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INTERNAL DOCUMENT
No. 286

I.O.S.D.L. STAND ALONE PUMP (SAP)

A Deep Water In-Situ Filtration Pump
Serial No. SAP

by

N.J. Hooker
and L.H. Wright

Natural Environment Research Council

INSTITUTE OF OCEANOGRAPHIC SCIENCES
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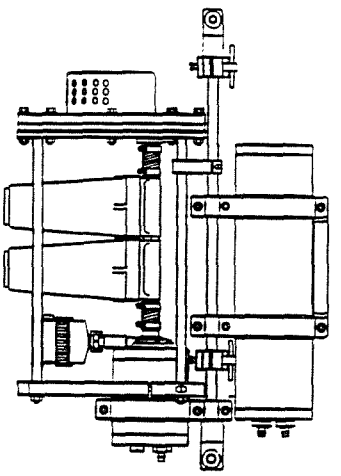

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HANDBOOK
MARCH 1989

CONTENTS

SPECIFICATION: IOSDL STAND ALONE PUMP SYSTEM

Physical

Major Components	: Pump/Motor case Control unit + battery case Filter stack Release bar assembly
Size	: 40 x 22 x 16 inches 1016 x 559 x 406 mm
Weight in air	: 110 lbs (50 kgs)
Weight in water	: 55 lbs (25 kgs)
Pump	: IOSDL design, centrifugal type magnetically coupled drive
Motor	: Permanent magnet type with disc armature 24 volt drive PML motor model G9M4
Filter size/type	: 293 mm diameter disc. GFC, GFF, Nuclepore or cartridge. Pore size is dependent on scientific requirements and vary from 1 micron upwards
Flow meter	: Kent mechanical volume displacement type with digital readout Type k198/25b flow rate 31-3000 ltres/hr Type k190/15b flow rate 20-2500 ltres/hr
Control electronics	: IOSDL electronic design mounted on pcb
Depth capability	: 0 to 5500 metres
Pump control	: Variable delay start ½ to 120 hrs, ½ hr step Variable pumping time ½ to 4 hrs, ½ hr step
Pump rate	: 1300 ltrs/hr @ zero head at 16 volts
Power	: Batteries, Lead Acid paste, 2 x 8 off 2V 5AH
Deployment methods	: 1. By mooring 2. Suspended by wire 3. For surface waters (down to 40 metres), use conducting cable and shipboard power supply
Ancillary equipment required	: 1. Battery charger Constant voltage, constant current 0-30V, 0-10 Amps 2. Filter handling facilities

SECTION 1 GENERAL INFORMATION

The STAND ALONE PUMP (SAP) is a device designed to pump large volume (1000 l+) sea-water samples through a series of filter configurations in order to collect suspended particulate material from the water column. The SAP consists of a motor/pump assembly which is powered by a 16 volt battery pack; control is achieved by an electronic timer which is adjustable to give a delay time followed by a run time. The volume of water sampled is dependent upon the filter configuration used and the concentration of suspended material in the sample, the maximum being 1200 l/hr. The flow is recorded using a mechanical flowmeter.

The pressure cases containing the pump/motor and the battery and electronics are arranged around an IOS release bar assembly allowing the equipment to be used either as part of a mooring or suspended from a ship.

The SAP has a working depth capability of 5500 m.

SECTION 2 OPERATION PROCEDURE

2.1 Setting the Timer

The pump operation is controlled by an electronic timer circuit which is first switched ON (Power Switch SWT5, see Fig. (a)), the green LED will then start flashing. When set the timer runs through a cycle which consists of a pre-set delay time followed by a running time. During this later phase the power is applied to the motor and the pump activated. Both these time periods are variable and are set by means of switches SWT 3 and SWT 4 on the pcb (see Fig.(a)) and the sequence initiated by SWT 1. The Switches SWT 3 and SWT 4 have multi-coloured sliders used to select a defined time period, the definitions of which are listed below:

SWT 3	DELAY TIME	SWT 4	ON TIME
brown	½ hr	brown	½ hr
red	1 hr	red	1 hr
orange	2 hrs	orange	2 hrs
yellow	4 hrs	yellow	4 hrs
green	8 hrs		
blue	16 hrs		
purple	32 hrs		
grey	64 hrs		

These switches are made by operating a slider, in the direction away from the OFF mark. This selects the value shown and operating more than one slider will result in the individual time values being added together to give a total time.

Example:

To select a 5 hr delay time and a 2 hr run time the following would be selected.

SWT 3		SWT 4	
brown	off	brown	off
red	on	red	off
orange	off	orange	on
yellow	on	yellow	off
green	off		
blue	off		
purple	off		
grey	off		

Note on selection restrictions:

The combinations possible from the SWT 3 delay time switch can be used in any permutation to give the required delay time in the range from ½ hr to 127.5 hrs. However SWT 4 could be set to run for 7.5 hrs which is outside of the performance capability of the battery pack and the practical limitations of filter packing capacity so therefore RUNNING TIME SHOULD BE LIMITED TO 4 HRS.

Activation of Control Cycle

To activate the delay/on time sequence SWT 1 is depressed once, every time subsequently this is depressed it will reset the start time of the cycle.

Test Cycle Facility

On setting the required time values it is sensible to check the function of the circuit by running it through the test cycle. This is achieved by holding down SWT 2 (RED BUTTON) and then pressing SWT 1 once. This activates the circuit by using second time pulses instead of 1 hour pulses thus allowing the complete delay and run time to occur in a few seconds rather than hours. The run time is indicated by the RED LED being lit.

2.2 **Pre-Deployment Procedure** (See Typical Deployment Checklist)

(a) Ensure that the battery pack is in a charged condition, the off load voltage should be 17-17.4V, 75-100% of full capacity (see Section 4 for further details).

(b) Set SWT 3 and SWT 4 to give required times. Remember to note the settings.

(c) Test the timer circuit by running the test cycle described in Section 2.1, with the battery pack connected to the motor tube to ensure the correct operation of the motor on command from the timer. On completion of this test the timer is ready to be reset using SWT 1. Remember to record the sequence start time.

(d) Carefully install the battery pack and timer assembly into its pressure case, checking that the 'O' ring seal is in good condition and is smeared with Vaseline.

(e) Reconnect the lead between the battery pack and the motor tube.

THE S.A.P. IS NOW READY FOR DEPLOYMENT.

2.3 Deployment Techniques

The equipment is built around the IOS release bar assembly which allows the unit to be deployed in a number of ways.

(a) On the end of a wire, lowered from the ship then allowed to run through operation cycle.

(b) In-line as part of a string mooring, deployed, activated then released.

(c) For sampling the upper 20 m or less it is possible to deploy the unit on a load-bearing line with a trailing power lead connected to the DC power supply used for battery charging. The voltage is adjusted to allow for the voltage drop in the cable and is set to give an initial current of 4 amps. In order to prevent damage to the control electronics this voltage must NEVER EXCEED 30V. Visual monitoring of the current drop will give an indication when the filter is packed and sampling complete. In the surface waters, where material densities are greatest, the sample time can be often only a few minutes and this is a very efficient way of sampling.

SECTION 3 SYSTEM DESCRIPTION

3.1 Electronic Control

Description of Circuit Operation

(a) Pump Timer Electronics (PCB1)

Refer to drawings (SAP1, 3, 4, 5 & 6).

Supply for the circuit is from the same battery pack that is used to supply the pump motor. The supply is connected to the printed circuit board via a three way 0.2 inch pitch screw connector (CON1), 0 volt to pin 1, +ve voltage to pin 2 which should not exceed +20 volts. +ve voltage is then connected via the printed circuit board to the supply side of the relay contacts RLA1, the switched output of RLA1 is then routed back to pin 3 CON1 for connection to the pump motor. +ve voltage is also connected via Power Switch SWT5 to IC8 (78L05) for regulation to +5 volts. A smoothing capacitor (C1) is connected between +ve voltage at IC8's input and 0 volts, also a pair of smoothing capacitors (C2) and (C3) are connected between the regulated +5 volt output (IC8) and 0 volt. This regulated +5 volts is used to power the CMOS logic circuitry, the various control switches and the pump motor relay coil (RLA1).

First stage of the logic circuit consists of IC1 combined with a 32768 Hz quartz crystal oscillator, R1, R2, C4, C5 and C6. The oscillator frequency can be monitored at pin 9 IC1 and is set to the precise frequency by adjusting variable capacitor C4. IC1 then divides this frequency through 14 stages to generate a precision 2 Hz/0.5 sec square wave output (Q14) at pin 3 IC1. The reset input (RST) pin 12 IC1 is connected through a logic inverter (1/6th IC7) to the circuit's reset switch (SWT1), this resets the 14 internal divider stages of IC1 with the rest of the circuit. The 2 Hz/0.5 sec square wave output is used as the output of the first stage of the circuit and provides a precision timebase for the rest of the circuit.

Second stage of the logic circuit IC2, IC3 is used to divide the timebase still further to generate 0.5 hr pulses for normal mode operation of the timer circuit or during 'test' mode, test switch (SWT2) held down, allow the previous 0.5 sec pulses to pass through. These two timing pulse outputs are selected by loading binary data into the JAM inputs J1-J4 IC2 and J0-J7 IC3 as shown

below:-

IC2	J1	J2	J3	J4
norm	1	1	1	1 = 15
test	1	0	0	0 = 1

IC3	J0	J1	J2	J3	J4	J5	J6	J7
norm	0	0	0	0	1	1	1	1 = 240
test	1	0	0	0	0	0	0	0 = 1

The results are:-

1. Normal mode 0.5 sec * 15 * 240 = 1800 sec/0.5 hr output
2. Test mode 0.5 sec * 1 * 1 = 0.5 sec output

This binary data is set up using the test switch (SWT 2), pull-up resistor (R3) and a logic inverter (1/6th IC7). The binary data is loaded into IC2 and IC3 when the reset switch (SWT1) is depressed or each IC reloads itself when its own carry out (CO) output goes low, this is done with a logical 'OR' arrangement on each IC's preset enable (PE) input. The 'OR' arrangement on IC1's (PE) input pin 1, uses a logical 'AND' gate (1/4 IC6) followed by a logic inverter (1/6th IC7) and on IC2 the (APE) input pin 9 uses diodes D1, D2 and resistor R4 to form a discrete logical 'OR' gate. The 0.5 hr or 0.5 sec output pulses from this stage are used as the timing intervals for the final stages. The green light emitting diode LED D5 is used to indicate which timing interval has been selected and is connected between output (Q1) pin 6 IC2 and 0 volts with a series resistor R7. During normal running mode 0.5 hr intervals, D5 flashes 0.5 sec ON, 0.5 sec OFF, for a cycle of 7.5 secs. During test mode it lights continuously.

The final stages of the logic circuit incorporate one 8 bit user presettable binary counter (IC4) for the 'DELAY TIME' and one 4 bit user presettable binary counter (IC5) for the 'ON TIME'. These two counters are user presettable by means of an 8 way DIL switch (SWT3) for 'DELAY TIME' selection and a 4 way DIL switch (SWT4) for 'ON TIME' selection together with 47k ohm resistor networks (RN1 and RN2). The DIL switches have each slider

connected through a 47k ohm resistor to 0 volts logic 0 in the 'OFF' position, which becomes connected to +5 volts logic 1 in the 'ON' position. These switches have labels on them indicating the time interval each slider represents, any combination of slider positions are allowed, the labelled values of each one in the 'ON' position are simply added together for each switch to obtain a suitable user defined time period for both the 'DELAY TIME' and 'ON TIME' counters.

Time periods available are in binary multiples of the pulse duration input to this stage i.e. in normal running mode 0.5 hr multiples in test mode 0.5 sec multiples. The required time periods are set up using the DIL switches to select the logic levels of the JAM inputs J0-J7 (IC4) 'DELAY TIME' and JAM inputs J0-J3 (IC5) 'ON TIME' and are loaded when reset switch SWT1 is depressed (see below):-

SWT3 No.	a	b	c	d	e	f	g	h
(IC4) input	J0	J1	J2	J3	J4	J5	J6	J7
binary value	1	2	4	8	16	32	64	128
time interval	0.5	1	2	4	8	16	32	64

SWT4 No.	a	b	c	d
(IC5) input	J0	J1	J2	J3
binary value	1	2	4	8
time interval	0.5	1	2	4

The above time intervals are in either hours or seconds as previously mentioned.

The timing pulses entering this final stage of the logic circuit are gated through to the required counter IC as it is needed. On pressing the reset switch SWT1 the carry out (CO) output of each counter is forced to logic 1 and both counters are loaded with a binary count corresponding to the logic levels at their JAM inputs, as selected on the DIL switches. When the reset switch is released both counters are ready to count down to zero when they receive rising edges from the timing pulses at the CLK inputs. When zero is reached in each

counter its carry out (CO) output is set to logic 0 indicating that the appropriate time duration for that counter has been completed.

The timing pulses are gated through to IC4 'DELAY TIME' counter first by ANDing them (1/4 IC6) with its own logic 1 carry out (CO) output. When the 'DELAY TIME' interval is complete (CO) goes low and IC4 will see no more CLK pulses and (CO) will be frozen low.

During the 'DELAY TIME', IC5 'ON TIME' counter will see no timing pulses. (CO) IC4 is inverted (1/6 IC7) then ANDed with (CO) IC5, this produces a logic 0 during 'DELAY TIME' but goes high when delay time is complete, this result is used as the 'PUMP MOTOR ON' signal and ANDed (1/4 IC6) with inverted timing pulses, the result of which is inverted again to provide the CLK input for IC5 'ON TIME' counter, the (CO) output IC5 remains high until the counter has completed the 'ON TIME' timing interval. (CO) IC5 then goes low which causes the 'PUMP MOTOR ON' signal to go low this completes the timing sequence and no further counting is done.

Output from the logic circuit is the 'PUMP MOTOR ON' signal which is applied to the gate of FET1. When the signal is logic 1 FET1 turns on and allows +5 volts to be applied across the relay coil (RLA/1), it also allows +5 volts to be applied across series pair resistor R6 and red light emitting diode LED D4. D4 is lit and indicates that the 'PUMP MOTOR ON' signal is present. Relay contacts close and allow +ve supply volts to be present at pin 3 on (CON1).

(b) Motor Control Circuit (PCB2)(refer to Tube Connections Diagram (SAP3))

The motor control circuit is mounted within the motor pressure case and is used to slowly increase the current flowing through the pump motor, bringing it up to full speed slow enough to prevent the magnetic drive from breaking as the filter pump comes on load. The acceleration time will vary with the load on the pump.

The circuit consists of a ramp voltage applied to the gate of a high power field effect transistor (FET2) whose Drain to Source resistance decreases as

the ramp voltage at its gate increases, allowing increasing current to flow through the motor, controlling the motor's acceleration until full load speed is reached. The ramp voltage is generated when the timer electronics close the contacts of (RLA/1), allowing the +ve volts from the battery pack to be switched to the +ve supply rail of the motor control circuit. When the +ve voltage is switched to the circuit, current is allowed to flow through diode (D6) and resistor (R8) to charge up capacitor (C7), this rising capacitor voltage is the ramp voltage that is applied to the gate of FET2.

3.2 **Motor/Pump**

The pump is a centrifugal type, driven via a magnetic coupling by a disc armature printed motor. The drive voltage is 16 volts and the maximum current drawn is 4 amps, this being at full flow. The advantages of using the magnetic coupling are that it eliminates the need for a driving shaft passing through the end-cap, which would require a power-consuming lip-seal, and thus reduces the number of batteries carried. In order for the limited amount of torque available from such a coupling to be fully utilised the frictional resistance of the moving parts such as the bearings must be low and this is achieved by using a ceramic shaft and bush supporting the impellor with a ceramic thrust washer taking the axial loading due to the magnetic forces. The impellor is restricted from excess axial movement by a tungsten-carbide pivot on its upper face which runs in a cup bearing of the same material. This configuration gives acceptable frictional resistance and low wear characteristics due to the ceramic components. Another condition of magnetic-couplings is that they have maximum rotational speed they can tolerate before decoupling. This effect is most noticeable when the impellor accelerates from rest to full speed when being switched on, and in order to lessen this snatching torque a slow-start voltage ramp circuit is employed to allow the power to be applied gradually over a few seconds.

Note: AVOID RUNNING PUMP DRY.

3.3 Filter Configuration

The material to be extracted from the water sample is collected by means of filter elements through which the sea-water passes. There are two configurations currently in use:

(a) A flat disc filter of 293 mm dia. which is supported on a flat plate within the FILTER HOUSING. This can be either a glass-fibre matt type (GFF or GFC) which has an average pore size dependent on its construction or a polycarbonate film (NUCLEPORE) whose pore size can be more accurately controlled.

The filter housing consists of a series of polypropylene plates which are arranged in such a way that a filter is sandwiched between the top plate and the filter-support plate which includes a perforated spiral feature to allow the water to percolate evenly across the filters's entire surface. The extreme edge of the filter has an O-ring and square section rubber seal to ensure that the water flows only through the TOP HAT into the filter and not via the edges. The entire assembly is constructed of plastic, including nuts and bolts, in an attempt to avoid sample contamination.

(b) A cylindrical cartridge filter which is held in a FLOWTECH CARTRIDGE HOLDER (type 1M), two of which are connected in series and placed between the output side of the filter housing and the input side of the pump.

Both types of filter are typically of 1 micron pore size although this is dependent on the experiment and could be changed to users' requirements.

3.4 Flow Recording

The volume of water sampled by the device is recorded on a mechanical flowmeter, the position of which is dependent on the configuration of filters in use. When using the two in-line Flowtech cartridge filters a KENT KSM type no. K134-15B is connected to the output side of the pump. When the cartridge filters are not required then a K198-25B flowmeter can be connected on the INPUT side in their place, this enforces less of a flow restriction than the smaller meter.

3.5 Flow Performance

When assessing the flow performance of the pump it is important to distinguish between tank test conditions where the voltages can be maintained by using C.V. power supplies, and actual environmental working conditions where the performance is influenced by the following factors:

(a) the filter configuration being used and the type of filter material,
(b) the concentration of suspended material in the water being filtered,
(c) the voltages powering the pump.

Fig. b shows the initial flow rates of the pump, first at a free flow condition and then with various filter materials and configurations. These values represent the initial flows as indicated by tank trials in fresh-water as opposed to the conditions prevalent in the ocean.

During sampling the filter will collect the particulate material as the water is drawn through it, and in doing so the flow rate will decrease as the individual pores of the filter become clogged. This happens much faster in surface waters where particle distributions are higher than in clearer mid-water depths. Once the filter has been packed to capacity there will be no more volume sampled and if the pump runs for any length of time after this then it is simply wasted time and battery capacity.

The most effective way to gauge the maximum filtering times for a particular water-column is to take a series of filters at the same depth, each one of an increased duration until the extended running time no longer results in increased volumes sampled. Following this approach will quickly build up

experience and enable the user to pre-assess required running times without wasting sampling time.

Added to this variable flow decrease is the effect of the voltage decreasing as the battery power is consumed and the result is that the flow performance declines in the form of a downward curve. The exact form of this curve is difficult to define as each deployment might have differing contributory factors, however sea trials on pumps coupled to a flow sensor, allowing real-time measurement of flow, have shown flow against time for typical filter configurations and commonly used filter materials in a mid-water situation.

IOS experience has shown that the longest practical run time required when using 1 micron filter elements in mid-water is THREE HOURS. Although the battery is capable of running for four hours it is more likely that filter saturation will have occurred by then and the volume pumped in the later stages would be minimal. As mentioned above, sampling in the surface waters or close to the sea-bed where resuspended sediments occur would result in these run times being reduced, in the worst case to a half hour.

SECTION 4 AUXILIARY EQUIPMENT

4.1 Battery Charger Requirement

The following charging conditions must be followed to ensure long life of the battery pack (BP1).

To enable full charge voltage to be repeatably achieved, DO NOT let the 'on load' battery pack voltage fall below 12.5 volts, this voltage is reached when 95% of the battery's capacity has been utilised.

To prevent permanent damage to the cells, DO NOT let the 'on load' battery pack voltage fall below 7 volts, below this voltage and damage to the battery pack cells will occur, 100% recharge will not be possible and battery pack capacity will be significantly reduced.

After a heavy discharge cycle, recharge the battery pack as soon as possible or 100% recharge may not be achieved.

Charging Conditions (see Battery Pack Characteristics)

There is no limit on the charging current imposed by the characteristic of the lead acid cell but the charging diodes D9 and D10 in the charging lead supplied, are limited to 6 amps, so DO NOT exceed 6 amps charging current.

Recommendations for a battery charger are:-

Heavy duty power supply with current and voltage limit controls so the maximum current output and maximum voltage output can be set when charging.

Method of charging:-

Carefully disconnect the 18" lead between the battery pack and the motor tube.

The battery pack assembly with the electronic timer circuit must be removed from the 20 inch pressure case, use the 6 inch C-spanner (supplied).

Once removed the assembly should be placed in the wooden charging rack (supplied) in close proximity to the charging supply.

DO NOT attempt the charge the battery pack while in the sealed pressure case.

1. Set the voltage limit control of the charging supply to 20 volts. DO NOT exceed 20 volts.

2. Set the current limit control on the charging supply to 0 amps.

3. Connect the charging lead (supplied) to the charger supply terminals, then plug the 4-way connector end of the lead to the 4-way bulkhead connector socket on the battery assembly end-cap. Now turn the current limit control up to about 4 amps. DO NOT exceed 6 amps.

The charging voltage will drop at first but as the cells charge up the voltage will increase back to 20 volts. After 1 hour of recharging the battery pack terminal voltage should be near to 16.65 volts.

When the charging current is down to 0.5 amp and the voltage up to 20 volts the battery pack should be fully charged, so the charger can be switched off and the charging lead disconnected.

ALLOW 3 OR 4 HOURS FOR A COMPLETE CHARGE AFTER A HEAVY DISCHARGE CYCLE.

SECTION 5 MAINTENANCE

5.1 Pre-Cruise

Batteries

Check the condition of batteries, their ability to take and hold a charge and the physical condition of the cases etc.

Electronics

Switch circuit ON (Power Switch SWT5, see Fig. (a)) and run circuit through a few test cycles, varying the time periods to ensure correct operation.

O-Rings

The O-ring seals in the end-caps and in the vicinity of the pump assembly should be checked for deterioration and replaced if required. The O-rings should be lightly greased with Vaseline, as should the grooves.

Pump Assembly

The motor assembly should be inspected by unscrewing the bottom end-cap of the pump-motor tube and withdrawing the motor assembly. This will allow access to check that the wires are secured to the terminals on the motor and that all screws holding this assembly together are tightened.

Important Note: There should be no reason to disturb the driving magnet assembly as this is set to give the running clearance necessary to avoid contact with the magnetic window. Deviation from the 0.055 thou of inch setting will either result in loss of effective coupling if the gap is increased or physical contact between the rotating drive magnets and the stationary window if gap is insufficient. This clearance allows for the deflection the window undergoes when subjected to the high hydrostatic pressures experienced at depth.

General

Prior to deployment check to ensure all fixing nuts and bolts are secure.

5.2 Post-Cruise

General

After deployment in sea-water it is important that the unit be washed down with fresh-water to remove any salt.

End-Caps and O-Rings

All end-caps should be removed from their pressure cases and the O-rings and O-ring grooves cleaned before re-assembly, as should the O-ring seals in the pump assembly.

Pump Assembly

During the dismantling of the pump and window the condition of the tungsten-carbide bearing components can be inspected for wear and the pump chamber cleared of any debris which might have colected around the top-bearing spider.

Whilst the screws which locate the pump housing are removed, the corresponding threads in the end-cap should be cleaned and refilled with Vaseline to prevent any corrosive reaction between the aluminium end-cap and the stainless screws.

Great care should be taken when re-assembling these pump components, with particular attention to aligning the rotor concentrically, so that it is free to rotate without fouling the pump-housing.

Battery Pack

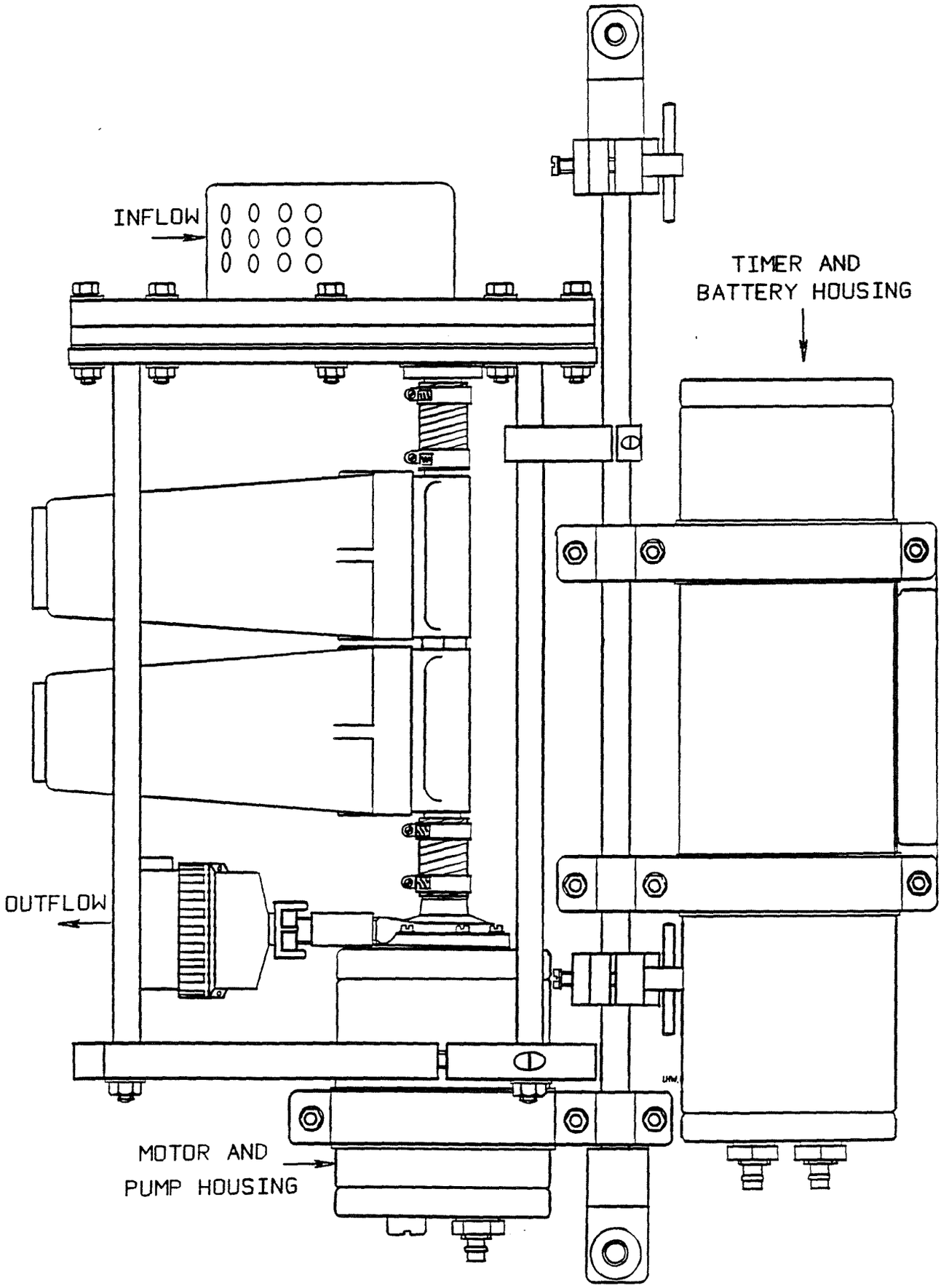
When work is completed it is important to recharge the pack to the capacity voltage in order to maximise the shelf life of the lead acid cells, periodic checking and recharging are also recommended.

Disabling the Electronics

Reset SWT 3 and SWT 4 so that all switches are in OFF position to avoid the possibility of accidental activation of circuit.

When decommissioning the SAP prior to a long period of inactivity (i.e. 2 months+), the electronics should be switched OFF (Power Switch SWT5, see Fig. (a)). For short intervals this is not required as providing the battery pack is fully charged then the power used by the active electronics, including the flashing green LED, is minimal.

Disconnect lead between battery pack and pump, clean both connector and lead.



FULL ASSEMBLY DRAWING STAND ALONE PUMP	DRAWING No IOSDL/ SAP9 DRAWN BY LHW DATE 17/3/88	SHEET No
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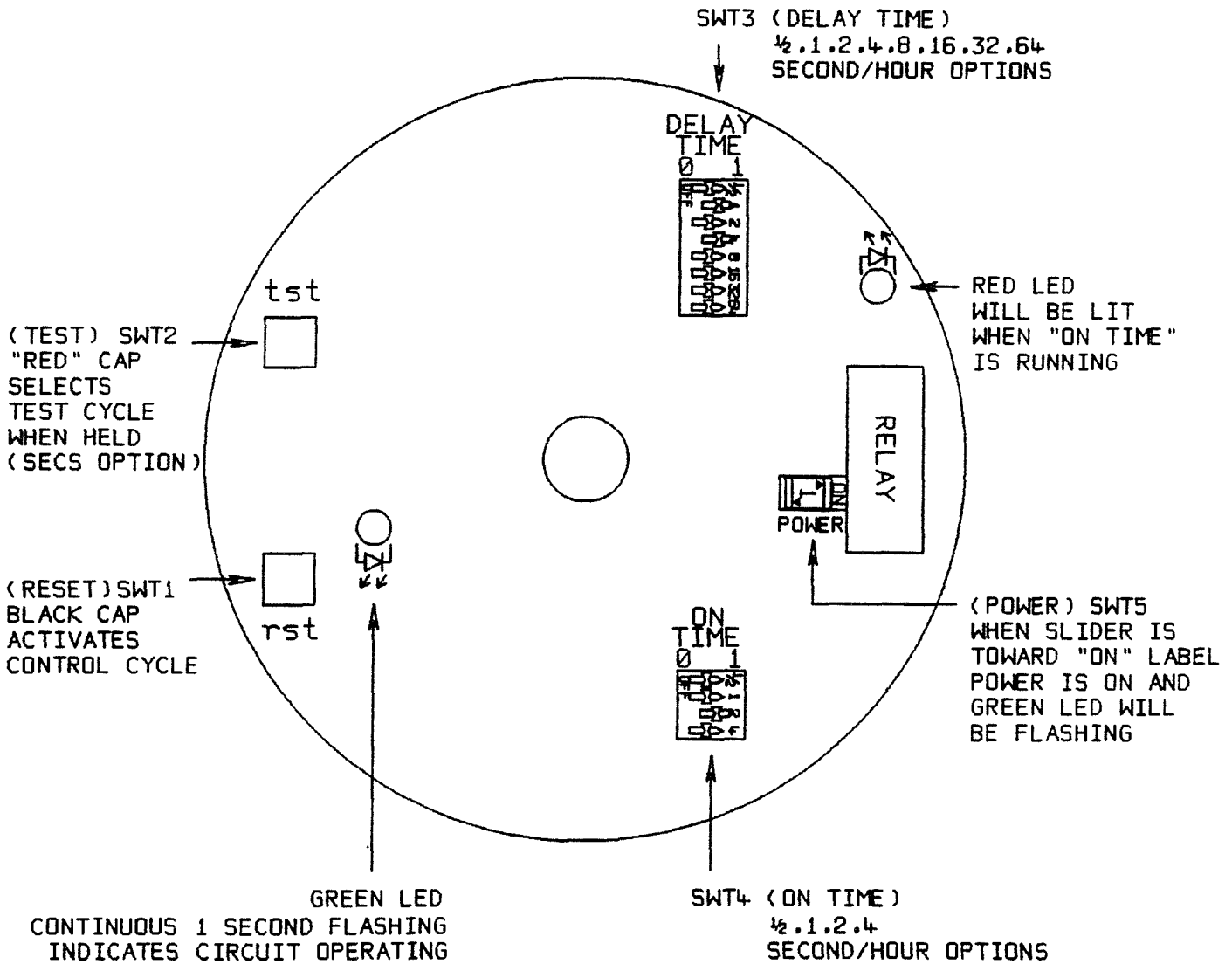
(fig a)



OPERATION LAYOUT STAND ALONE PUMP TIMER ELECTRONICS	DRAWING No IOSDL/ SAP2 DRAWN BY NJH DATE 1/12/88	SHEET No
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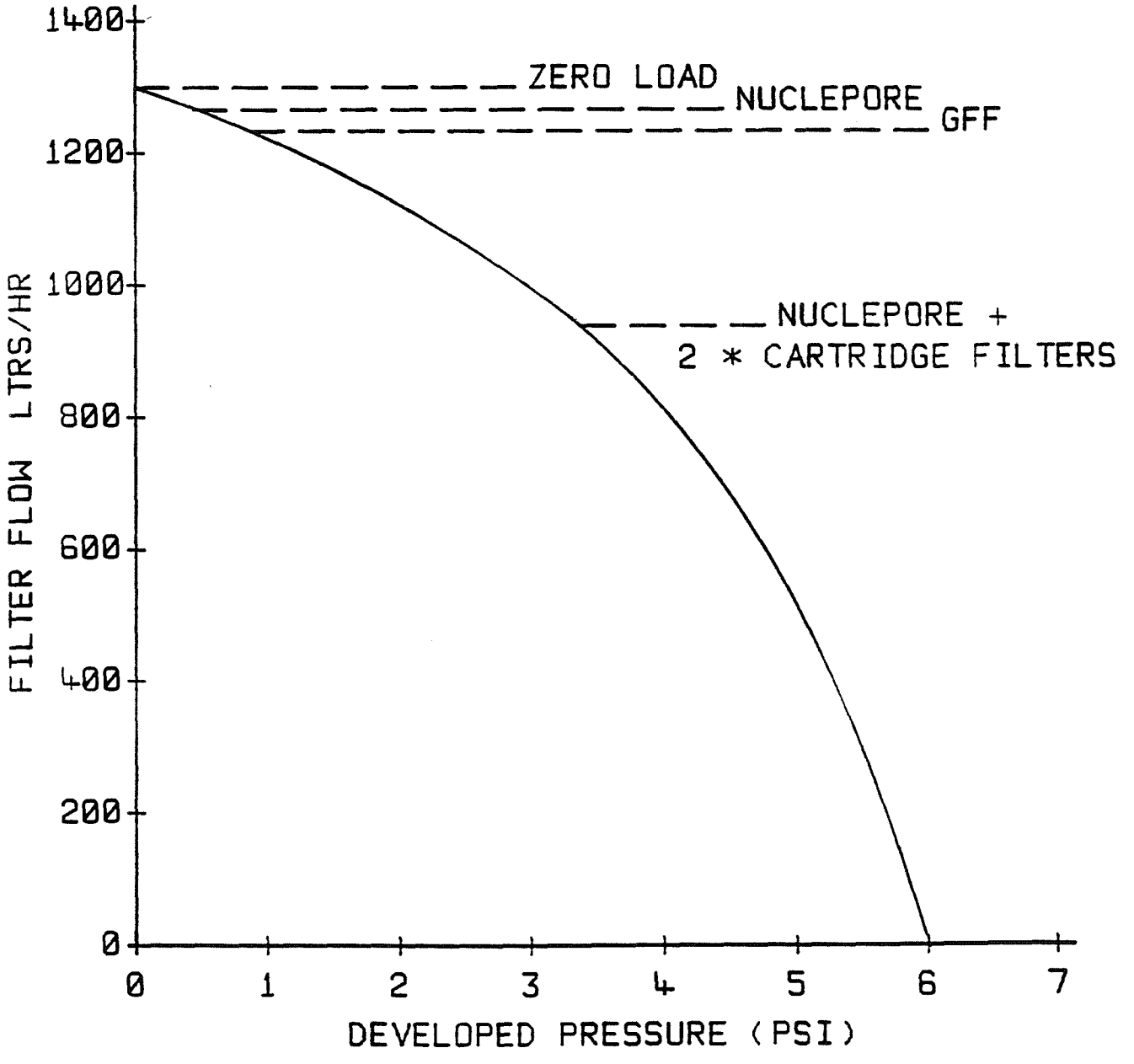
(fig b)

INITIAL PUMP FLOWS AGAINST DEVELOPED PRESSURES AT CONSTANT 16 VOLTS



FLOW GRAPH STAND ALONE PUMP	DRAWING No IOSDL/ SAP7 DRAWN BY NJH DATE 24/1/89	SHEET No
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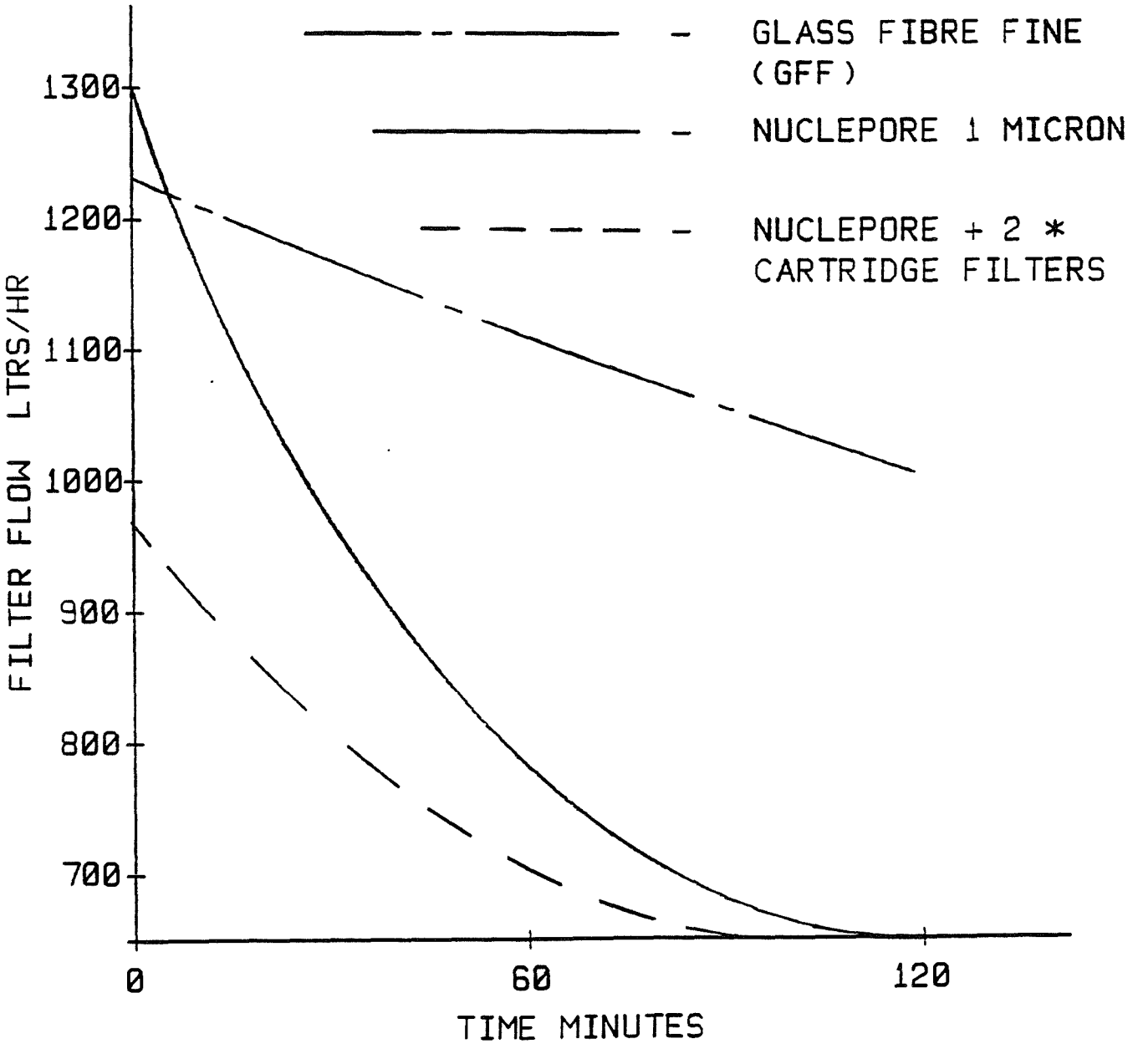
(fig c)

FILTER CONFIGURATION FLOW CHARACTERISTICS

MID-WATER COLUMN CONDITIONS



FLOW AGAINST TIME STAND ALONE PUMP	DRAWING No IOSDL/ SAP8 DRAWN BY NJH DATE 21/2/89	SHEET No
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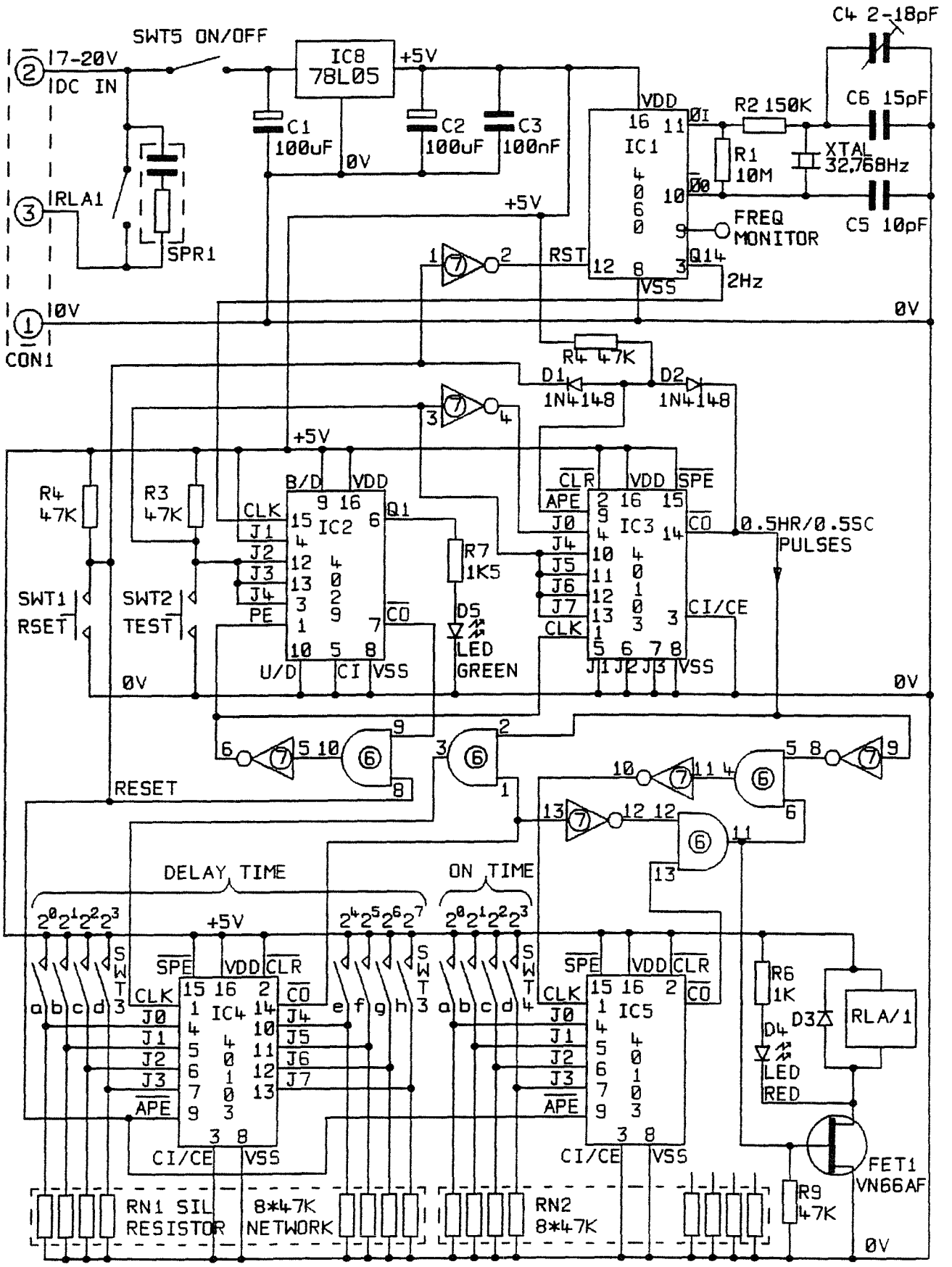
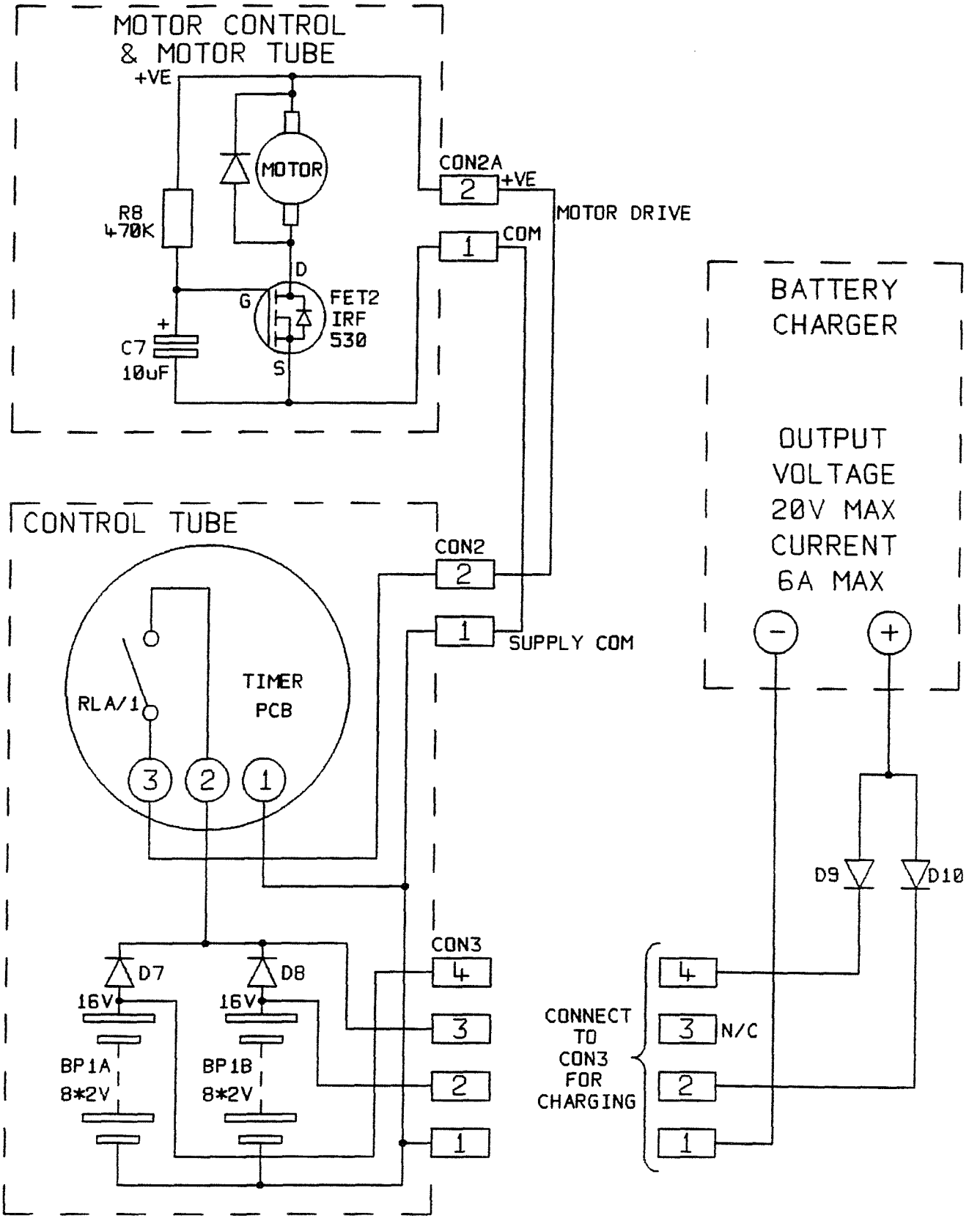


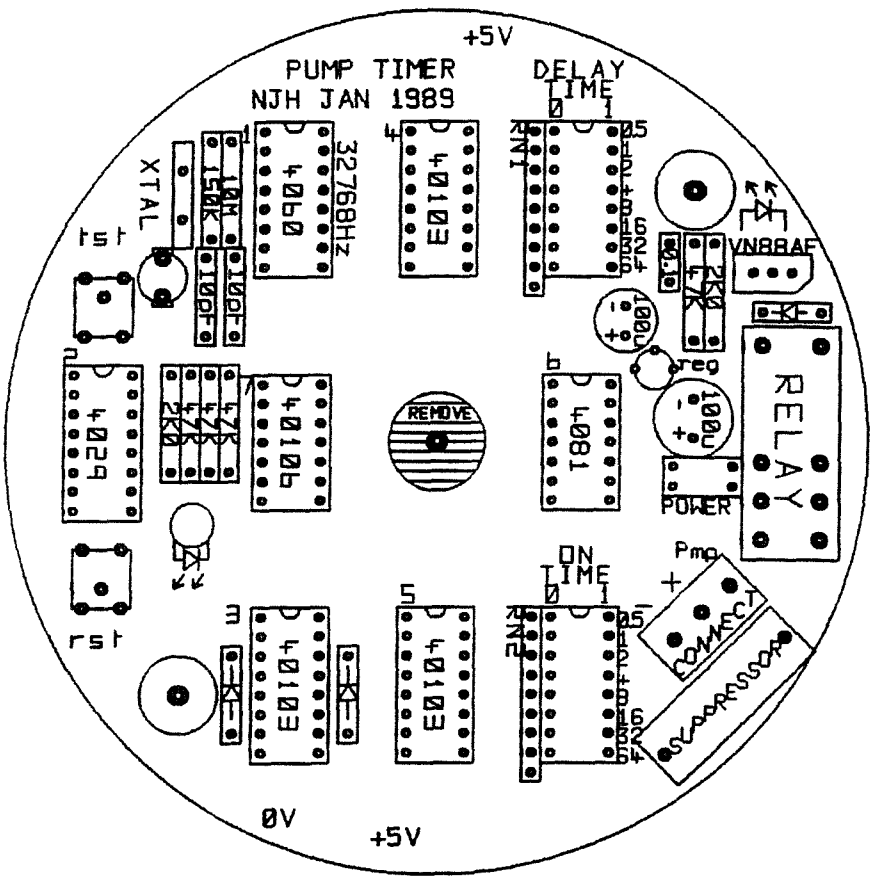
IC6 4081 4*AND
IC7 40106 6*INV

CIRCUIT DIAGRAM STAND ALONE PUMP TIMER ELECTRONICS	DRAWING No IOSDL/ SAP1 DRAWN BY NJH DATE 1/12/88	SHEET No
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY		

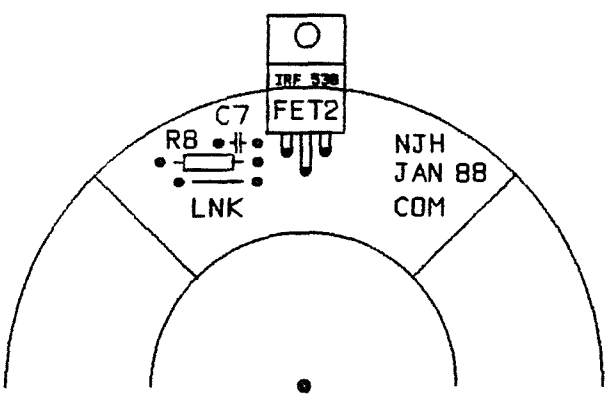


TUBE CONNECTIONS STAND ALONE PUMP TIMER ELECTRONICS	DRAWING No IOSDL/ SAP3 DRAWN BY NJH DATE 6/12/88	SHEET No
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY		

PCB1

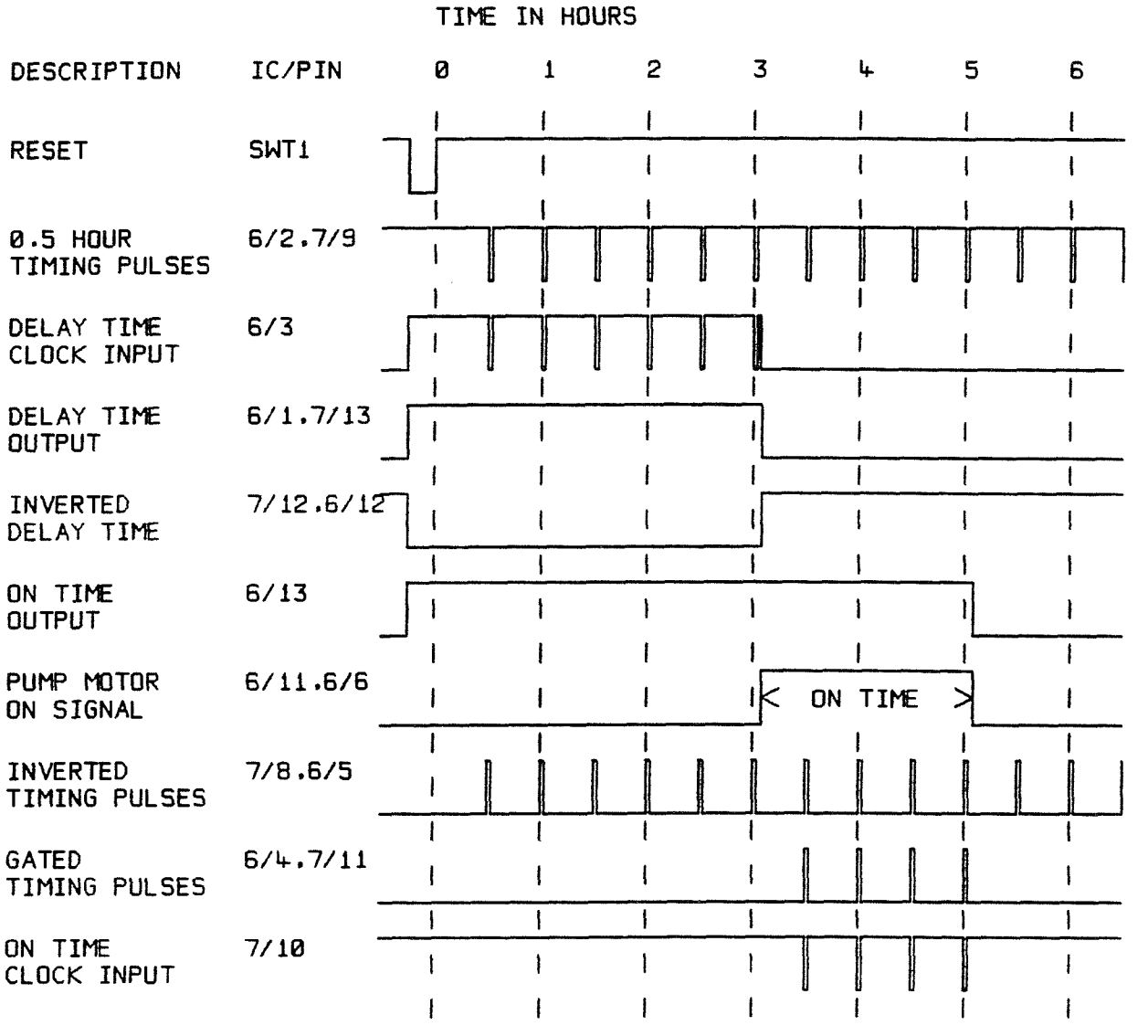


PCB2



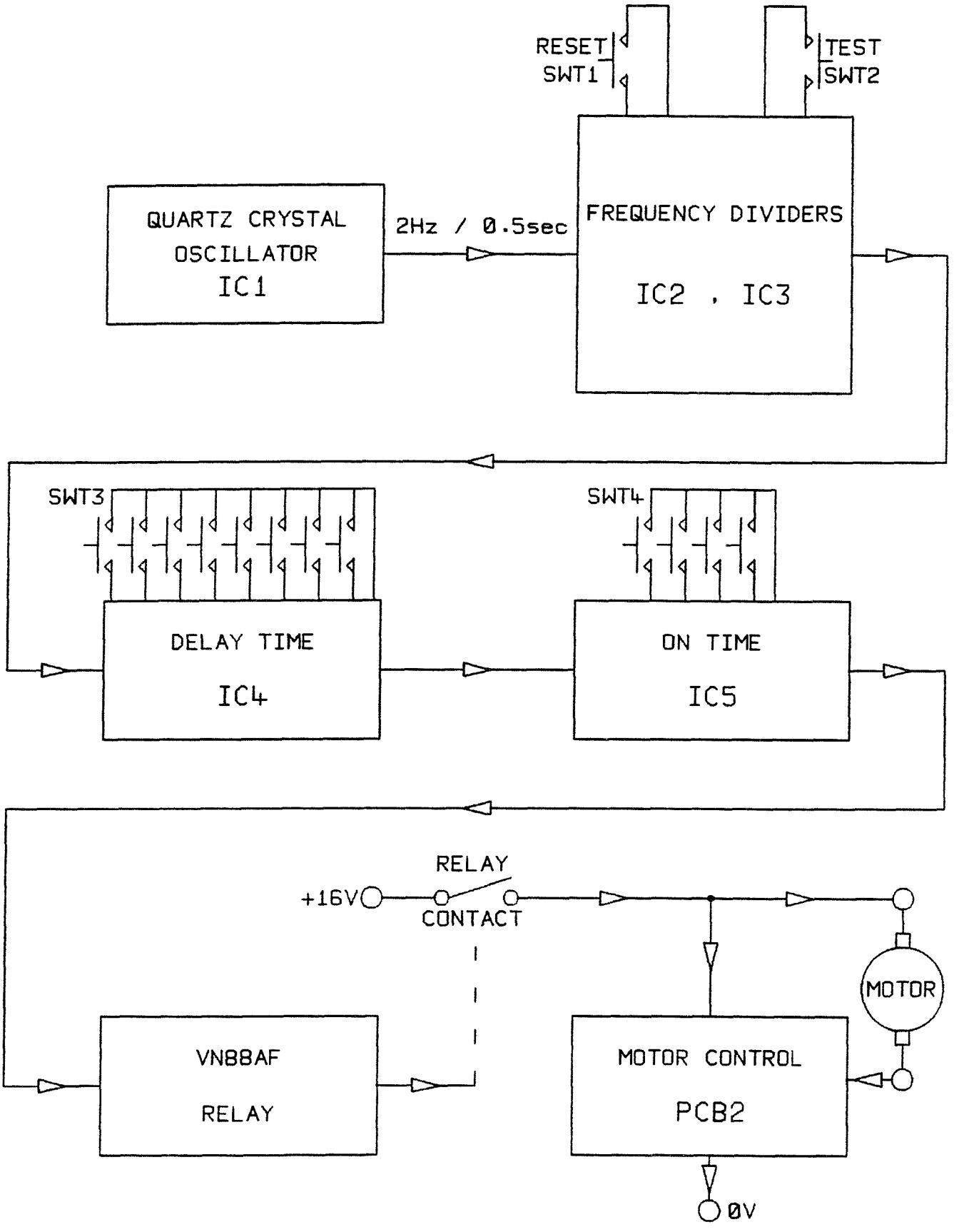
PRINTED CIRCUIT COMPONENT LAYOUTS STAND ALONE PUMP TIMER ELECTRONICS	DRAWING No IOSDL/ SAP4 DRAWN BY NJH DATE 21/2/88	SHEET No
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY		

PRINCIPLE WAVEFORMS OF THE PUMP TIMER ELECTRONICS

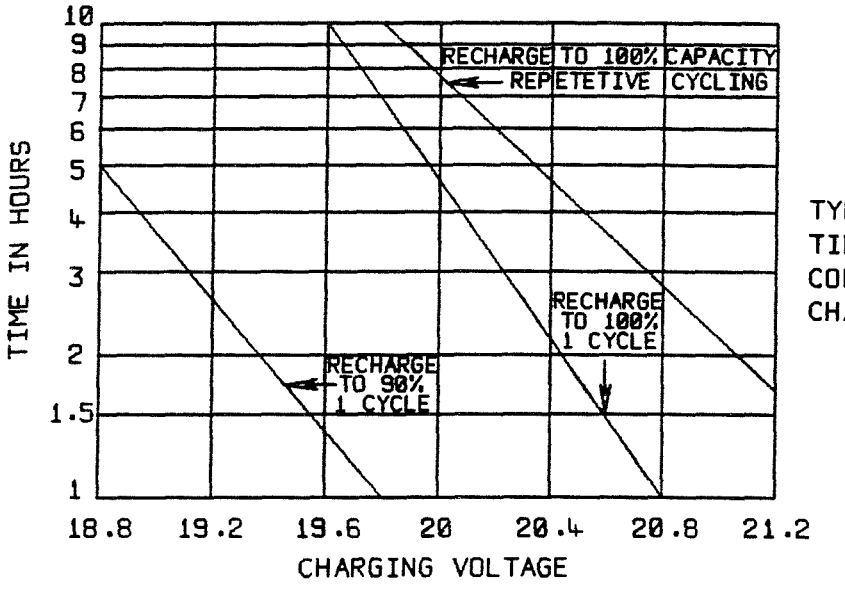


The example timing sequence above shows a 3 hour delay time followed by a 2 hour on time.

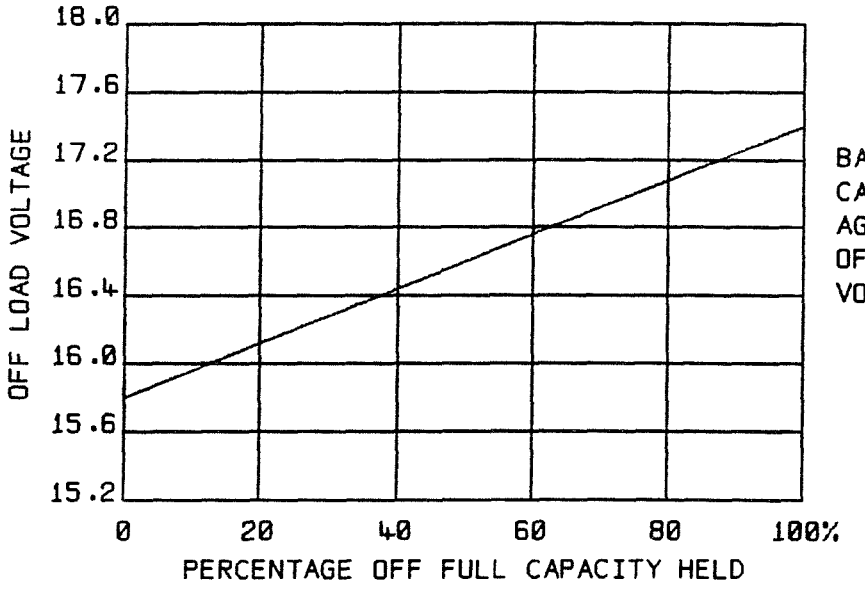
TIMING DIAGRAM STAND ALONE PUMP TIMER ELECTRONICS	DRAWING No IOSDL/ SAP5 DRAWN BY NJH DATE 7/12/88	SHEET No
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY		



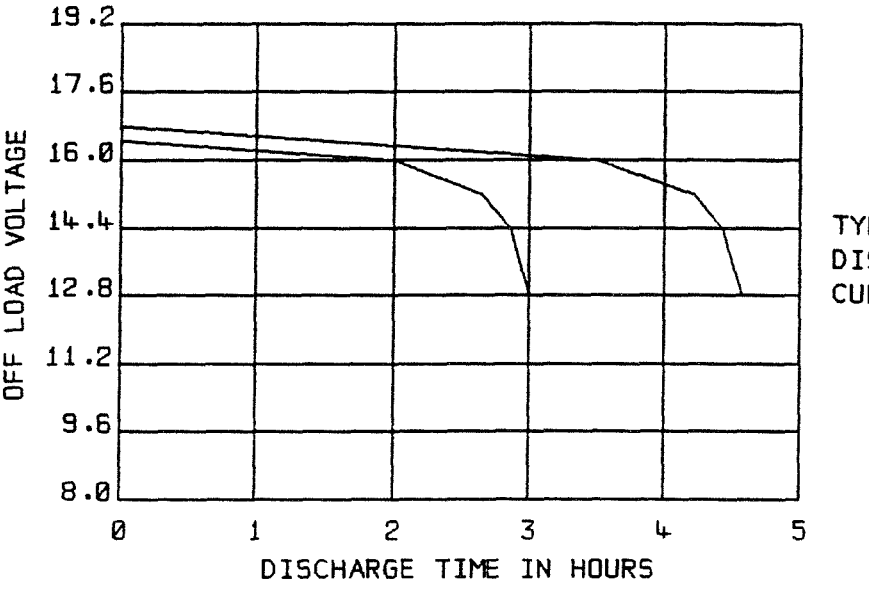
BLOCK DIAGRAM OF ELECTRONICS STAND ALONE PUMP TIMER ELECTRONICS	DRAWING No IOSDL/ SAP6 DRAWN BY NJH DATE 7/12/88	SHEET No
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY		



TYPICAL CHARGE TIMES USING CONSTANT VOLTAGE CHARGING UNIT



BATTERY PACK CAPACITY AGAINST OFF LOAD VOLTAGE



TYPICAL DISCHARGE CURVES

BATTERY PACK CHARACTERISTICS STAND ALONE PUMP	DRAWING No IOSDL/ SAP10 DRAWN BY NJH DATE 20/3/88	SHEET No
INSTITUTE OF OCEANOGRAPHIC SCIENCES DEACON LABORATORY		

STAND ALONE PUMP DEPLOYMENT CHECKLIST

SHIP'S NAME: CRUISE NO.:

DEPLOYMENT NO.: DATE: DAY NO.:

SHIP'S POSITION LAT. :

LONG.:

WATER DEPTH:

PUMPING DEPTH:

FILTER SIZE/TYPE:

FILTER LOADED Y/N:

CARTRIDGE LOADED Y/N:

FLOW SENSOR READINGS

PRE DEPLOYMENT:

POST DEPLOYMENT:

WATER PUMPED: LITRES

TIMER SETTINGS

DELAY TIME: HRS

ON TIME: HRS

SEQUENCE START TIME: HRS MIN SEC

TIME IN WATER: HRS MIN SEC

TIME OUT OF WATER: HRS MIN SEC

CIRCUIT DIAGRAM SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES & REMARKS	
	NAME	RATING	GRADE	TYPE	TRADE OR SUPPLIERS NAME	REFERENCE No.		
R1	Resistor	10M	5%	Metal Film ¼ Watt	Farnell Electronic Components Ltd	VR2510M	Each	£0.053
R2	"	150K	1%	" " " "	R.S. Components Ltd	149-026	Pack of 10	£0.26
R3-5	"	47K	"	" " " "	" " "	148-893	" " "	£0.26
R6,7	"	2K	"	" " " "	" " "	148-578	" " "	£0.26
R8	"	470K	"	" " " "	" " "	149-149	" " "	£0.26
R9	"	47K	"	" " " "	" " "	148-893	" " "	£0.26
RN1-2	Resistor Network	47K	2%	SIL 8-Commoned Thick Film ⅛ Watt	" " "	140-990	Each	£0.18
C1	Capacitor	100µF	35V	Electrolytic	FEC	100-829	"	£0.124
C2	"	"	25V	"	"	100-821	"	£0.143
C3	"	0.1µF	100V	Ceramic Epoxy Case	R.S.	125-733	Pack of 5	£2.47
C4	"	3-16pF	200V	Miniature Variable Ceramic	FEC	148-158	Each	£0.33
C5	"	10pF		Polystyrene 160V	"	105-054	"	£0.084
C6	"	15pF		" "	"	105-055	"	£0.084
C7	"	10µF	35V	Tantalum	FEC	100-906	"	£0.29
D1-3	Diode			IN4148	"	IN4148-NSC	"	£0.025
D4	LED Diode	Red		Standard	R.S.	586-475	Pack of 5	£0.90
D5	" "	Green		"	"	586-481	" " "	£0.90
D6	Diode			IN4148	FEC	IN4148-NSC	Each	£0.025
D7-10	"	8 Amp		80SQ045	"	80SQ045	"	£1.59
IC1	Integrated Circuit	CMOS		4060	"	CD4060BCN	"	£0.41
IC2	"	"		4029	"	CD4029BCN	"	£0.43
IC3-5	"	"		40103	"	HCF40103BEY	"	£0.73
IC6	"	"		4081	"	CD4081BCN	"	£0.18
IC7	"	"		40106	"	CD40106BCN	"	£0.34
IC8	"	5V Reg		78L05	"	LM78L05ACZ	"	£0.30

REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE
Prices November 1988								

CONTROL TIMER ELECTRONICS FOR STAND ALONE PUMP

INSTITUTE OF OCEANOGRAPHIC SCIENCES

ELECTRONICS COMPONENTS FOR DRG. No. I.O.S. / MISC 8

COMPILED BY NJH DATE 18/11/88 SHEET No. 1 of 2

ISSUED FOR ORDER No. FOR UNITS

CIRCUIT DIAGRAM SYMBOL	ELECTRONICS COMPONENT DESCRIPTION				IDENTIFICATION		ALTERNATIVES & REMARKS	
	NAME	RATING	GRADE	TYPE	TRADE OR SUPPLIERS NAME	REFERENCE No.		
XTAL	Crystal	32768 Hz		Quartz	Farnell Electronic Components Ltd	103-868	Each	£0.54
FET 1	Field Effect Transistor	1.3 Amp	N-Chan	Power Mosfet VN46AF	"	VN46AF	"	£0.74
FET 2	"	14 Amp	N-Chan	Power Mosfet IRF530	"	IRF530-IR	"	£1.04
SWT 1	Switch Red	50mA	24V	Keyboard Switch Pushbutton SPNO	"	146-202	"	£0.31
SWT 2	Switch Drk Gry	"	"	"	"	146-203	"	£0.31
SWT 3	Switches	1 Amp	50V	8 DIL Single Throw	"	SDS8014	"	£1.76
SWT 4	"	"	"	4 DIL " "	"	SDS4014	"	£1.15
SWT 5	Switch	"	100V	DIL SPCO	"	SDC1014	"	£0.78
RLA 1	Relay	10 Amp		6V 53Ω Coil SPDT	R.S. Components Ltd	347-848	"	£2.09
SPR 1	Suppressor	0.1µF +	100Ω	Contact Suppressor	"	238-463	Pack of 5	£5.44
CON 1	Connector	10 Amp		3 Way 0.2" Pitch	FEC	147-713	Each	£0.24
1 x	DIL Socket	8 Pin		Turned Pin	"	170-112	"	£0.19
2 x	"	14 Pin		" "	"	170-113	"	£0.34
6 x	"	16 Pin		" "	"	170-114	"	£0.38
BP 1	Battery Pack	10AH 16V	Lead Acid	16 x 5AH Cyclon Cells	"	147-181	"	£4.63
	Wire Black	6 Amp		Extra Flexible Silicone Insulated	"	146-951	5 m Coil	£4.18
	Wire Red	"		"	"	146-952	" "	£4.18
Lead 1	Inter-Connection	Plug each end	2 Pin	Brantner Double Ended	IOSDL Stores A19	VMG-2-FS 18"	Each	£24.56
Lead 2	Charging Lead	Plug one end	4 Pin	" " "	"	VMG-4-FS 42"	"	£46.73
CON 2/2A	Connector	Bulkhead	2 Pin	Brantner Socket	"	VSG-2-BCL	"	£31.54
CON 3	"	"	4 Pin	" "	"	VSG-4-BCL	"	£26.21
	Terminal Block	15A		12 Way Surface Mounting	FEC	L1350NI	"	£2.83

REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE
Prices January 1989								

CONTROL TIMER ELECTRONICS FOR STAND ALONE PUMP

INSTITUTE OF OCEANOGRAPHIC SCIENCES

ELECTRONICS COMPONENTS FOR DRG. No. I.O.S. / MISC 8

COMPILED BY NJH DATE 18/11/88 SHEET No. 2 of 2

ISSUED FOR ORDER No. FOR UNITS

I.O.S. FORM No. 103 (1/75)

PRINT TRIMMING LINE

297 x 363mm

	WORKSHOP DETAIL No. & DESCRIPTION	MATERIAL	No. OFF PER UNIT	No. OFF TOTAL REQD.	FINISH & REMARKS
1	Motor Housing	Al Alloy HID 48	1		Hard anodise ref. IOS Dwg 1945
2	Window Support End-Cap	Al Alloy HID 89	1		" " " " " "
3	Pivot	Tungsten Carbide	1		Mods to SP 3
4	Pivot Support Cap	St. St.			316 S16
5	Impellor	PVC	1		
6	Window	Titanium	1		
7	Upper Bearing Holder	Nylon	1		Mods to SP 4
8	Spider	PVC	1		
9	Pump Housing Part No. 630006	Polyprop	1		Mods to SP1
10	Motor-Side Coupling	Al Alloy HE 30	1		
11					
12					
13	Field Focus Ring	Mild Steel	1		
14					
15					
16	Motor Mods		1		Mods to SP 2
17	Motor Case End-Cap	Al Alloy HID 89	1		IOS Dwg No. N10/5230 Det. 2
18	Motor Support Ring	Al Alloy HE 30	1		Natural Anodise
19	Bush	Ceramic	1		Mod to SP 19
20	Shaft	Ceramic	1		Mod to SP 20
21	Shaft Support Ring	Polyprop	1		
22	Slow Start PCB				

REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE

STAND ALONE PUMP MOTOR/PUMP ASSY.

INSTITUTE OF OCEANOGRAPHIC SCIENCES. DEACON LABORATORY

WORKSHOP DETAILS FOR DRG. No. I.O.S. / 5557

COMPILED BY LHW DATE 2/12/88 SHEET No. 1

ISSUED FOR ORDER No. FOR UNITS

U.O.O. 1173/88 (5/93)

	STANDARD PART No. & DESCRIPTION	TRADE OR SUPPLIERS NAME & CATALOGUE REF. No.	No. OFF PER UNIT	No. OFF TOTAL REQD.	FINISH & REMARKS
1	Pump Housing (Body) C25	Charles Austin Pumps Ltd	1		Mod to Detail 9
2	Motor G9 M4	Printed Motors Ltd., Bordon	1		Mod to Detail 16
3	Pivot (for Rotor) No. 932108	W.S. Ocean Systems, Haslemere	2		Aanderaa CM Spares Mod to Det 3
4	Upper Rotor Bearing No. 971193	" " " "	2		" " " Mod to Det 7
5	Magnet (Driver) Ø 15 mm x 10 mm	Swift Levick, Supermagloy, S. Don	6		
6	Magnet (Driven) Ø 15 mm x 5 mm	" " " " "			
7	Screw St. St., Skt Hd M4 x 0.7 x 12		4		
8	Screw St. St., CSk Hd M4 x 0.7 x 40		4		
9	Socket Screw, St. St. M6 x 1 x 6		6		
10	Screw St. St., Skt Hd M3 x 0.5 x 6				
11	Screw St. St., Ch Hd M4 x 0.7 x 30		8		
12	Screw St. St., CSk Hd M1.6 x 0.35 x 6		3		
13	O Seal	50251	2		
14	Blanking Plug XSG	IOS Dwg 5243 Det. 11	1		A19 Stores
15	O Seal	50213	2		
16	O Seal 69.5 mm x 75.5 mm x 3 mm	RM 0695-30	1		
17	Connector	VSG 2 BCL	1		A19 Stores
18	D Washer Part No. 16225	Toton Pumps Ltd., Southampton	1		Ceramic
19	Ceramic Bush	" " " "	1		Mod to Det. 19
20	Ceramic Shaft Part No. 6244	" " " "	1		Mod to Det. 20
21	Washer Plain St. St. M4		8		
22	Washer Spring St. St. M4		12		
23	Washer Spring St. St. M3		1		
24	O Seal R42 75	Charles Austin Pumps Ltd	1		

REMARKS	ISSUE	DATE	REMARKS	DATE	ISSUE	REMARKS	ISSUE	DATE

STAND ALONE PUMP — MOTOR PUMP ASSY.

INSTITUTE OF OCEANOGRAPHIC SCIENCES

STANDARD PARTS FOR DRG. No. I.O.S./5557

COMPILED BY LHW DATE 2/12/88 SHEET No. 1

ISSUED FOR ORDER No. FOR UNITS

I.S.O. FORM No. 104 (1/75)

PRINT TRIMMING LINE

297 x 363 mm

WOKING OYELINE 0706/82

I.O.S. FORM No. 103 (1/75)

PRINT TRIMMING LINE

297 x 363mm

	WORKSHOP DETAIL No. & DESCRIPTION	MATERIAL	No. OFF PER UNIT	No. OFF TOTAL REQD	FINISH & REMARKS
26	Housing 20 inch long	HID 48	1		IOS Dwg 5417 Det. 18
27	End Cap (2 hole)	HID 89	1		IOS Dwg 5230 Det. 2
28	End Cap (No hole)	HID 89	1		IOS Dwg 5230 Det. 9
29	Spacer	PVC	4		
30	Soft Washer	Rubber	4		
31	Tie Rod A	M4 Brass Stud	2		
31	Tie Rod B	" " "	2		
32	Centre Rod	Al Alloy HE 30	1		Natural anodise
33	Pillar A	Tufnol Tube	16		5/16 OD x 3/16 ID
33	Pillar B	" "	2		
33	Pillar C	" "	2		
33	Pillar D	" "	2		
34	Centre Pillar	" "	4		3/4 OD x 5/8 ID
35	Base Plate	Tufnol Sheet	4		1/4 thick
36	Top Plate	" "	1		
37	PCB Guard	" "	1		
38	Electronics PCB	Fibre glass	1		
39	Splash Guard	Acrylic (clear)	1		

REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE

STAND ALONE PUMP BATTERY PACK/CONTROL TUBE

INSTITUTE OF OCEANOGRAPHIC SCIENCES. DEACON LABORATORY

WORKSHOP DETAILS FOR DRG. No. I.O.S. / 5557

COMPILED BY LHW DATE 2/12/88 SHEET No. 2

ISSUED FOR ORDER No. FOR UNITS

U.D.O. 1173/88 (5/93)

	STANDARD PART No. & DESCRIPTION	TRADE OR SUPPLIERS NAME & CATALOGUE REF. No.	No. OFF PER UNIT	No. OFF TOTAL REQD.	FINISH & REMARKS
26	Battery Cell 2V 5AH	Cyclon X001 Gate Energy Prod.	16		
27	Support Pillar	Holder Part No. 9510	4		
28	Nut Nylon M10 x 1.5 Washer Fd		2		
29	Nut Brass M4 x 0.7		4		
30	Washer Brass M4		4		
31	O Seal	50251	2		
32					
33	Connector	VSG 2 BCL	1		A19 Store
34	Connector	VSG 4 BCL	1		" "
35	O Seal	50213	2		" "
36	Connector Cable (Double End)	VMG-2-FS	1		" "
37	Blanking Plug	VMG-4 FSD	1		" "

REMARKS	ISSUE	DATE	REMARKS	DATE	ISSUE	REMARKS	ISSUE	DATE

STAND ALONE PUMP BATTERY PACK/CONTROL TUBE SUB ASSY. 'B'

INSTITUTE OF OCEANOGRAPHIC SCIENCES

STANDARD PARTS FOR DRG. No. I.O.S./5557

COMPILED BY LHW DATE 2/12/88 SHEET No. 2

ISSUED FOR ORDER No. FOR UNITS

	WORKSHOP DETAIL No. & DESCRIPTION	MATERIAL	No. OFF PER UNIT	No. OFF TOTAL REQD.	FINISH & REMARKS
47	Release Bar Assy. 36" Overall Length	Titanium	1		IOS Dwg 5348 Sub Assy. D
48	Half Clamp	"	6		IOS Dwg 5348 Det. 19
49	Clamp Rubber	Rubber	3		IOS Dwg 5156 Det. 41
50	Bolt	Titanium	9		SPS 10
51	Nut	"	9		SPS 13
52	Washer	"	18		SPS 16
53	Lower Support Split-Clamp	Polyprop	1		
54	Top Support Split-Clamp	"	1		
55	Strut	Titanium	4		
56	Filter Housing Top Plate	Polyprop	1		
57	Filter Support Plate	"	1		
58	Filter Housing Base Plate	"	1		
59	Support Plate Seal	Rubber	1		Shure 40/50
60	Base Plate Seal	"	1		" "
61	Top Hat	Polyprop	1		
62	Hose Connector	"	1		
63	Hose Connector Seal	Rubber	1		Shure 40/50
64	Hose	PVC Hose	2		See SP 71
65	Flow Meter Adaptor	Polyprop	1		
66	Flow Meter Connector		1		Mod to part of SP 67
67	Spacer	Polyprop	3		
68	Handle	"	1		
69	Wire Mount Split-Clamp	Titanium	2		Used with 4 mm or 6 mm wire
70	Clamp Bolt	St.St. 316 S16	2		IOS Dwg No. 5243 Det. 22
71	Tommy Bar	" " " "	2		" " " " " 23

REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE

STAND ALONE PUMP FRAME AND FILTER HOUSING ASSY.

INSTITUTE OF OCEANOGRAPHIC SCIENCES. DEACON LABORATORY

WORKSHOP DETAILS FOR DRG. No. I.O.S. / 5557

COMPILED BY LHW DATE 2/12/88 SHEET No. 3

ISSUED FOR ORDER No. FOR UNITS

U.D.O. 1173/88 (5/83)

I.O.S. FORM No. 103 (1/75)

PRINT TRIMMING LINE

297 x 363mm

	STANDARD PART No. & DESCRIPTION	TRADE OR SUPPLIERS NAME & CATALOGUE REF. No.	No OFF PER UNIT	No OFF TOTAL REQD.	FINISH & REMARKS
51	Screw Skt Hd St.St. M10 x 1.5 x 50		2		
52	Helicoil Insert St.St. M10 x 2½D		2		
53	Screw Skt Hd St.St. M6 x 1 x 50		2		
54	Nut St.St. M6 x 1		2		
55	Washer St.St. M6 Plain M6		2		
56	Screw Ch Hd Nylon M10 x 1.5 x 25		4		
57	Nut Washer Faced Nylon M12		4		
58	Washer Nylon M12		4		
59	Screw Ch Hd Nylon M8 x 1.25 x 25		8		
60	Bolt Nylon M10 x 1.5 x 60		8		
61	Nut Washer Faced Nylon M10 x 1.5		8		
62	Washer Nylon M10		8		
63	Screw Ch Hd Nylon M6 x 1 x 40		6		
64	Nut Washer Faced Nylon M6 x 1		6		
65	O Seal	OS 85 50-451	1		
66	Hose Clip St.St. Size 1 35 mm		4		
67	Flow Meter KSM K134-15B	Kent Flowmeters, Luton	1		
68	Cartridge Filter Type 1M	Flowtech Ltd., Reading	2		
69	3/4 BSP Hex Nipple (UPVC)	BTU Supplies, Guildford	1		
70	3/4 BSP Plain to Threaded Barrel Nipple	" " "	2		
71	Hose 1" ID Delivery Code 20	Medway Hydraulics, Chatham	2		
72	Screw St.St. Skt Hd M10 x 1.5 x 30		4		
73	Screw St.St. Ch Hd M6 x 1 x 8		2		
74	Washer St.St. M6		2		
75	Circlip, St.St. External 5/16"	Anderton Part No. 1400-31	2		

REMARKS	ISSUE	DATE	REMARKS	DATE	ISSUE	REMARKS	ISSUE	DATE

STAND ALONE PUMP — FRAME AND FILTER HOUSING ASSY.

INSTITUTE OF OCEANOGRAPHIC SCIENCES

STANDARD PARTS FOR DRG. No. I.O.S. / 5557

COMPILED BY LHW DATE SHEET No 3

ISSUED FOR ORDER No. FOR UNITS

I.S.O. FORM No. 104 (1/75)

PRINT TRIMMING LINE

297 x 363 mm

WOKING DYELINE 0706:82

I.O.S. FORM No. 103 (1/75)

PRINT TRIMMING LINE

297 x 363mm

WORKSHOP DETAIL No. & DESCRIPTION		MATERIAL	No. OFF		FINISH & REMARKS
			PER UNIT	TOTAL REQD.	
72	Clamp Nut	Brass 70/30	2		IOS Dwg No. 5243 Det. 26
73	4-10 mm Wire Clamp	Brass BS 251	2		" " " " " 40
74	C Spanner	Mild Steel	1		IOS Dwg No. 5230 Det. 14 Optional
75	Release Lever XSG U/W Plugs	PVC	1		" " " 1973 Sheet 1 Optional

REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE	REMARKS	ISSUE	DATE

STAND ALONE PUMP FRAME AND FILTER HOUSING ASSY.

INSTITUTE OF OCEANOGRAPHIC SCIENCES. DEACON LABORATORY

WORKSHOP DETAILS FOR DRG. No. I.O.S. / 5557

COMPILED BY LHW DATE SHEET No. 4

ISSUED FOR ORDER No. FOR UNITS

U.D.O. 1173/68 (5/73)

I.O.S. FORM No. 104 (1/75)

PRINT TRIMMING LINE

	STANDARD PART No. & DESCRIPTION	TRADE OR SUPPLIERS NAME & CATALOGUE REF. No.	No. OFF PER UNIT	No. OFF TOTAL REQD.	FINISH & REMARKS
76	Screw Skt Md St. M8 x 1.25 x 40		3		
77	Nut St. St. M8		3		
78	Washer Plain St. St. M8		6		
79	Washer Spring St. St.		3		

REMARKS	ISSUE	DATE	REMARKS	DATE	ISSUE	REMARKS	ISSUE	DATE

Stand Alone Pump — Frame and Housing (contd)

INSTITUTE OF OCEANOGRAPHIC SCIENCES. DEACON LABORATORY

STANDARD PARTS FOR DRG. No. I.O.S. / 5557

COMPILED BY LHW DATE 16/2/89 SHEET No. 4

ISSUED FOR ORDER No. FOR UNITS

U.D.O. 1175/88 (5/95)

297 x 363mm