TREE-NUREG-1131

for U.S. Nuclear Regulatory Commission

LOFT FUEL MODULES DESIGN, CHARACTERIZATION, AND FABRICATION PROGRAM

MALCOLM L. RUSSELL

June 1977

EG&G Idaho, Inc.

IDAHO NATIONAL ENGINEERING LABORATORY

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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H.A. Rau managed the design, development, and fabrication program for the instrumentation penetration assemblies and the fabrication program for the fuel module assembly. C. E. Forkel managed the fabrication program for the upper support structures. D. W. Hood, R. D. Wesley, and R. K. Welty (Exxon) provided technical supervision of the fuel rod thermocouple attachment (laser welding) program.

ABSTRACT

The loss-of-fluid test (LOFT) fuel modules have evolved from a comprehensive five-year design, characterization, and fabrication program which has resulted in the accomplishment of many technical activities of interest in pressurized water reactor fuel design development and safety research. This report summarizes the highlights which include:

(1) Determination of fundamental high-temperature reactor material properties

(2) Design invention related to in-core instrumentation attachment

(3) Implementation of advanced and/or unique fuel bundle characterization techniques

(4) Implementation of improved fuel bundle fabrication techniques

(5) Planning and execution of a multimillion dollar design, characterization, and fabrication program for pressurized water reactor fuel.

The total program described herein has achieved an objective of technical activity documentation and component characterization in a manner that (a) indicates the effort to provide a fuel module that will credibly represent a large pressurized water reactor (LPWR) fuel bundle during a loss-of-coolant accident (LOCA) and (b) determines the representative characteristics of the LOFT fuel bundles.

This document is an updated version of the previously published Aerojet Nuclear Company Report ANCR-1223, LOFT Fuel Modules Design Characterization and Fabrication Program, October 1975, which was distributed under category NRC-2.

CONTENTS

FIGURES

TABLES

LOFT FUEL MODULES DESIGN, CHARACTERIZATION, AND FABRICATION PROGRAM

I. INTRODUCTION

The loss-of-fluid test (LOFT) fuel modules have evolved from a comprehensive five-year design, characterization, and fabrication program which has resulted in the accomplishment of many technical activities of interest in pressurized water reactor fuel design development and safety research. This report summarizes the campaign highlights which include:

(1) Determination of fundamental high-temperature reactor material properties

(2) Design invention related to in-core instrumentation attachment

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(4) Implementation of improved fuel bundle fabrication techniques

(5) Planning and execution of a multimillion dollar design, characterization, and fabrication program for pressurized water reactor fuel.

II. FUNCTIONS

The general objectives of the LOFT Program are:

> To evaluate the capability of analytical methods to predict the loss-of-coolant accident (LOCA) response of large pressurized-water power reactors, the performance of the engineered safety systems, and the margins of safety inherent in that performance
>
> To identify any unexpected events or thresholds not presently accounted for in the analysis of plant response or in the design of engineered safety systems.

To accomplish the stated objectives the LOFT facility must provide data that have been produced under environments and conditions representative of that which would occur in large pressurized-water power reactors during an LOCA.

The LOFT core design evolved the core configuration shown in Figure 1. The test instrumentation design developed the following instrumentation to be attached to the fuel modules:

	Instrumentation Item	Quantity
(1)	Fuel rod cladding thermocouples	185
(2)	Guide tube thermocouples	11
(3)	Core inlet coolant thermocouples	17
(4)	Core outlet coolant thermocouples	21
(5)	Core liquid level detectors	3
(6)	Core inlet pressure taps	2
(7)	Core outlet and upper plenum pressure taps	4
(8)	Reactor vessel upper plenum pressure detectors	2
(9)	Neutron flux scan tubes	4
(10)	Neutron flux detectors	4
(11)	Upper structure thermocouples	10
(12)	Fuel module linear motion detectors	2
(13)	Core outlet flow detectors	3

In addition to composing the reactor core and providing test instrumentation locations, the fuel modules also provide:

(1) The materials and geometry features which will assure that the important heat transfer, hydraulic, mechanical, chemical, metallurgical, and nuclear behaviors are typical of those expected in large pressurized water reactors (LPWRs) during blowdown and emergency core coolant (ECC) injections

(2) The neutron absorber material needed, in conjunction with the borated water system, to control the reactivity of the LOFT core

(3) A neutron source that will allow reactor startup with the neutron multiplication within the measurement capability of the reactor startup instrumentation.

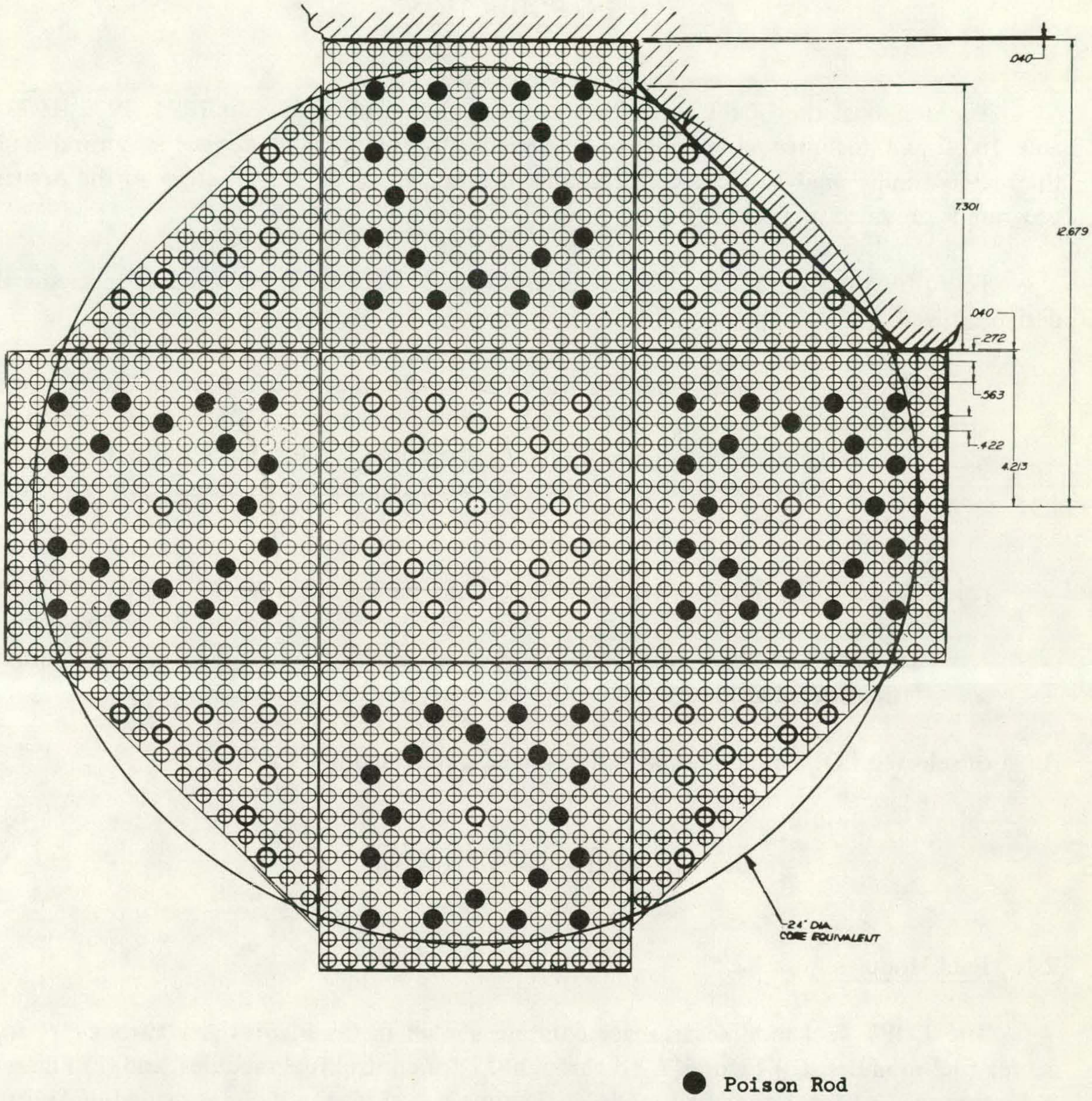


Fig. 1 LOFT core layout.

III. DESIGN

1. INTRODUCTION

The design of the LOFT fuel modules spanned the calendar years 1971, 1972, 1973, and 1974 and included comprehensive programs for mechanical design, structural and thermal-hydraulic analysis, and confirmatory testing. A list of contributors to the design program is provided in Table I.

To fulfill the functional and design requirements the LOFT fuel module mechanical design evolved:

(1) Modular-type units combining the basic fuel bundle (fuel rods, skeleton, spacer grids, guide tubes, end boxes, and control rods) with: (a) the test instrumentation detectors and cable leadouts, (b) an upper support structure extending to the reactor vessel top, (c) an instrumentation penetration assembly, and (d) the neutron source.

(2) Three basic design configurations: (a) the highly instrumented center (15 x 15 fuel rod array) module that does not contain control rods, (b) the control (15 x 15 fuel rod array with control rod assembly) module, and (c) the corner (triangular-shaped) module.

A list of selected LOFT fuel module design values is provided in Table II.

2. MECHANICAL DESIGN

2.1 Fuel Modules

The LOFT fuel module arrangements are shown in (a) Figures A-1 through -9 for center fuel modules, (b) Figures A-10 through -17 for control fuel modules, and (c) Figures A-18 through -30 for corner fuel modules. Figures A-1 through -30 are provided in Appendix A.

The fuel module quantities are based on two core loads plus spares as follows:

(1) First core load consisting of fuel-module types as follows: one center (Type A), three instrumented controls (Type B), two instrumented corners (Type C), one noninstrumented control (Type D), and two noninstrumented corners (Type E).

(2) A lot of spare fuel modules consisting of the following types: one center (Type A), one instrumented control (Type B), one instrumented corner (Type C), and

TABLE I

ORGANIZATIONS[a] INVOLVED IN LOFT FUEL MODULE DESIGN PROGRAM

	Mechanical			Thermal-Hydraulic Analysis			Thermal-Hydraulic Testing		Structural Analysis			Structural Testing		Miscellaneous Activities		
Component	EG&G	ENC	MPR	EG&G	ENC	MPR	EG&G	ENC	EG&G	ENC	MPR	EG&G	ENC	EG&G	BMI	IITRI
Fuel Rods		✓			✓			✓		✓			✓	✓		
Control Rods		✓			✓			✓		✓			✓	✓	✓	
Fuel Bundle Skeleton		✓			✓			✓	✓	✓			✓			
Upper Support Structure	✓		✓			✓		✓	✓		✓					
Instrumentation Penetration	✓			✓			✓		✓			✓				✓
Fuel Bundle Instrumentation Support		✓			✓			✓		✓						
Upper Structure Instrumentation Support	✓		✓						✓		✓					
Neutron Source		✓			✓			✓		✓			✓			

EG&G - EG&G Idaho, Inc., Idaho Falls, Idaho
BMI - Battelle Columbus Laboratories, Columbus, Ohio
ENC - Exxon Nuclear Company, Richland, Washington
IITRI - Illinois Institute of Technology Research Institute, Chicago, Illinois
MPR - MPR Associate, Inc., Washington, DC

[a] ERDA (formerly AEC) participated in the review of the design program.

TABLE II

LOFT FUEL MODULE DESIGN VALUES

Mechanical Design Values	
Fuel Pellet	
Fuel Material	UO_2 Sintered Pellets
Density, % of TD	93.0 ± 1.5
Enrichment, w/o Fissile, Average	4.00 ± 0.05
Diameter, in.	0.3659 ± .0005
Length, in.	0.600 ± 0.025
Dish	Both Ends
Dish Volume (total), % of Pellet Volume	2.0
Fuel Rod	
Active Fuel Length, in.	66.00 ± 0.20
Fuel Stack Density, % TD	91.1
Diametral Pellet-to-Clad Gap, in.	0.0075 ± 0.002
Plenum Length, gross, in.	3.00
Cladding Material	Zircaloy-4
Clad OD[a], in.	0.422 ± 0.002
Clad ID, in.	0.3734 ± 0.0015
Clad Thickness, nominal, in.	0.0243
Clad Thickness, minimum, in.	0.0228
Weight, lb	3.06
Fuel Bundle	
Number of Fuel Rods, square	204
Number of Fuel Rods, corner	70
Fuel Rod Array, square	15 x 15
Fuel Rod Array, corner	12 x 12 triangular
Fuel Rod Pitch, in.	0.563

TABLE II (continued)

Mechanical Design Values (continued)	
Fuel Rod Separation, nominal, in.	0.141
Fuel Rod Separation, minimum, in.	0.120
Fuel Bundle Length, in.	78.568
Fuel Weight, lb UO_2/lb U square assembly	511/450.3
Fuel Weight, lb UO_2/lb U corner assembly	175.4/154.5
Spacers	
Type	Egg-Crate - Integral Spring
Material	Inconel 718
Number per Bundle	5
Mechanical Integrity Bundle Average Design Burnup, MWd/MTM	30,000
Core Data	
Number of Fuel Bundles	9 (5 square - 4 corner)
Number of Active Fuel Rods	1300
Neutron Source	
Material	Californium-252
Strength (700 days after delivery)	2×10^8 n/sec
Control Rod Clusters	
Poison Material	80Ag-15In-5Cd
Poison Rods per Cluster	20
Weight, lb	87

Assembly weight, lb	Fuel Bundle Type				
	A	B	C	D	E
Fuel Bundle	698	700	268	686	262
Upper Support Structure	829	685	280	685	280
Fuel Module	1730	1730	800	1500	545

TABLE II (continued)

Thermal and Hydraulic Design Values	
Reference Design Thermal Output, (MWt)/Btu/hr	55/1876 x 10^8
Effective Flow Rate for Heat Transfer, lb/hr	
Maximum	4.28 x 10^6
High	3.42 x 10^6
Low	2.77 x 10^6
System Pressure, nominal, psig	2253
System Pressure, Design, psig	2208
Average Power Density, kW/l	∿109.4
Maximum Heating Rate, kW/ft rated power	19.0
Average Heating Rate, kW/ft	7.49
Active Heat Transfer Surface, ft^2	789.93
Maximum Heat Flux, (@ Overpower) Btu/hr-ft^2	644,830
Average Heat Flux, Btu/hr-ft^2	231,400
Maximum UO_2 Temperature, °F rated power	4700
Maximum Fuel Rod Surface Temperature, °F	664
MCHFR at Overpower Conditions[b]	1.30 (low flow)
Coolant Inlet Temperature, °F	
Maximum Flow	562
High Flow	557
Low Flow	551
Design Power Peaking Factors	
Heat Generated in Fuel, %	97.4
Relative Fuel Bundle Power Factor plus Local Power Peaking Factor	1.573

TABLE II (continued)

Thermal and Hydraulic Design Values (continued)	
Axial Power Peaking Factor	1.56
Total Nuclear Peaking Factor	2.45
Engineering Heat Flux Factor	1.03
Total Power Peaking Factor, Fq^N	2.53

[a] After etching.

[b] Based on W-3 correlation.

one center with zircaloy (instead of Type 304 stainless steel) guide tubes and pressurizable fuel rods (Type F).

(3) Core reload consisting of fuel module types as follows: one center (Type A), three instrumented controls (Type B), two instrumented corners (Type C), one noninstrumented control (Type D), and two noninstrumented corners (Type E). The reload fuel bundles also have pressurizable fuel rods.

The LOFT fuel modules include numerous examples of (a) mechanical design invention and/or development and (b) changes from contemporary design features, which are described in the following paragraphs.

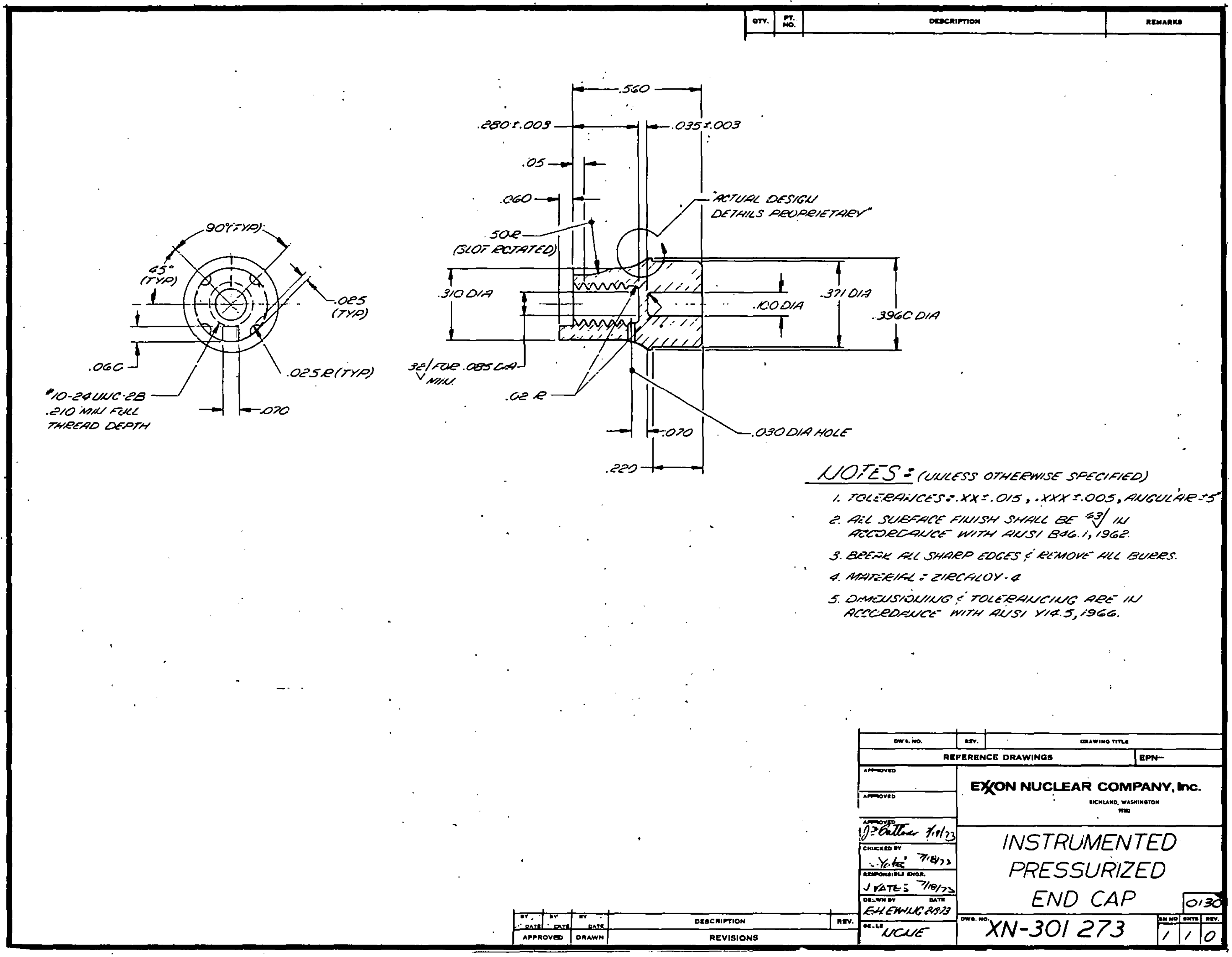
2.1.1 Fuel Rods.

(1) End Cap Seal Welds - The weld configuration is a proprietary design geometry developed by the LOFT fuel supplier which has a high demonstrated reliability.

(2) Instrumented Fuel Rod Upper End Cap - See Subsection 2.1.7, Fuel Bundle Instrumentation Attachment.

(3) Pressurizable End Cap - The reload and Type F fuel rods have a modified upper cap (see Figure 2) that allows the fuel rod to be pressurized to 800 psig maximum after fabrication of the fuel rods by a laser drilling and rewelding technique.

(4) Thermocouple Attachment - See Subsection 2.1 7, Fuel Bundle Instrumentation Attachment.



NOTES: (UNLESS OTHERWISE SPECIFIED)

1. TOLERANCES: .XX ±.015, .XXX ±.005, ANGULAR ±5°
2. ALL SURFACE FINISH SHALL BE 63/ IN ACCORDANCE WITH ANSI B46.1, 1962.
3. BREAK ALL SHARP EDGES & REMOVE ALL BURRS.
4. MATERIAL: ZIRCALOY-4
5. DIMENSIONING & TOLERANCING ARE IN ACCORDANCE WITH ANSI Y14.5, 1966.

DWG. NO.	REV.	DRAWING TITLE

REFERENCE DRAWINGS

EPN—

APPROVED

APPROVED

APPROVED 7/19/73

CHECKED BY Yates 7/18/73

RESPONSIBLE ENGR. J YATES 7/18/73

DRAWN BY E.H. EWING DATE 8/8/73

SCALE NONE

EXXON NUCLEAR COMPANY, Inc.
RICHLAND, WASHINGTON
99352

INSTRUMENTED
PRESSURIZED
END CAP

0130

DWG. NO. XN-301 273

SH NO	SHTS	REV.
1	1	0

Fig 2 LOFT instrumented pressurized end cap.

(5) Fuel Rod Assembly - The LOFT design configuration in conjunction with the supplier's proprietary comprehensive fabrication quality assurance programs is expected to provide exceptional reliability characteristics based on the supplier's fuel rod reliability record.

2.1.2 Spacer Grids.

(1) Intersection Joining Method - The LOFT spacer grids (see Figure 3) feature a TIG welded intersection joint compared to the brazed joints of contemporary designs. The technique is judged to provide design improvements in dimensional control and joint reliability although strength testing during the design development indicated that for tensile loading along the joint axis the welded joint was 40% weaker than a brazed joint. The structural design program (see Table IV) indicated that the additional strength of the brazed construction was not necessary for achieving the design objectives.

2.1.3 Skeleton (subassembly consisting of spacer grids, guide tubes, and end boxes).

(1) Triangular Skeleton Alignment - The triangular shape causes the control of twist and lean (runout from true position) to be difficult. The fabrication experience resulted in improvements to the fuel bundle assembly fixtures design and assembly instructions to achieve the triangular-shaped skeleton alignment objectives.

2.1.4 Control Rods.

(1) The control rod spiders (see Figure 4) were designed to be machined from forgings instead of the contemporary construction by brazing the fingers to the hub. Fabrication problems that were experienced included (a) unexpected porosity of the raw material even though satisfactory precautionary ultrasonic examination of the raw material had been performed, and (b) surface roughness above specified values. The solid spiders are considered to yield improvements in reliability compared to the contemporary construction.

2.1.5 Upper Support Structures (upper support structures provide lateral and hold-down support for the fuel bundles).

(1) Lateral Support - The lateral support is accomplished by achieving a close fit at three locations: the upper structure lower extremity and immediately above and below the reactor vessel nozzles. The close fit (room temperature) is approximately 0.010 inch between mating surfaces at the lower extremity and 0.055 inch between the mating surfaces adjacent to the nozzles. This lateral support is designed to provide the following features:

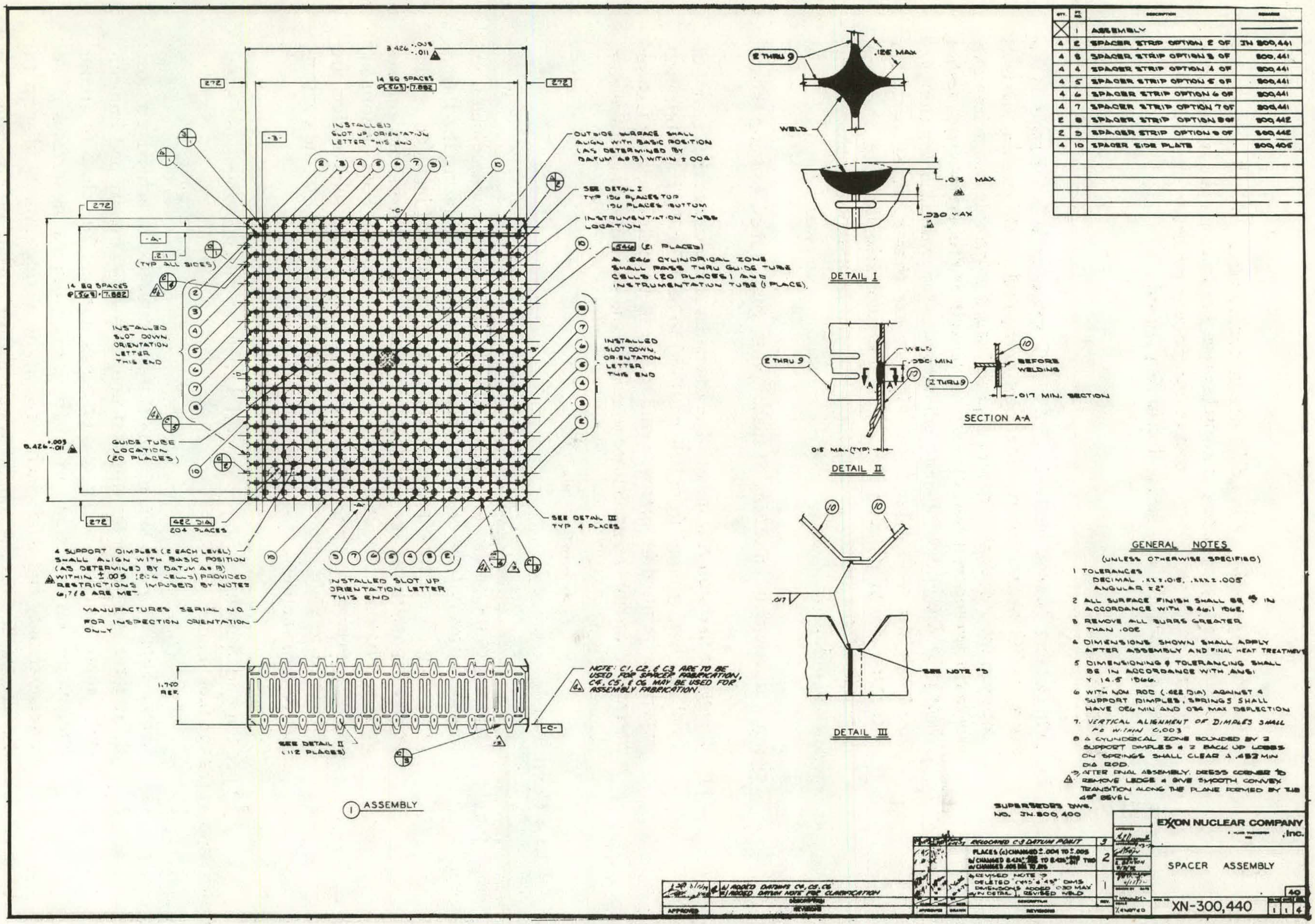


Fig. 3 LOFT 15 x 15 spacer grid.

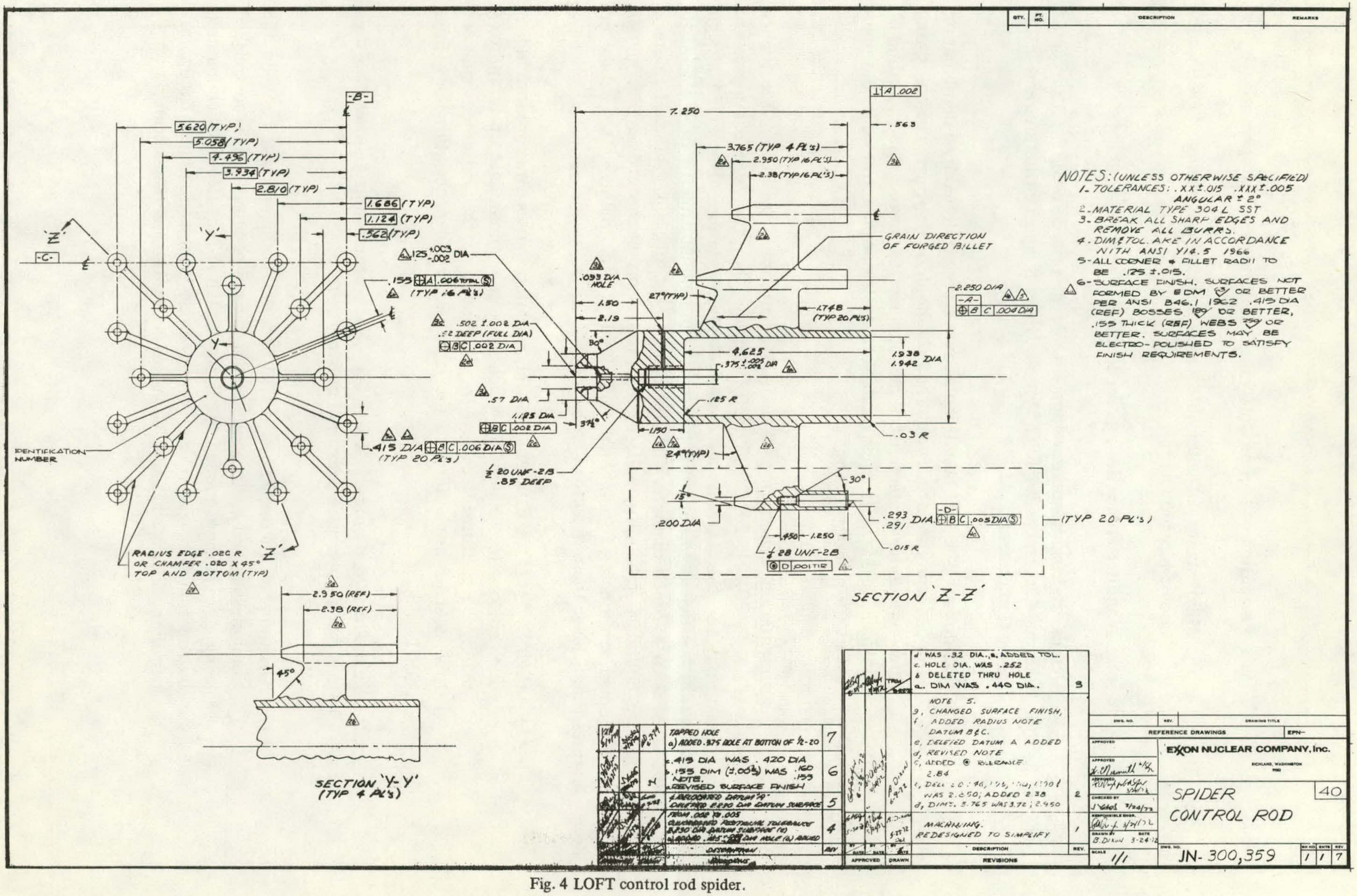


Fig. 4 LOFT control rod spider.

(a) Prevention of fuel module vibration during normal operation

(b) Maintenance of allowable stress limitations during (LOCE) subcooled blowdowns

(c) Noninterference during core loading.

Details of this design development are described in MPR letter report "Lateral Clearances for Fuel Module Upper Support Structures and Interfacing Components", May 24, 1972.

(2) Holddown - The fuel bundle holddown is accomplished by a combination of upper structure dead weight and coil-holddown springs. The coil spring force-deflection characteristics are designed to prevent the exceeding of allowable fuel bundle stress limitations during normal, transient, and planned LOCE plant operations.

2.1.6 <u>Instrumentation Penetration.</u> The Instrumentation Penetration (see Figure A-9, -10, -11, -12, -17, -20, -21, -22, -28, -29, -30) provides the primary coolant pressure boundary penetration for the LOFT fuel module instrumentation. The LOFT design objectives are (a) high efficiency in area for making the individual cable or tube seals (140 cables and 2 tubes in a 7-inch diameter and 40 cables and 4 tubes in a 4-inch diameter), (b) high-pressure boundary reliability, and (c) leakproof seals between dissimilar metals (titanum to Inconel, carbon steel to Inconel, and stainless steel to Inconel). The special design features that achieve these objectives are as follows:

(1) High Seal-to-Area Efficiency - Each penetration uses three or more individual buttons (see Figure 5) which (a) can accommodate up to approximately 35 instrument cables, (b) are brazed to the instrument cable or tube, and (c) are welded to the instrumentation penetration body (pressure plate).

(2) High-Pressure Boundary Reliability - Each penetration features two seals in series for increased pressure boundary reliability.

(3) Titanium to Inconel Seal - The pressure boundary seal between the titanium-sheathed thermocouples and Inconel penetration is accomplished using an explosion bonded titanium - tantalum-Inconel sandwich material button that is brazed to the thermocouple using a titanium - zirconium - beryllium filler metal and TIG welded to the Inconel penetration.

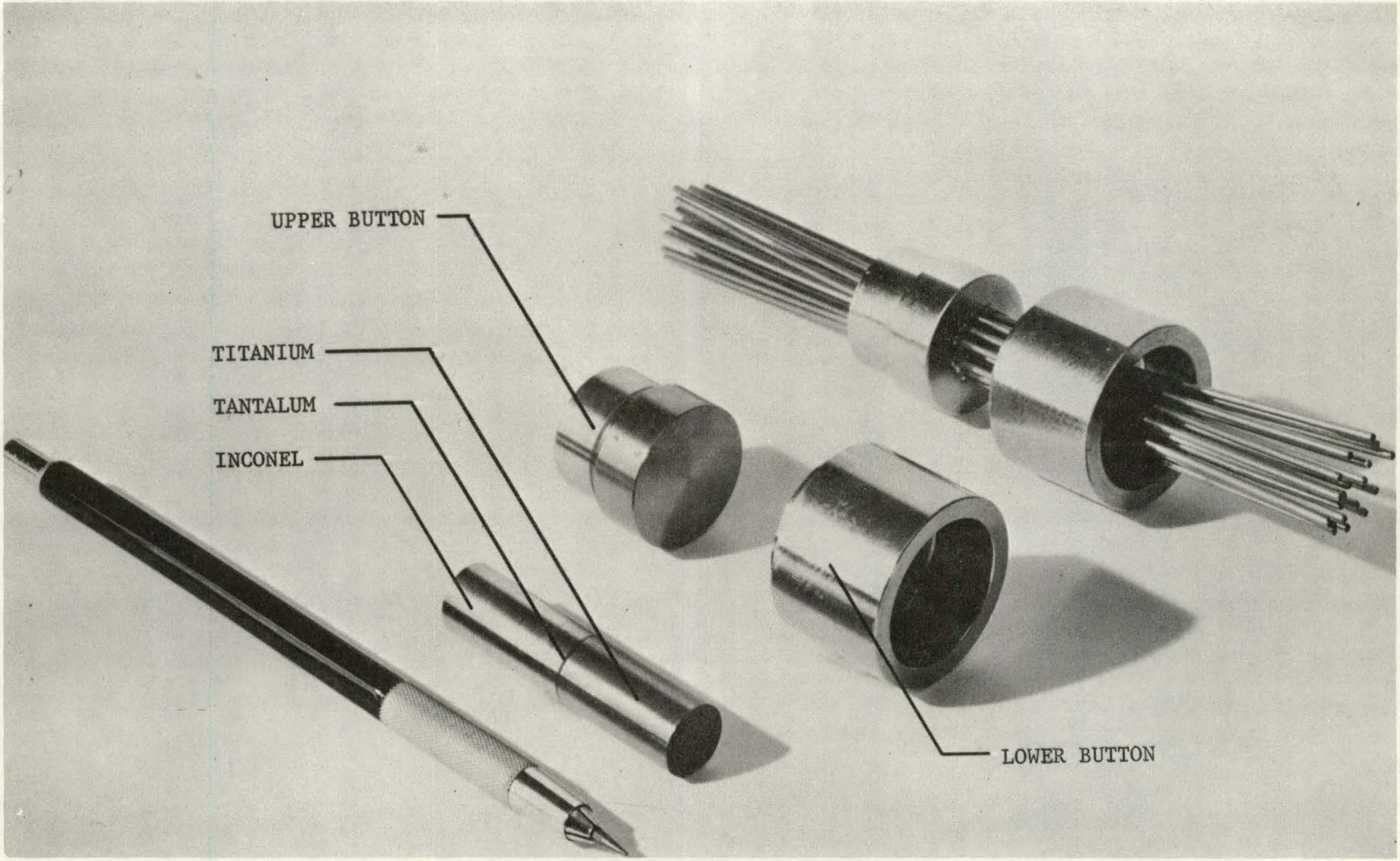


Fig. 5 LOFT braze button.

Selection of the braze material was based on an extensive brazing material evaluation which included selection of a satisfactory brazing filler material from seven candidate materials. This evaluation is described in IITRI report "IITRI-B6112-1, Evaluation of Brazing Filler Metals for C.P. Titanium Reactor Instrumentation Components", October 20, 1971. Process demonstrations have indicated this design will be successful.

(4) Stainless-Steel-to-Inconel Seal - The pressure boundary seal between the stainless-steel-sheathed instrument cables and Inconel is accomplished with a gold-nickel filler metal braze of the instrument cable to the Inconel button and TIG weld between button and penetration.

(5) Inconel-to-Carbon Steel - The pressure boundary seal between the instrumentation penetration and reactor vessel head is accomplished using K-seal type mechanical seals which were chosen over O-rings because they were judged to provide increased reliability for this service condition.

2.1.7 Fuel Bundle Instrumentation Attachment.

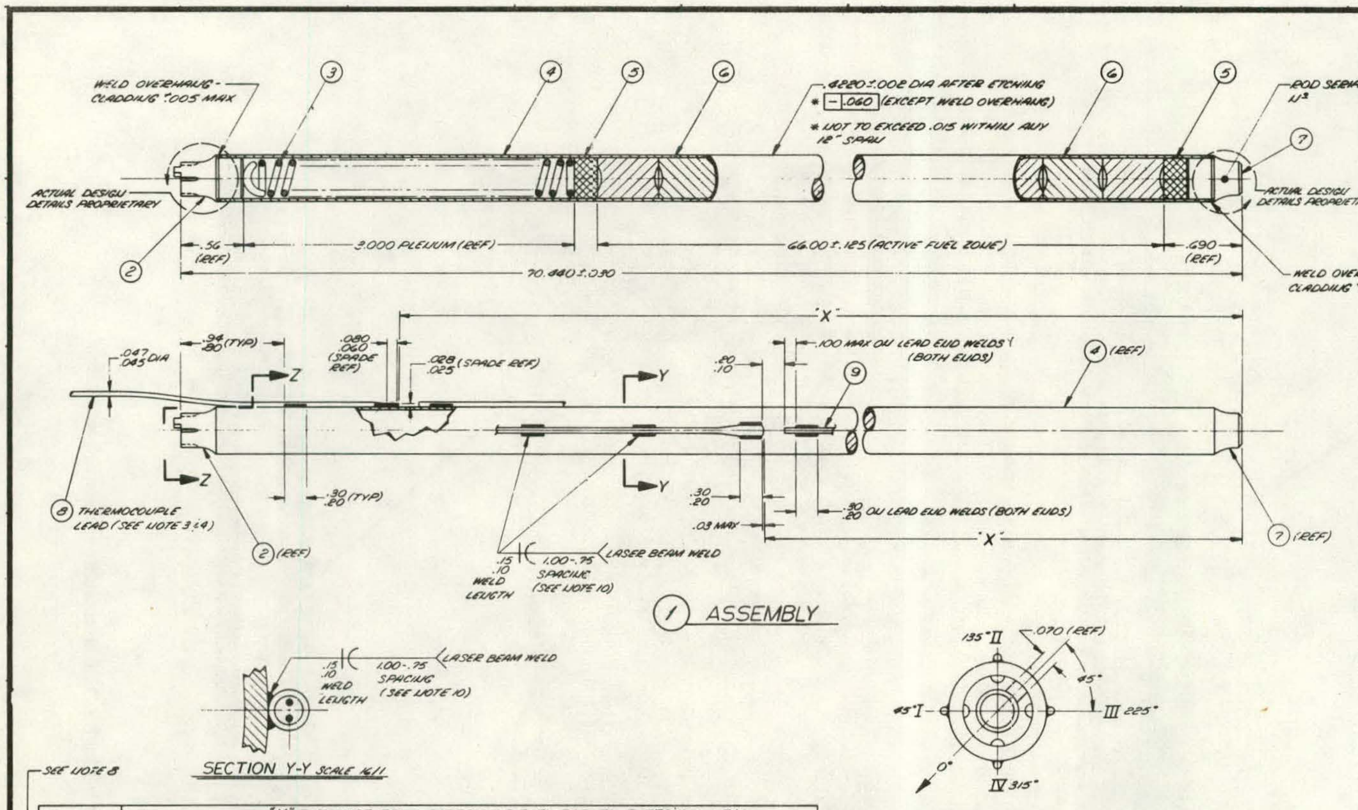
(1) Thermocouple Attachment - The LOFT design features titanium-sheathed thermocouples attached to the outside of zircaloy-clad fuel rods (see Figure 6) by laser welding using titanium filler wire. Titanium was selected over zircaloy because the technology for satisfactory fabrication of the small diameter zircaloy-sheathed thermocouples had not been developed. Noteworthy features of the weld design are as follows:

   (a) Alloy-Mixing - The mixing between titanium and zircaloy is precisely controlled for a compromise between strength enhancement obtained from high-mixing and corrosion resistance resulting from low-mixing. The photomicrographs show acceptable (Figure 7) and unacceptable (too-high and too-low) (Figures 8 and 9) mixing characteristics.

   (b) Heat-Affected Zone - The fragile thermocouple sheath (0.009 inch thick) heat-affected zone is precisely controlled to prevent penetration of the sheath during welding. The photomicrographs show an acceptable penetration condition (Figure 7) and results of reaching the thermocouple insulator (MgO) with the melt zone (Figure 10).

   (c) Weld Spacing - The individual weld nuggets, consisting of eight overlapping laser spots, are spaced at approximately 0.8-inch intervals to allow for differential thermal expansion between the zircaloy and titanium at temperatures expected during LOFT experiments.

QTY.	PT. NO.	DESCRIPTION	REMARKS
▼	1	INSTRUMENTED FUEL ROD ASSEMBLY	———
1	2	END CAP	300,436
1	3	PLENUM SPRING	300,338
1	4	CLADDING	300,336
2	5	INSULATOR DISC	300,337
AR	6	FUEL PELLET	300,343
1	7	END CAP OPTION #1	300,339
AR	8	THERMOCOUPLE	SUPPLIED BY CUSTOMER
AR	9	DUMMY THERMOCOUPLE	SUPPLIED BY CUSTOMER



SECTION "Z-Z"

FUEL ROD THERMOCOUPLE RADIAL LOCATION

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. TOLERANCES: .X ±.100, .XX ±.015, .XXX ±.005, ANGULAR ±5°
2. DIMENSIONING & TOLERANCING ARE IN ACCORDANCE WITH ANSI Y14.5, 1966.
3. SPADE RADIAL LOCATION TOLERANCE ±5°
4. THERMOCOUPLE LEAD RUNOUT TOLERANCE ±5°
5. ONE PELLET (EITHER END) IDENTICAL TO PART N° 6 EXCEPT FOR LENGTH (.200 MIN) MAY BE USED TO GIVE A TOTAL FUEL LENGTH AS SPECIFIED ON ASSEMBLY VIEW. THE PELLET SHORTENED BY GRINDING MAY BE USED AT PLENUM END OF THE COLUMN.
6. THE APPROPRIATE COMPONENT PART DWG., REV. & N° SHALL BE REFLECTED ON A SEPARATE PARTS LIST.
7. EXTEND TO THE LEVEL OF THE LOWEST THERMOCOUPLE WITH DUMMY THERMOCOUPLE.
8. CHROMEL-ALUMEL THERMOCOUPLE LEADS EXCEPT LOCATIONS DESIGNATED "PR" ON ROD TYPES 1B, 2B, 3B, 4B & 5B SHALL BE PLATINUM-RHODIUM
9. ADD A DUMMY LEAD ON OPPOSITE SIDE OF FUEL ROD AND EXTEND LEAD TO LEVEL OF LOWEST T/C.
10. WELD SPACING = WELD CENTER TO WELD CENTER 0.75 TO 1.00 INCH EXCEPT FOR THE LAST WELD ON EACH THERMOCOUPLE OR DUMMY THERMOCOUPLE WHERE THE GAP BETWEEN WELDS SHALL BE .03 TO .10. ONE WELD SPACING PER THERMOCOUPLE & DUMMY MAY HAVE A WELD SPACING 1.2 INCHES MAX. OR 0.6 INCHES MIN.

SEE NOTE 8

ROD TYPE		N° T/C	"X" DISTANCE FROM BOTTOM OF FUEL ROD TO BOTTOM OF T/C																			
			20	5.0	8.0	11.0	15.0	21.0	24.0	26.0	28.0	30.0	32.0	34.5	37.0	39.0	41.0	45.0	49.0	54.0	58.0	62.0
1A	1B	4	III				IV* PR							I* PR					II*			
2A	2B	4		IV				I* PR								II* PR				III*		
3A	3B	4			I					II* PR							III*				IV*	
4A	4B	4				II						III* PR						IV*				I*
5A	5B	4							III PR		IV* PR		I* PR		II* PR							
6		3				II						III**						IV*				
7		2					III								I*							
8		2						IV								II*						
9		2								I							III*					
10		2									III		I*									
11		1													I**							
12		1								II**												
13		1										III**										
14		4					I	II*		III*		IV*										
15		4										I	II*		III*	IV*						

* SEE NOTE 7

** SEE NOTE 9

APPROVED BY DATE	BY DATE	DRAWN BY DATE	DESCRIPTION	REV.
[illegible]	[illegible]	6-6-74	1.03/.10 DIM WAS .85/.10 a).028/.025 DIM WAS .031/.029 (b) IN NOTE 10	6
[illegible]	J. [illegible]	[illegible] 7-17-73	e) NOTE #3 RADIAL LOC TOL WAS 5.0° "SPADE REF" TO HOT JUNCTION DIMS. (d) .94/.80 DIM WAS .94 MAX (c) ADDED .30 TO .03 (b) REVISED NOTE #10 ORIGINAL (a) CHANGED DIM FROM a) REDRAWN-DUE TO CONDITION OF	5

APPROVED | DRAWN | REVISIONS

DWG. NO. | REV. | DRAWING TITLE

REFERENCE DRAWINGS | EPN—

APPROVED

APPROVED W.E. NIEMUTH 6-2-72

APPROVED G.A. SOFER 5-30-72

CHECKED BY J. YATES 5-26-72

RESPONSIBLE ENGR. R.A. PUGH 5-30-72

DRAWN BY DIXON DATE 2/7/72

SCALE 2/1 & NOTED

EXXON NUCLEAR COMPANY, Inc.
RICHLAND, WASHINGTON

INSTRUMENTED ROD

6040

DWG. NO. XN-300,466 | SH NO 1 | SHTS 1 | REV. 6

Fig. 6 LOFT instrumented fuel rod.

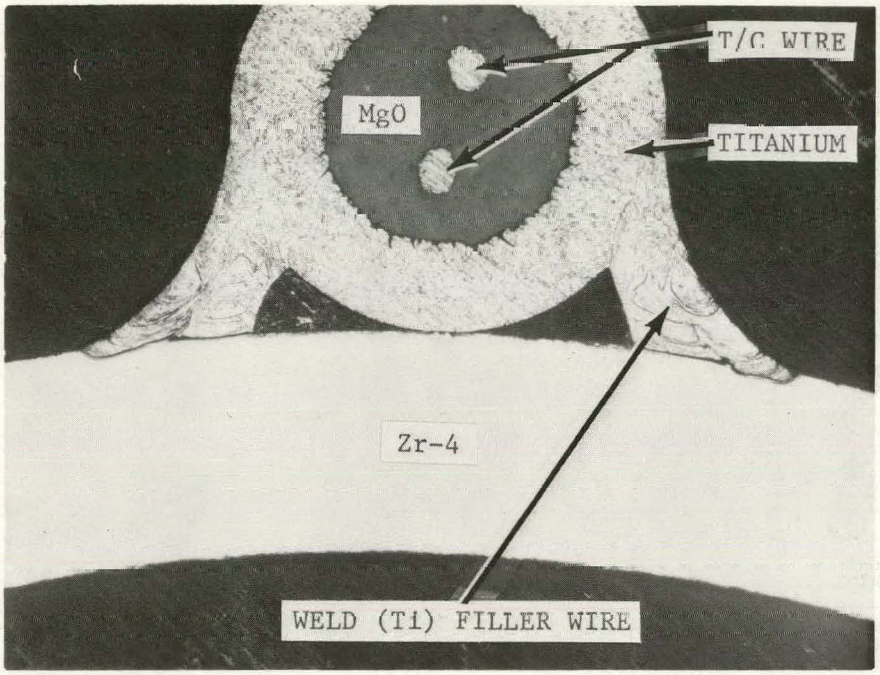


Fig. 7 LOFT laser weld – acceptable mixing.

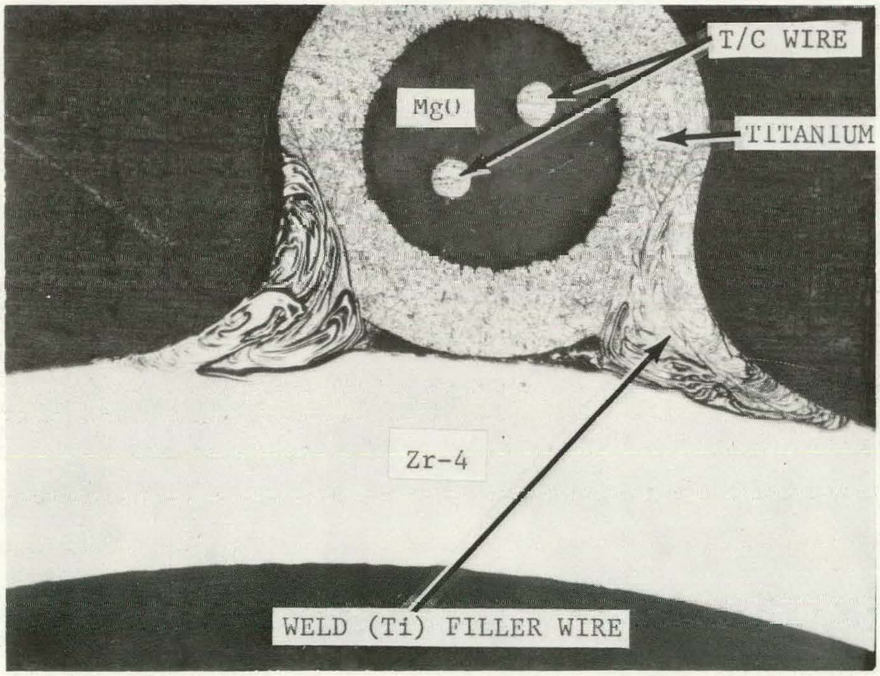


Fig. 8 LOFT laser weld – too much mixing.

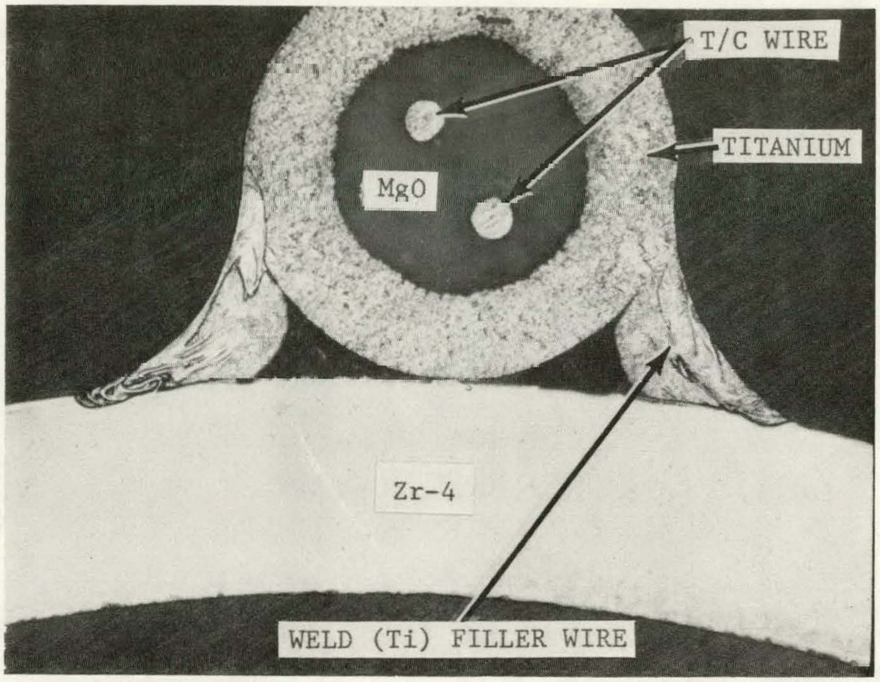


Fig. 9 LOFT laser weld – insufficient mixing.

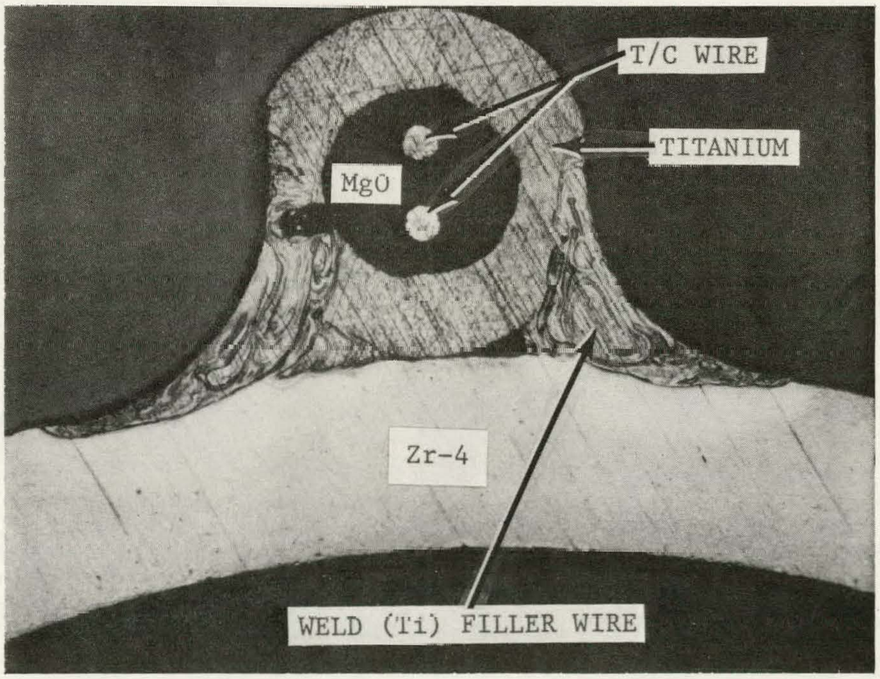


Fig. 10 LOFT laser weld – penetrated T/C sheets.

Thermal cycling and corrosion testing of the design indicate that the weld design will provide the following expected lifetimes:

Exposure to reactor coolant conditions (650°F and 2300 psig): 6000 hours.

Thermal cycles:

400 to 1100°F	(1 cycle)
400 to 1400°F	(5 cycles)
400 to 1500°F	(5 cycles)
400 to 1700°F	(5 cycles)

(2) Guide Tube Instrumentation Assembly - The LOFT fuel bundle design requires attachment of thermocouples to the guide tubes, locating fixed flux detectors inside the guide tubes, and routing lower end box coolant thermocouples inside the guide tubes in a manner that will satisfy the following design conditions:

(a) Differential Pressure Conditions - The components must withstand a differential pressure loading of 300 psi taken in the most adverse direction across each component, instrument, or mounting device, etc. The 300-psi loading requirement shall be evaluated assuming the same thermal conditions that exist at reactor full power (55 MWt).

(b) Temperature Conditions

	Rate of Change	Peak Temperatures
Zircaloy components at normal steady state operating conditions		675°F
Components attached to support tubes (guide tubes)	20°F/sec	2100°F (15 cycles only)

	Rate of Change	Peak Temperatures
Components attached to fuel assembly end boxes	20°F/sec	900°F (15 cycles only)

(c) Transient Termination - After five seconds at the maximum temperature, the instrumentation shall be assumed to be quenched by immersion in a saturated steam-water mixture at a pressure of 25 psia.

Exxon invented a design (see Figures 11, 12, and 13) consisting of a system of coiled instrument cables, intermediate supports, and precise positioning of thermocouple spades to satisfy the design conditions and instrument location requirements.

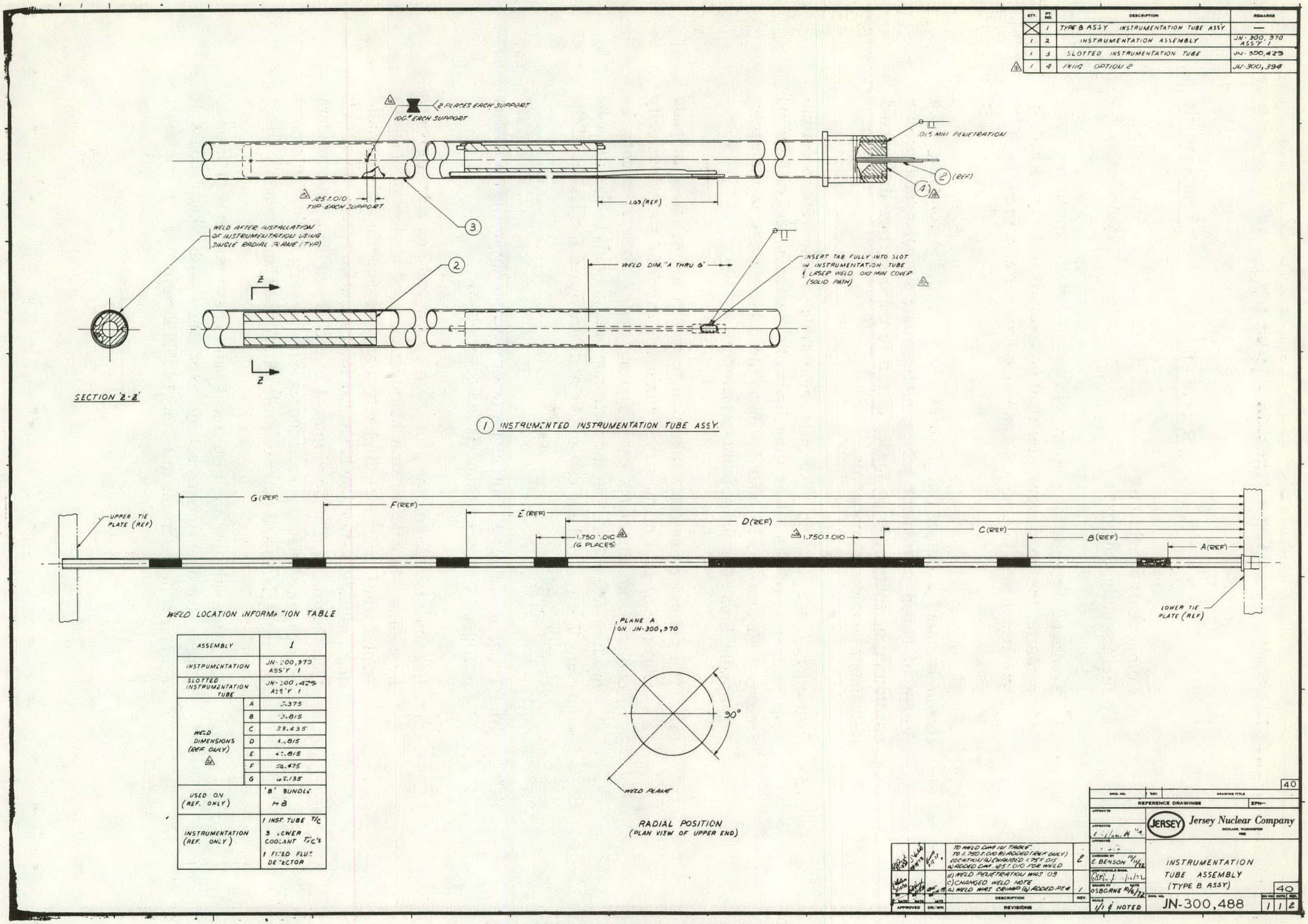
(3) Instrument Cable Routing - The instrument cable routing features continuous protection of the cables from hydraulic buffeting and differential pressures: Figures 14, 15, and 16 show the cable routing in the center fuel bundle. Some significant features include:

(a) The thermocouple cable transition from fuel rod to upper tie plate (Figure 16) in a manner that minimizes exposure to high-velocity coolant and eliminates cable flexing during thermal cycling by machine-screw fastening the instrumented fuel rods to the upper tie plate. The fuel rod end cap and tie plate are fluted for passage of the thermocouples.

(b) The thermocouple routing protection across the tie plate surface provided by recessed channels and cover plates.

(c) Instrument cable routing protection up the end box sides provided by compact bundles of straight cables clamped at close intervals by staples which are match fit, lightly pressed against the cable bundle, and protruding staple ends welded to the end box from the outside (see Figure 16). The development of this design included consideration of unsatisfactory experiences with crossing cables underneath the cable clamp and sharp or protruding cable clamp edges.

(d) Routing paths for the instrument cables have generous radii on all edges, avoiding unsatisfactory experience with sharp edges in contact with the fragile instrument cable sheaths.



QTY.	PT. NO.	DESCRIPTION	REMARKS
☒	1	TYPE B ASSY INSTRUMENTATION TUBE ASSY	—
1	2	INSTRUMENTATION ASSEMBLY	JN-300,970 ASS'Y 1
1	3	SLOTTED INSTRUMENTATION TUBE	JN-300,425
1b 1	4	PLUG OPTION 2	JN-300,394

WELD LOCATION INFORMATION TABLE

ASSEMBLY		1
INSTRUMENTATION		JN-300,970 ASS'Y 1
SLOTTED INSTRUMENTATION TUBE		JN-300,425 ASS'Y 1
WELD DIMENSIONS (REF ONLY) 2c	A	3.375
	B	[illegible]3.815
	C	23.435
	D	[illegible].815
	E	4[illegible].815
	F	56.475
	G	65.135
USED ON (REF. ONLY)		'B' BUNDLE H8
INSTRUMENTATION (REF. ONLY)		1 INST. TUBE T/C 3 LOWER COOLANT T/C's 1 FIXED FLUX DETECTOR

APPROVED		DR'WN	DESCRIPTION	REV.
			TO WELD DIM IN TABLE TO 1.750 ± .010 (c) ADDED (REF ONLY) LOCATION (b) CHANGED .075 ± .015 a) ADDED DIM .125 ± .010 FOR WELD	2
			d) WELD PENETRATION WAS .03 c) CHANGED WELD NOTE a) WELD WAS CRIMP (b) ADDED PT 4	1

REVISIONS

REFERENCE DRAWINGS

DWG. NO. REV. DRAWING TITLE

EPN—

Jersey Nuclear Company

RICHLAND, WASHINGTON

CHECKED BY E. BENSON 10/11/72

DRAWN BY OSBORNE 10/6/72

SCALE 1/1 & NOTED

INSTRUMENTATION
TUBE ASSEMBLY
(TYPE B ASSY)

DWG. NO. JN-300,488

1 1 2

40

Fig. 11 LOFT instrumented guide tube assembly.

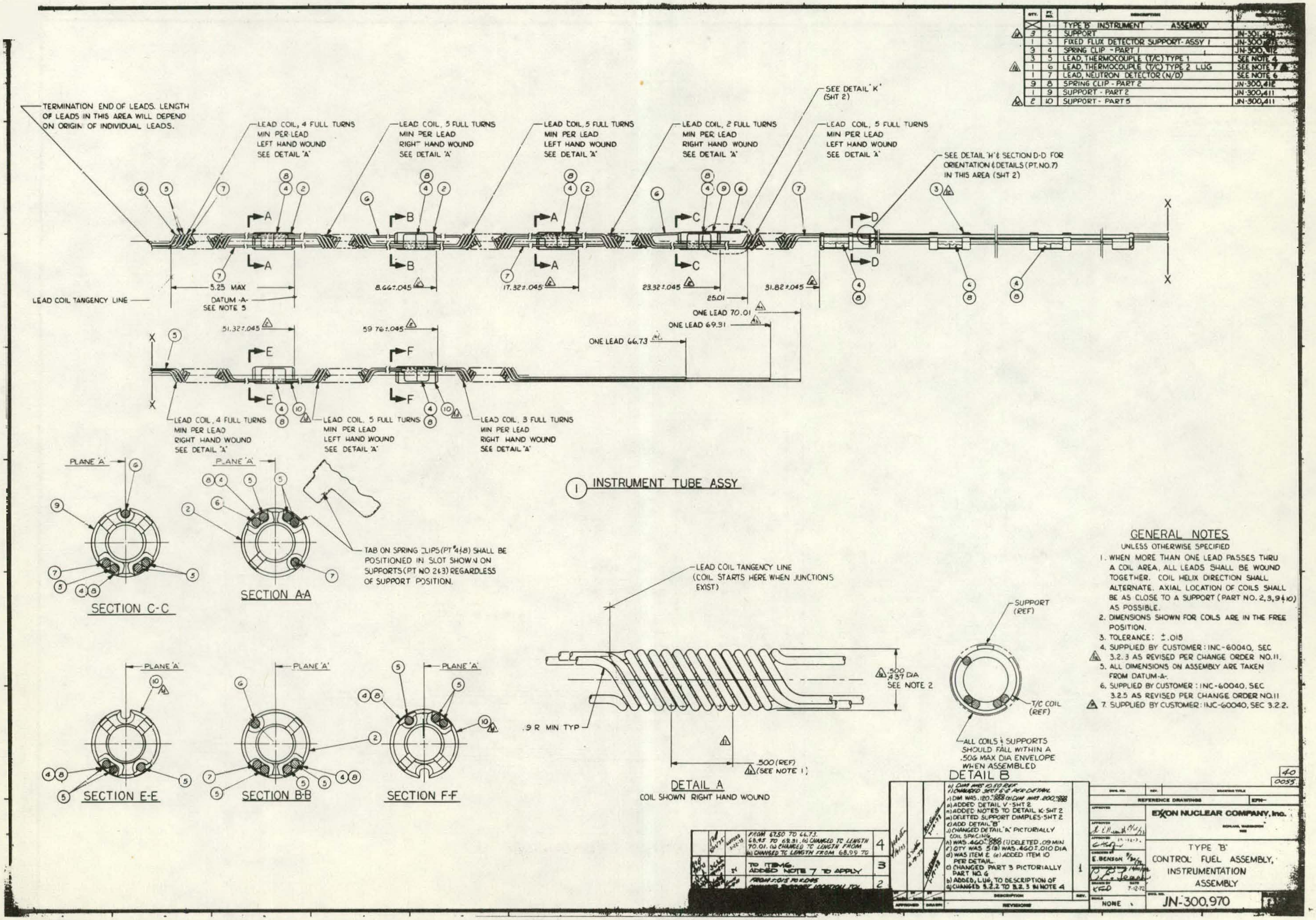


Fig. 12 LOFT guide tube instrumentation assembly.

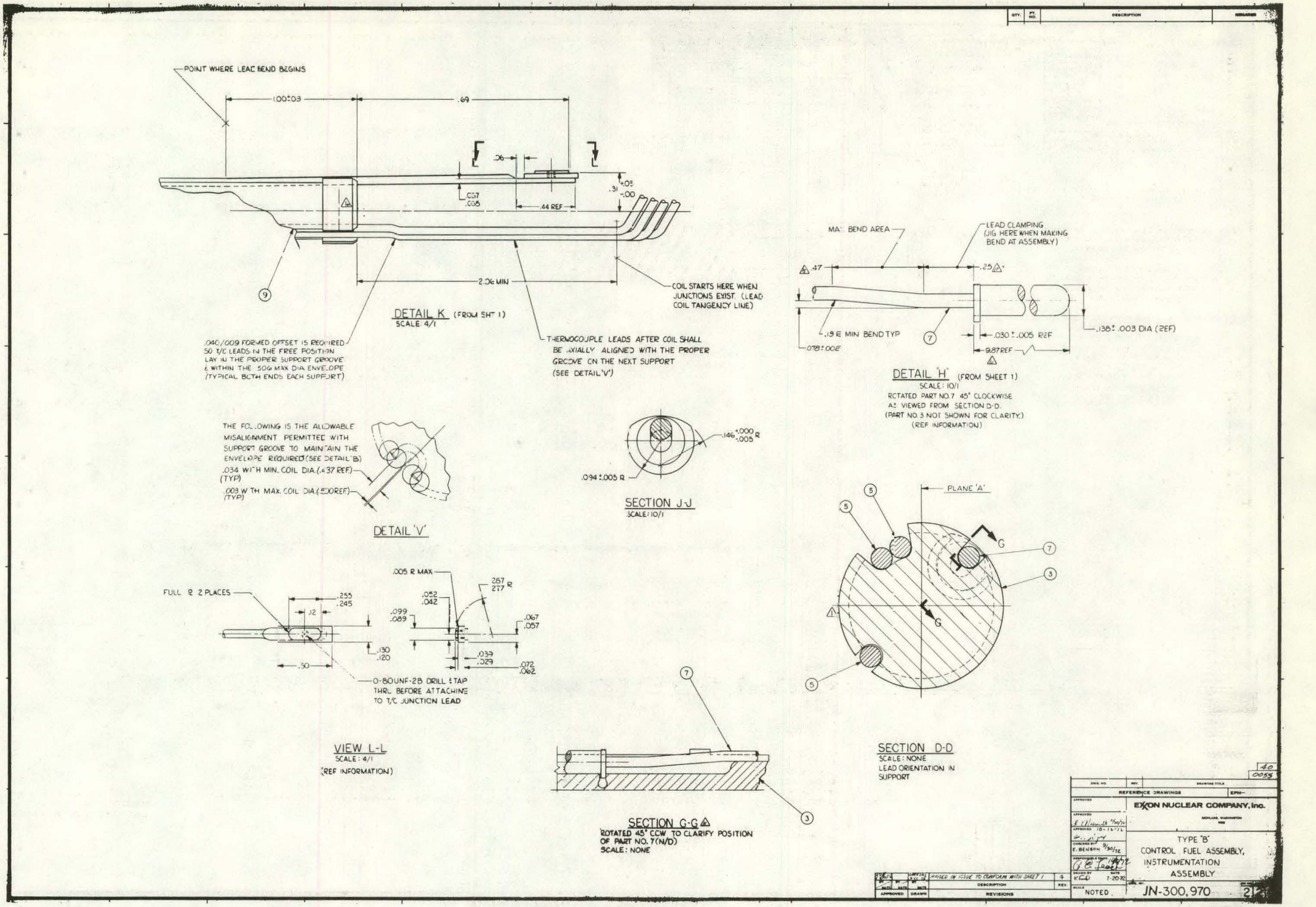
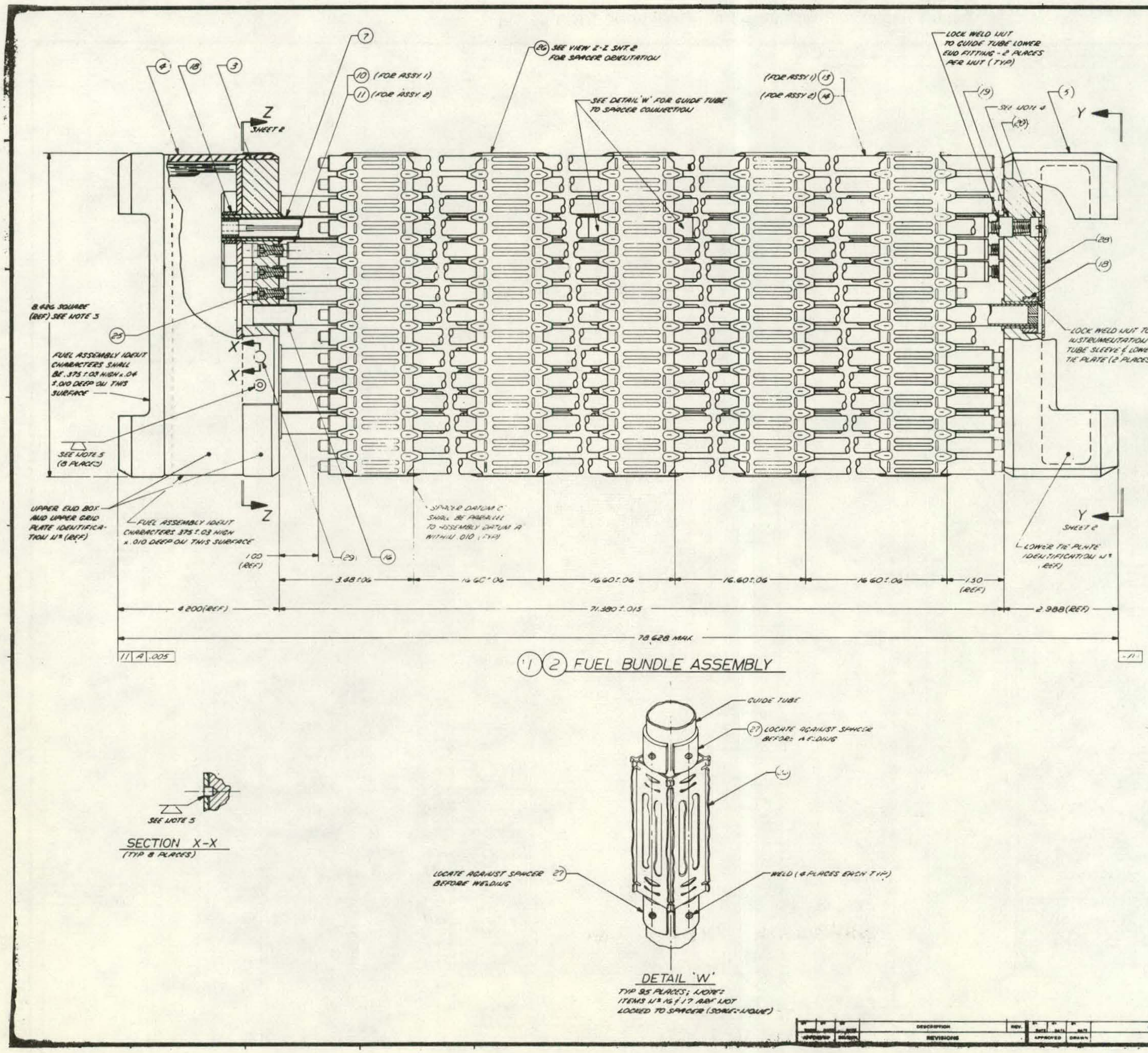


Fig. 13 LOFT guide tube instrumentation assembly.



QTY		PT NO	DESCRIPTION	REMARKS
	▼	1	FUEL BUNDLE ASSY (TYPE A5)	—
▼		2	FUEL BUNDLE ASSY (TYPE A6)	—
1	1	3	UPPER GRID PLATE ASSY	JN 300,345
1	1	4	UPPER END BOX ASSY	JN 300,346
1	1	5	LOWER TIE PLATE	[illegible]
2	2	6	INSTRUMENTED GUIDE TUBE ASSY 1	[illegible]
1	1	7	INSTRUMENTED GUIDE TUBE ASSY 3	[illegible]
1	1	8	INSTRUMENTED GUIDE TUBE ASSY 4	[illegible]
2	2	9	INSTRUMENTED GUIDE TUBE ASSY 6	[illegible]
–	19	10	INSTRUMENTED ROD ASSY (UNPRESSURIZED) (SEE TABLE ON SHT 2 FOR OPTION & QTY)	JN 300,466
19	–	11	INSTRUMENTED ROD ASSY (PRESSURIZED) (SEE TABLE ON SHT 2 FOR OPTION & QTY)	XN-301,277
12	12	12	GUIDE TUBE ASSY 1 (NON-INSTRUMENTED)	JN 300,343
–	185	13	STANDARD ROD (UNPRESSURIZED)	JN 300,463
185	–	14	STANDARD ROD (PRESSURIZED)	XN 301,275
1	1	15	FIXED FLUXED SCAN GUIDE TUBE ASSY.	JN-300,489
1	1	16	INSTRUMENTATION TUBE ASSY 1	JN-300,351
1	1	17	LIQUID LEVEL DETECTOR	SUPPLIED BY CUSTOMER
20	20	18	NUT UPPER GUIDE TUBE (OPTION 1)	JN-300,355
37	37	19	NUT LOWER GUIDE TUBE (OPTION 1)	JN-300,356
1	1	20	NUT LOWER GUIDE TUBE (OPTION 3)	JN-300,356
1	1	21	ROUTING FIXTURE	JN-300,416
		22		
		23		
1	1	24	SLEEVE (OPTION 2)	JN-300,419
19	19	25	CAP SCREW (INSTRUMENTED ROD)	JN-300,437
5	5	26	SPACER ASSEMBLY	JN-300,440
190	190	27	LOCKING RING (OPTION 1)	JN-300,428
1	1	28	THERMOCOUPLE COVER PLATE (OPTION 2)	JN-300,387
8	8	29	DOWEL	JN-300,399
7	7	30	SUPPORT GUIDE TUBE (OPTION 1)	JN-300,415
1	1	31	PIN	JN-300,991
8	8	32	UPPER COOLANT THERMOCOUPLE	SUPPLIED BY CUSTOMER
13	13	33	THERMOCOUPLE LEAD CLAMP (OPTION 2)	XN-300,444
3	3	34	THERMOCOUPLE LEAD CLAMP (OPTION 3)	XN-300,444
7	7	35	THERMOCOUPLE LEAD CLAMP (OPTION 4)	XN-300,444
2	2	36	THERMOCOUPLE LEAD CLAMP (OPTION 5)	XN-300,444

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. DIMENSIONAL TOLERANCES: .XX ±.015, .XXX ±.005, ANGULAR ±2°
2. DIMENSIONING & TOLERANCING ARE IN ACCORDANCE WITH ANSI Y14.5, 1966
3. CONSULT PRODUCT SPECIFICATION FOR BUNDLE ASSEMBLY SEQUENCE & WELD REQUIREMENTS
4. FUEL RODS (EXCEPT INSTRUMENTED) TO BE BOTTOMED ON LOWER TIE PLATE WITHIN .005
5. THE BUNDLE, VERTICALLY ALIGNED SHALL FIT WITHIN AN ENVELOPE OF PARALLEL BOUNDARY PLANES WITH AN 8.449 MAX. SQUARE CROSS SECTION. ALL FOUR SIDES OF THE LOWER TIE PLATE MUST LIE WITHIN THIS ENVELOPE BY A MINIMUM OF .005.
THE PERPENDICULARITY OF THE FUEL BUNDLE SHALL NOT EXCEED .020 MEASURED AS THE DISTANCE OF THE BUNDLE CENTERLINE AT THE UPPER TIE PLATE FROM PROJECTED BUNDLE CENTERLINE PERPENDICULAR TO DATUM 'A'.

REFERENCE DRAWINGS
EPN-

EXXON NUCLEAR COMPANY, Inc

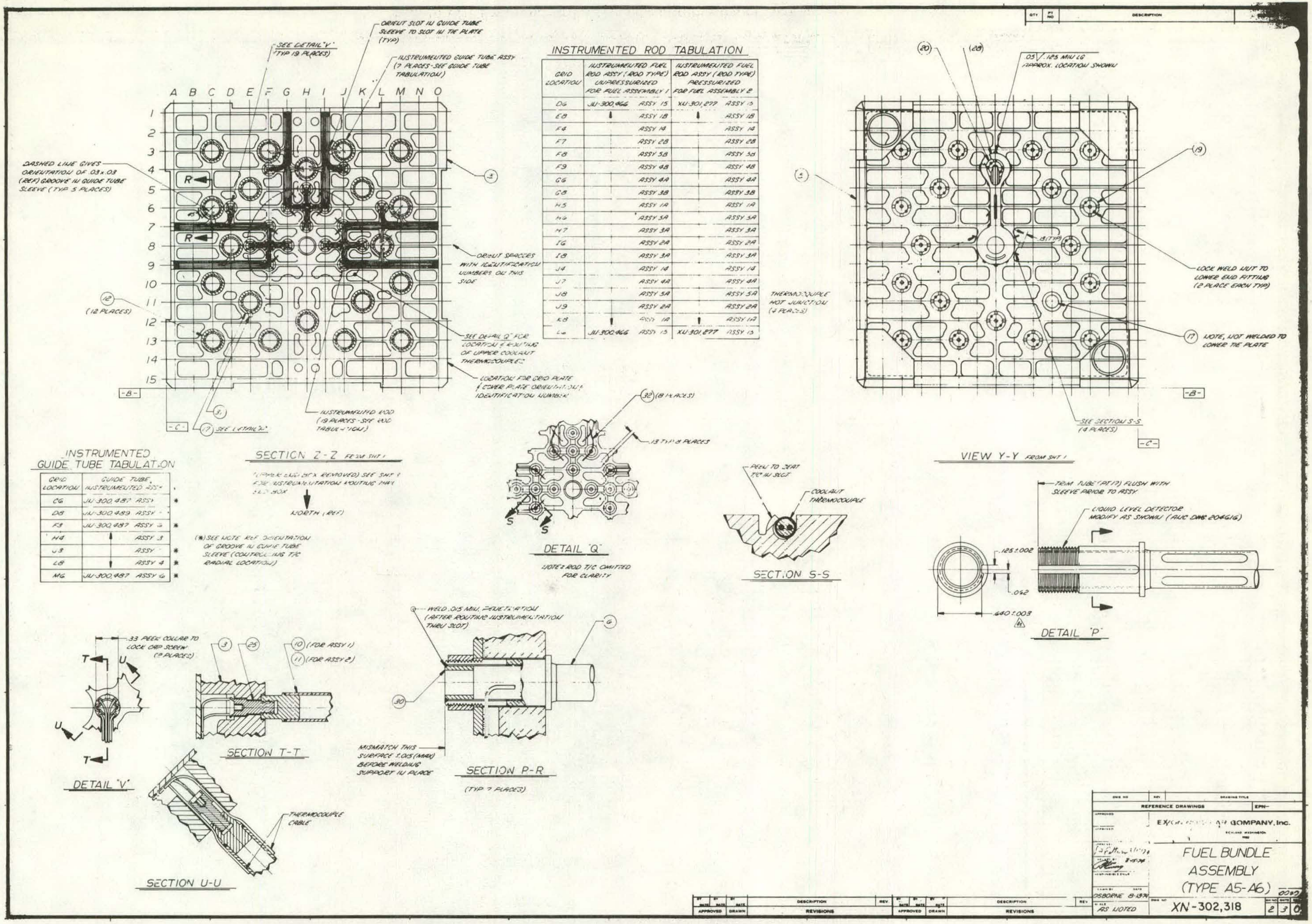
OSBORNE 8-18-74

14 & NOTED

FUEL BUNDLE
ASSEMBLY,
(TYPE A5-A6)

XN-302,318

Fig. 14 LOFT instrumented fuel bundle instrumentation routing.



INSTRUMENTED ROD TABULATION

GRID LOCATION	INSTRUMENTED FUEL ROD ASSY (ROD TYPE) UNPRESSURIZED FOR FUEL ASSEMBLY 1		INSTRUMENTED FUEL ROD ASSY (ROD TYPE) PRESSURIZED FOR FUEL ASSEMBLY 2	
D6	JN-300,466	ASSY 15	XN-301,277	ASSY 15
E8	↑	ASSY 1B	↑	ASSY 1B
F4		ASSY 1A		ASSY 1A
F7		ASSY 2B		ASSY 2B
F8		ASSY 5B		ASSY 5B
F9		ASSY 4B		ASSY 4B
G6		ASSY 4A		ASSY 4A
G8		ASSY 3B		ASSY 3B
H5		ASSY 1A		ASSY 1A
H6		ASSY 5A		ASSY 5A
H7		ASSY 3A		ASSY 3A
I6		ASSY 2A		ASSY 2A
I8		ASSY 3A		ASSY 3A
J4		ASSY 1A		ASSY 1A
J7		ASSY 4A		ASSY 4A
J8		ASSY 5A		ASSY 5A
J9		ASSY 2A		ASSY 2A
K8	↓	ASSY 1A	↓	ASSY 1A
L6	JN-300,466	ASSY 15	XN-301,277	ASSY 15

INSTRUMENTED GUIDE TUBE TABULATION

GRID LOCATION	GUIDE TUBE, INSTRUMENTED ASSY	
C6	JN-300,487 ASSY	*
D8	JN-300,489 ASSY	
F3	JN-300,487 ASSY 2	*
H4	↑ ASSY 3	
J3	ASSY	*
L8	↓ ASSY 4	*
M6	JN-300,487 ASSY 6	*

(*) SEE NOTE REF ORIENTATION OF GROOVE IN GUIDE TUBE SLEEVE (CONTROLLING T/C RADIAL LOCATION)

Fig. 15 LOFT instrumented fuel bundle instrumentation routing.

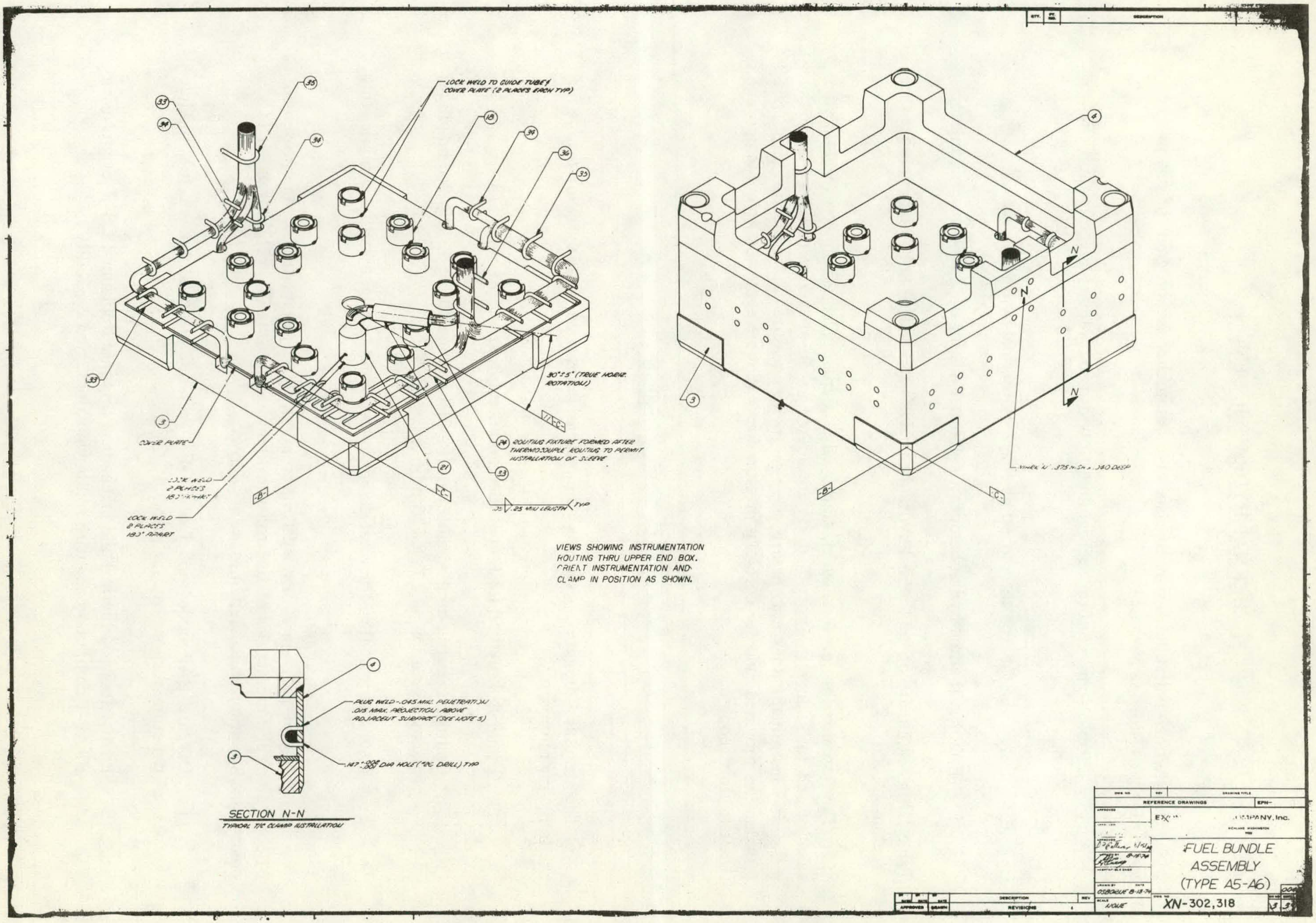


Fig. 16 LOFT instrumented fuel bundle instrumentation routing.

3. THERMAL-HYDRAULIC DESIGN

The thermal-hydraulic design consists of a comprehensive program of analysis and testing for the following purposes:

(1) Establish and confirm fuel module flow distribution and pressure drop characteristics

(2) Determine fuel rod thermocouple effect on thermal-hydraulic behavior

(3) Establish thermal-hydraulic operating limitations for the LOFT fuel modules.

Table III is a summary of the thermal-hydraulic analysis and testing tasks that comprise this program.

The flow distribution test, which employed a laser-Doppler velocimeter to obtain the velocity and turbulence intensity data, is considered an advance in technology since the measuring instrument does not disturb the flow being measured. The pressure drop test program has provided data for core exit pressure losses that are applicable to contemporary core exit flow geometries.

4. STRUCTURAL DESIGN

The structural design consists of a comprehensive program of analysis and testing for the following purposes:

(1) Establish structural loading of fuel modules during LOCEs

(2) Confirm the structural adequacy of the fuel module during anticipated handling, reactor operation, and LOCE conditions.

Table IV is a summary of the structural design analysis and testing tasks that comprise this program.

A continuing program is planned for development, use, evaluation, and improvement of computer code predictions of fuel rod and fuel module structural behavior under LOCE conditions. Specific planned activities are as follows:

(1) Develop SAP code model of LOFT fuel modules and predict fuel module structural response during planned LOCE events

(2) Predict fuel rod thermal and mechanical response to planned LOCE events using FRAP-T computer code with rod bowing prediction capability

TABLE III

LOFT FUEL MODULE THERMAL-HYDRAULIC DESIGN PROGRAM

Purpose	Performing Organization	Results	Documentation
A. Pressure Drop			
1. Preliminary predictions of LOFT fuel bundle pressure drop for use in LOFT primary system and fuel module upper support structure design.	ENC	The analysis predicted total fuel bundle flow loss coefficient of 6.62 (14.6 psi at 2.45 x 10^6 lb/hr-ft^2 flow rate).	Exxon report, "Preliminary Pressure Drop Calculations for Jersey Nuclear LOFT Fuel Assembly", January 6, 1971.
2. Prediction of upper structure pressure drop for use in LOFT primary system design.	MPR	The analysis predicted upper structure pressure drop of 5.5 psi at 3.1 x 10^6 lb/hr-ft^2.	MPR report, "Upper Plenum Pressure Drop", MPR-316, Volume II, Appendix G, December 22, 1971.
3. Pressure drop test data from flow distribution test.	ENC (Battelle Northwest Laboratories)	Testing results indicated spacer grids flow loss coefficient to be 3.65 (5 grids) compared to the predicted value of 3.53.	Exxon report, "XN-74-53, Analysis of the LOFT Instrumented Fuel Assembly Flow Distribution Experiments", October 15, 1974.
4. Pressure drop test data from Type A & C fretting corrosion test.	ENC	Test results indicated significant pressure drop mismatch between Type A & C fuel bundles at core exit and total fuel bundle flow loss coefficient of 8.55 for Type A and 9.74 for Type B.	Exxon report, "XN-75-61, Hydraulic Performance of LOFT Fuel Assemblies, Volumes I & II, June 1976..
5. Pressure drop test data from Type B fuel module mockup and modified Type A & C fretting corrosion test bundles.	ENC	Test results indicated acceptable improvement in core exit pressure drop mismatch of Type A, B, and C fuel bundles after the design changes to Type A & C components. Measured flow loss coefficients were:	Same as above.

	Inlet Flow*	Fuel Bundle	Upper Structure
Type A	3.00	5.62	7.35
Type B	3.00	5.62	7.29
Type C	3.41	5.265	8.20
Core Average	3.105	5.53	7.55

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* Includes core mounting plate.

TABLE III (continued)

Purpose	Performing Organization	Results	Documentation
B. Flow Distribution			
1. Determine fuel bundle flow distribution characteristics in region of high thermal flux (inlet).	ENC (Battelle Northwest Laboratories)	Test results provided velocity and turbulence index factor maps of the center fuel bundle obtained upstream and downstream of the first three spacer grids and confirmed that the flow distribution becomes uniform from the diffuser effects of spacer grids.	Exxon report, "XN-74-53, Analysis of the LOFT Instrumented Fuel Assembly Flow Distribution Experiments", October 15, 1974, abstract presented in "Water Reactor Safety Program - Experimental and Analytical Program Activities", Monthly Report, December 1974.
2. Determine core inlet flow distribution from reactor vessel lower plenum flow tests using a 2/3-scale model.	CEI	Test results indicated that the individual fuel bundle flow velocities at the bottom of the fuel rods did not exceed 3% of average core flow velocity.	Combustion Engineering report "CEND-369, LOFT Reactor Vessel Flow Model Test Program Test Report", October 1974.
3. Prediction of maximum fluid velocities in the core and upper plenum region during worst LOCE.	MPR	The evaluation concluded that 50 ft/sec was a conservative value after predicting maximum velocities as follows: a. core region 29.8 ft/sec b. upper plenum region 31 ft/sec c. upper plenum core flow 3.4 to 26.5 ft/sec d. at ρv^2 detector - center 11.4 ft/sec e. at ρv^2 detector - corner 26.8 ft/sec	MPR report "MPR-509, Report of LOFT Fuel Dynamic Analyses", Volume III, Section B.1, March 1976.
C. Thermal Mixing - Determine LOFT center fuel bundle interchannel thermal mixing coefficients.	ENC (Columbia University)	Test results confirmed that conventional bare-bundle interchannel thermal-mixing coefficient correlations are appropriate for LOFT predictions.	Exxon report, "XN-74-40, Thermal Mixing in LOFT Fuel Assemblies", December 2, 1974.
D. Departure from Nucleate Boiling (DNB)			
1. Preliminary prediction of LOFT fuel bundle DNB behavior for use in fuel bundle warranty limitations.	ENC	The analysis predicted that the LOFT low-flow limitation was 2.77 x 10^6 lb/hr based on the W-3 correlation prediction and a minimum allowable DNB ratio of 1.30.	Exxon report, "JN-72-14, Preliminary Thermal-Hydraulic Analysis for LOFT Fuel Assemblies", April 24, 1972.
2. DNB test data to confirm that the LOFT fuel bundle with thermocouples provided the same DNB behavior as fuel bundles without thermocouples.	ENC (Columbia University)	Test results indicated that a trend existed in the subcooled region that departed (adversely) from the W-3 correlation prediction.	Exxon report, "NX-73-30, LOFT Fuel Departure from Nucleate Boiling Test Analysis and Results", December 1973.

TABLE III (continued)

Purpose	Performing Organization	Results	Documentation
D. Departure from Nucleate Boiling (DNB) (continued)			
3. Additional DNB test data and evaluation to investigate and quantify adverse trend results of previous testing.	EG&G (Columbia University)	Test data were obtained from 25 rod test bundles with and without thermocouple simulation. The data evaluation indicated a DNB penalty (5 to 28% lower) caused by the LOFT fuel rod external thermocouple arrangement. A LOFT DNB correlation was developed which predicted a DNB ratio of 1.13 would satsify 95% confidence level safe operating criteria.	EG&G report, TREE-NUREG- 1043, Evaluation and Results of LOFT Steady State Departure from Nucleate Boiling Tests, April 1977.
E. Combined - Final prediction of LOFT fuel bundle thermal-hydraulic behavior based on evaluation of test program results.	ENC	Analysis incomplete.	Exxon report to be published.
F. Control Rods			
1. Prediction of control rod poison temperatures and guide tube flow rates.	ENC	The analysis predicted that the worst case temperature of the poison material would be 803°F maximum and that the guide tube flow rate should not exceed 1.84% of the total fuel bundle flow rate at worst case (withdrawn control rod) conditions.	Exxon report, "JN-72-15, LOFT Control Rod Cluster Design Report", July 18, 1972.
2. Prediction of control rod poison temperature during worst case planned LOCEs to evaluate potential melting (1425°F) of the AG-In-Cd poison material.	ANC[a]	The analysis which assumed both helium and argon fill gas conditions predicted that the melting temperature would not reach 1425°F until approximately 90 sec after initiation of the pipe break which corresponds to a fuel rod cladding temperature above 2000°F.	ANC LTR 1111-6, "LOFT Control Rod Poison Temperature History after a 100% Inlet LOCE with Delayed ECC Injection", June 27, 1972 and ANC letter report "Control Rod Poison Temperature History: Effect of Using Helium Instead of Argon in Control Rod Gas Space - HFR-5-72", July 11, 1972[a].
G. Neutron Source - Prediction of heat generation and cooling requirements.	ENC	The analysis predicted an equivalent heat source of 0.008 watt which could raise the capsule temperature only 1°F assuming convection cooling of the outside guide tube surface only.	Exxon report, "XN-74-48, Design Report, LOFT Neutron Source Assembly", December 1974.

TABLE III (continued)

Purpose	Performing Organization	Results	Documentation
H. Fuel Module Thermal Expansion - Prediction of differential thermal growth between the fuel module and its end supports during steady state and planned LOCE environments.	ANC[a]	The analysis predicted a differential thermal expansion of 0.804 inch for fuel modules with stainless steel guide tubes and 0.252 inch with zircaloy guide tubes.	ANC LTR 1111-7, "LOFT Fuel Assembly and Upper Support Structure Thermal Expansion Analysis", March 12, 1973[a].
I. Fuel Bundle Instrumentation Routing - Prediction of guide tube instrumentation component temperatures during reactor operation.	ENC	The analysis predicted that the coolant flow through the instrumented guide tubes satisfactorily maintains the instrumentation components at acceptable temperature levels.	ENC report, "JN-72-16, LOFT Instrumentation Routing Design Report", July 20, 1972.

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[a] ANC is now EG&G Idaho, Inc.

TABLE IV

LOFT FUEL MODULE STRUCTURAL DESIGN PROGRAM

Purpose	Performing Organization	Results	Documentation
A. General			
1. Preliminary prediction of fuel module axial loadings during representative expected LOCEs assuming 1 msec break time.	ANC[a]	A WHAM code analysis of the hydraulic environment and a lumped-mass-system response model analysis resulted in a prediction of a worst case loading of 8000 lb to a 15 x 15 size fuel bundle.	ANC LTR 1.1.1.3-1, "A Preliminary Dynamic Analysis of the LOFT Reactor Fuel Assemblies", January 28, 1971[a].
2. Prediction of LOFT fuel module axial loadings during representative expected LOCEs assuming 1 msec break time.	ANC[a]	A WHAM code analysis of the hydraulic environment and a SHOCK code analysis using a lumped-mass-system response model resulted in a prediction of a worst case loading of 11,668 lb to a 15 x 15 size fuel bundle.	ANC LTR 1115-25, "Dynamic Analysis of LOFT Reactor Flow Skirt-Core Filler Assembly for Nonnuclear and Nuclear Loss-of-Coolant Experiments", March 24, 1974[a].
3. Latest prediction of LOFT fuel module axial loadings during representative expected LOCEs using an improved model and assuming both 1-msec break of an 8-in. diameter pipe and 5-msec break of a 5-in. diameter pipe.	EG&G	A WHAM code analysis of the hydraulic environment and a SHOCK code analysis using a lumped-mass-system response model resulted in prediction of a worst case loading to a 15 x 15 fuel module of 11,140 lb and comparison loading of 14,035 lb if the energy absorption parameter is omitted in the WHAM hydraulic model. The slower (planned) break load was predicted to be 6248 lb with the energy absorption parameter.	EG&G LTR 1111-31, "Dynamic Analysis of the LOFT Reactor Fuel Modules for Subcooled Blowdown Loads", December 21, 1976.
4. Independent prediction of LOFT fuel module axial loadings from Item A.2 data.	MPR	The evaluation predicted a worst case loading of 11,540 lb to a 15 x 15 size fuel bundle.	MPR report, "MPR-509 Report of LOFT Fuel Module Dynamic Analysis", Volume II, Section A.2, March 1976.
5. Prediction of LOFT fuel module axial loadings during earthquakes.	MPR	The evaluation, using ANC[a] generated reactor vessel seismic response spectra, predicted a vertical loading of 5.03 g compared to 4.15 g for bedrock response spectra and 10 g from subcooled blowdown loads.	Same as above Volume II, Section A.3.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
A. General (continued)			
6. Prediction of LOFT fuel module lateral loadings during earthquakes.	MPR	The evaluation, using ANC[a] generated reactor vessel seismic response spectra, predicted a lateral loading of 6.7 g compared to 6.2 g for bedrock response spectra.	Same as above Volume II, Section A.4.
7. Prediction of LOFT fuel bundle guide tube and fuel rod local forces and deflections when mid-span lateral deflection equals the available clearances.	MPR	The evaluation predicted worst case loadings as follows: a. Fuel Rod Shear load 1.7 lb Axial load 5.7 lb Bending moment 12.6 in.-lb b. Guide Tube Shear load 6.25 lb Axial load 18.8 lb Bending moment 46.5 in.-lb	Same as above Volume II, Section A.5.
8. Prediction of LOFT fuel module lateral loadings during LOCE.	MPR	The evaulation predicted a lateral impact load of 922 lb assuming water-mass damping of the core barrel motion (undamped loads were predicted to be 2090 lb).	MPR report, "MPR-509, Report of the LOFT Fuel Module Dynamic Analysis", Volume II, Section A.6, Appendix A, March 1976.
9. Prediction of LOFT fuel module axial loadings during reflood.	MPR	The evaluation predicted an axial load of 6220 lb at 1700°F guide tube temperature on the 15 x 15 fuel bundle with stainless steel guide tubes and 3100 lb at 1700°F guide tube temperature on the 15 x 15 fuel bundle with zircaloy guide tubes.	Same as above Volume II, Section A.7.
B. Fuel Rods			
1. Prediction of fuel and cladding temperatures for use in other subsequent structural evaluations.	ENC	The analysis predicted a peak centerline fuel temperature of 4642°F assuming the linear heat generation rate of 19.0 kW/ft and using the Lyons UO_2 thermal conductivity correlation. The predicted maximum cladding temperature was 799°F at 19 kW/ft	Exxon reports: a. "JN-72-4, Standard LOFT Fuel Rod Design Report", March 2, 1972. b. "JN-72-5, Standard LOFT Fuel Rod Design Report Addendum 1", March 17, 1972.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
B. Fuel Rods (continued)			
2. Prediction of cladding strains to confirm that strain limitations of 1% are not exceeded.	ENC	The analysis, which included consideration of fuel swelling, thermal conditions, and power history, indicated the design satisfied the 1% strain limitation.	Same as above.
3. Prediction of fission gas release and resulting internal fuel rod pressure for use in subsequent structural evaluations.	ENC	The analysis, which included temperature-zoned release of all or portions of the volatile UO_2 impurities and gaseous fission products to the fuel rod void volume, predicted a total EOL gas pressure of 2500 psi assuming a commercial PWR lifetime requirement of 30,000 MWd/MTU.	Same as above.
4. Analysis of fuel rod cladding stresses to predict: a. Instantaneous collapse pressure b. Time to creep collapse c. Primary stresses d. Thermal-mechanical effects (mechanical bending, thermal bowing, temperature gradient and flow-induced vibrations) e. Axial loads from fuel bundle skeleton differential thermal expansion.	ENC	The analysis predicted the following: a. An instantaneous collapse pressure of 4697/2995 psig at 70 and 735°F. b. Time to creep collapse of approximately 1800 hours. c. Primary stresses slightly exceeding 1/3 of the minimum specified ultimate strength d. (Results included in c) e. A total force of 24 lb (stress results included in c).	Same as above (Item a).
5. Prediction of pellet stack holddown spring force requirement and spring characteristics.	ENC	The analysis results determined, the geometrical requirements for an Inconel X-750 spring that would provide a nominal 4 g spring force.	Same as above.
6. Prediction of potential fuel densification effects of fuel rod behavior. Specific parameters predicted were: a. Pellet stack gap size and frequency		The analysis which used the November 14, 1972, USAEC fuel densification guidelines predicted: a. Cladding collapse could occur in 1050 hours	Exxon report, "XN-73-28, LOFT Fuel Densification Study", October 22, 1973.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
B. Fuel Rods (continued)			
b. Cladding stresses c. Creation of power spikes d. Fuel centerline temperature e. DNB behavior.		b. Centerline fuel temperature less than melting at 19 kW/ft c. Precautions are necessary to preserve the 1.30 DNB margin.	
7. Analytical evaluation of fuel rod cladding stresses during worst case expected LOCEs.	MPR	The evaluation predicted a 22% stress intensity increase during the LOCE and concluded primary stresses would be less than yield stresses as long as the cold worked material properties are maintained.	MPR report, "MPR-509, Report of LOFT Fuel Module Dynamic Analysis", Volume II, Section B.4, March 1976.
8. Prediction of stresses in the fuel rod cladding at spacer grid contact locations during worst case LOCE and earthquake.	MPR	The evaluation predicted worst case load fuel cladding stress of 41,280 psi compared to 60,000 psi allowable.	MPR report, "MPR-509, Report of LOFT Fuel Module Dynamic Analysis", Volume III, Section C.6, March 1976.
9. Prediction of fuel rod stresses under Item E.12 (bowed guide tube) conditions.	MPR	The evaluation predicted no adverse (a) mechanical effects or (b) thermal effects based on FLECHT simulated flow blockage test results.	MPR report, "Addendum No. 2 to MPR-509, Report of LOFT Fuel Modules Dynamic Analysis", Appendix B, Attachment 1, December 1976.
C. Control Rods			
1. Prediction of buffer spring assembly characteristics required to absorb the terminal kinetic energy of the control rod cluster assembly.	ENC	The analysis determined that two concentric Inconel X-750 springs would achieve the design objective.	Exxon report, "JN-72-15, LOFT Control Rod Cluster Design Report", July 18, 1972.
2. Prediction of buffer spring stresses during absorption of control rod cluster assembly kinetic energy.	ENC	The analysis predicted stresses approximately 5% below allowable stresses.	Same as above.
3. Prediction of spider arm stresses during scram deceleration	ENC	The analysis predicted stresses, approximately 10% below allowable stresses.	Same as above.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
C. Control Rods (continued)			
4. Prediction of control rod elastic behavior under worst case misalignment conditions.	ENC	The analysis predicted the control rods to be flexible and accommodating to potential worst case misalignment conditions.	Same as above.
5. Prediction of control rod cladding stresses and collapse characteristics.	ENC	The analysis predicted that cladding stresses from external pressure, thermal gradients, and potential mechanical bending to be less than allowables. The internal collapse pressure was predicted to be 3140/2775 psi at RT and 650°F.	Same as above.
	MPR	This analysis which included as-built material and dimensional characteristics and more accurate analytical techniques predicted internal collapse pressures to be 3989/3711 psi at RT and 650°F.	ANC LTR-1111-16, "LOFT Control Rod Collapse Prediction", February 25, 1975[a].
6. Prediction of control rod vibration characteristics.	ENC	The analysis concluded that the control rod vibration within the guide tube would not be a problem.	Exxon report, "JN-72-20, LOFT Fuel Design Report - Addenda", September 18, 1972.
7. Prediction of control rod drop time to provide information for designing buffer springs and spider webs.	ANC[a] & ENC	The analysis predicted the control rod drop times to be 0.97 sec for 75% insertion and 2.97 sec for full insertion from full withdrawal at reactor operating conditions.	ANC internal letter BVW-4-71, "LOFT Scram Time Analysis", August 20, 1971[a]. ENC report (see C.1).
8. Experimental determination of control rod cluster drop time and confirmation of control rod cluster structural capabilities.	ENC	The experimental data confirmed the LOFT control rod cluster structural capabilities and indicated 0.75 and 2.0 sec to 75 and 100% insertion under expected alignment conditions, 0.95 and 2.15 sec to 75 and 100% insertion under simulated worst case misalignment conditions, and terminal velocity of 5.2 ft/sec.	ENC report, "XN-74-57, LOFT Reactor Control Cluster Insertion Tests", December 1974.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
9. Prediction of mechanical loads and thermal conditions during LOCE and seismic events.	MPR	The evaluation predicted loadings as follows: a. Vertical load 6.8 g (seismic event) b. Horizontal load 6.7 g (seismic event) c. Peak poison temperature 1472°F (LOCE reflood).	MPR report, "MPR-509, Report of LOFT Fuel Module Dynamic Analysis", Volume III, Section A.1, March 1976.
10. Prediction of stress under Item C.9 loading conditions for the following control rod components: a. Spider b. Control rod cladding end fittings, absorber rod, and spring c. Shafts d. Buffer springs and retainer e. Spring retaining bolt fastening.	MPR	The analysis predicted that all control rod components analyzed would have stress conditions below the allowable stresses.	Same as above Volume III Sections A.2 through A.6.
11. Prediction of control rod stresses under Item E.12 (bowed guide tube) conditions.	MPR	The evaluation predicted no adverse mechanical effects.	MPR report, "Addendum 2 to MPR-509, Report of LOFT Fuel Modules Dynamic Analysis," Appendix B, Attachment 1, December 1976.
D. Spacer Grids			
1. Establish spacer grid spring geometry to "force a node" when the fuel rod is vibrating, elastically accommodate manufacturing tolerances and imposed assembly deflection, accommodate fuel rod diametral changes and prevent damage to the fuel rod cladding.	ENC	A combined analytical and experimental program was employed. The analytical program was based on a beam model and the experimental program consisted of deadweight loading a single spacer grid cell mockup. A spring configuration was developed that satisfied the design requirements.	Exxon report, "JN-72-9, LOFT Fuel Rod Grid Spacers, Design Report", April 24, 1972.
2. Predict stresses in spacer grid springs and welds due to expected vertical loads.	ENC	A linear elastic analysis using a beam model predicted the maximum stresses to occur at the intersection welds and that the maximum stresses would not exceed allowable stresses.	Same as above.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
D. Spacer Grids (continued)			
3. Predict stresses in strip due to possible unbalanced spring-to-dimple load.	ENC	A linear elastic analysis using a shell model predicted a maximum stress intensity of 74,500 psi compared to the material allowable yield stress of 150,000 psi.	Same as above.
4. Evaluate combined effects of vertical and unbalanced loads.	ENC	The analytical evaluation predicted a maximum combined stress intensity of 101,200 psi.	Same as above.
5. Predict the fatigue behavior of the springs.	ENC	The analytical evaluation predicted the fatigue life, based on an alternating friction load (26,700 psi max), would not result in failure during the expected 10^3 to 10^6 number of cycles since the alternating stress limit for 10^6 cycles is 110,000 psi.	Same as above.
6. Determine the spacer grid weight.	ENC	The analysis predicted the weight to be 860 grams for the 15 x 15 spacer. Actual measured weights are 848.3 and 363.8 g for the 15 x 15 and corner spacer, respectively.	Same as above (analysis only).
7. Evaluation of spacer grid response to loadings during fuel loading (fuel assembly lower tie plate contacting spacer grid top at vertical velocity of 40 in./min).	ENC	The analysis, which used a beam model and the STRESS-II code, predicted that in the abrupt stop situation the spacer strips, under direct loading, would yield locally but not fracture at the strips or intersection joints.	Exxon report, "JN-72-20, LOFT Fuel Design Report - Addenda", September 18, 1972.
8. Evaluation of spacer grid response to a lateral 6-g load applied during shipment or a 1500 lb seismic load.	ENC	The analysis predicted maximum stress in the strips of 55,000 psi (approximately 80% of the allowable load).	Same as above.
9. Experimental determination of intersection joint strength.	ENC	The experimental results indicated a strength of 387 lb in tension compared to a 14 lb design requirement and 1135 lb in shear.	Exxon report, "XN-104, Report of Experimental Determination of LOFT Grid Spacer Strength", February 1973.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
D. Spacer Grids (continued)			
10. Experimental determination of side plate weld strength to evaluate shear resistance characteristics during the fuel loading condition of Item 7 above.	ENC	The experimental results indicated a weld joint bending moment capability of 1.39 in.-lb compared to the Item 7 predicted load of 0.2 in.-lb.	Same as above.
11. Experimental determination of spacer grid response to the fuel loading condition of Item 7.	ENC	The experimental results indicated the spacer grid would not fail catastrophically (fracture) up to loads of 4000 lb compared to the Item 7 loading condition of 3500 lb.	Same as above.
12. Experimental confirmation that the spacer grid design dampens fuel rod vibration and prevents damage by the fretting corrosion process.	ENC	The experiments, which included 1500-hour flow environment test of full-size 15 x 15 and corner instrumented fuel bundle prototypes, demonstrated that the design was satisfactory.	Exxon report, "XN-74-61, LOFT Fretting Corrosion Test Report", December 30, 1974.
13. Prediction of LOFT spacer grid lateral impact loads during LOCE and earthquake events.	MPR	The evaluation predicted worst case loadings or impact velocities as follows: a. LOCE 12.1 in./sec b. Earthquake 3630 lb.	MPR report, "MPR-509, Report of LOFT Fuel Module Dynamic Analysis", Volume II, Section A.6, March 1976.
14. Test of LOFT spacer grid lateral impact load capacity.	ENC & Westinghouse	The testing indicated the spacer grids could absorb, without permanent distortion, the following lateral impact loads: Westinghouse Test 4400 lb Exxon Test 3600 lb.	Same as above.
15. Prediction of moments and shear forces applied to spacer grid during fuel assembly lateral deflection.	MPR	The evaluation predicted worst case moments of 4.4 in.-lb and shear forces of 1.31 lb at each fuel rod location.	Same as above Volume II, Section B.3, Appendix A.
16. Prediction of stresses in the spacer grid structure during worst case LOCE and seismic loads.	MPR	The evaluation concluded that (a) the spacer grids should be capable of withstanding LOCE subcooled blowdown vertical loads, (b) spacer strip and intersection welds (fuel rod locations) stresses do not exceed allowables during lateral fuel	Same as above Volume II, Section B.3.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
D. Spacer Grids (continued)			
		assembly deflection (see Item A.7), (c) spacer strip intersection welds at guide tube locations exceed allowables, and (d) fatigue tests of the intersection weld joint should be run.	
17. Prediction of stresses in spacer grid springs and dimples during worst case LOCE and earthquake.	MPR	The evaluation concluded that neither LOCE or earthquake would result in adverse effects to the spacer grids.	Same as above Volume III, Section C.6.
E. Skeleton			
1. Preliminary prediction of guide tube geometry needed to satisfy the LOFT fuel technical specifications.	ENC	The analysis, which considered the combined effects of bending and column instability, predicted the required guide tube wall thicknesses of 0.038 in. for 304 SS and 0.100 in. for Zr-4 compared to a desired 0.015 in.	Exxon report, "JN-72-7, LOFT Fuel Supply Guide Tube Strength", April 4, 1972.
2. Prediction of guide tube structural response to expected axial loads (maximum) of 5490 lb (for 15 x 15 bundle) at room temperature.	ENC	This analysis predicted that the LOFT guide tube wall thickness should be 0.017 in. to satisfy the revised (compared to Item 1) LOFT fuel technical specifications.	Exxon report, "JN-72-10, LOFT Fuel Assembly Structural Design and Analysis", May 8, 1972.
3. Prediction of stresses in the upper and lower tie plates.	ENC	This analysis, which used a beam element analysis program, predicted the expected axial loading conditions would result in a maximum tie plate stress of 9000 psi compared to the allowable level of 14,000 psi.	Same as above.
4. Prediction of guide tube mechanical attachments stresses.	ENC	This analysis, which considered the attachment of the guide tube to sleeve, the guide tube to lower end cap, and upper sleeve to nut fastening system, indicated the attachments were capable of withstanding axial loads of 2000 lb.	Same as above for 304 SS. For Zr-4 see Exxon reports, "XN-74-47, LOFT Type F Fuel Assembly Structural Design and Analyses", December 1974 and "XN-74-41 Revision 1, LOFT Type F Fuel Assembly Structural Design and Analysis", July 1976.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
E. Skeleton (continued)			
5. Determination of guide tube to spacer grid locking ring attachment (4 spot welds per ring) strength.	ENC	The experimental results indicated the axial load capabilities to be 1620 lb for the 304 SS and 1170 lb for the Zr-4 compared to a design load of 200 lb.	Exxon report, "XN-104, Report of Experimental Determination of LOFT Grid Spacer Strength", February 1973.
6. Experimental determination of fuel bundle strength characteristics including separate determinations of tie plate and empty skeleton characteristics and fuel bundle response to worst case misalignment conditions.	ENC	The experimental results indicated: a. Tie plate (upper) yield stresses at 10,000 lb axial load b. Guide tube-spacer grid (skeleton) load capabilities of 22,000 lb c. No significant deterioration of axial strength in the misaligned condition d. A fuel bundle natural frequency of 320 Hertz.	Exxon report, "XN-74-28, LOFT Fuel Assembly Strength Test, Test Report", July 15, 1974.
7. Experimental determination of LOFT guide tubes mechanical properties in compression at high temperatures (1000, 1300, and 1500°F) for use in evaluating LOFT fuel bundle response during LOCEs.	ENC	The experimental results indicate mechanical properties in compression at these temperatures are lower (up to 40% for 304 SS and 10% for Zr-4) than published tensile mechanical properties data.	Exxon report, "XN-74-50, Guide Tube Compression Tests - Test Report", November 1974.
8. Prediction of guide tube and end box maximum expected temperatures during LOCE.	MPR	The evaluation concluded that the following maximum temperatures should be used for subsequent evaluations: a. Guide tubes 1700°F b. Upper end box 1000°F c. Lower end box 700°F	MPR report "MPR-509, Report of LOFT Fuel Module Dynamic Analyses", Volume III, Section A.7, March 1976.
9. Prediction of stress under worst case LOCE and seismic loads (see Items A.4 through A.9) for the following fuel bundle skeleton components: a. SS guide tubes b. Zircaloy guide tubes c. Upper end box d. Lower end box e. Instrumentation tube	MPR	The evaluation concluded that the following additional work should be accomplished: a. Modification of several Type F fastener connections b. Fatigue life testing of the spacer grid intersection welds and tie-plate-to-upper end box connection c. Elevated temperature load testing of the zircaloy guide tubes d. Reprediction of subcooled blowdown loads	Same as above Volume I, Appendix B, and Volume II, Section II.B.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
E. Skeleton (continued)			
f. Upper end box to tie plate connection g. SS guide tube to tie plate connections h. Zircaloy guide tube to tie plate connections i. Guide tube to spacer grid connection j. Instrumentation tube to lower tie plate connection k. Instrumented fuel rod to tie plate connection		e. More accurate prediction of guide tube temperatures during LOCE.	
10. Reprediction of stress under worst case LOCE loads (see Item A.3, Appendix A) for the upper tie plate to end box connection.	MPR	The evaluation predicted that the dowel pin bearing stress was 18,600 psi compared to 15,200 psi allowable and 48,270 predicted in Item E.9.	Same as above Volume II, Section A.6, Appendix A.
11. Additional prediction of guide tube thermal conditions and axial mechanical loads during worst case LOCE.	MPR	The evaluation, which considered results from FLECHT and Semiscale tests, predicted the following: a. Peak guide tube temperature 1540°F b. Hottest guide tube average temperature 1110°F c. Maximum radial guide tube temperature variance from average bundle guide tube temperature during saturated blowdown 152°F d. Maximum radial guide tube temperature variation in fuel bundle during reflood 750°F e. Maximum guide tube loads at 1700°F guide tube temperature 311 lb	MPR report, "Addendum 2 to MPR-509, Report of LOFT Fuel Module Dynamic Analysis", Appendix A, December 1976.
12. Prediction of stresses in stainless steel guide tubes considering the radial temperature gradients predicted in Item E.11.	MPR	The evaluation predicted bowing of the guide tubes contact, with fuel rods externally and control rods internally (where appropriate) while maintaining	Same as above Appendix B.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
E. Skeleton (continued)			
		(a) stresses within allowable values and (b) mechanical load carrying capacities.	
13. Prediction of stresses in zircaloy guide tubes considering the radial temperature gradients predicted in Item E.11.	MPR	The evaluation predicted the guide tubes have sufficient strength to withstand the resulting axial loads up to about 1500°F and recommended additional experimental investigation of the guide tube buckling characteristics at elevated temperature.	Same as above Appendix C.
F. Neutron Source			
1. Prediction of holddown spring assembly characteristics required to provide a 65-lb force of engagement.	ENC	The analysis determined that two concentric Inconel X-750 springs would achieve the design objective.	Exxon report, "XN-74-48, Design Report, LOFT Neutron Source Assembly", December 1974.
2. Experimental confirmation of design configuration during exposure to expected reactor operating conditions.	ENC	The experiment, which included a 1500-hour flow environment test of a prototype neutron source rod assembly demonstrated that the design was satisfactory.	Exxon report, "XN-74-61, LOFT Fretting Corrosion Test Report", December 30, 1974.
G. Upper Support Structure			
1. Prediction of LOFT fuel module upper structure axial loads during normal, LOCE, and LOCA conditions. The LOCE loads were predicted assuming an instantaneous break of an 8 in. Schedule 150 pipe close to the reactor vessel. The LOCA loads were predicted assuming an instantaneous break of an 1[illegible]-in. ID pipe in the reactor vessel outlet nozzle.	MPR	The analysis predicted the following axial loads:	MPR report, "MPR-316, Design Report for LOFT Fuel Assembly Upper Support Structures", November 1971.

	Load (lb)		
	Normal	LOCE	LOCA
Corner structure	185	1340	24,610
Control structure	534	3880	71,000
Center structure	384	2800	51,100.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
G. Upper Support Structure (continued)			
2. Prediction of corner structure stress and fatigue conditions under normal, LOCE, and LOCA conditions for the following components: a. Main support tube b. Lower and intermediate support pads c. Core plate pins d. Holddown spring e. Spring deflector.	MPR	The analysis predicted that all structure components analyzed would have (a) stress conditions below the allowable stresses and in most cases substantially below (factor of 10) allowables, and (b) no cumulative fatigue usage factor.	Same as above.
3. Prediction of center structure stress and fatigue condition under normal, LOCE, and LOCA conditions for the following components: a. Main support box structure b. Main support corner bars (at reactor vessel nozzle level) c. Instrument channel d. Lower, intermediate, and upper support pads e. Holddown spring f. Adjusting nut g. Orifice plate.	MPR	Same as above.	Same as above except Item 4 (lower support pads) and Item 7 are reported in MPR letter report, "Analysis of Center Fuel Module Orifice Modification", June 10, 1974.
4. Prediction of control guide structure stress and fatigue conditions under normal, LOCE, and LOCA conditions for the following components: a. Drive shaft shroud b. Control rod guide tubes c. Alignment pads d. Alignment pins.	MPR	Same as above.	Same as G.1.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
G. Upper Support Structure (continued)			
5. Prediction of control structure stress and fatigue conditions under normal, LOCE, and LOCA conditions for the following components: a. Main support box structure b. Main support corner bars (at reactor vessel nozzle level) c. Instrument channel d. Lower and intermediate support pads e. Upper core support plate pins f. Support gussets.	MPR	Same as above.	Same as above.
6. Preliminary prediction of thermal stresses during LOCE reflooding (bottom injection) or deluging (top injection).	MPR	The analysis predicted that (a) stress levels would be acceptable during reflooding, (b) stress levels during deluging could limit the number of cycles to 37, and (c) additional analysis should be performed.	Same as above.
7. Additional prediction of effect of LOCE top ejection on upper support structures.	MPR	This analysis predicted that unsatisfactory distortion could occur during top ejection.	MPR letter report, "Effects of Upper Plenum Injection of LOFT Fuel Module Upper Support Structures", May 10, 1973.
8. Prediction of natural frequency for the following: a. Control upper structures b. Center upper structures c. Corner upper structures d. Control rod shaft shroud e. Control rod guide structure	MPR	The analysis predicted the following natural frequencies: Control structure - 270 to 2380 cps Center structure - 270 to 2380 cps Corner structure - 105 to 545 cps Shroud - 360 cps Guide structure - 510 to 4100 cps.	Same as G.1.
9. Preliminary prediction of holddown spring design characteristics. This analysis included prediction of the holddown force requirements.	MPR	The analysis predicted the holddown springs should provide a holddown force of 6500 lb for 15 x 15 fuel modules and allow up to 0.70-inch differential growth of the fuel module.	Same as above.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
G. Upper Support Structure (continued)			
10. Additional prediction of holddown spring characteristics to provide a holddown force of 1000 lb for 15 x 15 fuel modules and 500 lb for corner fuel modules and spring rate of 2000 lb/in.	MPR	This analyses predicted a set of spring geometries to meet the specified requirements. In addition, evaluations were made of fuel bundle loading during LOCE subcooled blowdown and core heatup phases and predictions of improved fuel bundle guide tube characteristics.	MPR letter report, "Alternate Holddown Spring Designs for LOFT Fuel Modules", August 22, 1972.
11. Additional prediction of holddown spring characteristics to provide a spring constant of 55 lb/in.	MPR	This analysis resulted in a recommendation to correct the holddown spring constant to 500 lb/in. and predicted a set of spring parameters that satisfied the revised spring constant requirement.	MPR letter report, "Spring Constant for Fuel Module Holddown Springs", August 29, 1972.
12. Additional prediction of holddown spring characteristics to correct the differential growth requirement to 1.07 in. (center bundle) and 1.02 in. for corner and control bundles.	ANC[a]	The analysis predicted a set of spring parameters that satisfied the requirement for holddown force and spring constant.	ANC letter report, "LOFT Reactor Fuel Assembly Holddown Springs-Saff-22-72", October 12, 1972 and "Type F Fuel Module Holddown Spring-Saff-26-72", November 27, 1972[a].
13. Final prediction of holddown spring characteristics to correct a misunderstanding regarding the definition of "installed length" which had resulted in a higher than specified holddown load.	ANC[a]	This analysis resulted in the establishment of a set of spring design parameters that finally satisfied the requirement for holddown force, spring rate and differential growth.	Unpublished ANC analysis dated May 21, 1973[a].
H. Instrumentation Penetration			
1. Prediction of stresses during normal operating conditions for the following (5-in.-diameter penetration) pressure boundary components: a. Head bolts b. Pressure tube c. Pressure plate d. Braze buttons.	ANC[a]	The analysis predicted that the design for all configuration analyzed was adequate (within ASME Section III, Class I allowables) for the design conditions with one exception, which was corrected by increasing the quantity of heat bolts.	ANC letter report, "LOFT Instrumentation Center Penetration, 5 in. - Fors-3-73", April 4, 1973[a].

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
H. Instrumentation Penetration (continued)			
2. Prediction of stresses during normal operating conditions for Inconel-titanium upper and lower buttons, 304 SS lower button and the following weld designs: a. Pressure tube weld b. Teleflux tube weld c. Connector weld d. Lead seal weld e. Mounting sleeve weld f. Standoff weld.	ANC[a]	The analysis predicted that the design, for all configurations analyzed, was adequate (within ASME Section III, Class I allowables) for the design conditions with one exception, which was corrected by increasing the lead seal weld leg to at least 0.078 in. The button analysis used a finite element model of the button.	ANC letter report, "Analysis of LOFT Instrumentation Penetrations - BVW-5-73", July 9, 1973[a].
3. Prediction of stresses under expected loads for the following pivot arm components: a. Lower pivot pin b. Upper pivot pin c. Support bracket (part of upper structure) d. Arm (shoulder area).	ANC[a]	The analysis predicted the design, for all configurations analyzed, was adequate (within ASME Section III, Class I allowables) for vertical loadings up to 500 lb.	ANC letter report, "Analysis of LOFT Fuel Module Pivot Arm Assembly - BVW-4-73", May 23, 1973[a].
4. Experimental determination of titanium-tantalum-Inconel explosion-bonded sandwich (Detaclad) material mechanical characteristics under the following conditions: a. Simple tensile loading b. Ram tensile loading c. Braze cycling d. Bending loading e. Thermal cycling (100 cycles 135 to 650°F) f. Stress-corrosion (1300 psi stress levels for 3000 hours in 2500 psi, 600°F borated water simulating LOFT coolant chemistry conditions.	ANC[a]	The experiments indicated that the Detaclad material has (a) adequate load-carrying capability for the LOFT service conditions, (b) satisfactory corrosion resistance, and (c) satisfactory dimensional and mechanical properties stability under both brazing and normal operation thermal cycling.	ANC letter report, "Transmittal of Test Results Detaclad Composite Material, GU-9-73", July 10, 1973[a].

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
H. Instrumentation Penetration (continued)			
5. Experimental determination of the center fuel bundle instrumentation penetration assembly response to four 500-hour cycles of exposure to 2500 psi, 600°F borated water (simulating LOFT coolant chemistry condition) terminated by a blowdown plus a preliminary hydrostatic test at 3125 psig.	ANC[a]	The experimental results indicated satisfactory performance of the instrumentation assembly.	Not available.
6. Prediction of stresses under worst case LOCE and seismic loads for the instrumentation penetration pressure tubes.	MPR	The evaluation concluded that the pressure tube will not be adversely affected during LOCE or earthquakes.	MPR report, "MPR-509, Report of LOFT Fuel Module Dynamic Analysis", Volume III, Section A.1, March 1976.
I. Fuel Bundle Instrumentation Attachment			
1. Prediction of stresses in instrumented fuel rod-to-upper-tie-plate fastener arrangement.	ENC	The analysis predicted that allowable strength limitations would not be exceeded at an instrumented fuel rod cap screw torque of 8 in.-lb at ambient conditions.	Exxon report, "JN-72-20, LOFT Fuel Design Report Addenda", September 13, 1972.
2. Prediction of stresses and fatigue life in the coolant thermocouple hot-junction protrusion (0.125 in.) into the tie plate flow channel.	ENC	The analysis predicted that the design configuration would withstand both normal operating and the specified LOCE design conditions.	Exxon report, "JN-72-16, LOFT Instrumentation Routing Design Report", July 10, 1972.
3. Prediction of stresses in the instrument cable unsupported spans including the guide tube instrumentation assembly instrument cable coils.	ENC	The analysis, which included evaluation of flow-induced vibration, predicted that the design configuration was adequate (a) for a 300-psi transverse differential pressure except for the fuel rod themocouples where transverse loads of this magnitude were judged to be unappropriate, and (b) the specified temperature conditions.	Same as above.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
I. Fuel Bundle Instrumentation Attachment (continued)			
4. Prediction of stresses in the instrument cable bundle tiedowns (staples).	ENC	The analysis predicted that the design configuration could withstand the 300-psi transverse differential pressure.	Same as above.
5. Prediction of stresses in the liquid-level routing fixture.	ENC	The analysis predicted that the design configuration would withstand the 300-psi transverse differential pressure.	Same as above.
6. Experimental confirmation of fuel bundle instrument attachment designs to withstand expected normal reactor flow conditions.	ENC	The experiment consisted of 1500-hour flow environment tests of a full-size prototype and demonstrated that the design was satisfactory for expected normal reactor flow conditions.	Exxon reports, "XN-74-61, LOFT Fretting Corrosion Test Report", December 30, 1974, and "XN-75-12, LOFT Fretting Corrosion Test Report, Addendum 1, Instrumentation Examination Results", March 1975.
7. Experimental confirmation of fuel rod thermocouple attachment response to a series of temperature cycling programs representing reactor conditions as follows: a. Cycle program consisting of 1 cycle, 400 to 1100°F; 5 cycles, 400 to 1500°F; and 5 cycles, 400 to 1700°F b. Cycle program consisting of 20 cycles, 400 to 745°F; and 15 cycles, 400 to 1400°F.	ENC	The experiment results indicated that improvements could be made in the weld design since some weld failures occurred during testing.	Exxon report, "XN-74-62, LOFT Instrumented Fuel Rod and Guide Tube Thermal Cycling and Corrosion Test", December 31, 1974.
8. Experimental confirmation of guide tube instrumentation assembly (4 guide tube T/C models) response to a temperature cycling program (20 cycles, 400 to 675°F; and 15 cycles, 400 to 1400°F) representing normal reactor operating and LOCE conditions.	ENC	The experiment results indicate that the design is satisfactory.	Same as above.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
I. Fuel Bundle Instrumentation Attachment (continued)			
9. Experimental confirmation of fuel rod thermocouple attachment response to a combination thermal and hydraulic loading cyclic program representing expected LOCE conditions as follows: a. A three-cycle test consisting of heating to 1400, 1600, and 1900°F cladding temperature and blowing down (4-joule weld characteristics) b. A nine-cycle test consisting of heating to 1300°F (1 cycle), 1400°F (5 cycles), 1600°F (1 cycle), and 1700°F (2 cycles) (6.5-joule weld characteristics). Test specimens include full-length samples.	ANC[a]	The experiment results indicated that the weld characteristics of the 6.5-joule weld were satisfactory and the weld characteristics of the 4.0-joule welds were likely satisfactory based on the results of the abbreviated program.	ANC LTR-141-6, "LOFT Heater Pin Thermocouple Attachment Testing", May 17, 1973[a].
10. Experimental confirmation of fuel rod thermocouple attachment response to a combination thermal and hydraulic loading cycle program consisting of 21-thermal cycles by heating in steam to 1100°F (1 cycle), 1400°F (5 cycles), 1500°F (5 cycles), 1600°F (5 cycles), and 1700°F (5 cycles); each cycle followed by bottom flooding. The 10-in. test sample has 4 simulated thermocouples representing the full range of acceptable weld characteristics.	ANC[a]	This is a routine experimental program to confirm the stress and corrosion capabilities of the weld design. Recent results indicated that a new weld design based on 4.0 joules, 275 spot size, and 40 aperature was unsatisfactory.	ANC letter report, "Tube Furnace Thermal Cycle Tests, Mes-1-73", January 5, 1973[a]. Recent test results to be published.
11. Experimental confirmation of fuel rod thermocouple attachment corrosion behavior under the expected LOFT environment (borated water at 2500 psia and 650°F) conditions.	ANC[a]	This is a routine test of the long-term weld corrosion characteristics. Recent results indicated that the expected lifetime of the welds in the LOFT reactor would be about 6000 hours.	ANC LTR 1.4.1-29, "Autoclave Life Tests of LOFT Fuel Rod Thermocouple Welds", March 13, 1975[a].

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
I. Fuel Bundle Instrumentation Attachment (continued)			
12. Predict the maximum stresses under Items B.3 and C.9 loading conditions for the following components: a. Coolant thermocouple hot junction b. Guide tube T/C cable spans c. Fuel rod T/C cable spans.	MPR	The study concludes that the components evaluated meet ASME rocs requirements under the worst case LOCE and seismic loading conditions.	MPR report, "MPR-509, Report of LOFT Fuel Module Dynamic Analyses", Volume III, Section B.6, March 1976.
J. Upper Structure Instrumentation Attachment			
1. Predictions of stresses during normal operating, LOCE, and LOCA conditions for the following components: a. Density-velocity detector mounting bracket b. Density-velocity detector mounting flange (including fastener counter bore) c. Type C upper structure window-frame cutout for density-velocity detector bracket d. Type A upper structure window-frame cutout for density-velocity detector e. Type A density-velocity detector cable conduit f. Type A density-velocity detector cable conduit staples g. Free-field pressure detector mounting flange h. Displacement transducer bolt preload i. 1/4-in. cap screw j. 1/4-, 3/8-, and 3/4-in. capscrew locking cups.	MPR	The analyses predicted that the design of all components was adequate for normal operating, LOCE, and LOCA conditions with one exception which was corrected by adding a strategically located Type A density-velocity detector cable conduct support.	MPR letter report, "Design Analysis for Upper Core Support Structure Replaceable Instruments", May 21, 1973.

TABLE IV (continued)

Purpose	Performing Organization	Results	Documentation
J. Upper Structure Instrumentation Attachment (continued)			
2. Predict the maximum stresses under Item C.9 loading conditions for the center fuel module density-velocity detector cable conduit, conduit clips, and conduit clip attachment welds.	MPR	The study concluded the components evaluated meet the applicable ASME stress requirements.	MPR report, "MPR-509, Report of LOFT Fuel Module Dynamic Analysis", Volume III, Section B.4, March 1976.
3. Predict the maximum stresses under Item C.9 loading conditions for the following components: 1. Center fuel module a. Flux scan tube b. Flux scan tube bracket and fasteners. 2. Corner fuel module a. Pressure tubes b. Pressure and cable conduit tube clips and welds c. Flux scan tube, tube brackets, and fasteners.	MPR	The study concluded that the components meet the applicable ASME code stress requirements except for: a. Corner fuel module flux scan tube fasteners b. Center fuel module flux scan tube. Recommendations were made to reduce the fastener torque to 3.5 ft-lb (8.1 ft-lb specified) and raise the flux scan tube natural frequency of vibration by improvement in the support arrangement.	Same as above Volume III, Section B.5.

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(3) Predict worst case LOCE event guide tube temperature conditions with MOXY computer code

(4) Incorporate FRAP-T features into MOXY computer code and predict core-wide region of fuel rod damage during planned LOCE events with MOXY/SCORE computer codes

(5) Predict fuel rod cladding mechanical response to planned LOCE events at local worst case fuel rod positions with existing computer code.

The LOFT test data will be compared to the analytically predicted responses and appropriate code adjustments made for improved prediction capability.

5. MISCELLANEOUS DESIGN

The total design program effort also included some design activities classified as miscellaneous. These activities are of interest since the purposes of some were to determine fundamental material properties at high temperatures. Table V is a summary of these design activities.

TABLE V

LOFT FUEL MODULE MISCELLANEOUS DESIGN ACTIVITIES

Purpose	Performing Organization	Results	Documentation
A. Fuel Rod Cladding -- Determine the rate and amount of annealing of LOFT cold-worked zircaloy cladding when exposed to temperatures (800 to 1800°F) expected in LOCEs.	ANC[a]	The experimental results indicated that rapid annealing would occur in the 1100 to 1200°F range with more rapid rates up to 1500°F where instantaneous (less than 1 sec) annealing was indicated.	ANC LTR 1.1.1.1-4, "Zircaloy-4 Annealing Study", October 29, 1974[a].
B. Control Rod Poison -- Determine the fundamental material properties of melting temperature, and coefficient of expansion near the melting temperature of the LOFT 80Ag-15In-5Cd poison material.	BMI	The experimental results indicated the following properties: Melting temperature -- 1472 to 1562°F Volume expansion in melting -- 5.4% Thermal expansion coefficient after melting -- 3.83 x 10^{-2}in./in. °F (1562 to 1859°F) Thermal expansion below melting temperature -- 13.3 x 10^{6} in./in. °F.	ANC LTR 1.1.1.1-15, "Experimental Determination of Behavior of the Ag-In-Cd Poison Rod Alloy at Expected LOCE Temperatures", February 1975[a].
C. Control Rod Poison -- Determine the compatibility of the 80Ag-15In-5Cd LOFT poison material with Type 304 SS at expected LOCE temperatures (1400 to 2000°F).	ANC[a]	The experimental results indicated that the poison rod alloy and 304 SS are compatible.	Same as above.
D. Fuel Bundle Components -- Evaluate electrical discharge machining (EDM) as a technique for machining in-core components.	ENC	The combined literature information evaluation, corrosion tests and metallurgical investigation indicated the EDM is an acceptable machining technique.	Exxon report "JN-72-21, Evaluation of Electrical Discharge as a Technique for Machining In-Core Components", September 8, 1972.

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[a] ANC is now EG&G Idaho, Inc.

IV. FABRICATION PROGRAM

The fabrication for the LOFT fuel modules is based on the following objectives:

(1) Preproduction process demonstration of all difficult fabrication processes and measurement techniques

(2) Characterization of the fuel module with emphasis on characteristics that could influence the fuel bundle response during the LOCE

(3) Fabrication program based on the quality assurance requirements of RDT Standard F2-2.

1. PREPRODUCTION PROCESS DEMONSTRATION PROGRAM

The preproduction process demonstration program for fabrication processes was comprehensive and thorough. The program performed for fuel bundle fabrication at Exxon is summarized in Table VI. Similar comprehensive programs were performed -- for the upper support structures by L&S Machine Co. and for the instrumentation penetration assemblies and fuel module assembly by EG&G Idaho, Inc.

The process demonstration programs were effective in identification of unsatisfactory design and fabrication conditions and confirming that the corrective action was satisfactory.

The qualification/demonstration programs for measurement techniques were also comprehensive and thorough. Table VII is a summary of some of these qualification activities which are of special interest because of the unique character of the inspection. All equipment and inspection equipment operators are covered by a comprehensive program to maintain equipment accuracy and operator skills.

2. CHARACTERIZATION

The fuel module characterization is designed to provide (a) traceability to raw materials, fabrication processes, inspection techniques, and participating personnel, (b) measurement of characteristics which could influence the fuel bundle response during its use in the LOFT experimental program, and (c) measurement of characteristics required to demonstrate that the components satisfy the agreed upon specifications. Table VIII is a summary of some of the more important fuel bundle characteristics which have been or will be determined and recorded. The laser-Doppler determination of the fuel bundle flow

TABLE VI

LOFT FUEL BUNDLE FABRICATION PROCESS QUALIFICATIONS/DEMONSTRATIONS PROGRAM

Purpose	Performing Organization	Results	Documentation
1. Fuel rods			
a. End cap welds (WP-27 and -61	ENC	Satisfactory (40 welds each)	Exxon reports, 7/8/72 (WP-27) and 9/17/73 (WP-61).
b. Rotary fuel pellet pressing	ENC	Satisfactory (507 pellets)	Exxon report, 6/2/72.
c. Fuel rod assembly	ENC	Satisfactory (6 rods)	No report available.
d. Fuel rod pressurization	ENC	Satisfactory after a design modification to prevent contamination of the seal weld with spatter from the Inconel pellet holddown spring.	Exxon report, "XN-145, LOFT Prepressurization Process Demonstration", August 1973.
2. Fuel Bundle Skeleton			
a. Guide tube sleeve weld (WP-39)	ENC	Satisfactory (6 samples) with rework to correct alignment	Exxon report, 2/20/73.
b. Guide tube sleeve edge weld (WP-40)	ENC	Satisfactory (6 samples)	Exxon report, 1/30/73.
c. Guide tube lower end weld (WP-41)	ENC	Satisfactory (16 samples) with rework to correct alignment	Exxon report, 2/20/73.
d. 15 x 15 spacer grid intersection joint welds, end tab weld, and corner overlap weld (SP-114)	CARAN	Satisfactory (10 samples each) after changes were made to eliminate porosity in weld centers	Caran report, 8/19/72.
e. 15 x 15 spacer grid assembly (SP-114)	CARAN	Satisfactory (1 assembly) after design changes were made to center strips in slots during welding	Caran report, 8/19/72.
f. Corner spacer grid assembly (SP-117)	CARAN	Satisfactory (one)	No report available.
g. Spacer grid locking ring weld (WP-50)	ENC	Satisfactory (6 samples)	Exxon report, 9/3/74.
h. Instrumentation tube plug weld (WP-42)	ENC	Satisfactory (6 samples)	Exxon report, 2/5/73.
3. Fuel Bundle End Boxes			
a. Upper (15 x 15) end box 90-degree corner weld (LSWP-1)	L&S	Satisfactory (2 samples)	L&S report, March 1973.
b. Upper (corner) end box 45-degree corner weld (LSWP-3)	L&S	Satisfactory (2 samples)	L&S report, March 1973.

TABLE VI (continued)

Purpose	Performing Organization	Results	Documentation
3. Fuel Bundle End Boxes (continued)			
c. Upper end box side plate to collar weld (LSWP-2)	L&S	Satisfactory (1 sample)	L&S report, March 1973.
4. Fuel Bundle Instrumentation Attachment			
a. Guide tube thermocouple to guide tube attachment laser weld (WP-1C1)	ENC	Satisfactory (12 samples)	Exxon report, 3/12/73.
b. Guide tube assembly support to tube weld (WP-44)	ENC	Satisfactory (16 welds)	Exxon report, 2/5/73.
c. Differential pressure tube locking ring weld (WP-45)	ENC	Satisfactory (8 welds)	Exxon report, 3/1/73.
d. Liquid level routing fixture gusset and lock welds (WP-46)	ENC	Satisfactory (6 samples)	Exxon report, 3/19/73.
e. Coolant thermocouple hot junction attachment to tie plate (metal upset)	ENC	Satisfactory (4 samples)	Exxon report, 4/73.
f. Instrument cable bundle staple weld (WP-59)	ENC	Satisfactory (6 samples) after improvements for minimizing instrument cable heating	Exxon report, 3/22/74.
g. Lower tie plate to T/C cover plate weld (WP-52)	ENC	Satisfactory (14 samples)	Exxon report, 2/13/73.
h. Thermocouple seal weld (WP-56)	ENC	Satisfactory (12 samples)	Exxon report, 2/8/73.
i. Fuel rod thermocouple attachment laser weld	ENC	Satisfactory (1 full length, 4 T/C samples per machine) after numerous process improvements over a 3-year period. To date, approximately 6 full-length PPQ units, many 10-inch process requalification units and 57 prototypes have been fabricated as part of the total process demonstration program	
j. Fuel rod/tie plate fastener system (including metal upset)	ENC	Satisfactory (3 samples)	Exxon report, 3/73.
k. Guide tube instrumentation assembly	ENC	One satisfactory assembly per model	Exxon reports:

TABLE VI (continued)

Purpose	Performing Organization	Results	Documentation
4. Fuel Bundle Instrumentation Attachment (continued)			
(1) Type B instrumentation tube model			(1) To be published
(2) Two coolant thermocouple models			(2) 2/8/75
(3) Four coolant thermocouple models			(3) 2/8/75
(4) Fixed flux detector model			(4) No report available
(5) One guide tube T/C model			(5) 2/8/75
(6) Four guide tube T/C models.			(6) To be published.
5. Fuel Bundle Assembly			
a. Upper tie plate to end box weld (WP-49)	ENC	Satisfactory (8 samples)	Exxon report, 3/1/73.
b. Fuel bundle tack and retaining welds (WP-88)	ENC	Satisfactory (approximately 8)	Exxon report, 1/22/75.
c. Fuel bundle assembly plug weld (including pins and dowels) (WP-89)	ENC	Satisfactory (approximately 8)	Exxon report, 10/7/74.
d. Center (15 x 15) fuel bundle prototype	ENC	Successful (1 complete unit) -- The result indicated the following improvements were necessary or desirable: 1. ANC[a] furnished titanium-sheathed thermocouple quality 2. Fuel rod thermocouple attachment technique 3. Instrument cable bundle attachment to upper end box 4. Liquid level detector alignment 5. Lower end box thermocouple positioning 6. Skeleton alignment 7. Guide tube locking ring welding	Exxon monthly report for January 1973.
e. Corner instrumented fuel bundle prototype	ENC	Successful (1 complete unit) -- The results indicated satisfactory improvement of Items 1 through 5 above and indicated the following improvements were necessary or desirable: 1. Guide tube locking ring welding 2. Assembly shop management 3. Skeleton alignment tilt (caused by inherent triangular shaped sensitivity)	Exxon monthly report for July 1973.

TABLE VI (continued)

Purpose	Performing Organization	Results	Documentation
5. Fuel Bundle Assembly (continued)		4. Skeleton alignment twist (caused by guide tube residual torque introduced by nut torquing) 5. Clearance and access to lower end box guide tube nuts 6. Welding head access to peripheral spacer grid locking rings	
f. Control (15 x 15) fuel bundle prototype.	ENC	Successful (1 noninstrumented unit mock-up) -- The results indicated satisfactory improvement of Items 5.d. 6 and 7 and 5.e. 1 and 4 above.	No report available.
6. Control Rod Assembly a. Control rod end fitting seal weld (WP-54)	ENC	Satisfactory (14 samples)	Exxon report 6/10/74.
b. Control rod to spider plug weld (WP-55)	ENC	Satisfactory (10 welds)	Exxon report 4/3/74.
c. Extension shaft weld (WP-58)	ENC	Satisfactory (3 samples)	Exxon report 6/13/73.
d. Control rod assembly.	ENC	Successful (2 prototypes) -- The results indicated that improvements were desirable in reducing porosity in the spider raw material and spider surface finish.	
7. Neutron Source Assembly.	ENC	Successful (1 complete prototype) -- The results indicated improvements were desirable for positioning the tube-to-shaft crimping tool.	Same as Item 5.e.
8. Fuel Bundle Packaging and Shipping.	ENC	Successful [1 instrumented (15 x 15) control fuel bundle mockup] -- The results indicated improvements were desirable in shipping container cleanliness: inside (before packaging) and outside (during transport); and assuring all support equipment was installed.	No report available.

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[a] ANC is now EG&G Idaho, Inc.

TABLE VII

LOFT FUEL MODULE SPECIAL INSPECTION TECHNIQUE PROCESS DEMONSTRATIONS

Inspection Device/Technique	Performing Organization	Results	Documentation
A. LOFT fuel bundle and RCC alignment vertical gage	ENC	Satisfactory demonstration of repeatability on a center fuel bundle prototype.	ENC report, March 1973.
B. LOFT fuel bundle rod-to-rod inspection gage	ENC	Satisfactory comparison of measured versus actual dimensions in a typical 15 x 15 configuration.	ENC report, March 1973.
C. Fuel pellet diameter automatic inspection instrument	ENC	Satisfactory rejection of 10 oversize and 10 undersize pellets mixed into a batch of acceptable pellets.	ENC report, 6/22/71.
D. Fuel rod thermocouple attachment weld torque tests	ENC ANC[a]	Numerous test results developed a meaningful correlation between the torque test results and the thermal-cycling (strength) capabilities of the weld.	No report available.

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[a] ANC is now EG&G Idaho, Inc.

TABLE VIII

AS-BUILT LCFT FUEL BUNDLE CHARACTERISTICS TO BE DOCUMENTED

Item	Characteristics	Values	Notes
A. Fuel Bundle	1. Weight	NA	Actual value
	2. Length	78.568 ± 0.060 in.	Tabulate actual dimension
	3. Envelope		
	a. Square	8.449 in. square	Must fit full length with bottom centered
	b. Corner	7.429 in. legs x 10.506 in. hypotenuse	Must fit full length with bottom centered
	4. End surface squareness	Parallel to 0.005 in.	Certification of compliance
	5. Spacer grid spacing	16.60 ± 0.06 in.	Certification of compliance
	6. Pressure drop	Determined by test	Actual test data
	7. Flow distribution	Determined by test	Actual test data
	8. Strength	Determined by test	Actual test data
	9. Flow vibration sensitivity	Determined by test	Actual test data
	10. DNB	Determined by test	Actual test data
	11. Flow mixing	Determined by test	Actual test data
	12. Control rod drop time	75% of travel in 2 sec, 100% of travel in 3 sec	Determined by test, actual test data
	13. Rod-to-rod spacing	0.120 in. min	Determined with electronic device, Certification of compliance

TABLE VIII (continued)

Item	Characteristics	Values	Notes
B. Each Component	1. Chemical Composition:		
	a. Fuel pellet (UO_2)	Stoichiometric 2.00 to 2.02 oxygen to uranium ratio, 4.00% enrichment	Actual value per lot
	b. Fuel rod cladding	ASTM B 351 GR RA-2 (Zr-4)	Actual value per lot
	c. Fuel rod insulating washer	99.3% pure Al_2O_3	Actual value per lot
	d. Fuel rod spring (Inconel X-750)	AMS-5698B or 5699B	Actual value per lot
	e. Fuel rod end fittings	ASTM B351 GR RA-2 (Zr-4)	Actual value per lot
	f. Spacer grid straps	AMS 5596 C (Inconel 718)	Actual value per lot
	g. Locking rings	ASTM A 213 (304 L SS)	Actual value per lot
	h. Guide tube	ASTM A 213 (304 L SS)	Actual value per lot
	i. Guide tube fitting	ASTM A 276-70 (304 L SS)	Actual value per lot
	j. End boxes	ASTM A 240-70 (304 L SS)	Actual value per lot
	k. Miscellaneous fuel bundle components	Mostly 304 L SS	Actual value per lot
	l. Control rod poison	80% Ag, 15% In, 5% Cd	Actual value per lot
	m. Control rod cladding	ASTM A-213 (304 L SS)	Actual value per lot

TABLE VIII (continued)

Item	Characteristics	Values	Notes
B. Each Component (continued)	n. Control rod spring	AMS-5698 or 5699B	Actual value per lot
	o. Control rod end fitting	ASTM A 276-70 (304 L SS)	Actual value per lot
	p. Control rod spider	ASTM A 240-70 (304 L SS)	Actual value per lot
	q. Miscellaneous control rod components	Mostly 304 L SS	Actual value per lot
C. Fuel Pellet Drawing No. JN 300343	1. Impurities:		
	Individual	JN S30061, Appendix B	Value for each lot
	Total gaseous	0.10 cc/g	Vacuum outgassing at 3000°F, value for each lot
	Moisture	20 ppm max	Value for each lot
	Boron equivalent	3 ppm max	Value for each lot
	2. Diameter	0.3659 ± 0.0005 in.	Certification of compliance
	3. Length	0.600 ± 0.025 in.	Certification of compliance
	4. Perpendicularity	End surface $\perp$ 0.005 in.	Certification of compliance
	5. Dish geometry	0.420 in. spherical (both ends)	Certification of compliance
	6. Defects (chips, cracks)	See JN-S30061, Paragraph 3.5.3	Certification of compliance
	7. Density	93 ± 1.5% theoretical	Certification of compliance
	8. Surface finish	$63\sqrt{\quad}$ (RMS)	Certification of compliance
D. Fuel Rod Cladding JN 300336	1. Impurities:		
	Individual	JN-S30084, Appendix C	Value for each lot
	Finished product	N_2, H_2, O_2, C	Value for each lot
	Boron equivalent	40 ppm max	Value for each lot

TABLE VIII (continued)

Item	Characteristics	Values	Notes
D. Fuel Rod Cladding JN 300336 (continued)	2. Tensile properties ambient to 650°F	JN S30084, Paragraph 3.5.2	Value for each lot
	3. Flare	JN S30084, Paragraph 3.5.3	Value for each lot
	4. Burst	JN S30084, Paragraph 3.5.4	Value for each lot
	5. Defects	0.002 in. deep x 0.004 in. wide x 0.125 in. long max	Certification of compliance (test on each tube)
	6. Grain size	Size 7 longitudinal, 8 transverse (max)	Value for each lot
	7. Hydride orientation	F_N less than 0.30	Value for each lot
	8. Corrosion resistance	Weight gain per ASTM B 353	Value for each lot
	9. Wall thickness	0.0228 in. min	Value for each center assembly tube. Certification of compliance for others
	10. Inside diameter	0.3734 ± 0.0015 in.	Value for each center assembly tube. Certification of compliance for others
	11. Outside diameter	0.4240 ± 0.0015 in.	Value for each center assembly tube. Certification of compliance for others

TABLE VIII (continued)

Item	Characteristics	Values	Notes
D. Fuel Rod Cladding JN 300336 (continued)	12. Straightness	0.015 in. in 12 in.	Certification of compliance
	13. Surface finish	$32\sqrt{\text{max}}$	Certification of compliance
E. Fuel Rod End Caps	1. Impurities:		
	Individual	JN S30085, Appendix C	Value for each lot
	Finished product	N, H, O	Value for each lot
	Boron equivalent	40 ppm max	Value for each lot
	2. Tensile properties ambient and 650°F	JN S30085, Paragraph 3.5.3	Value for each lot
	3. Hardness	Rockwell 392 max	Value for each lot
	4. Defects	0.005 in. deep x 0.004 in. wide x 0.125 in. long max	Also 0.0136-in. diameter hole Value for each rod or bar
	5. Grain size	Size 7 max longitudinal and transverse	Value for each lot
	6. Corrosion resistance	Weight gain per ASTM B 351	Value for each lot
	7. Dimensions	Drawings JN-300460 and JN-300436	Certification of compliance
F. Fuel Rod Insulating Washer JN 300337	1. Impurities:		
	Individual	JN S30067 Paragraph 3.22	Value for each lot
	Total gases	0.05 cc/g	Vacuum outgas at 3000°F, value for each lot
	Moisture content	35 ppm max	Value for each lot
	Boron equivalent	76 ppm max	Value for each lot

TABLE VIII (continued)

Item	Characteristics	Values	Notes
F. Fuel Rod Insulating Washer JN 300337 (continued)	2. Compressive strength	250,000 psi	Value for each lot
	3. Pits, chips, and cracks	JN S30067, Paragraphs 3.3.3 and 3.3.4	Certification of compliance
	4. Dimensions	Drawing JN 300337	Certification of compliance
G. Fuel Rod Plenum Spring JN 300338	1. Boron equivalent (impurities)	1300 ppm max	Value for each lot
	2. Tensile properties (wire)	AMS 5698 B or AMS 5699B	Value for each lot
	3. Spring constant	10.4 ± 1.4 lb/in. at 3 in.	Certification of compliance
	4. Dimensions (free length, diameter, etc.)	Drawing JN 300339	Certification of compliance (0.360 ± 0.004 in. dia, 3.64 ± 0.020 in. free length)
H. Fuel Rod Assembly JN 300463	1. Fill gas purity (99.9% pure)	95% He min (5% Argon)	Verify by process qualification, certification of compliance
	2. Pellet stack weight	1134 g max to 1112 g min	Value for each stack
	3. Pellet stack length	66.000 ± 0.125 in.	Value for each stack
	4. End cap weld quality	JN S30106, Paragraph 3.3	Certification of compliance with 100% radiograph
	5. End cap weld strength	Joint efficiency 80% clad strength	Verify by process qualification
	6. Plenum length	3.00 in.	Certification of compliance w/radiographs on samples
	7. Pellet seating	No space	Certification of compliance w/radiographs on samples

TABLE VIII (continued)

Item	Characteristics	Values	Notes
H. Fuel Rod Assembly JN 300463 (continued)	8. Corrosion test	Free of white and brown corrosion	Each rod
	9. Pressure boundary defects	1 x 10^{-8} cc He/sec hr/max	(50-micron vacuum) each rod
	10. Straightness	0.015 in. in 12 in.	Certification of compliance
	11. Diameter	0.4220 ± 0.002 in.	Certification of compliance
	12. Length	70.380 in.	Value for each rod
I. Spacer Grid JN 300443 JN 300440	1. Boron equivalent	1250 ppm max	Value for each lot
	2. Welds:		
	a. Quality	JN S30154, Paragraph 3.2.2	Certification of compliance
	b. Intersection weld load capacity	Determined by test	Actual test data
	3. Tensile properties	Process control	See JN S30154, Paragraph 3.2.3
	4. Assembly bearing load capacity	Determined by test	Actual test data
	5. Fuel rod spring constant	2.5 lb at 0.020-in. deflection	Certification of compliance
	6. Guide tube spring constant	2 lb at 0.10-in. deflection	Certification of compliance
	7. Dimensions	See drawings	Certifications of compliance for each spacer

TABLE VIII (continued)

Item	Characteristics	Values	Notes
J. Guide Tube JN 300346	1. Boron equivalent	850 ppm max	Value for each lot
	2. Tensile properties:		
	Ambient and 650°F	JN S30034, Paragraph 3.3.1	Value for each lot
	Ambient to 1600°F	Determined by test	Actual test data
	Flare test	Determined by test	Value for each lot
	Burst test	Determined by test	ASTM A 450, value for each lot
	3. Grain size	Size No. 7 max	Value for each lot
	4. Straightness	0.015 in. in 12 in. max	Certification of compliance
	5. Defects	0.002 in. deep x 0.004 in. wide x 0.125 in. long max	All tubing (UT examination)
	6. Corrosion resistance	0.005 in./month max	ASTM A 262 Practice C
	7. Dimensions:		
	Inside diameter	0.511 ± 0.0015 in.	Certification of compliance
	Outside diameter	0.545 ± 0.0015 in.	Certification of compliance
	Miscellaneous	See drawing	Certification of compliance
K. End Boxes (tie plates, end box, and cover plate)	1. Boron equivalent	850 ppm max	Value for each lot
	2. Tensile properties:		
	Raw material	ASTM A 240	Value for each lot
	Finished parts	Determined by test	Actual test data
	3. Corrosion resistance	0.003 in./month max	ASTM A 262 Practice C Value for each lot

TABLE VIII (continued)

Item	Characteristics	Values	Notes
K. End Boxes (tie plates, end box, and cover plate) (continued)	4. Defects	Max holes 0.032-in. diameter at 0.5 in. from surface and 0.047-in.-diameter hole at 3 in. from surface	Certification of compliance
	5. Weld quality	See drawings	Certification of compliance
	6. Dimensions	See drawings	Certification of compliance
L. Control Rod Poison JN 300373	1. Impurities	JN S30220, Appendix B	Value for each lot
	2. Density	9.5 to 10.3 g/cm^3	Value for each lot
	3. Dimensions (length, diameter, etc.)	See drawing	Certification of compliance (66 ± 0.030 in. long x 0.398 ± 0.001 in. diameter)
M. Control Rod Assembly	1. Fit-up with fuel bundle	10-lb drag force max	Each assembly
N. Control Rod Assembly Hardware	The component characteristics will be documented in the same manner as fuel bundle pieces.		

distribution characteristics, the fuel bundle strength test, the DNB and thermal-mixing test, the control rod drop tests, and the pressure drop test (see Tables III and IV) are also components of the characterization program and demonstrate the emphasis given to fuel module characterization.

3. FABRICATION

The fabrication program is based on the quality assurance requirements of RDT Standard F2-2. All manufacturing and inspection operations are performed in accordance with detailed procedures and under facility conditions that assure cleanliness requirements are satisfied. Deviations from approved specifications of components or processes are formally reported and dispositioned by the appropriate technical agencies. The fuel bundle and upper structure fabrication programs at Exxon Nuclear Co. in Richland, Washington, and L&S Machine Co. in Latrobe, Pennsylvania, have been performed under a policy of full-time EG&G Idaho Quality Division surveillance and periodic technical audits by EG&G Idaho, MPR Associates, Inc. (Exxon only), and ERDA (Exxon only). Table IX is a summary list of the fabricators of the fuel module components. The performance of the principal fabricators was exemplary; each demonstrated skill, efficiency, pride in their product and corporate image, and responsiveness to frequent design changes and requests for technical assistance. The success of this fabrication program is indebted to these suppliers. Some interesting information from the fabrication program is as follows.

3.1 Laser Welding

This part of the fabrication program is of special interest because of the experience and limited success in performing an extremely difficult welding task. LOFT fuel rods require the welded attachment of fragile thermocouples having a sheath thickness of only 0.009 inch to the fuel rod. Up to four thermocouples are attached over virtually the entire fuel rod length. In some cases this required approximately 5000 weld spots that had to be (a) positioned on the filler wire between the thermocouple and fuel rod cladding within ±0.002 inch and (b) identical in size and thermal intensity. The welding equipment includes two identical units each consisting of a basic Korad (Korad Division of Hedron, Inc., Santa Monica, California) laser-driller model KWD which uses a YAG (Yttrium-Aluminum-Garnet) laser rod and a specially designed pneumatically controlled positioning and indexing tool provided by S/P Product Design of Costa Mesa, California.

This laser welding system has been in a continuous improvement status since late 1971. Equipment improvements include:

(1) Shutter positioning
(2) Power supply component shock mounting
(3) Power supply instrumentation
(4) Binocular sight reticle
(5) Optic alignment techniques

TABLE IX

LOFT FUEL MODULE FABRICATORS

Component	Fabricator	Address
1. Fuel pellets (UO_2)	Exxon Nuclear Co.	Richland, Washington
2. Fuel rod cladding (Zr-4)	Sandvik Special Metals Co.	Kennewick, Washington
3. Fuel rods	Exxon Nuclear Co.	Richland, Washington
4. Spacer grids (Inconel)	Caran Precision Eng'g Mfg'g Co.	Paramount, California
5. Guide tubes: SS	Superior Tube Co.	Morristown, Pennsylvania
Zr-4	Sandvik Special Metals Co.	Kennewick, Washington
6. End boxes	L&S Machine Co.	Latrobe, Pennsylvania
7. Fuel bundles	Exxon Nuclear Co.	Richland, Washington
8. Control rod poison (Ag-In-Cd)	Handy and Harman	New York, New York
9. Control rod spider	Allied Pacific Manufacturing Co.	Compton, California
10. Control rods	Exxon Nuclear Co.	Richland, Washington
11. Control rod cluster assembly	Exxon Nuclear Co.	Richland, Washington
12. Holddown springs	Duer Spring Co.	Coraopolis, Pennsylvania
13. Upper structure assemblies	L&S Machine Co.	Latrobe, Pennsylvania
14. Instr. Penetration Pivot Arm	United Precision Machine Works	Salt Lake City, Utah
15. Ti-Ta-Inconel Sandwich	EI Dupont deNemours & Co.	Wilmington, Delaware
16. Instr. Penetration Components	EG&G Idaho, Inc.	Idaho National Engineering Lab.
17. Neutron Source (Californium) Assembly	Monsanto Research Co.	Dayton, Ohio
18. Fuel Module Assembly	EG&G Idaho, Inc.	Idaho National Engineering Lab.

(6) Flash lamp support
(7) Tooling alignment techniques
(8) Preventive maintenance program
(9) Optical and pneumatic system cleanliness
(10) Laser beam intensity pattern measurement and adjustment techniques
(11) Laser room temperature stability.

The laser system production record is of interest because of an evalution of significant improvement in efficiency. A production record summary is shown in Table X.

The first core and spares compaign peak production period was preceded by development of techniques for measuring and adjusting the laser spot energy intensity pattern which solved a chronic problem of nonuniformity between the "frontside" and "backside" welds (see Figure 10). The reload core compaign was preceded by several process and equipment improvements designed to increase equipment reliability and reduce operator errors.

The complexity of the operation is very demanding on the operators, and operator errors accounted for approximately 5% of the rejected rods during the first core and spares production campaign. The system is capable of producing a four-thermocouple fuel rod in approximately 10 hours per machine.

3.2 Fuel Bundle Assembly

This activity has also undergone an evolutionary process to achieve the specified alignment objectives. The assembly is accomplished in a horizontal position for instrumentation handling purposes. Fuel bundle alignment objectives were achieved after several technical problems were solved. Some of the highlights are as follows:

(1) The skeleton assembly involves spacer grid attachment to the guide tubes by split rings positioned above and below the spacer grids and welded to the guide tubes. The locking-ring-to-spacer-grid separation was discovered to be important to spacer grid parallelism characteristics, and welding process improvements were required. It was later discovered that shrinkage from the locking-ring-to-guide-tube welding also contributed to the spacer grid parallelism, and welding sequence improvements were made.

(2) The upper end box is attached to the guide tubes by mechanical (threaded) techniques. The torquing of the nuts results in residual torque in the guide tubes which causes the free-standing skeleton or fuel bundle to twist. Process improvements were made to minimize residual torque in the guide tubes.

3.3 Fuel Module Assembly

The assembly of the LOFT instrumented fuel modules involves a complex process consisting of parallel (two fuel modules) assembly processes requiring coordinated,

TABLE X

LOFT FUEL ROD THERMOCOUPLE ATTACHMENT HISTORY

	Fabrication Data					
Campaign	Years	Duration (Week)	Total Rods	Rods Per Week	Rejects (%)	Laser TOE[a]
1. First core and spares:						
a. Average	1974 & 5	69	143	2.1	19	36
b. Peak production	1975	10	65	6.5	15	95
2. Reload core	1977	12	57	4.8	0	97

---

[a] Equipment time-operating efficiency.

sequenced, highly skilled participation by pipe fitters, mechanics, welders, equipment operators, and instrument cable brazing, splicing, and terminating technicians. Errors in the fuel module final assembly stages are especially serious, because the instrumentation is generally not replaceable and the completed instrumented fuel module value is approximately $500,000.

A program for management risk appraisal and correction was implemented using the results of the prototype assembly activities, a committee review of facility readiness, and the production activities. Improvements in fuel module quality and reductions in the fuel module assembly time, which were experienced during the assembly campaign, indicate the risk appraisal program was effective. Also fuel module damage was avoided during a flooding incident while the assembly facility was unattended by prior recognition of the risk and implementation of mitigating safeguards.

Technical highlights of the fuel module assembly program include the following:

(1) The brazing and welding process for sealing the instrument cable to the reactor pressure boundary was performed without instrument cable drainage. Special control of component dimensional and cleanliness characteristics likely contributed to process reliability. A technician-developed brazing-process sequence change resulted in an improvement in reproducibility.

(2) The hard-to-soft sheath instrument cable splice reliability and reproducibility was improved by development of (a) a stronger splice design (see Appendix A, Figure A-12 drawing zone -7C) and (b) a method for confirming the correct splice lead matchups (heat splice and measure detector output). The only instrument loss (one thermocouple) occurred at this assembly step.

(3) The development of a technique for confirming the function and location of each thermocouple. The technique consists of applying a focused stream of hot inert gas (argon) to the thermocouple hot junction and measuring the thermocouple output. Several location irregularities were discovered.

V. CONCLUSION

The total program for the design, characterization, and fabrication of the LOFT fuel modules has achieved an objective of technical activity documentation and component characterization in a manner that (a) indicates an effort to provide a fuel module that will credibly represent an LPWR fuel bundle during a LOCA and (b) determines the representative characteristics of the LOFT fuel bundles. The achievement of design objectives and success of the total fuel module design, characterization, and fabrication program will be determined by the performance of the fuel modules in the LOFT testing program. The planning and preparation activities for the interim fuel bundle inspection (requalification) and final fuel bundle examination (posttest autopsy) components of the LOFT testing program are proceeding.

APPENDIX A

LOFT FUEL MODULE ASSEMBLY DRAWINGS

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13	12	11	10	9	8	7	6	5	4	3	2	-	SHT	REV STATUS
G	M	L	G	N	N	N	B	L	G	L	N	N	REV	OF SHEETS

REVISIONS

ZONE	CHG LTR	DESCRIPTION	RELEASE DATE	CHK	P.E.	SUPV	BR MGR	OTHER
	A	DWG REVISED. SEE ECRA NO. L-5014 & L-5119 ADDED SHT 13.						
	B	DWG REVISED. SEE ECRA'S NO. L-5144, L-5440, L-5528 L-5801, L-6203 & L-5908	7-16-75	7-7-75	7-2-75			
	D	DWG REVISED SEE INC "C" ADCN, AND "D" DCN	10-17-75	10-17-75				
	G	SEE INC E AND F ADCN AND G DCN						
	M	SEE INC H, J, K, L ADCN AND M DCN		3/9/76				
	N	SEE INC N ADCN		5/6/76				

NOTES:

1 REMOVE ALL BURRS & SHARP EDGES.

2 WELD PER ASME BOILER & PRESSURE VESSEL CODE SECTION III AS SUPPLEMENTED BY RDT E15-2T.

3 INSTRUMENT LEADS TO BE BRAZED INTO BUTTON ASSYS PER ANC BRAZE PROCEDURE BR 1.2-460 & 461.

4 BUTTON ASSY. SHALL BE HELIUM LEAK CHECKED PER RDT F3-11T AFTER BRAZING & AFTER WELDING BUTTON SET INTO PRESSURE PLATE. PRESSURIZE AREA BETWEEN BUTTONS TO 60 PSIG. HELIUM. AFTER BRAZING, MAX. PERMISSIBLE LEAKAGE THRU BRAZE 10^{-6} ATM CC/SEC.

5 CLEANING & CLEANLINESS PER RDT F5-1T.

6 ALL WELDS PERFORMED AT THIS ASSY TO BE VISUALLY INSPECTED WITH 5-10X MAGNIFICATION. ACCEPTANCE CRITERIA PER RTD F6-2T PARA 6.3.2. & EXCEPTIONS AS NOTED IN THE SPECIFIC WELD PROCEDURES.

7 LOCK CUPS TO BE LOCKED BY DEFORMING CUP INTO GROOVES ON CAP SCREW HEAD EXCEPT AS NOTED. VISUALLY INSPECT. NO CRACKS ALLOWED.

8 LUBRICATE UNDER HEADS & ON THREADS OF ALL THREADED FASTENERS PER RDT F8-1T WITH 2 COATS OF NEOLUBE B, DAG 156 OR EQUIV.

9 TORQUE FASTENERS PER RDT F8-1T TO VALUE SHOWN IN TORQUE TABLE. TIGHTEN TO INITIAL TORQUE VALUE, RELAX TORQUE TO ZERO & RETORQUE TO FINAL TORQUE VALUE & LOCK IN PLACE AS SHOWN OR NOTED. REF 55.

10 MARK PER RDT F7-3T USING VIBRATING MARKING TOOL METHOD WITH 204024 & APPLICABLE DASH NO. & ASSIGNED SERIAL NO.

11 TO BE USED WITH CHROMEL-ALUMEL THERMOCOUPLE LEADS.

12 TO BE USED WITH PLATINUM-RHODIUM THERMOCOUPLE LEADS.

13 TO BE SUPPLIED AS PART OF INSTRUMENT BY INSTRUMENTATION BRANCH.

14 LOCKWIRE PER RDT M6-2T CLASS B.

15 THESE PARTS FURNISHED AS LOOSE PIECE ITEMS ON ASSYS 204388-3, 204389-3, 206807-1 OR 204614-1 AND ARE SHOWN IN L/M TO ASSIST IN PROCUREMENT AND/OR FABRICATION ONLY. SEPARATE ORDERING IS NOT REQD UNLESS PARTS ARE NOT INCLUDED IN THE PARENT ASSY PACKAGE. REF G/N 25.

16 INSTALL FITTING PER VENDOR'S INSTRUCTIONS EXCEPT TORQUE 1/4 TO 1/2 TURN BEYOND FINGER TIGHT

17 SURFACE ROUGHNESS 125√ UNLESS OTHERWISE NOTED.

18 WELD TO BE PERFORMED AFTER FINAL INSTALLATION OF FASTENER.

19 LIQUID PENETRANT INSPECT PER RDT F3-6T. ACCEPTANCE CRITERIA PER RDT F6-2T PARA 6.3.3.

20 ⓧ DENOTES TORQUE REQUIREMENTS. SEE TABLE FOR VALUES.

21 (W-X) DENOTES WELD IDENTIFICATION NO.

22 WELD TO BE PERFORMED IN UPPER .50 INCHES OF CHANNEL ONLY.

23 CAUTION: WELDS TO BE PERFORMED ALTERNATELY ON PARTS WITH COMPLETE COOLDOWN TO AMBIENT TEMPERATURE BETWEEN WELDS TO MINIMIZE DISTORTION CAUSED BY WELDING.

24 ANY INSTRUMENT WHICH ORIGINATES BELOW PLANE -M- MAINTAIN A LEAD LENGTH OF, 33.0 FOR BUTTONS B-1 AND B-4 AND A LEAD LENGTH OF 35.0 FOR BUTTONS B-3 AND B-2, FROM PLANE -M- TO SURFACE -G- DURING BRAZING OF BUTTONS, TO INSURE ADEQUATE LEAD LENGTH DURING FINAL ASSY.

25 THESE ASSYS INCLUDE LOOSE PIECE ITEMS. CARE SHOULD BE EXERCISED TO OBTAIN ALL THESE ITEMS AS A PART OF THE PARENT ASSY. REF G/N 15

26 THREAD LENGTH SHALL BE 1.12 MIN.

27 THIS ASSY MODIFIED BY 204614-1 ASSY 25

28 TO BE USED WITH FLOWMETER COIL LEADS.

29 THESE PARTS ARE NOT INTERCHANGEABLE AND ARE TO BE SERIALIZED AND MAINTAINED AS A MATCHED SET DURING HANDLING, STORAGE & ASSY.

30 ASSEMBLY SEQUENCE FOR THE FUEL MODULE ASSY SHALL BE IN ACCORDANCE WITH THE APPLICABLE SECTIONS OF THE LOFT FUEL HANDLING MANUAL.

31 DATUM -A- IS DEFINED AS THE VERTICAL REFERENCE CENTERLINE PASSING THROUGH THE CENTER OF BOUNDARY PLANES FORMED BY A RIGHT TRIANGLE HAVING 2 ADJACENT 7.590 SIDES. THE CENTER OF THE RIGHT TRIANGLE IS DETERMINED BY THE INTERSECTION OF LINES WHICH ARE PERPENDICULAR TO THE SIDES AND HYPOTENUSE OF THE TRIANGLE AND HAVING THEIR INTERSECTION POINT EQUI-DISTANT TO ALL 3 SIDES OF THE TRIANGLE.

32 DATUM -B- IS DEFINED AS THE VERTICAL REFERENCE CENTERLINE PASSING THROUGH THE CENTERS OF THE TRIANGULAR SECTIONS OF THE UPPER SUPPORT STRUCTURE LOCATING PAD AT STA 278.46 AND THE UPPER SUPPORT STRUCTURE LOWER END BOX AT STA 191.82. THE CENTER OF THE TRIANGULAR SECTIONS IS DETERMINED BY THE INTERSECTION OF LINES WHICH ARE PERPENDICULAR TO THE SIDES & HYPOTENUSE OF EACH TRIANGULAR SECTION AND HAVING THEIR INTERSECTION POINT EQUI-DISTANT TO ALL 3 SIDES OF THE TRIANGULAR SECTION.

33 DURING ASSY, HANDLING & STORAGE OF THE FUEL MODULE ASSYS PRECAUTIONS SHALL BE TAKEN TO INSURE THAT THE FINAL FUEL MODULE ALIGNMENT IS MAINTAINED.

34 CAUTION: THE FUEL ASSY AND/OR FUEL MODULE ASSY SHALL NOT AT ANY TIME BE ROTATED BEYOND THE HORIZONTAL ATTITUDE TO AN INVERTED ATTITUDE

35 THE UPPER SUPPORT STRUCTURE ④ OR ⑨ & FUEL ASSEMBLY SHALL BE ORIENTED TO EACH BY MATCHING THE LOWER END BOX FLANGE OF ④ OR ⑨ AND UPPER END BOX OF THE FUEL ASSY.

36 SPECIAL INSTRUMENTATION ASSY REQUIREMENTS, CONTINUITY CHECKS, HANDLING REQUIREMENTS & LEAD PREPARATION REQUIREMENTS SHALL BE IN ACCORDANCE WITH LMP 306 EXCEPT AS NOTED.

37 ASSY TO BE GAGED AFTER INSTALLATION & WELDING BY INSERTION & WITHDRAWL OF THE FOLLOWING GAGE:
  1 GAGE PROBE, PART NO. 135B9845, GENERAL ELECTRIC CO., SAN JOSE, CALIF.

GAGE MUST PASS THE FULL LENGTH OF THE CALIBRATION TUBE FREELY WHEN MANUALLY INSERTED & WITHDRAWN.

38 DATUM -B- SHALL BE COINCIDENTAL WITH DATUM -A- DURING ALIGNMENT. REF G/N 39.

39 THE ASSEMBLED ALIGNED FUEL MODULE IN THE VERTICAL POSITION BETWEEN STATIONS 113.25 & 278.46 SHALL FIT WITHIN THE ENVELOPE OF BOUNDARY PLANES HAVING A RIGHT TRIANGULAR CROSS SECTION WITH 2 ADJACENT 7.590 SIDES.

40 C-X DENOTES CONNECTOR REFERENCE DESIGNATION.

41 DURING ASSY, HANDLING, STORAGE & SHIPPING ACTIVITIES THE FUEL MODULE ASSY SHALL NOT BE SUBJECTED TO LOADS GREATER THAN 3G.

42 DURING ASSY & HANDLING ACTIVITIES WHICH ARE IN CLOSE PROXIMITY TO OTHER HARDWARE THE VERTICAL VELOCITY OF AN UNSUPPORTED FUEL MODULE ASSY SHALL NOT EXCEED 40 INCHES/MINUTE.

43 DURING ASSY & HANDLING ACTIVITIES WHICH ARE IN CLOSE PROXIMITY TO OTHER HARDWARE THE HORIZONTAL VELOCITY OF AN UNSUPPORTED FUEL MODULE ASSY SHALL NOT EXCEED 40 INCHES/MINUTE.

44 RECORDS SHALL BE MAINTAINED FOR EACH FUEL MODULE ASSY SO THAT ALL PARTS & SUBASSEMBLIES CAN BE TRACEABLE TO FABRICATION & SOURCE LOT.

45 WELDING PROCEDURE QUALIFICATION & PERFORMANCE QUALIFICATION OF THE WELDERS SHALL BE IN ACCORDANCE WITH RDT F6-2T WITH THE EXCEPTION OF PARAGRAPH 6.2.1.

46 HARD TO SOFT CABLE SPLICE JOINTS AND FINAL CONNECTOR ASSEMBLY SHALL BE MADE IN ACCORDANCE WITH LMP 224 & LMP 046.

47 INDIVIDUAL LEAD IDENTIFICATION TO BE TRANSFERRED FROM THE MI CABLE TO THE POTTING CUP AT THE TIME EACH SPLICE JOINT IS COMPLETED. MARKING SHALL BE IN ACCORDANCE WITH RDT F7-3T PARA 3.1.a ON INDICATED SURFACE.

48 PRIOR TO ASSEMBLY OF THE UPPER SUPPORT STRUCTURE ⑨ TO FUEL ASSEMBLY ADJUST CALIBRATION TUBE (54) TO OBTAIN THE 72.2 DIM NOTED. MEASURE & RECORD THE DIMENSION OF THE LENGTH THAT THE TUBE (54) EXTENDS ABOVE SURFACE -J-. DURING FINAL ASSY OF PRESSURE PLATE ⑤ TO THE TUBE (54) AND PERFORMANCE OF W-25 MAINTAIN THE RECORDED DIMENSION TO INSURE THE PROPER POSITION OF THE CALIBRATION TUBE (54) IN THE FUEL ASSY

49 THE TOTAL LENGTH OF THE FUEL ASSY AND UPPER SUPPORT STRUCTURE ④ OR ⑨ SHALL BE .20 INCHES LONGER THAN THE AS BUILT ENVELOPE DIMENSION (186.718) FROM THE BOTTOM SURFACE OF THE UPPER CORE SUPPORT PLATE ASSY REF DWG 204098 TO THE TOP SURFACE OF THE LOWER CORE SUPPORT STRUCTURE MOUNTING PLATE REF DWG 204065. THE REQUIRED TOTAL LENGTH SHALL BE OBTAINED BY MACHINING THE UPPER END OF THE SPRING DEFLECTOR IN ④ OR ⑨, SURFACE -C- OR -D- AS APPLICABLE, AS REQD TO OBTAIN DIM NOTED.

50 CAUTION: SPRING DEFLECTOR IS TO BE REMOVED FROM ASSY FOR SUBSEQUENT MACHINING PER 49. THIS REMOVAL SHALL BE PERFORMED BY THE USE OF AN 18-8 SST BOLT .750-10UNC-2A x 24.0 LONG WITH 2.25 MIN CHROME PLATED THREAD LENGTH AND AN 18-8 SST FLAT WASHER .750 NOM DIA TO RETAIN THE SPRING AND SPRING DEFLECTOR DURING DISASSEMBLY. TO RELAX SPRING AFTER FLANGE REMOVAL FROM HOUSING REQUIRES .67 SPRING TRAVEL FROM THE INSTALLED PRELOAD OF 386-427 LBS. BOLT & WASHER MAY BE USED FOR COMPRESSING SPRING & DEFLECTOR DURING REINSTALLATION OF FLANGE AND DEFLECTOR ONTO HOUSING.

51 PRIOR TO WELDING THE BUTTONS (62) THRU (67) AND TUBES (54), PT-1, PT-2 & PT-3 INTO PRESSURE PLATE ⑤ THE PRESSURE PLATE MUST BE POSITIONED AND CLAMPED WITH RESPECT TO THE SUPPORT STRUCTURE ⑨ PER DIMS NOTED.

52 PROTECTIVE CLOSURES REQUIRED FOR ALL TUBING ENDS PER RDT F7-2T. PLUGS OR CAPS SHALL CONFORM TO RDT F7-2T, PARA 6.5. A COMPLETE LISTING OF PROTECTIVE DEVICES INCORPORATED SHALL BE MAINTAINED. PRIOR TO INSERTION OF THE FUEL MODULE ASSY INTO THE REACTOR VESSEL AN INVENTORY OF THESE DEVICES SHALL BE MADE TO INSURE THEIR PROPER REMOVAL.

53 AFTER INSTALLATION OF (54) INTO (76), (79), (80), (81) & (82) CHECK TO INSURE THAT (54) IS NOT RESTRAINED IN THE VERTICAL ATTITUDE.

54 BUTTONS TO BE VISUALLY INSPECTED AFTER INSTALLATION & BRAZING OF INSTRUMENT LEADS TO INSURE THAT EACH LEAD IS FULLY BRAZED AS INDICATED BY THE PRESENCE OF A BRAZE FILLET FORMED AROUND EACH LEAD AT LOCATION SHOWN.

55 WHEN 2 OR MORE FASTENERS ARE REQD TO ASSEMBLE MATING PARTS ALTERNATELY TORQUE FASTENERS IN STEPS OF 1/3 THE APPLICABLE TORQUE VALUES SHOWN DURING ASSY UNTIL TORQUING IS COMPLETED.

56 B-X DENOTES INSTRUMENTATION BUTTON REFERENCE DESIGNATION.

57 DATUM -K- IS DEFINED AS THE VERTICAL REFERENCE PLANE FORMED BY THE EDGE SHOWN OF THE TRIANGULAR CROSS SECTION ON THE UPPER SUPPORT STRUCTURE LOWER FLANGE LOCATED AT STA 191.82.

58 DATUM -L- IS DEFINED AS THE VERTICAL REFERENCE CENTERLINE PASSING THROUGH THE CENTERS OF THE UPPER CORE SUPPORT PLATE LOCATING PIN HOLES IN THE ASSEMBLED UPPER FLANGE OF THE UPPER SUPPORT STRUCTURE.

59. REMOVED

60 THE DIM NOTED SHALL BE OBTAINED BY PERFORMING THE FOLLOWING STEPS:
  1 THE AS BUILT DIM FROM THE TOP SURFACE OF REACTOR VESSEL INSTRUMENT NOZZLES DESIGNATED H & P REF DWG 205142 TO THE BOTTOM OF THE PIVOT ARM SLOT IN THE CORE BARREL REF STA 293.40 ON DWG 204059 IS 46.820.
  2 SUBTRACT .250 FROM 46.820.
  3 SUBTRACT .125 FROM THE RESULTANT DIM OF STEP 2. THIS WILL GIVE THE MAXIMUM ALLOWABLE DIM NOTED ON THIS DWG.
  4 IF THE AS BUILT TOTAL DIM NOTED RESULTING FROM THE ASSY OF ⑤, ⑩ & ⑰ EXCEEDS THE DIM DETERMINED IN STEP 3, MACHINE SURFACE -F- TO MAKE DIM NOTED AS RESULT OF ASSY BE WITHIN THE LIMIT SPECIFIED IN STEP 3 PLUS 0.000 MINUS 0.060

61 AFTER MACHINING SPRING DEFLECTOR PER G/N 49 AND REINSTALLATION OF SPRING DEFLECTOR AND FLANGE ONTO THE UPPER SUPPORT STRUCTURE ASSY, MEASURE THE RESULTANT DIMENSION FROM SURFACE -C- OR -D-, AS APPLICABLE, TO SURFACE -J-. THIS RESULTANT DIM SHALL BE A MINIMUM OF 1.125.

62 INSTRUMENT LEAD ROUTING & HOOKUP SHALL BE IN ACCORDANCE WITH LMP 317 FIG 1

63. REMOVED

64 PT-X DENOTES PRESSURE TUBE REFERENCE DESIGNATION.

65 TO BE USED WITH PRESSURE TRANSDUCER LEADS.

66 SCREW HEAD TO HAVE .040 DIA HOLE THRU TO ACCOMODATE LOCKWIRE SIZE NOTED.

67 COOLANT TEMPERATURE THERMOCOUPLE TO BE INSTALLED PER LMP 306 AT LOCATION SHOWN.

68 STAKE OR DEFORM CHANNEL DOVE TAIL EDGE ON 12.0 CENTERS TO PREVENT COVER VIBRATION.

69 DURING ASSY & HANDLING ACTIVITIES SUPPORT SHALL BE PROVIDED FOR THE INSTRUMENTATION PENETRATION ASSY ABOVE DATUM -G- WHICH MAINTAINS ASSY AND/OR INDIVIDUAL COMPONENTS WITHIN .125 OF DIM NOTED

70 DURING ASSY HANDLING & STORAGE WHILE IN A HORIZONTAL POSITION THE FUEL MODULE ASSY MUST BE SUPPORTED AT THE FOLLOWING LOCATIONS SUCH THAT THE FUEL MODULE ALIGNMENT IS MAINTAINED:
  1 THE UPPER END BOX AT STA 191.82 AND LOWER END BOX AT STA 113.25 OF THE FUEL ASSYS.

G/N CONTINUED ON SHT 2 ZONE 8H

SEE SHT 2 FOR LIST OF MATERIAL

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.

PARTS LIST

PART DASH NO.	NEXT QTY PER	FINAL REQD ASSY	NEXT ASSY	USED ON
-10	2	2	204565	LOFT
-2	2	2	204566	LOFT
-1	2	2	204566	LOFT

APPLICATION

82 QUALITY ASSURANCE ESSENTIALITY LEVEL I DRAWING FORM

UNLESS OTHERWISE SPECIFIED
DIMENSIONING AND SYMBOLOGY ARE AMERICAN NATIONAL STANDARD
DIMENSIONS AND TOLERANCES ARE IN INCHES
TOLERANCES:
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
FRACTIONS ± 1/8
ANGULAR ± 2°
DO NOT SCALE DRAWING

DRAWN A.R. ROWLEY DATE 1-4-74
CHECKED 3-6-74
PROJECT ENGINEER 3/5/74
SUPERVISOR 3/5/74
3-5-74
BRANCH MANAGER 3/4/74

AEROJET NUCLEAR COMPANY
INCORPORATED
IDAHO FALLS, IDAHO

TITLE
CORNER FUEL MODULE ASSY, TYPE C & TYPE E
LOFT

DWG SIZE E
INDEX CODE NUMBER: AREA 0360 DWG TYPE 806 CL 43 ORIG 400
DRAWING NUMBER 204024
CHG LTR N
SCALE 1/1
RELEASE DATE MARCH 8, 1974
SHEET 1 OF 13

204024 N

Fig. A-1.

NOTES

70 CONTINUED:

2 THE 3 CENTRALLY LOCATED FUEL SPACER ASSYS BETWEEN STATIONS 113.25 AND 191.82.

3 THE LOWER END BOX AT STA 191.82 AND LOCATING PADS AT STA 278.46 OF THE UPPER SUPPORT STRUCTURES ④ OR ⑨.

△71 REMOVED

△72 THIS ASSY MODIFIED BY 206807-1 ASSY △25.

△73 TO BE USED WITH LIQUID LEVEL DETECTOR INSTRUMENT LEADS.

△74 CUSTOM FIT CLIP BY GRINDING LENGTH OF CLIP TAB INSERTED INTO HOUSING SLOT, UNTIL LEADS ARE A SLIP FIT WITHIN HOUSING SLOT.

△75 WELD THROAT THICKNESS SHALL BE .040 MIN.

76 THE ASSIGNED SERIAL NO. SHALL CONSIST OF THE DESIGNATION SN FOLLOWED BY THE APPLICABLE SEQUENTIAL 2 DIGIT NO OF THE ASSY.; EXAMPLE: SN-01, SN-02, SN-03, ETC.

△77 CUSTOM FIT CLIP BY REAMING CLIP I.D. UNTIL LEADS ARE A SLIP FIT WITHIN CLIP PRIOR TO WELDING CLIPS TO FUEL ASSY

△78 ALL HARD TO SOFT SPLICE JOINTS TO BE MADE WITHIN SPACE NOTED.

△79 DO NOT WELD ⑪ TO ⑩ UNTIL AFTER COMPLETION OF SPLICING OF SOFT CABLE TO M.I. CABLE, REF NOTE △46.

△80 INSTALL FITTINGS PER VENDORS INSTRUCTION EXCEPT TORQUE 3/4 TO 1 TURN BEYOND FINGER TIGHT. HELIUM LEAK TEST THE FITTING CONNECTION PER RDT F3-11T. PRESSURIZE TO 60 PSIG HELIUM. MAX PERMISSIBLE LEAKAGE IS 10^{-6} ATM CC/SEC.

△81 REMOVE MAT'L FROM THE PRESSURE PLATE AS NECESSARY TO PERMIT ASSY OF THE CALIBRATION TUBE INTO THE PRESSURE PLATE. THE TOP SURFACE OF THE PRESSURE PLATE SHALL BE .001-.005 INCHES LARGER THAN THE CALIBRATION TUBE O.D.

△82 REFER TO THE INDIVIDUAL COMPONENT DWGS. FOR THE APPLICABLE QUALITY LEVEL

△83 REMOVED

△84 QUALITY LEVEL II

△85 LASER BEAM WELD THE SPACER PINS TO THE UPPER & LOWER INSTRUMENT LEAD BUTTONS IN ACCORDANCE WITH LMP 317. TOTAL RUNOUT BETWEEN THE UPPER & LOWER BUTTON OUTSIDE DIAMETERS SHALL NOT EXCEED .002 AFTER WELDING.

△86 CUSTOM FIT CLIPS BY GRINDING THE CLIP TABS & WELLS UNTIL LEADS ARE A SLIP FIT WITHIN THE CLIP SLOT AND THE CLIPS ARE A FUNCTIONAL FIT WITHIN THE UPPER CORE SUPPORT STRUCTURE CHANNEL.

△87 THE ANGLE OF THE CLIPS SHALL CONFORM TO THE INSTRUMENT ROUTING AT THE LOCATION NOTED.

△88 MODIFY LENGH OF ITEM 53 TO PERMIT FLUSH FIT WITH BRACKET SURFACE PRIOR TO WELDING.

GENERAL NOTES CONTINUED ON SHEET 3 ZONE 5D

PARTS LIST CONTINUED ON SHEET 3

TORQUE TABLE △55

TORQUE IDENT NO ⓧ	INITIAL TORQUE FT/LBS	FINAL TORQUE FT/LBS	SHT/ZONE
1	89 ± 5	71 ± 4	4/4E
2	68 ± 4	55 ± 3	4/5,6D
3	14 ± 1	11 ± 1	5/7B,D
4	4.5 ± 1	3.5 ± 1	6/3E /8 B,F
5	14 ± 1	11 ± 1	6/4C
6	4.5 ± 1	3.5 ± 1	13/6F 6/4B
7	10 ± 1 IN/LBS	10 ± 1 IN/LBS	12/4G

WELD TABLE

WELD NO.	WELD FILLER	SHT/ZONE	WELD PROC. NO.
W-1	㉔	4/1E	S-2.30
W-2	㉔	4/1G	S-2.80
W-3	㉔	4/6E	S-2.30
W-4	㉔	5/6C	S-2.99
W-5	㉔	6/6G	S-2.95
W-6	㉔	6/8E 13/6G	S-2.81
W-7	㉔	6/4G	S-2.96
W-8	㉔	6/4F	S-2.96
W-9	㉔	6/7C	S-2.96
W-10	㉔	6/2B 13/1G	S-2.81
W-11	㉔	7/6E	S-2.97
W-12	㉔	7/7C 9/1C	S-2.98
W-13	㉔	7/5E	S-2.99
W-14	㉔	7/3C	S-2.99
W-15	㉔	7/3G	S-2.99
W-16	㉔	7/3F	S-2.99
W-17	㉔	8/8G	S-2.99
W-18	㉔	5/2G	S-2.93
W-19	㉔	8/1B	S-2.82
W-20	㉕	9/2E	1-2.84
W-21	㉕	9/2E	1-2.80
W-22	㉕	9/6F	IS-2.85
W-23	㉔	9/6D	S-2.94
W-24	㉔	9/6B	S-2.80
W-25	㉕	10/4H	IS-2.84
W-26	㉕	10/4E	IS-2.84
W-27	㉔	11/5E	S-2.86
W-28	㉔	11/5E	S-2.85
W-29	㉔	9/4D	S-2 94
W-30	㉕	11/8D	IS-2.82
W-31	㉕	11/5E	1-2.83
W-32	㉕	11/1F	IS-2.82
W-33	㉕	11/1D	1-2.33
W-34	㉕	11/1E	1-2.82
W-35	㉕	11/1D	1-2.33
W-36	㉕	12/5D	IS-2.30
W-37	㉔	9/4C	S-2.94
W-38	㉔	9/2C	S-2.34
W-39	㉔	9/4D	S 2.34
W-40	㉔	5/4F	S-2.92
W-41	㉔	12/2C	S-2.98

PARTS LIST

	-101	-2	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.
	4	4		205157-8	SPACER		26
	2	2		206143-22	CLIP		125
	1	1		206143-21	CLIP		124
	1	1		206143-20	CLIP		123
	1	1		206143-19	CLIP		122
	1	1		206143-18	CLIP		121
△84	AR	AR			SEALANT	SILICONE RUBBER RTV 102	120
	3	3		204852-21	SLEEVE		119
	3	3		204672-4	T/C CLIP		118
	1	1		204614-32	TUBE CLIP		117
				-116	REMOVED		116
			1	206875-1	DUMMY FOWMETER		115
	2	2		206143-15	CLIP		114
							113
	2	2		206143-11	CLIP		112
	4	4		206143-10	CLIP		111
	15	15		204389-17	CLIP		110
	15	15		204389-25	CLIP		109

CONTINUED ZONE A-7 THIS DWG.

	-101	-2	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.
△11	AR	AR			DUROFILM II HIGH TEMP CABLE 2 CONDUCTOR, TYPE K CHROMEL-ALUMEL, 22 GA SOLID TWISTED PAIR WITH SST SHIELD & JACKETED		108
△12	AR	AR			DUROFILM II HIGH TEMP CABLE 2 CONDUCTOR, TYPE S THERMOCOUPLE EXTENSION, 22 GA SOLID TWISTED PAIR WITH SST SHIELD & JACKETED		107
△28	AR	AR			DUROFILM II HIGH TEMP CABLE 3 CONDUCTOR, NICKEL PLATED COPPER, 22 GA SOLID WITH SST SHIELD & JACKETED		106
△65	AR	AR			DUROFILM II HIGH TEMP CABLE 2 CONDUCTOR, NICKEL PLATED COPPER, 22 GA SOLID WITH SST SHIELD & JACKETED		105
△73	AR				DUROFILM II HIGH TEMP CABLE, 1 CONDUCTOR, NKL PLATED COPPER, 22 GA SOLID WITH SST SHIELD & JACKETED		104
	1	1		206143-6	CLIP		103
	1	1		206143-7	CLIP		102
△69				-101	ASSEMBLY, TYPE C		101
	2	2		206143-5	CLIP		100
				-99	REMOVED		99
				-98	REMOVED		98
△15			2	204388-26	SOCKET LOCK		97
			2	204388 ITEM 25	SOCKET LOCK		96
			1	204388 ITEM 24	SOCKET LOCK		95
			3	204388 ITEM 16	SCREW		94
△15	2	2		204614 ITEM 26	PIN		93
△84	1	1		204-1-316	FERRULE, BACK	CRAWFORD FITTING CO. SOLON, OHIO	92
	1	1		203-1-316	FERRULE, FRONT	CRAWFORD FITTING CO SOLON, OHIO	91
△84	1	1		202-1-316	NUT	CRAWFORD FITTING CO SOLON, OHIO	90
	1	1		204852-22	SLEEVE		89
				-88	REMOVED		88
△13	AR				.040 DIA MINERAL INSULATED WIRE	INSTRUMENTATION LEAD	87
	1	1		248-A904 P001	CALIBRATION TUBE NUT	GENERAL ELECTRIC CO. SAN JOSE, CALIF	86
△15	8	8		204614-13	BOLT		85
	3	3	6	204614-12	BOLT		84
	3	3	6	204614-11	LOCK CUP		83
	1	1		204614-10	BRACKET		82
	1	1		204614-9	BRACKET		81
	1	1		204614-8	BRACKET		80
	5	5		204614-5	TUBE CLIP		79
	27	27		204614-4	TUBE CLIP		78
	8	8		204614-3	DUAL TUBE CLIP		77
△15	1	1		204614-31	BRACKET		76
	3	3		205157-9	SPACER		75
△15			1	206807-2	BRACKET ASSY		74
	1			XN300,331	FUEL ASSY, TYPE C	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	73
	19			205121-5	POTTING CUP		72
		1		205157-1	BUTTON-LOWER		71
		1		205157-3	BUTTON-UPPER		70
	1			206137-37	BUTTON-LOWER		69
	1			206137-36	BUTTON-UPPER		68
	1	1		206137-18	BUTTON-LOWER		67
	1	1		206137-16	BUTTON-UPPER		66
	1	1		206137-15	BUTTON-UPPER		65
	1	1		206137-17	BUTTON-LOWER		64
	1	1		206137-20	BUTTON-LOWER		63
	1	1		206137-19	BUTTON-UPPER		62
							61
	AR	AR			BRAZE ALLOY	Ti 48 Zr 48 Be 4	60
	8	8		205157-7	SPACER		59
	1	1		205157-5	SLEEVE		58
	2	2		206194-1	GASKET		57
△84	AR	AR			ELECTRICAL TERMINAL LUG		56
							55
△37 △15	1	1		205158-3	CALIBRATION TUBE		54
			3	205035-2	SCREW		53
△84	3	3		4SW6	SOCKET WELD UNION	CAJON CO. CLEVELAND, OHIO	52
	2	2		204672-1	THERMOCOUPLE - COOLANT TEMP		51

CONTINUED ON SHEET 3 ZONE 4H

REVISIONS

ZONE	CHG LTR	DESCRIPTION	RELEASE DATE	CHK	P.E.	SUPV	BR MGR	OTHER
	N							

	-101	-2	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.
△5	6	6		205186-7	SCREW		50
△5	3	3		205186-6	SCREW		49
△5	1	1		205186-1	BRACKET ASSY		48
△84	AR	AR	AR		LUBRICANT	NEOLUBE B	47
△91	AR	AR			.032 DIA WIRE	300 SERIES SST ANNEALED	46
△26	AR	AR			SCREW .138-32UNC-2A x .25 LONG	18-8 SST	45
△84 △15	1	1		4SW6	SOCKET WELD UNION	CAJON CO CLEVELAND OHIO	44
△13	AR	AR			.062 DIA MINERAL INSULATED WIRE	INSTRUMENTATION LEAD	43
△13	AR	AR			.046 DIA MINERAL INSULATED WIRE	INSTRUMENTATION LEAD	42
△15	2	2		204723-1	THRUST WASHER		41
△13	1	1		204720-3	PIN		40
△13	1	1		205185-1	BRACKET ASSY		39
	AR	AR				TUBE .250 O.D. x .035 WALL 304 SST ASTM A269	38
	11	11		205121-3	POTTING CUP		37
	11	11		205121-2	POTTING CUP		36
	1	1		JN300,498	RETAINING SLEEVE NEUTRON SOURCE	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	35
△13	2	2		205185-9	SCREW		34
	2	2		205185-7	SCREW		33
	2	2		204389 ITEM 33	SOCKET LOCK		32
	2	2		204389 ITEM 36	SOCKET LOCK		31
	1	1		204389 ITEM 32	SOCKET LOCK		30
	3	3		204389 ITEM 19	SCREW		29
△15	1	1		204389 ITEM 18	CHANNEL COVER		28
							27
	AR	AR			BRAZE ALLOY	BA_u4	26
	AR	AR			WELD FILLER METAL	INCONEL 82 CL ER NiCr3 AWS A5.14	25
	AR	AR	AR		WELD FILLER METAL	ER308L AWS A5.9	24
	2	2		204720 ITEM 14	WASHER		23
	AR	AR		2651-MM	POTTING COMPOUND	EMERSON-CUMMINGS CANTON, MASSACHUSETTS	22
	AR	AR				TUBING .125 DIA x .035 WALL 304 SST OR 304L SST ASTM A-269	21
△84	AR	AR			.020 DIA WIRE	300 SERIES SST	20
△66 △26	8	8		206143-17	SPECIAL GROUND LUG SCREW		19
△84	3	3			SET SCREW .250-20 UNC-2A x .250 LONG	18-8 SST	18
	1	1		204720-1	PIVOT ARM ASSY		17
	1	1		204600-1	FLOWMETER		16
△84	2	2		217-20R A102S-57	ELECTRICAL CONNECTOR	AMPHENOL INC. HARRISBURG, PA	15
							14
	1	1		-13	REDUCING UNION CONNECTOR	MAKE FROM 300-6-2-316 CRAWFORD FITTING CO. SOLON, OHIO	13
△15	2	2		204672-2	THERMOCOUPLE - STRUCTURE TEMP		12
	1	1		204852-1	INSTRUMENTATION STALK		11
	1	1		204851-1	PRESSURE TUBE		10
△25 △29 △27	1	1		204389-3	UPPER CORE SUPPORT STRUCTURE		9
△29 △50 △49 △15	1	1		-8	SPRING DEFLECTOR	MAKE FROM 204389-2	8
△29 △50 △49 △15			1	-7	SPRING DEFLECTOR	MAKE FROM 204388-2	7
		1		XN301,278	FUEL ASSY, TYPE C	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	6
	1	1		204850-1	PRESSURE PLATE		5
△72 △25 △29			1	204388-3	UPPER CORE SUPPORT STRUCTURE		4
			1	XN300,471	FUEL ASSY, TYPE E	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	3
△69				-2	ASSEMBLY, TYPE C		2
				-1	ASSEMBLY, TYPE E		1

Fig. A-2.

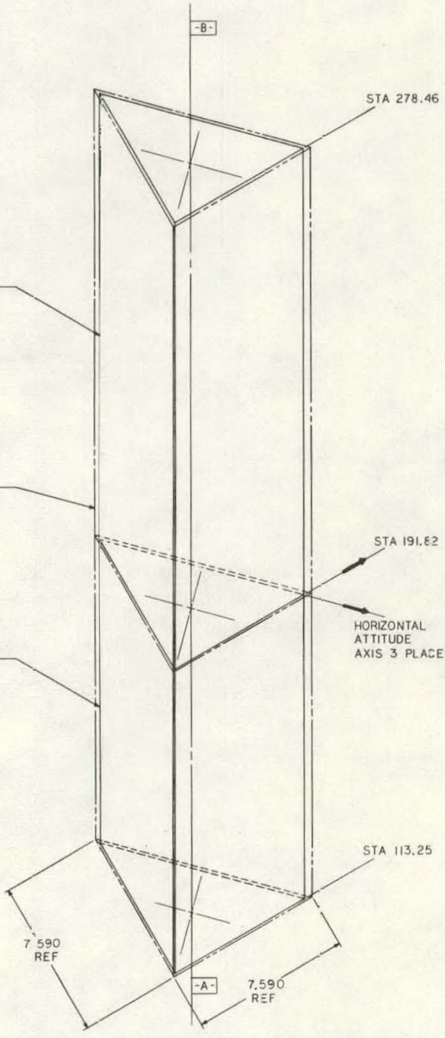
DWG SIZE	INDEX CODE NUMBER (AREA, DWG TYPE, CL, ORIG)	DRAWING NUMBER	REV
E	0360 80643400	204024	N
SCALE 1/1	CODE IDENT	RELEASE DATE 3/7/74	SHEET 2

204024 N

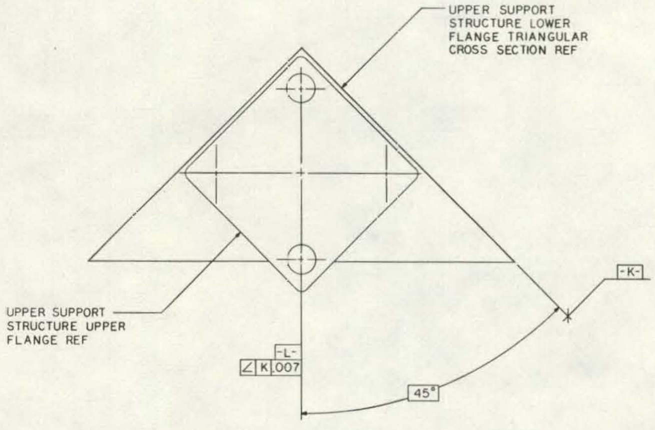
WELD TABLE			
WELD NO.	WELD FILLER	SHT/ZONE	WELD PROC. NO.
W-42	㉔	9/2B	S 2.94
W-43	㉔	9/1A	S 2.94
W-44	㉔	8/5D	S 2.92
W-45	㉔	13/4G	S 2.89
W-46	㉔	9/5G	S 2.94
W-47	㉔	9/5G	S 2.94
W-48	㉔	12/3F	S 2.81

CONTINUED FROM SHEET 2 ZONE 6A

REVISIONS								
ZONE	CHG LTR	DESCRIPTION	RELEASE DATE	APPROVED				
				CHK	P E	SUPV	BR MGR	OTHER
	L		3/8/74					



ALIGNMENT DIAGRAM
SEE G/N
SCALE:NONE



ALIGNMENT DIAGRAM
SEE G/N 57 & 58
SCALE:NONE

NOTES CONTINUED FROM SHEET 2 ZONE 8C

89. REDUCE BRACKET LENGTH TO OBTAIN DIMENSION NOTED PRIOR TO WELDING.
90. INSTALLATION OF THE BOLTS (ITEM 53) SHALL BE MADE PRIOR TO PERFORMING WELD W-45.
91. TIE THE INSTRUMENT LEADS INTO A BUNDLE IN ACCORDANCE WITH FHP 308, FIGURE 2 USING ITEM 46.
92. THIS BRAZE APPLIES ONLY TO SST SHEATHED M I CABLES. ITEM 20 TO BE GROUNDED AS SHOWN IN VIEW A B SHEET 12 ZONE 3F FOR TITANIUM SHEATHED M I CABLES.

84	8	8			NUT HEX .138-32UNC-2B	18-8 SST	127
	-101	-2	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.
	QTY REQD						

PARTS LIST

PARTS LIST CONTINUED FROM SHEET 2

DWG SIZE	INDEX CODE NUMBER (AREA, DWG TYPE, CL, ORIG)	DRAWING NUMBER	CHG LTR
E	0360806434000	204024	L
SCALE 1/1	RELEASE DATE 3/8/74	SHEET 3	

204024 L

Fig. A-3.

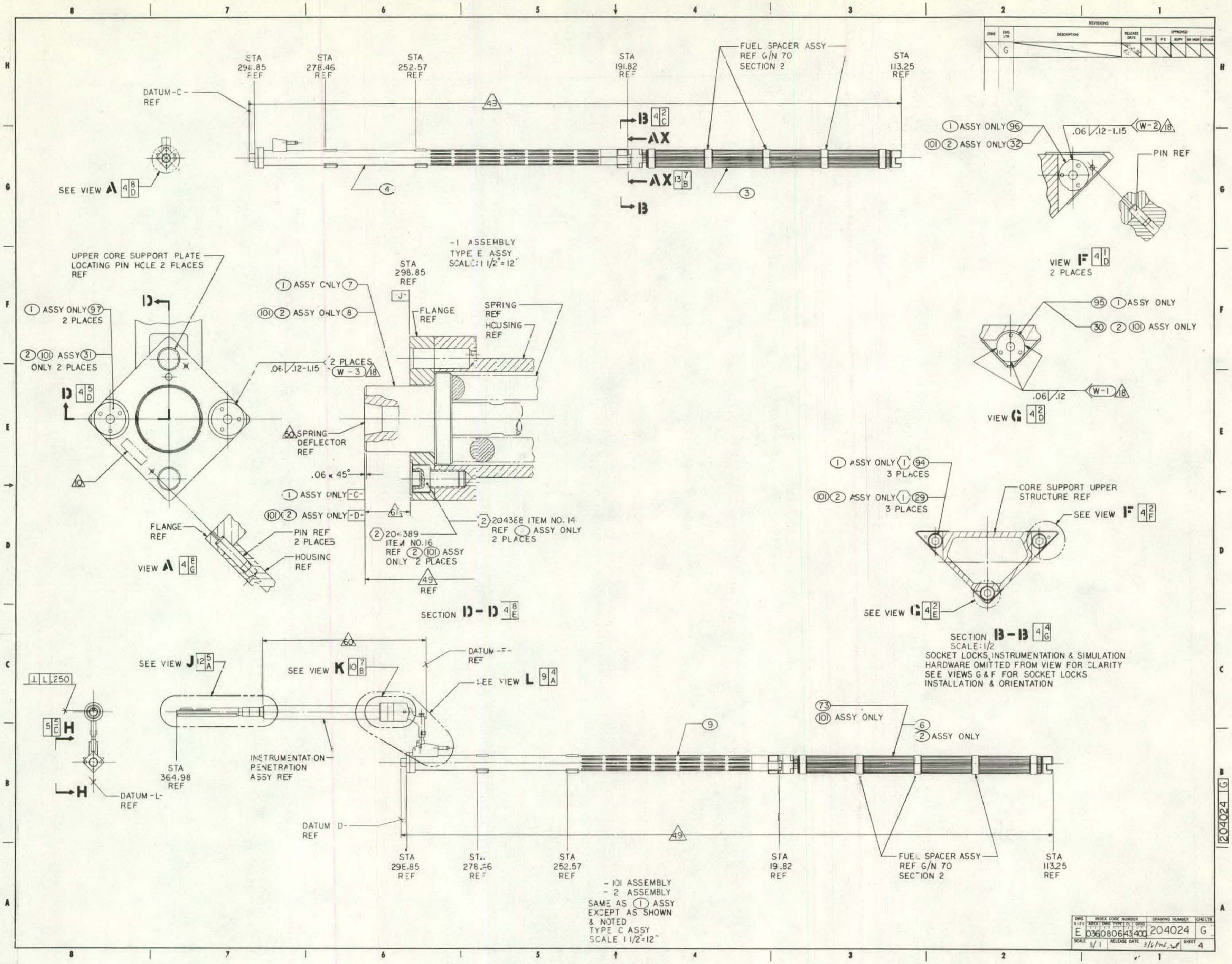
REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P.E.
SUPV
BR MGR
OTHER
G
STA 298.85 REF
STA 278.46 REF
STA 252.57 REF
STA 191.82 REF
FUEL SPACER ASSY REF G/N 70 SECTION 2
STA 113.25 REF
DATUM -C- REF
43
B 4 2 C
AX
AX 13 7 B
B
4
3
SEE VIEW A 4 8 D
① ASSY ONLY 96
101 ② ASSY ONLY 32
.06 .12-1.15 W-2 18
PIN REF
VIEW F 4 1 D
2 PLACES
95 ① ASSY ONLY
30 ② 101 ASSY ONLY
.06 .12 W-1 18
VIEW G 4 2 D
UPPER CORE SUPPORT PLATE LOCATING PIN HOLE 2 PLACES REF
① ASSY ONLY 97 2 PLACES
② 101 ASSY 31 ONLY 2 PLACES
D
D 4 5 D
.06 .12-1.15 2 PLACES W-3 18
16
FLANGE REF
PIN REF 2 PLACES
HOUSING REF
VIEW A 4 8 C
-1 ASSEMBLY TYPE E ASSY SCALE: 1 1/2" = 12"
STA 298.85 REF
-J-
① ASSY ONLY 7
101 ② ASSY ONLY 8
FLANGE REF
SPRING REF
HOUSING REF
60 SPRING DEFLECTOR REF
.06 × 45°
① ASSY ONLY -C-
101 ② ASSY ONLY -D-
61
② 204389 ITEM NO.16 REF ② 101 ASSY ONLY 2 PLACES
② 204388 ITEM NO. 14 REF ① ASSY ONLY 2 PLACES
49 REF
SECTION D-D 4 8 E
① ASSY ONLY ① 94 3 PLACES
101 ② ASSY ONLY ① 29 3 PLACES
CORE SUPPORT UPPER STRUCTURE REF
SEE VIEW F 4 2 F
SEE VIEW G 4 2 E
SECTION B-B 4 4 G
SCALE: 1/2
SOCKET LOCKS, INSTRUMENTATION & SIMULATION HARDWARE OMITTED FROM VIEW FOR CLARITY
SEE VIEWS G & F FOR SOCKET LOCKS INSTALLATION & ORIENTATION
60
SEE VIEW J 12 5 A
SEE VIEW K 10 7 B
DATUM -F- REF
SEE VIEW L 9 4 A
⊥ L .250
5 6 E H
H
DATUM -L- REF
STA 364.98 REF
INSTRUMENTATION PENETRATION ASSY REF
9
73 101 ASSY ONLY
6 ② ASSY ONLY
DATUM -D- REF
49
STA 298.85 REF
STA 278.46 REF
STA 252.57 REF
STA 191.82 REF
FUEL SPACER ASSY REF G/N 70 SECTION 2
STA 113.25 REF
- 101 ASSEMBLY
- 2 ASSEMBLY
SAME AS ① ASSY EXCEPT AS SHOWN & NOTED
TYPE C ASSY
SCALE 1 1/2" = 12"
DWG SIZE E
INDEX CODE NUMBER 0360806434 00
DRAWING NUMBER 204024
CHG LTR G
SCALE 1/1
RELEASE DATE 3/6/75
SHEET 4
204024 G
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-4.

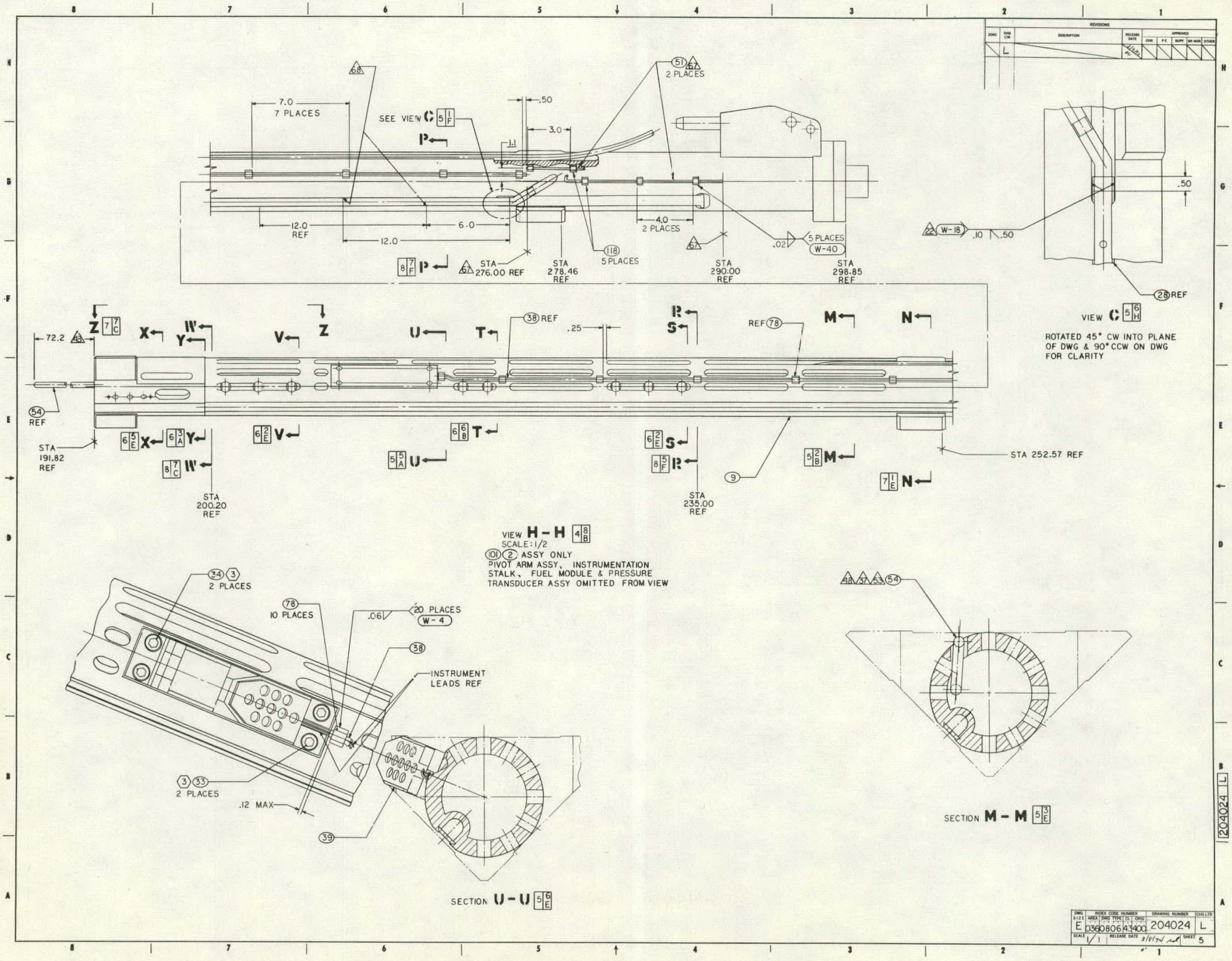

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P.E.
SUPV
BR MGR
OTHER
L
68
7.0
7 PLACES
SEE VIEW C 5 F
P
.50
3.0
1.1
51 67
2 PLACES
12.0
REF
6.0
12.0
4.0
2 PLACES
118
5 PLACES
67
.02
5 PLACES
W-40
8 F P
STA 276.00 REF
61
STA 278.46 REF
STA 290.00 REF
STA 298.85 REF
22 W-18 .10 .50
.50
28 REF
VIEW C 5 H
ROTATED 45° CW INTO PLANE OF DWG & 90° CCW ON DWG FOR CLARITY
72.2
Z 7 C
X
W
Y
V
Z
U
T
38 REF
.25
R
S
REF 78
M
N
54
REF
STA 191.82 REF
6 E X
6 A Y
8 C W
STA 200.20 REF
6 E V
6 B T
5 A U
6 E S
8 F R
STA 235.00 REF
9
5 B M
7 E N
STA 252.57 REF
VIEW H-H 4 B
SCALE: 1/2
101 2 ASSY ONLY
PIVOT ARM ASSY, INSTRUMENTATION STALK, FUEL MODULE & PRESSURE TRANSDUCER ASSY OMITTED FROM VIEW
34 3
2 PLACES
78
10 PLACES
.06
20 PLACES
W-4
38
INSTRUMENT LEADS REF
3 33
2 PLACES
.12 MAX
39
SECTION U-U 5 E
48 37 53 54
SECTION M-M 5 E
204024 L
DWG SIZE E
INDEX CODE NUMBER
AREA DWG TYPE CL ORIG
0360806 43400
DRAWING NUMBER 204024
CHG LTR L
SCALE 1/1
RELEASE DATE 3/8/74
SHEET 5

Fig. A-5.

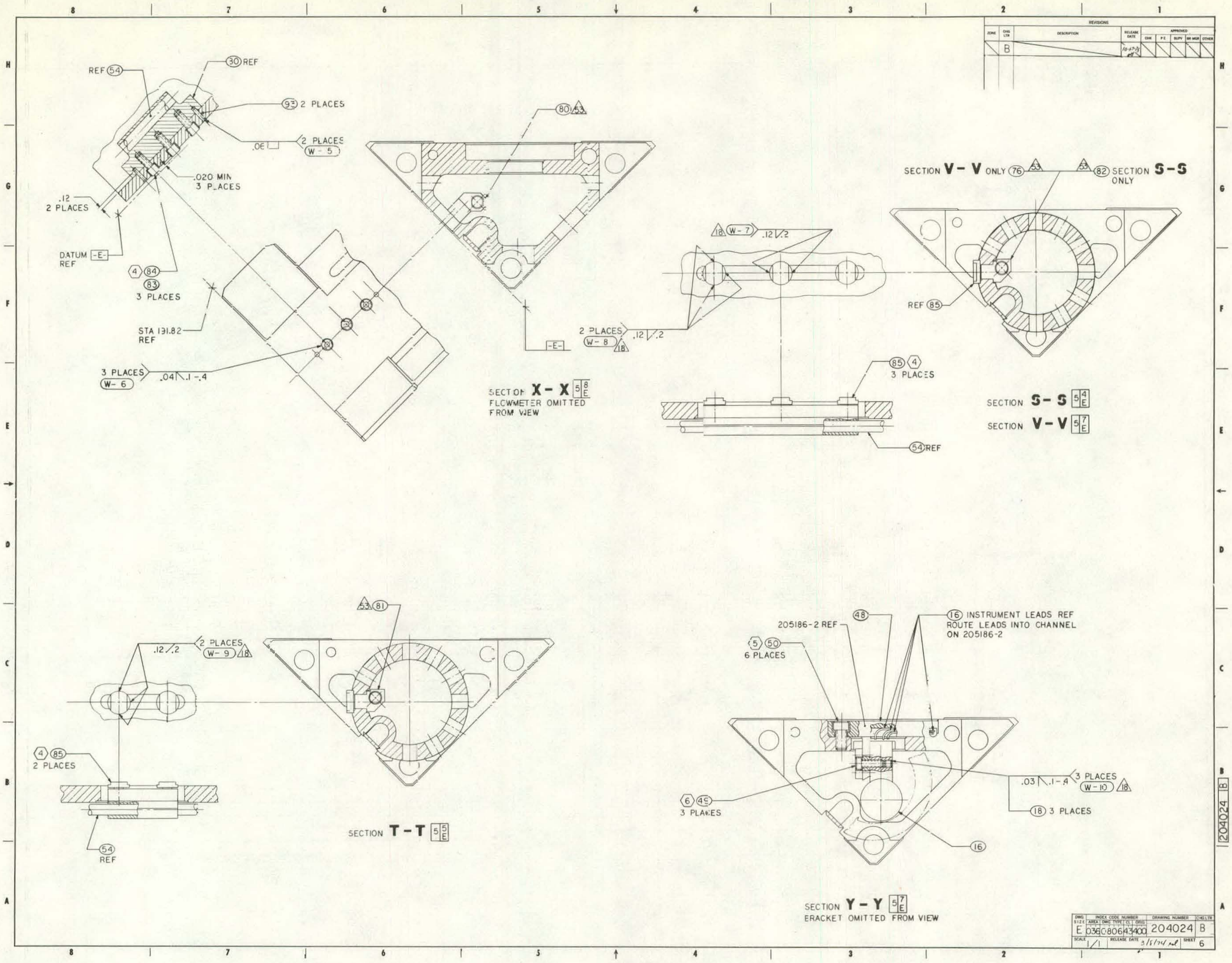

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
B
REF 54
30 REF
93 2 PLACES
.06
2 PLACES W-5
.020 MIN 3 PLACES
.12 2 PLACES
DATUM -E- REF
4 84
83 3 PLACES
STA 131.82 REF
3 PLACES W-6
.04 .1-.4
80 53
-E-
SECTION X-X 5 8 E
FLOWMETER OMITTED FROM VIEW
18 W-7 .12 .2
2 PLACES W-8 18
.12 .2
85 4 3 PLACES
54 REF
SECTION V-V ONLY 76 53
53 82 SECTION S-S ONLY
REF 85
SECTION S-S 5 4 E
SECTION V-V 5 7 E
53 81
.12 .2
2 PLACES W-9 18
4 85 2 PLACES
54 REF
SECTION T-T 5 5 E
205186-2 REF
48
16 INSTRUMENT LEADS REF ROUTE LEADS INTO CHANNEL ON 205186-2
5 50 6 PLACES
.03 .1-.4
3 PLACES W-10 18
18 3 PLACES
6 49 3 PLACES
16
SECTION Y-Y 5 7 E
BRACKET OMITTED FROM VIEW
DWG SIZE E
INDEX CODE NUMBER 036080643400
DRAWING NUMBER 204024
CHG LTR B
SCALE 1/1
RELEASE DATE
SHEET 6
204024 B
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-6.

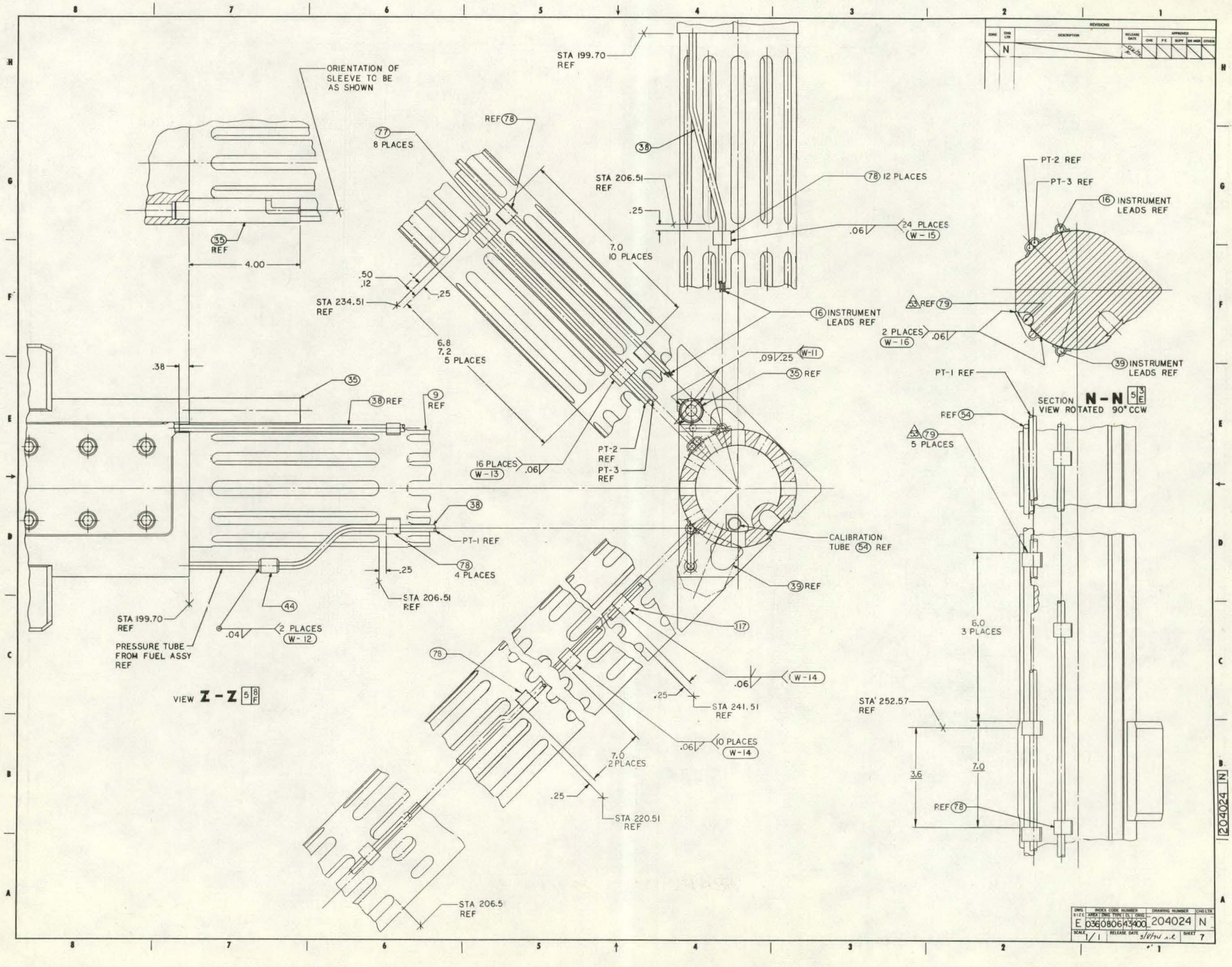
ORIENTATION OF SLEEVE TO BE AS SHOWN
35 REF
4.00
STA 199.70 REF
REF 78
77 8 PLACES
38
STA 206.51 REF
.25
78 12 PLACES
.06 24 PLACES W-15
7.0 10 PLACES
.50 .12
.25
STA 234.51 REF
6.8 7.2 5 PLACES
16 INSTRUMENT LEADS REF
.09 .25 W-11
35 REF
.38
35
38 REF
9 REF
PT-2 REF
PT-3 REF
16 PLACES W-13 .06
38
PT-1 REF
78 4 PLACES
.25
STA 206.51 REF
44
STA 199.70 REF
.04 2 PLACES W-12
PRESSURE TUBE FROM FUEL ASSY REF
VIEW Z-Z 5 8 F
CALIBRATION TUBE 54 REF
39 REF
117
.06 W-14
.25
STA 241.51 REF
78
.06 10 PLACES W-14
7.0 2 PLACES
.25
STA 220.51 REF
STA 206.5 REF
REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P.E.
SUPV
SR MGR
OTHER
N
PT-2 REF
PT-3 REF
16 INSTRUMENT LEADS REF
53 REF 79
2 PLACES W-16 .06
39 INSTRUMENT LEADS REF
PT-1 REF
SECTION N-N 5 3 E
VIEW ROTATED 90° CCW
REF 54
53 79 5 PLACES
6.0 3 PLACES
STA 252.57 REF
3.6
7.0
REF 78
204024 N
DWG SIZE E
INDEX CODE NUMBER AREA 036 DWG TYPE 0806 CL 43 ORIG 400
DRAWING NUMBER 204024
CHG LTR N
SCALE 1/1
RELEASE DATE 3/8/74
SHEET 7
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-7.

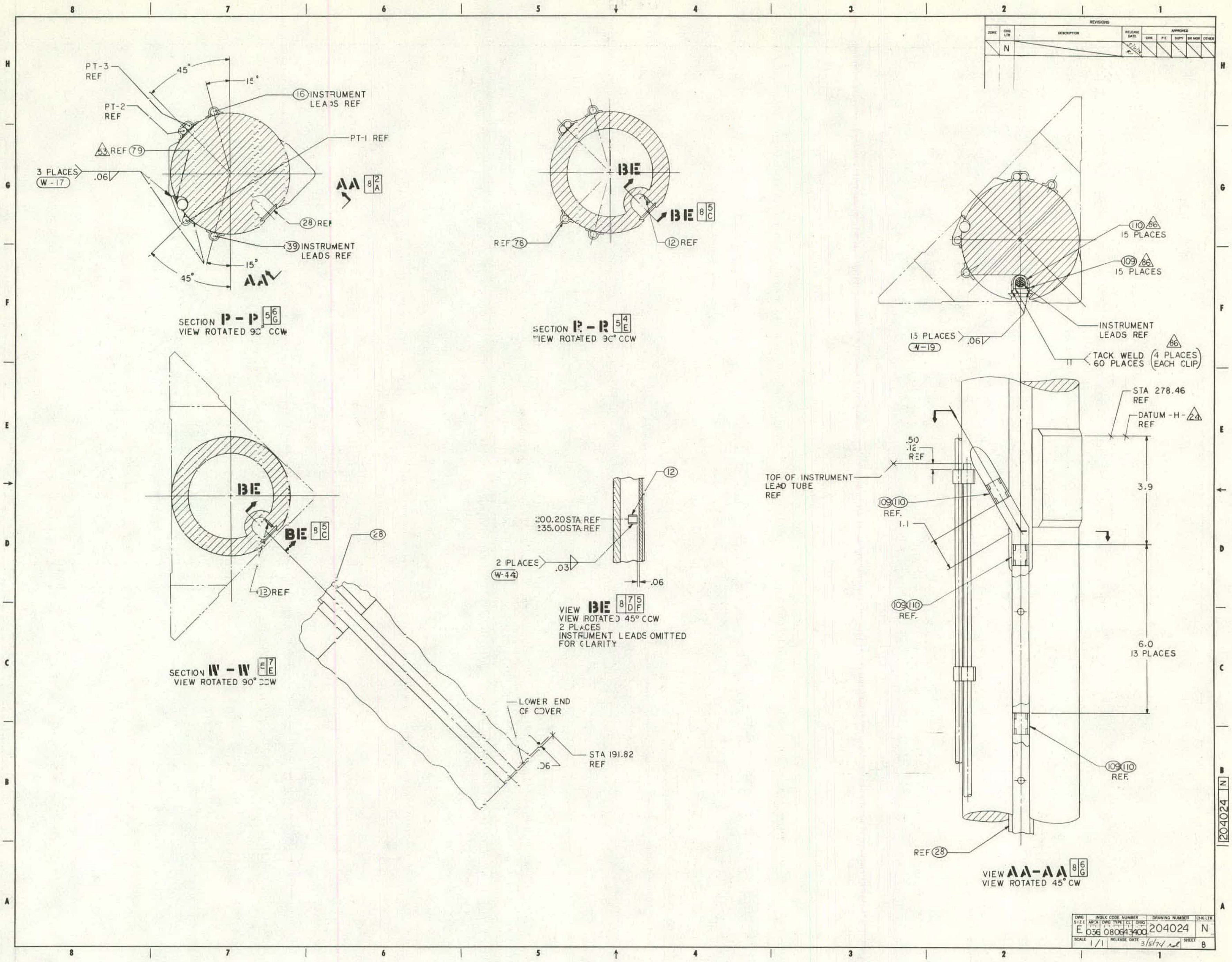

PT-3 REF
45°
15°
16 INSTRUMENT LEADS REF
PT-2 REF
PT-1 REF
53 REF 79
3 PLACES W-17
.06
AA 8 2 A
28 REF
39 INSTRUMENT LEADS REF
15°
45°
AA
SECTION P – P 5 6 G
VIEW ROTATED 90° CCW
BE
BE 8 5 C
REF 78
12 REF
SECTION R – R 5 4 E
VIEW ROTATED 90° CCW
110 86 15 PLACES
109 86 15 PLACES
INSTRUMENT LEADS REF
15 PLACES W-19 .06
86
TACK WELD 60 PLACES (4 PLACES EACH CLIP)
STA 278.46 REF
DATUM -H- 24 REF
BE
BE 8 5 C
12 REF
12
200.20 STA REF
235.00 STA REF
2 PLACES W-44 .03
.06
VIEW BE 8 7 5 D F
VIEW ROTATED 45° CCW
2 PLACES
INSTRUMENT LEADS OMITTED FOR CLARITY
28
SECTION W – W 6 7 E
VIEW ROTATED 90° CCW
LOWER END OF COVER
.06
STA 191.82 REF
.50 .12 REF
TOP OF INSTRUMENT LEAD TUBE REF
109 110 REF.
1.1
3.9
109 110 REF.
6.0 13 PLACES
109 110 REF.
REF 28
VIEW AA–AA 8 6 G
VIEW ROTATED 45° CW
REVISIONS
ZONE CHG LTR DESCRIPTION RELEASE DATE APPROVED CHK. P.E. SUPV. BR MGR OTHER
N
DWG SIZE E
INDEX CODE NUMBER AREA 036 DWG TYPE 08064 CL 3 ORIG 400
DRAWING NUMBER 204024
CHG LTR N
SCALE 1/1
RELEASE DATE 3/8/74
SHEET 8
204024 N
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-8.

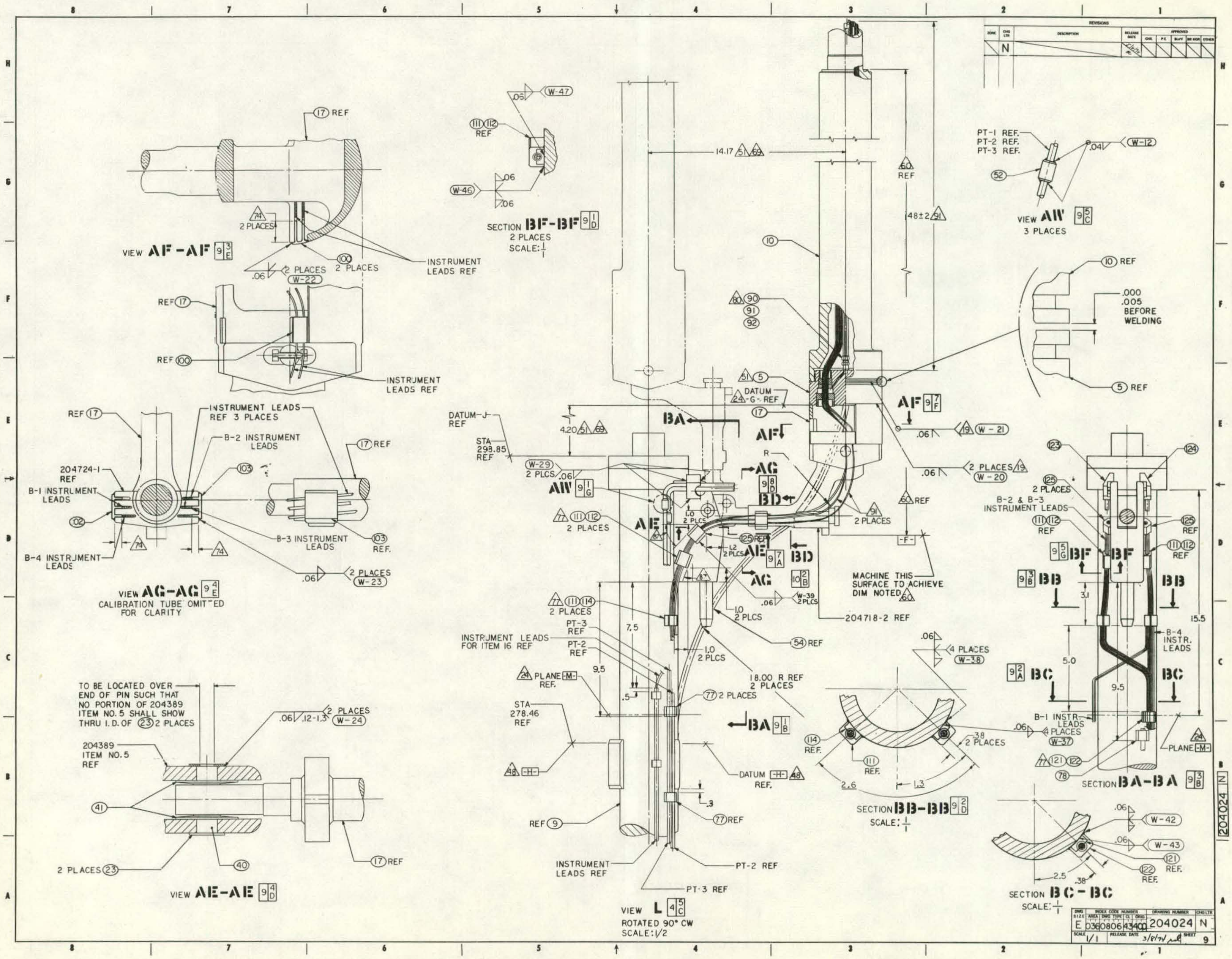

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
N
VIEW AF-AF 9 3/E
(17) REF
74 2 PLACES
.06 2 PLACES W-22
(100) 2 PLACES
INSTRUMENT LEADS REF
REF (17)
REF (100)
INSTRUMENT LEADS REF
SECTION BF-BF 9 1/D
2 PLACES
SCALE: 1/1
.05 W-47
(111)(112) REF
W-46 .06 .06
VIEW AW 9 5/C
3 PLACES
PT-1 REF.
PT-2 REF.
PT-3 REF.
.041 W-12
(52)
REF (17)
INSTRUMENT LEADS REF 3 PLACES
B-2 INSTRUMENT LEADS
204724-1 REF
B-1 INSTRUMENT LEADS
(103)
(17) REF
(102)
74
B-3 INSTRUMENT LEADS
(103) REF.
B-4 INSTRUMENT LEADS
.06 2 PLACES W-23
VIEW AG-AG 9 4/E
CALIBRATION TUBE OMITTED FOR CLARITY
14.17 51 69
60 REF
148±2 91
(10)
80 (90) (91) (92)
51 (5)
DATUM -G- REF
(17)
DATUM-J- REF
STA 298.85 REF
4.20 51 69
BA
AF
R
AG 9 8/D
BD
AF 9 7/F
.06 19 W-21
.06 2 PLACES 19 W-20
60 REF
91 2 PLACES
W-29 2 PLCS .06
AW 9 1/G
77 (111)(112) 2 PLACES
AE
1.0 2 PLCS
(125) REF
L2 2 PLCS
AE 9 7/A
BD
AG 10 2/B
.06 W-39 2 PLCS
-F-
MACHINE THIS SURFACE TO ACHIEVE DIM NOTED 60
204718-2 REF
77 (111)(114) 2 PLACES
1.0 2 PLCS
(54) REF
PT-3 REF
PT-2 REF
INSTRUMENT LEADS FOR ITEM 16 REF
7.5
9.5
1.0 2 PLCS
18.00 R REF 2 PLACES
24 PLANE -M- REF.
.5
(77) 2 PLACES
STA 278.46 REF
BA 9 1/B
48 -H-
DATUM -H- 48 REF.
.3
REF (9)
(77) REF
INSTRUMENT LEADS REF
PT-2 REF
PT-3 REF
VIEW L 4 5/C
ROTATED 90° CW
SCALE: 1/2
(10) REF
.000 .005 BEFORE WELDING
(5) REF
(123)
(124)
(125) 2 PLACES
B-2 & B-3 INSTRUMENT LEADS
(111)(112) REF
(125) REF
9 5/G BF
BF
(111)(112) REF
9 3/B BB
BB
3.1
5.0
9 2/A BC
BC
9.5
15.5
B-4 INSTR. LEADS
B-1 INSTR. LEADS
.06 4 PLACES W-37
77 (121)(122)
(78)
24 PLANE -M-
SECTION BA-BA 9 3/B
.06 4 PLACES W-38
.38 2 PLACES
(114) REF.
(111) REF.
2.6
1.3
SECTION BB-BB 9 2/D
SCALE: 1/1
.06 W-42
.06 W-43
(121) REF.
(122) REF.
2.5
.38
SECTION BC-BC
SCALE: 1/1
TO BE LOCATED OVER END OF PIN SUCH THAT NO PORTION OF 204389 ITEM NO. 5 SHALL SHOW THRU I.D. OF (23) 2 PLACES
.06 .12-1.3 2 PLACES W-24
204389 ITEM NO. 5 REF
(41)
2 PLACES (23)
(40)
(17) REF
VIEW AE-AE 9 4/D
DWG SIZE
INDEX CODE NUMBER
AREA
DWG TYPE
CL
ORIG
DRAWING NUMBER
CHG LTR
E 036 0806 43 400
204024
N
SCALE 1/1
RELEASE DATE 3/8/74
SHEET 9
204024 N
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-9.

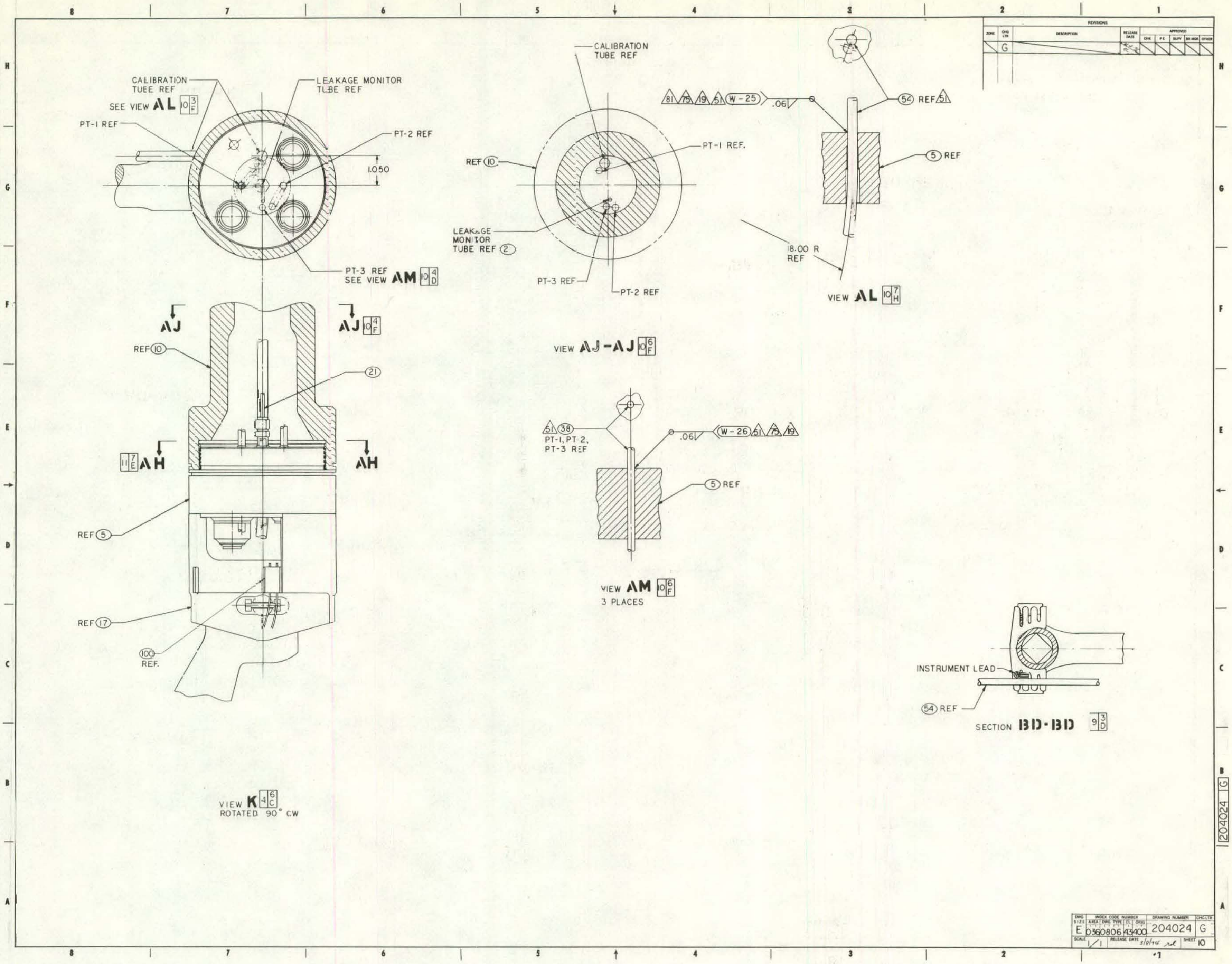

CALIBRATION TUBE REF
LEAKAGE MONITOR TUBE REF
SEE VIEW AL 10 3 F
PT-1 REF
PT-2 REF
1.050
PT-3 REF
SEE VIEW AM 10 4 D
AJ
AJ 10 4 F
REF (10)
(21)
11 7 E AH
AH
REF (5)
REF (17)
(100) REF.
VIEW K 4 6 C
ROTATED 90° CW
CALIBRATION TUBE REF
REF (10)
PT-1 REF.
LEAKAGE MONITOR TUBE REF (2)
PT-3 REF
PT-2 REF
VIEW AJ-AJ 10 6 F
81 75 19 51 W-25 .06
(54) REF 51
(5) REF
18.00 R REF
VIEW AL 10 7 H
51 (38)
PT-1, PT-2, PT-3 REF
.06 W-26 51 75 19
(5) REF
VIEW AM 10 6 F
3 PLACES
INSTRUMENT LEAD
(54) REF
SECTION BD-BD 9 3 D
REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P.E.
SUPV
BR MGR
OTHER
G
DWG SIZE
INDEX CODE NUMBER
AREA
DWG TYPE
CL
ORIG
DRAWING NUMBER
CHG LTR
E
0360806 43400
204024
G
SCALE 1/1
RELEASE DATE 3/8/74
SHEET 10
204024 G
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-10.

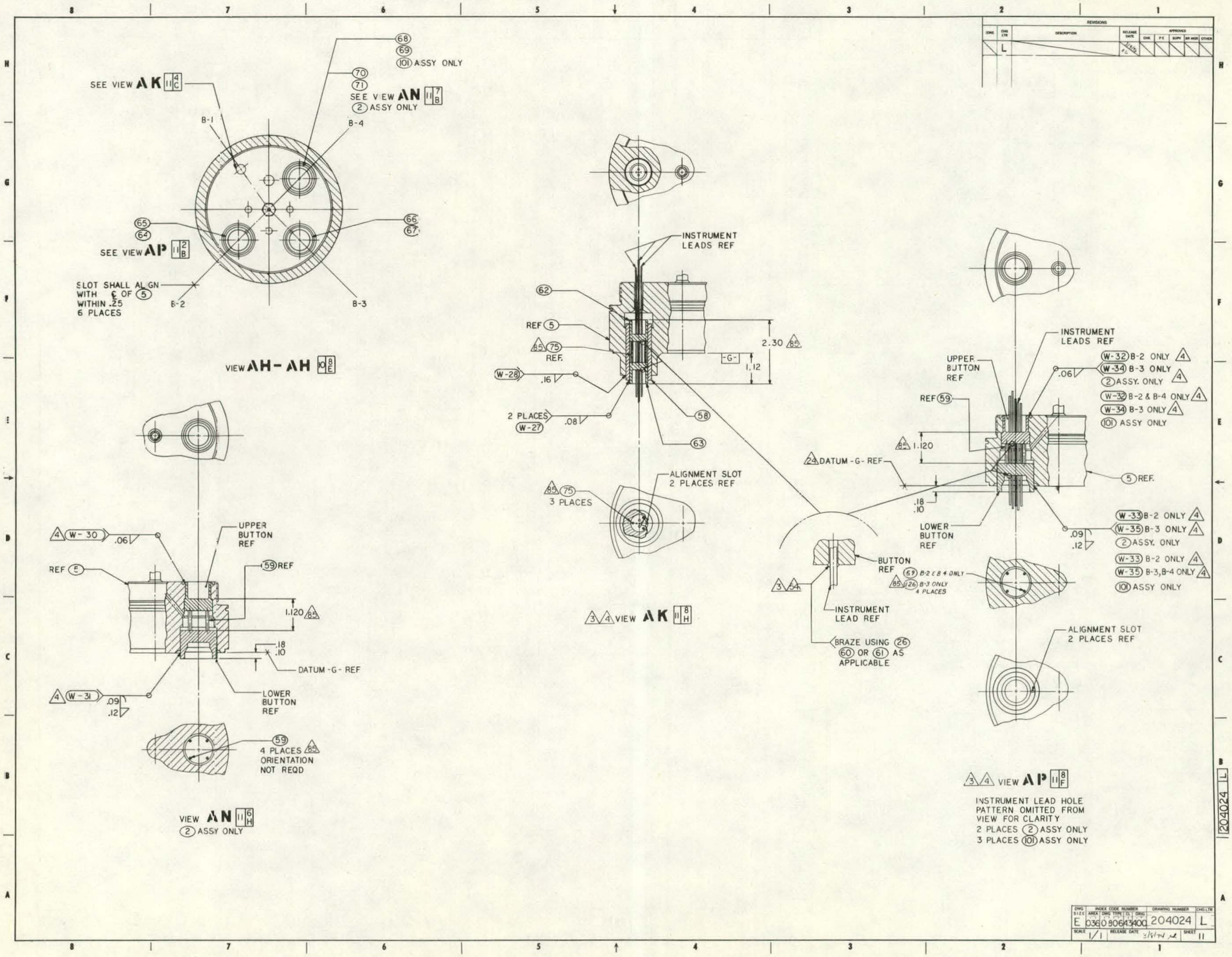

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P E
SUPV
BR MGR
OTHER
L
SEE VIEW AK 11 4 C
68
69
101 ASSY ONLY
70
71
SEE VIEW AN 11 7 B
2 ASSY ONLY
B-1
B-4
65
64
66
67
SEE VIEW AP 11 2 B
SLOT SHALL ALIGN WITH ℄ OF 5 WITHIN .25 6 PLACES
B-2
B-3
VIEW AH-AH 10 8 E
W-30
.06
UPPER BUTTON REF
REF 5
59 REF
1.120 85
.18
.10
DATUM -G- REF
W-31
.09
.12
LOWER BUTTON REF
59
4 PLACES 85
ORIENTATION NOT REQD
VIEW AN 11 6 H
2 ASSY ONLY
INSTRUMENT LEADS REF
62
REF 5
85 75 REF.
2.30 85
-G-
1.12
W-28
.16
2 PLACES
W-27
.08
58
63
ALIGNMENT SLOT 2 PLACES REF
85 75
3 PLACES
3 4 VIEW AK 11 8 H
BUTTON REF
59 B-2 & B-4 ONLY
85 26 B-3 ONLY 4 PLACES
3 54
INSTRUMENT LEAD REF
BRAZE USING 26 60 OR 61 AS APPLICABLE
INSTRUMENT LEADS REF
UPPER BUTTON REF
REF 59
.06
W-32 B-2 ONLY 4
W-34 B-3 ONLY
2 ASSY. ONLY 4
W-32 B-2 & B-4 ONLY 4
W-34 B-3 ONLY 4
101 ASSY ONLY
85 1.120
24 DATUM -G- REF
5 REF.
.18
.10
LOWER BUTTON REF
.09
.12
W-33 B-2 ONLY 4
W-35 B-3 ONLY 4
2 ASSY. ONLY
W-33 B-2 ONLY 4
W-35 B-3, B-4 ONLY 4
101 ASSY ONLY
ALIGNMENT SLOT 2 PLACES REF
3 4 VIEW AP 11 8 F
INSTRUMENT LEAD HOLE PATTERN OMITTED FROM VIEW FOR CLARITY
2 PLACES 2 ASSY ONLY
3 PLACES 101 ASSY ONLY
204024 L
DWG SIZE
INDEX CODE NUMBER
AREA
DWG TYPE
CL
ORIG
DRAWING NUMBER
CHG LTR
E
036 0 806 43 400
204024
L
SCALE 1/1
RELEASE DATE 3/8/74
SHEET 11
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-11.

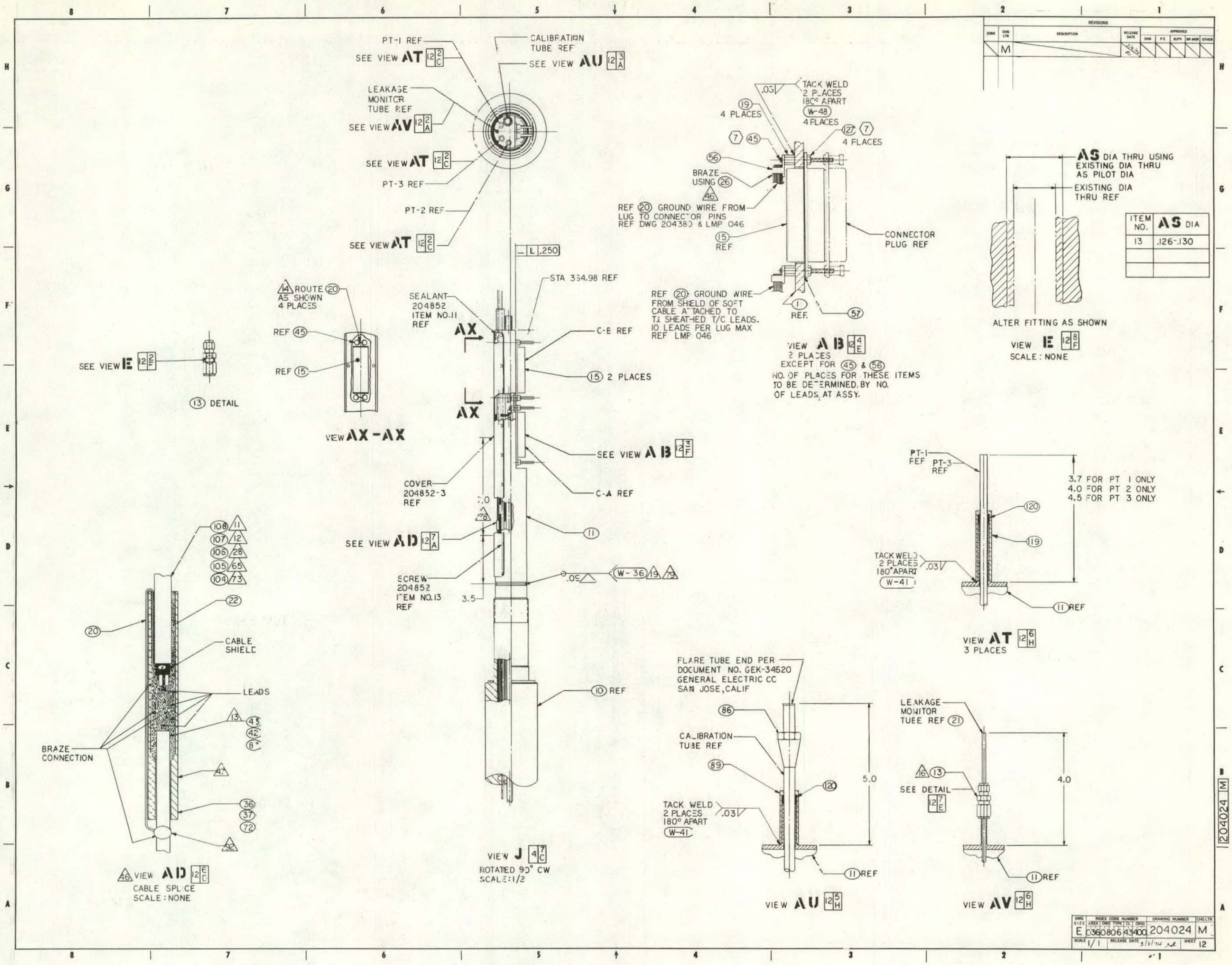

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P E
SUPV
BR MGR
OTHER
M
PT-1 REF
SEE VIEW AT 12 2 C
CALIBRATION TUBE REF
SEE VIEW AU 12 3 A
LEAKAGE MONITOR TUBE REF
SEE VIEW AV 12 2 A
SEE VIEW AT 12 2 C
PT-3 REF
PT-2 REF
SEE VIEW AT 12 2 C
L .250
STA 354.98 REF
SEALANT 204852 ITEM NO.11 REF
AX
C-E REF
15 2 PLACES
AX
SEE VIEW AB 12 3 F
COVER 204852-3 REF
C-A REF
7.0
78
11
SEE VIEW AD 12 7 A
SCREW 204852 ITEM NO.13 REF
3.5
.09
W-36 19 79
10 REF
VIEW J 4 7 C
ROTATED 90° CW
SCALE:1/2
14 ROUTE 20 AS SHOWN 4 PLACES
REF 45
REF 15
VIEW AX-AX
SEE VIEW E 12 2 E
13 DETAIL
108 11
107 12
106 28
105 65
104 73
22
20
CABLE SHIELD
LEADS
13 43 42 6
BRAZE CONNECTION
47
36
37
72
92
46 VIEW AD 12 E C
CABLE SPLICE
SCALE: NONE
.03
TACK WELD 2 PLACES 180° APART
W-48 4 PLACES
19 4 PLACES
127 7 4 PLACES
7 45
56
BRAZE USING 26
46
REF 20 GROUND WIRE FROM LUG TO CONNECTOR PINS REF DWG 204380 & LMP 046
15 REF
CONNECTOR PLUG REF
REF 20 GROUND WIRE FROM SHIELD OF SOFT CABLE ATTACHED TO TI SHEATHED T/C LEADS. 10 LEADS PER LUG MAX REF LMP 046
1 REF.
57
VIEW AB 12 4 E
2 PLACES
EXCEPT FOR 45 & 56
NO. OF PLACES FOR THESE ITEMS TO BE DETERMINED BY NO. OF LEADS AT ASSY.
AS DIA THRU USING EXISTING DIA THRU AS PILOT DIA
EXISTING DIA THRU REF
ITEM NO. | AS DIA
13 | .126-.130
ALTER FITTING AS SHOWN
VIEW E 12 8 F
SCALE: NONE
PT-1 REF
PT-3 REF
3.7 FOR PT 1 ONLY
4.0 FOR PT 2 ONLY
4.5 FOR PT 3 ONLY
120
119
TACK WELD 2 PLACES 180° APART
.03
W-41
11 REF
VIEW AT 12 6 H
3 PLACES
FLARE TUBE END PER DOCUMENT NO. GEK-34520 GENERAL ELECTRIC CO SAN JOSE, CALIF
86
CALIBRATION TUBE REF
89
120
5.0
TACK WELD 2 PLACES 180° APART
.03
W-41
11 REF
VIEW AU 12 5 H
LEAKAGE MONITOR TUBE REF 21
6 13
SEE DETAIL 12 7 E
4.0
11 REF
VIEW AV 12 6 H
204024 M
DWG SIZE E
INDEX CODE NUMBER 360806 43400
DRAWING NUMBER 204024
CHG LTR M
SCALE 1/1
RELEASE DATE 3/8/74
SHEET 12

Fig. A-12.

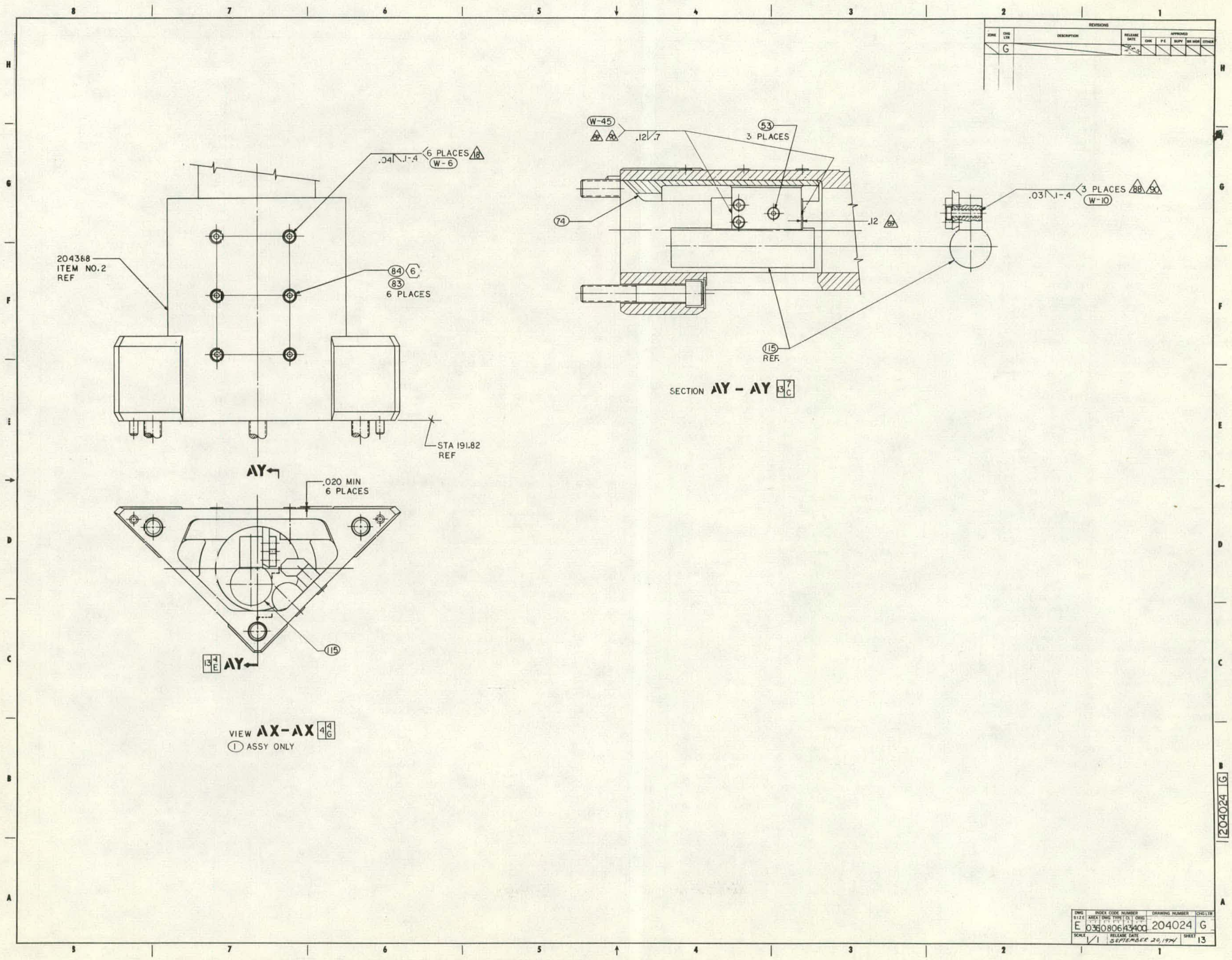

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P E
SUPV
SR MGR
OTHER
G
.04 1-.4 6 PLACES 18
W-6
204368
ITEM NO.2
REF
84 6
83
6 PLACES
STA 191.82
REF
AY
.020 MIN
6 PLACES
115
13 4 E AY
VIEW AX-AX 4 G
1 ASSY ONLY
W-45
88 90
.12 .7
53
3 PLACES
74
.12 87
.03 1-.4 3 PLACES 88 90
W-10
115
REF.
SECTION AY - AY 13 7 C
204024 G
DWG SIZE
INDEX CODE NUMBER
AREA
DWG TYPE
CL
ORIG
DRAWING NUMBER
CHG LTR
E
0360806434000
204024
G
SCALE
1/1
RELEASE DATE
SEPTEMBER 20, 1974
SHEET
13

Fig. A-13.

9	8	7	6	5	4	3	2	1	SHT	REV STATUS
C	F	C	C	E	D	C	H	H	REV	OF SHEETS

REVISIONS

ZONE	CHG LTR	DESCRIPTION	RELEASE DATE	APPROVED CHK	P.E.	SUPV	BR MGR	OTHER
	A	DWG REVISED. SEE ECRA NO. L-4951.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B	DWG REVISED. SEE ECRAS NO L-502 & L-5120	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	C	SEE 'C' DCN	[illegible]	[illegible]				
	H	SEE INC "D", "E", "F", "G" & "H" ADCN'S	9/1/76	9/1/76				

NOTES:

1 REMOVE ALL BURRS & SHARP EDGES.

2 WELD PER ASME BOILER & PRESSURE VESSEL CODE SECTION III AS SUPPLEMENTED BY RDT E15-2T.

△3 INSTRUMENT LEADS TO BE BRAZED INTO BUTTON ASSYS PER ANC BRAZE PROCEDURE BR 1.2 460 OR 461 AS APPLICABLE.

△4 BUTTON ASSY SHALL BE HELIUM LEAK CHECKED PER RDT F3-11T AFTER BRAZING & AFTER WELDING BUTTON SET INTO PRESSURE PLATE. PRESSURIZE AREA BETWEEN BUTTONS TO 60 PSIG HELIUM. AFTER BRAZING MAXIMUM PERMISSIBLE LEAKAGE THRU BRAZE 10^{-6} ATM CC/SEC

5 CLEANING & CLEANLINESS PER RDT F5-1T.

6 ALL WELDS PERFORMED AT THIS ASSY TO BE VISUALLY INSPECTED WITH 5-10X MAGNIFICATION. ACCEPTANCE CRITERIA PER RDT F6-2T PARA E.3.2 & EXCEPTIONS AS NOTED IN THE SPECIFIC WELD PROCEDURES.

7 LOCK CUPS TO BE LOCKED BY DEFORMING CUP INTO GROOVES ON CAP SCREW HEAD EXCEPT AS NOTED. VISUALLY INSPECT. NO CRACKS ALLOWED.

8 LUBRICATE UNDER HEADS & ON THREADS OF ALL THREADED FASTENERS PER RDT F8-1T WITH 2 COATS NEOLUBE, DAG 156 OR EQUIV.

9 TORQUE FASTENERS PER RDT F8-1T TO VALUE SHOWN IN TORQUE TABLE. TIGHTEN TO INITIAL TORQUE VALUE, RELAX TORQUE TO ZERO & RETORQUE TO FINAL TORQUE VALUE & LOCK IN PLACE AS SHOWN OR NOTED REF △55.

△10 MARK PER RDT F7-3T USING VIBRATING MARKING TOOL WITH 204025 & APPLICABLE DASH NO. & ASSIGNED SERIAL NO.

△11 WELD TO BE PERFORMED AFTER FINAL INSTALLATION OF ⑤ & ⑩.

△12 TO BE INSTALLED AFTER INSTALLATION OF ⑤ & ⑩ INTO ⑦.

△13 TO BE SUPPLIED AS PART OF INSTRUMENT BY INSTRUMENTATION BRANCH.

△14 LOCKWIRE PER RDT M6-2T CLASS B.

△15 AFTER MOUNTING ⑫ ONTO UPPER STRUCTURE ASSY ④ OR ⑨, HOLD 205188-1 IN PLACE & ADJUST 205188-8 TO OBTAIN DIM NOTED. WELD TO BE MADE AFTER ADJUSTMENT IS COMPLETED. REMOVE 205188-2 FROM ⑫ AFTER ADJUSTMENT & WELDING ARE COMPLETED.

16 REMOVED

17 SURFACE ROUGHNESS 125√ UNLESS OTHERWISE NOTED.

△18 WELD TO BE PERFORMED AFTER FINAL INSTALLATION OF FASTENER.

△19 LIQUID PENETRANT INSPECT PER RDT F3-6T. ACCEPTANCE CRITERIA PER RDT F6-2T PARA 5.3.3.

20 ⟨X⟩ DENOTES TORQUE REQUIREMENTS. SEE TABLE FOR VALUES.

21 (W-X) DENOTES WELD IDENTIFICATION NO.

22 REMOVED

23 REMOVED

△24 ANY INSTRUMENT WHICH ORIGINATES BELOW SURFACE $\boxed{-C-}$ OR $\boxed{-D-}$ SHALL MAINTAIN A LEAD LENGTH OF 18.0 ±.5 FROM SURFACES $\boxed{-C-}$ OR $\boxed{-D-}$ TO SURFACES $\boxed{-E-}$ OR $\boxed{-F-}$ DURING BRAZING OF BUTTONS TO INSURE ADEQUATE LEAD LENGTH DURING FINAL ASSY.

△25 A LVDT LEAD LENGTH OF 42.50±.50 SHALL BE MAINTAINED FROM THE LEAD EXIT POINT ON LVDT BRACKET TO POINT OF ENTRY ON LOWER BRAZE BUTTON.

26 REMOVED

△27 THIS ASSY MODIFIED BY 204613-1 ASSY △66.

△28 THIS ASSY MODIFIED BY 204613-15 ASSY △66.

△29 THESE PARTS ARE NOT INTERCHANGEABLE AND ARE TO BE SERIALIZED AND MAINTAINED AS A MATCHED SET DURING HANDLING, STORAGE & ASSY.

30 ASSEMBLY SEQUENCE FOR THE FUEL MODULE ASSY SHALL BE IN ACCORDANCE WITH FUEL HANDLING PROCEDURE FHP 302.

31 DATUM $\boxed{-A-}$ IS DEFINED AS THE VERTICAL REFERENCE CENTERLINE PASSING THROUGH THE CENTER OF A $\boxed{8.590}$ SQUARE ENVELOPE OF PARALLEL BOUNDARY PLANES.

32 DATUM $\boxed{-B-}$ IS DEFINED AS THE VERTICAL REFERENCE CENTERLINE PASSING THROUGH THE CENTERS OF THE 8.465-8.460 SQUARE UPPER SUPPORT STRUCTURE LOCATING PADS AT STA 302.27 AND THE 8.460-8.457 SQUARE UPPER SUPPORT STRUCTURE LOWER END BOX AT STA 191.82.

33 DATUM $\boxed{-B-}$ SHALL BE CO-INCIDENTAL WITH DATUM $\boxed{-A-}$ DURING ALIGNMENT REF G/N 34.

34 THE ASSEMBLED ALIGNED FUEL MODULE IN THE VERTICAL POSITION SHALL FIT WITHIN THE ENVELOPE OF PARALLEL BOUNDARY PLANES HAVING AN $\boxed{8.590}$ SQUARE CROSS SECTION.

35 REMOVED

36 DURING ASSY, HANDLING & STORAGE OF THE FUEL MODULE ASSYS PRECAUTIONS SHALL BE TAKEN TO INSURE THAT THE FINAL FUEL MODULE ALIGNMENT IS MAINTAINED.

37 CAUTION: THE FUEL ASSY AND/OR FUEL MODULE ASSY SHALL NOT AT ANY TIME BE ROTATED BEYOND THE HORIZONTAL ATTITUDE TO AN INVERTED ATTITUDE

△38 THE UPPER SUPPORT STRUCTURE ④ OR ⑨ & FUEL ASSEMBLY SHALL BE ORIENTED TO EACH OTHER BY MATCHING THE "N" MARKS ON THE LOWER FLANGE OF ④ OR ⑨ & (51) AND UPPER END BOX OF THE FUEL ASSY.

39 SPECIAL INSTRUMENTATION ASSY REQUIREMENTS, CONTINUITY CHECKS, HANDLING REQUIREMENTS & LEAD PREPARATION REQUIREMENTS SHALL BE IN ACCORDANCE WITH LMP 306 EXCEPT AS NOTED.

△40 ASSY TO BE GAGED AFTER INSTALLATION & WELDING BY INSERTION & WITHDRAWL OF THE FOLLOWING GAGE :

1 GAGE PROBE, PART NO. 13539845, GENERAL ELECTRIC CO., SAN JOSE, CALIF.

GAGE MUST PASS THE FULL LENGTH OF THE CALIBRATION TUBE FREELY WHEN MANUALLY INSERTED & WITHDRAWN.

41 DURING ASSY, HANDLING STORAGE & SHIPPING ACTIVITIES THE FUEL MODULE ASSY SHALL NOT BE SUBJECTED TO LOADS GREATER THAN 3G.

42 DURING ASSY, HANDLING & LOADING INTO THE REACTOR VESSEL THE VERTICAL VELOCITY OF AN UNSUPPORTED FUEL MODULE ASSY SHALL NOT EXCEED 40 INCHES/MINUTE.

43 DURING ASSEMBLY AND HANDLING ACTIVITIES WHICH ARE IN CLOSE PROXIMITY TO OTHER HARDWARE THE HORIZONTAL VELOCITY OF AN UNSUPPORTED FUEL MODULE ASSY SHALL NOT EXCEED 40 INCHES/MINUTE.

△44 MARK PER RDT F7-3T USING REMOVABLE TAG WITH 204025 & APPLICABLE DASH NO.

45 WELDING PROCEDURE QUALIFICATION & PERFORMANCE QUALIFICATION OF THE WELDERS SHALL BE IN ACCORDANCE WITH RDT F6-2T WITH THE EXCEPTION OF PARAGRAPH 6.2.1.

△46 HARD TO SOFT CABLE SPLICE JOINTS AND FINAL CONNECTOR ASSEMBLY SHALL BE MADE IN ACCORDANCE WITH LMP 224 & LMP 046.

△47 INDIVIDUAL LEAD IDENTIFICATION TO BE TRANSFERRED FROM THE MI CABLE TO THE POTTING CUP IN ACCORDANCE WITH LMP 224.

△48 PRIOR TO ASSEMBLY OF THE UPPER SUPPORT STRUCTURE ④ OR ⑨ TO FUEL ASSEMBLY ADJUST CALIBRATION TUBES (54) & (55) TO OBTAIN THE 72.2 DIM NOTED. MEASURE & RECORD THE DIMENSION OF THE LENGTH THAT THE TUBES (54) & (55) EXTEND ABOVE SURFACES $\boxed{-C-}$ OR $\boxed{-D-}$ AS APPLICABLE. DURING FINAL ASSY OF PRESSURE PLATE ⑤ TO TUBES (54) & (55) & PERFORMANCE OF WELD W-3 MAINTAIN THIS RECORDED DIMENSION TO INSURE THE PROPER POSITION OF THE CALIBRATION TUBES (54) & (55) IN THE FUEL MODULE ASSY.

△49 THE TOTAL LENGTH OF THE FUEL ASSY AND UPPER SUPPORT STRUCTURE ④ SHALL BE .200 INCHES LONGER THAN THE AS BUILT ENVELOPE DIMENSION FROM THE BOTTOM SURFACE OF THE REACTOR VESSEL CLOSURE HEAD REF DWG 794-E-062 C.E. AVERY CO, NEWINGTON, N.H. TO THE TOP SURFACE OF THE LOWER CORE SUPPORT STRUCTURE MOUNTING PLATE REF DWG 204065. THE REQUIRED TOTAL LENGTH SHALL BE OBTAINED BY MACHINING THE LOWER END REF SURFACE $\boxed{-C-}$ OF ⑦ AS REQD TO OBTAIN DIM NOTED.

△50 THE TOTAL LENGTH OF THE FUEL ASSY AND UPPER SUPPORT STRUCTURE ⑨ SHALL BE OBTAINED BY PERFORMING THE FOLLOWING:

1 REMOVE SHIM ⑧ FROM ASSY ⑨.
2 PROCEED IN THE SAME MANNER NOTED IN △49 EXCEPT REF SURFACE $\boxed{-D-}$ AND OMIT SHIM ⑧ THICKNESS WHEN DETERMINING THE LENGTH TO MACHINE ⑦.
3 REINSTALL SHIM ⑧ INTO ⑨ ASSY AFTER MACHINING.

△51 PRIOR TO WELDING THE BUTTONS (62) THRU (75) AND TUBES (54) & (55) INTO PRESSURE PLATE ⑤ THE PRESSURE PLATE MUST BE POSITIONED AND CLAMPED WITH RESPECT TO THE SUPPORT STRUCTURE ④ OR ⑨ AS FOLLOWS:

1 AFTER MACHINING ⑦ PER △49 OR △50 MEASURE TO THE NEAREST .010 THE DISTANCE FROM REF SURFACE $\boxed{-C-}$ OR $\boxed{-D-}$ TO THE CENTER OF THE HOLES IN ⑦ POSITIONING ㉝ 3 PLACES.
2 TO DETERMINE THE DIMENSION FROM REF SURFACE $\boxed{-C-}$ OR $\boxed{-D-}$ TO THE BOTTOM SURFACE OF ⑤ REF 204844-2 SUBTRACT .750 FROM THIS MEASURED DIMENSION.

CAUTION: CHECK CENTERLINE ORIENTATION OF ⑤ PRESSURE PLATE PRIOR TO WELDING TO INSURE THAT IT ALIGNS WITH THE CENTERLINE OF THE ④ OR ⑨ UPPER SUPPORT STRUCTURE WITHIN .062.

52 C-X DENOTES CONNECTOR REFERENCE DESIGNATION.

53 B-X DENOTES INSTRUMENTATION BUTTON REFERENCE DESIGNATION.

△54 BUTTONS TO BE VISUALLY INSPECTED AFTER INSTALLATION & BRAZING OF INSTRUMENT LEADS TO INSURE THAT EACH LEAD IS FULLY BRAZED AS INDICATED BY THE PRESENCE OF A BRAZE FILLET FORMED AROUND EACH LEAD AT LOCATION SHOWN.

△55 WHEN 2 OR MORE FASTENERS ARE REQD TO ASSEMBLE MATING PARTS ALTERNATELY TORQUE FASTENERS IN STEPS OF 1/3 THE APPLICABLE TORQUE VALUES SHOWN DURING ASSY UNTIL TORQUING IS COMPLETED.

△56 ACCEPTABLE SUBSTITUTE FOR 206144-1 IS 206144-3.

△57 BRACKET SHALL BE POSITIONED ON ⑤ SO THAT NO PORTION OF BRACKET OR ATTACHING WELDS SHALL EXTEND BEYOND THE OUTER DIA OF ⑤.

△58 AFTER INSTALLATION OF (80) CHECK TO INSURE THAT (54) & (55) ARE NOT RESTRAINED IN THE VERTICAL ATTITUDE.

△59 TO BE USED WITH CHROMEL-ALUMEL THERMOCOUPLE LEADS

△60 TO BE USED WITH PLATINUM-RHODIUM THERMOCOUPLE LEADS.

△61 TO BE USED WITH FLOWMETER COIL LEADS.

△62 TO BE USED WITH LVDT INSTRUMENT LEADS.

63 PROTECTIVE CLOSURES REQUIRED FOR ALL TUBING ENDS PER RDT F7-2T. PLUGS OR CAPS SHALL CONFORM TO RDT F7-2T, PARA 6.5. A COMPLETE LISTING OF PROTECTIVE DEVICES INCORPORATED SHALL BE MAINTAINED. PRIOR TO INSERTION OF THE FUEL MODULE ASSY INTO THE REACTOR VESSEL, AN INVENTORY OF THESE DEVICES SHALL BE MADE TO INSURE THEIR PROPER REMOVAL.

64 RECORDS SHALL BE MAINTAINED FOR EACH FUEL MODULE ASSY SO THAT ALL PARTS & SUBASSEMBLIES CAN BE TRACEABLE TO FABRICATION & SOURCE LOT.

△65 INSTALL FITTING PER VENDOR'S INSTRUCTIONS EXCEPT TORQUE 1/4 TO 1/2 TURN BEYOND FINGER TIGHT.

△66 THESE ASSYS INCLUDE LOOSE PIECE ITEMS. CARE SHOULD BE EXERCISED TO OBTAIN ALL THESE ITEMS AS A PART OF THE PARENT ASSY. REF G/N △67.

△67 THESE PARTS FURNISHED AS LOOSE PIECE ITEMS ON ASSYS 204390-3, 204390-45, 204613-1 OR 204613-15 AND ARE SHOWN IN L/M TO ASSIST IN PROCUREMENT AND/OR FABRICATION ONLY. SEPARATE ORDERING IS NOT REQD UNLESS PARTS ARE NOT INCLUDED IN THE PARENT ASSY PACKAGE. REF G/N △66.

68. INSTRUMENT LEAD ROUTING & HOOKUP SHALL BE IN ACCORDANCE WITH LMP 317.

69 REMOVED

△70 SCREW HEAD TO HAVE .040 DIA HOLE THRU TO ACCOMODATE LOCKWIRE SIZE NOTED.

△71 STAKE OR DEFORM CHANNEL DOVE TAIL EDGE ON 12.0 CENTERS WITH 2 ADDITIONAL STAKES 2 IN. ABOVE THE BOTTOM END TO PREVENT COVER VIBRATION.

△72 205188-8 MAY BE MACHINED IN ORDER TO ADJUST AND ACHIEVE DIM NOTED.

73 DURING ASSY & HANDLING ACTIVITIES SUPPORT SHALL BE PROVIDED FOR THE INSTRUMENTATION PENETRATION ASSY ABOVE DATUM $\boxed{-E-}$ OR $\boxed{-F-}$, AS APPLICABLE, WHICH MAINTAINS ASSY AND/OR INDIVIDUAL COMPONENTS WITHIN .125 OF DATUM $\boxed{-B-}$.

74 DURING ASSY, HANDLING & STORAGE WHILE IN A HORIZONTAL POSITION THE FUEL MODULE ASSYS. MUST BE SUPPORTED AT THE FOLLOWING LOCATIONS SUCH THAT THE FUEL MODULE ALIGNMENT IS MAINTAINED:

1 THE UPPER END BOX AT STA 191.82 AND LOWER END BOX AT STA 113.25 OF THE FUEL ASSYS.
2 THE 3 CENTRALLY LOCATED FUEL SPACER ASSYS BETWEEN STATIONS 113.25 AND 191.82.
3 THE LOWER END BOX AT STA 191.82 AND LOCATING PADS AT STA 302.27 OF THE UPPER SUPPORT STRUCTURES ④ OR ⑨.

△75 DESIGNATED STATION APPLIES ONLY PRIOR TO INSTALLATION OF THE FUEL MODULE ASSY INTO THE REACTOR VESSEL AND THE VALUE SHOWN WILL BE DECREASED BY .200 WHEN SUBSEQUENTLY INSTALLED IN THE REACTOR VESSEL.

△76 2-2 CONDUCTOR HIGH TEMP CABLES, NICKEL PLATED COPPER, 22 GA SOLID WITH SST SHIELD & JACKETED MAY BE USED AS ACCEPTABLE SUBSTITUTE FOR (105).

△77 TO BE USED WITH LIQUID LEVEL DETECTOR INSTRUMENT LEADS.

NOTES CONTINUED ON SHT 2

SEE SHT 2 FOR LIST OF MATERIAL

PART DASH NO.	NEXT QTY REQD PER ASSY	FINAL QTY REQD PER ASSY	NEXT ASSY	USED ON
H02	1	1	204566	LOFT
H01	1	1	204566	LOFT
-2	1	1	204566	LOFT
-1	1	1	204566	LOFT

APPLICATION

QUALITY ASSURANCE ESSENTIALITY LEVEL I

DRAWING FORM

△84

QTY REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.

PARTS LIST

UNLESS OTHERWISE SPECIFIED

DIMENSIONING AND SYMBOLOGY ARE AMERICAN NATIONAL STANDARD

DIMENSIONS AND TOLERANCES ARE IN INCHES

TOLERANCES:
DECIMALS: .X = ± .1
.XX = ± .03
.XXX = ± .010
FRACTIONS: ± 1/8
ANGULAR: ± 2°

DO NOT SCALE DRAWING

DRAWN A.R. ROWLEY 11-2-73
CHECKED 2-28-74
PROJECT ENGINEER 2/21/74
SUPERVISOR 2/27/74
B. Martin 2-28-74
BRANCH MANAGER 3/1/74

AEROJET NUCLEAR COMPANY
INCORPORATED
IDAHO FALLS, IDAHO

TITLE
CENTER FUEL MODULE ASSY,
TYPE A & TYPE F
LOFT

DWG SIZE E
INDEX CODE NUMBER: AREA 036 DWG TYPE 0806 CL 43 ORIG 400
DRAWING NUMBER 204025
CHG LTR H
SCALE 1/2
RELEASE DATE MARCH 1, 1974
SHEET 1 OF 9

204025 H

Fig. A-14.

78 THE ASSIGNED SERIAL NO SHALL CONSIST OF THE DESIGNATION S/N FOLLOWED BY THE APPLICABLE SEQUENTIAL 2 DIGIT NO OF THE ASSEMBLY. EXAMPLE SN-01, SN-02, SN-03, ETC.

△79 WELD THROAT THICKNESS SHALL BE .040 MIN.

△80 ALL HARD TO SOFT SPLICE JOINTS TO BE MADE WITHIN THIS SPACE.

△81 DO NOT WELD ⑪ TO ⑩ UNTIL AFTER COMPLETION OF SPLICING OF SOFT CABLE TO MI CABLE, REF NOTE △46.

△82 INSTALL FITTING PER VENDORS' INSTRUCTIONS EXCEPT TORQUE 3/4 TO 1 TURN BEYOND FINGER TIGHT.

△83 THE SIZE OF THIS WELD MUST NOT EXCEED .09.

△84 REFER TO THE INDIVIDUAL COMPONENT DRAWINGS FOR THE APPLICABLE QUALITY LEVEL.

△85 QUALITY LEVEL II

△86 LAZER BEAM WELD THE SPACER PINS TO THE UPPER AND LOWER LEAD BUTTONS IN ACCORDANCE WITH LMP 317. TOTAL RUNOUT BETWEEN THE UPPER AND LOWER BUTTON OUTSIDE DIAMETERS SHALL NOT EXCEED .002 AFTER WELDING.

△87 CUSTOM FIT CLIPS (ITEMS 110 AND 11) BY GRINDING THE CLIP TABS AND WELLS UNTIL LEADS ARE ARE A SLIP FIT WITHIN THE CLIP ASSY AND THE CLIPS ARE A FUNCTIONAL FIT WITHIN THE UPPER CORE SUPPORT STRUCTURE CHANNEL.

△88 CUSTOM FIT CLIP INTO MATING PART UNTIL LEADS ARE A SLIP FIT WITHIN CLIP SLOT.

△89 THIS BRAZE JOINT APPLIES ONLY TO SST SHEATH MI CABLES. ITEM 20 TO BE GROUNDED AS SHOWN IN VIEW R, SHT 7 ZONE 4F FOR TITANIUM SHEATHED MI CABLES.

△90 CUSTOM FIT CALIBRATION TUBE INTO PRESSURE PLATE BY REAMING PRESSURE PLATE .001-.005 INCHES LARGER THAN CALIBRATION TUBE O.D.

△91 THE AS BUILT DIMENSION FROM THE TOP OF THE "K" SEAL SURFACE ON THE PRESSURE TUBE, ITEM 10 (REF SURFACE AT STA. 347.19, SHT. 4, ZONE 7-B) TO THE TOP OF THE SLOTS IN THE PRESSURE PLATE, ITEM 5 (REF SHT. 4, ZONE 4-E) SHALL BE LESS THAN THE AS BUILT DIMENSION FROM THE TOP OF THE SLEEVE, ITEM 7 TO THE CENTER OF THE PIN (ITEM 33) HOLES PLUS 21.434 INCHES.

△92 CUSTOM FIT THE CALIBRATION TUBES, ITEMS 54 & 55 TO THE UPPER CORE SUPPORT STRUCTURE GUIDE TUBES (204613-23) BY REAMING THE .575/.585 DIA. CBORE (REF 204513 SHT. 1 ZONE 5/C) AS REQUIRED TO PERMIT A .004 TO .010 INTERFERENCE FIT WITH THE CALIBRATION TUBE CENTERING SPRING (REF DWG. 205158 ITEM 5)

TORQUE TABLE △55

TORQUE IDENT NO ⟨X⟩	INITIAL TORQUE FT/LBS	FINAL TORQUE FT/LBS	SHT/ZONE
1	89 ± 5	71 ± 4	5/8E
2	119 ± 5	95 ± 5	5/5E
3	14 ± 1	11 ± 1	6/8E
4	10 ± 1 IN/LBS	10 ± 1 IN/LBS	7/7F
5	14 ± 1	11 ± 1	5/3G
6	4.5 ± 1	3.5 ± 1	5/4G

WELD TABLE

WELD NO	WELD FILLER	SHT/ZONE	ANC WELD PROCESS
W - 1	㉕	7/4C	1S-2.80
W - 2	㉔	4/8D	S-2.80
W - 3	㉕	4/4D	1-2.80
W - 4	㉔	5/8D	S-2.80
W - 5	㉔	5/6E	S-2.80
W - 6	㉔	5/4E	S-2.8
W - 7	㉔	5/8C	S-2.82
W - 8	㉔	5/8H	S-2.83
W - 9	㉔	6/8B	S-2.84
W - 10	㉔	8/8C	S-2.85
W - 11	㉔	8/8C	S-2.86
W - 12	㉕	8/4D	1-2.82
W - 13	㉕	8/4C	1-2.83
W - 14	㉕	4/6D	1S-2.84
W - 15	㉔	9/8E	S-2.87
W - 16	㉔	9/6F	S-2.88
W - 17	㉔	9/8G	S-2.89
W - 18	㉕	9/3C, 1E	1-2.81
W - 19	㉕	9/4G, 3E	1S-2.85
W - 20	㉕	8/4D	1S-2.82
W - 22	㉔	7/7G	S-2.97

	-102	-101	-2	-1	PART OR IDENT. NO	NOMENCLATURE OR DESCRIPTION	MATERIAL / SPECIFICATION	ITEM NO
	20	16	20	20	205157 8	SPACER		113
	3	3	3	3	205157-9	SPACER		112
△67	28	28	28	28	204390-48	CLIP		111
△67	28	28	28	28	204390-49	CLIP		110
△85	8	8	8	8		NUT, HEX .138-32 UNC 2B	18-8 SST	109

QTY REQD

PARTS LIST

	-102	-101	-2	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.
△85 △59	AR	AR	AR	AR		DUROFILM II HIGH TEMP CABLE 2 CONDUCTOR, TYPE K CHROMEL-ALUMEL, 22 GA SOLID TWISTED PAIR WITH SST SHIELD & JACKETED		108
△85 △60	AR	AR	AR	AR		DUROFILM II HIGH TEMP CABLE 2 CONDUCTOR, TYPE S THERMOCOUPLE EXTENSION, 22 GA SOLID TWISTED PAIR WITH SST SHIELD & JACKETED		107
△85 △61	AR	AR	AR	AR		DUROFILM II HIGH TEMP CABLE 3 CONDUCTOR, NICKEL PLATED COPPER, 22 GA SOLID WITH SST SHIELD & JACKETED		106
△85 △62 △76	AR	AR	AR	AR		HIGH TEMP CABLE 4 CONDUCTOR, NICKEL PLATED COPPER, 22 GA SOLID WITH SST SHIELD & JACKETED		105
△85 △77	AR	AR				DUROFILM II HIGH TEMP CABLE, 1 CONDUCTOR NKL PLATED COPPER, 22GA SOLID WITH SST SHIELD & JACKETED		104
								103
					-102	ASSEMBLY, TYPE F		102
					-101	ASSEMBLY, TYPE A		101
								100
								99
								98
								97
	1	1			206137-37	BUTTON-LOWER		96
	1	1			206137-36	BUTTON-UPPER		95
	1				206137-35	BUTTON-LOWER		94
	1				206137-34	BUTTON-UPPER		93
△85	1	1	1	1	204-1-316	FERRULE, BACK	CRAWFORD FITTING CO. SOLON, OHIO	92
△85	1	1	1	1	203-1-316	FERRULE, FRONT		91
△85	1	1	1	1	202-1-316	NUT		90
△85	1	1	1	1	200-P-316	PLUG	CRAWFORD FITTING CO. SOLON, OHIO	89
△85 △44	1	1	1	1	-88	MALE CONNECTOR	MAKE FROM 100-1-1-316 CRAWFORD FITTING CO. SOLON, OHIO	88
△85	1	1	1	1	200-6-316	UNION	CRAWFORD FITTING CO. SOLON, OHIO	87
△85	2	2	2	2	248-A904 P001	CALIBRATION TUBE NUT	GENERAL ELECTRIC CO. SAN JOSE, CALIFORNIA	86
								85
								84
	6	6	6	6	206144-2	CLIP		83
	1	1	1	1	206144-1	BRACKET		82
								81
	2	2	2	2	206143-2	CLIP		80
	2	2	2	2	206143-3	CLIP		79
	1	1	1	1	206143-1	BRACKET		78
	1	1	1	1	206143-4	CLIP		77
								76
	4	4	4		206137-13	BUTTON-LOWER		75
	4	4	4		206137-7	BUTTON-UPPER		74
			1		206137-14	BUTTON-LOWER		73
			1		206137-8	BUTTON-UPPER		72
			1		206137-9	BUTTON-LOWER		71
			1		206137-3	BUTTON-UPPER		70
				4	206137-11	BUTTON-LOWER		69
				4	206137-5	BUTTON-UPPER		68
				1	206137-12	BUTTON-LOWER		67
				1	206137-6	BUTTON-UPPER		66
		1		1	206137-4	BUTTON-UPPER		65
		1		1	206137-10	BUTTON-LOWER		64
	1	1	1	1	206137-2	BUTTON-LOWER		63
	1	1	1	1	206137-1	BUTTON-UPPER		62
								61
	AR	AR	AR	AR		BRAZE ALLOY	Ti 48 Zr 48 Be 4	60
	4	8	4	4	205157-7	SPACER		59
	1	1	1	1	205157-5	SLEEVE		58
	4	4	4	4	206194-1	GASKET		57
△85	AR	AR	AR	AR		ELECTRICAL TERMINAL LUG		56
△92 △40	1	1	1	1	205158-8	CALIBRATION TUBE		55
△92 △40	1	1	1	1	205158-7	CALIBRATION TUBE		54
	1				XN302,320	FUEL ASSY, TYPE F	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	53
		1			XN302,318	FUEL ASSY, TYPE A	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	52
△67	1	1	1	1	204390-47	ORIFICE PLATE		51

QTY REQD

PARTS LIST

	-102	-101	-2	-1	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.
△67	6	6	6	6	205186-7	SCREW		50
△67	3	3	3	3	205186-6	SCREW		49
△67	1	1	1	1	205186-10	BRACKET ASSY		48
△85	AR	AR	AR	AR		LUBRICANT	NEOLUBE	47
△85	AR	AR	AR	AR		WIRE, .032 DIA	300 SERIES SST ANNEALED	46
△85 △70	16	16	16	16		SCREW .138-32UNC-2A x .25 LONG	18-8 SST	45
△85 △13	AR	AR	AR	AR		.125 DIA MINERAL INSULATED WIRE	INSTRUMENTATION LEAD	44
△85 △13	AR	AR	AR	AR		.062 DIA MINERAL INSULATED WIRE	INSTRUMENTATION LEAD	43
△85 △13	AR	AR	AR	AR		.046 DIA MINERAL INSULATED WIRE	INSTRUMENTATION LEAD	42
△85 △13	AR	AR				.040 DIA MINERAL INSULATED WIRE	INSTRUMENTATION LEAD	41
								40
△67	2		2		204390 ITEM 43	SCREW		39
	2	2	2	2	205121-4	POTTING CUP		38
	24	24	4	24	205121-3	POTTING CUP		37
	76	76	96	76	205121-2	POTTING CUP		36
	19	19			205121-5	POTTING CUP		35
△67	3	3	3	3	204390 ITEM 37	WASHER		34
	3	3	3	3	204390 ITEM 26	PIN		33
		2		2	204390 ITEM 25	SCREW		32
	2	2	2	2	204390 ITEM 42	SOCKET LOCK		31
	4	4	4	4	204390 ITEM 32	SOCKET LOCK		30
	4	4	4	4	204390 ITEM 12	SCREW		29
△67	2	2	2	2	204390 ITEM 11	CHANNEL COVER		28
						REMOVED		27
	AR	AR	AR	AR		BRAZE ALLOY	BAu4	26
	AR	AR	AR	AR		WELD FILLER METAL	INCONEL 82 CL ER NiCr3 AWS A5.14	25
	AR	AR	AR	AR		WELD FILLER METAL	ER308L AWS A5.9	24
								23
△85	AR	AR	AR	AR	2651-MM	POTTING COMPOUND	EMERSON-CUMMINGS CANTON, MASSACHUSETTS	22
	AR	AR	AR	AR			TUBING .125 OD x .035 WALL 304 SST OR 304LSST ASTM A-269	21
△85	AR	AR	AR	AR		.020 DIA WIRE	300 SERIES SST ANNEALED	20
△70	16	16	16	16	206143-17	GROUNDING LUG SCREW	18-8 SST	19
△85	3	3	3	3		SET SCREW .250-20 UNC-2A x .250 LONG	18-8 SST	18
								17
	1	1	1	1	204600-1	FLOWMETER		16
△85	4	4	4	4	217-2CR-A102S-57	ELECTRICAL CONNECTOR	AMPHENOL INC. HARRISBURG, PA	15
△85 △44	2	2	2	2	-14	BULKHEAD UNION CONNECTOR	MAKE FROM 600-61-316 CRAWFORD FITTING CO. SOLON, OHIO	14
△85 △44	1	1	1	1	-13	BULKHEAD UNION CONNECTOR	MAKE FROM 200-61-316 CRAWFORD FITTING CO. SOLON, OHIO	13
	2	2	2	2	205189-1	LVDT INSTRUMENT ASSY		12
	1	1	1	1	204843-1	INSTRUMENTATION STALK		11
	1	1	1	1	204843-1	PRESSURE TUBE		10
△66 △29 △28	1		1		204390-45	UPPER CORE SUPPORT STRUCTURE		9
△67	1		1		204390-44	SHIM △50		8
△29 △67	1	1	1	1	-7	SLEEVE △49 △50	MAKE FROM 204390-2	7
			1		XN301,279	FUEL ASSY, TYPE F-2	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	6
	1	1	1	1	204844-1	PRESSURE PLATE		5
△66 △29 △27		1		1	204390-3	UPPER CORE SUPPORT STRUCTURE		4
				1	XN301,269	FUEL ASSY, TYPE A3	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	3
					-2	ASSEMBLY, TYPE F		2
					-1	ASSEMBLY, TYPE A		1

QTY REQD

PARTS LIST

REVISIONS

ZONE	CHG LTR	DESCRIPTION	RELEASE DATE	CHK	P E	SUPV	BR MGR	OTHER
				APPROVED				
	H							

DWG SIZE	INDEX CODE NUMBER AREA	DWG TYPE	CL	ORIG	DRAWING NUMBER	REV
E	0360	806	43	400	204025	H
SCALE 1/2	CODE IDENT		RELEASE DATE 3-1-74		SHEET 2	

204025 H

Fig. A-15.

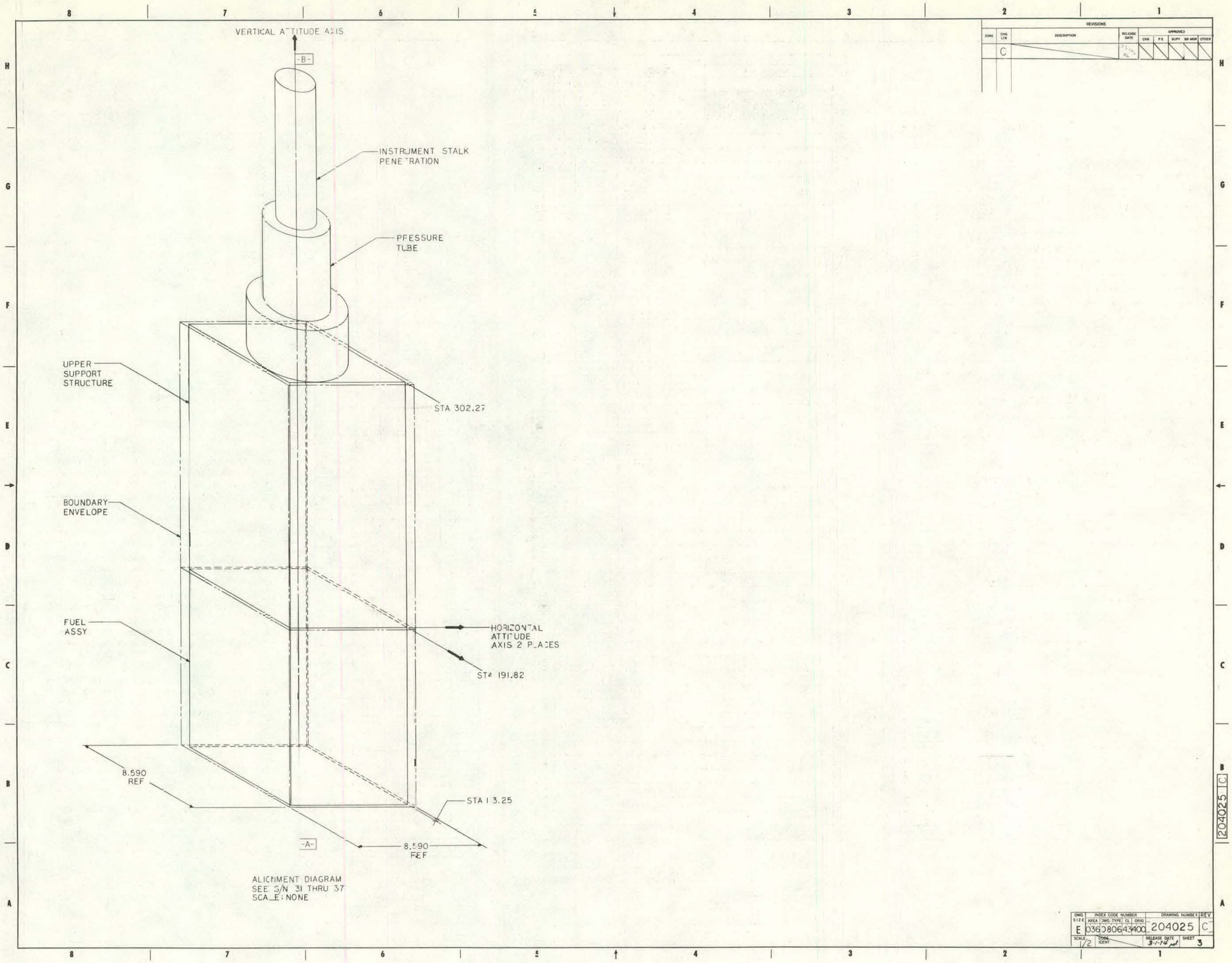

VERTICAL ATTITUDE AXIS
-B-
INSTRUMENT STALK PENETRATION
PRESSURE TUBE
UPPER SUPPORT STRUCTURE
STA 302.27
BOUNDARY ENVELOPE
FUEL ASSY
HORIZONTAL ATTITUDE AXIS 2 PLACES
STA 191.82
8.590 REF
STA 1 3.25
-A-
8.590 REF
ALIGNMENT DIAGRAM
SEE S/N 31 THRU 37
SCALE: NONE
REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P.E.
SUPV
BR MGR
OTHER
C
DWG SIZE
INDEX CODE NUMBER
AREA
DWG TYPE
CL
ORIG
E
036 0806 43 400
DRAWING NUMBER
204025
REV
C
SCALE
1/2
CODE IDENT
RELEASE DATE
3-1-74 pd
SHEET
3
204025 C
8
7
6
5
4
3
2
1
H
G
F
E
D
C
B
A

Fig. A-16.

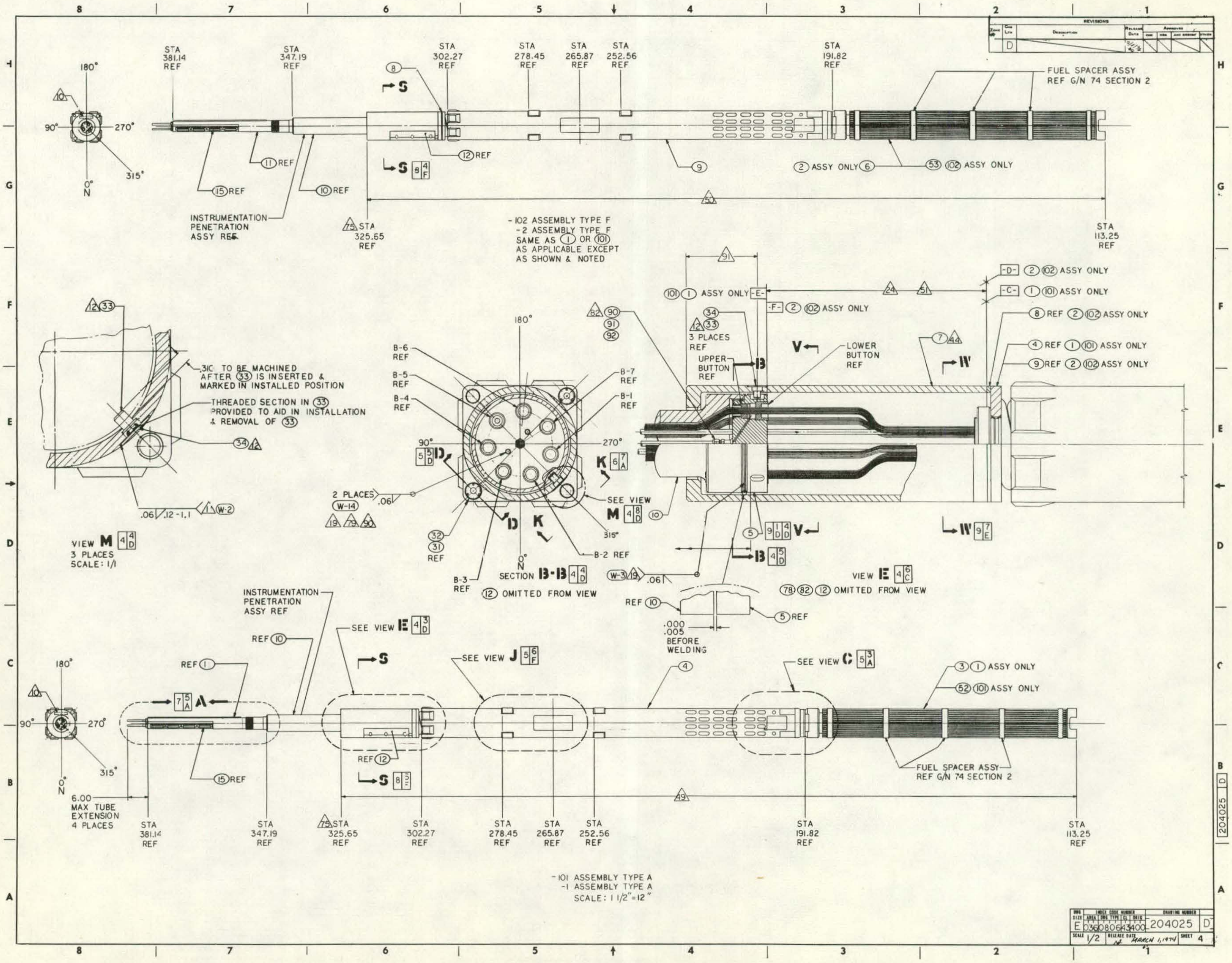
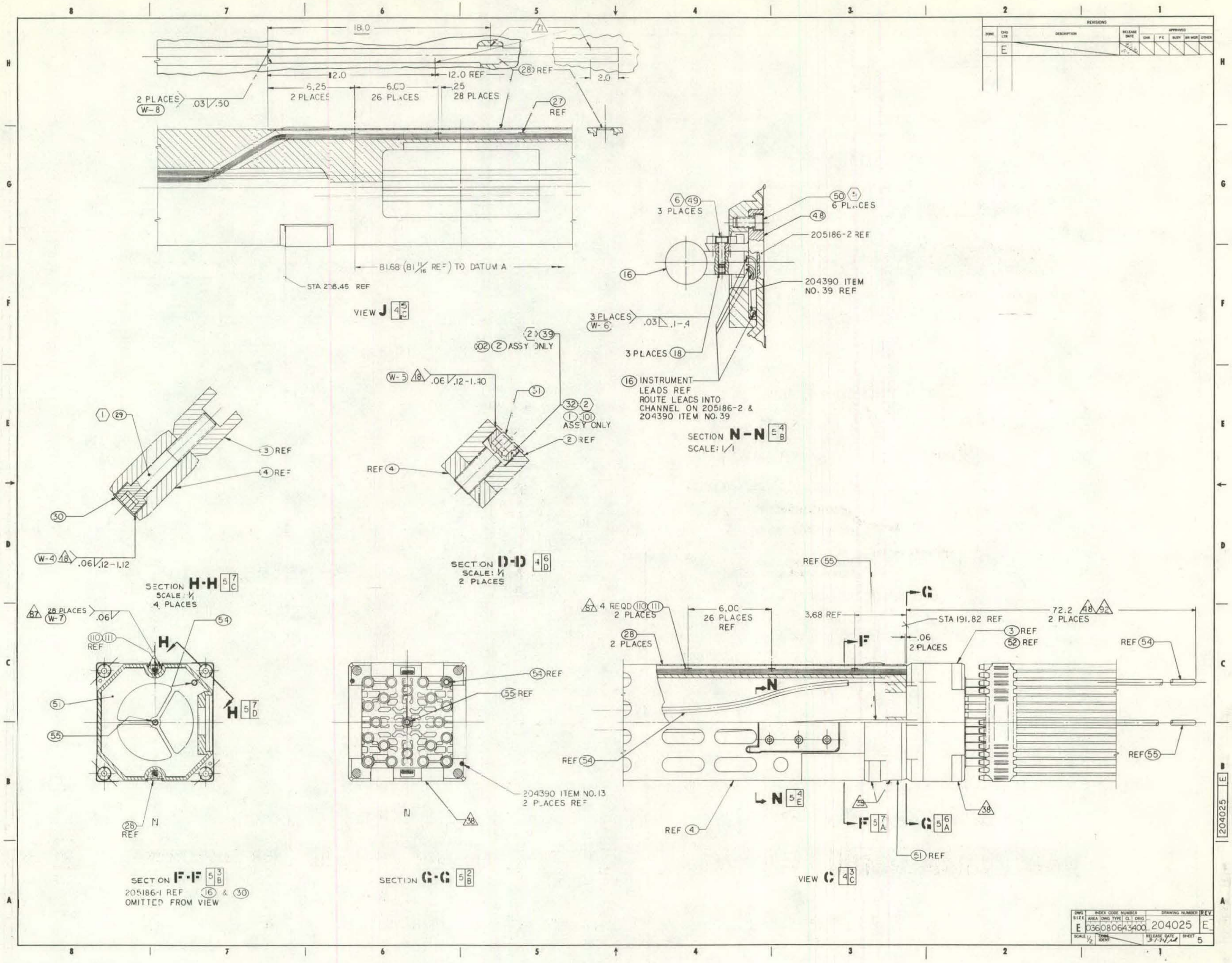

STA 381.14 REF
STA 347.19 REF
STA 302.27 REF
STA 278.45 REF
STA 265.87 REF
STA 252.56 REF
STA 191.82 REF
FUEL SPACER ASSY REF G/N 74 SECTION 2
180°
90°
270°
315°
0° N
S
S 8 4 F
(11) REF
(12) REF
(15) REF
(10) REF
(9)
(2) ASSY ONLY (6)
(53) (102) ASSY ONLY
INSTRUMENTATION PENETRATION ASSY REF
75 STA 325.65 REF
50
STA 113.25 REF
-102 ASSEMBLY TYPE F
-2 ASSEMBLY TYPE F
SAME AS (1) OR (101)
AS APPLICABLE EXCEPT
AS SHOWN & NOTED
12 (33)
.310 TO BE MACHINED AFTER (33) IS INSERTED & MARKED IN INSTALLED POSITION
THREADED SECTION IN (33) PROVIDED TO AID IN INSTALLATION & REMOVAL OF (33)
(34) 12
.06 / .12 -1.1 / 1 (W-2)
VIEW M 4 4 D
3 PLACES
SCALE: 1/1
B-6 REF
B-5 REF
B-4 REF
B-7 REF
B-1 REF
B-2 REF
B-3 REF
5 5 D
D
K 6 7 A
2 PLACES (W-14) .06
19 79 90
SEE VIEW M 4 8 D
(10)
(32) (31) REF
SECTION B-B 4 4 D
(12) OMITTED FROM VIEW
91
(101) (1) ASSY ONLY -E-
-F- (2) (102) ASSY ONLY
-D- (2) (102) ASSY ONLY
-C- (1) (101) ASSY ONLY
24
51
82 (90) (91) (92)
(34) 12 (33) 3 PLACES REF
UPPER BUTTON REF
B
V
LOWER BUTTON REF
(7) 44
W
(8) REF (2) (102) ASSY ONLY
(4) REF (1) (101) ASSY ONLY
(9) REF (2) (102) ASSY ONLY
(5) 9 1 D 4 D V
B 4 5 D
W 9 7 E
(W-3) 19 .06
REF (10)
(5) REF
.000 .005 BEFORE WELDING
VIEW E 4 6 C
(78) (82) (12) OMITTED FROM VIEW
INSTRUMENTATION PENETRATION ASSY REF
REF (10)
SEE VIEW E 4 3 D
SEE VIEW J 5 6 F
(4)
SEE VIEW C 5 3 A
(3) (1) ASSY ONLY
(52) (101) ASSY ONLY
REF (1)
7 5 A A
REF (12)
S 8 3 E
(15) REF
FUEL SPACER ASSY REF G/N 74 SECTION 2
49
6.00 MAX TUBE EXTENSION 4 PLACES
STA 381.14 REF
STA 347.19 REF
75 STA 325.65 REF
STA 302.27 REF
STA 278.45 REF
STA 265.87 REF
STA 252.56 REF
STA 191.82 REF
STA 113.25 REF
-101 ASSEMBLY TYPE A
-1 ASSEMBLY TYPE A
SCALE: 1 1/2" = 12"
REVISIONS
D
DWG SIZE E
INDEX CODE NUMBER 0360806434 00
DRAWING NUMBER 204025 D
SCALE 1/2
RELEASE DATE MARCH 1, 1974
SHEET 4
204025 D

Fig. A-17.



REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
E
18.0
71
12.0
12.0 REF
28 REF
2.0
6.25 2 PLACES
6.00 26 PLACES
.25 28 PLACES
2 PLACES
W-8
.03 / .50
27 REF
81.68 (81 11/16 REF) TO DATUM A
STA 218.45 REF
VIEW J 4 5/C
6 49 3 PLACES
50 5 6 PLACES
48
205186-2 REF
16
204390 ITEM NO. 39 REF
3 PLACES W-6 .03 .1-.4
3 PLACES 18
16 INSTRUMENT LEADS REF ROUTE LEADS INTO CHANNEL ON 205186-2 & 204390 ITEM NO. 39
SECTION N-N 5 4/B
SCALE: 1/1
2 39
002 2 ASSY ONLY
W-5 18 .06 / .12-1.40
31
32 2
1 101 ASSY ONLY
2 REF
REF 4
SECTION D-D 4 6/D
SCALE: 1/1
2 PLACES
1 29
3 REF
4 REF
30
W-4 18 .06 / .12-1.12
SECTION H-H 5 7/C
SCALE: 1/1
4 PLACES
87 28 PLACES W-7 .06
110 111 REF
54
H
51
55
H 5 7/D
28 REF
N
SECTION F-F 5 3/B
205186-1 REF 16 & 30 OMITTED FROM VIEW
54 REF
55 REF
204390 ITEM NO. 13 2 PLACES REF
38
N
SECTION G-G 5 2/B
REF 55
G
87 4 REQD 110 111 2 PLACES
6.00 26 PLACES REF
3.68 REF
STA 191.82 REF
72.2 18 92 2 PLACES
28 2 PLACES
F
.06 2 PLACES
3 REF
52 REF
REF 54
N
REF 54
REF 55
N 5 4/E
39
F 5 7/A
G 5 6/A
38
REF 4
51 REF
VIEW C 4 3/C
204025 E
DWG SIZE E
INDEX CODE NUMBER 036 080 643400
DRAWING NUMBER 204025
REV E
SCALE 1/2
RELEASE DATE
SHEET 5
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-18.

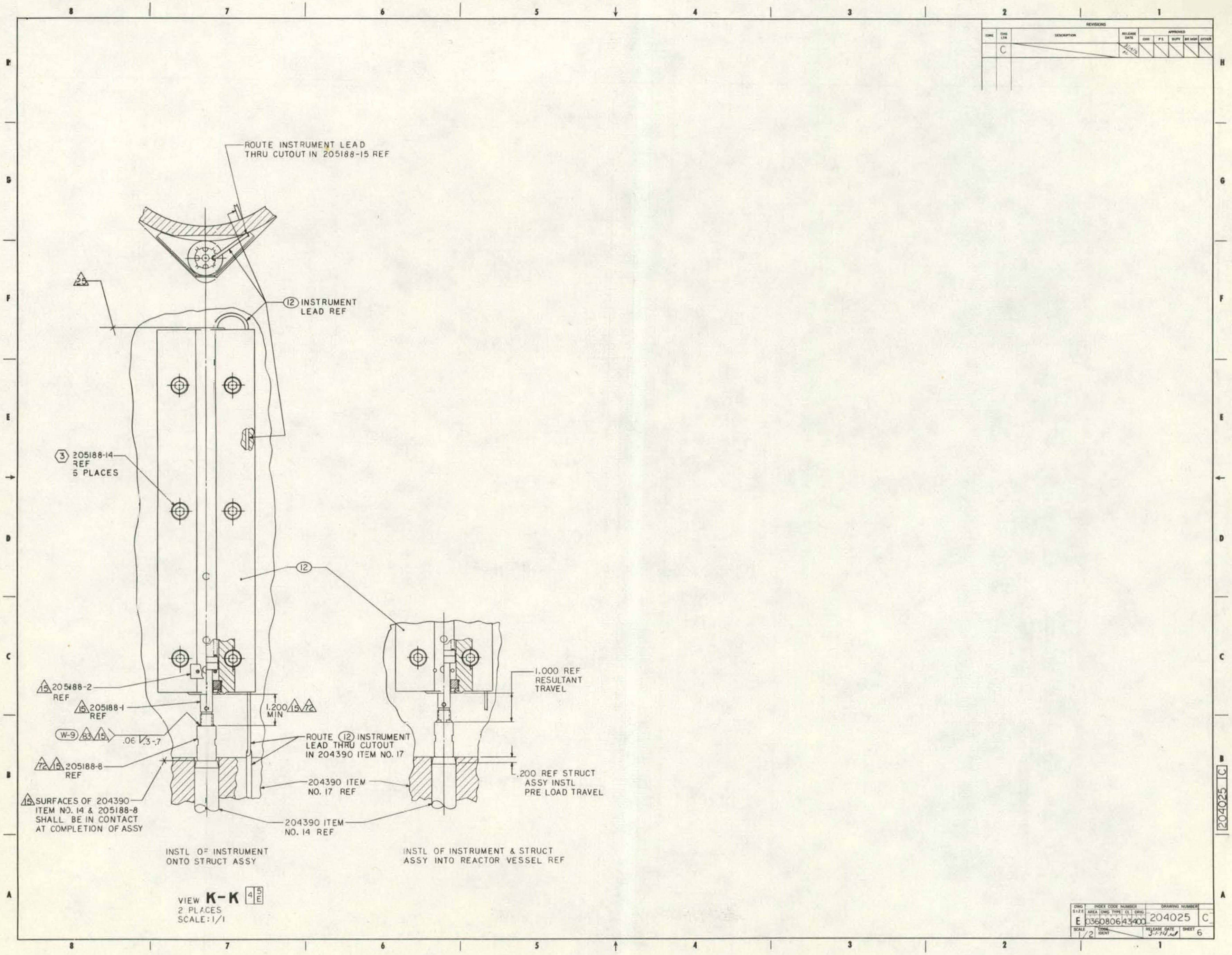
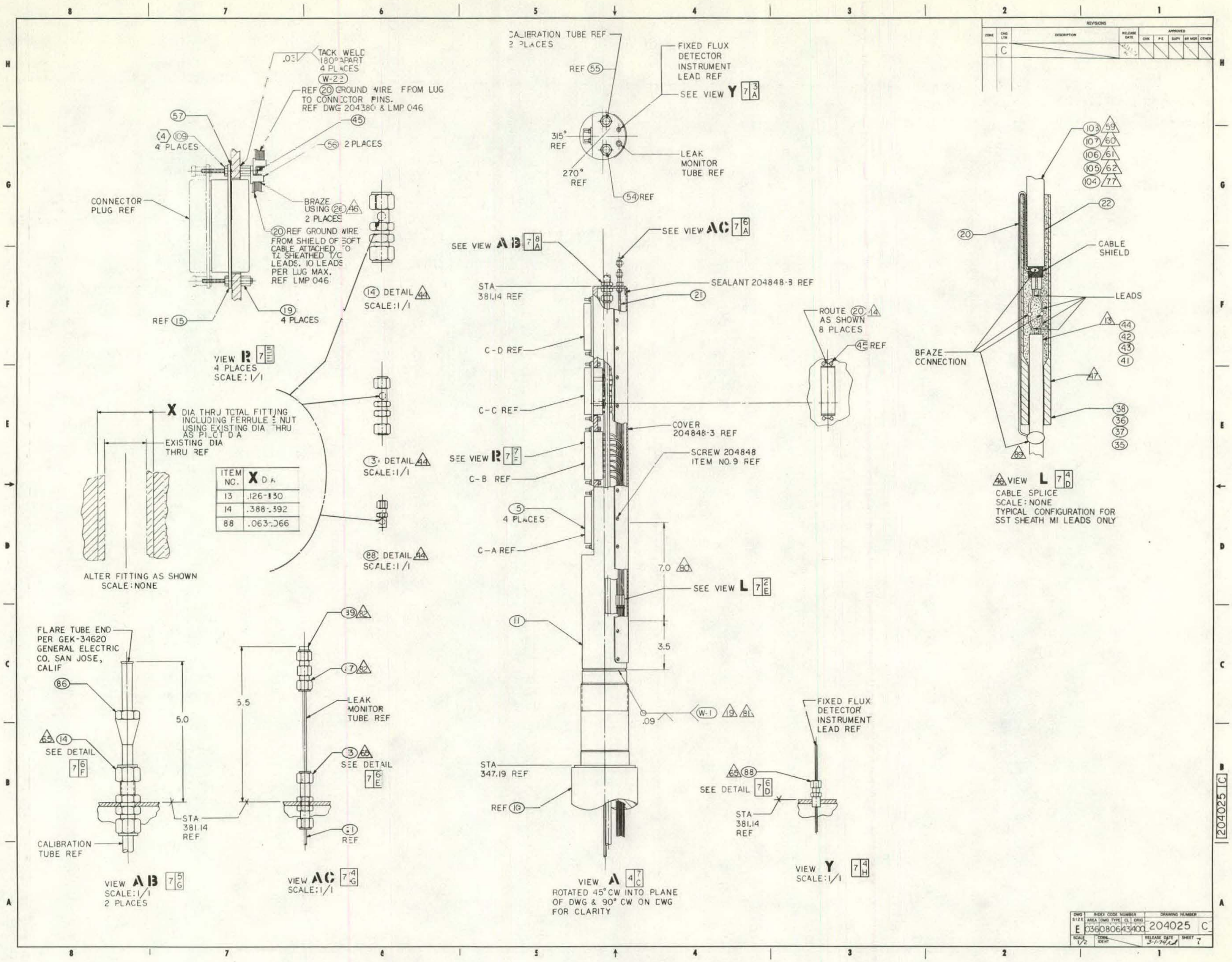
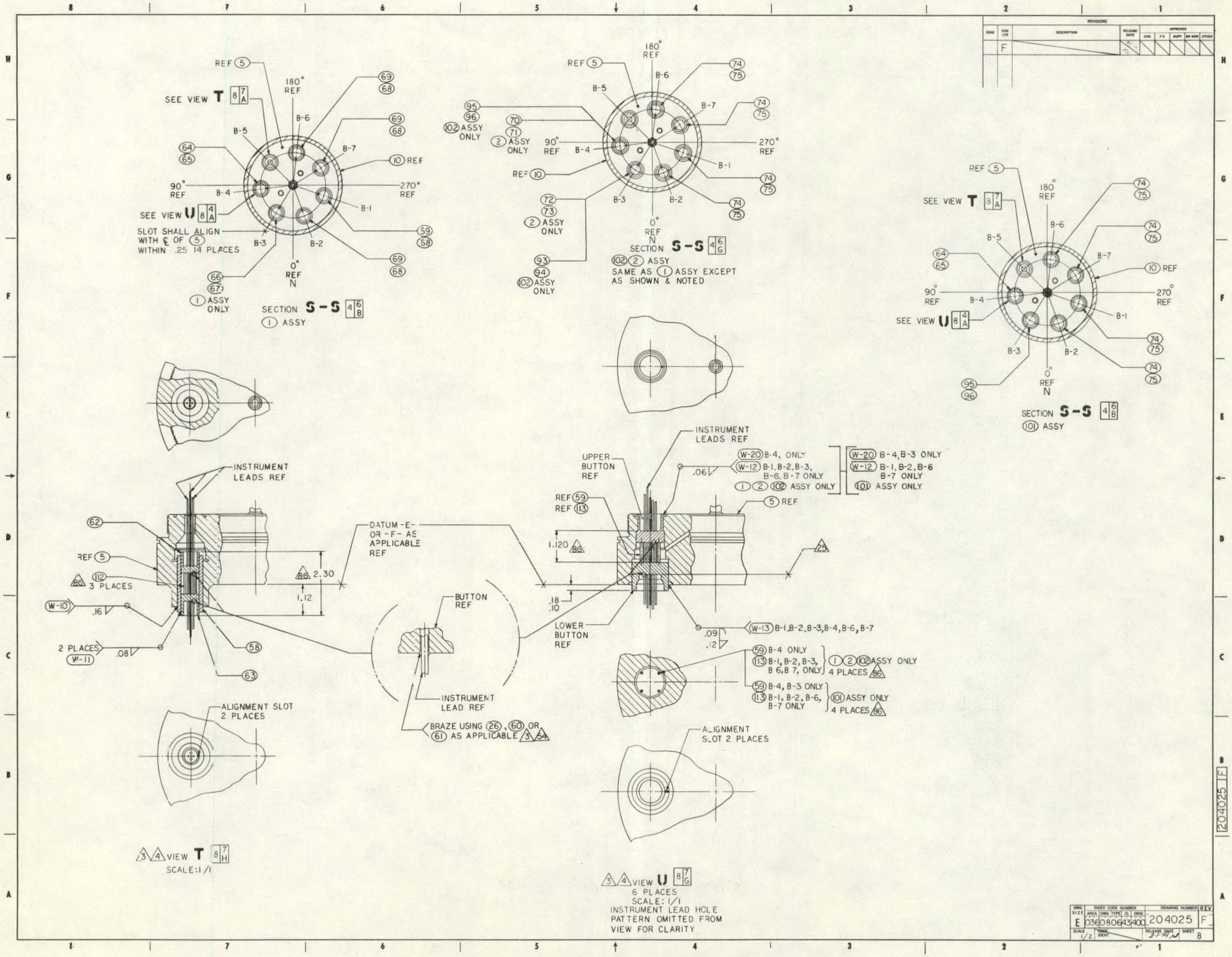

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
C
ROUTE INSTRUMENT LEAD THRU CUTOUT IN 205188-15 REF
25
(12) INSTRUMENT LEAD REF
(3) 205188-14 REF 5 PLACES
(12)
15 205188-2 REF
15 205188-1 REF
1.200 MIN 15 72
W-9 83 15 .06 .3-.7
ROUTE (12) INSTRUMENT LEAD THRU CUTOUT IN 204390 ITEM NO. 17
72 15 205188-8 REF
15 SURFACES OF 204390 ITEM NO. 14 & 205188-8 SHALL BE IN CONTACT AT COMPLETION OF ASSY
204390 ITEM NO. 17 REF
204390 ITEM NO. 14 REF
1.000 REF RESULTANT TRAVEL
.200 REF STRUCT ASSY INSTL PRE LOAD TRAVEL
INSTL OF INSTRUMENT ONTO STRUCT ASSY
INSTL OF INSTRUMENT & STRUCT ASSY INTO REACTOR VESSEL REF
VIEW K-K 4 5/E
2 PLACES
SCALE: 1/1
DWG SIZE E
INDEX CODE NUMBER AREA 036 DWG TYPE 0806 CL 43 ORIG 400
DRAWING NUMBER 204025 C
SCALE 1/2
CODE IDENT
RELEASE DATE 3-1-74
SHEET 6
204025 C

Fig. A-19.



ITEM NO.	X DIA
13	.126-.130
14	.388-.392
88	.063-.066

Fig. A-20.



REVISIONS
ZONE
DESCRIPTION
RELEASE DATE
APPROVED
F
REF (5)
180° REF
SEE VIEW T 8 7 A
(69) (68)
B-6
B-5
B-7
(64) (65)
(10) REF
90° REF
B-4
270° REF
SEE VIEW U 8 4 A
B-1
(59) (58)
SLOT SHALL ALIGN WITH ℄ OF (5) WITHIN .25 14 PLACES
B-3
B-2
0° REF N
(66) (67)
(1) ASSY ONLY
SECTION S-S 4 6 B
(1) ASSY
(95) (96) (102) ASSY ONLY
(70) (71) (2) ASSY ONLY
REF (10)
(72) (73) (2) ASSY ONLY
(93) (94) (102) ASSY ONLY
(74) (75)
SECTION S-S 4 6 G
(102) (2) ASSY
SAME AS (1) ASSY EXCEPT AS SHOWN & NOTED
SECTION S-S 4 6 B
(101) ASSY
INSTRUMENT LEADS REF
(62)
REF (5)
(86) (112) 3 PLACES
(W-10) .16
2 PLACES (W-11) .08
(58)
(63)
(86) 2.30
1.12
DATUM -E- OR -F- AS APPLICABLE REF
BUTTON REF
INSTRUMENT LEAD REF
BRAZE USING (26), (60) OR (61) AS APPLICABLE 3 54
ALIGNMENT SLOT 2 PLACES
3 4 VIEW T 8 7 H
SCALE: 1/1
UPPER BUTTON REF
REF (59)
REF (113)
1.120 (86)
.18 .10
LOWER BUTTON REF
.06
(W-20) B-4, ONLY
(W-12) B-1, B-2, B-3, B-6, B-7 ONLY
(1) (2) (102) ASSY ONLY
(W-20) B-4, B-3 ONLY
(W-12) B-1, B-2, B-6 B-7 ONLY
(101) ASSY ONLY
(5) REF
25
.09 .12
(W-13) B-1, B-2, B-3, B-4, B-6, B-7
(59) B-4 ONLY
(113) B-1, B-2, B-3, B 6, B 7, ONLY
(1) (2) (102) ASSY ONLY 4 PLACES (86)
(59) B-4, B-3 ONLY
(113) B-1, B-2, B-6, B-7 ONLY
(101) ASSY ONLY 4 PLACES (86)
ALIGNMENT SLOT 2 PLACES
3 4 VIEW U 8 7 G
6 PLACES
SCALE: 1/1
INSTRUMENT LEAD HOLE PATTERN OMITTED FROM VIEW FOR CLARITY
DWG SIZE E
INDEX CODE NUMBER
AREA 036 DWG TYPE 0806 CL 43 ORIG 400
DRAWING NUMBER 204025
REV F
SCALE 1/2
CODE IDENT
RELEASE DATE 3-7-74
SHEET 8
204025 F

Fig. A-21.

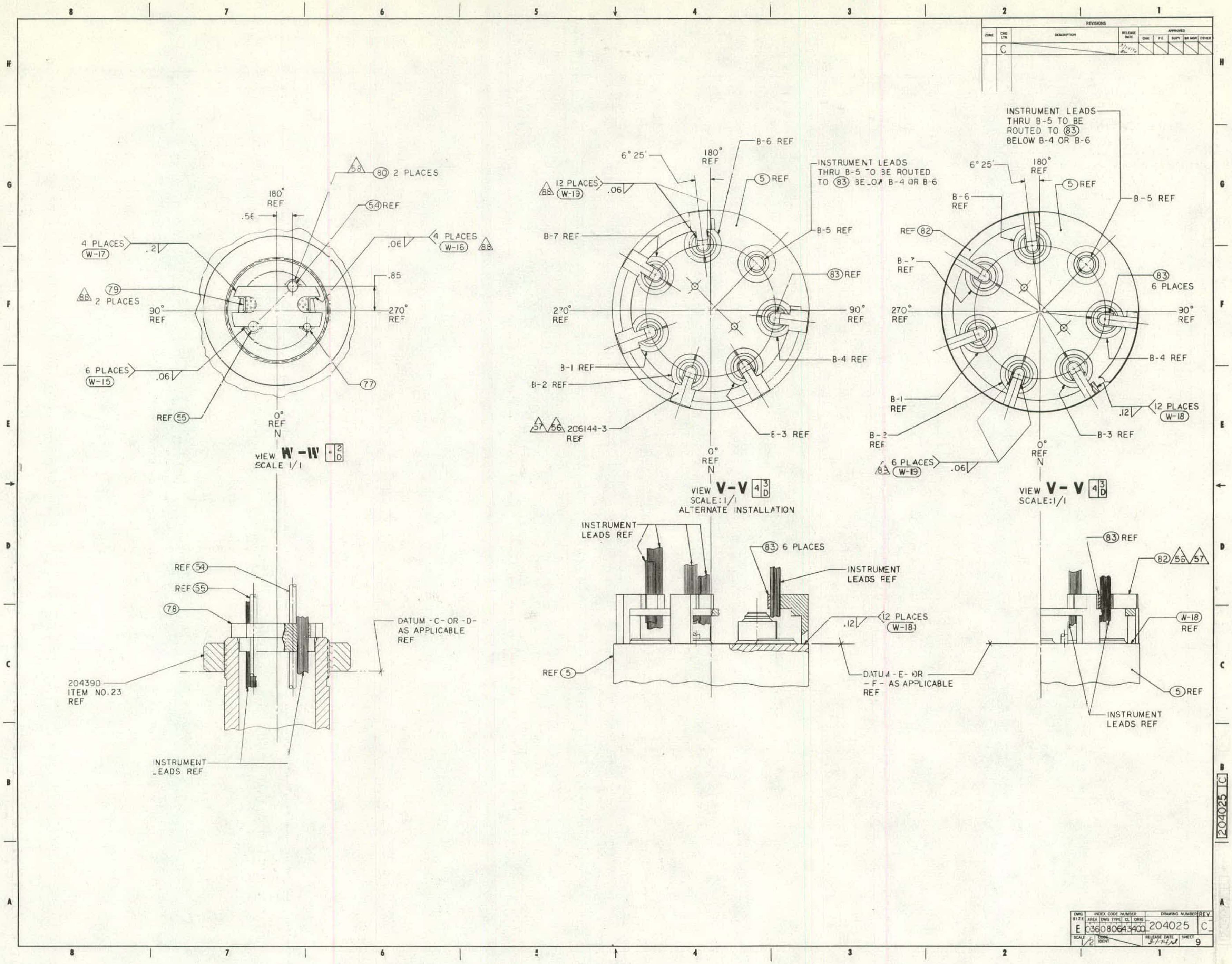

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P E
SUPV
BR MGR
OTHER
C
4 PLACES
W-17
.2
180° REF
.56
58
80 2 PLACES
54 REF
.06
4 PLACES
W-16
88
.85
79
88 2 PLACES
90° REF
270° REF
6 PLACES
W-15
.06
77
REF 55
0° REF N
VIEW W-W 2 D
SCALE 1/1
REF 54
REF 55
78
DATUM -C- OR -D- AS APPLICABLE REF
204390 ITEM NO.23 REF
INSTRUMENT LEADS REF
6° 25'
180° REF
B-6 REF
12 PLACES
88 W-19
.06
5 REF
INSTRUMENT LEADS THRU B-5 TO BE ROUTED TO 83 BELOW B-4 OR B-6
B-7 REF
B-5 REF
83 REF
270° REF
90° REF
B-1 REF
B-2 REF
B-4 REF
57 56 2C6144-3 REF
B-3 REF
0° REF N
VIEW V-V 4 3 D
SCALE:1/1
ALTERNATE INSTALLATION
INSTRUMENT LEADS REF
83 6 PLACES
INSTRUMENT LEADS REF
.12
12 PLACES
W-18
REF 5
DATUM -E- OR -F- AS APPLICABLE REF
INSTRUMENT LEADS THRU B-5 TO BE ROUTED TO 83 BELOW B-4 OR B-6
6° 25'
180° REF
5 REF
B-6 REF
B-5 REF
REF 82
B-7 REF
83 6 PLACES
270° REF
90° REF
B-4 REF
B-1 REF
.12
12 PLACES
W-18
B-2 REF
B-3 REF
83 6 PLACES
W-19
.06
0° REF N
VIEW V-V 4 3 D
SCALE:1/1
83 REF
82 55 57
W-18 REF
5 REF
INSTRUMENT LEADS REF
204025 C
DWG SIZE E
INDEX CODE NUMBER
AREA DWG TYPE CL ORIG
0360806434 00
DRAWING NUMBER 204025
REV C
SCALE 1/2
CODE IDENT
RELEASE DATE
SHEET 9
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-22.

8	7	6	5	4	3	2	1	SHT	REV STATUS
K	L	G	J	–	B	K	M	REV	OF SHEETS

ZONE	DWG LTR	DESCRIPTION	RELEASE DATE	CHK	P.E.	SUPV	BR MGR	OTHER
	A	DWG REVISED PER ECRA NO. L-5015	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	B	DWG REVISED PER ECRA'S NO. L-5127, L-5528, L-5609, L-6475, & L-5144 & B DCN	10/3/75	[illegible]				
	C	SEE INCORP. C ADCN	11/13/75	[illegible]				
	H	SEE INCORP D, E, F, G AND H ADCN	[illegible]	[illegible]				
	M	SEE INC J, K, L & M ADCN	[illegible]	[illegible]				

NOTES:

1 REMOVE ALL BURRS & SHARP EDGES.

2 WELD PER ASME BOILER & PRESSURE VESSEL CODE SECTION III AS SUPPLEMENTED BY RDT E15-2T.

△3 INSTRUMENT LEADS TO BE BRAZED INTO BUTTON ASSYS PER ANC BRAZE PROCEDURE BR 1.2-460 & 461.

△4 BUTTON ASSY. SHALL BE HELIUM LEAK CHECKED PER RDT F3-1T AFTER BRAZING, AND AFTER WELDING BUTTON SET INTO PRESSURE PLATE. PRESSURIZE AREA BETWEEN BUTTONS TO 60 PSIG HELIUM. AFTER BRAZING. MAX. PERMISSIBLE LEAKAGE THRU BRAZE 10^{-6} ATM. CC/SEC.

5 CLEANING & CLEANLINESS PER RDT F5-1T AS IMPLEMENTED BY LMP 001.

6 ALL WELDS PERFORMED AT THIS ASSY TO BE VISUALLY INSPECTED WITH 5-10X MAGNIFICATION. ACCEPTANCE CRITERIA PER RDT F6-2T PARA 6.3.2, WITH EXCEPTIONS AS NOTED IN THE SPECIFIC WELD PROCEDURES.

7 LOCK CUPS TO BE LOCKED BY DEFORMING CUP INTO GROOVES ON CAP SCREW HEAD EXCEPT AS NOTED. VISUALLY INSPECT. NO CRACKS ALLOWED.

8 LUBRICATE UNDER HEADS & ON THREADS OF ALL THREADED FASTENERS PER RDT F8-1T WITH 2 COATS OF ㊼

9 TORQUE FASTENERS PER RDT F8-1T TO VALUE SHOWN IN TORQUE TABLE. TIGHTEN TO INITIAL TORQUE VALUE, RELAX TORQUE TO ZERO & RETORQUE TO FINAL TORQUE VALUE & LOCK IN PLACE AS SHOWN OR NOTED. REF △55.

△10 MARK PER RDT F7-3T USING VIBRATING MARKING TOOL METHOD WITH 204026 & APPLICABLE DASH NO. & ASSIGNED SERIAL NO.

△11 TO BE USED WITH CHROMEL-ALUMEL THERMOCOUPLE LEADS.

△12 TO BE USED WITH PLATINUM-RHODIUM THERMOCOUPLE LEADS.

△13 TO BE SUPPLIED AS PART OF INSTRUMENT BY EXXON NUCLEAR CO.

△14 LOCKWIRE PER RDT M6-2T CLASS B.

△15 THESE PARTS FURNISHED AS LOOSE PIECE ITEMS ON ASSYS 204386-4 OR 204720-2 AND ARE SHOWN IN L/M TO ASSIST IN PROCUREMENT AND/OR FABRICATION ONLY. SEPARATE ORDERING IS NOT REQD UNLESS PARTS ARE NOT INCLUDED IN THE PARENT ASSY PACKAGE. REF G/N △25.

△16 INSTALL FITTING PER VENDOR'S INSTRUCTIONS EXCEPT TORQUE 1/4 TO 1/2 TURN BEYOND FINGER TIGHT

17 SURFACE ROUGHNESS 125√ UNLESS OTHERWISE NOTED.

△18 WELD TO BE PERFORMED AFTER FINAL INSTALLATION OF FASTENER.

△19 LIQUID PENETRANT INSPECT PER RDT F3-6T. ACCEPTANCE CRITERIA PER RDT F6-2T PARA 6.3.3.

20 ⓧ DENOTES TORQUE REQUIREMENTS. SEE TABLE FOR VALUES.

21 (W-X) DENOTES WELD IDENTIFICATION NO.

△22 WELD TO BE PERFORMED IN LOWER 7.43 INCHES OF CHANNEL ONLY.

23 CAUTION: WELDS TO BE PERFORMED ALTERNATELY ON PARTS WITH COMPLETE COOLDOWN TO AMBIENT TEMPERATURE BETWEEN WELDS TO MINIMIZE DISTORTION CAUSED BY WELDING.

△24 ANY INSTRUMENT WHICH ORIGINATES BELOW SURFACE $\boxed{-M-}$ SHALL MAINTAIN A LEAD LENGTH OF 32.5 FOR BUTTON B-1 AND A LEAD LENGTH OF 32.0 FOR BUTTONS B-2 & B-3 FROM PLANE $\boxed{-M-}$ TO SURFACE $\boxed{-G-}$ DURING BRAZING OF BUTTONS TO INSURE ADEQUATE LEAD LENGTH DURING FINAL ASSY.

△25 THESE ASSYS INCLUDE LOOSE PIECE ITEMS. CARE SHOULD BE EXERCISED TO OBTAIN ALL THESE ITEMS AS A PART OF THE PARENT ASSY. REF G/N △15

△26 THREAD LENGTH SHALL BE 1.12 MIN. SCREW HEAD TO HAVE .062 DIA HOLE THRU TO ACCOMODATE LOCKWIRE SIZE NOTED.

△27 SCREW HEAD TO HAVE .040 DIA HOLE THRU TO ACCOMODATE LOCKWIRE SIZE NOTED.

△28 STAKE OR DEFORM CHANNEL DOVE TAIL EDGE ON 12.0 CENTERS TO PREVENT COVER VIBRATION.

△29 THESE PARTS ARE NOT INTERCHANGEABLE AND ARE TO BE SERIALIZED AND MAINTAINED AS A MATCHED SET DURING HANDLING, STORAGE & ASSY.

30 ASSEMBLY SEQUENCE FOR THE FUEL MODULE ASSY SHALL BE IN ACCORDANCE WITH THE APPLICABLE SECTIONS OF THE LOFT FUEL HANDLING MANUAL.

31 DATUM $\boxed{-A-}$ IS DEFINED AS THE VERTICAL REFERENCE CENTERLINE PASSING THROUGH THE CENTER OF AN $\boxed{8.590}$ SQUARE ENVELOPE OF PARALLEL BOUNDARY PLANES.

32 DATUM $\boxed{-B-}$ IS DEFINED AS THE VERTICAL REFERENCE CENTERLINE PASSING THROUGH THE CENTERS OF THE 8.449-8.446 SQUARE UPPER SUPPORT STRUCTURE LOCATING PADS AT STA 278.46 EXCEPT AS NOTED AND THE 8.460-8.457 SQUARE UPPER SUPPORT STRUCTURE LOWER END BOX LOCATED AT STA 191.82 EXCEPT AS NOTED. REF G/N 63.

33 DURING ASSY. HANDLING & STORAGE OF THE FUEL MODULE ASSYS. ① OR ②, PRECAUTIONS SHALL BE TAKEN TO INSURE THAT THE FINAL FUEL MODULE ALIGNMENT IS MAINTAINED.

34 CAUTION: THE FUEL ASSY ③ OR ⑥ AND/OR FUEL MODULE ASSY ① OR ② SHALL NOT AT ANY TIME BE ROTATED BEYOND THE HORIZONTAL ATTITUDE TO AN INVERTED ATTITUDE

35 THE UPPER SUPPORT STRUCTURE ④ & FUEL ASSEMBLY ③ OR ⑥ SHALL BE ORIENTED TO EACH BY MATCHING THE LOWER END BOX FLANGE DOWEL PINS OF ④ AND UPPER END BOX ALIGNMENT HOLES OF ③ OR ⑥ EXCEPT AS NOTED. REF G/N 37.

36 SPECIAL INSTRUMENTATION ASSY REQUIREMENTS, CONTINUITY CHECKS, HANDLING REQUIREMENTS & LEAD PREPARATION REQUIREMENTS SHALL BE IN ACCORDANCE WITH LMP 306 EXCEPT AS NOTED.

△37 THE UPPER SUPPORT STRUCTURE ④ AND FUEL ASSY ⑥ SHALL BE ORIENTED TO EACH OTHER BY MATCHING THE INSTRUMENT LEAD CHANNELS OF THE UPPER SUPPORT STRUCTURE AND FUEL ASSY IN ADDITION TO THE REQUIREMENTS NOTED. REF G/N 35.

38 DATUM $\boxed{-B-}$ SHALL BE COINCIDENTAL WITH DATUM $\boxed{-A-}$ DURING ALIGNMENT. REF G/N 39.

39 THE ASSEMBLED ALIGNED FUEL MODULE IN THE VERTICAL POSITION BETWEEN STATIONS 113.25 & 278.46 SHALL FIT WITHIN THE ENVELOPE OF PARALLEL BOUNDARY PLANES HAVING AN $\boxed{8.590}$ SQUARE CROSS SECTION EXCEPT AS NOTED. REF G/N 63.

40 C-X DENOTES CONNECTOR REFERENCE DESIGNATION.

41 DURING ASSY, HANDLING, STORAGE & SHIPPING ACTIVITIES THE FUEL MODULE ASSY SHALL NOT BE SUBJECTED TO LOADS GREATER THAN 3G.

42 DURING ASSY & HANDLING ACTIVITIES WHICH ARE IN CLOSE PROXIMITY TO OTHER HARDWARE THE VERTICAL VELOCITY OF AN UNSUPPORTED FUEL MODULE ASSY ① OR ② SHALL NOT EXCEED 40 INCHES/MINUTE.

43 DURING ASSY & HANDLING ACTIVITIES WHICH ARE IN CLOSE PROXIMITY TO OTHER HARDWARE THE HORIZONTAL VELOCITY OF AN UNSUPPORTED FUEL MODULE ASSY ① OR ② SHALL NOT EXCEED 40 INCHES/MINUTE.

44 RECORDS SHALL BE MAINTAINED FOR EACH FUEL MODULE ASSY SO THAT ALL PARTS & SUBASSEMBLIES CAN BE TRACEABLE TO FABRICATION & SOURCE LOT.

45 WELDING PROCEDURE QUALIFICATION & PERFORMANCE QUALIFICATION OF THE WELDERS SHALL BE IN ACCORDANCE WITH RDT F6-2T WITH THE EXCEPTION OF PARAGRAPH 6.2.1.

△46 HARD TO SOFT CABLE SPLICE JOINTS AND FINAL CONNECTOR ASSEMBLY SHALL BE MADE IN ACCORDANCE WITH LMP 224 & LMP 046.

△47 INDIVIDUAL LEAD IDENTIFICATION TO BE TRANSFERRED FROM THE MI CABLE TO THE POTTING CUP AT THE TIME EACH SPLICE JOINT IS COMPLETED. MARKING SHALL BE IN ACCORDANCE WITH RDT F7-3T PARA 3.1.a. ON INDICATED SURFACE.

△48 ORIENTATION OF CONTROL ROD CLUSTER ASSY ⑯ INTO ① OR ② ASSY IS NOT REQD EXCEPT ⑯ MUST FIT FREELY INTO THE FUEL ASSY GUIDE TUBES. AFTER INSTALLATION, WITH THE ① OR ② ASSY IN A VERTICAL ATTITUDE, ⑯ IS TO BE WITHDRAWN OVER A LENGTH OF TRAVEL OF 65.0 DURING WHICH TIME THE WITHDRAWING FORCE SHALL NOT EXCEED BY MORE THAN 5 LBS MAX THE WEIGHT OF THE ⑯ ASSY. REF G/N 66.

△49 THE TOTAL LENGTH OF THE FUEL ASSY ③ OR ⑥ AND UPPER SUPPORT STRUCTURE ④ SHALL BE .20 INCHES LONGER THAN THE AS BUILT ENVELOPE DIMENSION (186.718) FROM THE BOTTOM SURFACE OF THE UPPER CORE SUPPORT PLATE ASSY REF DWG 204098 TO THE TOP SURFACE OF THE LOWER CORE SUPPORT STRUCTURE MOUNTING PLATE REF DWG 204065. THE REQUIRED TOTAL LENGTH SHALL BE OBTAINED BY MACHINING THE UPPER END OF THE SPRING DEFLECTOR IN ④ SURFACE $\boxed{-C-}$ OR $\boxed{-D-}$ AS APPLICABLE, AS REQD TO OBTAIN DIM NOTED.

△50 CAUTION: SPRING DEFLECTOR IS TO BE REMOVED FROM ASSY FOR SUBSEQUENT MACHINING PER △49. THIS REMOVAL SHALL BE PERFORMED BY THE USE OF TOOL 206774-1 TO RETAIN THE SPRING AND SPRING DEFLECTOR DURING DISASSEMBLY. TO RELAX SPRING AFTER FLANGE REMOVAL REQUIRES 1.694 SPRING TRAVEL FROM THE INSTALLED PRELOAD OF 978-1037 LBS WITH .872 THREAD ENGAGEMENT ON 204386 ITEM NO. 31. TOOL 206774-1 MAY BE USED FOR COMPRESSING SPRING AND DEFLECTOR DURING REINSTALLATION OF FLANGE AND DEFLECTOR ONTO HOUSING.

△51 PRIOR TO WELDING THE BUTTONS (68) THRU (73) INTO ⑤ THE PRESSURE PLATE MUST BE POSITIONED AND CLAMPED WITH RESPECT TO THE SUPPORT STRUCTURE ④ PER DIMS NOTED.

52 PROTECTIVE CLOSURES REQUIRED FOR ALL TUBING ENDS PER RDT F7-2T. PLUGS OR CAPS SHALL CONFORM TO RDT F7-2T, PARA 6.5. A COMPLETE LISTING OF PROTECTIVE DEVICES INCORPORATED SHALL BE MAINTAINED. PRIOR TO INSERTION OF THE FUEL MODULE ASSY, ① OR ②, INTO THE REACTOR VESSEL AN INVENTORY OF THESE DEVICES SHALL BE MADE TO INSURE THEIR PROPER REMOVAL.

△53 CHANNEL COVER 204386 ITEM NO. 36; CLIP 204386 ITEM NO. 37; AND CLIP 204386 ITEM NO. 41 MAY BE OMITTED ON ① ASSY ONLY.

△54 BUTTONS TO BE VISUALLY INSPECTED AFTER INSTALLATION & BRAZING OF INSTRUMENT LEADS TO INSURE THAT EACH LEAD IS FULLY BRAZED AS INDICATED BY THE PRESENCE OF A BRAZE FILLET FORMED AROUND EACH LEAD AT LOCATION SHOWN.

△55 WHEN 2 OR MORE FASTENERS ARE REQD TO ASSEMBLE MATING PARTS ALTERNATELY TORQUE FASTENERS IN STEPS OF 1/3 THE APPLICABLE TORQUE VALUES SHOWN DURING ASSY UNTIL TORQUING IS COMPLETED.

56 B-X DENOTES INSTRUMENTATION BUTTON REFERENCE DESIGNATION.

△57 INSTRUMENT LEAD ROUTING & HOOKUP SHALL BE IN ACCORDANCE WITH LMP 317, FIG 1.

△58 MARK PER RDT F7-3T USING REMOVABLE TAG WITH 204026 AND APPLICABLE DASH NO.

59 REMOVED

△60 THE DIM NOTED SHALL BE OBTAINED BY PERFORMING THE FOLLOWING STEPS:

1 THE AS BUILT DIM FROM THE TOP SURFACE OF REACTOR VESSEL INSTRUMENT NOZZLES DESIGNATED J, G & N REF DWG 205142 TO THE BOTTOM OF THE PIVOT ARM SLOT IN THE CORE BARREL REF STA 293.40 ON DWG 204059 IS 46.820.

2 SUBTRACT .250 FROM 46.820.

3 SUBTRACT .125 FROM THE RESULTANT DIM OF STEP 2. THIS WILL GIVE THE MAXIMUM ALLOWABLE DIM NOTED ON THIS DWG.

4 IF THE AS BUILT TOTAL DIM NOTED RESULTING FROM THE ASSY OF ⑤, ⑩ & ⑰ EXCEEDS THE DIM DETERMINED IN STEP 3, MACHINE SURFACE $\boxed{-F-}$ TO MAKE DIM NOTED AS RESULT OF ASSY BE WITHIN THE LIMIT SPECIFIED IN STEP 3 PLUS .000 MINUS .060.

△61 AFTER MACHINING SPRING DEFLECTOR PER G/N △49 AND REINSTALLATION OF SPRING DEFLECTOR AND FLANGE ONTO THE UPPER SUPPORT STRUCTURE ASSY, MEASURE THE RESULTANT DIMENSION FROM SURFACE $\boxed{-C-}$ OR $\boxed{-D-}$, AS APPLICABLE, TO SURFACE $\boxed{-E-}$. THIS RESULTANT DIM SHALL BE A MINIMUM OF 1.125.

△62 DIM APPLIES AFTER MACHINING PER △49.

63 THOSE PORTIONS OF THE LOCATING PADS AT STATIONS 278.46, 252.56 & 191.82 WHICH BY COMPONENT DESIGN EXTENDS BEYOND THE $\boxed{8.590}$ ENVELOPE ARE EXCLUDED FROM THE REQUIREMENTS OF G/N 39.

64 DURING HANDLING & SHIPPING ACTIVITIES IN WHICH THE ① OR ② ASSY IS IN A HORIZONTAL ATTITUDE THE CONTROL ROD CLUSTER ASSY ⑯ MUST BE RESTRAINED IN THE FULLY INSERTED POSITION.

65 THE WITHDRAWL & INSERTION OF THE CONTROL ROD CLUSTER ASSY ⑯ MUST BE CONTROLLED AT ALL TIMES AND THE ⑯ ASSY MUST NOT BE ALLOWED TO FREE FALL.

△66 CAUTION: PRIOR TO INSTALLATION OF ⑯ ASSY INTO ① OR ② ASSY CHECK TO INSURE THAT CONTROL ROD SHAFT JN300.374 IS ORIENTED ON CONTROL ROD SPIDER JN300,359 AS SHOWN SO THAT SUBSEQUENT HOOKUP WITH THE CONTROL ROD DRIVE MECHANISM COUPLING MAY BE ACCOMPLISHED.

△67 DATUM $\boxed{-J-}$ IS DEFINED AS THE VERTICAL REFERENCE PLANE FORMED BY THE EDGE SHOWN OF THE 204386 ITEM NO. 6 PART ON THE UPPER SUPPORT STRUCTURE.

△68 DURING ASSY & HANDLING ACTIVITIES SUPPORT SHALL BE PROVIDED FOR THE INSTRUMENTATION PENETRATION ASSY ABOVE DATUM $\boxed{-G-}$ WHICH MAINTAINS ASSY AND/OR INDIVIDUAL COMPONENTS WITHIN .125 OF DIMS NOTED.

G/N CONTINUED ON 2 8/H

SEE SHT 2 FOR LIST OF MATERIAL

QTY REQD	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.

PARTS LIST

PART DASH NO.	NEXT QTY PER ASSY	FINAL QTY REQD	NEXT ASSY	USED ON
-2	3	3		LOFT
-1	1	1		LOFT

APPLICATION △78

QUALITY ASSURANCE ESSENTIALITY LEVEL I

DRAWING FORM

UNLESS OTHERWISE SPECIFIED
DIMENSIONING AND SYMBOLOGY ARE AMERICAN NATIONAL STANDARD
DIMENSIONS AND TOLERANCES ARE IN INCHES
TOLERANCES:
DECIMALS X = ± .1
XX = ± .03
XXX = ± .010
FRACTIONS ± 1/8
ANGULAR ± 2°
DO NOT SCALE DRAWING

		DATE
DRAWN	A.R. ROWLEY	4-9-74
CHECKED	D H Buchanan Jr	5-21-74
PROJECT ENGINEER	[illegible]	5-17-74
	E [illegible]	5-17-74
QA	D Martin	5-17-74
PROJECT MANAGER	[illegible]	5-20-74

AEROJET NUCLEAR COMPANY
INCORPORATED
IDAHO FALLS, IDAHO

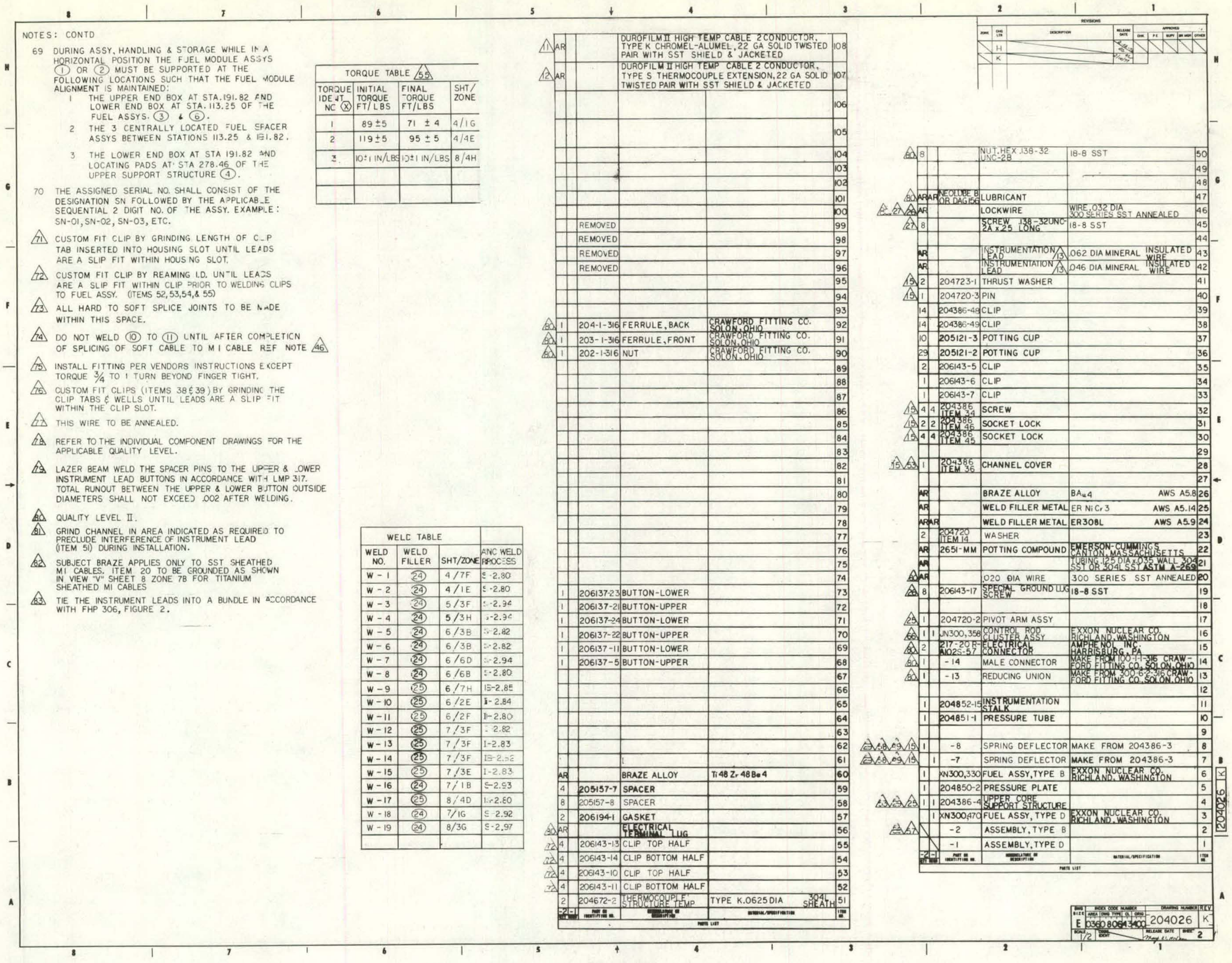
TITLE
CONTROL FUEL MODULE ASSY,
TYPE D & TYPE B
LOFT

DWG SIZE	AREA	DWG TYPE	CL	ORIG	DRAWING NUMBER	CHG LTR
E	0360	806	43	400	204026	M

SCALE 1/2 RELEASE DATE May 21, 1974 SHEET 1 OF 8

204026 M

Fig. A-23.



NOTES: CONTD

69 DURING ASSY, HANDLING & STORAGE WHILE IN A HORIZONTAL POSITION THE FUEL MODULE ASSYS ① OR ② MUST BE SUPPORTED AT THE FOLLOWING LOCATIONS SUCH THAT THE FUEL MODULE ALIGNMENT IS MAINTAINED:

1. THE UPPER END BOX AT STA. 191.82 AND LOWER END BOX AT STA. 113.25 OF THE FUEL ASSYS. ③ & ⑥.
2. THE 3 CENTRALLY LOCATED FUEL SPACER ASSYS BETWEEN STATIONS 113.25 & 191.82.
3. THE LOWER END BOX AT STA 191.82 AND LOCATING PADS AT STA 278.46 OF THE UPPER SUPPORT STRUCTURE ④.

70 THE ASSIGNED SERIAL NO. SHALL CONSIST OF THE DESIGNATION SN FOLLOWED BY THE APPLICABLE SEQUENTIAL 2 DIGIT NO. OF THE ASSY. EXAMPLE: SN-01, SN-02, SN-03, ETC.

△71 CUSTOM FIT CLIP BY GRINDING LENGTH OF CLIP TAB INSERTED INTO HOUSING SLOT UNTIL LEADS ARE A SLIP FIT WITHIN HOUSING SLOT.

△72 CUSTOM FIT CLIP BY REAMING I.D. UNTIL LEADS ARE A SLIP FIT WITHIN CLIP PRIOR TO WELDING CLIPS TO FUEL ASSY. (ITEMS 52, 53, 54, & 55)

△73 ALL HARD TO SOFT SPLICE JOINTS TO BE MADE WITHIN THIS SPACE.

△74 DO NOT WELD ⑩ TO ⑪ UNTIL AFTER COMPLETION OF SPLICING OF SOFT CABLE TO M I CABLE REF NOTE △46

△75 INSTALL FITTING PER VENDORS INSTRUCTIONS EXCEPT TORQUE 3/4 TO 1 TURN BEYOND FINGER TIGHT.

△76 CUSTOM FIT CLIPS (ITEMS 38 & 39) BY GRINDING THE CLIP TABS & WELLS UNTIL LEADS ARE A SLIP FIT WITHIN THE CLIP SLOT.

△77 THIS WIRE TO BE ANNEALED.

△78 REFER TO THE INDIVIDUAL COMPONENT DRAWINGS FOR THE APPLICABLE QUALITY LEVEL.

△79 LAZER BEAM WELD THE SPACER PINS TO THE UPPER & LOWER INSTRUMENT LEAD BUTTONS IN ACCORDANCE WITH LMP 317. TOTAL RUNOUT BETWEEN THE UPPER & LOWER BUTTON OUTSIDE DIAMETERS SHALL NOT EXCEED .002 AFTER WELDING.

△80 QUALITY LEVEL II.

△81 GRIND CHANNEL IN AREA INDICATED AS REQUIRED TO PRECLUDE INTERFERENCE OF INSTRUMENT LEAD (ITEM 51) DURING INSTALLATION.

△82 SUBJECT BRAZE APPLIES ONLY TO SST SHEATHED MI CABLES. ITEM 20 TO BE GROUNDED AS SHOWN IN VIEW "V" SHEET 8 ZONE 7B FOR TITANIUM SHEATHED MI CABLES

△83 TIE THE INSTRUMENT LEADS INTO A BUNDLE IN ACCORDANCE WITH FHP 306, FIGURE 2.

TORQUE TABLE △55

TORQUE IDENT NO ⟨X⟩	INITIAL TORQUE FT/LBS	FINAL TORQUE FT/LBS	SHT/ZONE
1	89 ± 5	71 ± 4	4/1G
2	119 ± 5	95 ± 5	4/4E
3	10 ± 1 IN/LBS	10 ± 1 IN/LBS	8/4H

WELD TABLE

WELD NO.	WELD FILLER	SHT/ZONE	ANC WELD PROCESS
W - 1	(24)	4/7F	S-2.80
W - 2	(24)	4/1E	S-2.80
W - 3	(24)	5/3F	S-2.94
W - 4	(24)	5/3H	S-2.94
W - 5	(24)	6/3B	S-2.82
W - 6	(24)	6/3B	S-2.82
W - 7	(24)	6/6D	S-2.94
W - 8	(24)	6/6B	S-2.80
W - 9	(25)	6/7H	IS-2.85
W - 10	(25)	6/2E	I-2.84
W - 11	(25)	6/2F	I-2.80
W - 12	(25)	7/3F	I-2.82
W - 13	(25)	7/3F	I-2.83
W - 14	(25)	7/3F	IS-2.82
W - 15	(25)	7/3E	I-2.83
W - 16	(24)	7/1B	S-2.93
W - 17	(25)	8/4D	IS-2.80
W - 18	(24)	7/1G	S-2.92
W - 19	(24)	8/3G	S-2.97

REVISIONS

ZONE	CHG LTR	DESCRIPTION	RELEASE DATE	APPROVED CHK	P.E.	SUPV	BR MGR	OTHER
	H		[illegible]					
	K		[illegible]					

PARTS LIST

	-2 QTY	-1 REQD	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	MATERIAL/SPECIFICATION	ITEM NO.
△11	AR			DUROFILM II HIGH TEMP CABLE 2 CONDUCTOR, TYPE K CHROMEL-ALUMEL, 22 GA SOLID TWISTED PAIR WITH SST SHIELD & JACKETED		108
△12	AR			DUROFILM II HIGH TEMP CABLE 2 CONDUCTOR, TYPE S THERMOCOUPLE EXTENSION, 22 GA SOLID TWISTED PAIR WITH SST SHIELD & JACKETED		107
						106
						105
						104
						103
						102
						101
						100
			REMOVED			99
			REMOVED			98
			REMOVED			97
			REMOVED			96
						95
						94
						93
△80	1		204-1-316	FERRULE, BACK	CRAWFORD FITTING CO. SOLON, OHIO	92
△80	1		203-1-316	FERRULE, FRONT	CRAWFORD FITTING CO. SOLON, OHIO	91
△80	1		202-1-316	NUT	CRAWFORD FITTING CO. SOLON, OHIO	90
						89
						88
						87
						86
						85
						84
						83
						82
						81
						80
						79
						78
						77
						76
						75
						74
	1		206137-23	BUTTON-LOWER		73
	1		206137-21	BUTTON-UPPER		72
	1		206137-24	BUTTON-LOWER		71
	1		206137-22	BUTTON-UPPER		70
	1		206137-11	BUTTON-LOWER		69
	1		206137-5	BUTTON-UPPER		68
						67
						66
						65
						64
						63
						62
						61
	AR			BRAZE ALLOY	Ti 48 Zr 48 Be 4	60
	4		205157-7	SPACER		59
	8		205157-8	SPACER		58
	2		206194-1	GASKET		57
△80	AR			ELECTRICAL TERMINAL LUG		56
△72	4		206143-13	CLIP TOP HALF		55
△72	4		206143-14	CLIP BOTTOM HALF		54
△72	4		206143-10	CLIP TOP HALF		53
△72	4		206143-11	CLIP BOTTOM HALF		52
	2		204672-2	THERMOCOUPLE STRUCTURE TEMP	TYPE K .0625 DIA 304L SHEATH	51
△80	8			NUT, HEX .138-32 UNC-2B	18-8 SST	50
						49
						48
△80	AR	AR	NEOLUBE B OR DAG 156	LUBRICANT		47
△[illegible] △27 △28	AR			LOCKWIRE	WIRE, .032 DIA 300 SERIES SST ANNEALED	46
△27	8			SCREW .138-32UNC-2A x .25 LONG	18-8 SST	45
						44
	AR			INSTRUMENTATION LEAD △13	.062 DIA MINERAL INSULATED WIRE	43
	AR			INSTRUMENTATION LEAD △13	.046 DIA MINERAL INSULATED WIRE	42
△15	2		204723-1	THRUST WASHER		41
△15	1		204720-3	PIN		40
	14		204386-48	CLIP		39
	14		204386-49	CLIP		38
	10		205121-3	POTTING CUP		37
	29		205121-2	POTTING CUP		36
	2		206143-5	CLIP		35
	1		206143-6	CLIP		34
	1		206143-7	CLIP		33
△15	4	4	204386 ITEM 34	SCREW		32
△15	2	2	204386 ITEM 46	SOCKET LOCK		31
△15	4	4	204386 ITEM 45	SOCKET LOCK		30
						29
15 △53	1		204386 ITEM 36	CHANNEL COVER		28
						27
	AR			BRAZE ALLOY	BAu4 AWS A5.8	26
	AR			WELD FILLER METAL	ER NiCr 3 AWS A5.14	25
	AR	AR		WELD FILLER METAL	ER308L AWS A5.9	24
	2		204720 ITEM 14	WASHER		23
	AR		2651-MM	POTTING COMPOUND	EMERSON-CUMMINGS CANTON, MASSACHUSETTS	22
	AR				TUBING .125 DIA x .035 WALL 304 SST OR 304L SST ASTM A-269	21
△80	AR			.020 DIA WIRE	300 SERIES SST ANNEALED	20
△28	8		206143-17	SPECIAL GROUND LUG SCREW	18-8 SST	19
						18
△25	1		204720-2	PIVOT ARM ASSY		17
△66	1	1	XN300,358	CONTROL ROD CLUSTER ASSY	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	16
△80	2		217-20R-A102S-57	ELECTRICAL CONNECTOR	AMPHENOL INC. HARRISBURG, PA	15
△80	1		-14	MALE CONNECTOR	MAKE FROM 100-1-1-316 CRAWFORD FITTING CO. SOLON, OHIO	14
△80	1		-13	REDUCING UNION	MAKE FROM 300-6-2-316 CRAWFORD FITTING CO. SOLON, OHIO	13
						12
	1		204852-15	INSTRUMENTATION STALK		11
	1		204851-1	PRESSURE TUBE		10
						9
△[illegible] △58 △59 △15	1		-8	SPRING DEFLECTOR	MAKE FROM 204386-3	8
△[illegible] △58 △59 △15		1	-7	SPRING DEFLECTOR	MAKE FROM 204386-3	7
	1		XN300,330	FUEL ASSY, TYPE B	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	6
	1		204850-2	PRESSURE PLATE		5
△63 △29 △25	1	1	204386-4	UPPER CORE SUPPORT STRUCTURE		4
		1	XN300,470	FUEL ASSY, TYPE D	EXXON NUCLEAR CO. RICHLAND, WASHINGTON	3
△[illegible] △57			-2	ASSEMBLY, TYPE B		2
			-1	ASSEMBLY, TYPE D		1

DWG SIZE	INDEX CODE NUMBER AREA / DWG TYPE / CL / ORIG	DRAWING NUMBER	REV
E	0360 806 4 3400	204026	K
SCALE 1/2	CODE IDENT	RELEASE DATE [illegible]	SHEET 2

204026 K

Fig. A-24.

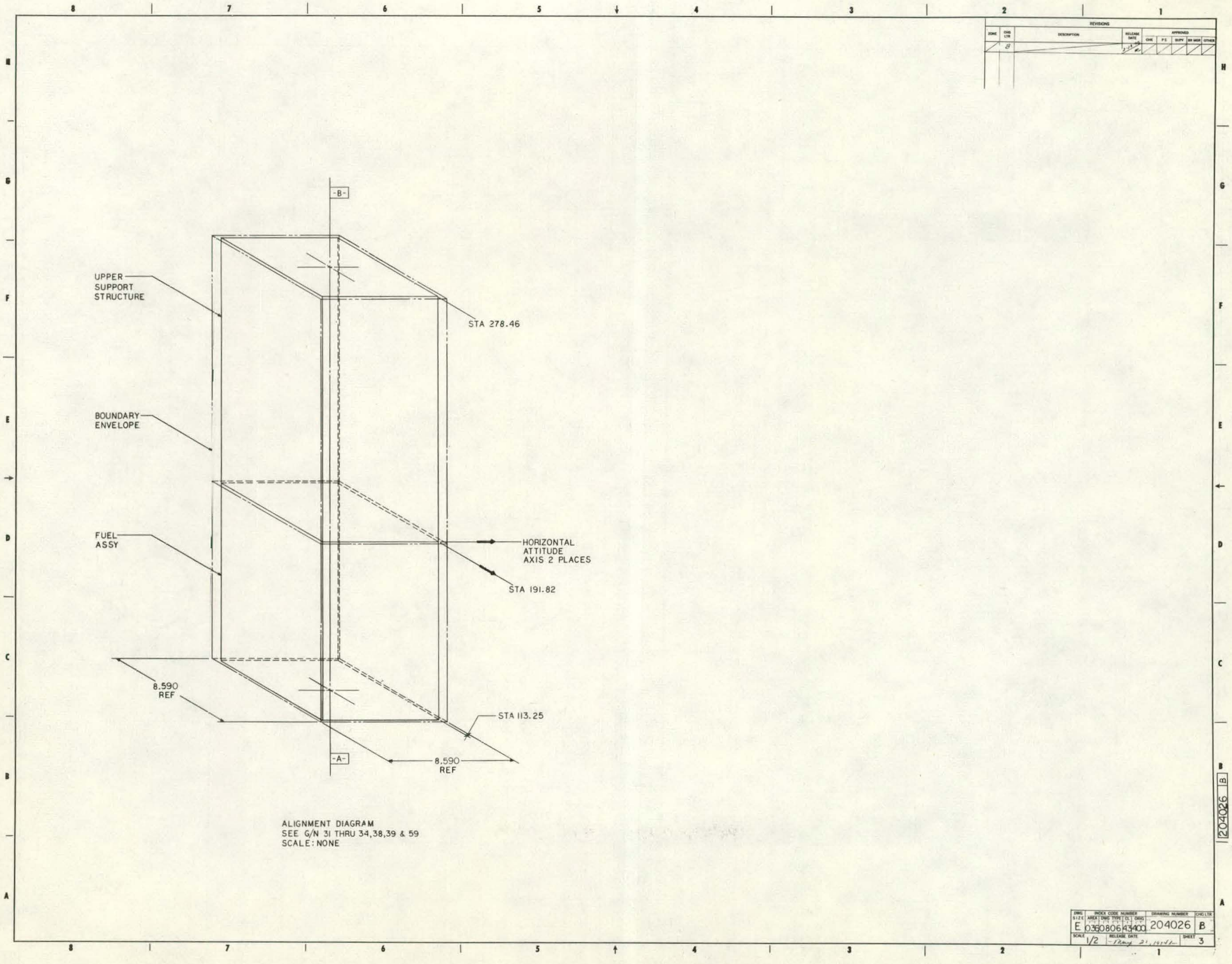

-B-
UPPER SUPPORT STRUCTURE
STA 278.46
BOUNDARY ENVELOPE
FUEL ASSY
HORIZONTAL ATTITUDE AXIS 2 PLACES
STA 191.82
8.590 REF
STA 113.25
-A-
8.590 REF
ALIGNMENT DIAGRAM
SEE G/N 31 THRU 34,38,39 & 59
SCALE: NONE
REVISIONS
B
204026 B
DWG SIZE E
INDEX CODE NUMBER 0360806 43400
DRAWING NUMBER 204026
CHG LTR B
SCALE 1/2
RELEASE DATE
SHEET 3

Fig. A-25.

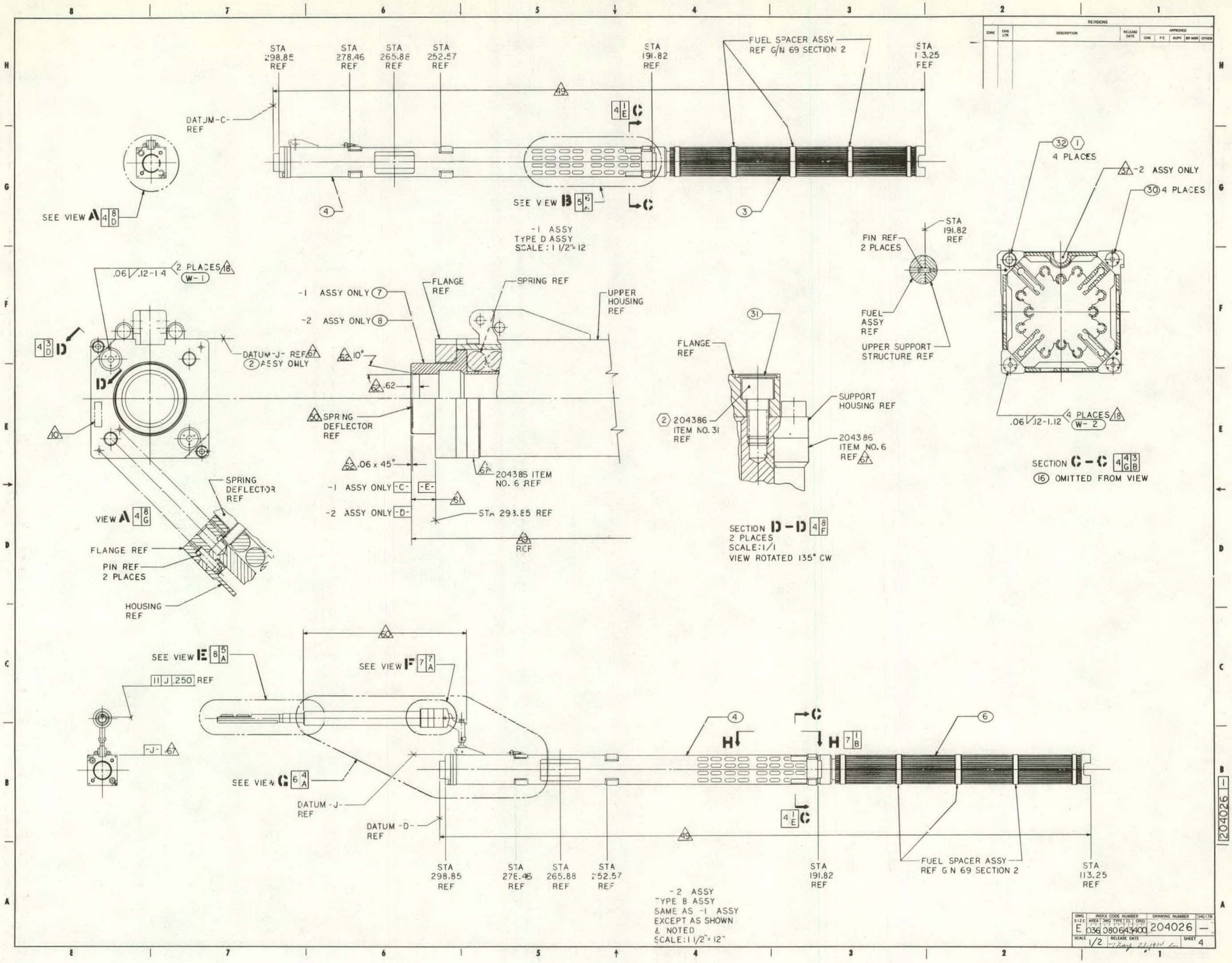

REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
STA 298.85 REF
STA 278.46 REF
STA 265.88 REF
STA 252.57 REF
STA 191.82 REF
FUEL SPACER ASSY REF G/N 69 SECTION 2
STA 113.25 REF
DATUM -C- REF
49
4 1/E C
SEE VIEW B 5 5/A
C
3
4
SEE VIEW A 4 8/D
-1 ASSY
TYPE D ASSY
SCALE: 1 1/2"=12
32 1
4 PLACES
37 -2 ASSY ONLY
30 4 PLACES
PIN REF 2 PLACES
STA 191.82 REF
FUEL ASSY REF
UPPER SUPPORT STRUCTURE REF
.06 / .12-1.12 4 PLACES 18 W-2
SECTION C - C 4 4/G 3/B
16 OMITTED FROM VIEW
.06 / .12-1.4 2 PLACES 18 W-1
4 3/D D
D
DATUM -J- REF 67
2 ASSY ONLY
10
VIEW A 4 8/G
SPRING DEFLECTOR REF
FLANGE REF
PIN REF 2 PLACES
HOUSING REF
-1 ASSY ONLY 7
-2 ASSY ONLY 8
FLANGE REF
SPRING REF
UPPER HOUSING REF
62 10°
62 .62
50 SPRING DEFLECTOR REF
52 .06 x 45°
67 204385 ITEM NO. 6 REF
-1 ASSY ONLY -C- -E-
51
-2 ASSY ONLY -D-
STA 298.85 REF
43 REF
31
FLANGE REF
2 204386 ITEM NO. 31 REF
SUPPORT HOUSING REF
204386 ITEM NO. 6 REF 67
SECTION D - D 4 8/F
2 PLACES
SCALE: 1/1
VIEW ROTATED 135° CW
60
SEE VIEW E 8 5/A
11 J .250 REF
SEE VIEW F 7 7/A
-J- 67
SEE VIEW G 6 4/A
DATUM -J- REF
DATUM -D- REF
4
C
H
H 7 1/B
6
4 1/E C
49
STA 298.85 REF
STA 278.46 REF
STA 265.88 REF
STA 252.57 REF
STA 191.82 REF
FUEL SPACER ASSY REF G N 69 SECTION 2
STA 113.25 REF
-2 ASSY
TYPE B ASSY
SAME AS -1 ASSY
EXCEPT AS SHOWN
& NOTED
SCALE: 1 1/2"=12"
DWG SIZE E
INDEX CODE NUMBER
AREA 036
DWG TYPE 0806
CL 43
ORIG 400
DRAWING NUMBER 204026
CHG LTR —
SCALE 1/2
RELEASE DATE May 21, 1971
SHEET 4
204026 -1
8 7 6 5 4 3 2 1
H G F E D C B A

Fig. A-26.

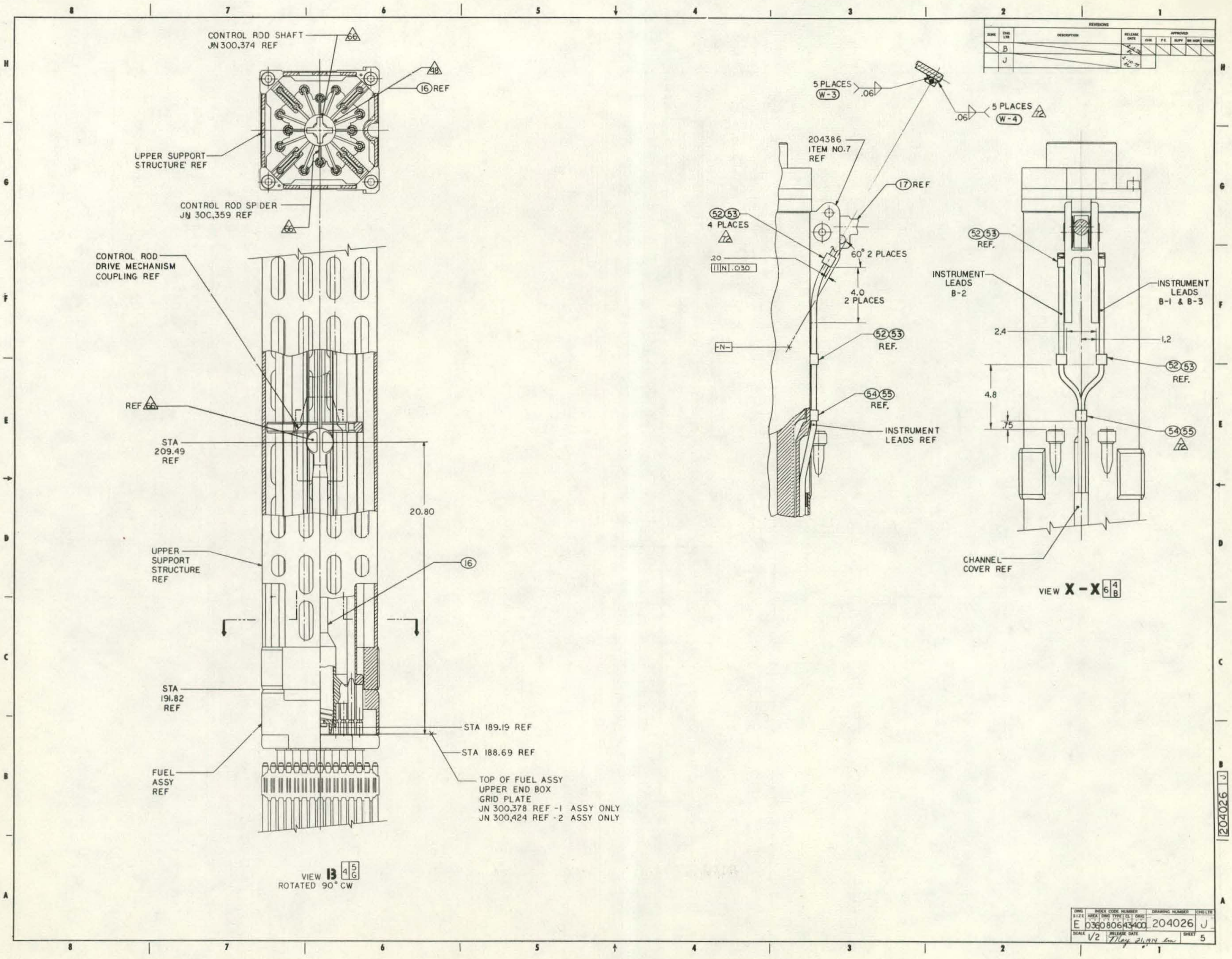

CONTROL ROD SHAFT
JN 300,374 REF
66
48
16 REF
UPPER SUPPORT STRUCTURE REF
CONTROL ROD SPIDER
JN 300,359 REF
66
CONTROL ROD DRIVE MECHANISM COUPLING REF
REF 66
STA 209.49 REF
20.80
UPPER SUPPORT STRUCTURE REF
16
STA 191.82 REF
STA 189.19 REF
STA 188.69 REF
FUEL ASSY REF
TOP OF FUEL ASSY
UPPER END BOX
GRID PLATE
JN 300,378 REF -1 ASSY ONLY
JN 300,424 REF -2 ASSY ONLY
VIEW B 4 5 G
ROTATED 90° CW
5 PLACES
W-3
.06
.06
5 PLACES
W-4
72
204386
ITEM NO.7
REF
17 REF
52 53
4 PLACES
72
60° 2 PLACES
.20
11 N .030
4.0
2 PLACES
-N-
52 53 REF.
54 55 REF.
INSTRUMENT LEADS REF
52 53 REF.
INSTRUMENT LEADS B-2
INSTRUMENT LEADS B-1 & B-3
2.4
1.2
52 53 REF.
4.8
.75
54 55
72
CHANNEL COVER REF
VIEW X – X 6 4 B
REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P E
SUPV
BR MGR
OTHER
B
J
2-10-75
DWG SIZE
INDEX CODE NUMBER
AREA
DWG TYPE
CL
ORIG
DRAWING NUMBER
CHG LTR
E
0360806434000
204026
J
SCALE
1/2
RELEASE DATE
May 21, 1974
SHEET
5
204026 J

Fig. A-27.

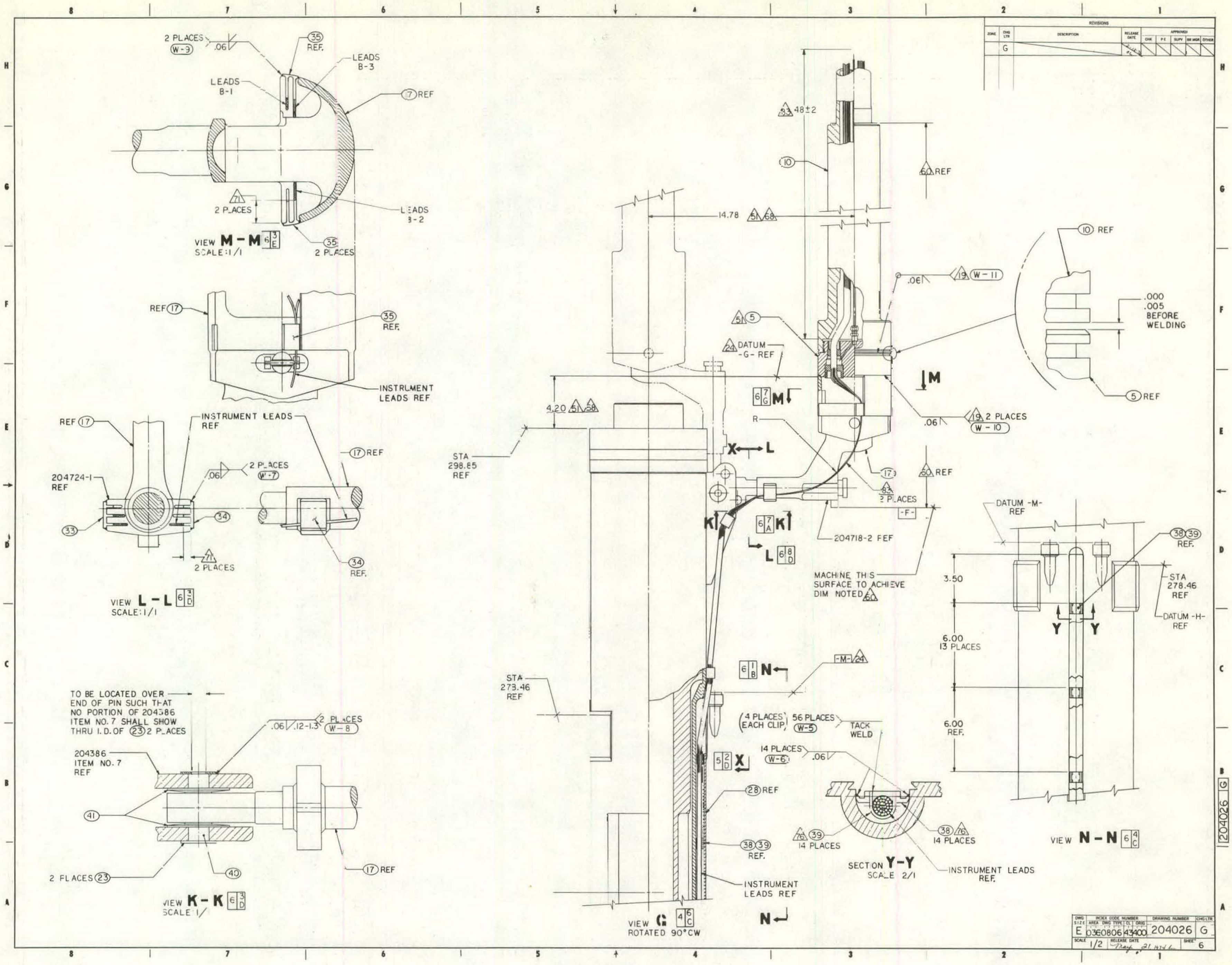
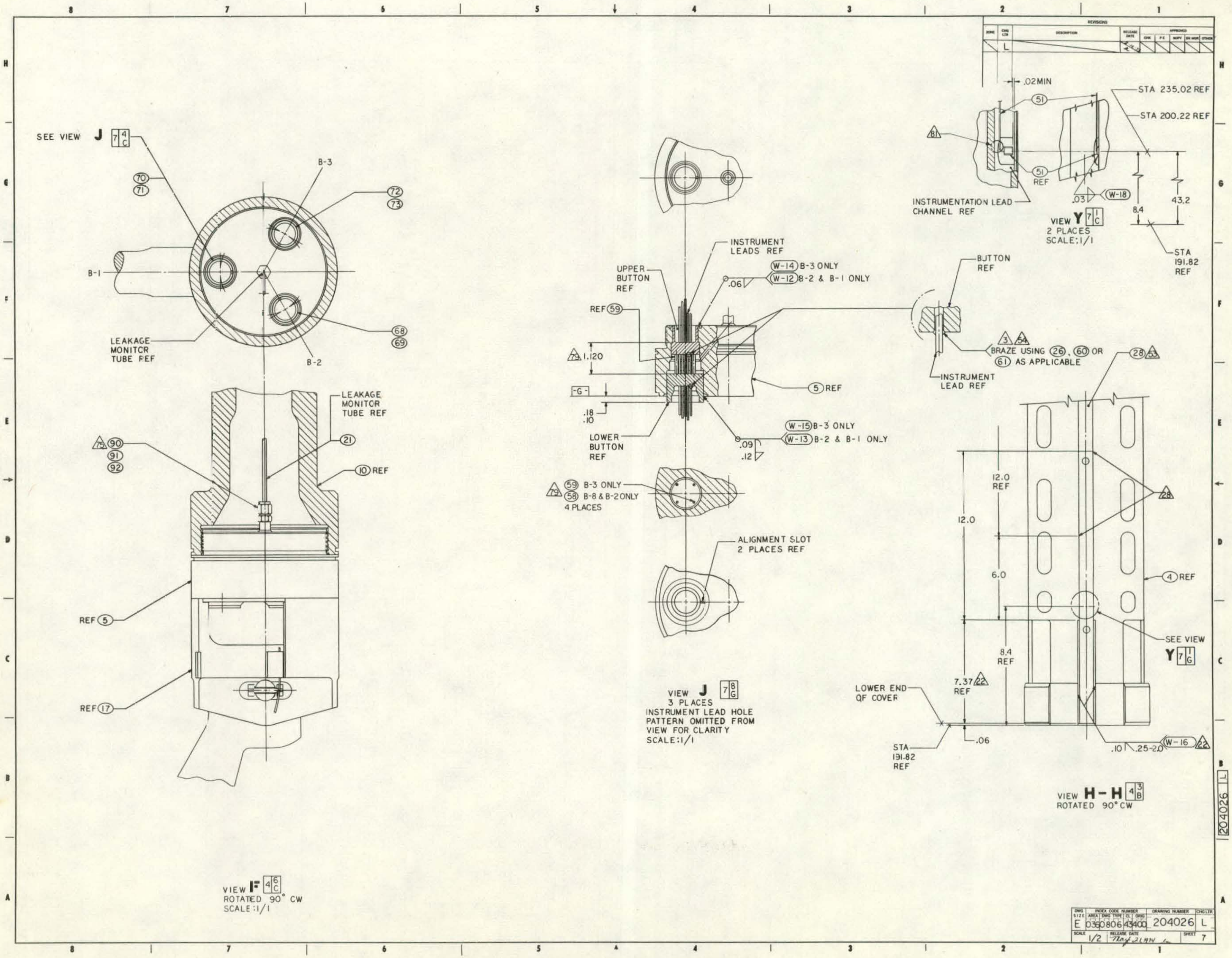

REVISIONS
G
2 PLACES
W-9
.06
35 REF.
LEADS B-3
LEADS B-1
7 REF
71
2 PLACES
LEADS B-2
35 2 PLACES
VIEW M - M 6 3 E
SCALE: 1/1
REF 17
35 REF.
INSTRUMENT LEADS REF
REF 17
INSTRUMENT LEADS REF
17 REF
204724-1 REF
.06
2 PLACES W-7
33
34
34 REF.
71 2 PLACES
VIEW L - L 6 3 D
SCALE: 1/1
TO BE LOCATED OVER END OF PIN SUCH THAT NO PORTION OF 204386 ITEM NO. 7 SHALL SHOW THRU I.D. OF 23 2 PLACES
.06 .12-1.3 2 PLACES W-8
204386 ITEM NO. 7 REF
41
40
17 REF
2 PLACES 23
VIEW K - K 6 3 D
SCALE: 1/1
33 48±2
10
60 REF
14.78 51 68
.06 19 W-11
5 5
24 DATUM -G- REF
6 7 G M
M
4.20 51 58
STA 298.85 REF
R
X L
.06 19 2 PLACES W-10
17
60 REF
83 2 PLACES
-F-
K
6 7 A K
L 6 8 D
204718-2 REF
MACHINE THIS SURFACE TO ACHIEVE DIM NOTED 60
10 REF
.000 .005 BEFORE WELDING
5 REF
DATUM -M- REF
38 39 REF.
STA 278.46 REF
DATUM -H- REF
3.50
Y Y
6.00 13 PLACES
6.00 REF.
VIEW N - N 6 4 C
STA 278.46 REF
6 1 B N
-M- 24
(4 PLACES EACH CLIP) 56 PLACES W-5
TACK WELD
14 PLACES W-6 .06
5 2 D X
28 REF
76 39 14 PLACES
38 76 14 PLACES
SECTION Y-Y
SCALE 2/1
INSTRUMENT LEADS REF.
38 39 REF.
INSTRUMENT LEADS REF
VIEW G 4 6 C
ROTATED 90° CW
N
204026 G
DWG SIZE E
INDEX CODE NUMBER 0360806 43400
DRAWING NUMBER 204026
CHG LTR G
SCALE 1/2
RELEASE DATE
SHEET 6

Fig. A-28.


REVISIONS
ZONE
CHG LTR
DESCRIPTION
RELEASE DATE
APPROVED
CHK
P E
SUPV
EN MGR
OTHER
L
SEE VIEW J 7 4 C
70
71
B-3
72
73
B-1
LEAKAGE MONITOR TUBE REF
B-2
68
69
LEAKAGE MONITOR TUBE REF
90
91
92
75
21
10 REF
REF 5
REF 17
VIEW F 4 6 C
ROTATED 90° CW
SCALE:1/1
INSTRUMENT LEADS REF
UPPER BUTTON REF
W-14 B-3 ONLY
W-12 B-2 & B-1 ONLY
.06
REF 59
79 1.120
-G-
.18
.10
LOWER BUTTON REF
W-15 B-3 ONLY
W-13 B-2 & B-1 ONLY
.09
.12
5 REF
59 B-3 ONLY
58 B-8 & B-2 ONLY
4 PLACES
79
ALIGNMENT SLOT 2 PLACES REF
VIEW J 7 8 G
3 PLACES
INSTRUMENT LEAD HOLE PATTERN OMITTED FROM VIEW FOR CLARITY
SCALE:1/1
.02MIN
51
STA 235.02 REF
STA 200.22 REF
81
51 REF
INSTRUMENTATION LEAD CHANNEL REF
.03
W-18
8.4
43.2
VIEW Y 7 1 C
2 PLACES
SCALE:1/1
STA 191.82 REF
BUTTON REF
3 54
BRAZE USING 26, 60 OR 61 AS APPLICABLE
INSTRUMENT LEAD REF
28 53
12.0 REF
12.0
28
6.0
4 REF
SEE VIEW Y 7 1 G
8.4 REF
7.37 22 REF
LOWER END OF COVER
.06
STA 191.82 REF
.10
.25-2.0
W-16
22
VIEW H-H 4 3 B
ROTATED 90° CW
204026 L
DWG SIZE
INDEX CODE NUMBER
AREA
DWG TYPE
CL
ORIG
DRAWING NUMBER
CHG LTR
E
0360806 43400
204026
L
SCALE 1/2
RELEASE DATE
May 21 1974
SHEET 7
8
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4
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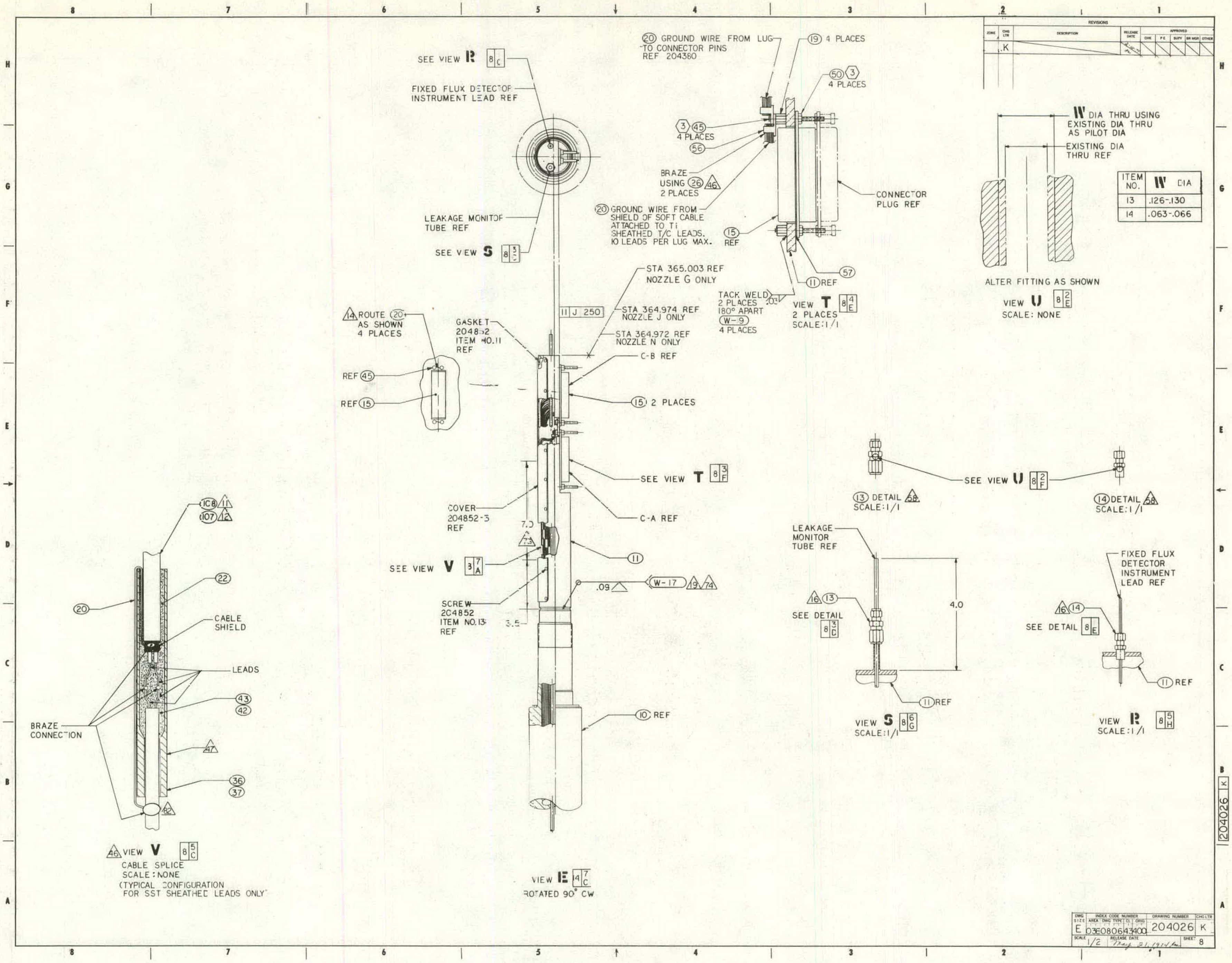
2
1
H
G
F
E
D
C
B
A

Fig. A-29.



ITEM NO.	W DIA
13	.126-.130
14	.063-.066

Fig. A-30.

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