Time Counter Module

7.g For The Aanderaa Current Meter

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Ocean Currents Measurement System

This documentation package explains the theory and operation of the Ocean Currents Measurement System developed for the MESA Program by the National Ocean Survey's Engineering Development Laboratory. The documentation is divided into seven subsystem manuals (listed below). This modularity provides the flexibility to change or make additions to a particular subsystem manual without replacing the entire package. It also allows two or more people to read different sections of the documentation at the same time.

Ocean Currents Measurement System Manuals

1. System Description
2. Peopleware Subsystem
3. A. Mooring Subsystem
   B. Recording Current Meter
4. Data Conversion and Processing Subsystem
5. Data Quality Control Subsystem
6. Maintenance and Failure Reporting Subsystem
7. Support Documentation Subsystem
   a. Aanderaa Compass Checkout Fixture
   b. Aanderaa Current Meter Test and Evaluation
   c. AMF Acoustic Release/Pinger
   d. SB-510 Seabeacon Surface Buoy
   e. Coast Guard 155 mm Lantern
   f. Aanderaa Current Meter In Situ Monitoring Group Manual
   g. Time Counter Module For The Aanderaa Current Meter

A TIME COUNTER MODULE

FOR

THE AANDERAA CURRENT METER

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May, 1975

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ABSTRACT

The Aanderaa current meter as supplied by the manufacturer has no provision for recording of real time information on the data tape. When processing the current meter data, if the expected number of records (computed from start and end times) does not correlate with the actual number of records, it is difficult and sometimes impossible to assign time to a data record. The Time Counter Module (TCM) eliminates this deficiency in the current meter by providing an hourly interval sequence number on the data tape.

Following the design and successful testing of a pre-prototype breadboard model, three engineering prototype models were fabricated and tested, including limited field testing. This report describes the tests performed and results obtained from these tests. TCM test data, detailed information on TCM theory of operation, installation and operational use are included in the Appendices.

Twenty additional TCM's are being procured for extensive field tests. A final report, to be inserted into this document, will be furnished upon completion of these tests.

TEST REPORT

Time Counter Module for Aanderaa Current Meter

I. INTRODUCTION

Three Time Counter Modules (TCM) were fabricated by Harry Diamond Laboratories (HDL) to EDL supplied schematics and specifications. The purpose of these engineering prototype models was to make the transition from the laboratory breadboard layout to a package which could be directly installed on a current meter (Figure 1) and thus permit additional tests including field tests to be performed (See Appendix A for detailed description and operation of the TCM).

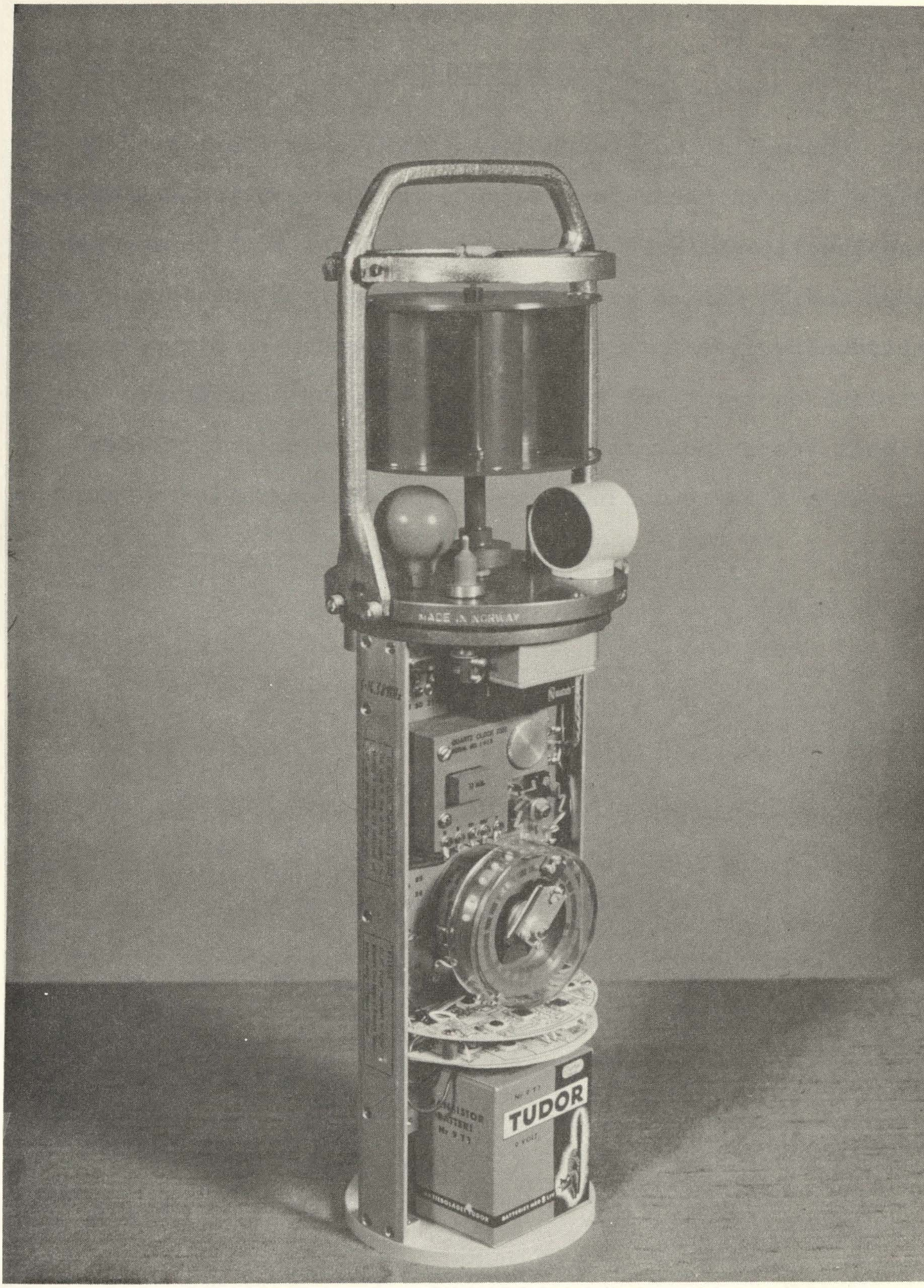


Figure 1. Aanderaa Current Meter with Time Counter Module

II. OBJECTIVE

The purpose of these tests was to (1) determine the operation to specification of the newly fabricated TCM's; (2) determine if temperature extremes would cause component failure or TCM malfunction due to undesirable temperature coefficients of any components; (3) determine the effect, if any, on the pressure calibration since the time word is written in place of the pressure data word; (4) determine reliability of operation under field use conditions; and (5) determine battery life under worst case temperature conditions.

III. PROCEDURE

The tests were conducted in accordance with the test plan detailed in Appendix B. Briefly the test plan requires that the engineering prototype models be excercised on the bench and in the environmental chamber to weed out the infant mortalities and determine equivalence between prototype and breadboard. Upon satisfaction of the laboratory tests the plan requires that the TCM's be placed in the field and evaluated after 30 days operation.

The procedure was modified somewhat after the field test to include additional battery/operation tests under simulated field conditions.

IV. RESULTS

A complete chronology of all tests performed on each TCM is given in Appendix B.

The first TCM was delivered by HDL during the last week of August, 1974 and the remaining two units were delivered in mid September, 1974. Upon visual inspection of the first unit, Serial No. 001, several defects were noted due to poor quality workmanship at HDL during assembly. Specific defects noted were several cold solder joints, a broken wire due to cutting strands when stripping insulation and a misrouted wire in the wiring harness. HDL was advised of the deficiencies and these were corrected. Visual inspection of the second and third units indicated no defects.

A. Operational Tests: Each TCM was then installed on a current meter and run for several hours to test for correct operation. The functions checked were output of time word and flag once per hour, proper incrementing of the time word, manual write function and reset. TCM No. 002 failed to give any output when initially tested. Upon inspection one IC chip was found to be reverse mounted. The unit was returned to HDL and the problem corrected. Following this, all three TCM's checked out satisfactorily.

The reduced battery voltage test showed no degradation of operation as the 9 volt supply voltage was reduced to 6.0 volts and the 4 volt clock voltage was reduced to 3.8 volts.

The third test of an operational nature was the accelerated test. With the frequency of the oscillator input signal to the TCM increased by a factor of 60, an hour count is generated once per minute instead of once per hour as under normal operation. This enables the TCM circuitry to cycle thru a full scale value of 1023 in 17 hours rather than the 43 days required at the normal oscillator input frequency of 16,384 Hz. A signal generator was used to provide the required frequency and a separate countdown circuit was developed to provide the current meter trigger signal of one pulse per minute (See Figure 1 B.1, Test Plan, Appendix B). (The current meter trigger signal and TCM oscillator input signal must be derived from the same time base for synchronization).

Each TCM was tested with the accelerated input conditions while recording the data on the current meter magnetic tape. A computer printout of the data was obtained with the following results:

TCM SN.	TIME WORDS WRITTEN (HOURS)	ERRORS
001	1080	1
002	1063	0
003	1440	0

All hour words were written correctly except for one error on TCM No. 001.

B. Environmental Tests: Each TCM was tested in the environmental chamber at $-5^{O}C$ and $+50^{O}C$ according to the temperature cycling schedule in the test plan (Appendix B). The current meter was placed on a 10 minute recording interval with the TCM in the normal operating mode, writing a time word once per hour, with the data being recorded on the current meter's magnetic tape. The results of this test were as follows:

TCM SN.	TIME WORDS WRITTEN (HOURS)	ERRORS
001	48	0
002	47	0
003	47	1

All hours words were written correctly except for one error on TCM No. 003. The error occured while the meter and TCM were at room temperature and was therefore not due to any temperature sensitivity on the part of the TCM.

C. Pressure Test: A pressure calibration check was performed on two of the current meters (SN 1257 and 1258) before TCM installation and again after the TCM's were installed. The complete data and results are shown in Appendix B. The variation in the pressure sensor output between before and after TCM installation pressure tests was within the $\pm$ 1 count resolution of the pressure sensor with the exception of one data point. At zero pressure the output from current meter Serial No. 1257 read 6 counts or 1.2 psi higher than the same reading at zero without a TCM.

This difference, which occurred on the downward cycle of the pressure run, is due to a small residual pressure on the sensor and occurs when the zero reading is taken before disconnecting the dead weight tester pressure fitting from the current meter. Considering the close agreement in the pressure data, it can be said that the TCM does not affect the pressure sensor calibration.

D. <u>Field Test:</u> The three current meters with TCM's installed were shipped to MESA, Floyd Bennett Field in mid October, 1974 to be used in a routine deployment in the New York Bight Survey. During pre-deployment calibration tests at Floyd Bennett one of the current meters (SN 719) experienced a leak (due to improper assembly) while in a salt water bath which damaged the TCM and rendered it inoperative. The two other meters (SN 1257 and 1258) were deployed on November 19, 1974 and retrieved again on November 29, for a total deployment time of 10 days. The data tapes were forwarded to Rockville for processing in the usual manner. The computer printout of the data showed the following results concerning the TCM:

Current Meter SN	TCM Ser. No.	Time Words Written (Hours)	Errors
1257	001	274	1
1258	003	274	0

Post retrieval checkout of the current meters at Floyd Bennett Field revealed lower than normal battery voltage which, as judged by the technician on the scene, would not have endured a 30 day deployment. The main 9 volt battery, tested under current meter load conditions, measured just under 8 volts following the 10 day deployment. An original requirement was that with the addition of the TCM, the battery life not be degraded below the 30 day capability of the meter. If this requirement could not be met, the TCM design would not be acceptable.

The current meters were shipped back to EDL for further tests to investigate the excessive battery drain problem. Upon investigation, two previously undetected current loops at the TCM current meter interface were found which were causing a continuous current drain of 250 μa to be drawn from the 9 volt battery during standby. This current drain was eliminated with the addition of a diode and a capacitor, resulting in zero current drain by the TCM from the 9 volt battery during standby. This modification was made to all three TCM's and also the breadboard model. (TCM SN 002 which had been damaged by salt water was repaired so that it could be used for the battery test).

Another factor contributing to lower than expected battery voltage after the field test was the fact that the batteries used in the meters were not fresh. The date code stamped on the batteries indicated that they were 14 months old at the time of deployment.

Following modification, each of the TCM's was allowed to operate overnight (19 hours) for an operational check. No problems were noted.

E. <u>Battery Drain Test:</u> A test was conducted to determine the battery capacity of both the Aanderaa supplied Tudor 9T1 and the U.S. equivalent Burgess D6 9 volt batteries. Also the total milliampere-hour consumption of the current meter, with and without TCM was determined. The test was conducted with the current meters in the environmental chamber with the temperature held at $0^{o}C$ to simulate worst case temperature conditions which could be encountered during a field deployment. Table I shows the current meters, sampling intervals, and batteries used in the test.

Table 1

Aanderaa Current Meter Battery Test Matrix

Meter Serial Number	Battery Type	Sampling Interval (Minutes)	Without TCM	With TCM
1340	Burgess D6	1	X	
1341	Tudor 9T1	1	X	
1347	Burgess D6	1		X
1342	Tudor 9T1	1		X
1339	Burgess D6	10	X	
1256	Burgess D6	10		X
1257	Tudor 9T1	10		X

Of primary interest were the meters on the 10 minute interval since this is the mode of operation most commonly used in the field. The one minute interval was used to accelerate the test and obtain battery discharge data more quickly.

Leads were brought out from the 9 volt battery of each current meter to a terminal strip so that voltages could be read. A Tektronix model DM 501 digital multimeter was used to read battery voltages. Readings were taken at least twice a day on the 1 minute interval meters. Two voltage readings were taken for each test point, an open circuit voltage reading and a voltage reading under current meter load. The open circuit voltage of each battery was read just before the current meter began its sample interval (to allow for maximum and uniform battery voltage recovery time). The voltage under current meter load was read at maximum load which is during the time when the compass clamping coil is energized.

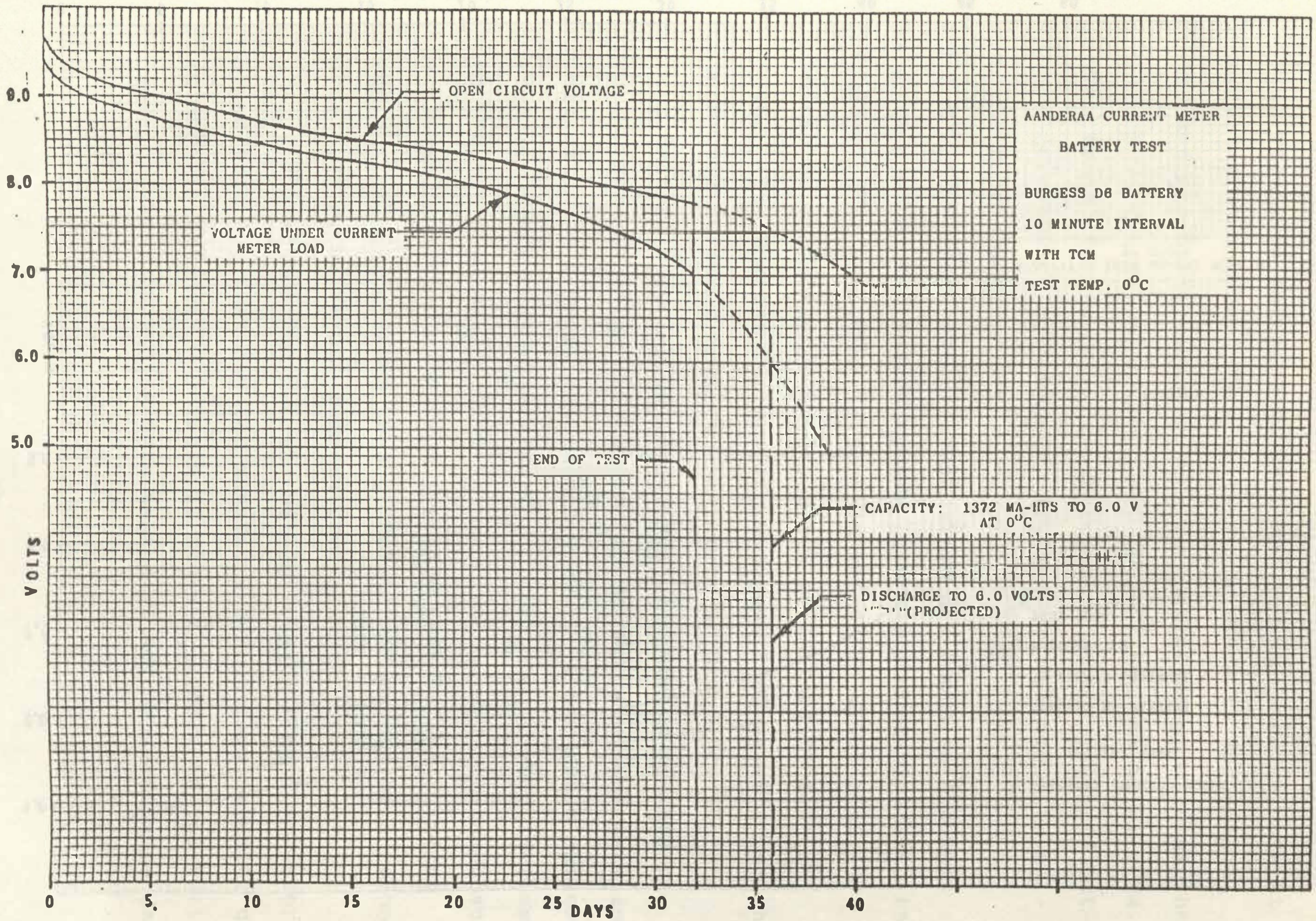
A tabulation and plots of all the voltage readings are given in Appendix B.

The 9 volt battery voltage is regulated to 6 volts in the current meter electronics board and for practical purposes, the battery voltage can go down to 6 volts with no degradation in current meter operation. (The drop across the regulator is less than 0.1 volt at 6.0 volts input voltage). Also for this reason, the cutoff point for the 9 volt battery is considered as the point where it has been discharged to 6 volts.

The current meters on the one minute sampling interval were allowed to remain in the test chamber and their voltage was monitored until they ceased to operate. Unfortunately the test of the three meters on the 10 minute sampling interval had to be terminated before the battery voltage reached the 6 volt cutoff point because the meters were needed for other tests at NSRDC. However, the Burgess battery discharge curves were extrapolated to 6 volts by comparison to the discharge curves from the one minute sampling interval data plots. An extrapolated discharge curve to 6 volts was not generated for the Tudor battery data. Because of the greater capacity of the Tudor battery, it's discharge curve was still in the flat portion when the test had to be terminated making any extrapolation very uncertain. Comparison of relative battery capacity between the Burgess and Tudor batteries was therefore made on the basis of the one minute sampling interval tests.

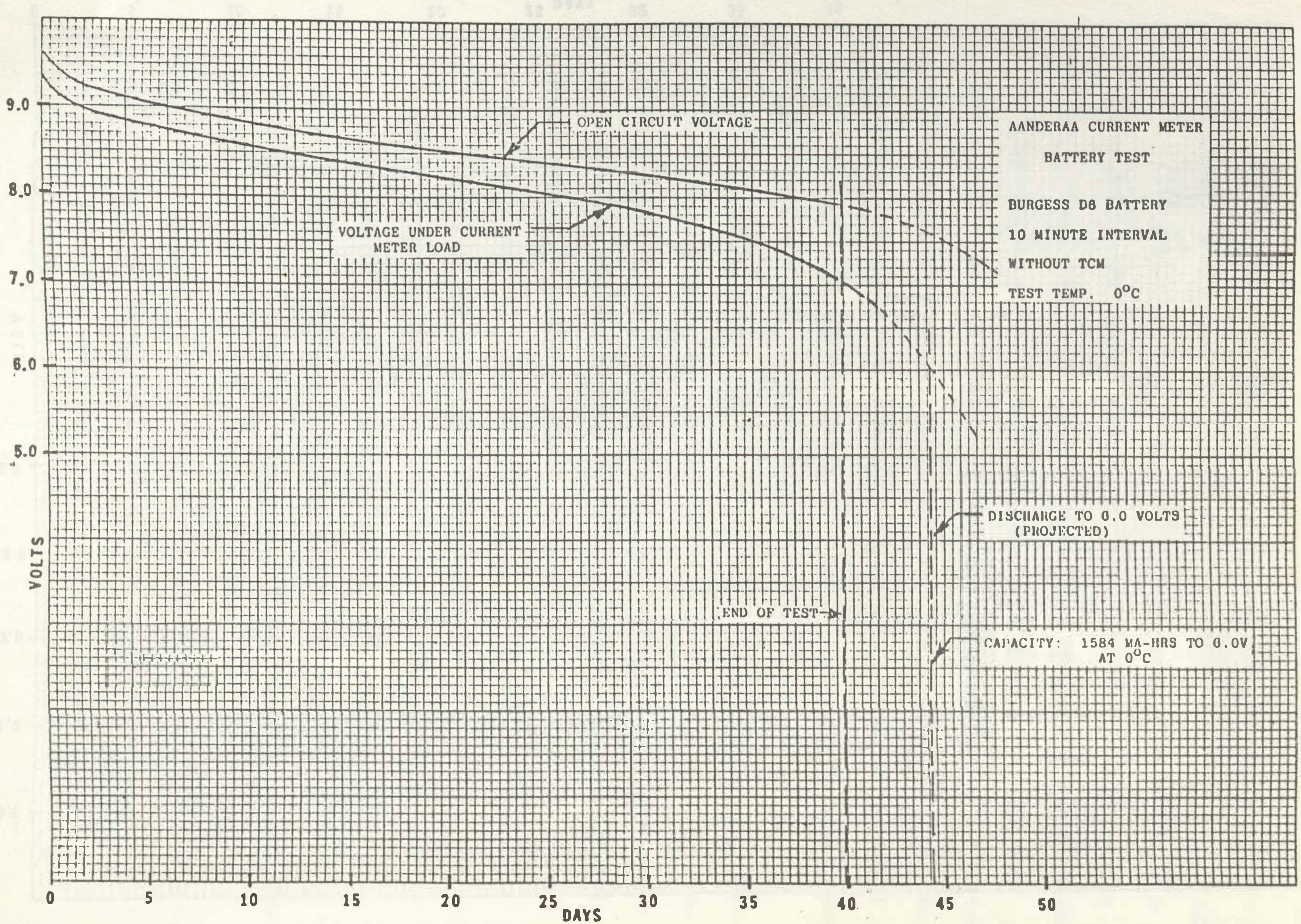
Battery Test Results: The discharge curves of Figures 2 and 3 show the results obtained from a Burgess battery with the current meter on a 10 minute interval, with and without a TCM. With a TCM the current meter is capable of running for 36 days and without a TCM 44 days (at test temperature of $0^{O}C$).

In order to compute required battery capacity in milliampere-hours from the test data, a value for the average current drain and average load resistance seen by the 6



AANDERAA CURRENT METER
BATTERY TEST
BURGESS D6 BATTERY
10 MINUTE INTERVAL
WITH TCM
TEST TEMP. 0°C
OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
END OF TEST
CAPACITY: 1372 MA-HRS TO 6.0 V AT 0°C
DISCHARGE TO 6.0 VOLTS (PROJECTED)
VOLTS
DAYS
9.0
8.0
7.0
6.0
5.0
0
5
10
15
20
25
30
35
40

Figure 2



9.0
8.0
7.0
6.0
5.0
VOLTS
OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
AANDERAA CURRENT METER BATTERY TEST
BURGESS D6 BATTERY
10 MINUTE INTERVAL
WITHOUT TCM
TEST TEMP. 0°C
DISCHARGE TO 6.0 VOLTS (PROJECTED)
END OF TEST
CAPACITY: 1584 MA-HRS TO 6.0V AT 0°C
0
5
10
15
20
25
30
35
40
45
50
DAYS

Figure 3

volt regulator during the "On-Time" of the Aanderaa current meter was computed. This analysis is shown in Appendix B. The average drain computed for the current meter without the TCM is 27 ma. and with the added load of the TCM is 28.6 ma. This translates, for 30 day operations, into a required battery capacity of 1080 ma.-hr. without the TCM and 1143 ma.-hr. with the TCM.

The measured battery capacities are shown in Appendix B for each battery and sampling interval combination with the exception of the Tudor battery 10 minute interval test for which the discharge curve could not be extrapolated to 6 volts. The Burgess D6 capacity is about 1300 ma.-hr. and the Tudor 9T1 is about 2000 ma. -hr. both at $0^{o}C$.

Battery capacity is significantly affected by temperature. Since the test was conducted at $0^{o}C$, the test data is valid at that temperature only. However, a projected battery capacity at $21^{o}C$ is also computed. The value of 60% increased battery capacity at $21^{o}C$ as used in the computation shown in Appendix B was taken from Eveready Battery Applications Engineering Data, pages 29-30, "Relative Capacity of A Carbon-Zinc Cell at Different Temperatures".

A comparison between the battery capacity data as determined from the test and the manufacturers battery capacity data is made in Appendix B. Table II shows a summary of the battery capacity data, including both test data and manufacturers data.

Table II

Summary of Battery Test Data Results

Battery Type	Without TCM	With TCM	Sampling Interval	Number of Samples*	Battery Capacity to 6.0V: Measured ma.-hr. @ 0^oC	Battery Capacity to 6.0V: Predicted From MFR's Data ma.-hr. @ 0^oC
Burgess D6	X		1 min.	5760	1380	1262
Tudor 9T1	X		1 min.	8928	2136	2152
Burgess D6		X	1 min.	5760	1472	1237
Tudor 9T1		X	1 min.	8064	2048	2152
Burgess D6	X		10 min.	6336	1584	1253
Burgess D6		X	10 min.	5184	1372	1208

Note: 1080 ma.-hr. required for 30 day (10 minute interval, 4320 samples) operation without TCM @ 0^o.

1143 ma.-hr. required for 30 day (10 minute interval, 4320 samples) operation with TCM @ 0^o.

* Current meter operates for 25 seconds/sample.

There is good agreement between the measured and manufacturers predicted performance.

During the TCM tests a report was received from the field that as the current meter supply voltage dropped below the 8 volt level, sync pulse drop out was occurring. This could not be confirmed. All data tapes were translated and computer printouts obtained from the data recorded during the battery test. The software is programed to print error messages when sync pulses are missing. It was found that sync pulses did not begin to drop below the tape transcriber threshold level until the current meter battery voltage (under load) dropped below 6 volts.

Battery Test Conclusions: The test results indicate that the Burgess D6 will power the Aanderaa current meter with TCM at the 10 minute sampling interval for about 36 days at worst case temperatures of 0°C. A Tudor 9T1 battery will power the current meter for about 50 days. This statement assumes that the current meter in question exhibits average current consumption and that the battery used is fresh.

V. CONCLUSIONS (TCM TESTS)

The laboratory tests and limited field tests with the engineering prototype TCM's demonstrated the satisfaction of the specifications. The TCM's operated satisfactorily in laboratory tests when subjected to temperatures from -5^{o}C to +50^{o}C. The pressure calibration was not affected by the addition of the TCM.

The battery drain question arising from the field tests was solved and verified with such a high confidence level that further field tests were not conducted.

The overall success of these tests led to the procurement of additional TCM's for extensive field tests. These procurements (10 units for C33, Oceanographic Division and 10 for MESA) are presently in progress and scheduled for delivery in August, 1975.

FINAL REPORT

The twenty additional TCM's being procured will undergo laboratory and field tests in accordance with the test plan detailed in Appendix C. At the completion of these tests, a final report will be furnished for inclusion into this document.

APPENDIX A

Description, Theory of Operation, Installation Instructions, and Operational Use of the Aanderaa Time Counter Module

AANDERAA TIME COUNTER MODULE

INTRODUCTION:

This document provides information on the theory of operation, installation and operational use of the Aanderaa Time Counter Module (TCM) Model 75. This module was designed by the Engineering Development Laboratory, Rockville, Maryland.

The Aanderaa current meter as originally supplied has no real time information recorded on the data tape. Time is assigned to a data record by counting from a known starting time and/or known ending time. This occasionally presents a problem if for some reason the data is not continuous from start to end. If an interruption in the data exists, the time continuity is lost. The purpose of the TCM is to correct this deficiency in the current meter by providing an hourly interval sequence number which is recorded on the data tape.

GENERAL DESCRIPTION:

The Aanderaa current meter's 16.384 KHz crystal clock frequency is divided down to produce one pulse per hour. These hourly pulses are totalized and stored in a 10-bit storage counter. The reset of the TCM is in common with the Aanderaa crystal clock reset to insure that the hour count occurs synchronously with the crystal clock trigger pulse. The stored hour count, which is a number between 0 and 1023, represents elapsed time in whole hours since reset. This time interval number is written on the tape once per hour during the data interval immediately following the hour count update. The time interval number is written on the data tape in place of the pressure word once per hour. During the remaining intervals, the pressure data is written in the normal fashion. During the same interval in which the time data is written, the conductivity word is forced to read 1023 to redundantly flag the interval as one containing time data. The TCM output does not influence the calibration of any of the sensors in the current meter during the time when normal data is written.

The TCM circuitry is built on two printed circuit boards rigidly fastened together and mounted directly above the 9 volt battery(Fig. A). The integrated circuits used are the CMOS type because of their low current drain. Due to space limitations the flat pack type of IC package is used. A DPDT relay is used to achieve the needed isolation between the sensitive bridge circuit of the current meter and the TCM.

The majority of the TCM circuitry is powered from the 4 volt Aanderaa Quartz clock battery with the exception of the current meter interface section which is powered from the 9 volt supply.

THEORY OF OPERATION:

In the following description, refer to the schematic diagram which is blocked into functional sections (Figure 4A) and the timing diagram (Figure 5A).

The "count down network" consists of two 14 stage binary ripple counters (IC 5 and 6) and ½ of a dual 4 input nand gate (IC 1). The input of the first counter chip (IC 5 pin 10) is connected to the oscillator terminal (OSC) on the Aanderaa clock (16384 HZ). This chip divides the

Aanderaa Clock Frequency down to one pulse per second. The output of IC 5 (pin 3) is connected to the input of IC 6 pin 10 and is counted down to provide a one pulse per hour output from IC 1 pin 1. After each hour count pulse is generated, IC 6 is reset (pin 11) to zero.

The two 7 stage binary counters, IC 11 and IC 12, are the "hour count storage" registers. The 1 P.P.H. signal is a negative going pulse which is connected to the input (pin 1) of IC 11.

The 1 pulse per hour signal is also connected to the clock input (pin 3) of flip-flop IC 2. When the hour pulse occurs, the Q output (pin 1, IC 2) goes high (write enable), enabling the nand gate IC 16, and allowing encoder pulses to pass to the control counter in the "function control section". The "write enable" signal also connects to pin 12 of IC 10 (the 20 count or relay enable gate). This allows only one 20 count pulse per writing cycle.

The "signal conditioner section" consists of a voltage divider (220k and 560k resistors in series across Aanderaa terminals 21 and N), a coupling capacitor, a filter circuit, and a monostable multivibrator (IC 3). The leading negative going edge of the -6 volt "ones" pulse from the encoder on terminal 21 triggers the one-shot IC 3. The encoder pulses which are nominally 25 milliseconds wide are stretched to 50 ms by the one-shot to ensure that encoder contact bounce or noise spikes will not generate multiple pulses.

The "function control section" consists of a 7 stage binary counter (IC 4), a triple 3 input nand gate (IC 10), 4 sections of a hex inverter, (IC 15), and a monostable multivibrator (IC 17). The counter and associated logic gates in this section are used to generate a reset pulse, relay enable signal and load command for the shift register. The positive going encoder pulses (clock) on the output of IC 3, pin 10 are gated through IC 16, inverted by IC 15 and then fed to the input of binary counter IC 4, pin 1. The appropriate outputs of the counter are connected to three nand gates (IC 10) which are enabled after 20, 30 and 40 counts respectively.

IC 10, pin 10 goes low on the trailing edge of the 20th encoder pulse. This signal is inverted (IC 15, pin 12) and becomes the relay enable signal fed to the clock input (pin 11) of flip-flop IC 2. When this input goes high, the Q_2 output, pin 13 goes high causing the relay to be energized (through voltage interface IC 9). Pin 13 of IC 2 will remain high until IC 2 is reset after the 40th encoder pulse.

IC 10, pin 6 goes low on the trailing edge of the 30th encoder pulse and triggers the one shot (2 sections of IC 15) which generates an 80 ms wide "load delay" pulse (IC 15, pin 6). The trailing edge of this pulse triggers a one-shot (IC 17, pin 6) with an output pulse width of 50 milliseconds. This is the "load pulse" connected to pin 9 of the shift registers, IC 7 and 8. When pin 9 (parallel / serial control input) is high, the time data in the hour count storage registers is loaded into the shift registers. The next ten encoder pulses (fourth or pressure-time word) from IC 16, pin 4 allow the time data to be serially shifted out and enter the "Current meter interface" section.

The third signal generated by the "function control" section is a reset. On the trailing edge of the 40th encoder pulse after the time word has been written, IC 10, pin 9 goes low causing the output of nand gate IC 16, pin 3 to go high. This output is connected to the reset input of the "write control" flip-flop IC 2, pin 4. When this flip-flop resets, $\bar{Q}$, goes high which in turn resets the function control counter IC 4 and the other half of flip-flop IC 2 (pin 10) de-energizing the relay.

The "CM interface" section consisting of IC 9 and 13 and relay 14 converts the 4 volt data signal from the shift register to a 9 volt signal which is connected to the CM bridge circuit thru the relay. It also converts the relay enable 4 volt level to 9 volts which activates the relay (input pin 5).

The relay coil is rated at 6 volts and is connected to the regulated 6 volt supply (relay pins 4 and 6). Its control input (Pin 5) requires a minimum current of one milliampere to operate. CMOS chips must operate at the higher voltages to provide the highest output current (2.5 ma at 10V for IC 9). By stepping the voltage up to 9 volts, IC 9 can supply 1.5 ma to reliably turn on the relay. The relay has double pole double throw contacts with one set of contacts used for the conductivity-flag word and the other set of contacts for the pressure-time word. With the relay in the de-energized state, the conductivity and pressure sensors are connected to the current meter bridge circuit through the normally closed contacts of the relay.

After the 20th encoder pulse at the completion of the temperature word, the relay is energized by the"relay enable" signal. Terminal 3 of the current meter, which is connected from the conductivity word segment on the current meter selector switch to pin 7 on the relay, is switched to terminal 14 or the negative side of the bridge. This causes the encoder to generate all "ones" in place of the conductivity word.

Terminal 4 of the current meter, which is connected from the pressure word segment on the current meter selector switch to pin 3 on the relay, is switched from the wiper arm on the pressure sensor potentiometer to the output of IC 13, pin 1 by the relay contacts. The stored hour count will now be fed to the bridge error amplifier during the time that pressure data would normally be written.

The output from shift registers IC 7 and 8 is inverted three times (IC 13). When pin 12, IC 8 is high, signifying a "one" in the most significant bit of the register, the output at pin 1, IC 13 will be low and a "one" or short pulse will be written by the encoder. A "zero" in the most significant bit of the register will give a low level at IC 8, pin 12 and a high at IC 13, pin 1, causing the encoder to write a zero or long pulse.

The shift pulses are negative going pulses, 50 milliseconds wide. Data is shifted out of the registers (IC 7 and 8) on the positive going or trailing edge of the shift pulse. The digitizing operation or point at which the current meter "decides" whether a "one" or a "zero" should be written is relatively close to the leading edge of the encoder pulse (approximately 30 microseconds from the leading edge). Therefore, a bit is written well before the next data bit will be shifted out and no critical timing edges exist.

After the 40th encoder pulse or after the time word has been written, the reset signal is generated and the relay is de-energized.

The "manual reset", which is in common with the reset terminal on the Aanderaa Quartz clock, is activated as per instructions for the Quartz clock (shorting terminals R and N on the clock). This will reset to zero the ripple counters IC 5 and 6, hour count storage registers IC 11 and 12, and the write control flip-flop IC 2.

The "manual write" control (IC 2, pin 6) is connected to common (terminal N) through the normally closed contacts of the momentary action manual write switch. By depressing this switch momentarily, pin 6 is lifted from common and connected to +4 volts, causing the flip-flop to be set. On the next recording cycle, time data will be written. This feature enables one to check the contents of the hour count storage registers without having to wait up to an hour for the regular time word to be written.

TIME COUNTER MODULE INSTALLATION

*CAUTION: Because MOS devices have extremely high input resistance, they are susceptible to damage when exposed to high static electrical charges. To avoid possible damage to the TCM during handling, installation, and operation, the following procedures should be followed:

1. All TCM leads should remain shorted together until actual connections are made to the current meter terminals.
2. Personnel should use grounded metal wrist straps while installing the TCM to avoid build-up of static charge.
3. Do not begin installation until voltage supplies have been disconnected. Transient voltages may cause permanent damage.
4. After installation: Do not manually trigger the current meter to run while the 4 volt clock supply is disconnected. MOS devices can be damaged if input signals are applied while the device supply voltage is off.

* Adapted from RCA Applications Note ICAN-6000, "Handling Considerations for MOS Integrated Circuits."

<u>TCM INSTALLATION PROCEDURE</u>

1. Disconnect the 4 volt supply to the Aanderaa Quartz clock by removing the battery.
2. Disconnect the 9 volt battery and remove it from the current meter.
3. On the encoder side of the electronics board, remove the lower spoolholder mounting screw and the pinch roller mounting screw. Attach the TCM to the electronic board just below the encoder with with the two previously removed screws passing through the respective TCM mounting brackets (See Figure 2). At the same time, reattach the lower spoolholder and pinch roller. While tightening the pinch roller mounting screw, readjust the pinch roller pressure to 500 gm-cm as per instructions in the "Aanderaa Current Meter Users Guide", page 11.
4. Mount the manual write push button switch under the upper frame block as shown in Figure 3.
5. The following existing connections on the electronic board must be removed before TCM leads are connected. (Insulate each removed terminal lug with tape. Do not unlace wire from harness):
   a. Wire to terminal 3.
   b. Wire to terminal 4.
   c. Wire to terminal C on pressure sensor.

For current meters without a pressure sensor:

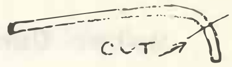
a. Remove jumper wire connecting terminal 4 to 14.

b. TCM lead (orange) which is labeled "To terminal C on pressure potentiometer" should be connected to terminal 14 instead.

The above procedures are the same for current meters with or without a conductivity sensor.

6. Connect all TCM leads to the appropriate electronics board and Quartz clock terminal screws as per color coding key on Assembly Drawing SK-1515-C, (Figure 6A), Page 43.

7. Discard the original battery clamp and use the clamp which is supplied with the TCM when installing the 9-volt battery.

8. Remove the L-shaped pin (Allen wrench) from the encoder and with a pair of heavy-duty side cutters, cut off part of the protruding portion to eliminate the possibility of the pin catching on the TCM. Cut the pin as follows, 

leaving the radius bend as this is necessary to keep the pin tight in the encoder. Replace the pin in the encoder after it has been cut.

TCM Checkout After Installation

1. Reinstall the 4 volt and 9 volt batteries.
2. Measure the current drain from the 4 volt and 9 volt supplies with a milliammeter (Triplett model 630 or equivalent). Disconnect the violet lead to terminal P on the Quartz clock and place the milliammeter in series with this lead to measure the current drain from the 4 volt supply. Current values should be as follows: standby current; 2-8 μa, operation current; 2-8 μa, and operation with relay; 2-8 μa with a pulse to 5-15 μa between word 3 and 4 (when checking operation current, actuate manual write switch before triggering current meter). Reconnect the violet lead to terminal P. Disconnect the blue lead to terminal 26 and place the milliammeter in series with this lead to measure the current drain from the 9 volt supply. Standby and operation current should be less than 2 μa. Operation with relay current should be 25 to 30 ma. Reconnect the blue lead to terminal 26 after completing the measurement.
3. Reset the Quartz clock (this also resets the TCM) and log the time of reset. Time of reset represents zero TCM time. One hour later the hour count should be one, etc.
4. Read out the current meter data for several sampling intervals and check conductivity and pressure words. They should read normal conductivity and pressure data (if these sensors are installed on the meter) on all intervals other than the even hour following reset intervals. (The current meter may be triggered to run externally from the Quartz clock with no effect on TCM operation).
5. Check the data sample one hour after reset. The time word should read one in place of the pressure word and the flag should read 1023 or all ones in place of the conductivity word.

6. To check out the manual write function, depress the manual write push button switch momentarily and externally trigger the current meter or allow the Quartz clock to trigger the meter on other than an even hour after reset. Time data should be read out as in Step 5.

7. Allow the current meter to run for at least 10 hours or overnight and check the time word again. It should correlate with the number of elapsed hours since reset. (Disconnecting the 9 volt battery does not affect the TCM hour count).

TIME COUNTER MODULE POST INSTALLATION CHECKOUT LOG

Current Meter Serial No. ________ Pressure Sensor: Yes ☐ No ☐

TCM Serial No. ______ Conductivity Sensor: Yes ☐ No ☐

1. 4 volt battery reinstalled: Yes ☐

   9 volt battery reinstalled: Yes ☐

2. Current Drain Test: 9 Volt (@ Terminal 26) 4 Volt (@ Terminal P)

   Standby Current ____________ μa. ____________ μa.

   Operation Current ____________ μa. ____________ μa.

   Operation w/Relay ____________ ma. ____________ μa.

3. Reset TCM by momentarily shorting terminals R and N on Quartz clock.

   Reset time: D ____ H ____ M ____ S ____

4. On intervals before one hour following reset:

   (input/output)

   a. Conductivity ________/________
   b. Pressure ________/________

5. On interval one hour after reset:

   a. Flag (word 3) ________
   b. Time (word 4) ________

6. Initiate manual write and trigger current meter:

   a. Time of reading: D ____ H ____ M ____ S ____
   b. Flag ________
   c. Time ________

7. After at least 10 hours of operation (monitor on the hour):

   a. Time of reading: D ____ H ____ M ____ S ____
   b. Flag ________
   c. Time ________

REMARKS:

Installed by ____________________ Date ____________

Tested by ____________________ Date ____________

TCM OPERATION

(Before Deployment of a Current Meter)

1. Check the 4 volt & 9 volt batteries and replace if necessary (as per established checkout procedures).
2. Reset the Aanderaa clock to correct time (WWV) and record the time of reset. (This entry must be added to CM Deployment log.)
3. Before threading the magnetic tape, check the TCM hour count storage register to be certain it has been reset to zero.
   a. Connect a strip chart recorder to the current meter electric terminal.
   b. Depress the manual write switch momentarily (located directly under the top end plate, encoder side).
   c. Trigger the CM to begin a measurement cycle.
   d. The strip chart record should show all "ones" in word 3 and all "zeros" in word 4. If an hour or more has elapsed since reset, the fourth word should correspond to the elapsed whole number of hours.
4. Thread recording tape in the regular manner.
5. Do not initiate a manual write after tape has been threaded as this will cause an extra time word to be recorded and cause confusion in the processing of the data.

DEPLOYMENT AND RECOVERY LOG FOR CURRENT METERS WITH TCM

(Note: Use this log in addition to regular Deployment and Recovery Logs)

Current Meter Serial No.______________

TCM Serial No._________________

DEPLOYMENT PHASE:

Quartz clock interval plug ________(minutes)

Clock reset time: D_____H_____M_____S_____

Before threading tape:

Initiate a manual write and monitor current meter time word.

Time of reading: D_____H_____M_____S_____

Time word________________(decimal value)

First record on tape: D_____H_____M_____S_____

RECOVERY PHASE:

Last record on tape: D_____H_____M_____S_____

After removing tape:

Initiate a manual write and monitor current meter time word.

Time of reading: D_____H_____M_____S_____

Time word _______________(decimal value)

Elapsed time since reset: H_____M_____

REMARKS:

Signed__________________ Date__________

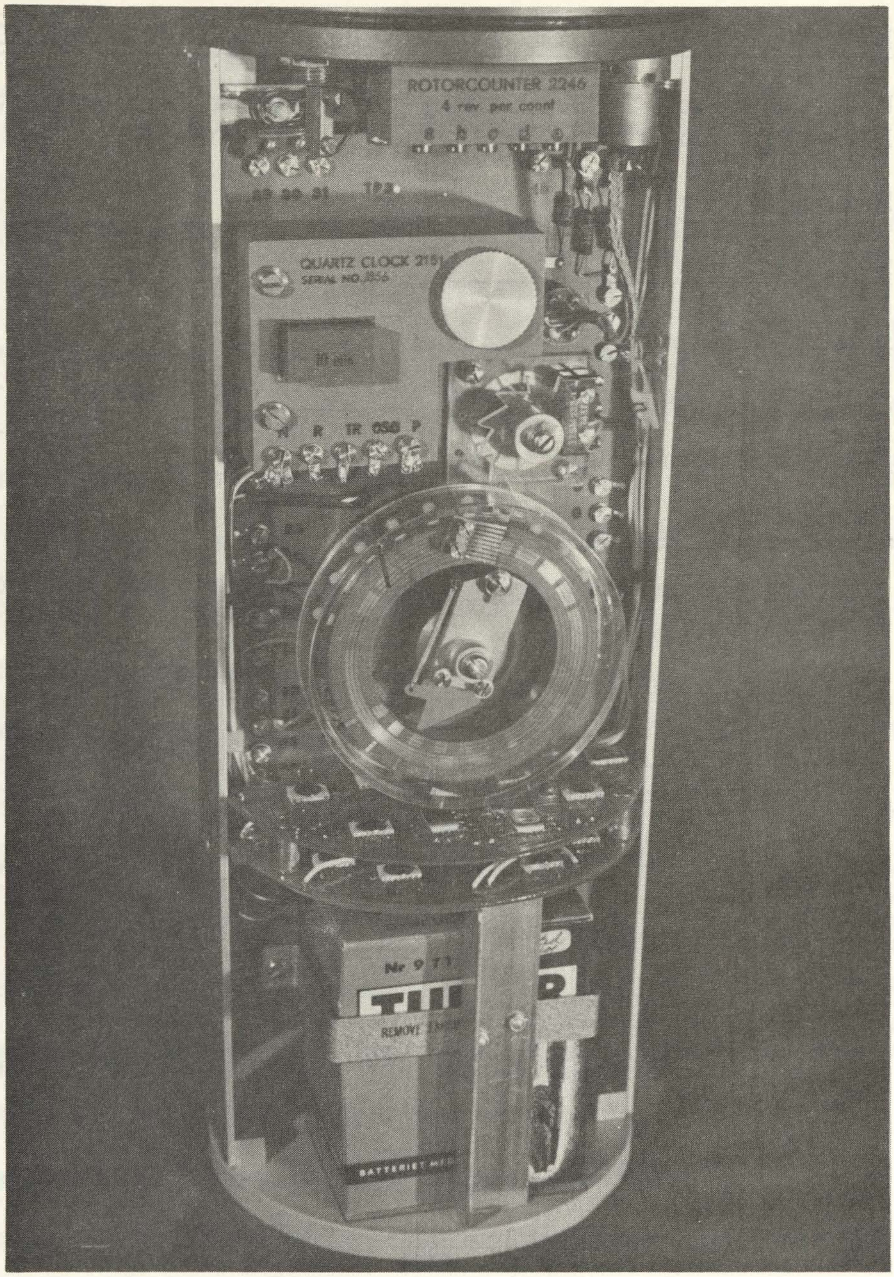


Figure 1A. Aanderaa Current Meter with Time Counter Module

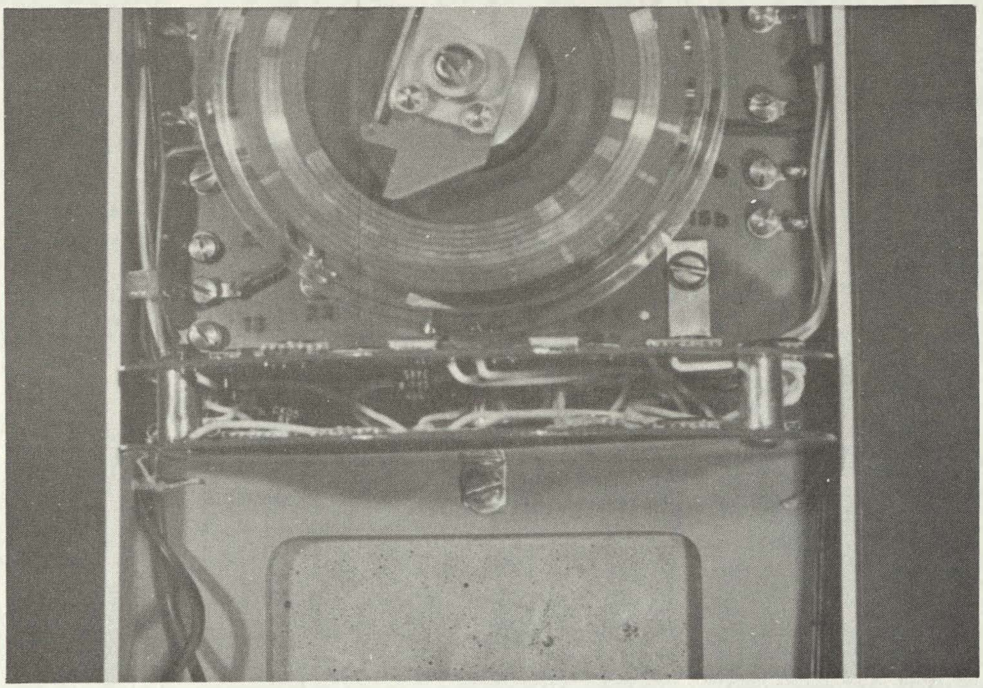


Figure 2A. Time Counter Module Mounting Detail

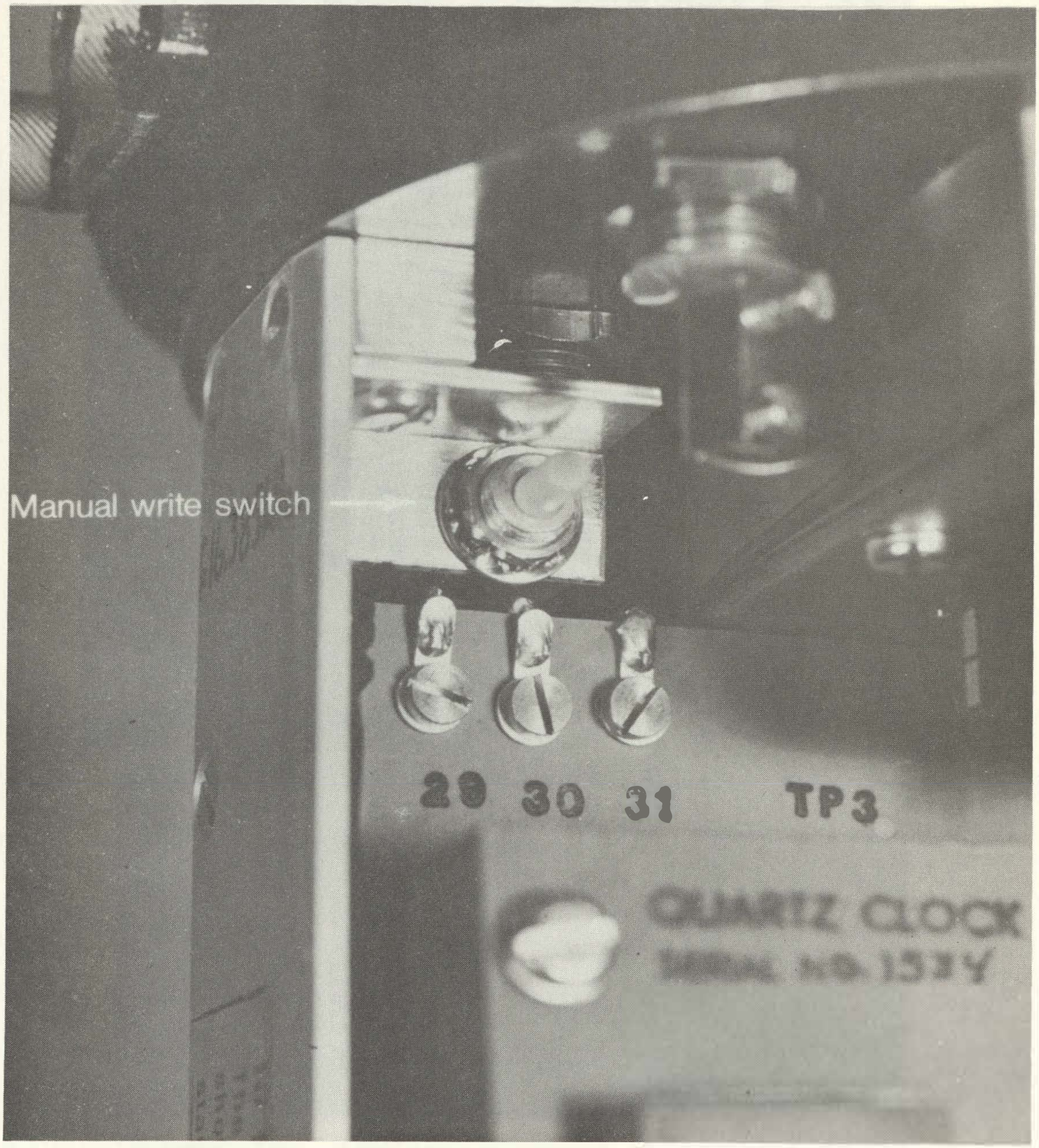


Figure 3A. Manual Write Switch Mounting Detail

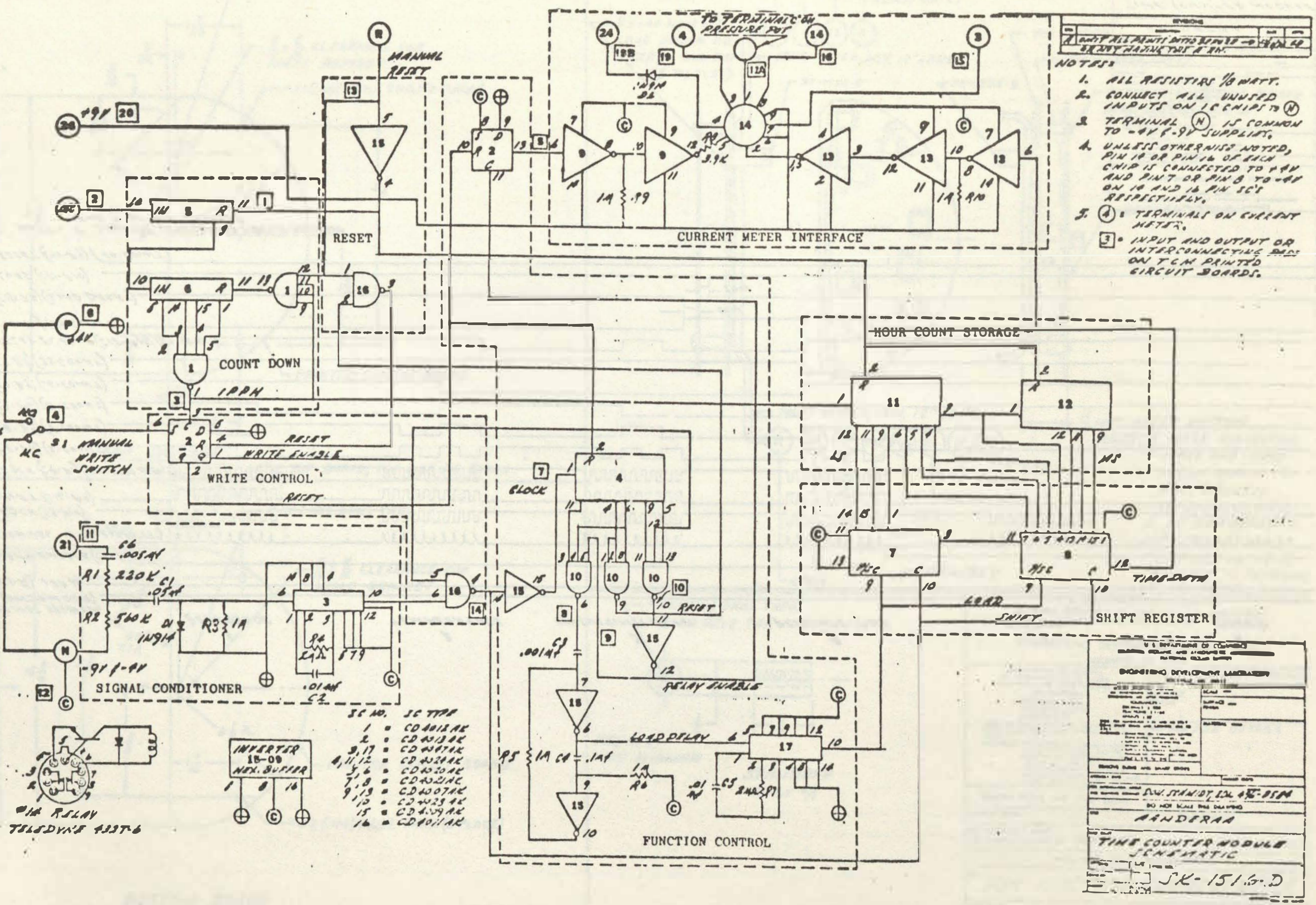

CURRENT METER INTERFACE
TO TERMINALS ON PRESSURE POT
MANUAL RESET
RESET
COUNT DOWN
WRITE CONTROL
S1 MANUAL WRITE SWITCH
RESET
WRITE ENABLE
SIGNAL CONDITIONER
CLOCK
RELAY ENABLE
LOAD DELAY
FUNCTION CONTROL
HOUR COUNT STORAGE
SHIFT REGISTER
LOAD
SHIFT
TIME DATA
INVERTER
15-09
HEX. BUFFER
IC NO.
IC TYPE
#1A RELAY
TELEDYNE 433T-6
NOTES:
1. ALL RESISTORS 1/8 WATT.
2. CONNECT ALL UNUSED INPUTS ON IC CHIPS TO (N)
3. TERMINAL (N) IS COMMON TO -4V & -9V SUPPLIES.
4. UNLESS OTHERWISE NOTED, PIN 14 OR PIN 16 OF EACH CHIP IS CONNECTED TO +9V AND PIN 7 OR PIN 8 TO -4V ON 14 AND 16 PIN IC'S RESPECTIVELY.
5. (4) = TERMINALS ON CURRENT METER.
6. [3] = INPUT AND OUTPUT OR INTERCONNECTING PADS ON TCM PRINTED CIRCUIT BOARDS.
AANDERAA
TIME COUNTER MODULE SCHEMATIC
SK-1516-D

Figure 4A

41

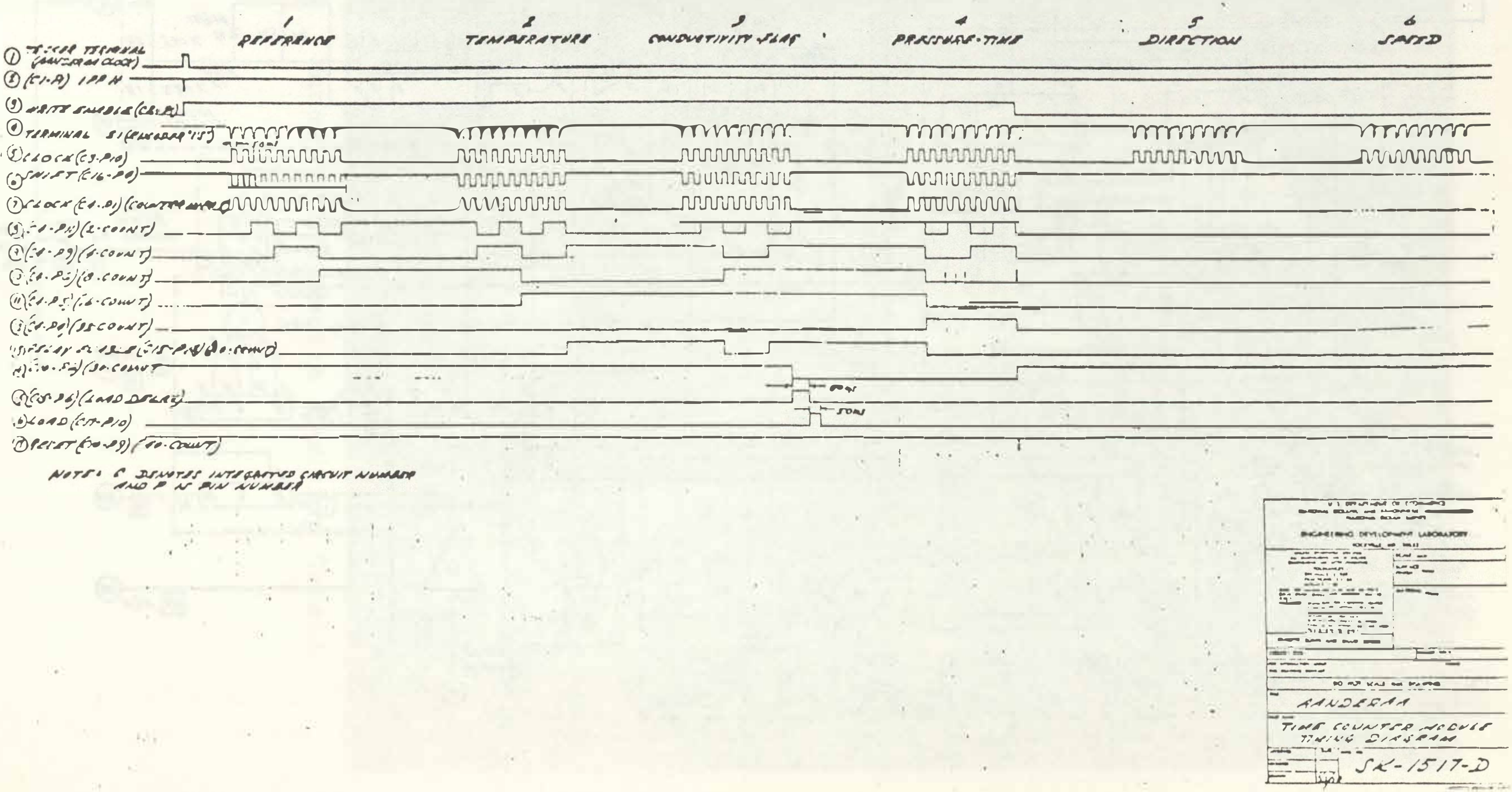
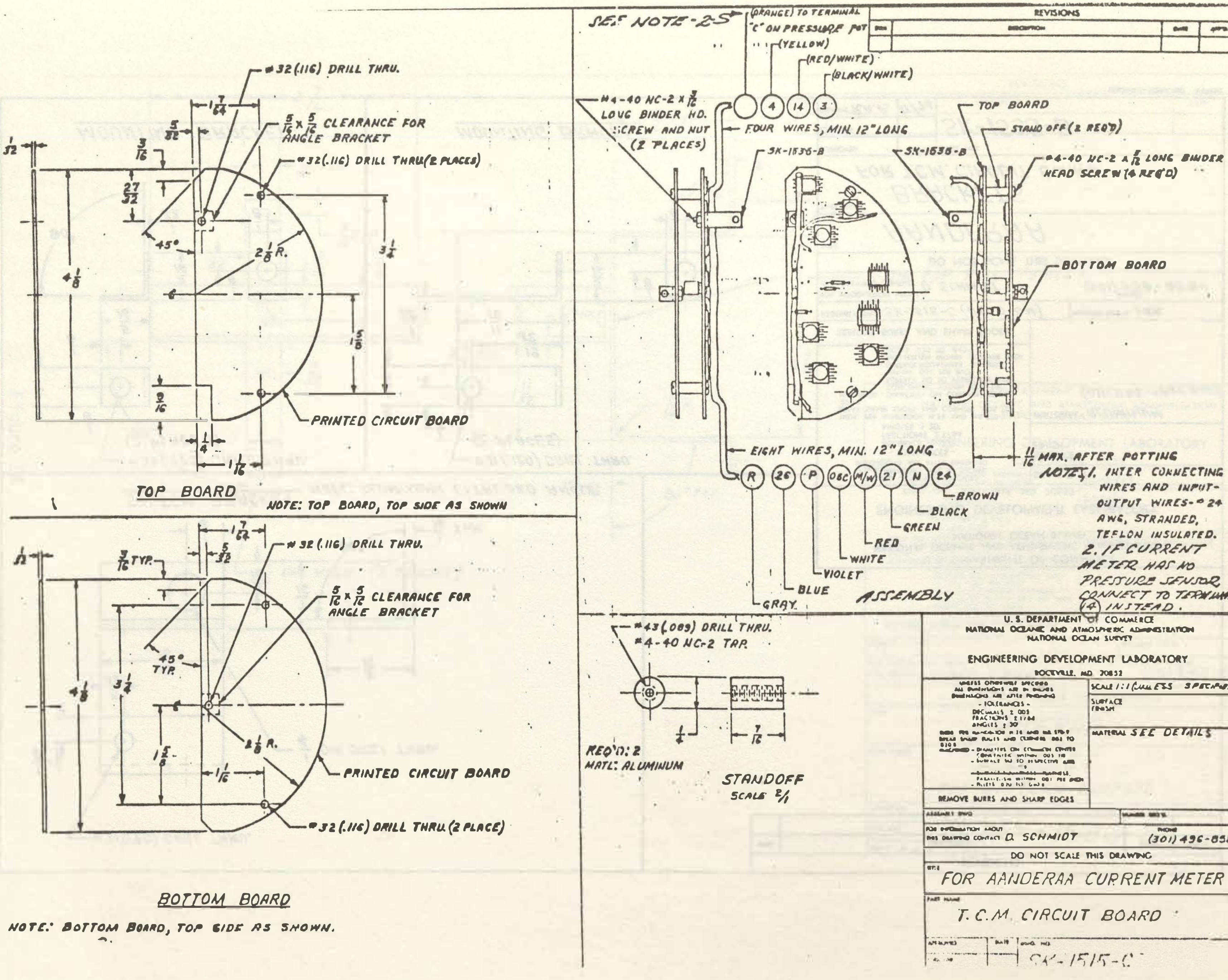

1
REFERENCE
2
TEMPERATURE
4
PRESSURE-TIME
5
DIRECTION
6
SPEED
ENGINEERING DEVELOPMENT LABORATORY
AANDERAA
TIME COUNTER MODULE
TIMING DIAGRAM
SK-1517-D

Figure 5A



TOP BOARD
NOTE: TOP BOARD, TOP SIDE AS SHOWN
#32 (.116) DRILL THRU.
5/16 x 5/16 CLEARANCE FOR ANGLE BRACKET
#32 (.116) DRILL THRU (2 PLACES)
PRINTED CIRCUIT BOARD
BOTTOM BOARD
NOTE: BOTTOM BOARD, TOP SIDE AS SHOWN.
#32 (.116) DRILL THRU (2 PLACE)
SEE NOTE-2
(ORANGE) TO TERMINAL "C" ON PRESSURE POT
(YELLOW)
(RED/WHITE)
(BLACK/WHITE)
#4-40 NC-2 x 3/16 LONG BINDER HD. SCREW AND NUT (2 PLACES)
FOUR WIRES, MIN 12" LONG
SK-1536-B
TOP BOARD
STAND OFF (2 REQ'D)
#4-40 NC-2 x 3/16 LONG BINDER HEAD SCREW (4 REQ'D)
BOTTOM BOARD
EIGHT WIRES, MIN. 12" LONG
11/16 MAX. AFTER POTTING
BROWN
BLACK
GREEN
RED
WHITE
VIOLET
BLUE
GRAY
ASSEMBLY
NOTES: 1. INTER CONNECTING WIRES AND INPUT-OUTPUT WIRES-#24 AWG, STRANDED, TEFLON INSULATED.
2. IF CURRENT METER HAS NO PRESSURE SENSOR CONNECT TO TERMINAL (14) INSTEAD.
#43 (.089) DRILL THRU.
#4-40 NC-2 TAP.
REQ'D: 2
MATL: ALUMINUM
STANDOFF
SCALE 2/1
REVISIONS
U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY
ENGINEERING DEVELOPMENT LABORATORY
ROCKVILLE, MD 20852
SCALE 1:1 (UNLESS SPECIFIED)
MATERIAL SEE DETAILS
REMOVE BURRS AND SHARP EDGES
D. SCHMIDT
(301) 496-858
DO NOT SCALE THIS DRAWING
FOR AANDERAA CURRENT METER
T.C.M. CIRCUIT BOARD
SK-1515-C

Figure 6A

43

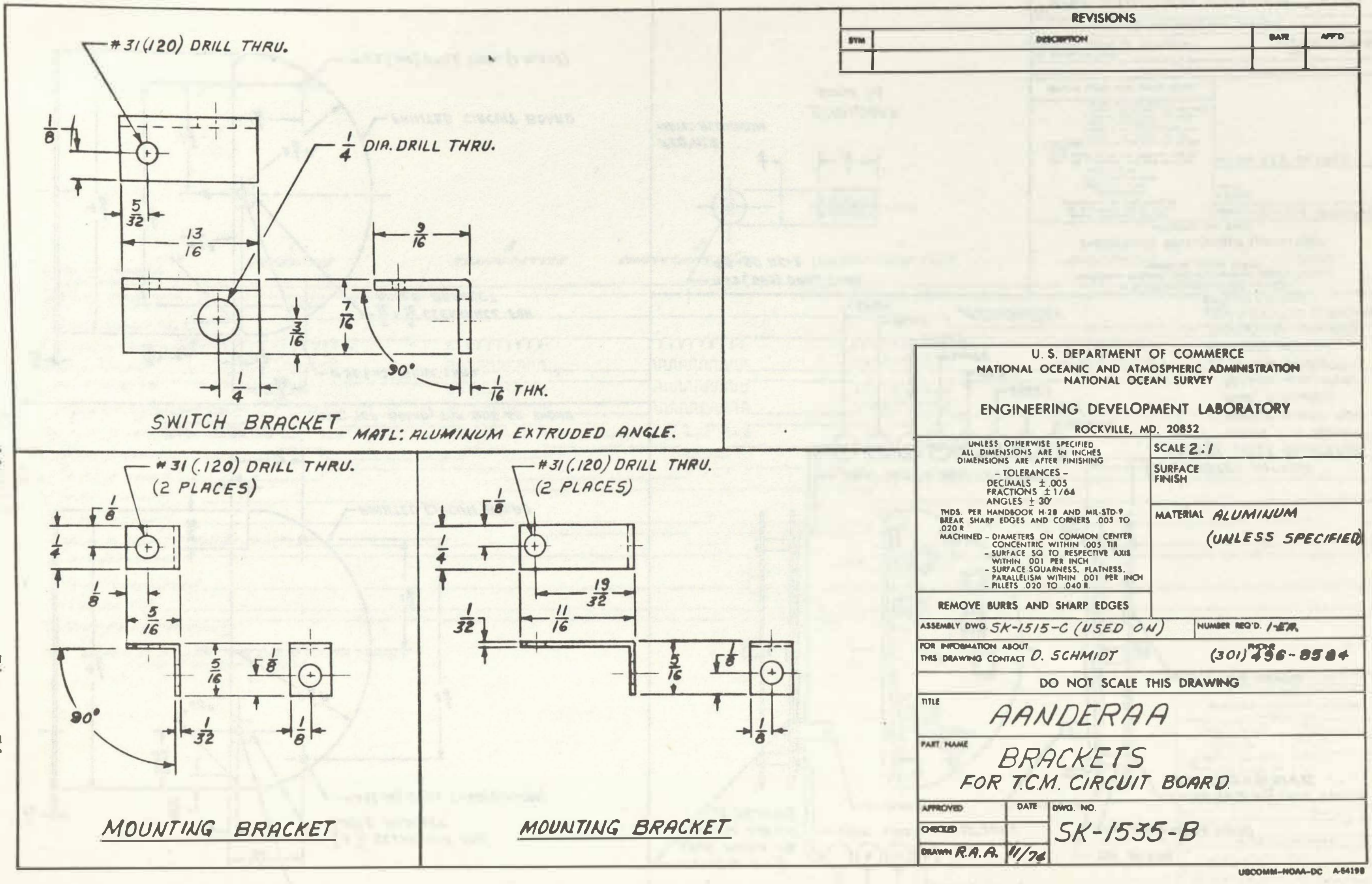

REVISIONS
SYM DESCRIPTION DATE APP'D
#31 (.120) DRILL THRU.
1/4 DIA. DRILL THRU.
SWITCH BRACKET
MATL: ALUMINUM EXTRUDED ANGLE.
1/16 THK.
90°
#31 (.120) DRILL THRU. (2 PLACES)
MOUNTING BRACKET
#31 (.120) DRILL THRU. (2 PLACES)
MOUNTING BRACKET
U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY
ENGINEERING DEVELOPMENT LABORATORY
ROCKVILLE, MD. 20852
UNLESS OTHERWISE SPECIFIED ALL DIMENSIONS ARE IN INCHES DIMENSIONS ARE AFTER FINISHING
- TOLERANCES -
DECIMALS ±.005
FRACTIONS ±1/64
ANGLES ±30'
THDS. PER HANDBOOK H-28 AND MIL-STD-9
BREAK SHARP EDGES AND CORNERS .005 TO .020 R
MACHINED - DIAMETERS ON COMMON CENTER CONCENTRIC WITHIN .005 TIR
- SURFACE SQ TO RESPECTIVE AXIS WITHIN .001 PER INCH
- SURFACE SQUARNESS, FLATNESS, PARALLELISM WITHIN .001 PER INCH
- FILLETS .020 TO .040 R
SCALE 2:1
SURFACE FINISH
MATERIAL ALUMINUM (UNLESS SPECIFIED)
REMOVE BURRS AND SHARP EDGES
ASSEMBLY DWG SK-1515-C (USED ON)
NUMBER REQ'D. 1-EA.
FOR INFORMATION ABOUT THIS DRAWING CONTACT D. SCHMIDT
PHONE (301) 496-8584
DO NOT SCALE THIS DRAWING
TITLE AANDERAA
PART NAME BRACKETS FOR T.C.M. CIRCUIT BOARD
APPROVED
CHECKED
DRAWN R.A.A.
DATE 11/74
DWG. NO. SK-1535-B
USCOMM-NOAA-DC A-84198

Figure 7A

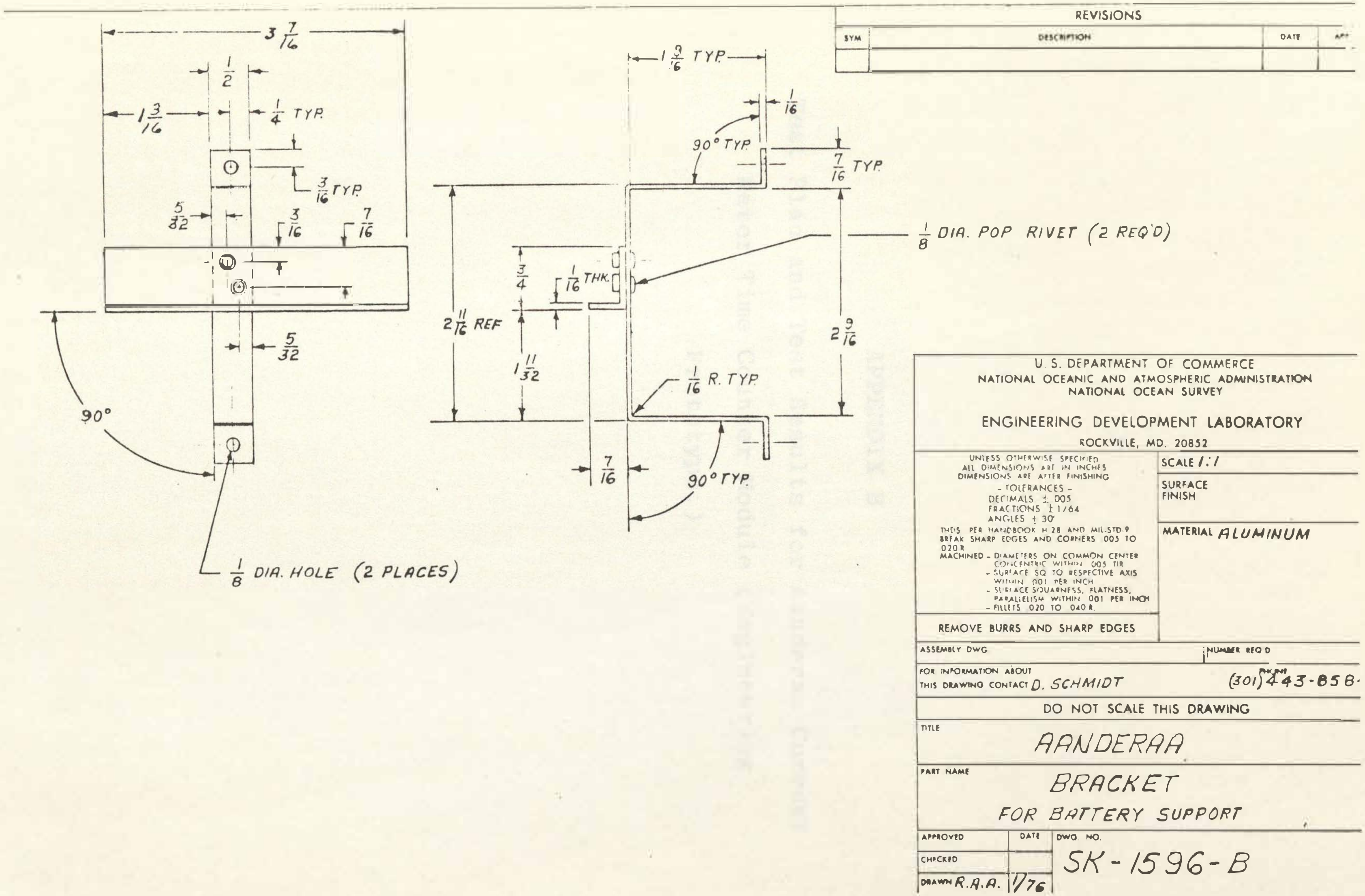

REVISIONS
SYM
DESCRIPTION
DATE
3 7/16
1/2
1 3/16
1/4 TYP.
3/16 TYP.
5/32
3/16
7/16
5/32
90°
1/8 DIA. HOLE (2 PLACES)
1 9/16 TYP.
1/16
90° TYP.
7/16 TYP.
1/8 DIA. POP RIVET (2 REQ'D)
3/4
1/16 THK.
2 11/16 REF
1 11/32
2 9/16
1/16 R. TYP.
7/16
90° TYP.
U. S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SURVEY
ENGINEERING DEVELOPMENT LABORATORY
ROCKVILLE, MD. 20852
UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
DIMENSIONS ARE AFTER FINISHING
- TOLERANCES -
DECIMALS ± .005
FRACTIONS ± 1/64
ANGLES ± 30'
SCALE 1:1
SURFACE FINISH
MATERIAL ALUMINUM
REMOVE BURRS AND SHARP EDGES
ASSEMBLY DWG
NUMBER REQ'D
FOR INFORMATION ABOUT THIS DRAWING CONTACT D. SCHMIDT
(301) 443-858-
DO NOT SCALE THIS DRAWING
TITLE
AANDERAA
PART NAME
BRACKET
FOR BATTERY SUPPORT
APPROVED
DATE
DWG. NO.
CHECKED
SK-1596-B
DRAWN R.A.A. 1/76

Figure 8A

APPENDIX B

Test Plan and Test Results for Aanderaa Current Meter Time Counter Module (Engineering Prototype.)

APPENDIX B.1

Test Plan for Aanderaa Time Counter Module
(Engineering Prototype)

I. Visual Inspection

Visually inspect each TCM for any observable construction flaws such as cold solder joints, shorted connections, etc.

II. Installation

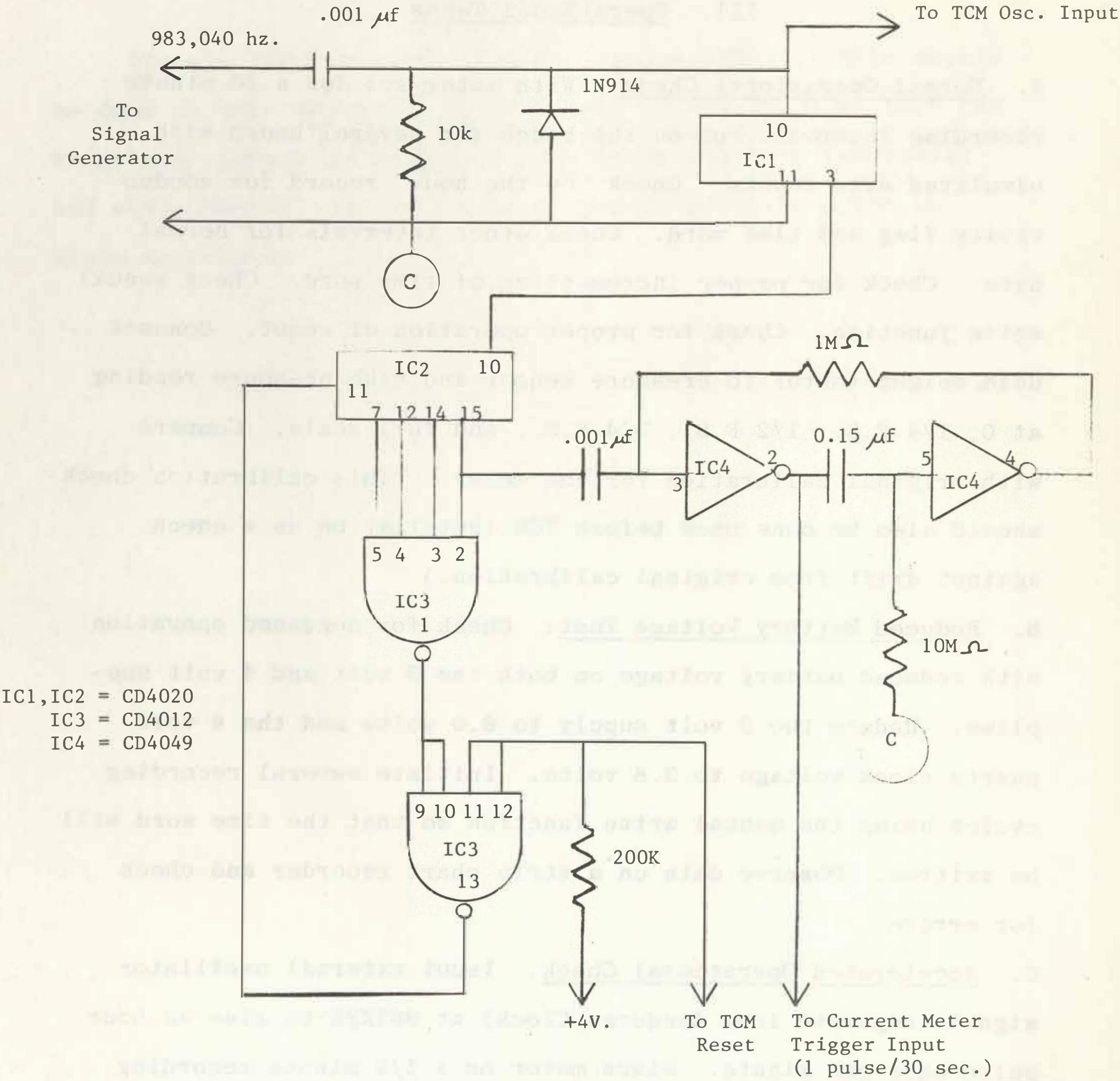
Install TCM's on three current meters (MESA). This should be done in EDL, Rockville, rather than in the field so that the three engineering prototypes can be given complete functional and environmental tests to assure proper operation prior to field deployment.

III. Operational Tests

A. Normal Operational Check: With meter set for a 10 minute recording interval, run on the bench for several hours with simulated data inputs. Check "on the hour" record for conductivity flag and time word. Check other intervals for normal data. Check for proper incrementing of time word. Check manual write function. Check for proper operation of reset. Connect dead weight tester to pressure sensor and take pressure reading at 0, 1/4 F.S., 1/2 F.S., 3/4 F.S., and full scale. Compare with original calibration for the meter. (This calibration check should also be done once before TCM installation as a check against drift from original calibration.)

B. Reduced Battery Voltage Test: Check for degraded operation with reduced battery voltage on both the 9 volt and 4 volt supplies. Reduce the 9 volt supply to 6.0 volts and the 4 volt quartz clock voltage to 3.8 volts. Initiate several recording cycles using the manual write function so that the time word will be written. Observe data on a strip chart recorder and check for errors.

C. Accelerated Operational Check: Input external oscillator signal (separate from Aanderaa Clock) at 983KHZ to give an hour pulse once per minute. Place meter on a 1/2 minute recording interval and record data on mag. tape. (TCM will cycle through 1024 counts in 16 hours.) This test will be done at room temperature overnight. Obtain a data dump of the tape and if the test is satisfactory, continue with the environmental tests.



Note 1: TCM Reset and Oscillator Input are connected to Test circuit. All other TCM connections are made to current meter as for normal installation.

Figure 1 B.1, ACCELERATED TCM TEST CIRCUIT

IV. Environmental Test (Temperature)

With meter in normal operation using simulated data inputs on a 10 minute interval and recording data on tape, place all three meters in environmental chamber. Cycle temperature in the following manner: 2 hours at -5°C followed by 2 hours at +50°C. Change from low to high temperature should be made as rapidly as chamber will allow. Repeat twice followed by 16 hours at room temperature. Repeat this 24 hour cycle twice. After test is completed, obtain data dump of tape and check for consistent writing of time data.

V. Field Tests

Return current meters to MESA operations along with TCM documentation. Check field data after processing by C33 for proper operation of TCM. At end of field season or after approximately three months use, inspect current meters and confer with field technicians to evaluate any field use problems.

TIME SCHEDULE

Delivery from HDL	10 weeks	August 23
Visual Inspection & Installation	1 week	August 30
Functional Tests	1 week	Sept. 6
Environmental Tests	1 week	Sept. 13
Ready for Field Testing	1 week	Sept. 18

APPENDIX B.2

Time Counter Module Test Chronology

The following is a chronology of the tests conducted with the three engineering prototype TCM's, showing the particular test performed, current meter used and brief description of results.

TIME COUNTER MODULE FOR AANDERAA

CURRENT METER - CHRONOLOGY OF TESTS CONDUCTED

TCM Serial No. 001

DATE	TEST	WITH CM SN	RESULTS/REMARKS
Rcvd. 8/29/74	Visual Inspection		One wire misrouted in wiring harness. One wire broken off at joint with P.C. pad. Different wire sizes used in wiring harness.
"	"		Wire strands cut when stripped of insulation. Several cold solder joints were resoldered.
8/29/74 to 8/30/74	Functional Check	719	Tested OK - TCM was run for 21 hours. TCM removed after test. Meter shipped to Norfolk for open house.
8/30/74 to 9/9/74	Functional Check	1258	Tested OK - TCM ran for 232 hours.
9/16/74 to 9/17/74	Accelerated Test X 60	1257	Test ran 18 hours at X 60 rate or equivalent to 1080 hours. Computer Printout - of 1080 hour words printed, one was in error.
10/8/74 to 10/10/74	Temp. Cycling	1257	
10/10/74	Pressure Test	1257	Comparison with data taken prior to TCM installation - within repeatability of pressure sensor. No measurable effect due to TCM
10/11/74	Ship to MESA, Floyd Bennett Field for Field Test.		
11/19/74 to 11/29/74	MESA Field Deployment	1257	From computer printout, total time was 274 hrs. Time written correctly 273 times, one error. 9 volt battery voltage lower than expected, indicating excessive current drain.
12/6/74		1257	Received back in EDL from MESA, Floyd Bennett Field.
12/9/74 to 12/12/74	Current Drain Test	1257	Modification to circuit; diode between relay and terminal (24) and .005 μF capacitor at terminal (21) to reduce current drain.

TIME COUNTER MODULE FOR AANDERAA

CURRENT METER - CHRONOLOGY OF TESTS CONDUCTED

TCM Serial No. 001

DATE	TEST	WITH CM SN	RESULTS/REMARKS
12/12/74 to 12/13/74	Functional Test	1257	Tested OK. End test after 19 hours.
12/13/74 to 1/14/75	Battery Drain Test	1257	10 minute interval. Test run for total of 770 hrs. Correct time words written are 667 and 3 errors. Tudor battery voltage under load at end of test = 8.0 volts.

TIME COUNTER MODULE FOR AANDERAA

CURRENT METER - CHRONOLOGY OF TESTS CONDUCTED

TCM Serial No. 002

DATE	TEST	WITH CM SN	RESULTS/REMARKS
Rcvd. 9/17/74	Visual Inspection	-	Looked OK.
9/17/74	Functional Check	1258	TCM did not function. One IC chip was mounted 180° improperly. Returned to HDL and repaired.
9/17/74 to 9/18/74	Functional Check	1258	Tested OK - run for 18 hours.
9/18/74 to 9/19/74	Accelerated Test X 60	1258	TCM cycled equivalent to 1063 hrs. From computer printout 1063 time words correct, no error.
10/7/74 to 10/9/74	Temp. Cycling	719	Temp. cycled -5° to 50°C Test ran for 47 hours. From computer printout, time written correctly 47 times. No error.
10/9/74	Pressure Test	719	Calibration check was not performed before TCM installation. Results indicate a slight downward shift from original Aanderaa calibration which may be due to aging.
10/9/74	Ship to MESA, Floyd Bennett Field because of urgent need for a current meter, and field test of TCM.		
10/15/74	Temp, Cond. at MESA cal. lab.	719	Salt water leaked into current meter, damaging TCM and rendering it inoperative.
11/1/74		Not installed in a meter	Received back in EDL from MESA, Floyd Bennett Field. Damage to top board, several circuit lands eaten through from corrosion. At least one chip destroyed.
12/12/74	Repaired and Installed	1347	Repaired TCM, replaced IC 15 and installed on SN 1347.
12/12/74	Current Drain Tests	1347	Modifications to circuit; diode between relay and terminal (24), and .005 µF capacitor at terminal (21) to reduce current drain.

TIME COUNTER MODULE FOR AANDERAA

CURRENT METER - CHRONOLOGY OF TESTS CONDUCTED

TCM Serial No. .002

DATE	TEST	WITH CM SN	RESULTS/REMARKS
12/12/74 to 12/13/74	Functional Check	1347	Tested OK. End test after 19 hours.
12/13/74 to 12/18/74	Battery Drain Test	1347	On 1 minute interval. Meter ran for total of 6720 records, equivalent to 46 days. Total correct time words written is 112 for 112 hours.

TIME COUNTER MODULE FOR AANDERAA

CURRENT METER - CHRONOLOGY OF TESTS CONDUCTED

TCM Serial No. 003

DATE	TEST	WITH CM SN	RESULTS/REMARKS
9/18/74	Visual Inspection		OK
9/18/74	Functional Check	1256	Tested OK.
9/19/74 to 9/20/74	Accelerated Test X 60	1256	Test was only partially successful because current meter malfunctioned during test. Test inconclusive. Meter sent to Aanderaa for repair.
9/24/74 to 9/25/74	Accelerated Test X 60	1258	Test no good because signal generator inputting accelerated time base drifted off frequency.
9/27/74 to 9/30/74	Accelerated Test X 30	1258	Test no good - same problem as previous test. Also problem of low battery voltage.
9/30/74 to 10/2/74	Accelerated Test X 30	1258	Test ran for equivalent of 1440 hrs. Computer printout was clean.
10/7/74 to 10/9/74	Temp. Cycling	1258	Temp. cycled -5°C to 50°C. Test ran for 47 hrs. From computer printout, one time work not written. After test was completed, Quartz clock was found to be malfunctioning.
10/9/74	Pressure Test	1258	Comparison with data taken prior to TCM installation - within repeatability of pressure sensor. No measurable effect due to TCM.
10/16/74 to 10/21/74	Functional Check	1258	Installed new Quartz clock received from Aanderaa. Tested OK - end test after 112 hrs.
10/22/74	Ship to MESA, Floyd Bennett Field for field test.		
11/19/74 to 11/29/74	MESA Field Deployment	1258	From computer printout, total time was 274 hrs. Time written correctly 274 times, no errors. 9 volt battery voltage lower than expected, indicating excessive current drain.

TIME COUNTER MODULE FOR AANDERAA

CURRENT METER - CHRONOLOGY OF TESTS CONDUCTED

TCM Serial No. 003

DATE	TEST	WITH CM SN	RESULTS/REMARKS
12/6/74		1258	Received back in EDL from MESA, Floyd Bennett Field.
12/9/74		1256	Removed TCM from SN 1258 (meter inoperative when received from F.B.) and installed on SN 1256.
12/9/74 to 12/12/74	Current Drain Test	1256	Modifications to circuit; diode between relay and teminal (24) and .005μF capacitor at terminal (21) to reduce current drain.
12/12/74 to 12/13/74	Functional Check	1256	Tested OK. End test after 19 hours.
12/13/74 to 1/14/75	Battery Drain Test	1256	10 minute interval. Test run for total of 770 hours. Correct time words written are 669 and 1 error. Burgess battery voltage under load at end of test = 7.0 volts.

APPENDIX B.3

Plotted Data of Pressure Sensor Calibration Check, With and Without TCM

The following two plots show results of the test for possible affect by the TCM on pressure sensor calibration.

The manufacturers accuracy specification for the pressure sensor is ± 1% of full scale (in this case full scale was 200 psi or 140 meters depth). Resolution is ± 1 count or ± 0.14 meters depth.

A test run consists of test points taken every 20 psi from zero to full scale and back to zero. The data for each meter with and without TCM is plotted on the same graph.

The calibration equation supplied by the manufacturer, expressed in terms of depth in meters, was used to convert the pressure sensor reading to engineering units. The difference value shown on the ordinate axis represents pressure sensor output reading minus dead weight tester input pressure. The data shows that in general the pressure difference between before and after TCM installation are within the sensor resolution and therefore no measurable affect on pressure sensor calibration due to the TCM was observed. (The data point at zero pressure for current meter Serial No. 1257 is explained in the report).

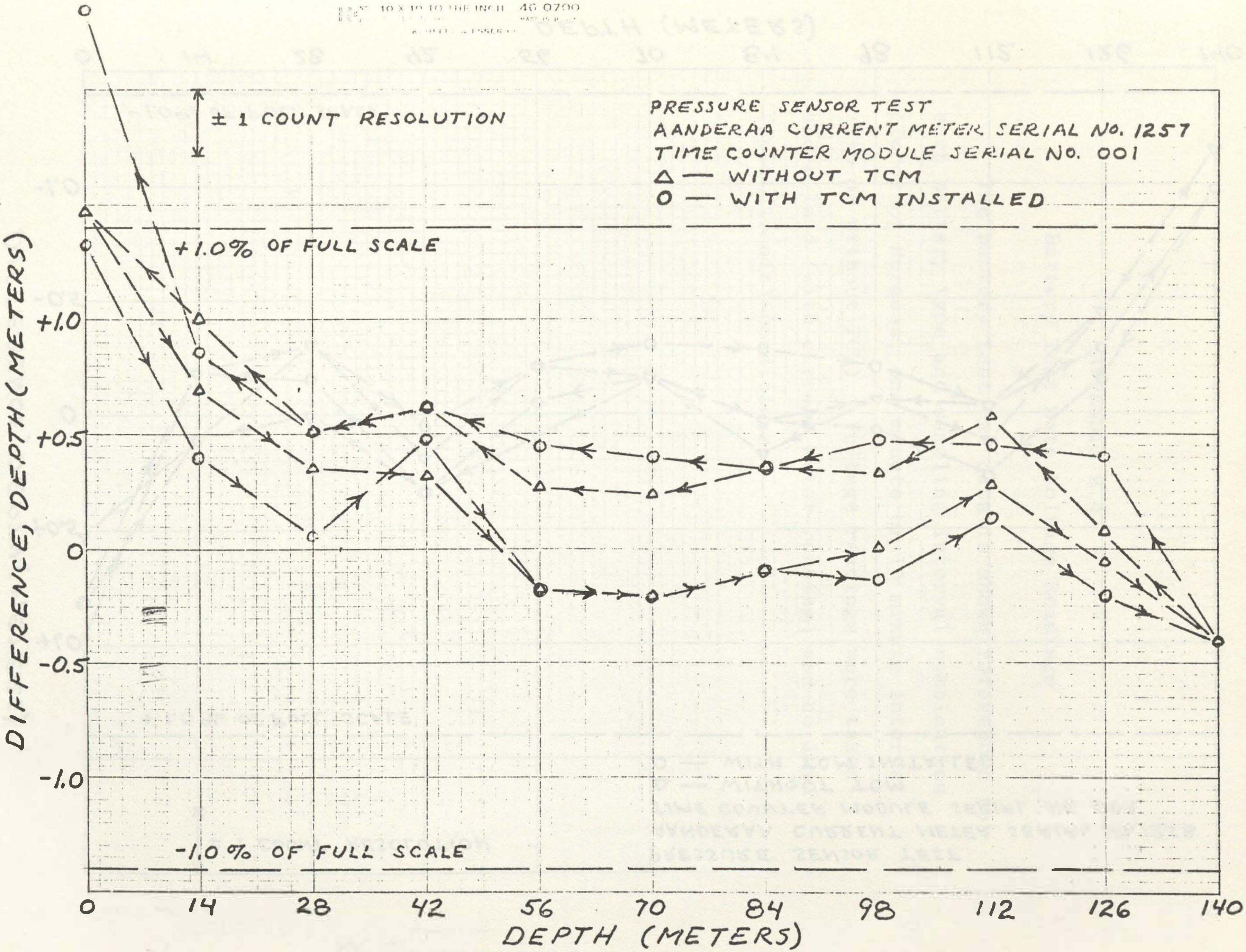

PRESSURE SENSOR TEST
AANDERAA CURRENT METER SERIAL NO. 1257
TIME COUNTER MODULE SERIAL NO. 001
Δ — WITHOUT TCM
O — WITH TCM INSTALLED
± 1 COUNT RESOLUTION
+1.0% OF FULL SCALE
-1.0% OF FULL SCALE
DIFFERENCE, DEPTH (METERS)
+1.0
+0.5
0
-0.5
-1.0
0
14
28
42
56
70
84
98
112
126
140
DEPTH (METERS)

Figure 1 B.3

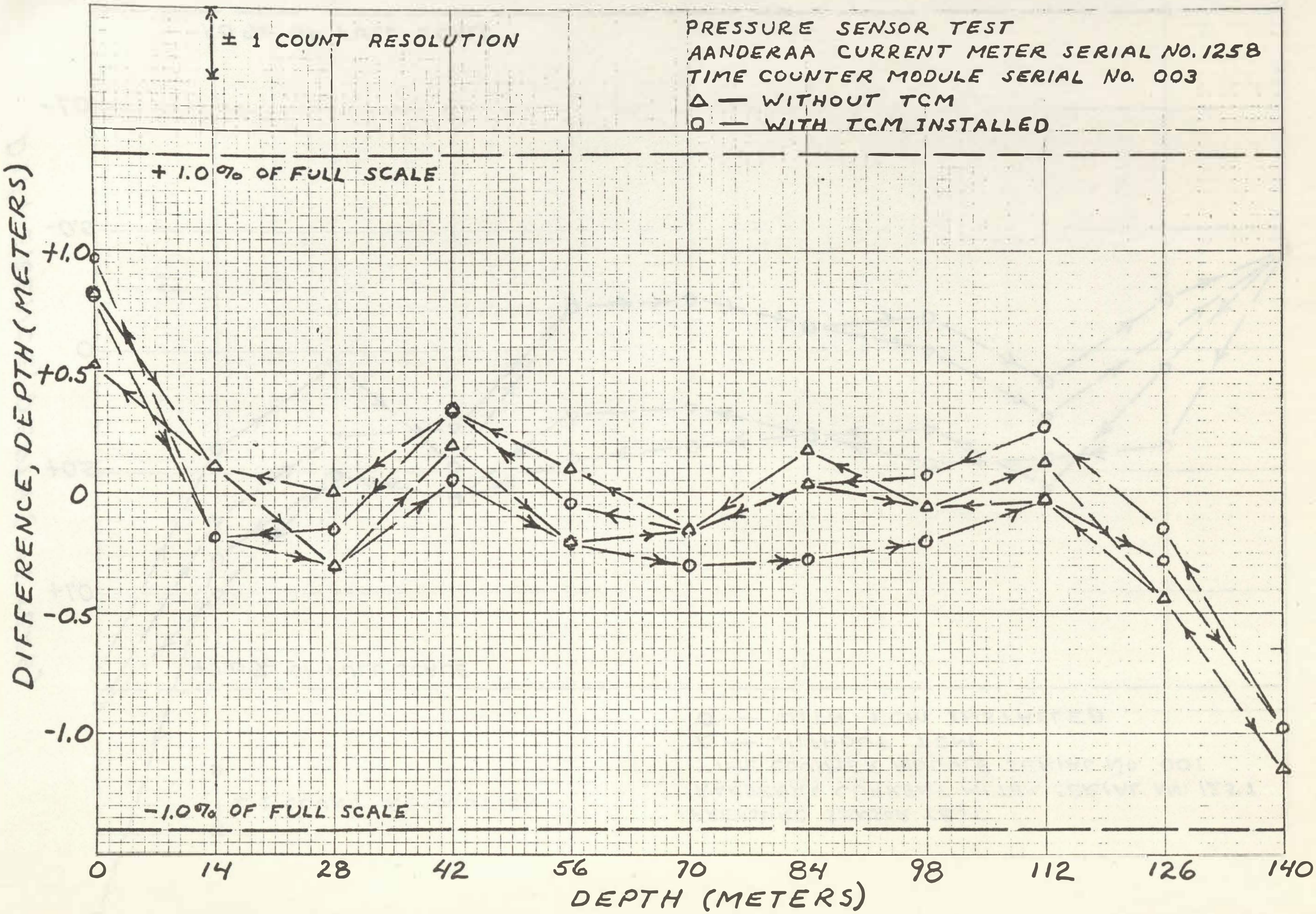

± 1 COUNT RESOLUTION
PRESSURE SENSOR TEST
AANDERAA CURRENT METER SERIAL NO. 1258
TIME COUNTER MODULE SERIAL NO. 003
Δ — WITHOUT TCM
O — WITH TCM INSTALLED
+ 1.0 % OF FULL SCALE
-1.0 % OF FULL SCALE
DIFFERENCE, DEPTH (METERS)
+1.0
+0.5
0
-0.5
-1.0
0
14
28
42
56
70
84
98
112
126
140
DEPTH (METERS)

Figure 2 B.3

APPENDIX B.4

Battery Test Data Voltage Readings

The battery test raw data is shown referenced to each battery type and sampling interval combination (Tudor or Burgess, one minute or 10 minute interval, with or without TCM). Voltage readings were taken under load (with current meter running) and no load (open circuit) conditions.

BATTERY TEST DATA - VOLTAGE READINGS - LOAD: MINIMUM READING OBSERVED WITH CURRENT METER RUNNING. NO LOAD; OPEN CIRCUIT VOLTAGE

AT -1.5°C

DATE	TIME	SN 1256 BURGESS BATTERY 10 MIN INTERVAL WITH TCM		SN 1257 TUDOR BATTERY 10 MIN INTERVAL WITH TCM		SN 1339 BURGESS BATTERY 10 MIN INTERVAL WITHOUT TCM		SN 1341 TUDOR BATTERY 1 MIN INTERVAL WITHOUT TCM		SN 1340 BURGESS BATTERY 1 MIN INTERVAL WITHOUT TCM		SN 1342 TUDOR BATTERY 1 MIN INTERVAL WITH TCM		SN 1347 BURGESS BATTERI 1 MIN INTERIAL WITH TCM	
		LOAD	NO LOAD	LOAD	NO LOAD	LOAD	NO LOAD	LOAD	NO LOAD	LOAD	NO LOAD	LOAD	NO LOAD	LOAD	NO LOAD
12/13	1500	9.44	9.65	9.28	9.79	9.36	9.64	9.46	9.92	9.39	9.60	9.36	9.82	9.46	9.64
"	1700	9.29	9.57	9.25	9.74	9.23	9.60	9.31	9.73	9.08	9.32	9.22	9.65	9.19	9.38
12/14	0830	9.15	9.40	9.10	9.64	9.12	9.44	8.46	9.00	8.25	8.51	8.52	8.97	8.38	8.57
"	1300	9.11	9.37	9.11	9.61	9.09	9.41	8.47	8.91	8.17	8.41	8.36	8.90	8.24	8.47
"	1600	9.12	9.35	9.11	9.60	9.09	9.39	8.42	8.87	8.09	8.34	8.37	8.84	8.21	8.40
12/15	0930	9.01	9.25	9.01	9.54	9.02	9.30	8.07	8.60	7.78	8.09	7.95	8.56	7.85	8.11
"	1330	9.00	9.23	9.00	9.52	9.01	9.28	8.01	8.52	7.69	8.01	7.95	8.47	7.78	8.03
12/16	0830	8.92	9.15	8.88	9.46	8.93	9.20	7.72	8.26	7.34	7.73	7.61	8.22	7.35	7.73
"	1300	8.70	9.17	ENCODER FAILED REPLACED WITH SPARE.		8.94	9.22	7.74	8.25	7.28	7.69	7.65	8.22	7.34	7.69
"	1600	8.91	9.15	9.07	9.38	8.91	9.20	7.69	8.20	7.16	7.46	7.59	8.17	7.24	7.64
"	1730	8.82	9.16	8.89	9.40	8.90	9.21	7.71	8.20	7.15	7.62	7.59	8.17	7.20	7.63
12/17	0830	8.84	9.10	8.86	9.35	8.92	9.16	7.42	8.04	6.53	7.34	7.36	8.01	6.74	7.36
"	1300	8.82	9.09	8.83	9.35	8.89	9.15	7.41	7.99	6.16	7.20	7.24	7.95	6.32	7.21
"	1500	8.85	9.08	8.86	9.34	8.85	9.15	7.41	7.97	5.95	7.12	7.22	7.93	6.05	7.13
"	1900	8.79	9.07	8.81	9.33	8.88	9.14	7.34	7.93	5.41	6.93	7.15	7.89	5.54	6.92
12/18	0800	8.82	9.04	8.84	9.31	8.84	9.11	7.16	7.80	4.12	6.10	6.93	7.72	4.13	6.02
"	0930	—	—	—	—	—	—	7.09	7.78	4.06	5.97	6.90	7.70	3.70	5.89
"	1100	—	—	—	—	—	—	7.05	7.77	3.70	5.84	6.85	7.68	3.50	5.73
"	1230	8.79	9.03	8.82	9.30	8.81	9.10	7.04	7.74	3.60	5.68	6.82	7.64	3.50	5.55
"	1400	—	—	—	—	—	—	—	—	3.50	5.56	—	—	3.40	5.43
"	1900	8.78	9.02	8.80	9.29	8.82	9.09	6.95	7.68	END OF TEST		6.58	7.56	END OF TEST	
12/19	0800	8.75	8.98	8.72	9.27	8.76	9.06	6.40	7.48			5.88	7.24		
"	1300	8.71	8.97	8.70	9.26	8.76	9.05	6.37	7.40			5.50	7.11		
	1630	8.68	8.96	8.72	9.25	8.75	9.04	6.18	7.33			5.31	6.95		
12/20	0800	8.65	8.92	8.70	9.23	8.71	9.01	5.30	6.90			3.80	6.05		
12/21	0800	8.62	8.86	8.70	9.21	8.65	8.96	END OF TEST				END OF TEST			
12/22	0830	8.55	8.80	8.63	9.18	8.60	8.91								
12/23	0800	8.52	8.74	8.61	9.15	8.59	8.87								
12/24	0730	8.41	8.69	8.59	9.13	8.52	8.83								
12/26	0830	8.35	8.61	8.51	9.07	8.50	8.76								
12/27	0830	8.30	8.57	8.48	9.04	8.46	8.73								
12/28	0900	8.27	8.54	8.45	9.02	8.43	8.69								
12/30	0830	8.20	8.46	8.40	8.96	8.35	8.63								
12/31	0830	8.14	8.44	8.38	8.94	8.31	8.61								
1/2	0830	8.05	8.37	8.32	8.89	8.25	8.55								
1/3	0830	7.99	8.32	8.30	8.85	8.24	8.52								
1/4	1500	7.96	8.27	8.26	8.82	8.21	8.49								
1/6	0830	7.81	8.19	8.22	8.78	8.15	8.45								
1/7	0830	7.73	8.15	8.19	8.76	8.05	8.41								
1/8	0830	7.67	8.10	8.17	8.73	8.05	8.38								
1/9	0830	7.59	8.05	8.16	8.71	8.01	8.35								
1/10	0830	7.51	8.01	8.13	8.68	7.94	8.32								
1/11	0900	7.42	7.96	8.11	8.66	7.87	8.29								
1/12	1330	7.33	7.91	8.09	8.63	7.80	8.25								
1/13	0930	7.20	7.87	8.05	8.61	7.76	8.23								
1/14	0930	7.04	7.82	8.02	8.58	7.72	8.20								
1/14	1730	7.00	7.81	8.02	8.57	7.70	8.19								
1/15	1500	END OF TEST		END OF TEST		7.60	8.15								
1/16	0830					7.61	8.13								
1/17	0900					7.55	8.09								
1/20	0830					7.25	7.98								
1/21	1530					7.15	7.95								
1/22	0830					7.07	7.93								
						END OF TEST									

APPENDIX B.5

Plotted Battery Test Discharge Data

Figure 1 B.5-Burgess D6 Battery, 10 Minute Interval, with TCM

Figure 2 B.5-Burgess D6 Battery, 10 Minute Interval, without TCM

Figure 3 B.5-Tudor 9T1 Battery, 10 Minute Interval, with TCM

Figure 4 B.5-Burgess D6 Battery, 1 minute Interval, with TCM

Figure 5 B.5-Burgess D6 Battery, 1 Minute Interval, without TCM

Figure 6 B.5-Tudor 9T1 Battery, 1 Minute Interval, with TCM

Figure 7 B.5-Tudor 9T1 Battery, 1 Minute Interval, without TCM

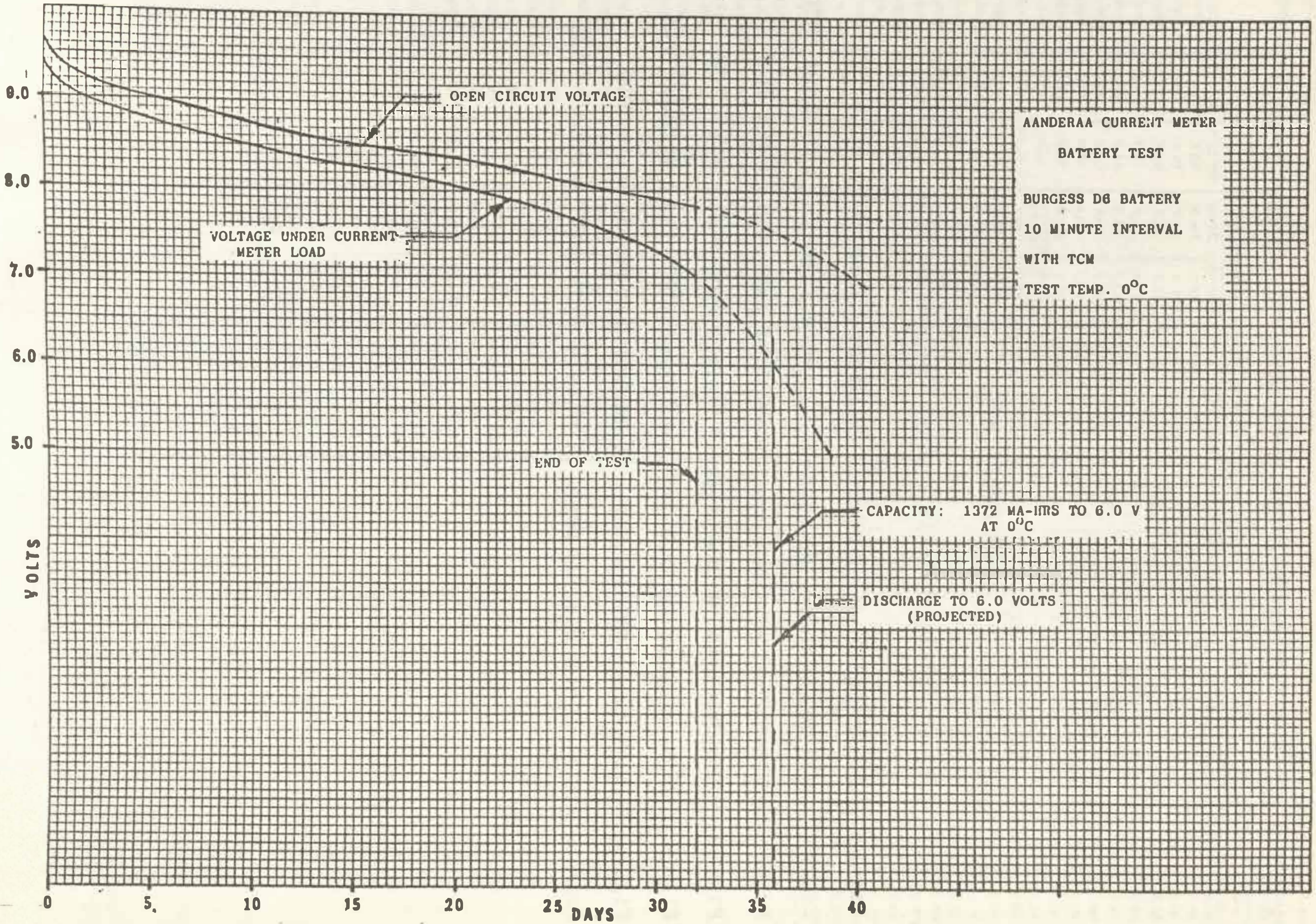
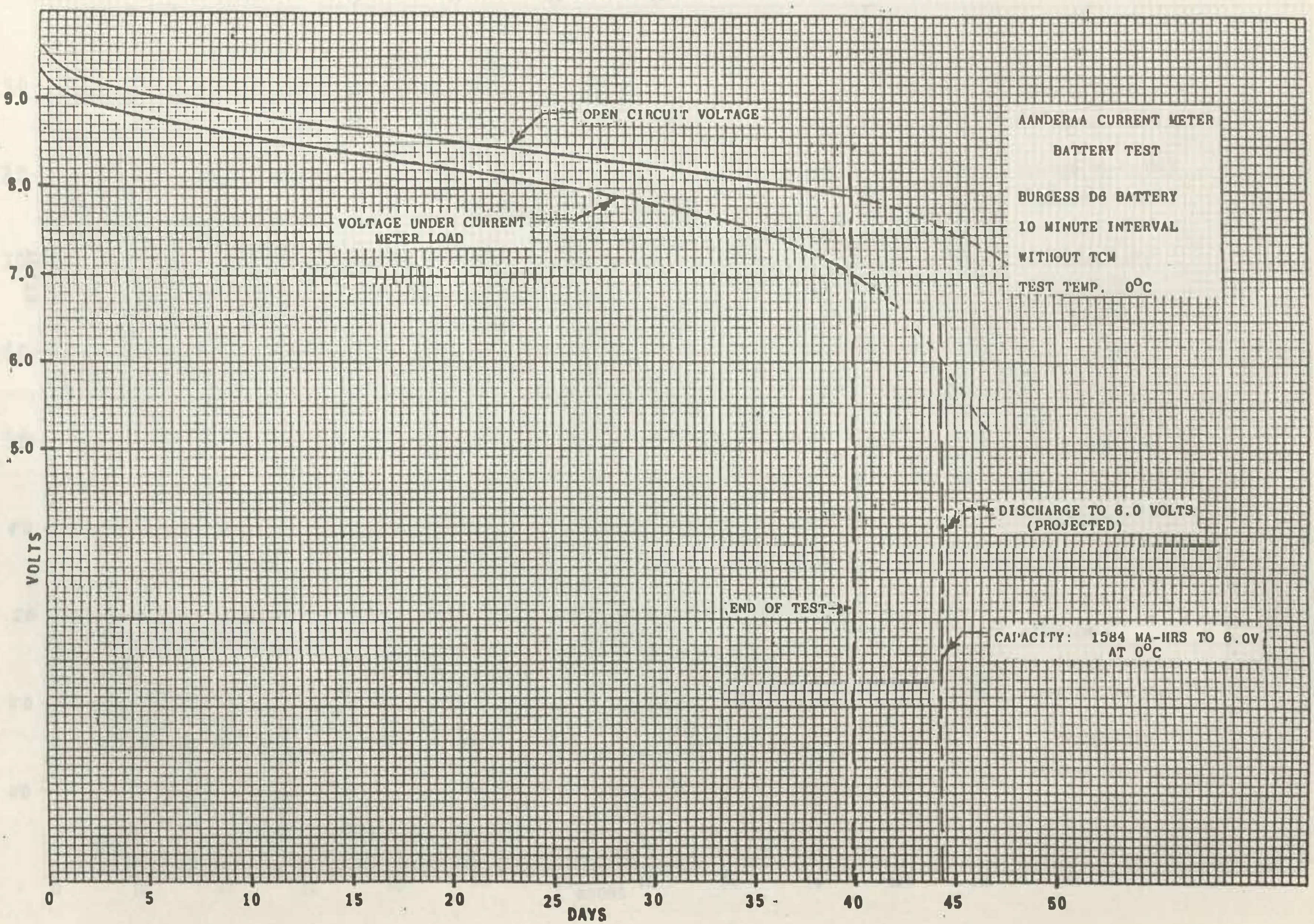

9.0
8.0
7.0
6.0
5.0
VOLTS
OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
AANDERAA CURRENT METER
BATTERY TEST
BURGESS D6 BATTERY
10 MINUTE INTERVAL
WITH TCM
TEST TEMP. 0°C
END OF TEST
CAPACITY: 1372 MA-HRS TO 6.0 V AT 0°C
DISCHARGE TO 6.0 VOLTS (PROJECTED)
0
5
10
15
20
25
DAYS
30
35
40

Figure 1B.5



OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
AANDERAA CURRENT METER
BATTERY TEST
BURGESS D6 BATTERY
10 MINUTE INTERVAL
WITHOUT TCM
TEST TEMP. 0°C
DISCHARGE TO 6.0 VOLTS (PROJECTED)
END OF TEST
CAPACITY: 1584 MA-HRS TO 6.0V AT 0°C
VOLTS
9.0
8.0
7.0
6.0
5.0
DAYS
0
5
10
15
20
25
30
35
40
45
50

Figure 2B.5

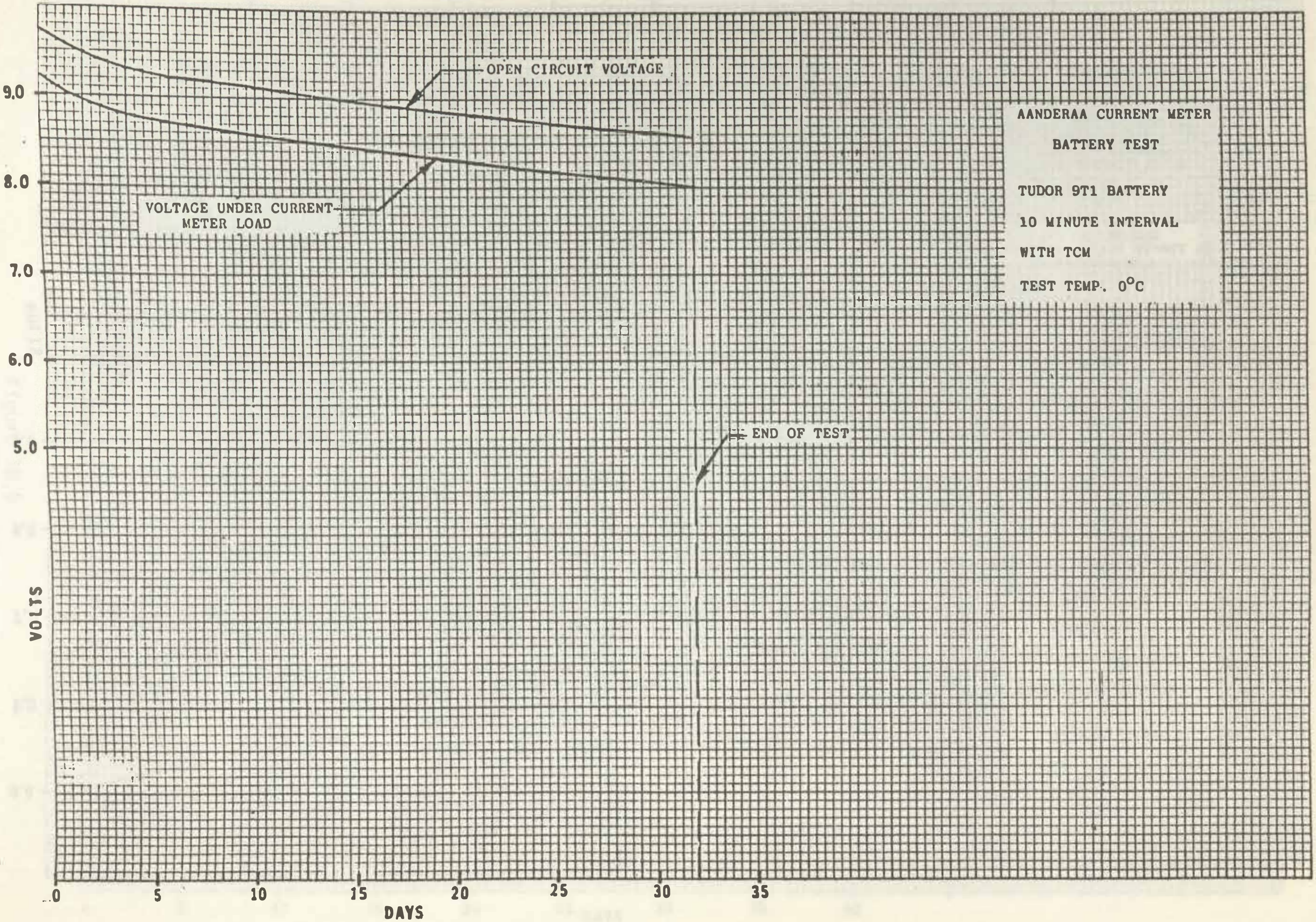

OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
AANDERAA CURRENT METER
BATTERY TEST
TUDOR 9T1 BATTERY
10 MINUTE INTERVAL
WITH TCM
TEST TEMP. 0°C
END OF TEST
9.0
8.0
7.0
6.0
5.0
VOLTS
0
5
10
15
20
25
30
35
DAYS

Figure 3B.5

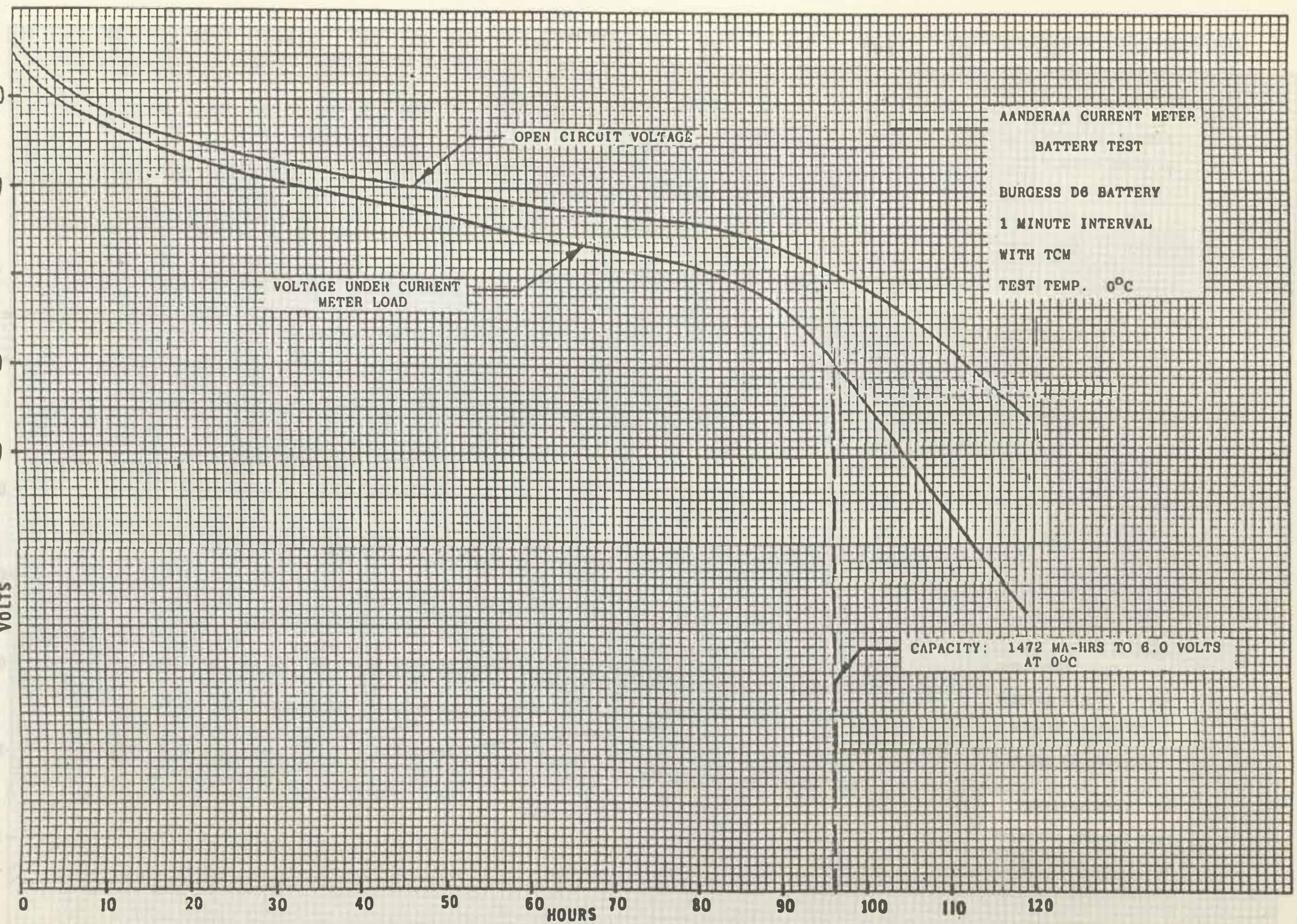

AANDERAA CURRENT METER
BATTERY TEST
BURGESS D6 BATTERY
1 MINUTE INTERVAL
WITH TCM
TEST TEMP. 0°C
OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
CAPACITY: 1472 MA-HRS TO 6.0 VOLTS AT 0°C
9.0
8.0
7.0
6.0
5.0
VOLTS
0
10
20
30
40
50
60
70
80
90
100
110
120
HOURS

Figure 4B.5

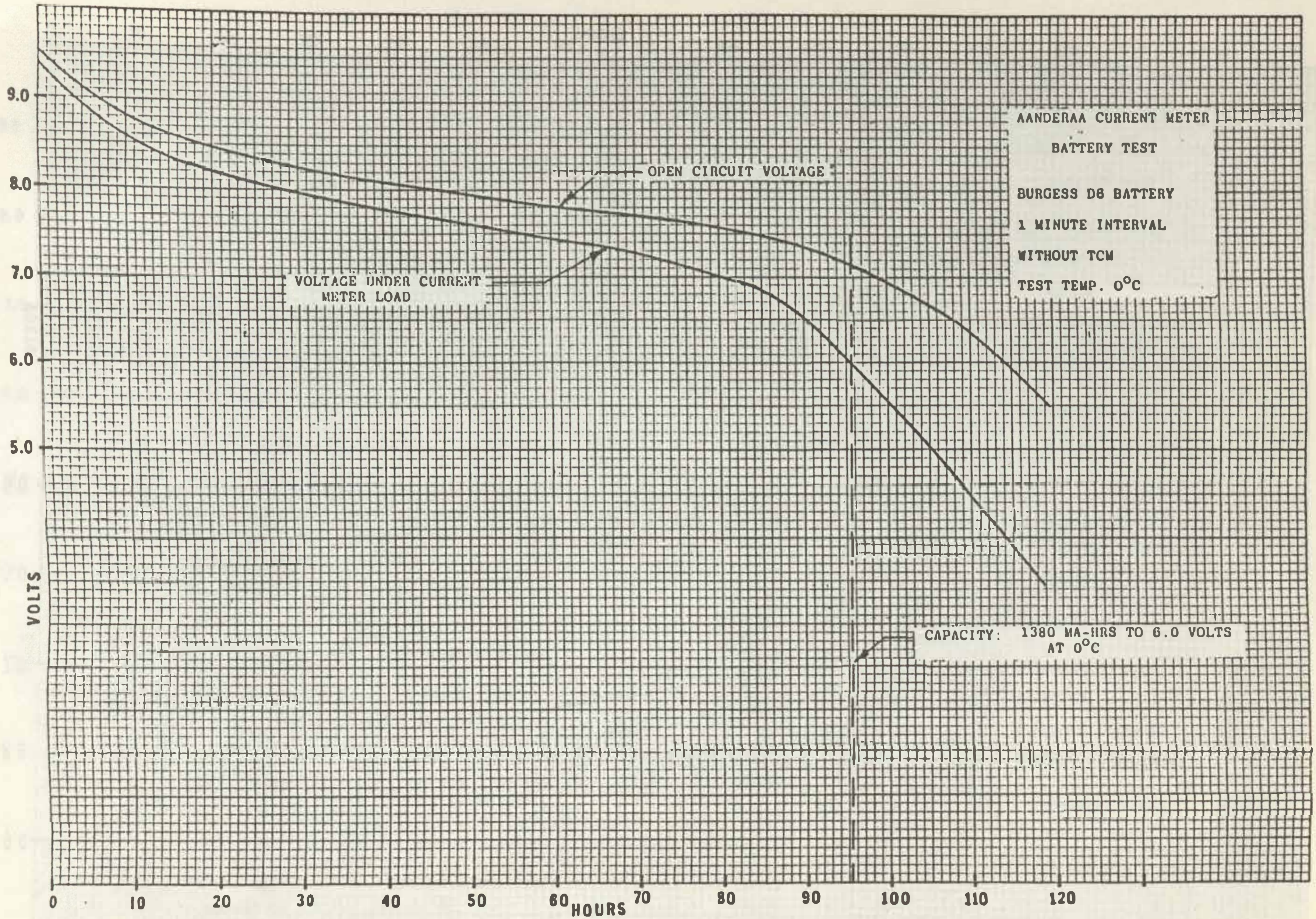

AANDERAA CURRENT METER
BATTERY TEST
BURGESS D6 BATTERY
1 MINUTE INTERVAL
WITHOUT TCM
TEST TEMP. 0°C
OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
CAPACITY: 1380 MA-HRS TO 6.0 VOLTS AT 0°C
VOLTS
9.0
8.0
7.0
6.0
5.0
HOURS
0
10
20
30
40
50
60
70
80
90
100
110
120

Figure 5B.5

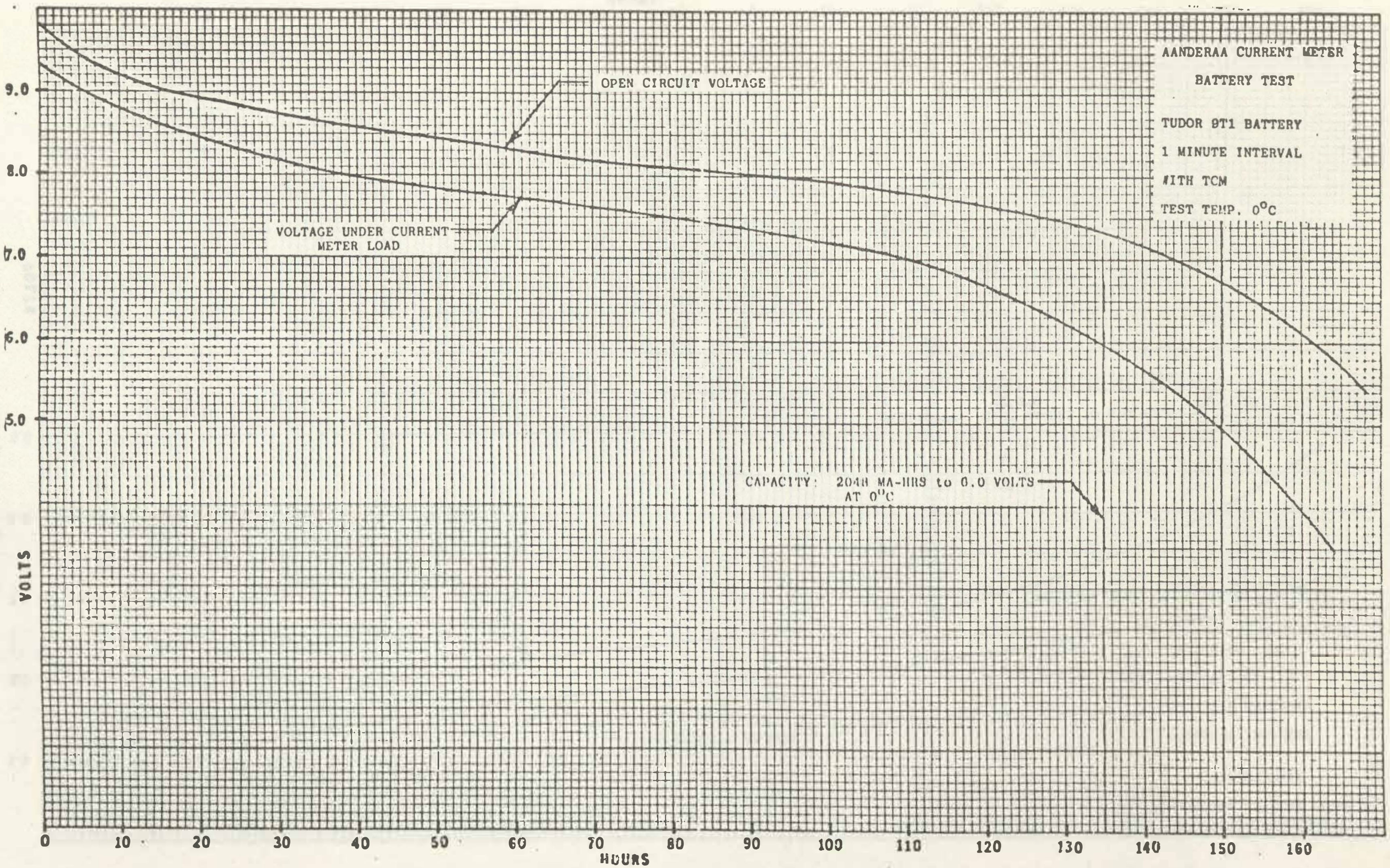

AANDERAA CURRENT METER
BATTERY TEST
TUDOR 9T1 BATTERY
1 MINUTE INTERVAL
WITH TCM
TEST TEMP. 0°C
OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
CAPACITY: 2048 MA-HRS to 0.0 VOLTS AT 0°C
VOLTS
9.0
8.0
7.0
6.0
5.0
HOURS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160

Figure 6B.5

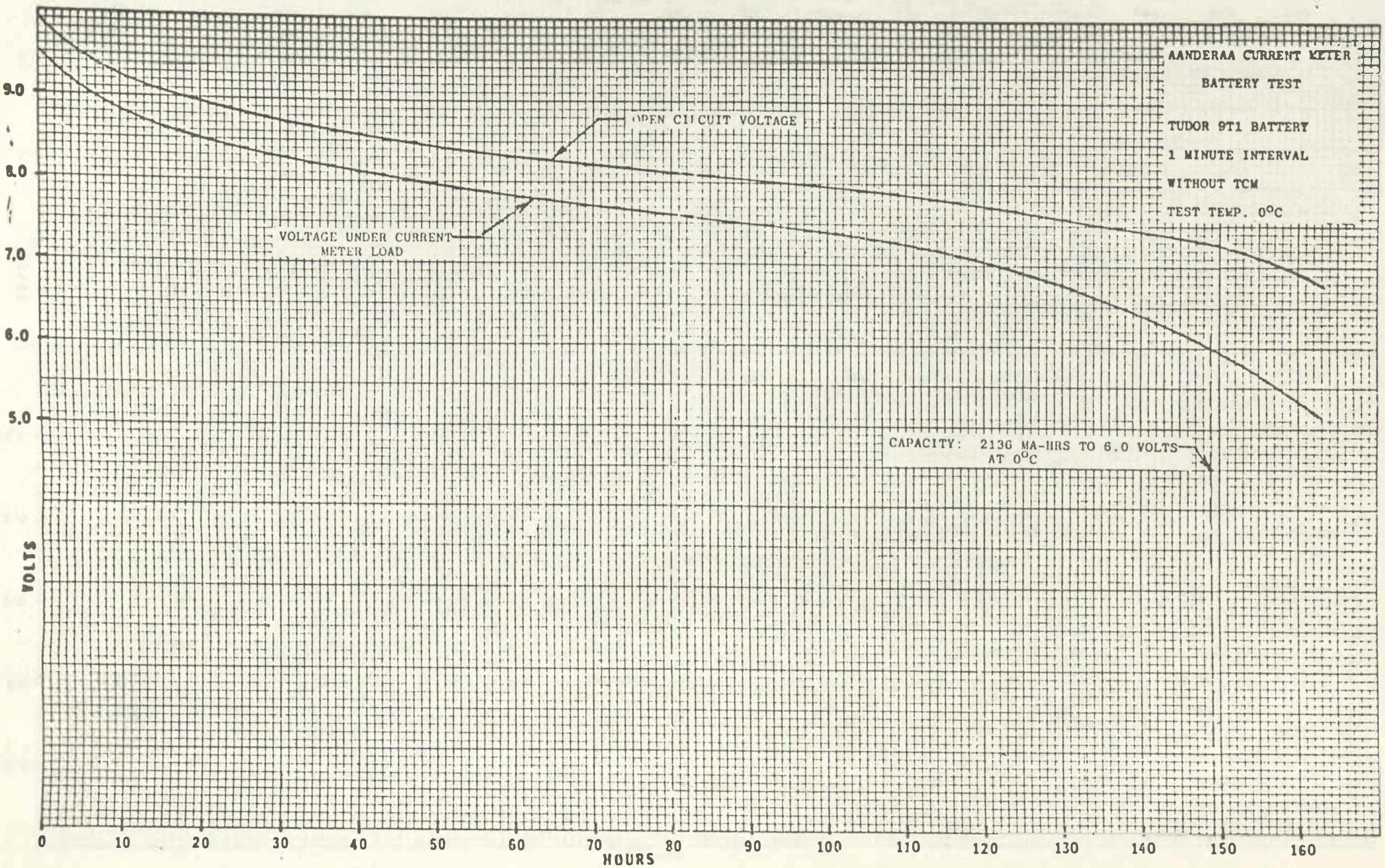

AANDERAA CURRENT METER
BATTERY TEST
TUDOR 9T1 BATTERY
1 MINUTE INTERVAL
WITHOUT TCM
TEST TEMP. 0°C
OPEN CIRCUIT VOLTAGE
VOLTAGE UNDER CURRENT METER LOAD
CAPACITY: 2136 MA-HRS TO 6.0 VOLTS AT 0°C
VOLTS
HOURS
9.0
8.0
7.0
6.0
5.0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160

Figure 7B.5

APPENDIX B.6

Computation of Average Current Drain for the Aanderaa Current Meter

A. Computation of Average Current Drain for the Aanderaa Current Meter.

The total current drain from the 9 volt main battery is composed of a number of discrete events. To obtain an average value for this current drain, the following analysis was performed.

Data Format: 6 words @ 10 bits/word = total of 60 bits plus a sync pulse in elapsed time of 25 seconds.

From: Aanderaa Current Meter User's Guide, Page 23;

25 sec. x 7 ma. (motor)

25 sec. x 9 ma. (electronic board)

30 pulses x .081 sec. x 40 ma ("0" pulses) } Encoder

30 pulses x .022 sec. x 4 ma. ("1" pulses) } Encoder

30 pulses x .081 sec. x 17.5 ma. ("0" pulses) } Acoustic Transducer

30 pulses x .022 sec. x 17.5 ma. ("1" pulses) } Acoustic Transducer

4.75 sec. x 15 ma. (compass clamping)

1 sec. x 50 ma. (sync. pulse)

TOTAL: 675 ma. sec./sample

$$I_{avg} = \frac{675 \text{ ma. sec./sample}}{25 \text{ sec./sample}} = 27 \text{ ma. (at regulated 6.0 volts)}$$

$$R_L = \frac{6V}{.027a} = 222.2\ \Omega$$

B. Additional Current Drain Caused by TCM.

$$\text{Relay current} = \frac{6V}{200\Omega} = 30 \text{ ma.}$$

Relay on for 2 word lengths or 8 sec./sample = 30 ma x 8 sec

= 240 ma. sec.

Relay on once every 6 samples; $\frac{240 \text{ ma. sec}}{6}$ = 40 ma.sec./sample

Total Average Current Drain with TCM;

675 ma. sec. + 40 ma. sec. = 715 ma. sec/sample

$$I_{avg} = \frac{715 \text{ ma. sec}}{25 \text{ sec.}} = 28.6 \text{ ma.}$$

$$R_L = \frac{6}{.0286} = 209.8\ \Omega$$

C. Actual Current Meter Running Time for 10 Minute Interval;

1. 25 sec./sample
2. 6 samples/hour x 25 sec./sample = 150 sec./hour
3. 24 hr./day x 150 sec./hr. = 3600 sec./day = 1 hr./day
4. 6 samples/hr. x 24 hr./day = 144 samples/day
5. 30 days/month x 144 samples/day = 4320 samples/month

APPENDIX B.7

Battery Capacity Computations

I. Burgess D6 Battery, 10 Minute Interval, with TCM

II. Burgess D6 Battery, 10 Minute Interval, without TCM

III. Burgess D6 Battery, 1 Minute Interval, with TCM

IV. Burgess D6 Battery, 1 Minute Interval, without TCM

V. Tudor 9Tl Battery, 1 Minute Interval, with TCM

VI. Tudor 9Tl Battery, 1 Minute Interval, without TCM

I. Aanderaa Current Meter SN 1256

From Burgess Battery Test Curves

1. Burgess D6 Battery, 10 Minute Interval, with TCM @0^oC

V_{avg} = 8.0 volts (integrated avg. voltage over test period from 9.4 V. to 6.0 V.)

R_L = 209.8Ω (with TCM)

$I_{avg} = \frac{8.0V}{209.8\Omega} = 38.1$ ma.

Number of hours operation down to 6.0V.

36 days x 144 samples/day = 5184 samples

$\frac{5184 \text{ samples} \times 25 \text{ sec/sample}}{3600 \text{ sec/hr}}$ = 36 hrs. current meter operation*

36 hrs x 38.1 ma = 1372 ma-hrs. @ 0^oC

$\frac{1372}{60\%}$ = 2287 ma. hrs. @ 21^oC

2. From Burgess Battery Data Book;
Pg. 52 Data for No. 5 cell

Service life to 1.0 V/cell, discharged 4 hrs/day

at 38 ma. ⟶ 53 hrs.

38 ma. x 53 hrs = 2014 ma.-hrs @ 21^oC

2014 x .60 = 1208 ma.-hrs @0^oC

3. Battery capacity required for 30 day operation at 10

Minute Interval with TCM;

38.1 ma. x 30 hrs. = 1143 ma-hrs.

Note: 30 days at 10 minute interval is equivalent to 30 hrs current meter running time.

* Current Meter Operation - defined as the time during which the current meter is fully operational, i.e. 25 seconds per sample.

II. Aanderaa Current Meter SN 1339

From Burgess Battery Test Curves

1. Burgess D6 Battery, 10 Minute Interval, no TCM @ $0^{o}C$

V_{avg} = 8.0 volts (intergrated avg. voltage over test period from 9.3V to 6.0V)

R_L = 222.2 Ω (without TCM)

$I_{avg} = \frac{8.0}{222.2}$ = 36 ma.

Hours of operation down to 6.0V

44 days x 144 samples/day = 6336 samples

$\frac{6336 \times 25}{3600}$ = 44 hrs. current meter operation

44 hrs. x 36 ma. = 1584 ma-hrs @ $0^{o}C$

$\frac{1584}{60\%}$ = 2640 ma-hrs @ $21^{o}C$

2. From Burgess Battery Data Book
Pg. 52 No. 5 cell,

Service life to 1.0^{V}/cell; dishcarged @ 4hrs/day

at 36 ma ⟶ 58 hrs.

36 x 58 = 2088 ma-hrs. @ $21^{o}C$

2088 x 60% = 1253 ma-hrs @ $0^{o}C$

3. Battery capacity required for 30 day operation

at 10 minute interval without TCM

36 ma. x 30 hrs. = 1080 ma.-hrs.

III. Aanderaa Current Meter SN 1347

From Burgess Battery Test Curves

1. Burgess D6 Battery, 1 Minute Interval, with TCM @ 0^oC

$V_{avg.}$ = 7.72 volts (integrated avg. voltage over test period from 9.4 to 6.0V)

R_L = 209.8Ω (with TCM)

$I_{avg.} = \frac{7.72}{209.8} = 36.8$ ma.

Hours of operation down to 6.0V

96 hrs. x 60 = 5760 samples

$\frac{5760 \times 25}{3600}$ = 40 hrs current meter operation

40 hrs x 36.8 ma. = 1472 ma.-hrs @ 0^oC

$\frac{1472}{60\%}$ = 2453 ma.-hrs. @ 21^oC

2. From Burgess Battery Data Book; p. 52 No. 5 cell,

service life to 1.0V/cell; discharged @ 4 hrs/day

at 36.8 ⟶ 56 hrs.

36.8 ma. x 56 hrs = 2061 ma.-hrs. @ 21^oC

2061 x 60% = 1237 ma.-hrs. @ 0^oC

IV. Aanderaa Current Meter SN 1340

From Burgess Battery Test Curves

1. Burgess D6 Battery, 1 Minute Interval, No. TCM @ $0^{o}C$

$V_{avg.}$ = 7.66 volts (integrated avg. voltage over test period from 9.3V to 6.0V)

R_L = 222.2Ω (without TCM)

$I_{avg.} = \frac{7.66}{222.2} = 34.5$ ma.

Hours of operation down to 6.0V

96 hrs. x 60 = 5760 samples

$\frac{5760 \times 25}{3600}$ = 40 hrs. current meter operation

40 hrs. x 34.5 ma. = 1380 ma.-hrs. @ $0^{o}C$

$\frac{1380}{60\%}$ = 2300 ma.-hrs. @ $21^{o}C$

2. From Burgess battery data book;
p. 52 No. 5 cell

Service life to 1.0V/cell; discharged @ 4 hrs./day

at 34.5 ma. ⟶ 61 hrs.

34.5 x 61 = 2104 ma-hrs. @ $21^{o}C$

2104 x 60% = 1262 ma.-hrs. @ $0^{o}C$

V. Aanderaa Current Meter SN 1342

From Tudor Battery Test Curves

1. Tudor 9T1 Battery, 1 Minute Interval, with TCM @0°C

   V_{avg} = 7.63 volts (integrated avg. voltage over test period from 9.3 to 6.0V)

   R_L = 209.8Ω (with TCM)

   $I_{avg} = \frac{7.63}{209.8\Omega} = 36.4$ ma.

   Hours of operation down to 6.0V

   135 hrs x 60 = 8100 samples

   $\frac{8100 \times 25}{3600} = 56.25$ hrs. current meter operation

   56.25 x 36.4 = 2048 ma-hrs @ 0°C

   $\frac{2048}{60\%} = 3412$ ma-hrs @ 21°C

2. From Burgess Battery Data Book:
   p. 54 "Z" cell, service life to 1.0V/cell

   $\frac{36.4}{2} = 18.2$ ma ⟶ 94 hrs.

3. From discharge curves supplied by Tudor;

   Service life to 6.0V

   3586 ma-hrs @ 20°C

   (at I_{avg} = 17.1 ma., 4 hr/day)

VI. Aanderaa Current Meter SN 1341

From Tudor Battery Test Curves

1. Tudor 9T1 Battery, 1 Minute Interval, no TCM @ $0^{O}C$

V_{avg} = 7.65 volts (integrated avg. voltage over test period from 9.4 to 6.0V)

R_L = 222.2Ω (without TCM)

$I_{avg} = \frac{7.65}{222.2} = 34.4$ ma

Hours of operation down to 6.0V

149 hrs x 60 = 8940 samples

$\frac{8940 \times 25}{3600} = 62.08$ hrs. current meter operation

62.08 x 34.4 ma = 2136 ma-hrs @ $0^{O}C$

$\frac{2136}{60\%}$ = 3560 ma-hrs @ $21^{O}C$

2. From Burgess Battery Data Book:
pg. 54 "Z" cell, service life to 1.0V/cell

$\frac{34.4}{2}$ = 17.2 ma → 100 hrs.

34.4 ma x 100 hrs = 3440 ma-hrs @ $21^{O}F$

3. From discharge curves supplied by Tudor:

Service life to 6.0V

3586 ma-hrs @ $20^{O}C$

(at I_{avg} = 17.1 ma., 4 hr/day)

APPENDIX B.8

Manufacturers Battery Discharge Data

GRAPH NO. 27

BURGESS

NUMBER 5 CELLS
(ASA Cell Size B)

Estimated Service Life When Discharged 4 Hrs. Per Day At 70° F.

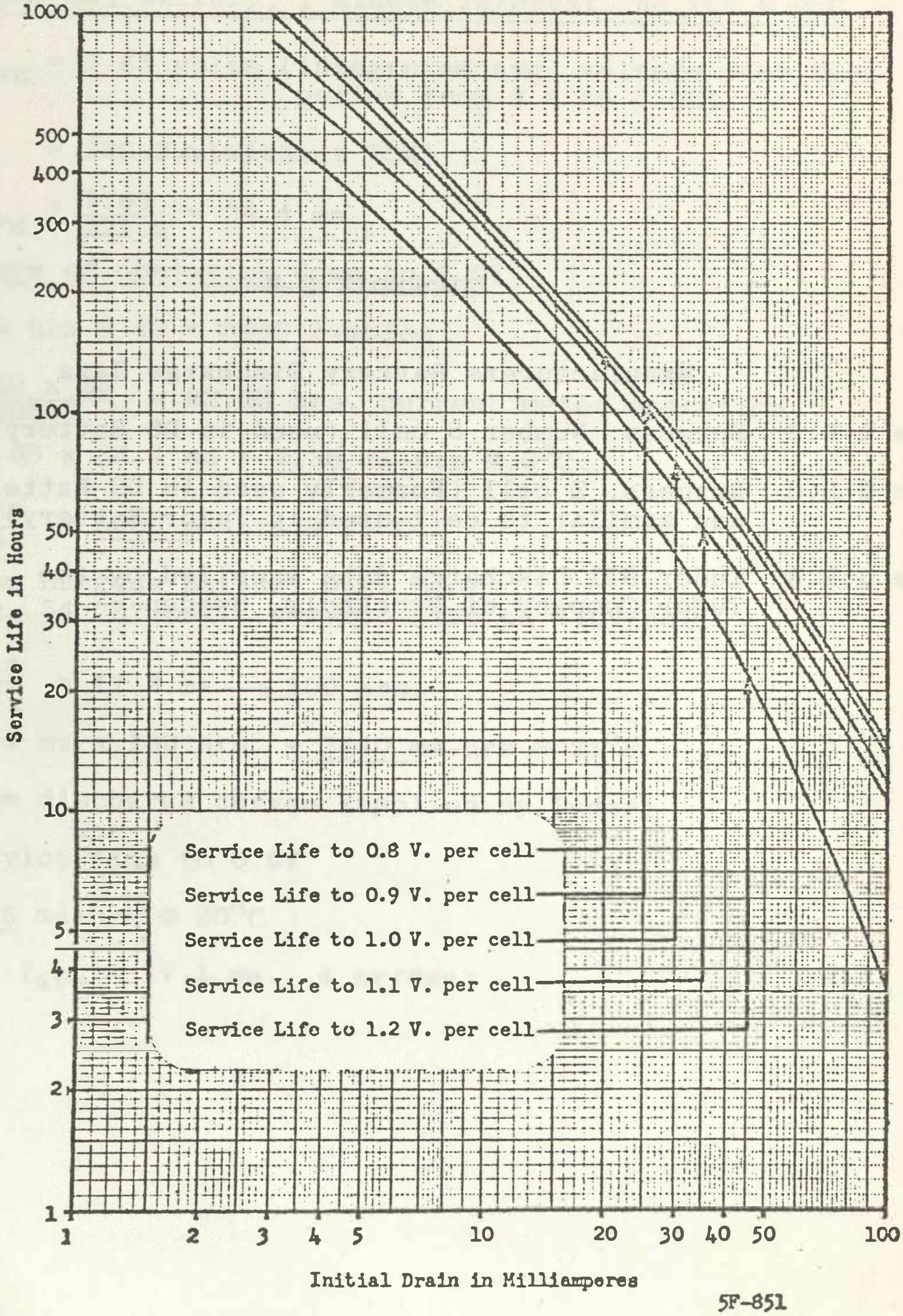


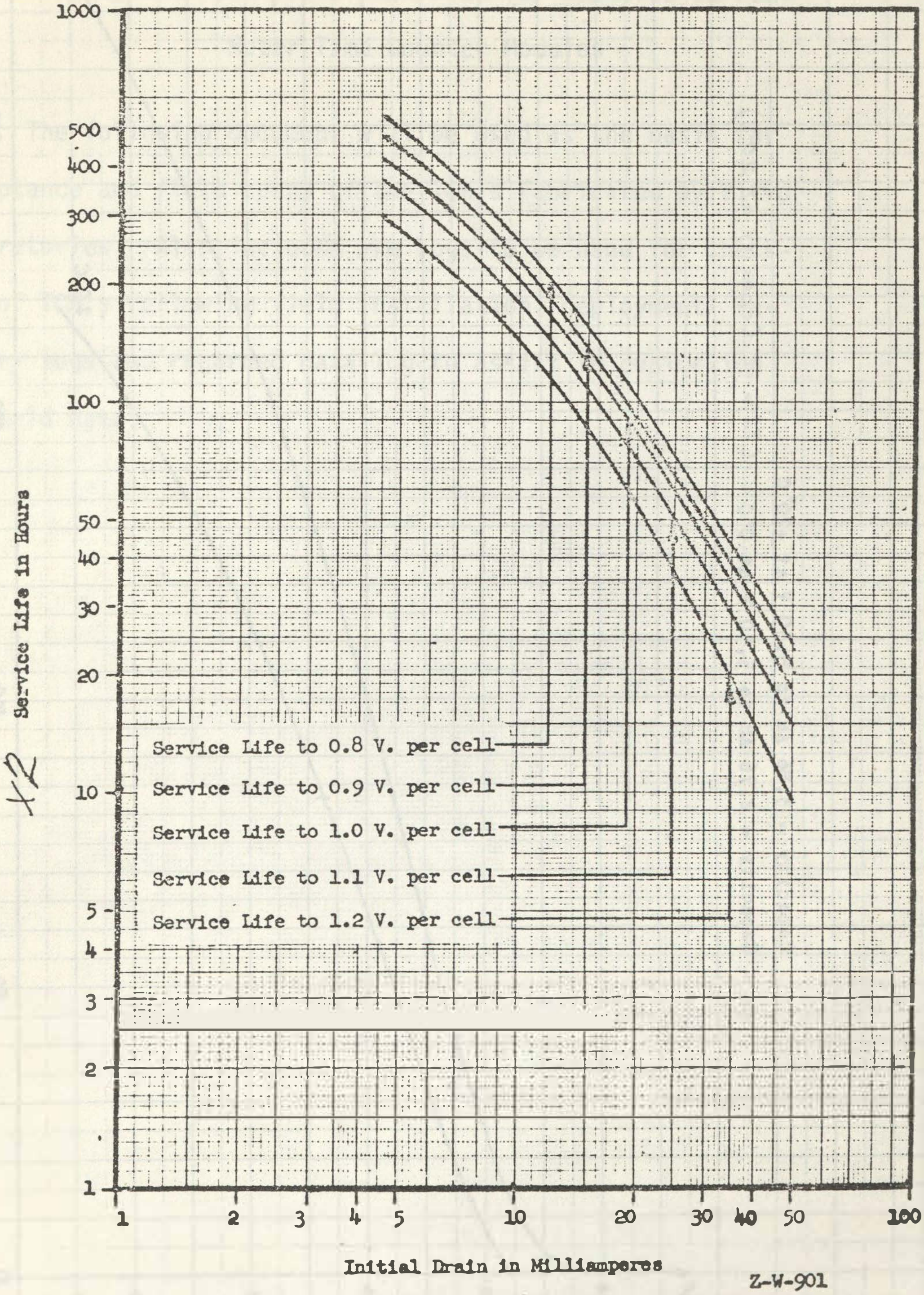
Figure 1 B.8

GRAPH NO.

29

BURGESS 'Z' CELLS

Estimated Service Life When Discharged 4 Hrs. Per Day At 70° F.



Z-W-901

Figure 2 B.8

Discharge curve for Tudor 9T1
15C ohm 4 h/day

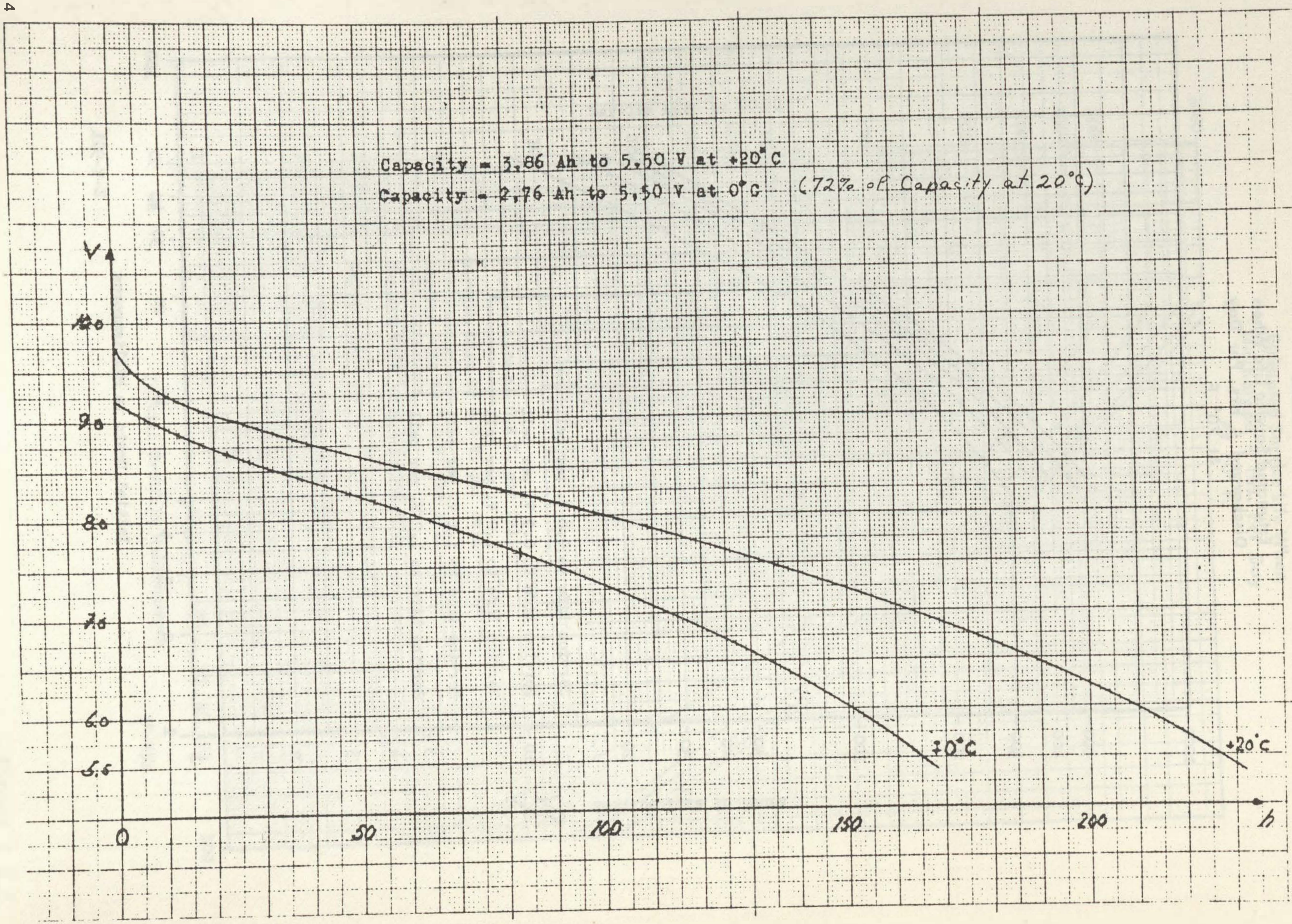


Figure 3 B.8

APPENDIX C

Acceptance and Field Test Plan for Aanderaa Current Meter Time Counter Modules

The following document will be used as the basis for acceptance and field tests of the TCM's fabricated by Vitro Laboratories. Also included are logs to be used for check-out of TCM's following field installation, deployment/ re-covery logs and recorded data log to assist in evaluation of field data.

Time Counter Module for Aanderaa Current Meter
Acceptance and Field Test Plan
(For TCM's Fabricated by Vitro Labs)

I. Acceptance Tests

A. Receive first assembled TCM unpotted from Vitro for testing.

1. Incoming inspection: Visual inspection for construction flaws such as cold solder joints, shorted connections, broken input/output wires at P.C. board junctions, etc. Also check for correct mounting of components on P.C. boards and correct color coding of input/output leads.

2. Install TCM on a current meter as per instructions in Appendix A, "TCM Installation Procedure".

3. Operational Tests. (Reference Appendix B.1, Test Plan, sec. III. A. and C.)

a. Reset TCM and Quartz clock.
b. Check words 3 and 4 on other than even hour intervals for conductivity and pressure data.
c. Check interval one hour after reset for correct flag and time data.
d. Test manual write function.
e. Test reset operation.
f. Conduct pressure sensor calibration check and compare data with before TCM installation pressure sensor calibration check.
g. Conduct accelerated test to exercise TCM through 1023.

4. Environmental Tests.

a. Temperature. (Same as sec. IV, Appendix B.1, Test Plan).

B. Return TCM to Vitro Labs for potting.

C. After potting of first TCM, repeat Test sections A.2,3, and 4.

D. For TCM units 2 through 20:

1. Before potting, conduct Test sections A.1,2,and 3.
2. After potting, repeat Test section A.2 and 3.

II. Field Tests

A. Deliver TCM's with documentation; 10 units to MESA, Floyd Bennet Field and 10 units to C72, Marine Engineering Division, Electronic Systems Branch.

The documentation accompanying the TCM's includes all installation and operating instructions. Post installation checkout logs and deployment/recovery logs as attached to this Test Plan are supplied.

When installing TCM's, those current meters with a history of data lost due to time correlation problems should be selected.

After the TCM's have been installed and as current meters with TCM's are used, copies of completed logs should be sent to the Engineering Development Lab., C612, WSC 2, Rockville, Md. 20852, c/o of Donald Schmidt.

As field data is received and processed by C33, the data will be checked for correct recording of time words, using the attached sample log sheet.

TIME COUNTER MODULE
ACCEPTANCE TEST LOG

TCM Serial No. ______________ Date: ______________

Meter S/N: ______________ Technician: ______________

VISUAL INSPECTION:

ELECTRICAL TEST: 9 Volt (@ Terminal 26) 4 Volt (@ Terminal P)

	9 Volt (@ Terminal 26)	4 Volt (@ Terminal P)
Standby Current	______ μa	______ μa
Operation Current	______ μa	______ μa
Operation w/Relay	______ ma	______ μa

Time Word OK: ☐ YES ☐ NO

Flag Word OK: ☐ YES ☐ NO

Manual Write OK: ☐ YES ☐ NO

Manual Reset OK: ☐ YES ☐ NO

COMMENTS:

TIME COUNTER MODULE
ACCEPTANCE TEST LOG

PRESSURE TEST:

Calibration Equation: Depth (Meters) = ________ + ________ · N

Tolerance: ± 1% of Full Scale

Without TCM:

Test Points	INPUT (Dead Wt.) PSI	Depth (Meters)	OUTPUT (Aanderaa) Decimal	Depth (Meters)	Δ_1
0					
1/4 F.S.					
1/2 F.S.					
3/4 F.S.					
1 F.S.					

With TCM:

Test Points	INPUT (Dead Wt.) PSI	Depth (Meters)	OUTPUT (Aanderaa) Decimal	Depth (Meters)	Δ_2	$\Delta_1 - \Delta_2$
0						
1/4 F.S.						
1/2 F.S.						
3/4 F.S.						
1 F.S.						

REDUCED BATTERY VOLTAGE TEST: (9Volt Supply @ 6 Volts, 4 Volt Supply @ 3.8 Volts)

Time Word OK: ☐ YES ☐ NO

Flag Word OK: ☐ YES ☐ NO

Manual Write OK: ☐ YES ☐ NO

Manual Reset OK: ☐ YES ☐ NO

TIME COUNTER MODULE
ACCEPTANCE TEST LOG

ACCELERATED OPERATION:

Tape No. ______________ Start Tape ______________ (Date/Time) End Tape ______________ (Date/Time)

OSC. Input Freq. ______________

Trigger Interval ______________ (Minutes) Last Time Word ______________

From Computer Printout:

Number Correct Time Words ______________ Errors ______________

COMMENTS:

ENVIRONMENTAL TEST:

Time of TCM Reset ______________ (Date/Time) (10 Minute Interval).

Tape No. ______________ Start Tape ______________ (Date/Time) End Tape ______________ (Date/Time)

START TIME	TEMP.	TIME WORD
	-5°C	
	50°C	
	-5°C	
	50°C	
	room temp.	
	-5°C	
	50°C	
	-5°C	
	50°C	
	room temp.	

From Computer Printout:

Number Correct Time Words ______________ Errors ______________

COMMENTS:

TIME COUNTER MODULE POST INSTALLATION CHECKOUT LOG

Current Meter Serial No. ________ Pressure Sensor: Yes ☐ No ☐

TCM Serial No. ______ Conductivity Sensor: Yes ☐ No ☐

1. 4 volt battery reinstalled: Yes ☐

   9 volt battery reinstalled: Yes ☐

2. Current Drain Test: 9 Volt (@ Terminal 26) 4 Volt (@ Terminal P)

	9 Volt (@ Terminal 26)	4 Volt (@ Terminal P)
Standby Current	______ μa.	______ μa.
Operation Current	______ μa.	______ μa.
Operation w/Relay	______ ma.	______ μa.

3. Reset TCM by momentarily shorting terminals R and N on Quartz clock.

   Reset time: D_____ H _____ M _____ S _____

4. On intervals before one hour following reset:
   (input/output)
   a. Conductivity _______/_______
   b. Pressure _______/_______

5. On interval one hour after reset:

   a. Flag (word 3) __________
   b. Time (word 4) __________

6. Initiate manual write and trigger current meter:

   a. Time of reading: D _____ H _____ M _____ S _____
   b. Flag __________
   c. Time __________

7. After at least 10 hours of operation (monitor on the hour):

   a. Time of reading: D _____ H _____ M _____ S _____
   b. Flag __________
   c. Time __________

REMARKS:

Installed by ____________________ Date __________

Tested by ____________________ Date __________

DEPLOYMENT AND RECOVERY LOG FOR CURRENT METERS WITH TCM

(Note: Use this log in addition to regular Deployment and Recovery Logs)

Current Meter Serial No.______________

TCM Serial No.________________

DEPLOYMENT PHASE:

Quartz clock interval plug ________(minutes)

Clock reset time: D_____H_____M_____S_____

Before threading tape:

Initiate a manual write and monitor current meter time word.

Time of reading: D_____H_____M_____S_____

Time word________________(decimal value)

First record on tape: D_____H_____M_____S_____

RECOVERY PHASE:

Last record on tape: D_____H_____M_____S_____

After removing tape:

Initiate a manual write and monitor current meter time word.

Time of reading: D_____H_____M_____S_____

Time word _______________(decimal value)

Elapsed time since reset: H_____M_____

REMARKS:

Signed__________________ Date__________

TIME COUNTER MODULE RECORDED DATA LOG

Current Meter Serial No. ____________

TCM Serial No. ____________

Date TCM installed ____________

Date Current Meter deployed ____________

Date Current Meter Recovered ____________

Survey Location ____________

FROM PRINTOUT:

First Time word ____________ (decimal value)

Last Time word ____________ (decimal value)

Total Number Recorded Time Words ____________

Total Number Correct Time Words ____________

Total Number Erroneous Time Words ____________

Total Number Missing Time Words ____________

Total Number Flag errors ____________

REMARKS:

Signed ____________________ Date ______________