AEC RESEARCH AND DEVELOPMENT REPORT

HW-69200 PT2

PLUTONIUM SPIKE FUEL ELEMENTS FOR THE PRTR

PART II -- THE MARK I-H

R. E. SHARP

MARCH, 1961

HANFORD LABORATORIES

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

GENERAL ELECTRIC

AEC-GE RICHLAND, WASH.

HW-69200 PT2

UC-25, Metals, Ceramics and Materials
(TID-4500, 16th Ed.)

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By

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Reactor and Fuels Research and Development
Hanford Laboratories Operation

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Work performed under Contract No. AT(45-1)-1350 between the
Atomic Energy Commission and General Electric Company

Printed by/for the U. S. Atomic Energy Commission

Printed in USA. Price 75 cents. Available from the

Office of Technical Services
Department of Commerce
Washington 25, D. C.

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INTRODUCTION

The task of setting up a fabrication process from the research and development level to the pilot fabrication scale is an important one. This has been especially true in the fabrication of plutonium enriched reactor fuel elements which require special handling due to the characteristics of the highly toxic plutonium material. The outstanding challenge has been not just to develop a plutonium spike fuel element but to demonstrate a process which despite the glove box restrictions will enable plutonium to compete with other types of fuel element enrichments.

The possibility of using a by-product of power reactors (plutonium) for core enrichment has been intriguing to scientists of many nations. So much so that the AEC established a Plutonium Recycle Program at the Hanford Atomic Products Operation to evaluate the concept. An essential part of this program was the development and fabrication of the plutonium spike fuel elements for the Plutonium Recycle Test Reactor (PRTR).

The following report covers the process and specifications used in fabricating the first plutonium spike core loading for the PRTR power tests. A record system was used to aid in the fabrication and to trace the history of any fuel element rod and its components if needed later. Also complete records were kept to determine the costs of each operation in the process. This it was hoped would point the way to decreasing costs on successive fabrications.

SUMMARY

The Mark I-H plutonium spike fuel elements were fabricated at a comparable cost to the 19-rod cluster uranium dioxide feed elements used

in the Plutonium Recycle Test Reactor. It is felt that this achievement was due to the following:

(1) the constant development effort given to cut costs,
(2) the surprising ease in handling the plutonium-aluminum alloy core,
(3) the use of an unbonded element, and
(4) the resulting small reject rate.

Specifications

The following drawings cover the dimensions used in the Mark I-H 19-rod cluster plutonium spike fuel element (Figure 1).

Fuel Element Assembly (Figure 1a)
Bottom End Caps (Figure 1b)
Top End Caps (Figure 1c)
Center End Cap (Figure 1d)
Fuel Rod Assembly (Figure 1e)
End Bracket (Figure 1f)

Materials

1. Reactor grade Zircaloy-2 is used on end caps, end brackets, strip and buckles for bands and wire for wire wrap.

2. Zircaloy-4 sheath tubing[1] is used and will pass inspection as set forth in the Appendix.

3. The core material is corrosion resistant type plutonium-aluminum alloy of Al-2Ni - 1.8 Pu.[2] A chemical analysis is run on each melt for plutonium and may vary from 1.70 to 1.95. The nickel is weighed for alloying and checked by the corrosion test but no analysis is taken. A corrosion sample is taken from the center of one extrusion per melt and is tested in a static autoclave for 24 hours at 350 C in pH-10 demineralized water. Acceptance is by visual inspection.

   The aluminum used for alloying is of two types 8001 (0.6 maximum iron 0.05-0.35 silicon) and 1345 (0.55 maximum impurities of 0.4 maximum iron, 0.3 maximum silicon, 0.1 maximum copper, 0.05 other).

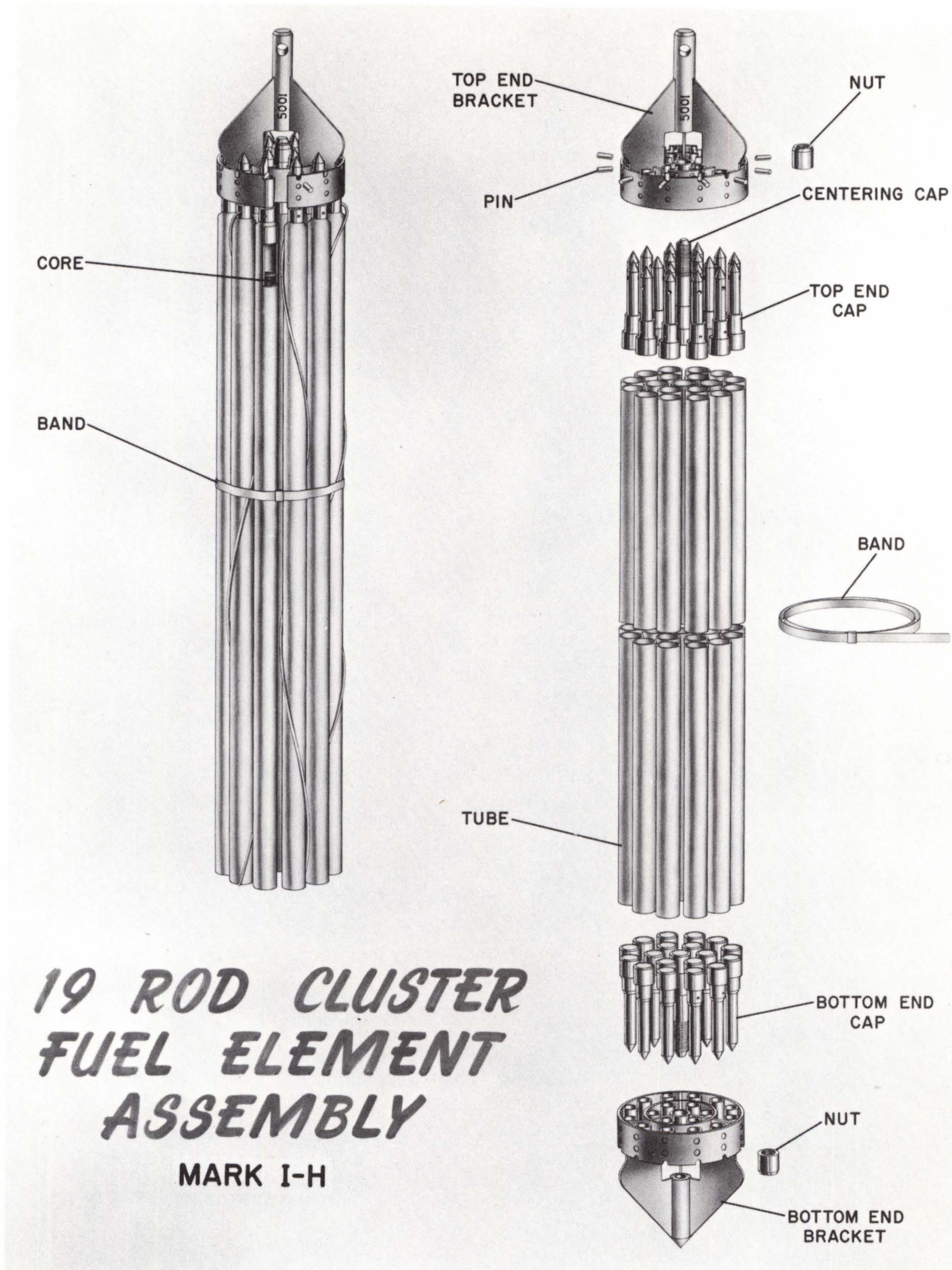

TOP END BRACKET
NUT
PIN
CENTERING CAP
CORE
TOP END CAP
BAND
BAND
TUBE
19 ROD CLUSTER FUEL ELEMENT ASSEMBLY
MARK I-H
BOTTOM END CAP
NUT
BOTTOM END BRACKET

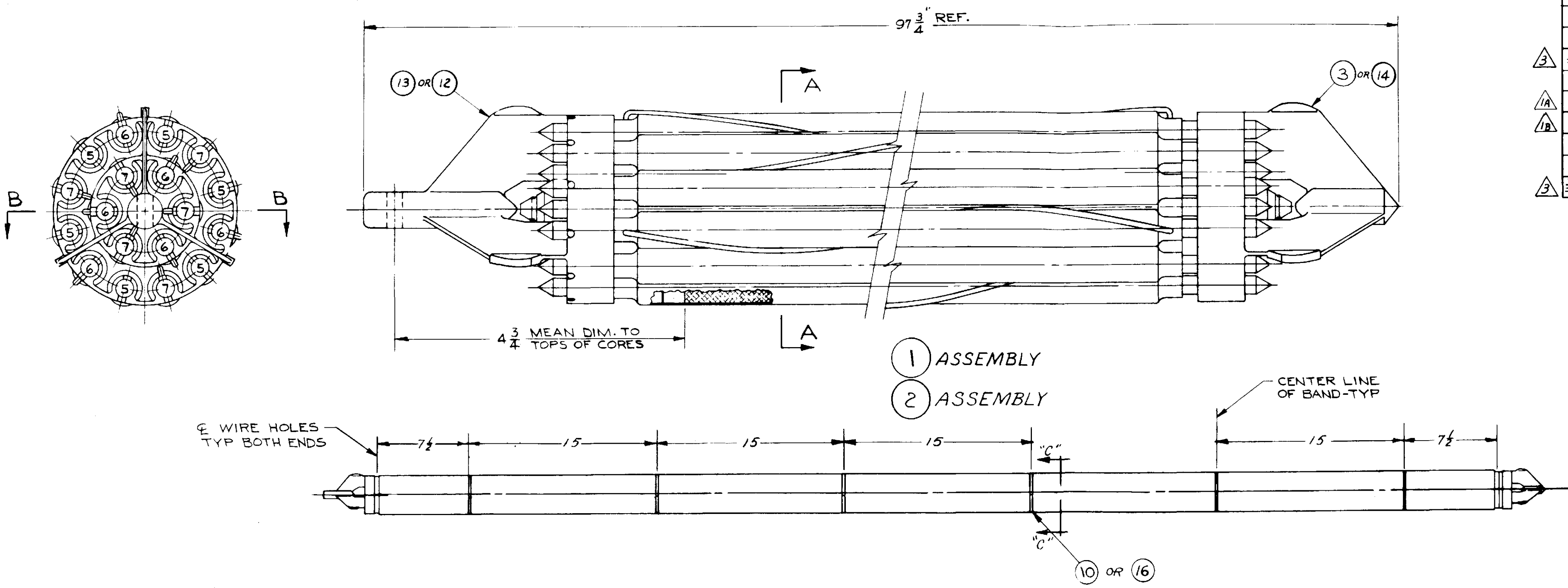
FIGURE 1

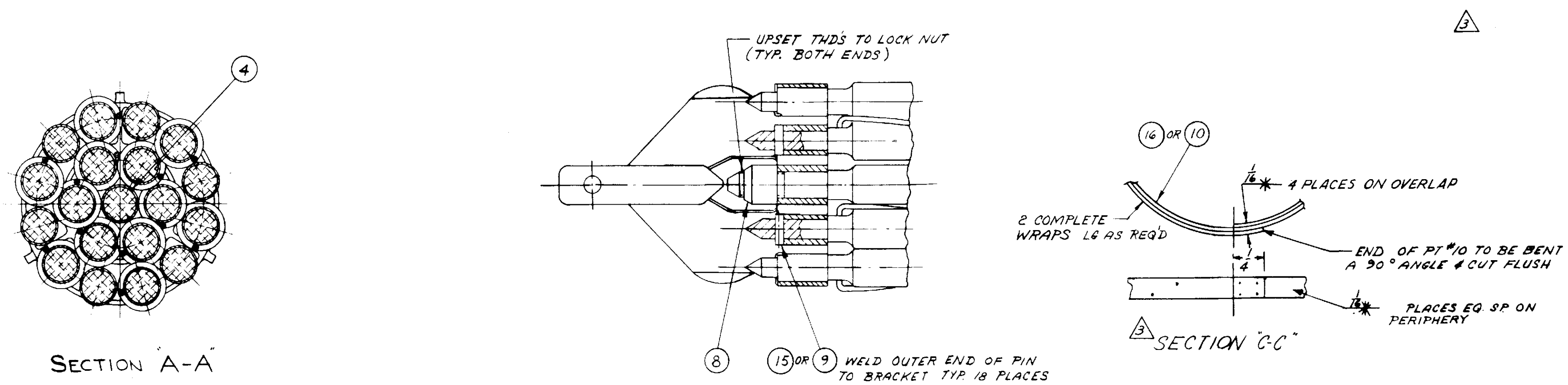
	QTY.		PT. NO.	DESCRIPTION	MATERIAL
		X	1	ASSEMBLY (ZIRCALOY)	
	X		2	ASSEMBLY (STAINLESS)	
	1		3	BOTTOM BRACKET-SST	H-3-13329 P-2
	1	1	4	ROD ASSEMBLY, CENTER	H-3-13637 P-1
	6	6	5	ROD ASSY, NO WIRE	H-3-13637 P-4
	6	6	6	ROD ASSY, C.W. WIRE	H-3-13637 P-2
	6	6	7	ROD ASSY, CCW WIRE	H-3-13637 P-3
	2	2	8	NUT	H-3-13326 P-3
		18	9	PIN $\frac{.125}{.124}$ DIA. X .438 LG.	ZIRCALOY-2
		6	10	BAND $\frac{3}{16}$ WIDE x .010 THK	
△3		~~6~~	~~11~~	~~BUCKLE~~	
	1		12	TOP BRACKET - SST	H-3-13329 P-1
△1A		1	13	TOP BRACKET - ZIRCALOY	H-3-13637 P-1
△1B		1	14	BOTTOM BRACKET-	H-3-13638 P-1
	18		15	PIN $\frac{.125}{.124}$ DIA x .438 LG	304-L SST
	6		16	BAND $\frac{3}{16}$ WIDE x .010 THK	
△3	~~6~~		~~17~~	~~BUCKLE~~	

GENERAL NOTES

ALL PARTS (UNLESS OTHERWISE NOTED) SHALL CONFORM TO THE FOLLOWING:

1. TOLERANCES: FRACTIONAL $\pm\frac{1}{8}$ DECIMAL $\pm .005$ ANGULAR $\pm$ ~



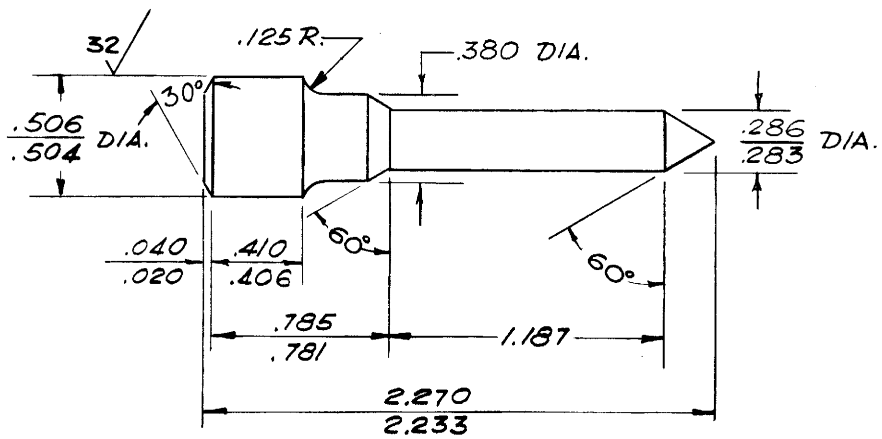


SECTION "B-B"

AEC-GE RICHLAND, WASH.

FIGURE 1a

PRTR Fuel Element
Fuel Element Assembly, 19-Rod Cluster, Mark I-H



MAT'L - ZIRCALOY-2

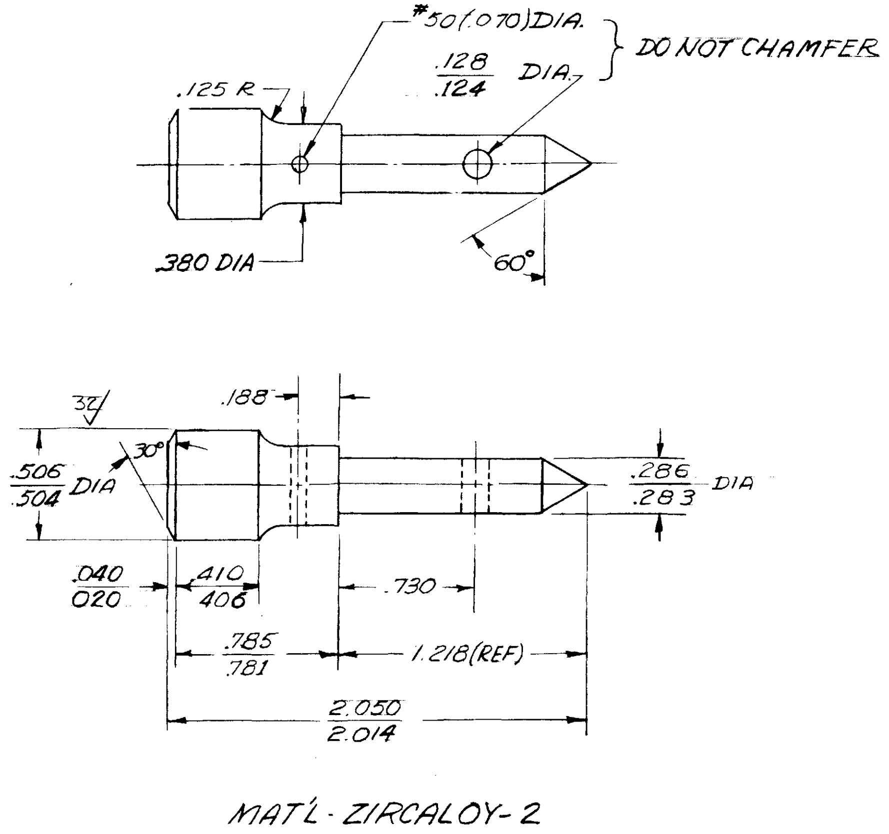
GENERAL NOTES

ALL PARTS (UNLESS OTHERWISE NOTED) SHALL CONFORM TO THE FOLLOWING:

1. TOLERANCES: FRACTIONAL ± 1/64 DECIMAL ± .005 ANGULAR ± 0°30'
2. PARTS TO SHOW GOOD WORKMANSHIP, FREE FROM BURRS, UNMARRED AND CLEAN.
3. BREAK ALL CORNERS.
4. ALL MACHINED SURFACES 63√ (ASA B46.1 - 1955)
5. ALL MATERIAL TO BE AS SPECIFIED, OR EQUAL QUALITY.

FIGURE 1b

PRTR Fuel Element
Bottom End Caps, 19-Rod Cluster, Mark I-H



GENERAL NOTES

ALL PARTS (UNLESS OTHERWISE NOTED) SHALL CONFORM TO THE FOLLOWING:

1. TOLERANCES: FRACTIONAL ± 1/64 DECIMAL ±.005 ANGULAR ± 0°30'
2. PARTS TO SHOW GOOD WORKMANSHIP, FREE FROM BURRS, UNMARRED AND CLEAN.
3. BREAK ALL CORNERS.
4. ALL MACHINED SURFACES 63 (ASA B46.1 - 1955)
5. ALL MATERIAL TO BE AS SPECIFIED, OR EQUAL QUALITY.

FIGURE 1c

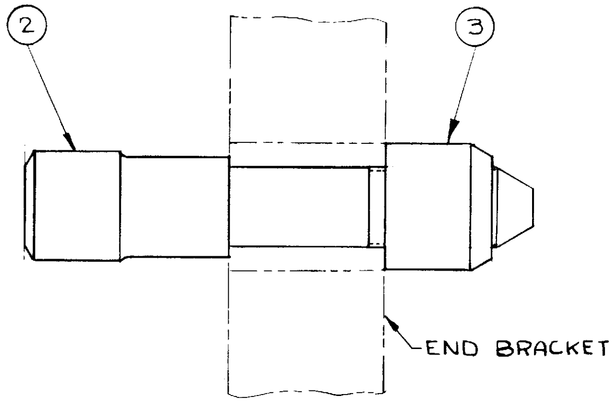
PRTR Fuel Element
Top End Caps, 19-Rod Cluster, Mark I-H

QTY.	PT. NO.	DESCRIPTION	MATL
X	1	ASSEMBLY	
1	2	END CAP CENTER	ZIRCALOY-2
1	3	NUT	

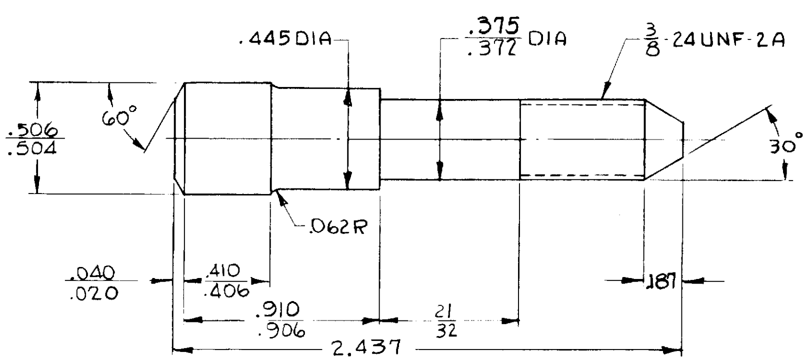
GENERAL NOTES

ALL PARTS (UNLESS OTHERWISE NOTED) SHALL CONFORM TO THE FOLLOWING:

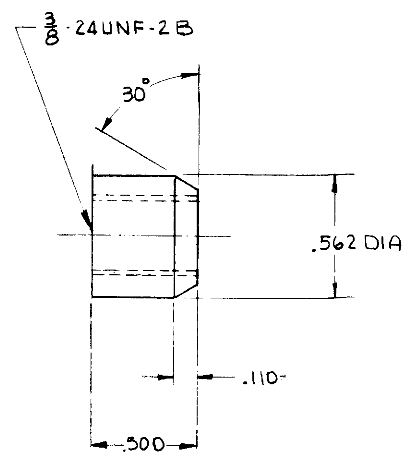
1. TOLERANCES: FRACTIONAL ± 1/64 DECIMAL ±.005 ANGULAR ±0°30'
2. PARTS TO SHOW GOOD WORKMANSHIP, FREE FROM BURRS, UNMARRED AND CLEAN.
3. BREAK ALL CORNERS.
4. ALL MACHINED SURFACES 63√ (ASA B46.1 - 1955)
5. ALL MATERIAL TO BE AS SPECIFIED, OR EQUAL QUALITY.



(1) ASSEMBLY



(2) ZIRCALOY-2

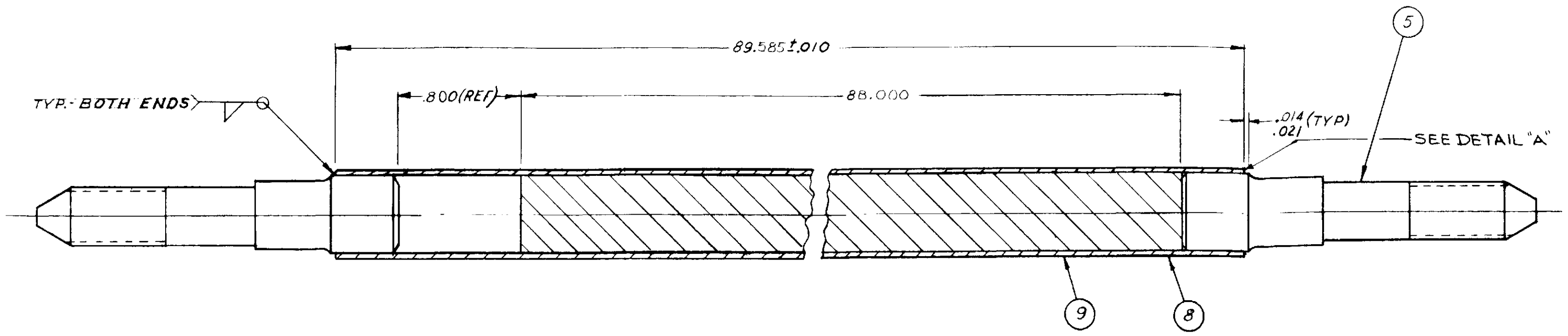


(3) ZIRCALOY-2

FIGURE 1d

PRTR Fuel Element
Center End Cap, 19-Rod Cluster, Mark I-H

QTY.				PT. NO.	DESCRIPTION	MAT'L	DWG. NO.
			X	1	ASSEMBLY, CENTER		
		X		2	" CW WIRE		
	X			3	" CCW "		
X				4	" NO WIRE		
			2	5	END CAP, CENTER	ZIRCALOY-2	H-3-13636 PT. #2
1	1	1		6	" " TOP, WITH WIRE HOLE	"	H-3-13636
1	1	1		7	" " BOTTOM	"	H-3-13634
1	1	1	1	8	TUBE $\frac{.500}{.495}$ I.D. X $\frac{.038}{.032}$ WALL	ZIRCALOY-4	
1	1	1	1	9	CORE	AL Pu	
	1	1		10	WIRE .072 DIA. LG. AS REQ'D	ZIRCALOY-2	

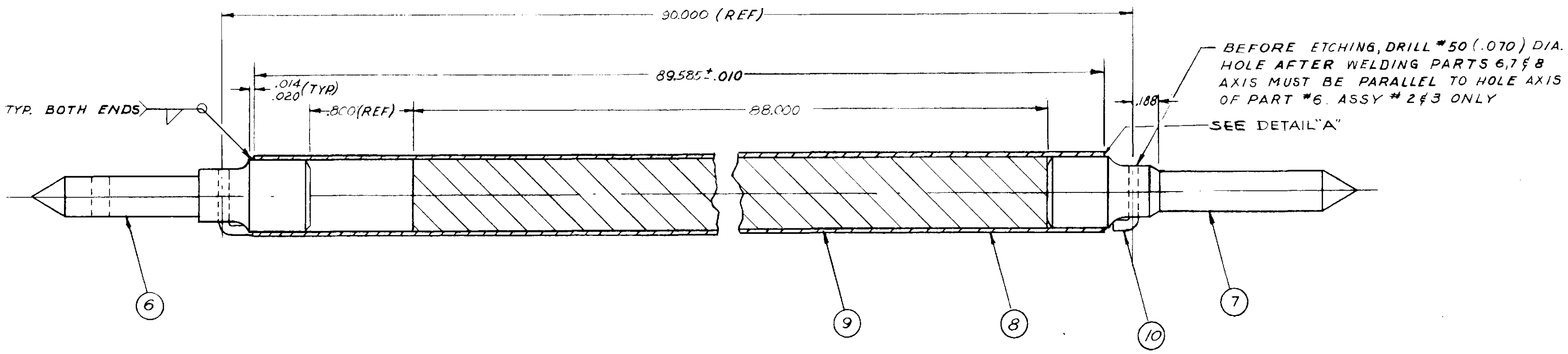


(1) ASSEMBLY

GENERAL NOTES

ALL PARTS (UNLESS OTHERWISE NOTED) SHALL CONFORM TO THE FOLLOWING:

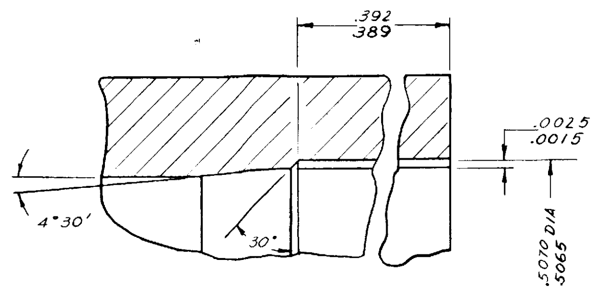
1. TOLERANCES: FRACTIONAL ± 1/64 DECIMAL ± .005 ANGULAR ± 0°30'
2. PARTS TO SHOW GOOD WORKMANSHIP, FREE FROM BURRS, UNMARRED AND CLEAN.
3. BREAK ALL CORNERS.
4. ALL MACHINED SURFACES √ (ASA B46.1 - 1955)
5. ALL MATERIAL TO BE AS SPECIFIED, OR EQUAL QUALITY.



(2) ASSEMBLY
CW WIRE WRAP 10.000 PITCH DIA.

(3) ASSEMBLY
CCW WIRE WRAP 10.000 PITCH DIA.

(4) ASSEMBLY
NO WIRE



DETAIL-A
DETAIL OF TUBE END
(TYP. BOTH ENDS)

FIGURE 1e

PRTR Fuel Element
Fuel Rod Assembly, 19-Rod Cluster, Mark I-H

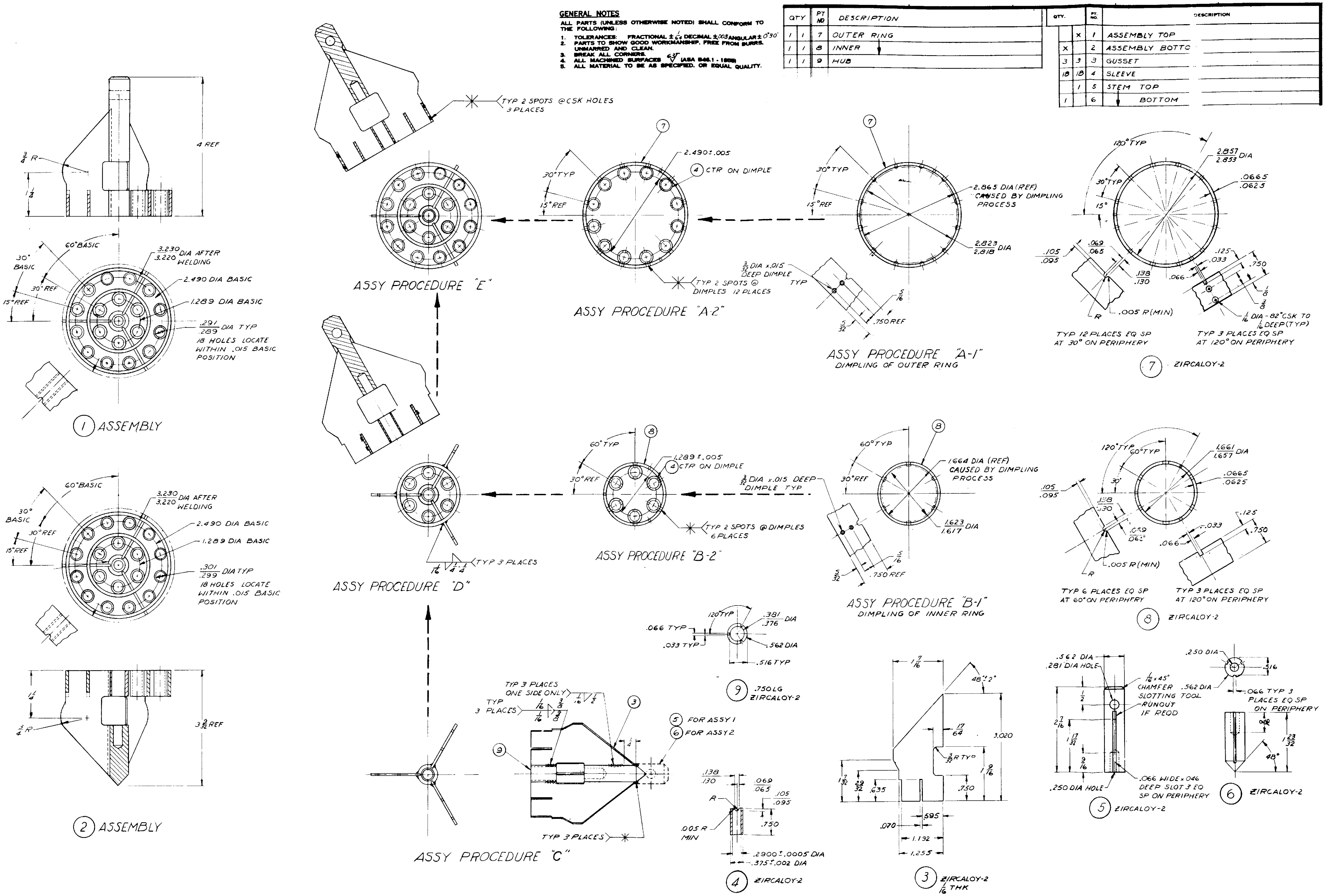


FIGURE 1f

PRTR Fuel Element
End Bracket, 19-Rod Cluster, Mark I-H

Fuel Element Fabrication Steps

Tube Preparation

1. Grit blast a 3/16-inch number using punched cards as stencils on each tube, starting with 1001. Number is recorded in tube book versus manufacturing number, Example: 1597 . . . . EA-50-(C).

2. Wash in hot, detergent bath using stiff bristle brush on inside and sponge on the outside. Rinse in hot clean water and air dry.

3. Gage inside diameter and outside diameter on electronic gaging machine (Figure 2). Tube shall be gaged by locating maximum ID on one end and in that position driving the tube the full length, rotate 90 degrees and return. Standardize gage and recorder by using gaging standards on the ID and OD gages and set recorder to record a one-half centimeter sweep equal to 0. 001 inch (one mil). With this setting the chart can be read to 0. 1 mil (Figure 3).

   Restandardize after each ten tubes, reset if out over 0. 1 mil. Gage special full length tube after every 20 tubes, and check against original chart for dimensional repetition. If chart shows more than 0. 3 mil deviation from original chart on the standard, completely recheck all equipment and regage the 20 tubes gaged since the previous standard check.

4. The blue tube card (Figure 4) originates at this step and follows the tube up through loading. The information is recorded on the card after each step in the process.

5. Tubes are cut to length and counterbored as in Drawing No. H-3-13637. Each tube is checked for length in length gage.

6. Tubes are degreased after machining in a combination vapor and hot liquid degreaser using trichloroethylene or perchlorethylene as a solvent.

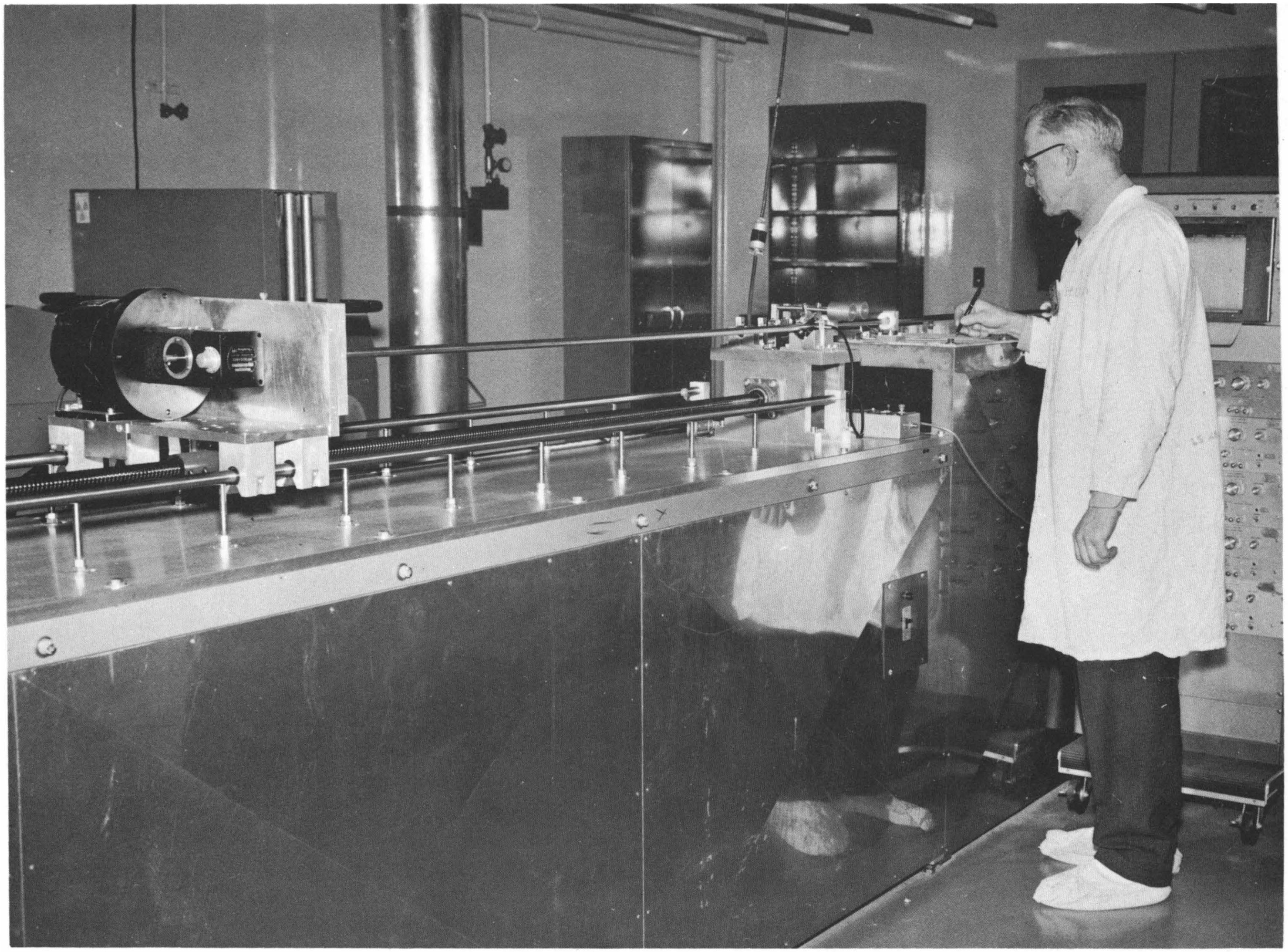


FIGURE 2

Electronic Gaging Machine

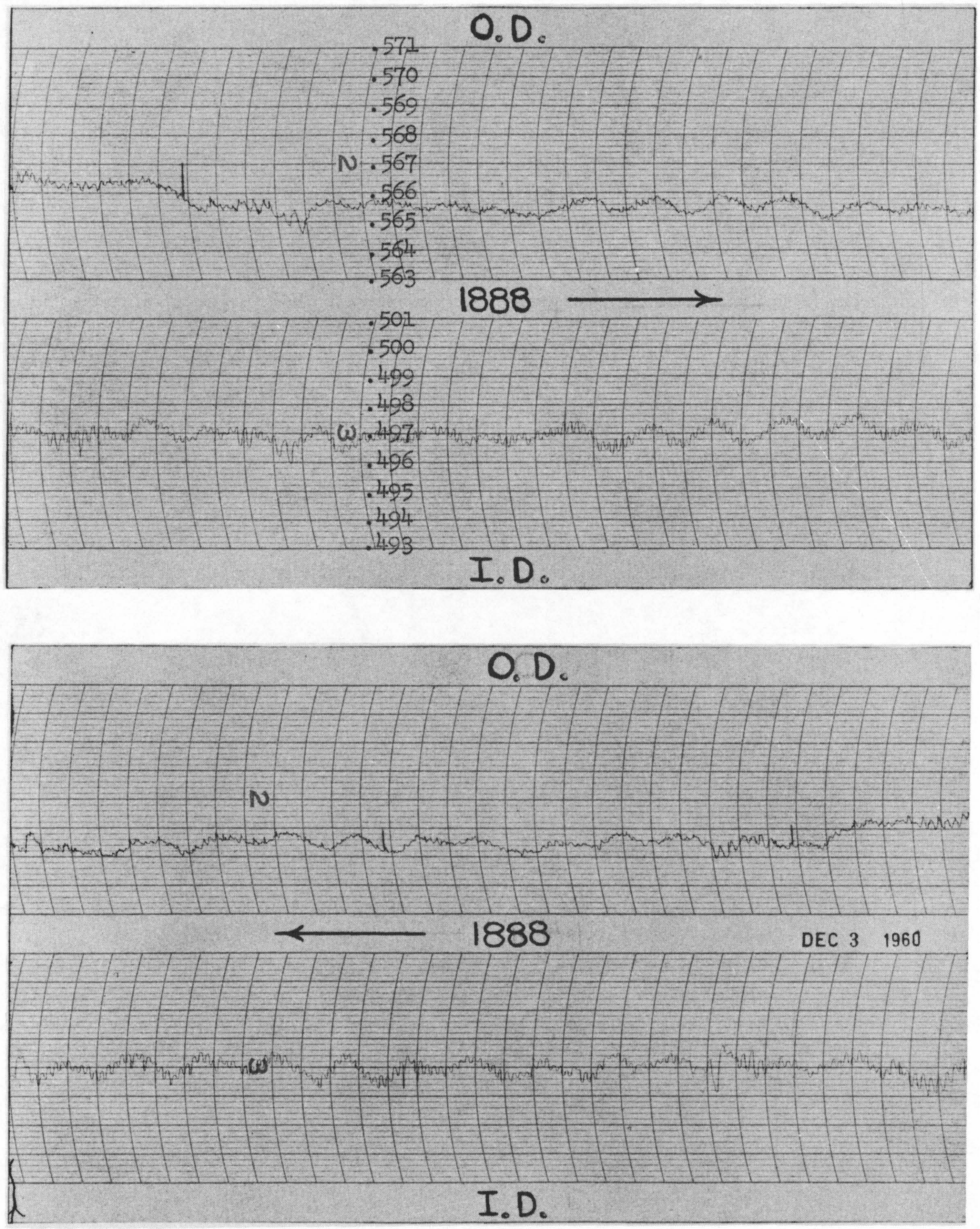
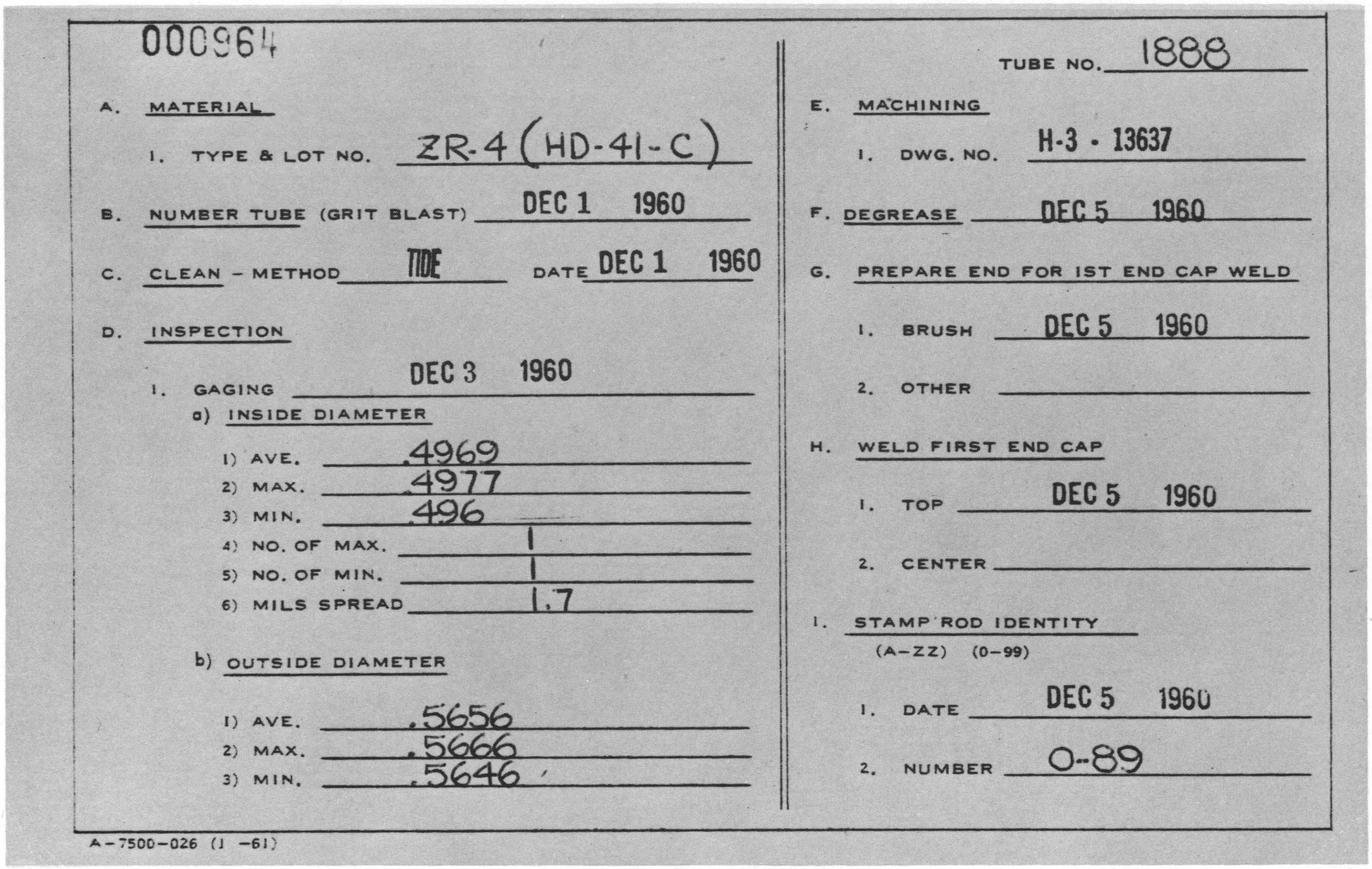


FIGURE 3

Gaging Chart



000964

TUBE NO. 1888

A. MATERIAL

1. TYPE & LOT NO. ZR-4 (HD-41-C)

B. NUMBER TUBE (GRIT BLAST) DEC 1 1960

C. CLEAN - METHOD TIDE DATE DEC 1 1960

D. INSPECTION

1. GAGING DEC 3 1960

a) INSIDE DIAMETER

1) AVE. .4969

2) MAX. .4977

3) MIN. .496

4) NO. OF MAX. 1

5) NO. OF MIN. 1

6) MILS SPREAD 1.7

b) OUTSIDE DIAMETER

1) AVE. .5656

2) MAX. .5666

3) MIN. .5646

E. MACHINING

1. DWG. NO. H-3 - 13637

F. DEGREASE DEC 5 1960

G. PREPARE END FOR 1ST END CAP WELD

1. BRUSH DEC 5 1960

2. OTHER

H. WELD FIRST END CAP

1. TOP DEC 5 1960

2. CENTER

I. STAMP ROD IDENTITY (A-ZZ) (0-99)

1. DATE DEC 5 1960

2. NUMBER 0-89

A-7500-026 (1 -61)

FIGURE 4

Blue Tube Card

7. The primary end cap closure is made by a tungsten arc, helium gas, fusion weld process using a fillet type head weld joint.[3] The degreased tube is prepared for welding by brushing one inch back from the end with a rotating stainless steel wire brush. The top end cap is degreased and slipped into the counter bored tube before loading into the welding box. After loading 18 tubes into the welding box extension or "Gatling gun", the chamber is evacuated to a pressure of 2 x 10^{-4} mm mercury and backfilled with welding grade helium. The welds are made in a static helium atmosphere. The cans are unloaded after welding and the weld zone brushed in the same manner as the tube. The permanent rod number is stamped on the 3/8-inch diameter of the end cap with 1/8-inch numbers and letters. The letter is stamped on one side and the number on the opposite side. The rod identification sequence started with A-0 and is scheduled to go to ZZ-99. Each letter change represents 100 rods (0 through 99).

8. The cans produced by welding the first end cap in the tube are separated and stored for core loading according to the minimum ID's. For example, a 0.496 can would be one with a minimum ID of from 0.4960 to 0.4969 inches.

Core Preparation

1. The first step in fabricating cores is the casting of extrusion billets from a prepared plutonium aluminum alloy designated "CSO".[4] The extrusion billets are cast to size and require no machining.[5] All work is done in a glove box (Figure 5). Six billets are cast from one melt. The melts are numbered consecutively and the billets lettered; for example - CSO #44-B is the second billet cast in the 44th melt using CSO alloy.

2. The billets are hot (525 C) extruded at a 27:1 extrusion ratio in a hooded 280-ton extrusion press (Figure 6). Approximately 200 inches of 0.503-inch diameter core is extruded from each billet. This length is sufficient for two finished cores. When a melt has been extruded the cores are transferred together to the drawbench.

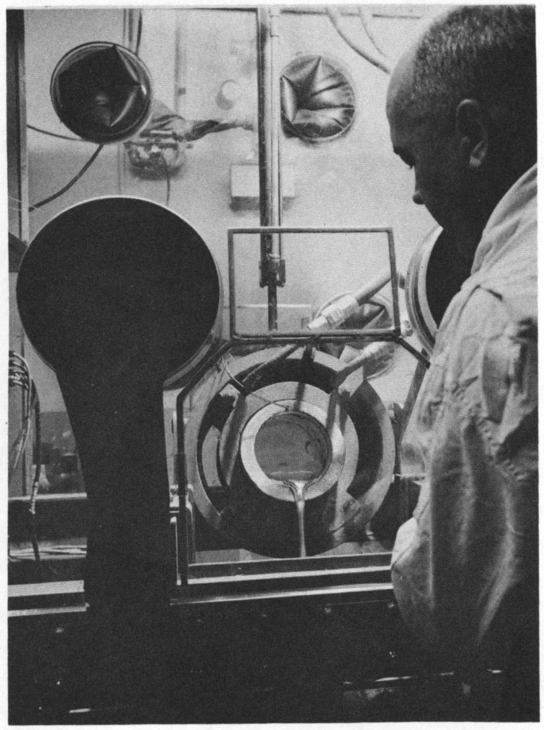


FIGURE 5

Casting Pu-Al Billets

FIGURE 6

Core Extrusion Operation

3. The drawing operation consists of pointing, coating with lubricant and drawing in the drawbench hood (Figure 7). Cores are handled in bundles of 12 or of one melt. One end is pointed by machining the 0.503-inch diameter to 0.480 inch for about 8 inches. After pointing, the core is dipped in Oakite No. -12*, and stored in a rack to dry. All cores from one melt are drawn to the same size. The drawn cores are transferred to the straightener hood in a portable glove box (Figure 8). The yellow core card (Figure 9) originates at this step and is filled out with the appropriate information after each operation.

4. The drawn cores are straightened in a hooded rotary straightener (Figure 10) and then cut to a finished length of 88 inches with a cut-off saw (Figure 11) located at one end of the straightener hood. Several inches are cut from each end of the cores to eliminate the unstraightened ends which is a characteristic of the rotary straightener. The length is held to ± 10 mils by using a set stop when cutting the final end. The finished cores are transferred to the assembly hood in a portable glove box.

5. Identification throughout the core preparation is kept by melt numbers and diameter on the bundle of cores and not on an individual core.

Rod Fabrication

1. The rod fabrication begins with the mating of a finished can and a finished core.

2. The cans and cores are matched to give a minimum diameter gap of four mils and a maximum gap as little over four mils as possible. This is done in the fabrication with six sizes of cans and six sizes of cores set up as follows:

Minimum Tube Diameter	Core Diameter
0.4930 - 0.4939	0.4890 + 0.0000 - 0.0002
0.4940 - 0.4949	0.4900 + 0.0000 - 0.0002
0.4950 - 0.4959	0.4910 + 0.0000 - 0.0002
0.4960 - 0.4969	0.4920 + 0.0000 - 0.0002
0.4970 - 0.4979	0.4930 + 0.0000 - 0.0002
0.4980 - 0.4989	0.4940 + 0.0000 - 0.0002

*Oakite Products, Inc., 19 Rector Street, New York 6, New York

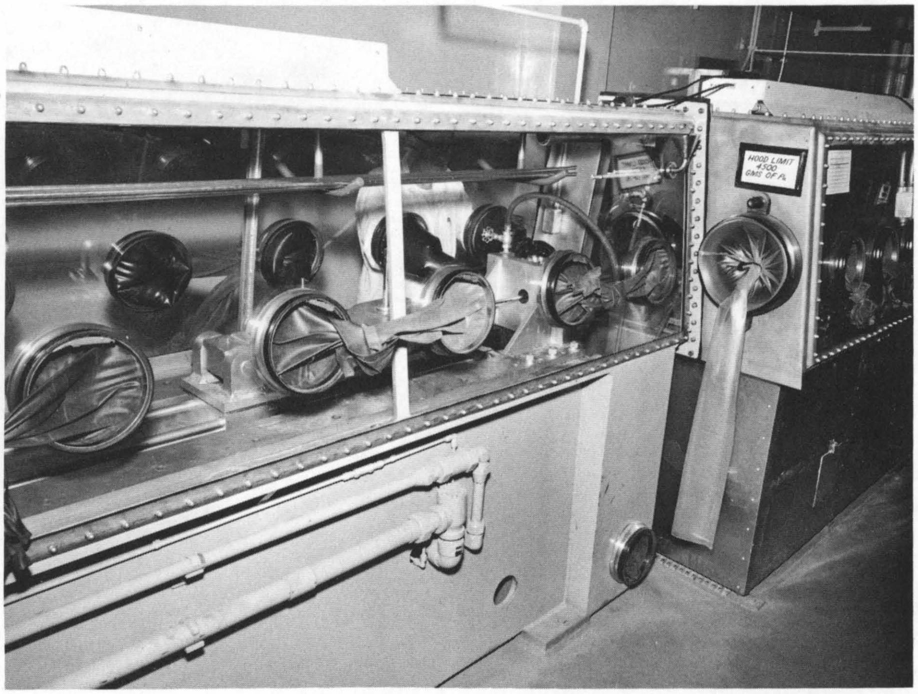


FIGURE 7

Core Drawing Operation

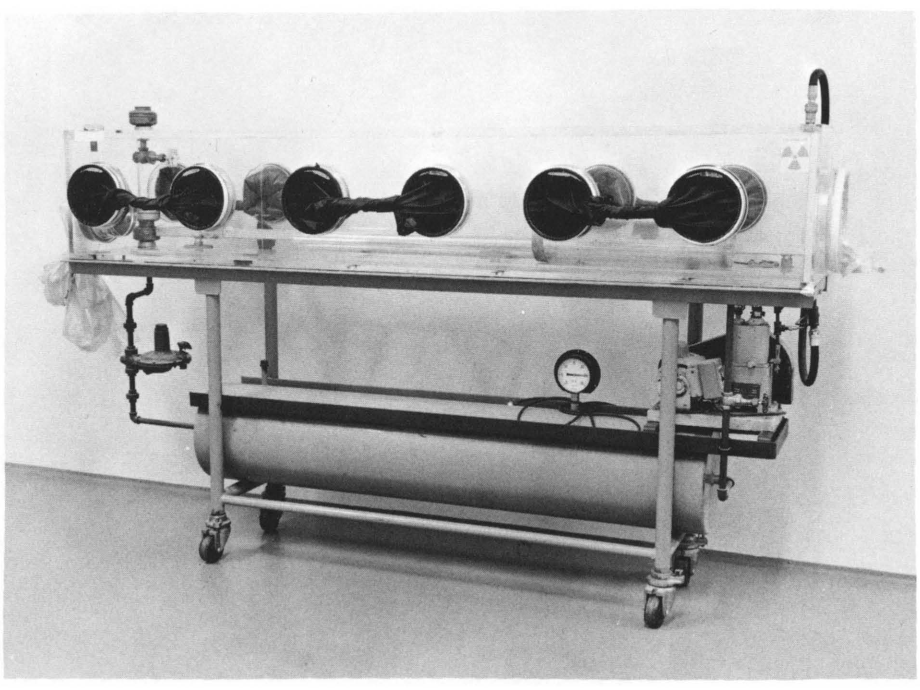


FIGURE 8

Portable Glove Box

0C0964

CORE NUMBER CSO 79

A. DRAW DEC 27 1960

1. DIE SIZE .4925

B. STRAIGHTEN DEC 28 1960

C. CUT DEC 28 1960

1. LENGTH ______

D. GAGE DEC 28 1960

1. MAX. .4917

2. MIN. ______

E. WEIGHT DEC 29 1960

1. TOTAL 766.2

2. PU ______

F. COATING – NONE ✓ DAG ______ DATE DEC 29 1960

G. ROD NO. 0-89

A-7500-028(1-61)

FIGURE 9

Yellow Core Card

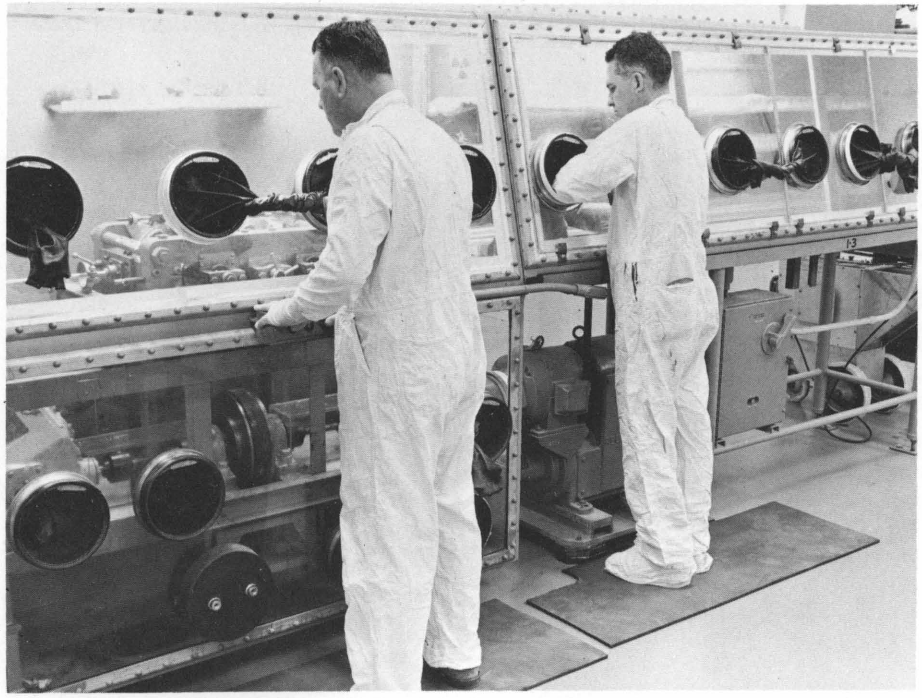


FIGURE 10

Hooded Rotary Straightener

FIGURE 11

Hooded Cut-Off Saw

The rods are then classed by letter according to the minimum and maximum gap.

Classification	Minimum Gap	Maximum Gap
A	4 mils	6 mils
B	4 mils	7 mils
C	4 mils	8 mils
D	4 mils	9 mils
E	4 mils	10 mils

Class I rods shall be those which meet all specifications and requirements for full power operation. Class II and III shall be those which fail to meet all specifications.

3. The cans shall be prepared for loading (Figure 12). The outside of the open end of the can is covered with aluminum foil and taped; next four tubes are inserted into a "cow" bag and taped to the bag. Normally four tubes with the same minimum ID are chosen, i. e. , 0.495's -- minimum ID's between 0.4950 and 0.4959 inches. The bag is attached to a 12-inch glove port on the assembly hood using standard bagging techniques.

4. Four cores to match the tubes are selected and are usually the same size and melt number. The cores are wiped clean with trichloroethylene saturated gauze just before weighing and inserting into the can. The core weight is recorded to one-tenth of a gram. The orange rod card (Figure 13) originates at this step and information tieing the three cards together (core, tube, and rod) shall be filled in at the time of loading.

5. After loading, the bag is sealed across the four fingers and the loaded rods separated from the bag.

6. The three cards representing the components of the fuel element rod are stamped with a common cross-index number and recorded at this point of the process. The records consist of two books, one has the

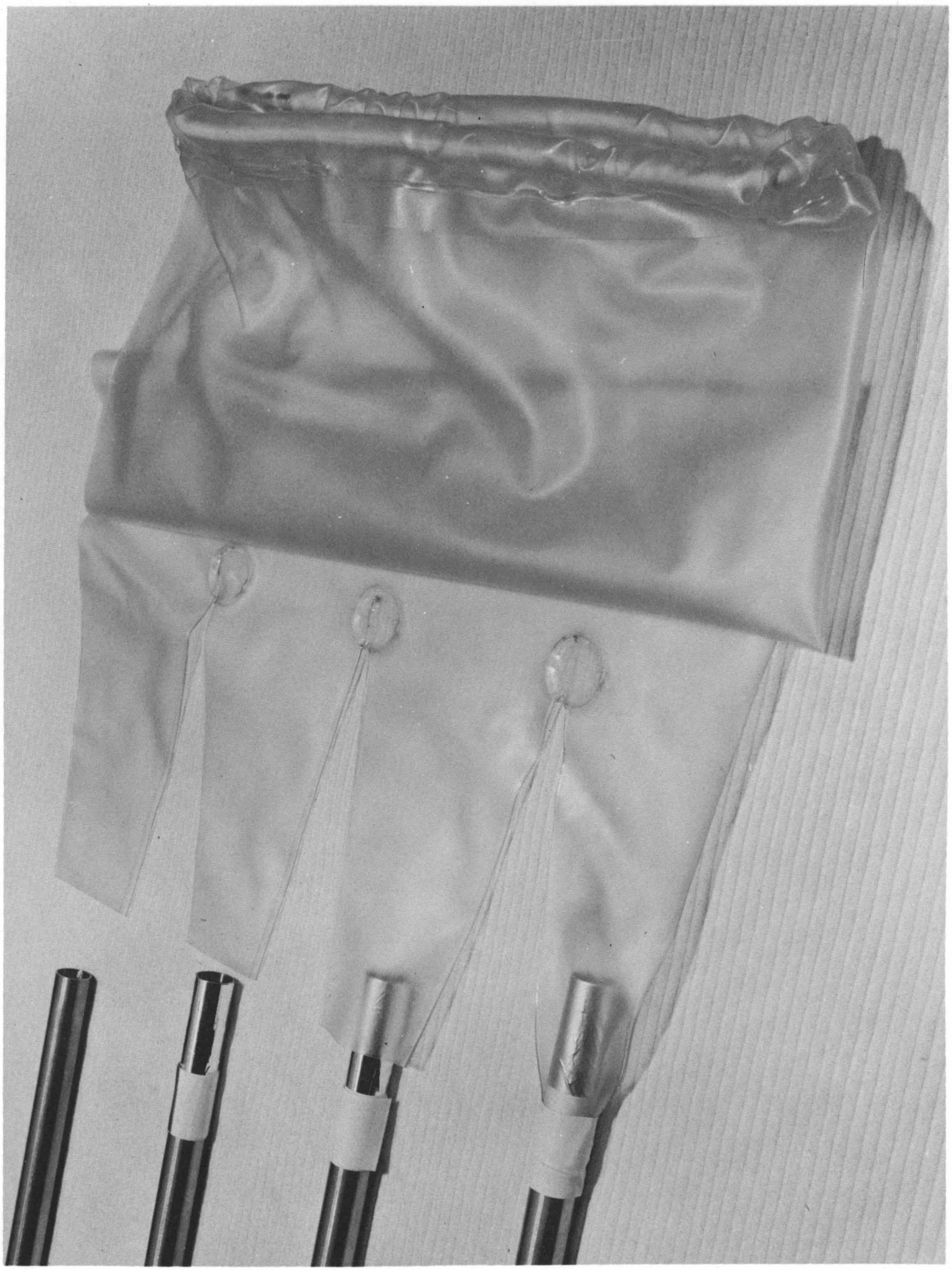


FIGURE 12
Sequence of Preparing Cans for Core Loading

000964 **CLASS I-A** ROD NO. 0-89

A. LOADING DEC 29 1960

1. CORE NO. CSO 79 EX(CS054)
2. TUBE NO. 1888 EX(2313)

B. WELD SECOND END CAP

1. BOTTOM JAN 5 1961
2. CENTER ______

C. CLEAN WELDS

1. BRUSH JAN 5 1961
2. OTHER ______

D. DRILL JAN 9 1961

E. CLEAN JAN 9 1961

F. ETCH JAN 9 1961

1. PROCESS ______

G. LEAK CHECK JAN 9 1961

H. AUTOCLAVE

1. AUTOCLAVE NO. 2
2. DATE IN JAN 11 1961
3. TIME AT 400 C 36

I. RECYCLE

1. ______ 1. ______
2. ______ 2. ______
3. ______ 3. ______

J. WIRE WRAP

1. CLOCKWISE ______
2. COUNTER CLOCKWISE ______
3. TENSION ______

A-7500-027 (1-61)

FIGURE 13

Orange Rod Card

cross-index number versus the rod number and tube number. The other has the rod number versus cross-index number, class, sheath material, minimum and maximum ID, core number and size, minimum and maximum gap and tube ID mil spread.

After recording, the core and tube cards are filed consecutively according to the cross-index number. The class is stamped on the rod card and it is returned to follow the rod through the process.

7. The rods are prepared for loading into the welding box. Using double surgeon's gloves in front of an open front hood, the remaining plastic bag, which was sealed off, and the protective aluminum foil are stripped from the rod by removing the tape with tweezers. The end of the rod inside and out, is cleaned thoroughly using an alcohol saturated cotton pad. The gloves and rod are then checked for contamination. If the rod is uncontaminated a special plastic stopper with a built-in filter is inserted into the rod. The outer glove is sometimes contaminated in this operation, however the end of the rods are seldom hot. If they are, the decontamination process is repeated.

8. The second end closure is accomplished in the same manner as the first with the following exceptions. The clean degreased bottom or center end caps are stored in the welding box and are inserted one at a time just prior to the welding operation. The welding sequence is as follows:

   (1) The plastic stopper is removed from the rod and is dropped in a metal can placed below the rods (Figure 14)

   (2) A bottom end cap is inserted in the rod unless there is a mark on the rod signifying a center rod in which case a center end cap is used.

9. A radiation check is made for possible alpha contamination on the rods after removing from welding chamber.

10. The weld and weld affected zone on the final closure is brushed using a power stainless steel brush.

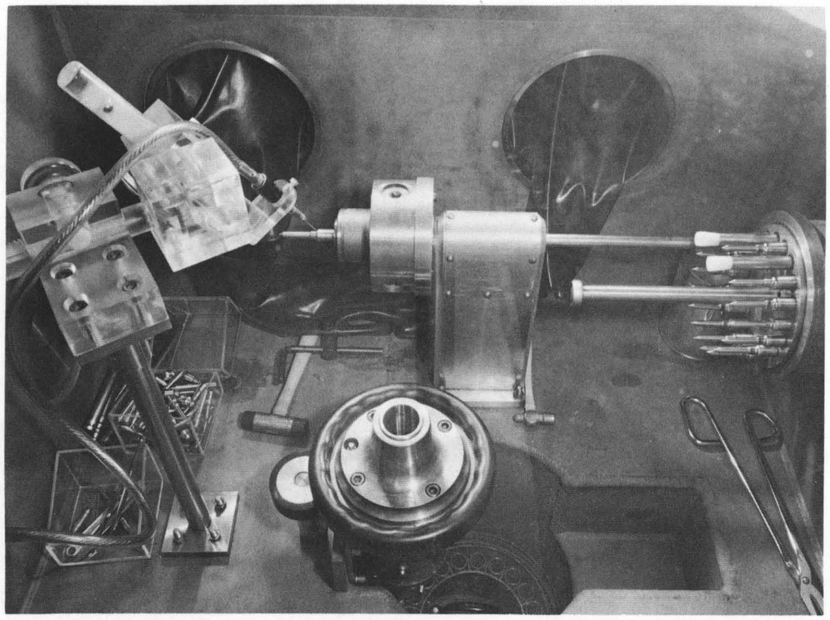


FIGURE 14

Final End Closure Operation

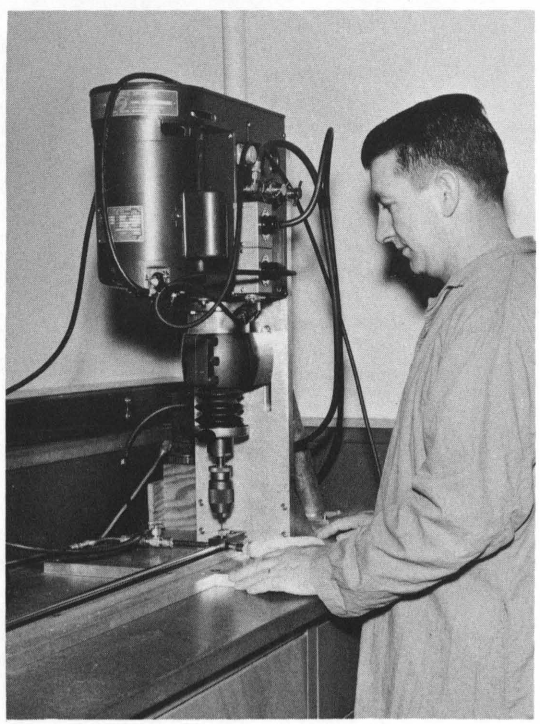


FIGURE 15

Drilling Operation

11. The wire hole is drilled using a number 48 drill (0. 076) in the bottom end cap with a semi-automatic drilling machine (Figure 15). A fixture holds the rod in position and the second hole is drilled in the same plane and 90 inches from the first. An automatic cycling unit is used in the drilling to eliminate drill breakage. Although only 12 of the 19 rods in a cluster are wire wrapped, all rods (other than the center) are drilled for wire wrapping to eliminate extra parts and more selective assembling.

12. Rods are wiped clean with acetone before etching.

13. Rods are etched in a nitric-hydrofluoric acid ($HNO_3 HF$) solution (3. 7 volume per cent of 51 per cent Tech Grade HF, 30 volume per cent of 71 per cent Reagent Grade HNO_3 and 66. 3 volume per cent demineralized water) to remove approximately two mils from the surface. The time in the etch solution is usually seven minutes. The etching action is stopped by a rapid transfer from the etching tank to a stop tank of aluminum nitrate solution (15 w/o $Al(NO)_3 \cdot 9H_2O$).

    The rods are next rinsed in hot tap water and followed by cold demineralized water measuring 300,000 ohms or greater. The temperature of the first three baths is controlled at 22-25 C, 40 C, and 50-60 C respectively. Seventy-two rods are the maximum number to be etched before changing the acid and stop solutions. The rods are wiped dry using paper towels. The dry etched rods are checked for smearable alpha contamination.

14. All handling of rods after etching through the final assembly of the fuel element clusters is done using clean, specially treated, cotton gloves.

15. All rods are helium leak tested. The rods are tested by placing in a chamber, evacuating to 1×10^{-3} mm Hg and testing for helium with a mass spectrometer. Any detection of helium rejects the rod.

16. Rods are wiped down with alcohol prior to loading autoclave rack.

17. Rods are autoclaved for 36 hours in 400 C, 1300 psi steam. A check for alpha contamination is made on the lid, rack and fuel element rods after opening each autoclave.

18. Rods are inspected after autoclaving for white corrosion or other surface defects. If any defects are found the rod is recycled through grit blasting, etching and autoclaving. Any defects remaining after recycling the rod twice, rejects the rod permanently. After inspecting, rods are inclosed in polyethylene tubing, separated according to class and stored in special boxes.

19. Twelve rods of each cluster are wrapped with autoclaved Zircaloy-2 wire 0.072-inch diameter. Six are wrapped clockwise and six counter-clockwise. The wire is wrapped in a ten-inch pitch with a controlled tension of five pounds (Figure 16). The wire is fusion welded in the end cap holes with a helium gas, tungsten arc, automatic spot welding gun (Figure 17). After each rod is wire wrapped it is wiped down with gauze saturated with alcohol, inspected and returned to its plastic covering.

Cluster Assembly

1. Nineteen finished fuel element rods of one class are selected and arranged for assembly according to the position in the cluster. These positions are shown in Figure 18. After laying out the rods in order of assembly the white cluster card (Figure 19) is filled in with the position letter versus the rod number. Rods, numbers and positions are checked and rechecked at this point in that they will not be checked at any future step. The plastic covers are removed from the rods just prior to the assembly.

2. A set of autoclaved end brackets are selected and the number stamped on the top end bracket is recorded on the cluster card. This number started with 5001 for the plutonium fuel elements.

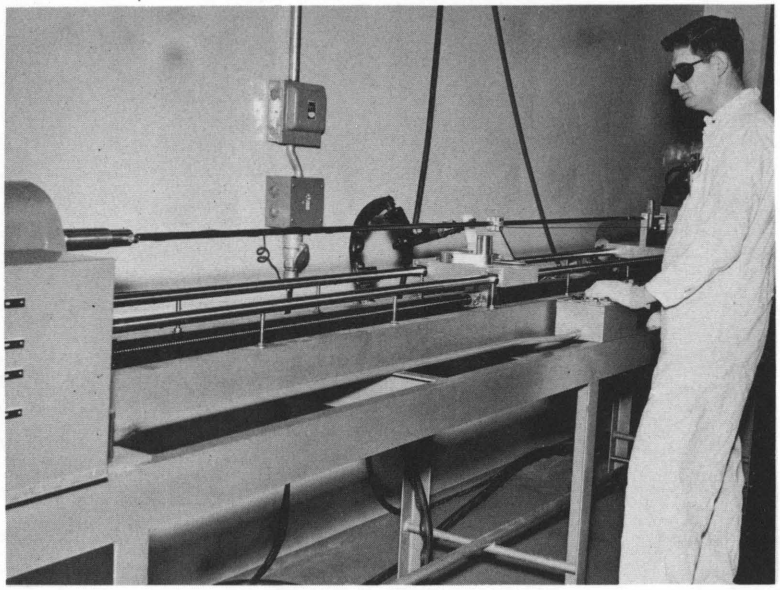


FIGURE 16

Wire Wrapping Machine

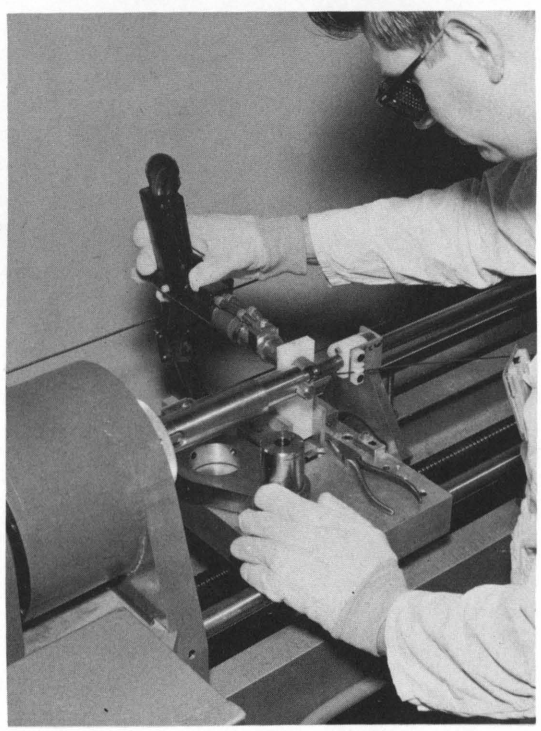


FIGURE 17

Primary Wire Weld

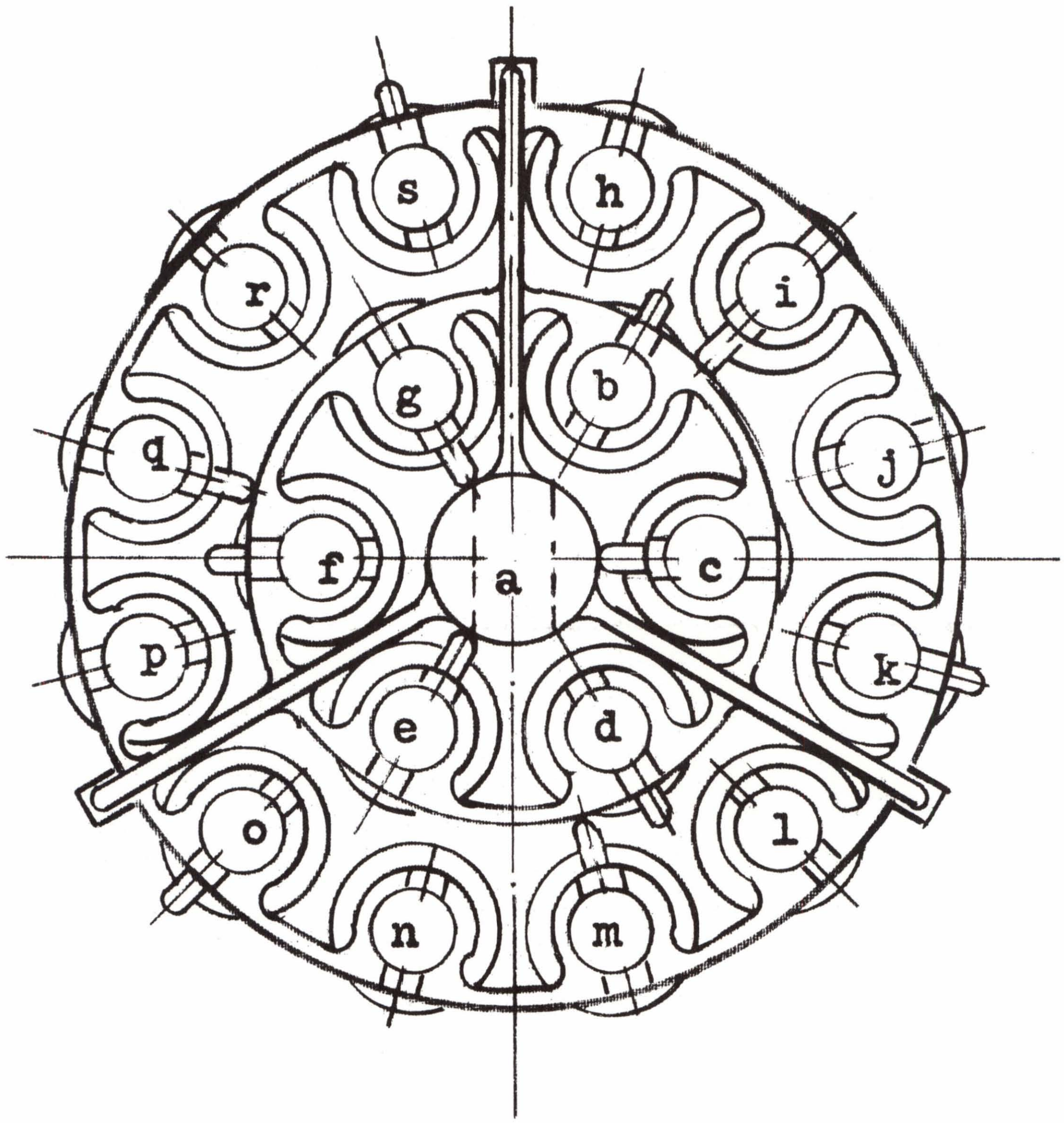
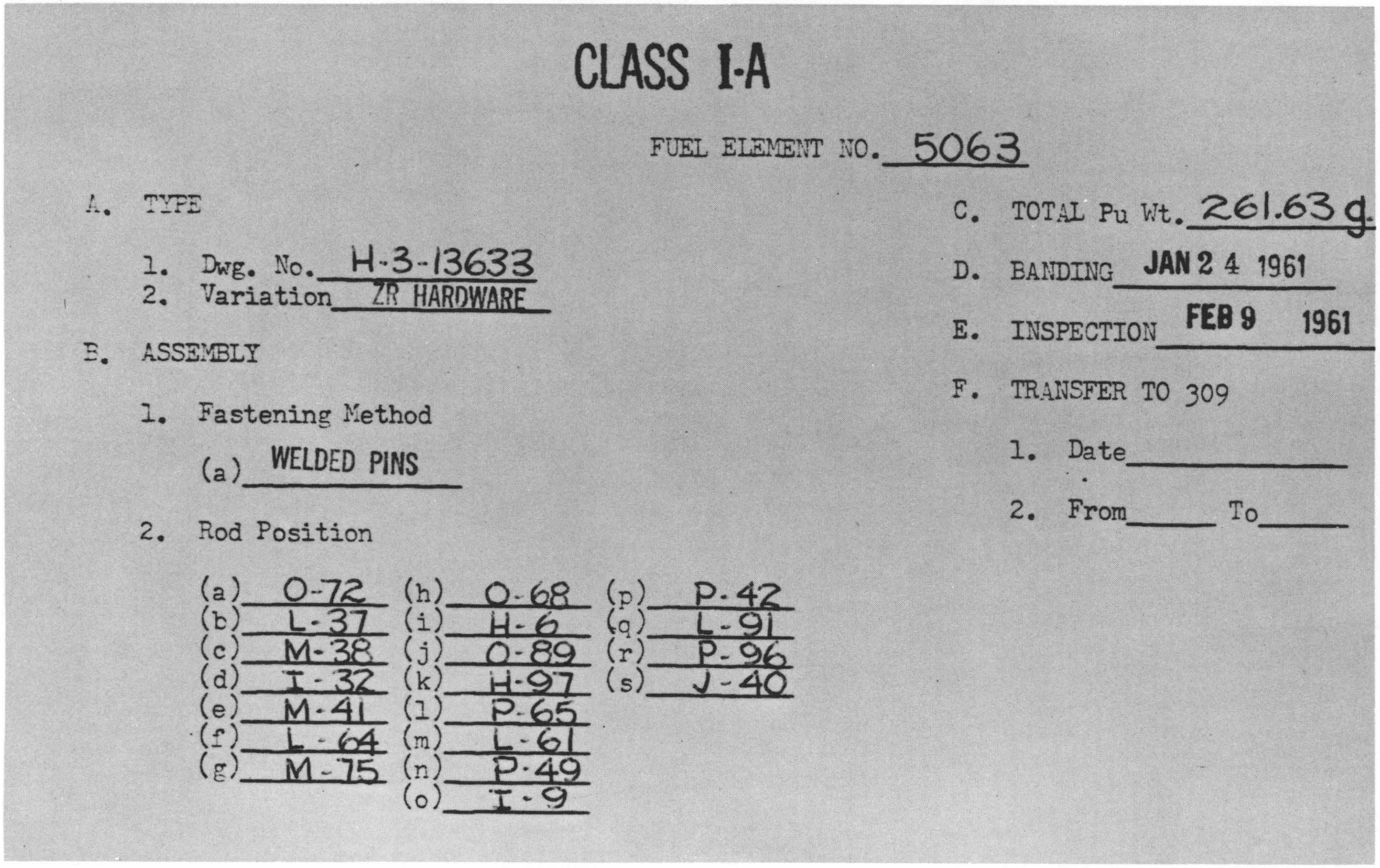


FIGURE 18

PRTR Rod Location



CLASS I-A

FUEL ELEMENT NO. 5063

A. TYPE

1. Dwg. No. H-3-13633
2. Variation ZR HARDWARE

B. ASSEMBLY

1. Fastening Method

   (a) WELDED PINS

2. Rod Position

(a) O-72	(h) O-68	(p) P-42
(b) L-37	(i) H-6	(q) L-91
(c) M-38	(j) O-89	(r) P-96
(d) I-32	(k) H-97	(s) J-40
(e) M-41	(l) P-65	
(f) L-64	(m) L-61	
(g) M-75	(n) P-49	
	(o) I-9	

C. TOTAL Pu Wt. 261.63 g.

D. BANDING JAN 24 1961

E. INSPECTION FEB 9 1961

F. TRANSFER TO 309

1. Date__________

2. From_____ To_____

FIGURE 19

White Cluster Card

3. The top end bracket is pinned to the assembly fixture and the center rod position (a) is fastened to the bracket with an autoclaved Zircaloy nut. The rods in the six-rod ring are fastened by inserting autoclaved Zircaloy pins through the hole in the top end cap. After the six-rod ring is filled with rods, the pins are welded to the end bracket with a helium gas, tungsten arc automatic spot welding gun. Next the 12-rod ring is fastened and welded in the same manner (Figure 20).
4. The bottom end bracket is slipped on and fastened in place with a nut on the center rod.
5. The cluster is banded with six circumferential Zircaloy bands (Figure 21). After the bands are in position and tightened the two 10 mil strips making up the band are resistance spot welded together in twelve places.
6. The nuts at the top and bottom are staked to the center rod.
7. The finished cluster is covered with a "zippertube" type plastic bag and stored awaiting transfer to the reactor (Figure 22).
8. The plutonium in each core is calculated from the total core weight and the plutonium melt analysis of that core. The total plutonium weight per cluster is taken from this information and recorded on the cluster card for inventory and transfer purposes.

CRITICALITY

Criticality was recognized as a permanent hazard in the fabrication of plutonium bearing fuel elements. For this reason each step in the process was reviewed and approved by Critical Mass Physics Operation.

ACKNOWLEDGMENT

The author wishes to acknowledge his indebtedness to the personnel of Plutonium Fuels Development Operation who have made invaluable contributions in the development of these specifications.

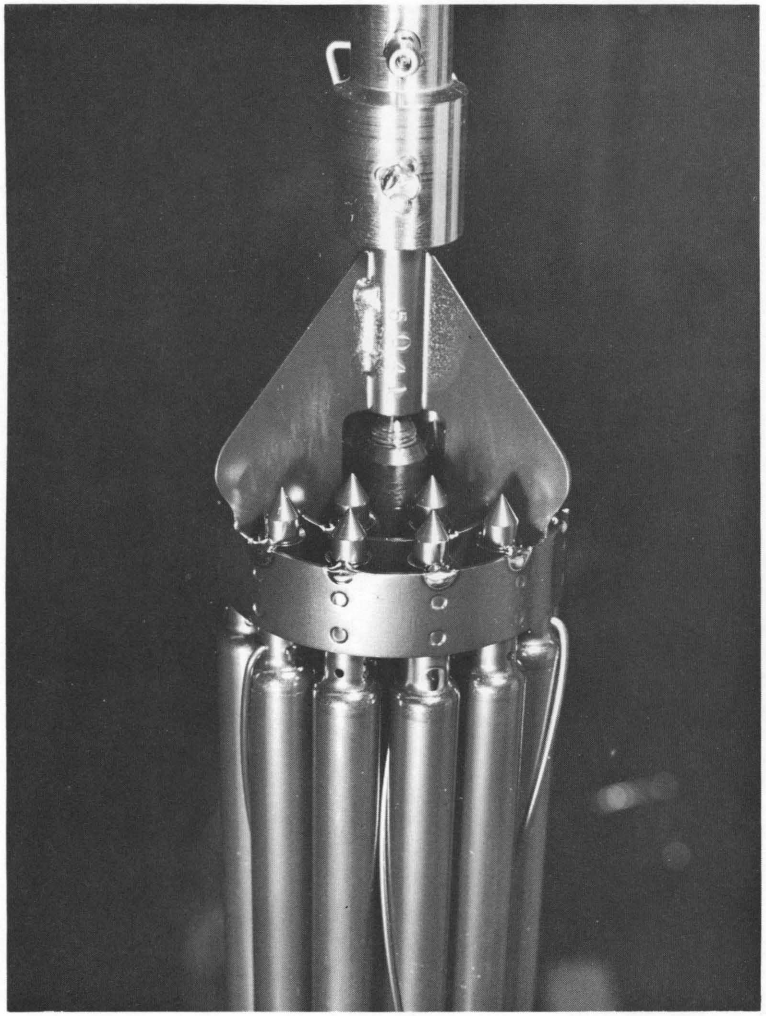


FIGURE 20

Top of Cluster Showing Welded Pins

FIGURE 21

Banding of Cluster

FIGURE 22

Fuel Elment Storage

APPENDIX

Nondestructive Testing of Sheath Tubing at Hanford[6]

The following is an outline of the cleaning steps and nondestructive tests performed on the sheath tubing:

A. Cleaning

1. Outside surface cleaned with detergent and hot water.
2. Inside surface brushed with detergent and hot water.
3. Both inside and outside surfaces vapor degreased.

B. Ultrasonic Test

1. Ultrasonic equipment standardized against outside and inside surface defect standards.
2. Rejection level is between 0. 004 and 0. 002 inch.

C. Eddy Current and Radiograph

1. Each tube is eddy current tested for wall thickness variation using a ten per cent thinning as a rejection level.
2. Each reject tube is radiographed to confirm the eddy current results.

D. White-Light Borescope

1. Each tube is presently white-light borescoped to detect and correlate with the fluorescent penetrant results defects such as impressed material, pits and scratches. The number of tubes examined may be reduced to about ten per cent if correlation with fluorescent penetrant is good.

E. Fluorescent Penetrant

1. Outside and inside surface examined for fluorescent penetrant bleed-back indications.
2. Indications are wiped with a cloth dampened with an alcohol-based developer and allowed to sit for 30 seconds or longer. If indication reappears tube is rejected, if indication does not reappear it is considered spurious.

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