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INFORMAL REPORT

SUITCASE OCEANOGRAPHY

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NAVAL OCEANOGRAPHIC OFFICE
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ABSTRACT

Recent developments in microelectronics and packaging techniques offer expanding opportunities to the oceanographic community for developing new highly flexible, portable data acquisition and processing systems. These "suitcase" systems will permit certain types of oceanographic survey work to be performed from non-oceanographic vessels or ships of opportunity. Since ship time represents a substantial portion of the overall cost of oceanographic data acquisition significant savings are offered by the suitcase oceanography concept.

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This report has been reviewed
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Division Director

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SUITCASE OCEANOGRAPHY

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Washington, D.C.

Summary

Recent developments in microelectronics and packaging techniques offer expanding opportunities to the oceanographic community for developing new highly flexible, portable data acquisition and processing systems. These "suitcase" systems will permit certain types of oceanographic survey work to be performed from non-oceanographic vessels or ships of opportunity. Since ship time represents a substantial portion of the overall cost of oceanographic data acquisition significant savings are offered by the suitcase oceanography concept.

Introduction

Oceanographic data are being gathered at a rapidly increasing rate. Over the next five years, increases by a factor of six would not be unexpected. A recent study by Travelers Research Center Inc.[1] identified 112 separate parameters that are measured at sea. These parameters vary from common measurements of temperature and salinity to more esoteric measurements of xy vorticity component and magnetic field inclination. The data are gathered from a variety of platforms including ships, submersible vehicles, buoys, aircraft, rigid bottom mounted structures and even satellites. At present, ships play the major role in oceanographic data acquisition. High cost of ship operation becomes a significant factor in the overall cost per data point. The average oceanographic survey ship costs from $2000 to $4000 per day to operate, hence much thought has been given to the possibility of collecting data from vessels having other primary missions, commercial cargo ships or Naval vessels for instance.

These "ships of opportunity", as they have been called, would allow the collection of certain types of oceanographic data at a relatively low cost, depending upon the degree of interference between data collection and the primary mission of the vessel. On a completely not to interfere basis measurements such as depth profiling, surface temperature and salinity, meteorological observations, and limited temperature/depth profiles (using the expendable bathythermograph) could be made.

On a limited interference basis, where the ship is occasionally stopped or otherwise specially manuvered, water samples, bottom sediment samples, salinity and temperature profiles, and other data may be gathered. Although not all oceanographic survey requirements can be adapted to a ships of opportunity concept, many routine measurements can be taken, hence there is a requirement for a somewhat unique set of instruments designed specifically for use aboard ships of opportunity.

Ships of opportunity equipment can be separated into two broad categories, non-portable and portable. Non-portable equipment consists of instrumentation vans equipped with sensing, analysis, and recording equipment. The vans are outfitted for a particular mission. Feasibility of the instrumented van concept has been demonstrated by several projects. However, the size, weight, power requirements, and mobility of the vans limits their application. Thus a requirement exists for portable equipment, (portable meaning carryable by two men and a boy.) Use of portable oceanographic instrumentation to solve these problems has been dubbed "Suitcase Oceanography."

Recent developments in microelectronics and packaging techniques offer expanding opportunities to the oceanographic community for developing new, highly flexible portable data acquisition and processing systems.

Oceanographic Measurement Requirements

The study of oceanographic measurement requirements which was recently completed for the U.S. Coast Guard by the Travelers Research Center, contains a comprehensive analysis of Agency Mission Operations (AMO's). The survey

Table 1*

MARINE METEOROLOGICAL AND OCEANOGRAPHIC DATA REQUIREMENTS VS 5-YR BUOY STATE-OF-THE-ART

1	2	3	4	5	6	7	8	Range		11	12
No.	Parameter	Units	Ocean	Sfc	Atmos.	Par. SOA*	Non-buoy param.	9 Min	10 Max	Accuracy	Comp. par(s)
(1)	Surface water temperature	deg C		x		Yes		-5	40 deg C	0.01 deg C	2
2	Water temperature	deg C	x	x		Yes		-5	40 deg C	0.01 deg C	
(3)											
4	Salinity	ppt	x	x		Yes		0	42 ppt	0.01 ppt	
5	Wave elevation (x, y, t)	ft		x		Yes		0	100 ft	1 pct	
6	Water pressure	psi	x			Yes		0	10,000 psi	0.25 pct	
(7)	Bottom pressure variation	psid	x			Yes		0	2.5 psid	0.004 psid	6
8	Current direction	deg	x	x		Yes		0	360 deg	1 deg	
9	Current speed	kts	x	x		Yes		0.05	10 kts	.03 kts	
[10]	Current transport		x	x		No					
[11]	Vertical current		x	x		No					
12	Sound speed	fps	x			Yes		4500	5800 ft/sec	1 ft/sec	
(13)	Acoustic parameters		x			Yes					12
(14)	Incident radiation	ly/min		x		Yes		0.01	2 ly/min	1 pct	117
15	Ambient noise	db	x			Yes		-80	-20db re p_0 = 1 dyne/cm^2	3db	
		for freq range						0.1	60 kc		
16	Infrared surface radiation	ly/min		x		Yes		0	2 ly/min	2 pct	
17	Transparency	pct/m	x			Yes		0	70 pct/m	2 pct	
(18)	Light transmission	pct/m	x			Yes					17
19	Water level	ft		x		Yes	x	-3	13 ft	0.1 ft	
20	Tidal fluctuation	ft		x		Yes		0	60 ft	0.01 ft	
21	Water depth	ft	x	x		Yes		0	36,000	0.1 pct	
(22)	Wave height trace	ft		x		Yes		0	100 ft	1 pct	5
23	Inclination	deg		x		Yes		0	90 deg	1 deg	
[24]	Sea state	code		x		No					
(25)	Roughness	ft		x		Yes		0	10 ft	5 pct	5
(26)	Wave height spectrum E	ft^2		x		Yes		1	1500 ft^2	5 pct	
	F	cycles sec^{-1}						0	1 cycles sec^{-1}		5
(27)	Wave direction spectrum dir	deg		x		Yes		0	360 deg	5 pct	5
	f	cycles sec^{-1}						0	1 cycles sec^{-1}		
(28)	Swell height spectrum E/Δf	ft^2/cycle/sec		x		Yes		1	1500 ft^2	5 pct	5
	F	cycles sec^{-1}						0	0.1 cycle sec^{-1}		
(29)	Wave height	ft		x		Yes		0	100 ft	0.2 ft	5
(30)	Wave direction	deg		x		Yes		0	360 deg	5 deg	5
(31)	Wave period	sec		x		Yes		1	120 sec	0.1 sec	5
(32)	Swell height	ft		x		Yes		0	100 ft	15 pct	5
(33)	Swell direction	deg		x		Yes		0	360 deg	10 deg	5
(34)	Swell period	sec		x		Yes		5	1200 sec	15 pct	5
[35]	Silicate		x			No					
[36]	Nitrate	mga/lt	x			No					
[37]	Chlorophyl	microgm/lt	x			No					
38	Oxygen	ml/l	x			Yes		0.5	9 ml/l	0.1 ml/l	
[39]	Phosphates	mga/lt	x			No					
[40]	Water chemicals		x			No					
[41]	Nutrients		x			No					
[42]	Biological parameters		x			No					
[43]	Plankton		x			No					
44	Radiological chemicals		x			Yes					
45	Carbon dioxide	Atm	x			Yes		10^{-4}	12.0 x10^{-4} Atm	3 pct	
46	Turbidity	pt/ml	x			Yes		1	1000 pt/ml	1 pt/ml	
47	PH	no dim.	x			Yes		1	13	0.2	
[48]	Water sediment		x			No					
[49]	EH	volts	x			No					
[50]	Water visibility	ft	x			No					
[51]	Sediment load		x			No					
[52]	Sediment rate		x			No					
[53]	Sediment movement		x			No					
54	Sediment deposit	ft	x			Yes				0.5 ft	
(55)	Bathymetry	ft	x			Yes	x	16	36,000 ft	6 ft	21
[56]	Bottom cores					No					
[57]	Ozone				x	No					
[58]	Cosmic radiation				x	No					
(59)											

Table 1 (Continued)

1	2	3	4	5	6	7	8	Range		11	12
No.	Parameter	Units	Ocean	Sfc	Atmos.	Par. SOA*	Non-buoy param.	9 Min	10 Max	Accuracy	Comp. par(s)
60	Magnetic field intensity F	gammas		x		Yes		10^4	10^5 gammas	1 gamma	
61	Gravity	mgal		x		Yes	x	$.95 \times 10^6$	10^6 mgals	2.0 mgal	
(62)	Albedo	pct		x		Yes		0	100 pct	10 pct	117, 118
(63)											
[64]	Air density				x	No					
(65)	Weather data			x		Yes					78, 84
(66)	Surface weather			x		Yes					78, 84
67	Wind direction	deg		x		Yes		0	360 deg	2 deg	
68	Wind speed	kts		x		Yes		0	160 kts	0.5 kt	
(69)	Wind stress	dynes/cm^2		x		Yes		0	10^7 dynes cm^{-2}	10 pct	67, 68, 71
70	Atmospheric pressure	mb		x		Yes		800	1099 mb	0.1 mb	
71	Air temperature	deg C		x		Yes		-25	60 deg C	0.1 deg C	
(72)	Relative humidity	pct		x		Yes		5	100 pct	1 pct	70, 71, 73
73	Dew point	deg C		x		Yes		-12	40 deg C	0.2 deg C	
74	Insolation	ly/min		x		Yes		0.01	2.0 ly/min	1 pct	
(75)	Light penetration	pct/m	x	x		Yes		10	98 pct/m	4 pct	17
[76]	Refractive index	n		x		No					
77	Ambient light	ly/min	x	x		Yes		0	2.0 ly/min	1 pct	
78	Total cloud amount	pct		x	x	Yes		0	100 pct	10 pct	
[79]	Cloud base	100 ft		x	x	No					
[80]	Cloud top	100 ft		x	x	No					
[81]	Cloud type	code		x	x	No					
[82]	Visibility	n mi		x	x	No					
[83]	Vertical motion				x	No					
84	Precipitation rate	in/hr		x		Yes		0	12 in/hr	0.01 in/hr	
(85)	Precipitation amount	in		x		Yes		0	12 in	0.01 in	84
(86)	Specific humidity	g/kg		x		Yes		0	20 gm/kg	0.1 gm/kg	70, 71, 73
87	Ice accumulation	in/hr		x		Yes					
(88)	Wind force	dynes/cm^2		x		Yes		0	10^7 dynes cm^{-2}	10 pct	67, 68, 71
[89]	Ice breakup			x		No					
(90)	Integrated wind speed	kts		x		Yes		0	160 kts	2 kts	67, 68
(91)	Wet bulb temperature	deg C		x		Yes		-25	60 deg C	1 deg C	70, 71, 73
[92]	RAOB (T, p, RH)				x	No					
[93]	RAWIN (D S)				x	No					
[94]	RAWINSONDE (T, p, RH, D, S)				x	No					
[95]	Ice crystal size			x	x	No					
[96]	Flux-momentum			x	x	No					
[97]	Flux-mass			x	x	No					
[98]	Flux-heat		x	x	x	No					
[99]	Flux water vapor			x		No					
100	Propagation loss	db	x			Yes				db	
(101)											
(102)											
[103]	Reynolds stress			x		No					
[104]	XY vorticity component		x	x		No					
[105]	Stability		x	x		No					
106	Atmospheric electricity	k volts		x	x	Yes					
(107)	Transmissivity	pct	x	x		Yes		0	100 pct	2 pct	17
108	Templet		x	x		Yes					
(109)	Conductivity	mmho/cm	x	x		Yes		0.1	60 mmho/cm	0.01 mmho/cm	2, 4, 6
110	Photography of bottom					Yes	x				
[111]	Resultant wind direction	deg		x		No					
[112]	Resultant wind speed	kts		x		No					
(113)	Extinction of light	pct/m	x	x		Yes		0.05	0.50 pct/m	1 pct	17
(114)	Ambient surface light	ly/min		x		Yes		0	1 ly/min	2 pct	77
115	Magnetic field declination D	deg		x		Yes		0	180 deg	0.1 deg	
116	Magnetic field inclination I	deg		x		Yes		0	180 deg	0.1 deg	
117	Total radiation in	ly/min		x		Yes		0.01	2 ly/min	1 pct	
118	Total radiation out	ly/min		x		Yes		0.01	2 ly/min	1 pct	

*Source: "National Requirements for Marine Meteorological and Oceanographic Data", Eugene J. Aubert, Volume 1, Part 1, Travelers Research Center, Inc., Report 7485-253, Hartford, Connecticut (Contract No. TCG 16790-A) April 1967.

NUMBER OF AMO's

(AGENCY-MISSION-OPERATIONS)

PARAMETER	NO.
WATER TEMP.	(2)
CURRENT SPEED	(9)
CURRENT DIRECT.	(8)
SALINITY	(4)
WIND SPEED	(68)
WIND DIRECTION	(67)
AIR TEMPERATURE	(71)
ATMOS. PRESSURE	(70)
WAVE ELEVATION	(5)
OXYGEN	(38)
SOUND SPEED	(12)
DEW POINT	(73)
WATER DEPTH	(21)
WATER PRESSURE	(6)
TIDAL FLUCTUATION	(20)
TOTAL CLOUD AMT.	(78)
RAWINSONDE	(94)
TRANSPARENCY	(17)
BIOLOGICAL PARAM.	(42)
PRECIPITATION RATE	(84)
WATER CHEMISTRY	(40)
INSOLATION	(74)
AMBIENT LIGHT	(77)
VISIBILITY	(82)

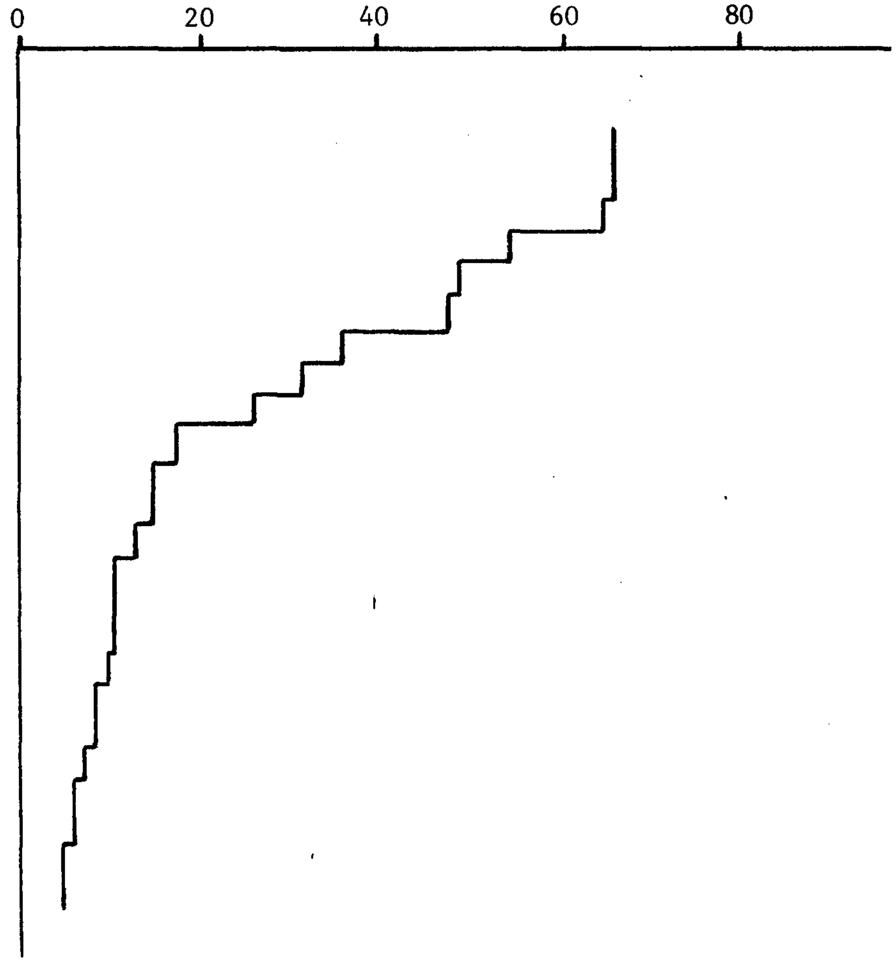

Figure 1

PARAMETER	NO.	MODE		INSTRUMENT
		"Not to Interfere"	"Limited Interference"	
WATER TEMPERATURE	2	-2 to 35°C ± .2°C (600ft) -2 to 36°C ± .1°C (surface)	-4 to 35°C ±.05°C (36000ft) -2 to 35°C ±.02°C (surface)	XBT, Suitcase STD
CURRENT SPEED	9	NONE	LIMITED	Parachute Drogue and Direct Readout Current Meters
CURRENT DIRECTION	8	NONE	LIMITED	
SALINITY	4	28 to 37.5 ppt ±.03ppt (surface)	0 to 51 ppt ±.003ppt (surface) 30 to 40ppt ±.05ppt (36000ft)	Injection Salinograph Lab Salinometer, Suitcase STD
WIND SPEED	68	0 to 100 kts ± .5 kt (surface)	0 to 100 kt ±.5 kt (surface)	Anemometer
WIND DIRECTION	67	0 to 360° ± 2° (surface)	0 to 360° ±2° (surface)	Anemometer
AIR TEMPERATURE	71	-25 to 60°C ± .1°C (surface)	-25 to 60°C ±.1°C (surface)	Thermometer
ATMOSPHERIC PRESS.	70	800 to 1099mb ±.1mb (surface)	800 to 1099mb ±.1mb (surface)	Barometer
WAVE ELEVATION	5	0 to 40 ft. ± 1%	0 to 40 ft ± 1%	Infrared Wave Height Sensor
OXYGEN	38	NONE	.5 to 9ml/l ±.1ml/l (36000ft)	Demand Water Sampler Lab Oxygen Analyzer
SOUND SPEED	12	4500 to 5800fps ± 1fps (200ft)	4500 to 5800fps ±1fps (36000ft)	Velocimeter
DEW POINT	73	-12 to 40°C ±.2°C (surface)	-12 to 40°C ±.2°C (surface)	
WATER DEPTH	21	0 to 36000 ft. ±.1%	0 to 36000 ft ±.1%	Fathometer
WATER PRESSURE	6	N/A	0 to 36000 ft ±.5%	Pressure Transducer
TIDAL FLUCTUATION	20	NONE	NONE	
TOTAL CLOUD AMT.	78	0 to 100% ± 10% (surface)	0 to 100% ± 10% (surface)	
RAWINSONDE	94	(Deployment Possible)	(Deployment Possible)	Rawinsonde (T,P,RH,D,S)
TRANSPARENCY	17	NONE	0 to 70% m ± 2%	
BIOLOGICAL PARAM.	42	LIMITED	Various	Jet Net, Water Sampler, etc.
PRECIPITATION RATE	84	0 to 12 in/hr ±.01 in/hr	0 to 12 in/hr ±.01 in/hr	
WATER CHEMICALS	40	Various (surface)	Various (surface & deep)	Autoanalyzer, Sampler, etc.
INSOLATION	74	.01 to 2 ly/min ± 1% (surface)	.01 to 2 ly/min ± 1% (surface)	
AMBIENT LIGHT	77	NONE (Ex. surface)	0 to 2 ly/min ± 1%	
VISIBILITY	82	Visual estimate	Visual estimate	

SHIPS OF OPPORTUNITY CAPABILITIES

TABLE 2

was based on 78 validated AMO's which were considered to form a composite of the national requirements. 112 separate, though not necessarily independent parameters to be measured were identified.(See Table 1) Oceanographic, biological, chemical, meteorological and geophysical variables were included. Transformations were used to identify common parameters (for instance, swell height and swell period can both be determined from the measurement of wave elevation) of which there were 77. The study then went on to identify 40 common and unique parameters suitable for measurement from buoys.

The data presented up to this point in the Travelers Research Center study can be analyzed in a slightly different way with some rather interesting results. It is possible to determine the number of AMO's which require a particular parameter, and by ranking this in terms of the 77 common parameters, to derive a sort of indicator of where-the-action-is (and will be in the coming years) in oceanographic instrumentation. Although this approach does not give the exact ratio of, for instance, wave height sensors to sound speed meters, it does give an indication as to the relative agency wide interest in each parameter on a national basis.

The results of this analysis are shown in Figure 1. (Only those parameters corresponding to five or more AMO's are shown.) Water temperature, and current speed and direction are at the top of the list. This set of 24 parameters is further analyzed in Table 2 in terms of making the measurement from a ship of opportunity.

On a limited interference basis, only tidal fluctuations definitely are not suitable for measurement from a ship of opportunity. Current speed and direction measuring capabilities are also very limited. Feasibility studies are under consideration for an expendable type current meter analagous to the recently developed expendable BT (a low cost device which provides a temperature versus depth record and can be deployed from a ship moving at a speed of up to 30 knots.) This, of course, could provide only instantaneous current profiles and a question arises as to the need for this type of information. Conventional current measurements are made over long periods of time in order to determine (among other things) the time variation of the currents.

On a totally not to intefere basis, in addition to tidal fluctuations and currents, comprehensive oxygen profiles, sound speed profiles, and transparency and ambient light profiles can not presently be obtained from ships of opportunity. Instruments under development such as the underway water sampler and towable variable depth packages show promise of extending the profiling depth range for these underway measurements. An expendable ambient light meter would seem to be well within the realm of feasibility, although no effort on such a device is known to be in progress.

Of the 24 top parameters measurement requirements, 21 of them can either be completely or partially satisfied by ships of opportunity using state-of-the-art instrumentation. Projecting the ongoing instrumentation development into the state-of-the-art five years hence, virtually all of the parameters would fall into the above category, with the probable exception of time series current measurements. Buoys seem to be the logical choice for this requirement.

Design Considerations

Most ships of opportunity probably will not have adequate winching capabilities, repair facilities, navigation positioning equipment, and numerous other supporting services. These constraints will determine the design philosophy of the instrument packages. For instance the concept of winchless sensor packages, such as the newly developed pop up corers (a device that is thrown over the side, sinks freely to the bottom and takes a core as it penetrates, releases, floats back to the surface and is retrieved with the sample intact) can also be applied to the self-contained STD system.

The lack of adequate maintenance personnel and facilities on board will dictate that a minimum of service functions, such as tape or film replacement and operating adjustments, be required. Rigid demands for high instrument reliability must be met. Closely connected to this requirement is the problem of designing instruments that are operator proof. In essence this means a minimum of switches, controls and procedures required for its successful operation along with a built in tolerance for operator errors. Unfortunately, this often competes design-wise with the reliability requirements; i.e., more automatic operation with fewer parts is difficult to achieve. This is a real area of challenge to the oceanographic instrument producers. Unique power requirements will be impractical, hence many of the instruments will be operated by self-contained rechargeable batteries while the others will contain rugged converters designed to operate from the often unpredictable ships power. This is no minor problem since ships power variations from 110 ± 20 vac to 60 ± 3 cps are not uncommon during normal ship operations. More than a few computers and other expensive instruments have been put out of commission because of voltage spikes of 40 volts or more.

The navigation positioning difficulty is perhaps one of the most fundamental problems to the ship of opportunity program (and to the national oceanographic effort as well.) Highly accurate oceanographic data tied to an inaccurate position can be less than useless and in some cases can be downright detrimental. A seamount reported miles from its true position could prove disastrous to a modern submarine. At best, later verification could be obviated.

The data positioning problem is discussed in considerably more detail in a recently completed study, "National Data Program for Marine Environment."[2] The IRLS positioning system which shows promise of solving this problem and of being simple and low cost is described in detail in another section of this paper. From a systems point of view, the problem is to tie the position data directly to the oceanographic data, which is to understate the case, no minor consideration.

Suitcase Instrumentation

A family of suitcase type instruments is under development for ships of opportunity. They are designed to fulfill several types of missions, therefore some systems operate independently of the ship, while others use the ship's power and winches, and require that the ship be hove-to for operation. Each instrument is being designed to operate independently of the others, however, a combination of instruments may be deployed simultaneously as shown in Figure 2. In addition to collecting oceanographic data, these systems can provide navigation data and a telemetry capability for data transmission to a shore station.

A deck data recorder-processor is used for recording the oceanographic data. The recorder will accept data from up to ten instrument systems. The data is recorded digitally on magnetic tape, and printed on paper tape. Data from any one source can be displayed on a visual, decimal digit display. The deck recorder also provides an interface between each instrument system and a satellite interrogation, recording, and location system (IRLS), and other radio teletype systems. An additional function of the deck data recorder-processor is to provide battery checking and charging capabilities for submersible systems operating independent of ship's power.

SUITCASE

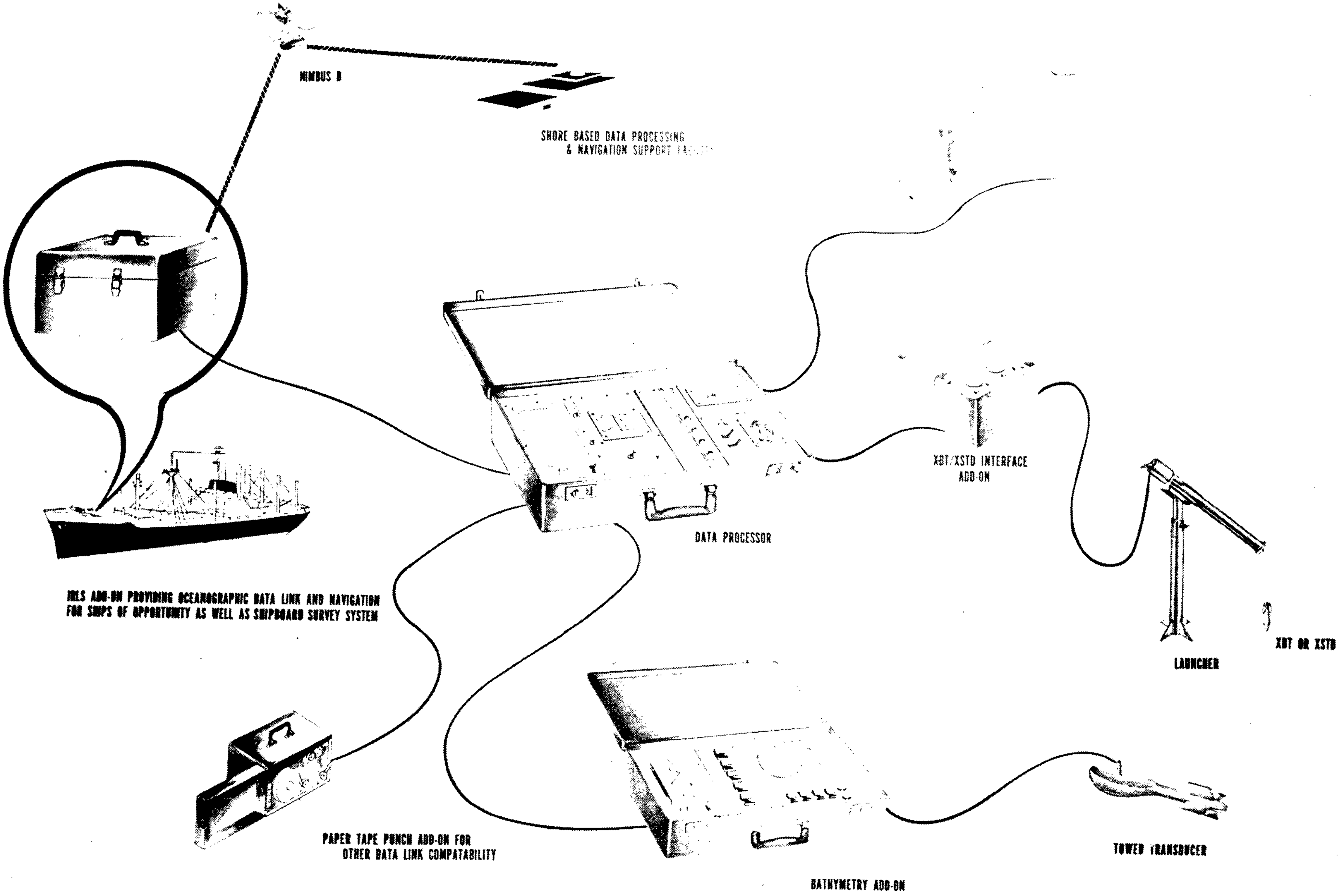

Figure 2

Magnetic tapes taken from the deck recorder are returned to shore stations for processing; the paper tape print out is used for shipboard work; and the visual display allows an oceanographer to monitor data as it is received and processed.

Salinity-Temperature-Depth System

The first instrument designed specifically for suitcase oceanography is a self-contained salinity-temperature-depth system. The system consists of conductivity, temperature, and pressure sensors, measurement and compensation circuits, a scanner, an A/D converter, digital recording electronics, a magnetic tape recorder, and a battery power supply.

The sensor package is located at the base of the pressure case. Salinity is derived from seawater conductivity which is measured by a seawater coupled inductive probe. Pressure and first and second order temperature corrections are automatically applied to the measured conductivity, providing an output that is proportional to salinity. Temperature is sensed by platinum resistance thermometers and pressure is sensed with a strain-gauge transducer. The pressure sensor is temperature compensated and provides an output indicative of depth.

The salinity, temperature, and depth outputs are applied to a scanning circuit that sequentially selects each parameter and presents it to an AC digital bridge for conversion to digital format. When the digital bridge is balanced, the data is read into a magnetic tape recorder in a binary coded decimal format. The magnetic tape recorder is a 7-track, IBM compatible recorder capable of holding 100 feet of 1/2 inch magnetic tape. The seven track recording head utilizes the NRZI recording method. Data is recorded with a packing density of 200 BPI.

Before each mission, the battery power supply is charged, a data sampling rate is chosen, and magnetic tape is loaded in the tape recorder.

Heading data such as run numbers, navigation information, or time may be recorded from a small deck unit. Then the STD system is closed and sealed.

The STD system is attached to a steel cable and lowered to a desired depth. A messenger is released from the ship and starts the recording process. Data is collected as the STD is raised to the surface. When the STD is removed from water, it is automatically shut down by a seawater switch. Additional casts may be made without opening the pressure case. IR gaps are automatically placed between data recorded from each cast. At the completion of the mission, the magnetic tape is removed from the STD, and is processed on a computer.

A second type of salinity-temperature-depth system being developed is essentially the same as that described above. However, the IBM compatible tape recorder will be replaced with a read/write tape recorder. In this system the magnetic tape in the STD is erased, and the battery pack is checked and charged before each cast. Then the STD is attached to a cable, a cast made, and the instrument returned to the surface. The STD is then interrogated by a deck data processor and controller. Salinity, temperature, and depth data is displayed, recorded, and transmitted to shore as necessary.

Another STD system is the expendable salinity-temperature-depth (XSTD) system. With this system salinity and temperature profiles may be obtained from ships of opportunity on a completely not-to-interfere basis. The XSTD system consists of four major parts, an expendable sensor probe, a sensor launcher, a deck unit and a recorder. The expendable probe contains a conductivity sensor, temperature sensors and a telemetry device for transmission of conductivity and temperature to the deck unit. The launcher is used to deploy the expendable sensor. In addition, the launcher provides an interface between the expendable probe and the deck unit. Conductivity and temperature received by the deck unit is converted to salinity and temperature. Depth of the probe is derived in the deck unit from the sink rate of the probe. Salinity, temperature, and depth is then digitized and recorded by a digital printer, a magnetic tape recorder, a strip chart recorder, or the deck data processor.

Wave Height System

To measure ocean waves from ships, an infrared wave height sensor is being developed which measures the changing range between the ships bow, and the water. A varying DC output signal indicates the combined effects of wave height and ship motion. Because wave height is the desired output, vertical acceleration of the bow is measured and doubly integrated to a DC output proportional to ship vertical motion. The outputs of the wave height sensor and the double integrator are then summed to give a DC output indicative of wave height. This signal is then recorded, and simultaneously processed to provide significant wave height data which is also displayed.

The infrared wave height sensor is essentially a ranging device. A crystal controlled oscillator, a buffer amplifier, and a power output circuit drive and modulate an infrared source diode. Transmitter optics form a 7.5° beam. Receiving optics, designed to encompass the transmitted beam, collect the back scattered and reflected radiation. A solid state photo diode detects the infrared energy modulation. This signal is then amplified and filtered. A sample of the transmitter modulation signal is phase shifted and phase compared with the received signal giving a variable DC signal proportional to the wave height and vertical position of the bow of the ship. The range between the bow and smooth water is removed by phase shifting the transmitter reference modulation signal such that an output of zero volts is obtained when the ship is in port. Any DC drift in the output from the phase comparator is removed by AC coupling this output to the recorder and the significant wave height computer.

The bow mounted accelerometer is gimbal mounted and fluid damped to remove pitch and roll effects from the acceleration data.

A special purpose computer provides a continuous real time value for significant wave height in accordance with the formula: $H_{1/3} = 2.87\ H_{RMS}$, where H_{RMS} is the root mean square value of wave height taken over a 20 minute interval. The wave input is squared and normalized and is then averaged by an active filter having a time constant of 20 minutes. The square root of the average voltage is taken. (All of the above steps are performed with analog circuits.) The normalized RMS voltage is then scaled, giving an output current proportional to significant wave height. This current is measured and displayed by a digital current meter which also has digital outputs for data recording.

IRLS System

A satellite interrogating, recording, and locating system, Figure 3, will be used to transmit data from ships of opportunity to a surface station, and to provide precise positioning data to the ship. The IRLS in the satellite receives an interrogation sequence program from the command station which sets up the sequence of coded transmissions relating to orbit time to the surface station. A new interrogation program is transmitted for each orbit. When the shipboard station receives the assigned code, it transmits its own address back to the satellite. The satellite in turn, after it recognizes the proper return signal, transmits a confirming reply back to the station and readies the storage system to receive the surface station data. After the surface station receives the confirmation, it then starts the data transmission. In the event that a surface station does not reply to the satellite interrogation, the system in the satellite pauses and three seconds later the interrogation sequence is repeated.

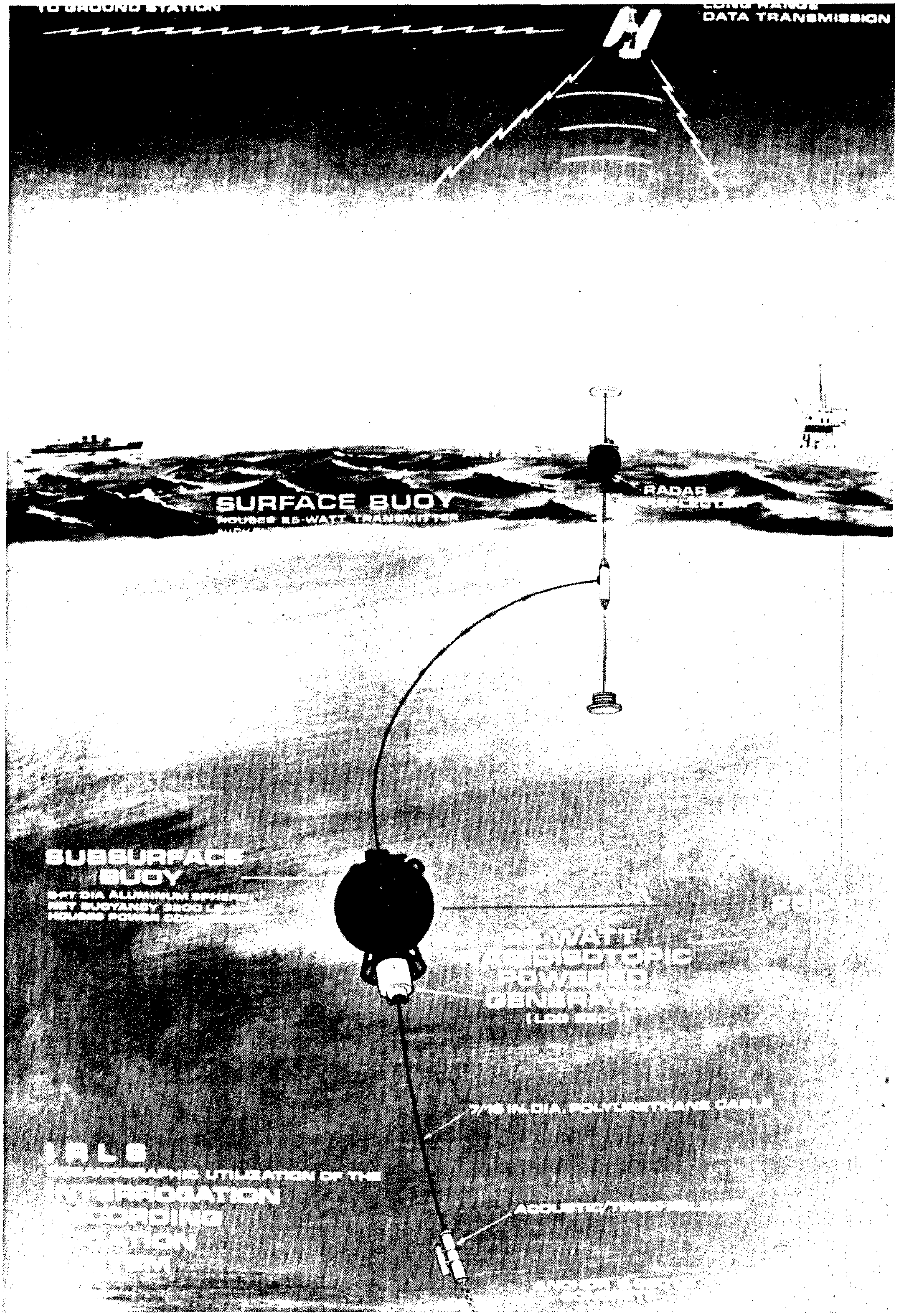
TO GROUND STATION
LONG RANGE
DATA TRANSMISSION
SURFACE BUOY
HOUSES 25-WATT TRANSMITTER
RADAR
SUBSURFACE
BUOY
ALUMINUM SPHERE
NET BUOYANCY
HOUSES POWER
WATT
RADIOISOTOPIC
POWERED
GENERATOR
7/16 IN. DIA. POLYURETHANE CABLE
I R L S
OCEANOGRAPHIC UTILIZATION OF THE
INTERROGATION
RECORDING
LOCATION
SYSTEM
ACOUSTIC/TIMED RELEASE

Figure 10a

The data is received by the IRLS from the ship of opportunity and is loaded serially into a magnetic core memory. When all the data from the ship has been loaded, an end of message signal automatically stops the memory load and terminates the interrogation. The satellite then initiates the next interrogation cycle. At the completion of the orbit, the master ground station commands the readout of all data stored during the orbit. The data received on the ground is stored in a buffer memory and is processed by a computer.

The location of a surface station is determined by establishing the geometrical relationship and the range between the satellite and the surface station. The geometrical relationship is defined by a plane triangle generated by two different positions of the satellite along its orbit with the surface station forming the last stationary point. The distance is determined by measuring the round trip propagation of the radio waves of the two positions. These data are transmitted to the surface station at the completion of the satellite interrogation of the surface station.

Additional Systems

Possibilities for expansion of suitcase instrumentation is governed by the need for data. Feasibility studies are being made of an expendable current meter, similar to the expendable salinity-temperature-depth system. Meteorological instruments are generally portable and repackaging and modifications to the outputs will allow their use on ships of opportunity. Bathymetric data may also be collected by some ships of opportunity. Small winches and booms may be temporarily welded to a ship deck to allow the towing of some acoustic transducers. Transceivers and recorders may now be classed as portable. Addition of digital timing circuits will allow digitization of these data for interfacing with the remainder of the suitcase systems.

Design of suitcase instrumentation systems for measurement of sound speed, water chemistry, and ambient light are also possibilities for future design.

CONCLUSIONS

Suitcase type instrumentation will provide the oceanographer with a quick reaction survey capability in addition to increasing the utilization of ships of opportunity for gathering selected kinds of oceanographic data. Although not all oceanographic measurements can be made with this kind of equipment, many of the more important ones can be. The promise of the IRLS satellite data link and low cost positioning device, though yet not fully proven, hopefully will solve the perennial position problems associated with ships of opportunity and provide rapid access to the survey data.

This new family of instruments will be characterized by expendability, will be largely self-contained and utilize a building block approach, will utilize digital magnetic tape recording techniques and their design will provide ruggedness, portability, and reliability.

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13. ABSTRACT

Recent developments in microelectronics and packaging techniques offer expanding opportunities to the oceanographic community for developing new highly flexible, portable data acquisition and processing systems. These "suitcase" systems will permit certain types of oceanographic survey work to be performed from non-oceanographic vessels or ships of opportunity. Since ship time represents a substantial porton of the overall cost of oceanograhic data acquisition significant savings are offered by the suitcase oceanography concept.