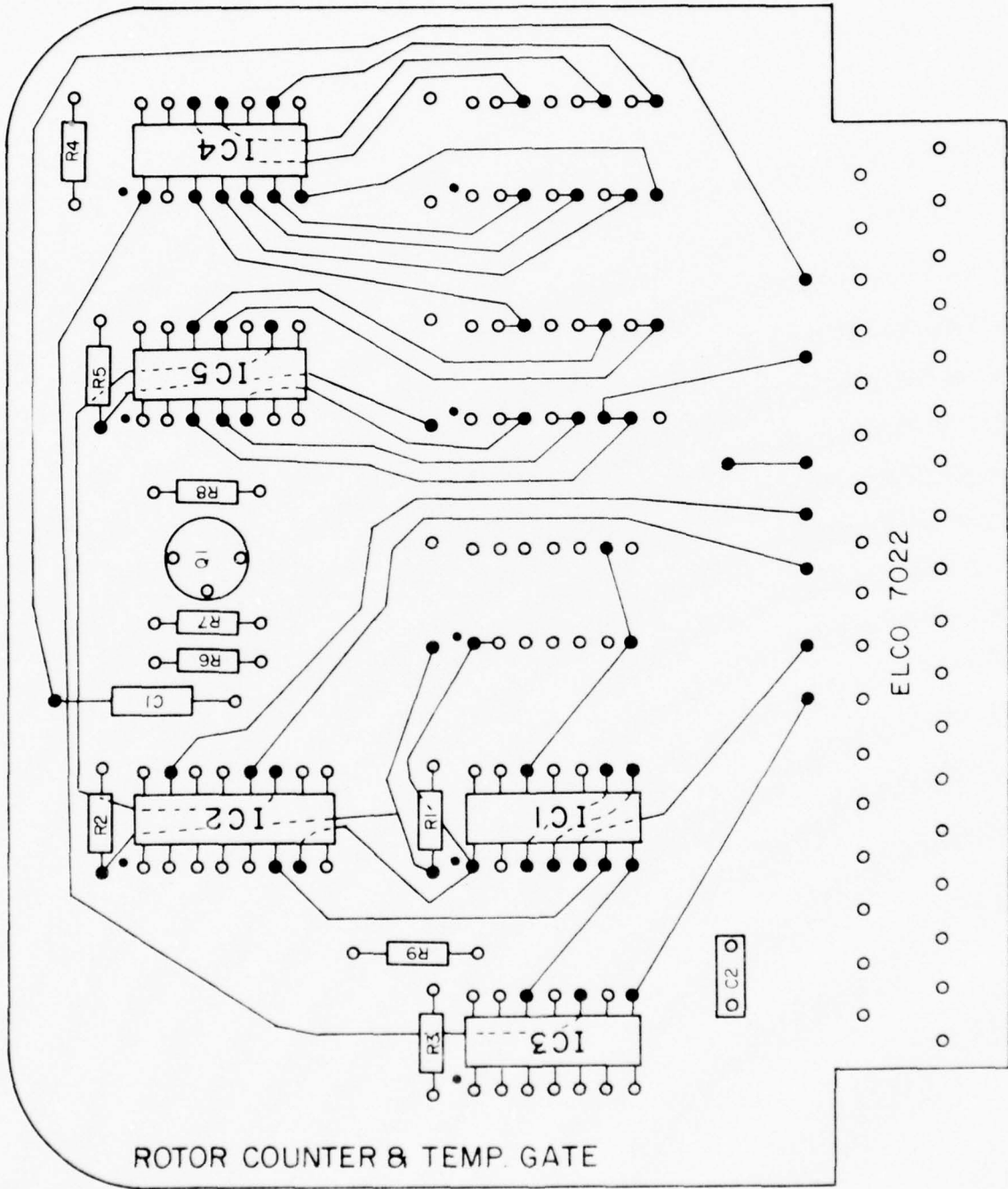
W.H.O.I. PROGRAM BOARD COMP SIDE



WH.01. 850 CLOCK COMP SIDE



WH.O.I. SHIFT REGISTER COMP SIDE

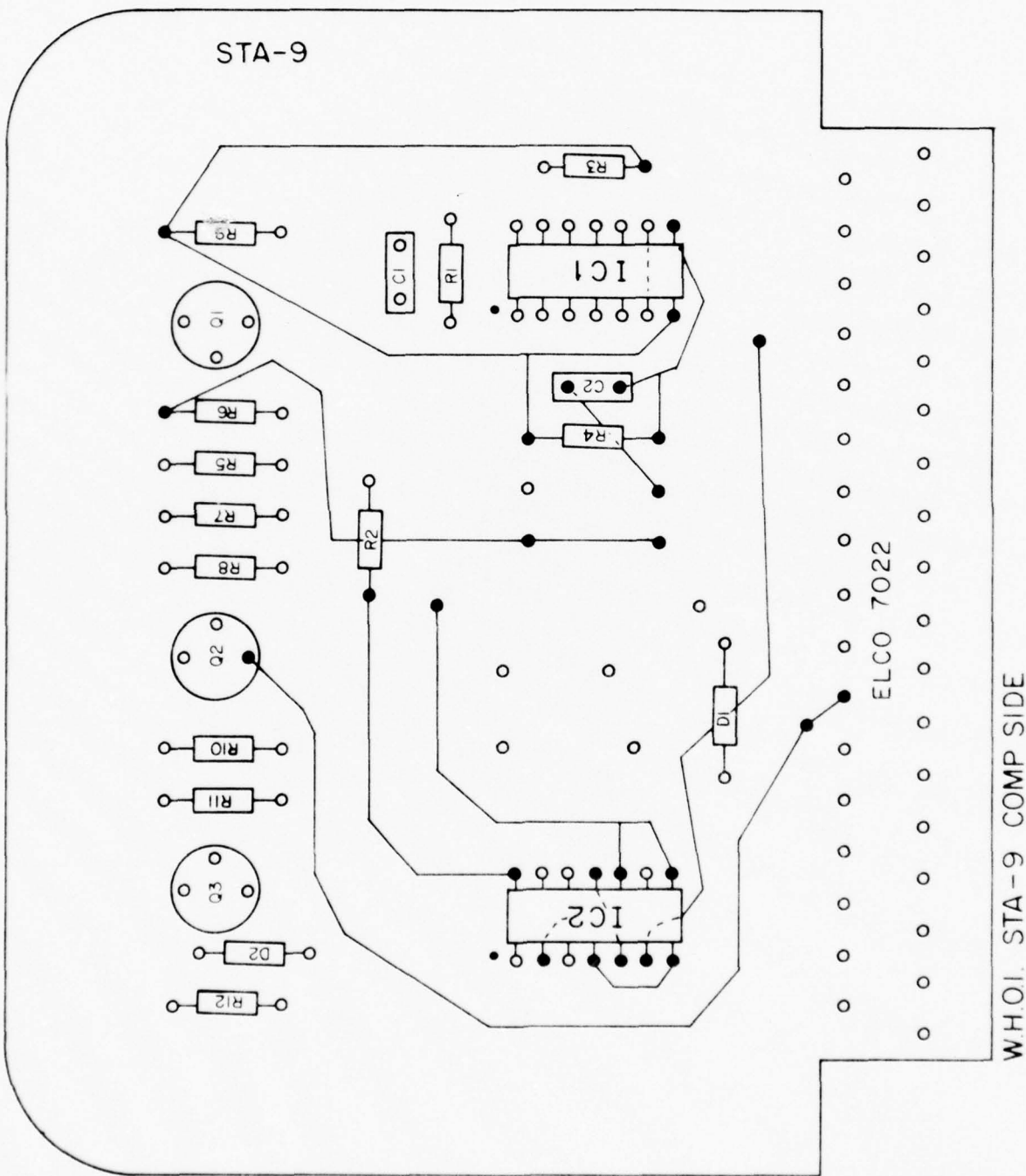


ROTOR COUNTER & TEMP. GATE

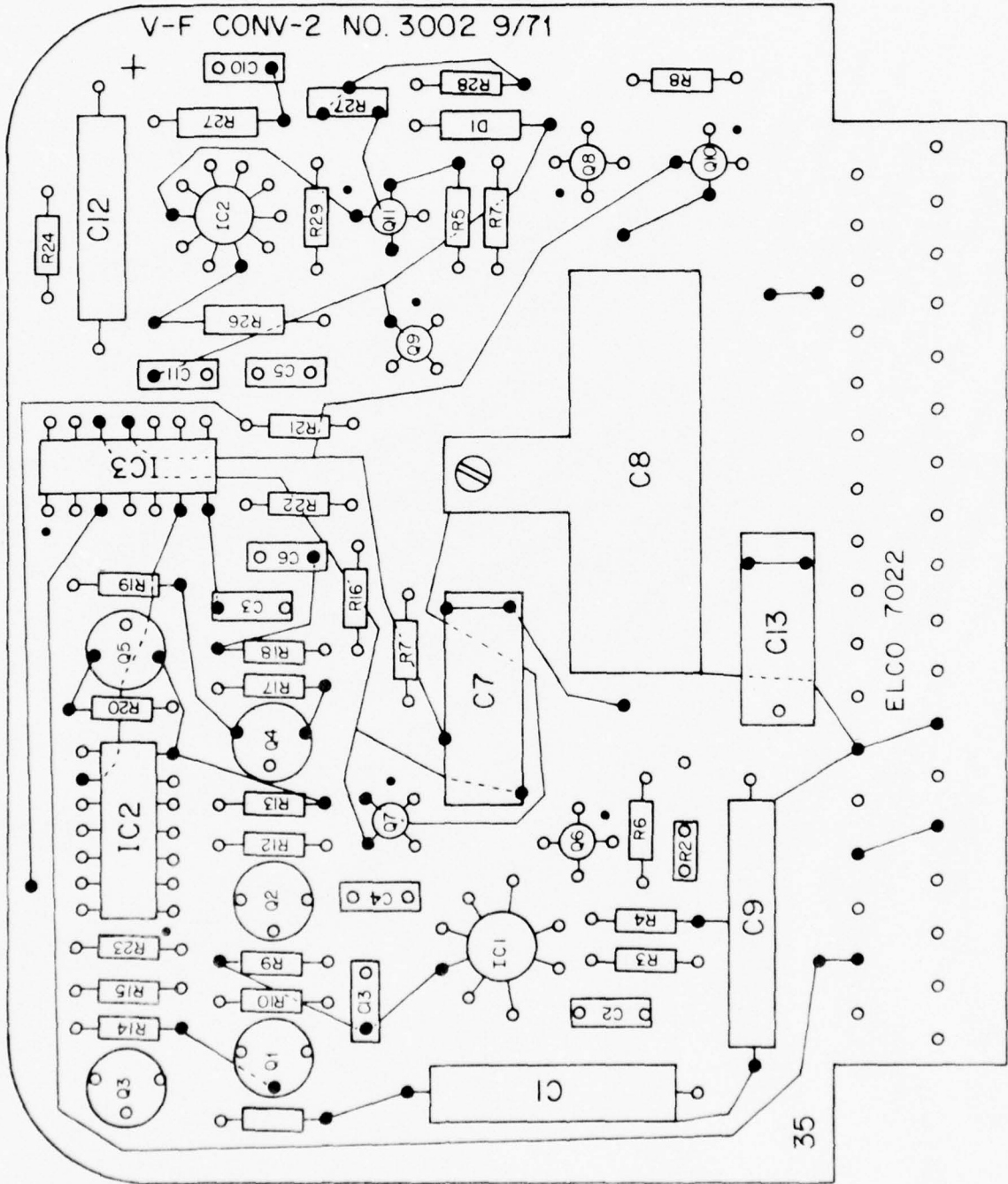
ELCO 7022

ROTOR COUNTER & TEMP GATING (C.S.)

OC2



WH.OI. STA-9 COMP SIDE



APPENDIX E. 850 Electronics Parts List (COS/MOS).

PARTS LIST - LOG-5

59

Item No.	Description	Manufacturer	Specification	Symbol	Quantity
1	Resistor		2.7Ω, 1/4W, 5%	R ₁ , R ₂ , R ₃ , R ₄	4
2	Resistor		470Ω, 1/4W, 5%	R ₆ , R ₉	2
3	Resistor		4.7k, 1/4W, 5%	R ₅	1
4	Resistor		5.1k, 1/4W, 5%	R ₁₂	1
5	Resistor		10k, 1/4W, 5%	R ₈ , R ₁₀ , R ₁₄ , R ₁₆ , R ₁₇ , R ₁₈ , R ₁₉	7
6	Resistor		47k, 1/4W, 5%	R ₁₁	1
7	Resistor		100k, 1/4W, 5%	R ₇ , R ₂₀	2
8	Resistor		560k, 1/4W, 5%	R ₁₃ , R ₁₅	2
9	Capacitor	Sprague	150D105×9015A	C ₁	1
10	Capacitor	Erie	CK05B×102k	C ₂ , C ₃ , C ₄	3
11	Diode		IN914	D1	1
12	Diode		IN5234B	D2	1
13	Diode		IN5242B	D3	1
14	Transistor		2N2222	Q1, Q2	2
15	Transistor	Motorola	MJ480	Q3	1
16	Transistor		2N2907	Q4	1
17	Integrated Circuit	RCA	CD4001AE	IC4	1
18	Integrated Circuit	RCA	CD4012AE	IC1	1
19	Integrated Circuit	RCA	CD4049AE	IC3	1
20	Integrated Circuit	RCA	CD4093BE	IC2	1

PARTS LIST - PROGRAM

Item No.	Description	Manufacturer	Specification	Symbol	Quantity
1	Resistor		2.7 Ω , 1/4W, 5%	R ₁ , R ₂ , R ₃ , R ₄ , R ₅ , R ₆ , R ₇ , R ₈	8
2	Resistor		2.2K, 1/4W, 5%	R ₉	1
3	Capacitor	Erie	CK05B*681K	C ₁	1
4	Integrated Circuit	RCA	CD4011AE	IC8	1
5	Integrated Circuit	RCA	CD4012AE	IC5	1
6	Integrated Circuit	RCA	CD4040AE	IC1	1
7	Integrated Circuit	RCA	CD4049AE	IC2, IC3, IC4	3
8	Integrated Circuit	Motorola	MCL4510CP	IC6, IC7	2

PARTS LIST - DIGITAL CLOCK

Item No.	Description	Manufacturer	Specification	Symbol	Quantity
1	Resistor		2.7Ω, 1/4W, 5%	R ₁ , R ₂ , R ₃ , R ₄ , R ₅ , R ₆	7
2	Resistor		330Ω, 1/4W, 5%	R ₁₃	1
3	Resistor		470Ω, 1/4W, 5%	R ₂₀	4
4	Resistor		10K, 1/4W, 5%	R ₇ , R ₈ , R ₉ , R ₁₀	1
5	Resistor		22K, 1/4W, 5%	R ₂₁	1
6	Resistor		82K, 1/4W, 5%	R ₁₅	1
7	Resistor		470K, 1/4W, 5%	R ₁₂	1
8	Resistor		1M, 1/4W, 5%	R ₇	1
9	Capacitor	Erie	CK05B×104K	R ₁₁ , R ₁₄ , R ₁₆ , R ₁₇ , R ₁₈	5
10	Capacitor	Erie	CK05B×103K	C ₁	1
11	Diode		IN3605	C ₂	1
12	Diode		IN4694	D ₂ , D ₃ , D ₄ , D ₅ , D ₆	5
13	Transistor		2N2369	D ₁	1
14	Transistor		2N3566	Q ₂	1
15	Transistor		2N4124	Q ₁	1
16	Integrated Circuit	RCA	CD4007AE	Q ₃ , Q ₄	2
17	Integrated Circuit	RCA	CD4013AE	IC2	1
18	Integrated Circuit	RCA	CD4020AE	IC6	1
19	Integrated Circuit	RCA	CD4024AE	IC3	1
20	Integrated Circuit	RCA	CD4040AE	IC1, IC5	2
21	Oscillator	Bulova	XO-107	IC4	1
				OSC	1

PARTS LIST - SHIFT REGISTER

Item No.	Description	Manufacturer	Specification	Symbol	Quantity
1	Resistor		2.7Ω, 1/4W, 5%	R ₁ , R ₂ , R ₃ , R ₄ , R ₅ , R ₆	6
2	Resistor		270K, 1/4W, 5%	R ₇ , R ₈ , R ₉ , R ₁₀ , R ₁₁ , R ₁₂ R ₁₃	7
3	Integrated Circuit	RCA	CD4019AE	IC2, IC3, IC4, IC5	4
4	Integrated Circuit	RCA	CD4021AE	IC6	1
5	Integrated Circuit	RCA	CD4071AE	IC1	1

PARTS LIST - ROTOR COUNTER AND TEMPERATURE GATE

Item No.	Description	Manufacturer	Specification	Symbol	Quantity
1	Resistor		2.70, 1/4W, 5%	R ₁ , R ₂ , R ₃ , R ₄ , R ₅	5
2	Resistor		10K, 1/4W, 5%	R ₇ , R ₉	2
3	Resistor		15K, 1/4W, 5%	R ₆	1
4	Resistor		22K, 1/4W, 5%	R ₈	1
5	Capacitor	Erie	CK05B×103K	C ₁	1
6	Capacitor	Erie	CK05B×102K	C ₂	1
7	Integrated Circuit	RCA	CD4001AE	IC3	1
8	Integrated Circuit	RCA	CD4011AE	IC1	1
9	Integrated Circuit	RCA	CD4024AE	IC4, IC5	2
10	Integrated Circuit	RCA	CD4049AE	IC2	1

PARTS LIST - STA-9

Item No.	Description	Manufacturer	Specification	Symbol	Quantity
1	Resistor		2.7 Ω , 1/4W, 5%	R ₁ , R ₂	2
2	Resistor		2.2K, 1/4W, 5%	R ₆ , R ₈	2
3	Resistor		3.9K, 1/4W, 5%	R ₃	1
4	Resistor		5.6K, 1/4W, 5%	R ₁₁	1
5	Resistor		8.2K, 1/4W, 5%	R ₁₀	1
6	Resistor		10K, 1/4W, 5%	R ₅ , R ₇	2
7	Resistor		22K, 1/4W, 5%	R ₉	1
8	Resistor		100K, 1/4W, 5%	R ₄	1
9	Capacitor	Erie	CK05B \times 68IK	C ₁ , C ₂	2
10	Diode		IN91	D ₁ , D ₂	2
11	Transistor		2N697	Q ₃	1
12	Transistor		2N5223	Q ₁ , Q ₂	2
13	Integrated Circuit	RCA	CD4001BE	Q ₁	1
14	Integrated Circuit	RCA	CD4013AE	Q ₂	1

PARTS LIST - VOLTAGE-FREQUENCY CONVERTER

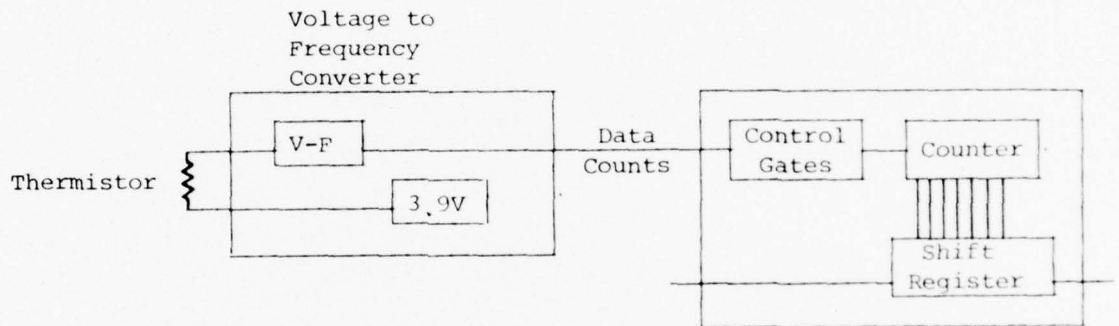
Item No.	Description	Manufacturer	Specification	Symbol	Quantity
1	Resistor		2.7Ω, 1/4W, 5%	R ₂₃ , R ₂₄	2
2	Resistor		1K, 1/4W, 5%	R ₅ , R ₇ , R ₈ , R ₉ , R ₁₆ , R ₁₉	5
3	Resistor		4.7K, 1/4W, 5%	R ₁₁ , R ₁₂	2
4	Resistor		10K, 1/4W, 5%	R ₃ , R ₄	2
5	Resistor		15K, 1/4W, 5%	R ₂₈	1
6	Resistor		22K, 1/4W, 5%	R ₂₀ , R ₂₁ , R ₂₂	3
7	Resistor		24.9K, 1/2W, 1%	R ₂₆ , R ₂₇	2
8	Resistor	Vishay	37.3K, 1/2W, .01%	R ₂	1
9	Resistor		68K, 1/4W, 5%	R ₂₉	1
10	Resistor		220K, 1/4W, 5%	R ₉	1
11	Resistor		270K, 1/4W, 5%	R ₁₃ , R ₁₄ , R ₂₅	3
12	Resistor		330K, 1/4W, 5%	R ₁₀	1
13	Resistor		470K, 1/4W, 5%	R ₁₇	1
14	Resistor		560K, 1/4W, 5%	R ₁₅	1
15	Resistor		1M, 1/4W, 5%	R ₆ , R ₃₀	2
16	Resistor		2.7M, 1/4W, 5%	R ₁₈	1
17	Potentiometer	Allen Bradley	20K, Type ZA	R ₃₀	1
18	Capacitor	TRW	X463UW	C ₁	1
19	Capacitor	Erie	CK06B×103K	C ₄ , C ₁₀ , C ₁₁ , C ₁₃	4
20	Capacitor	Sprague	260P10452S4	C ₉	1
21	Capacitor	Sprague	CSR13B1S7KP	C ₁₂	1
22	Capacitor		Silver Mica 100 pf	C ₂	1

PARTS LIST - VOLTAGE-FREQUENCY CONVERTER (Contd.)

Item No.	Description	Manufacturer	Specification	Symbol	Quantity
23	Capacitor	Erie	CK05B×271K	C ₁₆	1
24	Capacitor	Erie	CK05B×471K	C ₅ , C ₆	2
25	Capacitor		DS463	C ₇	1
26	Capacitor		MUM02W	C ₁₃	1
27	Capacitor	ARCO	5407pf Type KTB	C ₈	1
28	Diode		IN4686	D ₁	1
29	Transistor		2N3566	Q ₂	1
30	Transistor		2N3643	Q ₁ , Q ₃ , Q ₅	3
31	Transistor		2N6118	Q ₄	1
32	Transistor		2N4220	Q ₁₁	1
33	Transistor		3N155	Q ₁₀	1
34	Transistor		3N169	Q ₆ , Q ₇ , Q ₈ , Q ₉	4
35	Integrated Circuit	RCA	CD4001AD	IC3	1
36	Integrated Circuit	RCA	CD4013AD	IC2	1
37	Operational Amplifier	National	LM208A	IC1	1
38	Operational Amplifier	National	LH0001C	IC4	1

APPENDIX F. Temperature Modifications

The block diagram of the temperature system is shown below. A thermistor controls the rate at which the V-F converter oscillates. Data counts are gated thru the multiplexing gates and counted on the Rotor Counter and Temperature Gate Board, then transferred into the Shift Registers.



The V-F converter is mounted in the rear of the recorder, this can be seen in Fig. 1. The electronics rack to cage mounting plate (Fig. A) must be drilled and tapped to accept the thermistor block (Fig. B). A complete thermistor assembly (Fig. C) can be purchased from AMF⁶ under part number 106-55298.

The thermistor is connected to the V-F by a two-conductor shielded cable (Belden 83318), all other connections are made with #22 stranded teflon wire.

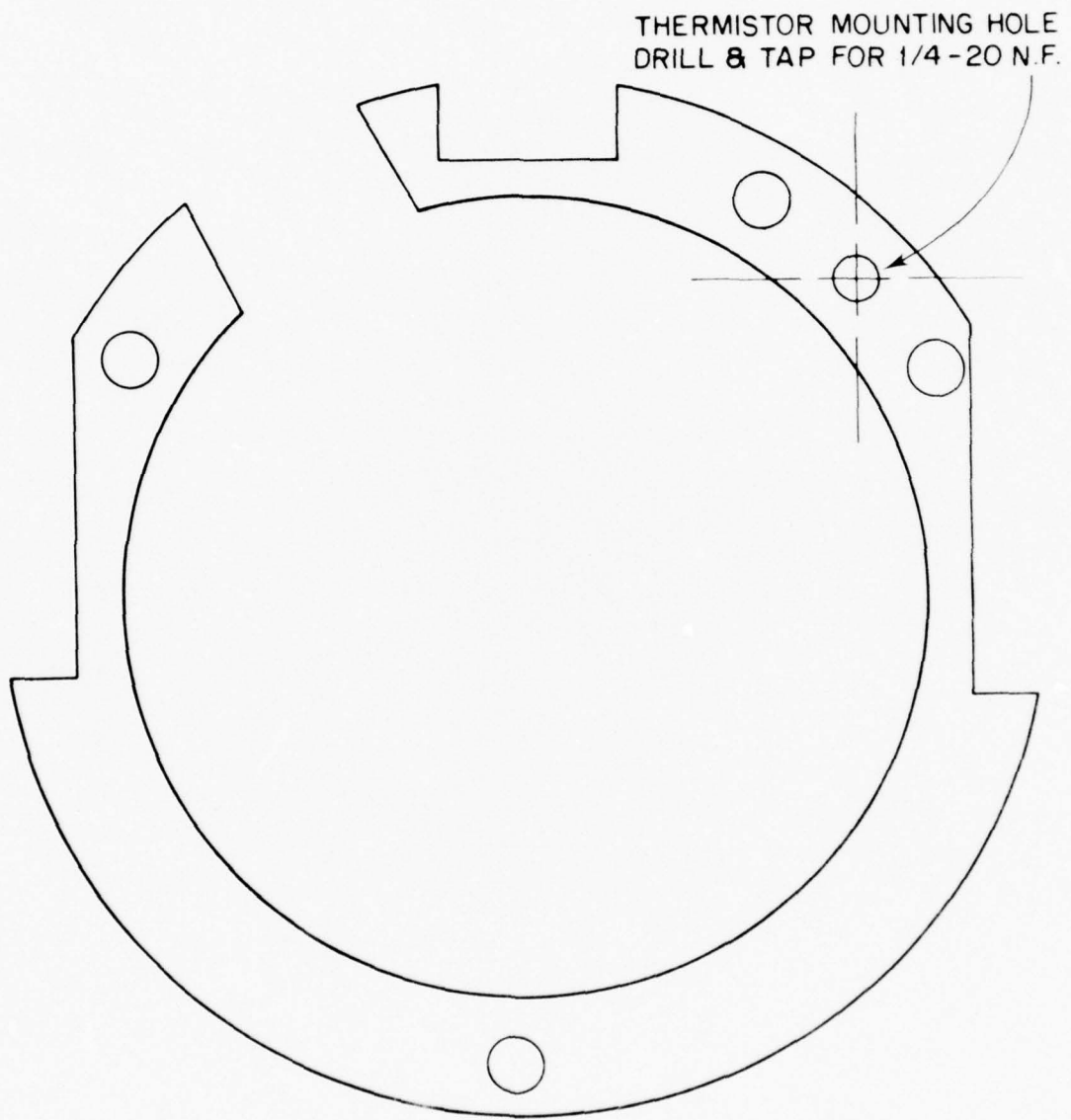


Fig. A. Mounting Plate

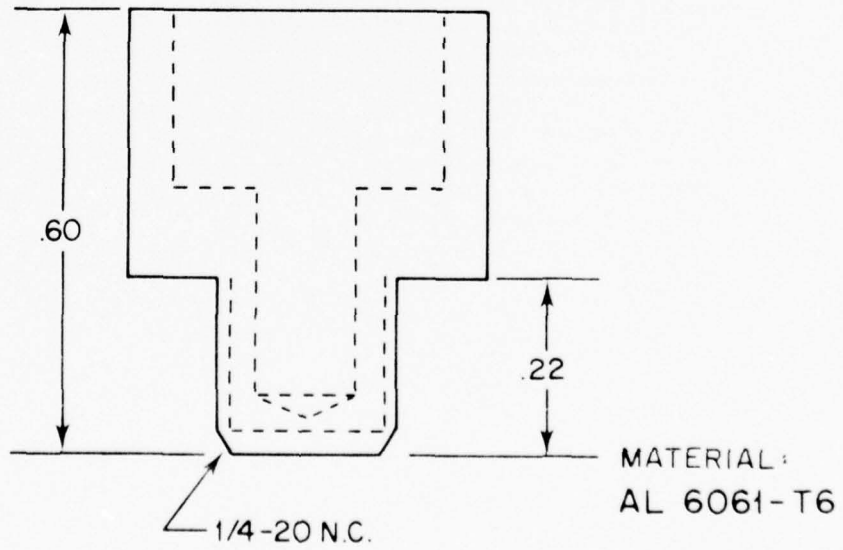
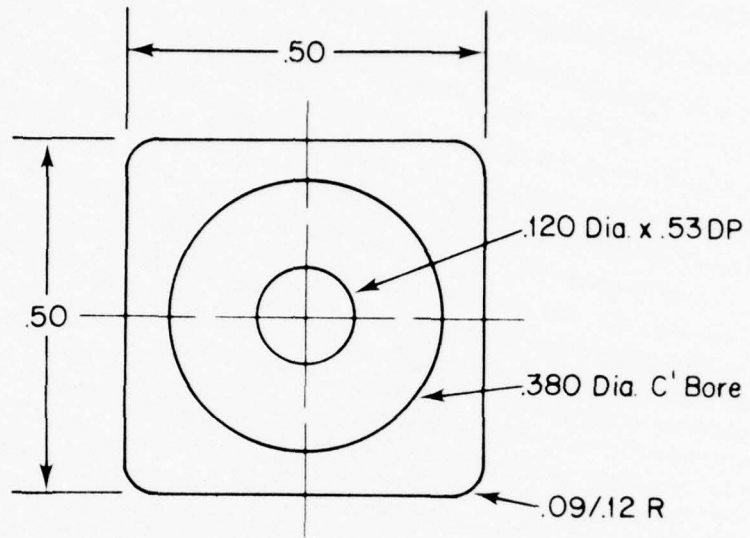
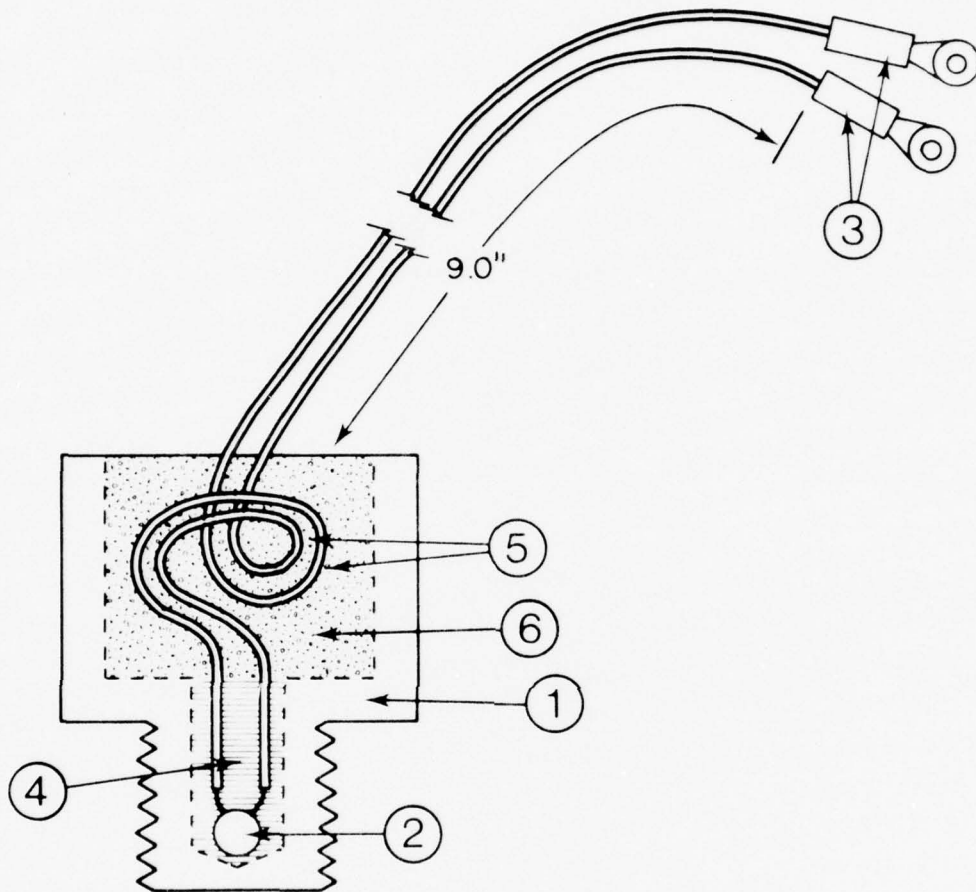


FIG. B THERMISTOR BLOCK

**NOTE:**

- 1) Attach No. 3 to No. 5 & solder leads to Thermistor
- 2) Place Thermistor into drilled hole & fill with No. 4
- 3) Coil Wire (2/3 turns) place as shown and pot with No. 6

1	THERMISTOR BLOCK (FIG. B)
2	THERMISTOR (YSI 44032)
3	TERMINAL (AMP 34142)
4	THERMAL GREASE (DC 340)
5	WIRE, TEFLON (# 22 AWG)
6	POLYURETHANE COMPOUND

FIG. C THERMISTOR ASSEMBLY
(AMF PART # 106-55298)

APPENDIX G. Anode and Bearing Modifications.

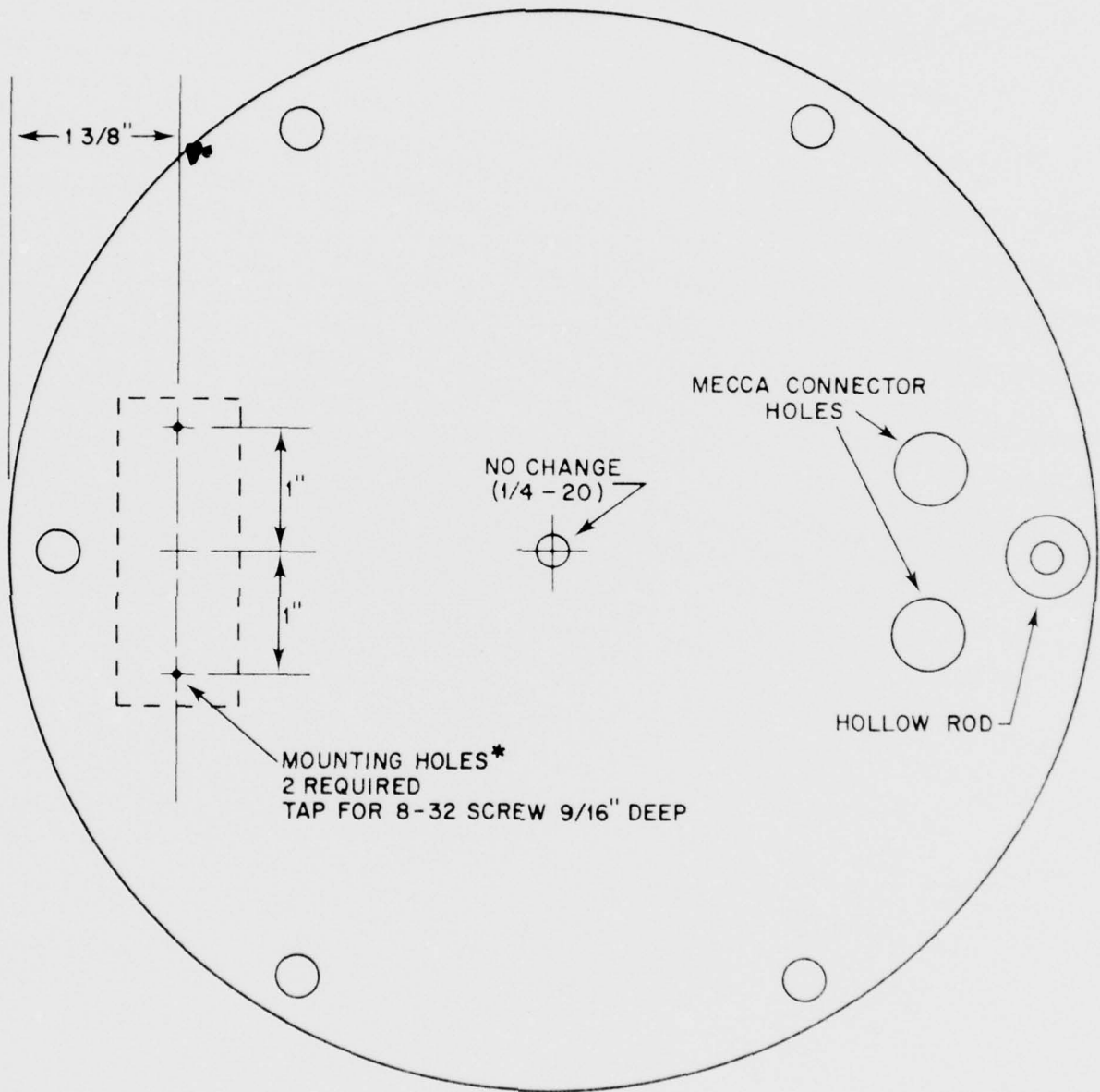
The COS/MOS 850 current meter has a Delrin^{(R)7} bearing configuration similar to that on W.H.O.I. VACM's (Vector Averaging Current Meter). The cage plates are modified, Figs. A, B, and C, to accept the new bearings and anodes. The journal bearings are made from Delrin 150 and have a Kennametal K801 tungsten carbide thrust plate. The new pivots are Kennametal, these are inserted into the original pivot holders.

Figures D thru M show all the parts for the new bearing configuration. A set of bearings is assembled in the following sequence:

- 1) The old pivots are replaced with the new .593 in. pivots (Figure F-2).
- 2) A thrust plate (Figure H) is inserted into the bearing (Figure G): 2 required.
- 3) A thrust plate (Figure H), and .500 in. pivot (Figure F-1) are inserted into the center bearing (Figure I).
- 4) The new pivots and bearings are assembled on the rotor and vane with pivots up and bearings down; as shown in Figure 3.
- 5) A .500 in. pivot (Figure F-1) is inserted into the new lower pivot holder (Figure K).

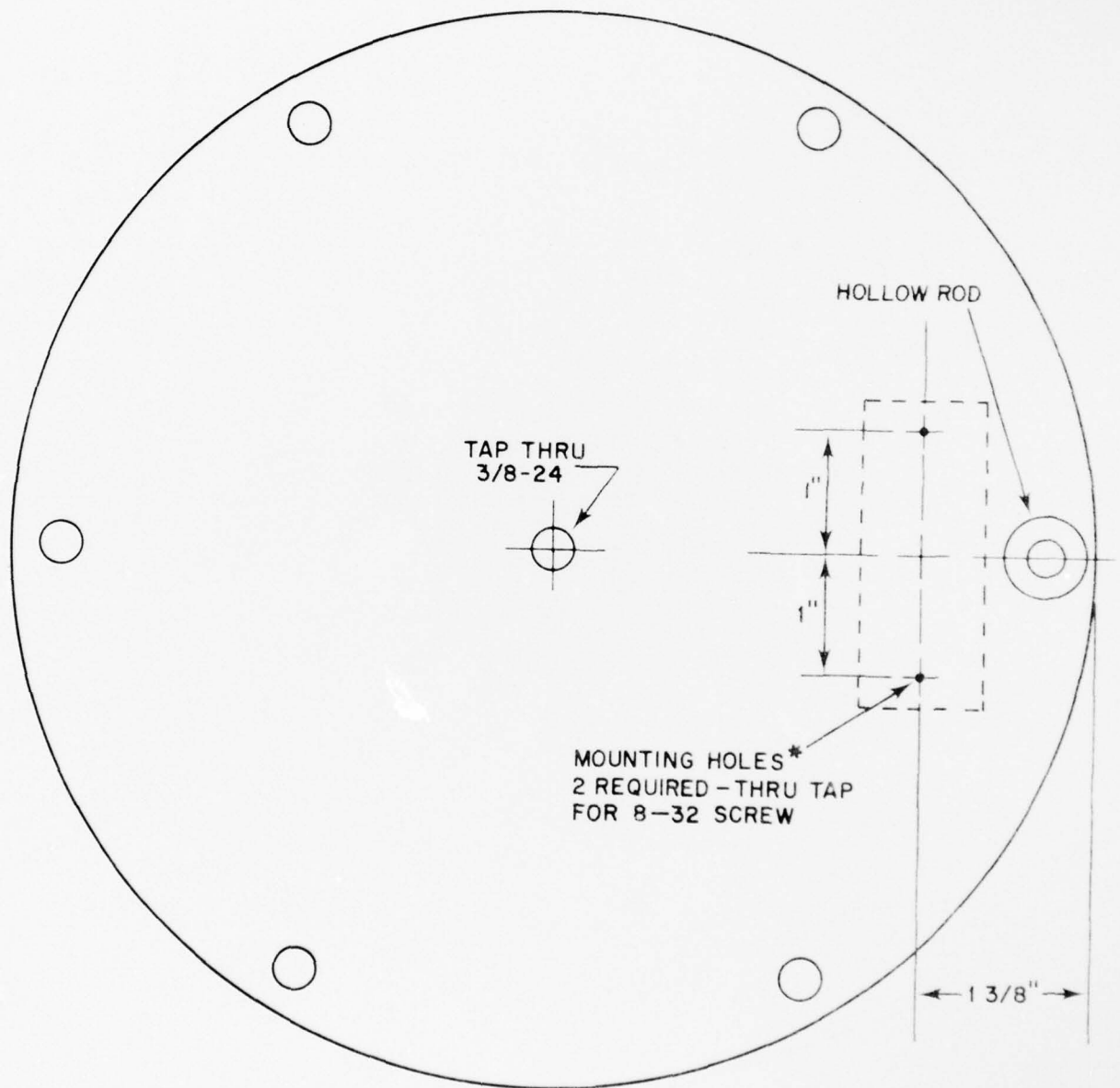
In addition to the above the vane donut is modified as shown in Figure M. The cage is assembled, Figure 3, and the bearings adjusted as outlined in section VII-C.

This new bearing design has allowed us to improve upon the anodic scheme; a sacrificial anode is attached to each cage plate and the upper end cap assembly. Figures N thru R show the details of the anodes and mounting plates.



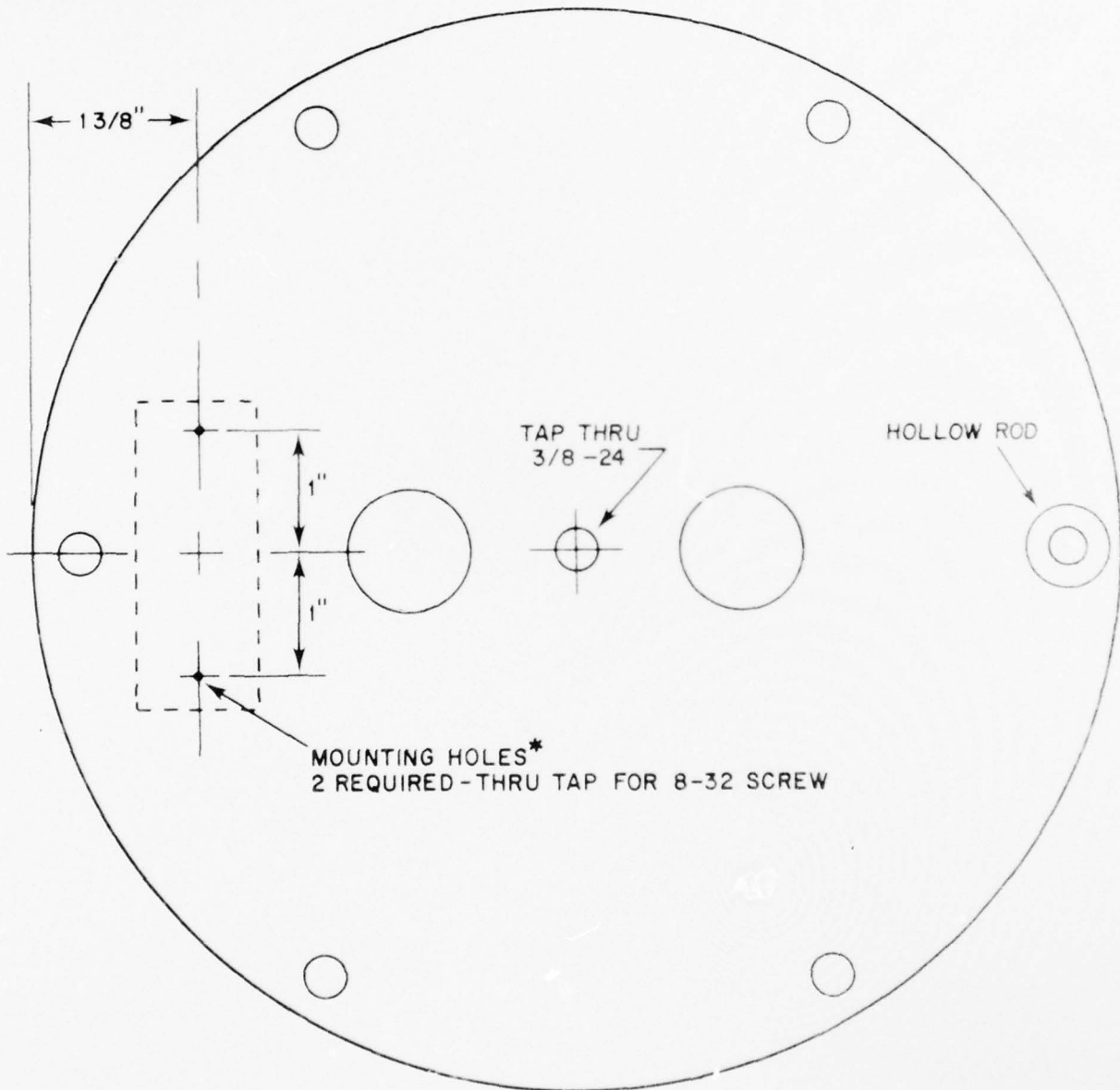
*ANODES MOUNTED ON VANE SIDE OF PLATE

Fig. A. Top Plate



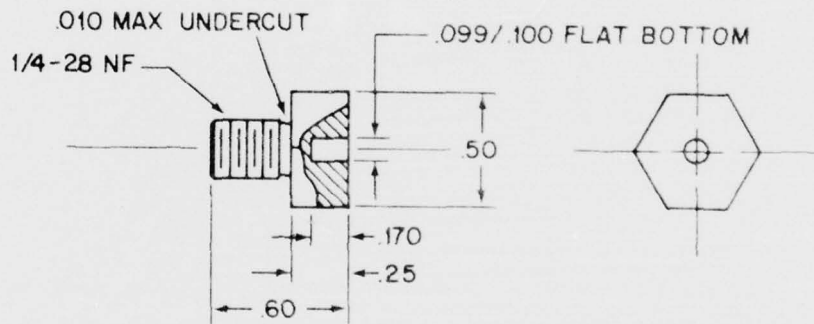
* ANODE MOUNTED ON VANE SIDE OF PLATE

Fig. B. Center Plate



* ANODE MOUNTED ON SAME SIDE AS ROTOR

Fig. C. Bottom Plate

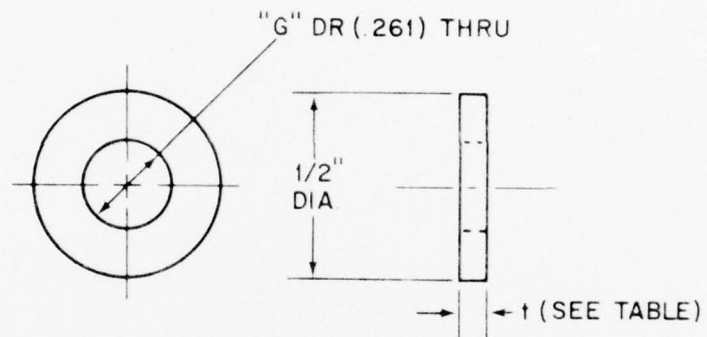


MATL: DELRIN 150

TOLS: .XX \pm .015

.XXX \pm .005

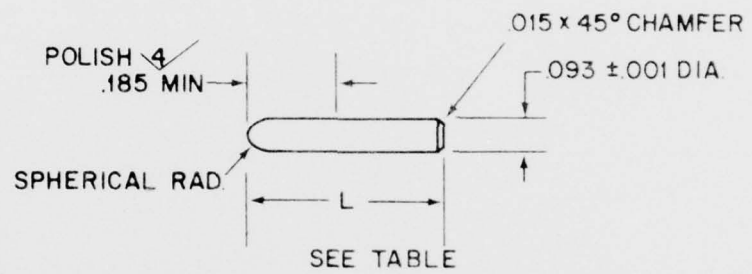
Fig. D. Bearing - Upper Vane



DASH NO.	t (INCHES)
1	.020
2	.030
3	.045
4	.062
5	.090
6	.125

MATERIAL: DELRIN 150
 TOLS: FRAC. $\pm 1/64$ "
 DEC. $\pm .005$ "

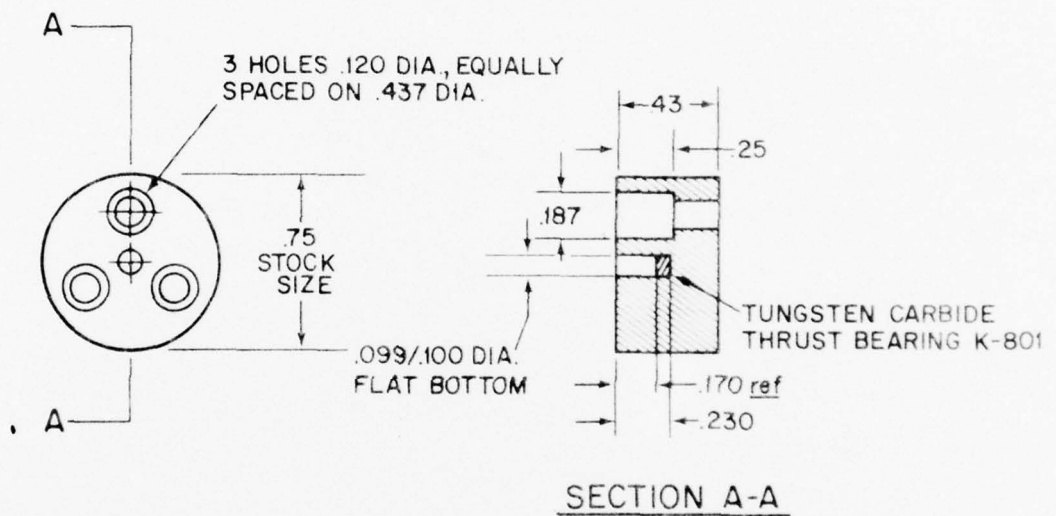
Fig. E. Spacers



PART NO.	L (INCHES)
10197.16 -1	.500
10197.16 -2	.593

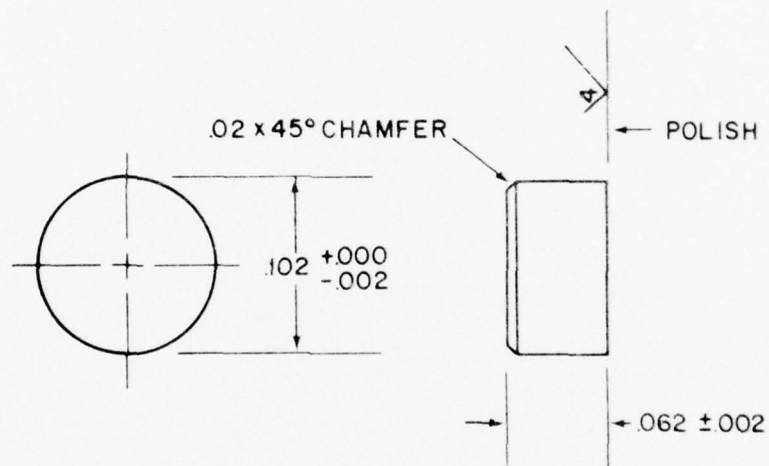
MATERIAL: USE KENNAMETAL, K801 TUNGSTEN CARBIDE
 TOLERANCES: ±.005 UNLESS OTHERWISE SPECIFIED

Fig. F. Pivot



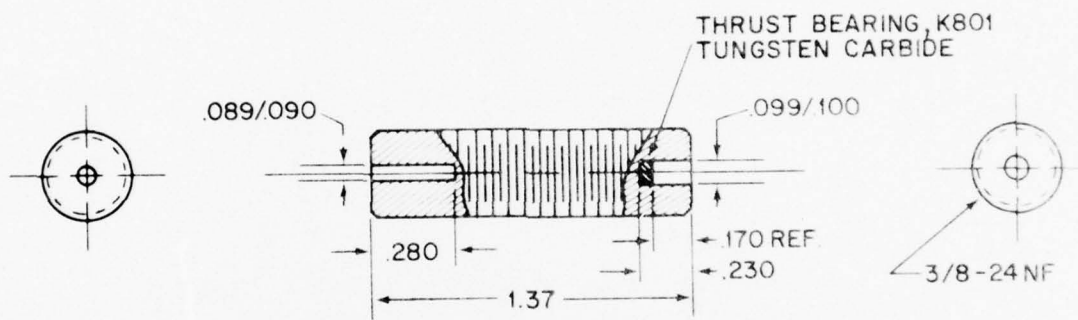
MATL: DELRIN 150
 TOLS: .XX ± .015
 .XXX ± .005

Fig. G. Bearing - Rotor/Vane



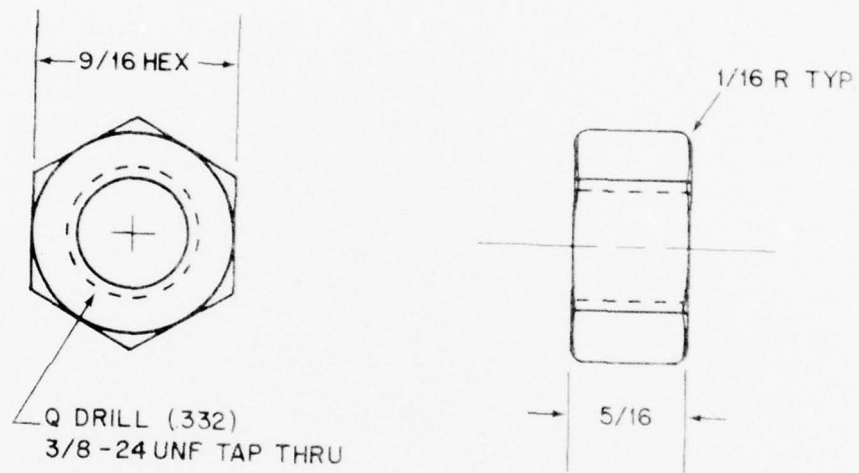
NOTE: MAKE FROM KENNAMETAL CORP.
PART NO. 87513, K801 TUNGSTEN CARBIDE

Fig. H. Thrust Bearing



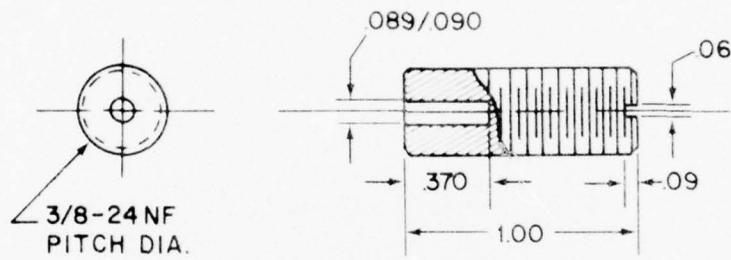
MATL: DELRIN 150
TOLS: .XX ± .015
.XXX ± .005

Fig. I. Center Bearing/Pivot



MATL: DELRIN 150
TOLS: $\pm 1/64$

Fig. J. Center Nut



MATL: DELRIN 150
TOLS: .XX ± .015
.XXX ± .005

Fig. K. Pivot Holder - Lower Rotor

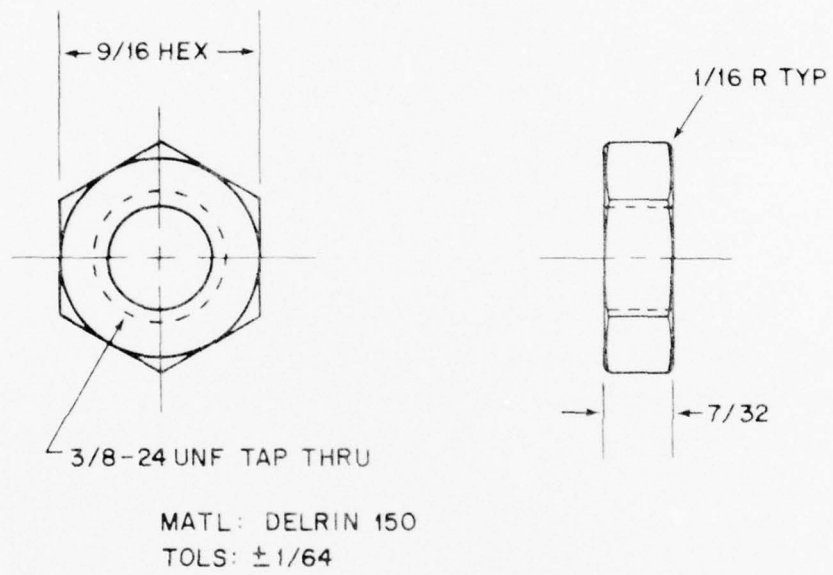
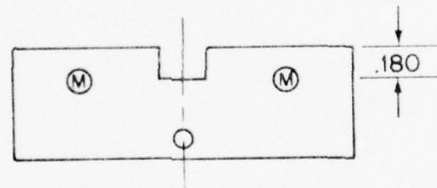
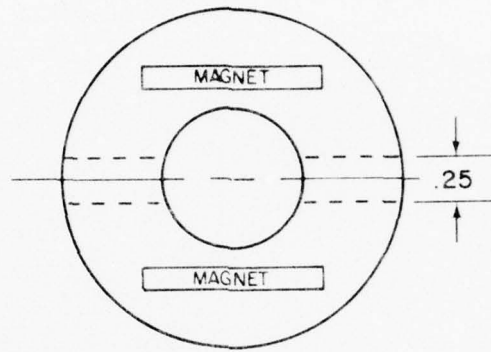
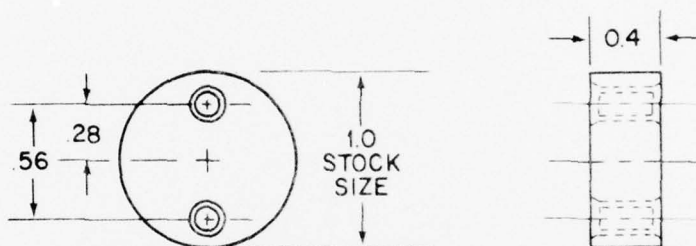


Fig. L. Lower Nut



SLOT MUST BE ADDED AS SHOWN

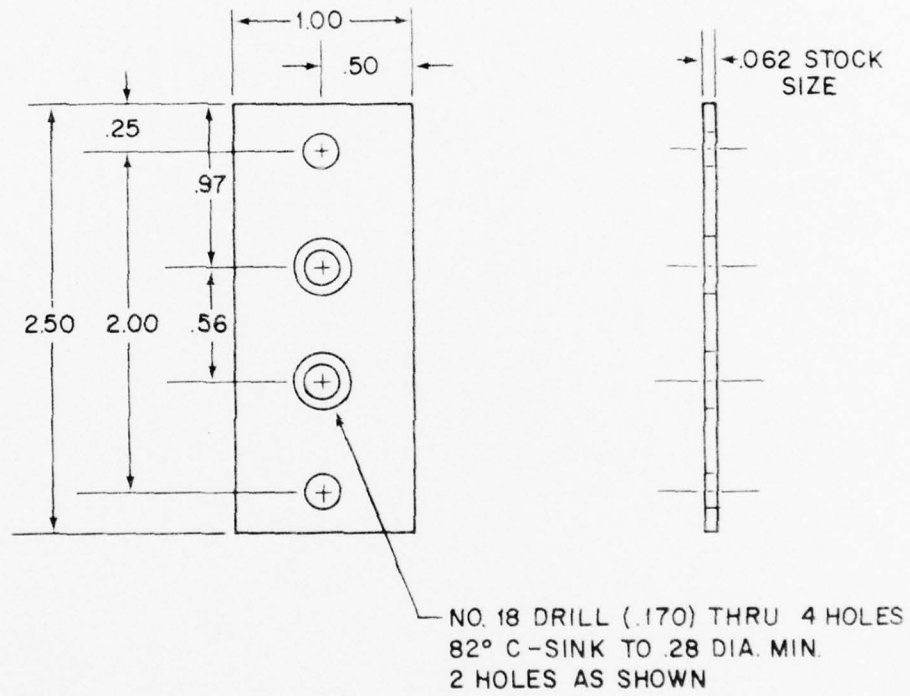
Fig. M. Vane Donut Modification



NO. 36 (.106) DIA. THRU
6-32 NC-2 TAP THRU
82° C'SINK TO .17 BOTH ENDS 2 HOLES

MATL: ANODE QUALITY ZINC
TOLS: .XX ± .01
.X ± .03

Fig. N. Anode - Cage



REMOVE BURRS AND SHARP EDGES

MATL: 316 STAINLESS STEEL

TOLS: .XX±.01

Fig. O. Anode Mounting Plate - Cage

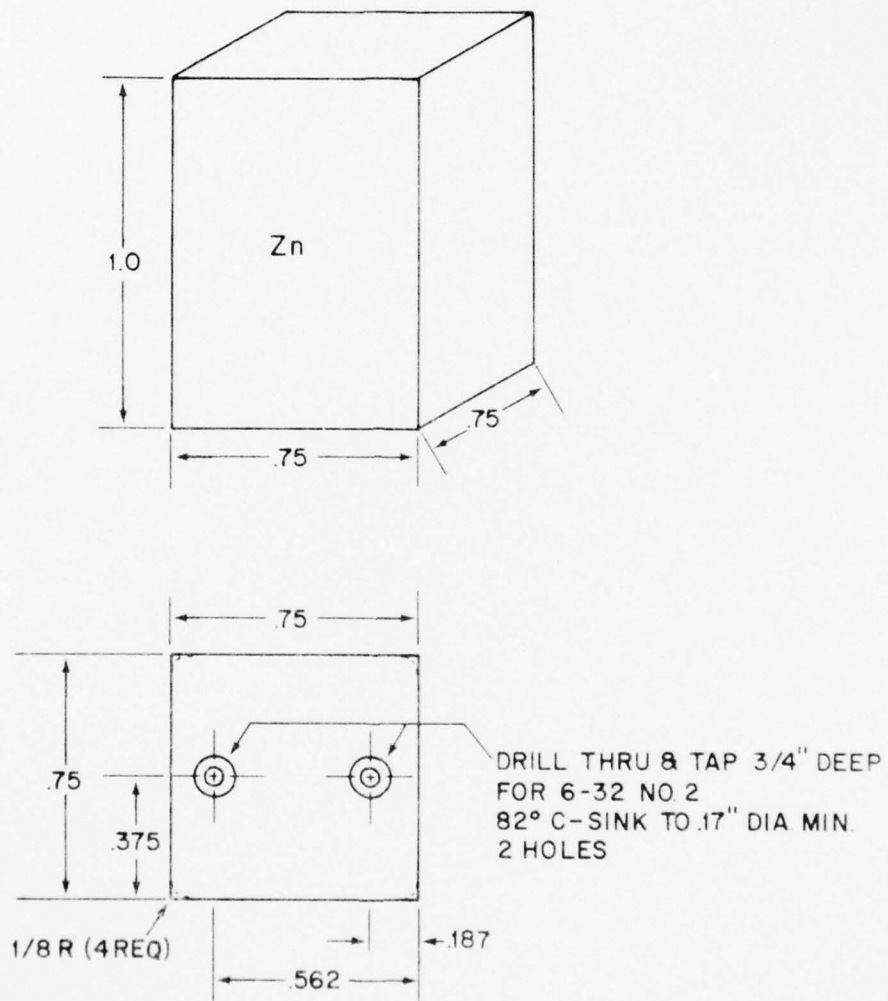


Fig. P. Anode - Upper Bail

AD-A043 125

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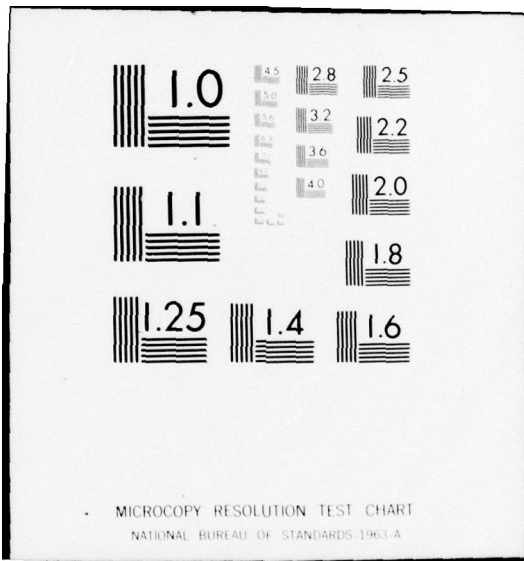
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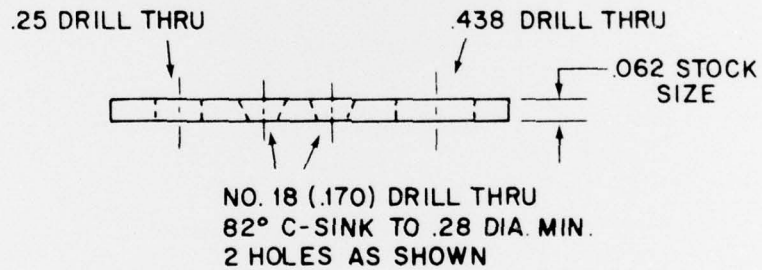
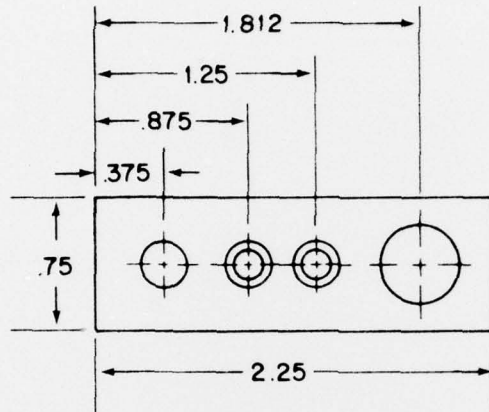
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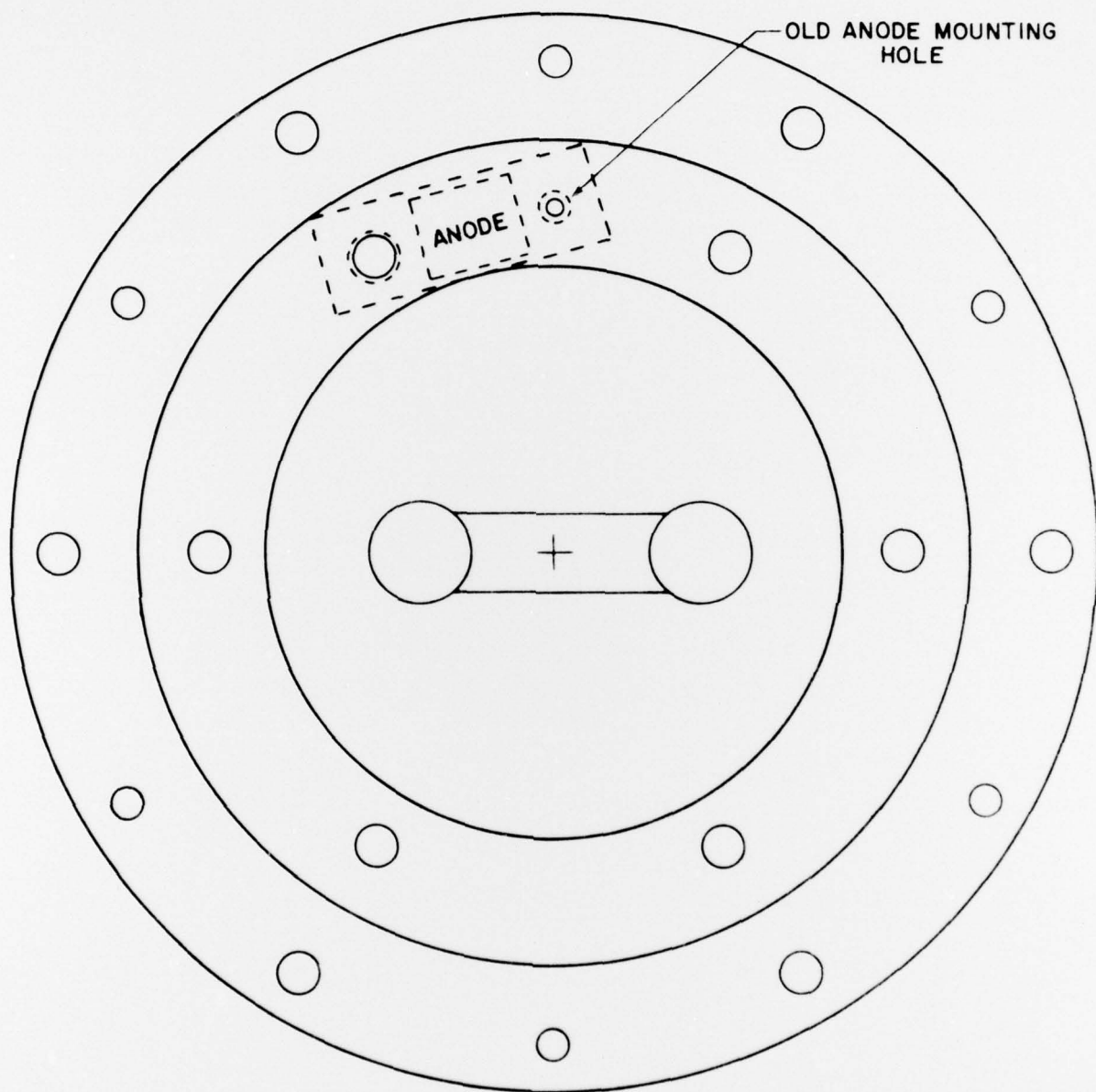
END
DATE
FILMED
9-77
DDC





REMOVE SHARP EDGES
316 STAINLESS STEEL
TOLS: .XX ± .01

Fig. Q. Anode Mounting Plate - Upper Bail



NOTE: ANODE PLATE MOUNTS IN EXISTING HOLES
NO MODIFICATIONS TO PLATE ARE REQUIRED

Fig. R. Upper Bail Anode Mounting

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