

**Development of a Cable Reel Deployment System  
Using a Rotary Joint  
for  
Kilometer Lengths of Two-Fiber Multi-Mode Fiber Optic Cable**

J.A. Curtiss and J.R. Jahelka

August 11, 1995

Work described herein was funded by the  
Defense Nuclear Agency  
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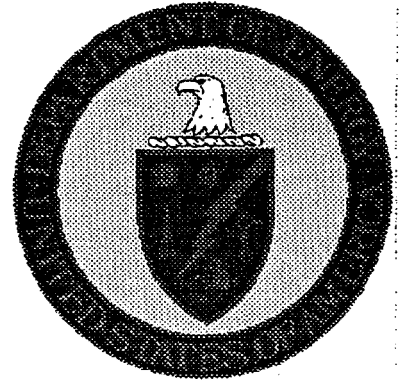
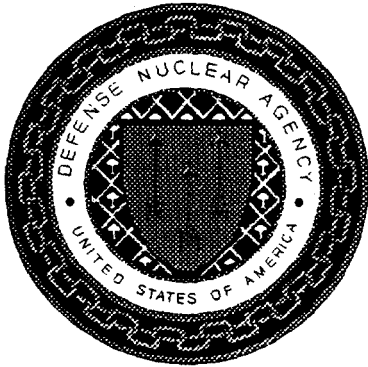
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BNL-52477

SSN-95-26  
Task No. 8.172



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<b>bnl</b>	brookhaven national laboratory
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**Development of a Cable Reel Deployment System  
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Kilometer Lengths of Two-Fibre Multi-Mode Fiber Optic Cable**

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**SUMMARY**

Brookhaven developed a mobile unit which communicated with a base station over a 2-fiber multimode fiber optic cable. One of the design requirements was maintaining constant communication with the base station during the time the mobile unit was moved about. To provide uninterrupted communications, deployment of the 1-km long fiber optic cable was initially performed with a "spinning reel" mechanism.

The spinning reel mechanism proved to be mechanically unsuitable, and so the cable deployment mechanism was redesigned to spool the cable off the reel. The requirement for uninterrupted communications required a two-channel fiber optic rotary joint in the design. Incorporation of the rotary joint into the design is described, and appropriate reference material is included.

**A FIBER OPTICS APPLICATION**

Brookhaven National Laboratory (BNL) recently developed a two-component system for use during remote inspections. The system consists of a mobile unit with television cameras and other equipment, and a stationary base station.

A variety of signals must be continually transmitted between the two system components as the mobile unit is moved from one location to another. Two channels of broadband (10MHz) NTSC video are transmitted from the mobile unit to the base station, and a bi-directional "talk set" provides audio communication between personnel at each location. In addition, several channels of RS-232 are required to support present and future instruments used at the mobile unit and controlled by personnel at the base station.

Radio signal transmission between the mobile unit and base station was ruled out, because the signals might contain sensitive information or the equipment might be used in areas where radio emissions might be undesirable. For cable systems, the integrity of electrical transmissions might be compromised through "leaks" through the outer braid, or a severed cable might serve as a source of ignition in a hazardous area. Based on these constraints, a fiber optic cable was selected to provide the communications link between the battery-powered mobile unit and the base station. We chose to use a 2-fiber Tactical Fiber Optic Cable Assembly (TFOCA) developed for the U.S. military by AT&T. The TFOCA system offers rugged field-cleanable hermaphroditic connector assemblies.

† Work described in this paper was performed under the auspices of the U.S. Department of Energy, Contract DE-AC02-76CH00016

which allow for simple addition of more cable lengths. Designed for field deployment, the connectors may be dropped in the mud, and simply sluiced off with water and re-mated. TFOCA system components include bulkhead connectors, splicing kits, and tools for field repair. Details of TFOCA system components are provided in Appendix B.

Catalog-item fiber optic adapters by Force, Inc., Christiansburg, VA. (703-382-0462) provide sufficient signal-handling versatility that the AT&T cable system may be used for this application. A video signal at 1550  $\eta\text{m}$  and a second video signal at 1300  $\eta\text{m}$ , are combined by a wavelength-division-multiplexer (WDM). A talk set signal at 850  $\eta\text{m}$  is combined with these two signals by using a second WDM, for transmission of the three analog signals over one of the multimode fibers in the TFOCA cable. For digital signals, 8 channels of 100 khz TTL are handled by transmitter/receiver pairs at 1300  $\eta\text{m}$  and at 1300  $\eta\text{m}$  on the second multimode fiber. The TTL signals are configured into 8 channels of RS-232 by Black Box Corp. signal adapters. The arrangement of Force, Inc. adapters is detailed in the first referenced paper.

## BASIC DESIGN CRITERIA

For the remote inspection system designed by BNL, a cart resembling a wheel chair is used for the mobile unit. A cabinet containing the necessary fiber-optic communication electronics is mounted at the seat level, and space is available below the seat level for mounting the reel of fiber optic cable and the cable deployment mechanism. The cable must pay out as the cart is rolled forward, to lie directly onto the floor as the mobile unit straddles it. The unit is not powered: pushing on the cart causes the cable to be stripped from the reel. There should also be a method for conveniently retrieving the cable.

The remote inspection system requires continuous communications during movement of the remote unit and deployment of the fiber optic cable. In addition, there may be times when the cable reel must be dismounted and an additional length of TFOCA cable connected into the system.

Delicate fiber optic components must not be exposed to damage, and the system must be arranged so that personnel only mate the rugged TFOCA connectors. The system must be designed for assembly and use by relatively untrained personnel and without the use of tools or specialized equipment. The system must safely accommodate the weight of the TFOCA cable, which is available from AT&T in lengths of 300 meters (10 kg, 22 lbs) and 1000 meters (33 kg, 73 lbs).

## SELECTION OF DESIGN APPROACH

Fishermen know there are two methods of deploying line: by spooling it off tangent to the reel, as in deep-sea fishing; or by spinning it axially off the end of the reel in loops, as in bass fishing with a spin-cast reel.

In a design attempt to allow long cable runs, BNL constructed loss budgets of signal attenuation occurring in the cable, connectors, WDM's, and active components. If a spooling approach were selected, a rotary joint would be required in order to maintain continuous communication over the fiber optic cable during deployment of the remote inspection system. BNL found a source for the rotary joint, as described later in this paper, and although losses in the rotary joint were nominal, it was early in the design stage and BNL attempted to maintain a conservative approach to

transmitter/receiver signal margins. As a result, the spinning reel approach was selected as the initial design for the cable deployment mechanism.

### SPINNING REEL ARRANGEMENT

In the spinning reel design, the cable reel was mounted to the mobile unit and remained stationary. The free end of the cable was peeled off into a rotating cable guide mounted on the same axis as the reel, and was routed through the guide into a center support where it exited the assembly.

The Force, Inc. and AT&T TFOCA fiber optic communication system performed flawlessly and transparently during field testing of the system, indicating adequate optical signal margin. The spinning reel cable deployment system, however, did not function as designed. The mechanism was cumbersome and unreliable, and was subject to frequent mechanical jams. In addition, the vertical loops of cable left in the mobile unit's wake presented a trip hazard to personnel and threatened to become tangled on equipment.

The spinning reel configuration was abandoned, and the fiber optic rotary joint was re-visited.

### A TWO-CHANNEL FIBER OPTIC ROTARY JOINT

Focal Technologies Incorporated manufactures multiple-fiber rotary joints, with standard designs from 1 to 10 fibers. BNL's application required use of two multimode fibers with simultaneous signal transmission at three wavelengths. Focal provided an off-the-shelf design for BNL, in a package conservatively rated for flux budget purposes at 3.0 dB insertion loss at 1550 and 1300  $\eta\text{m}$ , and 5.0 dB loss at 850  $\eta\text{m}$ . In fact, Focal's final inspection test report shows optical losses as not exceeding 3.0 dB on both fibers at all wavelengths.

Optical Loss S/N 214015	850 $\eta\text{m}$		1300 $\eta\text{m}$		1550 $\eta\text{m}$	
	min	max	min	max	min	max
fiber 1	2.5 dB	3.0 dB	2.0 dB	2.5 dB	2.1 dB	2.6 dB
fiber 2	2.0 dB	2.5 dB	1.6 dB	2.2 dB	1.4 dB	2.0 dB

Communication distances in systems using the fiber optic rotary joint are, of course, limited by total optical insertion loss. Signal attenuation over the fiber optic cable acts to decrease the 12- to 15-dB margin between transmitted signal strength and the sensitivity of the receiver. As a design goal, the minimum communications path margin should be 3 dB. Cable losses are about 1 dB per km, and each connector adds about 1 dB loss. Allowing 3 dB of loss through the rotary joint, Brookhaven's current arrangement will allow communication over more than 1 km of TFOCA cable. For simpler systems, with fewer wavelength-division multiplexers and/or fewer connectors, communication distances may be considerably longer.

Note that decreasing component attenuation to increase distance is not practical; neither is increasing receiver sensitivity. Further, fiber optic amplifiers are not available for multiple wavelengths. The best way to increase maximum transmission distance is to increase the strength

of the transmitted signal. While the described approach uses only currently-available commercial equipment, discussions are under way with Force, Inc. to explore their upgrading the transmitters from using laser diodes to using low-power lasers.

## SPOOLING REEL ARRANGEMENT

The flawless performance of the Force, Inc. fiber optic electronics during field testing indicated that we were not pushing the envelope of optical signal margin. We were unable to make any measurements, since this technology was new to our group and we did not have appropriate optical instrumentation. Depending on conservative manufacturer's data from both Force, Inc. and Focal Technologies, we obtained the required fiber optic rotary joint from Focal, were pleased with loss figures documented in their final inspection test report, and inserted the device into our signal path. The test was successful, and we then started design of the rotary joint/cable reel assembly.

There were conflicting requirements in designing a rugged assembly weighing about 45 kg (100 lbs) and capable of handling 1 km of cable, while protecting the relatively delicate optical fibers and type ST connectors used to link the rotary joint to the TFOCA system. Also, the system must allow the fiber optic rotary joint to be easily transferred to another reel without requiring tools. While mounted on the center of rotation of the reel, the rotary joint is not designed to support any side load which might lead to increased losses and bearing damage. In response to these constraints, a simple and a unique method of cable reel support was designed in which the reel is supported by the cable reel rim.

In the new design, the cable reel rim is supported by 2 inch dia. tubular conveyor rollers, selected because they contain all the components (bearings, axle, housing, etc.) needed to provide the rotary support for the reel assembly. Two conveyor rollers support the reel, and are the only contact with the reel while the mobile unit is being rolled on a level surface. A third roller, mounted above and behind the reel, provides support and allows cable deployment to continue when the mobile unit is tilted, as when carrying the device up a stairway. A removable crossbar is provided to secure the reel in position while the mobile unit may be out of position. A 3/4 inch dia. cam-follower roller installed on each side of the reel keeps the reel centered on the supporting conveyor rollers. An additional conveyor roller is placed below the reel to guide the cable onto the floor, since the reel support rollers are counter-rotating with respect to the cable path and the resulting friction would cause the mechanism to jam.

The dimensions of the mobile unit frame determined the maximum diameter and length of the cable reel. The inside diameter of the core had to be large enough to accommodate the fiber optic rotary joint package, and yet be small enough to permit a full kilometer of cable to be wound on the reel. A dimensional compromise was reached that allowed all requirements to be satisfied, and the reel was made of aluminum to minimize the assembled weight. A 3/4 inch hex nut is provided on the axis of the reel on the end opposite the fiber optic rotary joint to allow connection of a hand or power driven tool to rewind the fiber optic cable after deployment. The total arrangement is mechanically rugged.

The Focal Technologies rotary joint is housed in a stainless steel circular can, measuring about 80 mm (3 in.) in diameter by 100 mm (4 in.) long, with the fiber optic leads extending from each end. Details of the rotary joint are provided in Appendix C. The device itself is rugged, having been designed for marine, defense and industrial environments, and it has been successfully tested to MIL-

STD-167 (shipboard vibration) and in shock to 20g. While the rotary joint does not require protection, the relatively fragile ST fiber optic connectors should not be exposed to damage.

The bulk of the Focal Technologies rotary joint was packaged in a can to house and protect the fiber optic cables and connectors. The can was made large enough to contain the cable and connectors, yet compact enough to permit the entire assembly to be mounted within the core of the cable reel. The two fiber optic leads within the can are mated with an AT&T bulkhead connector, which extends axially from the can. When the rotary joint is to be inserted into the cable reel, the inner end of the cable, which extends into the reel hub, is first mated with the bulkhead connector on the protective can. Then, the rotary joint is inserted into the end of the cable reel until a rim on the housing bottoms on a mounting flange located inside the core of the reel. The can is held in position on the flange by inserting 3 push-button quick-release pins, and it is held tightly with springs. The two fiber optic cables extending outside of the rotary joint and cable reel, which do not rotate with the reel, are protected by a rectangular can which is likewise large enough to contain the cable and connectors. These fibers are mated with an AT&T cable which extends from the can and terminates in a rugged TFOCA connector for handling by personnel.

There may be times when the cable reel/fiber optic rotary joint package assembly must be dismounted and removed from the cart so an additional length of fiber optic cable can be spliced into the system. This simple and unique method of supporting the cable reel by the rim allows a full cable reel to be inserted into the system and the assembly replaced in the cart without the use of any tools or specialized equipment. Fragile components are protected and relatively untrained personnel can perform the task.

In addition to being a simpler design, the rotary joint system will lay cable directly on the floor, without loops of cable produced by the spinning reel arrangement. This design, therefore, presents much less of a trip hazard to operators of the mobile unit, and the cable is less likely to become tangled on equipment in rooms under inspection. Nevertheless, the operators must always be aware of the path of the fiber optic cable.

## PHOTOGRAPHS AND ATTACHMENTS

There are two photographs in Appendix A. The first photograph shows the cable reel and rotary joint in place in the lower section of the mobile unit. The cable reel is loaded with 300 meters of fiber optic cable, and the additional capacity is sufficient for handling a total of 1000 meters. The cable is shown exiting the mobile unit between the reel support roller and the cable guide roller, so that the cable is stripped from the reel when the unit is pushed forward. The vertically-arranged enclosure at the left of the cable reel is the stationary housing of the rotary joint assembly, and the standing fiber optic cable exits the top of the box to connect with the electronics module directly above.

The second photograph in Appendix A shows an "exploded view" of the system components. The rotary joint is shown in the foreground. To assemble the system, the fiber optic cable exiting the reel cavity is plugged onto a bulkhead connector at the rear of the rotary joint assembly, and the assembly is then inserted into the reel cavity. The three quick-release pins are used to secure the components in a fixed position.

Appendix B contains details of the AT&T TFOCA cable system. A 2-fiber multimode cable is used in this equipment, and the selection is indicated by the mark on the first page of this appendix. Details of the cable connectors are provided, as well as the bulkhead connector.

Manufacturer's literature describing the Focal Technologies Inc. fiber optic rotary joint is provided in Appendix C. While the 2-fiber multimode device we used in this project is described, Focal manufactures a variety of electrical slip rings and fiber optic rotary couplings. BNL was very satisfied both with the support Focal provided during the design phase, and with construction and operation of the unit we incorporated into the equipment.

Finally, Appendix D contains drawings we used to fabricate the cable reel and the housing for the fiber optic rotary joint.

#### ACKNOWLEDGEMENTS

The Defense Nuclear Agency funded development of the system requiring the fiber optic communication system. Exploration of expanded applications for the system, as well as development of the method of cable deployment by using a fiber optic rotary joint, was funded by the Department of Energy, Office of Safeguards and Security.

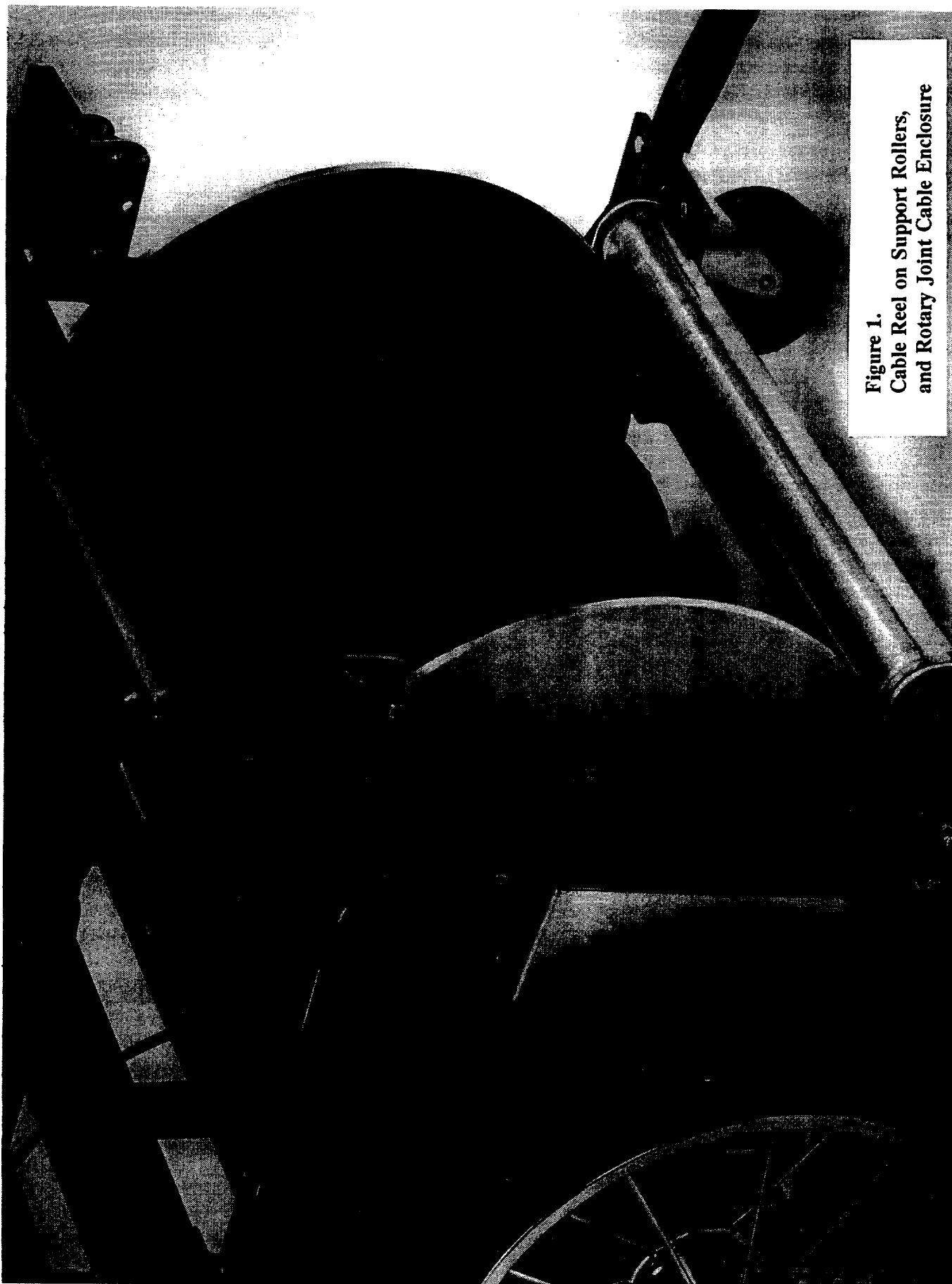
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1. Joseph A. Curtiss and Joseph P. Indusi, "Managed Access by Controlled Sensing (MACS)," *INMM 35th Annual Proceedings*, July 1994, Vol. XXIII., pp. 794-799.
2. Joseph A. Curtiss and Joseph P. Indusi, "MACS as a Tool for International Inspections," *INMM 36th Annual Proceedings*, July 1994, Vol. XXIV.

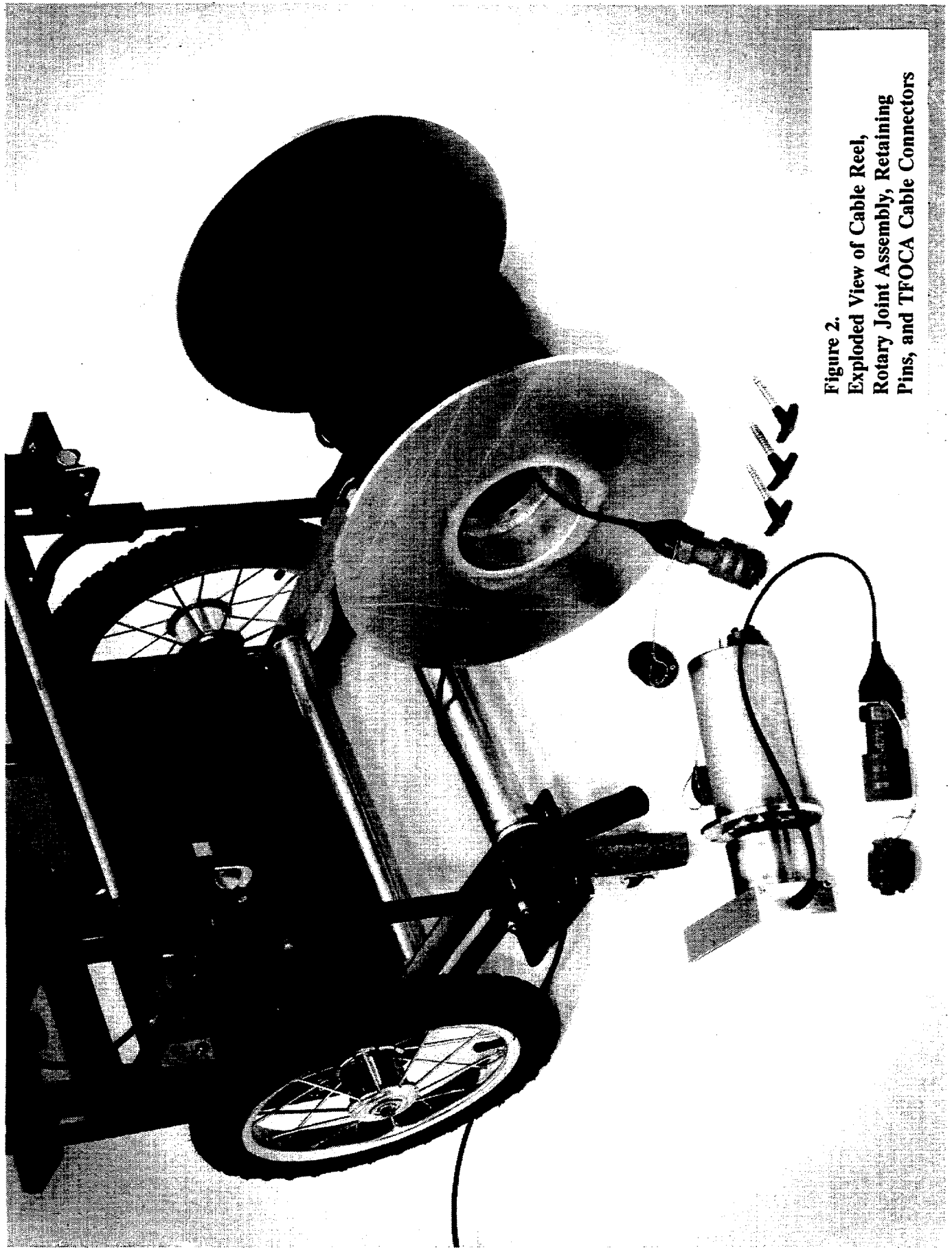
#### APPENDICES

- A. Photographs
- B. AT&T TFOCA Cable
- C. Fiber Optic Rotary Joint
- D. Fabrication Drawings

**Appendix A.  
Photographs**



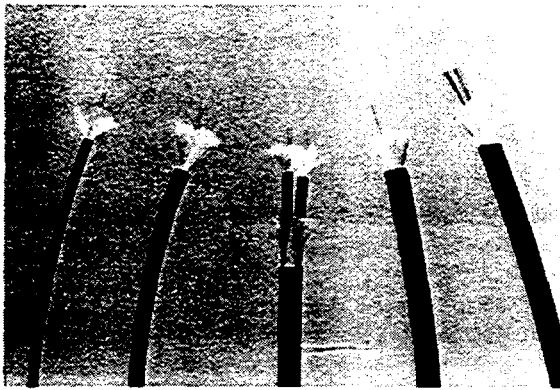
**Figure 1.**  
**Cable Reel on Support Rollers,**  
**and Rotary Joint Cable Enclosure**



**Figure 2.**  
**Exploded View of Cable Reel,**  
**Rotary Joint Assembly, Retaining**  
**Pins, and TFOCA Cable Connectors**

**Appendix B.**  
**AT&T TFOCA Cable**

# Singlemode and Multimode *LIGHT FORCE*<sup>TM</sup> Cables LTC Tactical Cables



Tactical Cable

LTC tactical cables are of a ruggedized design for harsh environment applications. They were specifically engineered to satisfy the stringent environmental and mechanical requirements for United States military tactical operations. These cables consist of 1, 2, or 4 radiation-hardened multimode or singlemode fibers. Each 100-Kpsi fiber has a dual acrylate coating and a 900- $\mu$ m polyester elastomer buffer. For the 1-fiber cables, Aramid yarns are stranded over the buffered fiber and the flame-retardant polyurethane outer jacket is extruded over the yarn. For the 2- and 4-fiber cables, the buffered fibers are twisted together, forming the center of the cable. *Kevlar*<sup>®</sup> yarns are stranded around the buffered fibers in two opposing layers to provide a torque-balanced design. Completing the all-dielectric cable are four evenly spaced reinforcing elements and a flame-retardant polyurethane jacket extruded directly over the *Kevlar* yarns. A duplex version is also available which consists of two 0.10-inch (2.5-mm) single-fiber cables covered with Aramid yarn and a common flame-retardant jacket.

**Note:** Ruggedized single-fiber and 2-fiber connectors are available for these cables and can also be found in this section of this catalog. For a copy of cable performance test results, contact your AT&T sales representative.

#### Technical Specifications:

Cable Designs:	1, 2, and 4 fiber
Fiber Types*:	
Multimode:	50/125 $\mu$ m*, 62.5/125 $\mu$ m*, 100/140 $\mu$ m
Singlemode:	8.3/125 $\mu$ m*
Fiber Diameter:	
With Coating:	250 $\mu$ m
Buffered:	900 $\mu$ m
Attenuation	
(Multimode) @ 850/1300 nm:	$\leq$ 3.75/1.5 dB/km (50 $\mu$ m RH) $\leq$ 4.0/1.5 dB/km (62.5 $\mu$ m RH) $\leq$ 6.0/3.0 dB/km (100 $\mu$ m)
(Singlemode) @ 1310/1550 nm:	$\leq$ 0.5/0.4 dB/km (depressed clad) $\leq$ 0.5/0.35 dB/km (dispersion shifted)
Bandwidth:	
(Multimode) @ 850/1300 nm:	160/400 MHz km (50 $\mu$ m RH) 160/350 MHz km (62.5 $\mu$ m RH) 100/100 MHz km (100 $\mu$ m)
Operating Temperature Range:	-67°F to +185°F (-55°C to +85°C)
Tensile Strength:	100 Kpsi

\* Fibers meet radiation requirements for MIL-F-49291B.

#### Cable Specifications:

Description	Single Fiber	Duplex	2- and 4-Fiber
Outside Diameter	0.10 in. (2.5 mm), 0.16 in. (4.0 mm)	0.24 in. (6.0 mm) oval	0.24 in. (6.0 mm)
Weight	0.40 lb./100 ft. (6 kg/km), 1.00 lb./100 ft. (15 kg/km)	0.80 lb./100 ft. (12 kg/km)	2.13 lbs./100 ft. (32 kg/km)
Bend Radius	0.25 in. (6.35 mm), 0.40 in. (10.0 mm)	0.25 in. (6.35 mm)	0.59 in. (15.08 mm)
Tensile Load	270 N, 1350 N	270 N	1780 N

## Tactical Cable Ordering Information

### Cable Code Identifiers:

- 1st Grouping: LTC = Lightguide Tactical Cable
- 2nd Grouping: 1st field: # fibers;  
 2nd field: L = 62.5  $\mu$ m, M = 50  $\mu$ m, C = 100  $\mu$ m, S = Singlemode, D = Dispersion Shifted;  
 3rd field: H = Radiation Hardened, X = unused;  
 4th field: S = 2.5 mm (0.10 in.), R = 4.0 mm (0.16 in.)  
 5th field: D = Duplex
- 3rd Grouping: 1st field: A = Version
- 4th Grouping: 1st field: C = Connector installed on each end of cable, X = unused;  
 2nd field: /1000 or /300 = Cable Assembly length in meters

**Note:** All cables come standard on wood or fiberboard reels (65 pounds [29.25 kg]) unless otherwise ordered. Optional lightweight reels available are for 300 meters (13 pounds [5.9 kg]) and 1000 meters (18 pounds [8.2 kg]). All cables meet military specifications MIL-C-85045E unless otherwise noted.

### Single-Fiber Cable

Product Code	Fibers	Fiber Type	Cable OD	Comcode	Mil Spec
LTC-1MHS-A-X	1	50 $\mu$ m	0.10 in. (2.5 mm)	105 362 750	MIL-C-85045E
LTC-1MHR-A-X	1	50 $\mu$ m	0.16 in. (4.0 mm)	105 736 227	MIL-C-85045E
LTC-1LHS-A-X	1	62.5 $\mu$ m	0.10 in. (2.5 mm)	105 362 784	MIL-C-85045E
LTC-1CXS-A-X	1	100 $\mu$ m	0.10 in. (2.5 mm)	105 292 402	MIL-C-85045E
LTC-1SXS-A-X	1	Singlemode	0.10 in. (2.5 mm)	105 363 204	MIL-C-85045E
LTC-1SXR-A-X	1	Singlemode	0.16 in. (4.0 mm)	105 736 219	MIL-C-85045E
LTC-1DXS-A-X	1	Dispersion Shifted	0.10 in. (2.5 mm)	105 556 567	MIL-C-85045E

### Duplex Cables

Product Code	Fibers	Fiber Type	Cable OD	Comcode	Mil Spec
LTC-2MHSD-A-X	2	50 $\mu$ m	0.24 in. (6.0 mm)	106 883 333	MIL-C-85045E
LTC-2LHSD-A-X	2	62.5 $\mu$ m	0.24 in. (6.0 mm)	106 883 358	MIL-C-85045E
LTC-2SXSD-A-X	2	Singlemode	0.24 in. (6.0 mm)	106 883 374	MIL-C-85045E

### 2- and 4-Fiber Cables

Product Code	Fibers	Fiber Type	Cable OD	Comcode	Mil Spec
LTC-2MH-A-X	2	50 $\mu$ m	0.24 in. (6.0 mm)	105 331 631	MIL-C-85045E/8
LTC-2LH-A-X	2	62.5 $\mu$ m	0.24 in. (6.0 mm)	105 672 356	MIL-C-85045E/8
LTC-2SX-A-X	2	Singlemode	0.24 in. (6.0 mm)	105 297 410	MIL-C-85045E/8
LTC-4MH-A-X	4	50 $\mu$ m	0.24 in. (6.0 mm)	106 082 936	MIL-C-85045E
LTC-4LH-A-X	4	62.5 $\mu$ m	0.24 in. (6.0 mm)	106 082 944	MIL-C-85045E
LTC-4SX-A-X	4	Singlemode	0.24 in. (6.0 mm)	106 082 951	MIL-C-85045E

Lightweight Mil Spec Cable Reels	Comcode
300-Meter Capacity	106 548 290 (Replaces RC 435/U)
1000-Meter Capacity	106 548 308 (Replaces RC 453B/G)

# Singlemode and Multimode *LIGHT FORCE* Tactical 2-Fiber Connector



Tactical 2-Fiber Connector Assembly

AT&T 2-fiber tactical connectors are specifically engineered to satisfy the stringent environmental and mechanical requirements for tactical military and heavy-duty commercial applications. The connector and housing assembly are hermaphroditic, facilitating nonselective coupling with similar connectors. This ruggedized connector and housing will withstand the repeated handling and connection/disconnection cycles typically required for rapid fiber optic cable deployment and retrieval in a tactical or commercial harsh environment application, and will continue to maintain stable connector performance.

This 2-fiber connector's unique design and environmentally protected construction provide protection from high compressive and tensile loads, dust, and dirt. In addition, waterproof seals at every interface ensure outstanding resistance to moisture penetration. Every connector is protected by its own captive hermaphroditic dust cover and is color-coded to differentiate singlemode from multimode models. Additionally, the hermaphroditic forward ends differ to make it impossible to accidentally mate singlemode and multimode connectors. The cable termination is designed to firmly anchor the cable to the connector housing without special tooling. These connectors are field-mountable and repairable with the 1A Lightguide Repair Kit or can be ordered as a complete cable/connector assembly. Cable assemblies have been tested in accordance with DOD-STD-1678 and MIL-STD-810C. The connector meets the requirements of MIL-C-83526/12-01.

**Note:** For a copy of the connector performance test results, contact your AT&T sales representative. For descriptions of cables and bulkhead connectors which are complementary to this product, see this section of catalog.

#### Technical Specifications:

**Materials:** Olive drab cadmium over aluminum housing, stainless steel cable retention hardware, elastomer seals

**Insertion Loss:** (Plug to plug, plug to bulkhead)

Multimode: 1.0 dB max.

Singlemode: 0.8 dB max.

**Connector Dimensions:**

Outside Diameter: 1.57 in. (4.0 cm)

Weight: 10.16 oz. (290.5 g)

Length (excluding bend limiter): 3.0 in. (7.62 cm)

**Temperature Range:** -67°F to +185°F (-55°C to +85°C)

**Mating Durability:** Multimode: 2000 cycles

Singlemode: 1000 cycles

### Tactical 2-Fiber Connector Ordering Information

**Note:** To field assemble this connector, you will need a TFOCA Connector (D-181577 Kit of Parts), a Consumables Kit (D-181576), the 1031A Tool Kit, and a 1026A Tool (Heat Stripper for *Hytrel*® Buffered Fiber). These parts, with the exception of the stripper tool, are included in the 1A Repair Kit.

- **Tactical 2-Fiber Connector Repair Kit** (Contains all parts required to assemble twelve connectors.)

Product Code	Fiber Type	Comcode
1A Repair Kit	All	105 198 386

- **Tactical 2-Fiber Cable Repair Kit**

Product Code	Fiber Type	Comcode
2A Repair Kit	All	105 336 390

- **Consumables Kit**

Product Code	Fiber Type	Comcode
D-181576	All	105 213 136

- **Tool Kit**

Product Code	Fiber Type	Comcode
1031A1	All	104 369 996
1026A	All	105 514 764

- **Assembly Instruction Manual**

**Comcode:** 106 826 241

**Note:** All factory-installed connectorized assemblies listed below meet military specification MIL-C-49292/7A. All cable assemblies come standard on wood or fiberboard reels (65 pounds [29.25 kg]) unless otherwise ordered. Optional lightweight Mil spec reels are available for 300-meter (13-pound [5.9 kg]) and 1000-meter (18-pound [8.2 kg]) assemblies. A 3-day Training Course (ND2641) is available for TFOCA Retermination and Repair.

- **Tactical 2-Fiber Connector Assembly** (Includes cable with two factory-installed connectors.)

Product Code/Length (Meters)	Fiber Type	Comcode
LTC-2MH-A-C/1000	50 μm	105 243 331
LTC-2MH-A-C/300	50 μm	105 243 349
LTC-2SX-A-C/1000	Singlemode	105 544 506
LTC-2SX-A-C/300	Singlemode	105 544 514

- **Customized Tactical 2-Fiber Connector Assembly** (Customer-specified cable length with two factory-installed connectors.)

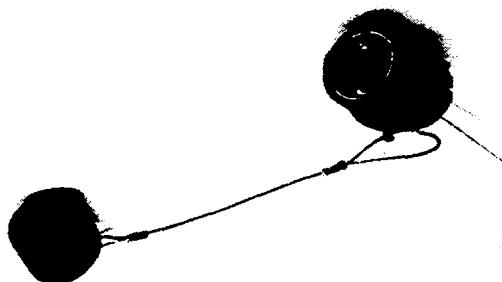
Fiber Type	Connector Comcode	Equipped with Cable Comcode
50 μm or 62.5	105 243 612	105 331 631
Singlemode	105 552 277	105 297 410

- **Lightweight Mil Spec Cable Reels**

Product Code	Comcode
300-Meter Capacity	106 548 290
1000-Meter Capacity	106 548 308

# Singlemode and Multimode *LIGHT FORCE* Tactical 2-Fiber Bulkhead Connector

The AT&T Tactical 2-Fiber Bulkhead Connector is engineered to satisfy the stringent environmental and mechanical requirements for tactical military and heavy-duty commercial applications. These duplex bulkhead connectors are hermaphroditic to facilitate non-selective coupling with 2-Fiber Tactical Connectors, while the connector tips differ so as to make it impossible to mate singlemode and multimode connectors by accident. Each bulkhead connector is protected by a captive hermaphroditic dust cover. These connectors can be ordered with various cable and buffered fiber configurations for splicing to terminal equipment. Back-to-Back Bulkhead Couplers are also available for 2-Fiber Tactical Connector and ST connector-to-connector applications.



Tactical 2-Fiber Bulkhead Connector

**Note:** For descriptions of 2-Fiber Tactical Connectors, Mil ST Connectors and Cables which are complementary to this product, see this section of the catalog. Ask your AT&T sales representative about customized variations for Bulkhead Connector assemblies.

#### Technical Specifications:

Insertion Loss (plug to bulkhead):

Multimode: 1.0 dB max.

Singlemode: 0.8 dB max.

Temperature Range: -67°F to +185°F (-55°C to +85°C)

#### Tactical 2-Fiber Bulkhead Connector Ordering Information

- **Bulkhead Connector with Two Factory-Installed Mil ST Connectors** (Bulkhead Connector is Jamb Nut Mount type. Mil ST connectors are Non-Optical Disconnect type. Cable is Duplex Tactical type.)

Fiber Type	Cable Length	Comcode	Mil Spec/Slash Sheet-Part No.
50 $\mu$ m	3.28 ft. (1.0 m)	106 612 336	MIL-C-83526/13
50 $\mu$ m	6.56 ft. (2.0 m)	106 612 344	MIL-C-83526/13
50 $\mu$ m	9.84 ft. (3.0 m)	106 612 351	MIL-C-83526/13

- **Bulkhead Connector with Buffered Fiber Pigtailed** (Bulkhead Connector is Jamb Nut type.)

Fiber Type	Pigtail Length	Comcode	Mil Spec/Slash Sheet-Part No.
50 $\mu$ m	3.28 ft. (1.0 m)	105 243 596	MIL-C-83526/13-01
Singlemode	3.28 ft. (1.0 m)	105 544 431	MIL-C-83526

- **Bulkhead Connector with Buffered Fiber Pigtailed** (Bulkhead Connector is Rear Mount type.)

Fiber Type	Pigtail Length	Comcode	Mil Spec/Slash Sheet-Part No.
50 $\mu$ m	3.28 ft. (1.0 m)	105 513 477	MIL-C-83526

- **Back-to-Back Bulkhead Coupler** (For joining two 2-Fiber Tactical Connectors.)

Comcode	Mil Spec/Slash Sheet-Part No.
105 510 176	MIL-C-83526

- **Back-to-Back Bulkhead Coupler** (For joining one 2-Fiber Tactical Connector with two *ST* connectors.)

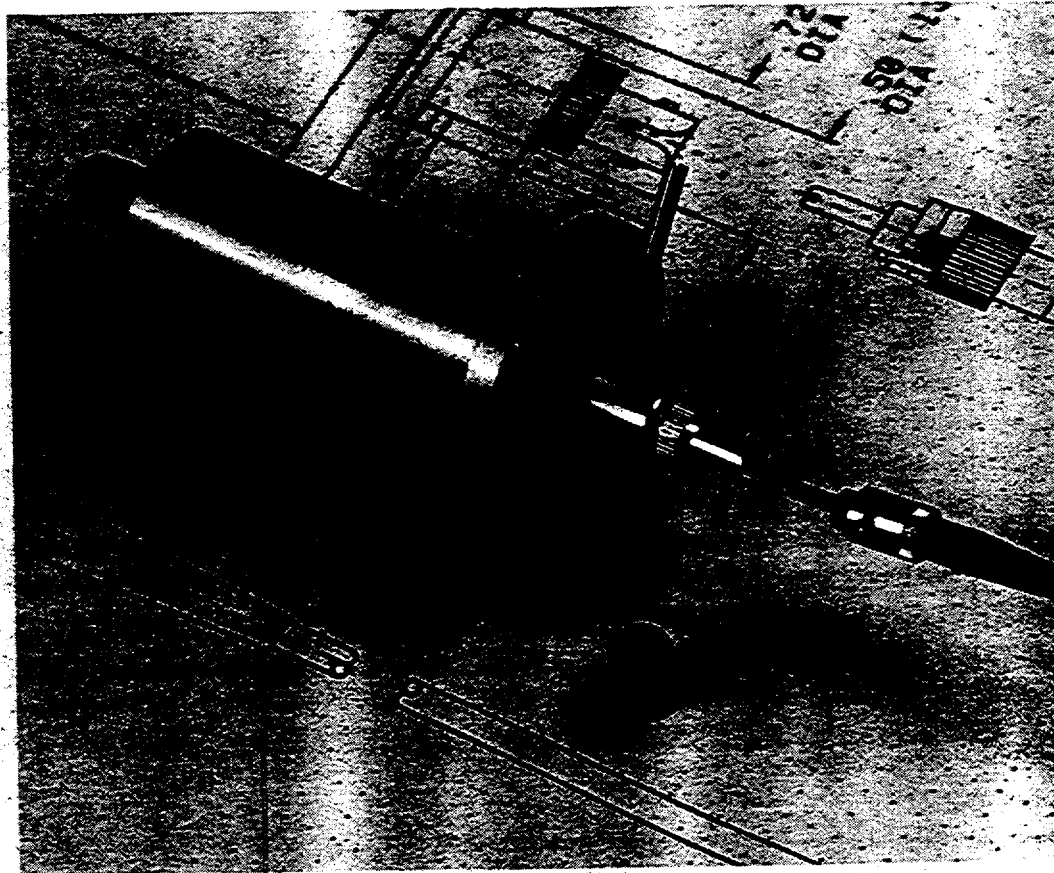
Comcode	Mil Spec/Slash Sheet-Part No.
106 072 390	MIL-C-83526

- **Loop Back Test Plug** (For terminating and testing cables or receptacles.)

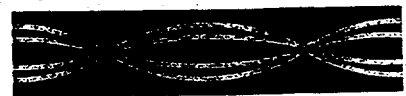
Comcode	Optical Loss (1290 nm)	Mil Spec/Slash Sheet-Part No.
106 662 679	0.0 dB	MIL-C-83526/14-01
106 662 687	23.5 dB	MIL-C-83526/14-02
106 662 695	10.0 dB	MIL-C-83526/14-03
106 662 703	15.0 dB	MIL-C-83526/14-04
106 662 711	20.0 dB	MIL-C-83526/14-05

**Appendix C.**  
**Fiber Optic Rotary Joint**

**FIBER OPTIC ROTARY JOINTS  
ELECTRICAL SLIP RINGS  
FLUID ROTARY UNIONS**

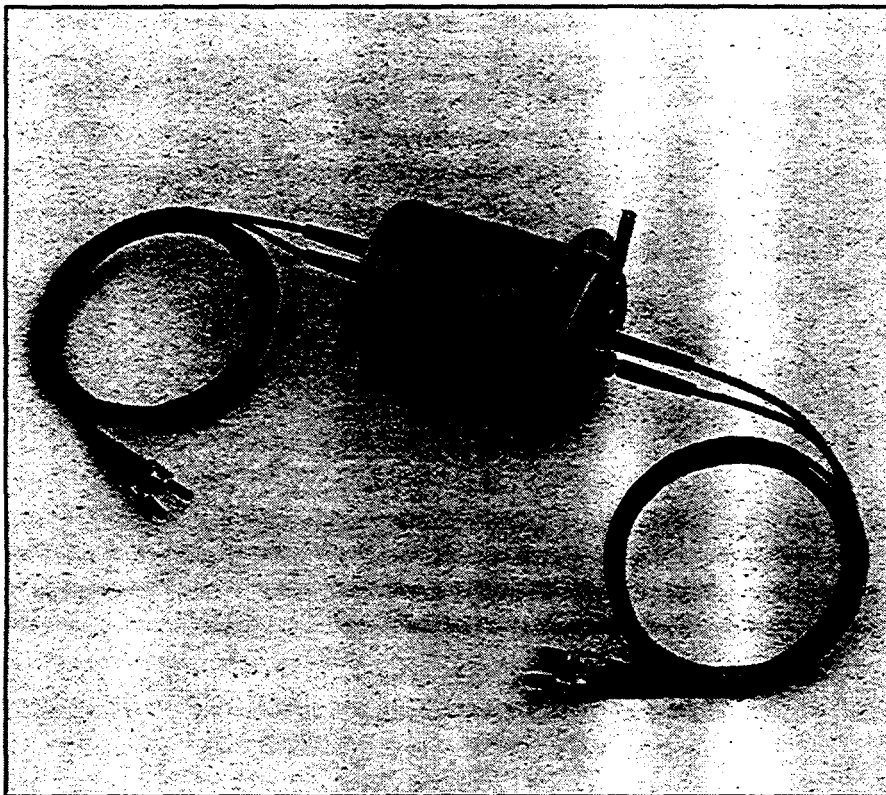


**FOCAL**



# Fiber Optic Rotary Joint

## Model 214



### Features

The Model 214 has been designed to meet the demand for a compact, two-pass fiber optic rotary joint (FORJ). It is passive and bidirectional, and allows the transfer of signals on two separate optical fibers across rotational interfaces. The Model 214 fits into the enclosure of the compact Focal Model 180 electrical slip ring, giving the bandwidth of optical fiber combined with electrical power in a single convenient package, with ISO 9000 quality.

### Applications

Industrial machine tools, material handling systems, towed array winches, dipping sonar reels, turrets, robots and ROV handling systems.



For further information contact:

**Focal Technologies Inc.**  
40 Thornhill Drive, Unit 7  
Dartmouth, Nova Scotia  
Canada B3B 1S1

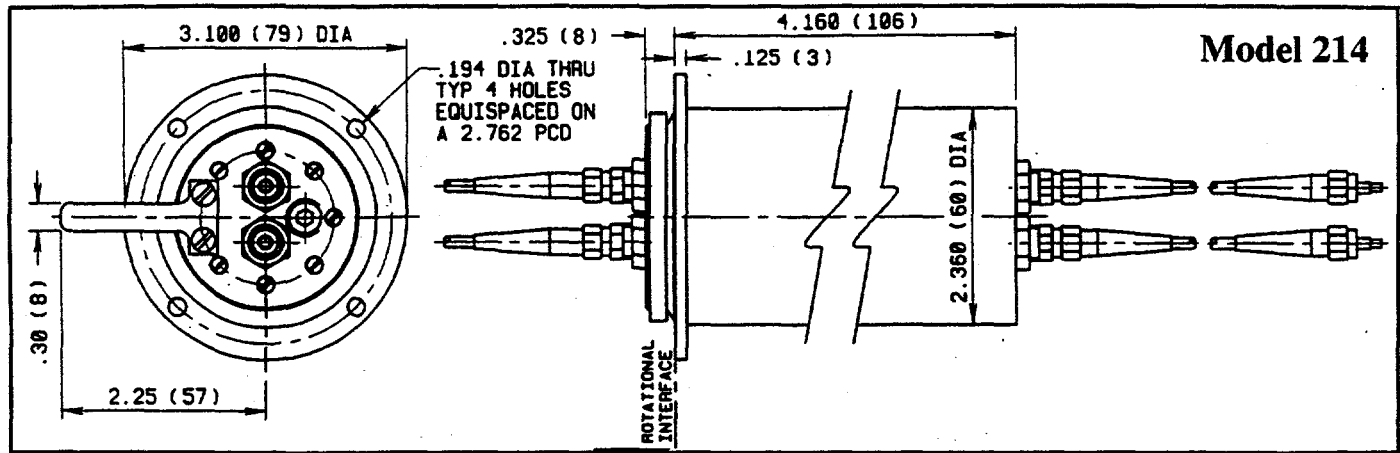
Tel: (902) 468-2263

Fax: (902) 468-2249

Toll free in USA: 1-800-361-2263



Notes: All measurements shown are in inches (mm).  
Specifications subject to change without notice.



10/94

### Options

**Hybrid Units:**

Combined with electrical and/or fluid slip rings.

**Pressure-compensation:**

Fluid-filling for deep submergence to 10,000 psi (69,000 kPa).

**Fiber Size (µm):**

200/230 available at higher insertion loss (consult factory).

**Mounting:**

Customized mounting flange available.

**Materials:**

Anodized aluminum exterior.

**Pigtail Length:**

As required.

**Connectors:**

Installation of other connectors.

**Lower Return Loss:**

Consult factory.

### Specifications

**Insertion Loss:**

3.0 ± 0.5 dB for 50/125, 62.5/125 or 100/140 µm fiber.

**Return Loss:**

-10 dB dry.

**Wavelengths:**

850, 1300 or 1550 nm.  
Consult the factory for multiple wavelength operation.

**Crosstalk:**

< -90 dB.

**Dispersion:**

< 5 picoseconds (calculated).

**Rotational speeds:**

Up to 100 rpm dry and 60 rpm fluid-filled. Higher speeds are possible but should be discussed with the factory.

**Temperature:**

-40 to +60 deg Celsius.

**Vibration:**

Tested to MIL-STD-167-1 (Ships).

**Exterior Materials:**

Stainless steel.

**Terminations:**

24 inch (600 mm) long pigtails of loose tube construction; each fiber with a .125 inch (3 mm) diameter PVC jacket, Kevlar strength member; ST connector each end.



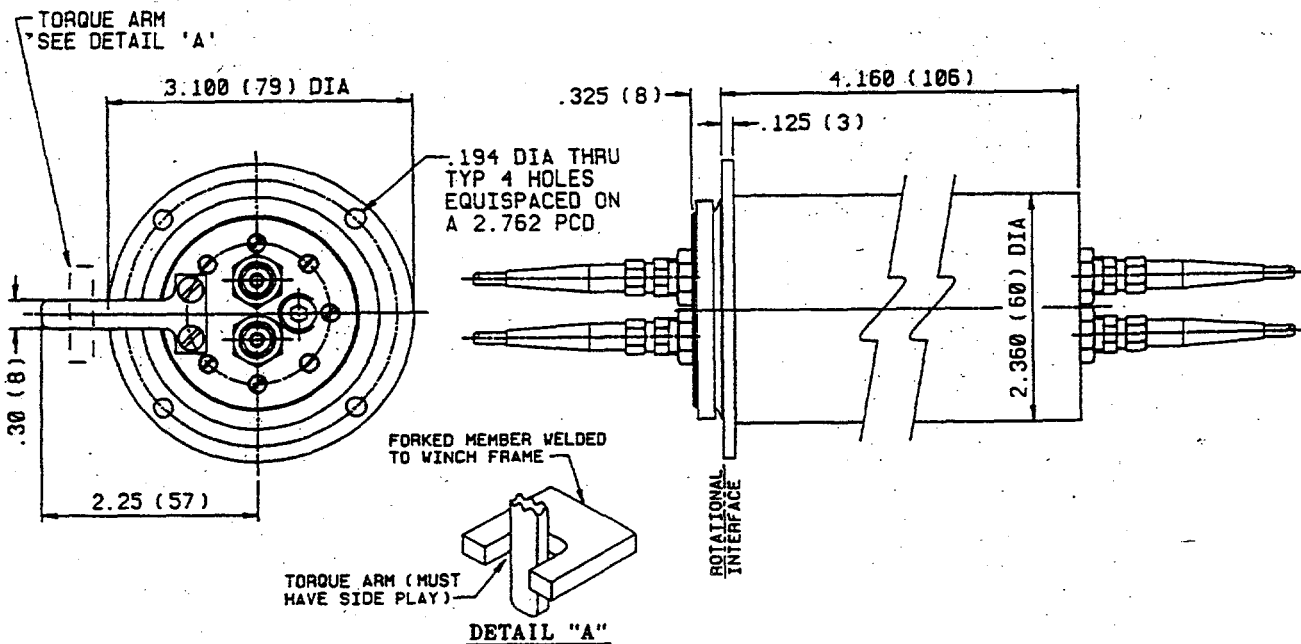
Focal Technologies Inc.  
40 Thornhill Drive, Unit 7, Dartmouth  
Nova Scotia, Canada B3B 1S1  
Tel: 902-468-2263 Fax: 902-468-2249

### MODEL 214 FORJ MOUNTING

Mounting of the FORJ is extremely critical to its proper operation and if done incorrectly will result in increased optical loss as well as mechanical damage to the unit. For these reasons FOCAL recommends that the unit be installed in a Model 180 type enclosure at the factory; however, if the customer wishes to mount the FORJ themselves, the following is the only method suitable for proper operation.

The Model 214 FORJ must be hard mounted to the stationary frame of the enclosure from the four .19 inch diameter holes in the mounting flange, shown below, such that the central axis of the FORJ is co-axial with the rotating element which will in turn drive the FORJ. The actual FORJ shaft rotation must be done in such a way that no side load or eccentric loading of the FORJ shaft occurs. This is done by "loose dogging" the TORQUE ARM. At no point must the drive mechanism impart any side load or offset driving load to the FORJ shaft.

In addition to the mounting, the Model 214 FORJ must be isolated from any environmental conditions such as excessive humidity, moisture, dust or any type of mechanical damage. This is best accomplished by installing the FORJ in a suitable enclosure.



**Appendix D.**  
**Fabrication Drawings**

BY J. JAHELKA DATE 04/06/95

SUBJECT ROTARY JOINT

SHEET No. 1 OF 1

CHKD. BY \_\_\_\_\_ DATE \_\_\_\_\_

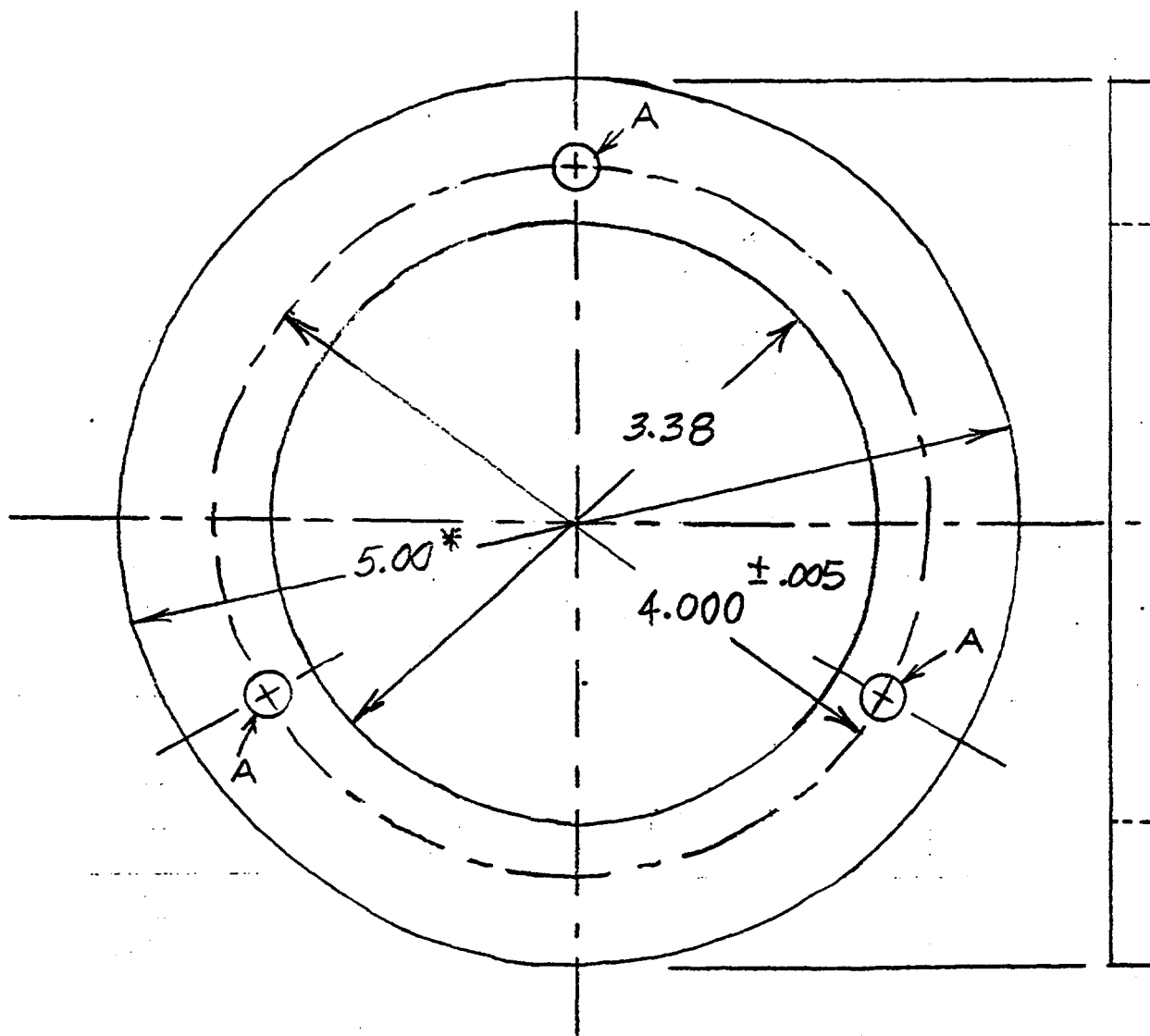
MOUNTING RING - ALUM

JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE / ACRS

SK-JRJ504066



HOLES: A - .250 REAM - 3 PLCS EQUALLY SPACED  
HOLE PATTERN MUST MATCH RING - SK-JRJ504067

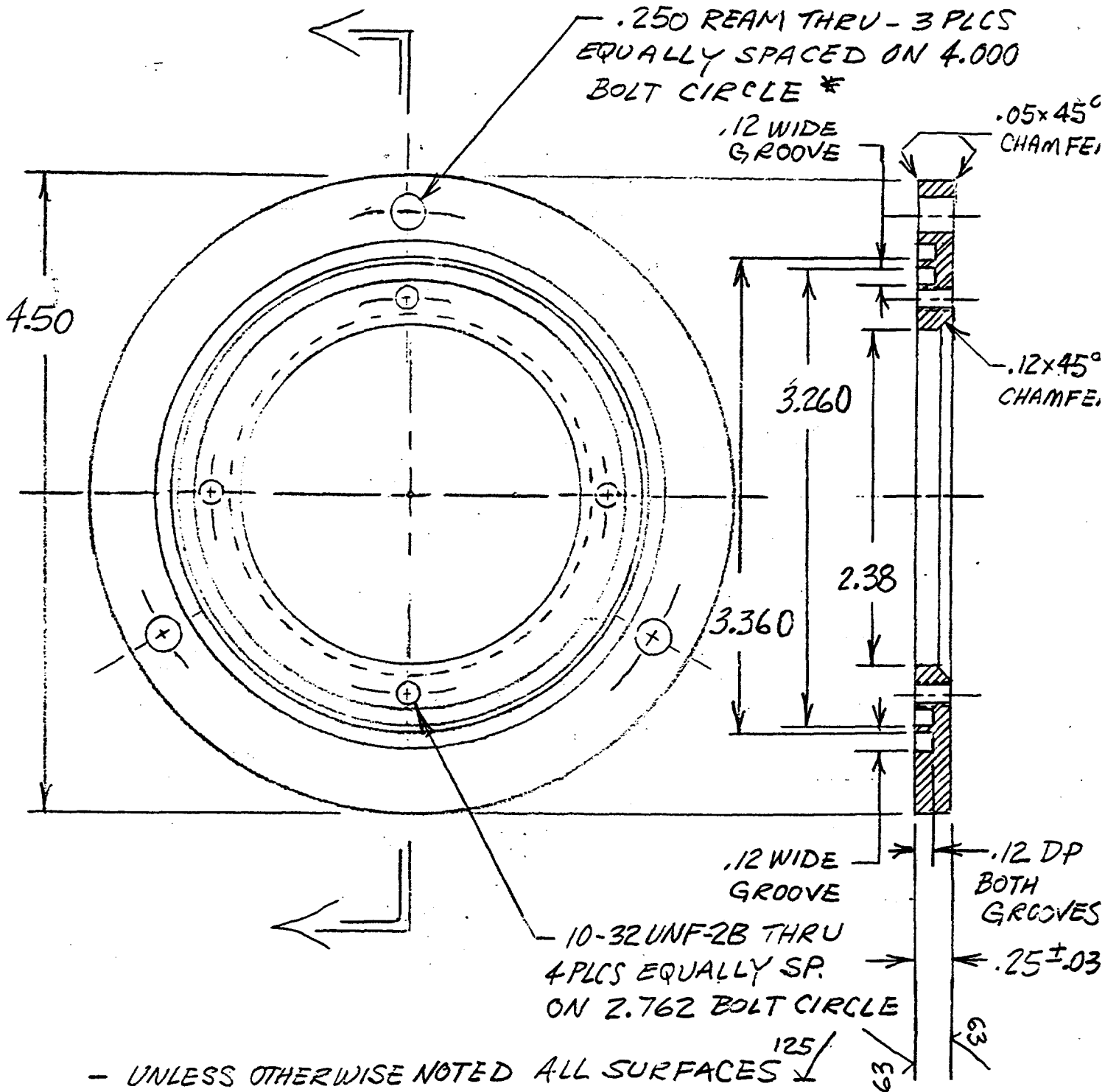
\* OUTSIDE DIAMETER MUST BE SNUG FIT INSIDE  
TUBE - SK-JRJ504068

MATERIAL: F02810 1/4" 6061-T6 ALUM PLATE  
CHAMFER ALL CUT EDGES .03 x 45°

BY J. JAHNELKA DATE 04/06/95  
CHKD. BY \_\_\_\_\_ DATE \_\_\_\_\_  
QTY PER ASSY - 1

SUBJECT ROTARY JOINT  
MOUNTING RING - ST. STL  
DEPT. OR PROJECT DOE/ACRS

SHEET No. 1 OF 1  
JOB No. 04845  
SK-JRJ504067



- UNLESS OTHERWISE NOTED ALL SURFACES  $\sqrt{125/63}$
- GROOVES ARE WELD PREPS AND MAY HAVE RADIUSED CORNERS AT BOTTOM.
- MATERIAL: 304 STAINLESS STEEL
- \* HOLE PATTERN MUST MATCH RING - SK-JRJ504066

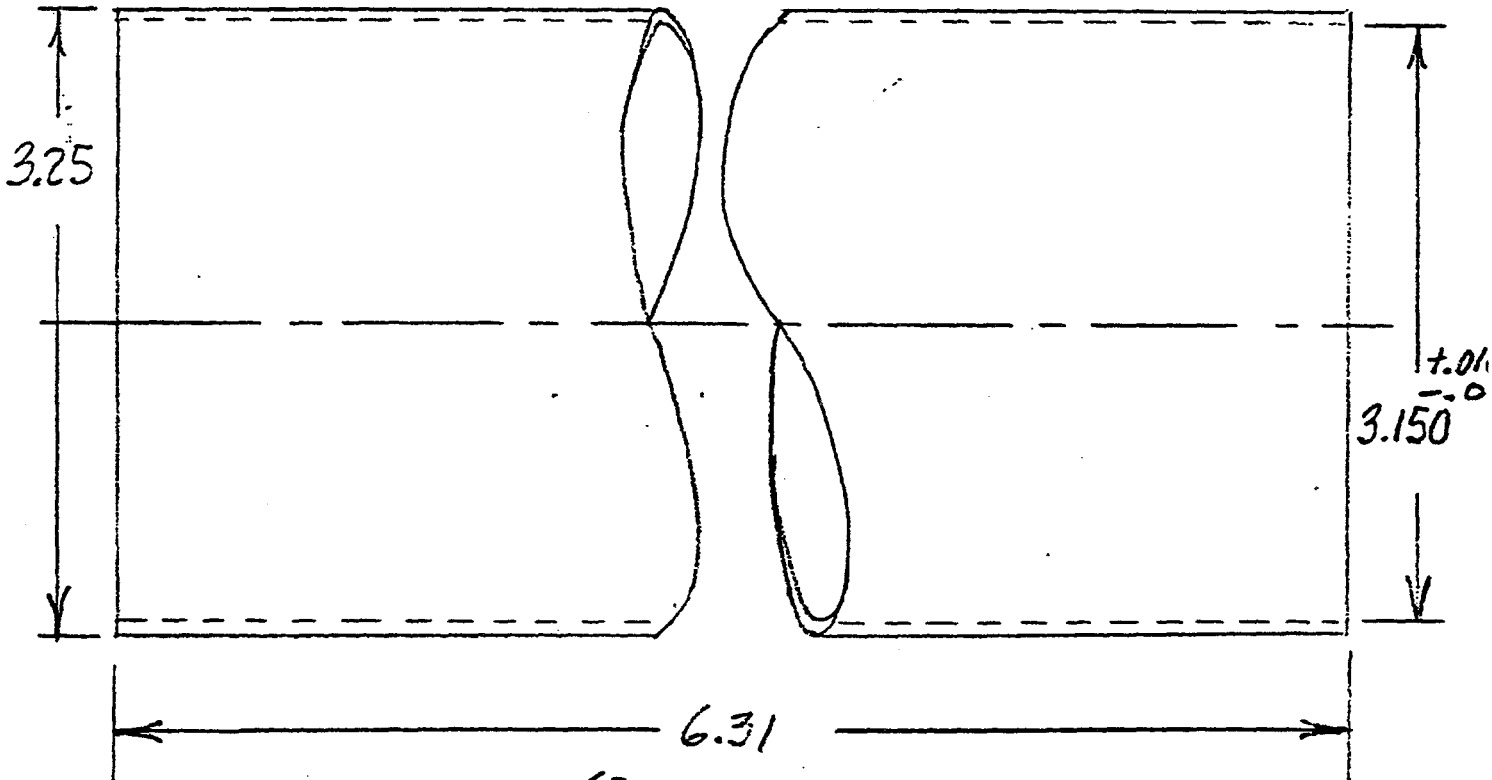


BROOKHAVEN NATIONAL LABORATORY

BY: J. JAHLEKA DATE: 04/07/95  
CHKD. BY: \_\_\_\_\_ DATE: \_\_\_\_\_  
QTY PER ASSY - 1

SUBJECT: ROTARY JOINT FIXED  
END CAN BODY  
DEPT. OR PROJECT: DOE/ACRS

SHEET No. 1 OF 1  
JOB No. 04845  
SK- JRJ504073



CUT SURFACES <sup>63</sup>✓

MATERIAL: 304 STAINLESS STEEL  
CAN BE MADE FROM - 3" SCHEDULE 40 PIPE  
REF DIMENSIONS 3.50 OD X 3.068 ID X .216 WALL

BY J. JAHNELKA DATE 04/07/95

SUBJECT ROTARY JOINT FIXED

SHEET No. 1 OF 1

CHKD. BY DATE

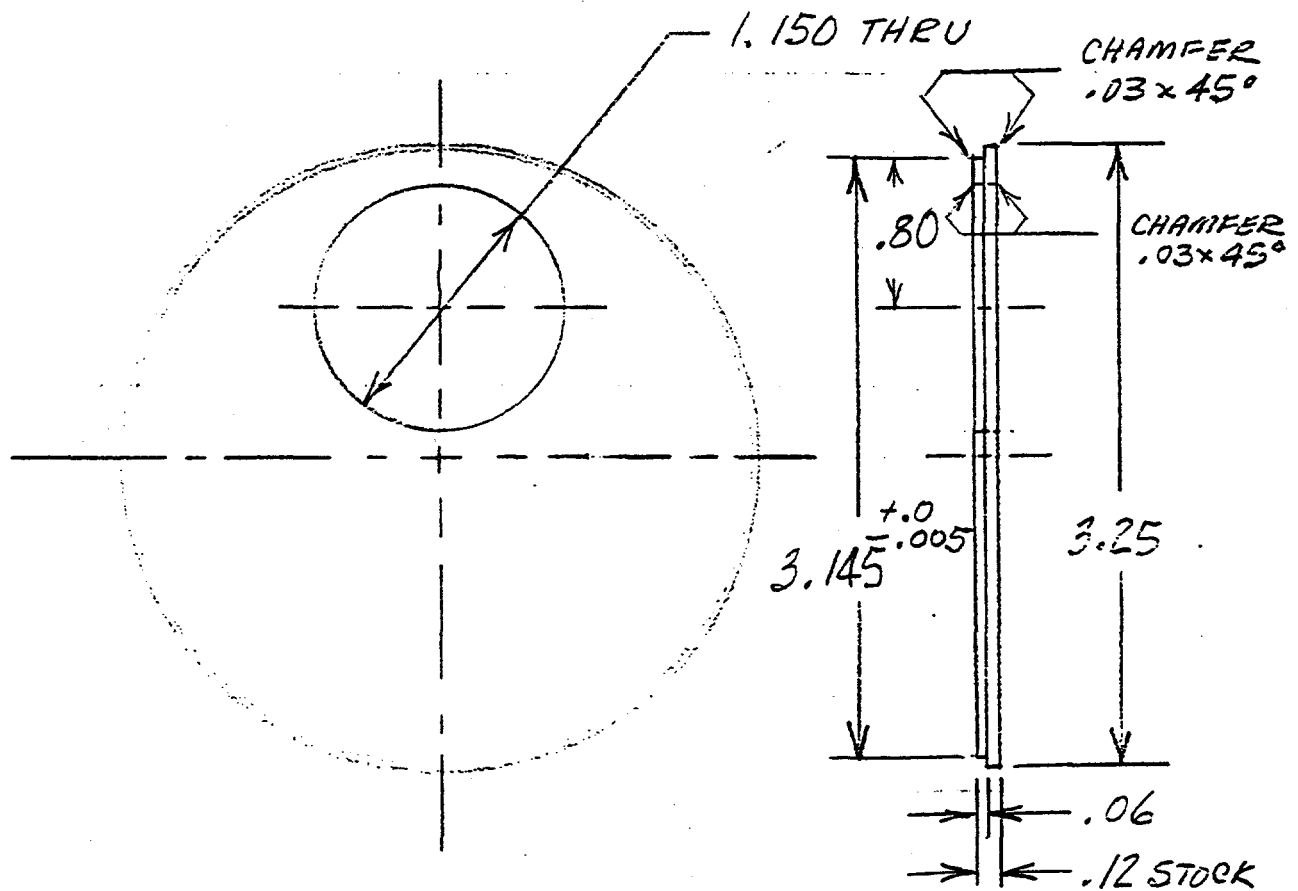
END CAN - BOTTOM

JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE/ACRS

SK-JRJ504074



CUT SURFACES 125

MATERIAL: 304 STAINLESS STEEL

BY J. JAHNELKA DATE 04/11/95

SUBJECT MOVEABLE CAN  
WELDMENT

SHEET No. 1 OF 1

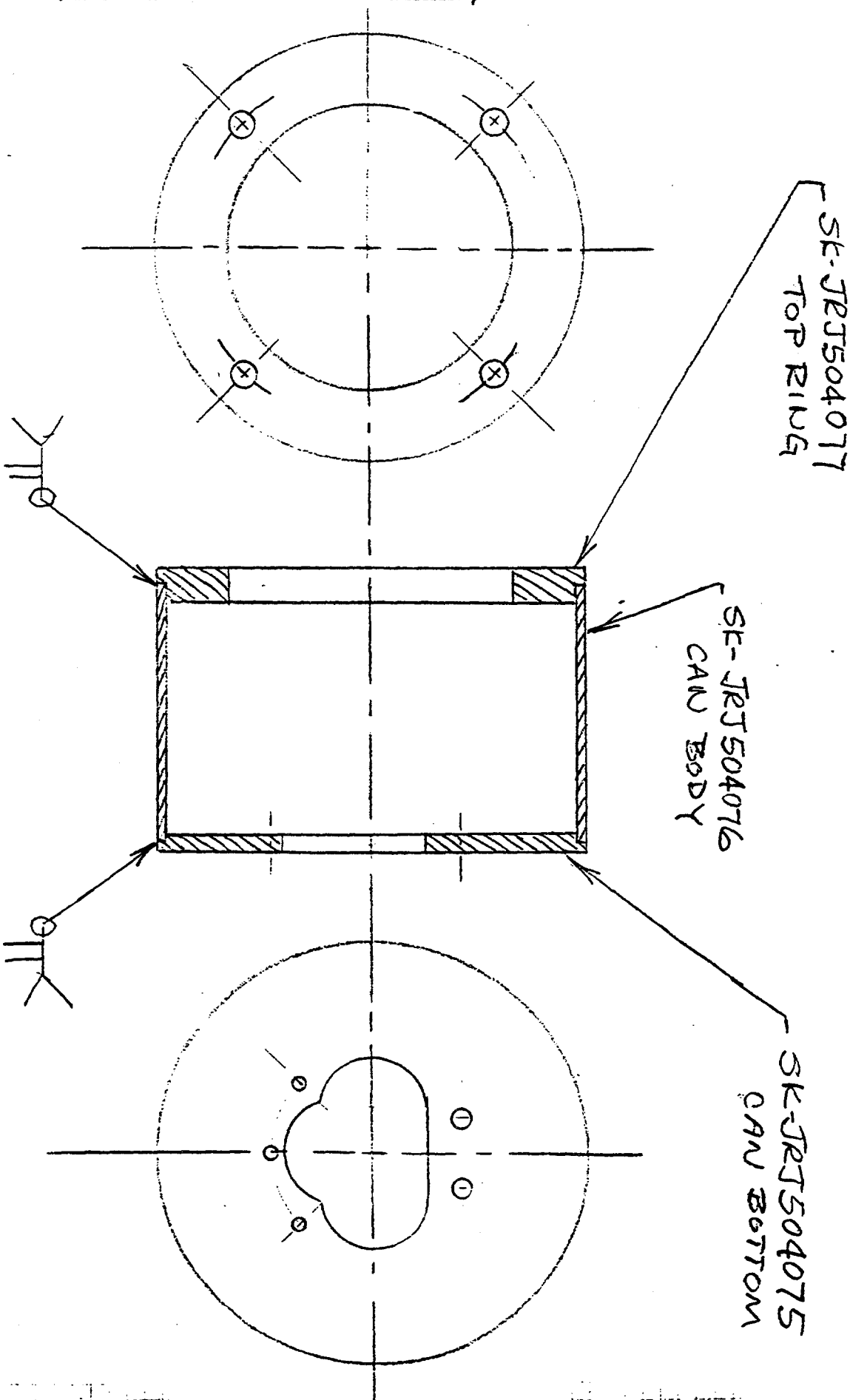
CHKD. BY \_\_\_\_\_ DATE \_\_\_\_\_

JOB No. 04845

QTY PER ASSY. 1

DEPT. OR PROJECT DOE/ACRS

SK-JRJ504112



BOLT HOLE ORIENTATION TO BE NOMINALLY AS SHOWN - ALIGNMENT IS NOT CRITICAL



BROOKHAVEN NATIONAL LABORATORY

BY JJAHELKA DATE 04/07/95

SUBJECT ROTARY JOINT MOVEABLE

SHEET No. 1 OF 1

CHKD. BY DATE

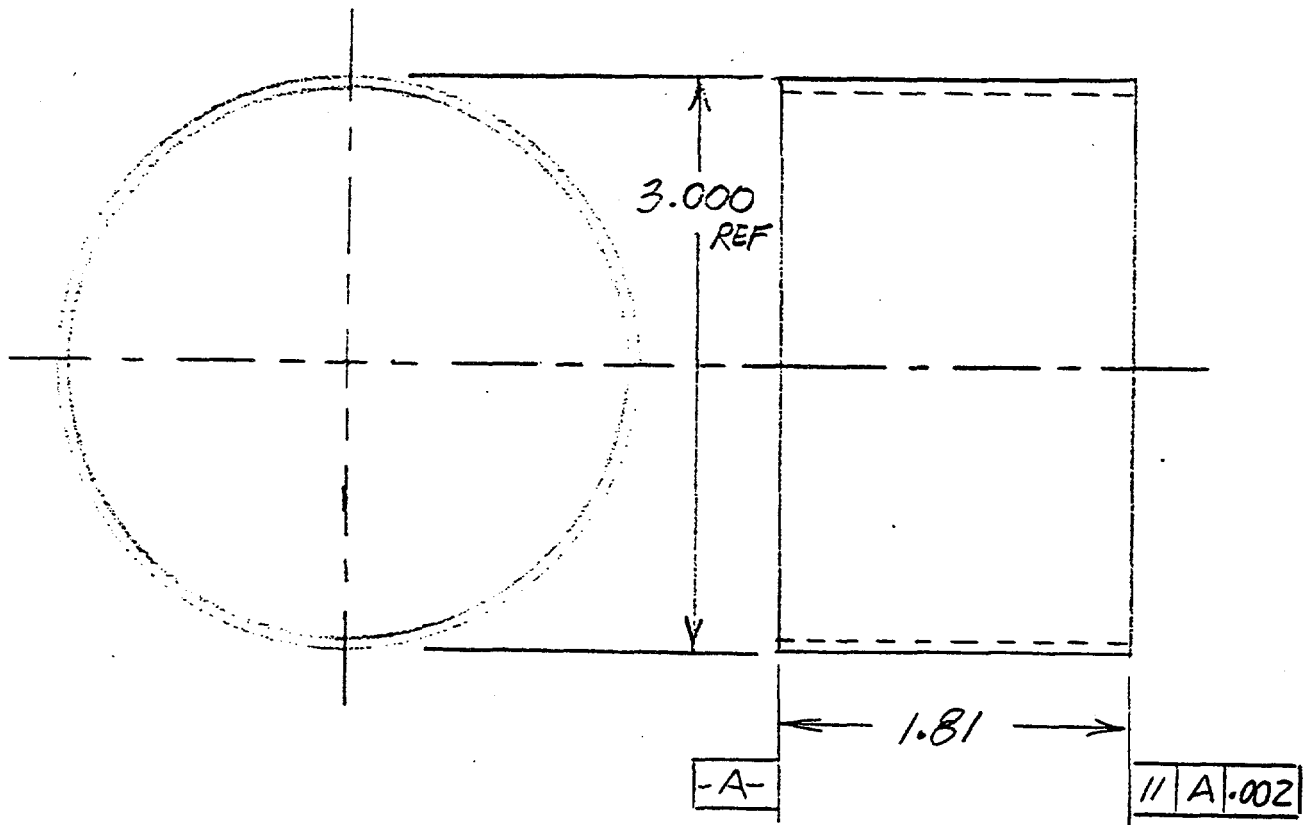
END CAN-BODY

JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE/ACRS

SK-JRS504076



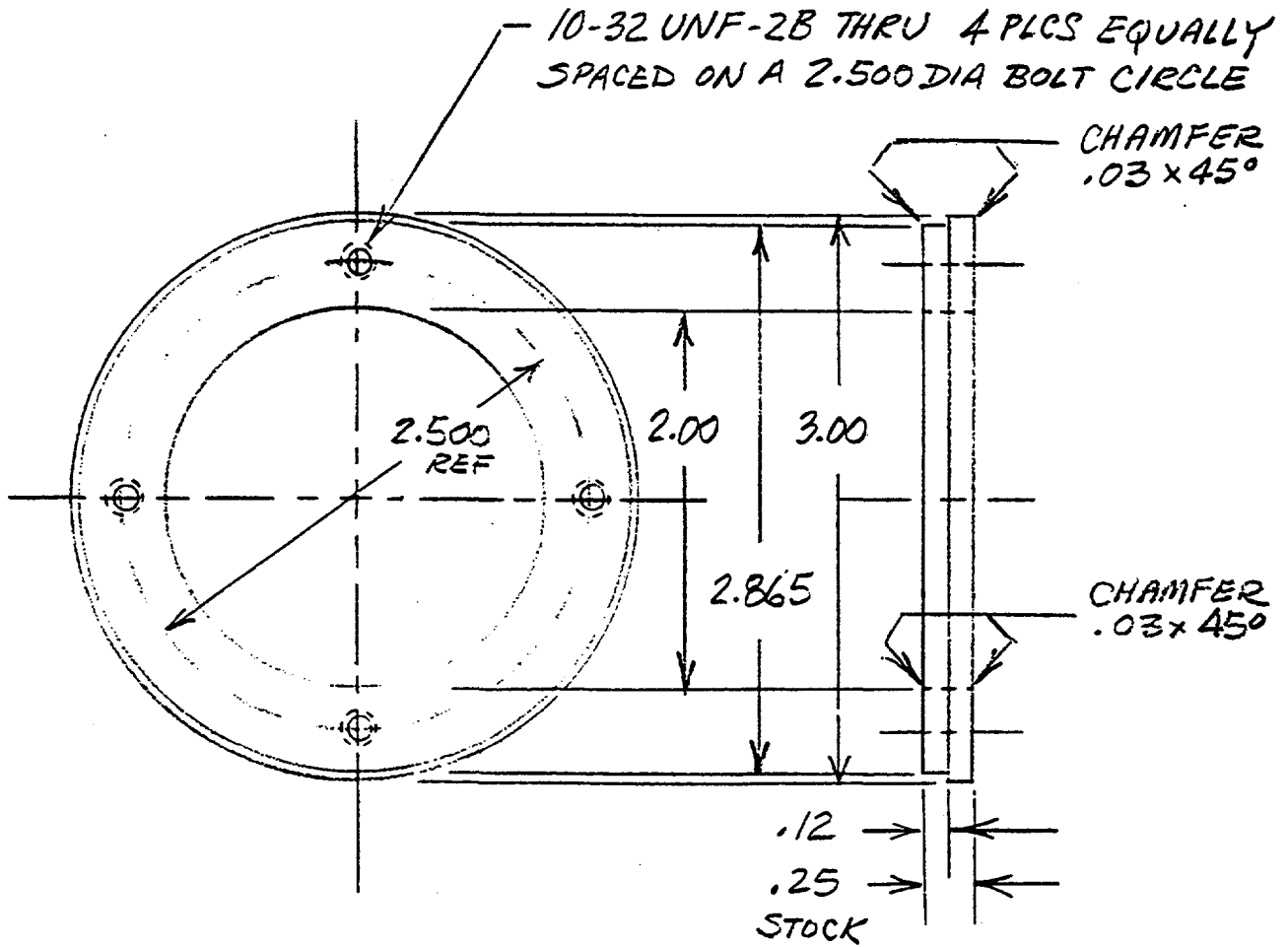
CUT SURFACES <sup>125</sup> ✓

MATERIAL: F-81050 304 STAINLESS STEEL  
3" OD X .065 WALL TUBE

BY JJAHELKA DATE 04/07/95  
CHKD. BY \_\_\_\_\_ DATE \_\_\_\_\_  
QTY PER ASSY - 1

SUBJECT ROTARY JOINT MOVEABLE  
END CAN - TOP RING  
DEPT. OR PROJECT DOE/ACRS

SHEET No. 1 OF 1  
JOB No. 04845  
SK-JRT504077



CUT SURFACES <sup>125/</sup> ✓

MATERIAL: 304 STAINLESS STEEL

BY J. JAHNELKA DATE 04/07/95

SUBJECT ROTARY JOINT MOVEABLE

SHEET No. 1 OF 1

CHKD. BY DATE

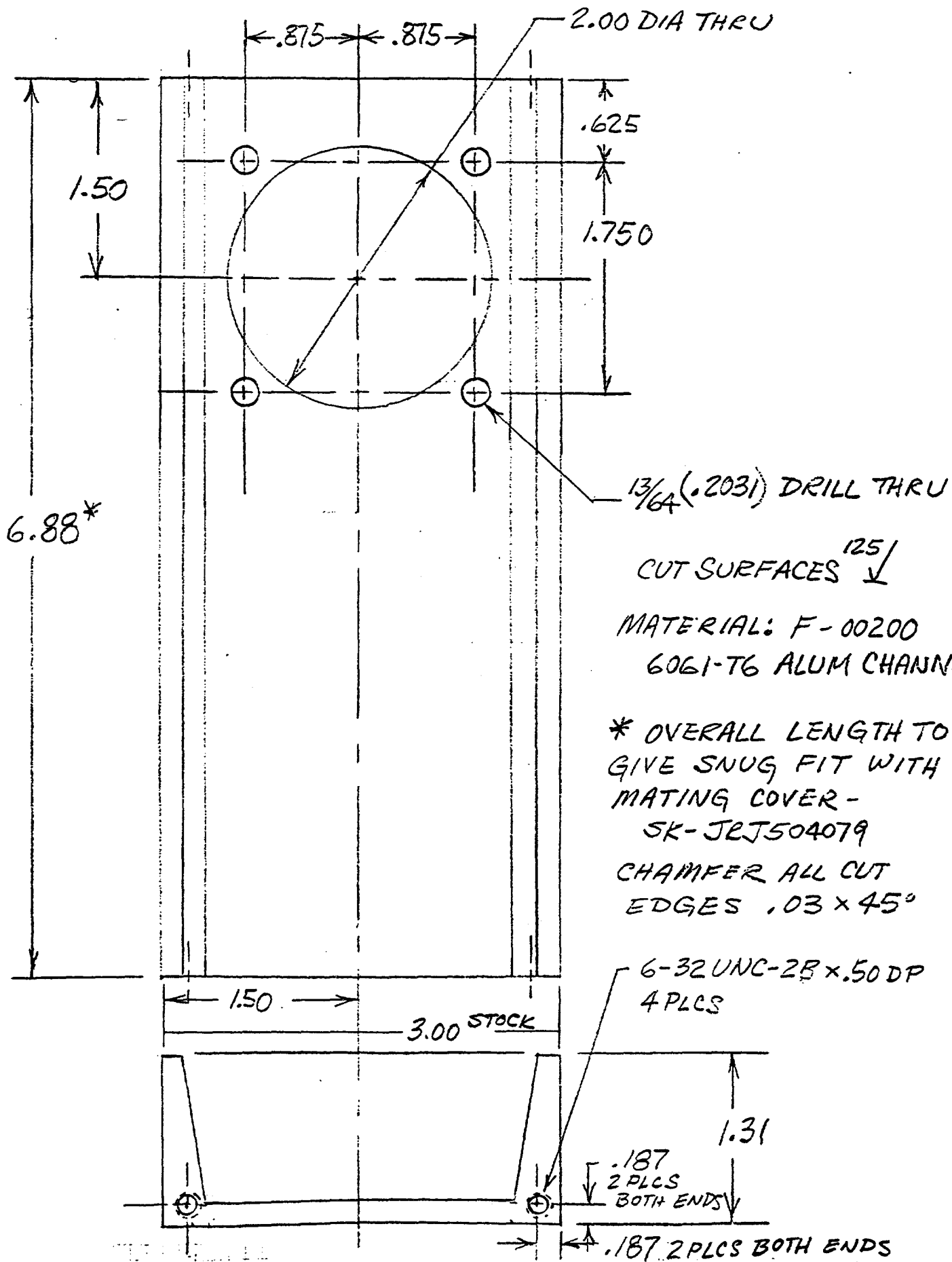
END BOX - BODY

JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE/ACRS

SK-JEJ504078



BY J. JAHNELKA DATE 04/07/95

SUBJECT ROTARY JOINT MOVEABLE

SHEET No. 1 OF 1

CHKD. BY DATE

END BOX - COVER

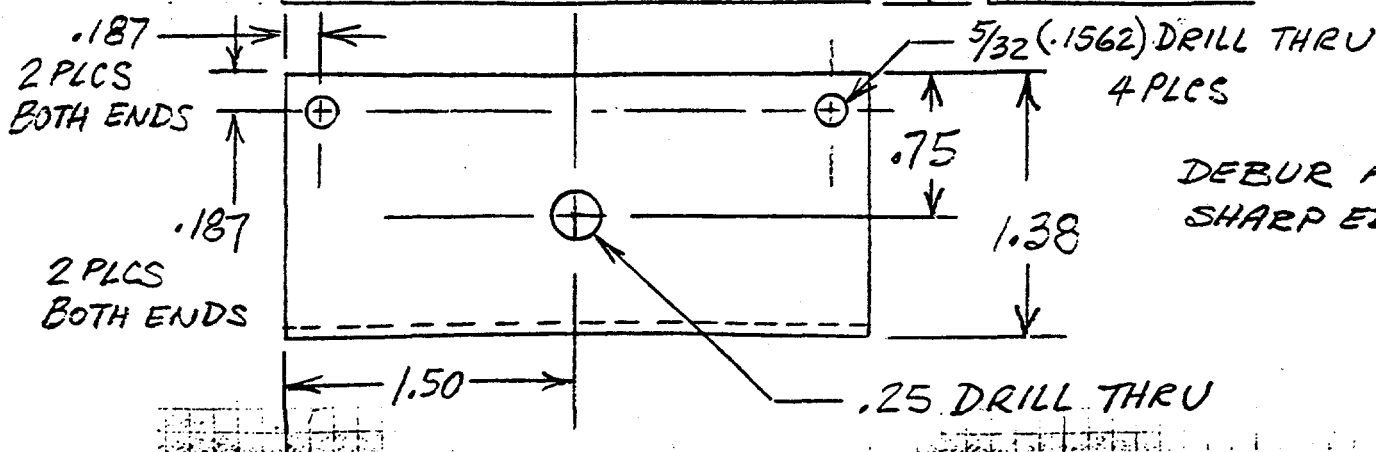
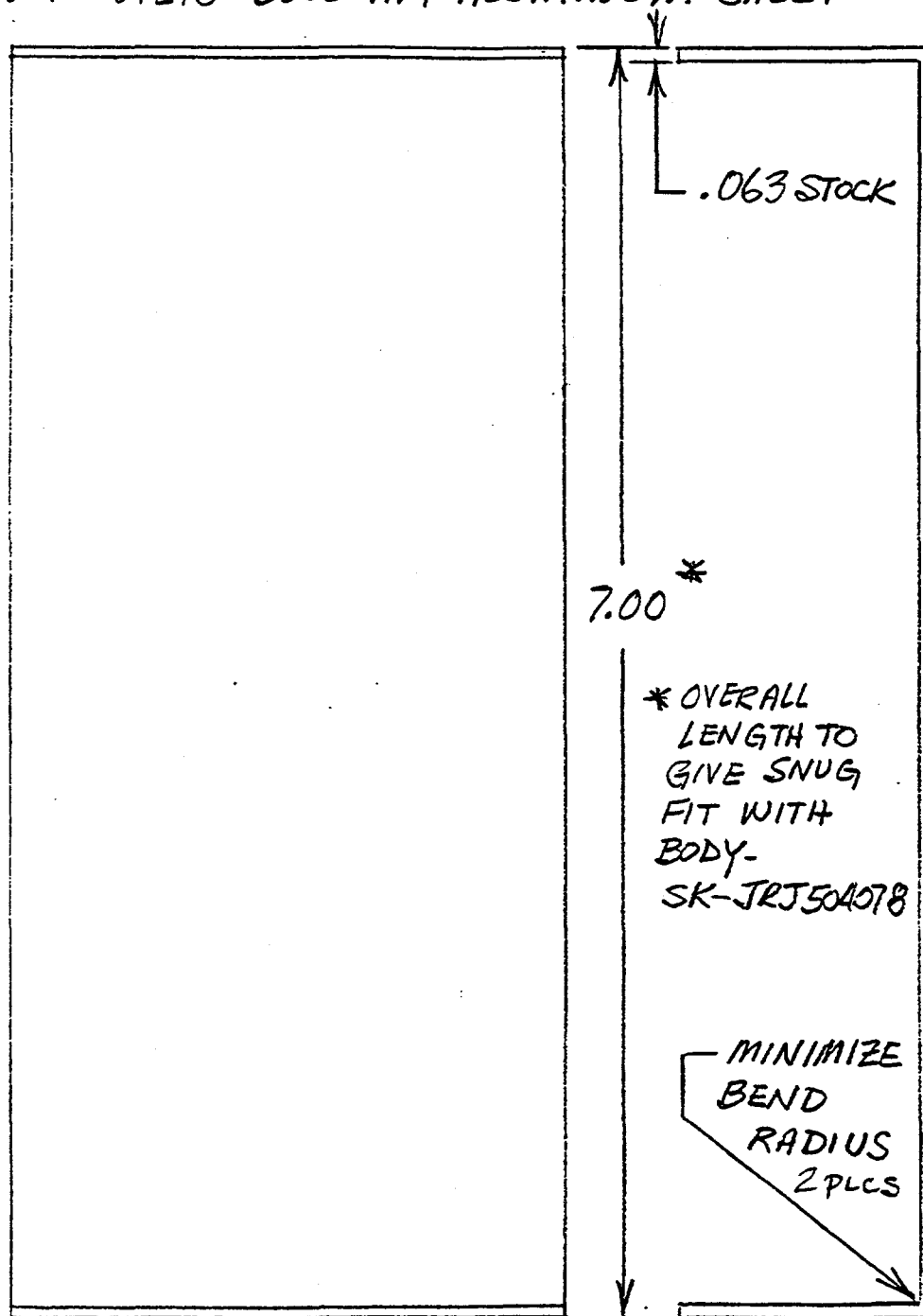
JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE/ACRS

SK-JRJ504079

MATERIAL: F-07210 3003-H14 ALUMINUM SHEET



BY J. JAHNELKA DATE 04/11/95

SUBJECT CABLE REEL

SHEET No. 1 OF 1

CHKD. BY DATE

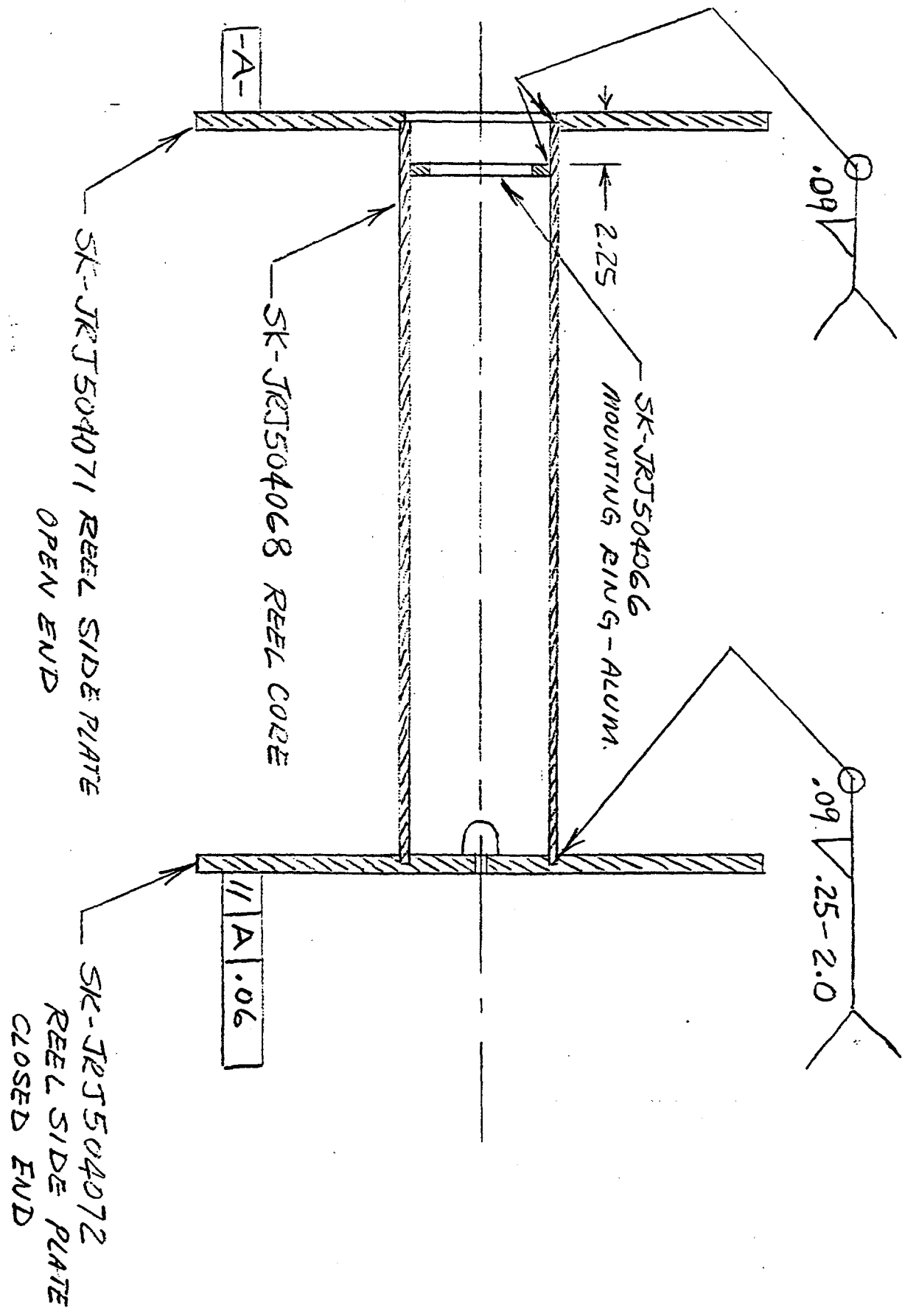
WELDMENT

JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE/ACRS

SK-JRJ504113



BY J. JAHNELKA DATE 04/06/95 SUBJECT CABLE REEL CORE

SHEET No. 1 OF 1

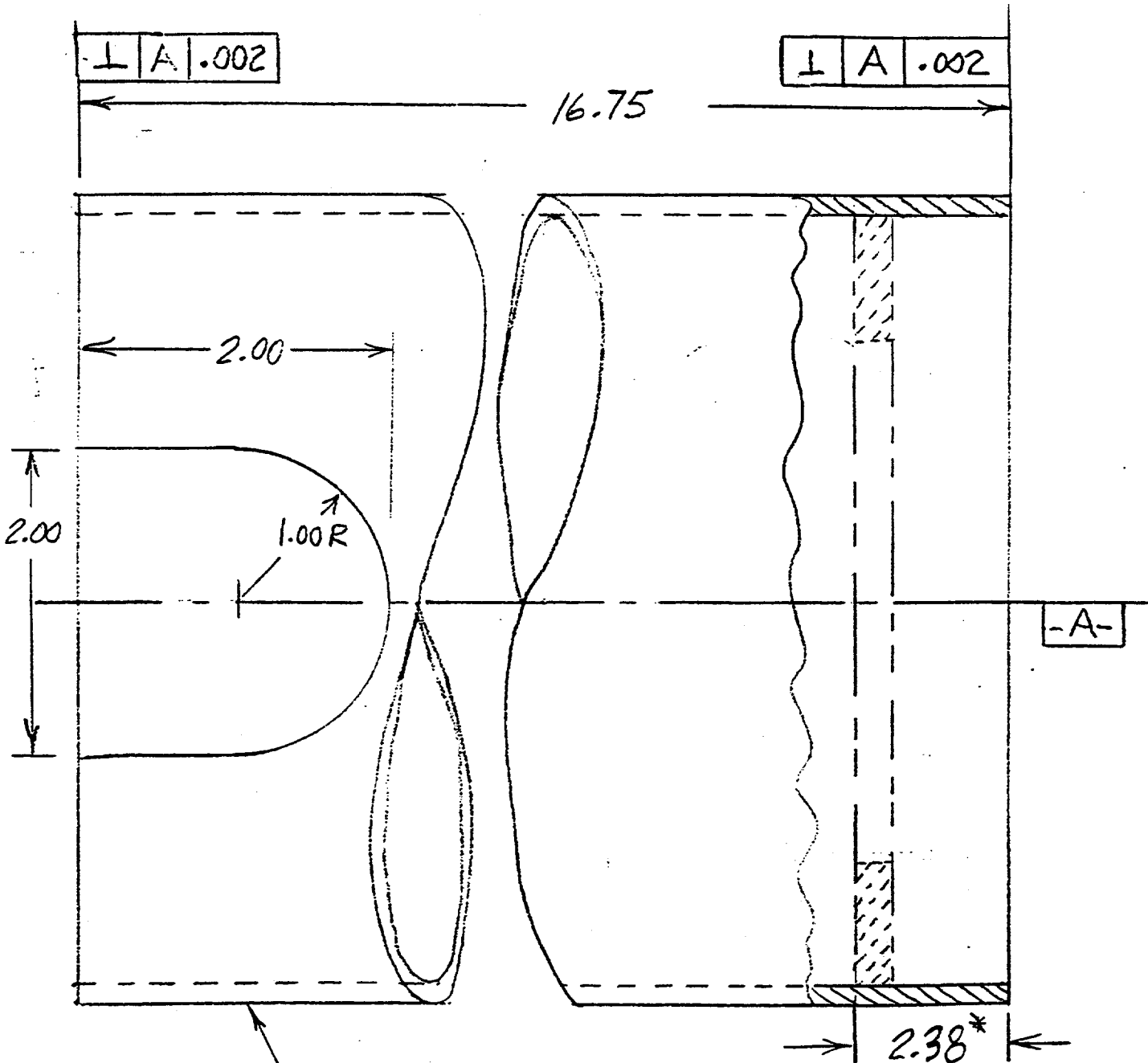
CHKD. BY DATE

JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE/ACRS

SK-JRJS04068



5.25 OD x .125 W 6061-T6 ALUMINUM TUBE

CUT SURFACES  $\sqrt{125}$   
CHAMFER ALL CUT EDGES .03 x 45°

\* POSITION OF RING - SK-JRJS04066 - TUBE MAY BE BORED OVERSIZE IF NEEDED - 5.030 MAX

BY J. JAHNELKA DATE 04/07/95

SUBJECT CABLE REEL SIDE

SHEET No. 1 OF 1

CHKD. BY DATE

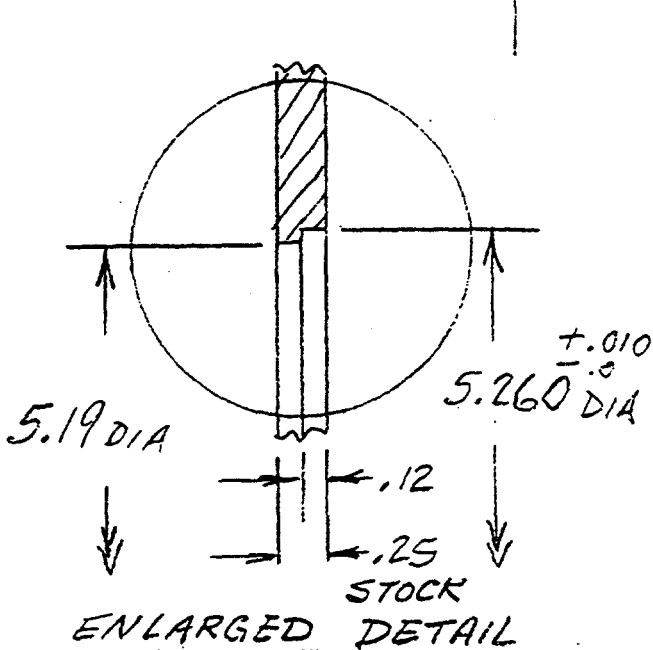
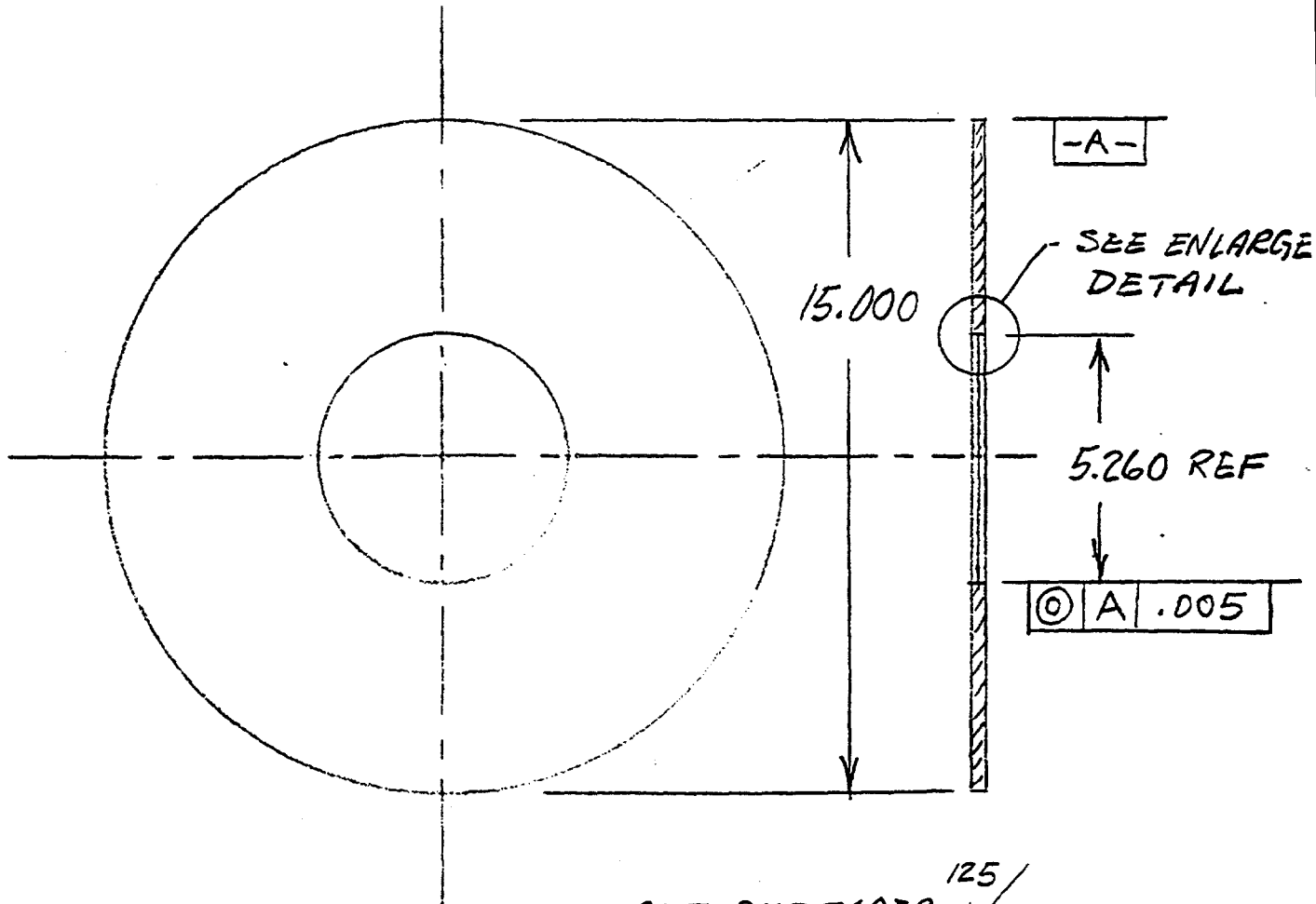
PLATE - OPEN END

JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE/ACRS

SK-JRJ504071



CUT SURFACES  $\sqrt{125}$

MATERIAL: F-02810 1/4" 6061-T6 ALUMINUM PLATE

CHAMFER ALL CUT EDGES .03x45°

BY JJAHELKA DATE 04/07/95

SUBJECT CABLE REEL SIDE

SHEET No. 1 OF 1

CHKD. BY DATE

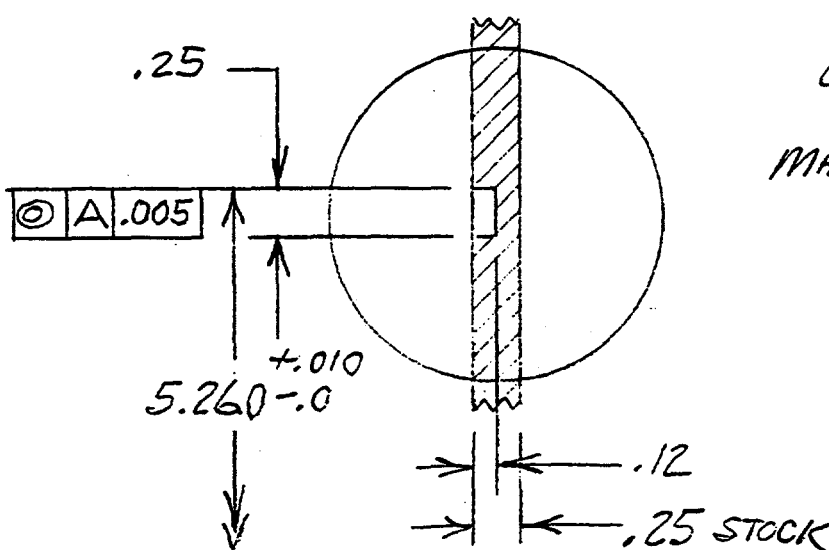
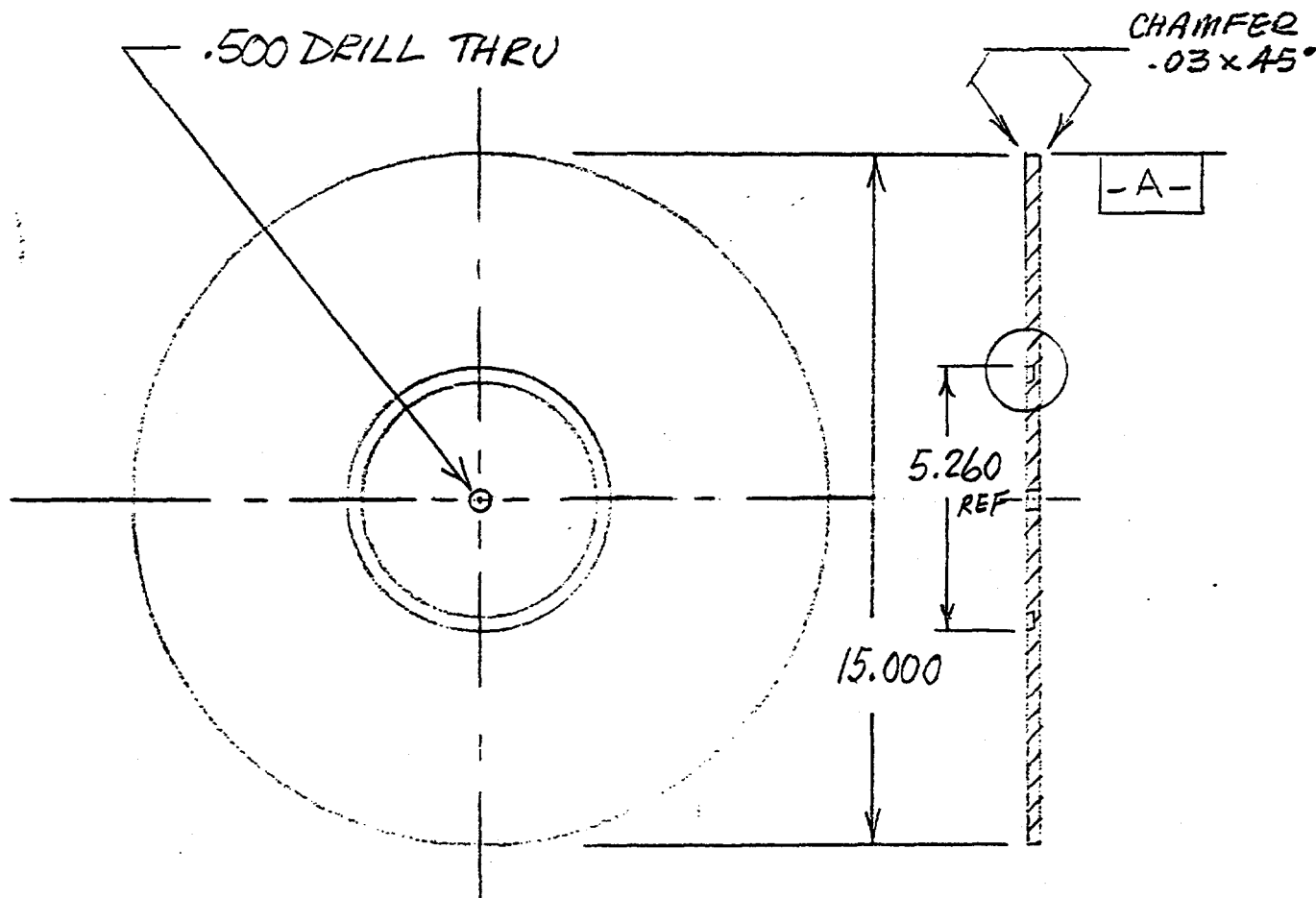
PLATE - CLOSED END

JOB No. 04845

QTY PER ASSY - 1

DEPT. OR PROJECT DOE/ACKS

SK-JRJ504072



ENLARGED DETAIL

125/  
 CUT SURFACES ✓  
 MATERIAL: F-02B10 1/4"  
 6061-T6 ALUMI PLATE