A SEA FLOOR WINCH SYSTEM

FOR

WIRE LINE RE-ENTRY OF DEEP SEA BOREHOLES

by

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Abstract

The following report describes the scientific motivations for the use of a Sea Floor Winch System for Wireline Re-entry of Deep Sea Boreholes and presents a conceptual design for the winch system.

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PART I. WIRELINE RE-ENTRY AND BOREHOLE GEOPHYSICAL EXPERIMENTS

1. Introduction

The capability to re-enter a deep sea borehole from a surface vessel was demonstrated in July-August, 1989 on the Low Frequency Acoustic Seismic Experiment (LFASE). The next step is to develop a system for routine reentries so that borehole experiments can be carried out to address a broad range of scientific objectives. Scripps Marine Physics Laboratory (MPL) has the main contract with the United States Science Advisory Committee (USSAC) to develop this routine system. Woods Hole has been asked through a sub-contract from Scripps to provide a description of the need for a seafloor winch for borehole experiments and to conceptually design such a sub-system.

Two groups in addition to the drilling program have re-entered deep sea boreholes. In August 1988, Jacques Legrand from IFREMER, re-entered Hole 396B using a docking assembly (NADIA) which was placed in the cone by the submersible, Nautille (Figure 1; Legrand et al, 1989). Logging tools are lowered into the hole by a deep sea winch powered hydraulically from the submersible.

On the LFASE project, Fred Spiess, from SIO-MPL, re-entered Hole 534 twice using a system suspended from the R/V Melville with a thruster near the bottom (Figure 2). A docking system containing electronic recording equipment, designed and built by WHOI, was placed in the cone but the docking system did not have a winch.

This report discusses various configurations of wireline re-entry gear and provides justification for a winch on the docking system.

Figure 1: Schematic configuration of the NADIA system for submersible assisted re-entry.

Seismic Array Deployed and Connected to Ship

Figure 2: Schematic configuration of the LFASE system for re-entry from a surface ship.

2. Types of Borehole Experiments

The original wireline re-entry objectives encompassed four types of experiment:

- a) Short term logging measurements - This category includes measurements, like routine logging, in which an instrument is lowered into and out of the hole once for a typical duration of a few hours. The tool is lowered to the bottom and the measurements are made continuously as the tool is pulled up the hole. Although this category includes routine logging tools currently run from the drill ship, it also includes some specialty tools which could be run with wireline re-entry. Even routine tools may need to be run with wireline re-entry for specific objectives or on a remedial basis.
- b) Intermediate station measurements - This category includes oblique seismic experiments and packer experiments in which a tool takes a fixed station in the hole while the data acquisition procedure is carried out over a period from a few hours to a few days. The borehole equipment remains attached to the ship.
- c) Long term station measurements - This category includes long term seismic and strain monitoring where the tool is held at a fixed station for a few days to a few months or years, with data acquired via seafloor recording or telemetry.
- d) Long term profiling experiments - This category includes measurements acquired over the depth of the borehole over long periods of time. For example, in hydrothermal areas, it would be useful to know the variation of borehole temperature with time. A sequence of continuous temperature - depth profiles would be acquired by lowering a thermistor on a seafloor winch repeatedly on a preprogrammed schedule over a period of a few months or years.

CONFIGURATION #1

CONFIGURATION #2

CONFIGURATION #3

CONFIGURATION #4

Figure 3: Four possible configurations of a re-entry system from a surface ship
Configurations 3 and 4 require a bottom mounted winch.

3. Wireline Re-entry Configurations

All of the above borehole measurements can be accomplished with a combination of the four wireline re-entry configurations shown in Figure 3. In the first configuration, the logging tool is attached (or close to) the re-entry probe and the thruster is above the probe by a distance slightly greater than the deepest measurement required (up to 1500 m). This was the configuration used in the first wireline re-entry at Hole 534 in July 1989. Temperature, caliper and pressure measurements were made in the top 152m of the hole. Heave was not a problem in this case because of relatively calm sea state and because the calipers prevented the tool from falling back down the hole. This configuration is the simplest to deploy and applies to continuous logging operations. It uses coaxial cable between the probe and thruster, and between the thruster and the ship. The mechanical and electrical interface to the logging tool is made in the probe. Depth is obtained from pressure measurements at the probe. The disadvantages of this configuration are i) the ship induced heave and ii) the large separation between thruster and probe on re-entry.

The second configuration has a docking system between the probe and thruster with a series of sensors above the probe. This configuration was used for the borehole seismic experiment on LFASE and is suitable for medium to long term station experiments. The thruster can be disconnected from the docking system. The docking system sits in the cone so all depths below it are constant and known. The docking system has i) the electronic interface between the borehole sensors and the ship for shipboard monitoring, ii) a seafloor recording capability, iii) a data recovery module and iv) acoustic transponders to trigger functions in the electronics. Heave and horizontal ship motion are relieved from the docking system by a "slack tether" beneath the thruster.

The third configuration is similar to the second but the logging tool resides on or just below the docking unit until after re-entry. Then the tool is lowered on coax cable from a winch. This system has not yet been built but has components similar to the LFASE docking system and the IFREMER re-entry frame, NADIA. The second part of this report discusses a conceptual design of this system. The advantages of this system are i) the re-entry probe is close hauled to the docking system to facilitate re-entry ii) heave and horizontal ship motion are removed from the borehole apparatus, iii) continuous profiles can be acquired or intermediate term stations can be occupied, iv) multiple lowerings on a long term experiment can be carried out.

The fourth configuration has seven conductor logging cable on the winch, and the re-entry probe on the sled. The re-entry probe would not enter the hole. There would be a standard mechanical interface to the logging tools at the end of the cable. An electrical interface on the sled would convert signal and power requirements from the seven conductor format to telemetry on the coax. This configuration can accommodate any tool that runs on seven conductor wireline. A complete borehole geophysics program would be accomplished by "shuttling" the package back and forth to the hole.

4. Advantages of a Seafloor Winch

There are four principal advantages of a winch on the docking system as in configurations 3 and 4 above:

a) The distance between the re-entry probe and the thruster can be minimized to facilitate re-entry. In the LFASE experiment, the distance between the probe and thruster was about 335m. However, re-entry would get more difficult as the distance between the thruster and probe increased. Experiments at Hole 504B, for example, would require a thruster probe separation of over 1550m. With a winch on a docking system, the thruster probe separation could be kept to 250m or less. (With a docking system there is about 250m of slack tether to provide a

watch circle for the thruster around the cone. This is not necessary if there is no docking system.)

Legrand et al (1989) published a table of Re-entry Holes up to August 1988. Of 38 holes with re-entry cones, 5 had excellent chances of re-entry and 19 had good chances of re-entry. Of the 24 holes rated good or better, 9 were deeper than 1000m.

b) The principal advantage of a docking system is that it eliminates motion in the logging tools caused by heave of the ship. On LFASE which had relatively calm seas, heave induced motion was about 2-3m. Even logging from the drill ship has been degraded by heave induced motion but the seriousness depends on the particular measurement and its objectives.

c) The quality of some measurements such as gravity would be degraded by accelerations from the heave. Although gravity measurements are routinely made at sea by integrating over long periods, better data is obtained by a fixed sensor. The borehole provides this opportunity, so why not use it.

d) Some features in the borehole are observed at scales of centimeters (e.g. fractures from the televiewer.) Although it may be possible to correct the televiewer records for heave, if depth is measured accurately enough, it would be preferable to make the measurements without heave.

5. Borehole Measurements Affected by Heave

Langseth and Spiess (1987) discuss the scientific opportunities that reliable wireline re-entry could provide and outline the types of tools that may be deployed by wireline re-entry. Our task here is to review these instruments and to discuss the importance of heave to each. We are assuming that a deep sea winch is necessary to remove heave for most tools.

The Formation Microscanner and Digital Borehole Televier are designed to study borehole irregularities and fractures on the scale of a few tens of millimeters to centimeters. Although it may be possible through post-processing to remove the effects of heave (if depths are known sufficiently well) it would be preferable to keep the tool either stationary or moving slowly in the well for high resolution studies.

"Tools with high spatial resolution such as the borehole televier, or a high resolution resistivity tool operate up to their full potential only if the tools are completely isolated from the surface ship motion. This stability can be achieved using wireline re-entry because a module can be set in the re-entry cone that provides a fixed reference for controlling lowering and hoisting of the instrument." (Langseth and Spiess, 1987.)

"Even when time has been allocated for televier logging, data quality has been severely degraded by ship heave..." (Langseth and Spiess, 1987.)

"It is essential to have high quality televier logs of holes before the setting of packers or the emplacement of some downhole measurement packages as part of a wireline re-entry program. One way of doing this would be to deploy an ocean floor winch system (similar to the IFREMER system described in section IV) that could be lowered from the surface ship and set into the re-entry cone. Because the winch would be decoupled from the ship heave, the image degradation that has plagued previous televier logs would be virtually eliminated in this system. One possible scenario for relieving the drill rig time constraints on future ODP legs would be to log each new hole from the drill ship using the televier at relatively high winch speeds in order to obtain a detailed 360° caliper log of the hole. A slower, consequently higher resolution televier survey could then be conducted by a wireline re-entry system at a later date." (Langseth and Spiess, 1987.)

"The Formation Microscanner is another tool like the borehole televiwer that must be isolated from heave of the ship to realize the full resolution of the device." (Langseth and Spiess, 1987.)

The accelerations caused by heave will complicate the reduction of borehole gravity data.

Sidewall coring devices may be aimed at horizons only a few centimeters thick. Positioning the device with this resolution in the presence of heave would be extremely difficult if not impossible.

Wireline packers, borehole water samplers, and resealing devices would probably not be seriously affected by heave.

For vertical seismic profiling (VSP), heave induced noise will degrade the quality of the records. This has been observed routinely on VSP's from the drill ship over the past thirteen years.

For oblique seismic experiments, large scale resistivity measurements, electro magnetic sounding, strain measurements, and long term seismic experiments, heave can be eliminated by simply suspending the sensor a fixed distance below the docking system, provided that it is not necessary to emplace the sensor too deeply or at multiple locations.

6. Conclusions

In many borehole geophysical applications it may be possible to live with the tool and/or cable motion generated by heave by redesigning hardware, by carrying out more sophisticated data reduction procedures or by accepting compromises in the scientific objectives. However, we feel that a wireline re-entry program will be most successful if it provides comparable quality data to land experiments without significant effort on the part of the scientific user to either re-design equipment or to carry out new, complicated reduction

procedures. (In fact, a good way to ensure that only a small group of select users are involved in the wireline re-entry program would be to maximize the amount of effort required by the user.) We recommend that the wireline re-entry system provide a standard interface to the user (for example, the seven conductor logging cable or its analog) and that the burden of dealing with heave related issues not be placed on the user.

"Re-entry techniques can make significant improvements in data obtained by high resolution logging instruments that require isolation from the heave of the ship." (Langseth and Spiess, 1987.) The wireline re-entry program has been sold, in part, on its ability to remove heave and hence improve the quality of logs.

PART II SEA FLOOR WINCH SYSTEM CONCEPTUAL DESIGN

1. Design Objectives

The purpose of the sea floor winch system is to permit the controlled, smooth lowering of sensor packages into deep sea boreholes. This winch system can be installed on the LFASE docking basket or any similar structure suitable for deployment into a deep sea borehole re-entry cone. The system can be operated with the cone docking unit connected to an attending ship via a wireline or can perform independently in a long term profiling and recording mode. In the first case lowering protocol is controlled by ship based operators. In the self operating mode the lowering sequences must be preprogrammed and actuated by a sea floor installed controller.

Preliminary operating characteristics of the winch are as follows:

Instrument Lowering Depth = 1000 meters below sea floor, maximum

Lowering Speed = 10 cm/sec, nominal

Payload, i.e. immersed weight of lowered instrument, up to 250
lbs. (114 Kg)

Number of Round Trips: 50 for 75 lbs. (34 Kg) load
25 for 150 lbs. (69 Kg) load
15 for 250 lbs. (114 Kg) load

Winch Operating Depth = 6000 meters

2. Winch System Description

The main components of the winch system include: the frame, the winch drum, the motor, the gear train, the head sheave, the winch performance monitoring sensors (meters out, cable speed, cable tension), the lowering/data cable and the slip rings. The electrical power, winch control, and data processing equipment include: the battery pack, a DC power regulator, the deployment programmer and motor controller, the sea floor recording unit, and the ship to winch system

telemetry interface. Components selected to satisfy the operating characteristics previously mentioned are hereafter described in some detail.

Figures 4, 5 and 6 depict the conceptual layout and dimensions of the winch system. Figure 7 shows the electrical conceptual diagram.

Frame - The main structure (see Figure 4) is constructed of three inches diameter schedule 40 aluminum 6061-T6 welded pipe. Several holes are drilled all over the frame to allow for quick flooding of the frame during deployment. High strength fiberglass grating is used as deck material for the two lower rings. Batteries, winch and the other instruments are fastened to the fiberglass decks with stainless steel brackets. The complete structure is welded and can safely sustain a tensile load of 10,000 lbs. across the frame. Air weight of frame is 600 lbs. and wet weight is 491 lbs.

A bell mouth made of fiberglass fairleads the profiling instrument and the cable into the borehole. This bell mouth is secured to the second lower ring and extends to the bottom ring.

Winch - The winch assembly consists of: motor, speed reduction gear, drum, level wind, sheave and slip rings.

Motor: The model chosen for this particular application is a Moog 303-029A .42HP Series Brushless motor fabricated by Moog Inc., (NY). This model exceeds the torque requirement for lifting a maximum payload of 250 lbs. At a continuous operating speed of 3,000 RPM, with a power of 0.42 HP, the electrical requirement is well within the batteries output. The motor is placed inside an oil filled pressure compensated housing and coupled to the speed reducer. A Moog 152-400 Series motor controller is housed in a separate pressure case and connected to the motor by a Brantner pigtail.

Figure 4: Sea Floor Winch System for Wireline Re-Entry of Deep Sea Boreholes - Front View

Figure 5: Sea Floor Winch System for Wireline Re-Entry of Deep Sea Boreholes - Side View

Figure 6: Sea Floor Winch System for Wireline Re-Entry of Deep Sea Boreholes - Top View

Figure 7: Sea Floor Winch System - Electrical Functional Diagram

Speed Reducer: An Harmonic Drive Unit steps down the motor velocity to a suitable drum velocity of 4.8 RPM. The unit consists of a HD Pancake component gear set (dual ratio), which gives a final ratio of 1:625. The output torque is well within the maximum payload requirement. This speed reducer is fabricated by Harmonic Drive Division, Emhart Machinery Group (MA). The unit is housed in the motor oil filled pressure compensated case.

Slip Rings: An eight rings units, Model 180, fabricated by Focal Technologies Inc. (Nova Scotia, CA) is placed in an oil compensated housing opposite to the motor. A Brantner pigtail connects the electrical slip rings to the telemetry interface unit, and the recording unit.

Sheave: The payout unit includes the sheave and the sensors to monitor cable speed, meters out, and cable tension. The diameter of the sheave is 22 inches. The sensors are mounted in a pressure housing and connected to the system controller via a Brantner pigtail. This unit is fabricated by Metrox Inc. (CA).

Drum: The grooved drum and winch frame are built of aluminum 6061-T6. The winch barrel is one foot in diameter and 18 inches long. The drum flanges have a diameter of two feet. This arrangement will accommodate 1,000 meters of 3/8 inch diameter electromechanical cable. The winch frame is bolted to the fiberglass deck (middle lower ring), reinforced by aluminum chain plates. The cable payout speed is of 0.25 ft/sec (8 cm/sec) at 4.8 RPM.

Level Wind: A level winder will be provided to ensure proper spooling of the cable on the drum.

Cable - The electromechanical cable for this application is Kevlar armored. It has a coaxial cable core (configuration #3, Part I) or seven AWG 20 conductors with polypropylene insulation (configuration #4, Part I). In the latter case, the core of the cable consists of a

plastic rod filler around which the seven conductors are placed. A mylar tape holds the core together and a black polyurethane jacket is extruded over it. A Kevlar braid constitutes the strength member with a breaking strength of 1,400 lbs. An outer jacket of black polyurethane is extruded over the cable for further protection. Final nominal O.D. is 0.375 inches. The cable air weight is 75 lbs. for 1,000 ft. and wet weight is 25 lbs. per 1,000 ft. This product is manufactured by Consolidated Products Corporation (CA).

Power Supply - The main power supply provides electricity to the winch motor, the controller and the profiling instrument. The sea battery model SB 12-65 fabricated by Deep Sea Power and Light (CA) was chosen for this purpose. This model is rechargeable and pressure compensated and can operate at full ocean depth (6,000 m.). The same model has been successfully deployed in the LFASE experiment and in several other deep ocean applications at WHOI. Air weight of each battery is 100 lbs., immersed weight is 34 lbs.

A total of 36 batteries connected in 18 parallel assemblies placed in series is needed. The power output is 24 volts at 990 amp-hours (derated for temperature). Such power supply can sustain: 50 profiling trips at 75 lbs. of instruments payload, 25 trips at 150 lbs. or 15 trips at a max load of 250 lbs. The batteries are provided with pigtails and underwater Impulse connectors which plug into a junction box. The junction box pressure housing is made of aluminum. Fuses for each battery assembly are located inside it to prevent shorts from damaging the controller and the other instruments. Four batteries are located in the lower deck and the remainder is on the second deck, distributed in eight stacks of four each (Figure 3).

The total weight of the battery packs is 3600 lbs. (1636 Kg) in air, and 1224 lbs. (556 Kg) when immersed.

Power Regulator - The purpose of the power regulator is to provide constant voltage to the motor controller and associated electronics. It also provides the switching electronics to change power sources from ship power to battery power.

Controller - The motor controller, a Moog Model 152-41X and the computer controlling the lowering sequence - including emergency stops triggered by 1) lack of tension (or cable speed) while paying out, indicative of an obstruction in the borehole or 2) excessive tension while retrieving, indicative of a trapped instrument, are contained in an aluminum pressure housing.

Telemetry Interface - Provides the signal coding for winch control commands and instrument data transmission from or to the surface ship through the MPL/SIO telemetry system.

Sea Floor Recording Unit - In the independent, self recording mode, the winch system will include a high capacity mass data storage recorder with optical disks as used in the LFASE program. This recorder will be housed in a separate pressure case. Emergency recovery of the data package, by acoustically activated release, can be provided as it was in the LFASE program.

Ship Cable Release - The release mechanism to separate the frame from the ship cable, is a motor driven release Model MR500 B, built by Interocean Inc. (CA). This unit is mounted atop of the frame and can sustain a maximum tensile load of 10,000 lbs. The same model was deployed on the LFASE experiment and successfully test released under a load of 10,000 lbs. The motor is connected to the controller thru a Brantner pigtail. The release is operated acoustically from the ship.

Appendix A "Winch System Components" contains manufacturer's data sheets for most of the components mentioned.

3. Cost Estimate

The estimated cost of the components is as follows:

(36) Batteries SB-12-65 @ \$1,300.00 each, less 20% discount	\$ 37,440.00
Drum and bearings	3,000.00
Level Wind	1,500.00
Motor Moog 303-029A and Controller	3,000.00
Slip rings (Focal)	1,500.00
Ship cable disconnect (Interocean) Model RR 5000 BIO	3,700.00
Controller pressure case	1,500.00
Junction box	750.00
Pigtails and connectors	3,000.00
Sheave and sensors (Metrox)	9,800.00
Reduction gear	1,800.00
Frame	<u>10,000.00</u>
TOTAL	\$76,990.00

4. References:

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2. D.E. Koelsch, R.G. Goldsborough, H.O. Berteaux and R.A. Stephen, "A multinode three component seismic system for Deep Sea Drilling Program (DSDP), boreholes," In: Proceedings of the Marine Technology Society, Marine Instrumentation, 1990, San Diego, CA.
3. Legrand, J. et al, 1989. Campagne FARE: "Wireline re-entry of DSDP Hole 396B using the NADIA system." Trans. A.G.U., 70, 729-731, 741.
4. Langseth, M.G. and Spiess, F.N., 1987. "Science opportunities created by wireline re-entry of deep sea boreholes." JOI-USSAC Report.
5. R.G. Walden and C. Collins, "Bottom Mounted Profiling Winch". WHOI Technical Report, WHOI-84-12.
6. Bonde, L.W., 1972. "A Survey of Underwater Winches." Technical report No. 348, prepared for The Naval Facilities Command.

Appendix A:

COMPONENTS TECHNICAL DATA

- 1) Sea battery
- 2) Electromechanical cable
- 3) Motor controller
- 4) Brushless motor
- 5) Speed reducer
- 6) Slip rings
- 7) Sheave
- 8) Connectors
- 9) Release

Rechargeable Pressure Compensated Batteries

SEABATTERIES are a unique submersible power system designed to perform in the high pressure/low temperature environs of the deep ocean. Field tests to 5900 meters have proven SEABATTERIES to be reliable at great depths. At the heart of each system is a maintenance free rechargeable lead-acid battery utilizing a non-liquid electrolyte. Each battery is pressure modified and mounted in a virtually indestructible polyethylene case filled with an inert oil. Built into the top of each case is a resilient urethane diaphragm which provides continuous equalization with ambient pressure. The transparent diaphragm, incorporating an integrally molded valve assembly for filling and venting, permits visual inspection of battery status. The diaphragm's dual seal design ensures leakage will not occur. Six threaded inserts for mounting are molded into the bottom of the case to aid in secure installation. SEABATTERIES include convenient carrying handles.

FEATURES:

- Rated for Full Ocean Depth
- No Significant Gas Buildup During Normal Charge Discharge Cycles
- Reliable Ambient Pressure Seals
- No Electrolyte Spillage or Stratification Problems
- Excellent Capacity Retention
- No Pressure Retaining Housings Which Can Rupture Explosively
- Electrical Penetrators Shielded by Case Geometry
- Fully Invertable, Operable at Any Depth and Orientation

APPLICATIONS:

Acoustics	Instrumentation	Telemetry
Illumination	Video Sleds	Submersibles
Diver Operated Tools	Back-up Power Supplies	Photographic Systems

SeaBattery

SPECIFICATIONS

SB 12-65

SB 24-38

Depth Rating

Full Ocean Depth

Batteries
Type
Model

Maintenance Free Lead-Acid
Yuasa NP 65-12 Yuasa NP38-12

Nominal Voltage

12 Volt

24 Volt

Nominal Capacity
20 Hour Rate (see reverse)

65.0 AH

38.0 AH

Weight
Air
Seawater

45 Kg (100 LBS)
15 Kg (34 Lbs)

49 KG (108 Lbs)
19 Kg (42 Lbs)

Energy Density (20 Hr Rate)

26.5 WH/Liter
(0.4 WH/Cu In)

30.6 WH/Liter
(0.5 WH/Cu In)

Specific Energy (20 Hr Rate)
Air

17 WH/Kg
(7.8 WH/Lb)

18 WH/Kg
(8.3 WH/Lb)

Seawater

52 WH/Kg
(23 WH/Lb)

47 WH/Kg
(21 WH/Lb)

Maximum Discharge Current

500 Amps

200 Amps

Internal Resistance

35 Milliohms

35 Milliohms

Operating Temperature Range
Charge
Discharge

-15 C to 50 C (5 F to 122 F)
-20 C to 60 C (-4 F to 140 F)

Case Material

Molded Polyethylene

Diaphragm Material

Molded Polyether Urethane

Compensating Fluid

High Purity Mineral Oil

Hardware

316 SS 1/4-20 Bolts

Mounting

303 SS 1/4-20 Threaded Inserts

Standard Connector

Impulse Enterprise
VMK-2-FS (special) Polarized

Sealed Construction

Can Be Operated In Any Position

DIMENSIONS Centimeters (Inches)

END VIEW

SIDE VIEW

TOP VIEW

BOTTOM VIEW

CHARACTERISTICS OF UNMODIFIED YUASA CELLS

SOURCE: YUASA BATTERY CO., LTD.

DISCHARGE RATES

SB 12-65				SB 24-38			
AMPS	VOLTS	RATE	CAPACITY	AMPS	VOLTS	RATES	CAPACITY
3.25	10.50	20 Hrs	65.0 A.H.	1.9	21.00	20 Hrs	38.0 A.H.
6.05	10.50	10 Hrs	60.5 A.H.	3.5	21.00	10 Hrs	35.0 A.H.
11.05	10.20	5 Hrs	55.2 A.H.	6.46	20.40	5 Hrs	32.3 A.H.
39.00	9.60	1 Hr	39.0 A.H.	22.8	19.20	1 Hr	22.8 A.H.

DeepSea Power & Light Co.

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CORP.

REVISION

DESCRIPTION

DATE APPRO

SINGLE CONDUCTORS-7 UNITS

AWG No. 20 (7/.0126") B/C

P.P. INSULATION

COLOR CODE: BROWN

RED

ORANGE

YELLOW

GREEN

BLUE

VIOLET

ELASTIC ROD FILLER

INTERSTICES WATERBLOCKET

PVC/MYLAR TAPE

INNER JACKET
BLACK POLYURETHANE

STRENGTH MEMBER
KEVLAR BRAID

OUTER JACKET
BLACK POLYURETHANE

NOMINAL O.D.----- .375"
WEIGHT IN AIR----- 75 LBS./MFT.
WEIGHT IN SEA WATER----- 25 LBS./MFT.
BREAKING STRENGTH----- 1,400 POUNDS
MAXIMUM LOAD----- 250 POUNDS
MIN. BEND DIAMETER----- 12 INCHES

SOUTH
BAY

CABLE DIVISION

CONSOLIDATED PRODUCTS CORPORATION

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CHECKED	CH	APPROVAL		

152-400 Series BRUSHLESS MOTOR CONTROLLER

MOOG BRUSHLESS TECHNOLOGY

152-400 Series Brushless Motor Controller

FEATURES

- Sinusoidal, 3 Phase Drive
- Cold Plate Mounting
- Rotor Position Data
- Closed Loop Velocity or Current Control
- Resolver Based System
- Auto Foldback
- Plug-in I/O and Logic Supply Connections

PROTECTION

- Overcurrent
- Short Circuit
- Over Temperature
- Feedback Loss
- Low and High Input Voltage

SPECIFICATIONS

Input Supply

Logic:
+20 Vdc
@ 1.4 amp; Model 410, 420
@ 2.0 amp; Model 430
+12 Vdc @ 0.38 amp
-12 Vdc @ 0.15 amp

Power:
24 to 325 Vdc

Output: 3 Ratings

Continuous 5, 10, 20 A
Peak 10, 20, 40 A

Speed Ranges

0-500 rpm
0-1500 rpm
0-5000 rpm
0-10,000 rpm

Switching Frequency: 5KHz

Operating Temperature: 0-50°C

Weight: 8 lbs

VERTICAL MOUNTING REQUIRED

NOTES:

1. Dimensions in brackets are in millimeters

MODEL NUMBER DEFINITION

303 Series BRUSHLESS MOTORS

FEATURES

- Lowest Inertia
- Integral Resolver
- Smallest Size
- Lightest Weight
- Face & Flange Mount

OPTIONS

- Totally Sealed
- Custom Shaft
- Custom Connectors

SPECIFICATIONS

MOTOR	UNITS	MODELS	
		303-029A	303-030A
PERFORMANCE Δ Continuous Stall Torque Δ Peak Stall Torque Δ No Load Speed Torque Constant Back EMF Constant Mechanical Time Constant	lb-in lb-in rpm lb-in/Arms Vpk/Krpm msec.	5.5 17 8600 3.53 34.1 2.33	15.0 60 10900 2.78 26.9 1.14
ELECTRICAL Max. Voltage Resistance $\emptyset - \emptyset$ Δ Continuous Stall Current Δ Peak Stall Current Electrical Time Constant	Volts-pk Ohms Arms Arms msec.	350 19.00 1.60 7.0 0.64	350 2.00 5.40 25.6 1.24
MECHANICAL Inertia — w/o brake Weight — w/o brake	lb-in-sec ² lb.	0.00016 3.0	0.00037 4.0
BRAKE — OPTIONAL Torque (minimum) Power Input (maximum) Inertia (additional) Weight (additional)	lb-in Watts lb-in-sec ² lb.	N/A	N/A

NOTES:

- Δ 1 With motor mounted on a 12" x 12" x 0.5" aluminum heat sink in a 40°C still air ambient.
- Δ 2 Includes K_t linearity and current thermal time limit.
- Δ 3 At 295 Vdc minimum bus voltage.
4. Currents are rms phase amperes.
5. Specification tolerances are $\pm 10\%$.
6. See performance curves for system limits.

RESOLVER — TRANSMITTER

	SPECIFICATIONS
Input voltage	4.0 Vac rms
Input frequency	3400 Hz
Input current	≤ 75 mA rms
Transformation Ratio	0.5

▽ = Limit of controller Model 152-41X.

▽ = Limit of controller Model 152-42X

= Designates Continuous Operating Area

1.38 HP
200 RPM
1.38 - 200 = 0.125 HP

2000 : 200 gear ratio
10

LOAD LIMIT APPLIED TO MIDPOINT OF SHAFT EXTENSION
 CONSULT FACTORY FOR OTHER LOADING CONDITIONS.

[illegible]

1. Dimensions in brackets are in millimeters

The diagram illustrates the electrical connections for a 3-phase winding. On the left, a 'THERMOSTAT' is connected to a '3 PHASE WINDING' (represented by a circle). The winding is connected to a 'MOTOR CONNECTOR' block with terminals A through M. A 'GROUND' symbol is also shown. Below the motor connector, a bracket labeled 'DRIVE OR CONTROLLER PHASE CONNECTION' points to terminals B, A, C, and a ground symbol. On the right, a 'TX' (resolver) is connected to a 'RESOLVER CONNECTOR' block with terminals A through F. The resolver is also connected to a ground symbol. The resolver connector terminals are labeled with signals: S1, S3, S2, S4, R1, and R2.

The Most Axially Compact, Single-Stage, High-Ratio Gearing Available

DYNAMIC CIRCULAR SPLINE:

An internal gear which has the same number of teeth as the Flexspline and which rotates at the same speed and in the same direction as the Flexspline. It is the output element to which an output shaft is connected.

WAVE GENERATOR:

An elliptical bearing and the rotating input element of transmission. It is connected to a motor or other input shaft and imparts a rotating elliptical shape to the Flexspline.

FLEXSPLINE:

A thin-walled steel ring with external spline teeth that progressively engage the internal teeth of the Static Circular Spline and Dynamic Circular Spline at the major axis of its rotating elliptical shape. The Flexspline rotates in the opposite direction of the Wave Generator. Speed reduction relative to the Wave Generator is equal to one-half the number of teeth on the Flexspline's outside edge. For example, if the Flexspline has 200 teeth, the reduction ratio will be 100:1.

STATIC CIRCULAR SPLINE:

A fixed nonrotating internal gear which provides mechanical grounding for the transmission. It has two more teeth than the Flexspline to establish a positive transmission reduction ratio equal to one-half the number of Flexspline teeth.

- Ratios from 80:1 to 160:1 in standard products
- Dual ratios in the same envelope to as high as 40,000:1
- Low backlash

HDF Pancake gearing consists of two Circular Splines which mesh with a common Flexspline to create an extremely axially compact, single-stage gear reduction. The Static Circular Spline turns at the same ratio that it would if it were used in a cup drive, i.e., two teeth, per input revolution. The Dynamic Circular Spline rotates with the Flexspline at a 1:1 ratio and becomes the output member.

HDF Pancake gearing is recommended for light-duty speed reduction and phasing/differential applications. Other Pancake

gearing models are available for heavier-duty applications. (See data sheets enclosed in accompanying folder.)

Backlash

Unlike cup component gearing, pancake gearing does exhibit some backlash at the tooth mesh. With pancake gearing, there is no cone angling of the Flexspline teeth as a result of deflection as in cup-type gearing, (see zero-backlash illustration on page 2), therefore, some minor relative motion is possible between teeth during operation. Because pancake gearing consists of two Circular Splines, each with a different number of teeth, clearance must be allowed for meshing with the Flexspline teeth on the same pitch line. Backlash is typically in the 10 to 35 arc minute range.

Installed Relationship

Pancake Efficiencies

HDF EFFICIENCY VS. OUTPUT TORQUE

HDF EFFICIENCY VS. RATIO

Dimensions (mm)

SIZE 14

SIZE 20

SIZES 25, 32, and 40

SIZE 50

SIZE	A	B	C ₁	C ₂	D	E ₁	E ₂	F	G	H	J	K	L	N	O	P	R MAX.	APPROXIMATE WEIGHT	
																		LBS.	KGS.
14	50	5	10.5	11.4	15*	3.75*	.75*	18*	36	14*	44	M3	6*	—	—	0.2	32	0.2	.091
20	70	6	12.5	14.4	11.4	0.95*	2.05*	20	53	20	60	M4	9	10.4	3	0.2	47	0.7	.318
25	85	8	16.5	18.4	12.8	0.35	3.35	24	66	25	75	M5	11	12.8	4	0.2	59	1.3	.590
32	110	10	20.5	22.4	15.6	0.95	3.95	34	84	36	100	M6	14	16.3	5	0.2	77	2.3	1.043
40	135	13	27.0	30.4	19.4	1.8	5.8	40	103	42	120	M8	14	16.3	5	0.4	95	4.4	1.996
50	170	12	33.0	36.4	23.2	2.9*	6.9*	50	135	54	150	M10	19	21.8	6	0.4	119	7.3	3.311

NOTE: Dimensions are for reference only. Required specification prints furnished on request. It is recommended that our engineering staff be given the opportunity to review application approaches since the full extent of design options is more than can be conveniently described in this brochure.

NOTE: C₂ dimensions include hardened wear washers supplied with pancake gear sets. (See specification prints.)

Ratings Table¹

HDF SIZE	RATIO ⁴	MAXIMUM INPUT RPM		OUTPUT TORQUES @ INPUT RPM						MAXIMUM OUTPUT TORQUE ³		APPROXIMATE WAVE GENERATOR INERTIA		MAXIMUM BACKLASH (arc min.)
				3500		1750		500						
		Grease	Oil	lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in	Nm	lb-in ²	Kg-cm ²	
14	80	3500	6000	44	5	56	6	85	10	90	10	0.011	0.033	36
	100			44	5	56	6	85	10	90	10			34
	110			44	5	56	6	85	10	90	10			31
20	80	2200	6000	195	22	246	28	250	28	250	28	0.049	0.144	33
	100			195	22	246	28	300	34	300	34			28
	120			195	22	246	28	350	40	350	40			26
	160			195	22	246	28	370	42	390	44			22
25	80	2000	5000	320	36	406	46	425	48	425	48	0.124	0.362	28
	100			320	36	406	46	600	68	600	68			25
	120			320	36	406	46	615	69	700	79			21
	160			320	36	406	46	615	69	780	88			19
32	80	500	4500	640	72	810	92	950	107	950	107	0.45	1.31	23
	100			640	72	810	92	1200	136	1200	136			20
	120			640	72	810	92	1230	139	1400	158			18
	160			640	72	810	92	1230	139	1550	175			15
40	80	1250	4500	1350	153	1705	193	1700	192	1700	192	1.17	3.43	23
	100			1350	153	1705	193	2400	271	2400	271			18
	120			1350	153	1705	193	2585	292	2700	305			16
	160			1350	153	1705	193	2585	292	3100	350			11
50	80	1000	3500	2525	285	3180	359	3100	350	3100	350	3.39	9.89	16
	100			2525	285	3180	359	4200	475	4200	475			16
	120			2525	285	3180	359	4825	545	5200	588			14
	160			2525	285	3180	359	4825	545	5800	655			8

NOTES 1) Output Torques based on B 10 Life of 3000 hours
2) Thermal limited 50% duty cycle recommended with on time not exceeding 15 minutes

3) This torque is not to be exceeded under any circumstances including momentary overload

4) Consult factory for special high rates up to approximately 40,000 1

Electrical Slip Ring

Model 180

Features

Ideal for smaller systems such as mini ROVs, oceanographic instruments, side scan sonars and land based seismic systems.

Model 180 is a compact and rugged unit designed for marine use. It has a stainless steel exterior with O-ring and energized lip seals for weather protection. Heavy duty ball-races are lubricated and sealed for life.

It is an adaptable unit with several major options:

It can be supplied with a single bi-directional, passive multimode fiber optic rotary joint, enclosed within a slightly longer body.

For use in hazardous locations the unit may be ordered with a CSA certified enclosure.

Another adaption is for use underwater as an oil-filled, pressure compensated **electro-mechanical swivel** with a maximum continuous rating of 3 tonnes.

For further information contact:

Focal Technologies Inc.
40 Thornhill Drive
Unit 7
Dartmouth, Nova Scotia
Canada B3B 1S1
Tel: (902) 468-2263
Fax: (902) 468-2249

(Shown with optional connectors)

Focal Technologies Inc.

Note:

All measurements shown are in mm (inches)

Options**Underwater:**

Focal supplies optional oil-fill and air-bleed fittings.

Explosion-proof:

Focal supplies gas purge and pressure relief fittings.

Alternatively, the unit may be ordered as a CSA approved explosion-proof enclosure.

Connectors:

Focal will supply and install connectors or install customer supplied connectors.

Specifications**Electrical:**

Available from 4-24 rings. All circuits are rated to 1000V, 7A continuous, with total current not to exceed 100 A.

Signal noise less than 1 microvolt RMS and peak to RMS noise ratio 10:1

Mechanical:

Rotation: maximum 200 rpm

Brushes: 2 per ring.

Brush Life: 5,000,000 rotations or more

Exterior: stainless steel.

Operating temperature: -40 to +55° C.

NOTE: These specifications may be exceeded if approved by Focal for specific application.

Terminations:

Standard is 610 mm/2 feet of loose wire pigtails. These pigtails exit the slip ring through 1/2 inch NPT female ports for connection to fittings and conduit.

Insertion Length:

Part No.	Length L1
180-0001-08	134 (5.275)
180-0001-16	185 (7.275)
180-0001-24	236 (9.275)

Standard, sheave with speed/payout sensor and load pin for tension

ORDERING GUIDE

PART NUMBER	5102-35	5102-22
"A" (INCHES)	35	22
"B" (INCHES)	4.0	3-1/8
"C" (INCHES)	30-1/4	18-1/8
"D" (INCHES)	12-3/16	9-3/4
"E" (INCHES)	8-1/32	5-5/8
"F" (INCHES)	4-1/2	3-1/8
"G" (INCHES)	46-7/16	31-9/16
"H" (INCHES)	10-3/8	7-5/8
"I" (INCHES)	1-1/8	13/16
"J" (INCHES)	12	6

- SPEED/PAYOUT SENSOR**
ARROW POINTS IN DIRECTION
OF MAGNET TRAVEL FOR
PAYOUT (COUNT UP)
(OUT-1 PRECEEDS OUT-2)
- LOAD PIN ASSEMBLY J**
- SPECIFICATIONS:**
1. MAXIMUM SPEED: 4200 FT/MIN (SEE ORDERING GUIDE).
 2. MAXIMUM WORKING LOAD: 12,000 LBS.
 3. INTERNAL SENSOR: DUAL HALL EFFECT.
 4. SENSOR HOUSING: STAINLESS STEEL, SEALED FOR OFFSHORE APPLICATIONS.
 5. ELECTRICAL OUTPUT: DUAL QUADRATURE SQUARE WAVE.
 6. POWER: 5-15 VDC AT 30mA.
 7. J-BOX: NEMA-4 RATED, SPLASH PROOF, DUST PROOF PAINTED STEEL WITH NEOPRENE GASKET AND PASSIVATED SCREWS IN COVER. PAINTED GRAY ENAMEL.
 8. ELECTRICAL CONNECTIONS: J-BOX TERMINAL BLOCK.
 - PIN 1 (RED) = +EX (LOAD PIN)
 - PIN 2 (GREEN) = +SIG (LOAD PIN)
 - PIN 3 (WHITE) = -SIG (LOAD PIN)
 - PIN 4 (BLACK) = -EX (LOAD PIN)
 9. LOAD PIN SPECIFICATION:
 - A) CAPACITY: 12,000 LBS.
 - B) OVERLOAD: 150% OF CAPACITY WITHOUT DAMAGE; 300% OF CAPACITY WITHOUT FAILURE.
 - C) SENSING ELEMENT: DUAL BRIDGE 350 OHM STRAIN GAGES.
 - D) OUTPUT: APPROXIMATELY 2mV PER VOLT EXCITATION AT RATED CAPACITY. EXACT OUTPUT PROVIDED WITH CALIBRATION DATA.
 - E) EXCITATION: 10 VOLTS D.C. OR A.C. NOMINAL, 15 VOLTS MAXIMUM.
 - F) CALIBRATION ERROR: LESS THAN ±0.5% OF FULL CAPACITY INCLUDING HYSTERESIS, REPEATABILITY AND NONLINEARITY BASED ON BEST STRAIGHT LINE.
 - G) TEMPERATURE RANGE: 30°F TO 130°F OPERATING; -40°F TO +180°F STORAGE.

UNLESS OTHERWISE SPECIFIED		CONTRACT NO.		METROX INC. SAN DIEGO, CALIFORNIA	
DIMENSIONS ARE IN INCHES FRACTIONS 1/16, 1/8, 1/4, 3/8, 1/2, 5/8, 3/4, 7/8, 1, 1 1/8, 1 1/4, 1 1/2, 1 3/4, 2, 2 1/4, 2 1/2, 2 3/4, 3, 3 1/4, 3 1/2, 3 3/4, 4, 4 1/4, 4 1/2, 4 3/4, 5, 5 1/4, 5 1/2, 5 3/4, 6, 6 1/4, 6 1/2, 6 3/4, 7, 7 1/4, 7 1/2, 7 3/4, 8, 8 1/4, 8 1/2, 8 3/4, 9, 9 1/4, 9 1/2, 9 3/4, 10, 10 1/4, 10 1/2, 10 3/4, 11, 11 1/4, 11 1/2, 11 3/4, 12, 12 1/4, 12 1/2, 12 3/4, 13, 13 1/4, 13 1/2, 13 3/4, 14, 14 1/4, 14 1/2, 14 3/4, 15, 15 1/4, 15 1/2, 15 3/4, 16, 16 1/4, 16 1/2, 16 3/4, 17, 17 1/4, 17 1/2, 17 3/4, 18, 18 1/4, 18 1/2, 18 3/4, 19, 19 1/4, 19 1/2, 19 3/4, 20, 20 1/4, 20 1/2, 20 3/4, 21, 21 1/4, 21 1/2, 21 3/4, 22, 22 1/4, 22 1/2, 22 3/4, 23, 23 1/4, 23 1/2, 23 3/4, 24, 24 1/4, 24 1/2, 24 3/4, 25, 25 1/4, 25 1/2, 25 3/4, 26, 26 1/4, 26 1/2, 26 3/4, 27, 27 1/4, 27 1/2, 27 3/4, 28, 28 1/4, 28 1/2, 28 3/4, 29, 29 1/4, 29 1/2, 29 3/4, 30, 30 1/4, 30 1/2, 30 3/4, 31, 31 1/4, 31 1/2, 31 3/4, 32, 32 1/4, 32 1/2, 32 3/4, 33, 33 1/4, 33 1/2, 33 3/4, 34, 34 1/4, 34 1/2, 34 3/4, 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IMPULSE

SUBCONN UNDERWATER MATEABLES
BULKHEAD AND IN-LINE

IL/BH/DC-4-F/M

Cable length : 24 inches
Pigtail length : 12 inches

InterOcean systems, inc.
 2500 Harbor Court
 San Diego, CA 92111-1999
 (619) 581-1101
 Telex phone 669066X 81001

MODEL MR5000B**MOTOR DRIVEN RELEASE**

The InterOcean Acoustic Release System uses a unique Motor Driven Release, Model MR5000B. It may be repeatedly re-used as the unit need not be disassembled in order to be rearmed. A complete check-out of the unit, just prior to deployment, assures that all aspects of the Release are working properly.

The Motor Driven Release utilizes a DC motor in a pressure compensated, oil-filled chamber. The motor rotates a notched shaft which, when rotated 90°, permits the hook to fall free and release the anchoring mechanism. The unit will release with no load or up to its full rated tensile load of 2,250 kg. Optional versions of the Release are available for 4,500 kg or 11,300 kg tensile loads. For special, heavy construction applications, units rated for 64,000 kg and 450,000 kg are also available.

SPECIFICATIONS

- Power:** +9 VDC Nominal
- Load:** 2268 Kg (5000 lbs.) Maximum
Tensile Load, STD — 4536 Kg
(10,000 lbs.) and 11,300 Kg (25,000
lbs.) available
- Material:** Aluminum, 7075T-6 Alloy Hard
anodized, Epoxy Paint, or Steel
- Weight:** 4.8 Kg (10.5 lbs.) Aluminum;
17 Kg (38.0 lbs.) Steel
- Width:** 15.2 cm (6 inches) overall
- Thickness:** 13.7 cm (5.4 inches) overall
- Length:** 26.7 cm (10.5 inches) overall