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SUBJECT: Recent Developments in Magnet Design and
Fabrication Procedures (BSR Type Magnets)
TO: Distribution
FROM: J. R. Tallackson and R. T. Santoro

ABSTRACT

This report describes design changes and fabrication techniques intended to improve performance of rod magnets for the Bulk Shielding Reactor II (BSR-II). Magnet performance data is included.

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INTRODUCTION

The development of the Bulk Shielding Reactor II (BSR-II) required a design change which substituted rapid, spring accelerated safety rod insertion for the simple gravity drop previously used in the BSR-I and Pool Critical Assembly (PCA). Spring loading increased the force on the rod magnet by 66 lbs. and, if rod weight and viscous drag in the shock absorbers and guide bushings is included, the load which the magnet must lift exceeds the capability of the average PCA magnet. Space considerations dictated a magnet no larger than the PCA type. Therefore, the basic PCA design was altered by removal of the 0.005 inch air gap at the center pole. This theoretically zero air gap magnet, if made with extreme care, will provide sufficient holding force for the spring loaded shim-safety rods used in the BSR-II.

This zero air gap can never be attained in practice. The sealing can produces an internal air gap which is sensitive to temperature and to fabrication procedures. Since load capacity is a strong function of air gap it became necessary to establish fabrication techniques which minimize the internal air gap and get maximum performance from the magnet material.

This report describes, in detail, the steps that have been taken in an attempt to produce high-load capacity canned magnets (Fig. 1), of consistently uniform quality. It also describes, briefly, an experimental model designed to eliminate the can and its associated air gap.

It should be noted, however, that the attempts which have been made to improve canned magnet performance have been only partially successful. A great deal of effort has been expended in engineering and by the Shop. There has been no completely satisfactory solution to the air gap problem inherent with this design considering the limitations imposed by available space and the mandatory requirement of a sealed can around the magnetic structure.

MAGNET DESIGN AND FABRICATION PROCEDURES

I. Heat Treatment of Ferro-Nickel Core Material:

Originally, the design called for a strain relief anneal at 1650°F in a dry hydrogen atmosphere. This was revised as follows:

1. Parts are to be completely cleaned and degreased before annealing.
2. Furnace atmosphere to be pure, dry hydrogen having a dew point of at least -60°F.
3. Raise the temperature of the work to 2050°F $\pm$ 50°F and hold at this temperature for at least 4 hours.
4. Parts to be cooled in the furnace at a rate not to exceed 100°F per hour until a temperature of 1100°F is reached. Cooling rate may then be increased.

The improvement effected by the higher temperature anneal is illustrated by Fig. 2. Both tests were conducted with the same core and armature. This magnet uses no seal can and hence contains no large air gaps of unknown magnitude; therefore, it is reasonable to assume that the improvement in holding force is entirely due to the change in annealing practice.

II. Fabrication (Refer to Dwg. D-30882 to D-30885 inclusive):

1. A consistent source of trouble in the canned magnet design is the unwanted air gap of unknown magnitude resulting from imperfect contact of the can bottom, Pc. B3, with the pole faces of the core, Pc. A. Refer to either of Assembly Drawings D-30882 or D-30442 which describe the BSR-II and PCA magnets, respectively. These magnet designs are identical with one exception--the PCA design calls for a machined air gap of 0.005 inch. Additional air gap is produced by one or more causes as follows:
 - A. Lack of flatness of the inside face of the can bottom.
 - B. The cylindrical sleeve of the can is not square with the bottom of the can.
 - C. Lack of flatness of the pole faces of the core and lack of squareness of these pole faces referred to the cylindrical axis of core.
 - D. Off-centered assembly of the Magnet Support, Dwg. D-30886, Pc. 4.
 - E. Thermal distortion produced by welding the can to the core assembly.
 - F. Can face and core separation induced by the difference in thermal expansion coefficients of can and core material.

2. The foregoing, A to F inclusive, will now be considered in more detail.

- A. The can assembly is finish machined after assembly. The final machining on the inside face of the can bottom requires a long narrow tool holder with corresponding flexibility and loss of accuracy. It should be kept in mind that flatness tolerances of 0.0005 inch or less are required and the tooling setup necessitated by can geometry is not ideal. If the can is held in a three or four jaw chuck during machining of the face and bore, there is reason to believe that the release of localized clamping pressures when the work is removed from the chuck will result in distortions that will affect performance.
- B. The same general considerations outlined in A) above apply to the problem of machining the outside and inside diameters of the can.

The following tolerances are in order:

- a. Flatness of both sides of can bottom, Pc. B3 should be within 0.0005 inch of a true plane.
- b. Mean inside diameter of the can (average of two diameters measured 90° apart) should be maintained within ± 0.005 inch. Out of roundness; i.e., the difference in inside diameters measured at two places 90° apart should be 0.005 inch or less.
- c. Wall thickness should be held to ± 0.0025 inch.

A machining procedure which has produced satisfactory cans is as follows:

- a. Mount the can sleeve, without the bottom, Pc. B2 on a mandrel and rough turn the outside diameter. Leave sufficient stock (0.030 inch to .040 inch) for subsequent finish machining.
- b. Counterbore one end to accept the can bottom Pc. B3 then braze Pc. B3 to Pc. B2.
- c. Using heavy wall brass tubing or cored bar stock, make a disposable pot chuck, see Fig. 3, and finish machine inside diameter and inside face of can bottom.
- d. With the can mounted on a mandrel, finish machine the outside diameter and outside face of the can bottom. NOTE: The fits over the mandrel and in the pot chuck are to be very light hand push fits which produce a minimum of distortion and necessitate very light cuts.

C-D. Flatness and squareness deviations in the core will result in lowered performance. However, since the core is relatively sturdy the clamping problems are greatly reduced; it is not felt that this has been a source of trouble. The core should be finish machined after the coil is potted and after the core is assembled to the magnet support, Dwg. D-30886, Pc. 4. This will insure that the 2.250 inch diameter welding lip on Pc. 4 is concentric with the magnet outside diameter.

E. Welding the can in place is a critical operation. Recommended procedure is as follows:

Determine the best angular position of the can with respect to the core. This is now done by running a series of holding force tests at constant current with the can at various angular positions referred to the core, Fig. 5 illustrates the results of such a test. The wide spread in holding force readings is attributed to small variations in air gap between can and core and can and armature. The final position selected for this particular magnet was at 100° which gave good values of holding force and, with the exception of one test point, consistent values of holding force.

The foregoing leaves much to be desired. The wide variation in holding force at a particular location is ample proof that the holding force characteristics are extremely sensitive to very minute changes in position. The test procedure is destructive in that the holding force measurement destroys the position information; the exact duplication of a "best position" to use during the welding setup is largely a matter of luck.

It is reasonable to assume that a usable relationship exists between holding force and inductance. Such a method, in which the best position is determined by inductance measured at the time of welding, should be investigated. It is non-destructive of data and would also serve as an inspection technique.

The welding setup is shown on Fig. 6. It was assumed that the can should be in slight axial tension after welding;

therefore the water bath temperature was set at $95^{\circ} \pm 5^{\circ}\text{F}$ so that the difference in thermal coefficients of expansion would produce tension in the can walls at a lower temperature. It is apparent that excessive tension in the can wall will result in bowing at the bottom; zero tension will, in all probability, produce loose axial contact with the can bottom. In either case, excessive air gap and insufficient force result.

III. Design:

The can design was changed by the addition of annular grooves at the upper end as in Fig. 7. The grooves were added to increase flexibility and with the hope that the transmission of thermally induced strains produced by welding would be reduced. Data at this time is insufficient to draw a positive conclusion as to the merit of this idea.

The clearance between the inside diameter of the can and the outside diameter of the core was increased so that the only contact between the can and the core assembly is at the pole faces and at the upper weld. It was further specified, that in setting up to weld, a finite, discernible, radial gap exist between the weld lips on the can and the weld lip on the magnet support, Dwg. D-30886, Pc. 4. This was an effort to eliminate radial interferences which will most certainly produce an air gap between can bottom and the pole faces of the core. Fig. 8, a gamma ray photograph of a finished magnet shows that these clearances were obtained. A set of magnet cans in which the cylindrical portion was made in two pieces, Fig. 9, was made. It was thought that the shorter cup end would facilitate the machining problem on the inside face of the end. The opinion of shop personnel on the effectiveness of this idea is divided.

IV. Design and Development Recommendations:

If more magnets of this type are required the following aspects of the design and fabrication should be explored in an effort to produce magnets which maintain intimate contact between the core and the bottom of the can.

1. Use of can material with a thermal coefficient of expansion more nearly the same as that of the core material. A ferro-nickel can should be considered.
2. Optimization of the temperature at which the assembly is held during welding.
3. Using inductance or some other form of non-destructive test to optimize can location with respect to core.

4. Interposing a constant force device, such as a Belleville spring, which will maintain constant axial force between core and can face.
5. Secure by means of a suitable epoxy resin (Araldite), the can to the core. A suggested method is to obtain optimum can position in accordance with II-2-E above and, with magnet current set to produce a holding force of 100 lbs. or more, inject Araldite in the annular space between can and core. Magnet current would be maintained until the Araldite had cured.

At this time we are unable to obtain high performance canned magnets consistently as a simple shop procedure; considerable engineering follow-up is required and, more often than not, a considerable amount of re-work is involved. This is time-consuming and expensive. It is evident that the principal difficulties are centered on the assembly of the magnet can to the core. The solution of these problems is less evident. The problem of differential expansion of can and core is inherent to the design and unless the can and core can be maintained at virtually constant temperature, or temperature difference, admits no perfect solution.

In support of the above, Figs. 10 and 11 are offered in evidence, these are:

- Fig. 10 - Holding Force vs. Current for 7 magnets of same basic design and fabricated with extreme care and considerable re-working.
- Fig. 11 - Holding Force vs. Current in the "as rec'd" condition from the Shop. These magnets were made in strict accordance with Dwg. D-30882 to D-30885 inclusive, but with no special emphasis placed on critical operations. They were annealed at 1650°F, not at 2050°F and are included only to show the variation in characteristics. Note the wide variation in performance.

RC-84, EXPERIMENTAL MAGNET DESIGN

Investigations have also been made on the characteristics of RC-84, Fig. 13. This is a canless magnet similar in size and interchangeable with the original BSR-II magnet. The design of RC-84 substitutes a rolled-in closure ring between pole pieces of the core for the seal can. The integrity of the closure is checked with a helium leak detector before acceptance. The rolling in procedure has been perfected by the Central Machine Shops. There is, however, only a limited amount of information available on the operating characteristics of this magnet and, although its use at SPERT indicates that it may be a successful design, it is felt that more service data on more magnets must be collected to determine its acceptability. The holding force vs. current characteristics are most satisfactory. Reference to Fig. 2 clearly illustrates this point.

RESULTS OF HIGH TEMPERATURE ANNEALING ON THE MAGNET CAN

It was proposed that the holding force of the magnet would be improved if the magnetic material in the can face was annealed after brazing in place. This was done as instructed in paragraph I.

The results of the annealing are as follows:

1. It was hoped that sufficient stress relaxation would take place during the anneal and produce stress relaxation in the metal. When the can was heated, the effect was lost due to the large difference between the thermal coefficients of expansion of the ferro-nickel pole faces and the stainless steel can and annular ring which separates the pole faces.

Radial cracks developed in the ferro-nickel can bottom, Fig. 12. It was hoped that stress relaxation during the anneal would prevent this. In the temperature range from 0°F to 400°F the coefficients of thermal expansion for stainless steel and ferro-nickel are 9×10^{-6} in/in/°F respectively. This large difference in expansion coefficients is responsible for the thermal stresses which produced the radial cracks during the annealing cycle.

2. The holding force was not improved as a result of the annealing nor was it obviously reduced. This observation cannot, however, be considered as bona fide since the effect of heat treatment produced distortions in the can which may have altered the geometry. As a result holding force characteristics could not be compared with previous tests.
3. The cans have been rebuilt using pre-annealed ferro-nickel and constructed per the attached memo from Mr. W. O. Wilson, Shop Foreman, Central Machine Shops. Test data on these magnets will be presented at a later date.

March 29, 1960

To: R. T. Santoro

Re: Magnet Cans
Print D-30883

Part B-3 (Magnet Can Bottom) was made according to the print with the exception that the 8-1/4" drilled holes were omitted and a 3/16" drill was used. This left a web of approximately 1/32" between the holes.

This procedure was followed so that the difference in expansion rates between Ferro-Nickel and Stainless Steel would not cause the Ferro-Nickel parts to crack when silver soldered.

On Part B-4 (Magnet Can Seal Ring) the dimensions (1.972 and 1.200) were changed to 1.960 and 1.205. This change gave .005" diametral clearance on bore to inner ring and .015" diametral clearance to outer ring. To solder parts together, heat was applied to center of can bottom, heating from center to outside. By the time the part was heated to temperature, each component was in a relaxed position with enough clearance for silver solder to flow freely.

The outer portion of part B-3 was made to a diameter of 2.300" with a close (.001 to .002) fit to magnet can sleeve (part B-2). All assemblies were vacuum checked to insure the absence of leaks.

H. Q. Wilson
W. O. Wilson

CONCLUSIONS AND RECOMMENDATIONS

1. The separate welded can design specified by Dwg. D-30882 and D-30442 is marginal in performance if the magnet load exceeds 75 lbs.

2. This design (1 above) is difficult to fabricate, costly, and characterized by lack of product uniformity. It performs satisfactorily when used to retain light, gravity accelerated rods.

3. Further investigations of RC-84, described above, should be made. This type of magnet should eliminate a great number of the problems described herein and if preliminary tests are indicative it will be an improvement in terms of costs, holding force characteristics and reproducibility.

<u>No.</u>	<u>Title</u>
1.	Magnet Assembly (Dwg. 30882)
2.	Experimental Magnet RC-84 Performance Curves Illustrating Annealing Effects
3.	Pot Chuck Setup for Finish Machining I.D. of Can and Inside
4.	Can Orientation Setup
5.	Can Orientation Test (Typical) for Optimum Position Selection
6. and 6a.	Welding Procedure Drawings
7.	Can Design Change (Showing Grooves)
8.	Gamma Ray Photograph of Assembled Magnet
9.	Two-Piece Can
10.	Force vs Current Curves of Magnets (PCA "X", BSR-II-No. 4, BSR-II-No. 2, 8-X-59-2, Magnets 10-21-59-1 to 10-39-59-4 incl.
11.	Force vs Current Curves for BSR-II Magnets 1 to 4 incl., with 1650°F anneal
12.	Photograph Showing Cracked Can Resulting from High Temperature Annealing
13.	Experimental Magnet Assembly - RC-84

ACKNOWLEDGEMENT

The authors wish to thank Mr. W. O. Wilson, Central Machine Shops, and his staff for their assistance and suggestions vital to this report. We also thank Mr. C. B. Stokes, Instrumentation and Control Division for his assistance in collecting data and, Mr. H. J. Wallace, Metallurgy Division, for his help in annealing the magnet materials.

PARTS LIST

PART NO	QTY	DESCRIPTION (NAME, SIZE, ETC.)	MATERIAL
1	1	MAGNET CORE ASSEMBLY	
2	1	MAGNET CAN ASSEMBLY	
3	1	MAGNET COIL ASSEMBLY	
4	1	CONTROL PLATE ACCELERATOR SPRING	302 S.S.
5	1	SWITCH MOUNTING COLLAR 1/8" X 1/8" X 1/8"	1100 ALUM.
6	1	SOCKET CAP SCREW #10-24 NC 2 X 1/8" LONG	S.S.
7	1	MAGNET SUPPORT - SEE DETAIL	304 S.S.
8	1	SOCKET CAP SCREW #10-24 NC 2 X 1/8" LONG	S.S.
9	1	ACCELERATOR TUBE ASSEMBLY	304 S.S.
10	1	MICRO-SWITCH - CAT NO 1251-1	
11	1	ROUND HEAD MACH SCREW #2-56 NC 2 X 1/4"	302 S.S.
12	1	SPRING - OBSOLETE WIRE - SEE DETAIL	302 S.S.
13	1	RETAINING RING - 1/8" X 1/8" X 1/8" HUBBARD HUBBARD	420 S.S.
14	1	PUSH ROD - SEE DETAIL	302 S.S.
15	1	SET SCREW-HEX SOCKET - 1/8" X 20 NC 2 X 1/4" LONG	S.S.
16	1	FINISHED HEX JAM NUT - 1/8" X 20 NC 2	S.S.
17	1	SPRING RETAINER	304 S.S.

FIGURE 1

SEAL WELD CAN ASSEMBLY TO MAGNET SUPPORT:

1. ATTACH A 45 VOLT BATTERY TO MAGNET LEADS AND PLACE ARMATURE Ø30x77-7 AGAINST BOTTOM FACE.
2. INVERSE MAGNET IN WATER UP TO SEAL WELD, BEFORE WELDING.
3. AFTER SEAL WELDING, HELIUM LEAK TEST THE ASSEMBLY.

NOTE:

THIS ASSEMBLY IS PART 26 OF CONTROL ELEMENT ASSEMBLY E 30875

ACCELERATOR TUBE ASSEMBLY	D30877
SWITCH MOUNTING COLLAR	D30886
CONTROL PLATE ACCELERATOR SPRING	C30880
MAGNET COIL ASSEMBLY	D30885
MAGNET CORE ASSEMBLY	D30884
MAGNET CAN ASSEMBLY	D30885
CONTROL ELEMENT ASSEMBLY	E30875
REFERENCE DRAWINGS	QWG NO.
BULK SHIELDING REACTOR II	REF 8010

MAGNET ASSEMBLY

OMI RADIATION LABORATORY
UNION CARBIDE NUCLEAR COMPANY
A DIVISION OF UNION CARBIDE CORPORATION
OMI BLDG, YORKTOWN, N.Y.

DESIGNED BY *E. S. Allen*
CHECKED BY *E. S. Allen*
DATE *1-7-58*

D-30882

LTR	REVISIONS	DATE	APPD	APPD
1	1-7-58	C. Allen	1-7-58	
2	1-7-58	C. Allen	1-7-58	

GENERAL SPECIFICATIONS:
1. Break all sharp edges 1/32" max., unless otherwise specified.
2. The fabricator may choose the type, grade or finish of material unless otherwise specified.
MACHINE FINISH SPECIFICATIONS:
1. Finish grade shall be in accordance with ASA Standard B46.1-1957.
2. Dimensions shown are the maximum authorized tolerance.
3. The tolerance for dimensions indicated, unless noted, shall be as follows:
FRACTIONS: ± .005
DECIMALS: ± .005
INCHES: ± .005
SCALE: FULL SIZE

CLASSIFICATION
UNCLASSIFIED
DATE BY *E. S. Allen*
REVISIONS: 1
REASON: 1
SCALE: FULL SIZE

PARTS LIST

PART NO.	DWG NO.	QTY	DESCRIPTION (NAME, SIZE, ETC.)	MATERIAL
B-1	This Sheet	1	Magnet Can Sleeve - 2" Sch. #40 Pipe x 5 1/2" Long	SST-304
B-2	This Sheet	1	Magnet Can Bottom - 2" 500 Dia. x 5/8" Thick	SST-304
B-3	This Sheet	1	Magnet Can Seal Ring - 1.975 Dia. x 3/8" Thick	SST-304

Die Ref. F-1 - Fit With Part B-4 This Sheet

1.975

1.200

Die Ref. F-1 - Fit With Part B-4 This Sheet

B-3 MAGNET CAN SEAL RING
Mat'l - SST 304
1 Req'd
Scale: 1" = 1"

GENERAL SPECIFICATIONS:

- Break of sharp edges 1/16 max. unless otherwise specified.
- The fabricator may choose the type, grade or finish of material unless otherwise specified.

MACHINE FINISH SPECIFICATIONS

- Finish symbols are in accordance with ASA Standard B46.1 (1963).
- Roughness height values are the maximum statistical average deviation from the mean surface, expressed in microinches.
- For surfaces not otherwise indicated, roughness height shall not exceed 32/.

Magnet Assembly		D-30883
REFERENCE DRAWINGS		DWG NO.
BULK SHIELDING REACTOR II		REV. 3010
B MAGNET CAN ASSEMBLY & DETAILS		
OAK RIDGE NATIONAL LABORATORY OPERATED BY UNION CARBIDE NUCLEAR COMPANY A DIVISION OF UNION CARBIDE AND CARBON CORPORATION OAK RIDGE, TENNESSEE		
SUBMITTED	APPROVED	DATE
J. R. [Signature]	[Signature]	11-1-51
D-30883		REV.

LTR	REVISIONS	DATE	APPROVED	DATE
1	1	11-1-51	[Signature]	11-1-51
2	2	11-1-51	[Signature]	11-1-51
3	3	11-1-51	[Signature]	11-1-51
4	4	11-1-51	[Signature]	11-1-51
5	5	11-1-51	[Signature]	11-1-51

$\frac{1}{8}$ " Drill x $\frac{1}{8}$ " Deep

#21 (159) Drill x $\frac{1}{8}$ " Deep
#10-32 NF-2 Bottom Tap
4 Holes Equally Spaced
Match with Pt No 4 Draw D-30886

NOTE: See Assembly Procedure This Sheet

A-1 MAGNET CORE ASSEMBLY
Scale: 1" = 1"

A-2 INSIDE POLE
Mat'l - Ferromagnetic Alloy (47% Ni - 53% Fe)
1 Req'd.
Scale: 1" = 1"

A-3 OUTSIDE POLE
Mat'l - Ferromagnetic Alloy (47% Ni - 53% Fe)
1 Req'd.
Scale: 1" = 1"

A-1 YOKE SUPPORT
Mat'l - SST 347
1 Req'd.
Scale: 1" = 1"

A-4 POLE ALIGNMENT FIXTURE
Mat'l - SST 347
1 Req'd.
Scale: 1" = 1"

A-5 POLE ALIGNMENT FIXTURE
Mat'l - SST 347
1 Req'd.
Scale: 1" = 1"

PARTS LIST

PART NO.	DWG NO.	NO. REQ'D.	DESCRIPTION (NAME, SIZE, ETC.)	MATERIAL
A-1	This Sheet	1	Yoke Support - 1.400 Dia. x 1.200 lg.	SST-347
A-2	This Sheet	1	Outside Pole - 2.240 Dia. x 3.00 lg.	Ferromagnetic Alloy
A-3	This Sheet	1	Inside Pole - 1.975 Dia. x 3.00 lg.	Ferromagnetic Alloy
A-4	This Sheet	1	Pole Alignment Fixture - 2.000 Dia. x 3.00 lg.	SST-347
A-5	This Sheet	1	Pole Alignment Fixture - 1.975 Dia. x 3.00 lg.	SST-347

ASSEMBLY PROCEDURE

- 1- Weld Inside Pole, Part A-3, To Yoke Support, Part A-1, Using Inconel Rod.
- 2- Weld Inside Pole & Yoke Support Assy. To Outside Pole, Part A-2, With Pole Alignment Fixture, Part A-4, in Place.
- 3- With Pole Alignment Fixture, Part A-4, in Place Stress Anneal Magnet Core Assy. At 1650° F in a Hydrogen Atmosphere And Furnace Cool.
- 4- Drill (And Tap) Required Holes And Machine 1.375 Dia.
- 5- Slot Outside Pole & Face Of Inside Pole With $\frac{1}{8}$ " Wide Milling Cutter.
- 6- Slot Remainder Of Inside Pole With 23 Gauge, 18 Tooth, Raker Set Band Saw, With Pole Alignment Fixtures, Parts A-4 & A-5 in Place. Remove All Burrs.

GENERAL SPECIFICATIONS:

1. Break all sharp edges 1/64 max. when otherwise specified.
2. The fabricator may choose the type, grade or finish of material when otherwise specified.

MACHINE FINISH SPECIFICATIONS:

1. Finish symbols are in accordance with ASA Standard B46.1 - 1947.
2. Roughness height values are the maximum arithmetical average deviation from the mean surface, expressed in microinches.
3. For surfaces not otherwise indicated, roughness height shall not exceed 32.

THIS DRAWING CLASSIFIED UNCLASSIFIED	
DATE	BY
10-25-58	J. L. W.
LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED	
FRACTIONS	± .005
DECIMALS	± .005
ANGLES	± .01°
SCALE As Noted	

Magnet Assembly - Detail Sheet # 1	
D-30886	D-30886
REFERENCE DRAWINGS	
DWG NO.	DWG NO.
BULK SHIELDING REACTOR II	
A MAGNET CORE ASSEMBLY & DETAILS	
OAK RIDGE NATIONAL LABORATORY	
OPERATED BY UNION CARBIDE NUCLEAR COMPANY	
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION	
OAK RIDGE, TENNESSEE	
DESIGNED BY	ACCEPTED BY
J. L. W.	J. L. W.
D-30884	

LIT.	REVISIONS	DATE	APPROVED	APPROVED
DRAWING NO D-30884				
DESIGN	DATE	DESIGNED	DATE	APPROVED
J. L. W.	10-25-58	J. L. W.	10-25-58	J. L. W.
ENGINEER	DATE	ENGINEER	DATE	APPROVED
C. J. W.	10-25-58	C. J. W.	10-25-58	C. J. W.

Technical drawing of a circular plate with the following specifications:

- Overall Diameter: 100
- Outer Holes: 6 holes, each with a diameter of $\frac{1}{2}$ Drill Thru, spaced at 30° intervals.
- Inner Holes: 6 holes, each with a diameter of $\frac{1}{8}$ Drill Thru, spaced at 30° intervals.
- Center Holes: 6 holes, each with a diameter of $\frac{1}{8}$ Drill Thru, spaced at 30° intervals.
- Bottom Drilling: 3 Holes, each with a diameter of $\frac{1}{8}$ Drill Thru.

NOTES
 1 THIS DRAWING IS IDENTICAL TO DWG D 30445
 EXCEPT THAT NO RETAINING RING IS REQUIRED
 HERE

- 1 Finish all sharp edges 1/64 max. unless otherwise specified
- 2 The fabricator may choose the type, grade or finish of material unless otherwise specified

- 1 Finish symbols are in accordance with ASA Standard B46.1 - 1947
- 2 Roughness height values are the maximum arithmetic average deviation from the mean surface expressed in microns/inches
- 3 For surfaces not otherwise indicated, roughness height shall not exceed $\frac{0.005}{\sqrt{R}}$

- 3- Solder Lead In Conduit, Carry C-3, To Magnet Core Assy
- 4- Insert Ignition Tubing, Part C-4, In Boss As Shown
- 5- Insert Magnet Coil Leads Through Ignition Tubing And Align Coil With Respect To The Lead In Holes
- 6- Cement Coil In Place Using Dux Cement
- 7- Vacuum Impregnate This Assy To Top Of Slots Plus 1/2" Minus 0.0"
- 8- After Curing For 72 Hours, Vacuum Impregnate Lead-In Conduit, Filling Core To Insure Complete Filling Of Tube. There Must Be No Traps Which Can Collect Water
- 9- After An Additional 72 Hour Curing, Machine Assy To Finished Dimensions. Remove Araldite To Bare Metal On Face And Undercut Araldite Old Dues Between Poles

VACUUM IMPREGNATING SPECIFICATIONS
 Wind Friction Tape Around Yoke Support To Protect Hoist
 Partially Fill A Suitable Polyethylene Tube With Anhydride Al_2SO_4
 (8% Accelerator) Suspend Assy By Wire And Submerge Until
 Anhydride Level Reaches The Top Of The Slots If Cart Is Taken Not
 To Be Too Much Air Into Argonite While Adding Accelerator.
 The Remaining Bubbles Can Be Removed By Alternately Vacuum
 Pumping And Admitting Air Evacuation Must Stop As Soon As The
 Plastic Begins To Thicken. The Polyethylene Tube Must Be Partially
 Submerged In Water To Prevent overheating During The Process.
 The Impregnated Assy. Must Be Cured For 72 Hours Before Working.

MAGNET COIL - ASSEMBLY & DETAILS	D-30465
Magnet Core Assembly & Details	D-30466
Magnet Assembly	D-30462
REFERENCE DRAWINGS	DWG. NO.
BULK SHIELDING REACTOR II	
DRAWING NO. 3010	
(C) MAGNET COIL ASSEMBLY & DETAILS	
OAK RIDGE NATIONAL LABORATORY OPERATED BY UNION CARBIDE NUCLEAR COMPANY A DIVISION OF UNION CARBIDE AND CARBON CORPORATION OAK RIDGE, TENNESSEE	
APPROVED	APPROVED
G. R. Ray	E. F. Blair
	F. W. W. W.
	D-30465

Fig. 2.

TYPICAL POT CHUCK SETUP FOR FINISH
MACHINING I.D. OF CAN AND INSIDE

Fig. 3.

BSR II MAGNET FABRICATION
PROCEDURE USED TO OBTAIN OPTIMUM
CAN POSITION WITH RESPECT TO COIL

1. The Reactor Control Dept. set-up using Magnet Amplifier Pulser. (Any good, stable power supply with a current meter will suffice.) was used as a current source. Load was measured on a Baldwin Load Cell and recorded on a Brown recording potentiometer.
2. A series of labeled witness marks were placed on upper edge of can. These are marks A, B, C, etc., on sketch at left. A single witness mark is placed on the core.
3. Additional witness marks are placed on the bottom edge of can and armature to obtain reproducible positioning of can and armature during the test procedure.
4. The can and armature, using witness marks per (3) above, are centered to eyeball accuracy and slid vertically up and over core until the can bottom contacts the core. (During this operation care must be observed to prevent applying any lateral force to the can.) and voltage is applied to the magnet. Magnet current MUST be maintained at same value during test.
5. The can - core witness mark correspondence was noted, current checked and load applied until armature dropped. This procedure was repeated several times at each position (A, B, C, etc.) to insure consistent performance at each point or to establish, with certainty, that behavior at a particular position is inconsistent within the accuracy limitations of the test procedure.
6. The procedure (4) and (5) above was repeated at each point. Data was examined and additional locations were tested in an effort to obtain a location giving maximum force. The best angular location of can with respect to the core was thus selected and a final, bold witness mark placed on the can. This mark is the one referred to on FIGURE-5, and used to determine can location during final seal welding.

Fig. 4.

DURING TEST CAN WAS ROTATED WITH RESPECT TO CORE AND THE DIFFERENT POSITIONS NOTED BY INDEX POINTS PER SKETCH.

COIL CURRENT, ALL TESTS 200 MA

Fig. 5.

Fig. 6.

ORNL-LR-Dwg.-50824
UNCLASSIFIED

WITH ARMATURE ON THE FACE OF THE CAN
AND WITH MAGNET ENERGIZED (30 TO 40 VOLTS)
THE SIDES OF THE MAGNET CAN MUST NOT BE IN
CONTACT WITH THE SIDES OF THE MAGNET CORE.

REFER TO:
D-30882 AND FIGURE 6

BSR II
MAGNET ASSEMBLY
AUXILIARY SKETCH

Fig. 6 A.

ORNL-LR-Dwg.-50825
UNCLASSIFIED

-18-

THIS IS A REVISION TO DRAWING D30883, MAGNET CAN ASS'Y, BSR II MAGNET

MAGNET CAN GROOVING

Fig. 7

Fig. 8.

ORNL-LR-Dwg.-50826
UNCLASSIFIED

2 PIECE CAN

MADE IN AN ATTEMPT TO FACILITATE
MACHINING THE INSIDE FACE (A)

Fig. 9.

Fig. 10.

Fig. 11.

ORNL Photo 48768
UNCLASSIFIED

Fig. 12.

PARTS LIST

PART NO.	DWG. NO.	NO. REQD.	DESCRIPTION (NAME, SIZE, ETC.)	MATERIAL
----------	----------	-----------	--------------------------------	----------

ORNL-LJ-DWG. 50020
UNCLASSIFIED

PL # 018882
018882

WELD PINS LOCATED PER
1/2 IN. 018882 AND
ASSOCIATED CHRS

MAGNET COIL
DIA 018882

THESE SURFACES TO
BE IN SAME PLANE
WITHIN 0.005 IN. TO
WELD PINS. PINS
NOT EXCEED 0.005 IN.

DETAIL

WELD PINS TO BE IN
SAME PLANE WITHIN 0.005 IN.
TO WELD PINS. PINS
NOT EXCEED 0.005 IN.

BEFORE EXPAND LIT IN 10% DIA
INTO HOLE

INSIDE POLE
1.075 DIA
MATERIAL: FERRONICKEL
83% NI, 54% Fe

THESE DIMS TO PROVIDE DIA 1.075
INDEPENDENT DIA OF PL 018882 AND
PL 018882

SCALE RING
1.075 DIA
MATERIAL: 304 SS

OUTSIDE POLE
1.075 DIA
MATERIAL: FERRONICKEL
83% NI, 54% Fe

NO.	REVISIONS	DATE	APPD	APPD
DRAWING NO. D-				
DRAWN	DATE	CHECKED	DATE	APPROVED
DESIGNED	DATE	SUBMITTED	DATE	APPROVED

THIS DRAWING CLASSIFIED
AS
PER
LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED
FRACTIONS: 2
DECIMALS: 2
ANGLES: 2
SCALE

FIGURE 13
REFERENCE DRAWINGS
DWG. NO.
BLDG. NO.
MATERIAL: 304 SS - FOR TYPE WITH MODIFIED TENSILE STRENGTH
OAK RIDGE NATIONAL LABORATORY OPERATED BY UNION CARBIDE NUCLEAR COMPANY A DIVISION OF UNION CARBIDE AND CARBON CORPORATION OAK RIDGE, TENNESSEE
SUBMITTED
ACCEPTED
APPROVED
DATE: 3-26-59
REV
D-RC-04

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