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TOOLS AND EQUIPMENT FOR UNDERWATER CONSTRUCTION AND SALVAGE. (U)
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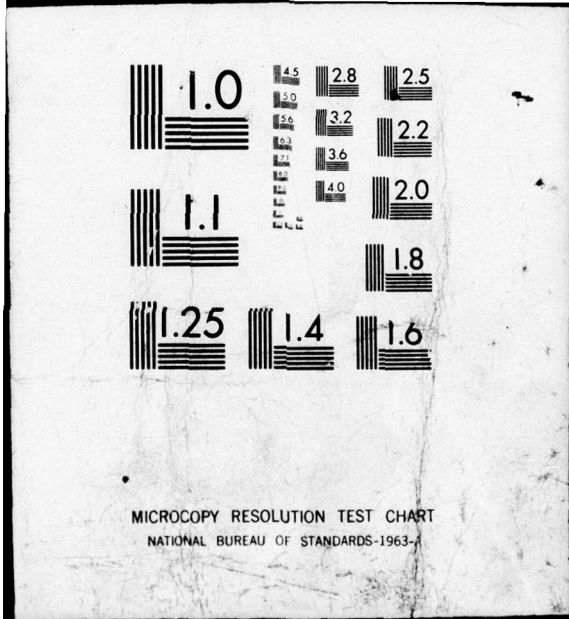
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TOOLS AND EQUIPMENT FOR UNDERWATER CONSTRUCTION AND SALVAGE

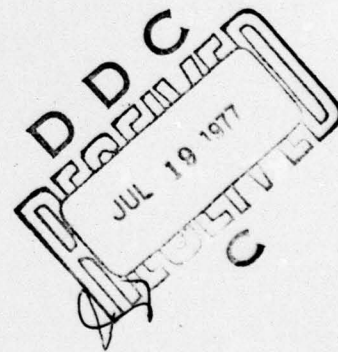
A SUMMARY OF TOOLS AND EQUIPMENT
DEVELOPED AND EVALUATED BY CEL



August 1976

CIVIL ENGINEERING LABORATORY
Naval Construction Battalion Center
Port Hueneme, California 93043

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**Civil Engineering Laboratory
TOOLS AND EQUIPMENT FOR UNDERWATER
CONSTRUCTION AND SALVAGE (Final),**

Presented is a summary of underwater tools and related equipment developed, designed, modified or evaluated by CEL. The descriptions of the tools are intended to acquaint the reader with the existence of each tool and its characteristics, capabilities, and limitations. A bibliography is included. Part of the bibliography consists of non-referenced reports closely related to underwater construction and salvage.

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FOREWORD

Since 1967, the Construction Systems Division of the Civil Engineering Laboratory's Ocean Engineering Department has had a continuing program for developing equipment and techniques to improve the Navy's underwater work capability. As a result, CEL engineers have considerable experience and expertise in developing and adapting tools for underwater use. They place a strong emphasis on ease of maintenance and compatibility with both the seawater environment and with the diver-operator.

Presented here is a summary of underwater tools and related equipment developed, designed, modified, or evaluated by CEL. The descriptions of the tools are intended to acquaint the reader with the existence of each tool and its characteristics, capabilities, and limitations. A bibliography is included. Part of the bibliography consists of reports not referenced in the tool summary but which are closely related to underwater construction and salvage. Further information, including availability of any tools, can be obtained by writing to CEL or calling the Director of the Construction Systems Division at (805) 982-5423 or Autovon 360-5423.

NOTE

1. Where competitive products exist, the tools pictured in this summary are considered to be typical of tools used for similar purposes and which have similar operating principles. Brand names are mentioned for ready recognition by the reader and are not to be construed as a recommendation or an endorsement of any commercial product.

2. General maintenance for all of the tools and equipment described consists of a fresh water rinse after each use in seawater. Some items require additional specific maintenance which is described.

3. Plans are available for CEL designed or specified tools and CEL modifications to commercially available tools.

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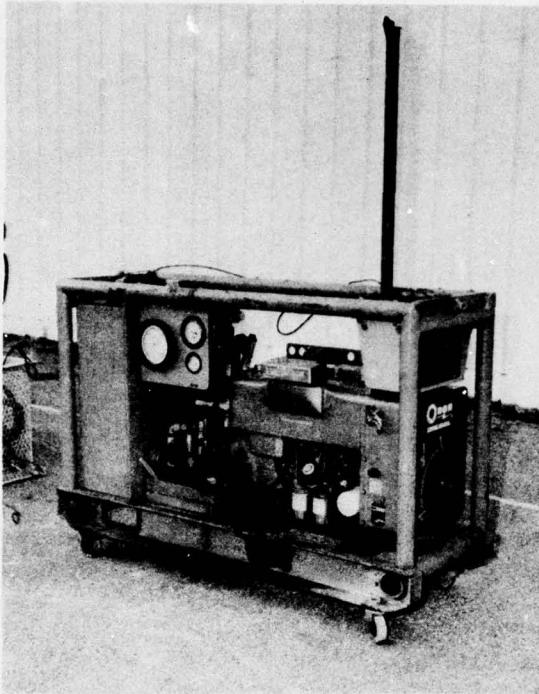
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I
TOOL POWER SOURCES

DIESEL HYDRAULIC POWER SOURCE



Availability: CEL designed

Size: 20 in. x 36 in. x 30 in.

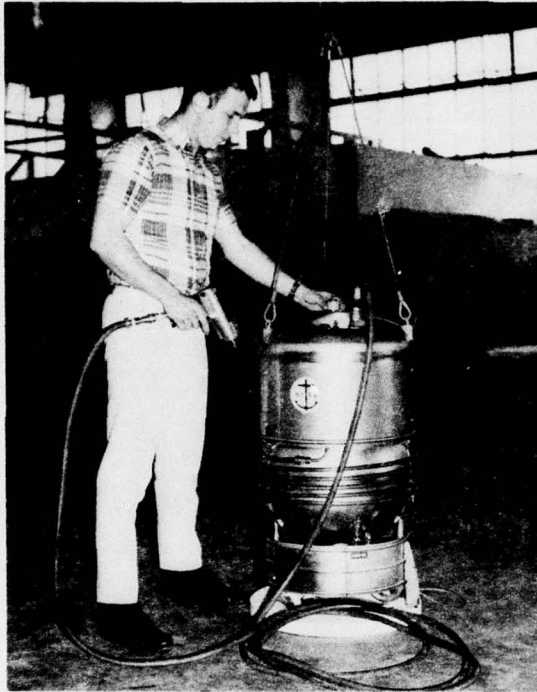
Weight: 1,700 lb

Application: Portable power source for diver-operated hydraulic tools. A 20-hp diesel engine drives a pump which can supply 2-15 gpm at up to 2,000 psi.

Remarks: A manually adjustable valve provides overpressure protection.

Reference: 1, 16.

CRYOGENIC PNEUMATIC POWER SOURCE



Availability: CEL specified

Size: 18 in. diam x 3 ft

Weight: 290 lb in air

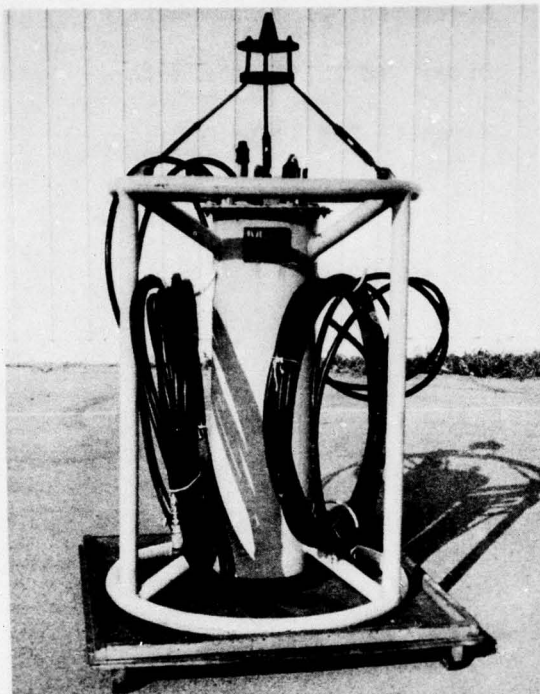
Power Required: None

Application: Uses stored liquid nitrogen to supply gaseous nitrogen for operating pneumatic tools. Tools requiring up to 20 scfm at a depth of 120 ft can be operated continuously for 15 minutes. The rate of gaseous nitrogen production is automatically controlled to meet the tool demand. Buoyancy of the unit is controlled by venting gaseous nitrogen into the buoyancy shroud.

Remarks: A supply of liquid nitrogen is necessary for recharging.

Reference: 2.

ELECTRO-HYDRAULIC CONVERTER



Availability: CEL specified

Weight: 1,000 lb in air;
600 lb in seawater

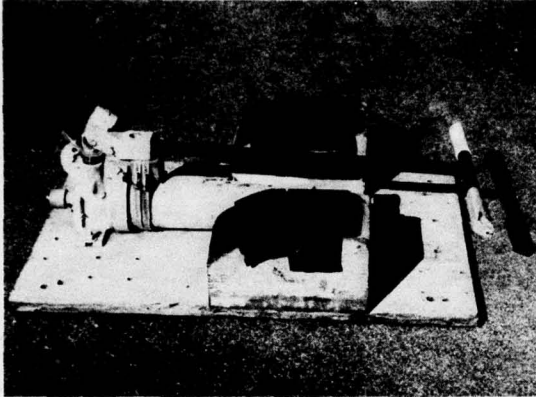
Power Required: 440 V, 3-phase,
60 Hz (12 kw)

Application: Supplies 6 to 8 gpm of hydraulic oil at 1,800 psi for operating hydraulic tools. A special safety circuit protects the diver from electrical shock. The converter has been used by divers at a depth of 200 ft; its design depth is 1,000 ft.

Remarks: Electrical safety devices must be utilized and safety procedures followed to insure diver safety.

Reference: 16.

HYDRAULIC HAND PUMP



Availability: Commercially available
- CEL modified

Size: 20 in. x 30 in.

Weight: 60 lb

Shown: Enerpac
Model: P80

Application: A diver-operated pump that can supply small volumes of hydraulic oil at up to 4,000 psi for operating rams, cable cutters, nut splitters, etc.

Modification: Handle reversed to pump on the up stroke.

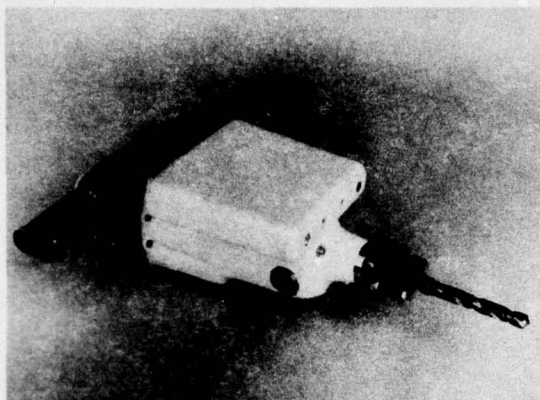
Remarks: Pressure compensation is recommended to prevent seawater leakage into the cylinder.

Reference: 9, 13.

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II
DIVER-OPERATED MOTOR-ACTUATED HYDRAULIC TOOLS

HAND-HELD HYDRAULIC ROCK DRILL



Availability: CEL designed

Size: 9 in. x 9 in. x 19 in.

Weight: 19 lb in water without ballast

Power Required: 8 gpm hydraulic
oil @ 1,000 psi

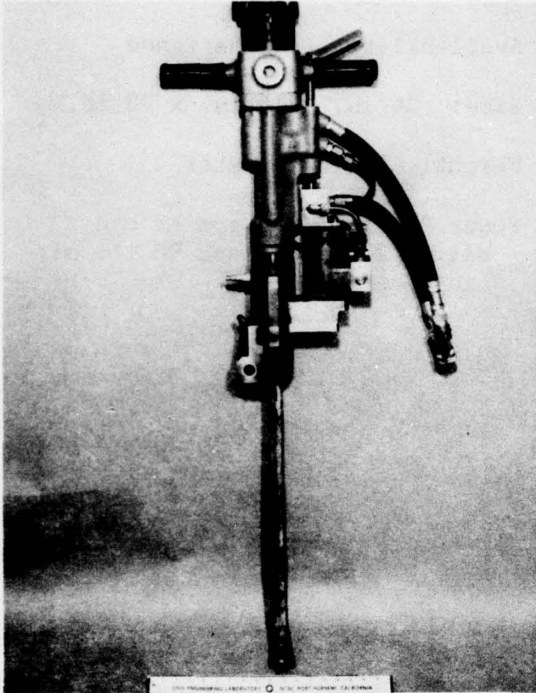
Application: Drills holes up to 18 in. deep in rock using carbide tipped percussion bits 1/4 in. to 1-1/2 in. in diameter. The tool can be used to take core samples using 2 ft long, 1/2 in. to 2-1/2 in. diameter core barrels. One diver can operate the drill; drilling force is provided by 30 lb of removable lead ballast. The drill is designed for use to depths of 120 ft. Typical underwater drilling rate using a 3/4 in. diameter bit is: Granite 3-3/4 in./min; Coral. 5-1/2 in./min.

Maintenance: The shaft seals must be replaced after 5 hr of operation.

Remarks: By pressure-compensating the drill housing, the depth capability can be extended.

Reference: 3, 4.

LARGE HOLE ROCK DRILL



Availability: CEL designed

Size: 30 in. x 5 in. x 16 in.

Weight: 102 lb in air;
84 lb in seawater

Power Required: 10 gpm hydraulic
oil at 1,500 psi

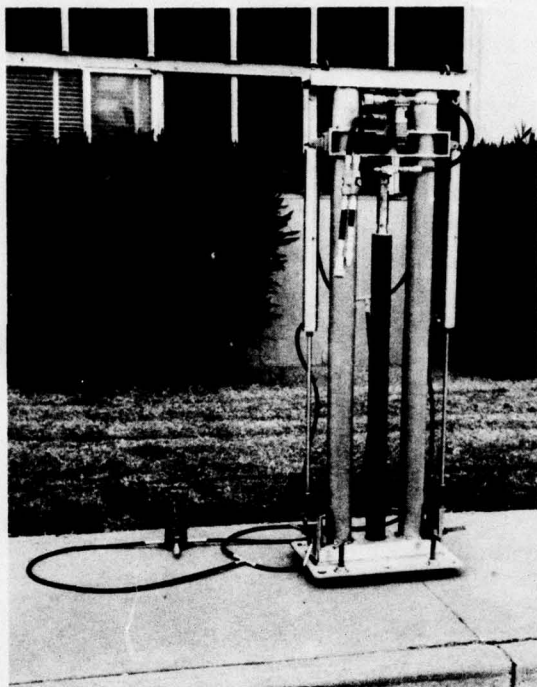
Application: Drills holes from 1-1/4 in. to 4 in. in diameter in rock and coral. A standard 1-in. hex drill steel is used. Either air or water can be continuously pumped down the drill steel to clear chips from the hole being drilled. Typical drilling rate in granite using a 2-in. bit is: on land, 5 in./min; in water, 3 in./min.

Maintenance: The rotational mechanism must be disassembled and lubricated after each underwater use.

Remarks: This is an experimental tool, and further development is required. The drill has been successfully used in an underwater construction job.

Reference: 4.

DIVER-OPERATED CORE DRILL



Availability: CEL designed

Size: 24 in. x 16 in. x 73 in.

Weight: 70 lb in water

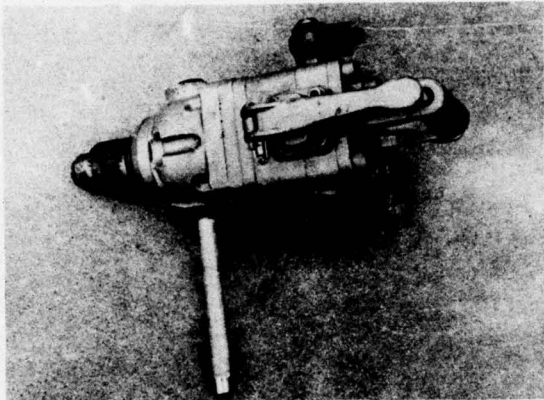
Power Required: 8 gpm of hydraulic
oil at 2,000 psi and 90 cfm air
at 100 psi maximum

Application: The tool is used to obtain rock core samples 3 in. in diameter. The pneumatic cylinders develop a thrust of up to 600 lb when the base is anchored to the seafloor. Cores up to 12 ft long can be obtained using three 4-ft-long core barrel segments. Typical coring rate in concrete is 0.4 ft/min. The core drill is not suitable for retrieving soft sediment core samples.

Remarks: The Hand-Held Hydraulic Rock Drill can be used to drill holes for the anchoring bolts.

Reference: 4.

HYDRAULIC DRILL



Availability: Commercially available

Weight: 21 lb

Power Required: 5 to 8 gpm
hydraulic oil at 800 to 2,000 psi

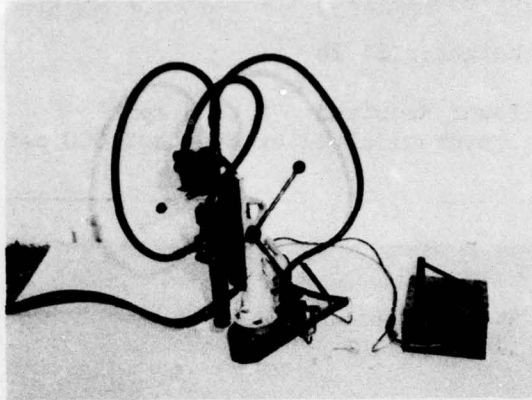
Shown: Fairmont
Model: #H5410

Application: Underwater drilling of metal or wood. Rotary motion only.

Remarks: A rotary motion drill is not suitable for use by divers since they cannot supply adequate reaction forces.

Reference: 6.

HYDRAULIC DRILL PRESS



Availability: CEL designed

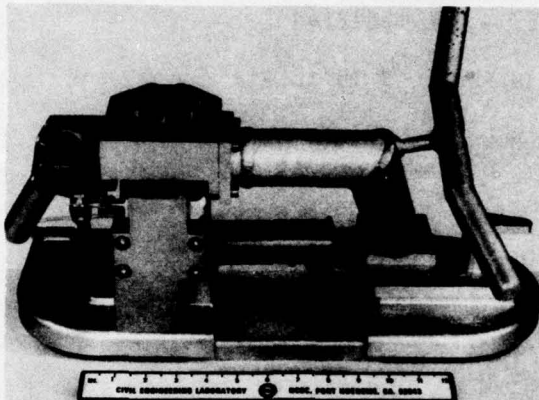
Size: 16 in. x 6 in. x 24 in.

Weight: 100 lb

Power Required: 5-7 gpm hydraulic
oil at 1,500 psi

Application: Used for drilling holes in magnetic materials. An electromagnetic base clamps the tool to the workpiece. Drill speed is variable between 160 and 740 rpm. A pressure-compensated battery is a part of the tool.

HAND-HELD HYDRAULIC BANDSAW



Availability: CEL designed

Size: 12 in. x 18 in. x 8 in.

Weight: 21 lb in seawater

Power Required: 8 gpm hydraulic
oil at 500 psi

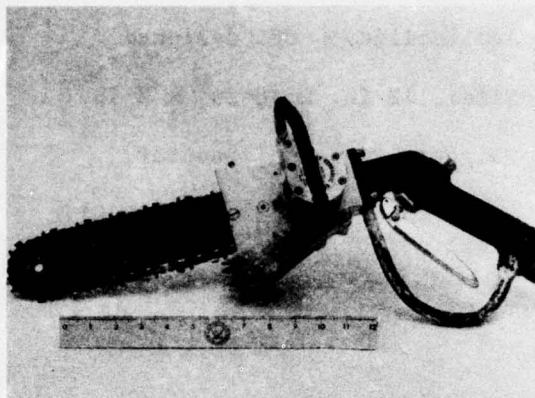
Application: Underwater cutting of metals, cables, and other materials. The saw is easily handled by a diver; the tool weight forces the blade through the work. The saw geometry limits cuts to workpieces 4-1/8 in. x 3-1/2 in. in cross section. The saw cuts double-armored coaxial cable, 3-1/2 in. in diameter, in one minute.

Maintenance: Periodic greasing of the chain drive.

Remarks: Saw blades can be changed underwater.

Reference: 4.

HYDRAULIC CHAIN SAW



Availability: Commercially available
- CEL modified

Weight: 7 lb in air

Power Required: 8 gpm hydraulic
oil at 1,000 to 2,000 psi

Shown: Ackley
Model: 7H

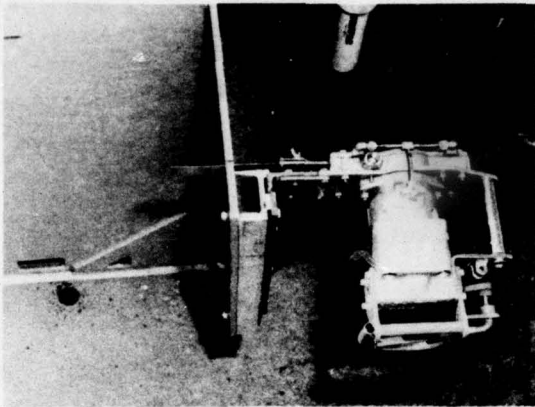
Application: Used for cutting wood underwater. The saw can be operated by one diver. Chain speed: 3,000 to 3,500 fpm.

Modification: Changed trigger to full-hand type; added dogs for gripping the work.

Maintenance: Removal, cleaning, and lubrication of the chain after each use.

Remarks: The tool is potentially dangerous and must be operated with caution.

HYDRAULIC HACKSAW



Availability: Commercially available
- CEL modified

Weight: 25 lb

Power Required: 3 to 4 gpm hydraulic
oil at 1,400 psi

Shown: Fairmont Tool and
Forging Division
Model: H5100

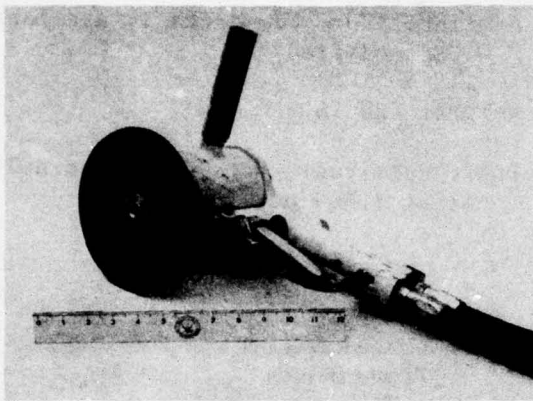
Application: Used for underwater metal cutting. The saw may be either hand held or attached to the workpiece.

Modification: Trigger mechanism changed.

Remarks: Performance is marginal. The tool must be clamped to the work because of high reaction forces. The blade changing method should be improved.

Reference: 13.

HYDRAULIC GRINDER



Availability: Commercially available
- CEL modified

Size: 12 in. x 11 in. x 4 in.

Weight: 14 lb

Power Required: 4 to 6 hp;
hydraulic oil at 4 gpm

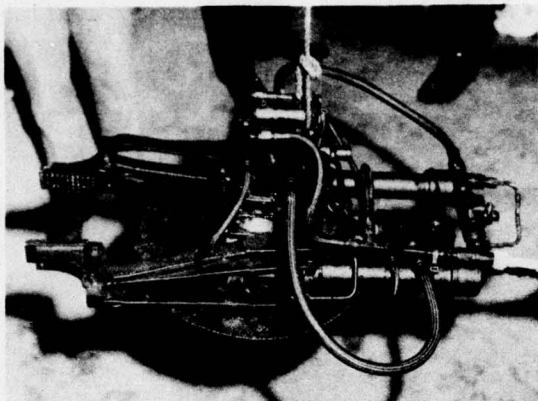
Shown: Ackley
Model: 24HS

Application: Used for general underwater grinding; preparing weld bevels; removing jammed nuts or bolt heads.

Modification: Trigger changed to full-hand type; wheel guard removed.

Reference: 7.

ROTARY ABRASIVE CUTTER



Availability: CEL specified

Weight: 50 lb in water

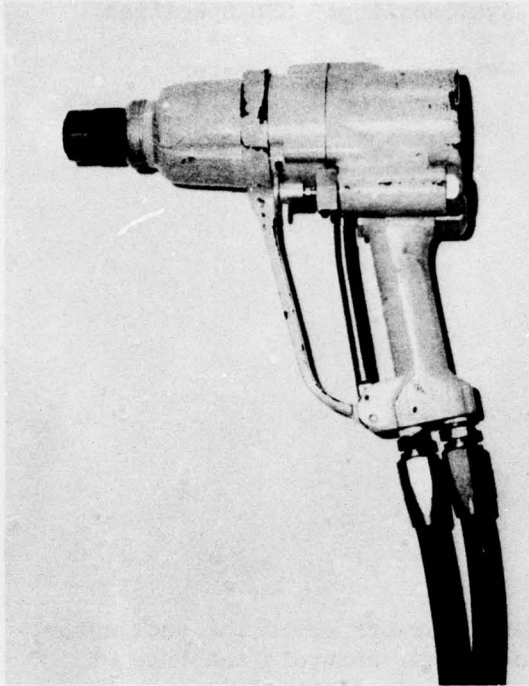
Power Required: Up to 10 gpm
hydraulic oil at 2,000 psi

Application: Used as an underwater metal cut-off saw. The tool automatically clamps to the workpiece, and a diver controls the rate of automatic feed. The abrasive disc is 18 in. in diameter.

Remarks: Hydrodynamic drag on disc limits performance at high rpm.

Reference: 9.

HYDRAULIC IMPACT WRENCH



Availability: Commercially available

Size: 6 in. diam x 17 in.

Weight: 10.5 lb in air

Power Required: 6 gpm hydraulic
oil at 1,000 to 1,500 psi

Shown: Ackley
Model: 6HS

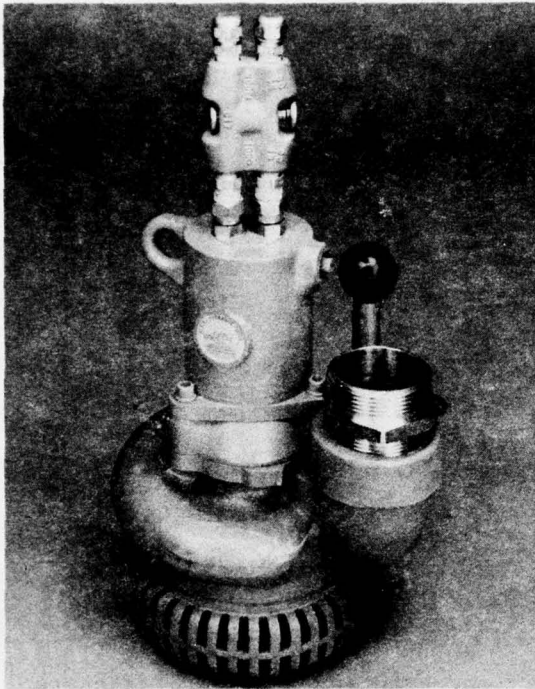
Application: Used for drilling, threading, and nut and bolt tightening. Delivers 1,700 blows/min and up to 250 ft-lb of torque. Either hex socket or square drives are available.

Maintenance: The wrench must be field stripped and re-greased after each use.

Remarks: Larger capacity units are available.

Reference: 7.

HYDRAULIC SUMP PUMP



Availability: Commercially available

Size: 10 in. x 12 in. x 20 in.

Weight: 57 lb

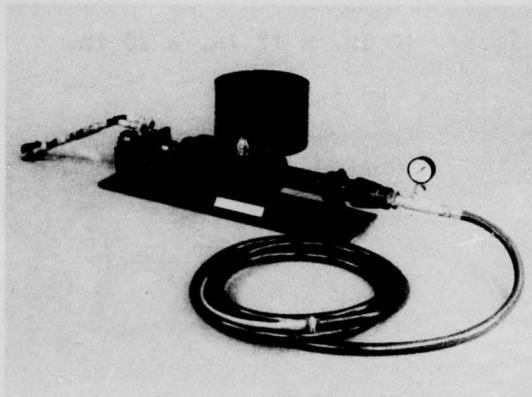
Power Required: 4 to 12 gpm
hydraulic oil at 2,000 psi

Shown: Ackley
Model: 2250H

Application: Used for pumping or jetting. Output flow can be adjusted from 40 to 360 gpm.

Remarks: Above 5 gpm hydraulic input, the pump must be restrained to prevent case rotation.

DIVER-OPERATED GROUT DISPENSER



Availability: CEL designed

Size: 6 in. x 42 in. x 18 in.

Weight: 50 lb in air

Power Required: 6 gpm hydraulic
oil at 500 psi

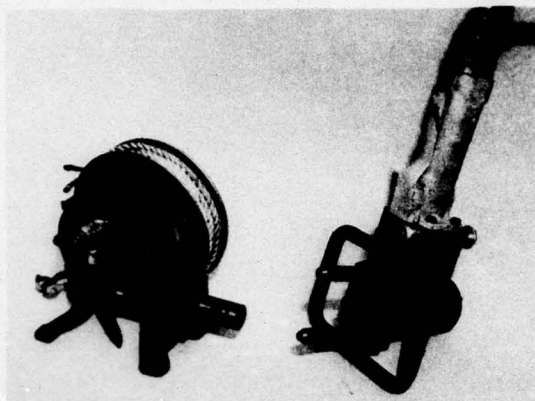
Application: The tool dispenses slurry for grouting seafloor fasteners and for patching or repairing submerged concrete structures. The hopper holds 2 gallons of grout which can be dispensed at a rate of 3 gpm at 80 psi above ambient. The hopper can be re-filled underwater.

Maintenance: All bearings must be cleaned after each use.

Remarks: The tool is an experimental model not suitable for extended use. A lower maintenance model can be designed.

Reference: 4, 8.

HYDRAULIC WINCH



Availability: CEL designed

Weight: (Winch) 13 lb in water;
(Handle) 17 lb in water

Power Required: 6.5 gpm hydraulic
oil at 1,000 to 2,000 psi

Application: Used by construction divers for moving or positioning heavy equipment. Line speed is 20 fpm at 500 lb line pull; the reel has a capacity of 50 feet of 3/8 in. nylon line. The power handle develops 460 in-lb of torque at 6.5 gpm and 1,500 psi.

Remarks: The power handle is removable for use with several winch heads.

Reference: 13.

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III
DIVER-OPERATED PISTON-ACTUATED HYDRAULIC TOOLS

HYDRAULIC CONCRETE BREAKER



Availability: Commercially available
- CEL modified

Size: 6 in. x 12 in. x 24 in.

Weight: 65 lb

Power Required: 8 gpm hydraulic
oil at 1,500 psi

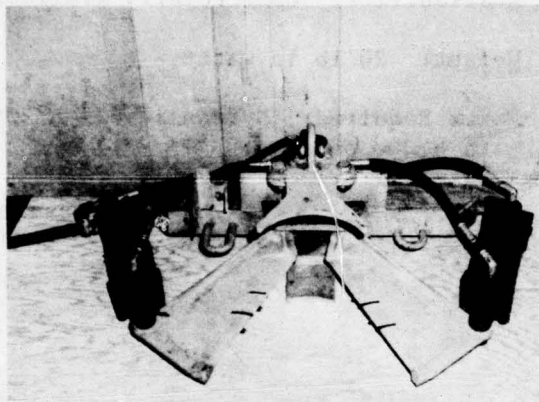
Shown: Racine Construction Tool Co.
Model: Concrete Breaker

Application: Chipping or breaking rock or concrete. Any 1-1/8-in. hex breaker tools, such as chisels, clay spades, wedges, asphalt cutters, tampers, etc., can be used with the tool. The impact force of 4,500 lb per blow also can be used to drive small piles into soft sediments.

Modification: Added pneumatic pressure compensation to the impact chamber to keep the chamber dry, thus increasing performance underwater.

Remarks: Back pressures above 200 psi cause the tool to stall so the return line hose must be kept short or larger diameter return hoses must be used.

PILE CUTTER



Availability: Commercially available
- CEL modified

Size: 30 in. x 55 in. x 40 in.

Weight: 600 lb in air; 460 lb
in seawater

Power Required: 5 gpm hydraulic
oil at 2,000 psi

Shown: Allen Hydraulics
Model: TS-12

Application: Used for removing wooden piles by cutting them at the mudline. Two divers position the cutter using a lift bag for buoyancy. Piles up to 13 in. in diameter can be cut in less than 10 seconds.

Modifications: Replaced standard blades and hydraulic cylinders with larger ones; added positioning yokes, lift bag hook, and a diver-operated hydraulic control valve. Serrated teeth hold the cutter against the pile.

Remarks: The shearing action of the blades makes a clean cut and leaves the pile relatively unsplintered for easy capping. Piles can be cut at any height by positioning the cutter using a lift bag.

WIRE ROPE CUTTER



Availability: Commercially available

Weight: 20 lb in water

Power Required: hydraulic oil at up
to 6,000 psi

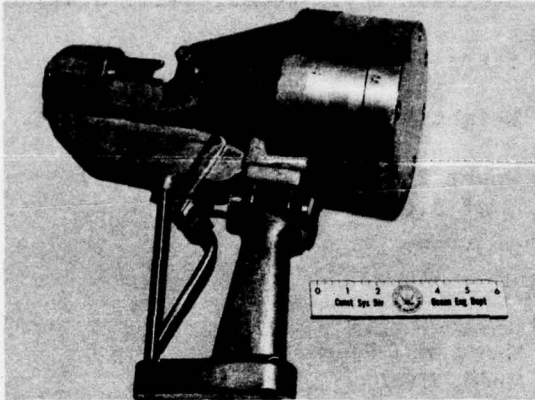
Shown: H. K. Porter
Model: HRC-118

Application: Used for cutting wire rope up to 1-1/8 in. in diameter. Will cut 1 in. steel wire rope 6 x 19 IWRC with 3,000 psi and 5/8-in. reinforcing bar with 6,200 psi.

Remarks: The tool works well even with a dull cutter, and there is no chip accumulation on the cutters.

Reference: 13.

OPEN-CENTERED HYDRAULIC CABLE CUTTER



Availability: CEL specified

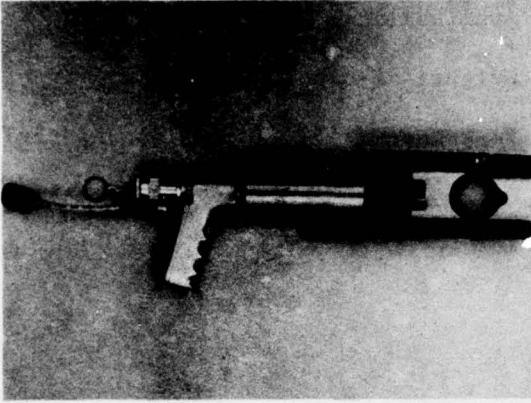
Weight: 27 lb in water

Power Required: 1 to 5 gpm hydraulic
oil at 2,000 psi

Application: Cuts wire rope up to 1 in. in diameter and mild steel
barstock to 5/8 in. in diameter.

Reference: 13.

HYDRAULIC ACSR CABLE CUTTER



Availability: Commercially available

Size: 20 in. x 4 in.

Weight: 28 lb

Power Required: hydraulic oil
at 5,000 psi

Shown: H. K. Porter
Model: 25662

Application: Cuts ACSR cable up to 2-1/2 in. in diameter. The tool can be adjusted to leave a cable's steel center core uncut. The cutter will not cut wire rope.

HYDRAULIC SOFT CABLE CUTTER



Availability: Commercially available

Size: 12 in. x 12 in.

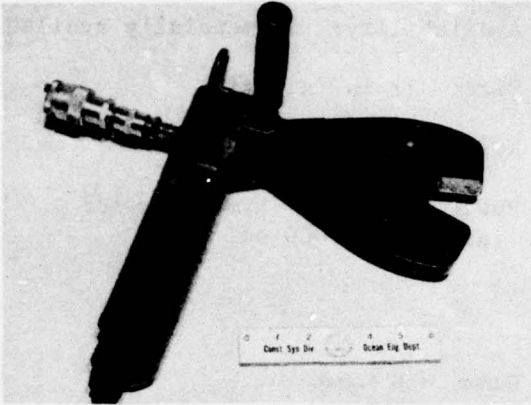
Weight: 15 lb

Power Required: hydraulic oil
at up to 4,000 psi

Shown: H. K. Porter
Model: 177089

Application: Cuts 3-in.-diam copper and aluminum power and communications cables. Will not cut ACSR cable.

HYDRAULIC BARSTOCK CUTTER



Availability: Commercially available

Weight: 19 lb

Power Required: hydraulic oil at up
to 10,000 psi

Shown: H. K. Porter

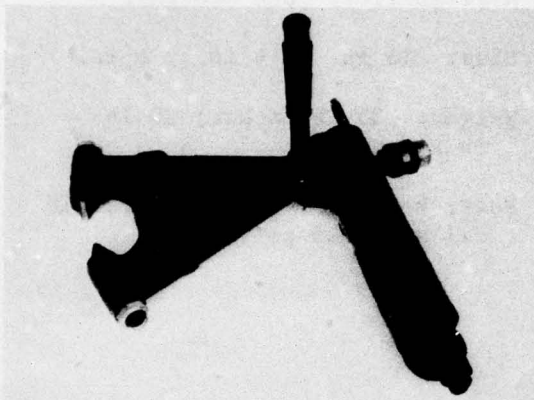
Model: 1770 CDX

Application: Cuts mild steel, hard steel, stainless steel, tempered spring wire and hard chain. Capacities are 5/8-in. diameter for mild and stainless steels and 1/2-in. diameter for the other materials.

Remarks: Other cutter heads are available to be attached to the cylinder.

Reference: 13.

HYDRAULIC NUT SPLITTER



Availability: Commercially available

Size: 3 in. x 12 in. x 15 in.

Weight: 29 lb without
hydraulic pump

Power Required: hydraulic oil at
up to 6,000 psi

Shown: H. K. Porter
Model: 1790 PQ

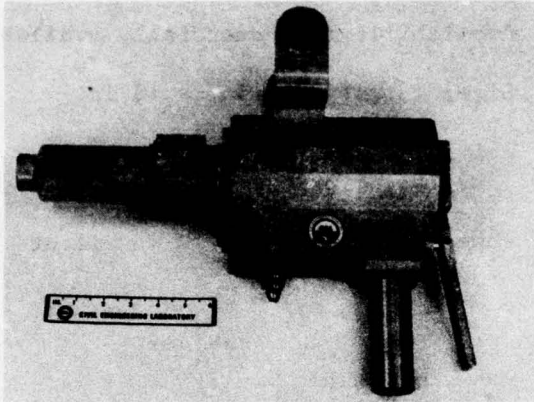
Application: The tool destructively removes galled or deformed nuts. Nuts up to 1-7/8 in. across the flats and up to Rockwell C15 hardness can be split. Bolt threads may be damaged by the cutters. The cutters are replaceable. Tool requires 4 in. clearance beyond opposite flats on the nut.

Maintenance: The hydraulic cylinder pressure and dust seals must be periodically replaced.

Remarks: In air, the split nut halves fly off with considerable speed, and they should be contained for safety; underwater, their energy is quickly spent, and they travel only a few inches.

Reference: 4.

BLIND BOLT FASTENING TOOL



Availability: CEL designed

Size: 16 in. x 14 in. x 6 in.

Weight: 35 lb in air; 30 lb
in seawater

Power Required: 2 gpm hydraulic
oil at 8,000 psi

Application: Installs one-piece fasteners that require access to only one side of the workpiece (blind bolts). Using the tool a diver can install a blind bolt which securely fastens two workpieces together in five seconds. Blind bolts range in size up to 5/8-in. in diameter.

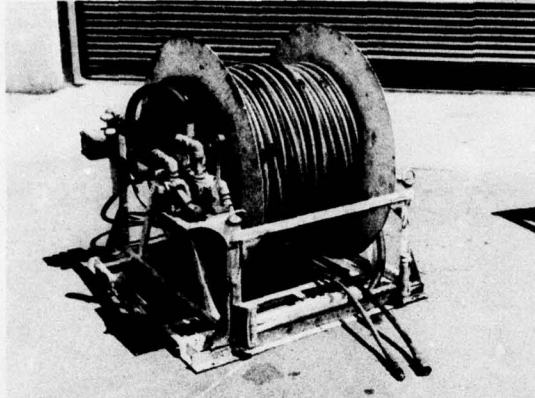
Remarks: By interchanging nose pieces on the tool, the various sized fasteners can be installed.

Reference: 4.

1957 TECHNICAL BULLETIN

IV
HYDRAULIC TOOL ACCESSORIES

HYDRAULIC HOSE REEL



Availability: CEL designed

Size: 3-1/2 ft x 3-1/2 ft x 4 ft

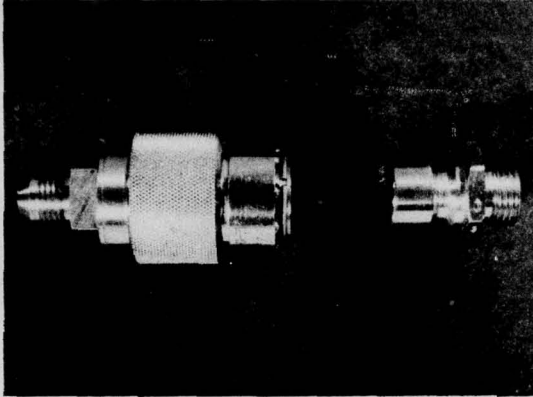
Weight: 460 lb without hose

Power Required: 5 to 8 gpm hydraulic
oil at 2,000 psi

Application: The hydraulically powered hose reel deploys and retrieves hydraulic hose lines and supplies oil flow to a tool. Hydraulic hoses are permanently connected to the hose reel which is in turn connected to a hydraulic power source. A valve on the reel selects either reel power or tool power. The reel is designed to hold 300 ft of dual -12 double wire braid hydraulic hose.

Remarks: This reel greatly reduces the amount of deck space and manpower necessary to handle hydraulic lines.

UNDERWATER MATEABLE HYDRAULIC QUICK DISCONNECTS



Availability: Commercially available

Weight: 1 lb

Shown: Seaton-Wilson

Model: Z552-M8K(S/N 23) Male

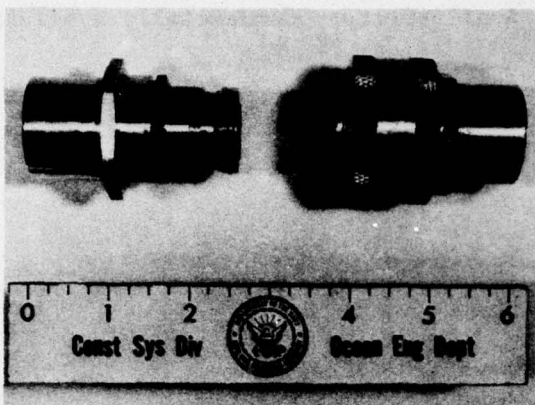
Z553-M8G (S/N 22) Female

Application: Used for making hydraulic connections underwater with minimal inclusion of seawater. Using these connectors, a diver can use one pair of hydraulic hoses and interchange tools as needed without surfacing. The connectors are limited to 300-ft depths when supplied from a surface power source; the depth capability can be extended to 20,000 ft by using a pressure-compensated power source.

Remarks: Water inclusion rate: 0.01 ml/connection at a depth of 70 ft.

Reference: 5, 10.

UNDERWATER MATEABLE HYDRAULIC QUICK DISCONNECTS



Availability: Commercially available

Weight: 1.5 lb

Shown: Snap-Tite

Model: S29N8-8-F(Y) Male

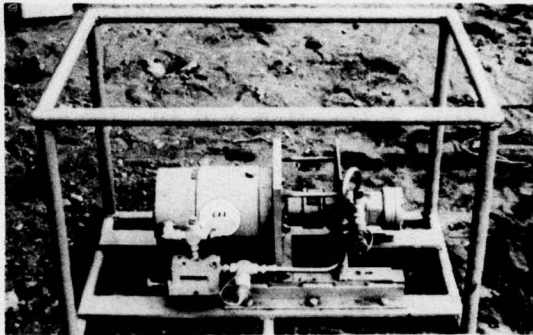
S29C8-8-F(Y) Female

Application: Used for making hydraulic connections underwater with minimal inclusion of seawater. Using these connectors, a diver can use one pair of hydraulic hoses and interchange tools as needed without surfacing. The connectors are limited to 300-ft depths when supplied from a surface power source; the depth capability can be extended to 20,000 ft by using a pressure-compensated power source.

Remarks: Water inclusion rate: 0.17 ml/connection at a depth of 70 ft.

Reference: 5, 10.

HYDRAULIC PRESSURE INTENSIFIER



Availability: CEL designed

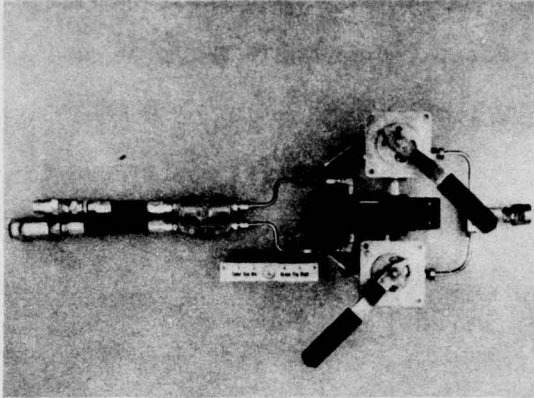
Size: 18 in. x 15 in. x 36 in.

Weight: 200 lb

Power Required: 13 gpm hydraulic
oil at 1,500 psi

Application: Used to power tools with high pressure, low flow requirements. A hydraulic motor, which runs from a primary hydraulic power source, drives a high pressure piston pump. Input flow to the motor controls output flow; a relief valve controls output pressure. The intensifier uses the oil reservoir of the primary hydraulic source. Maximum output is 2 gpm at 10,000 psi.

HYDRAULIC PRESSURE INTENSIFIER



Availability: Commercially available
- CEL modified

Size: 2 in. diam x 8 in. long

Weight: 5.2 lb

Power Required: 0.4 to 2 gpm
hydraulic oil at up to
1,600 psi

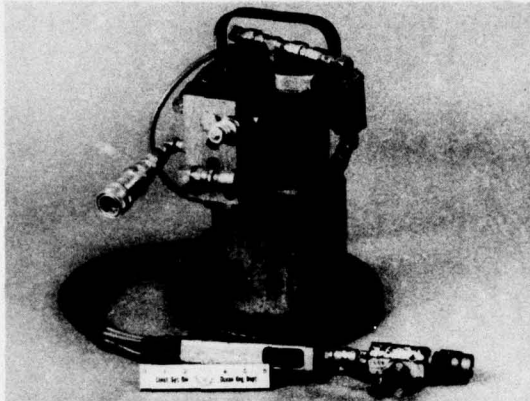
Shown: Fluid Controls, Inc.
Model: 1T11-4T-S

Application: Boosts hydraulic pressure available from a power source. The intensifier can produce up to 0.3 gpm of hydraulic oil flow continuously at 10,000 psi. Fixed intensification ratio 6.5:1.

Modification: Added external plumbing to accommodate both single- and double-acting cylinders.

Reference: 11.

HYDRAULIC PRESSURE INTENSIFIER



Availability: Commercially available
- CEL modified

Size: 10 in. diam x 18 in. high

Weight: 55 lb in seawater

Power Required: 0.5 to 4 gpm
hydraulic oil at up to 1,000 psi

Shown: Stanley Hydraulics
Model: Intensa-Press

Application: Boosts hydraulic pressure available from a power source. The intensifier supplies 11 cu in. of oil per cycle at up to 10,000 psi. It will not supply continuous high pressure flow. Several minutes are required between each cycle to recharge the unit. Fixed intensification ratio 10:1.

Modification: Added check valves and plumbing so that the unit could be recycled while maintaining pressure in a tool.

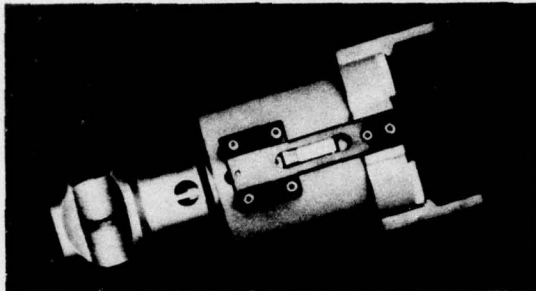
Remarks: The unit is best suited to tools that require less than 11 cu in. to operate. The weight of the intensifier and the complex plumbing make it difficult to deploy.

Reference: 11

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V
MANIPULATOR TOOLS

WORK SYSTEMS PACKAGE HYDRAULIC CABLE CUTTER



Availability: CEL designed

Size: 14 in. x 7 in. x 6 in.

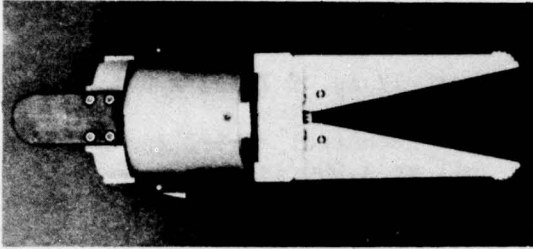
Power Required: 2-1/2 gpm hydraulic
oil at 3,000 psi

Application: This tool is designed for deep ocean cable cutting while being handled by a manipulator. Hydraulic connections are automatically made when a suitable manipulator grasps the tool. Cables and wire rope up to 1-1/8 in. in diameter can be cut.

Remarks: Usable to depths of 20,000 ft.

Reference: 5.

WORK SYSTEMS PACKAGE HYDRAULIC SPREADER



Availability: CEL designed

Size: 19 in. x 7 in. x 6 in.

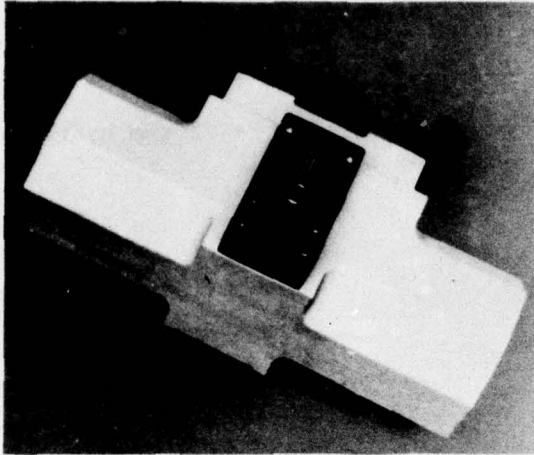
Power Required: 2-1/2 gpm hydraulic
oil at 3,000 psi

Application: The tool is designed for use by a manipulator and produces a force of 5,000 lb. Hydraulic connections are automatically made when a suitable manipulator grasps the tool.

Remarks: Usable to depths of 20,000 ft.

Reference: 5.

WORK SYSTEMS PACKAGE HYDRAULIC JACK



Availability: CEL designed

Size: 12 in. x 7 in. x 7 in.

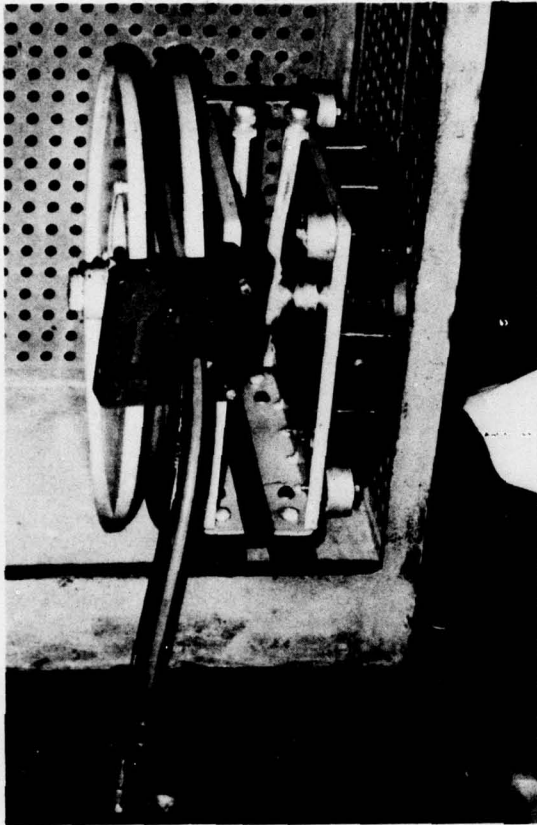
Power Required: 2-1/2 gpm hydraulic
oil at 3,000 psi

Application: The jack is designed for use with a manipulator. Hydraulic connections are automatically made when a suitable manipulator grasps the tool. The jack exerts a force of 20,000 lb and has a stroke of 8 in.

Remarks: Usable to depths of 20,000 ft.

Reference: 5.

HOSE REEL



Availability: CEL designed

Size: 18 in. OD x 12 in.

Power Required: None

Application: The reel holds hose for a manipulator-held tool. It can accommodate two 15-ft-long, 1/4-in.-ID hoses. A pressure-compensated, oil-immersed spring motor powers the reel return mechanism. Depth capability is 4,000 ft.

Maintenance: The reel is designed for 6 months maintenance free immersed duty, at which time it must be disassembled and cleaned.

Remarks: The reel motor does not have sufficient torque to retract the hose with a tool attached. The depth capability can be extended by enlarging the pressure-compensation system.

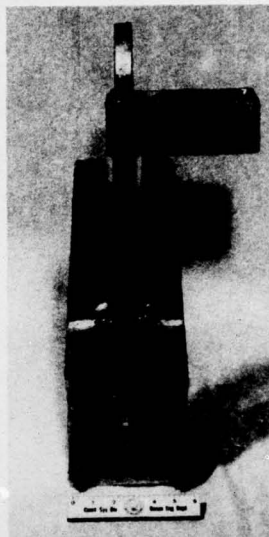
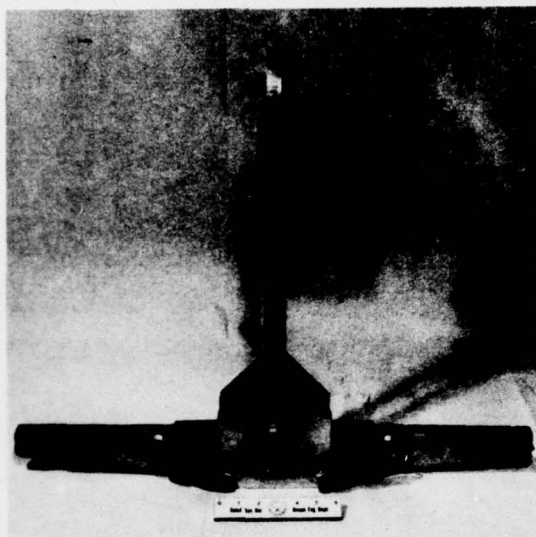
Reference: 5.

TOGGLE LIFT DEVICE

Availability: CEL designed

Size: 23 in. tall by 27 in. wingspan

Weight: 45 lb in seawater



Application: Manipulator can insert the toggle into holes ranging in size from 8 in. to 17 in. wide to lift objects weighing up to 10,000 lb. The toggle wings are normally extended; as the toggle is pushed through a hole, the wings fold and are re-extended by gravity.

Limitations: The toggle may slip out of holes larger than 17 in. wide.

Reference: 5.

EXPLOSIVE CABLE CUTTER

Availability: CEL specified

Size: 16 in. x 4 in. x 3 in.

Weight: 24 lb

Power Required: Electrical; 24 volts,
24 amps

Application: A manipulator-held tool for deep ocean use in cutting wire rope from $\frac{3}{4}$ in. to 1- $\frac{1}{2}$ in. in diameter. The device is designed for use to 20,000 ft. It cannot be reloaded underwater.

EXPLOSIVE PADEYE UNIT

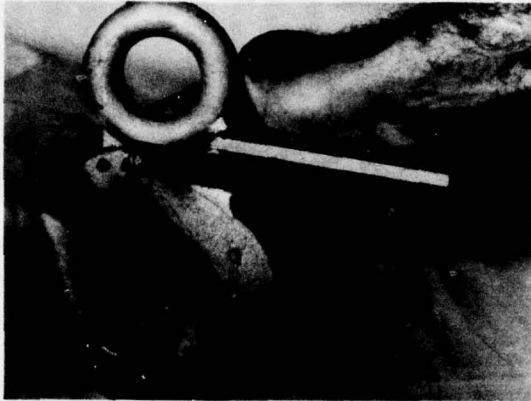
Availability: CEL specified

Size: 11 in. long by 3 in. diam

Weight: 7 lb

Application: This manipulator-held device explosively drives a stud-padeye unit into steel plate. Padeyes can be attached to steel plate from 1/4 in. to 5/8 in. in thickness and will support 500 to 2,000 lb of lift depending upon the lifting angle. The unit cannot be reloaded underwater. Since plate penetration depends on the size of the charge, the thickness of the plate must be estimated, and the appropriate charge selected in advance.

SAFETY SNAP HOOK



Availability: CEL designed

Size: 8 in. x 8 in. x 1-1/2 in.
throat opening

Weight: 5 lb

Application: Used by diver or a manipulator for attaching to padeyes, lines, etc. The nominal lifting capacity is 10,000 lb. The hook is designed for up to 6 months continuous immersion without maintenance.

Reference: 5.

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VI
MISCELLANEOUS DEVICES

HYDRAULIC TRENCHER



Availability: Commercially available
- CEL modified

Size: 24 ft x 8 ft x 9 ft

Weight: 25,000 lb

Power Required: up to 105 gpm
hydraulic oil at 5,000 psi

Shown: Vermeer
Model: T600C

Application: Trenching/cable laying in sand, coral, and rock. A trench 6 in. wide and 30 in. deep can be cut in soft coral at a rate of 5 ft/min. Hard rock can be cut at reduced rates. A diver-operator controls the trencher directly so trenching is limited to diver depths. Mobility is limited by seafloor topography. The disc cutter can be replaced by a chain bar cutter that can cut a trench 18 in. wide by 8 ft deep.

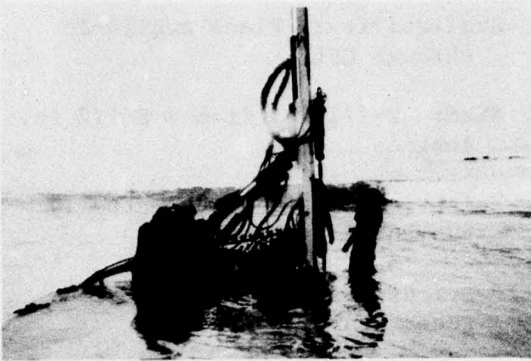
Modifications: Converted from self-contained diesel to all hydraulic power with a remote power source. A backhoe/dozer blade assembly was added.

Maintenance: Requires complete lubrication after each underwater use.

Remarks: This is a developmental model and is being modified to operate reliably.

Reference: 4.

PNEUMATIC TRACK DRILL



Availability: Commercially available
- CEL modified

Size: 20 ft x 7 ft x 7 ft

Weight: 22,000 lb

Power Required: 600 scfm air
at 125 psi

Shown: Worthington
Model: 1290 D

Application: Drills holes from 1-1/4 in. to 4 in. in diameter as much as 20 ft deep in all types of rock. The drill is designed for use to a depth of 120 ft and is operated by one diver. Mobility is limited by the seafloor topography.

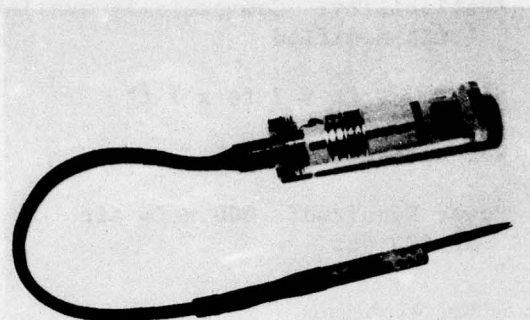
Modifications: Sealed and pressure-compensated the hydraulic system; partially sealed the pneumatic systems.

Maintenance: General lubrication, flushing, and draining of tramming motors and partial disassembly of the drill mechanism (drifter) after each use.

Remarks: The large volume of exhausting air bubbles from the drifter can cause nausea and vertigo in the diver-operator.

Reference: 4, 14.

UNDERWATER VOLTMETER



Availability: Plans available
through CEL

Size: 2-1/2 in. diam x 8-1/2 in.
long

Weight: 2 lb in air; neutrally
buoyant in seawater

Power Required: self-contained,
rechargeable batteries

Shown: Pacific Missile Test Center
Model: PMR/ME - 4/U

Application: The digital voltage read out aids in determining the galvanic corrosion potential of metal structures in seawater. This information is used to assess the performance of corrosion protection systems. A titanium probe and an Ag-Ag Cl reference cell are used. The instrument is designed for use to 120-ft depths. Voltage range is 10^{-4} volts to 9999 volts.

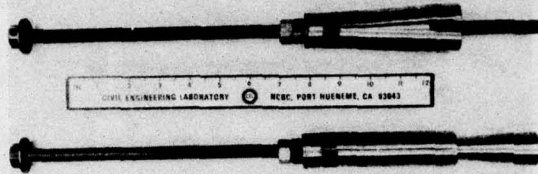
Maintenance: Recharge batteries as required.

TITANIUM ROCK BOLT

Availability: CEL designed

Size: 1-1/4 in. diam x
18 in. long

Weight: 2 lb



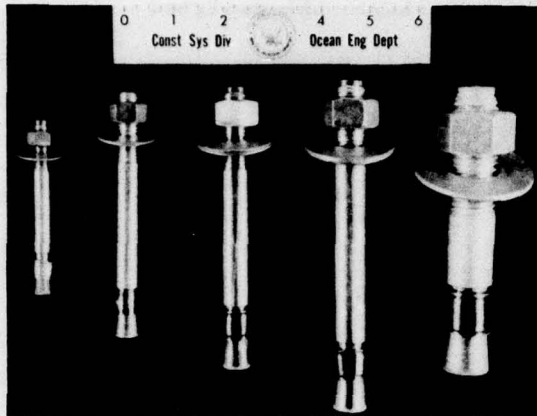
Application: Used for attaching or anchoring to rock or coral. The bolt is a high expansion, reusable type suitable for use in coral formations. Pull out strength in coral is 6,000 to 12,000 lb. A larger version of this design has been used to anchor a barge.

Remarks: Titanium has virtually an infinite life in seawater. The CEL hand-held hydraulic rock drill can be used to prepare holes for the bolts.

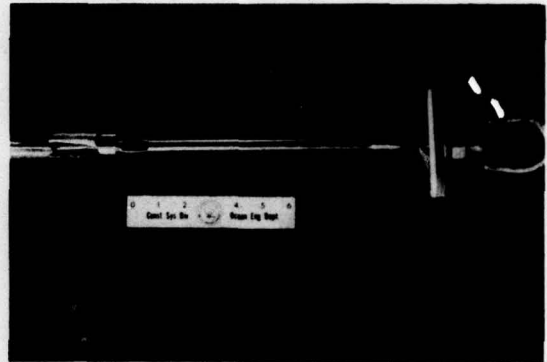
Reference: 3, 4.

SEAFLOOR FASTENERS (rock bolts)

Availability: Both commercially available



Shown: Phillips Masonry
Model: Wedge Anchor



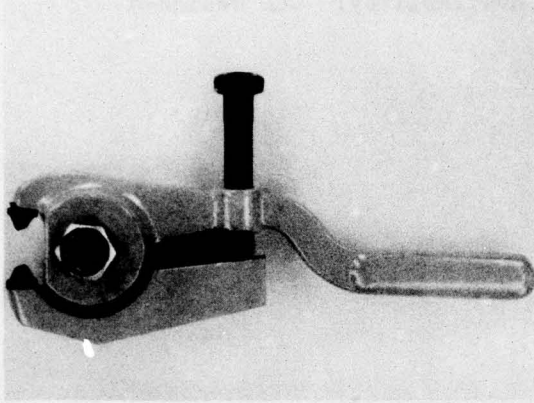
Shown: Williams
Model: Spin Lock Rock Bolt

Application: Used as attachment points on rocks. Can be used to immobilize cables and pipes.

Remarks: Cathodic protection should be provided for long life installations. Installation holes can be prepared using the CEL hand-held hydraulic rock drill.

Reference: 3, 4.

MANUAL NUT SPLITTER



Availability: Commercially available
- CEL modified

Size: 12 in. x 5 in. x 1 in.

Weight: 3 lb

Power Required: Manual power or
an impact wrench

Shown: H. K. Porter
Model: 1390 PQ

Application: Used to destructively remove corroded, deformed or galled nuts. Bolt threads may be damaged by the cutter blades. The cutters are replaceable. The tool requires minimal clearance around the nut.

Modifications: One jaw of the tool was redesigned to increase the tool capacity from 3/4 in. to 1 in. nuts. New, wider cutter blades and a stronger drive screw are used.

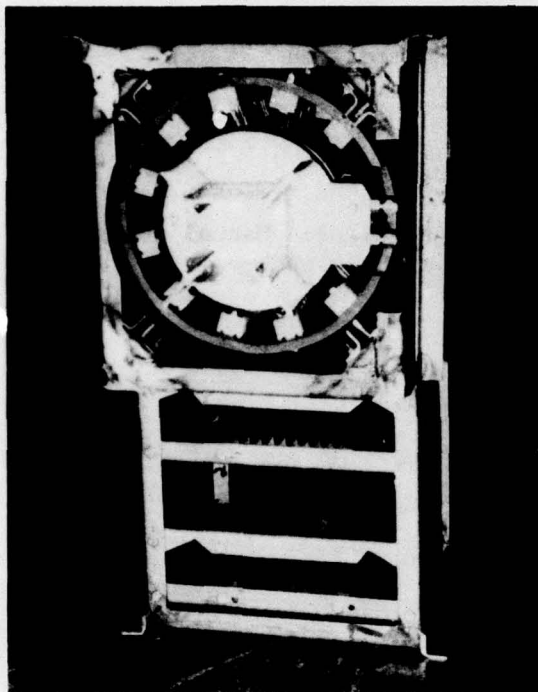
Remarks: The tool is contained in a kit which has all necessary spare parts for removing 1,000 nuts.

In air, the split nut halves fly off with considerable speed, and they should be contained for safety; underwater their energy is quickly spent, and they travel only a few inches.

Reference: 4.

BRUSH TOOL HOLDERS

Availability: CEL designed



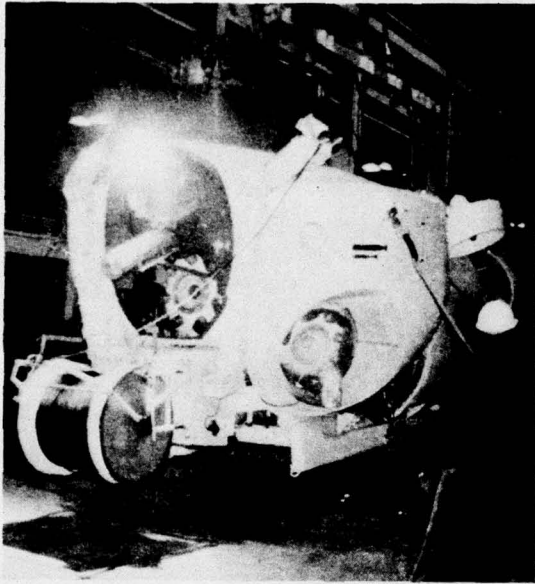
Application: Designed for holding manipulator tools. An interference fit between nylon brush bristles and the tool holds the tool firmly in its rack.

Maintenance: If the bristles take a set, they can be restored to their original condition by steaming.

Remarks: The brush bristles use an over-center action to positively lock the tool in its rack. The nylon electrically isolates the tool from surrounding metals to minimize corrosion. New brushes can be field fitted to new or modified tools.

Reference: 5.

FREE SURFACING RECOVERY SYSTEM



Availability: CEL designed

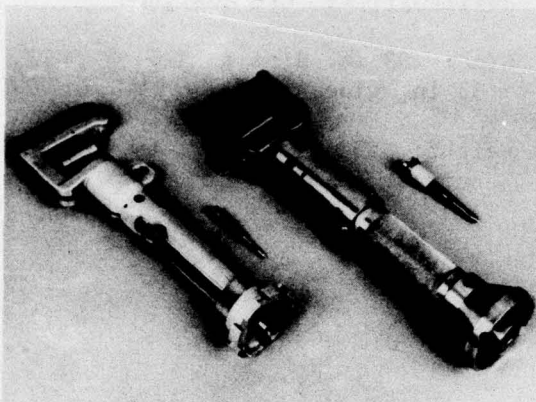
Size: 33 in. diam x
35 in. wide

Weight: 530 lb in air; 80 lb
buoyant at 6,000 ft

Application: A buoyant reel designed to be carried to a maximum depth of 6,000 ft by a submersible and attached to an object to be recovered. The submersible releases the reel which pays out a recovery line as it ascends. The line is capable of lifting a load of 12,000 lb.

Remarks: The system includes a rewind/shipping stand that requires 110 VAC power.

POWER VELOCITY STUD GUN



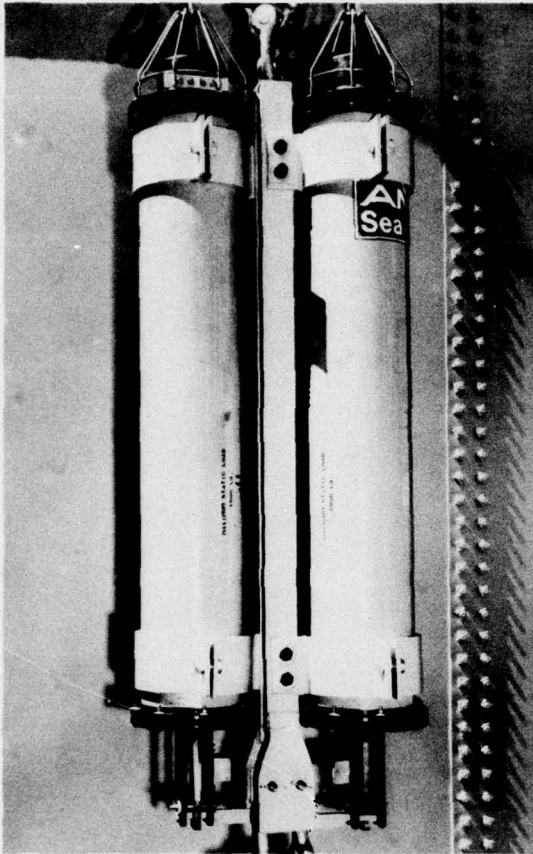
Availability: Commercially available

Shown: Mine Safety Appliance Co.
Model: D

Application: Used for attaching patches, padeyes, etc., for salvage.
Will attach a stud to 1-1/8 in. plate; pull out strength is 29,000 lb.

Reference: 12.

ACOUSTIC RELEASE COUPLING DEVICE



Availability: CEL designed

Size: 47 in. x 2-1/2 in. x 3-1/2 in.

Weight: 55 lb

Application: Provides a redundant release capability and increases the load capacity of acoustic releases. Two releases are used; by triggering either one of them the release mechanism is actuated, and the device uncouples from a clump anchor. The principal use is for recovering deep ocean instrument packages.

Remarks: A similar device has been fabricated for use with dissimilar acoustic releases.

LIFT BAG



Availability: Commercially available
- CEL modified

Size: 24 in. diam x
75 in. long

Weight: 25 lb

Shown: Arrow Products
Model: Lift Bag

Application: Provides controlled buoyancy of up to 800 lb to recover objects or move them along the ocean floor. A separate air supply is required. Buoyancy is controlled by a zipper which runs the length of the bag, excess air escapes below the zipper during ascent.

Modification: Added a stiffer bar across the lower support ring.

UNDERWATER ANGLE MEASURING DEVICE



Availability: CEL designed

Size: 3 ft diam x 4 ft high

Weight: 50 lb in air; 35 lb
in seawater

Application: Used by divers to measure plane angles on the seafloor.
Accuracy is $\pm 1/2$ minute of arc.

Remarks: Limited by local visibility.

Reference: 15.

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VII
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