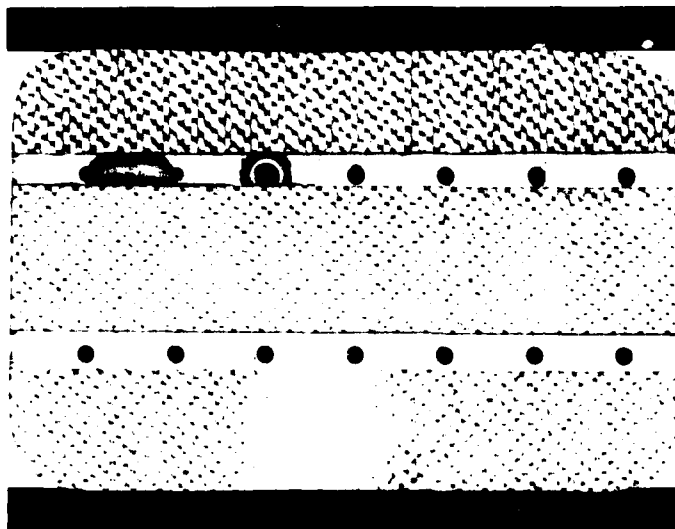


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CONVAIR ASTRONAUTICS

CONVAIR DIVISION OF GENERAL DYNAMICS CORPORATION

CORROSION AND LUBRICATION
OF THE
UMBILICAL PLUGGENERAL DYNAMICS
ASTRONAUTICS

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INTRODUCTION:

Successful launching of the Atlas Missile requires the instantaneous disconnect of all direct contact electrical monitoring leads. This is accomplished by triggering the release of cocked springs. As these springs return to their rest position they push the mating cable away from the plug and break electrical contact.

OBJECTIVE:

The objectives of this test request ^{was} are to:

- 1) Alleviate corrosion problems in umbilical connectors and
- 2) To determine if lubrication is required in the umbilical plug and if so, what lubricant.

CONCLUSIONS:

- 1) There were no major corrosion problems to be alleviated in the umbilical connectors examined under this test request.

Minor corrosion problems (specks of rust) can be alleviated by a periodic application of WD-40 Preservative Oil (Rocket Chemical Corporation, San Diego 20, California) over all moving parts.

- 2) The umbilical connector does not require lubrication. Both the cocking mechanism and the manual release mechanism of the plug examined under this test request satisfied the requirements of Report No. 27-06168.

RECOMMENDATIONS:

- 1) The part should be periodically sprayed with a light preservative oil such as WD-40, (Rocket Chemical Corp., San Diego 20, California) to guard against corrosion.
- 2) Solder flux remaining on the electrical harness after assembly should be removed with alcohol. This will reduce or eliminate corrosion on parts exposed to the electrical harness.
- 3) Coaxial connections should be doubly checked to prevent poor electrical contacts.
- 4) Operators should rely on the indicator guide to determine when the plug is cocked. The indicator guide in Figure 1 shows the plug to be overcocked. When properly cocked the unpainted portion of the movable guide should be barely visible behind the stationary guide.
- 5) Plugs with bent collet leaves should be removed from service as they no longer satisfy the Engineering Drawing (Gray and Huleguard 562-340). They can be detected by retracting the collet pins while observing the extended collets. Figure 4 shows a bent collet leaf which did not contract.
- 6) The thickness of the electrolyzed chrome plate should be increased at the collet tip to improve wearing qualities.
- 7) The clearance between the collet and the housing should be examined to reduce friction at this surface.

SPECIMEN:

Part Name:	Umbilical Connector
Manufacturer:	Gray and Huleguard Los Angeles 46, Calif.
Manufacturer's Part No.:	562-700
Applicable Specification Report Number:	27-06168
	"Connector, Electrical, Umbilical, Ground to Missile, Specification for"
Number of Specimens Received:	Two (2)
Condition of Specimens:	a. This connector was physically damaged in a drop at Point Loma. b. This connector had a broken lanyard cable.

Figure 1 is a photograph of the Umbilical Connector. The shield assembly which is not shown has been removed to disclose the internal moving parts. The shield assembly included a small window so that the indicator gage can be observed. The connector operates in the following manner: when the hexagonal nut, attached to the pinion gear is turned; the acme screw, keyed to the gear plate, rotates. The acme nut, prevented from rotating by the six alignment rods, moves to the top of the plug. The collets, attached to the acme nut, protrude past the housing. If the cocking handle, which is connected to the collet pins through the walking beam, is pulled, the collet tips may compress and slip into the receptacle collet insert. Figure 2 demonstrates the relative positions of these parts when the collet pins return to their normal position and lock the receptacle in place.

When the pinion gear is rotated in the other direction, the collets, which can no longer retract, draw the receptacle to the housing and compress the release springs. At this stage, the plug is fully mated electrically and mechanically.

SPECIMEN: (CONTINUED)

Mechanical disconnect occurs when the collet pins are retracted. Retraction may be induced by energizing the solenoid or by pulling on the manual release lanyard. When the collet pins retract, the collet tips disengage themselves from the receptacle collet insert. The compressed release springs are now free to expand and separate the parts.

PROCEDURE:

Torque measurements are used to describe the force required to retract the collets or to cock the plug. Torque values were taken at the hexagonal nut with a 150 inch pound torque wrench. The accuracy of this instrument is better than ± 5 inch pounds. Tension measurements are used to describe the force required to retract the collet pins. Tension measurements were taken from the end of the walking beam with a calibrated "fish" scale. The scale was manufactured by John Chatillon and is designated "Guage R". It measures up to 40 pounds in 1/2 pound divisions. The length of the scale is four inches. Reading error is a maximum of 1/2 pound. The accuracy is better than 1 pound. The tension and torque measurements were performed with the Umbilical connector locked in a horizontal position.

- 1) The cable was attached to the connector before lubrication. The hexagonal nut was rotated until the plug was fully cocked as determined by the indicator guide. The final torque value was recorded. The scale was placed on the walking beam and tension increased until "disconnect" occurred. The final tension value was recorded.
- 2) The effect of lubrication on the cocking mechanism was determined by torque measurements in the unmated condition. These values were recorded at each revolution of the hexagonal nut. They were taken before and after applying a light lubricating oil, "3 in 1", (manufactured by: Boyle Midway Inc., 29 E. 40th St., N.Y.C.) to the pinion gear, gear plate, race bearings (located at both ends of the acme screw), alignment rods, acme threads and the outside of the collets.
- 3) The effect of lubrication on the release mechanism was determined by tension measurements in the unmated condition. These were performed before and after applying a light lubricating oil to the pivot points, the collet pins, and the alignment bushings.

PROCEDURE: (CONTINUED)

- 4) The connecting cable was again locked into position and torque measurements repeated. The difference between these values and those from Test 2b should correspond to the force required to compress the release springs.
- 5) Tension measurements were taken as the mated plug was cocked to determine whether the degree of cocking affects the release requirements.
- 6) The plug was examined for signs of corrosion which might possibly interfere with a successful disconnect. Corrosion present on the collet tips was removed and tension measurements repeated.
- 7) The plug was examined for other corrosion loci. A second plug which had been physically damaged in a drop at Point Loma was disassembled in order to study the moving parts. It was now thoroughly examined for signs of corrosion and lubrication needs. Metallographic specimens of corroded areas were examined under the microscope.
- 8) The plug was examined for mechanical and electrical defects which could interfere with plug performance.

RESULTS:

- 1) The torque required to complete the cocking operation of the unlubricated plug was 60 inch pounds. This value satisfies the requirements of Astronautics Specification 27-06168. Paragraph 3.5.2.3.5 specifies:

ENGAGEMENT: Plug and receptacle engagement shall be such that it may easily be accomplished by hand, by one person with the use of ordinary hand tools.

An operator using an ordinary nine inch socket or crescent wrench may apply 100 inch pounds of torque. This is considerably more torque than was required to fully cock the Umbilical Connector. Disconnect occurred when 22 pounds of tension were applied at the end of the walking beam. This value satisfies the requirements of Astronautics Specification 27-06168. Paragraph 3.5.2.3.2.2 specifies:

MECHANICAL RELEASE: The force required to eject the plug mechanically by means of the release lanyard shall not be less than 25 pounds nor more than 100 pounds.

The tension value of 22 pounds as measured from the end of the walking beam corresponds to a 35 pound force measured from the lanyard. Lanyard tension values could not be directly determined because the lanyard cable was broken. They can be calculated from walking beam tension values if the mechanical advantage is determined. The mechanical advantage gained by using the walking beam rather than the lanyard is 1.6:1. This is the inverse ratio of their respective distances from the pivot point.

RESULTS: (CONTINUED)

- 2) Lines 2 and 3 of Table I show that lubrication reduced the initial torque values from 38 to 15, 36 to 14, and 30 to 11 inch pounds. A wide range of torque values, from 2 to 15 inch pounds, exists in the lubricated, unmated condition. This indicates a variable friction surface unaffected by lubrication. Scratches on the collet shank demonstrate this type of friction surface between the collet and the housing assembly. This friction surface disappears when the collets are retracted or the release springs compressed.
- 3) Lubrication of the collet pins, bushings, and pivot points with "3 in 1" oil reduces the tension required for release in the unmated condition. The tension required for release before lubrication is shown on line 7 of Table I. The tension required for release after lubrication is shown on line 8. The effect of permanent lubricants could not be evaluated. This type of evaluation would require disassembly of the connector, application of the lubricant, and reassembly. Reassembly requires special jigs and mechanical fixtures.

RESULTS: (Continued)

- 4) Torque values are higher when the cable is locked in place than when disconnected, i.e., 35 to 2, 36 to 2, 38 to 2, 40 to 2, 44 to 2, and 45 to 2 inch pounds. The initial constant value of 20 inch pounds on line 4 of Table I appears to be a gross error because more torque should be required as the release springs are compressed. A misalignment problem permits the collets to rub against the housing. From line 3 of the table we can see that this friction surface disappears as the collets are retracted. When we correct for this friction surface, the difference between lines 3 and 4, we see that the net force required for spring compression obeys the following equation.

$$F = 2 \times \text{Number of Hexagonal Nut Rotations} + 5$$

This equation is a restatement of Hooke's Law:
 "Within the elastic limit of any body the
 ratio of the stress (F) to the strain (n)
 is constant (k); $F = kn$ "

Torque values rise very rapidly when the collets reach their limit of travel. Forceful "bottoming out" can strip the gears. Chipped and mangled teeth were observed on the pinion gear. This indicates that excessive torque was applied after the collets had reached their limit of travel.

RESULTS: (CONTINUED)

- 5) The degree to which a mated plug is cocked affects the tension required for release. Cocking corresponds to pushing the cable upwards in Figure 2 while restraining the collets. The cable catch presses the collet into the collet pin and increases the friction surface. Movement at this friction surface becomes more difficult as the release springs are compressed and almost impossible if the plug is overcocked.

- 6) The encircled area on Figure 2 is subject to the greatest strain because the cable catch digs into the collet when the release springs are compressed. Figure 3 is a photomicrograph of this portion of the collet. It shows the damaged chrome finish and corroded base metal. Buffing this portion of the collet tip had no measurable effect on the tension requirements. Collet tips with a thicker chrome finish should better withstand the abrasive effects of repeated mating cycles. How well the thicker coating can withstand the excessive localized forces associated with overcocking is pure conjecture. The collet tip was the only area of corrosion, visible on the assembled plug, which might possibly interfere with a successful disconnect.

RESULTS: (CONTINUED)

- 7) There were minute areas of corrosion on both of the plugs which were examined. There was however only one spot of rust which might possibly interfere with the successful operation of the plug. This area was on the race bearing located beneath the gear plate. Complete disassembly was required before this area could be examined. Rust would not be present if the bearing had been kept adequately lubricated. The lack of lubrication on a concealed moving part cannot be tolerated on a critical assembly as dry bearings tend to freeze.

Type III cadmium plated springs showed the typical chromate colored corrosion product. Specks of rust were present on several retainers and on the Acme nut itself. General mild corrosion of this type, though not detrimental to plug operation, can be limited by applying light preservative oils such as WD-40.

Corrosion was also evident on areas surrounding the electrical harness. It takes the form of small localized deposits. Specks of solder rosin are also evident and many of these coincide with corrosion loci.

Polished metallographic specimens were examined under the microscope. They revealed little but mild surface corrosion.

RESULTS: (CONTINUED)

- 8) A coaxial connection to a "canon" plug was not secured. Although the shielding was exposed, the fitting which assures positive electrical contact was not tightened. This type of electronic wiring defect can seriously affect the reliability of an important monitoring circuit. Some collet leaves are bent. Figure 4 shows how a bent collet leaf appears when viewed head on. Collets which have bent leaves no longer satisfy the Grey and Huleguard Engineering Drawing P/N 562-340. Collet tips which fail to contract when the collet pin is retracted can interfere with a successful disconnect. A collet cannot rapidly extricate itself from the cable if one of its leaves hang up.

N O T E: The test data from which this report has been prepared are recorded in Astronautics Engineering Notebook 7652 pages 54-60, 65-69, 115 and 116.

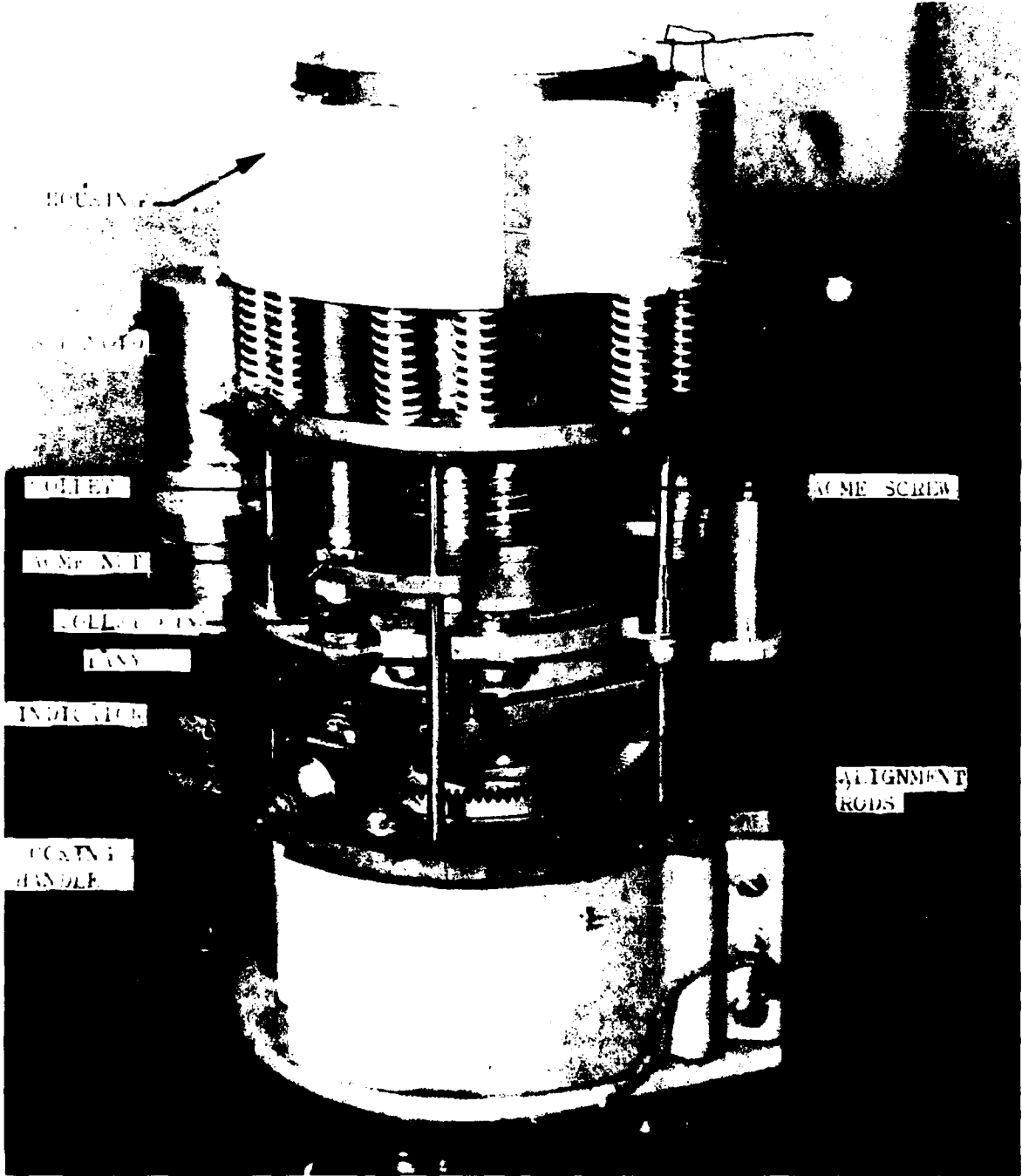
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3	M3442	Collet Tip at the Mating Surface	16

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FIGURE 1
UMBILICAL CONNECTOR WITH SHIELD ASSEMBLY REMOVED



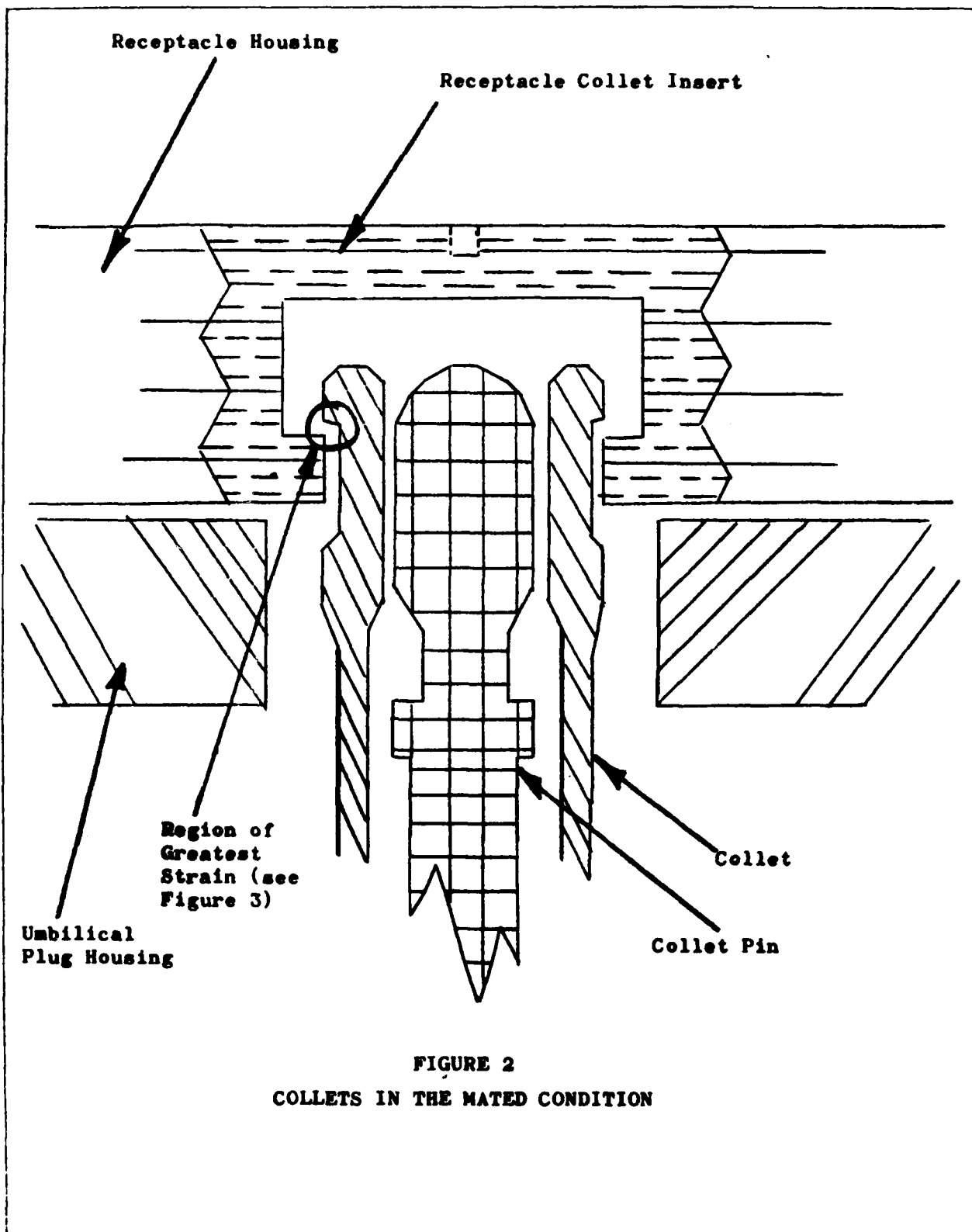


FIGURE 2
COLLETS IN THE MATED CONDITION

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FIGURE 3
COLLET TIP AT THE MATING SURFACE



COLLECT TIP AT THE MATING SURFACE
FIGURE NO. 3

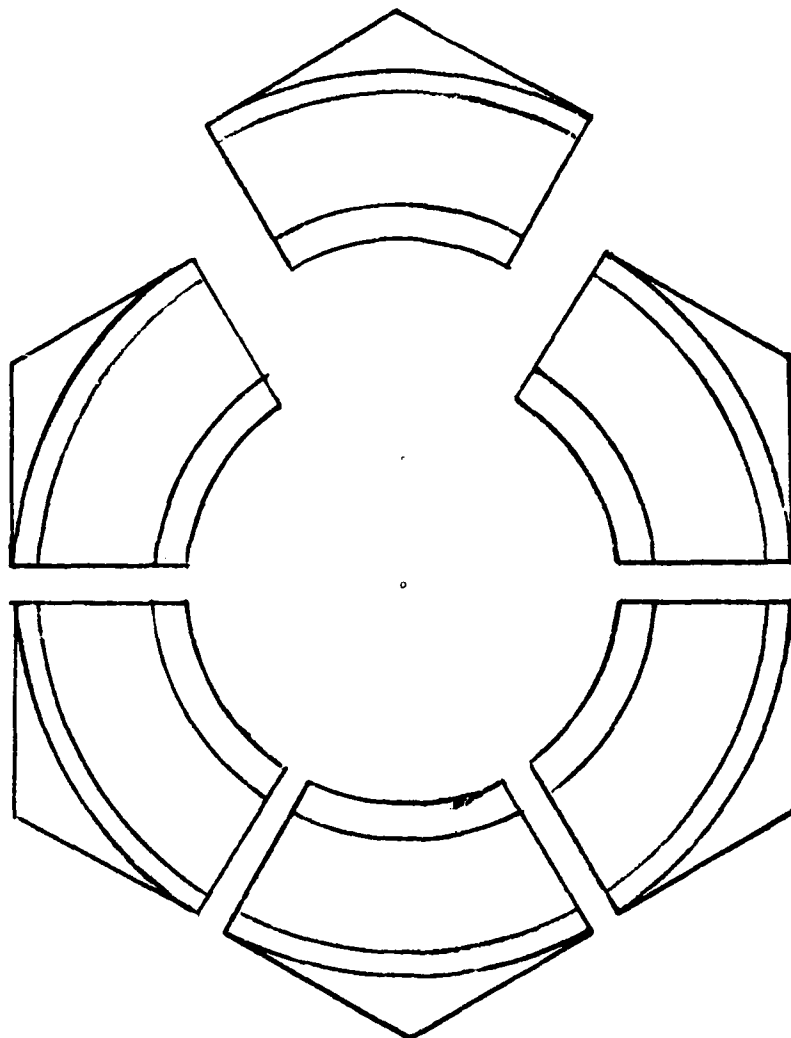


FIGURE 4
BENT COLLET LEAF (TOP VIEW)

TABLE I
UMBILICAL CONNECTOR TEST DATA

HEXAGONAL NUT ROTATION FROM FULL EXTENSION	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
TORQUE IN INCH POUNDS:																				
1 To cock the plug before lubrication.																				60
2 To retract the collets before lubrication.	38	36	30	28	28	28	24	19	18	16	14	12	8	6	4	3	3	3	2	3
3 To retract the collets after lubrication.	15	14	11	8	7	6	7	6	5	4	3	3	2	2	2	2	2	2	2	2
4 To cock the plug after lubrication.	20	20	20	20	21	23	25	26	28	28	30	32	35	35	36	38	40	41	15	50
5 Force to compress the release springs Line 4 minus line 3	5	6	9	12	14	17	18	19	27	24	27	29	33	33	34	36	38	42	43	50
TENSION IN POUNDS:																				
6 To release the cable before lubrication.																			22	
7 To retract the collets before lubrication.							13	13	13	14	13	12	12	12	13	13	13	13	12	
8 To retract the collets after lubrication.							11	11	11	11	11	11	11	11	11	11	11	12	12	
9 To release the cable after lubrication.							11	14	14	14	14	14	14	15	15	16	16	16	26	
10 To release the cable after buffing the collet tips.															16	16	16	16	25	