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INFORMAL REPORT

A TAUT WIRE BUOY ARRAY FOR ENVIRONMENTAL MONITORING IN AUTEC

OCTOBER 196[illegible]

NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390

INFORMAL REPORT

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ABSTRACT

The Taut Wire Buoy Array (TWBA) of the AUTEC Environmental Monitoring Station has recently completed recording more than two years of almost continuous temperature and pressure data from 14 selected levels at a fixed site in the Tongue of The Ocean. This report covers some of the general aspects of the system, including: array description and operation, significant events of its existence, and data handling and programming.

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This report has been reviewed and is approved for release as an UNCLASSIFIED Informal Report.

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INTRODUCTION

It is the purpose of this report to call attention to a significant and unique prototype electronic system, the Taut Wire Buoy Array (TWBA), functioning in the Tongue of the Ocean as a permanently installed deep-water environmental monitor. In support of the Atlantic Underwater Test and Evaluation Center, the U.S. Naval Oceanographic Office sponsored installation of the TWBA in the Tongue of the Ocean (TOTO) at a point roughly eight miles east of Salvador Point, Andros Island. (Array 1 in Figure 1)

An important step was reached in the history of the TWBA, when in October of 1967 the system had collected more than two years of almost continuous temperature and pressure data. These data are available to those interested agencies or persons having a requirement for it. Closer study of these data applying electronic data processing methods is being completed, which will enhance and intensify our present knowledge about the time variations of temperature within the water column in TOTO.

The major task for NAVOCEANO in AUTEC is to define the oceanographic environment in TOTO so that meaningful interpretations can be made of test data from range operations conducted there. With the advent of this monitoring system prototype, a technological milestone has been reached, providing an abundance of high quality data, thereby enabling better comprehension of ocean environments.

The pronounced success of this monitoring array has since led to expansion of the system by the installation of two new arrays in September, 1967. The ramifications of system expansion and the increased advantage of synoptic environmental measurements in TOTO will be the subject of a later report.

Attention in this report will be focused on the general aspects of the original one-array system: system and subsystem description; chronology of significant events in contracting, developing, installing, and operating the TWBA, and data handling and programming.

ENVIRONMENTAL MONITORING SYSTEM

FUNCTIONS

The Taut Wire Buoy Array has 24 measuring instruments (21 temperature, 3 pressure) together with frequency multiplexing

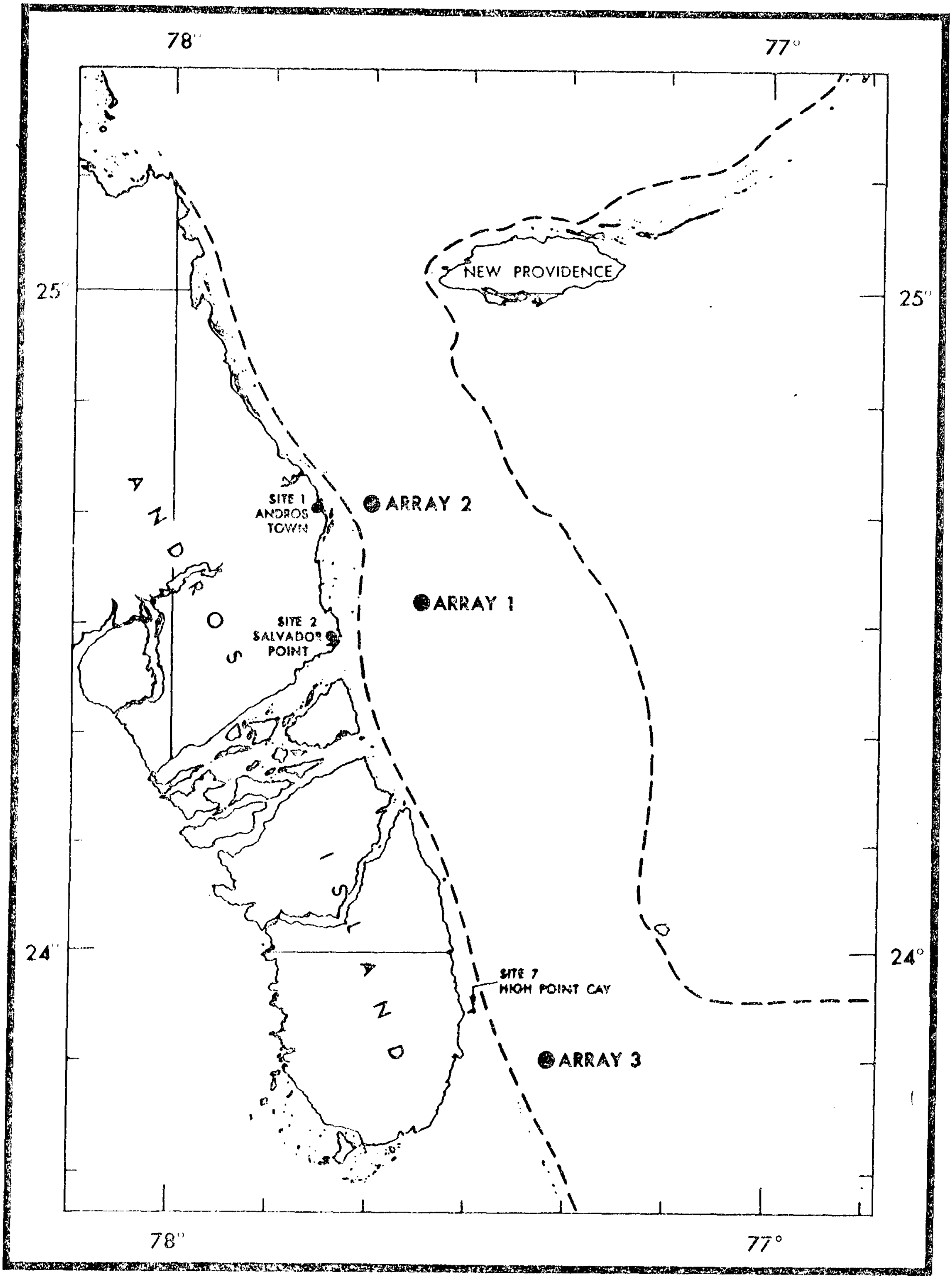


FIGURE 1 TAUT WIRE BUOY ARRAY LOCATIONS

units installed at 14 selected levels along a taut, vertical, armored coaxial cable in 1643 meters of water (Figure 2). Information gathered at the TWBA is transmitted along a 10-mile stretch of submarine coaxial cable to the shore station (Figure 3) near Salvador Point, AUTEC Site 2, where the data are normally recorded on magnetic tape and/or paper tape. When the tape recorder becomes inoperable only paper punch tape recording is possible. Direct print-outs can automatically be made simultaneously by means of an electric typewriter, a Friden Flexowriter in this case.

Output frequencies from the sensors are demultiplexed and processed to provide real-time digital data in standard metric units. These data are displayed visually on the preset frequency counters, while simultaneously being recorded and stored in a format for direct input to computers. The display of data for any depth may be monitored continually in a manual mode which provides sensor values every five seconds.

The date and time is entered on the record with each sequential scanning of the array. Incorporation into the system of a digital clock and calendar provides these and other manually controlled data.

The mode of sampling may be at 32, 16, 8, 4, or 2 minute intervals. Since the sequential sampling duration requires eighty-five seconds, the least possible sampling mode must be two-minutes. Level one through level fourteen respond in sequence when electronically scanned (Table 1). Temperature is recorded at all fourteen levels and, at each even-number level, a secondary sensor was attached for redundant temperature sampling. Pressure readings are sampled at levels 1, 3 and 8.

Sound velocities at 6 levels in the array configuration (level 2, 4, 8, 10, 13 and 14) were to be included in the data records. During the first array installation one velocimeter proved to not be operable and two others failed shortly afterward.

SYSTEM DESCRIPTION

Sensors

Table 1 gives the locations of all sensors in the array in depth from the surface at low water. Following is a description of the sensors:

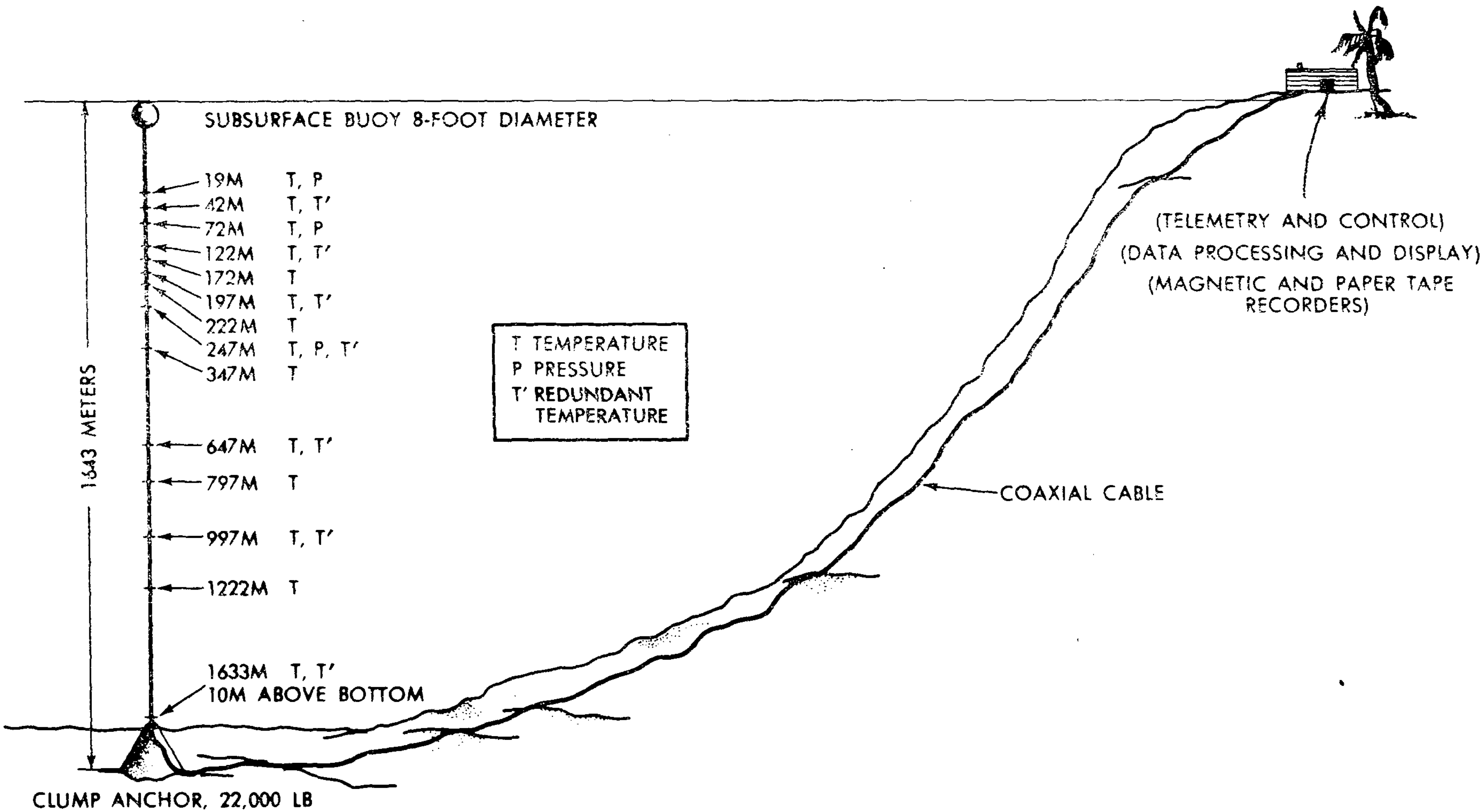


FIGURE 2 AUTEC ENVIRONMENTAL MONITORING ARRAY

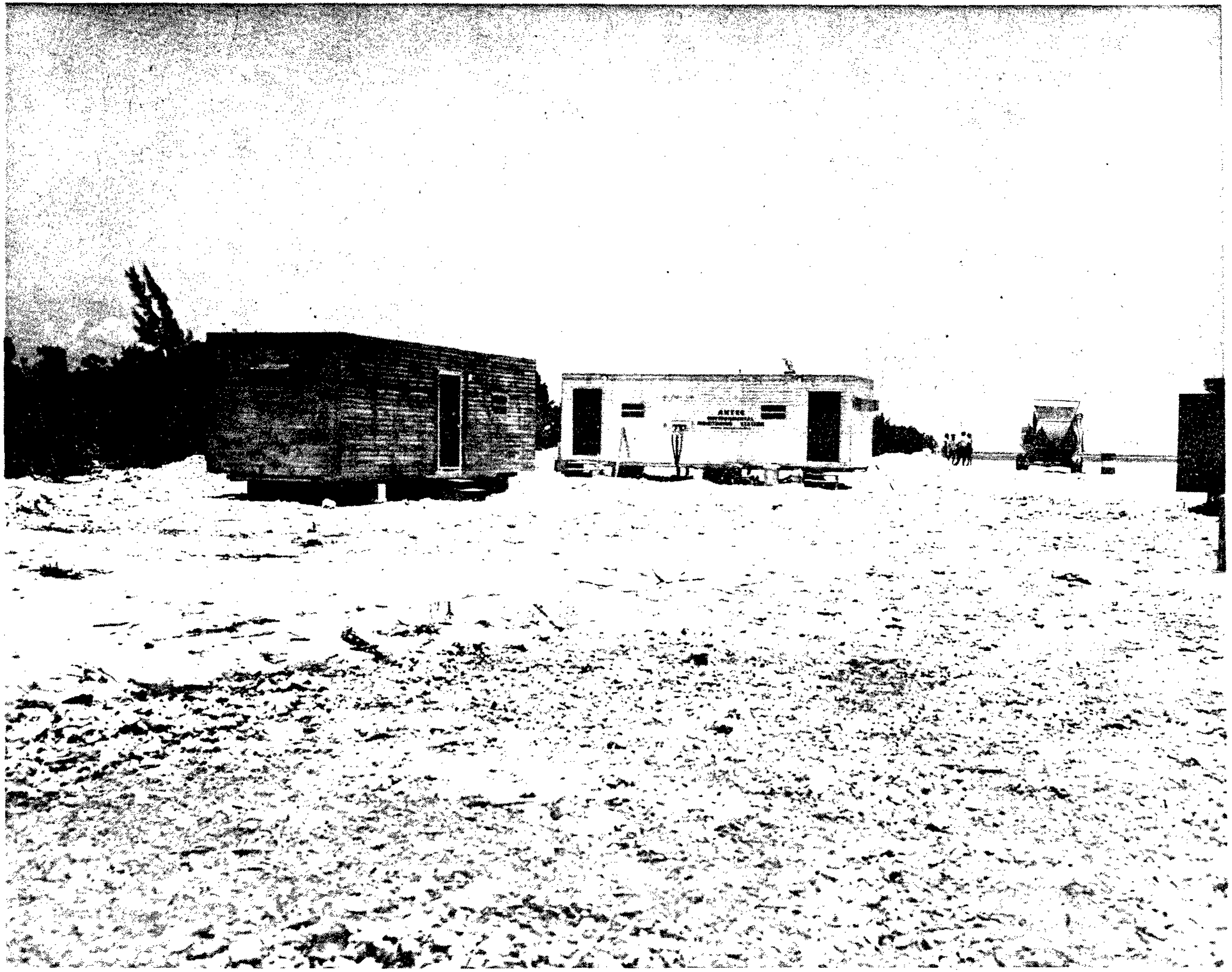


FIGURE 3 AUTEC SITE #2 SHORE STATION

1. Temperature Sensors. Model 4003, manufactured by the Hytech Division of the Bissett-Berman Corporation, are the primary temperature sensors. These units employ a rapid response, platinum wire resistance-controlled telemetry oscillator operating in IRIG* subcarrier bands 7, 8, and 9. Located at all fourteen levels, they transmit information as FM signals. PARALOC**, an electronic circuit which converts the resistance of the platinum thermometer into a frequency corresponding to the temperature, is employed with all of the temperature sensors.

2. Secondary (Redundant) Temperature Sensors. Modified Model 4005 sensors (Hytech) operate in portions of IRIG bands 10, 11, and 12.

3. Pressure Sensors. Model 4004 WB sensors (Hytech) employ strain-gauge type sensors in conjunction with a resistance-controlled oscillator similar to that in the temperature sensor. The 19-and 72-meter units operate in IRIG band 11 with +9.75 percent bandwidth. The 247-meter unit operates in portions of bands 12 and 13.

At each of the fourteen levels on the array, telemetry units provide for group band-shifting of the sensor subcarrier tones upwards into suitable data transmission bands lying between 40 KHz and 285 KHz. Telemetry units are designed to minimize the possibility of generating interfering frequencies in the array should a malfunction occur. These units also supply regulated voltage to the associated sensors.

Array Physical Description

Buoyancy Tanks - One subsurface buoy (or buoyancy tank) provides the lift necessary to maintain tautness and stability to the array by maintaining a total net buoyancy of 26,600 pounds. Adequate tension for restricting the buoy to within a 50-yard scope at the subsurface float is based on a design current profile varying from 1 knot at the surface to 0.4 knots below 1000 feet. The top of the tank is 15 meters below the sea surface.

The tank, eight feet in diameter and spherical in form, is comprised of shaped, 1/4-inch welded steel plate segments, and is finished with four coats of zinc chromate primer and two

* Standard term in the electronic industry for a telemetry band

** A HYTECH registered tradename

TABLE I

Sensor Location, AUTEC Environmental Monitoring Array, Salvador Point

Sensor Level	Sensor No. and Type*	Depth from Surface at Low Water (Meters)	(Feet)
1	1(T), 2(P)	19	62
2	3(T), 4(T')	42	138
3	5(T), 6(P)	72	236
4	7(T), 8(T')	122	400
5	9(T)	172	564
6	10(T), 11(T')	197	646
7	12(T)	222	728
8	13(T), 14(P), 15(T')	247	810
9	16(T)	347	1138
10	17(T), 18(T')	647	2123
11	19(T)	797	2615
12	20(T), 21(T')	997	3271
13	22(T)	1222	4009
(Bottom) 14	23(T), 24(T')	1633	5358

*(T) Temperature, Hytech Model 4003 with Rosemont probe
(T') Temperature (Redundant), Hytech Model 4005 with Rosemont probe
(P) Pressure, Hytech Model 4004 WB with strain gage

coats of anti-fouling red vinyl paint. Two internal steel partitions divide the tank into three buoyancy sections, two of which can together provide sufficient buoyancy for the array. The buoyancy tank is shown in Figure 6.

Anchor - The anchor assembly is a reinforced concrete and scrap iron clump weighing 22,000 pounds in air and 17,000 pounds in water and it is connected to the array at the fishplate. A lowering line connected at this point, used to lower the array during final installation, was streamed out in a given direction from the array and dropped to the bottom. Future retrieval of the array will be achieved by first grappling this line. By bringing up the anchor assembly with this line, undue strain will be negated on the array cable and its components.

Transmission Cables - The array cable is a double-armored coaxial cable with a breaking strength of 38,000 pounds. An insulated solid copper core conductor with a return circuit of copper tapes constitute the electrical portion of the cable. At breakouts along the array cable are positioned the sensors with associated multiplex equipment, mounted in steel, cage-like enclosures.

Measures have been taken, both conventional and unconventional, to protect the array cable and its components against fouling and corrosion. Conventional means are employed, such as: zinc galvanizing, zinc anodes, and anti-fouling paint. The passage of D.C. current into the sea water through a special, nonconsuming electrode, composed of silver-alloyed lead, causes the release of poisonous chlorine gas to retard fouling - a most unconventional approach to the fouling problem. The toxicity of the gas released has affect only within inches of the electrode surface.

The array cable terminates at the fishplate assembly, the point at which it is spliced to the submarine coaxial (sea) cable (Figure 8). The anchor attachment hardware also is joined to the fishplate assembly.

The electrical portions of the sea cable and of the shore-end cable (the last cable link for transmission into the shore facilities) are of similar fabrication. These two cables were also spliced on shipboard, and the splice was lowered well seaward of the reef.

Toward shore, the more heavily armored shore-end cable is secured by bags of ready-mix concrete; and on shore, the cable is entrenched to its termination point.

Shore Station Electronics

The shore station equipment accomplishes six major functions:

(1) demultiplexing;
(2) sequential scanning of signals, level by level;
(3) digitizing of sensor signals at each level in scientific (metric) units;
(4) conversion of digital signals to required format for recording;
(5) control of each of three recording devices;
(6) timing and generation of time and identifying codes.

The entire array and shore station electronics is powered at the shore station by a 120-volt, single-phase, 60-cps utility power generator. Shore station electronics are housed at the instrument room in standard, six-foot electronics racks (Figure 5-center and right rack).

A pair of regulated power supply units (Trygon Electronics Inc. Model M 160-5A), connected in series, supply power for the array sensors and multiplex units. They provide a current capacity to 5 amperes at voltages up to 320 volts, though the array normally runs on 3 amperes at 225 volts.

Frequency multiplexed signals coming from the array pass through a power separation filter which separates the array signals from the D.C. power. Array signals then pass to a bank of relays which, under control of the timing logic, connect the desired signal separation filter. These filters, identical to the ones used in the array multiplexer units, separate the sensor signals from one another and from unwanted demodulation products. Signals are then applied to the appropriate digitizing counters to be read as input data.

Data Processing Subsystem

Input data, consisting of time and day of the year, auxiliary data (inserted by manual thumb-wheel switches), record number, and the temperature and pressure readings from the TWBA, are presented to the tape recorder and Flexowriter in binary coded decimal (BCD) form and are visually displayed in decimal numbers. The six-digit record number derived from a stepping switch counter, the day-of-the-year, and the time in hours and minutes begin each readout cycle. The time, in hours (to 24), minutes and seconds is derived from a one pulse-per-second input supplied to a Parabam digital clock. A one pulse-per-day input is supplied the Parabam digital calendar for the year. Three digits for the day of the year, two for the hour, and two for the minutes give a total of seven digits in the date-time group. (Appendix I)

As the recording cycle is synchronized with a two-minute period, the time is recorded once each two-minute period on the exact minute at which the scan cycle begins.

The actual measured temperature and pressure readings are sampled in sequence from level 1 through level 14. These parameters are displayed on HP Model 5214L preset counters, which convert the presented input frequencies to BCD output in scientific units. Five digits of information are recorded from each counter, alternately interrogated.

Two basic modes of operation provided by the data processing subsystem are "record" and "playback".

RECORD MODE - With the sequential readout of the entire array in record mode, data from the digitizing counters are read, reformatted, and recorded on magnetic tape and/or punched paper tape, and/or a Flexowriter listing. The desired repetition rate of array scan for maximum data output is two minutes. A pinboard programmer, however, allows selection of any or all data for printout at any of the five selected rates: 2, 4, 8, 16 or 32 minutes.

Five seconds are allowed at each level for the digital display on the preset counters and the recording, both on tape or by the Flexowriter, of two six-digit data words. The program control subsystem switches the data, one word at a time, from the counters and is presented, one character at a time, to the tape recorder and to the Flexowriter.

In order to make individual sensor checks, a "manual" switch is thrown which permits the observation of data from any level without recording it. In the manual mode, new data are digitized each five seconds.

PLAYBACK MODE - Previously recorded data may be reviewed by playing the data back through the Flexowriter in the same format as it was recorded. Following the printing of each character, the Flexowriter signals the tape recorder that it is finished. The recorder then reads out another character, concurrently generating a command for the Flexowriter to print it. The Flexowriter will print the data at the maximum operating speed of 9.6 characters per second. Figure 4 shows in simplified form how the data flows through the data processing subsystem.

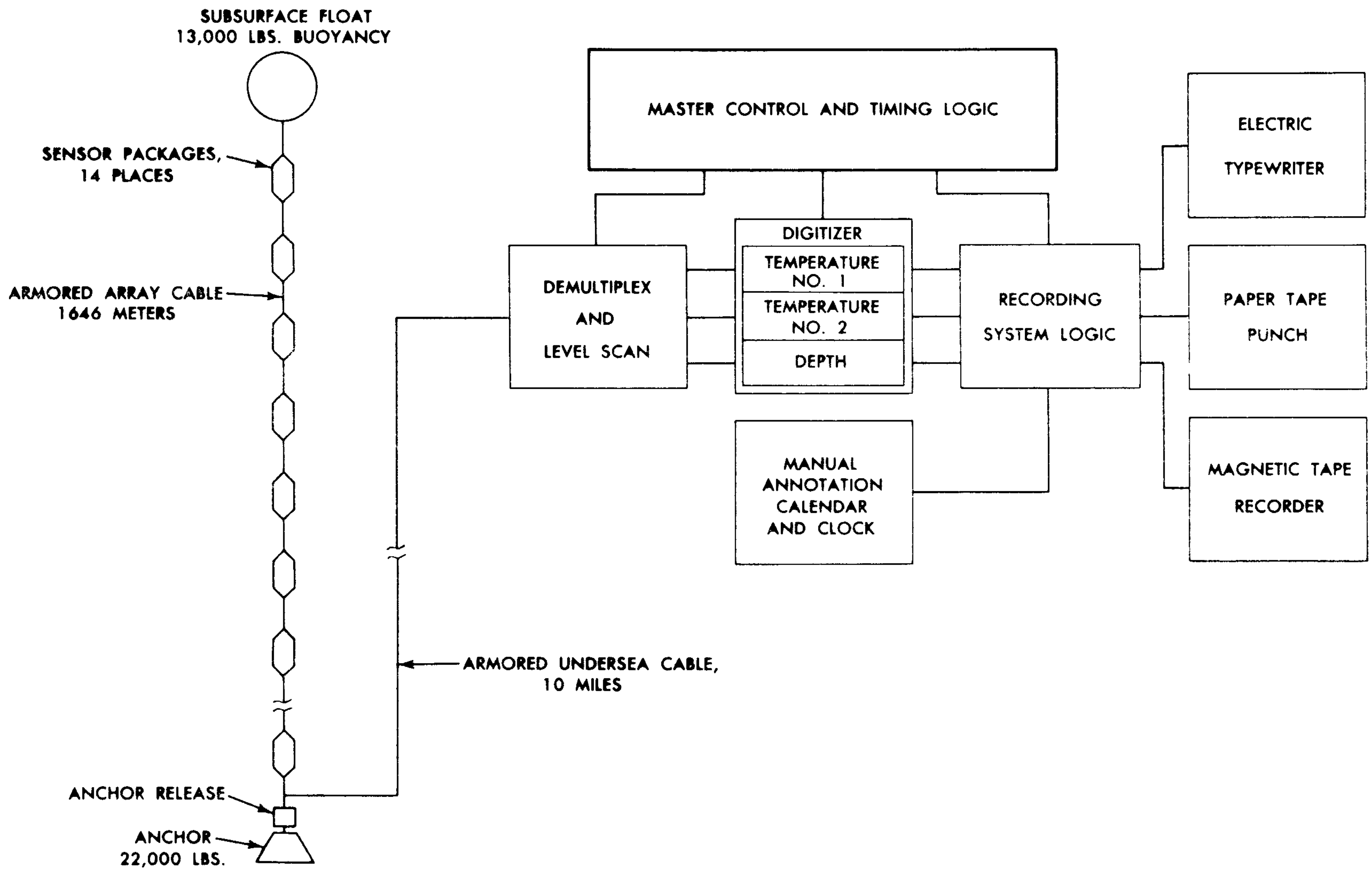
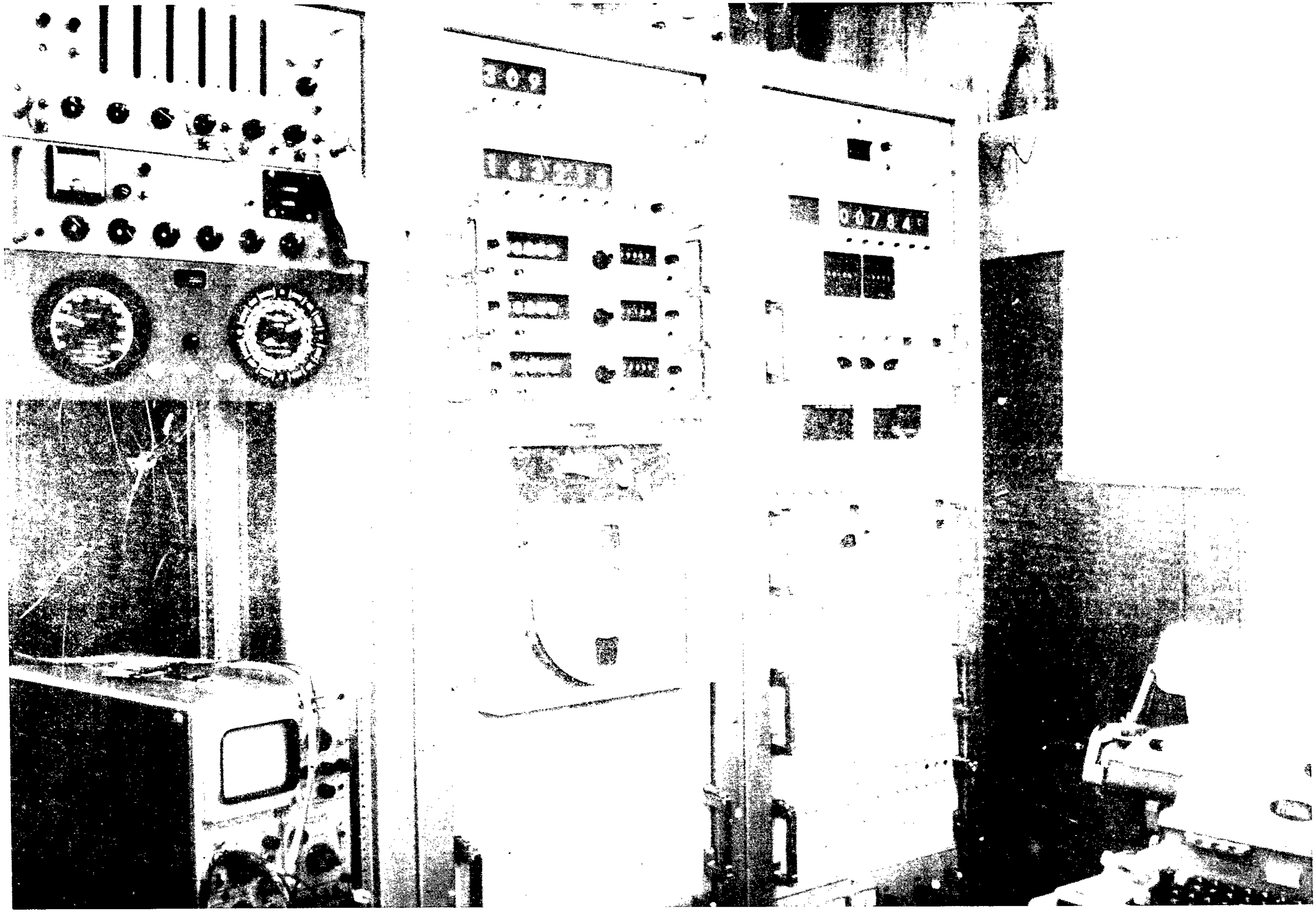


FIGURE 4 TAUT WIRE BUOY ARRAY, SIMPLIFIED BLOCK DIAGRAM

FIGURE 5 TWBA SHORE STATION INSTRUMENTATION



MONITORING STATION

The AUTEC Environmental Monitoring Station is located at AUTEC Site 2, just adjacent to Cargill's Wells Settlement, and a few hundred yards north of Salvador Point. Two trailers, a laundry shack and a generator building comprise that part of Site 2 occupied by NAVOCEANO personnel.

Two NAVOCEANO personnel man the station at any one time, an oceanographer and an electronic technician. A scarcity of personnel frequently necessitated substituting of physical science technicians for oceanographers.

It is the primary duty of the oceanographer to monitor and make an evaluation of data from the TWBA. He makes daily validity checks of temperature and pressure data for all sensors, relying upon an "envelope" of historical data for comparison. He makes comparisons of data from redundant temperature sensors to provide additional information on sensor performance. The oceanographer may interrupt automatic sampling at any time in order to intensify surveillance of certain sensors during the data validity checks by placing the system in "manual" mode.

Secondary functions for the site oceanographer are maintaining a weather station and making weather and supplementary oceanographic observations. Standard meterorological instruments, i.e., hygrothermograph, microbarograph, rain gage, and anemometer, are located at the site for the purpose of recording air temperature, relative humidity, amount of precipitation, and wind speed and direction. Cloud type and amount are also recorded during observation times. A bubbler tide gage installed in the instrument room continuously records sea level variations in the site turning basin. The tide graph is annotated daily in order to check the clock mechanism in the tide gage recording system. A fixed tide staff provides a rough visual calibration factor with which the oceanographer can determine tide gage accuracy in recording tide height. The site oceanographer makes his observations at 0700, 1200, and 1700 hours daily. At these times, he also measures the sea surface temperature in degrees Fahrenheit using a simple bucket thermometer.

The duties of the electronics technician are basically to maintain all electronic equipment, primarily the shore electronics for the TWBA, and to assist in site maintenance. When drifting occurs between redundant temperatures, or a sensor malfunctions, he runs frequency checks at each sensor to verify malfunction.

The site personnel also give support to other NAVOCEANO personnel involved in duties that include functions at Site 2, providing this service does not in any way interfere with their own mission.

Since the installation of a telephone by RCA, site personnel can more easily arrange for supply delivery to Site 2. Boat and, less often, helicopter are the means of transportation used to supply the site, always a troublesome activity. Prior to telephone installation, site personnel had to arrange travel to Fresh Creek to order supplies and to phone NAVOCEANO. These inconvenient trips often were difficult to arrange besides being time-consuming. With telephone communications now available at Site 2, the necessity for leaving the monitoring station has been kept to a minimum.

SIGNIFICANT EVENTS

BACKGROUND

Prior to the installation of the environmental monitoring array, NAVOCEANO's efforts in support of the projected AUTEC Range had been dependent upon shipboard operations. NAVOCEANO's responsibility to define and document the ocean environment for AUTEC by shipboard methods required frequent surveys in both the Tongue of the Ocean and Exuma Sound. Operations were either acoustical, hydrographic, geodetic, or oceanographic in nature, or a varying combination of all or some of these. They sampled and measured certain parameters employing methods ranging from those considered of a classical nature to others of a high degree of sophistication.

Short-term variations in physical properties in excess of what previously had been considered possible led to the initial concept of a permanent monitor for certain parameters in TOTO. G.S. Ruggles pointed out in his IMR, "Periodic Variations Within the Water Column in the Tongue of the Ocean, Bahamas", that two independent sets of data, March 1962 and May 1962, definitely show that the time rates of change of a parameter which characterize long-period fluctuations at a given level are much less than the time rates of change attributed to the ebb and flow of the tide". He advocated an effort to develop a permanently installed oceanographic monitoring systen that would permit recording both short-term and long-term changes in oceanographic and acoustic parameters.

From studies based on data collected from ship operations, apparent amplitudes and phase relationships of temperature variations were documented, and, on this basis, sensor depths were later selected. It was found necessary to locate the sensors in horizontal layers providing optimum results. Determination of aperiodic vertical displacement of horizontal layers and the extent of migration would thus be made possible.

Project AUTEC*deemed it advisable in mid-1963 to prepare a formal requirements specification for the Taut Wire Buoy Array.

CONTRACT HISTORY

Actual contract development began on 3 May 1963 when NAVOCEANO solicited fixed-price technical and cost proposals in accordance with NAVOCEANO's performance specification ID-DE-0442 (dated 15 March 1963). In response, fifteen companies submitted technical proposals for evaluation. The technical proposals contained detailed information on specific sensors and the system design that would furnish NAVOCEANO its required data.

An evaluation panel consisting of NAVOCEANO technical personnel was appointed on 31 July 1963 to evaluate the fifteen proposals that had been received. The three companies that had submitted technically feasible proposals were selected for further negotiations by the contracting officer. Cost negotiations ensued and on 23 December 1963 the contract was awarded to the Martin Company (later assigned to the subsidiary company, Bunker-Ramo) for the lowest priced, technically qualified offer. The promised delivery date was to be exactly six months later, on 23 June 1964.

During the following months, a demonstration of systems workability was viewed at the contractor's plant by NAVOCEANO personnel. The cable and sensors had been earlier subjected to a test pressure of 3000 psi at the David Taylor Model Basin with no apparent malfunctioning.

INSTALLATION

Initial Implantment

On 22 July 1964 the array was installed, initially touching down in water 60 feet deeper than the design depth of 5400 feet. The array was lifted and moved, however, into a shallower depth where allowable depth tolerances on the flotation buoy were encountered. The submarine cable was laid to a point just seaward

*Project AUTEC refers here to NAVOCEANO's effort in TOTO.

of the Andros Barrier reef on 22 July. Cable laying from seaward of the reef to the shore facilities was accomplished on 23 July 1964, and the two submarine cables were spliced by the 24th.

Upon immersion, one temperature sensor and a sound velocimeter failed. The remaining two sound velocimeters failed subsequent to implantation. Power supply and tape recorder malfunctioning plagued the system during three weeks of intermittent operation until it ceased to operate entirely on 19 August. On both the 19th and 29th of August, attempts were made to "bake out" intermittent short circuits in the system by applying a current overload, but this did not remedy the situation. On 1 November 1964, the array was retrieved by Bunker-Ramo and shipped back to the plant for refurbishing.

Second Implantment

A second implantment of the TWBA was made in April 1965, after factory rework. All sensors performed for a period of approximately twelve hours before a short developed in the array cable at the breakout for sensor level nine. The array was immediately retrieved and efforts were made on site to repair the malfunction. The attempts were unsuccessful, however, and the array and sea cable were entirely recovered and returned for additional rework.

Final Implantment

The AUTEC TWBA was finally implanted on Thursday, 21 October 1965. This implantation, in a depth of nearly 5400 feet, at last provided NAVOCEANO with an operating deep-water environmental monitoring system.

The period from 6 October to 18 October was spent in preparing the array for installation, with actual implantment commencing on the morning of 18 October. Three ships were required for the operation: the cable ship, WESTERN UNION, which was the control ship; the H.J.W. FAY; and the H.G. WILLIAMS, a tug.

The array cable was played out over the port side of the WESTERN UNION and towed away by the support vessel, H.J.W. FAY (Figures 6, 7). Flotation devices kept the array buoyant until the entire array cable was stretched horizontally between the two ships. The fishplate (Figure 8), termination point for the array and sea cables, was passed from the WESTERN UNION to the tug, H.G. WILLIAMS. The H.G. WILLIAMS then lowered the cable and sea anchor with a lowering line while the WESTERN UNION played out the sea cable. Monitoring sensor frequencies along the cable from the deck of the WESTERN UNION, after placing of the array on the bottom, showed the system to be

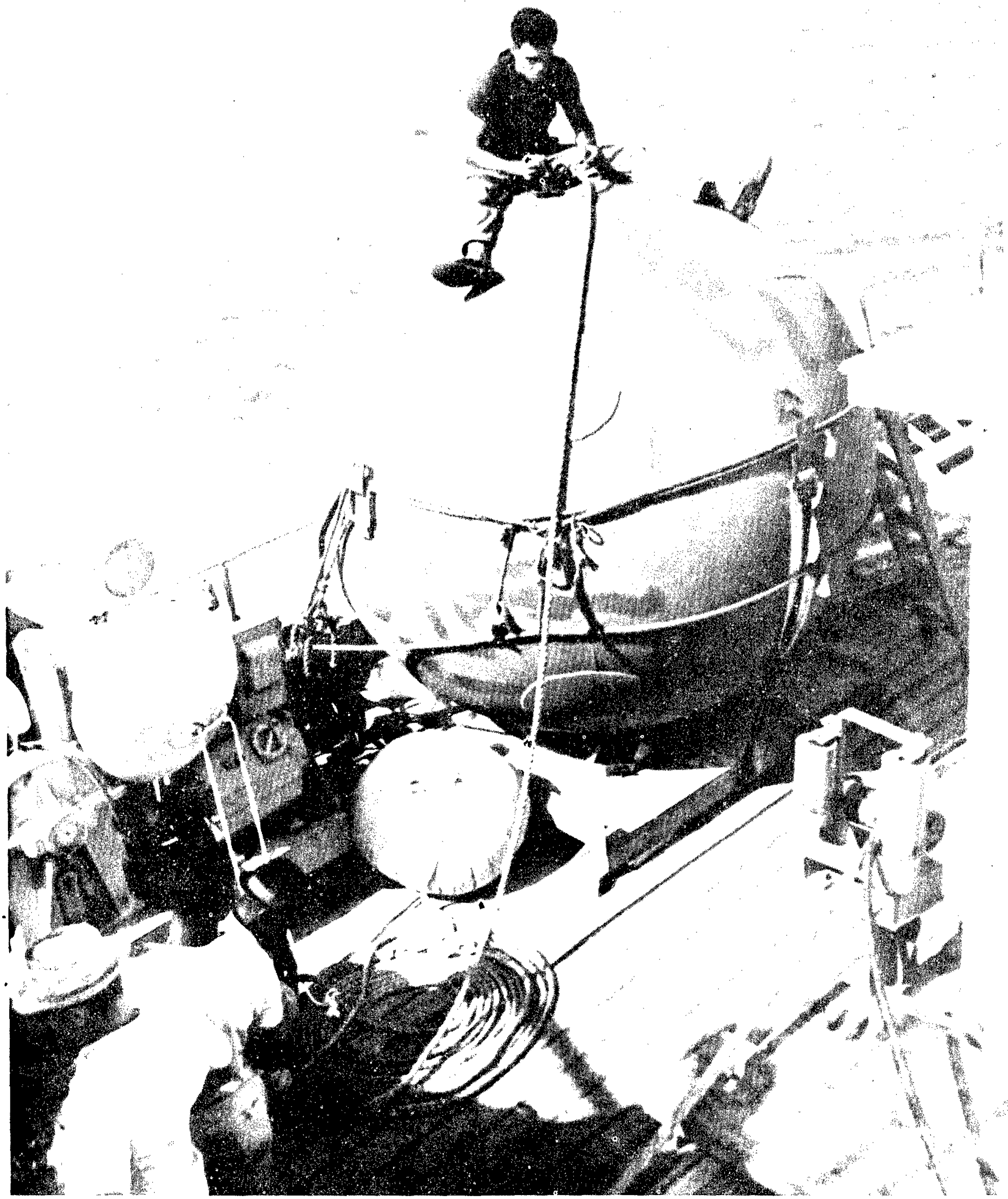


FIGURE 6 BUOYANCY TANK

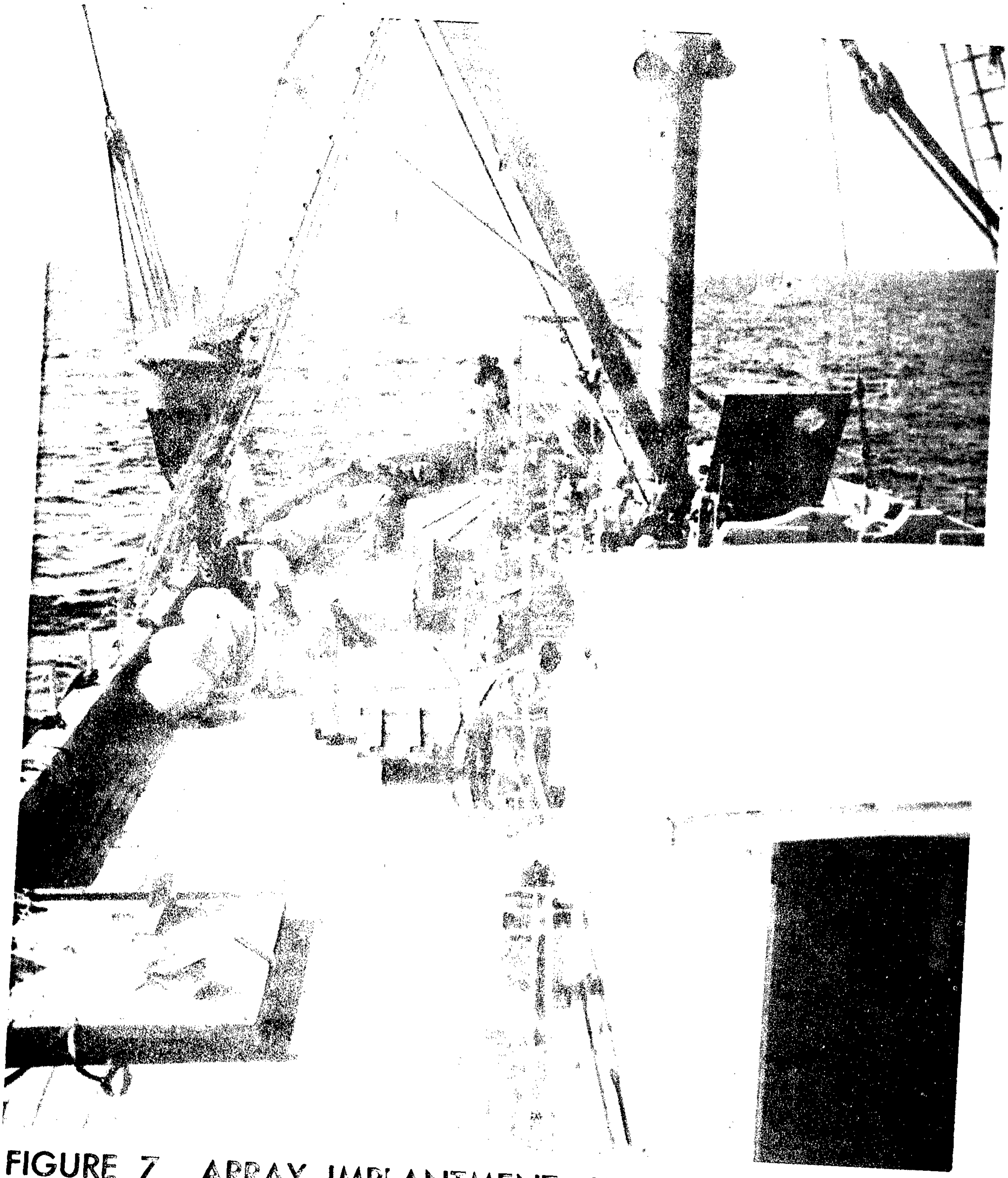


FIGURE 7 ARRAY IMPLANTMENT—H.J.W. FAY TOWING AWAY ARRAY CABLE

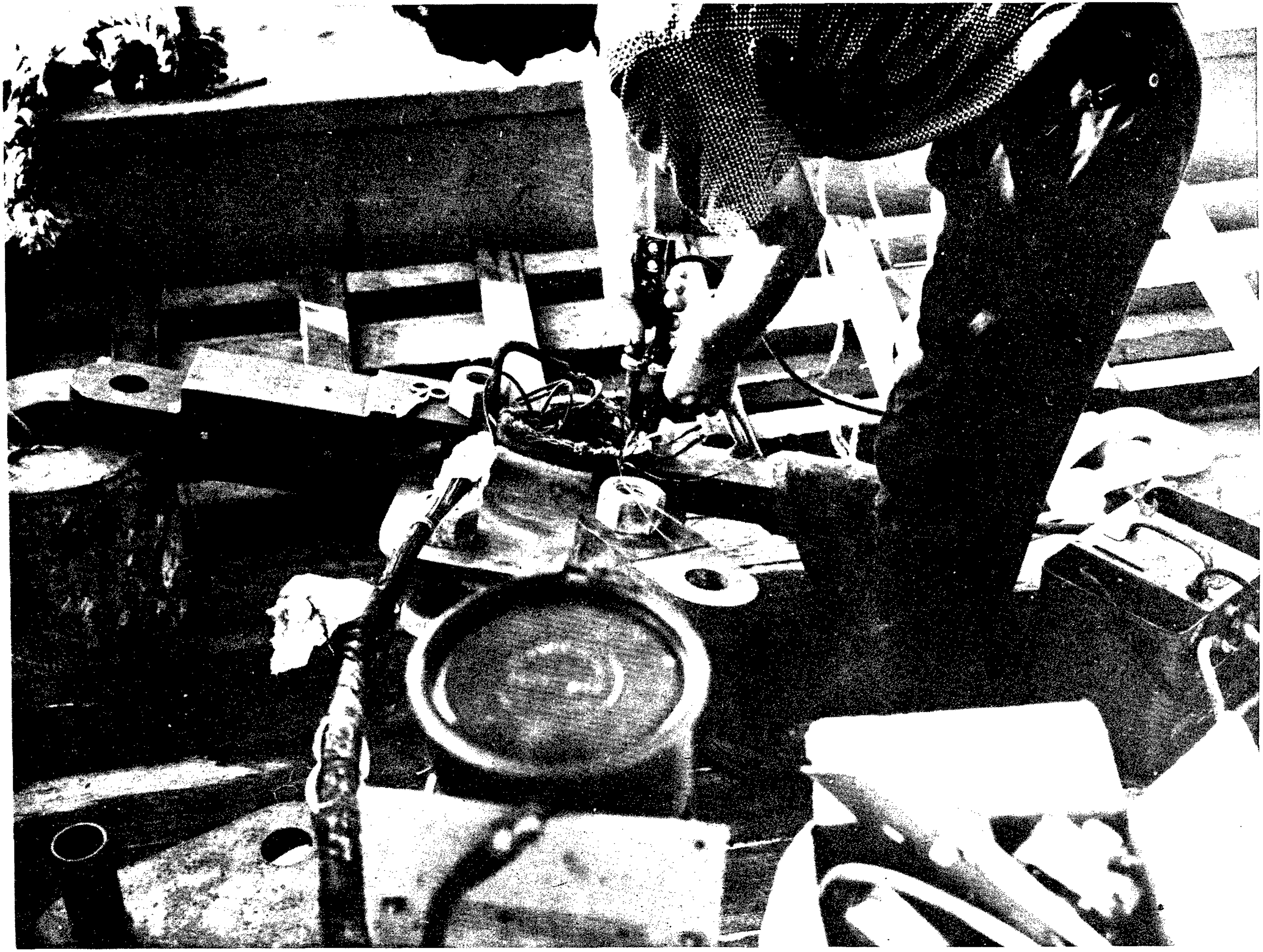


FIGURE 8 SPLICING OF ARRAY AND SEA CABLES

100 percent operational. Following this check, the remaining seven miles of sea cable was laid toward the shore station at Site 2. Splicing the shore and sea cables was completed at 2400 hours on 21 October, thus terminating the implantment operation. From that time on, all monitoring was performed at the shore station.

Some sensor failures and data handling problems occurred during the ensuing forty-five day acceptance period; however, the system continued to operate within the limits of acceptance performance. Among problems occurring within the data handling system were: the data sampling rate controls not sequencing properly, and the tape recorder failing to operate in the playback mode.

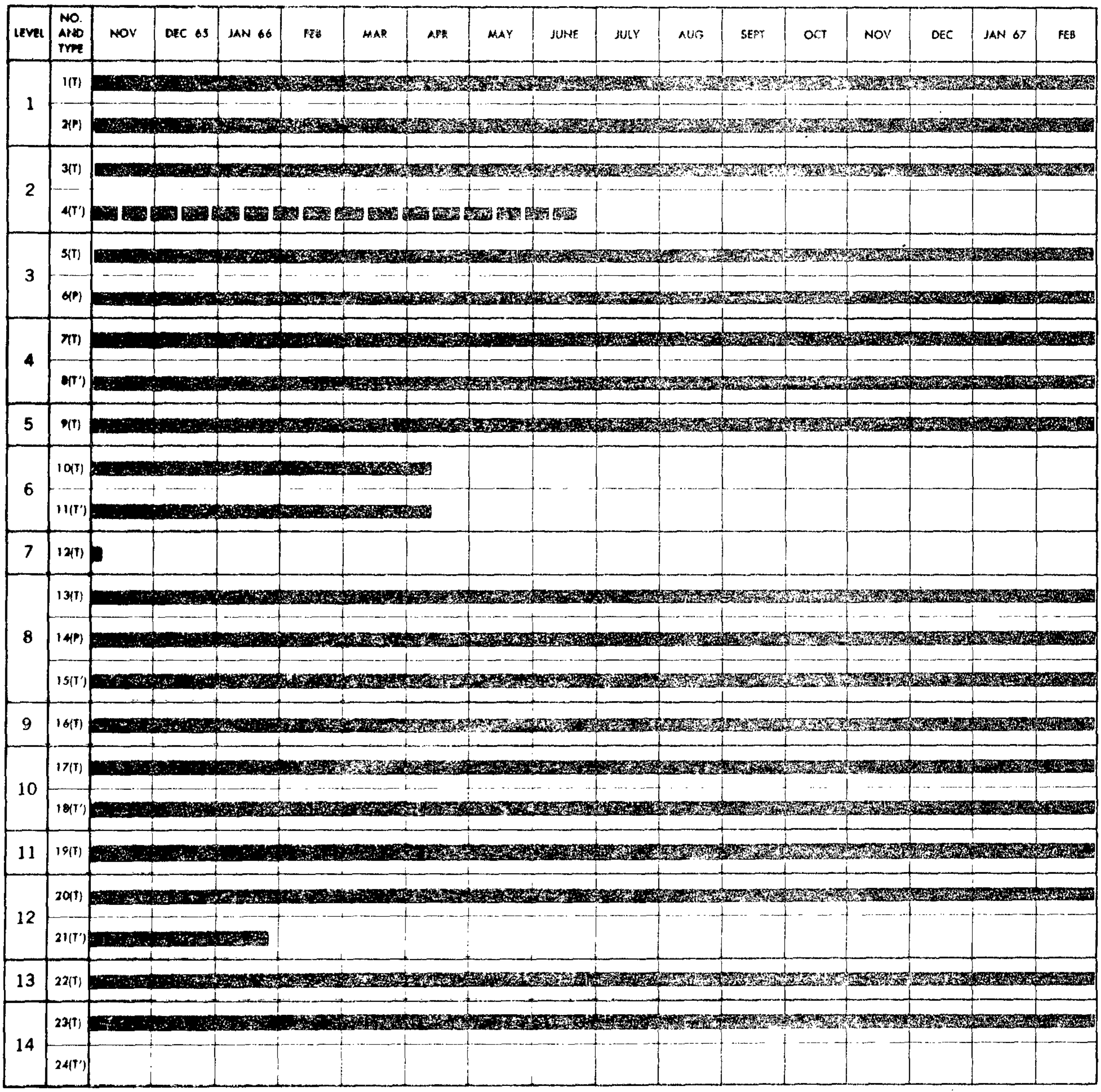
OPERATION

SENSOR ENDURANCE

The TWBA temperature and pressure sensors have been remarkably reliable and consistent since installation. Of the 24 sensors on the array, 17 still function properly and only 6 have not lasted. The Sensor Endurance Bar Graph (Figure 9) shows the functional duration of all sensors through February 1967. Broken bars indicate erratic operation; solid bars indicate operation at an acceptable performance level.

Reasons for sensor failure may be inferred, but definite conclusions would be impossible to make without first examining the sensor and break-out area. The inaccessibility of the underwater portion of the array makes it impossible to inspect the suspect individual sensor when a failure is discovered. Recovery and overhaul are excessively costly operations that must be restricted to total or near-total array failures.

All of the six temperature sensors that failed did so within the first six months in the operational period of the system. The last sensor to give out was sensor 4 at level 2, which had been drifting and functioning erratically until it ceased operating on 20 June 1966. Both temperature sensors at level 6 failed on 13 April 1966. Sensor 21 at level 12 stopped on 26 January 1966. Also, on 6 November 1965, sensor 12 at level 7 failed. Though sensor 24 at level 12 functioned properly when monitored from the deck of the WESTERN UNION during installation procedure, it did not do so when monitoring commenced at the shore station. There is no data record, therefore, from sensor 24.



T - TEMPERATURE P - PRESSURE T' - REDUNDANT TEMPERATURE

FIGURE 9 SENSOR ENDURANCE BAR GRAPH

It appears that, unless marine fouling or more catastrophic events soon occur, the marine environment has determined the "survival of the fittest" of these sensors. From all indications the system has essentially stabilized itself, and it should continue operating at an acceptable level of performance for some time.

SENSOR ACCURACY

All sensors were pre-tested in a laboratory tank to prove capability of the sensors to operate accurately under pressure conditions simulating those encountered in the sea.

The total loss of sensor data within the accuracy specified (±0.05°C for temperature sensors; ±0.25% of full scale for pressure sensors) defines "sensor failure". Conversely, all sensor data collected within these limits defines sensor accuracy. This definition, established in the contract for the 45-day test period, leaves no question of marginal sensor operation; the limits are very clearly defined. Yet, to expect absolute conformity to those accuracy specifications is nearly impossible.

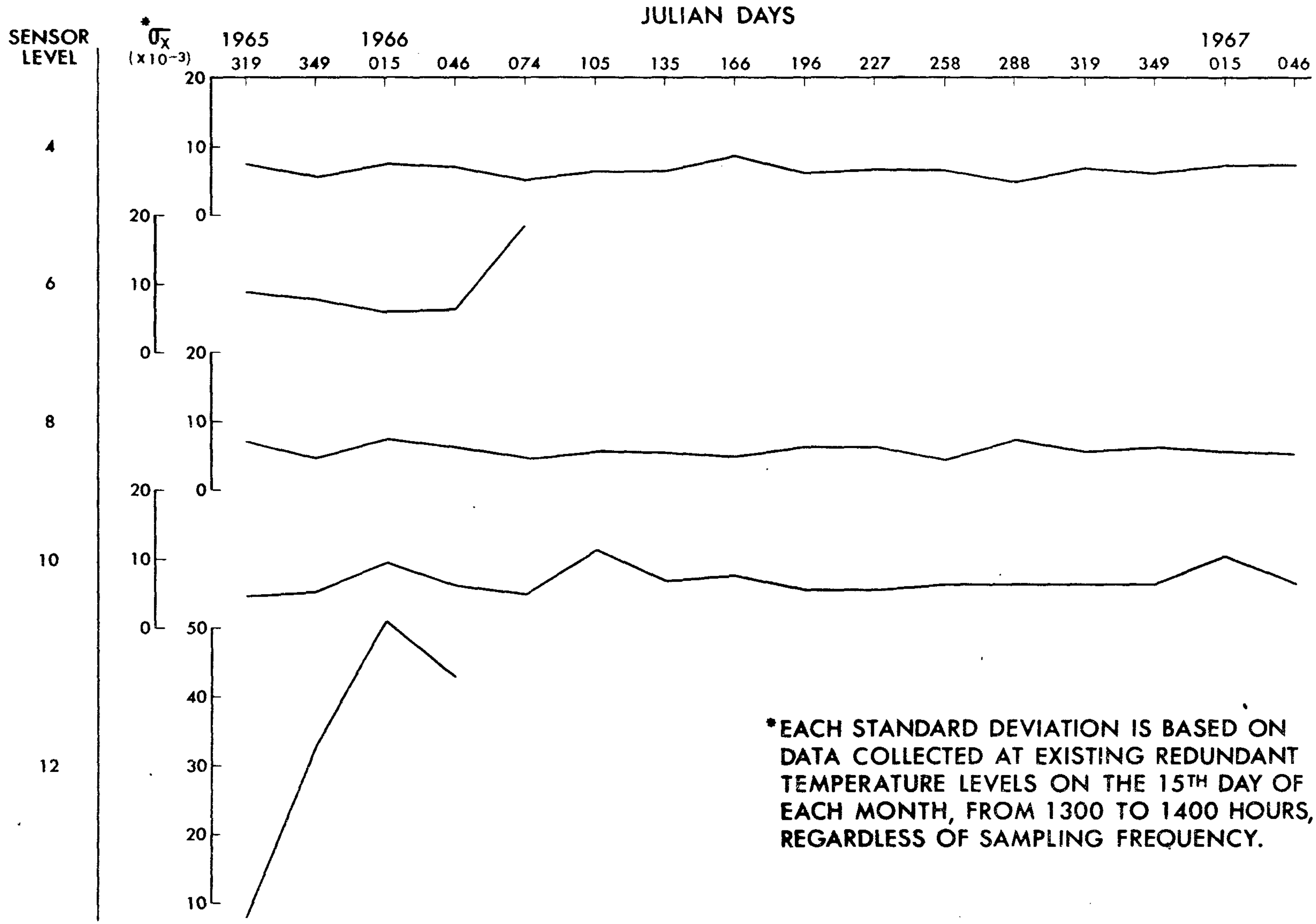
Temperature sensors are declared to be operating accurately if the output values conform to the range of historical values appropriate to that sensor depth. Accurate operation of pressure sensors is declared if (1) output values remain conformable to expected values based on the knowledge of approximate buoy depth, or (2) the relative depth readings of two pressure sensors clearly conform to the design dimension (± allowable errors) between the two sensors.

An even more important determination of sensor accuracy is predicated on performance with time. The time concept implies consistency and stability in sensor operation and will be approached separately for both temperature and pressure sensors.

TEMPERATURE SENSOR STABILITY

A consistent departure of greater than 0.10°C in corrected temperature values at levels of redundancy defines a failure of one or both sensors at that level. Clearly, a satisfactory degree of accuracy of the entire array with time is suggested by adequate conformity with this standard over all the levels of redundancy.

One way of graphically demonstrating the maintaining of accurate operation of the TWBA is to show statistical consistency between temperature values at redundant levels- (See figure 10). By plotting the standard deviation from the mean



*EACH STANDARD DEVIATION IS BASED ON DATA COLLECTED AT EXISTING REDUNDANT TEMPERATURE LEVELS ON THE 15TH DAY OF EACH MONTH, FROM 1300 TO 1400 HOURS, REGARDLESS OF SAMPLING FREQUENCY.

FIGURE 10 STANDARD DEVIATIONS FROM THE MEAN OF REDUNDANT TEMPERATURE (°C.) DIFFERENCES of one-hour temperature differences per month (1300-1400 hours on the 15th day of each month was selected) from November, 1965, through February, 1967, this consistency can be shown.

Dispersions about a mean temperature difference maintain consistency throughout this 14-month period as demonstrated by temperature sensors at levels 4, 8, and 10. At level 6, both sensors failed on 13 April 1966. The sudden positive gradient occurring between (Julian) days 046 and 074 reveals sensor trouble. At level 12 a steep positive gradient occurring from the outset results from difficulty with sensor 21. As it drifted, the dispersions about the mean temperature difference grew increasingly large.

In calculating the means for days 074 and 166, 1966, only eight differences were averaged as compared to thirty for each of the other days. Fewer values were available for that same hour as the array was operating on the 8-minute sampling mode rather than on the 2-minute mode. The results, though representing fewer samples, seem equally valid in presentation.

Note that for levels 4, 8, and 10, almost all of the dispersions fall between 0.007 and 0.010°C, maintaining consistency throughout.

PRESSURE SENSOR STABILITY

The only way of making a continuous accuracy check of the pressure sensors of the TWBA is to employ methods based on pressure reading differences. There is no "envelope" of historical data upon which to compare pressure readings for validity as there is for temperature data. Only the constancy of pressure differences between sensors over long periods is truly indicative of stable pressure sensor performance.

Pressure data in decibars from the 316th day of 1965 at 0000 hours were used to determine how accurately the pressure sensors were positioned on the array (Table 2). The results may be used as a reference for future pressure data as it can be assumed that positions on the array cable will remain constant. The corrected value at each level was used to arrive at an estimated actual geometric depth, which compares favorably to the depths as planned in the array construction. Table 2 lists the results of calculations: Standard Geopotential Depth, Estimated Geopotential Distance from the Surface, and finally, Geometric Depth.

Starting with the corrected pressure reading at level 01, 19.52 decibars, one can follow through the table to determine

TABLE 2

PRESSURE SENSOR DATA

I. Data Selected: Time 0000 hours (mid-tide range), Day 316, 1965

Level 1 reading 19.50 + 0.02 correction = 19.52 decibars
Level 3 reading 72.92 + 0.18 correction = 73.10 decibars
Level 8 reading 251.0 - 0.10 correction = 250.0 decibars

II. Comparisons

A. Depth Estimations

LEVELS	1	3	8
STANDARD GEOPOTENTIAL DEPTH (dynamic meters)	18.99	71.09	243.0
ESTIMATED GEOPOTENTIAL DISTANCE FROM SURFACE* (dynamic meters)	19.03	71.27	243.7
ESTIMATED GEOMETRIC DISTANCE (meters)**	19.41	72.70	248.6
ARRAY CONSTRUCTION PLAN (meters)	21.4	75.0	248.6

B. DIFFERENCES

LEVELS	1 - 3	3 - 8	1 - 8
PRESSURE (decibars)	53.6	176.9	230.5
STANDARD GEOPOTENTIAL (dynamic meters)	52.1	171.9	224.0
ESTIMATED ACTUAL GEOPOTENTIAL (dynamic meters)	52.2	172.4	224.7
ESTIMATED ACTUAL GEOMETRIC (meters)	53.3	175.9	229.19
CONSTRUCTION (meters)	53.6	175	238.6

* Obtained by using the equation: $\alpha\,dp$, the Hydrostatic Equation. The average Specific Volume in the upper layer reported by Magnitzky and French (Ref. 2) is 0.9749.

** Sverdrup, Johnson, and Fleming approximate the geometric depth should be 1.02 times the Geopotential depth: (19.03) 1.02 - 19.41 meters.

the estimated actual geometric depth, 19.41 meters.

First, employ table II of "The Oceans" (p. 1054) and interpolate to obtain the Standard Geopotential Depth, 18.99 dynamic meters, a value that would exist in an homogeneous ocean at 0 °C. and 35°/oo salinity.

Second, the Estimated Geopotential Distance from the Surface is determined by α dp, the Hydrostatic Equation. The average value of specific volume (α) is reported by Magnitzky and French (ref. 2) to be 0.9749. The Estimated Geopotential Distance from the surface is 19.03 dynamic meters.

Third, Sverdrup, Johnson, and Fleming relate both the approximate geometric depth and the standard geopotential depth to pressure in decibars. 990 meters (geometric) is equivalent to 970.4 meters (geopotential). This leads to the approximation that geometric depth should be 1.02 times the geopotential (The Oceans, p. 1054). This factor times 19.03 gives us the geometric depth of 19.41 meters. For level 03 and level 08, the same procedure is followed.

Table 2-B reveals the close comparisons of planned positions of sensors in the array to the calculated results. These small differences between derived depths and the construction plan depths can be explained by a combination of sensor error, cable measurement error, and variations in cable strain.

ARRAY DATA

CONTINUITY

Data from the TWBA may set precedent as a record amount resulting from the operation of any permanently installed, buoyed environmental monitor. Data collected since the successful reinstallation of the array, aside from being abundant, is of high quality. The continuity of the data is marred, however, by gaps resulting mostly from system shut-down, whether voluntarily or involuntarily.

Voluntary shut-down of the TWBA occurs for the following reasons: (1) switching to another generator for power source; (2) closing up the station during times of natural disaster, i.e., hurricane, floods, etc.; (3) changing magnetic tapes. Involuntary shut-downs, which cause the greatest record loss, occur when: (1) the array fails or malfunctions; or (2) the generator fails or malfunctions.

Other gaps may show up in the data record for reasons unrelated to system stoppage, such as: (1) running checks or tests on the equipment, (2) running sensor checks (system on the manual mode provides no data record) and (3) playing back the tape. In these cases the array is in operation but not in the "record" mode.

The cause of most recording time lost lies with the generators which originally supplied power to the array. Normal wear has been the greatest source of trouble with generators. The most common of these have been: worn brushes, faulty fuel pump, electrical wire disconnects, corroded commutator, clogged fuel line, and fuel leaks.

Troubles arising from the TWBA also create gaps in the data record, especially when parts replacement time is involved. For example, in late December 1966 and early January, 1967, much of the record was lost in waiting for a power supply replacement.

Most of the troubles arising in the array came from within the recording subsystem, such as: faulty logic cards, malfunctions in the stepping mechanism for demultiplexing of array signals, relays burning out, and a variety of problems with the Flexowriter and tape recorder.

Data breaks may also derive from within the AUTEC Statistical Analysis Program. Limits for each sensor are written into the program, above or below which all non-compliant data are rejected. Recent expansions have had to be made when it was discovered that realistic data were being rejected.

It is difficult to account for many of the smaller record gaps, especially those which appear in data recorded early in the career of the TWBA. Serious "bugs" in any electronic system arise most frequently in the early operational stages, and the TWBA was no exception. At that time, concentration was focused more on system operational evaluation than on the quantity or quality of recorded data. Also, frequent checks were necessary to test system operation. Data record breaks resulting from these were most often unreported in the site situation reports.

Data continuity is illustrated in Figure 11. Continuity was determined by visually scanning the data-time group of the corrected print-outs. By following along the date-time group in chronological sequence, time gaps were immediately discerned and depicted in the graph.

The TWBA Data Continuity Record shows only record gaps of

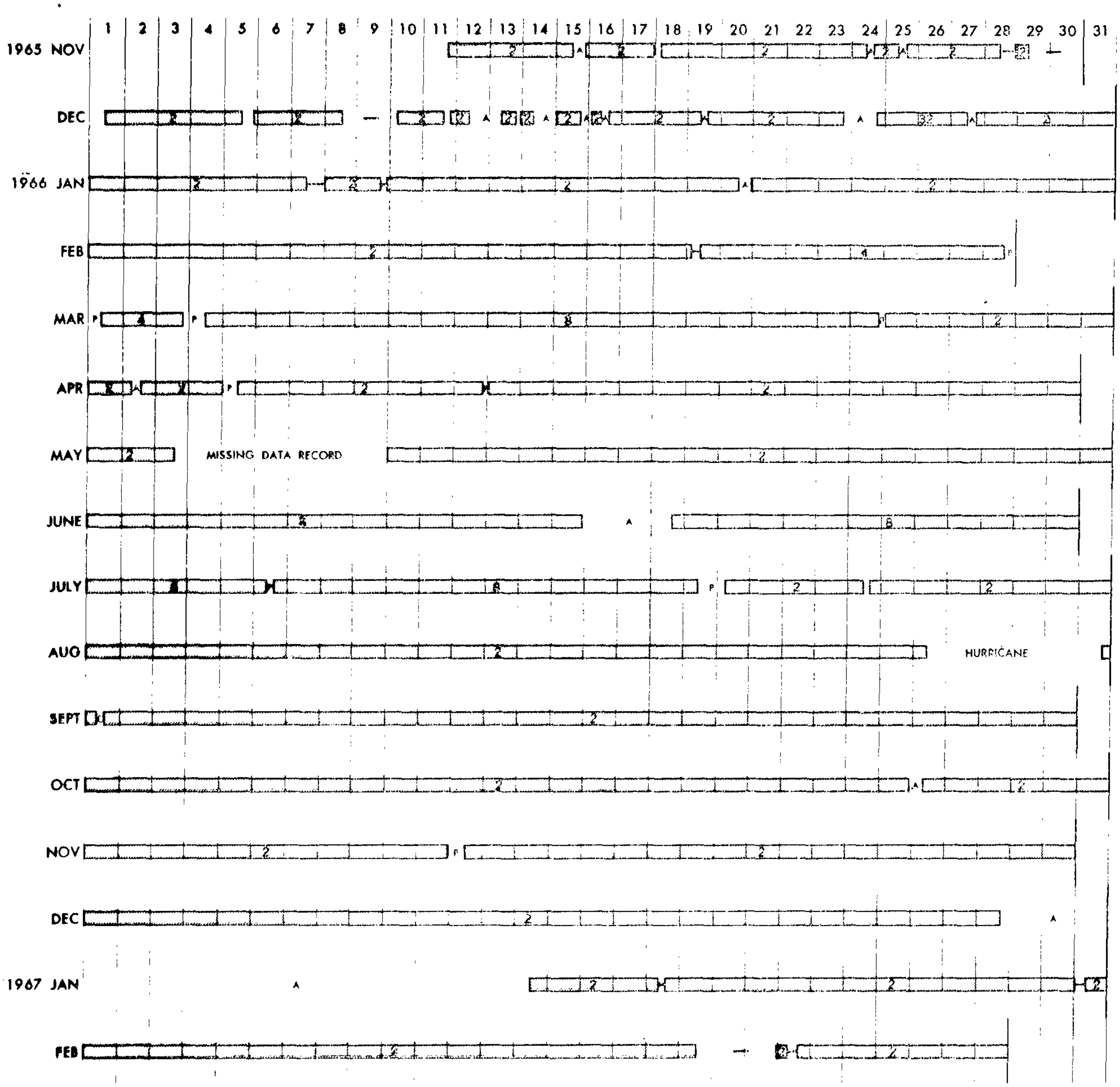


FIGURE 11 TWBA DATA CONTINUITY
(ONLY DATA BREAKS >4 HOURS DEPICTED)

greater than 4-hour duration. Although array operation commenced on 21 October, 1965, the more convenient starting date of 11 November is used on this graph. Only data through February, 1967, are presented in Figure 11.

Numbers enclosed within the continuity bars in Figure 11 are the sampling time modes employed during the respective operating intervals. Most frequently the 2-minute mode has been used in sequential sampling. The variety of modes used early in the operation of the TWBA was the result of system experimentation.

These gaps of greater than 4 hours usually result from failure or malfunction within the system (A) or with the generators powering the system (P). The record gap for 3 to 9 May 1966, is due to missing data for which there can be found no explanation.

To facilitate data analysis and to readily identify the reasons for data gaps in time sequences from the array, a procedure has been initiated for system operators to follow when restarting the recording subsystem following any interruption in automatic sampling. The procedure is to substitute the manually controlled data field for "year" with one of the identifications in Table 3. This will be done for the first record only after automatic sampling and data recording is resumed. (see below)

TABLE 3

CODING SCHEDULE FOR (COMPUTER) IDENTIFICATION OF OFF-TIME ON THE TAUT WIRE BUOY ARRAY

1111	Array failure or malfunction
2222	Power failure (Generator)
3333	checks or test being made on equipment
4444	Generators switched
5555	Hurricane or natural disaster
6666	Sensor check/system on manual mode
7777	Tape change
8888	Corrected error in digital clock

DIGITAL FORMAT

Tapes are written in low density (200 bits/inch), odd parity, IBM-format Binary Coded Decimal numeric form. Characters are entered onto five of the seven tape channels, specifically channels 1,2,3,4 and 7 (a parity channel). Figure 12a shows how each numeric character from 0 to 9 is entered onto tape channels. Note that zero is recorded on tape as a blank with a mark in the parity channel.

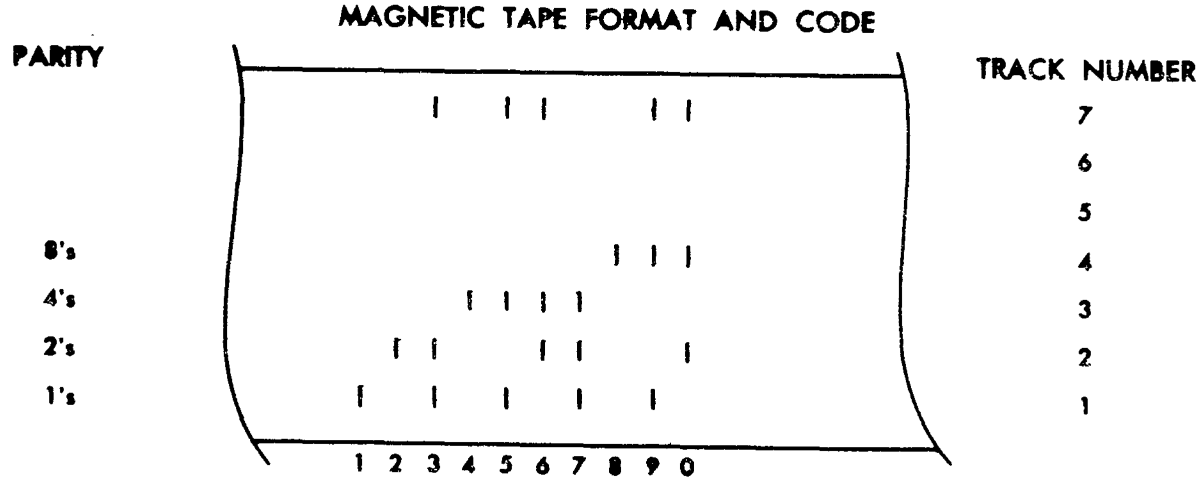


FIGURE 12a EXAGGERATED SEGMENT OF MAGNETIC TAPE SHOWING BINARY CODED DECIMAL FORM

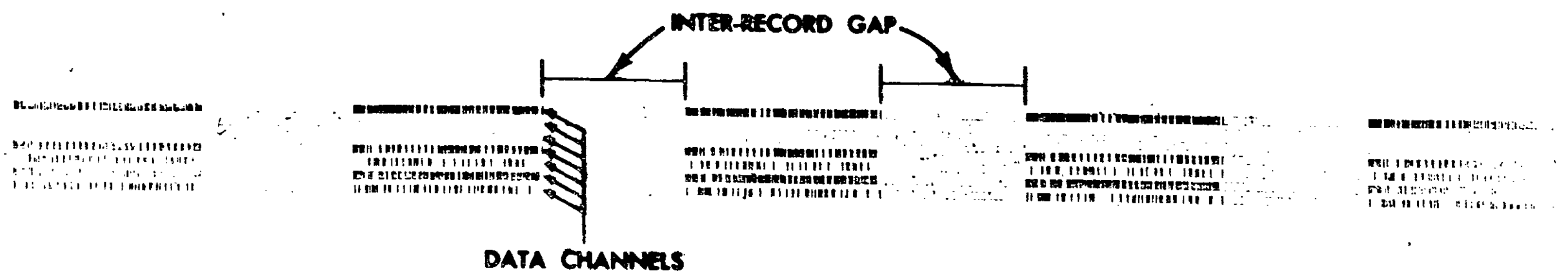


FIGURE 12b "DEVELOPED" SEGMENT OF MAGNETIC TAPE SHOWING INDIVIDUAL DATA RECORDS

A complete RECORD on an original tape has 168 characters followed by an END-OF-RECORD mark consisting of three blank spaces, then a special mark which is a longitudinal parity check character. Figure 12b is a continuous real record sequence on magnetic tape with data channels and inter-record gaps indicated.

ACCUMULATED DATA

The "valid" chronological sequence of original data tapes as they are presently numbered is as follows: 6,7,12,11,10, 13,14 . . . and so on. Number 21 has never been assigned to a tape. Tapes 1 and 5 were test tapes, therefore not included. Program rewriting by Bunker-Ramo Corporation of tapes 8 and 9 resulted in new numbers, 12 and 11, being substituted respectively. Each tape differs from the others in record duration and in sampling modes used during the data collection. Data backlog continues to be one of the major problems in processing and analyzing the array data, resulting from the inavailability of the required amount of computer time. Eventually, all of the tapes will be consolidated, the chronology errors eliminated and the data corrected and processed. Data presentations will be performed for regular time periods; e.g., monthly summaries. Future consolidation will eliminate the existing haphazard numerical order with the assignment of new numbers to the tapes.

COMPUTER PROGRAMS

Several programs have been written to facilitate the retrieval, evaluation, and presentation of the data. One program converts the original magnetic tape to an "intermediate" tape by reformatting the data, placing the array number before rather than after the record number, and reducing the number of characters from 168 to 120. The reduction is made possible by deleting unused characters in each data word (each sensor field utilizes only four of the six digits available in each parameter field).

The AUTEC Statistical Analysis Program (ASAP) is the major tool for the processing of TWBA data tapes. In addition to performing editing and correcting functions, this program performs basic statistical analyses upon the data sequences from the array sensors. Following is an outline of ASAP functions (see Appendix II for the 1200 hours, Day 296, to 2358 hours, Day 298, 1965).

1. Eliminate erroneous sensor readings according to the following criteria:

a. Any sensor reading falling outside the maximum and minimum parameter limits (envelope);
b. Any sensor reading exceeding a predetermined time rate of change.

2. Corrects recorded values using data provided by the manufacturer.

3. Computes (Appendix II-1 through II-6):

a. the mean and standard deviation from the mean for data sequences from each sensor;
b. the mean arithmetic change between consecutive observations of each sensor (sign considered);
c. the mean change (sign not considered) and standard deviation between consecutive observations of each sensor;
d. total number of data points and missing points;
e. the maximum and minimum reading from each sensor, frequency of occurrence, and time of first occurrence.

4. Compares corrected temperature values at the same depth (Appendix II-6) by computing the mean difference between paired (redundant) sensor readings and the standard deviation from the mean.

5. Compares corrected temperature values at different depths (Appendix II-7) by computing the average gradients between them in units/meter and computing the standard deviations of gradients.

6. Computes the average difference between pressure sensors.

The AUTEC Statistical Analysis Program has recently been documented as an informal report by the program developer.

A Data Compacting Program has been written that averages observations over specified time periods, thereby reducing the bulk of data listings (Appendix III). This type of program offers the advantages of handling ease and of serving users not particularly interested in short-term variations in the parameters measured.

Plotting programs have been prepared for analog representation of temperature with depth and of temperature with time. The plotter programs are written for use on the Calcomp plotter, which is a digital incremental drum plotter with a basic resolution of five-thousandths of an inch. The plotter programs are flexible in size up to the maximum of 29 inches - the width of the drum. Figure 13 is a temperature with depth profile plotted for 1000 hours on Julian day 105, 1966. Figure 14 shows time-series temperature plots for selected sensors over a 24-hour period, 1000 hours (LCT) on day 281 to 1000 hours (LCT) on day 282, 1966. A second sample time-series representation, figure 15, covers levels 1,2, and 3 for the period 11-13 October, 1966.

Figure 16 shows a short temperature time-series for the interval 0000 to 0922 hours on day 297, 1965. Although not an automated plot, this figure is a reasonably typical sampling of the array data and demonstrates the value of analog presentations in interpreting and evaluating time series data from the array. In order to avoid confusion, only primary sensor readings were plotted, and certain recording levels were omitted as superfluous to a streamlined plot. A general rise in the temperature is immediately noticable in the graph at about 0500 hours. The thermal gradient between sensors 1 and 5 is greatest between 0000 and 0200 hours and smallest between 0400 and 0700 hours. The most definite rise is shown by sensor 7 to occur between 0300 and 0600. This is probably the expression of a semidiurnal high tide, and although it is supported by temperature plots of deep sensors, the magnitude of change in the latter is far less. Sensor 9 (172 meters) exhibits the largest fluctuations which are anomalous in that temperatures, peaking at 0300 hours, fall to a low during a time span when the other plots show a high.

Other programs on the development agenda that are based on array data involve harmonic analyses and power spectra.

The major technical problems in the storage and retrieval of the array data have been solved, but there still remain some data processing problems arising from the backlog of data accumulated over the long period of almost continuous operation. The overall length and continuity of the TWBA data record make it a valuable tool for detailed oceanographic studies, especially the longer term processes about which little is presently known.

AUTEC ENVIRONMENTAL MONITORING ARRAY DATA

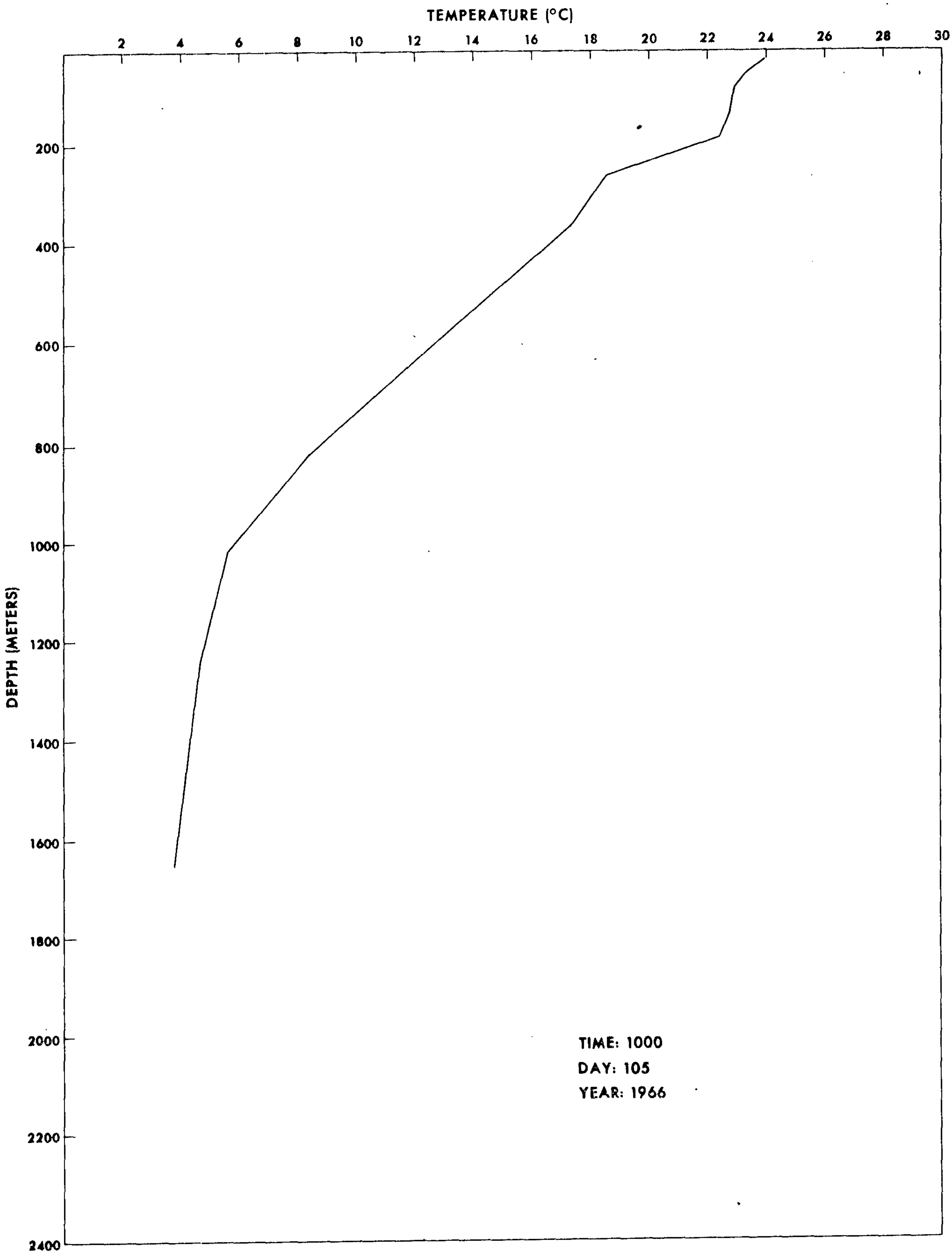


FIGURE 13 TEMPERATURE - DEPTH PROFILE

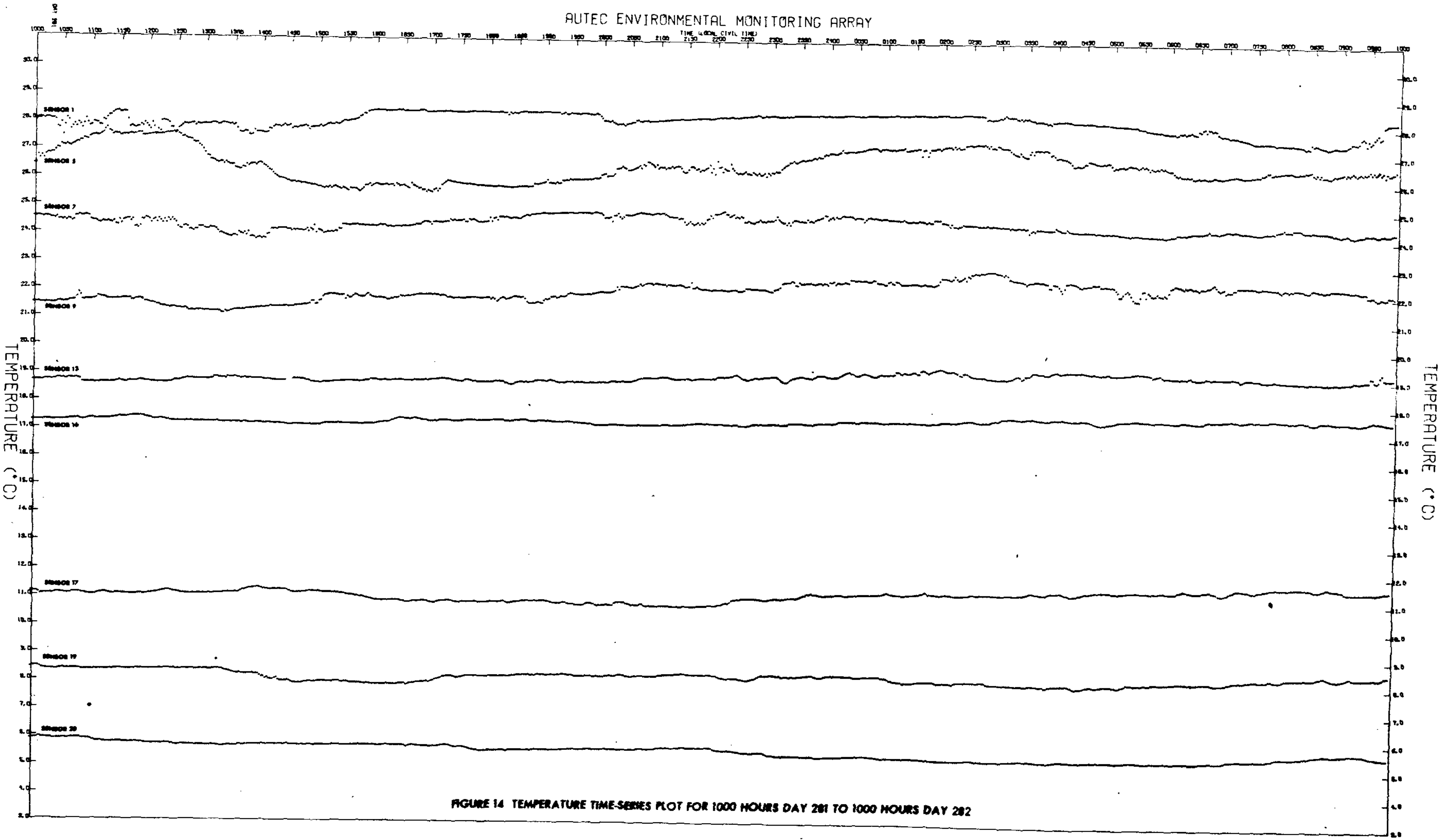


FIGURE 14 TEMPERATURE TIME-SERIES PLOT FOR 1000 HOURS DAY 281 TO 1000 HOURS DAY 282

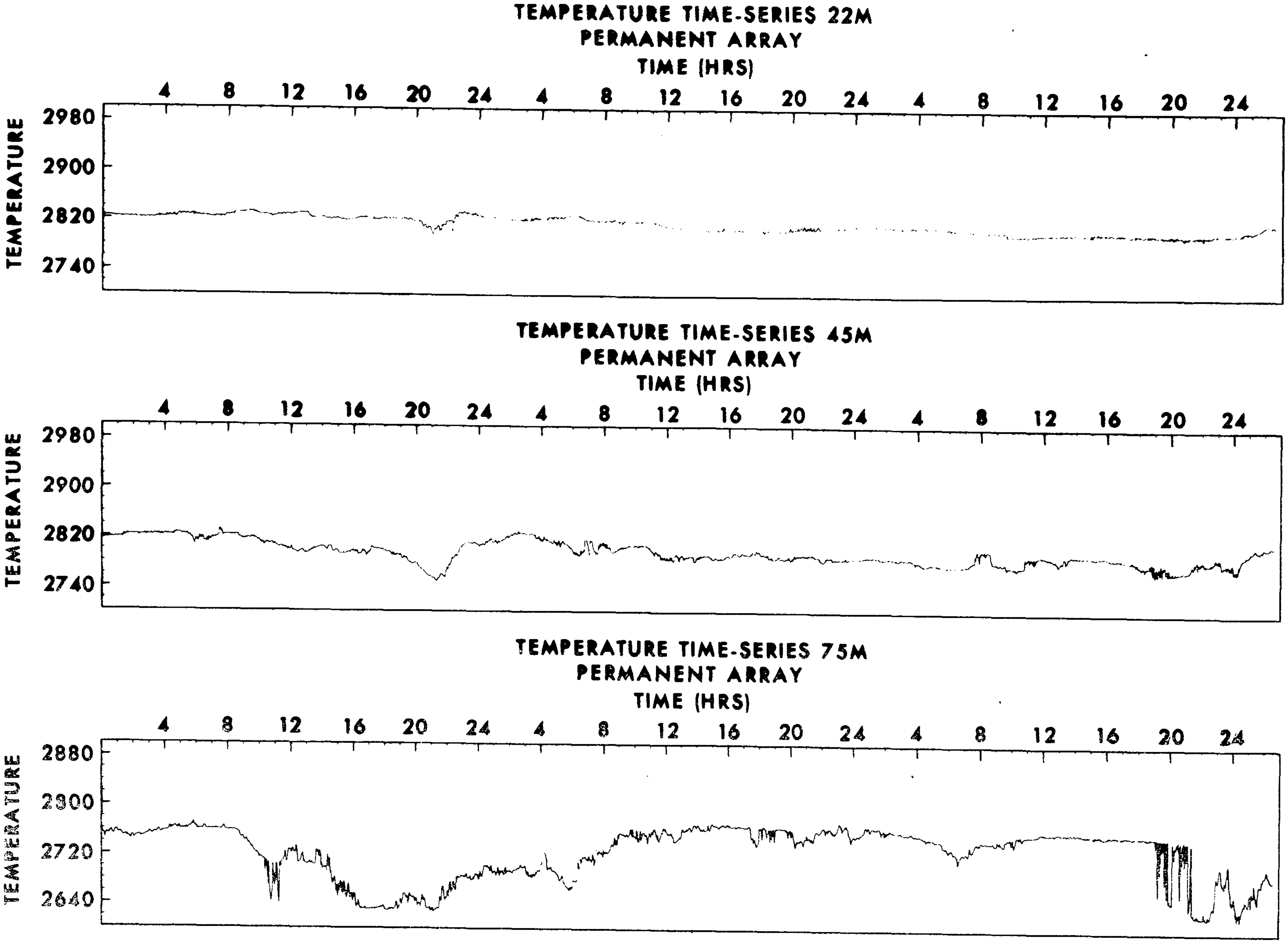


FIGURE 15 TEMPERATURE TIME-SERIES FOR 11-13 OCTOBER, 1966

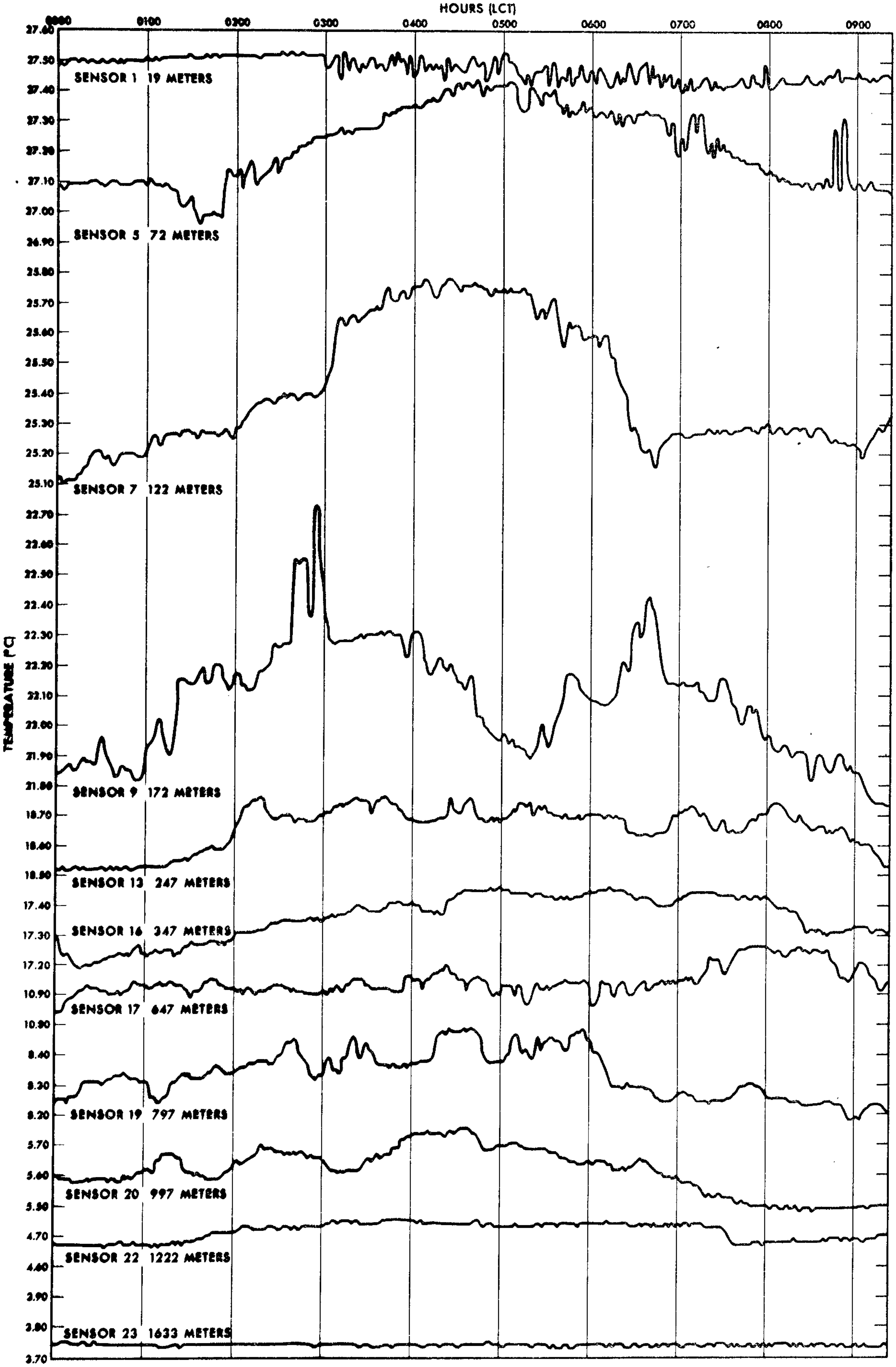


FIGURE 16 TWBA TEMPERATURE TIME SERIES, DAY 297, YEAR 1965, 0000-0922 HOURS

All data tapes are stored at the Data Processing Systems Office at NAVOCEANO, however, requests for any data should be directed to the National Oceanographic Data Center (NODC). Data for specified time periods will consist of edited and corrected temperature and pressure data listings reduced to page size, such as it appears in page 1-1 of the Appendix. Note that in page 1-1, the first and second data columns that do not have headings are the "Array Number" and the "Record Number". Data columns that are blank or partially blanked out are the result of exclusion by the program (ASAP) of unacceptable data. Decimal places fall after the second digit in each four-digit group, except for sensor 14 (P) where the decimal falls after the third digit of the four-digit group.

NEW ARRAY INSTALLATION

Two new taut wire buoy arrays have been installed in TOTO, similar in design to the existing TWBA, but with slight changes in sensor locations. One array is located southeast of High Point Cay (AUTEC Site 7) and the other is located southeast of Andros Town (AUTEC Site 1).

The manner of data transfer for the two new arrays has been altered for the expanded 3 - array monitoring system. Data from Site 2 and Site 7 is telemetered to the Central Data Collection Point at the Command Control Building at Site 1. Data from the Site 1 array is cabled directly into the same point, where data from all three arrays are recorded on magnetic tape. A microwave transmission network, primarily used for weapons range tracking operations, is used for array data transmission. Data sampling is performed sequentially, requiring no more than two minutes per array and no more than six minutes for all three arrays. The order of reporting is a Site 1, Site 2, Site 7 sequence (Figure 1).

Bissett-Berman Corporation installed the additional arrays in early September, 1967. As the contractor, it was their responsibility to implant the array, lay the transmission cable to shore, and install the shore terminal equipment into existing government-furnished facilities. A more comprehensive report on the expansion of the AUTEC Environmental Monitoring System to a 3-array system will be forthcoming.

APPENDIX I

AUTEC ENVIRONMENTAL MONITORING ARRAY

		YEAR	DAY TIME 1 2(P) 3 4 5 6(P) 7 8 9 10		11 12 13 14(P) 15 16 17 18	19	20	21	22	23	24
I	201	1965	29618482756206327612762269074212510249722203	0	01940185925231856175011081108	846	557	556	468	369	
I	202	1965	29618502755205527612762269174152510249822203	0	01939185925221856175111051105	846	557	556	467	368	
I	203	1965	29618522753205927612761269174202512250022022152		01939185825221856175011061105	846	557	555	467	369	
I	204	1965	29618542756205927612762269174182512250022202	0	01941185825221856175111021102	845	557	555	467	368	
I	205	1965	29618562754205927612761269074162512250122202	0	01942185825231857175110971098	845	558	555	468	372	
I	206	1965	29618582755205227612761269174092512250022197	0	01942185825231856175110941094	844	558	556	467	373	
I	207	1965	29619002754206127602761269074202512250021972291		01940185925231857175010951094	845	558	556	467	370	
I	208	1965	29619022756205827592759268974172513250122202	0	01939185925231857174810971097	845	558	556	467	373	
I	209	1965	29619042755205827592758269074152515250222201	0	01938185925221857175010981098	844	558	556	467	369	
I	210	1965	29619062756206127572757269074162514250222198	0	01936185925221857175011001099	845	558	556	467	372	
I	211	1965	29619082756204927582759269074122514250121972153		01935185925221857174911021101	845	557	555	467	371	
I	212	1965	29619102757206127592759269074202516250322202	0	01935186025231857175011021102	845	557	555	467	368	
I	213	1965	29619122755205727602761269174182518250522203	0	01938185925221857175111021101	845	556	554	467	368	
I	214	1965	29619142753204827612761269274082515250322201	0	01941186025221857175011041103	845	557	555	468	369	
I	215	1965	29619162755205827612761269374212513250122022057		01940185925221857175011051104	844	557	555	467	369	
I	216	1965	29619182756205727612761269274162512250022032086		01941185925221857174911051104	844	557	555	469	368	
I	217	1965	29619202756205827612760269174192512250022042082		01939185925231857174911051104	844	557	555	468	369	
I	218	1965	29619222756205427612761269074092515250222203	0	01938185925221856174811051105	842	556	555	467	370	
I	219	1965	29619242757205227612762268974152515250322002084		01937185825211856174811051105	844	556	553	468	367	
I	220	1965	29619262758205627612760269274132515250321972084		01935185925211857174711061105	844	555	554	468	368	
I	221	1965	29619282756205827602760269174162515250421962085		01938185925211857174711071107	845	555	553	467	366	
I	222	1965	29619302757204927572758269174092515250421962089		01936185825221856174711081107	846	556	553	467	372	
I	223	1965	29619322756205127602760269474182515250421962090		01934185825221855174611081107	845	556	554	467	366	
I	224	1965	29619342757205327602760269374152516250421962090		01932185725221854174711071107	846	556	554	466	371	
I	225	1965	29619362757205227582758269374112516250421962087		01931185725211854174711071107	846	557	554	467	369	
I	226	1965	29619382756205327572757269574132516250421982084		01931185625211854174611071106	846	556	554	467	373	
I	227	1965	29619402756205027572758269674012518250521992077		01931185625221854174611071106	846	556	554	467	368	
I	228	1965	29619422756205127582759269574132519250622002074		01931185625211854174611071106	845	556	554	467	368	
I	229	1965	29619442756204827612761269574052518250621982069		01932185525221854174611071106	844	556	553	467	370	
I	230	1965	29619462756204827602760269574102517250421962065		01930185525211853174511071107	844	555	553	467	370	
I	231	1965	29619482756203527612761269573972517250421952065		01930185525211853174311071107	844	554	552	467	370	
I	232	1965	29619502757204627612761269574052518250621942064		01928185525221853174411061106	842	553	552	467	368	
I	233	1965	29619522757204427632763269774042519250722193	0	01929185525221853174611051105	842	553	552	467	371	
I	234	1965	29619542756203827622763269774032518250522190	0	01930185525221853174711041104	842	554	552	467	372	
I	235	1965	29619562757204227632763269774032515250321902068		01929185525221853174811021102	841	553	552	467	370	
I	236	1965	29619582757204627622762269874082515250321882062		01930185525221854174511011100	841	553	551	466	368	
I	237	1965	29620002758204327622761269774032517250621862062		01929185625211854174610991098	841	552	550	466	370	
I	238	1965	29620022757203927622762269473992519250621862057		01928185525211853174611001099	844	552	550	466	369	
I	239	1965	29620042757203627632763269374012518250622188	0	01927185525211853174611021101	842	552	549	466	370	
I	240	1965	29620062757204527622763269474012518250622187	0	01926185425211852174611031102	844	551	550	465	368	
I	241	1965	29620082756204327622763269473952519250722186	0	01925185425201853174411051104	844	551	549	466	369	
I	242	1965	29620102756203927612762269274032521250822177	0	01925185425211852174311051103	844	552	549	466	368	
I	243	1965	29620122756204027622762269274012520250822172	0	01924185425221852174311031103	844	551	549	466	371	
I	244	1965	29620142756204327622762269174022519250722175	0	01925185425201852174311031103	842	550	548	466	369	
I	245	1965	29620162755204227632762269374012519250822187	0	01924185525201852174211031102	842	550	548	466	367	
I	246	1965	29620182757204027632764269474022520250722182	0	01919185425211852174211031102	841	550	548	466	368	
I	247	1965	29620202755203927622763269473992519250622183	0	01915185425211852174211021101	840	551	549	466	369	
I	248	1965	29620222756204027622763269473972519250722183	0	01915185425211852174210991098	839	553	551	466	370	
I	249	1965	29624002755204127632762269474032519250622181	0	01917185425211852174210971098	838	553	551	466	368	
I	250	1965	29621362756204427622762269574032518250522180	0	01918185425201853174210971097	838	552	549	466	369	
I	251	1965	29620282757203427622763269573952514250122182	0	01915185425201852174110981097	837	550	548	466	366	

APPENDIX II

ANALYSIS OF MONITORING ARRAY FROM 1200 HRS, DAY NO. 296 TO 2358 HRS, DAY NO. 298.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
1	27.47	0.14	-0.00	0.02	0.16	830	2

THE MAXIMUM VALUE WAS 27.58. THIS VALUE OCCURRED 7 TIMES AND OCCURRED FIRST ON DAY 296 AT 1716 HOURS.

THE MINIMUM VALUE WAS 24.23. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 2012 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
2	19.99	0.54	0.00	0.07	0.17	825	7

THE MAXIMUM VALUE WAS 20.76. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 297 AT 710 HOURS.

THE MINIMUM VALUE WAS 17.67. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 2236 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
3	27.56	0.12	-0.00	0.01	0.02	830	2

THE MAXIMUM VALUE WAS 27.73. THIS VALUE OCCURRED 2 TIMES AND OCCURRED FIRST ON DAY 297 AT 402 HOURS.

THE MINIMUM VALUE WAS 27.26. THIS VALUE OCCURRED 4 TIMES AND OCCURRED FIRST ON DAY 298 AT 2348 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
4	27.57	0.13	-0.00	0.01	0.02	832	0

THE MAXIMUM VALUE WAS 27.73. THIS VALUE OCCURRED 7 TIMES AND OCCURRED FIRST ON DAY 297 AT 354 HOURS.

THE MINIMUM VALUE WAS 27.26. THIS VALUE OCCURRED 2 TIMES AND OCCURRED FIRST ON DAY 298 AT 2350 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
5	27.17	0.26	0.00	0.02	0.04	830	2

THE MAXIMUM VALUE WAS 27.68. THIS VALUE OCCURRED 12 TIMES AND OCCURRED FIRST ON DAY 298 AT 1454 HOURS.

THE MINIMUM VALUE WAS 26.69. THIS VALUE OCCURRED 2 TIMES AND OCCURRED FIRST ON DAY 296 AT 1438 HOURS.

APPENDIX II

ANALYSIS OF MONITORING ARRAY FROM 1200 HRS, DAY NO. 296 TO 2358 HRS, DAY NO. 298

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
6	73.64	0.41	0.00	0.05	0.09	803	29

THE MAXIMUM VALUE WAS 74.36. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 297 AT 800 HOURS.

THE MINIMUM VALUE WAS 72.86. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 1506 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
7	25.50	0.42	0.00	0.02	0.03	829	3

THE MAXIMUM VALUE WAS 26.46. THIS VALUE OCCURRED 4 TIMES AND OCCURRED FIRST ON DAY 298 AT 1648 HOURS.

THE MINIMUM VALUE WAS 24.88. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 1236 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
8	25.38	0.42	0.00	0.02	0.03	832	0

THE MAXIMUM VALUE WAS 26.35. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 1654 HOURS.

THE MINIMUM VALUE WAS 24.77. THIS VALUE OCCURRED 3 TIMES AND OCCURRED FIRST ON DAY 296 AT 1236 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
9	22.18	0.43	0.00	0.02	0.04	830	2

THE MAXIMUM VALUE WAS 23.28. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 1602 HOURS.

THE MINIMUM VALUE WAS 21.47. THIS VALUE OCCURRED 2 TIMES AND OCCURRED FIRST ON DAY 296 AT 1236 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
10	20.81	0.98	0.00	0.14	0.54	401	431

THE MAXIMUM VALUE WAS 26.53. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 2008 HOURS.

THE MINIMUM VALUE WAS 18.25. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 1646 HOURS.

APPENDIX II

ANALYSIS OF MONITORING ARRAY FROM 1200 HRS, DAY NO. 296 TO 2358 HRS, DAY NO. 298

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
11	21.31	2.53	0.01	0.09	0.43	115	717

THE MAXIMUM VALUE WAS 26.92. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 297 AT 308 HOURS.

THE MINIMUM VALUE WAS 17.99. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 297 AT 403 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
12	19.32	0.15	0.00	0.01	0.02	831	1

THE MAXIMUM VALUE WAS 19.61. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 1948 HOURS.

THE MINIMUM VALUE WAS 18.88. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 2158 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
13	18.66	0.13	0.00	0.01	0.03	827	5

THE MAXIMUM VALUE WAS 18.94. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 1932 HOURS.

THE MINIMUM VALUE WAS 17.98. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 1430 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
14	251.72	0.42	0.00	0.07	0.11	803	29

THE MAXIMUM VALUE WAS 252.45. THIS VALUE OCCURRED 20 TIMES AND OCCURRED FIRST ON DAY 297 AT 626 HOURS.

THE MINIMUM VALUE WAS 250.90. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 1504 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
15	18.64	0.13	0.00	0.01	0.01	832	0

THE MAXIMUM VALUE WAS 18.91. THIS VALUE OCCURRED 5 TIMES AND OCCURRED FIRST ON DAY 298 AT 1924 HOURS.

THE MINIMUM VALUE WAS 18.37. THIS VALUE OCCURRED 6 TIMES AND OCCURRED FIRST ON DAY 296 AT 1320 HOURS.

APPENDIX II

ANALYSIS OF MONITORING ARRAY FROM 1200 HRS, DAY NO. 296 TO 2358 HRS, DAY NO. 298

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
16	17.38	0.11	-0.00	0.00	0.01	829	3

THE MAXIMUM VALUE WAS 17.62. THIS VALUE OCCURRED 9 TIMES AND OCCURRED FIRST ON DAY 296 AT 1344 HOURS.

THE MINIMUM VALUE WAS 17.19. THIS VALUE OCCURRED 2 TIMES AND OCCURRED FIRST ON DAY 297 AT 16 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
17	10.96	0.09	0.00	0.01	0.02	828	4

THE MAXIMUM VALUE WAS 11.26. THIS VALUE OCCURRED 3 TIMES AND OCCURRED FIRST ON DAY 296 AT 1556 HOURS.

THE MINIMUM VALUE WAS 10.75. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 1236 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
18	10.95	0.12	0.00	0.02	0.12	831	1

THE MAXIMUM VALUE WAS 11.27. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 1600 HOURS.

THE MINIMUM VALUE WAS 8.60. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 2012 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
19	8.33	0.14	-0.00	0.01	0.02	828	4

THE MAXIMUM VALUE WAS 8.62. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 1716 HOURS.

THE MINIMUM VALUE WAS 8.03. THIS VALUE OCCURRED 3 TIMES AND OCCURRED FIRST ON DAY 298 AT 1932 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
20	5.63	0.09	0.00	0.01	0.02	829	3

THE MAXIMUM VALUE WAS 5.84. THIS VALUE OCCURRED 5 TIMES AND OCCURRED FIRST ON DAY 296 AT 1552 HOURS.

THE MINIMUM VALUE WAS 5.35. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 2340 HOURS.

APPENDIX II

ANALYSIS OF MONITORING ARRAY FROM 1200 HRS, DAY NO. 296 TO 2358 HRS, DAY NO. 298

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
21	5.62	0.09	-0.00	0.01	0.01	832	0

THE MAXIMUM VALUE WAS 5.83. THIS VALUE OCCURRED 4 TIMES AND OCCURRED FIRST ON DAY 296 AT 1552 HOURS.

THE MINIMUM VALUE WAS 5.45. THIS VALUE OCCURRED 7 TIMES AND OCCURRED FIRST ON DAY 296 AT 2048 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
22	4.72	0.04	0.00	0.00	0.01	830	2

THE MAXIMUM VALUE WAS 4.80. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 298 AT 1918 HOURS.

THE MINIMUM VALUE WAS 4.64. THIS VALUE OCCURRED 9 TIMES AND OCCURRED FIRST ON DAY 296 AT 2138 HOURS.

SENSOR NUMBER	MEAN VALUE	STD. DEV	MEAN CHANGE	AVERAGE CHANGE	ST DEV CHANGE	DATA POINTS	MISSING POINTS
23	3.76	0.19	0.00	0.04	0.21	806	26

THE MAXIMUM VALUE WAS 5.90. THIS VALUE OCCURRED 1 TIMES AND OCCURRED FIRST ON DAY 296 AT 2312 HOURS.

THE MINIMUM VALUE WAS 3.61. THIS VALUE OCCURRED 5 TIMES AND OCCURRED FIRST ON DAY 296 AT 1556 HOURS.

APPENDIX II

ANALYSIS OF MONITORING ARRAY FROM 1200 HRS, DAY NO. 296 TO 2358 HRS, DAY NO. 298

SENSOR NUMBERS	AVERAGE DIFFERENCE	STANDARD DEVIATION	DATA POINTS	DEPTH (METERS)
3- 4	-0.01	0.01	830	45.
7- 8	0.12	0.01	829	125.
10-11	0.11	0.37	56	200.
13-15	0.02	0.02	827	250.
17-18	0.00	0.01	828	650.

APPENDIX II

ANALYSIS OF MONITORING ARRAY FROM 1200 HRS, DAY NO. 296 TO 2358 HRS, DAY NO. 298

SENSOR NUMBERS A - B	AVERAGE GRADIENT (UNITS/M.)	ST. DEV GRADIENT	DATA POINTS	DEPTH(M.) SENSOR A	DEPTH(M.) SENSOR B
1- 3	-0.0037	0.0054	830	20.	45.
1- 4	-0.0040	0.0055	830	20.	45.
1- 5	0.0053	0.0064	830	20.	75.
3- 5	0.0128	0.0117	830	45.	75.
4- 5	0.0131	0.0118	830	45.	75.
5- 7	0.0335	0.0049	829	75.	125.
5- 8	0.0359	0.0049	830	75.	125.
5- 9	0.0499	0.0027	830	75.	175.
7- 9	0.0663	0.0036	829	125.	175.
8- 9	0.0639	0.0036	830	125.	175.
19-20	0.0135	0.0007	828	800.	1000.
19-22	0.0085	0.0003	828	800.	1225.
19-23	0.0055	0.0003	804	800.	1636.
20-22	0.0041	0.0003	829	1000.	1225.
22-23	0.0023	0.0005	806	1225.	1636.
2- 6	53.5846	0.1000	801	20.	75.
2-14	231.6692	0.5167	799	20.	250.
6-14	178.0858	0.5329	801	75.	250.

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APPENDIX II

* ANAL CF MONITORING ARRAY SENSORS

1965 295 2334 1965 295 2336 DATA IS RECORDED AT 2 MINUTES INTERVAL

BREAKS IN DATA GREATER THAN 8 MINUTES

YEAR	DAY	HOUR	YEAR	DAY	HOUR	
1965	295	2338	1965	296	1236	
1965	296	1338	1965	296	1342	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	296	1342	1965	296	1344	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	1428	1965	296	1432	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	296	1432	1965	296	1434	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	1442	1965	296	1446	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	296	1446	1965	296	1448	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	1448	1965	296	1452	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	296	1456	1965	296	1458	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	1502	1965	296	1552	
1965	296	1600	1965	296	1606	DATA IS RECORDED AT 6 MINUTES INTERVAL
1965	296	1606	1965	296	1608	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	1620	1965	296	1634	
1965	296	1658	1965	296	1702	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	296	1702	1965	296	1704	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	1752	1965	296	1758	DATA IS RECORDED AT 6 MINUTES INTERVAL
1965	296	1758	1965	296	1800	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	1800	1965	296	1804	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	296	1804	1965	296	1806	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	2022	1965	296	2400	
1965	296	2400	1965	296	2136	DATA IS RECORDED AT *4 MINUTES INTERVAL
1965	296	2136	1965	296	2028	DATA IS RECORDED AT *8 MINUTES INTERVAL
1965	296	2028	1965	296	2030	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	2134	1965	296	2134	DATA IS RECORDED AT 0 MINUTES INTERVAL
1965	296	2134	1965	296	2138	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	296	2138	1965	296	2140	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	296	2226	1965	296	2238	
1965	296	2318	1965	296	2322	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	296	2322	1965	296	2324	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	297	422	1965	297	426	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	297	426	1965	297	428	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	297	520	1965	297	524	DATA IS RECORDED AT 4 MINUTES INTERVAL
1965	297	524	1965	297	526	DATA IS RECORDED AT 2 MINUTES INTERVAL
1965	297	922	1965	297	1000	

APPENDIX III

AUTEC 10

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YEAR 1965

DAY FROM	DAY TO	TIME(LCT) FROM	TIME(LCT) TO	T 1	P 2	T 3	T 4	T 5	P 6	T 7	T 8	T 9	T 10	T 11	T 12	T 13	P 14	T 15	T 16	T 17	T 18	T 19	T 20	T 21	T 22	T 23	T 24
296	296		1314	2755	1952	2761	2761	2680	7311	2497	2485	2154	2000	1997	1892	1846	2512	1843	1759	1086	1085	821	562	560	471	363	0
296	296	1316	1356	2755	1955	2761	2761	2677	7314	2504	2492	2158	2007	2004	1894	1845	2512	1843	1760	1091	1090	822	566	564	473	363	0
296	296	1358	1438	2755	1960	2760	2761	2675	7319	2509	2497	2162	2011	2009	1900	1849	2512	1847	1760	1094	1093	827	568	567	474	363	0
296	296	1440	1616	2755	1966	2760	2760	2675	7326	2515	2503	2170	2017	2009	1908	1853	2513	1851	1759	1098	1098	833	571	570	474	363	0
296	296	1618	1710	2756	1980	2759	2760	2676	7340	2517	2504	2178	2019	2009	1915	1857	2514	1854	1759	1101	1100	837	572	571	473	363	0
296	296	1712	1750	2756	1992	2759	2760	2676	7351	2518	2506	2183	2023	2009	1919	1857	2516	1855	1758	1105	1104	841	572	571	472	363	0
296	296	1752	1836	2756	2001	2759	2760	2677	7361	2519	2506	2187	2012	2009	1921	1857	2517	1855	1757	1105	1105	843	571	569	472	364	0
296	296	1838	1916	2756	2008	2759	2760	2679	7368	2518	2506	2188	2020	2009	1923	1857	2517	1855	1756	1105	1104	843	569	568	471	364	0
296	296	1918	1956	2756	2013	2759	2760	2680	7372	2518	2505	2189	2027	2009	1924	1857	2518	1855	1755	1105	1104	843	567	566	471	365	0
296	296	1958	2036	2756	2016	2760	2760	2682	7375	2517	2505	2189	2028	2009	1924	1857	2518	1855	1754	1104	1104	843	566	564	470	365	0
296	296	2038	2116	2755	2017	2760	2760	2683	7376	2517	2504	2188	2028	2009	1923	1856	2518	1854	1752	1103	1103	842	564	563	470	366	0
296	296	2118	2156	2755	2016	2760	2761	2685	7375	2516	2503	2188	2028	2009	1921	1855	2518	1853	1750	1102	1101	841	563	561	469	366	0
296	296	2158	2246	2755	2013	2760	2761	2686	7373	2514	2502	2187	2028	2009	1920	1855	2518	1852	1749	1100	1099	839	562	551	469	366	0
296	295	2248	2328	2754	2010	2760	2761	2688	7369	2514	2502	2185	2028	2009	1920	1854	2517	1852	1747	1099	1098	838	562	560	469	366	0
295	297	2330	8	2754	2006	2761	2761	2689	7365	2514	2502	2185	2028	2009	1920	1854	2517	1852	1746	1098	1097	837	562	560	469	367	0
297	297	10	48	2754	2002	2761	2761	2690	7361	2514	2502	2185	2028	2009	1920	1854	2517	1852	1745	1098	1097	837	562	560	468	367	0
297	297	50	128	2753	1999	2761	2762	2691	7358	2515	2503	2186	2028	2009	1920	1854	2516	1852	1743	1097	1097	836	562	560	468	368	0
297	297	130	208	2753	1997	2762	2762	2692	7356	2516	2503	2187	2028	2007	1921	1854	2516	1852	1742	1097	1096	836	562	560	468	368	0
297	297	210	248	2753	1995	2762	2763	2693	7354	2517	2504	2190	2028	1999	1922	1855	2516	1853	1742	1097	1096	836	562	561	469	368	0
297	297	250	328	2753	1994	2762	2763	2695	7353	2519	2506	2192	2028	2027	1923	1856	2516	1854	1742	1096	1096	836	562	561	469	369	0
297	297	330	408	2753	1995	2763	2763	2697	7353	2521	2509	2194	2028	2087	1923	1857	2516	1855	1742	1096	1096	836	563	551	469	369	0
297	297	410	450	2753	1996	2763	2764	2698	7354	2524	2511	2194	2028	2090	1924	1857	2516	1855	1742	1096	1096	837	563	562	469	369	0
297	297	452	532	2752	1998	2763	2764	2700	7356	2526	2513	2194	2028	2090	1925	1858	2516	1856	1742	1096	1095	837	564	562	469	370	0
297	297	534	612	2752	2000	2763	2764	2702	7359	2527	2515	2195	2028	2090	1926	1859	2516	1856	1742	1096	1095	837	564	562	470	370	0
297	297	614	652	2752	2003	2764	2764	2703	7361	2527	2515	2196	2028	2090	1927	1859	2517	1857	1742	1096	1095	837	564	562	470	370	0
297	297	654	732	2751	2005	2764	2764	2704	7364	2527	2515	2197	2028	2089	1928	1859	2517	1857	1742	1096	1095	836	563	562	470	370	0
297	297	734	812	2751	2007	2763	2764	2704	7366	2527	2515	2197	2028	2096	1929	1860	2517	1857	1742	1096	1095	836	563	561	470	370	0
297	297	814	852	2751	2009	2763	2764	2704	7368	2527	2515	2196	2028	2096	1929	1860	2517	1858	1741	1096	1096	836	562	561	470	370	0
297	297	854	1008	2751	2010	2763	2764	2704	7369	2527	2515	2196	2032	2096	1929	1860	2517	1857	1741	1095	1096	835	562	560	470	370	0
297	298	1010	1242	2750	2009	2762	2763	2706	7368	2529	2517	2197	2045	2096	1929	1860	2517	1857	1741	1096	1095	835	562	560	470	371	0
298	298	1244	1500	2750	2007	2762	2762	2707	7366	2532	2520	2199	2048	2096	1929	1860	2517	1858	1741	1096	1095	835	562	560	470	371	0
298	298	1502	1542	2749	2005	2761	2761	2708	7364	2535	2523	2202	2055	2096	1929	1861	2517	1858	1740	1095	1095	836	562	560	470	371	0
298	298	1544	1622	2749	2004	2760	2761	2710	7363	2539	2526	2206	2060	2096	1930	1861	2517	1859	1740	1095	1094	835	562	560	470	372	0
298	298	1624	1702	2749	2003	2760	2760	2712	7362	2542	2529	2209	2061	2096	1930	1862	2517	1860	1740	1095	1094	836	562	561	471	372	0
298	298	1704	1742	2749	2003	2759	2760	2713	7362	2544	2531	2212	2062	2096	1930	1863	2517	1861	1740	1095	1094	836	563	561	471	372	0
298	298	1744	1936	2748	2003	2758	2759	2714	7362	2546	2534	2214	2064	2096	1931	1864	2517	1861	1739	1095	1094	836	563	561	471	373	0
298	298	1938	2016	2748	2004	2758	2758	2714	7363	2547	2535	2215	2066	2096	1931	1864	2517	1862	1739	1095	1094	835	563	562	471	373	0
298	298	2018	2100	2748	2005	2757	2758	2715	7363	2548	2535	2216	2068	2096	1932	1865	2517	1862	1739	1095	1095	835	563	562	471	373	0
298	298	2102	2142	2747	2005	2757	2757	2716	7364	2548	2536	2217	2070	2096	1932	1865	2517	1863	1739	1095	1095	834	563	562	471	373	0
298	298	2144	2300	2747	2001	2756	2757	2716	7364	2549	2537	2217	2070	2096	1932	1865	2517	1863	1738	1095	1095	833	563	561	471	373	0
298	298	2302	2356	2747	1999	2755	2756	2717	7364	2549	2537	2218	2070	2096	1932	1865	2517	1863	1738	1095	1095	833	563	561	471	374	0
298	299	2358	38	2746	1998	2755	2755	2717	7363	2550	2538	2218	2069	2096	1932	1865	2517	1863	1737	1095	1094	832	563	561	471	374	0
299	299	40	120	2746	1997	2754	2755	2718	7361	2550	2538	2219	2069	2096	1932	1865	2516	1863	1737	1095	1094	832	563	561	471	374	0
299	299	122	200	2745	1996	2753	2754	2718	7360	2551	2539	2221	2069	2096	1932	1865	2516	1863	1737	1095	1094	832	563	561	471	374	0
299	299	202	242	2745	1994	2753	2753	2718	7358	2551	2539	2223	2069	2096	1932	1865	2516	1863	1737	1094	1094	832	563	561	471	374	0
299	299	244	322	2744	1993	2752	2753	2718	7357	2552	2540	2224	2069	2096	1933	1866	2516	1864	1736	1094	1094	832	563	561	471	374	0
299	299	324	402	2744	1992	2752	2752	2718	7356	2553	2541	2226	2069	2096	1933	1866	2516	1864	1736	1094	1094	832	563	561	471	375	0
299	299	404	442	2743	1992	2751	2751	2718	7355	2554	2541	2228	2069	2096	1934	1867	2516	1864	1736	1094	1094	832	563	561	471	375	0
299	299	444	522	2743	1992	2750	2751	2718	7355	2554	2542	2230	2069	2096	1934	1867	2516	1865	1736	1094	1093	833	563	561	471	375	0
299	299	524	602	2742	1992	2750	2750	2718	7355	2555	2543	2232	2069	2096	1935	1867	2516	1865	1736	1094	1093	833	563	561	471	375	0

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13. ABSTRACT

The Taut Wire Buoy Array (TWBA) of the AUTEC Environmental Monitoring Station has recently completed recording more than two years of almost continuous temperature and pressure data from 14 selected levels at a fixed site in the Tongue of The Ocean. This report covers some of the general aspects of the system, including: array description and operation, significant events of its existence, and data handling and programming.

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Taut Wire Buoy Array (TWBA) TOTO						
Environmental Monitoring						
Temperature Sensing (or sampling)						
Pressure Sensing (or sampling)						
Andros Island, Bahamas						
AUTEC Statistical Analysis Program (ASAP)						