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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Reference No. 62-21

Telemetering Current Meter

WOODS HOLE, MASSACHUSETTS

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

Reference No. 62-21

Telemetering Current Meter

by

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and

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APPROVED FOR DISTRIBUTION ________________
Paul M. Fye, Director

TELEMETERING CURRENT METER

The telemetry of oceanographic data has received much attention of late as techniques and equipment have become available. Most of this attention has been directed toward general principles, however, with little mention of system details. Much of the equipment which has been developed in other fields is applicable here but there are some factors that are unique to oceanography. Among these are - a highly corrosive environment, extremely high pressures at some transducer locations and the necessity for transmitting data along a road which must also serve as a mooring. The latter problem is treated in detai in another report, but it should be noted here that it is generally desirable to place the power required by a transducer at the transducer location for the practical reason that power transmission over two miles of wire is extremely inefficient.

The measurement of ocean currents becomes much more feasible when a semi-permanent station can be set out in the desired area and interrogated from shore when phenomena of interest are expected to occur. One may know imme stel whether or not the system is operating correctly and if the phenomenon is preser In this way the current meters need not be worked continuously but only when something of interest is taking place. And should the mooring be lost the accumulated data is not lost with it.

The current meter described in this article is a direct descendent of line of current meters developed, tested, and used over the past 2 1/2 years by Dr. W. S. Richardson at Woods Hole Oceanographic Institution. Because the requirements for data telemetry are entirely different from those of data storag the internal workings of the telemetering instrument are quite different from those of the recording instruments. The transducer systems (compass, vane and rotor assemblies), however, are almost identical. Advantage was taken, wherever possible, of housing and construction techniques and components developed by Dr. Richardson. Therefore the only "debugging" required in the system was related to the electronics in the cu rent meter, the calibrat' n of the transducers having been completely worked out. The Richardson current meter is described in WHOI Reference No. 62-6. Figure 12 shows the Savonius rotor calibration.

The current meter, itself is shown in Figure 1 with components of the various bays indicated. Figure 2 is the circuit diagram. The current meters are placed in a mooring, either on conducting cable or polypropylene rope fitted with conductors. Alternatively the current meter may be used aboard ship by lowering to desired depth on conducting line. In the latter case one would put the electrical output of the current meters directly on a strip chart recorder such as a portable Sanborn. When the current meters are used in a mooring the electrical output is fed to the input circuitry aboard the buoy and transmitted to shore.

As in the Richardson meter the speed is determined by the number of revolutions per unit time of a Savonius rotor. The information is coupled through the aluminum end cap by means of two strong, teflon coated, bar magnets (such as those used for stirring by chemists) which drive a magnetic rotor follower. The rotor follower is shown in Figure 3. The follower magnets are affixed to one end of an aluminum cylinder which rides on carbide and sapphire bearings. A small light bulb is placed inside the cylinder at the top end and the photran looks through a hole in the rotor follower case. When this hole lines up with a hole in the rotating aluminum cylinder the photran "sees" the light bulb and puts out a pulse. These pulses are stored in a seven level "flip flop" counter until read out. Figure 4 shows the rotor follower and associated circuitry and Figure 5 shows the flip-flop board.

The current direction is determined from the difference between the positions of a magnetic compass, which registers the orientation of the instrument housing and a vane which gives the bearing of the current relative to the housing. Both the magnetic compass and magnetically coupled vane follower drive seven level Gray binary discs. The position of these discs is determined in each unit by a radial line of seven "light pipes" which look through the disc at a flash tube mounted inside the units and activate photrans when they see light. The photrans (seven each for compass and vane follower) are PNPN light triggered switches which (like all PNPN switches) have an inherent binary memory. They are connected in the circuit as shown in Figure 2 so that if their particular channel in the Gray binary disc is clear they see light and trigger giving an output signal of plus 7.5 volts. If the Gray disc channel shows black the particular photran output is minus 7.5 volts. A typical grey coded disc is shown in Figure 10. The flip-flops are powered in a similar manner giving either plus or minus outputs so that at no time is a zero signal used to convey information - plus signals mean binary zeros and minus signals mean binary ones. Figure 6 shows the compass and Figure 7 the vane follower.

All the data bits are fed in proper order to the scan switch shown in Figures 8 and 9. This unit also contains the cams and microswitches which control the photran circuit power, the flash tube trigger circuit drive motor power and Shockley power. The system operates as follows:

PROGRAM

1. Interrogate buoy from shore based transmitter (manual or automatic) Buoy automatically programs remainder of cycle.
2. Buoy sends a -24 volt D.C. signal down the line to all current meters in the mooring (current meters are electrically in parallel - mechanically in series. The number of current meters is limited only by practical considerations).
3. The -24 VDC signal triggers the Shockley diode Sh 2 in the lockup circuit activating Ry 1 which in turn activates Ry 2. This relay supplies the power (3 voltages) and simultaneously, a reset pulse to the Harman Kardon flip flop (FF) board so that the rotor counts may be stored.
4. The -24 VDC signal also triggers the transistor switch TR 1 in the rotor lite circuit so that the rotor revolutions are seen by the FF trigger photran Ph 1 as lite pulses through a magnetically coupled lite chopper. As the Savonius rotor spins the lite pulses are converted by Ph 1 to electrical pulses which store in the FF board via a Schmitt trigger. The FF board contains seven flip flops allowing a maximum count of 127 pulses. Separate magnetic lite choppers have been made that supply from 6 pulses per rotor revolution to 1 pulse per 10 rotor revolutions so that the total counts in the count interval may be made to fall in a range consistent with efficient use of the counting circuit.
5. The -24 VDC signal is chronometrically controlled to give an accurate count interval. This interval would typically fall in a range from 10 to 90 seconds using appropriate lite chopper coupling.

6. When the -24 VDC is turned off the transistor switch in the rotor lite circuit extinguishes the rotor lite by cutting off power to Ry 3. The Shockley diode Sh 2, however remains conducting due to its binary memory which causes relay Ry 1, and hence, relay Ry 2 to remain closed so that the stored rotor counts will be available for readout. Operations 2 through 6 occur simultaneously in all current meters.

7. Buoy now begins to interrogate each current meter individually. Each current meter is equipped with a resonance reed relay tuned to a specific frequency. A precisely tuned 12 V audio tone is impressed on the line which activates the resonance reed relay Ry 5 through T2 and TR2 via the home position of the SCAN SWITCH. After a short delay determined by the value of C9 and R13 the transistor TR3 conducts activating Ry 4. The contacts of Ry 4, when closed place -7.5 volts on the motor MO1 which drives it off its home position. The length of the audio tone is controlled so that as the motor goes off home position the audio tone is stopped so that the line will be clear for conducting the data bits from the scan switch. Now just as the motor drives the scan switch off its home position it closes the micro-switch S1 via a cam affixed to the motor shaft. This switch puts the -7.5 volts directly on the motor and remains closed until the scanning is complete when it again opens to stop the scan switch on its home position.

8. Positions 1 through 4 of the scan switch are alert pulses and are hooked directl to the -7.5 volt supply. Positions 5 through 8 are code positions used to identify the particular current meter. These four bits allow use of up to 16 current meters in one mooring without repetition of code words.

The code bits are wired directly to the plus and/or minus 7.5 volt supplies depending upon the code word desired. While the scan switch is scanning positions 1 through 6 the motor shaft cams 1) turn on the photran power and 2) trigger the flash tubes V_1 and V_2 locking the vane and rotor follower orientation in the photran memory circuit.

9. The scan switch continues its one revolution picking off the 7 flip flop outputs which yields a 7 bit straight binary number proportional to current speed and the 7 compass bits and finally the 7 vane follower bits. The 7 vane bits when compared to the 7 compass bits yield the magnetic sec of the current. These last two 7 bit numbers are in Gray binary and may be compared as Gray directly or converted individually to straight binary, decimal binary or magnetic or true bearing and then compared.

10. After reading the 32nd bit the photran power microswitch is turned off and a fourth microswitch momentarily opens the lockup circuit resetting the Shockley diode Sh 2.

11. The scan switch returns to "home" and the motor microswitch S_1 opens stopping the scan switch on home and returning the current meter to its standby position. This standby position of the current meter requires only 2 µ amps of current from the contained supply.

12. The buoy circuitry then repeats steps 7 through 11 for the current meters remaining in the line. The time required for each interrogation is approximately 10 seconds. Hence, the entire interrogation time for a string of 10 current meters would be 15 seconds + 10 x 10 seconds = 115 seconds. The program may then be repeated in its entirety or the buoy and current meters may be left on standby until further information is desired.

The current meters are provided with enough battery power to operate (to 1.2 volts/cell end point) once per hour for 1 year. The standby life of the system is equivalent to the shelf life of the batteries.

Format

The frequency shift keying (FSK) method was chosen for its ability to transmit information over longer distances with less chance of noise interference. The coding system chosen was pulse duration modulation (PDM) so that 7 bit binary numbers could be transmitted in such a way to give a quadrupally redundant code, i.e. the information can be derived from the received signal by four independant decoders and compared with each other. If the four decoded signals agree then the information is taken as real. If agreement is not complete then an attempt is made to locate the source of disagreement (usually a noise pip). If an obvious source cannot be found then the data is disregarded. A further aid to choosing the correct data is a parity bit transmitted at the end of the last code word which tells the absolute number of binary "ones" that were fed to the transmitter. The overall usefulness of the system is enhanced if a decoding and monitoring system is operated in parallel with the receiver. In this case, if the data is found to be untrustworthy the operator immediately reinterrogates the system in hopes that the disrupting source was random and will not show up twice in succession.

The output of the current meter is shown in Figure 11A. This output, when transmitted received and discriminated, is shown in Figure 11B. By looking at the expanded section of Figure 11B one can see where the quadruple redundancy arises. If the discriminated signal is centered about zero as indicated, the four decoders may operate as follows:

1) first decoder (integrator) detects signals between 5 and 7 units long on positive side of zero.

2) second decoder detects signals between 1 and 3 units long on positive side,

3) third decoder detects signals between 3 and 5 units on negative side and

4) fourth decoder detects signals between 7 and 9 units long on negative side. Coincidence circuits are not needed because the program is chronometrically controlled. Printout of the four separate words (i.e. location, rotor counts, compass and vane) is triggered by a detector which operates on the negative side and activated by a signal between 13 and 19 units long. The extra long signal on f_1 is due to the spaces between words as shown in Figure 11A. Each code word begins with the least significant bit and the "spaces" are used for printout to prevent crossover of words in case a bit is missed.

One complete current meter has been built and tested on monoconductor cable at sea aboard the R.V. CHAIN. Readings were taken at various depths in the Gulf Stream during March 1962. No difficulties were encountered and 13 more meters are being manufactured for use in a mooring this autumn. The readout system described above is now being assembled and we expect to have the entire system operational by late summer. Obviously, in this type of work there are many possible sources of trouble which cannot be foreseen and there will likely be a number of modifications throughout the system before it becomes reliable. We feel the current meter itself, because of previous experience with its primary components will be an increasingly useful tool with only minor changes.

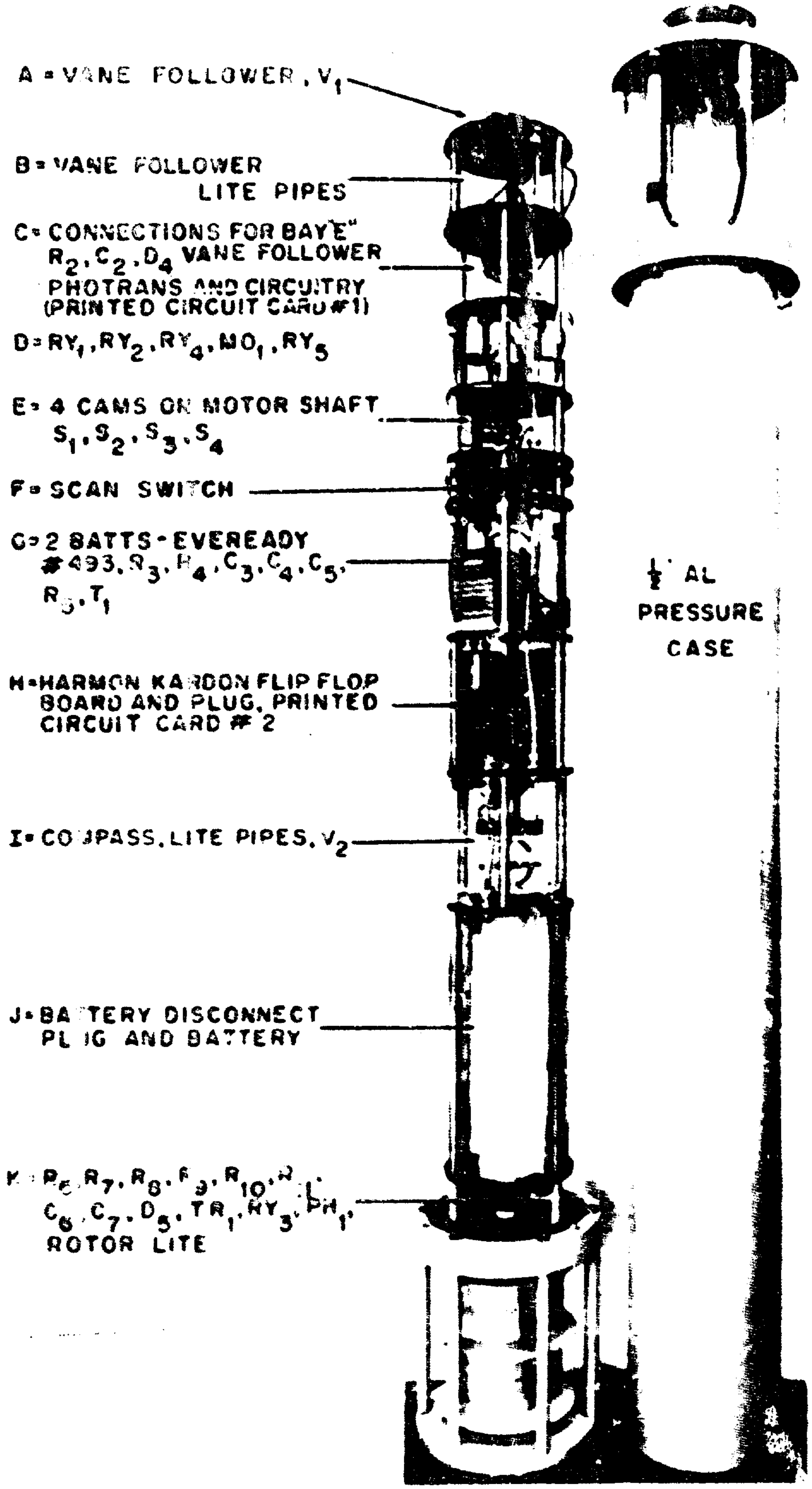

A = VANE FOLLOWER, V1
B = VANE FOLLOWER LITE PIPES
C = CONNECTIONS FOR BAY "E" R2, C2, D4 VANE FOLLOWER PHOTRANS AND CIRCUITRY (PRINTED CIRCUIT CARD #1)
D = RY1, RY2, RY4, MO1, RY5
E = 4 CAMS ON MOTOR SHAFT S1, S2, S3, S4
F = SCAN SWITCH
G = 2 BATTS - EVEREADY #493, R3, R4, C3, C4, C5, R5, T1
H = HARMON KARDON FLIP FLOP BOARD AND PLUG, PRINTED CIRCUIT CARD # 2
I = COMPASS, LITE PIPES, V2
J = BATTERY DISCONNECT PLUG AND BATTERY
ROTOR LITE
1/2" AL PRESSURE CASE

FIG. 1

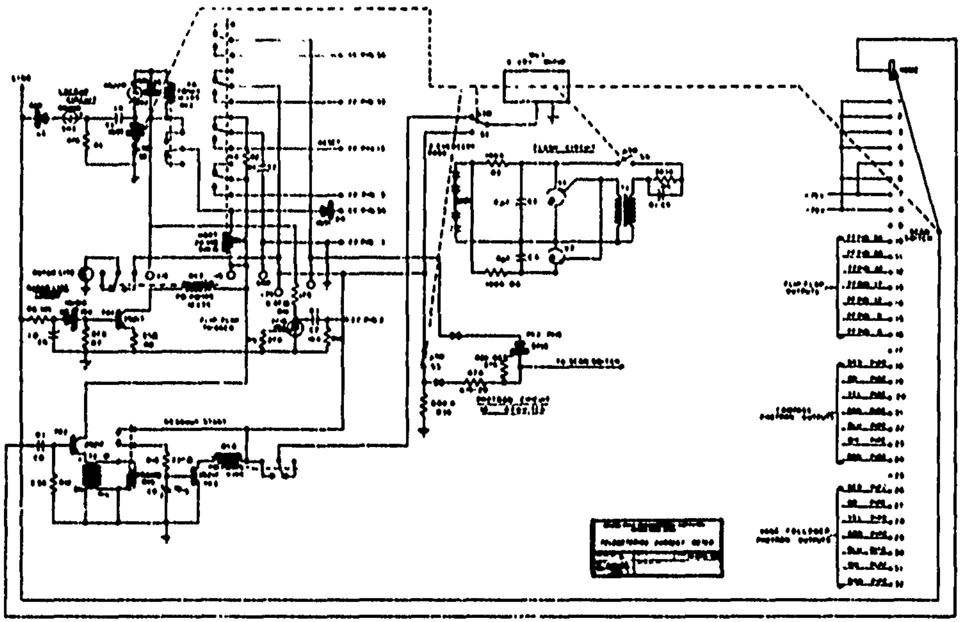


FIG.2

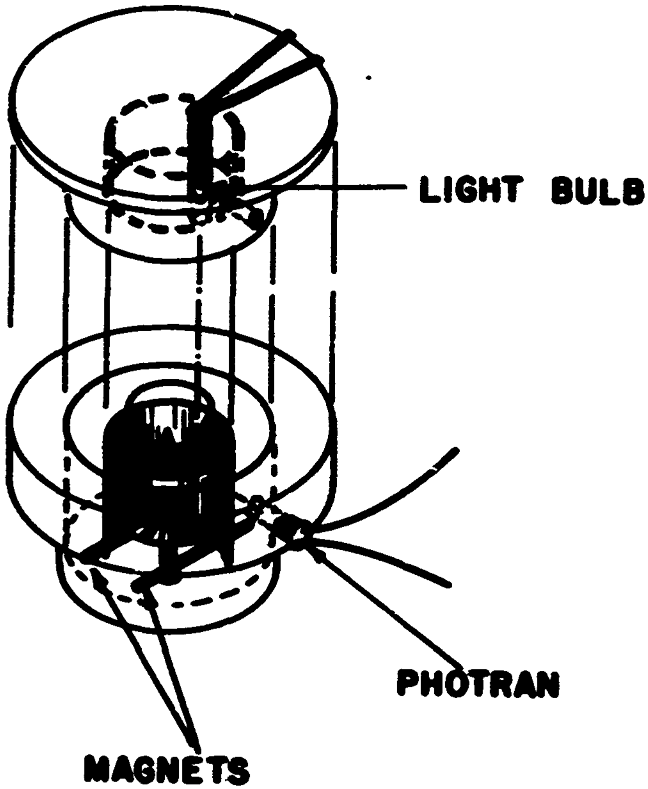
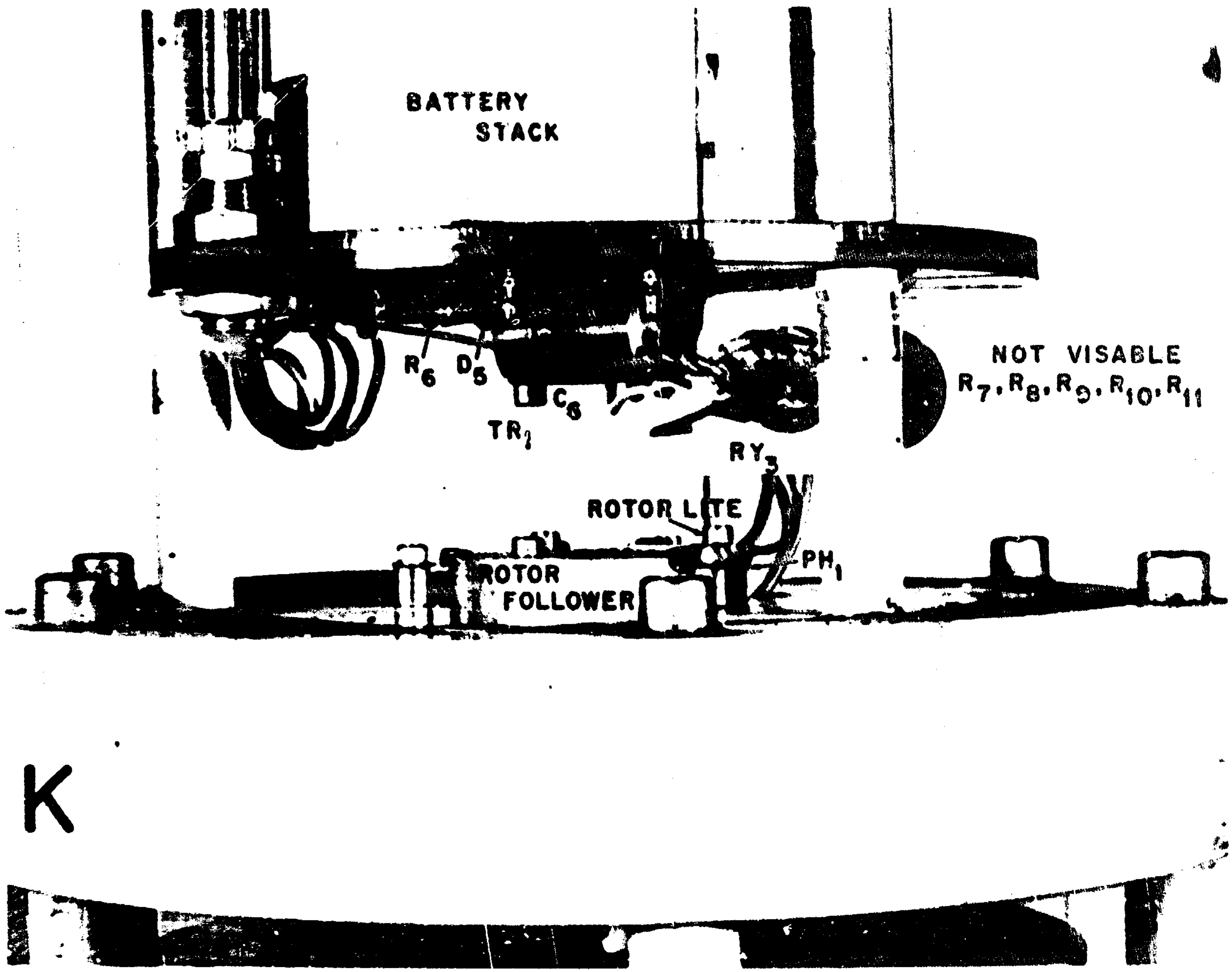
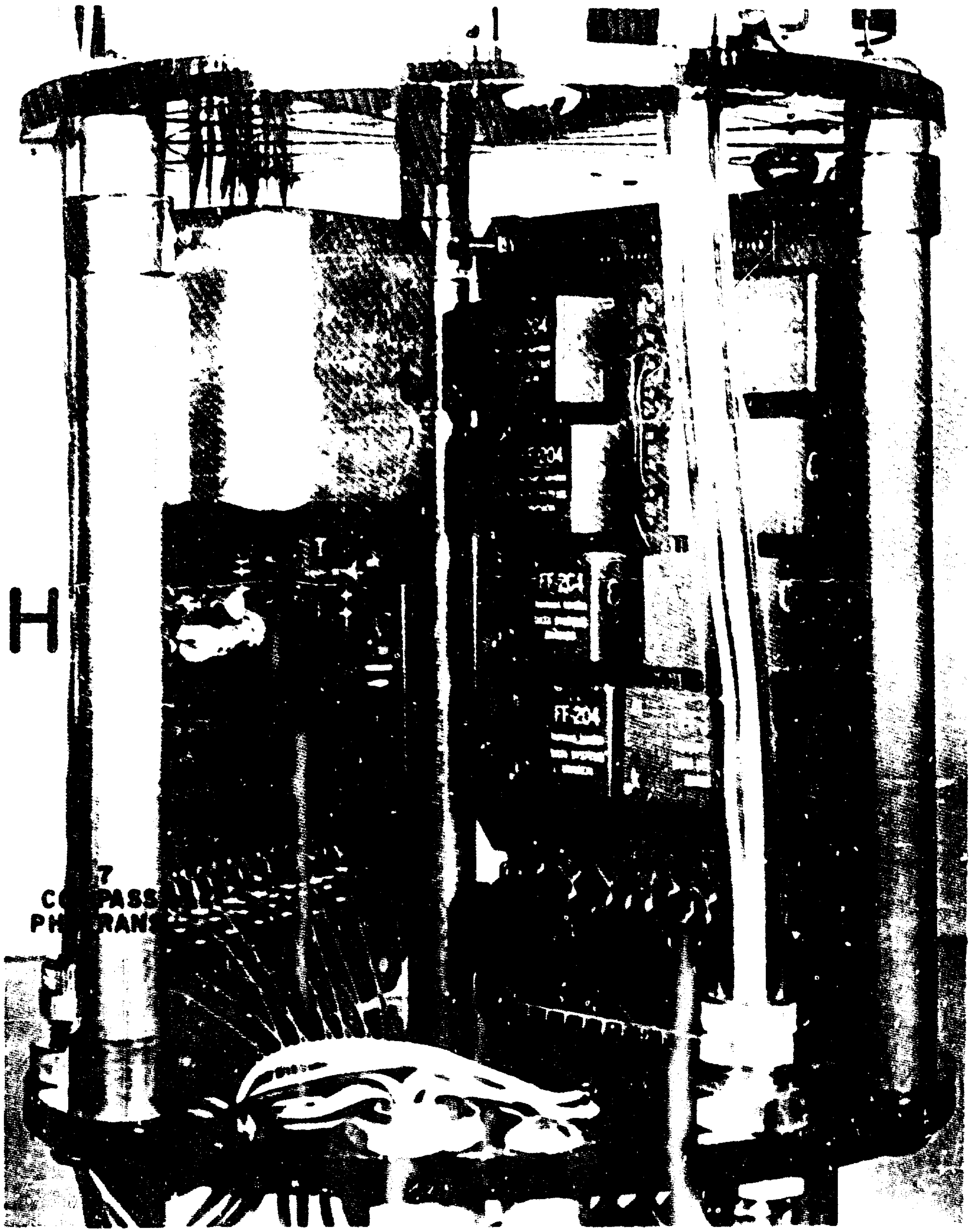


FIG.3



BATTERY STACK
R6
D5
TR1
C6
RY3
NOT VISABLE
R7, R8, R9, R10, R11
ROTOR LITE
PH1
ROTOR FOLLOWER
K

FIG. 4


H
FT-204

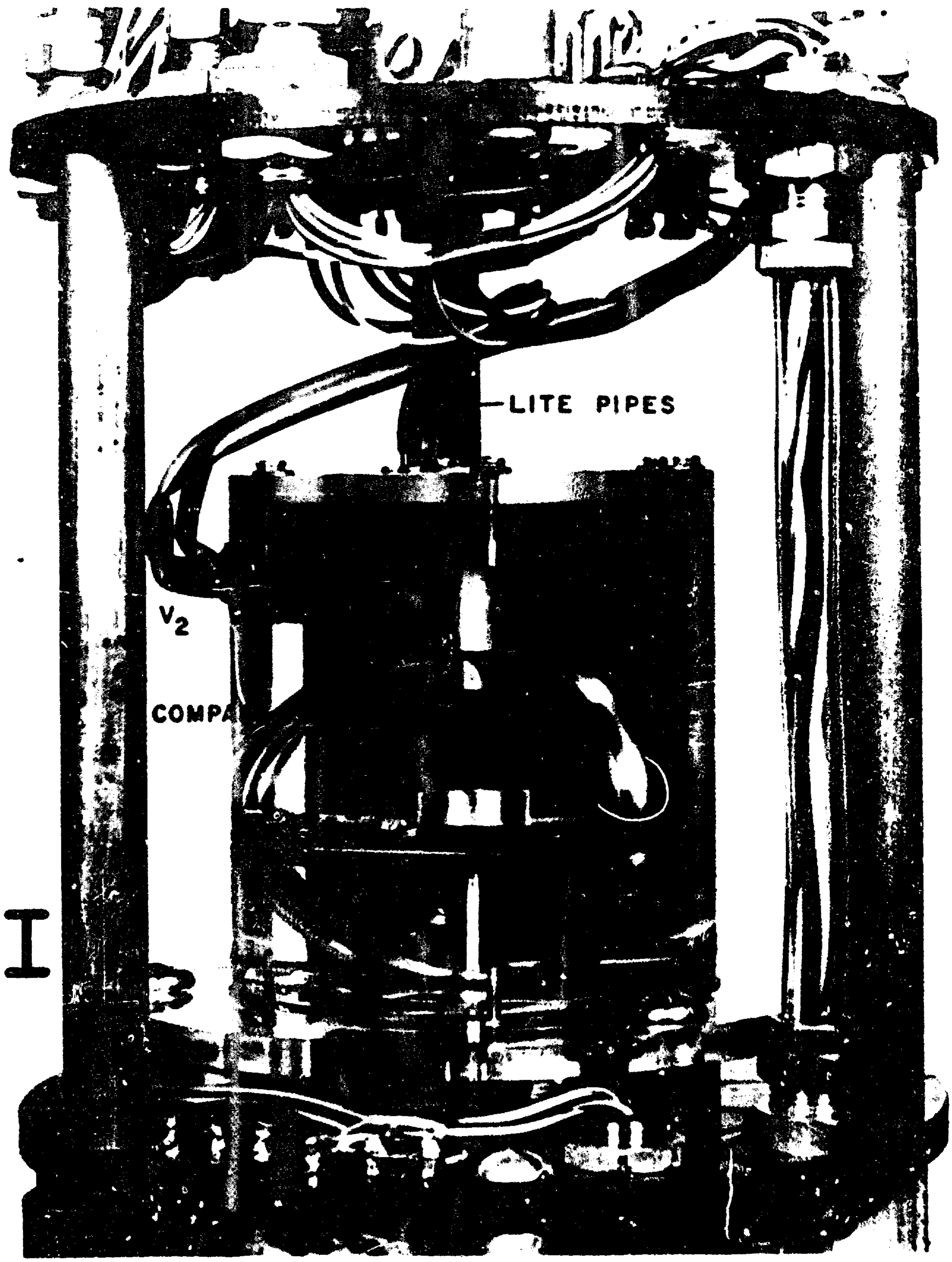


FIG. 6

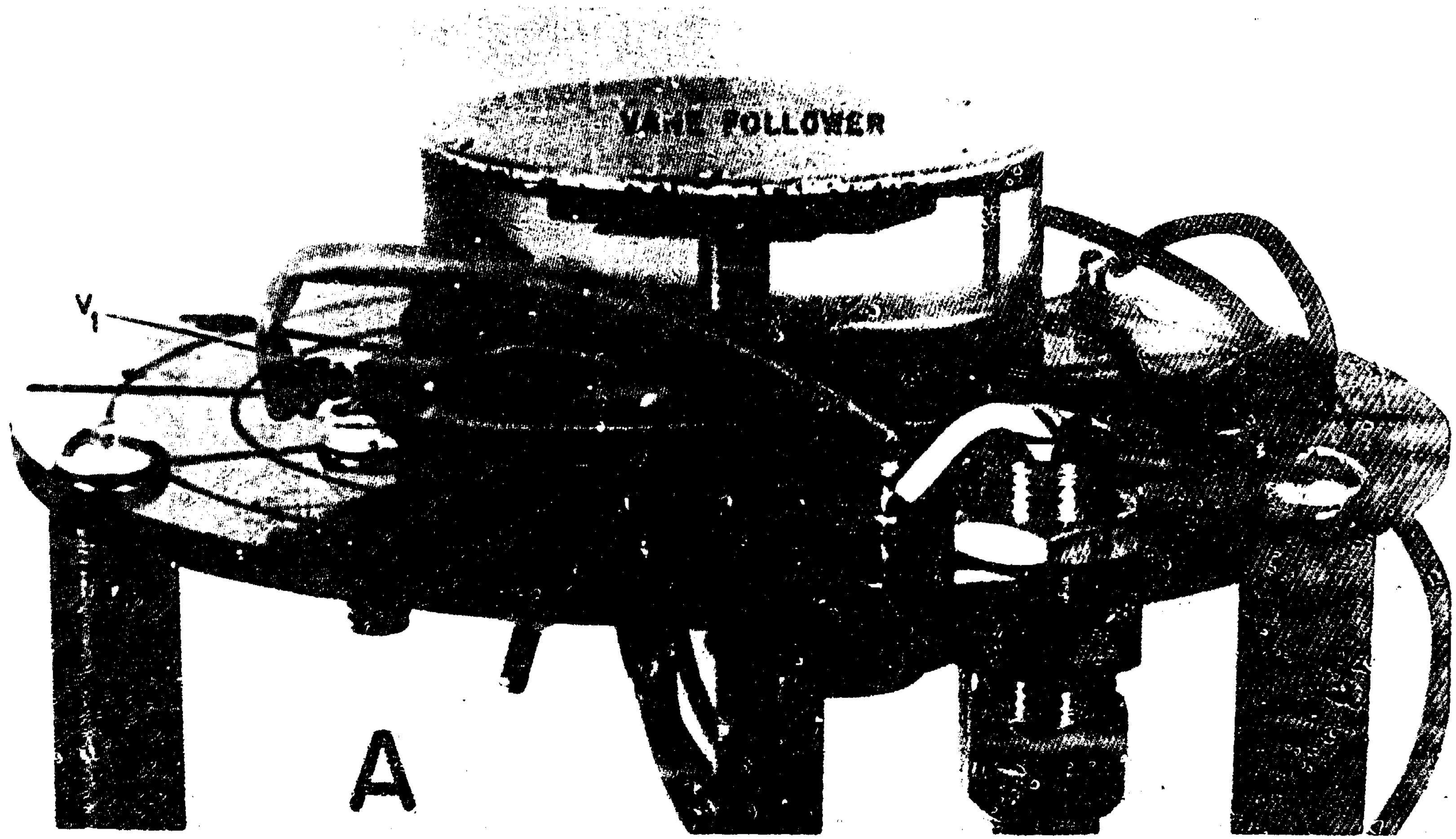


FIG. 7

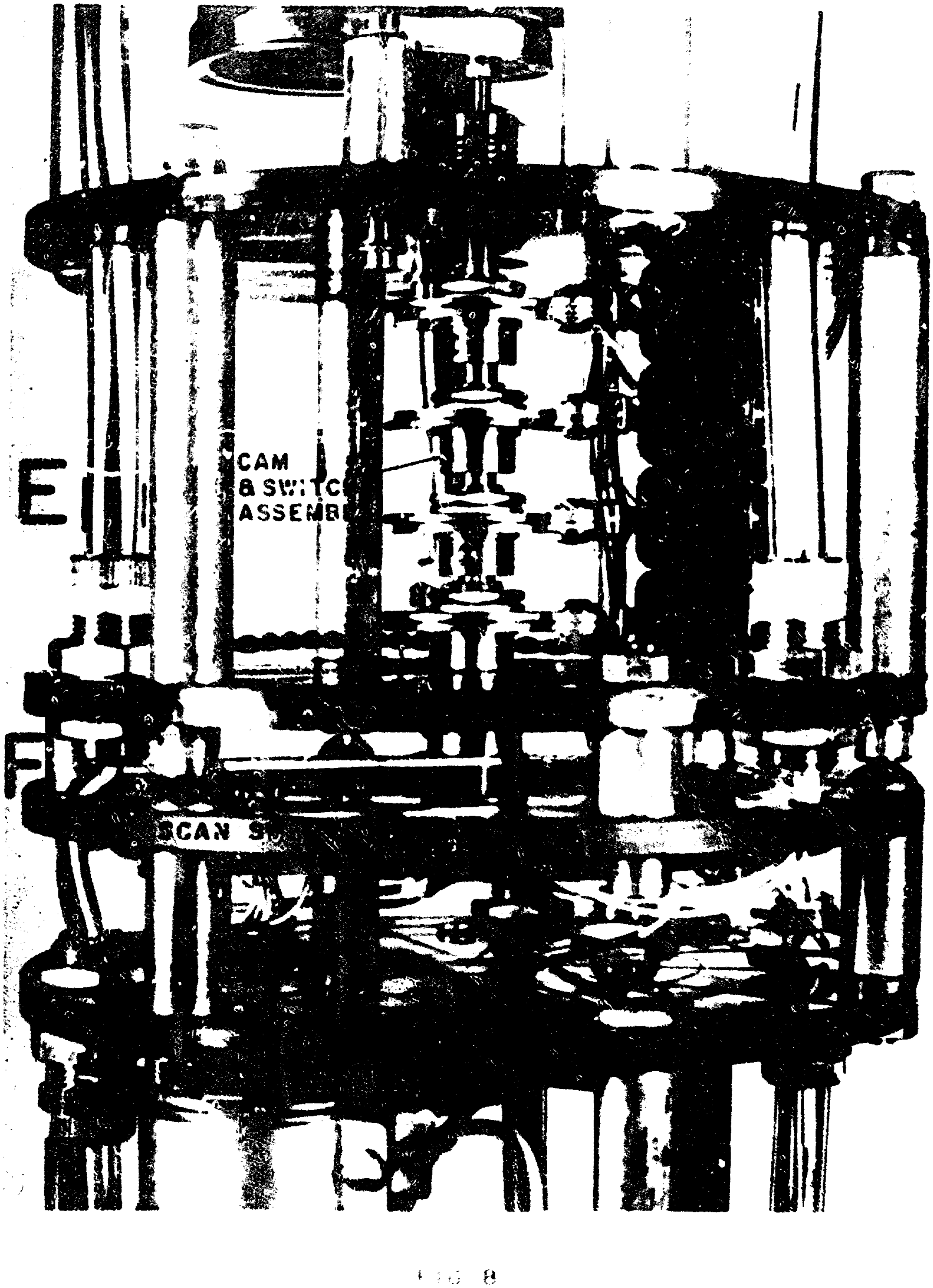


FIG. 8

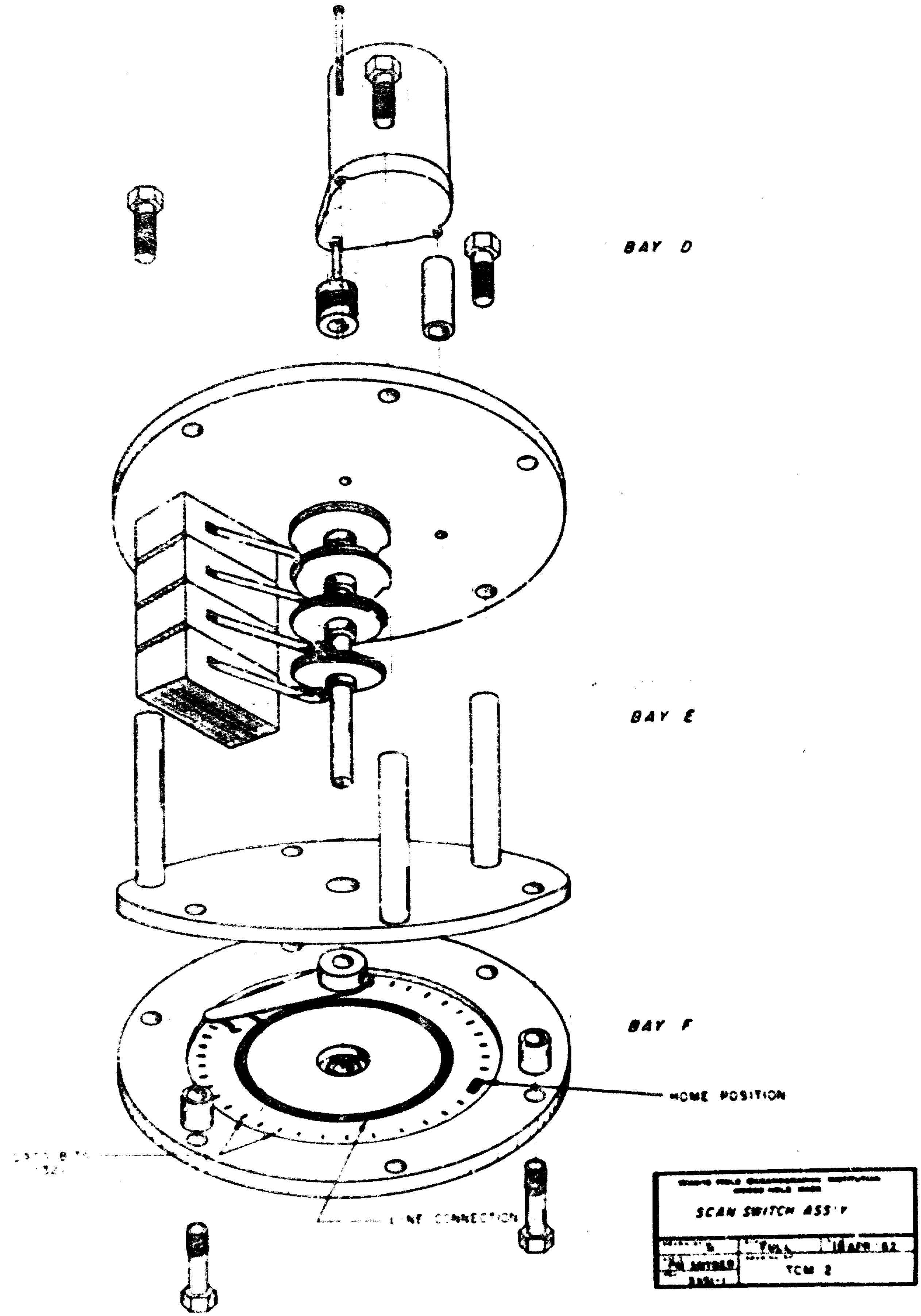

BAY D
BAY E
BAY F
HOME POSITION
LINE CONNECTION
SCAN SWITCH ASS'Y
TCM 2

FIG. 9

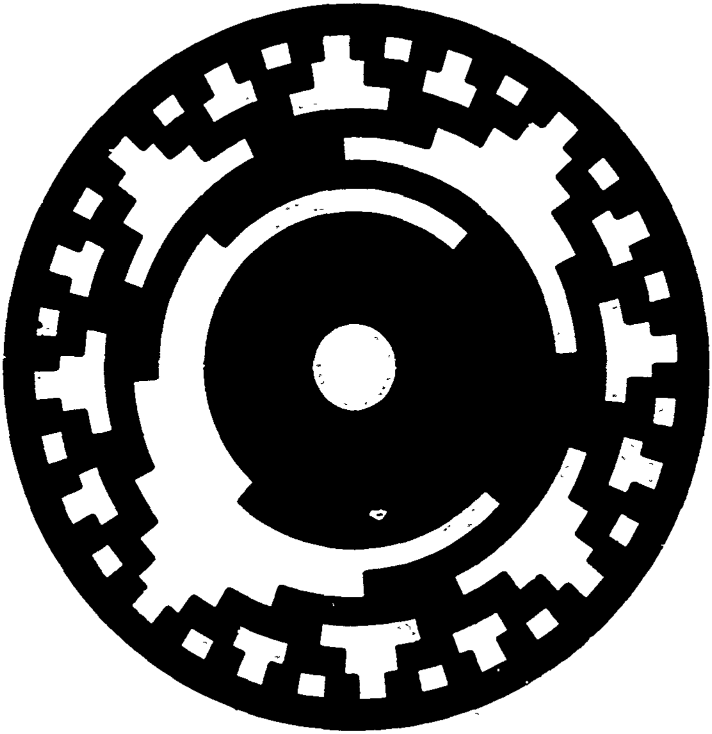
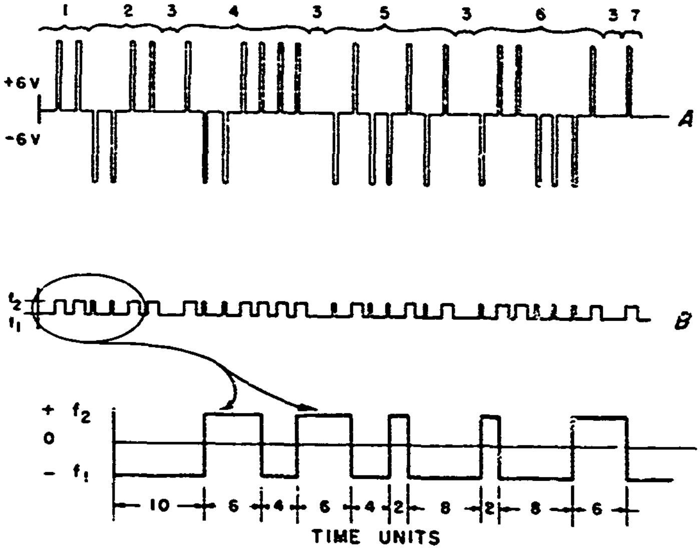
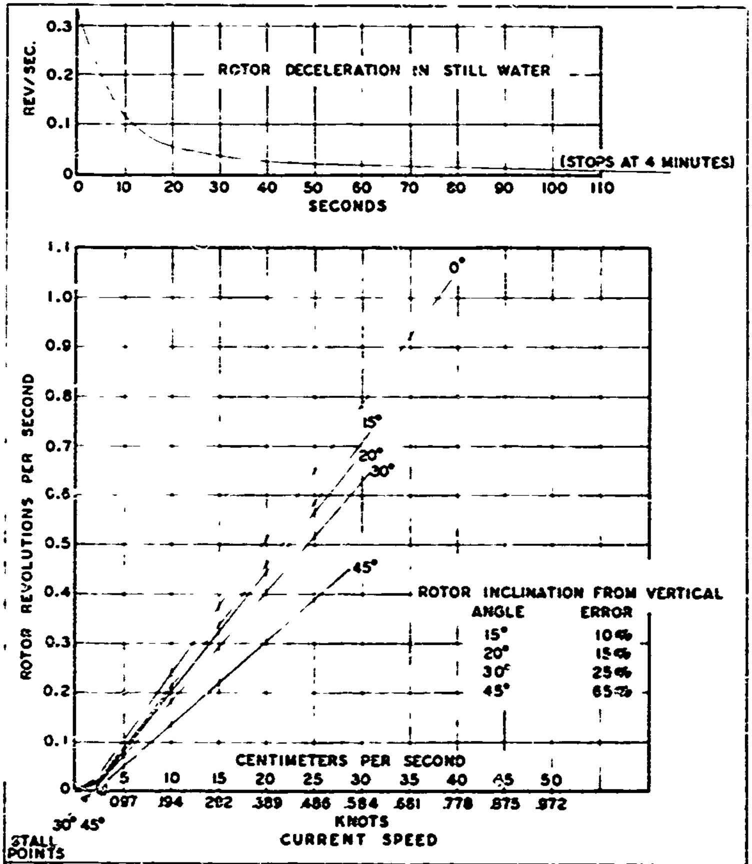


FIG.10



START
1 ALERT PULSES
2 LOCATION CODE
3 SPACE
4 ROTOR COUNT — STRAIGHT BINARY
5 COMPASS READING - GREY BINARY
6 VANE READING — GREY BINARY
7 PARITY BIT

FIG.11



DATE 12-8-61

DRAWN BY G.E.G.

SCALE

DATA SUPPLIED BY WOODS HOLE OCEANOGRAPHIC INSTITUTION

TITLE CALIBRATION OF SAVONIUS METER

USED ON CURRENT METER

DWG NO A-168 REV 0

FIG 12

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