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1972 B S LEBENSON, J A SCHLEGEL
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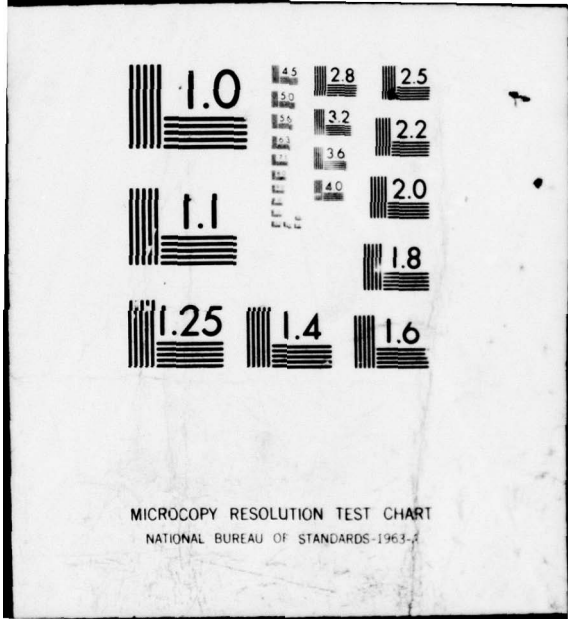
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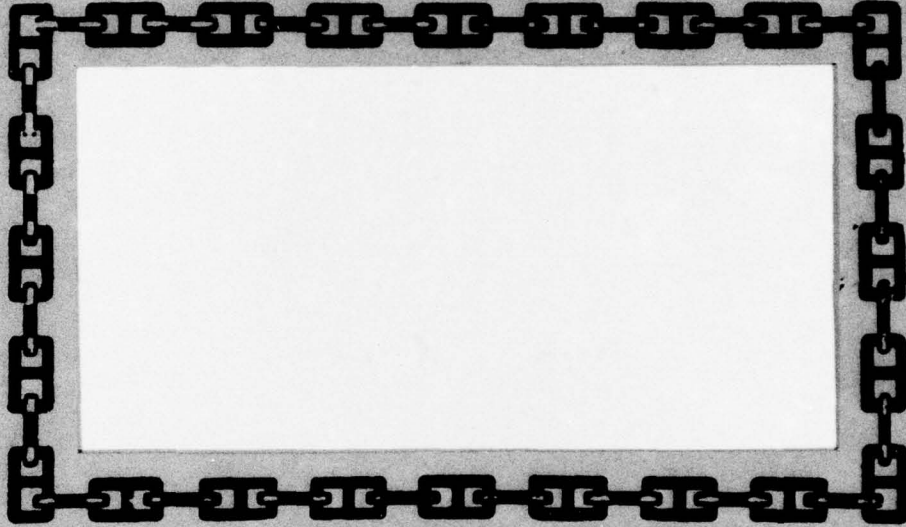
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EXPERIMENTAL DIVING UNIT REPORT
24-72

EVALUATION OF THE
THERMO-JET CUTTING TORCH

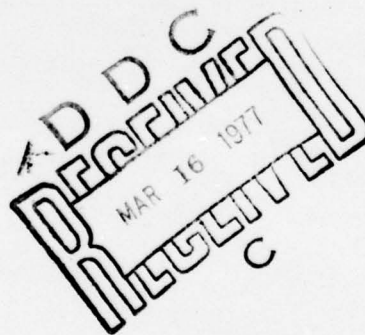
by

LTJG B. LEBENSON, USNR
HTI J. SCHLEGEL, USN

AD #

Submitted

B. S. LEBENSON
LTJG, USNR
Asst Project Officer



Approved

C. M. Jones
CDR, USN
Officer in Charge

1. INTRODUCTION

The Thermo-Jet Cutting Torch is designed for cutting heavy metals and other materials (e.g. concrete) at rates faster than standard Oxy-arc equipment. The system is electrically initiated and thermally propagated.

After extensive testing, using eleven different operators, the system, as marketed in late 1972, was found to be unsuited for fleet use.

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TABLE OF CONTENTS

	<u>Page</u>
1. INTRODUCTION	i
2. DESCRIPTION	1
3. PROCEDURE	1
4. RESULTS AND DISCUSSION	3
5. CONCLUSIONS	5
6. RECOMMENDATIONS	6
 FIGURES	
1. THERMO JET CONNECTION SCHEMATIC	7
2. SPIRAL BURNS	8
3. SPIRAL BURNS	9
4. SPIRAL BURNS	10
5. SPIRAL BURNS	11
6. CLOSE-UP OF INSULATION FOLLOWING BURN	12
7. COMPARISON OF BURNS	13
APPENDIX A	14

2. DESCRIPTION

2.1 The Thermo-Jet cutting torch is manufactured and marketed in the United States by Taylor Divina and Salvage Co., Inc. of Belle Chase, La. It is designed for cutting heavy metals and other materials (e.g. concrete) at rates faster than standard Oxy-Arc equipment.

2.2 The entire set-up (as sold during late 1972) consists of a power source, an HP oxygen bank, a console for loading oxygen and switching power, oxygen hose and welding lead and a Kerie Cable. The Kerie Cable is 6 x 37 plow steel wire rope manufactured without any core. The wire is then encased in a nylon sheathing and an oxygen fitting is fitted on one end. The absence of a core provides a pathway for the oxygen sufficiently clean for oxygen service. The strands of wire are used for conduction of electricity and are thermally consumed in the cutting process. (See figure 1) The cables are normally supplied in 100 foot lengths.

2.3 At the console, the high pressure oxygen is reduced to the desired pressure (generally about 250 psi) via a hand loader. The negative side of the power source is attached to the hot side of the knife switch and a 200 or 300 amp welding cable is led from the console to the fitting on the Kerie Cable. The oxygen is led to the proximal (topside) end of the cable via a 3/8" I.D. rubber hose which is recommended for use with oxygen.

2.4 The cutting process is electrically initiated by a power source of either 2-twelve volt batteries in series or a D.C. welding generator. Once the cutting process is initiated, the power is turned off, and the cable continues to burn as long as oxygen pressure is maintained. To terminate the burning process, the oxygen is turned off at the console. Once the pressure of oxygen gets below a critical point, the cable extinguishes itself. The burning of the cable can be stopped almost instantly by opening the oxygen vent valve on the console.

3. PROCEDURE

3.1 The experimental plan for testing and evaluating the Thermo-Jet was to cut four different projects, each at open sea depths of 15, 60, 90 and 150 feet. The four projects were labeled as follows:

- a. Railroad track
- b. 4" x 4" ingot of 4340 steel
- c. 3" O.D. Monel Shaft
- d. 2" 4340 steel plate, 9" wide

3.2 Two divers, one in a standard MK V Deep Sea outfit and one dressed in a Unisuit with a Kirby-Morgan KMB-8 Bandmask, were to descend to the work bench to each make two cuts on two of the projects, i.e. four cuts per man per dive. This was planned in accordance with the following schedule:

DIVER	U = Uni-Suit				H = Hard Hat			
	<u>15'</u>		<u>60'</u>		<u>90'</u>		<u>150'</u>	
	DRESS	PROJECT	DRESS	PROJECT	DRESS	PROJECT	DRESS	PROJECT
1	U	A, B	H	C, D	U	A, B	H	C, D
2	H	A, B	U	C, D	H	A, B	U	C, D
3	U	A, B	H	C, D	U	A, B	U	C, D
4	H	A, B	H	C, D	H	A, B	H	C, D
5	U	C, D	H	A, B	U	C, D	H	A, B
6	H	C, D	U	A, B	H	C, D	H	A, B
7	U	C, D	H	A, B	U	C, D	H	A, B
8	H	C, D	U	A, B	H	C, D	H	A, B
9	U	C, D	H	A, B	U	C, D	H	A, B
10	H	C, D	U	A, B	H	C, D	H	A, B

3.3 The values to be measured per cut were the length of cable burned, time necessary to gain ignition, time used for cut and the amount of oxygen consumed.

3.4 The power source used was two-twelve volt car batteries in series. Each battery was rated at 70 amp-hrs and was charged each night to maintain its capacity.

3.5 Orientation training was done on the surface with each man doing at least one cut on a railroad track. Two hundred psi oxygen was loaded in at the console. When pressure was reached at the work site, the knife switch was closed and an arc was struck. As soon as ignition was attained the knife switch was opened and the worker proceeded with his cut.

3.6 After surface orientation, the same procedure was followed at depth with the exception of O₂ pressure which was increased to 250-280 psi in accordance with instructions for the rig from the U. S. manufacturer (see Appendix A). A safety observer was at all times at the work site with the working diver and a standby diver was dressed on deck.

4. RESULTS AND DISCUSSION

4.1 All tests were conducted at the Navy Civil Engineering Laboratory's test pier facilities in Port Hueneme, California during January - March 1973.

4.2 Surface training proceeded well; however, no values were recorded since it was felt that orientation would not reflect a realistic evaluation of the apparatus.

4.3 Upon reaching the 15 ft. site, two divers descended to the work bench. Diver 1 could not gain ignition of the cable with O_2 pressures set at 250, 280, 300 and 325 psi and held constant. The power source used was two-12 volt batteries in series. After several attempts to gain ignition failed, the cable was given to Diver 2, who repeated the process. Neither diver was successful at igniting the cable even though some spark was being given off. Both divers tried to scrape the tip of the cable along the work and also tried to gain ignition by holding the tip solidly against the project. The Kerie Cutting Cable would not start to burn in either case nor would it ignite when an arc was struck directly on the ground clamp.

The cable was then brought to the surface, a new end section put on, and returned to the divers. The process was again repeated with no success.

4.4 After discussion it was felt that perhaps the O_2 supply was too small (the hose in use was approximately 1/4" I.D.); a larger hose would have a smaller friction loss per unit length than would a smaller diameter hose. Therefore, 3/8" I.D. hose was obtained and used in place of the smaller hose.

4.5 The project was again taken to 15 feet and the previous procedure was repeated. Again all attempts at ignition were fruitless. Again the section of cable was brought back to the surface and changed. After several efforts were made, the second cable finally ignited, but extinguished itself almost immediately. The O_2 pressure on the line at the time was 280 psi. All the tests were run with a clean tip, therefore, there was no slag or melted sheathing preventing good contact.

4.6 The apparatus was brought ashore and all five available lengths of the cable were tested in the following manner:

4.6.1 An Aeroquip fitting was fitted to the open end of the Kerie Cable and attached to a pressure gauge. Fifty pounds of pressure was loaded in at the console and the pressure was measured at the distal end. The pressure loss varied between 24 and 39 psi.

4.6.2 All the cables were then ignited in air using a 24 volt power source i. e., two-12 volt batteries in series. The sections were then ignited underwater in a 3' x 3' x 3' test tank filled with fresh water: Ignition was gained with just a small amount of difficulty. However, four of the five cables did not burn smoothly, there was sputtering of the flame and in some instances, the cable burned in a spiral manner

(See Figures 2, 3 and 4). When burning followed this pattern, the effectiveness of the jet was tremendously reduced. The sheathing did not burn off readily; as much as 11 inches of plastic hung off the burning end (See Figures 5 and 6). A comparison of types of burns is shown in Figure 7.

4.7 After discussion with the U.S. manufacturer, a D.C. welding generator was obtained for use as the power source for ignition. The generator was set up on a wharf in the harbor and the work bench was lowered to the bottom at a depth of 34 feet (from pneumofathometer readings). The same procedure was followed as before with the exception of the power source, which was now a D.C. welding generator. Ignition took place almost instantaneously and the cable continued to burn. Once cutting was started, the time for completion was rather short. Average times were as follows:

Railroad track	4::27
4" x 4" ingot of 4340 steel	1::33

4.7.1 The following problems were encountered:

- a. Spiral burn
- b. Lost ignition - after igniting the torch simply went out.
- c. A number of small O_2 explosions occurred when cutting the 4" x 4" steel ingot. This was most probably due to the failure of the diver to lift the torch every few seconds as is recommended.
- d. Failure of the sheath to burn off properly.

4.8. On many occasions, especially when a spiral burn occurred, the cable was brought to the surface and the end was chopped off with a cable cutter. Therefore, a burn was always started with an even tip. This was a time-consuming procedure and would not be practicable at a depth/time where decompression comes into play.

4.9 The Kerie Cable oxidizes readily after contact with water and oxygen. After use for 30 minutes in salt water, the cable changed color within one hour. A blackish spiral occurred inside the sheathing and some iron oxide was found to be present. This seemed to be an extremely rapid rate of corrosion.

4.10 Of the five available lengths of cable, only one (the section which had been used during training) burned well. One other section burned better than the others, and three were tested and were found to be virtually useless.

4.11 LTJG Lebenson, LTJG Parisi and HT1 Schlegel went to Ocean Systems, Inc. of Santa Barbara, California to compare their system with the one being tested. The console which Ocean Systems, Inc. has made in Great Britain. Instead of a number of valves as is present on the Taylor console, there is one three-way gate valve. The knife switch is also spring loaded in order to prevent arcing when the switch is opened.

4.12 LTJG Levenson discussed the Kerie Cable with Mr. Del Thomason and was told that Ocean Systems had a number of O₂ explosions, especially in annular spaces. LTJG Levenson tried Ocean System's rig in the open tank at Santa Barbara City College. The cable there burned fairly well and much smoother than the Taylor-obtained ones. The power source utilized was a D.C. Welding generator.

4.13 Three new 100 foot sections of cable were obtained from Taylor. There were some slight modifications on these:

4.13.1 The sheathing seemed to have a different, smoother texture. It burned better than previous cable in that the nylon melted off much more readily than before.

4.13.2 The fitting to the O₂ delivery hose was crimped on rather than being an Aeroquip fitting. In one of the three cables the core hole had been crimped closed, thereby making that section unserviceable.

4.14 A project was set up on the surface and a D.C. welding generator was used for the power source. O₂ pressure was set at 250 psi. The new cable ignited, sputtered and extinguished itself. The section was chopped clean and reignited--this time it burned in a spiral pattern. The burning was halted, a piece chopped off, and the process repeated several times. Again, spiral burns continued to occur.

4.15 The last section of cable was attached and lit off. Ignition was readily attained, but the burning jet would hardly make a dent in a 4" x 4" ingot of 4340 steel. One foot sections were cut off and the process repeated--no progress was made. It was at this point that the experiments were concluded.

5. CONCLUSIONS

5.1 Based upon the results obtained from experimentation, it appears that the Thermo-Jet Cutting Torch needs further development before it can be used as an effective tool. Where the problems lay at the present time has not been determined; some of the possibilities are outlined as follows:

5.1.1 Quality control is poor. The cable is purchased by Taylor Diving and Salvage, Inc. from a firm in England in 3000 foot lengths. It is cut into 100 foot sections and fittings are put on each piece. Therefore, there should not be such a drastic difference between sections of cable from the same lot.

5.1.2 The piping in the console is 1/4" I.D. Therefore, there may be a large pressure loss. There is no way to compare this piping with that in the console belonging to Ocean Systems, Inc. since their console was not disassembled.

5.2 It would seem that when the cable is burning in a spiral pattern, the fastest burning strand would be hot enough to cut the other strands and start a new, even burn. However, this is not the case. The

unburned strands did, however, show evidence of exposure to relatively high temperatures.

5.3 The console is unsafe as presently constructed. The operator must reach over the knife switch in order to manipulate the hand loader and valves. This could be readily remedied by rotating the pressure gauges 180°, thereby having the operator work from the opposite end.

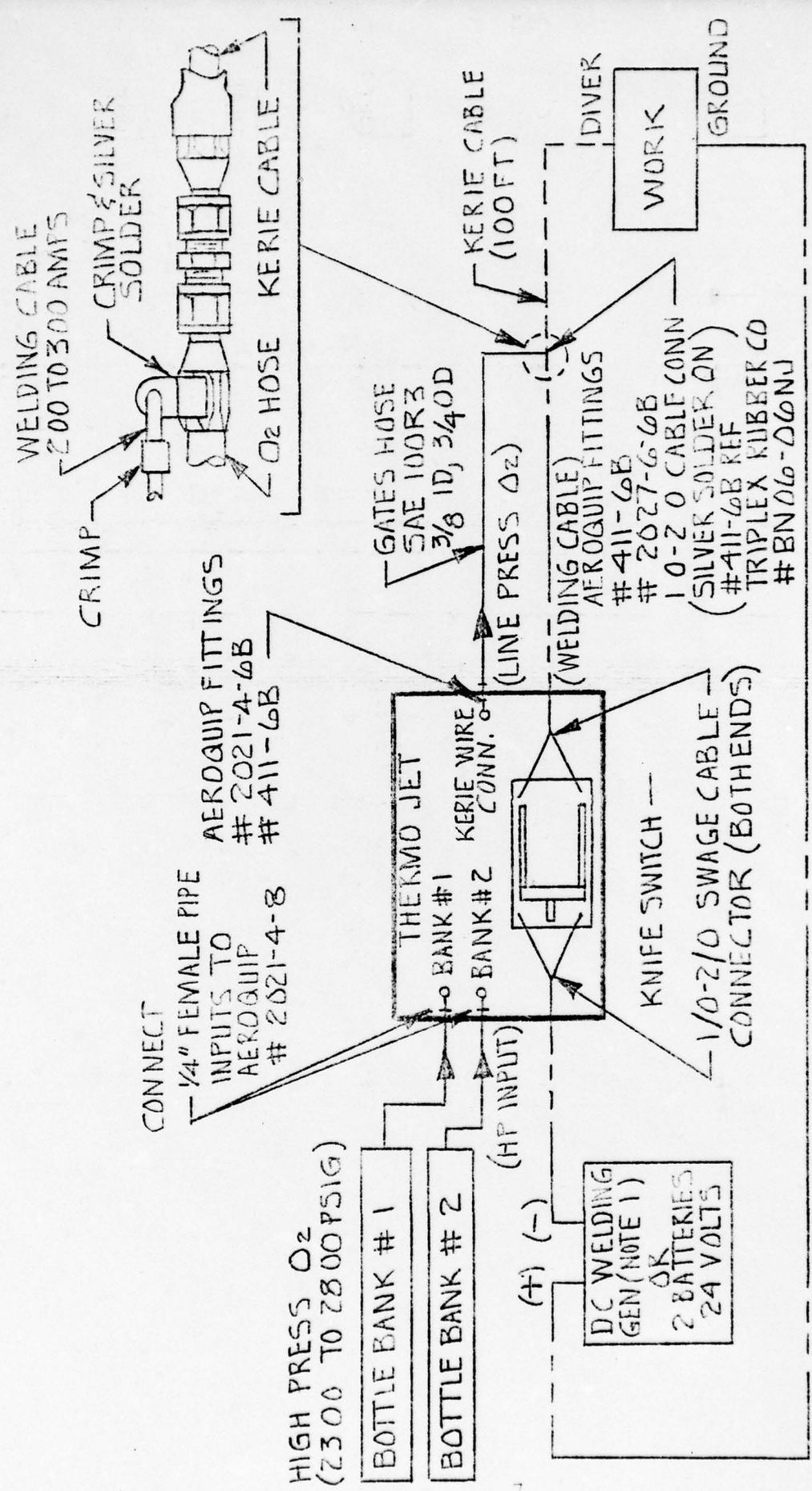
The system does not live up to its advertisements in that the cable would not light off when two-twelve volt batteries in series were used as the power source. Evidently not enough heat was generated to cause ignition to take place.

5.4 Copious amounts of oxygen are consumed during cutting. This fact might cause a logistics problem aboard a smaller vessel.

6. RECOMMENDATIONS

6.1 The Thermo-Jet Cutting Torch appears to have good potential. However, at this time in its development it does not seem to be adequate for fleet use.

6.2 Therefore, it is recommended that further tests not be made until the manufacturer can correct those problems with the rig which have already been outlined.



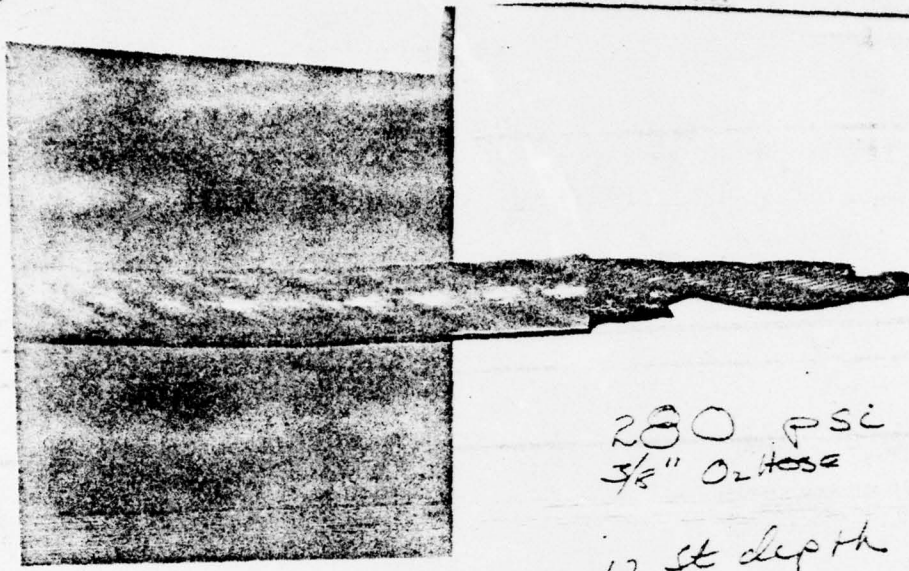
NOTE:
1. DC WELDING GENERATOR
MAX 400 AMPS, 60-80 VOLTS
OPEN CIRCUITS

FIGURE 1
THERMO JET CONNECTION
SCHEMATIC



Spiral Burns, plastic insulation cut
away to show the strands

FIGURE 2

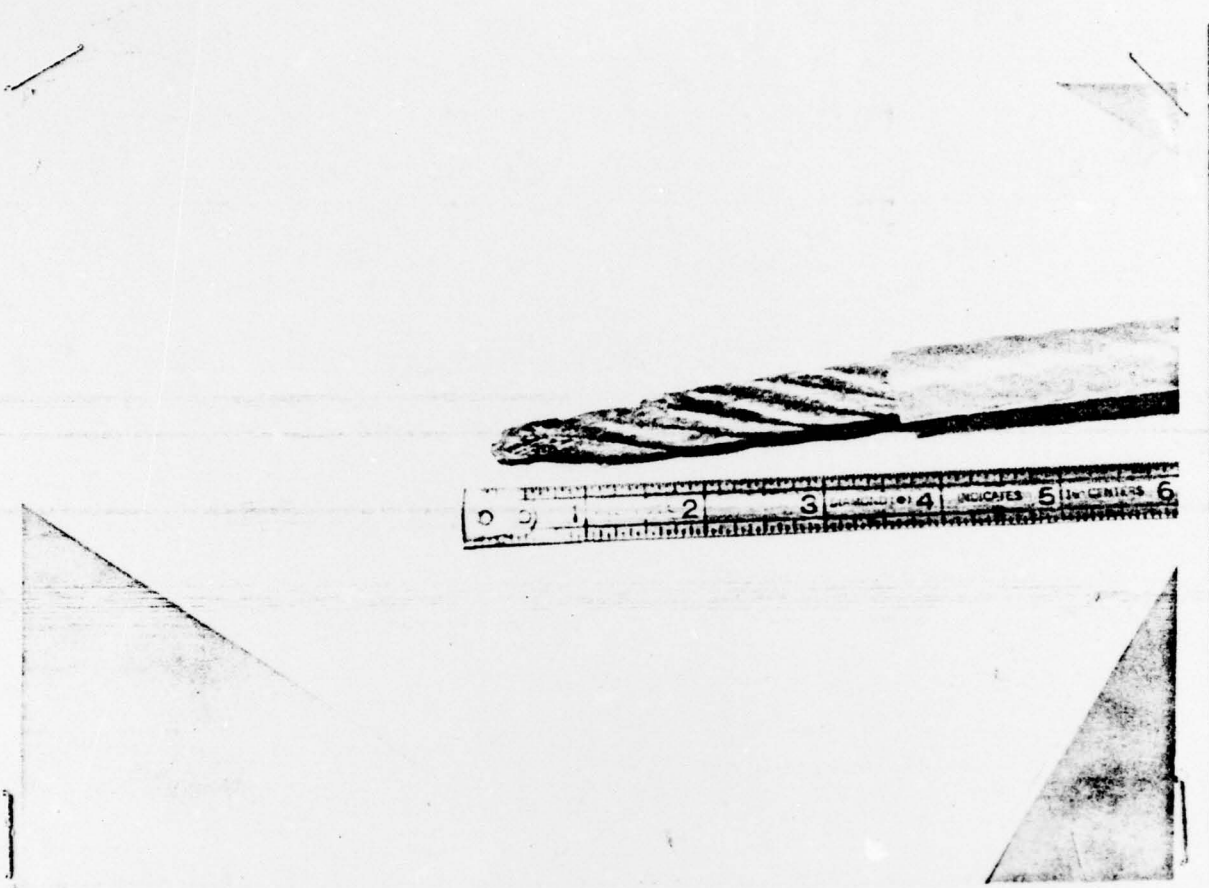


280 psc
3/8" O.D. hose

12 ft depth

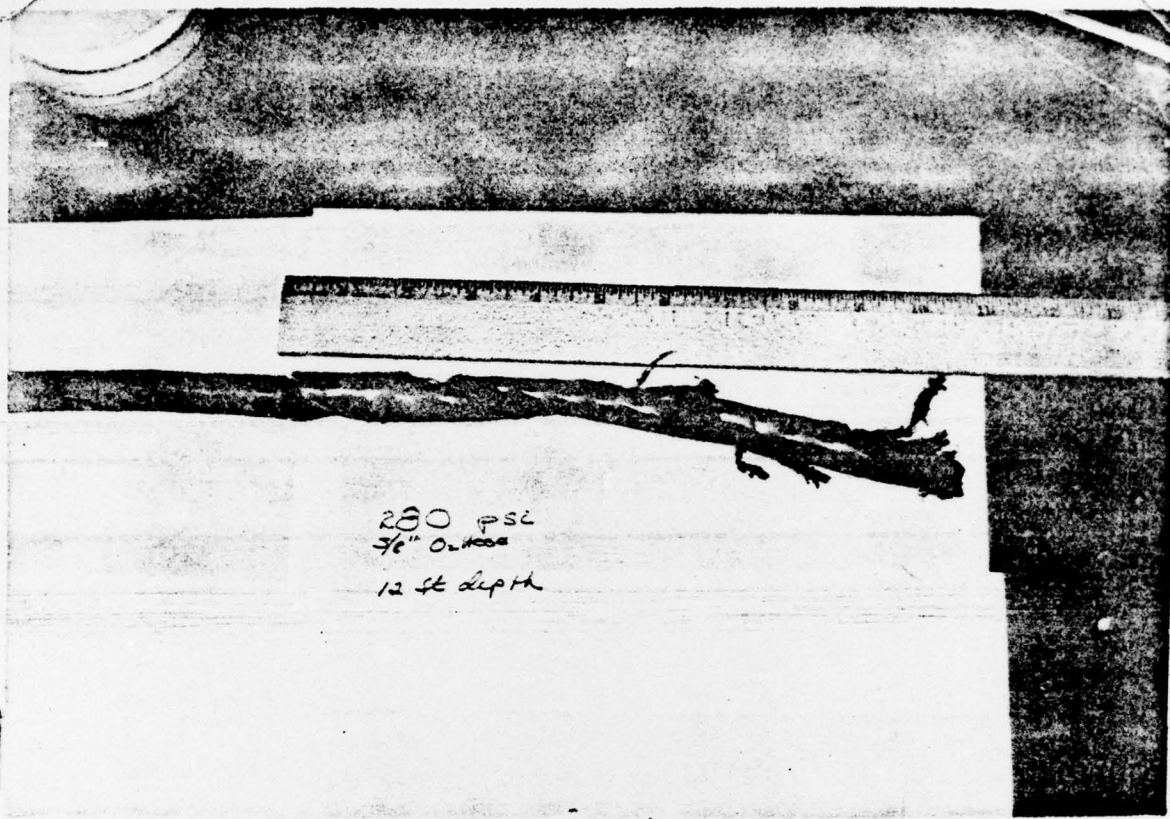
Spiral Burns, plastic insulation cut
away to show the strands

FIGURE 3



Spiral Burns
Insulation cut away to show strands

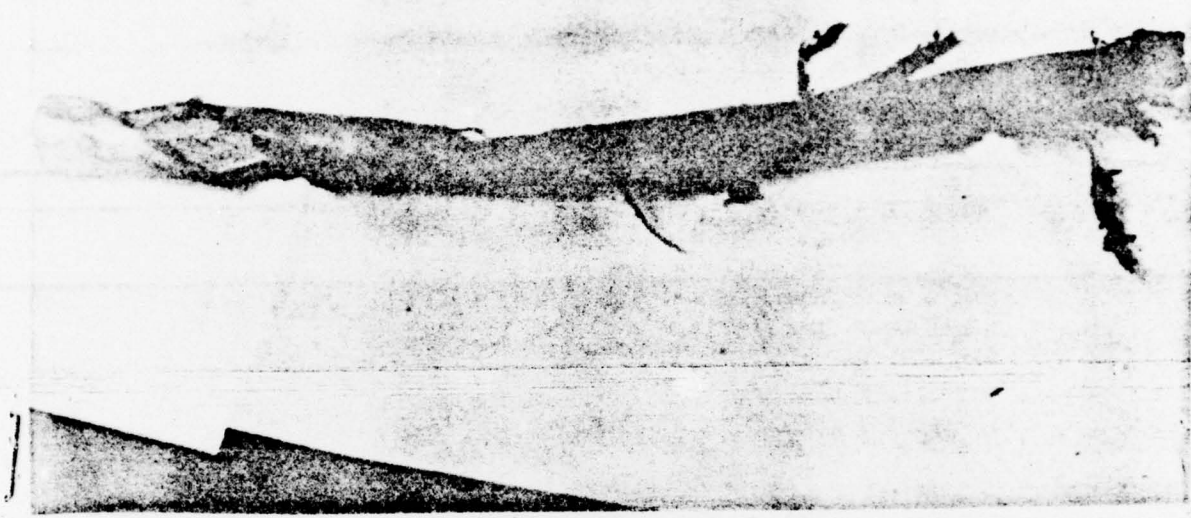
FIGURE 4



Spiral Burns
Cable as it appeared after a cut

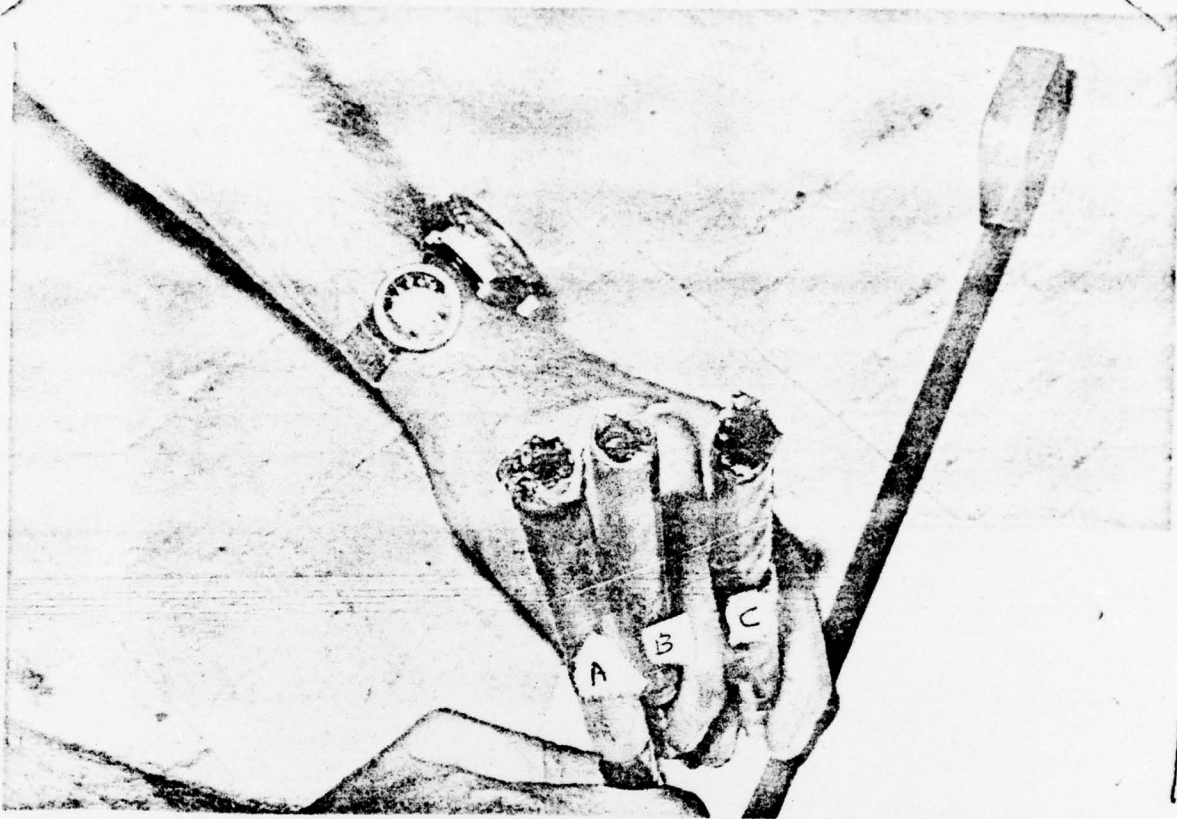
FIGURE 5

1 - depth



Close-up of Insulation following
a spiral burn

FIGURE 6



- A - Good Burn
- B - Good Burn - O₂ Vented
- C - Spiral Burn

Comparison of Burns

FIGURE 7

APPENDIX A

THERMO-JET TORCH
OPERATING INSTRUCTIONS

(As received from
The Vendor, late 1972)

THERMAL ARC CUTTING EQUIPMENT

SETTING UP EQUIPMENT

1. Connect three bottles of O_2 to Control Unit at position marked HIGH PRESSURE O_2 IN using the 10 ft. of high pressure hose supplied and stamped 'Panel' on the connection.
2. Connect extension leads to unit at positions-NEG AMPS OUT TO CUTTING CABLE and L.P. CUTTING O_2 OUT.
3. Connect Kerie cutting cable to the extension leads and slide red insulating sleeve over the joint.
4. Connect D.C. generator or supply (max. 400 amps, 50 - 80 volts open circuit) or 1 or 2 twelve volt car batteries (in series) - negative side to control unit, + positive side to earth or metal to be cut. Use 200 or 300 amp welding cable.

PREPARING TO CUT

First try out equipment on the surface to familiarize yourselves with it. Set up as described and use a thick piece of mild steel as practice material.

Set O_2 pressure at about 200 lbs. p.s.i. and switch O_2 on, close knife switch and touch practice metal with tip of Kerie cable. The cable should ignite immediately; lift knife switch when ignition takes place. Proceed to cut metal starting at the edge. No dark glasses are required and with care there will be no splash back.

There are two oxygen off positions, namely CUTTING O_2 OFF and CUTTING O_2 OFF & VENT. In the first 'off' position the Kerie cable will continue to burn until the O_2 in the line is used up. However, to kill the flame quickly, use the OFF & VENT position although this is rather wasteful on oxygen.

CUTTING UNDER WATER

O_2 pressure should be set at approximately 250 lbs. p.s.i., the diver takes down the Kerie cable and when ready to cut, orders "switch on". The attendant turns on the O_2 and closes knife switch. When the diver reports ignition (the needle on the ammeter will drop to zero) the knife switch is lefted and the diver proceeds to cut using the same method as in oxy-arc cutting.

FURTHER INFORMATION

It is advisable to use 2 twelve volt car batteries in series, although it is possible to gain ignition with only one. Ignition is

difficult to obtain when ammeter reads less than 100 amps when striking arc. When using batteries, the Kerie cable should be chopped clean before cutting commences

When hooking D.C. welding generators into the system to gain ignition, say 400 amps, 60 - 80 volts open circuit, ignition will take place no matter what condition the end of the Kerie cable is in providing the wire can make contact with the work. When switching off, the diver should rub the end of the cable against the work to prevent the molten nylon from insulating the end of the cable, thus ensuring further ignition.

Mild steel should start to cut as soon as the flame touches it, but should the pressure to the Kerie cable drop below approximately 120 lbs. p.s.i. it will cease to cut metal even though the cable is still burning furiously. Do not waste cable trying to cut, change over bottles.

2-1/4" plate can be cut at one pass with O² pressure at about 280 lbs. p.s.i. When cutting thicker metal, pressure can be raised to 300 lbs. p.s.i.

Pressures just below 200 lbs. p.s.i. should be used when cutting WIRES from propellers, etc., to prevent damage to shaft or vessel. As the cutting cable is consumed and becomes shorter, O² pressure can be reduced, e.g. from 250 p.s.i. to 220 p.s.i. when approximately 50 ft. of the cable is left. When cable is used up, always switch off in plenty of time.

FURTHER HINTS

In an emergency when no generator or batteries are available, the cable can be ignited in the following manner. Chop the end of the cable clean and open up the center. Poke down a small amount of wire wool or paper (about the size of a filter tip) for about 1", leaving a small amount protruding, turn on oxygen (5 lbs. p.s.i.) and light wire wool with a match, immediately hold the end of the cable against wood or concrete and raise the pressure to 50 lbs. p.s.i. The burning cable can now be passed to the diver, who when in position to cut asks for the pressure to be raised for cutting.

The burning cable can also be used very effectively as an underwater light at O² pressures around 80 - 100 lbs. p.s.i. When cutting metal covered in thick bitumen, etc. (e.g. field joints on pipelines) to earth or + lead can be made up into the diver's shot and the metal weight used as a striking plate to gain ignition.

As this system is basically for heavy duty cutting, O² consumption on thin metal is obviously rather high for the work done, therefore when cutting sheet piles, it may be advantageous to the operator to cut the clutches or joints only with the Kerie cable and the pans or recesses with the carbon arc system. Speed and costwise the thermal arc system will hold its own against any other form of underwater cutting in any conditions on metal over 3/4" thick.

CONSUMPTION - CABLE

Kerie cable is supplied in 100 ft. lengths and will burn off at a rate of 1 ft. in 40 seconds during normal cutting. When cutting 2" thick plate each foot burned should cut 9" of plate.

CONSUMPTION - O²

3 x 240 cubic ft. O² bottles will cut approximately 9 ft. of 2" plate.

EXPLOSIONS

Any underwater equipment can cause explosions regardless of gas pockets if the temperature of the metal reaches a critical point, the explosion taking place deep in the cut, as thermic cutting equipment can bring on this critical temperature quickly, care must be taken when cutting metal over 3" thick. When cutting thick metal, the cable (or lances) should be withdrawn momentarily every three or four seconds to allow water to enter the cut.

UNDER NO CIRCUMSTANCES SHOULD ANY ATTEMPT BE MADE TO CAUSE A FIRE OR INFERNO DEEP INTO THICK SECTION STEEL

The cutting of thick metal, that is propellor shafts, etc., should be done from the outside working round the circumference. If a considerable amount of cutting is to be done, it would be advisable to replace the diver's front glass with thick perspex (particularly if it is thin laminated glass) as perspex will repel hot slag, prevent pitting and thermal cracking.

See that the equipment is kept free from oil or grease contamination. However, the Schrader On-Off valve and connections between extension leads and Kerie cable may be lightly lubricated with PURE SILICONE GREASE, ONLY!

When work is completed, isolate panel from O² supply. Always use high pressure O² hose supplied NEXT TO THE PANEL, and if extensions are required they should be joined to this, as the original hose is specially insulated.

* 1/15/70 (retyped without changes for this report)
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THE THERMO JET

Taylor Diving & Salvage Co., Inc. has been appointed sole U.S. manufacturing and marketing agent for THERMO JET, a completely new system for cutting heavy metals and many other materials at speeds up to 20 times faster than with standard oxy-arc equipment.

THERMO JET combines portability, flexibility, speed and economy and is amazingly simple to operate.

Taylor Diving presently offers THERMO JET in Models 300 and 600, with numbers representing maximum water depths recommended for using the units.

The controls and gauges of the THERMO JET unit are contained in a single lightweight case.

The consumable electrode, known as Kerie Cutting Cable, is a tough, highly flexible material which is both the electrical and oxygen conductor.

An oxygen hose of suitable length and size for the job involved, 24 volt D.C. source, and an oxygen supply, are all that is needed to use the cutting unit.

A D.C. welding machine is unnecessary, but can be used where available.

The THERMO JET ignites with only half the amperage required for carbon arc cutting and is then self sustaining. It is extinguished simply by venting the oxygen within the Keri Cable at the THERMO JET unit.

The THERMO JET unit is designed to use Keri Cutting Cable for heavy duty cutting and conventional oxy-arc equipment for thin metal. THERMO JET is vastly superior to other forms of underwater and surface cutting on metals thicker than 1/2 inches.

SPEED

THERMO JET is ready for cutting in a matter of minutes and can be operated by personnel with minimal cutting experience. In contrast to oxy-arc cutting where the operator must maintain a critical distance to keep his arc, THERMO JET's Kerie Cable is simply held close to the member and the cutting is accomplished.

A tender needs very little training to properly control the THERMO JET unit.

*re-typed without change for this report.

During a typical assignment, THERMO JET has cut through a solid 16 inch steamship tail shaft with a one inch thick phosphor bronze outer sleeve, in slightly under 30 minutes. In another application, THERMO JET took only 35 seconds to cut a five inch solid steel shaft. Eight minutes were required to cut completely through double plated 15 inch steel I beams.

Barnacles and other types of marine growth have no effect on THERMO JET as it does with other forms of thermal cutting. It burns through fouling and other non-metal substances with equal speed and dispatch.

PORTABILITY

THERMO JET's controls and gauges are housed in a specially designed high impact fiberglass case with a total weight of only 40 pounds. The container conforms to military specifications and is fitted with heavy duty hardware. When closed for shipment, the unit can withstand severe shocks without being damaged and is bouyant, as long as the case is intact.

Controls for THERMO JET Models 300 and 600 are almost identical, the principal difference being in increased oxygen pressure and flow capability.

KERIE CABLE

Kerie Cable is supplied in standard 100 foot lengths and will burn off at the rate of one foot in 40 seconds during normal cutting. When cutting two inch thick plate, for example, each foot of cable burned should cut nine inches of plate.

OXYGEN CONSUMPTION

Three standard 240 cu. ft. oxygen bottles will cut approximately nine feet of two inch plate. THERMO JET's operational economy is best realized in cutting heavier materials where standard oxy-arc equipment is slow and costly. The greatest asset is the tremendous increase in productive cutting time over any other thermal cutting method. This is especially important in underwater operations, as it makes maximum use of the diver's bottom time.

AVAILABILITY

THERMO JET units are supplied by Taylor Diving & Salvage Co., Inc. on a sale, lease, or lease-purchase basis. The initial cost of THERMO JET is often offset by savings realized in the first few applications.

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253 650

y/B

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Diver tools Underwater cutting Salvage tools Cutting torch						