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Deacon Laboratory

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SeaSoar - the IOSDL towed undulating vehicle

J Smithers

1991

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES
DEACON LABORATORY

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ABSTRACT

This manual gives a description of the system, its development, current design and performance. The operational and maintenance notes are based on long experience gained from handling and operating this equipment at sea, on a variety of vessels.

KEYWORDS

BATFISH
CABLE FAIRING
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FLUORIMETER
SEASOAR

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1. INTRODUCTION.

During 1974 a towed vehicle that could follow a predetermined path controllable from onboard ship, was obtained. This vehicle known as 'Batfish' was manufactured by Hermes Electronics Ltd.

It was towed on a 600 m length of tow-cable comprising 7 inner electrical conductors, surrounded by two torque balanced, load bearing armoured layers. To reduce drag and achieve operation to 400 meters, a fairing manufactured by Fathom Oceanology Ltd, was fitted to the cable. A Neil Brown CTD (Conductivity, temperature and Depth probe) with specially designed pressure housing was mounted in the vehicle and first used during the Global Atmospheric Temperature Experiment (GATE).

The vehicle design originated at Bedford Institute of Oceanography and is currently being manufactured by Guildline Instruments Ltd. During the last decade, the design of the system has been gradually altered to suit the changing needs of the IOSDL scientific program. The vehicle design has been altered to such an extent, that it was decided to market it as a separate system in its own right, with the new name of 'SeaSoar'.

SeaSoar is as a large volume, controllable depth, towed instrument carrier, capable of carrying a variety of instruments. Speeds of up to 9 knots ,to depths of 410m are achievable, following a path through the sea, controlled and adjustable from onboard a ship. Data and vehicle control signals are transmitted to the towing vessel via the multicore tow-cable. The vehicle has controllable pitch wings providing lift in the downwards direction (needed to drive the vehicle down against the tow-cable drag).

By varying their pitch angle, the vehicle may be made to dive or climb as required. Movement of the wings is obtained by driving a radial lever welded to the centre axle assembly, from a hydraulic ram. This is controlled from the system deck unit via a hydraulic servo valve (Moog Valve). Power for the ram operation is derived from a hydraulic pump driven by an impeller mounted at the stern of the vehicle.

The deck unit generates a sawtooth signal, whose peak-peak amplitude and up/down rate is adjustable.

The difference between this and the SeaSoar CTD pressure transducer signal, controls the servo valve via a current drive amplifier, thus forming a feedback loop, Fig 1.

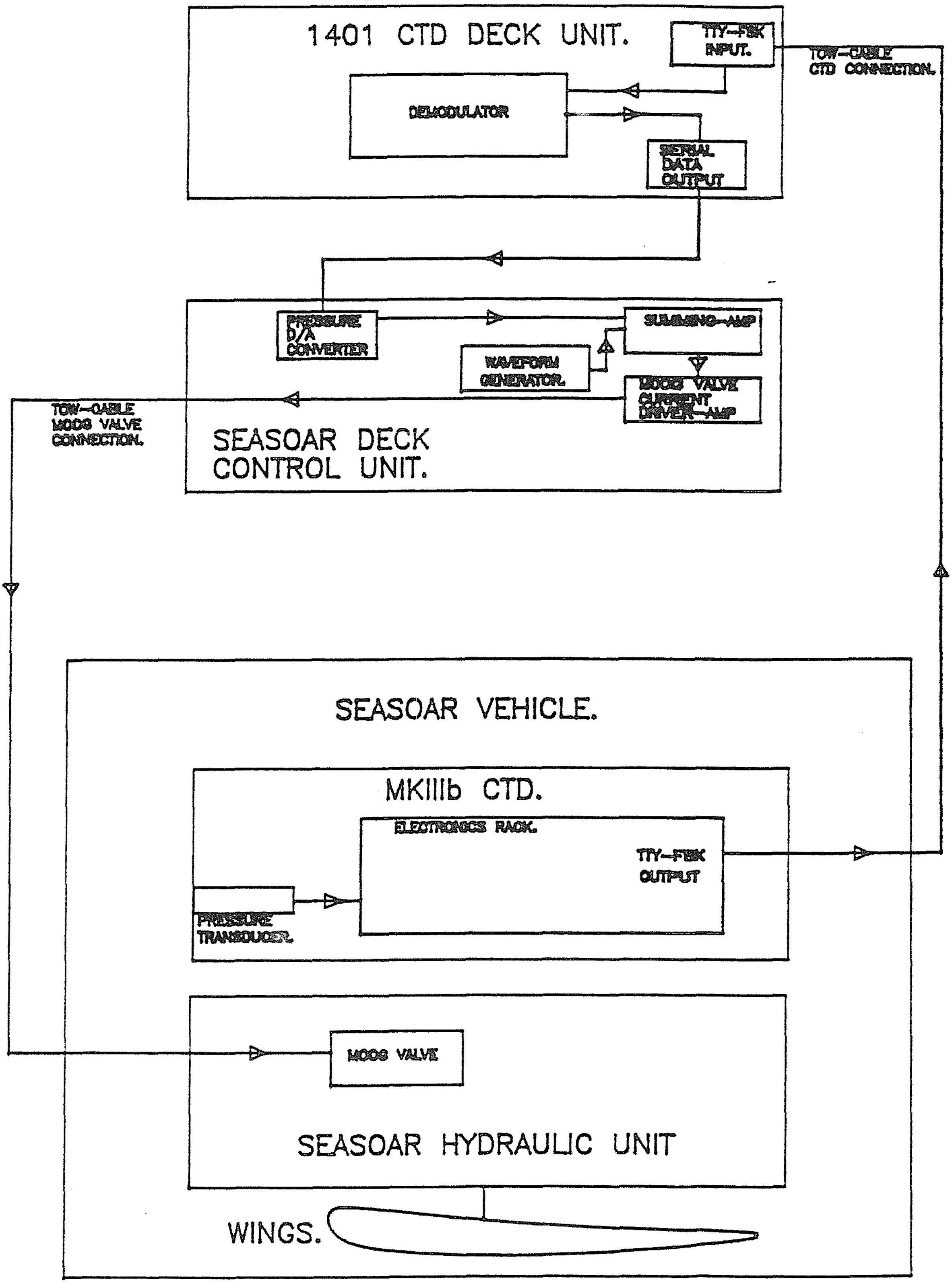

FIG.	1.	SEASOAR/CTD DECK UNIT FEEDBACK LOOP.	DRAWN	J.SMITHERS
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2. GENERAL SPECIFICATION.

BODY		
Overall length(impeller to bridle)	1.93 m	
Overall height(rudder bar down)	0.98 m	
Overall width		1.35 m
Weight (in air,inc hydraulic unit, exc sensors)		180 kg

CABLE (Rochester Corporation)		
Type No.		7-H-325A
Breaking strain		4,200 kg
Diameter		8.2 mm
No. of cores		7
Weight in sea-water		0.21 kg m^{-1}

PERFORMANCE	Faired	Unfaired
Maximum Depth	410 m	100 m
Maximum Tow Speed	9 knots	9 knots
Minimum operating speed	6 knots	6 knots
Max rate of depth change	1.6 m sec^{-1}	4.5 m sec^{-1}
Level tow accuracy	+ 3 m	+ 1 m

WINCH		
Drum diameter (minimum)	1.75 m	0.45 m
Drum capacity	600 m	250 m
Maximum pull	500 kg	300 kg
Maximum line speed	1 m/sec	1 m sec^{-1}
Minimum line speed	5 m/min	5 m min^{-1}

3. DEVELOPMENT.

During the earlier experiments in which Batfish was used, it soon became obvious that the servicing interval required by the hydraulic unit was too short for the current usage.

The unit was re-engineered entirely, using the basic original hydraulic circuit.The emphasis of this new design was on maximum integrity of the hydraulic circuitry.The prime problem was that of keeping the operating hydraulic fluid and the surrounding sea-water separate. Three types of seal were involved, rotational,oscillatory and static.

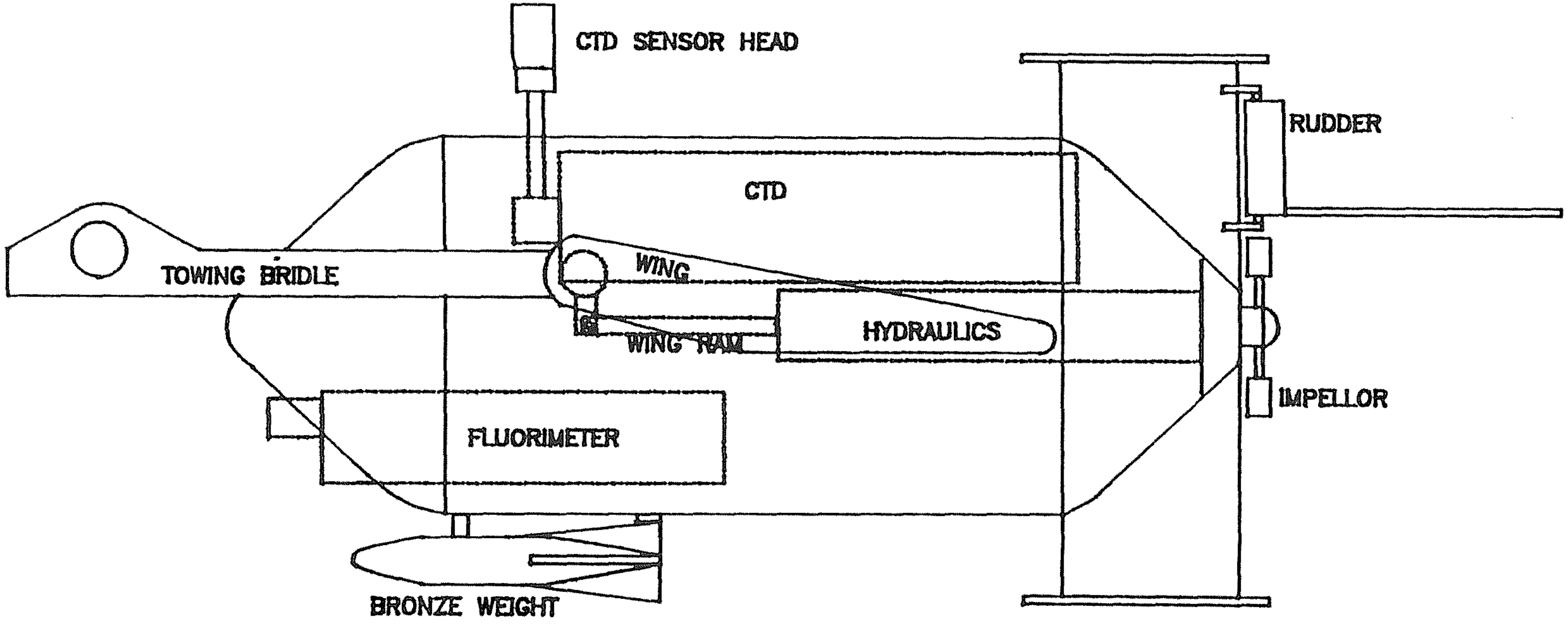
In many cases pressures across the seals are both positive and negative at various points in the flight path of the vehicle. Static seals are generally single axial compression 'O' rings. The leakage path through the rotational seal is lengthened by surrounding the inner seal with an oil filled and pressure balanced space through which the drive shaft passes, and fitting back-to-back lip seals between this space and the sea.

The ram at the front of the unit is surrounded by an oil filled and pressure balanced flexible bellows to back up the seal around the ram itself. Lastly, the entire hydraulic unit is surrounded with an oil filled and pressure balanced space. Thus it is necessary for two leaks to occur in any one path before sea water can mix with the operating fluid.

The outer case of the unit was originally made of aluminium. A pressure case manufactured from plastic and stainless steel was tried, in order to extend the lifetime of the unit, but this has since been replaced with one made entirely of stainless steel. The original aluminium unit was first fitted to the Hermes Batfish and operated successfully with this vehicle.

The eventual loss of this vehicle required the replacement of the entire vehicle, and at that time it was decided to take the opportunity to produce a new vehicle with redesigned body. As there was a requirement to carry several instruments Eg. CTD, Fluorimeter, Water sampler; it was decided to increase the volume considerably. The new vehicle used the same configuration of lift surfaces as the original, though their construction differed, and the body was made rectangular in section throughout its entire length. The body comprised a bedstead shaped aluminium centre section with GRP nose and tail sections bolted on. The centre section was closed top and bottom by removable aluminium alloy panels. This arrangement allowed maximum accessibility for loading the vehicle. Two problems soon became evident with this Mainframe. Firstly, corrosion rates were excessive, and secondly the frame was not stiff enough in torsion.

To overcome these problems the current stainless steel deep sided frame was designed and has proved to be both durable and stiff. An experiment that involved hanging a streamlined body containing a second set of sensors some 2 m below the main vehicle, highlighted the advantage of increasing the hitherto very low static stability of the vehicle. From that time on, a similar small streamlined weight was fitted close beneath the centre body, Fig 2.



NOT TO SCALE.

FIG. 2.

SEASOAR VEHICLE
SHOWING INSTRUMENT LAYOUT.

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The towing bridle underwent a series of changes, mostly to stiffen it due to the heavier body and increased driving loads. The current, rather massive stainless steel bridle is the end result.

Originally a tapered stainless steel ferrule fitting inside the cable armouring and pulling into a similar tapered female within an aluminium block, was used to transfer the cable towing forces to the vehicle. This arrangement put considerable local bending stresses into the cable, resulting in eventual local armour wire and electrical conductor breakage. The present termination, consists of a small narrow friction drum welded at the front of, and between the two sides of the towing bridle. The tow-cable is wound around this drum and then clamped. Although somewhat bulky, this arrangement treats the cable gently. To date little or no damage has occurred at this point since the system was fitted.

Electrical conductor breakage still occurs however, between this towing arrangement and the cable entry point into the vehicle. As the towing bridle moves up and down there has to be some movement of the cable at the entry point to the vehicle. This causes work hardening of the electrical conductors with eventual breakage. Careful arrangement of the cable at this point (Fig 9.) helps to minimise this problem.

Two alterations have been made to the design of the original lift surfaces. Though their relative spacing has remained similar, the tail surfaces are now flat plastic plates instead of the original GRP foils. This change was made on largely economic grounds and had no noticeable effect upon the vehicle flight. The original NACA 6428 wing section has been retained but has undergone several strengthening changes.

The wing axles are 50mm diameter stainless steel to which are welded perforated plates fore and aft. This inner structure is locked into the GRP outer skin through the inner end plate and the high density foam wing filling. An attempt was made to replace these relatively expensive foil sections with flat steel plates of slightly increased width/chord ratio. However, problems of strength and rate of change of lift with wing pitch angle terminated these experiments when the wings folded up. The reason for this experiment was again one of economy.

Similarly to the Hydraulic Unit, the Deck Control Unit uses a similar design to the original but has been rebuilt and improved using modern components, to allow for ease of access and servicing.

4. PERFORMANCE.

SeaSoar may be operated with or without a fairing on the tow-cable. The tow-cable used is manufactured by the Rochester Corporation, Type No. 7-H-325A and the fairing by Fathom Oceanology Ltd, Type No. 478.

This fairing is of the rigid, segmented and fully enclosed variety.

Normally an unfaired cable is 250 m in length and a faired one 600 m, with 550 m of fairing fitted to the seaward end. The fairing reduces the drag of the cable by a factor of about 4, however, the additional mass of the long faired cable reduces the available rate of change of depth. In either case, the parameter that controls the ultimate performance of the vehicle is the strength of the cable.

Cable Type No. 7-H-325A has a makers guarantied minimum breaking strain of 4,200 kg and on test has been shown to withstand 6,000 kg with no sign of damage. In operation the maximum cable tension allowed under normal circumstances is 1200 kg. Factors which will immediately affect cable tension are:

a) depth of vehicle.
b) rate of change of depth downwards.
c) speed of tow.
d) vertical motion of tow point on vessel.

To some extent these may be traded off against one another when setting up a path for the vehicle to follow.

4.1 Faired cable.

A typical example of the path of the vehicle is shown in Fig 3. This type of undulation is usually called a 'yo-yo'.

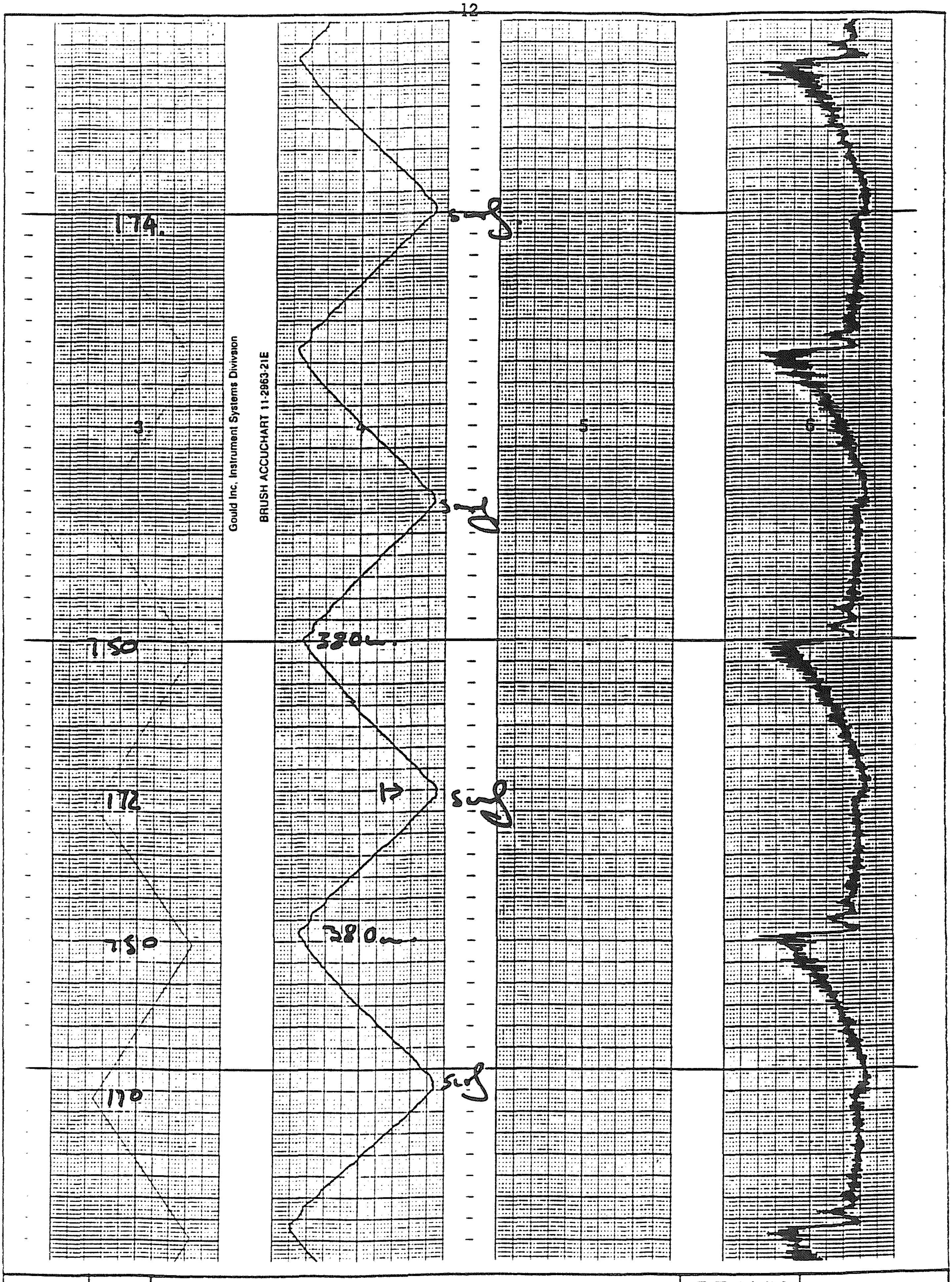

FIG. 3. TYPICAL SEASOAR 'YO-YO'

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In the case shown, the vehicle was towed on a 600 m length of faired cable with about 550 m of cable in the water. A maximum depth was being aimed for, the towing speed was just over 7.5 knots and the peak cable tensions were close to 1400 kg.

With this length of faired cable, the maximum vertical velocity was 1 m sec^{-1} so the time to complete one full 'yo-yo' from surface to 400 m and back was about 13 mins in which time the towing vessel travelled about 3000 m. Using this length of cable it is sometimes difficult to obtain a smooth transition between ascent and descent. This is probably due to the pitch angle of the wings.

Some fine tuning is often required at this point in order to reduce cable tensions due to sudden dives after the 'yo-yo' apex has been passed.This can be trimmed with the lead-lag networks incorporated in the control unit summing amplifier. When flying the vehicle horizontally, there are some depths at which it is very difficult to maintain a steady depth, this is due to an unstable configuration at that particular tow speed. Slight changes in either speed or depth should produce level flying within about 3 m of the desired level.

4.2 Unfaired cable.

The vehicle may be towed on a plain cable of up to 250 m in length. When working in shallow water it is normal practice to arrange to have slightly less cable out, than the depth of water. Thus in the event of a ship breakdown the vehicle may hang safely clear of the seabed. 250m of cable will allow a maximum depth of about 90m to be attained.

Putting out extra cable has little effect on achievable depth because of the increased drag. The much smaller size of the winch necessary to handle this amount of cable allows the system to be operated from quite small fishing vessels if required.

Also the whole handling of the vehicle and the cable is very much simpler than when a faired cable is used.

Typically, a 'yo-yo' obtained when the vehicle is towed on an unfaired cable gives a range from surface to 90m, completed in less than a minute, with ascent and descent velocities in excess of 3m sec^{-1} . The maximum rate of change of depth is approximately 4.5 m sec^{-1}. During horizontal towing there should be no difficulty in maintaining the vehicle within 1 m of the level desired.

Normally the system uses depth of vehicle, (pressure) in the feedback loop. However, any of the parameters measured at the vehicle could be used, although considerable caution should be exercised in this case and it is not an advisable course for the inexperienced operator. Temperature could be used as the feedback parameter, in order to follow isotherms. However, the very large temperature gradients that can occur in some parts of the ocean (Eg Iceland-Faeroes channel etc), would make it extremely difficult for the vehicle to follow. Any deep, well-mixed surface layer (top 200-300 m of the N.Atlantic during winter) or temperature inversions would also serve to confuse the system.

5. DESCRIPTION.

The details of the operation of SeaSoar are to some extent dependent upon the ship layout, type of winches and deck handling equipment available.

Though the following notes are derived from operation of SeaSoar on only five different vessels, all of the principles and most of the details will be applicable to any SeaSoar operation.

5.1 Winches.

Two winches are available for use with SeaSoar, with a third of new design soon to be introduced. One is for unfaired cable and the other faired. 250 m of unfaired cable is carried on a small electrically powered conventional winch. It is driven by a single phase motor through a reduction gearbox and a two speed directional gearbox. The two gears give line speeds of approximately 1 m sec^{-1} and 5 m min^{-1} with a line pull of 250 kg at the high speed. A variable speed control would be better with a speed range within these limits.

The horizontal drum is Lebus grooved so that a lead screw is unnecessary. The drum has an 8-way slipring unit fitted to it. The winch has a hand operated band brake and a dog clutch that allows the drum to rotate freely. A strain gauge tension link is fitted to the structure of the winch and is linked to the drum when towing. This allows towing loads to be transmitted to the vessel without having to pass through the winch transmission system. 600 m of faired cable is carried on a vertical axis capstan, hydraulically driven. The cable has to be wound on in a single layer so the drum used is about 1.75 m in height and diameter. The capstan is merely a hydraulic motor complete with the necessary control valves and a hand operated brake.

Haul and veer line speed are controlled progressively by a bidirectional dead man's handle type of valve and are dependant upon the pressure and capacity of the hydraulic power supply. The hydraulic system incorporates a valve arrangement to prevent freewheeling of the winch drum in the event of hoses blowing on the input or return connections to the shipboard hydraulic outlets. A hand operated by-pass valve is also incorporated to allow the winch drum to freewheel, but only after the tow-cable strain gauge has been fitted between the lower drum cheek plate and load point attached to the vessel.

A minimum of 150 bar and a flow of 30 l min^{-1} are recommended. Due to the difficulty of aligning the fairing onto a vertical drum, no lead screw is fitted, instead the cable is guided by hand onto the grooved drum.

The new winch design will feature a horizontal drum to allow the length of tow-cable payed out to be varied, thus catering for water depths less than 600 m. There will be a fairing guide and lead screw incorporated into this design. Cable strain will also be measured with an integral fitted load cell. The whole assembly will fit onto a standard container flatbed, for ease of carriage and fitting.

5.2 Tow-cable lead.

The unfaired cable should not lead around guide blocks or rollers that are less than 25 cm in diameter. Ideally, a minimum bending radius of 25 cm should be used for any bends of the cable during towing. Generally, the small winch can be sited such that it is closely in line with the aft towing point obviating the use of any but the actual towing sheave.

The faired cable should not be run over less than 60 cm diameter sheaves in the unloaded condition, and the amount of bending should be kept to a minimum. Normally with faired cable, the last 50 m on the shipboard end is left unfaired. This allows towing sheaves to be of a smaller size than would otherwise be the case. For either system a large purpose built snatch block of 100 cm diameter with a deep 'U' shaped polyurethane covered face has been successfully employed.

5.3 Lifting equipment.

In order to launch and recover the vehicle, it is necessary to have some means of lifting it over the stern of the vessel. Ideally an 'A' frame is used for this. In which case the tow-cable is led over the snatch block attached to the 'A' frame via a cable of sufficient capacity to bear the fault strain load of 4000 kg. This cable length should be variable to allow adjustment of the height of block for optimum position during various stages of the launch or recovery. A small auxiliary winch mounted on the side of the 'A' frame is ideal for this purpose.

The 'A' frame should extend as far behind the vessel as the deck is above sea water level. This is to ensure that the SeaSoar vehicle cannot swing forward and contact the ship's stern during recovery.

Alternatively a crane can be used. In this case a 'Cherry Picker' type with the sheave closely attached to the end of the jib should be employed. This is to control the swing of the vehicle once it is off the deck.A crane of the Hiab variety is best suited for this.

5.4 Deck unit.

The present deck unit consists of six sections;

power supply + 12 volts, + 5 volts,
waveform generator,
summing amplifier,
valve current driver,
waveform output buffers,
pressure D/A converter.

(see section 5.5. Circuit diagrams).

5.4.1 Power supply and Dither Oscillator, (Fig 4).

This is a standard encapsulated commercial unit supplying + 12 volts stabilised at 250 mA per rail, from which + 5 volts are derived from standard regulators IC1 and IC2.

The Dither oscillator is of the standard Wien bridge type comprising IC3 and associated components. The output is a — Hz square wave of — volts pk-pk. This provides a small continuous movement of the Moog servo valve to prevent 'Stickion'.

Supply to the unit is 240 V AC 50 Hz.

5.4.2 Control waveform generator, (Fig 5).

In the automatic undulating mode, the waveform generator produces a sawtooth waveform signal whose amplitude depends upon the settings of the maximum and minimum depth potentiometers VR3,VR2 and the slope depends upon the settings of the up and down rate potentiometers VR1,VR4.

The voltage set by VR3 and the output of the integrator IC2, is compared by a comparator, IC4. When these outputs are equal in voltage level, IC4 will turn on setting IC5a NOT Q low (-5 volts). Diode D2 will turn off and D1 on, thus applying -5 volts to one end of VR1(up rate). A proportion of this voltage as determined by the setting of VR1 is fed back to the inverting input of the integrator whose rate of change of output will be dependent upon this input voltage. As the vehicle then climbs, the comparator IC3 will turn on depending upon the setting of VR2(min depth) and integrator output, IC5 will then reset and the NOT Q will go high, thus turning D1 off and D2 on. Therefore +5 volts will be applied to one end of VR4(down rate). The output of the integrator will reverse at a rate controlled by the proportion of voltage applied from VR4. The process then repeats itself as before. The output of the integrator is also connected to a voltage follower IC1. In the automatic undulating mode the signal then passes through the override/normal switch combination, back to the manual/auto switch, then on to the summing amplifier.

5.4.2.1 Undulating control.

In this mode the waveform generator is used to control the flight path of the SeaSoar vehicle. During a tow the minimum depth will usually be set to allow the vehicle to just skim the sea surface, and the maximum to that required for the 'yo-yo'. Both of these will need some adjustment if either the up or down rate controls are altered. The sea state, ship speed and any changes in ocean current flow will also affect the 'yo-yo' limits, requiring some adjustment of the maximum and minimum depth controls.

5.4.2.2 Manual control.

In this mode the output from IC1 is disconnected by the manual/auto switch. The output from VR3 (max depth) is fed directly to the summing amplifier. This output is also switched to both comparators, thus effectively holding the integrator output at the maximum depth setting.

5.4.3 Summing Amplifier and Servo Valve current driver, (Fig 6).

The SeaSoar vehicle is controlled by various signals fed to the summing amplifier.

5.4.3.1 Depth input.

This signal is derived from the CTD pressure transducer and ranges from 0-10 volts full scale with a maximum pressure of 1000 dBars. This depth signal is then scaled by R1/R2 before being fed to the summing amplifier. The ratio of R1/R2 is set such that the depth voltage will balance that of the waveform generator when the vehicle is at that depth. Output from an invertor IC3 can be switched to suit the polarity of the depth signal available.

5.4.3.2 Dither.

A small low frequency square wave is supplied from an oscillator mounted on the power supply board. This is used to keep the servo valve moving slightly, and thus prevents 'sticktion'.

5.4.3.3 Bias.

This is normally set on the front panel to a value of 500 corresponding to a zero volt level. This control is available to offset any bias that there may be in the Moog servo valve, although with the hydraulic system now in use this has not been required to date. Very small alterations in bias can effect the vehicle flight, so adjustments to this control must always be small.

5.4.3.4 Override.

When switched in this mode, output from the waveform generator is disconnected and control is direct from the override potentiometer.

N.B. In this mode there is no depth signal feedback in circuit, therefore control of the Moog valve is direct from this potentiometer. A zero volt level is obtained with a setting of 500.

When using this control, ensure that the valve currents are kept low, 1 or 2 mA as very fast wing movements and hence fast changes of depth of the vehicle can occur. Occasionally, if for example the vehicle is stuck on the surface, larger valve currents can be used.

Important: Take great care when doing this, as cable tensions can rise dramatically if a rapid dive occurs.

5.4.3.5 Loop gain.

This potentiometer controls the overall gain of the system, which includes both electrical response of the servo valve and dynamic response of the cable/vehicle combination. Insufficient gain will result in sluggish response of the vehicle and excessive lag, while too much gain results in violent oscillation of the vehicle about its mean path with attendant high cable strains. A setting of 980 may be increased to just below the level of instability during a run.

5.4.3.6 External input.

This input is supplied for user waveforms such as a sinewave and should be negative going. With any externally generated waveform, the frequency and maximum and minimum levels must be varied externally.

The output of the summing amplifier is applied to a current driving amplifier IC2/IC4 before being fed down the tow-cable to the Moog valve in the hydraulic unit.

5.4.4 Command and Pressure buffers, (Fig 7).

IC1,IC2 and IC3 are straightforward voltage following buffer amplifiers. These are included to provide buffering of the command and pressure waveforms before display on a chart recorder.

5.4.5 Pressure and Temperature D/A converters, (Fig 8).

This circuit has been added to provide the pressure output feedback signal necessary for control of the SeaSoar vehicle. Previously the older style of Neil Brown CTD deck units provided this facility but this is no longer so with the new 1401 CTD deck units. The bi-polar serial data output stream from the 1401 deck unit is converted to a uni-polar signal (0 to +5v) by R1/R2 and switching diode D1. It is then fed from an inverting buffer IC1a to switches S1/S2 and inverting buffer IC1b. IC1b and S2 allow the data to be inverted if necessary before driving the UART (Universal Asynchronous Receiver Transmitter) IC2. S1 and IC1b perform the same operation as before passing data to a set of serial to parallel shift registers IC7 and IC8.

The serial data stream is sent at a Baud rate of 9600 and is composed of a series of 11 bit words as follows:- 1 start bit, 8 data bits, 2 stop bits and no parity. A Baud rate generator IC4 with crystal controlled oscillator provides a 153.6 Khz clock signal to the Uart (Ie 16 * Baud rate). This clock signal is divided by 16 using binary counter IC6a. As data is shifted into the Uart, each bit is clocked into registers IC7 and IC8 by IC6a. During the transmission of data there is a short period at the end of the data frame when all of the bits will be high. These data bits will be clocked into IC7 and IC8, therefore all of the outputs of the registers will be high. Diodes D2-D12 and D17 'OR' all of the outputs and will be turned off. Pull up resistor R5 will hold the input of IC1c high. Consequently the output of IC1d will also be held high. This holds the decade counters IC9, IC10 and IC2 in a reset state. On transmission of data, the low state of the first, or start bit, will pull the input of IC1c and IC1d low.

On receiving the complete word the DR output of IC2 will go high and clock the 'D' type flip-flop IC5b. IC5b Q output will go high and NOT Q low as its D input is held high to the supply voltage. The DR output also resets decade counters IC9,IC10 after each data word has been transmitted. The states of the Q and NOT Q will be reset depending upon the time constant set by R6/C4. As NOT Q goes high again it will clock flip-flop IC5a. Similarly NOT Q output will go momentarily high and pulse the DRR input of IC2. This acknowledges that data has been received and allows IC2 to accept the next word. This process repeats itself with each data word. Because of the presence of the start bit, the node of the 'OR' diodes will remain low during data transmission, and IC9, IC10 will count up each data word. The pressure data is two eight bit data words long and is sent least significant first.

In the reset state the A0 outputs of the decade counters are set high and the remaining outputs low. On a count of 2 Ie the least significant byte of the pressure word, A2 of IC9 goes high. This output is gated by IC11a with A0 of the second decade counter. The A0 output of this counter will go high after a count of 10, thus inhibiting the output of AND gate IC11a during counts 11-18. C5/R10 produce a short pulse from the output of IC11a which is inverted by IC12a. The low level output, pulses the A0 input of IC12a and enables transfer of the four high order bits of the least significant pressure byte between the parallel outputs of IC1 to D/A converter IC3. The next word pulse sets A3 of IC9 high. This is similarly gated by IC11b with A0 of IC10. The low level pulse obtained at the output of IC12b enables A1,A2 of IC3 and transfers the four middle and high order bits of the most significant pressure byte from IC2 to IC3. The low A3 input of IC3 latches the data present on the inputs. The A3 output of IC9 is gated with A0 of IC10 by IC11c, C7/R12 produce a short pulse as before which is inverted by IC12c.

This pulse is then delayed by R14/C9, inverted by IC12e and latches the analogue output of IC3 into the sample/hold amplifier IC13, providing the analogue pressure output. The A4 and A5 outputs of IC9 are used in the same way to transfer the four low, middle and high order bits of the two temperature words via IC11b,IC12b,IC11d,IC12d and IC12f to sample/hold amplifier IC14. It can be seen that this process only converts the top 12 bits of the 16 bit pressure and temperature words. After a complete data frame, all of the serial data bits are high, the outputs of IC7,IC8 go high and IC9,IC10 and IC2 are reset via IC1c,IC1d until the first start pulse of the next data frame.

It is possible during the data frame, for spurious pulses to occur at the node of the 'OR' diodes. This is probably due to the occasional slip between the receiver UART and the transmitter UART clocks in the 1401 deck unit. When the output of IC1c goes high on the start bit of the first data word, the Q output of 'D' type flip-flop IC16 goes high and the NOT Q low, as the D input is held high to the supply. The NOT Q output is connected via a diode to 'OR' this signal with D2-D12 etc. Variable resistor VR2, is connected between the Q output and reset input of IC16a, and a 1 uF capacitor from reset to ground. The pulse length obtained at the Q, NOT Q outputs is controlled by this potentiometer and is set to be just slightly shorter than the data frame length. When 'ORed' with the data bits, this prevents any spurious pulses that may occur from being passed to IC9, IC10.

5.5 SeaSoar Deck Control Unit, circuit diagrams and parts lists.

See Figs 4-8, for circuit diagrams and parts lists.

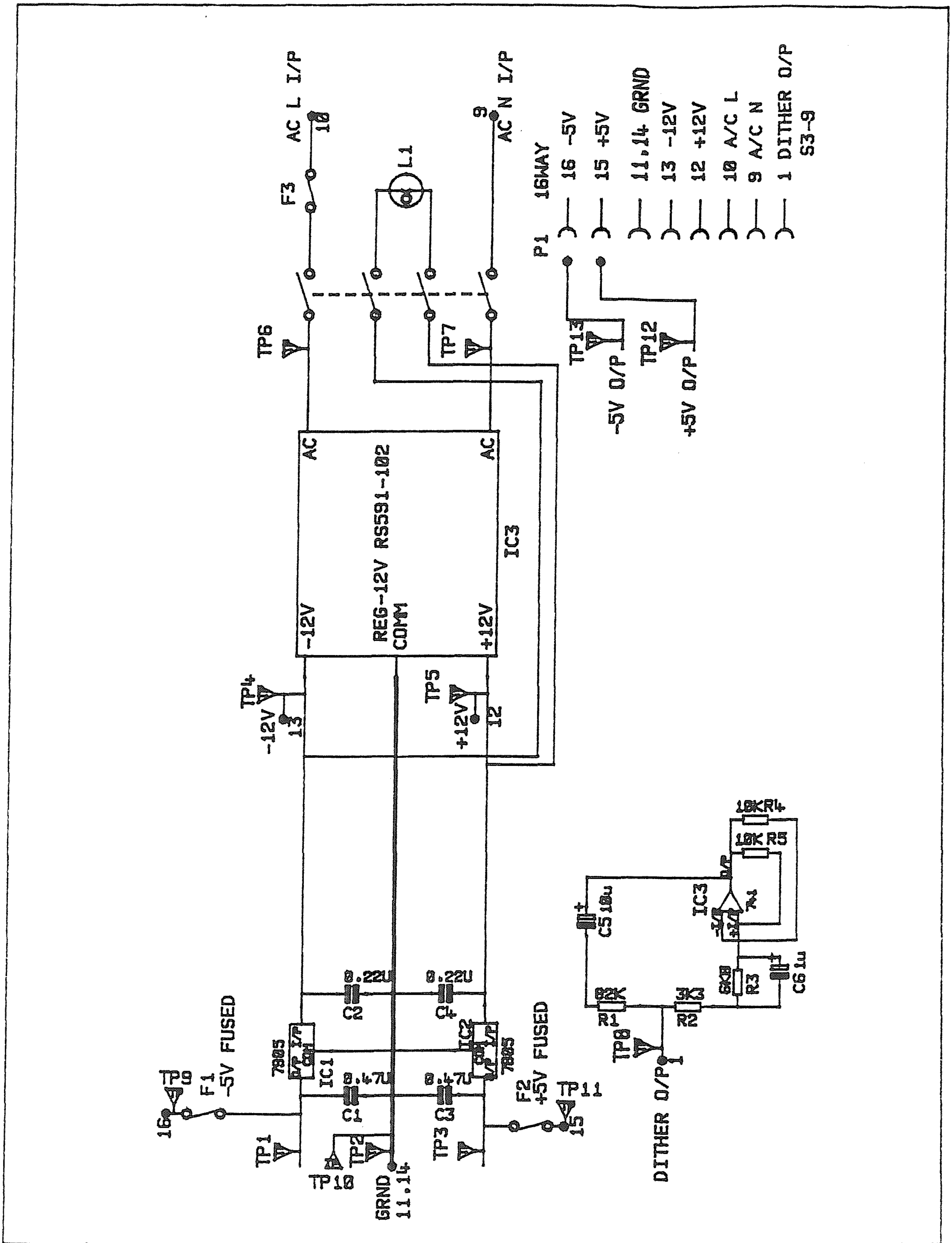

FIG. 4.

SEASOAR BOARD1
POWER SUPPLIES AND DITHER O/P.

DRAWN J.SMITHERS

INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

DATE 09-06-90

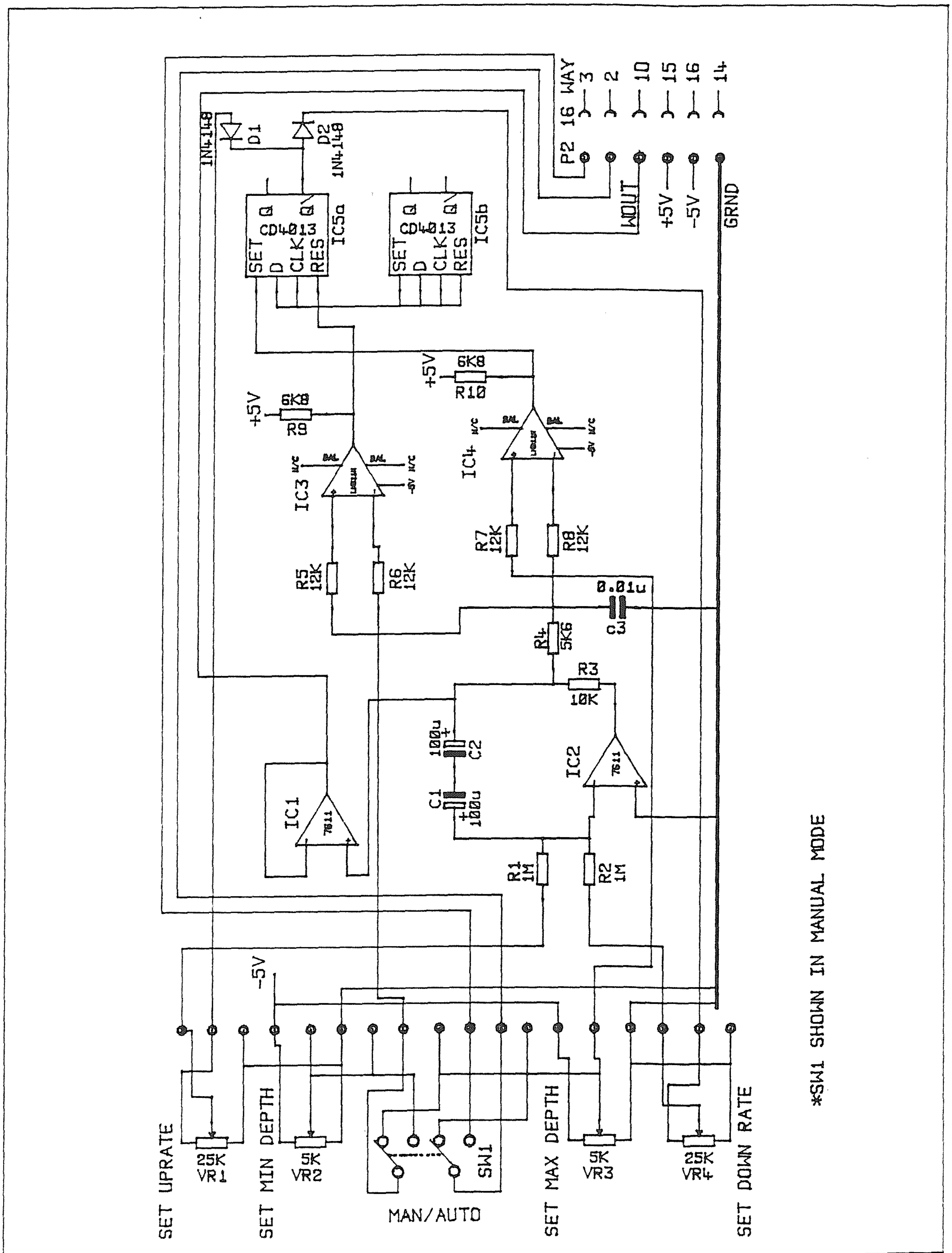

FIG.	5.	SEASOAR BOARD2 CONTROL WAVEFORM GENERATOR	DRAWN	J.SMITHERS
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.			DATE	08-09-90

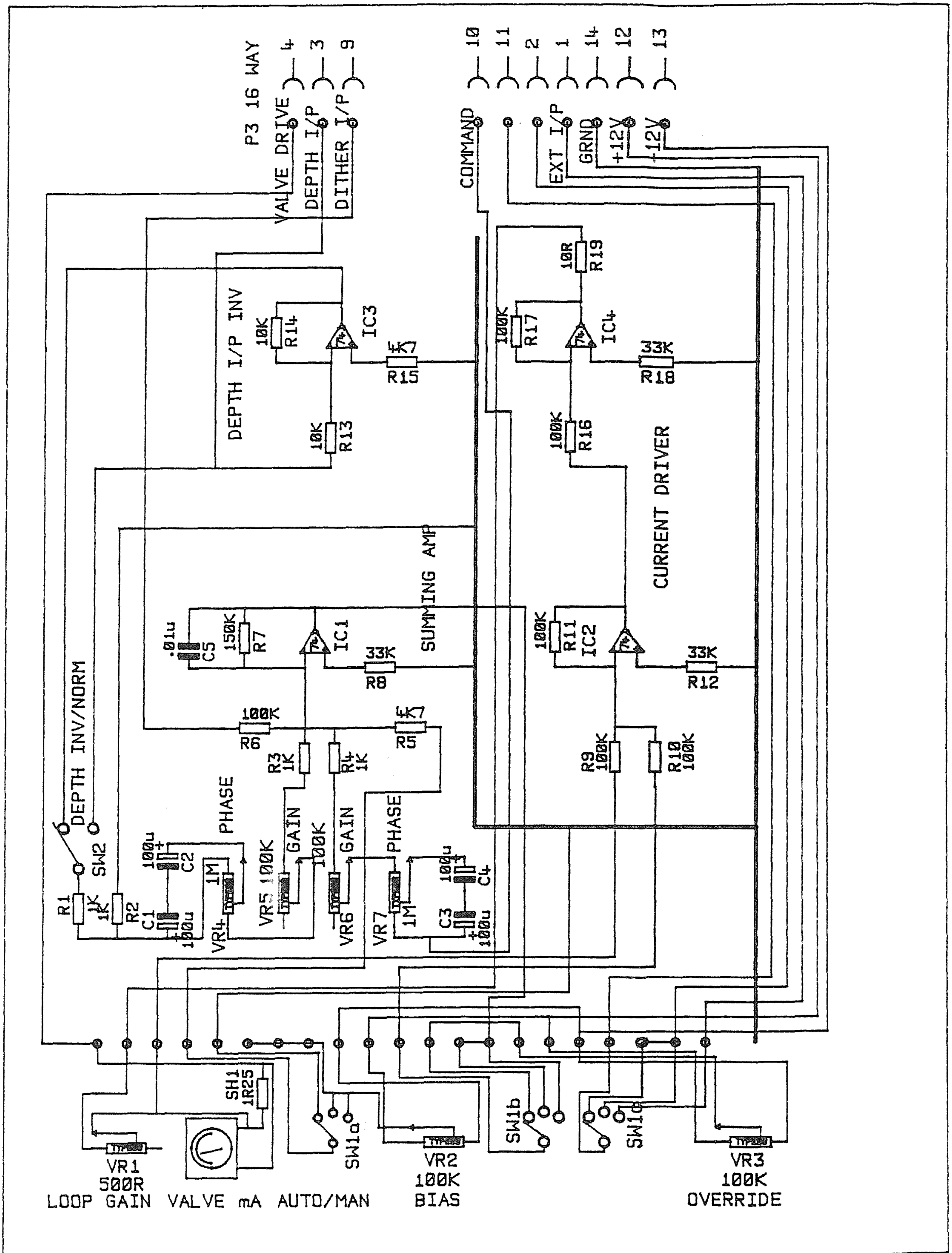

FIG.	6.	SEASOAR BOARD3 SUMMING AMP/VALVE CURRENT DRIVER.	DRAWN	J.SMITHERS
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.			DATE	11-06-90

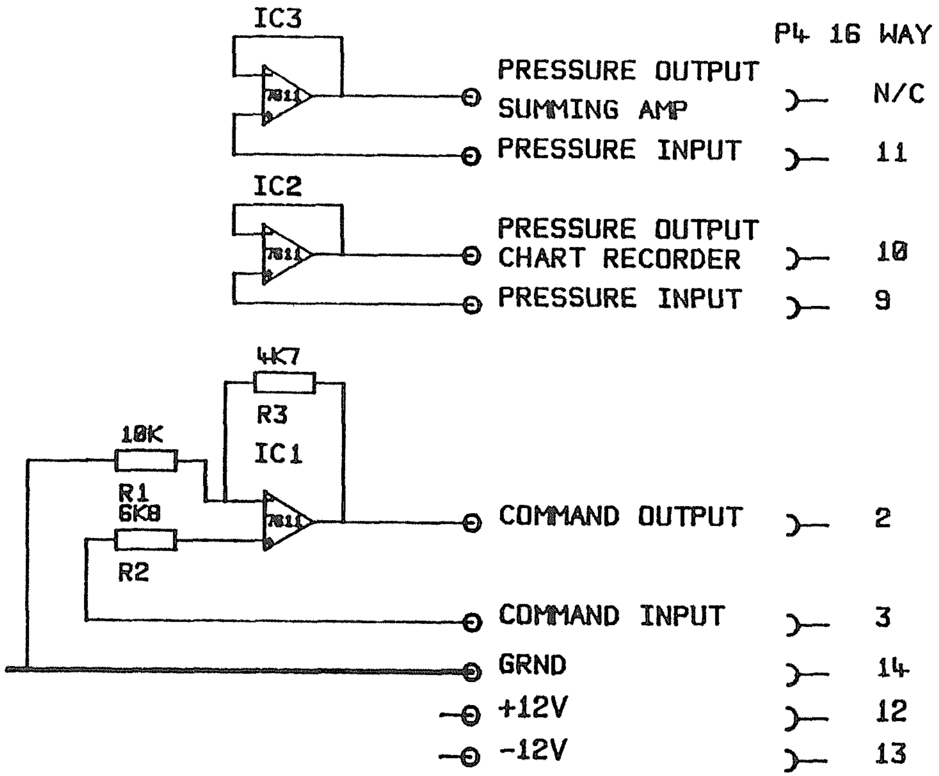

FIG. 7.

SEASOAR BOARD4
COMMAND/PRESSURE BUFFERS.

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DRAWN J.SMITHERS

DATE 11-06-90

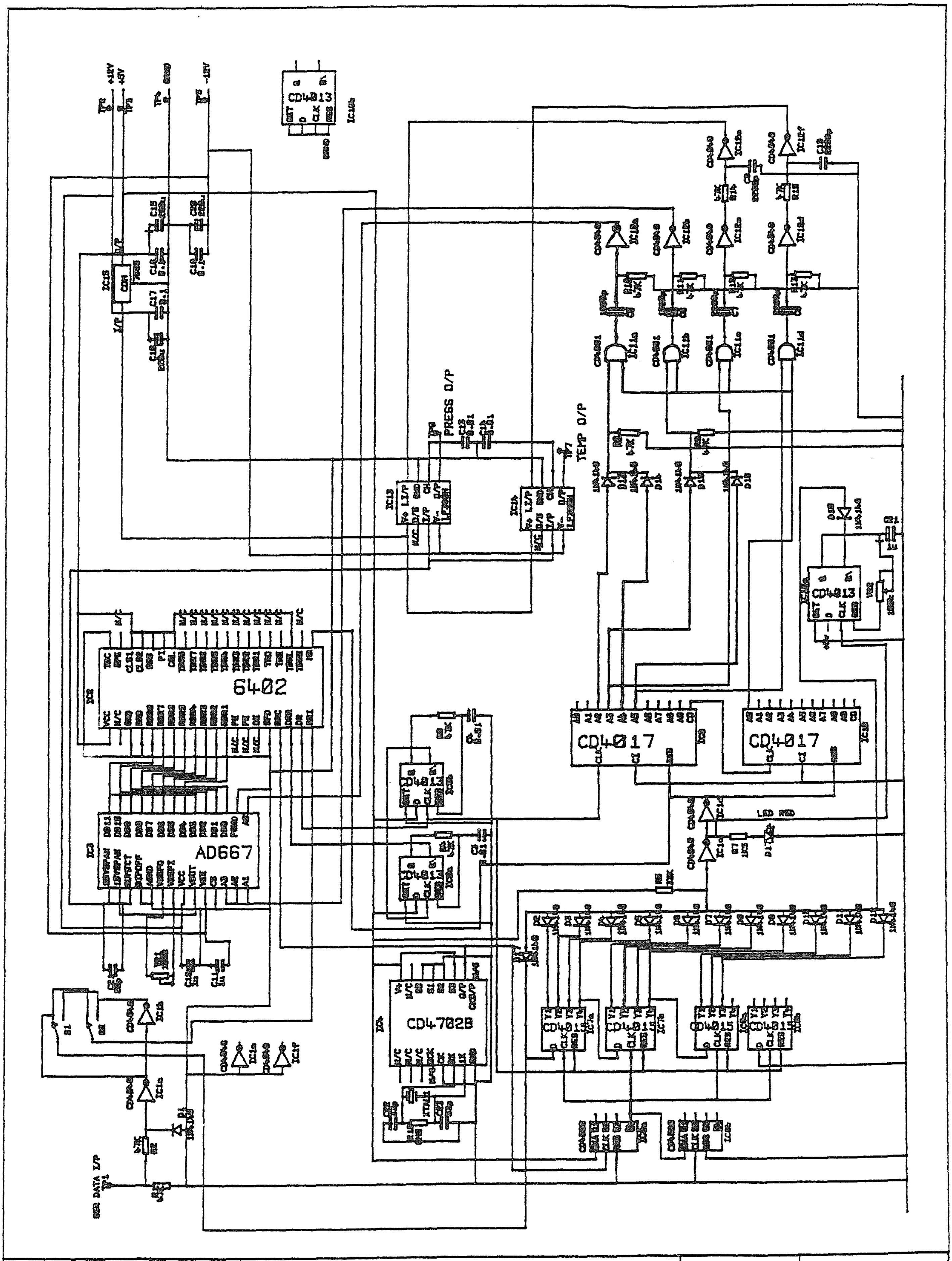

FIG. 8.

SEASOAR BOARDS.
PRESSURE/TEMPERATURE D/A.

DRAWN J.SMITHERS

DATE 23-01-91

INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

CCT DIAG' SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
PSU	ENSCAPSULATED POWER SUPPLY		250 mA PER RAIL	12-0-12V	RS COMPS	561-102	ANY EQUIVALENT
REG1	REGULATED POWER SUPPLY		1A	7905 -5V	"	306-049	"
REG2	REGULATED POWER SUPPLY		1A	7805 +5V	"	305-808	"
IC1	OP-AMP			741	"	305-311	"
SW1	SWITCH	250VAC	2A	ILLUMUNATED LATCHING	"	335-643	"
SW1	SW' GUARD				"	335-722	"
SW1	SW' RED LENS				"	335-744	"
L1	BULB		24V 50mA	WEDGE END	"	586-655	"
F1	FUSE		500 mA	QUICK BLOW 20 mm	"	412-138	"
F2	"		500 mA	"	"	412-138	"
F3	"		100 mA	"	"	412-100	"
	FUSE HOLDER			PANEL MTG 20 mm	"	412-021	FUSEHOLDERS FOR F1.F2 & F3
C1	CAPACITOR	0.47uF	160V	WIMA MKC4	IOSDL STORES		CAPACITORS 10% TOLERANCE
C2	"	0.22uF	"	"	"		"
C3	"	0.47uF	"	"	"		"

SEASOAR DECK CONTROL UNIT.
POWER SUPPLIES AND DITHER O/P.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARD1
COMPILED	J.SMITHERS	DATE	22-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	1/1

CCT DIAG.	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
SYMBOL	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
C4	CAPACITOR	0.22uF	160V	WIMA MKC4	IOSDL STORES		ANY EQUIVALENT
C5	"	10uF	"	WIMA ELECTROLYTIC	"		"
C6	"	1uF	"	"	"		"
R1	RESISTOR	82K	1/4W	METOX	"		"
R2	"	3K3	"	"	"		"
R3	"	6K8	"	"	"		"
R4	"	10K	"	"	"		"
R5	"	10K	"	"	"		"
P1	PLUG			16-WAY	VERO ELEC'S	27-0380C	"
S1	SOCKET			16-WAY	"	27-0381J	"

SEASOAR DECK CONTROL UNIT.
POWER SUPPLIES AND DITHER O/P.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARD1
COMPILED	J.SMITHERS	DATE	22-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	1/2

CCT DIAG' SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
IC1	OP-AMP			7611	RS COMPS	308-887	CMOS OP-AMP O/P SWING TO SUPPLY VOLTAGE
IC2	"			7611	"	308-887	"
IC3	COMPARATOR			LM 311N	"	308-843	ANY EQUIVALENT
IC4	"			LM 311N	"	308-843	"
IC5	D TYPE FF			CD4013	IOSDL STORES		"
VR1	MULTITURN POTENTIOMETER	25K	1.5W	10 TURN	RS COMPS	173-524	"
VR2	"	5K	"	"	"	173-502	"
VR3	"	5K	"	"	"	173-502	"
VR4	"	25K	"	"	"	173-524	"
	DIGITAL DIAL MECHANISM			CIRCULAR 10 TURN	"	502-582	USE WITH VR1-4
SW1	SWITCH			DPDT	WAYCOM	MST 216 N/C	"
C1	CAPACITOR	100uF		WIMA ELECTRO'	IOSDL STORES		"
C2	"	100uF		"	"		"
C3	"	0.01uF		WIMA FKC	"		"

SEASOAR DECK CONTROL UNIT.
WAVEFORM GENERATOR.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARD2
COMPILED	J.SMITHERS	DATE	22-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	2/1

CCT DIAG' SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
R1	RESISTOR	1M	1/4W	METOX	IOSDL STORES		ANY EQUIVALENT 10% TOLERANCE
R2	"	1M	"	"	"		"
R3	"	10K	"	"	"		"
R4	"	5K6	"	"	"		"
R5	"	12K	"	"	"		"
R6	"	12K	"	"	"		"
R7	"	12K	"	"	"		"
R8	"	12K	"	"	"		"
R9	"	6K8	"	"	"		"
R10	"	6K8	"	"	"		"
D1	DIODE		150V 1A	BYX/150	"		ANY EQUIVALENT
D2	"		"	"	"		"
P2	PLUG			16-WAY	VERO ELEC'S	27-0380C	"
S2	SOCKET			16-WAY	VERO ELEC'S	27-0381J	"

SEASOAR DECK CONTROL UNIT.
WAVEFORM GENERATOR.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARD2
COMPILED	J.SMITHERS	DATE	22-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	2/2

CCT DIAG. SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES & REMARKS
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	
IC1	OP-AMP			741	IOSDL STORES		ANY EQUIVALENT
IC2	..			..	..		..
IC3	..			..	..		..
IC4	..			..	..		..
VR1	MULTITURN POTENTIOMETER	500R	1.5W	WIREWOUND 10 TURN	RS COMPS	173-473	
VR2	..	100K	1.5W	..	..	173-546	
VR3	..	100K	1.5W	..	..	173-546	
VR4	..	1M	1W	CERMET 25T TYPE80	IOSDL STORES		ANY EQUIVALENT
VR5	..	100K	1W	..	..		..
VR6	..	100K	1W	..	..		..
VR7	..	1M	1W	..	..		..
SW1	SWITCH		240VAC 0.15A	4P3W	RS COMPS	327-670	MIDGET WAFER
SW2	..		240VAC 2A	SPDT MSP106D	..	339-241	PUSH TO MAKE PUSH TO BREAK
M1	METER			25-0-25 uA 1250OHM	..	259-454	

SEASOAR DECK CONTROL UNIT.
SUMMING AMP AND VALVE CURRENT DRIVER.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARD3
COMPILED	J.SMITHERS	DATE	22-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	3/1

CCT DIAG° SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
C1	CAPACITOR	100uF	10V	TANTALUM BEAD	RS COMPS	102-746	ANY EQUIVALENT 10% TOLERANCE
C2	··	100uF	··	··	··	102-746	··
C3	··	100uF	··	··	··	102-746	··
C4	··	100uF	··	··	··	102-746	··
C5	··	100uF	··	··	··	102-746	··
R1	RESISTOR	1K	1/4W	METOX	IOSDL STORES		ANY EQUIVALENT 10% TOLERANCE
R2	··	1K	··	··	··		··
R3	··	1K	··	··	··		··
R4	··	1K	··	··	··		··
R5	··	4K7	··	··	··		··
R6	··	100K	··	··	··		··
R7	··	150K	··	··	··		··
R8	··	33K	··	··	··		··
R9	··	100K	··	··	··		··
R10	··	100K	··	··	··		··

SEASOAR DECK CONTROL UNIT.
SUMMING AMP AND VALVE CURRENT DRIVER.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARD3
COMPILED	J.SMITHERS	DATE	23-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	3/2

CCT DIAG. SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
R11	RESISTOR	100K	1/4W	METOX	IOSDL STORES		ANY EQUIVALENT 10% TOLERANCE
R12	"	33K	"	"	"		"
R13	"	10K	"	"	"		"
R14	"	10K	"	"	"		"
R15	"	4K7	"	"	"		"
R16	"	100K	"	"	"		"
R17	"	100K	"	"	"		"
R18	"	33K	"	"	"		"
R19	"	10R	"	"	"		"
	DIGITAL DIAL MECHANISM			CIRCULAR 10 TURN	RS COMPS	502-582	
	DIGITAL DIAL MECHANISM			CIRCULAR 10 TURN	RS COMPS	508-885	
SH1		1R25					METER SHUNT SOT FOR 25-0-25 mA
P3	PLUG			16-WAY	VERO ELEC'S	27-0380C	
S3	SOCKET			16-WAY	VERO ELEC'S	27-0381J	

SEASOAR DECK CONTROL UNIT.
SUMMING AMP AND VALVE CURRENT DRIVER.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARD3
COMPILED	J.SMITHERS	DATE	23-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	3/3

CCT DIAG.	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
SYMBOL	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
IC1	OP-AMP			7611	RS COMPS	308-887	CMOS OP-AMP O/P SWING TO SUPPLY VOLTAGE
IC2	OP-AMP			7611	..	..	..
IC3	OP-AMP			7611	..	..	..
R1	RESISTOR	10K	1/4W	METOX	IOSDL STORES		ANY EQUIVALENT
R2	..	6K8	..	..	..		..
R3	..	4K7	..	..	..		..
P4	PLUG			16-WAY	VERO ELEC'S	27-0380C	
S4	SOCKET			16-WAY	VERO ELEC'S	27-0381J	

SEASOAR DECK CONTROL UNIT.
COMMAND/PRESSURE BUFFERS.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARD4
COMPILED	J.SMITHERS	DATE	23-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	4

CCT DIAG. SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
R1	RESISTOR	47K	0.4W	METAL FILM MR25	IOSDL STORES		ANY EQUIVALENT
R2	"	47K	"	"	"		"
R3	–	–	–	–	–	–	M&D NOT USED
R4	RESISTOR	47K	0.4W	METAL FILM MR25	IOSDL STORES		ANY EQUIVALENT
R5	"	33K	"	"	"		"
R6	"	47K	"	"	"		"
R7	"	1K5	"	"	"		"
R8	"	47K	"	"	"		"
R9	"	"	"	"	"		"
R10	"	"	"	"	"		"
R11	"	"	"	"	"		"
R12	"	"	"	"	"		"
R13	"	"	"	"	"		"
R14	"	"	"	"	"		"
R15	"	"	"	"	"		"

SEASOAR DECK CONTROL UNIT.
PRESSURE/TEMPERATURE D/A.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASAOR BOARDS
COMPILED	P.GWILLIAM	DATE	03-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	5/1

CCT DIAG. SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
C1/C2	CAPACITOR						M&D NOT USED
C3	"	.01uF		POLYESTER	IOSDL STORES		ANY EQUIVALENT
C4	"	.01uF		POLYESTER	STC/IOSDL STORES		
C5	"	1nF		CERAMIC	"		
C6	"	1nF		CERAMIC	"		
C7	"	2.2nF		CERAMIC	"		
C8	"	2.2nF		CERAMIC	"		
C9	"	2.2nF		CERAMIC	"		
C10	"	2.2nF		CERAMIC	"		
C11	"	1uF		ELECTRO.	IOSDL STORES		
C12	"	1uF		ELECTRO.	"		
C13	"	.01uF		POLYESTER	"		
C14	"	.01uF		POLYESTER	"		
C15	"	220uF		ELECTRO.	"		
C16	"	0.1uF		CERAMIC	STC/IOSDL STORES		

SEASOAR DECK CONTROL UNIT.
PRESSURE/TEMPERATURE D/A.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARDS
COMPILED	P.GWILLIAM	DATE	03-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	5/2

CCT DIAG' SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES & REMARKS
	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	
C17	CAPACITOR	0.1uF		CERAMIC	IOSDL STORES		ANY EQUIVALENT
C18	''	220uF		ELECTRO'	''		''
C19	''	0.1uF		CERAMIC	''		''
C20	''	220uF		ELECTRO'	''		''
C21	''	20pF		SIL MICA	''		''
C22	''	1uF		ELECTRO'	''		''
							''
VR1	POT'R	100R		PCB PRESET	''		''
VR2	POT'R	100K		PCB PRESET	''		''
IC1	6 STAGE INV CMOS			CD4049B	IOSDL STORES		''
IC2	UART			6402	RS COMPS	309-284	''
IC3	12 BIT DAC			AD667JN	RS COMPS	632-972	''
IC4	BAUD RATE GENERATOR			4702B	RS COMPS	305-517	''
IC5	DUAL 4 STAGE SR			4013B	IOSDL STORES		''

SEASOAR DECK CONTROL UNIT.
PRESSURE/TEMPERATURE D/A.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARDS
COMPILED	P.GWILLIAM	DATE	03-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	5/3

CCT DIAG.	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES
SYMBOL	NAME	VALUE	RATING	TYPE	SUPPLIERS NAME	REF No.	& REMARKS
IC6	DUAL BIN COUNTER			CD4520B	IOSDL STORES		ANY EQUIVALENT
IC7	DUAL 4 STAGE SR			CD4015B	"		"
IC8	DUAL 4 STAGE SR			CD4015B	"		"
IC9	DECADE COUNTER			CD4017B	"		"
IC10	DECADE COUNTER			CD4017B	"		"
IC11	QUAD AND GATE			CD4081B	"		"
IC12	6 STAGE INV CMOS			CD4049B	"		"
IC13	SAMPLE/HOLD AMPLIFIER			LF398H	RS COMPS	307-086	"
IC14	SAMPLE/HOLD AMPLIFIER			LF398H	RS COMPS	307-086	"
IC15	VOLTAGE REGULATOR			7805 +5V	IOSDL STORES		"
IC16	DUAL D TYPE FF			CD4013B	"		"
D1	DIODE			BAT85	RS COMPS	300-975	SIL SIGNAL SCHOTTKY BARRIER DIODE
D2-D16 D18	DIODE			1N4148	IOSDL STORES	"	SILICON GP
D17	LED		2mA	RED 3mm	RS COMPS	588-386	MIN LOW CURRENT LED

SEASOAR DECK CONTROL UNIT.
PRESSURE/TEMPERATURE D/A.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARDS
COMPILED	P.GWILLIAM	DATE	03-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	5/4

CCT DIAG' SYMBOL	ELECTRONICS COMPONENT DESCRIPTION NAME	VALUE	RATING	TYPE	IDENTIFICATION SUPPLIERS NAME	REF No.	ALTERNATIVES & REMARKS
S1	SWITCH			SPDT VERT PCB	RS COMPS	334-224	PCB MOUNTING
S2	SWITCH			"	RS COMPS	334-224	PCB MOUNTING

SEASOAR DECK CONTROL UNIT.
PRESSURE/TEMPERATURE D/A.
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.

ELECTRONICS COMPONENTS FOR		DRG No.	SEASOAR BOARDS
COMPILED	P.GWILLIAM	DATE	03-01-91
DRAWN	J.SMITHERS		
ISSUE	2	SHEET	5/5

6. ASSEMBLY NOTES.

6.1 Tow-cable.

Terminate the cable as instructed in section 6.1.1.

Assemble the cable round the friction drum on the end of the SeaSoar towing bridle as instructed in section 6.1.2.

6.1.1 Termination of the SeaSoar Tow-cable.

The method described has been used successfully by IOS for many years and is suitable for any oceanic depth. It may be put into service directly it has been completed though it is preferable to allow 12 hours for it to set slightly. It will take longer than this to fully cure depending upon the materials employed. The completed connection will not transmit axial loading and does not take kindly to continual bending. Breakouts can be built up using the same method of construction but extra care must be taken as they are more susceptible to leakage. It is not advisable to construct a joint with more than one or two breakouts (Y joints) if this can be avoided.

METHOD.

Before terminating the tow-cable the inboard side of the slip ring assembly should be connected with a cable to the SeaSoar deck unit. Run the necessary cables as far as the SeaSoar deck unit but do not connect to it. An 8-way screened cable should be used for this (Eg. 8 core metvin). A tow-cable length of 12 feet will be necessary for termination and fitting to the SeaSoar vehicle. This should be stripped of any fairing and the 'Cowtail' slid on as far as the last fairing stopper.

Using PVC tape wrap a layer of several turns around the cable 3 feet from the cut end. A pair of heavy duty cutters (side cutting variety are ideal) are then used to remove the top layer of armouring back to the PVC tape. The cut ends should then be taped over to prevent the sharp ends of the armouring from causing injury. A second layer of PVC tape is then wrapped around the cable 3-4 inches from the cut end, the inner layer of armouring should be cut back to this and the ends wrapped as before. The graphite lubricated sheath can now be removed exposing the 7 conducting cores. These are usually coloured as follows;- 1 Red, 1 Black and 5 plain unmarked.

It is useful if the red and black wires can be used as the CTD pair. The armouring can be used as the ground return line but only if this has been previously connected to the winch slip ring assembly. Assuming that this is not the case then the best arrangement is as follows:-

Use 3 conductors for the ground (including the black wire) for the CTD power and servo valve grounds. Another two (including the red wire) for the CTD power/signal connection, and the remaining two for the servo valve drive signal.

Although failure of the electrical conductors can occur by wires shorting together, it is more usual for a break or open circuit to occur. Therefore doubling up on the conductors does help to lengthen the time between recoveries due to cable failure.

Strip the insulation from the conductors for a length of 6-8 mm. Twist the bared ends into the 3 groups that will be required. Bare the inboard ends of the deck unit cable. The 3 groups can now be identified at this end using an ohmmeter, although only the ground group will be positively known. Twist the bared ends together in their appropriate groups.

At the outboard end of the cable, use a lead terminated with crocodile clips to short the CTD power/signal and ground groups together. Return to the inboard end and identify these two groups and mark. Mark the remaining group as the servo valve drive.

Take a 42 inch 2 pin Brantner double ended tail and divide into two, only one end of this will be used for the termination. Remove the locking sleeve from the cable as there will be insufficient room to eventually fit the terminated cable to the vehicle if this is left on. Take two single pin tails, these will be used for the servo valve connections.

Remove the outer sheath from the Brantner connector for about 2 inches, exposing the two conductors and strip the insulation on these back by 6-8 mm. Do the same with the two single pin leads. Make sure the outer sheaths of these cables are clean and if necessary use a proprietary degreasing agent to achieve this.

The white coloured conductor of the Brantner is connected to the large pin and will be used for the CTD ground connection and the other for the CTD power/signal connection. Slide lengths of heat shrink sleeving onto the 3 groups to be soldered. Solder the white connection together with one of the single pin leads to the 3 conductors nominated for the ground connection.

Solder the grey Brantner connection to the group nominated for the CTD power/signal. Solder the remaining single pin connection to the servo valve drive lead. The heat shrink sleeving can now be positioned and using a hot air gun, shrunk in place. These soldered and sleeved leads should now be positioned neatly together and either taped in place or held with lacing cord. Check for electrical continuity and correct connections.

One of two solutions may now be used to cover the whole of this joint. This can be either a rubber solution such as 'Cow-gum' or a Silicone adhesive/sealant (Silastic).

The former will adhere better to the outer covering of the cables used. The solution used should cover the joint, the inner armouring of the cable for a distance of 6 inches back and the CTD and servo valve cables for about 4 inches back. Make sure that any spaces around the joint are liberally filled with the solution and allow it to become tacky before proceeding any further. Hold the cable horizontally using a soft jawed vice and support the connector ends. A second vice is ideal for this operation.

Take an 18 inch length of self amalgamating tape and remove the backing strip. Starting from the armoured end, wind this tape around the cable stretching it to about half its original width and overlap the turns by about half their width. Be careful to support the soldered joints as too much strain can break them at this stage. A second person is useful to support the cable. Continue winding the tape on until you reach the soldered connections.

Wind sufficient turns around both the single cables and the Brantner to cover a length of about 4 inches. Lift one of the single cables and fold it back along the joint out of the way getting your partner to hold it. Wrap two more turns around the remaining cables making sure that the tape binds closely in to where the folded cable breaks out. Replace the cable and wrap a further two turns back over the previous two. Lift this cable back out of the way and wrap a further two turns tight against the breakout around the remaining cables. Now lift the second single cable up and back out of the way and wrap 2 more turns around the remaining Brantner cable keeping tight up to the breakout.

Lay the second of the single cables back in place and wrap two turns around all of the cables. Once more lift this second cable out of the way and lay on two more turns. Replace and wrap the whole, working back towards the joint. Do the same with a second layer of tape. The method of covering at the single cables should be as before, but will now occur slightly further down the cable. Try to wrap the tape around the joint area so as to make a neat tapered section.

The whole area should now be covered with two or three layers of good quality PVC tape. Check the conductor groups again at this stage for electrical continuity. You will not want to remake the termination after you have fitted it to the vehicle, then to discover that something is wrong. Allow the joint to set for at least 12 hours if possible before installing the cable in the vehicle.

Before testing the cable and its terminations it is wise to set up the instruments to be used with SeaSoar on the bench, connect to the CTD deck unit and check for correct operation prior to installation in the vehicle.

First, install the Fluorimeter in the vehicle if this is required. Connect the two single pin conductors to the hydraulic unit. Connect the Fluorimeter to the CTD. Connect the CTD to the tow-cable and lay it in position on its nylatron supports but do not clamp it in place at this stage. The SeaSoar wings will probably be in the up position at this time. Connect the inboard ends of the tow-cable to the SeaSoar deck unit. Connect the appropriate lead from the CTD deck unit sea-cable output to the CTD deck unit connection on the rear of the SeaSoar control unit.

Set the Override/Manual switch to override. Set the override control to 550, this will give a servo valve current of between 5-10 mA down, providing all connections have been properly made. Assuming that valve current is correct, then return to the vehicle and rotate the impeller in a clockwise direction.

N.B. Never turn the impeller anti-clockwise as this may cause damage to the hydraulic unit. The wings will move in the down direction if all is well. It is possible that nothing will happen and a fair degree of resistance felt when trying to turn the impeller. If this is the case then swap the two connections to the hydraulic unit and try again. The wings should now move downwards. Set the override control to 450, this will give 5-10 mA up. Repeat the previous check to make sure the wings now return to the up position.

If there is no servo valve current then it will be necessary to check through the terminations at both ends of the cable. Disconnect the two single pin connectors. With the override control set to 450 and the cable now open circuit, measure the voltage at these two connections. It should be +10 to +12 volts. Set the override to 550 and check again, the voltage should now read -10 to -12 volts. If these voltages are not obtained then there is something wrong with either the inboard connections to the deck unit or to the outboard termination.

First check the inboard end for errors as once again you will not want to reterminate the outboard end unnecessarily. If there is no obvious break in the wiring then the termination is the most likely cause of the problem and will have to be remade. Turn on the CTD deck unit and power supply. If only a MKIIIb CTD is being used then the supply voltage should be adjusted to give a load current of 110 mA.

With a fluorimeter in circuit adjust the supply voltage to give a load current of 350 mA. The CTD deck unit SIGNAL and SENSE/IDLE Leds should flash if all is well. Check that the fluorimeter is flashing. If not, then switch off immediately, as circuitry inside of the CTD will have to dump the excess current causing overheating or damage to some of its components. However in this case, if the CTD alone is still functioning correctly, then switch off, disconnect the Fluorimeter and repeat the test to complete the tow-cable checks. You will then have to ascertain and correct the Fluorimeter problem.

If everything is functioning properly then the cable can be installed in the SeaSoar vehicle according to the following section for installation instructions.

6.1.2 Installation of SeaSoar tow-cable.

This operation can be carried out by one person but is generally easier for two. Fig 9. shows the SeaSoar bridle/Tow-cable layout. Assuming one person, then the technique is as follows:-

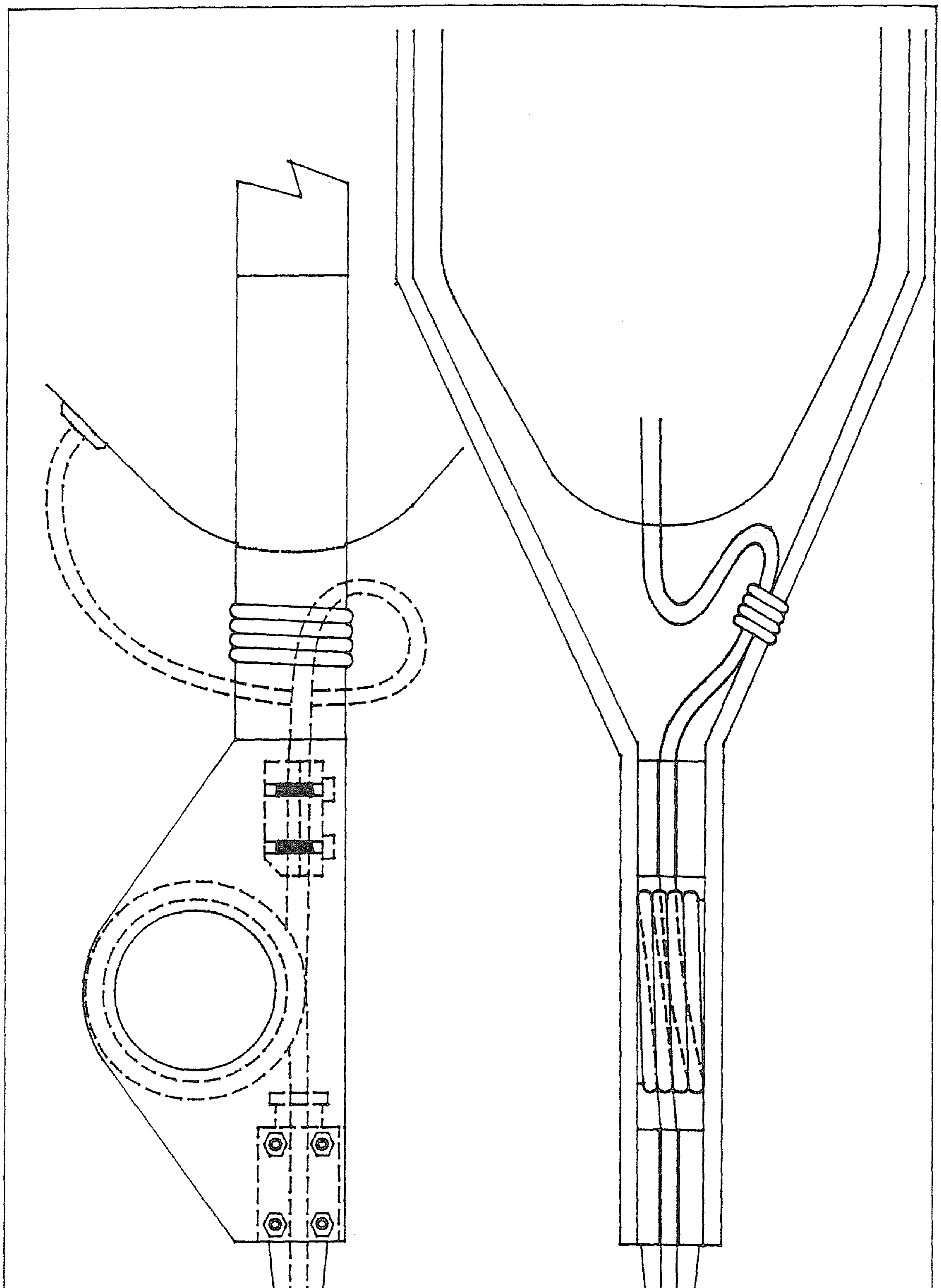

FIG.	9.	SEASOAR BRIDLE. TOW–CABLE LAYOUT.	DRAWN	J.SMITHERS
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY.			DATE	31–01–91

Stand at the front of the vehicle with the towing bridle lowered. Pass the CTD and Hydraulic connections up from below and between the towing friction drum and fixing clamp, being careful not to stress or bend the termination. You will now see the reason for removing the locking sleeve from the CTD connector (there is not much room). Pass the cable through and pull it towards you, then down and around the drum. You can now push the 'cowtail' back between the bridle cheeks. As this is a reasonably tight fit it will remain in place. Pull the cable down to the ground and hold it tight with your foot. This leaves both hands free to wind on the next turn. Pass the connectors up between friction drum and fixing clamp again. Slide the 'cowtail' out and pass the cable down in front pulling it tight, and up against the previous turn. Hold it in position with your foot and replace the 'cowtail'. Repeat this exercise until you have four complete turns around the drum. Push one of the 'cowtail' retaining bolts into place to secure it. Raise the bridle and pull down on the cable keeping it tight whilst you fit and tighten the cable fixing clamp into place. Once this is done then the remaining three bolts for the 'cowtail' can be fitted. You will find that as you tighten the front pair the rear pair will become loose, so tighten them all just sufficiently to avoid this and then fit locknuts. Lay the cable tight along the inside of the bridle. Using codline or similar, about 6-8 inches from the fixing clamp, bind 4-5 turns of this around both the bridle arm and the cable and tie off. Loop the cable down towards the ground and then back up through the space between the vehicle nose cone and the cable clamping point.

Pass the cable through the entry point on the front/top of the GRP nose cone. As you do this, pass the connectors underneath any instrument mounting brackets, being careful to avoid unduly bending the termination joint. Pull the connectors and cable through to the rear of the vehicle. Push the two halves of the brass, fairlead into the cable entry and fit the rear split fixing ring over these from inside of the vehicle and screw in place. The cable can now be clamped at both sides of the fairlead using two sets of split clamps and hose clips. Before fully tightening these clamps pull the cable into the vehicle to leave a reasonable loop between the vehicle and the bridle. Raise and lower the bridle to make sure that the loop does not foul or rub against the GRP nose. As the bridle is raised and lowered the loop merely opens and closes a little, rather than the harsh bending that would take place if the cable where passed directly from its clamping point into the vehicle. Although the introduction of this loop may not seem particularly important, it has gone a long way to extending the time between cable breakdowns. The cable terminations should be held in place at intervals by cable ties, taking care that they cannot foul or be crushed by any of the moving parts within the vehicle.

6.2 Wings.

The four locking bolts in the wing axle connector hold the wings into the body of the vehicle. Removal of these four bolts will allow the wings to be withdrawn. Some waggling and pulling will be required. On reassembly, ensure that the axles are well greased with an underwater grease before entering them into the connector.

6.3 Test box.

This consists of a 4.5 volt battery connected to a pair of plugs that mate with the connectors fitted to the hydraulic unit. Ideally a two pole change-over switch is fitted. This then allows the Moog servo valve within the hydraulic unit to be switched in either direction so that the ram can be moved in and out when the impeller is rotated. This is most useful during maintenance of the unit and when checking before launch.

6.4 Instrumentation.

The bracketry supplied is designed to suit a Neil Brown MKIIIb CTD in the top of the body and a Chelsea Instruments Aquatracka beneath it. A rectangular hole is cut in the body top cover to allow the CTD sensors to protrude vertically into clear water. Similarly, a hole is cut in the GRP nose allowing the whole of the Aquatracka lens turret to protrude, Fig.2. As there are a variety of pressure cases available for the Neil Brown, it may be necessary to either pack the CTD mounting clamps with rubber, or alternatively move the position of the two nylatron supports. Ideally, the special thin wall stainless steel CTD case designed by IOSDL, especially for use in SeaSoar, should be used for the Neil Brown CTD. The side plates of the body may be drilled to suit positioning of the supports for a variety of lengths and diameter of instrument.

7. OPERATION.

7.1 Pre-launch checks.

Ensure that the range of wing movement is set correctly. This can be adjusted by altering the length of the push rod/rods between the hydraulic unit and the wing axle drop arm. If twin push rods are in use, it is important to see that they are both set to the same length after any adjustment. If they are allowed to operate set unevenly, the result will be wear of the hydraulic unit ram. Initially the wings should be set so that the maximum wing down available is 17 degrees from the horizontal as measured from the flat of the wing end plate, and the up angle 19 degrees from the horizontal. This may be set by altering the position of the stops behind the twin push rod yoke. There are no stops when only the single push rod is used. For this reason it is preferable to use the twin rod arrangement when using a faired cable. The additional wing up available when only the centre push rod is used is useful when towing on short unfaired cables.

Check that all the split pins in the push rod system are in place and in good order. Check that all locknuts are tight.

Install the required instrument package/s and connect it/them, and the hydraulic unit to the tow-cable. Ensure that the cable can move as freely, as necessitated by the movement of the towing bridle, and that all connecting cables between instruments are well clear of all moving parts within the vehicle.

7.2 Setting up the CTD and SeaSoar systems for a SeaSoar run.

The method of setting up the CTD system for use with SeaSoar, obviously involves a different cabling arrangement to connect the CTD deck unit to the SeaSoar winch and then on to the SeaSoar vehicle itself. Refer to Figs 10 and 11 for connection details. Termination and installation of the tow-cable should have been carried out at this stage. The batch files SEASOAR.BAT and SSCON2.BAT residing in the PS2TAPE directory, need to be edited before starting SeaSoar operations.

See section 7.3.1 for details.

Set up the SeaSoar deck unit as follows:

Bias 500	Gain 980
Up 80	Down 50
Min Depth 270	max Depth 700
Man/Auto to Man	
Override/Normal to override	
Override 450	

If the tow-cable connections are correct, the valve current should read 5 - 10 mA and when the impeller on the vehicle is turned clockwise, the wings should move upwards. If the wings move downwards then reverse the connections to the hydraulic unit. When the wings move correctly , increase the override potentiometer to 550, the wings should now move downwards. A setting of 500 on the override potentiometer produces a zero volt level and thus zero valve current.

NB. Never rotate the impeller in an anti-clockwise direction, as this can cause damage within the hydraulic unit.

Return the override potentiometer to its original setting of 450 and put the wings in the up position ready for launch.

With the vehicle finally boxed up, inspect the entire vehicle to ensure that all fixings are in place and all is ready for launch.

Switch on the CTD deck unit and set the load current to the correct level for the instrument configuration used.

Select either the CTDCON2 directory if the twin conductivity cell CTD is being used. If not then the CTD directory may be selected.

The CTDCON2 version of the software can be used for any CTD.

Run CTDCON2 or SEASOAR depending upon the directory chosen.

Use the /M option for a test listing.

Check that the CTD, Fluorimeter and Lightmeter if used are working correctly. If all is well, then follow the launch procedure.

7.3 Launch.

The new SeaSoar winch soon to be introduced, will allow any length of cable suited to requirements, to be paid out. Handling will also be different, as the height of the cable above deck, will not allow manual manipulation, nor should that be necessary. Problems in manually spooling the faired cable onto or off the drum, will be overcome by use of a horizontal drum and spooling gear. The strain measuring device will be included as an integral part of the winch assembly.

The following instructions refer only to the operation of existing winches available at the time of writing.

Set the ship's speed to 6 knots. A course should be chosen that minimises any rolling of the ship. This could be either into or with any swell prevalent. Experience of operating SeaSoar from RRS Discovery has shown that it is quite reasonable to launch the vehicle with the ship running downwind before a 30 knot wind and 7 m high seas.

When operating SeaSoar from RRS Charles Darwin in bad weather, a down wind course is both safer and easier due to the large seas that can be shipped onboard when heading into the swell.

It this method of launch is used, it may be preferable to hold the vehicle on manual (not overide) control below the surface after 100m of cable have been payed out. This is to prevent the vehicle surfing and overtaking the tow-cable.

It is important to keep tension on the cable at all times otherwise it is liable to become slack and then snatch tight. This can cause both injury to handling personnel and damage to the cable. It is also possible that the cable will take a turn around one of the wings which will go unnoticed until the vehicle is fully deployed, the ship brought up to speed, and an attempt made to control SeaSoar.

With the cable run over the sheave connected to the lifting device, 'A' frame or crane, the vehicle may now be lifted outboard and lowered into the water. This operation requires the careful co-ordination of the winch and 'A' frame (and auxiliary winch if used) drivers. For this reason it is best that the first launch be carried out by experienced operators in as calm a sea as possible and preferably in daylight.

If the winch placement is close to the lifting device, then care must be taken to ensure that the tow-cable does not come off of the top of the winch drum (when using faired cable) as the vehicle is lifted. Pull the rudder from its retainers and allow it to hang horizontally behind the vehicle. Remove sensor covers from the CTD unit just before deployment.

Once the vehicle is in the water sufficient cable should be payed out to relieve any tendency to snatch.

A check should then be made that the CTD/Instrument packages are functioning and that there is 5 - 10 mA of servo valve current in the up direction. Cable can now be paid out, but not too fast as to allow any slackness in the tow-cable, that may result in loose turns being taken around the vehicle.

When the required amount of cable has been payed out, usually 200-250 m for unfaired or 500-600 m for faired cable, the winch strain gauge can be attached and the towing force transferred to it.

In the case of the unfaired cable, this involves pinning the free end of the tension link to the winch drum and declutching the drive train. For the vertical capstan, it is necessary to attach one end of the strain gauge link to a strong part of the ship's structure. Remember that loads of up to 2000 kg are possible during normal operation and that fault conditions with the vehicle could easily double this.

The other end is then shackled to the winch drum lower cheek and the By-pass Valve opened to allow free rotation of the drum. In both cases it is important to ensure that the break is OFF.

It is best to try and align the strain link with the cable so as to reduce the side forces acting on the drum bearings to a minimum. It is important to remember that in the case of the plain cable winch there will be considerable correction to be made to the strain reading due to the difference of between the diameter of the wire remaining on the drum and the point on the drum to which the link is attached.

Lastly a wire stopper is attached to the cable to act as a safety link should either parts of the winch or the strain gauge link fail. This stopper should be attached to a shackle provided on the winch base with just enough slack nylon warp of sufficient strength to withstand a sudden load of 2000 kg.

NB. Throughout the launch it is well worthwhile to have one person in overall charge who has nothing else to do but to oversee the operation and to call a halt if any of the several parts are in difficulty.

7.4 Towing.

Once the vehicle is fully deployed set the override/normal switch to normal. The Manual/Auto switch should be in the manual mode. Allow the vehicle to settle to the depth governed by the setting of the maximum depth control.

The ship speed may now be increased to 6 knots. Vary the maximum depth setting by a small amount (no more than about 10 divisions) and check if the expected response is obtained.

It is difficult to give precise settings for the deck unit controls due to the number of variables affecting the vehicle response:- vehicle weight and weight distribution, wing angle pitch setting, ship speed, length of cable in water etc, but the values suggested have been found to give good starting guidelines.

The vehicle response will be rather sluggish at this speed but should be enough to turn the impeller and provide some hydraulic control.

If all seems well then return the maximum depth control to its original position (Ie Maximum expected.). The Manual/Auto switch can now be placed in the auto mode but only when the sawtooth command waveform is just starting its up path.

The vehicle should respond but will probably not reach the surface and will be rather slow to turn.

At this stage it is a good idea to start the acquisition software, as it may take an inexperienced operator sometime to settle the SeaSoar vehicle. Set-up and run as explained in the CTD operational manual, using CTDCON2 or SEASOAR from the appropriate directories. The parameters chosen for graphing the data must be against time when SeaSoaring. This is accomplished by choosing 'SCAN' for the x-axis. A setting of 125,000 as the maximum limit for this parameter, will give just over 4 hours of data on screen with the present MKIIIB CTDs.

Increase the ship speed to 7 knots and monitor the vehicle performance. If all is well the ship speed may now be increased to its operational speed of 8-8.5 knots, depending upon the prevailing sea state etc. Some adjustment will be necessary to the minimum and maximum depth settings to obtain the proper flight path.

NOTE:

When adjusting any of the deck unit settings, it is important to remember that the time constant of the total loop is very long, so do allow a full 'yo-yo' or two for the vehicle to settle down before making further adjustments. The up and down rate settings advised will give a flight path of surface to 400 m and back in 13 minutes with a faired cable of 600 m.

If several runs with SeaSoar have been completed and experienced operators are in charge ,then it will be found unnecessary to go through the first manual tests. However, make sure that the vehicle is at maximum depth before switching to Auto and that the sawtooth command waveform is just starting its up path. Once again, remember to allow a full 'yo-yo' or two for the vehicle to settle down before making further adjustments. The vehicle can be flown horizontally if required by switching to Manual and using the Maximum depth potentiometer for control.

With a faired cable and reasonably calm sea, most depths can be maintained + 3 m. However there are some configurations and speed combinations which are difficult to maintain, and in these cases as much variation as + 10 m may be expected. Generally when towing an unfaired cable + 1 m can be maintained at all depths down to approximately 100 m with just over 200 m of cable in the water.

7.5 Backing up data files.

Before attempting to back-up data files when running SeaSoar you first need to edit one or two batch files in the PS2TAPE directory.

Type CD\PS2TAPE <return>

Either use the DOS utility EDLIN or the EDIT facility in XtreePro, to edit batch files SEASOAR.BAT and SSCON2.BAT, or copy these files to C:\WIN386 and edit them using the WRITE facility. If using WRITE, then remember to copy the edited versions back to the PS2TAPE directory.

The SEASOAR.BAT file is as follows:

```
C:
CD \PS2TAPE
PS2TAPE BACKUP /n DARWIN51 /a /r /q /s C:\*.*
CD \CTD\DATA
DEL *.EDT
```

```
DEL *.HDR
DEL *.PL1
DEL *.PL2
CD\CTD
EXIT
```

The SSCON2.BAT file is as follows:

```
C:
CD \PS2TAPE
PS2TAPE BACKUP /n DARWIN51 /a /r /q /s C:\*.*
CD\CTDCON2\DATA
DEL *.EDT
DEL *.HDR
DEL *.PL1
DEL *.PL2
CD\CTDCON2
EXIT
```

The third line needs to be edited to update DARWIN51 to the appropriate ship\cruise number. This need only be done at the beginning of each cruise.

When the tape backup option (function key F5) is selected the appropriate batch file is run, depending on which directory you are operating in. Only files that are new or have been changed will be copied to tape.

The .EDT copy of the raw data , header (.HDR) and screen save (.PL1, .PL2) files are then deleted from drive C:. This frees some of the hard disc space for further use. Whilst this is not so important when making vertical casts, space does become a problem with long SeaSoar runs. It may then become necessary to delete the .RAW data files as well.

The integral tape streamer has proved to be very reliable, therefore you can feel confident on being able to recover the data from tape, even if you have deleted the raw data files. During SeaSoar operations, it will be necessary to back up the data files at regular intervals, preferably once every 4 hour watch period. To do this end the run by pressing CTRL+ F10. Answer questions as prompted, replying with "NO" to an up-cast.

The .RAW data files will be automatically copied to drive C:, with a .EDT file extension and the cast number will be updated. At the appropriate prompt, save the displayed screens by pressing function key F2. Press function key F5 to backup data to the PS2 tape streamer. This process takes approximately 5 minutes in all, during which time data will not be logged by the PS2 system. This is not usually critical, as data are being logged in parallel, by the shipboard computer. The PS2 system is after all, generally only a display and backup facility.

If the system were being used without shipboard computing facilities, then this could pose a problem. The only way around this, would be to run two PC systems and switch quickly between them.After backing up the files, control is returned to the acquisition software, but you will need to select the 'Deploy Instrument' option manually, to restart the process.

7.6 Recovery.

In general recovery is the reverse of the launch procedure with a number of points to note.

The deck unit should be switched to override and the override control set at 450 before the ship speed is allowed to fall below 7 knots. This will ensure that the wings will be in an up attitude and will reduce both the line pull required of the winch, and any tendency for slack turns to occur as the ship heaves.

The ship speed should now be reduced to 2-3 knots or else the system drag will produce loads too high for either winch to handle. If using the faired cable extra hands will be required to lead the cable onto the winch drum. As the wire passes onto the drum the fairing should be tapped down gently with a hide mallet to prevent any of the sections catching on the next layer to be wound on.

The 'A' frame position and height of the towing sheave should be adjusted to enable the fairing to be led inboard without damage and comfortably onto the winch drum. When the vehicle reaches the surface and is reasonably close to the ship, hauling should stop and the 'A' frame extended outboard. The height of the towing sheave will also require adjustment to allow room between it and the deck for the vehicle. Hauling can now recommence slowly. Once the vehicle is clear of the water it should be lifted straight up to the towing sheave to minimise any pendulum. This may mean that it is not possible to cope with the fairing as it is laid on close to the top of the winch drum.

At this stage safety of the handling personnel and the vehicle is of prime importance, so if a few pieces of fairing get damaged then do not stop hauling to sort it out, this can be done once the vehicle is inboard and safely in its transit cradle.

The 'A' frame can be brought inboard and the vehicle height controlled by the winch.

8. MAINTENANCE.

8.1 Cable.

Every effort should be made to treat both the fairing and cable gently. Kinking should be avoided at all times. If after recovery any broken armouring wires are found then the cable should be reterminated. The termination should last in excess of 100 hours, but this will be very much determined by the sea states in which the vehicle is operated. When towing for long periods it is good policy to move the cable position at the sheave regularly.

If runs of 5 days or more are envisaged, then retermination of the cable as a matter of course is advised.

At the end of the cruise the cable, fairing and winch should be thoroughly washed down with fresh water and stored undercover on return to IOS.

8.2 Vehicle.

All moving parts and bushes should be inspected at regular intervals throughout the cruise. This includes the wing, bridle bearings and rudder pintle bushes.

The push rods have bronze pins. All these parts should have a life in excess of 1000 hours, though once wear starts, particularly in the wing and bridle bushes, it can accelerate fast. Inspect the wings each time the vehicle is recovered, paying particular attention to the glue lines of the skins and the end fillets. As the vehicle is subjected to some vibration, particularly when towed on an unfaired cable, all screwed fastenings need regular checking.

On return to the Institute the vehicle should be thoroughly overhauled and any worn or damaged parts replaced.

8.3 Hydraulic Unit, Impeller shaft and bushes.

Each time instrumentation is removed from the vehicle, check the hydraulic unit for oil leaks. If any have occurred these will be obvious by the presence of some oil in the bottom of the vehicle. Inspect the bellows around the push rod at the front of the unit for splits, cracks or hardening of the rubber. If a leak is suspected, then the unit should be replaced with a spare, or immediately overhauled if none is available.

The key on the impeller is subject to wear and should be inspected and replaced as necessary. At the same time inspect the tail shaft bush for wear.

It is easier to reach the screws from the tail end if the impeller is removed first.

Place the unit in a soft jawed vice and open the main body drain plug. Inspect the quality of the oil. If any water is present, drain it out, replace the plug and refill the body via the top plug making sure that all the air is excluded. To do this, set the ram at its mid point before removing the top drain plug and refill full - use the test box to operate the servo valve. Carry out a similar check on the aft section by clamping the unit vertically.

If either test shows more than a few ml of sea water, then there is a leak which must be rectified before the unit can be re-used. The most likely points of oil/water exchange are the rubber piston rod bellows at the front and the lip seals at the tail shaft.

Before storage of the unit, it is as well to open both sections, inspect and fill with clean oil. If just the aft section has to be opened, proceed as follows:-

Place the unit horizontally in a soft jawed vice and slacken the 8 csk screws that hold the tail cone in place. Place a container of at least 1 l capacity beneath the joint and gradually easing the screws, pull the cone back. Once the joint is open the oil will flow out. Inspect the oil for foreign matter and particles of water. Withdraw the cone completely, maintaining the tail shaft with it. If water is present in more than a very small amount, withdraw the tail shaft forward out of the tail cone. Keep all of the parts of the thrust race on the shaft. If the shaft shows slight wear at the seal points, place it in a lathe and polish with crocus paper. If the wear is bad then replace the shaft. It should last over 1000 hours.

Inspect the two seals in the tail cone and replace if a new shaft has been fitted. Check the fit of the shaft in the glass filled PTFE bush, replace bush if slack. It is normally quite a loose fit. Clean and inspect the exposed rear end of the unit, paying particular attention to the exposed rubber finger. If it needs replacing, cut the whipping, remove finger, unscrew adaptor, whip on a new finger and screw back into place. Check tail cone 'O' seal and ensure that the space is clean before reassembling and refilling with clean oil.

NB. The oil used in the system is Shell Tellus 37 or equivalent.

It is important that oil used to refill these is filtered before use. As supplied, oil is not clean enough. Filter oil once through a 100 um filter. Oil for the inner hydraulic system should be passed through at least a 20 um filter. It is easier to assemble the shaft onto the coupling before sliding the tail cone onto it. The outer lip seal should be well smeared with an underwater grease before assembling the PTFE thrust washer and impeller.

If the forward bellows need replacing it is necessary to drain most of the oil from the main section of the unit. Then clamp the unit vertically with the ram upwards, remove the clamp ring and push-rods and replace the bellows. When tightening the push-rod nuts on the new bellows, ensure that the rubber is not extruded out of the clamping washers. When refilling this section with oil, make sure that all the air is out of the bellows and that the piston rod is about halfway out.

N.B. there will be sea water in the four long rubber fingers internally which vent out through small holes close to the piston rod bellows. Do not let this drip into the oil system. While the bellows are off, inspect the push-rod for scoring. If a large quantity of water has entered the main body of the hydraulic unit, it will be necessary to strip the cone entirely from the hydraulic circuitry. To do this, start by removing the tail cone as far as described above.

Remove the inner part of the drive coupling and the four cap nuts from inside the exposed end plate. Remove the csk screws holding the cylindrical cone to the front end plate and then withdraw the case complete with the rear end plate. This will expose the hydraulic circuit. Inspect for loose joints or fixings. If the reservoir bellows show signs of wear - this may happen if oil has leaked out of the hydraulic system - replace it. In this case it will be necessary to set the ram full in, then fill the new reservoir right up, making sure that no air is left within the circuit.

If for any reason sea water has penetrated the hydraulic circuit, return the entire unit to IOSDL for overhaul.

9 STRAIN GAUGE AMPLIFIER AND DECK UNIT CIRCUIT DIAGRAMS.

Figs 12,13.

10. ACKNOWLEDGEMENTS.

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