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MANUAL NUT SPLITTERS FOR D'.VER USE.(U)
MAY 77 S A BLACK, S S SERGEV
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A diver-operated, compact, manual nut splitter was designed, built, and tested that can split stainless steel nuts (R_c 50 hardness) up to 1 inch across the flats. The nuts can be split in 30 to 45 seconds with a powered wrench or in 3 minutes manually. Four tool kits, each consisting of the nut splitter and spare parts were delivered to the Navy Underwater Construction Teams for their use.

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1. Diver tools – Manual nut splitter   I. YF52.556.999.01.304

A diver-operated, compact, manual nut splitter was designed, built, and tested that can split stainless steel nuts (R_c50 hardness) up to 1 inch across the flats. The nuts can be split in 30 to 45 seconds with a powered wrench or in 3 minutes manually. Four tool kits, each consisting of the nut splitter and spare parts were delivered to the Navy Underwater Construction Teams for their use.

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CONTENTS

INTRODUCTION

Under the sponsorship of the Naval Facilities Engineering Command (NAVFAC), the Civil Engineering Laboratory (CEL) has been developing tools and techniques to assist underwater construction divers. The program objective is to improve the safety and reliability of tools currently in use by the Navy's Underwater Construction Teams (UCT) and to develop new tools that will increase the scope of work performed.

One of the tasks frequently assigned to the UCT's is the installation, maintenance, and repair of oceanographic cables at diver depths. Presently, cast iron split pipe (Figure 1) is assembled around the cable to provide abrasion protection and stabilization against wave forces. Each split pipe section is approximately 3 feet long and is assembled using eight 5/8-inch bolts with nuts and lock washers. Both mild steel and stainless steel fasteners are used on the pipe.

During repair operations the divers have repeatedly experienced problems in removing the nuts and bolts from the split pipe sections. Abrasion of bolts on seafloor rock in combination with corrosion and marine fouling often make it impossible to remove the nuts with conventional wrenches. In these cases, a hydraulically powered abrasive wheel is used to grind through the nut. This procedure is extremely time consuming, requires two divers, and can be very dangerous because of the exposed high speed cutting wheel.

BACKGROUND

An investigation was conducted to determine what equipment and techniques were commercially available to remove the fasteners. It was found that the simplest, fastest, and most practical method was to remove the fasteners by cutting the nuts in half. Three commercially available tools (Figure 2) were purchased and tested by splitting 15/16-inch stainless steel nuts. A description of the tools is contained in Table 1. The evaluation criteria included:

(a) Be safe and simple to operate

(b) Require little or no maintenance

(c) Split the 5/8-inch (15/16-inch across the flats) stainless steel nuts in a single operation

(d) Fit within the confines of the split pipe

(e) Employ easily removable cutters

(f) Be compatible with existing tool systems

Of the three tools tested none met all the criteria: Type I did not open wide enough to accommodate the split pipe nuts; Type II would split the nuts, but two cuts were required to remove the nut; Type III provided an adequate opening and enough force to split the nuts, but would not fit within the confines of the split pipe sections. Based on an analysis of the tests and the operational criteria, it was determined that a modified version of the Type I splitter would function as required.

TOOL MODIFICATIONS

The tool would probably be used more frequently in its diver application than its original design function of occasional homeshop use. Therefore, in addition to modifying the tool to allow wider opening, it was made stronger for repeated use. A summary of tool modifications is shown in Table 2. The modified tool is shown in Figure 3.

Arm and Handle

The most extensive modification was the fabrication of a new arm (Figure 4). Changing the shape of the arm provided clearance for the nuts. The drive screw contact area was hard-faced to minimize deformation from expected compressive loads of about 120,000 psi. The small arm was modified to accept a 3/4-inch grade 8 pivot bolt. This was accomplished after tests with the standard 5/8-inch-diameter pivot bolt showed deformation of the unit when subjected to shear loads on the order of 100,000 pounds.

Drive Screw

Based on laboratory tests it was determined that the drive screw would be subjected to compressive loads from 15,000 pounds to a maximum of 30,000 pounds when splitting the 15/16-inch nuts. In addition, the tool drive screw would be operated at times with an impact wrench, which would result in very high friction forces on the thread contact surfaces. These high loads in combination with poor sliding surface lubrication conditions required testing a number of candidate drive screws before an acceptable design was found. The testing involved splitting nuts while monitoring the drive screw torque. The nuts were split both by hand using a ratchet wrench and with a hydraulic impact wrench. After the nut was split the drive screw was checked for thread deformation. The drive screw was assumed to have failed when it could no longer be turned easily by hand. Hand operation is required so that a diver can easily attach the tool to the nut to be split.

An unplated SAE grade 8 bolt with class 2 thread was selected as the drive screw. A ball bearing was installed in the contact end to reduce wear and sliding friction forces at the contact surface. With this bolt, up to 40 nuts were split with no significant signs of thread deformation.

Cutters

The original cutters were not wide enough to fit fully on the flats of 15/16-inch nuts. Also, when attempts were made to split the stainless steel nuts, the cutters deformed at the cutting edge, resulting in excessive torque at the drive screw.

A number of experimental cutters were fabricated and tested. Test criteria included drive screw torque and number of nuts split. This information is summarized in Table 3.

The AISI L-6 tool steel did not perform adequately, primarily due to the presence of a decarburized skin resulting from heat treating. The soft skin rolled, dulled the edge, and resulted in very high drive torque. Attempts to remove the skin by grinding did not improve cutter performance. However, the use of AISI S-1 tool steel eliminated the decarburized skin problem.

Heat treatment was shown to have an important effect on cutter life. For a hardness less than R_c 56, edge deformation resulted in excessive drive torques. For a hardness greater than R_c 59, cutter brittleness resulted in sheared shanks and chipped cutter edges. A secondary bevel, Figure 5, provided increased cutter life. Thus, cutters fabricated from S-1 tool steel heat-treated to R_c 57 and with a secondary bevel of 75 degrees were found to have prolonged life and acceptable torque. A copper washer placed between the cutter and the tool properly seated the cutter. Without the washer, uneven seating often resulted in side loads and subsequent shearing of the cutter shank. An O-ring provided a simple means of firmly holding the cutters in the tool.

TOOL OPERATION

The nut splitter was tested both on land and underwater to determine both operational procedures and overall performance. The testing showed the performance of the cutters and drive screws to be as previously discussed. Nuts can be split manually in 3 minutes or with a powered wrench in 30 to 45 seconds. Recommended operational procedures were established and incorporated into an operations and maintenance manual that is provided with each kit. A complete summary of the operation instructions is given below:

1. Orient the cutter blades so that the edges are parallel to each other.

2. Place the splitter on the nut so that the ends of the handle or arm do not contact the split pipe.

3. Position the cutter blades as close as possible to the centers of opposing flats of the nut so that they contact the full height of the nut and do not engage the washer or lock washer.

4. Secure the nut splitter in place by hand-tightening the drive screw.

5. Torque the drive screw with the socket wrench or an impact wrench. Note: when the nut splitter is operated in air, the split nut will fly off with considerable velocity. To reduce the hazards, head and eye protection must be worn. In addition, the nut should be covered loosely with a cloth rag to contain the split nut. When underwater, the energy of the split half is rapidly expended so that danger does not exist.

6. One side of the nut may split first. If this happens, examine the position of the cutters on the nut. If properly aligned, continue to split the remaining nut half; if incorrectly positioned, remove and reposition the nut splitter or remove the loosened nut by turning.

Occasionally it was observed that when both halves of the nut were split, the half restrained by the splitter remained attached to the bolt. Turning the bolt sometimes removed this half. On other occasions, the half was removed by an additional cut with the splitter.

TOOL KIT

Due to the unusually high stresses encountered in splitting the 15/16-inch stainless steel nuts, some of the nut splitter parts are designed to wear and be replaced on a regular schedule. For the UCT's, a kit (Figure 6) was made up that contains sufficient replacement parts to split 1,000 nuts. A listing of the kit contents and replacement schedule is contained in Table 4.

RESULTS AND CONCLUSIONS

The nut splitter was developed to meet the specific requirement of removing damaged 15/16-inch stainless steel nuts from split pipe. With the kit, adequate spare parts are available to remove more than 1,000 nuts. The task can be accomplished either manually using a socket and a ratchet wrench or hydraulically using an impact wrench.

Hand operation requires the diver to exert forces up to 25 pounds at the end of a 15-inch breaker bar. On a limited basis this force normally poses no problems. However, in conditions where it is expected that many nuts will be split, it is recommended that an impact wrench be used. If it becomes necessary to remove a substantial number of nuts manually, cutters with a sharper secondary angle would result in reduced drive torque. However, a decreased cutter life would be expected.

The present cutters were selected on the basis of limited tests and a trade off between drive torque and life. Optimization of the cutter angle, drive torque, and material hardness could result in a tool that requires less operational torque and has increased cutter life.

POST OPERATION

The first field use of the nut splitter was successful, but it did demonstrate some potential problems in using the tool. The operation occurred immediately after the development work discussed in this report, and the divers were not fully instructed in using the nut splitter. Also, the working environment was hostile, with poor visibility, heavy surge, and cold water that required the divers to wear awkward three-fingered mittens. These factors combined to make it difficult to align the cutter blades parallel to each other and to properly position the blades on the nuts. These problems were, of course, considered during the development process and the product was thought to be the best compromise solution. This design allows the most versatile use of the nut splitter in a variety of applications beyond just that of split pipe nut removal.

However, if these problems remain after divers are properly trained in the use of the nut splitter, these design modifications are recommended:

1. Fabricate the cutter blades from octagonal stock as shown in Figure 7 and modify the nut splitter handles accordingly. (This shape will allow indexing and positive orientation of the cutters.)

2. Fabricate an attachable alignment jig for specific applications.

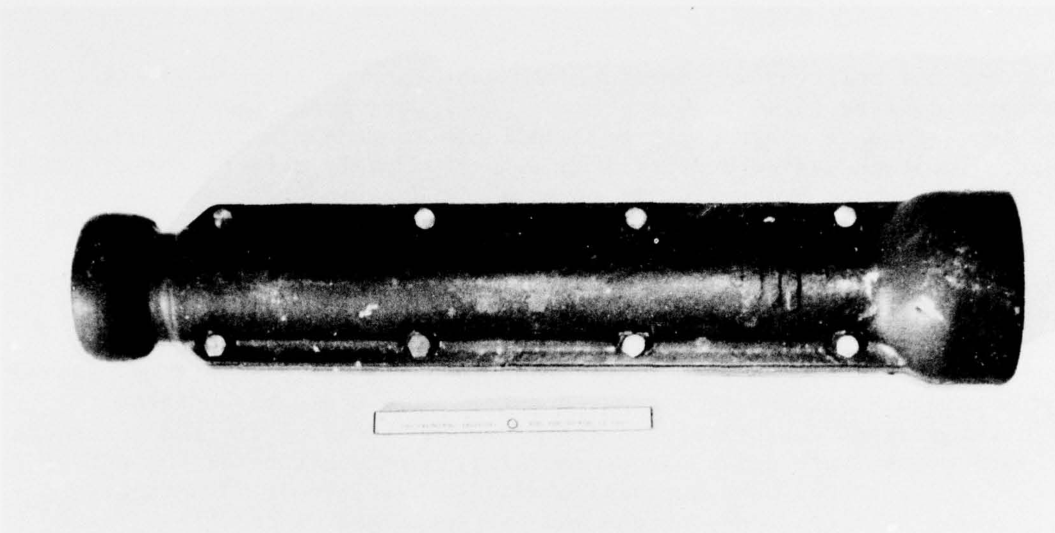

Figure 1. Split pipe section of the type used to protect cables.

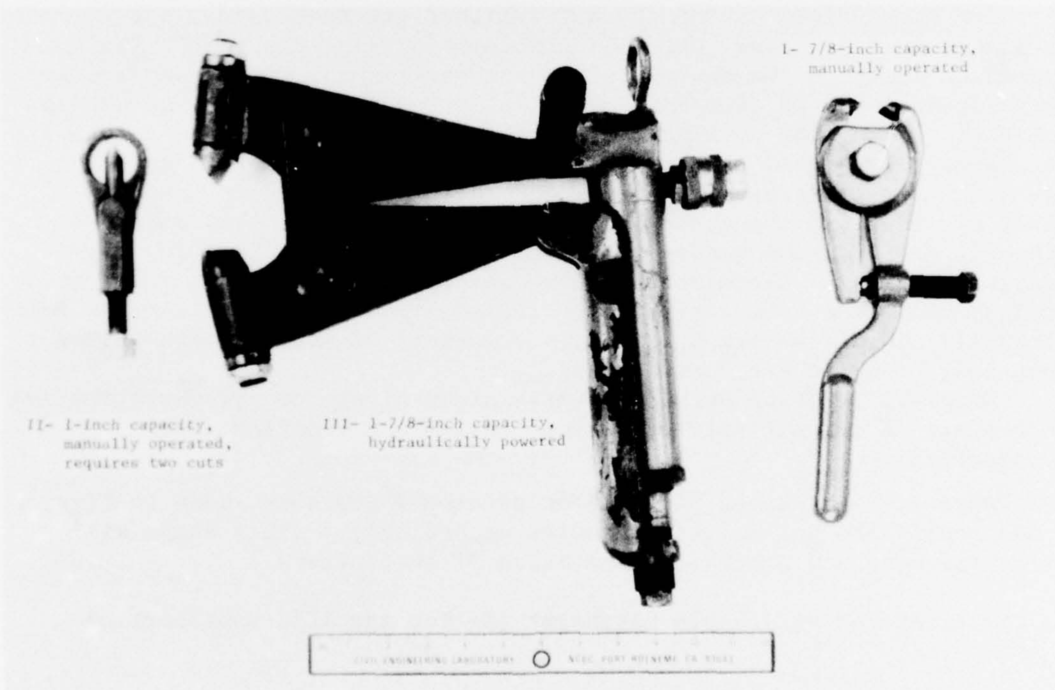

Figure 2. Commercially available nut splitters.

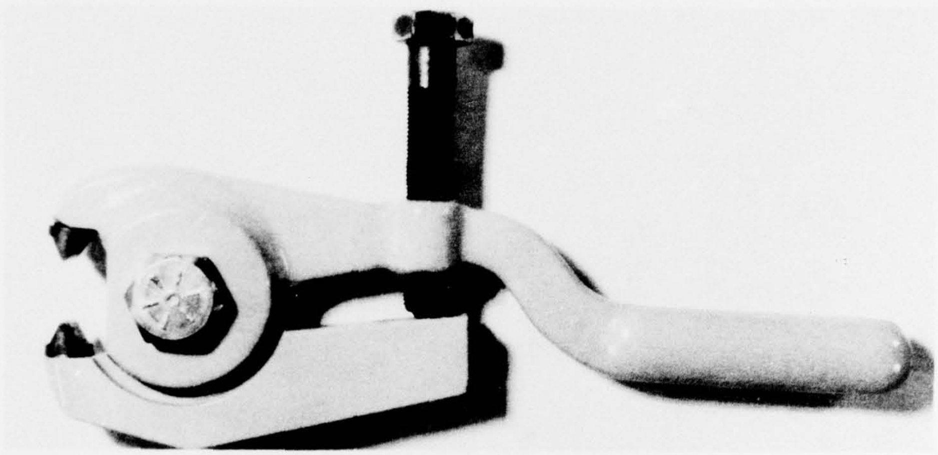

Figure 3. Modified nut splitter. Capacity increased to 1 inch; new, wider, harder cutter blades; larger diameter pivot bolt; stronger drive screw.

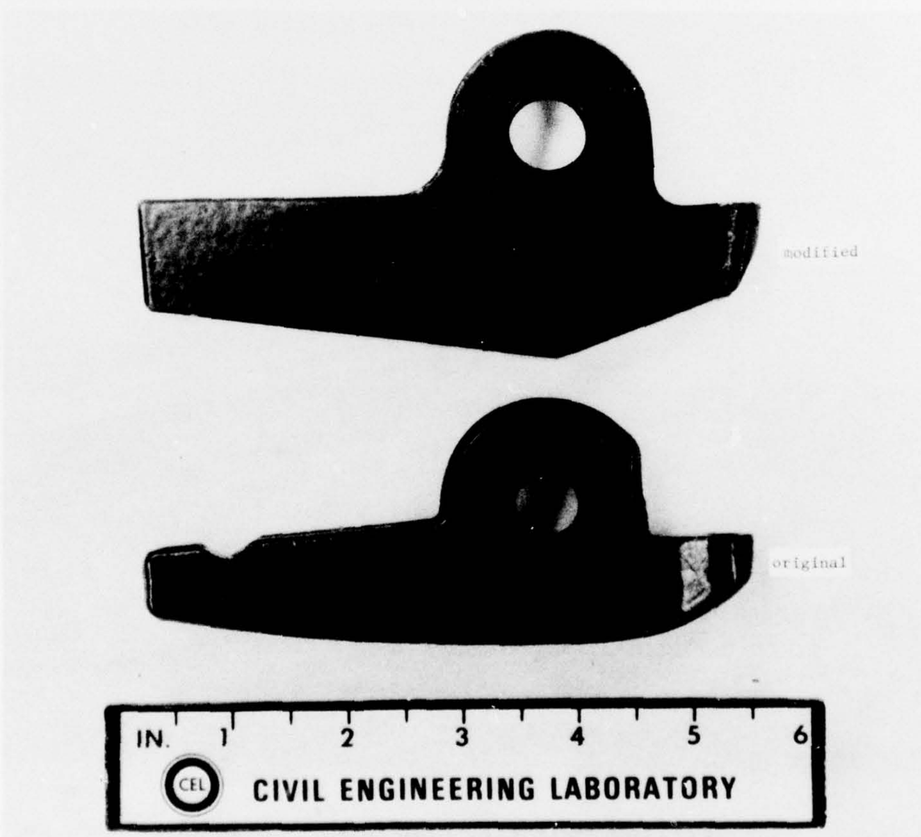

Figure 4. Modified small arm. Shape changed to increase tool capacity.

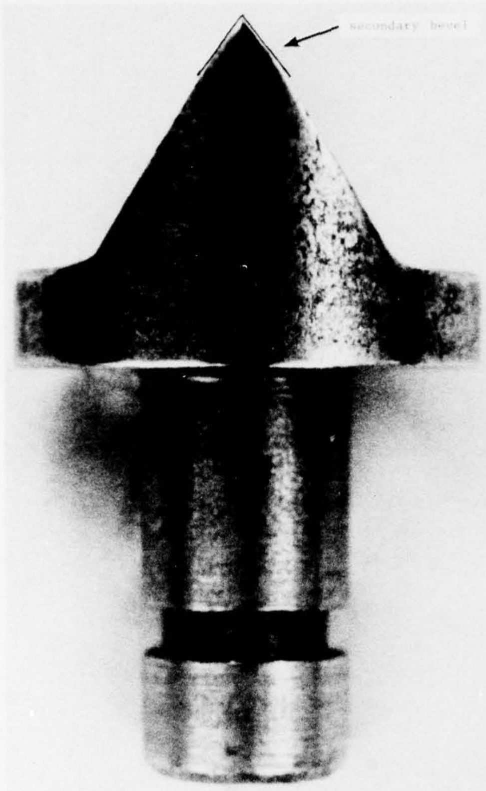

Figure 5. Cutter with secondary bevel angle. The bevel reduces wear at the cutting edge.

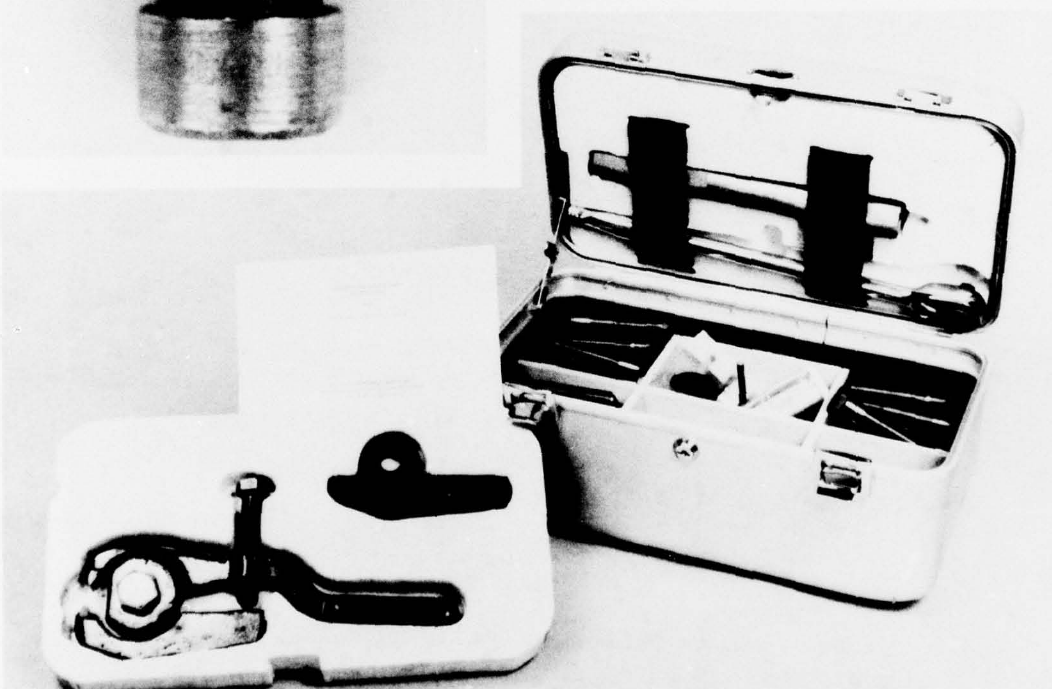

Figure 6. Nut splitter tool kit. Contains sufficient spare parts to split 1,000 nuts.

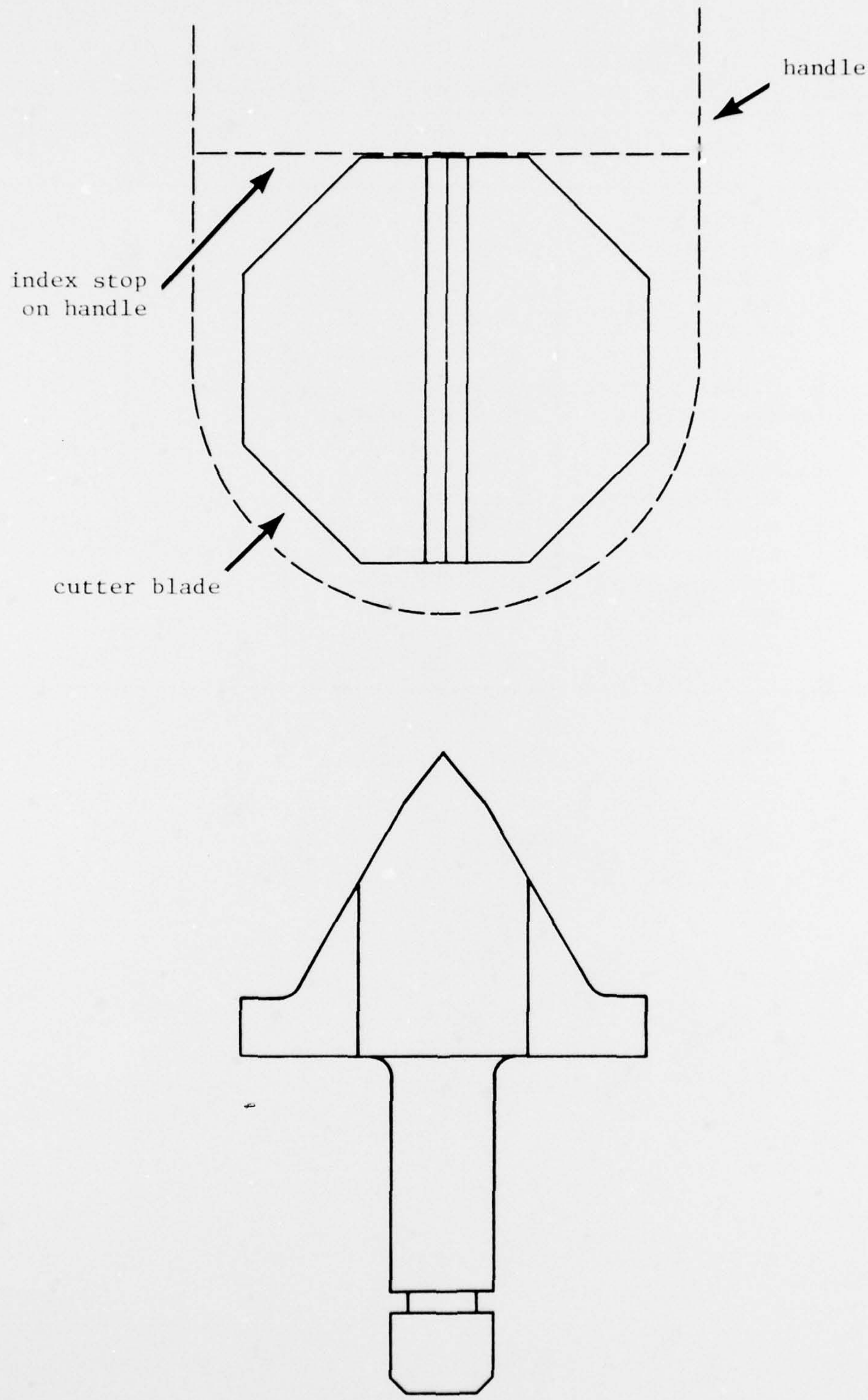

Figure 7. Octagonal cutter blade.

Table 1. Comparison of Commercially Available Nut Splitters

Type	Description	Nut Capacity	Size (in.)	Weight (lb)
I	Pliers type, two cutters, manual drive screw, hand-operated	3/4-inch across flats	12x6x1	4
II	Single cutter, requires two cuts, manual drive screw, hand-operated	15/16-inch across flats	6x2x1	3/4
III	Pinch type, hydraulic ram operated, requires hydraulic pump	1-7/8-inch across flats	16x14x3	22

Table 2. Modifications to Pliers-Type Nut Splitter

Tool Part	Modification	Description
Small arm	Shape changed to increase nominal nut capacity and to improve the drive screw/small arm contact angle; drive screw contact area hard-faced	AISI 4340 heat-treated to R_c 28-32. Tooltectic 6HSS hard-facing
Handle	Pivot bolt hole increased to 3/4-inch diameter	Modified commercial part
Drive screw	Commercial drive screw replaced with a high-strength bolt; a 7/16-inch ball bearing installed in the end of the bolt	SAE grade 8 bolt and commercial ball bearing
Pivot bolt	Commercial part changed to a high-strength bolt; increased size from 5/8-inch to 3/4-inch diameter	SAE grade 8 bolt
Pivot bolt jam nut	Nut added to lock the pivot bolt in place	Thin height elastic stop nut
Cutter blade	Commercial part replaced with a wider blade having a secondary cutter bevel	AISI S-1 tool steel heat-treated to R_c57-60

continued

Table 2. Continued

Tool Part	Modification	Description
Cutter blade washer	A 0.020-inch-thick copper washer added under the blade to evenly distribute contact stresses	Soft copper
Rubber stop	A rubber pad added to the small arm to help correctly position the cutter blades on the nut	—

Table 3. Results of Cutter Tests

Cutter Number	Material	Hardness	Blade Angle (deg)	Bevel Angle (deg)	Nuts Cut	Torque (ft-lb)	Remarks
1	unknown	R_c 38	60	-	1 to 2	unknown	Standard cutters too soft and too narrow
2	AISI L-6 tool steel	R_c 53-60	60	-	5 to 15	35to60	Torque depends on cutter wear; cutter edge tended to roll over due to soft, decarburized skin
3	AISI S-1 tool steel	R_c 50	60	-	1	30	Severe cutter deformation; too soft
4	S-1	R_c 60	60	-	20	24	Edge worn and unusable after 20 nuts
5	S-1	R_c 60	60	90	24	25	Secondary bevel achieved by sanding cutting edge to angle; edge worn
6	S-1	case hardened R_c 55	60	-	1 to 4	20	Case-hardened cutters sheared off at the shank; too brittle
7	S-1	R_c 55	60	-	2 to 5	30	Cutter edge badly deformed; too soft

continued

Table 3. Continued

Cutter Number	Material	Hardness	Blade Angle (deg)	Bevel Angle (deg)	Nuts Cut	Torque (ft-lb)	Remarks
8	S-1	$R_c 55$	60	75	24	35	Same cutters as (7); secondary bevel appears to increase cutter life; edge worn
9	S-1	$R_c 57$	60	75	16	40	Test stopped due to drive screw failure
10	S-1	$R_c 57$	60	110	22	61	Broad bevel angle produced high torque; cutting edge still good
11	S-1	$R_c 57$	60	75	22	47	Cutters still good; no wear on the edge

Table 4. Contents of Nut Splitter Kit

Item	Number in Kit	Description	Replacement Schedule or Function
Assembled nut splitter	1 ea	Handle, arm, drive screw, pair cutter assembly, pivot bolt and nut	—
Small arm	1 ea	4340 tool steel, heat-treated to R_c 28-32	Replace when severely deformed or broken
Cutter Assembly	60 pr	S-1 tool steel, heat treated to R_c 57, with O-ring and copper washers	Replace when edge becomes excessively worn or chipped, or when drive torque exceeds 60 ft-lb (estimate 30+ nuts)
Drive Screw	60 ea	5/8 x 18 SAE grade 8 bolt with ball bearing installed in end	Replace when its threads are badly deformed or when it cannot be turned freely by hand (estimate 30+ nuts)
Pivot Bolt and Nut	5 assembly	3/4 x 12 SAE grade 8 bolt	Replace when excessively deformed, causing excessive misalignment between opposing cutter edges
Rubber Stop	10 ea	1/4 x 1-inch rubber strip, 1/6-inch thick	For ease of alignment and centering cutters on nut to be split

continued

Table 4. Continued

Item	Number in Kit	Description	Replacement Schedule or Function
"T" wrench	1 ea	T-shaped brass rod	To aid in removing damaged cutters
Cutter holder	4 ea	Plastic strip with cutouts for cutter shank	Used to hold two pair of cutters for underwater handling with gloves
Impact socket	1 ea	15/16-in. impact socket	To turn drive screw with impact wrench
Impact Adapter	1 ea	5/8-in. hex drive to 1/2-in. square drive	To use with standard hydraulic impact wrench
Standard socket	1 ea	5/8-in. flank drive socket	To turn drive screw with hand ratchet wrench
Ratchet wrench	1 ea	18-in.-long reversible ratchet socket wrench	To torque drive screw
Extension handle	1 ea	8-in.-long handle	Fits on nut splitter handle to provide increased leverage
Lubricant	5 tubes	Antisieze lubricant	To lubricate drive screw and mating faces of handle and arm

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NAVOCEANSYSCEN CODE 4099 (E. Hamilton), San Diego CA; Code 409 (D. G. Moore), San Diego CA; Code 6344 (R. Jones); Code 65 (H. Talkington); Code 6565 (Tech. Lib.), San Diego CA; Code 7511 (PWO)
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NAVSEC Code 6034 (Library), Washington DC
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