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DEVELOPMENT AND EVALUATION OF MAGNETIC AND ELECTRICAL MATERIALS CAPABLE OF OPERATING IN THE 800° TO 1600°F TEMPERATURE RANGE

First Quarterly Report

by

P. E. Kueser et al

prepared for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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FIRST QUARTERLY REPORT
(NOVEMBER 12, 1964 - FEBRUARY 28, 1965)
NAS3-6465

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
CONTRACT NAS3-6465

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Space Power Systems Division
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PREFACE

The work reported here was sponsored by the Space Power Systems Division of the NASA Lewis Research Center under contract NAS3-6465. Mr. R. A. Lindberg of NASA has provided the Project Management for the program. His review and suggestions as well as those of Mr. T. A. Moss, also of NASA, are gratefully acknowledged. The Westinghouse Aerospace Electrical Division (WAED) is responsible for the Technical Direction of the program. The Westinghouse Research and Development Center (WR&D) is conducting Tasks 2, 3 and 4 of Program I on Optimized Magnetic Materials for Application in the 1000 to 1200°F Range, the Investigation for Raising the Alpha to Gamma Transformation, and Creep Testing of Rotor Materials. Eitel-McCullough (EIMAC) is responsible for the Bore Seal Development, Task 1 of Program III. All other tasks are being conducted at the Westinghouse Aerospace Electrical Division (WAED).

In a program of this magnitude a large group of engineers and scientists are involved in its progress. An attempt to recognize those who are contributing directly, together with their area of endeavor, follows:

Program I - Magnetic Materials for High Temperature Operation

Task 1 - Optimized Precipitation Hardened Magnetic Materials for Application in the 1000 to 1200°F Range.

Dr. K. Detert (WR&D); J. W. Toth (WAED)

Task 2 - Investigation for Raising the Alpha to Gamma Transformation Temperature in Cobalt-Iron Alloys.

Dr. K. Detert (WR&D); J. W. Toth (WAED)

Task 3 - Dispersion-strengthened Magnetic Materials for Application in the 1200-1600°F Range.

Dr. R. J. Towner (WAED)

Task 4 - Creep Testing.

M. Spewock (WR&D); D. H. Lane (WAED)

Program II - High Temperature Capacitor Feasibility

R. E. Stapleton (WAED)

Program III - Bore Seal Development and Combined Material Investigation Under a Space Simulated Environment

Task 1 - Bore Seal Development

R. C. McRae, Dr. L. Reed (EIMAC); J. W. Toth (WAED)

Tasks 2, 3, 4 - Stator and Bore Seal, Transformer and Solenoid

W. L. Grant, H. .E. Keneipp, D. H. Lane, R. P. Shumate, J. W. Toth (WAED)

Dr. A. C. Beiler (WAED) and Dr. G. W. Weiner (WR&D) are acting as consultants on Program I.

ABSTRACT

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This is the first quarterly report on Contract NAS3-6465 for the Development and Evaluation of Magnetic and Electrical Materials Capable of Operating in the Temperature Range from 800°F to 1600°F. Advanced space electric power systems are the area of eventual application.

Program I is directed at developing high-temperature magnetic material with satisfactory strength for rotor use. The ternary alloy systems of cobalt-nickel-iron are under study with the cobalt and iron corners of the phase diagram. Thirty to forty per cent cobalt gives the greatest saturation at 600°C. The additions of beryllium to a composition of 15% nickel-25% cobalt-balance iron improves the stability of the alpha phase. Eighteen pre-alloyed atomized powders and 12 composite powders have been examined for use as dispersion-strengthened magnetic materials.

Program II will determine the feasibility of a high-temperature capacitor using high quality dielectric materials. Pyrolytic boron-nitride has been prepared in thicknesses of 0.0015 ± 0.0005 inches; Lucalox alumina rods to 0.006 inches thick.

Program III incorporates combinations of materials into a stator with bore seal, a transformer, and a solenoid for investigations of compatibility under electrical stress and space-simulated conditions of elevated temperature. A system for loading and sealing alkali-metals in vacuum is in the progress of assembly. The stator, transformer and solenoid designs for use in space-simulated testing have been completed.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

TABLE OF CONTENTS (Cont.)

LIST OF FIGURES

LIST OF TABLES

SECTION I

INTRODUCTION

This is the first quarterly report on Contract NAS3-6465 for the Development and Evaluation of Magnetic and Electrical Materials Capable of Operating in the Temperature Range from 800°F to 1600°F. The period of performance is from November 12, 1964 through February 28, 1965. The program consists of three Programs with their related tasks as follows:

Program I - Magnetic Materials for High-Temperature Operation

- Task 1 - Optimized Precipitation Hardened Magnetic Materials for Application in the 1000 to 1200°F Range
- Task 2 - Investigation for Raising the Alpha to Gamma Transformation Temperature in Cobalt-Iron Alloys
- Task 3 - Dispersion-Strengthened Magnetic Materials for Application in the 1200 to 1600°F Range
- Task 4 - Creep Testing

Program II - High-Temperature Capacitor Feasibility

Program III - Bore Seal Development and Combined Material Investigations Under a Space Simulated Environment

- Task 1 - Bore Seal Development
- Task 2 - Stator and Bore Seal
- Task 3 - Transformer
- Task 4 - Solenoid

In Program I, limitations in magnetic material performance at elevated temperature have been recognized from Contract NAS3-4162 and the development of materials incorporating improved magnetic and mechanical properties is being pursued. In most cases, high-strength compromises the magnetic properties; therefore, a balance between these two variables is sought.

Program II is directed at determining the feasibility of applying high-quality dielectric materials and their processes to a high-temperature (1100°F) capacitor which is lightweight and suitable for static power conditioning apparatus used in space applications.

Program III incorporates combinations of materials previously evaluated under Contract NAS3-4162 into a stator with a bore seal, a transformer, and a solenoid; all of which will be evaluated under space-simulated conditions at elevated temperature.

The three Programs will be reported consecutively in Sections II, III and IV. Each of these Sections is further subdivided into a summary of the technical progress, a discussion, and the program for the next quarter.

SECTION II

PROGRAM I - MAGNETIC MATERIALS FOR HIGH-TEMPERATURE OPERATION

Program I is directed at the improvement and further understanding of magnetic materials suitable for application in the rotor of an alternator or motor in advanced space electric power systems.

Task 1 is concerned with precipitation-hardened magnetic materials in the 1000 to 1200°F range. These materials are of the iron-cobalt-nickel ternary system. The two specific areas of interest are the iron and cobalt corners of the ternary system.

Task 2 is a small research investigation for determining the feasibility of raising the alpha to gamma transformation temperature in the iron-cobalt system; thereby increasing the useful magnetic temperature of this system.

Task 3 is directed at applying dispersion-strengthening mechanisms to magnetic materials to achieve useful and invariant mechanical and magnetic properties in the 1200 to 1600°F range. Because both variables are influenced differently by particle size and spacing, a compromise is sought thereby tailoring the materials to the need of dynamic electric machines.

Task 4 is a creep program on Nivco alloy (approximately 72% cobalt, 23% nickel and certain other elements) which will generate 5000 hour design data in a vacuum environment (1×10^{-6} torr). This material represents a presently available magnetic material with the highest useful application temperature.

A. TASK 1 - OPTIMIZED PRECIPITATION-HARDENED MATERIALS FOR HIGH-TEMPERATURE APPLICATION.

1. Summary of Technical Progress

a.) Twenty ferritic and twenty cobalt base alloys were selected and approved for evaluation as high-strength magnetic alloys.

b.) All of the ferritic alloys and most of the cobalt-base alloys have been melted.

c.) Transformation temperatures of ten ferritic alloys were determined during fast and slow cooling. Several of these alloys were subjected to isochronal aging between 842°F (450°C) and 1202°F (650°C). Hardness and coercivity were tested at room temperature.

d.) Magnetic saturation measurements at room temperature were made on all of the ferritic alloys.

e.) Three of the cobalt base alloys have been subjected to isochronal aging between 932°F (500°C) and 1382°F (750°C). Hardness and coercivity were determined at room temperature.

2. Discussion

A suitable alloy composition must be found which gives good strength at elevated temperatures combined with good magnetic properties. The target ultimate tensile strength for the alloy at 1100°F is 125,000 psi or better. The target stress to produce 0.40% creep strain in 1000 hours at 1100°F is 76,000 psi or greater. The 10,000 hour stress target at 1100°F is 80 to 90% of that at 1000 hours. The target magnetic saturation for the developmental alloy is 13,000 gauss or better at 1100°F and a coercive force less than 25 oersteds. In order to screen a variety of compositions, the Vickers hardness, coercivity, magnetic saturation, and temperature stability of the magnetic phase were selected as suitable parameters to evaluate the different alloy compositions.

Two general areas of basic alloy composition are regarded as most hopeful. First, body-centered ferritic alloys of iron and cobalt using additional components for obtaining high strengths by a precipitation hardening mechanism (Group A). Second, cobalt base alloys with alloying additions to obtain precipitation strengthening (Group B).

In the ferritic alloys, the maraging treatment gives high strength compared to highly alloyed carbon steels. The maraging treatment requires a certain amount of nickel present (15% - 25%) in the alloy. One goal of the screening program will be to find a suitable composition which can make use of a maraging treatment applied to a Fe-Co alloy with sufficient temperature stability of the alpha phase.

In the cobalt base alloys, another strengthening mechanism will be tried. This mechanism gives rise to considerable strengths in nickel-cobalt alloys by the formation of the face centered, ordered cubic phase (Ni_3Al) designated gamma prime. The formation of gamma prime, however, requires the presence of a certain amount of nickel in the alloy.

The Group A alloys 1-A-1 to 1-A-10 (Table II-1) were selected based on a review of literature and on results available from previous studies by Westinghouse. The composition, 15 nickel and 25 cobalt, will allow a martensitic transformation which is a prerequisite for maraging treatment. Furthermore, it has been established that stability of the alpha phase can be expected up to 1202°F (650°C) for 500 to 1000 hours. The influence of titanium, molybdenum and tantalum has been recognized as suitable for maraging treatment. W, Nb, V, Cr, Al, Be, Sb, Sn, Si and Mn will be evaluated for their potential to exert a strengthening influence on a maraging treatment. The effect of alloying on the temperature of transformation will be checked to determine whether the martensitic transformation can be applied and whether the martensitic phase is sufficiently stable at temperature.

Tests on the Group A alloys 1-A-11 to 1-A-20 (Table II-1) will define a suitable composition which is lower in nickel (12%). It is expected that saturation will be increased compared to the 15 nickel containing alloys. However, there is some doubt whether a martensitic transformation will occur during cooling.

In the cobalt-base alloys, the series 1-B-1 to 1-B-12 (Table II-2) will produce some information as to the region in which high saturation is attained and what portion will be sacrificed when nickel is added to obtain a suitable strength by gamma prime formation. The alloys 1-B-13 to 1-B-15 were selected to define the role of nickel in achieving strength by the formation of gamma prime.

TABLE II-1. Group A - Precipitation-Hardening Alloys

Number	Nominal Alloy Composition (Weight Percent)
1-A-1	55 Fe - 15 Ni - 25 Co - 5 W
1-A-2	58 Fe - 15 Ni - 25 Co - 2 Nb
1-A-3	58 Fe - 15 Ni - 25 Co - 2 V
1-A-4	58 Fe - 15 Ni - 25 Co - 2 Cr
1-A-5	59.5 Fe - 15 Ni - 25 Co - 0.5 Al
1-A-6	58 Fe - 15 Ni - 25 Co - 2 Be
1-A-7	58 Fe - 15 Ni - 25 Co - 2 Sb
1-A-8	58 Fe - 15 Ni - 25 Co - 2 Sn
1-A-9	58 Fe - 15 Ni - 25 Co - 2 Si
1-A-10	58 Fe - 15 Ni - 25 Co - 2 Mn
1-A-11	88 Fe - 12 Ni
1-A-12	83 Fe - 12 Ni - 5 Co
1-A-13	78 Fe - 12 Ni - 10 Co
1-A-14	73 Fe - 12 Ni - 15 Co
1-A-15	68 Fe - 12 Ni - 20 Co
1-A-16	63 Fe - 12 Ni - 25 Co
1-A-17	58 Fe - 12 Ni - 30 Co
1-A-18	53 Fe - 12 Ni - 35 Co
1-A-19	48 Fe - 12 Ni - 40 Co
1-A-20	43 Fe - 12 Ni - 45 Co

TABLE II-2. Group B - Precipitation-Hardening Alloys

Number	Nominal Alloy Composition (Weight Percent)
1-B-1	95 Co - 5 Fe
1-B-2	90 Co - 5 Fe - 5 Ni
1-B-3	85 Co - 5 Fe - 10 Ni
1-B-4	80 Co - 5 Fe - 15 Ni
1-B-5	75 Co - 5 Fe - 20 Ni
1-B-6	70 Co - 5 Fe - 25 Ni
1-B-7	65 Co - 5 Fe - 30 Ni
1-B-8	85 Co - 10 Fe - 5 Ni
1-B-9	80 Co - 15 Fe - 5 Ni
1-B-10	75 Co - 20 Fe - 5 Ni
1-B-11	70 Co - 25 Fe - 5 Ni
1-B-12	65 Co - 30 Fe - 5 Ni
1-B-13	86 Co - 5 Fe - 5 Ni - 3 Ti - 1 Al
1-B-14	81 Co - 5 Fe - 10 Ni - 3 Ti - 1 Al
1-B-15	76 Co - 5 Fe - 15 Ni - 3 Ti - 1 Al
1-B-16	81 Co - 10 Fe - 5 Ni - 3 Ti - 1 Al
1-B-17	76 Co - 15 Fe - 5 Ni - 3 Ti - 1 Al
1-B-18	71 Co - 20 Fe - 5 Ni - 3 Ti - 1 Al
1-B-19	66 Co - 25 Fe - 5 Ni - 3 Ti - 1 Al
1-B-20	61 Co - 30 Fe - 5 Ni - 3 Ti - 1 Al

a. EXPERIMENTAL PROCEDURE

All of the alloys were prepared by the levitation melting technique. In general, about 20 grams of the pure constituents, present as tiny chips and in powder form, were compacted at a pressure of 220,000 psi applied for one minute. High purity materials were used. Iron and cobalt of electrolytic grade, better than 99.9 percent pure, and nickel in the powder form, with a purity of 99.98 percent, were used. The levitation melting was performed in a funnel-shaped coil with five windings. The frequency used was in the range of 550 kc; the input of energy was in the range of 3 to 5 KW. The melting was done in a chamber which was evacuated to 1 x 10^{-2} torr, then backfilled using argon (10 ppm O_2 maximum, 5 ppm H_2, 40 ppm N_2) with a dewpoint of -85°F under reduced pressure on the order of 75 mm Hg. The material was held for about eight seconds in the molten state and then dropped into a copper mold by cutting the power. The mold was slightly tapered to provide a bar shaped ingot with a 9/32 inch diameter on one end and 5/16 inch diameter on the upper end. The length was 1-7/8 inches. Dilatometer test specimens were machined from the ingot. The specimens were one inch long, 1/4 inch in diameter and contained a hole for inserting a thermocouple. The samples for saturation measurements were small cylinders with a 1/10 inch diameter and 1/10 inch in length. The dilatometer tests were made under argon by heating up to 1832°F (1000°C), then cooling while recording the change in length at temperature. The heating rate applied was of the order of 90°F/min (50°C/min) and 1.8 to 3.6°F/min (1 to 2°C/min.).The cooling rate was 90°F/min (50°C/min) and 9°F/min (5°C/min). After the samples had been tested in the dilatometer, the samples were cold rolled to flat strips of 95 mil thickness. The samples were homogenized and austenitized in an argon flushed tube furnace at 1832°F (1000°C) for 30 minutes. Then the samples underwent isochronal anneal as follows. The samples were held for one hour at temperature with intermittent increases of 90°F (50°C) between 842°F (450°C) and 1382°F (750°C). Aging at these temperatures was done in a salt bath. * Hardness and coercivity were measured on these

*Thermosalt No. 311 was used for aging treatments in the range of 842°F (450°C) to 1022°F (550°C).
Thermosalt No. 914 was used for aging treatments in the range of 1112°F (600°C) to 1292°F (700°C).
Thermosalt No. 1018 was used for aging treatments at 1382°F (750°C).
All designations are those of the Carmac Chemical Co.

samples. The Vickers hardness was measured at room temperature with a load of 50 kilograms. Coercivity was measured in a Forster probe. The magnetizing field was 1300 oersteds.

Saturation was measured in a magnetic field with a gradient of 980 oersteds per centimeter. The mean value of the applied field was on the order of 10,000 oersteds. For measuring the saturation at high temperature, a small electric resistance furnace was placed into the gap of the magnet which was double wound to avoid any additional field by the electric current passing through the windings. This technique reduced the residual field below 100 millioersteds.

b. RESULTS

Testing of the alloys 1-A-1 to 1-A-20 was undertaken. The alloys 1-A-1, 1-A-5, 1-A-6, 1-A-7, 1-A-8, 1-A-9 broke during cold rolling. Further investigations will be made to determine modifications needed to permit rolling. Dilatometer measurements were made on alloys 1-A-1 to 1-A-20. The results of the dilatometer tests are listed in Tables II-3 and II-4. The room temperature saturation measurements of the samples 1-A-1 to 1-A-10 are listed in Table II-5. Saturation curves at room temperature and at 1112°F (600°C) for samples 1-A-11 to 1-A-20 are shown in Figure II-1. The approximate saturation in gauss may be obtained by multiplying the cgs magnetic moment by one hundred. In Table II-6, the maximum hardness which could be obtained by the isochronal anneal is listed for several alloys at the particular aging temperature. Coercivity is also listed. Isochronal annealing has shown that only the 1-A-2 alloy showed considerable strengths after maraging treatment. Figure II-2 shows coercivity and hardness as a function of aging temperature for this alloy.

Testing of all the additions to the alloy composition of 15 nickel, 25 cobalt balance iron (Alloys 1-A-1 to 1-A-10) had shown that beryllium was the only element which would increase the stability of the alpha phase considerably. The addition of 5% tungsten (1-A-1), 2% chromium (1-A-4), 2% manganese (1-A-10), 2% tin (1-A-8) and 2% vanadium (1-A-3) decreased the temperature stability sufficiently that one cannot expect adequate stability at 1112°F (600°C). All the additions except beryllium decreased the transformation temperature into alpha phase during the cooling (See Table II-4). The influence of silicon was very pronounced.

TABLE II-3. Transformation Temperature in Degrees Fahrenheit and Centigrade of Fe-15Ni-25Co Alloys With Modifiers

Alloy Designation	Nominal Alloy Composition (Weight Percent)	Heating $\alpha \rightarrow \gamma$				Cooling $\gamma \rightarrow \alpha$			
		90°F/min	(50°C/min)	1.8°F/min	(1°C/min)	90°F/min	(50°C/min)	9°F/min	(5°C/min)
1-A-1	55 Fe - 15 Ni - 25 Co - 5 W	1425 - 1551	774 - 844	1087 - 1450	586 - 788	752 - 572	400 - 300	721 - 554	383 - 290
1-A-2	58 Fe - 15 Ni - 25 Co - 2 Nb	1472 - 1634	800 - 890	1193 - 1542	645 - 839	916 - 662	491 - 350	891 - 680	477 - 360
1-A-3	58 Fe - 15 Ni - 25 Co - 2 V	1472 - 1603	800 - 873	1112 - 1530	600 - 832	878 - 678	470 - 359	948 - 783	509 - 417
1-A-4	58 Fe - 15 Ni - 25 Co - 2 Cr	1450 - 1587	788 - 864	1065 - 1472	574 - 800	828 - 628	442 - 331	863 - 680	462 - 360
1-A-5	59.5 Fe - 15 Ni - 25 Co - 0.5 Al	1521 - 1652	827 - 900	1164 - 1515	629 - 824	986 - 781	530 - 416	1033 - 839	556 - 448
1-A-6	58 Fe - 15 Ni - 25 Co - 2 Be	1548 - 1666	842 - 908	1447 - 1630	786 - 888	1326 - 1207	719 - 653	1517 - 1265	825 - 685
1-A-7	58 Fe - 15 Ni - 25 Co - 2 Sb	1515 - 1634	824 - 890	1175 - 1490	635 - 810	846 - 631	452 - 333	903 - 729	484 - 387
1-A-8	58 Fe - 15 Ni - 25 Co - 2 Sn	1456 - 1594	791 - 868	1112 - 1515	600 - 824	932 - 709	500 - 376	966 - 752	519 - 400
1-A-9	58 Fe - 15 Ni - 25 Co - 2 Si	1434 - 1612	779 - 878	1195 - 1503	646 - 817	815 - 572	435 - 300	855 - 669	457 - 354
1-A-10	58 Fe - 15 Ni - 25 Co - 2 Mn	1472 - 1618	800 - 881	1058 - 1450	570 - 788	786 - 545	419 - 285	842 - 610	450 - 321

TABLE II-4. Transformation Temperature in Degrees Fahrenheit and Centigrade of Iron - 12 Nickel Alloys With Varying Cobalt Content

Alloy Designation	Nominal Alloy Composition (Weight Percent)	Heating $\alpha \rightarrow \gamma$ 90°F/min	(50°C/min)	1.8°F/min	(1°C/min)	Cooling $\gamma \rightarrow \alpha$ 90°F/min	(50°C/min)	9°F/min	(5°C/min)
1-A-11	88 Fe - 12 Ni	1240 - 1328	671 - 720	1143 - 1261	617 - 683	657 - 829	347 - 443	984 - 721	529 - 383
1-A-12	83 Fe - 12 Ni - 5 Co	1323 - 1386	717 - 752	1207 - 1384	653 - 751	952 - 779	511 - 415	943 - 779	506 - 415
1-A-13	78 Fe - 12 Ni - 10 Co	1386 - 1441	752 - 783	1207 - 1463	653 - 795	984 - 815	529 - 435	997 - 826	536 - 441
1-A-14	73 Fe - 12 Ni - 15 Co	1459 - 1530	793 - 832	1249 - 1521	676 - 827	1089 - 914	587 - 490	1072 - 896	578 - 480
1-A-15	68 Fe - 12 Ni - 20 Co	1494 - 1573	812 - 856	1175 - 1560	635 - 849	1157 - 972	625 - 522	1143 - 1006	617 - 541
1-A-16	63 Fe - 12 Ni - 25 Co	1551 - 1639	844 - 893	1193 - 1585	645 - 863	1173 - 984	634 - 529	1170 - 932	632 - 500
1-A-17	58 Fe - 12 Ni - 30 Co	1515 - 1634	824 - 890	1249 - 1582	676 - 861	1177 - 975	636 - 524	1182 - 945	639 - 508
1-A-18	53 Fe - 12 Ni - 35 Co	1481 - 1625	805 - 885	1227 - 1594	664 - 868	1130 - 952	610 - 511	1155 - 1009	624 - 543
1-A-19	48 Fe - 12 Ni - 40 Co	1472 - 1625	800 - 885	1157 - 1618	625 - 881	1107 - 921	597 - 494	1173 - 993	634 - 534
1-A-20	43 Fe - 12 Ni - 45 Co	1463 - 1643	795 - 895	1130 - 1594	610 - 868	1085 - 905	585 - 485	1107 - 968	597 - 520

TABLE II-5. Saturation Magnetic Moment (emu/g) at Room Temperature Annealed at 1832°F (1000°C) for 30 Minutes, No Aging

Alloy Designation	Nominal Alloy Composition (Weight Percent)	Saturation (emu/g)	Change in Saturation vs. 60 Fe-15 Ni-25 Co (emu/g)
1-A-1	55 Fe - 15 Ni - 25 Co - 5 W	197.6	-17.6
1-A-2	58 Fe - 15 Ni - 25 Co - 2 Nb	208.4	-6.8
1-A-3	58 Fe - 15 Ni - 25 Co - 2 V	206.4	-8.8
1-A-4	58 Fe - 15 Ni - 25 Co - 2 Cr	204.8	-10.4
1-A-5	59.5 Fe - 15 Ni - 25 Co - 0.5 Al	212.0	-3.2
1-A-6	58 Fe - 15 Ni - 25 Co - 2 Be	194.8	-20.4
1-A-7	58 Fe - 15 Ni - 25 Co - 2 Sb	210.8	-4.4
1-A-8	58 Fe - 15 Ni - 25 Co - 2 Sn	210.8	-4.4
1-A-9	58 Fe - 15 Ni - 25 Co - 2 Si	202.0	-13.2
1-A-10	58 Fe - 15 Ni - 25 Co - 2 Mn	214.0	-1.2
	60 Fe - 15 Ni - 25 Co	215.2	

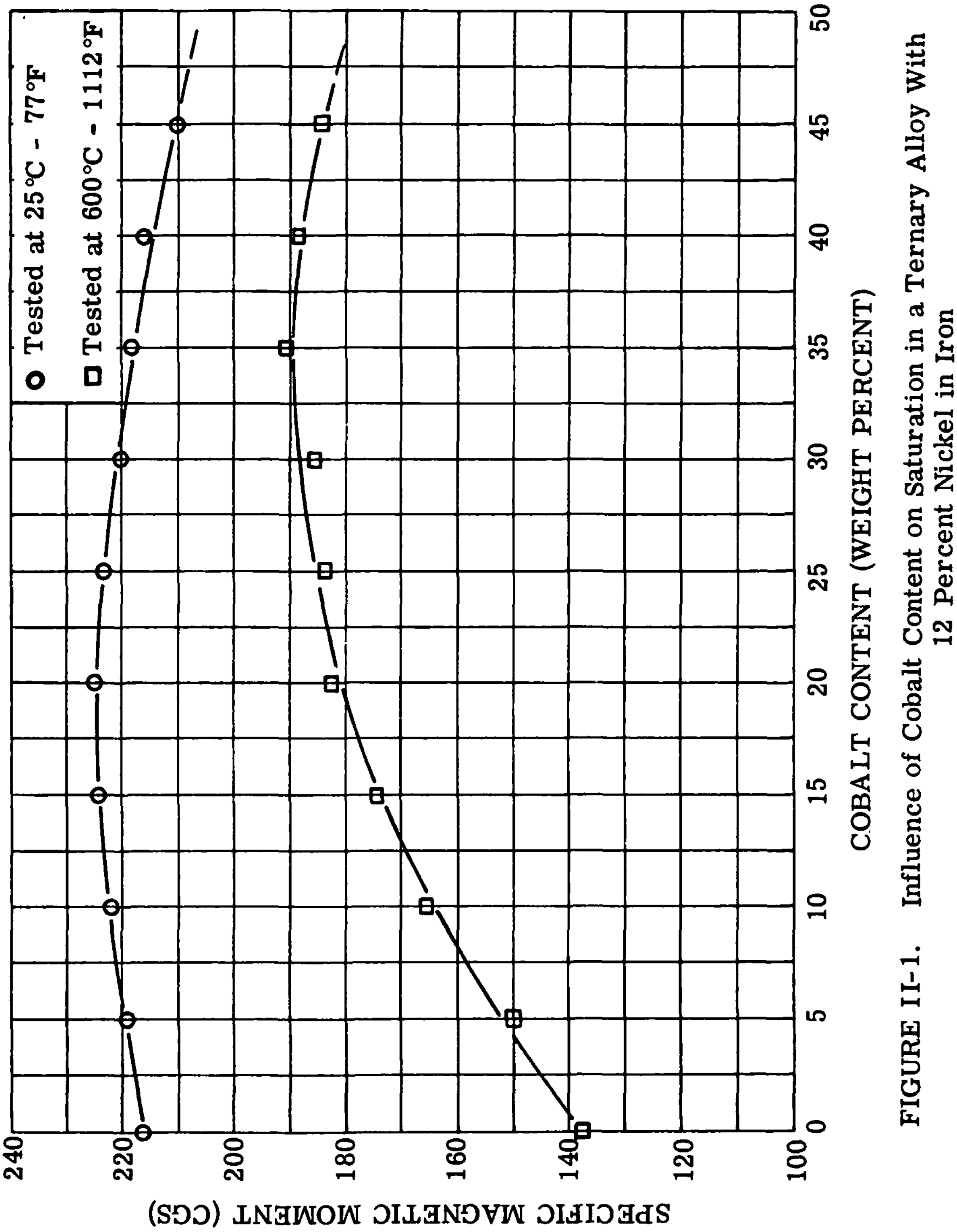


Figure II-1. Magnetic Moment vs. Cobalt Content for 12% Ni in Iron

TABLE II-6. Maximum Hardness Obtained by Isochronal Aging

Alloy Designation	Nominal Alloy Composition (Weight Percent)	Aging Temperature at Which Maximum Room Temperature Hardness was Obtained (°F)	(°C)	Total Aging Time (Hours)	Maximum Room Temperature Hardness (VHN)	Room Temperature Coercivity at Maximum Hardness (Oersteds)
1-A-2	58Fe-15Ni-25Co-2Nb	932	500	2[(1)]	558	27.4
1-A-3	58Fe-15Ni-25Co-2V	932	500	2[(1)]	390	18.3
1-A-4	58Fe-15Ni-25Co-2Cr	1022	550	3[(1)]	391	20.1
1-B-13	86Co-5Fe-5Ni-3Ti-1Al	1112	600	4[(1)]	218	1.62
1-B-14	81Co-5Fe-10Ni-3Ti-1Al	1292	700	6[(1)]	239	2.45
1-B-15	76Co-5Fe-15Ni-3Ti-1Al	1292	700	6[(1)]	273	3.36

(1) - Total aging time consists of one hour at 450°C plus one hour at each 50°C increment. (e.g. total time for alloy 1-A-4 equals 1 hour at 450°C plus 1 hour at 500°C plus 1 hour at 550°C). See text page 8.

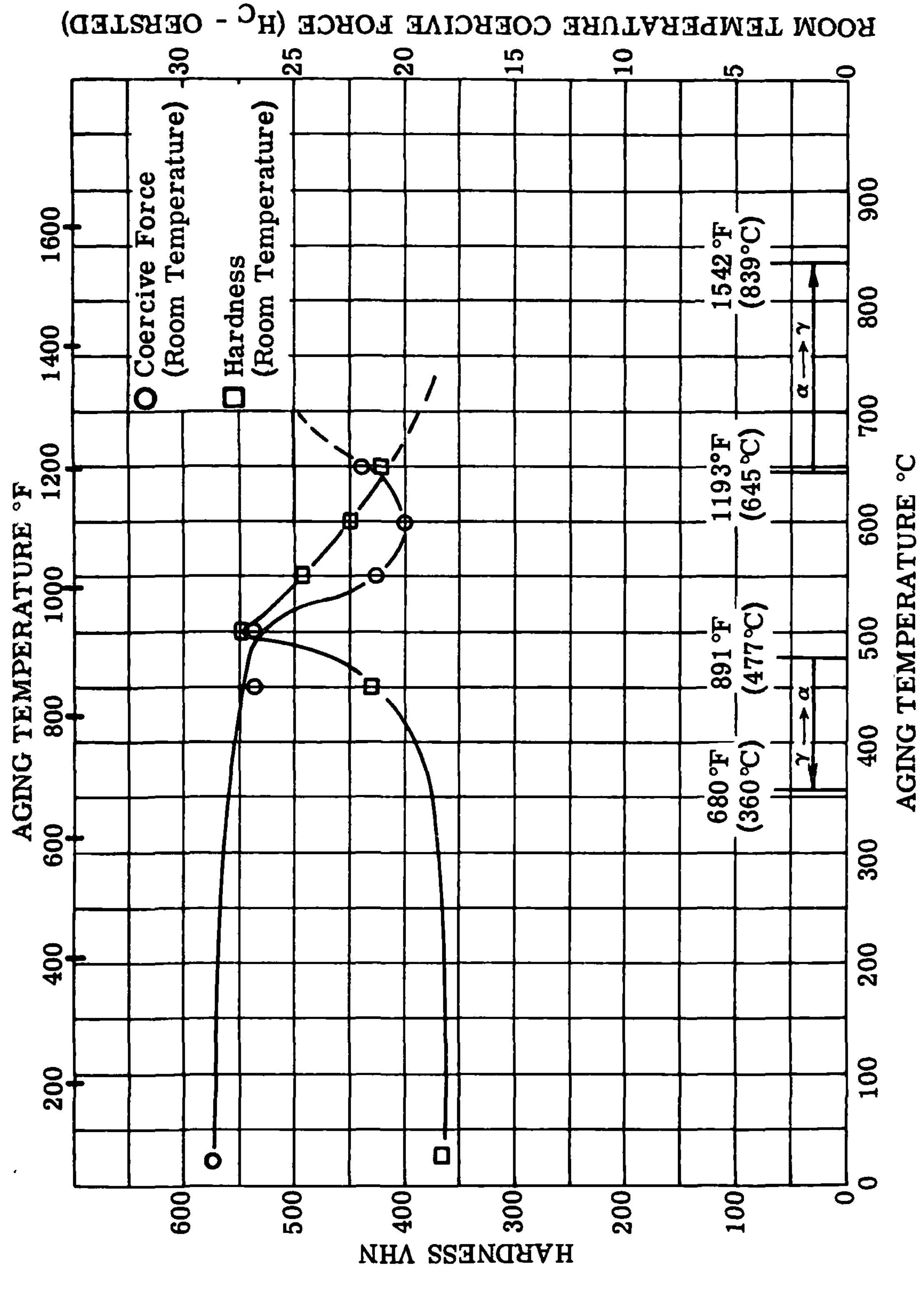


FIGURE II-2. Hardness and Coercive Force of Alloy 1-A-2 (58Fe-15Ni-25Co-2Nb) at Room Temperature After Aging One Hour at Temperature Between 450°C and Maximum Temperature in 50°C Increments

Figure II-2. Room Temperature Hardness and Coercive Force of Alloy 1-A-2

The saturation measurements showed that all additions decreased the saturation at room temperature compared to a ternary alloy of 15 nickel and 25 cobalt, balance iron (Table II-5).

From the alloys tested for response to maraging treatment (Table II-6), it is seen that the effect of niobium addition (Alloy 1-A-2) is similar to the addition of titanium in maraging steels if atomic percent additions are compared. Vanadium and chromium apparently have no effect on strengthening. The other series A alloying additions have not been tested.

Testing the series of alloys containing 12 nickel (Alloys 1-A-11 to 1-A-20) showed the influence of cobalt on saturation (Figure II-1). Thirty to forty percent cobalt give the highest saturation at 1112°F (600°C). Alloys with twenty to thirty percent cobalt show slightly reduced values of saturation. The dilatometer test showed that, with the exception of the binary alloy (88 Fe - 12 Ni) and the alloy with 45 Co, all alloys appear to have sufficient stability of the alpha phase (Table II-4).

The testing of the cobalt base alloys is in its initial stage. One could generally see that the strengths will not reach comparable levels to the alloys where maraging can be applied. (Comparison of hardness of alloys are shown in Table II-6.) By the same reason, the obtained values of the coercivity are considerably lower. The three alloys (1-B-13 through 1-B-15) tested show that increase in the nickel content will lead to increased strengthening if the same amount of aluminum and titanium are added.

3. Program for the Next Quarter

The tests of the alloys already melted will be completed. The phases formed in the precipitation hardening process must be identified and their stability must be ascertained during isochronal aging at a suitable temperature. After completing the results, and pending approval, a new series of alloys will be started. The tests of the new alloys shall fulfill two different goals. One will be to determine the suitable composition range of the primary components and the second is to find the best combination of suitable alloying elements to obtain the desired magnetic and mechanical properties.

B. TASK 2 - INVESTIGATION FOR RAISING THE ALPHA TO GAMMA TRANSFORMATION TEMPERATURE IN COBALT-IRON ALLOYS.

1. Summary of Technical Progress

a.) Eighteen cobalt-iron alloys were selected for evaluation (Table II-7).

b.) Eight alloys have been melted in the form of ingots by the levitation melting technique.

2. Discussion

a. BACKGROUND

Evaluating the results of previous research work, including that performed at the Westinghouse Research Laboratories, and a survey of the binary cobalt-iron phase diagram led to the selection of the basic alloy compositions shown in Table II-7.

The highest transformation temperature of 1805°F (985°C) will be obtained with an alloy containing 45 Co. The highest value of saturation (B_s) at temperatures above 1292°F (700°C) are measured in Fe-50 Co (B_s = 10,000 gauss at 1742°F (950°C). So a basic composition Fe:Co at 1:1 appears most suitable for initial efforts to raise the transformation temperature by addition of alloying elements.

Addition of one weight percent of the elements known to raise the alpha to gamma transformation temperature in pure iron will be checked for their influence on transformation temperature and saturation of the 1:1 cobalt-iron alloy. The first 12 alloys were selected based on this argument. The alloys with columbium and tantalum contain only 0.5 weight percent of the alloying elements because it is questionable whether the solubility limit will extend above this value in the temperature region to be tested.

Chromium and zinc close the gamma region of iron, although the transformation temperature of iron will initially be lowered by the addition of either element. The addition of gold to iron decreases the transformation temperature but slightly.

TABLE II-7. Alloys Selected for Alpha-Gamma Transformation Study

Number	Nominal Alloy Composition (Weight Percent)
2-0	50.0 Fe - 50.0 Co
2-1	49.5 Fe - 49.5 Co - 1 Al
2-2	49.5 Fe - 49.5 Co - 1 As
2-3	49.5 Fe - 49.5 Co - 1 Be
2-4	49.5 Fe - 49.5 Co - 1 Ge
2-5	49.5 Fe - 49.5 Co - 1 Mo
2-6	49.5 Fe - 49.5 Co - 1 P
2-7	49.5 Fe - 49.5 Co - 1 Sb
2-8	49.5 Fe - 49.5 Co - 1 Si
2-9	49.5 Fe - 49.5 Co - 1 Sn
2-10	49.5 Fe - 49.5 Co - 1 Ti
2-11	49.5 Fe - 49.5 Co - 1 V
2-12	49.5 Fe - 49.5 Co - 1 W
2-13	49.75 Fe - 49.75 Co - 0.5 Nb
2-14	49.75 Fe - 49.75 Co - 0.5 Ta
2-15	49.5 Fe - 49.5 Co - 1 Cr
2-16	49.5 Fe - 49.5 Co - 1 Zn
2-17	49.5 Fe - 49.5 Co - 1 Au
2-18	49.5 Fe - 49.5 Co - 1 Mn

In the case that all alloys tested do not indicate a potential for extending the temperature range where an alloy with magnetization saturation superior to pure cobalt can be used, a second series may be suggested.

It is anticipated that a second series of alloys would include additions of 0.5 weight percent rare earth elements. It is not known whether alloying is possible and what effect it might have on transformation temperature and saturation. It is known that the number of Bohr magnetons in some of these alloys are very high. Gadolinium, terbium, dysprosium, holmium, erbium, and thulium have effective Bohr magneton numbers of eight or higher. A unique kind of interaction of the electrons might be expected if these elements prove soluble in the Fe-Co matrix.

b. EXPERIMENTAL PROCEDURE: (See Section II. A. 2. a.)

c. RESULTS

The alloys numbered 2-0, 2-1, 2-3, 2-5, 2-7, 2-17, and 2-18 were melted as 15 gram ingots by the levitation melting technique described in Section II. A.

The melting of alloys 2-2, 2-6, and 2-16 has been postponed until master melts are available because of the difficulties anticipated during melting of compounds having high-vapor pressures at the melting temperatures.

Alloys 2-3 and 2-17 will be remelted. There are indications that splashes during casting may have caused inhomogeneities in these ingots.

Testing of alloys on this program has not started.

3. <u>Program for Next Quarter</u>

Dilatometer tests to define the transformation temperature will be conducted.

C. TASK 3 - DISPERSION-STRENGTHENED MAGNETIC MATERIALS FOR APPLICATION IN THE 1200-1600°F RANGE.

1. Summary of Technical Progress

a.) Purchase Orders for 18 prealloyed cobalt base and cobalt-iron base atomized powders were completed and submitted for approval to the NASA Contracting Officer prior to placing the orders with suppliers.

b.) Specifications for cobalt and cobalt-iron base composite powders containing dispersions of alumina and thoria, and a summary of quotations received were prepared and submitted for review to the NASA Project Manager before preparing Purchase Orders. Later these will require approval by the NASA Contracting Officer.

c.) Specifications for cobalt and cobalt-iron base extrusions containing dispersions of alumina and thoria, and a summary of quotations received were prepared before writing Purchase Orders.

d.) A number of discussions were held with possible suppliers and various reports reviewed. Dr. F. R. Morrall of the Cobalt Information Center visited Westinghouse to discuss projects on the dispersion-strengthening of cobalt which his organization had sponsored elsewhere.

2. Discussion

a. PREALLOYED ATOMIZED POWDERS

The 18 prealloyed atomized powders to be used in the program are listed in Table II-8. The end product which will be fabricated from each powder and tested is extruded rod. In the first phase of this task, which involves an initial evaluation of various compositions, the amount of dispersed phase is of the order of 10 percent by volume.

The atomizing process will provide an extremely rapid quench of the molten powder particles to the solid state [(1)]. This insures that the constituent particles of high-melting point, which solidify first, will be dispersed and not have time to grow above submicron size before the cobalt or cobalt-iron matrix has solidified.

(1) - Towner, R. J., "Atomized Powder Alloys of Aluminum", Metal Progress, May 1958, p. 70

TABLE II-8. Atomized Powders

Atomized Powder Number	Nominal Composition (Weight Percent)
1	Pure cobalt
2	Pure cobalt - 2.0 boron
3	Pure cobalt - 1.0 boron - 2.2 titanium
4	Pure cobalt - 1.0 boron - 4.2 zirconium
5	Pure cobalt - 1.0 boron - 4.2 columbium
6	Pure cobalt - 1.0 boron - 8.3 tantalum
7	Pure cobalt - 4.0 cerium
8	Pure cobalt - 2.5 aluminum
9	Pure cobalt - 1.3 beryllium
10	27 cobalt - 73 iron
11	26.5 cobalt - 71.5 iron - 2.0 boron
12	26.1 cobalt - 70.7 iron - 1.0 boron - 2.2 titanium
13	25.6 cobalt - 69.2 iron - 1.0 boron - 4.2 zirconium
14	25.6 cobalt - 69.2 iron - 1.0 boron - 4.2 columbium
15	24.5 cobalt - 66.2 iron - 1.0 boron - 8.3 tantalum
16	25.9 cobalt - 70.1 iron - 4.0 cerium
17	26.3 cobalt - 71.0 iron - 2.7 aluminum
18	26.6 cobalt - 72.0 iron - 1.4 beryllium

Powder Nos. 1 and 10, pure cobalt and 27 percent cobalt-73 percent iron, do not contain alloy additions and will serve as bases for comparison with the other compositions. The two percent boron additions in powder Nos. 2 and 11 will be present partially in solid solution and partially as dispersed particles of metal boride compound. The change in solid solubility of boron with temperature is slight, so that the amount of metal boride particles out of solution will be approximately the same at room and elevated temperatures.

The boron additions in powder Nos. 3 through 6 and 12 through 15 are for the purpose of formation of submicron boride particles containing titanium, zirconium, columbium, and tantalum which are stable at high temperatures and resist agglomeration. Powder Nos. 7 and 16 contain cerium and will provide another dispersion-hardening agent, the intermetallic compound $CeCo_5$. The aluminum and beryllium containing powders, Nos. 8, 9, 17, and 18, will be given internal oxidation treatments to form Al_2O_3 and BeO dispersed particles at elevated temperatures where the aluminum and beryllium are in solid solution. Also, the cerium containing alloys Nos. 7 and 16 may be considered for internal oxidation treatments.

Based on technical capability for meeting our specifications, the number of compositions quoted on, price, and delivery time, purchase orders were prepared for buying 14 powders from Hoeganaes Sponge Iron Corporation and four powders from Domtar Chemicals Ltd. All four vendors who quoted would undertake to atomize these compositions on an experimental effort basis. Discussions were held with suppliers concerning ways of insuring homogeneity of composition of powder particles from start to end of a run. Homogeneity is assured by the following production methods the vendors will use: (1) induction melting and holding which exerts a stirring action on the melt, and (2) the short production time (about 5 minutes) to atomize a 100 lb. melt. Sampling of the powder stream during atomizing to check composition is not possible in the supplier's equipment.

b. COMPOSITE POWDERS

The compositions of the powders for which quotations were solicited from suppliers are listed in Table II-9. The amount of dispersed oxide is constant, 10 percent by volume. The iron powders Nos. 5 through 8 can be mixed with the cobalt powders to produce cobalt-iron base compositions. Another approach is to purchase cobalt-

TABLE II-9. Composite Powders

Composite Powder Number	Nominal Composition (Weight Percent)	Particle Size of Oxide (Microns)
1	95.25 Co + 4.75 Al_2O_3	0.01-0.06
2	95.25 Co + 4.75 Al_2O_3	0.1-0.6
3	88.8 Co + 11.2 ThO_2	0.01-0.06
4	88.8 Co + 11.2 ThO_2	0.1-0.6
5	94.7 Fe + 5.30 Al_2O_3	0.01-0.06
6	94.7 Fe + 5.30 Al_2O_3	0.1-0.6
7	87.6 Fe + 12.4 ThO_2	0.01-0.06
8	87.6 Fe + 12.4 ThO_2	0.1-0.6
9	25.6 Co + 69.2 Fe + 5.20 Al_2O_3	0.01-0.06
10	25.6 Co + 69.2 Fe + 5.20 Al_2O_3	0.1-0.6
11	23.7 Co + 64.2 Fe + 12.1 ThO_2	0.01-0.06
12	23.7 Co + 64.2 Fe + 12.1 ThO_2	0.1-0.6

iron powders Nos. 9 through 12 directly. Selection of the final approach and compositions to be purchased will be justified in terms of the technical capability of the supplier, processing technique used to make the material, price and delivery time.

The oxide particles will be dispersed in metal particles or the oxide and metal phases will be intermixed so that when the powders are fabricated into extrusions an even distribution of the submicron oxide particles in the metal matrix will result.

The summary of quotations received on composite powders in accordance with our specifications shows that four vendors can supply some or all of the powders made by the following processes: (1) coating of suspended oxide core particles by precipitation of metal from aqueous solution, (2) high intensity arc co-vaporization of mixed oxides of cobalt or cobalt-iron, aluminum, and thorium followed by hydrogen reduction of cobalt or cobalt-iron oxides to metal, (3) a proprietary semi-metallic powder process, and (4) mechanical mixing of metal and alumina powders, and thermal decomposition of thorium salt on metal powder to introduce thoria.

c. EXTRUSIONS OF DISPERSION-STRENGTHENED COBALT AND COBALT-IRON ALLOYS

Quotations from suppliers have been received on the compositions listed in Table II-10. All compositions contain 10 percent by volume of oxide with the exception of No. 9 which contains two percent by volume. Selection of the final compositions will be based on technical capability of the vendor and processing technique used to make the material.

Suppliers of extrusions of dispersion-strengthened cobalt and cobalt-iron have proposed the following processes in accordance with our specifications: (1) mechanical mixing of metal and alumina powders, and thermal decomposition of a thorium salt on metal powder, and (2) co-dissolving the desired elements in a volatile solvent, flash-drying, grinding and reduction of matrix oxides. After the above powders are prepared, compacting, sintering, and extrusion are performed.

TABLE II-10. Supplier Extrusions

Extrusion Number	Nominal Composition (Weight Percent)	Particle Size of Oxide (Microns)
1	95.25 Co + 4.75 Al_2O_3	0.01-0.06
2	95.25 Co + 4.75 Al_2O_3	0.1-0.6
3	88.8 Co + 11.2 ThO_2	0.01-0.06
4	88.8 Co + 11.2 ThO_2	0.1-0.6
5	25.6 Co + 69.2 Fe + 5.20 Al_2O_3	0.01-0.06
6	25.6 Co + 69.2 Fe + 5.20 Al_2O_3	0.1-0.6
7	23.7 Co + 64.2 Fe + 12.1 ThO_2	0.01-0.06
8	23.7 Co + 64.2 Fe + 12.1 ThO_2	0.1-0.6
9	97.74 Co + 2.26 ThO_2	0.01-0.06

3. Program for Next Quarter

a.) After purchase orders for prealloyed atomized powders have been approved by the NASA Contracting Officer, the orders will be placed with vendors.

b.) Purchase orders for composite powders and extrusions of dispersion-strengthened cobalt and cobalt-iron alloys will be submitted for approval to the NASA Contracting Officer.

c.) Once purchased materials are received, processing and testing will be initiated.

D. TASK 4 - CREEP TESTING.

1. Summary of Technical Progress

a.) A reliable vacuum-creep capsule design previously developed by Westinghouse was modified and the design improved for use on NAS 3-6465.

b.) Nivco alloy (72Co-23Ni and other elements) was selected for the 5,000 to 10,000-hour vacuum creep tests.

c.) Sufficient Nivco bar was obtained from Westinghouse programs to conduct the vacuum creep tests. Official approval to test Nivco alloy was obtained from NASA. Creep test data will be included in subsequent reports as it becomes available after the start of testing.

2. Discussion

Figure II-3 represents the vacuum creep capsule design to be used in the elevated temperature tests on magnetic materials for rotor application. The design was the result of a Westinghouse program where various vacuum chamber designs, pumping systems, and extensometers were evaluated to determine a system which could provide meaningful data at reasonable cost. Included in the extensometer evaluation were measurements of strain using mechanical methods located at various positions along the specimen and the use of strain gages. A slab of Nivco alloy bar was obtained from Westinghouse programs for testing on NAS 3-6465. The composition of the alloy to be tested is listed below in weight percent.

C	Co	Ni	Mn	Si	Ti	Al	Zr	Ingot No.
0.01	Bal	22.5	0.32	0.15	2.15	0.28	0.95	AC-232

Creep sample blanks were cut from the slab which had been solution annealed at 1725°F in air for one hour and water quenched. The blanks were rough machined and will be aged for 25 hours at 1225° ± 5°F.

As part of the program, a series of vacuum measurements were made on the proposed capsule configuration to evaluate pressure losses in the design. These included both hot and cold capsule vacuum measure-

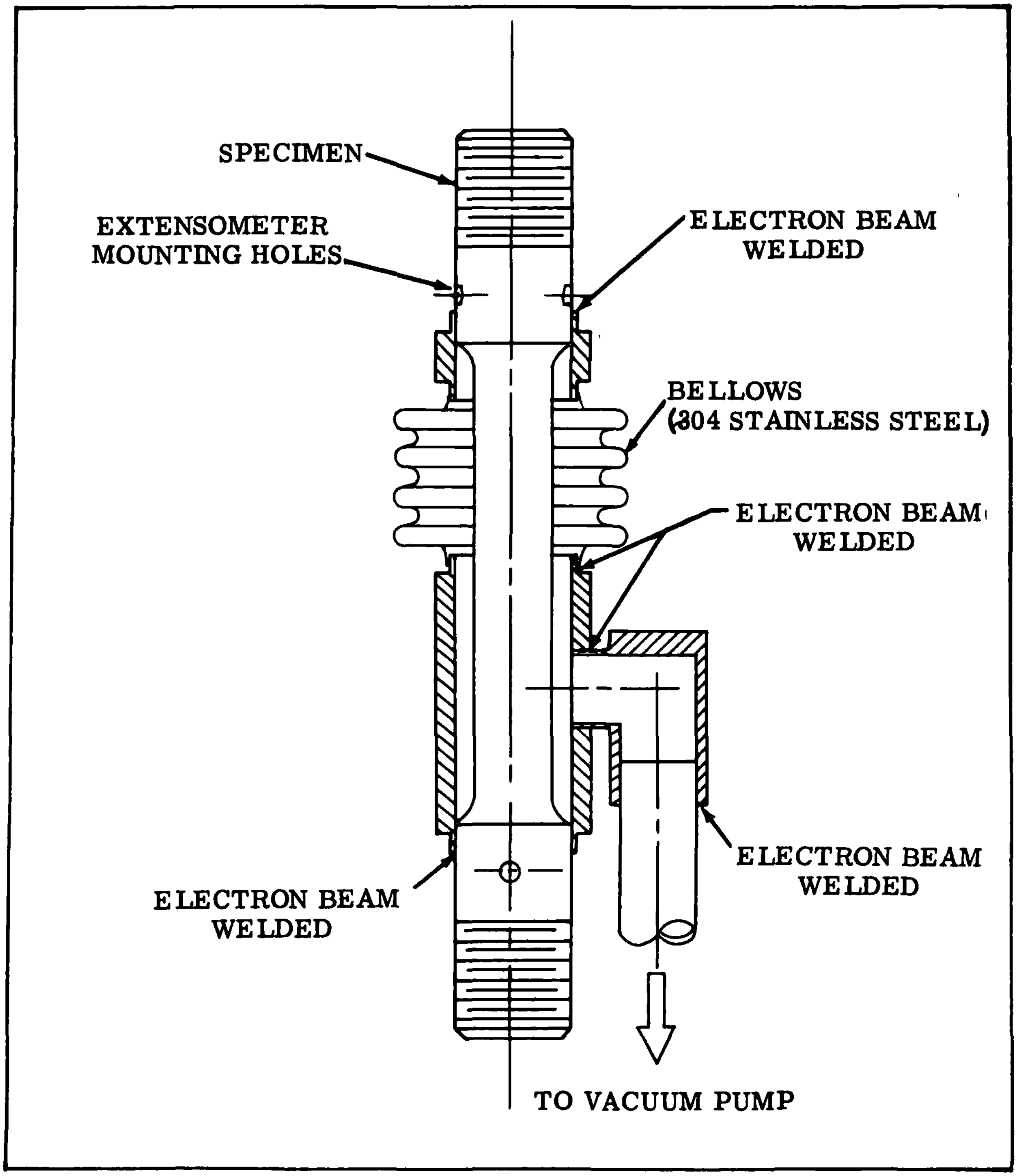


FIGURE II-3. Encapsulated Vacuum Creep Specimen ments at a position on the upper end of the capsule (position of highest pressure) as well as at a position upstream from the vacuum pumps. Because the total capsule is heated, the ionization gage could not be located at the capsule top end; therefore, data were obtained by brazing a 12-inch extension onto the capsule and locating the ionization gage at the top of this extension outside of the hot zone. After a 48-hour bakeout, a cold-trapped, oil diffusion pumped capsule at 860°F achieved a pressure of 8.2×10^{-7} torr at the capsule extensions.

A similar series of vacuum measurements were made using a four liter per second ion pump. After 22 hours at 570°F, the pressure at the capsule extension was observed to be 6.1×10^{-7} torr and at the pumping port it was observed as 2.1×1.0^{-7} torr. After 23 hours and an increase in temperature to 1050°F, the pressure was 5.5×10^{-7} torr at the pump port and 3×10^{-6} torr at the top of the capsule extension. A new ion-pumping system of twice the capacity is being procured and will be available by April 1 to use in the test program. It should allow improved vacuum conditions during testing over that observed with the older ion pump. In addition, the removal of the capsule extension will reduce the chamber volume being pumped.

As part of a Westinghouse program to determine bellows reliability, one type of 304 stainless steel bellows has been held at 1350°F in air for more than 4000 hours. Twice monthly the bellows is removed from the furnace and leak checked using a mass spectrometer. As of this date, the bellows has remained leak tight. A second bellows was removed from an actual creep test capsule at 2056 hours for metallographic examination. An examination failed to reveal any degree of deterioration in the bellows. No evidence of intergranular penetration by oxygen was present.

3. <u>Program for Next Quarter</u>

a.) Creep testing at 1000°F and 1100°F will be initiated.

SECTION III

PROGRAM II - HIGH TEMPERATURE CAPACITOR FEASIBILITY

This program will study the feasibility of building a lightweight capacitor suitable for operation up to 1100°F. It will utilize high-purity dielectric materials and specialized fabrication methods. The ultimate application is in lightweight, high-temperature, power-conditioning equipment suitable for space application. The design goal is a capacitor of 100 to 200 microfarad volts per cubic inch. This range is comparable with conventional low-temperature capacitors.

A. SUMMARY OF TECHNICAL PROGRESS.

1.) Major equipment items purchased by Westinghouse for machining and electroding single wafer capacitors are operating satisfactorily. The items include a precision wafering machine, an ultrasonic cutter and machine tool, a vibratory lapping/polishing machine, an ultrasonic cleaner and a three electrode or "triode" sputtering system.

2.) Lucalox rods have been reproducibly sliced to a thickness of 10 mils. These wafers were lapped and polished to 6 mils. Grain pull outs have not been completely eliminated and represent a potential problem area particularly for wafers lapped to thicknesses less than 6 mils.

3.) A one inch square wafer of pyrolytic boron nitride (Boralloy, High Temperature Materials, Inc.) sliced from a 1 x 1 x 1/8 inch block of "as received" material was lapped to a thickness of 1.5 mils. In this thickness range, the material is very flexible, translucent and free of pin holes or pull outs.

4.) An order has been placed for six groupings of differently processed BeO wafers lapped to 10 mils. The vendor, Consolidated Ceramics and Metallizing Corp., will machine the wafers from commercial stock ranging in purity from 99.8 to 99% BeO and one group of wafers will be hot pressed. The other materials are sintered from dry pressed and isostatically pressed BeO.

5.) Five suppliers are being contacted concerning the availability of ultra high purity sputtering target materials of rhodium and platinum (for capacitor electrodes).

6.) A wafer holding fixture is being fabricated for sputtering nobel metal electrodes through glass masks. Preliminary designs were made for a small vacuum test furnace with tantalum radiation shields. The furnace will be set up in the CV-18 evaporator (Consolidated Vacuum Corporation) which has been evacuated to about 5 x 10^{-8} torr with a liquid nitrogen cooled baffle.

B. DISCUSSION.

1. Dielectric Materials Selection

Four dielectric materials are presently being considered for single layer capacitor evaluation in terms of fabricability and electrical properties. Based on these results, a final selection will be made. It is planned to obtain actual chemical analysis on the material selected for preparing multi-layer and monolithic type capacitors.

Included in the group of materials initially selected are aluminum oxide (single crystal and polycrystalline), pyrolytic boron nitride and beryllium oxide. It will be necessary to perform precision machining, lapping and polishing operations on these as received materials to achieve the desired test capacitor thicknesses and surface finishes for comparative evaluation. Electrical data will be obtained on single wafer capacitors electroded by sputtering platinum and/or rhodium films on opposing surfaces. A flow diagram is shown in Figure III-1 to illustrate this approach.

A tabulation of significant properties for a total of ten different materials considered as possible candidates is shown in Table III-1. Included in the table are all of the materials which are known to be available commercially that have superior electrical properties at elevated temperatures. Table III-2 shows a typical spectrochemical analysis for each specific material selected for preliminary study. It is noteworthy that although all the materials listed have very low impurity contents, pyrolytic boron nitride (Boralloy, High Temperature Materials, Inc.) has a total metal impurity level of less than 0.0003%. The oxygen content of this material is not given; however, it is generally considered that the oxygen as B_2O_3 in pyrolytically deposited boron nitride is substantially lower than it is for the hot pressed material.

2. Single Wafer Fabrication

In addition to a materials property tabulation, Table III-1 summarizes the present status of the program as indicated in the appropriate columns.

The major equipment items obtained for preparing single wafer capacitors are:

a.) WMSA Precision Wafering Machine manufactured by Micromesh Manufacturing Corporation. The machine is equipped with a variable spindle speed motor and two variable longitudinal table speed ranges (0 to 1/4 and 0 to 3 inches per minute).

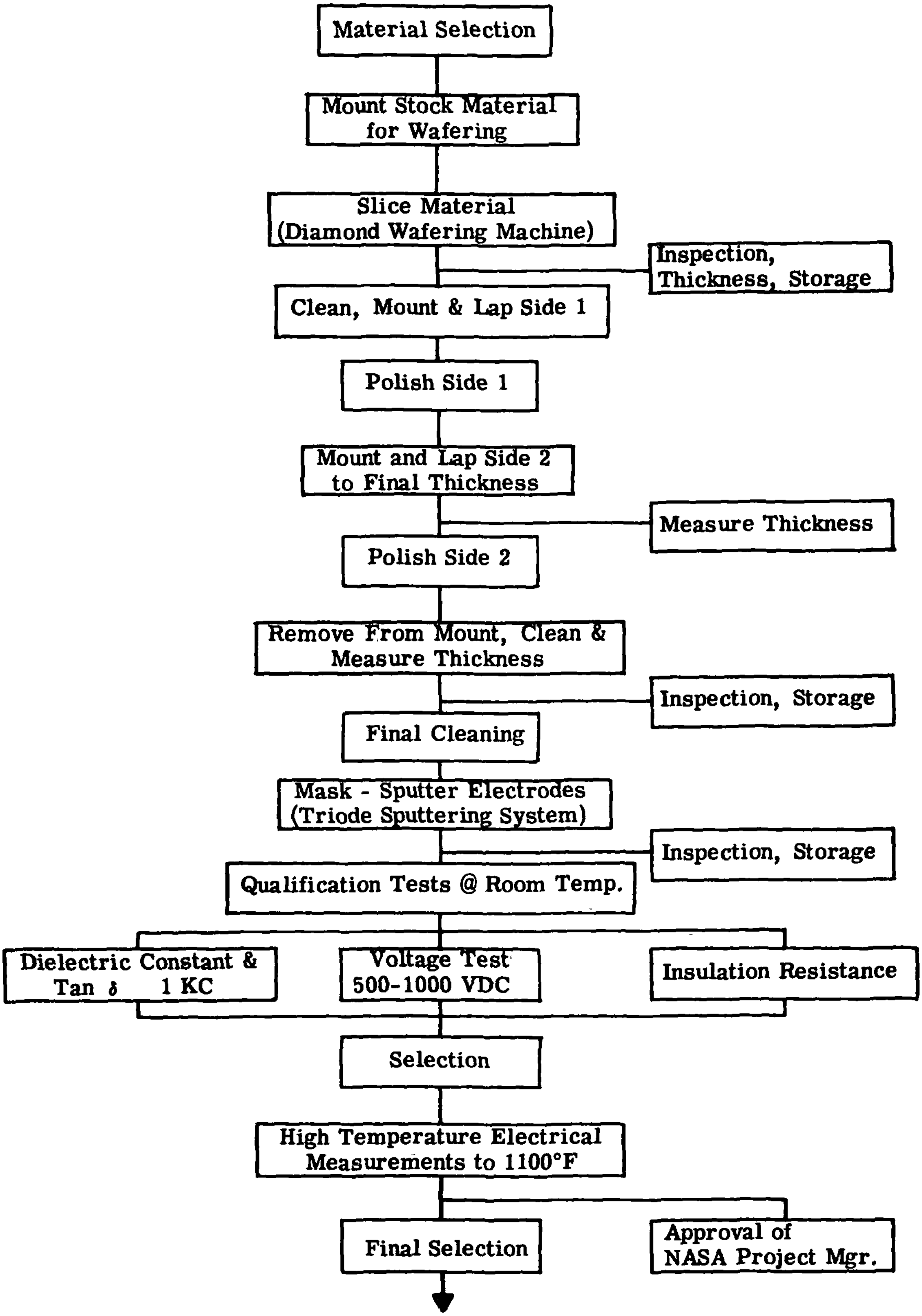


FIGURE III-1. Preparation and Evaluation of Single Layer Capacitors

TABLE III-1. Tabulation of Dielectric Material Properties and Present Status

Material	Microstructure	Process Method	Mfg. or Source and Trade Name	Form (As Received)	Purity	Density - % of Theoretical	Prese Statu
Al_2O_3	Single Crystal	Verneuil (flame fusion)	Linde Div. Union Carbide Corp.	"Boule" ~ 3/4" Diameter x 3" long	< 100 ppm impurities (2)	~100	Two boules on hand
Al_2O_3	Polycrystalline	Pressed and Sintered	General Electric "Lucalox"	Rods 3/4 to 1-1/4" diameter	99.9% Al_2O_3 (2)	~100	0.006" thick wafers - sliced, lapped & polished
Al_2O_3	Polycrystalline	Hot Pressed	(W)AED (experimental)	Disks	Starting Material < 100 ppm impurities	~100	Several 0.370 X 0.010" disks availabl
BN	Hexagonal layer High degree of orientation	Pyrolytic decomposition of BCl_3 and NH_3	High Temperature Materials Inc. "Boralloy"	Plates 1 X 1 X 1/8" 2 X 2 X 1/4"	Total impurities ≅ 100 ppm (2)	~ 98	0.001 to 0.002" wafers - sliced, lapped & polished
BN	Polycrystalline	Hot Pressed	Carborundum Company	None Ordered	97% BN	>93.4	Not selected as candidate material
BN	Polycrystalline	Hot Pressed	National Carbon Company	None Ordered	~ 95 to 97% BN	~ 90	Not selected as candidate material
BeO	Polycrystalline	Pressed and Sintered	Coors BD 99.5	(1)	99.5% BeO	~ 95	(1)
BeO	Polycrystalline	Pressed and Sintered	American Lava Corp. Alsimag 754	(1)	99.5% BeO		(1)
BeO	Polycrystalline	Hot Pressed	Atomics International (experimental)	Not known at present	Starting material - Minox AAA (2)	~99.7	Sample requeste
MgO	Single Crystal	Cooled Melt	Norton Co. "Magnorite"	None Ordered	99.9% MgO	~100	Not selected as candidate material

1. An order has been placed with Consolidated Ceramics Inc. for machined disks of
2. See Table III-2 for spectrochemical analysis of materials.

ELECTRICAL PROPERTIES					
DC Resistivity Ohm-Cm (Approximate Values)	Tan δ	Dielectric Constant	Electric Strength (Voltage Breakdown)	Remarks	Data Reference
400°C - 7 X 10^{12} 600°C - 7 X 10^{10}	@ 10^5 cps ⊥ to optic axis 400°C - 0.0002 600°C - 0.001	@ 10^5 cps 60° to optic axis K@20°C - 9 K@900°C - 10	1700 volts/mil @ 60 cps, 20 mil thick sample (Room temperature)	No electrical breakdown strength at elevated temperature. Tan δ and dielectric constant data not given for 60 cps to 50 kc freq. vs. temp.	Linde Industrial Crystals Bulletin F-814-C F-917-B
400°C - 1 X 10^{13} 600°C - 3 X 10^{10}	@ 9720 mc 20°C - 0.000025	@ 9720 mc 20°C - 9.9	1700 volts/mil @ 20°C, 20 mil thick sample	Low frequency (60 cps to 50 kc) Tan δ and dielectric constant not given. High temperature voltage breakdown not given.	Company Data Bulletin
400°C - 5 X 10^{12} 600°C - 9 X 10^{10}	Not Measured	Not Measured	Not Measured		AF33(615)1360
400°C - 10^{14} 600°C - 10^{13}	@ 4kmc, "a" direction RT to 649°C, approximate 0.0004 over the temperature range	K 3.4 "c" direction @ RT, not measured at elevated temperature	4000 volts/mil in "c" direction, d-c 10 to 20 mil sample (not measured at elevated temperature)	Low frequency data not available (vs. temperature) (60 cps to 50 kc)	Materials in Design Eng., Feb 1964 (M. Bosche & D. Schiff)
420°C - 1.7 X 10^{11} 550°C - 8.3 X 10^8 660°C - 3.4 X 10^7	@ 10^3 cps 400°C - 0.012 600°C - 0.14	@ 10^3 cps 400°C - 4.5 600°C - 6.5	1450 volts/mil @ RT, sample 10 mils thick	Not selected as candidate material because of low density.	Company Data Bulletin
482°C - 5 X 10^8 1000°C - 1 X 10^7	@ 10^3 cps 300°C - 0.015 575°C - 1.0	@ 10^3 cps 21°C - 4.4 300°C - 4.52	500-1000 volts/mil, thickness not known	Not selected as candidate material because of low density.	Company Data Bulletin H-8745
300°C - >10^{15} 500°C - 5 X 10^{13} 700°C - 1.5 X 10^{10}	No low frequency data given	@ 1 mc 6.7	700 volts/mil average RMS at RT, 10 mil sample thickness		Company Data Bulletin
400°C - 10^{13} 600°C - 10^{12}	No low frequency data given	~7	None given		Company Data Bulletin
No measurements	No measurements	No measurements	No measurements	Sample requested.	Private communication from R. L. McKisson
600°C - 1.6 X 10^{12} 1000°C - 10^8	@ 100 cps 25°C - 0.0003	@ 100 cps 25°C - 9.65	No data given	Not selected as candidate material because of hydroscopic characteristics.	Norton Co. Memo Feb. 1, 1963

O from various commercial sources

TABLE III-2. Spectrochemical Analysis of Candidate Dielectrics

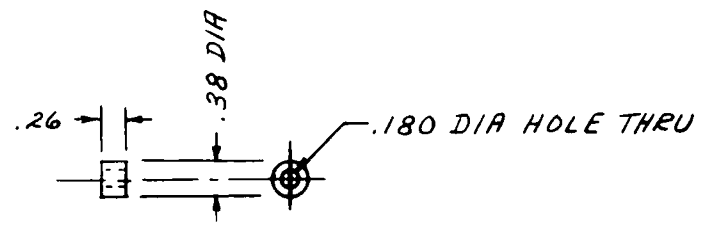
MATERIAL	ELEMEN											
	Al	Fe	Mg	Ti	Mn	V	Na	Cu	Ni	Ca	Cr	Ga
	Percent (											
Lucalox (General Electric Co.)	Major	0.002	0 15	(1)	(1)	(1)	(1)	(1)	(1)	0.004	(1)	(1)
	Parts Per Millio											
Linde Sapphire (Single Crystal Al_2O_3)	(1)	< 2	< 2	(2)	(2)	(2)	(2)	(2)	(2)	9	(2)	(2)
	Percent (%)											
Boralloy Boron Nitride (3) (Pyrolytic Bn) (High Temperature Materials Inc.)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	0.0001	(1)	0.0001	(1)	(1)
	Parts Per Million											
Minox AAA BeO powder used to prepare hot pressed materials by Atomics International	75	35	50	1	1	--	75	1	7	80	15	--

(1) Not detected.

(2) These elements not listed.

(3) Total impurities less than 0.003%. Thirty-four additional elements listed as not detected.

Si	Mo	B	Zr	Cd	Pb	Ba	Bi	Co	Sm	Li	REFERENCE SOURCE
).03	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	ASD TR-61-628, Part II Studies of the Brittle Behavior of Ceramic Materials, April 1963 - Contract AF33(616)7465
ppm)											
6	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	Letter from Mr. B G Benak (Linde Co)
0.0001	(1)	Major	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	Company Data Sheet Dated February 1, 1965
m)											
25	<3	<1	<30	<1	<2	<5	<5	<1	<5	<5	Letter from R. L. McKisson (Atomics International)



SPACER ~ MAKE FROM MINIMUM 99% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

TOOL REF Ⓦ P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

Ⓦ INTERNAL INFO & DATA

LYP 19038

NEXT ASSY

TOLERANCE, MFG SPECS PER LA 551
DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES
UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 | 3 PLACE .XXX±.005 | ANGLES ±1°
PROCESS TO BE APPLIED AS INDICATED ON DWG.
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE | B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART | AR = AS REQ'D
Ⓥ = VERY IMPORTANT

DFTM	HGO	1/19/65
DFTM	[illegible]	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

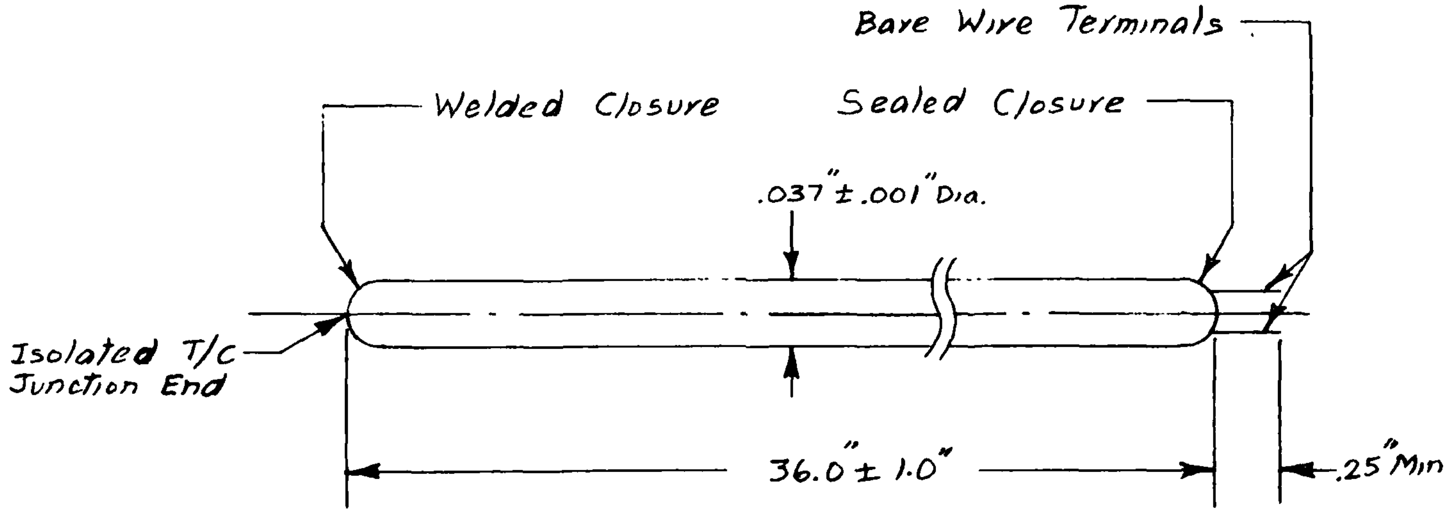
AEROSPACE ELECTRICAL DIVISION
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO. U.S.A.

TITLE SPACER

CODE IDENT NO.	SIZE	DRAWING NO.
83843	B	EDSK 326786
SCALE 1/1	WEIGHT	SHEET

DWG. EDSK 326786

W FORM NO. 23325-J



Note: Thermocouples are to be kept straight at all times.

SINGLE DIAMETER SHEATHED THERMOCOUPLE

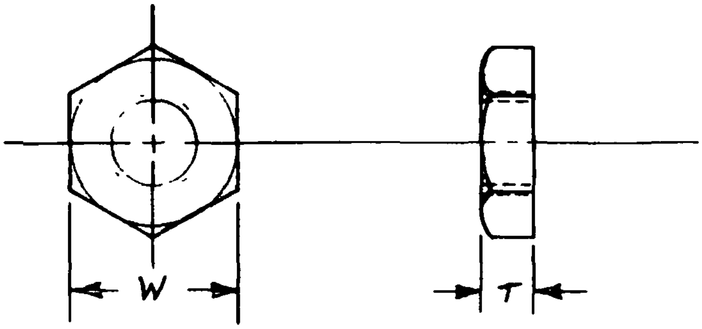
Reference (W) D-Spec # 709747

EDSK 326796

wg 2-18-65

SKETCH SHEET
FORM 28577

WESTINGHOUSE ELECTRIC CORPORATION



Material - Hastelloy Alloy B Rod

Dash No.	Thread	W ±.005	T ±.008	Stock
1	#8 (.164)-32 NC-2B	.338	.187	1/2 Dia
2	1/4-28 UNF-2B	.428	.219	5/8 Dia

NUT - HEXAGONAL

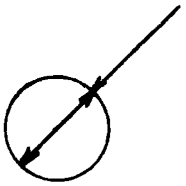
W.L. Grant 4-21-65 | EDSK 327503

SKETCH SHEET
FORM 28577

WESTINGHOUSE ELECTRIC CORPORATION

Conductor
20% Nickel-Clad Silver

.032 ± 1% Diameter



Dimensions in inches
Scale 20:1

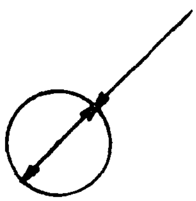
EDSK 326533

H.E. Keneipp 12-21-64

SKETCH SHEET
FORM 28877

WESTINGHOUSE ELECTRIC CORPORATION

Conductor
28% Inconel-Clad Silver



.032 ±1% Diameter

Dimensions in inches
Scale 20:1

EDSK 326534 A

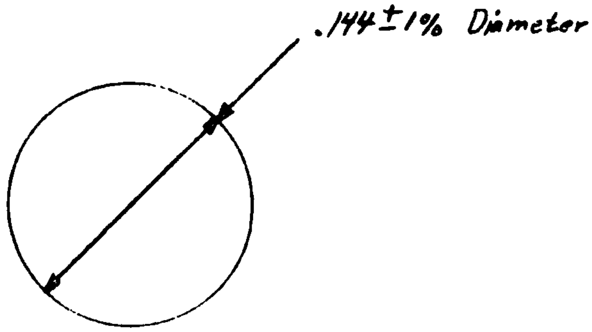
Rev. A - 12-29-64
28% was 20%

H.E. Keneipp 12-21-64

SKETCH SHEET
FORM 28577

WESTINGHOUSE ELECTRIC CORPORATION

Conductor
20% Nickel-Clad Silver



Dimensions in inches
Scale 10:1

EDSK 326535

H. E. Keneipp 12-21-64

APPENDIX A

STATOR MATERIALS SUMMARY

APPENDIX A

STATOR ASSEMBLY

DRAWING NO.	TITLE	MATERIAL
EDSK 326681	Stator Assembly	-
EDSK 326618	Stack, Stator, Wound	-
EDSK 326602	Stack, Stator, Wound (Practice) (1)	-
EDSK 326550	Details	See Drawing
EDSK 326603	Details	See Drawing
EDSK 326620	Details	See Drawing
EDSK 326622	Details	See Drawing
EDSK 326619	Forging	Hiperco 27 Alloy (27 Co - Fe)
EDSK 326793	Forging, Cut Up	Hiperco 27 Alloy (27 Co - Fe)
EDSK 326549	Punching Stator	Hiperco 27 Alloy (27 Co - Fe)
EDSK 326686	Insulator, Tube	99 Al_2O_3
EDSK 326680	Insulator, Tube	99 Al_2O_3
EDSK 326626	Details, Slot	99 Al_2O_3
EDSK 326625	Insulation, Liner	99 Al_2O_3
EDSK 326794	Insulation, Tube	99 Al_2O_3
EDSK 326795	Thermocouple	(Inconel Cladding, Platinel II
EDSK 326796	Thermocouple	wire system, Al_2O_3 Insulation)
P15C8278-12	Pin, Spring	CRES-AMS 5506
EDSK 327502	Screw	Hastelloy Alloy B
EDSK 326531	Conductor	Nickel Clad Silver (20% Clad area) (2)
EDSK 326532A	Conductor	Inconel Clad Silver (28% Clad area) (2)

(1) - Used in a program to define conductor winding methods.

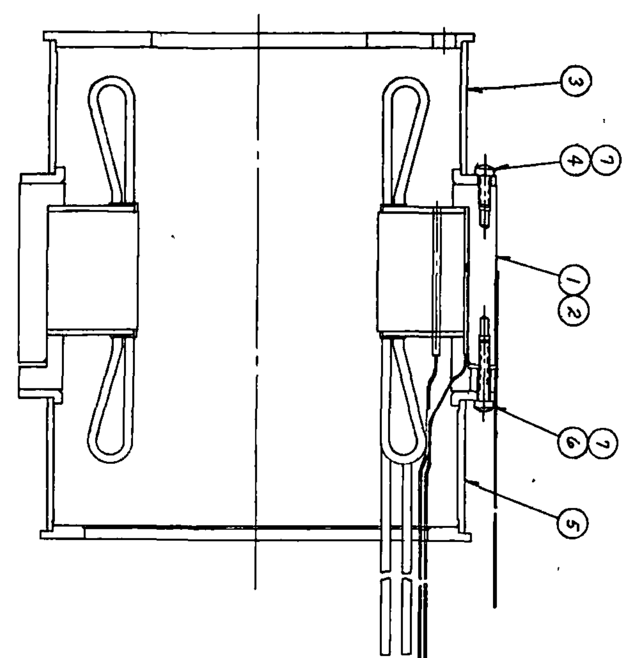
(2) - All conductors insulated with Anaconda's Anadur, a refractory-oxide-filled glass insulation.

2 / / / / 1 / 6 37

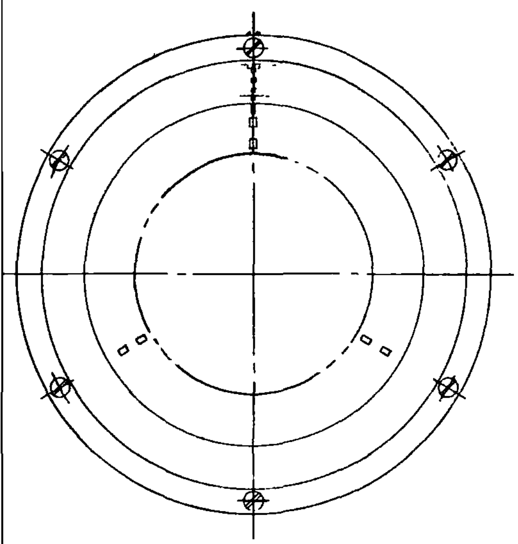
INTERNAL INFO & DATA

RENE 41 IN ITEMS 4 & 6 WAS RENE 4
S#LYP19037 MERRILL 2 2 65
MILLER 2-3-65
1 W. L. Grant 2 3 65

ITEMS 4+6 CHANGED TC EDSK CALL-OUT
2 W. L. Grant ' 1 65



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



QTY REQD PN-2	QTY REQD PN-1	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.
AR	AR	B	WIRE, SST	.032 DIA 7860-2				7
6	6		SCREW	EDSK 327502-4				6
1	1		END BELL	EDSK 326622 ASSY NO 2				5
6	6		SCREW	EDSK 327502-3				4
1	1		END BELL	EDSK 326622 ASSY NO 1				3
1	-		STACK, STATOR	EDSK 326618 PN-2				2
-	1		STACK, STATOR	EDSK 326618 PN-1				1

LIST OF MATERIAL OR PARTS LIST

SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

TOOL REF (W) P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE AND SPECS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DWG. TOLERANCES ON FRACTIONS ±1/64, DECIMALS ±.005, ANGLES ±1°

PROCESS TO BE APPLIED AS INDICATED ON DRAWING

GOV'T SPEC

(W) SPEC

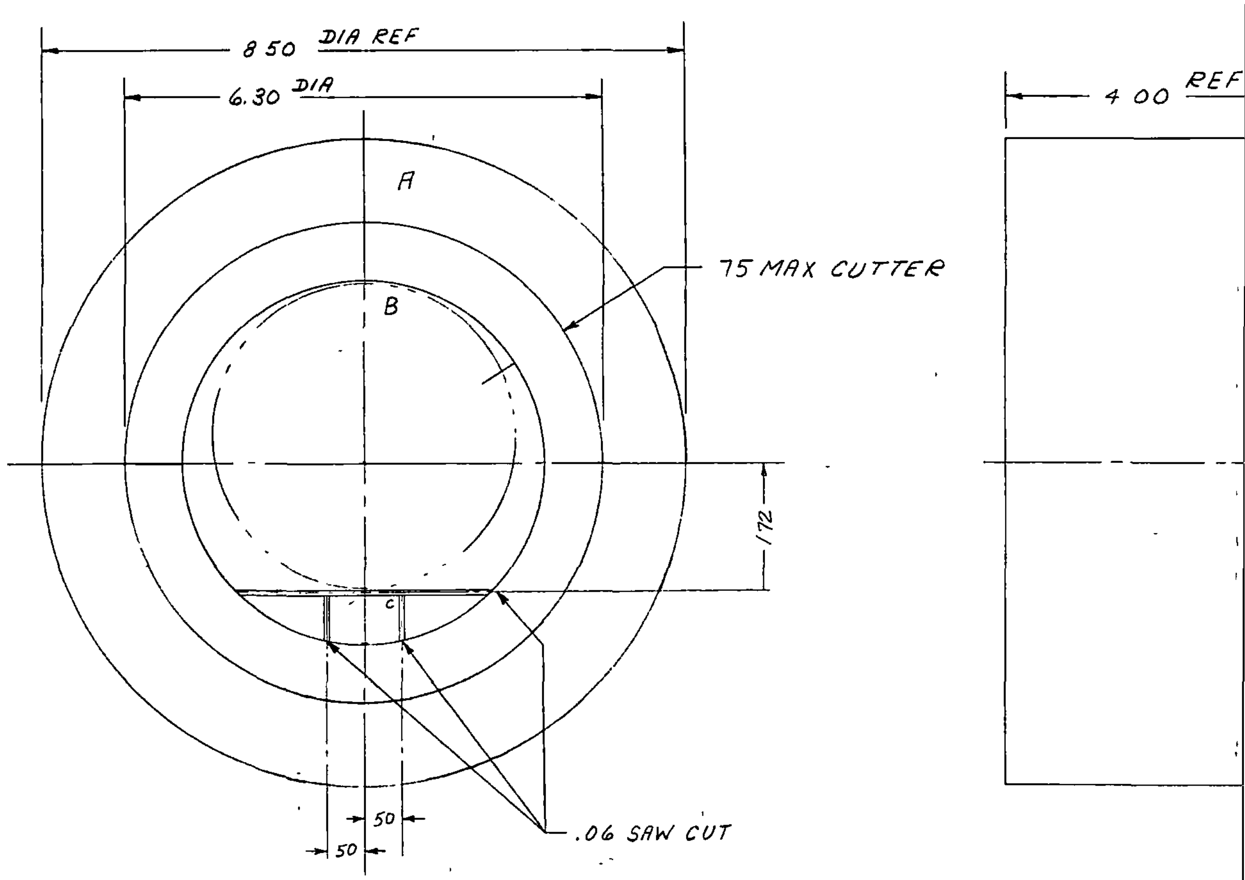
SYMBOLS: (W) = WESTINGHOUSE; BC = SPEC SOURCE CONT DWG; V = VENDOR PART; AR = AS REQ'D; (!) = VERY IMPORTANT

DFTM	HGO	1/22/65
DFTM	EJ	1-25-65
ENGR	H.H. Huff	1-25-65
ENGR	W. L. Grant	1-25-65
MFR		
TEST		
(W) PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.

TITLE: STATOR ASSY

CODE IDENT NO.	SIZE	DRAWING NO.
83843	F	EDSK 326681
SCALE 1/1	WEIGHT	SHEET

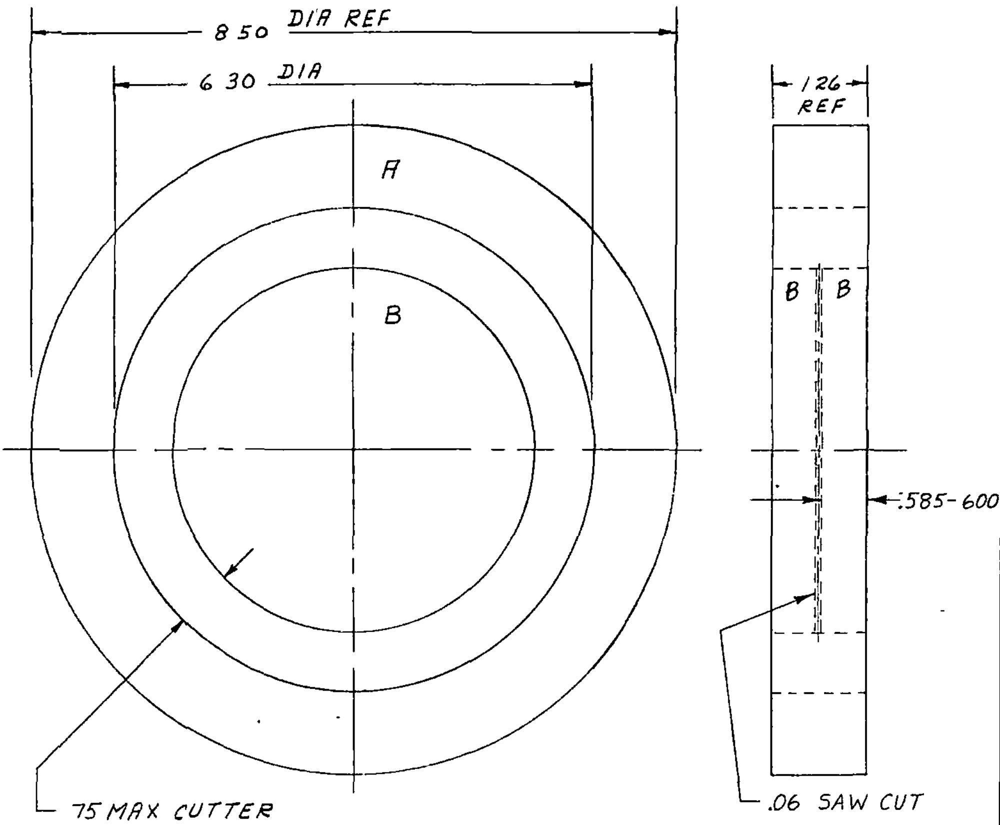


CUT UP FORGING EDSK 326619 ITEM NO 3 AS SHOWN. PART "A" TO BE USED TO MAKE FRAME EDSK 326603 ITEM NO 4, PART "B" TO BE USED TO MAKE HOUSING EDSK 326688 ITEM NO 2 PART "C" TO BE USED TO MAKE BAR EDSK 326688 ITEM NO 6

ITEM N

S-LYF 19039
INTERNAL INFO & DATA
REVISED CUTTER MAX WIDTH FROM 38 TO 75 MAX REVISED PICTURE TO MATCH
1 W L Grant 5-1-65
ITEM 2 - RT VIEW ADDED SAW CUT & 585-600 DIM
2 W L Grant 5-26-65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



CUT UP FORGING EDSK 326619 ITEM NO 2 AS SHOWN.
PART "A" TO BE USED TO MAKE RETAINING RING EDSK 326603 ITEM NO 5,
AND PART "B" TO BE USED TO MAKE RING EDSK 326688 ITEM NO 5

AND

1

ITEM NO 2

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX ±.02 3 PLACE .XXX ±.005 ANGLES ±1°

TOOL REF Ⓦ P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE, MFG SPECS PER EA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DWG. TOLERANCES ON
FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2°
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE R = SEE MATERIAL
K = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
Ⓥ = VERY IMPORTANT

DFTM	HGO	1/22/65
DFTM	[illegible]	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

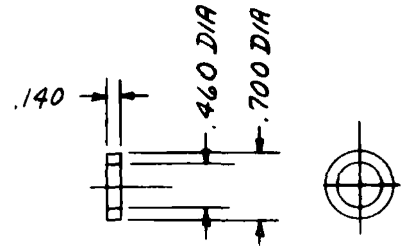
AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA OHIO, U.S.A.

TITLE FORGING, CUT UP

CODE IDENT NO	SIZE	DRAWING NO
83843	D	EDSK 326793

SCALE 1/1 | WEIGHT | SHEET

DWG EDSK 326793



NOTE ~ .460 DIA MUST BE CONCENTRIC WITH .700 DIA WITHIN .0005 T.I.R.

BUSHING ~ MAKE FROM MINIMUM 99.5% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

TOOL REF / P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED | SPARES CANNOT BE FURN

SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

TOLERANCE, ... SPECS PER LA 531
DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 | 3 PLACE .XXX±.005 | ANGLES ±1°
PROCESS TO BE APPLIED AS INDICATED ON DWG.
GOV'T SPEC
SPEC
SYMBOLS
= WESTINGHOUSE; B = BASE MATERIAL
SC = SPEC/SOURCE CONT DWG; AR = AS REQ'D
V = VENDOR PART
= VERY IMPORTANT

NEXT ASSY

DFTM	HGO	1/20/65
DFTM	[illegible]	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DIVISION
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO. U.S.A.

TITLE: BUSHING

CODE IDENT NO.	SIZE	DRAWING NO.
83843	B	EDSK 326787

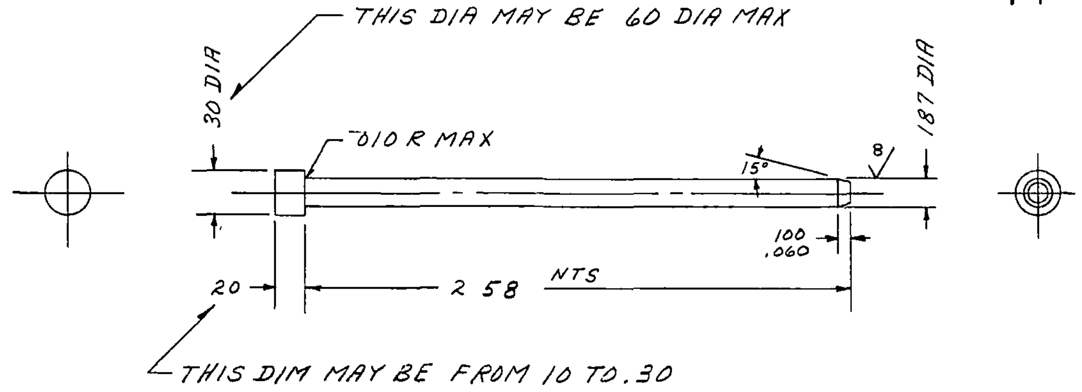
SCALE 1/1 | WEIGHT | SHEET

INTERNAL INFO & DATA
LYP 19039

DWG EDSK 326787

FORM NO. 33301

SYM	REVISIONS DESCRIPTION	DATE	APPROVED



GUIDE ROD ~ MAKE FROM MINIMUM 99.5% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

DFTM HGO	1/11/65	AEROSPACE ELECTRICAL DEPARTMENT Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ LIMA, OHIO U.S.A.
DFTM	1-25-65	TITLE SOLENOID ARMATURE, GUIDE ROD
ENGR	1/25/65	
ENGR W L Grant	1-25-65	
MFR		
TEST		
Ⓦ PROJ ENGR APPD		CODE IDENT NO. 83843 · SIZE C · DRAWING NO EDSK 326687
APPD FOR		
BY		SCALE 2:1 · WEIGHT · SHEET

TOLERANCE MFG SPECS PER LA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES, DO NOT SCALE DWG
TOLERANCES ON FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
⊖ = VERY IMPORTANT

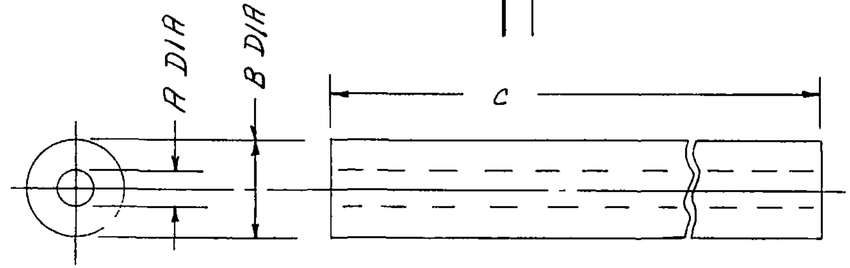
Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

DIMENSIONS IN INCHES – DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 · 3 PLACE .XXX±.005 · ANGLES ±1°
TOOL REF Ⓦ P/N
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED SPARES CANNOT BE FURN
NEXT ASSY

S.LYP 19039
Ⓦ INTERNAL INFO & DATA
10 TO 30 DIM WAS .10 TO .50
S=LYP19039 MERRILL 2-2-65
MILLER 2-3-65
W L Grant 2-3-65
1

PART NO	DIA A	DIA B	LENGTH C
-1	062	125	.70
-2	062	.188	2 50
-3	.044	094	2 50

EDSK 326686



NOTE ~ STRAIGHTNESS TOLERANCE 1/16 INCH PER FOOT OF LENGTH

INSULATOR ~ MAKE FROM MINIMUM 99% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

DFTM	HGO	1/11/65
DFTM	[illegible]	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA OHIO U.S.A.

TITLE: INSULATOR, TUBE

CODE IDENT NO. 83843 | SIZE C | DRAWING NO EDSK 326686

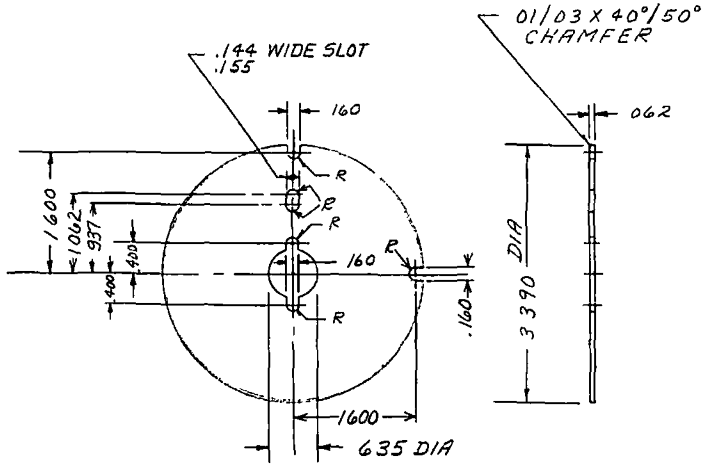
SCALE NTS | WEIGHT | SHEET

TOLERANCE MFG SPECS PER LA 351
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG.
TOLERANCES ON FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
SPEC
SYMBOLS: =WESTINGHOUSE B=BULK MATERIAL; =SPEC/SOURCE CONT DWG; =VENDOR PART AR=AS REQ'D; =VERY IMPORTANT
NEXT ASSY

SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

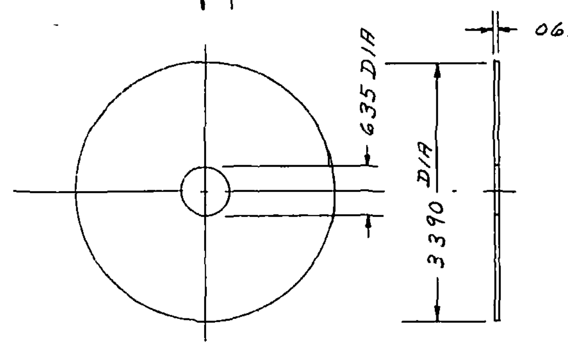
DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 3 PLACE .XXX±.005 ANGLES ±1°
TOOL REF P/N
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED SPARES CANNOT BE FURN

S LYP19039
INTERNAL INFO & DATA



END PLATE ~ MAKE FROM MINIMUM 99.5% PURITY
HIGH DENSITY AL_2O_3 (ALUMINA)

ITEM NO 2



END PLATE ~ MAKE FROM MINIMUM 99.5% PURITY
HIGH DENSITY AL_2O_3 (ALUMINA)

ITEM NO 1

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

S. LYP 19039

Ⓦ INTERNAL INFO & DATA

.144/.155 DIA HOLE LOCATED ON VERTICAL ℄ 1.000 UP FROM HORIZONTAL ℄ REMOVED. .144/.155 WIDE SLOT & RELATIVE DIM ADDED. .160 WIDE SLOT LOCATED ON HORIZONTAL ℄ WAS LOCATED OPPOSITE .160 WIDE SLOT ON VERTICAL ℄.
S# LYP19039 MERRILL 2-2-65
MILLER 2-3-65
W.L. Grant 2-3-65

1

DIMENSIONS IN INCHES – DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES
UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02
3 PLACE .XXX±.005
ANGLES ±1°

TOOL REF Ⓦ P/N
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED
SPARES CANNOT BE FURN
NEXT ASSY

TOLERANCE MFG SPECS PER IA 231
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG
TOLERANCES ON
FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
⊗ = VERY IMPORTANT

DFTM	HGO	1/14/65
DFTM		1-25-65
ENGR		1/25/65
ENGR	W.L. Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

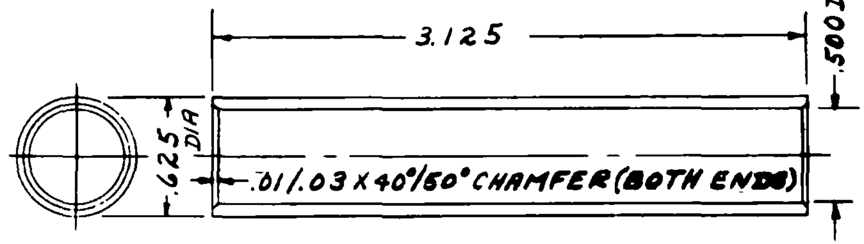
AEROSPACE ELECTRICAL DEPARTMENT
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO U.S.A.

TITLE END PLATE

CODE IDENT NO	SIZE	DRAWING NO
83843	C	EDSK 326684

SCALE 1/1 WEIGHT SHEET

ENGRG DEPT FORM LINCOLN-GRAPHIC CORP



NOTE ~ TUBE I.D. MUST BE STRAIGHT WITHIN .005 T/R

INSULATOR ~ MAKE FROM MINIMUM 99% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

TOOL REF Ⓦ P/N	NOT TOOLED	PROD TOOLED	TOOLS SCRAPPED SPARES CANNOT BE FURN

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

LYP 19039

Ⓦ INTERNAL INFO & DATA

NEXT ASSY

TOLERANCES, INFO SPECS PER LA 201
DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 | 3 PLACE .XXX±.005 | ANGLES ±1°
PROCESS TO BE APPLIED AS INDICATED ON DWG.
GOV'T SPEC
Ⓦ SPEC

SYMBOLS
Ⓦ =WESTINGHOUSE B=RAW MATERIAL
SC =SPEC/SOURCE CONT DWG
V =VENDOR PART AR=AS REQ'D
Ⓥ =VERY IMPORTANT

DFTM	HGO	1/11/65
DFTM	E. Miller	1-25-65
ENGR	NHKnapp	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

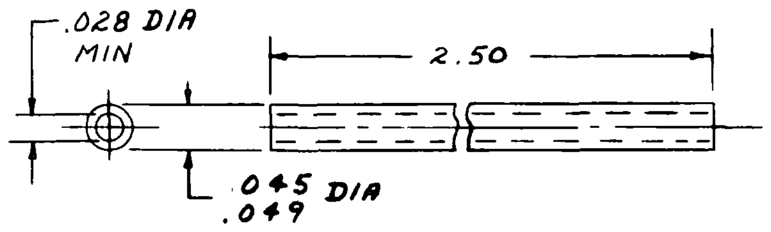
AEROSPACE ELECTRICAL DIVISION
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO. U.S.A.

TITLE INSULATOR, TUBE

CODE IDENT NO.	SIZE	DRAWING NO.
83843	B	EDSK 326685
SCALE 2:1	WEIGHT	SHEET

EDSK 326685

W FORM NO. 2235-J



NOTE ~ STRAIGHTNESS TOLERANCE 1/16 INCH PER FOOT OF LENGTH

INSULATOR ~ MAKE FROM MINIMUM 99% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

TOOL REF P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED | SPARES CANNOT BE FURN

SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

E-LYB19037 INTERNAL INFO & DATA

NEXT ASSY

STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 | 3 PLACE .XXX±.005 | ANGLES ±1°
PROCESS TO BE APPLIED AS INDICATED ON DWG.
GOV'T SPEC
SPEC
SYMBOLS

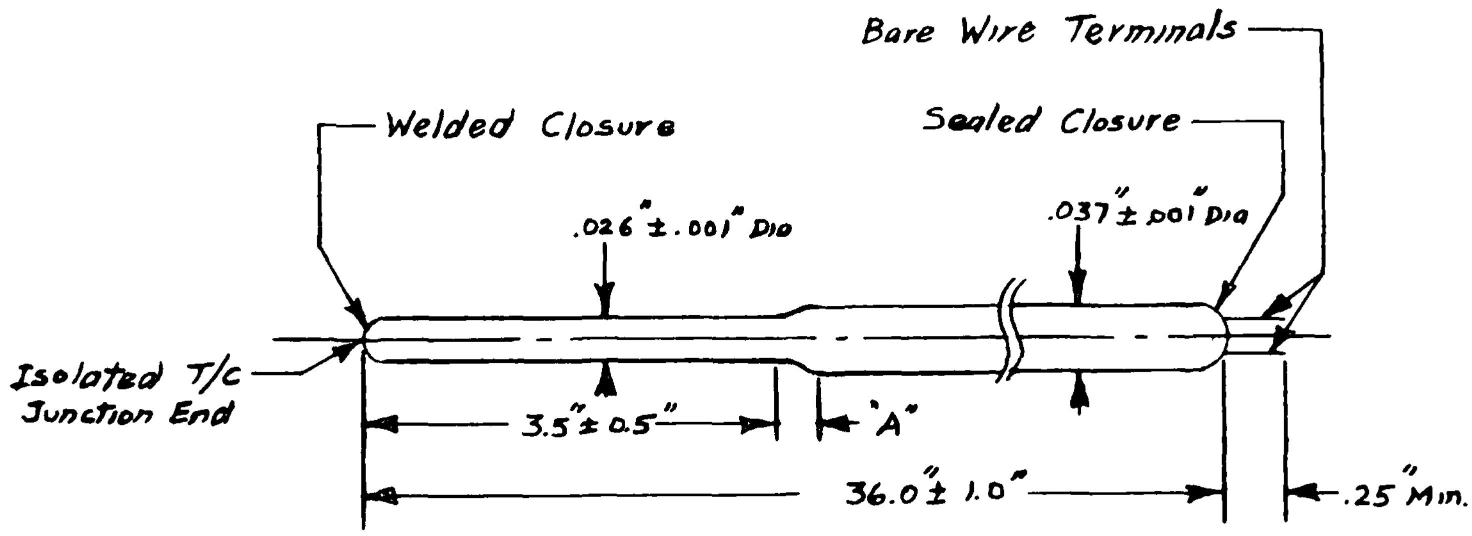
DFTM	HGO	1/8/65
DFTM	GT	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DIVISION
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO. U.S.A.

TITLE INSULATOR, TUBE

CODE IDENT NO.	SIZE	DRAWING NO.
83843	B	EDSK 326680
SCALE 10/1	WEIGHT	SHEET

DWG. EDSK 326680



Note: Thermocouples are to be kept straight at all times.

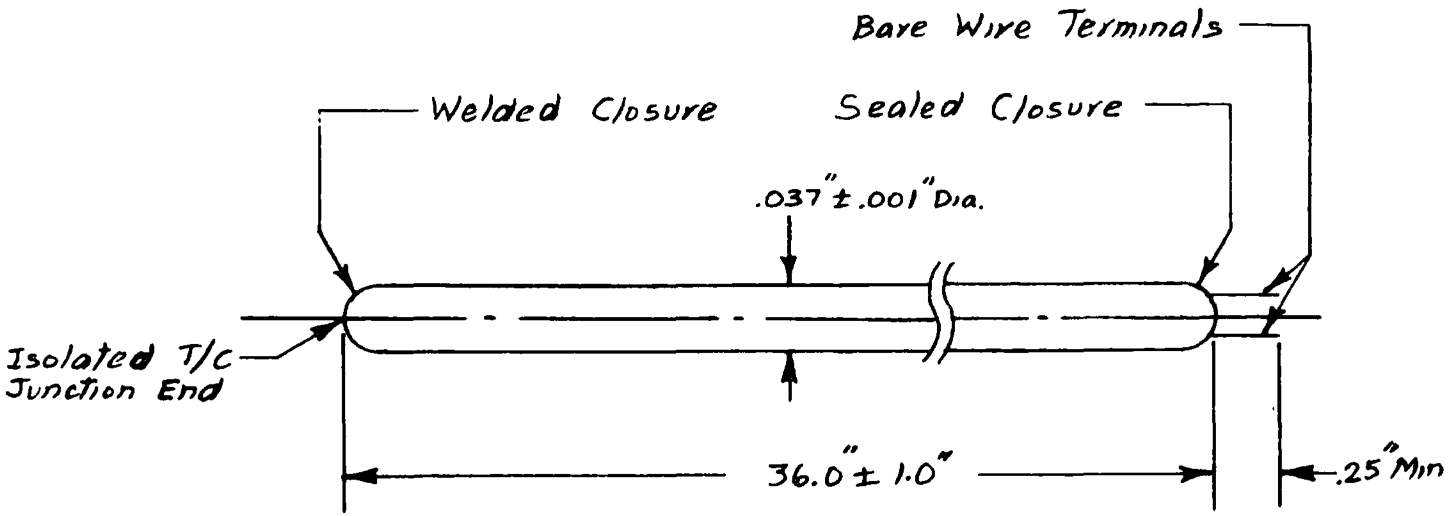
"A" – Dimension as required for forming operation – 1.0 inch maximum. OD surface must be continuous thru transition.

DUAL DIAMETER SHEATHED THERMOCOUPLE

Reference Ⓦ D-Spec # 709747

EDSK 326795

wlg 2-18-65



Note: Thermocouples are to be kept straight at all times

SINGLE DIAMETER SHEATHED THERMOCOUPLE

Reference (W) D-Spec # 709747

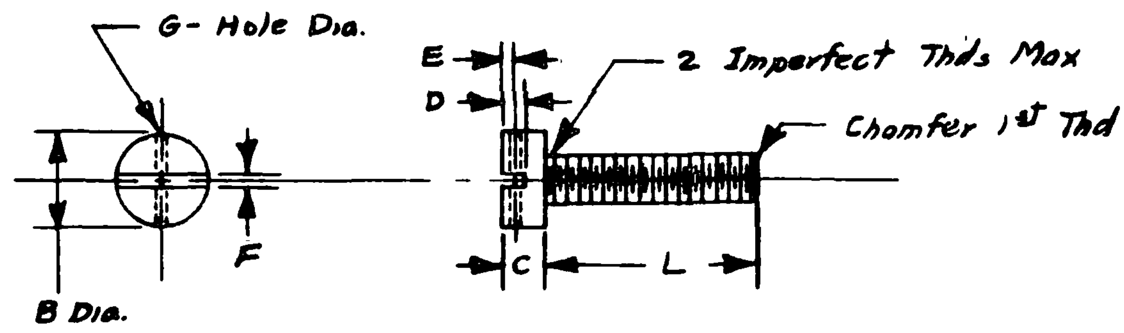
EDSK 326796

wg 2-18-65

(W)

SKETCH SHEET
FORM 28877

WESTINGHOUSE ELECTRIC CORPORATION



Material - Hastelloy Alloy B Rod

Dash No.	Thread	B Dia ±.003	C ±.003	D ±.005	E ±.005	F ±.003	G Dia ±.002	L ±.005	Stock
1	#8 (164)-32 NC-2A	.270	.156	.078	.050	.062	.040	.500	3/8 Dia
2	" " " "	.270	.156	.078	.050	.062	.040	.750	3/8 Dia
3	#10 (.190)-32 NF-2A	.313	.156	.078	.050	.062	.040	.500	7/16 Dia
4	" " " "	.313	.156	.078	.050	.062	.040	1.00	7/16 Dia
5	1/4-28 UNF-2A	.414	.207	.103	.078	.062	.040	.500	1/2 Dia

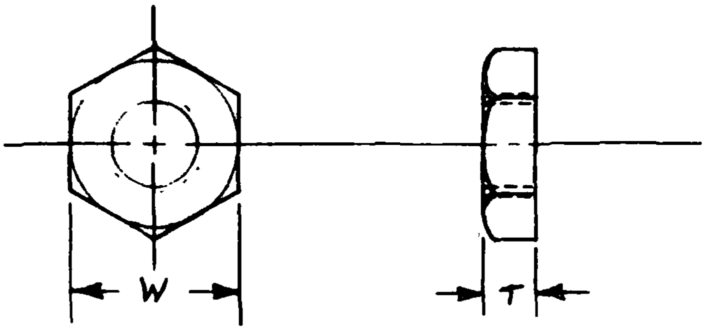
SCREW - FLAT FILLISTER HEAD

W. L. Grant 4-21-65 EDSK 327502

EDSK 327502

SKETCH SHEET
FORM 28877

WESTINGHOUSE ELECTRIC CORPORATION



Material - Hastelloy Alloy B Rod

Dash No.	Thread	W ±.005	T ±.008	Stock
1	#8 (.164)-32 NC-2B	.338	.187	1/2 Dia
2	1/4-28 UNF-2B	.428	.219	5/8 Dia

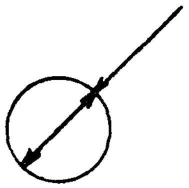
NUT - HEXAGONAL

W.L. Grant 4-21-65 EDSK 327503

SKETCH SHEET
FORM 28577

WESTINGHOUSE ELECTRIC CORPORATION

Conductor
20% Nickel-Clad Silver



Dimensions in inches
Scale 20:1

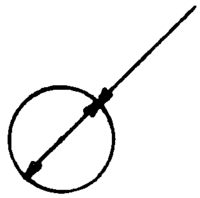
EDSK 326533

H.E. Keneipp 12-21-64

SKETCH SHEET
FORM 28577

WESTINGHOUSE ELECTRIC CORPORATION

Conductor
28% Inconel-Clad Silver

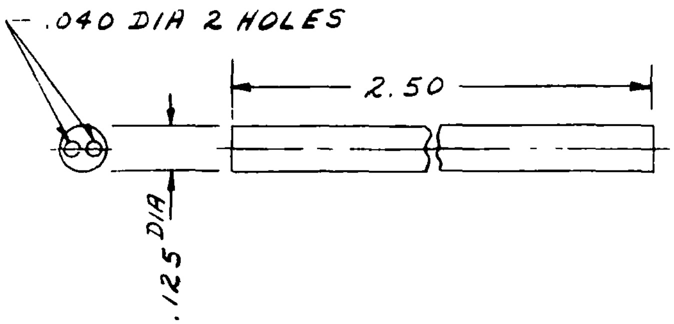


Dimensions in inches
Scale 20:1

EDSK 326534 A

Rev. A - 12-29-64
28% was 20%

H.E. Keneipp 12-21-64



NOTE ~ STRAIGHTNESS TOLERANCE 1/16 INCH PER FOOT OF LENGTH

INSULATOR ~ MAKE FROM MINIMUM 99% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

DWG. ED-K 326794

LIST OF MATERIAL OR PARTS LIST

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO.

TOOL REF Ⓦ P/N
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED
SPARES CANNOT BE FURN

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

INTERNAL INFO & DATA
LYP19037

NEXT ASSY

TOLERANCE, AND SPECS PER LA 851
DIMENSIONS IN INCHES – DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE XX±.02 | 3 PLACE XXX±.005 | ANGLES ±1°
PROCESS TO BE APPLIED AS INDICATED ON DWG
GOV'T SPEC
Ⓦ SPEC

SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CON'T DWG
V = VENDOR PART AR = AS REQ'D
Ⓥ = VERY IMPORTANT

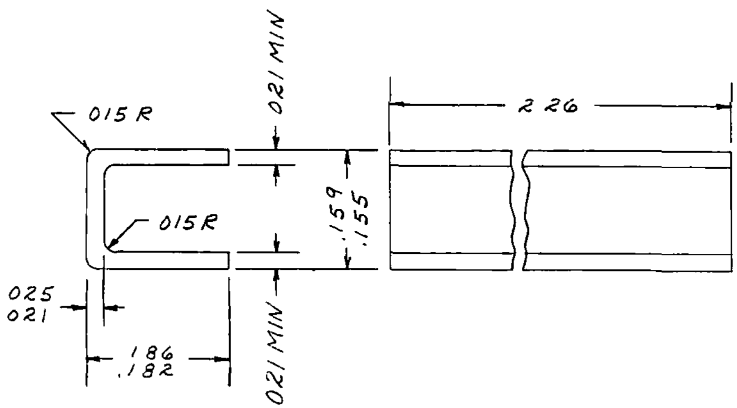
DFTM	HGO	1/22/65
DFTM	[illegible]	1-25-65
ENGR	HCK[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DIVISION
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO. U.S.A.

TITLE INSULHTOR, TUBE

CODE IDENT NO.	SIZE	DRAWING NO.
83843	B	EDSK 326794
SCALE 4/1	WEIGHT	SHEET

W FORM [illegible]



NOTE ~ LINER MUST FIT IN .160/.159 WIDE, STRAIGHT SLOT, .20 DEEP, FULL LENGTH OF LINER

NOTE ~ A .1095/.1085 WIDE, STRAIGHT FLAT BAR MUST PASS THRU FULL LENGTH OF LINER

INSULATION, LINER - MAKE FROM MINIMUM 99 % PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA OHIO U.S.A

DFTM	[illegible]	1/9/65
DFTM	[illegible]	1-25-65
ENGR	[illegible signature]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

TITLE INSULATION, LINER

CODE IDENT NO. 83843 | SIZE C | DRAWING NO EDSK 326625

SCALE 2/1 | WEIGHT | SHEET

TOLERANCE MFG SPECS PER LA 351
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG. TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2°
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
SPEC
SYMBOLS: W = WESTINGHOUSE; B = BULK MATERIAL; SC = SPEC/SOURCE CONT DWG; V = VENDOR PART; AR = AS REQ'D; = VERY IMPORTANT

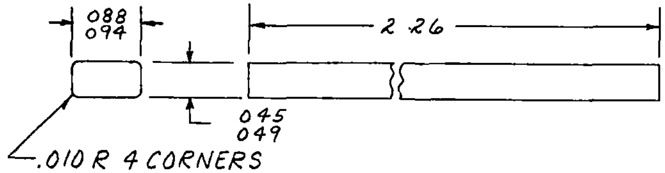
SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE XX±.02 | 3 PLACE XXX±.005 | ANGLES ±1°
TOOL REF P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

5LYP190[illegible]
INTERNAL INFO & DATA
160/159 DIM WAS 160/1595 MERRILL
5#LYP19037 2-2-65
MILLER 2-3-65
W L Grant 2-3-65

1	99% WAS 99.5%
2	W L Grant 5-1-65

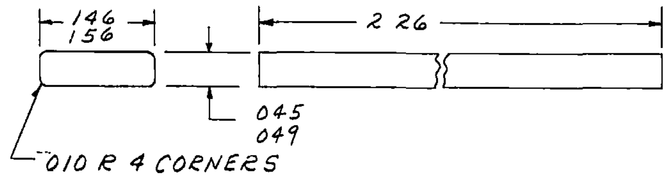
ENGRG DEPT FORM [illegible]



NOTE ~ ALL SIDES OF SPACER MUST BE STRAIGHT AND FLAT WITHIN .005 TIR

SPACER ~ MAKE FROM MINIMUM 99 % PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

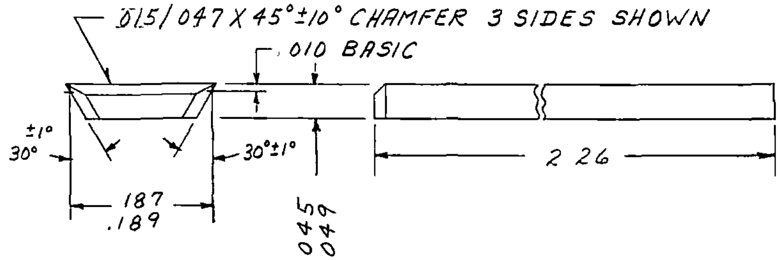
ITEM NO. 1



NOTE ~ ALL SIDES OF SPACER MUST BE STRAIGHT AND FLAT WITHIN 005 TIR

SPACER ~ MAKE FROM MINIMUM 99 % PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

ITEM NO. 2



NOTE ~ ALL SIDES OF WEDGE MUST BE STRAIGHT AND FLAT WITHIN 005 TIR

WEDGE ~ MAKE FROM MINIMUM 99 % PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

ITEM NO. 3

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

DFTM	HGO	1/13/65
DFTM	67	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA OHIO U.S.A.

TITLE DETAILS, SLOT

CODE IDENT NO 83843 | SIZE C | DRAWING NO EDSK 326626

SCALE 10/1 | WEIGHT | SHEET

TOLERANCE MFG SPECS PER LA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG. TOLERANCES ON FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS Ⓦ = WESTINGHOUSE B = BULK MATERIAL SC = SPEC/SOURCE CONT DWG V = VENDOR PART AR = AS REQ'D Ⓥ = VERY IMPORTANT

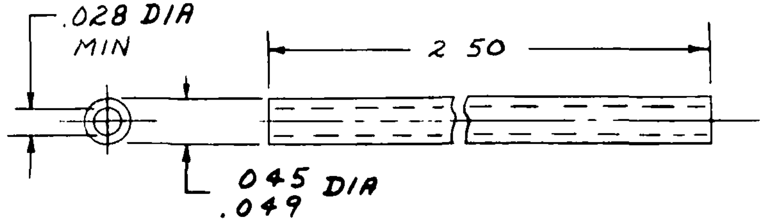
NEXT ASSY

DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX ± .02 3 PLACE .XXX ± .005 ANGLES ± 1°

TOOL REF Ⓦ P/N
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED SPARES CANNOT BE FURN

Ⓦ SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

S.LYP19037
Ⓦ INTERNAL INFO & DATA
99 % WAS 99.5% - 3 PLACES 1 WL Grant 5-11-65



NOTE ~ STRAIGHTNESS TOLERANCE 1/16 INCH PER FOOT OF LENGTH

INSULATOR ~ MAKE FROM MINIMUM 99% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 3 PLACE .XXX±.005 ANGLES ±1°

DFTM	HGO	1/8/65
DFTM		1-25-65
ENGR		1/25/65
ENGR	J L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DIVISION
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.

TITLE INSULATOR, TUBE

CODE IDENT NO.	SIZE	DRAWING NO
83843	B	EDSK 326680

SCALE 10/1 WEIGHT SHEET

TOOL REF P/N · NOT TOOLED · PROD TOOLED · TOOLS SCRAPPED · SPARES CANNOT BE FURN

SPECIFICATION REFERENCE · GOVERNMENT SPECIFICATION · NAME OF PROCESS

INTERNAL INFO & DATA L17B19037

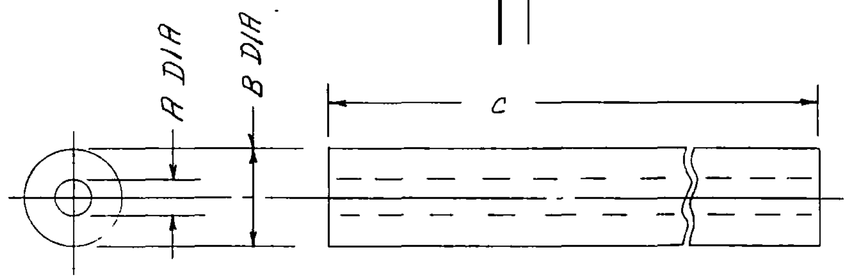
NEXT ASSY

DWG. EDSK 326680

PART NO	DIA A	DIA B	LENGTH C
-1	062	125	.70
-2	062	.188	2 50
-3	.044	094	2 50

EDSK 326686

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



NOTE ~ STRAIGHTNESS TOLERANCE 1/16 INCH PER FOOT OF LENGTH

INSULATOR ~ MAKE FROM MINIMUM 99% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

DFTM HGO	1/11/65
DFTM [illegible]	1-25-65
ENGR [illegible]	1/25/65
ENGR W L Grant	1-25-65
MFR	
TEST	
Ⓦ PROJ ENGR APPD	
APPD FOR	
BY	

AEROSPACE ELECTRICAL DEPARTMENT
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO U.S.A.

TITLE INSULATOR, TUBE

CODE IDENT NO.	SIZE	DRAWING NO
83843	C	EDSK 326686

SCALE NTS | WEIGHT | SHEET

TOLERANCE, MFG SPECS PER LA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG.
TOLERANCES ON
FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CON'T DWG
V = VENDOR PART AR = AS REQ'D
Ⓥ = VERY IMPORTANT

NEXT ASSY

DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 3 PLACE .XXX±.005 ANGLES ±1°

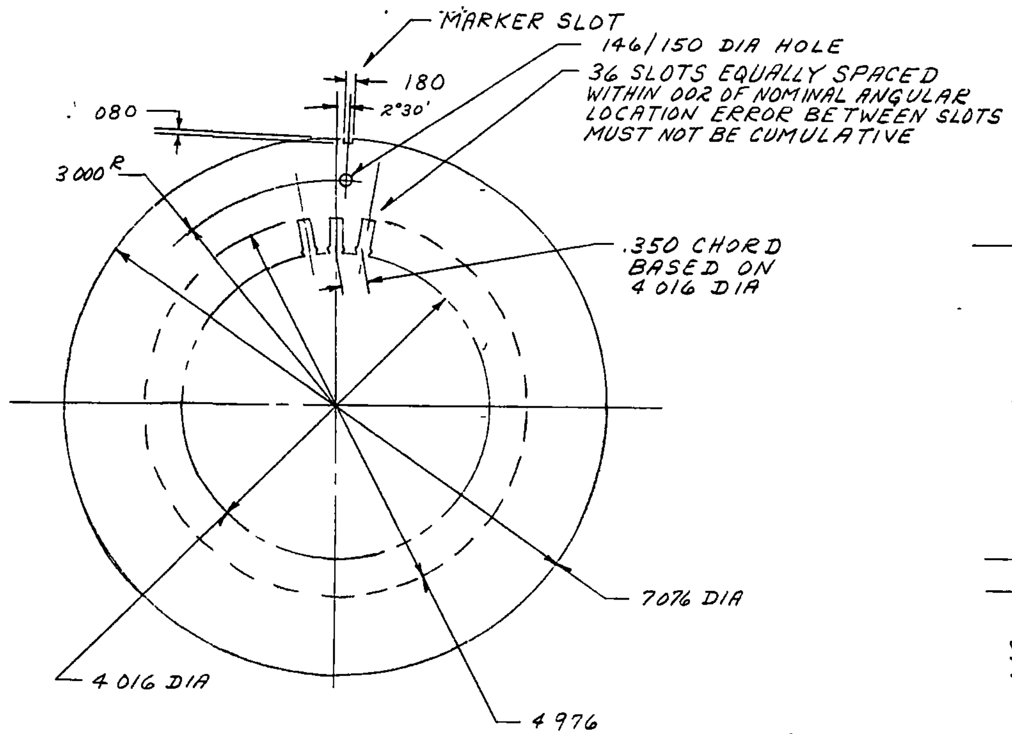
TOOL REF Ⓦ P/N
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED SPARES CANNOT BE FURN

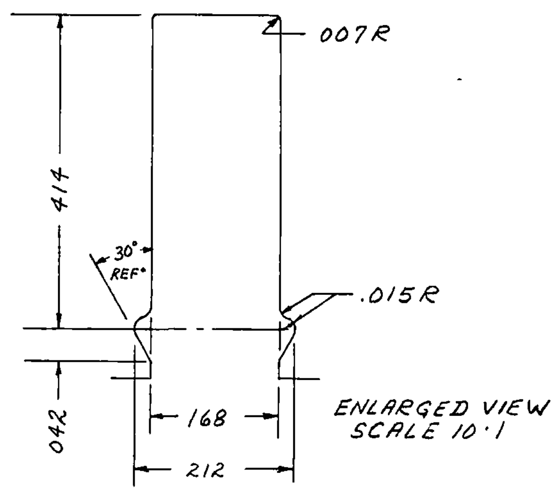
Ⓦ SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

S. LYP19039
Ⓦ INTERNAL INFO & DATA

ENGRG DEPT FORM [illegible] LINCOLN-GRAPHIC CORP

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED





EDSK326549 ITEM 1 ONLY, ANNEAL PER PDS 8000Z AK BY MAGNETICS INC, BUTLER, PA CODE 90797
AFTER ANNEALING INSULATE PER INSTRUCTIONS OF ENGINEER

LA 405	NONE	PUNCHING TOLERANCE
SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO
1		PUNCHING			STEEL SHEET	.014 THK 10501 DC	2
1		PUNCHING	HIPERCO 27		SHEET	.008 THK 13202 AC	1

LIST OF MATERIAL OR PARTS LIST

TOLERANCE MFG SPECS PER LA 331
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DWG.
TOLERANCES ON FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
SPEC
SYMBOLS
W = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ D
= VERY IMPORTANT

TOOL REF P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

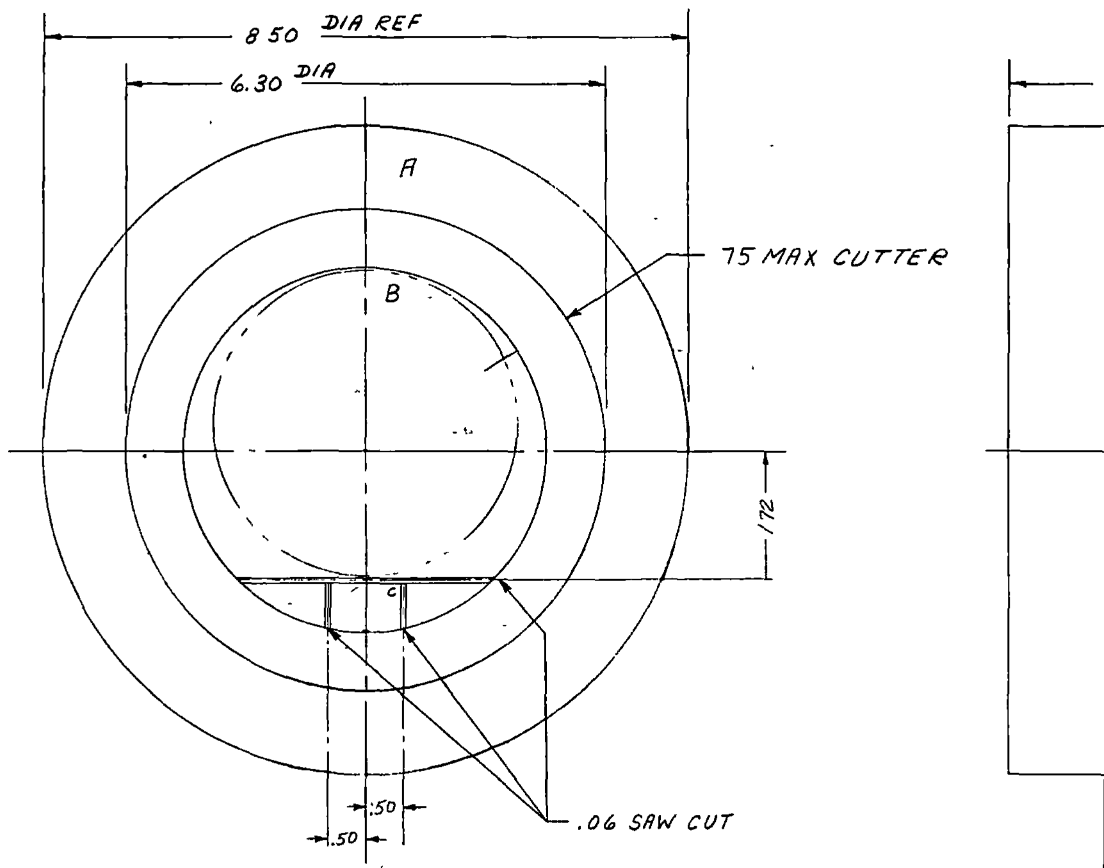
DFTM	HGO	1/4/65
DFTM	G7	1-25-65
ENGR	McK...	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO U S A

TITLE PUNCHING, STATOR, STEEL

CODE IDENT NO	SIZE	DRAWING NO
83843	C	EDSK 326549
SCALE 1'/10 /	WEIGHT	SHEET

S. LYP 19037 INTERNAL INFO & DATA



CUT UP FORGING EDSK 326619 ITEM NO. 3 AS SHOWN. PART "A" TO BE USED TO MAK
EDSK 326603 ITEM NO 4, PART "B" TO BE USED TO MAKE HOUSING EDSK 326688
PART "C" TO BE USED TO MAKE BAR EDSK 326688 ITEM NO 6

S. LYP 19039

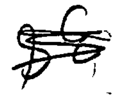
INTERNAL INFO & DATA

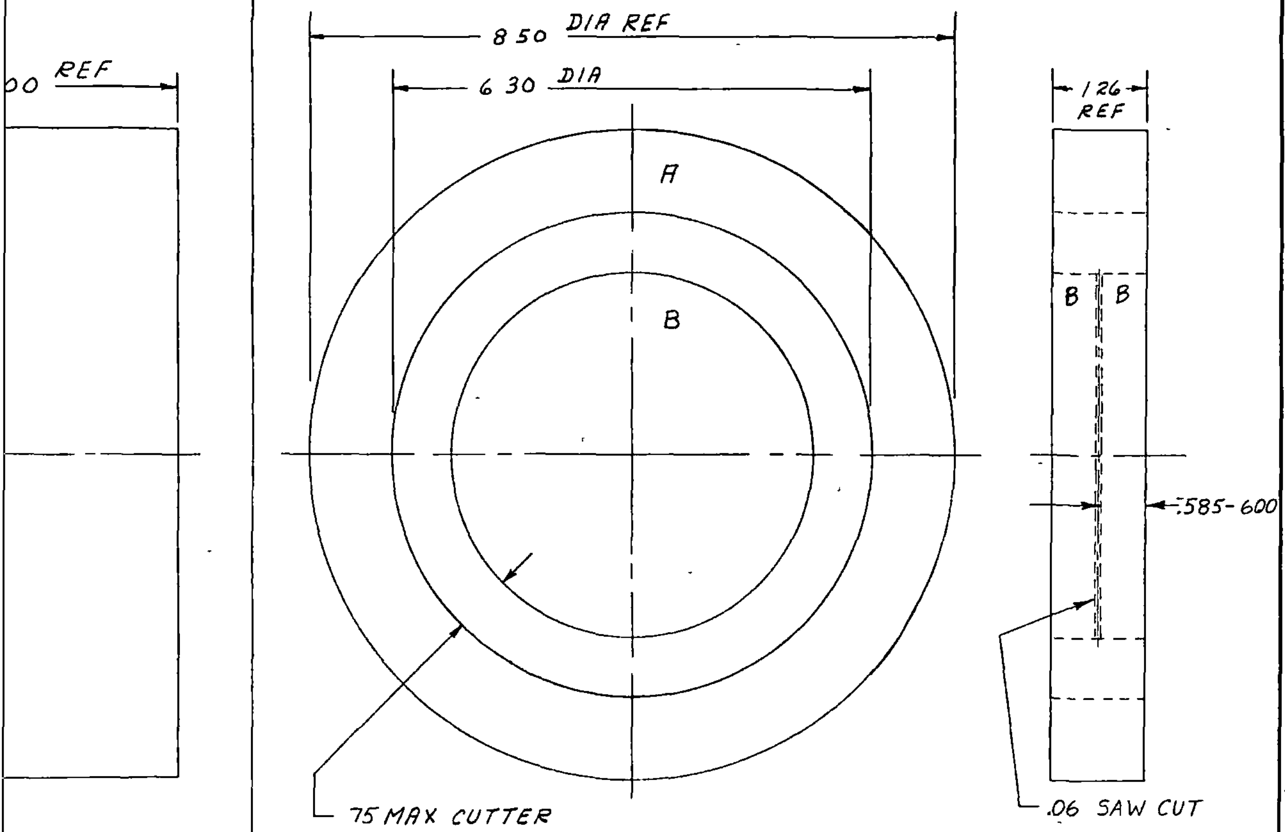
REVISED CUTTER MAX WIDTH FROM .38 TO .75 MAX REVISED PICTURE TO MATCH

1 W L Grant 5-1-65

ITEM 2 - RT VIEW ADDED SAW CUT & 585-600 DIM

2 W L Grant 5-26-65





CUT UP FORGING EDSK 326619 ITEM NO. 2 AS SHOWN.
PART "A" TO BE USED TO MAKE RETAINING RING EDSK 326603 ITEM NO 5,
AND PART "B" TO BE USED TO MAKE RING EDSK 326688 ITEM NO 5

FRAME
EM NO 2, AND

ITEM NO 1

ITEM NO. 2

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

DFTM	HGO	1/22/65
DFTM	CJ	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR, APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA OHIO U.S.A.

TITLE FORGING, CUT UP

CODE IDENT NO 83843 SIZE D DRAWING NO EDSK 326793

SCALE 1/1 WEIGHT SHEET

DWG EDSK 326793

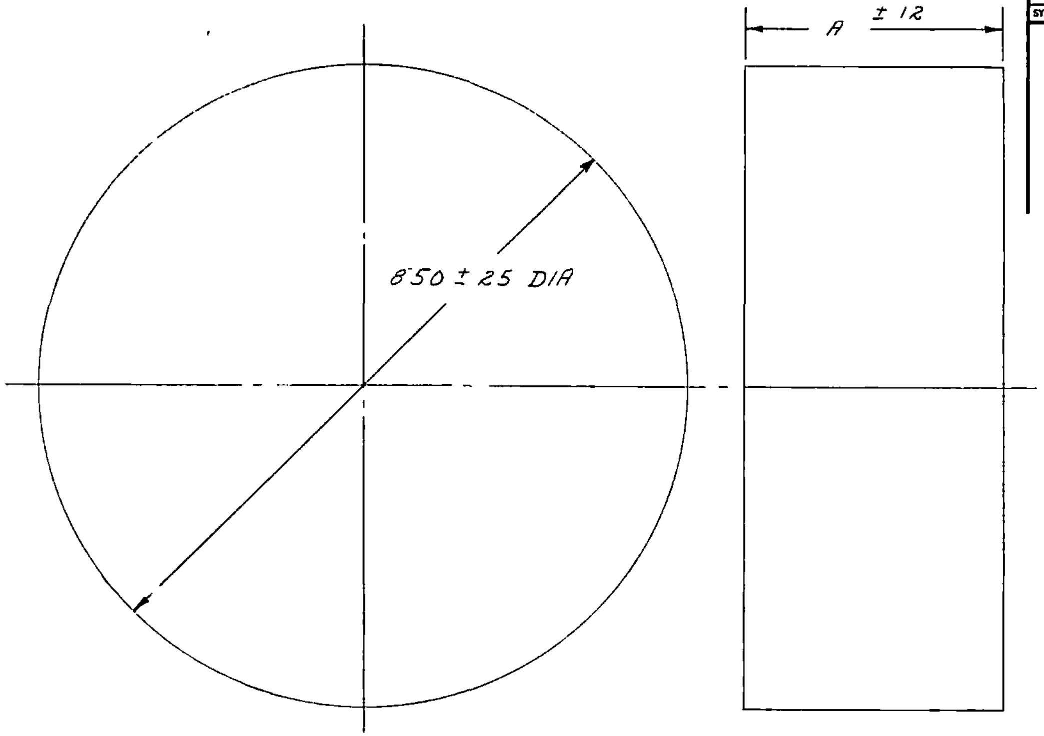
SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

DIMENSIONS IN INCHES - DO NOT SCALE DRAWING STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED 2 PLACE .XX ± .02 3 PLACE .XXX ± .005 ANGLES ± 1°

TOOL REF P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE, MFG SPECS PER LA 531
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DWG.
TOLERANCES ON FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
SPEC

SYMBOLS
= WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
= VERY IMPORTANT



EDSK 326619	DIM "A"
ITEM NO 1	3.40
ITEM NO 2	1.26
ITEM NO 3	4.00

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

~NOTE~

MATERIAL SHALL BE MADE TO MEET WESTINGHOUSE PDS 13225AB WITH THE FOLLOWING ADDITIONAL REQUIREMENTS 1. THAT CERTIFICATION OF ACCEPTABLY PASSING ULTRASONIC INSPECTION BE PROVIDED 2: THAT THE MATERIAL BE SHIPPED WITHOUT BEING ANNEALED, HOWEVER IN THE ANNEALED CONDITION SAID FORGING SHALL BE CERTIFIED TO MEET THE MECHANICAL AND MAGNETIC PROPERTIES OF PDS 13225 AB

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

TOLERANCE, MFG SPECS PER LA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG. TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2°
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
W SPEC
SYMBOLS
W = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AE = AS REQ'D
⊕ = VERY IMPORTANT

DFTM	HGO	12/31/64
DFTM	[illegible]	1-25-65
ENGR	DH [illegible]	1/4/65
ENGR	[illegible]	1/4/65
MFR		
TEST		
W PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO U.S.A.

TITLE FORGING

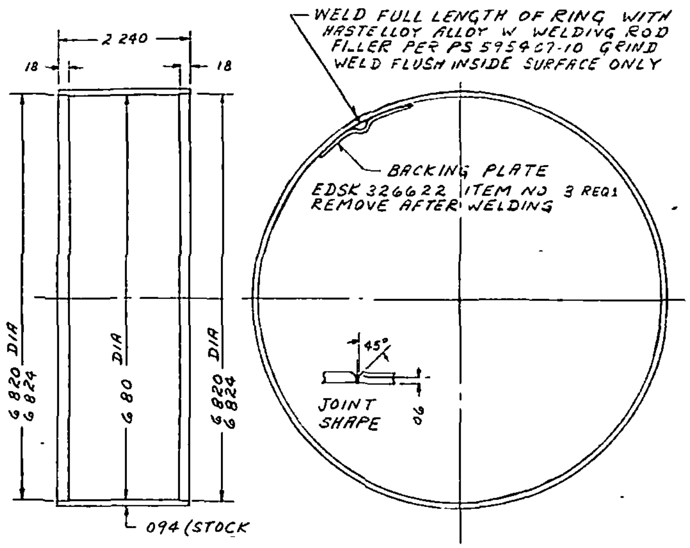
CODE IDENT NO	SIZE	DRAWING NO
83843	C	EDSK 326619
SCALE 1/1	WEIGHT	SHEET

W SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

TOOL REF W P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

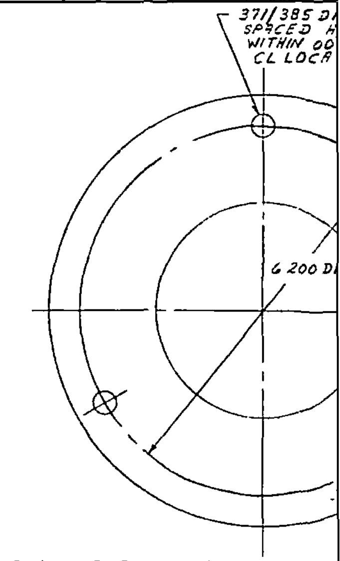
S. LYP19037 W INTERNAL INFO & DATA

ENGRG DEPT FORM 53390-J LINCOLN-GRAPHIC CORP

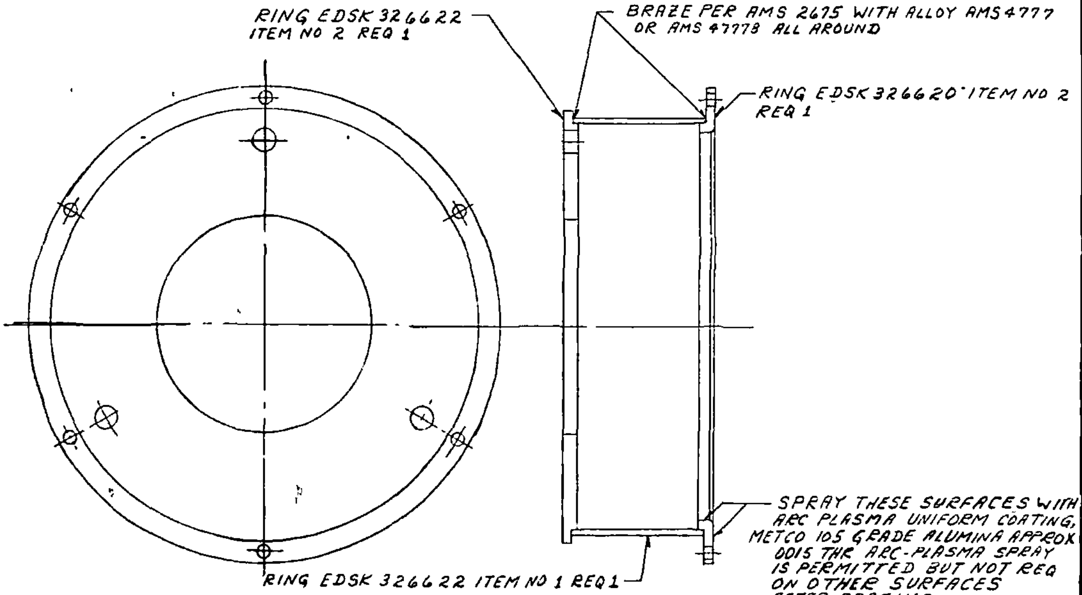


RING~MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B333-62

ITEM NO 1

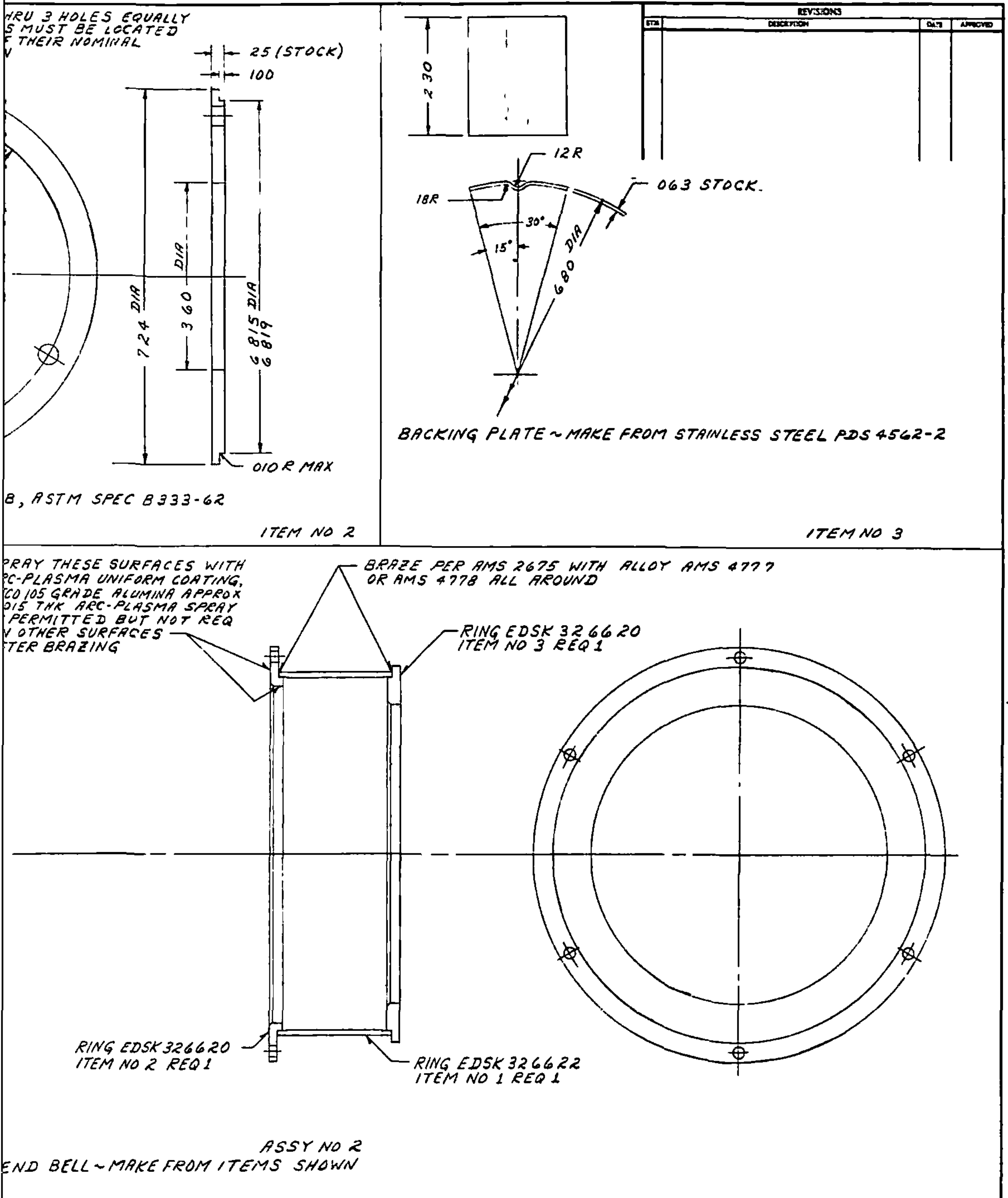


RING~MAKE FROM HASTELLOY ALL



ASSY NO 1
END BELL ~ MAKE FROM ITEMS SHOWN

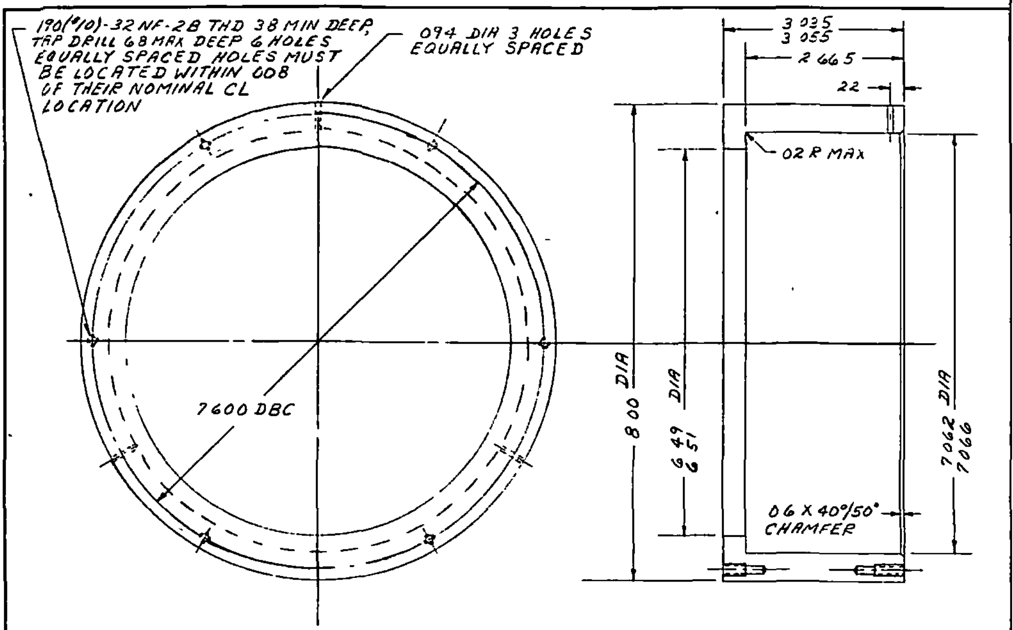
INTERNAL INFO & DATA



QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.

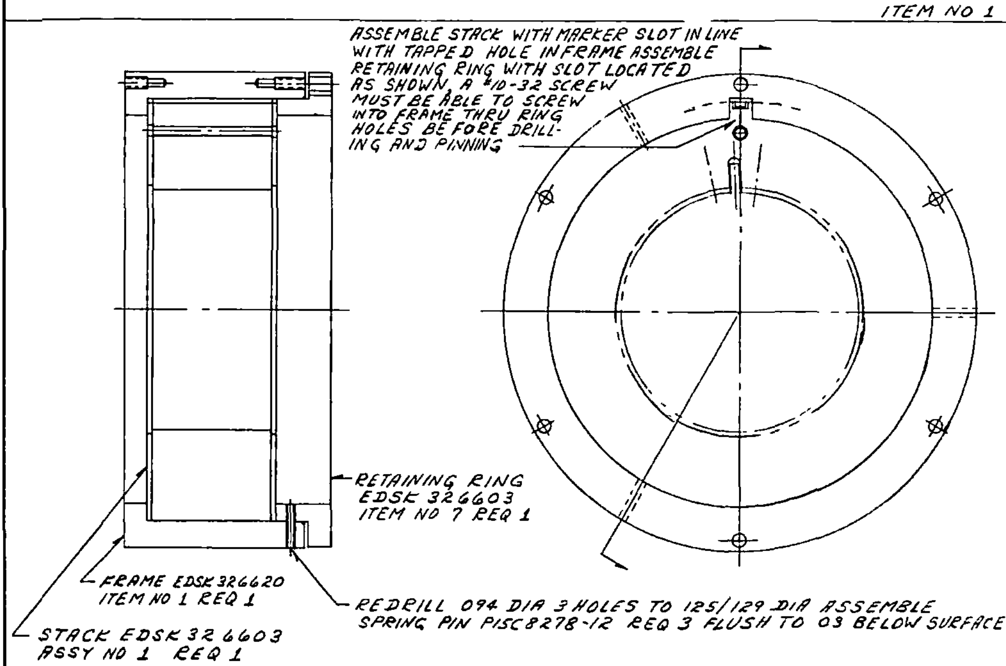
LIST OF MATERIAL OR PARTS LIST

DFTM HGO	1/7/65	AEROSPACE ELECTRICAL DEPARTMENT WESTINGHOUSE ELECTRIC CORP LIMA, OHIO, U.S.A.
DFTM	1-25-65	
ENGR	1/26/65	TITLE DETAILS
ENGR W L Grant	1-26-65	
MFG		
TEST		
PROJ ENGR APPD		CODE IDENT NO. 83843 · SIZE F · DRAWING NO. EDSK 326622
APPD FOR		
BY		SCALE 1/1 · WEIGHT · SHEET



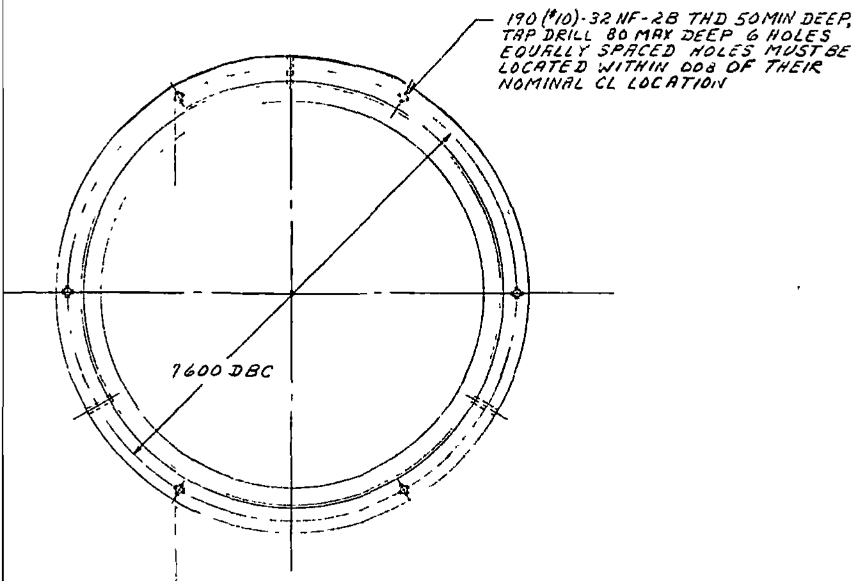
FRAME ~ MAKE FROM EDSK 326603 ITEM NO 4

ITEM NO 1



ASSY NO 1

STACK, STATOR ~ MAKE FROM ITEMS SHOWN



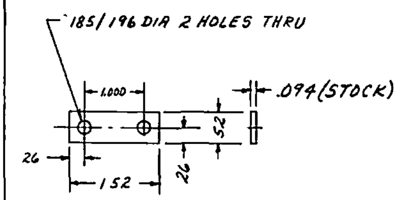
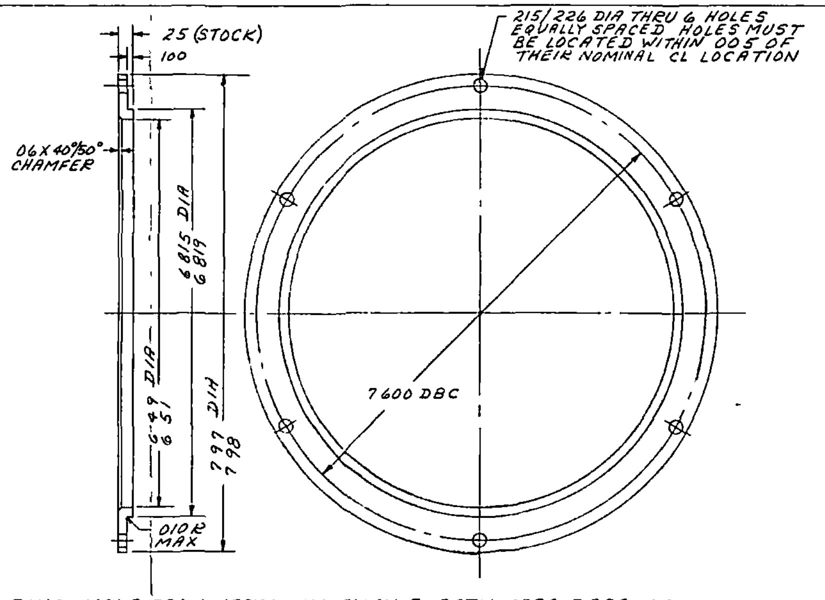


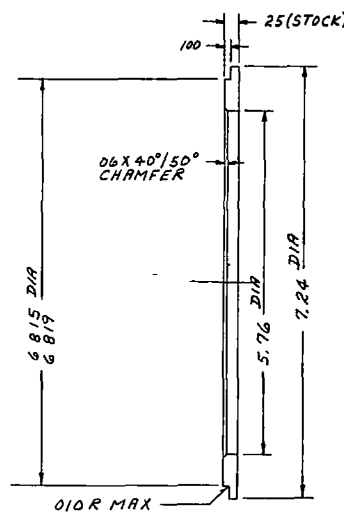
PLATE ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B333-62

ITEM NO 4



RING ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B333-62

ITEM NO 2



RING ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B333-62

ITEM NO 3

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

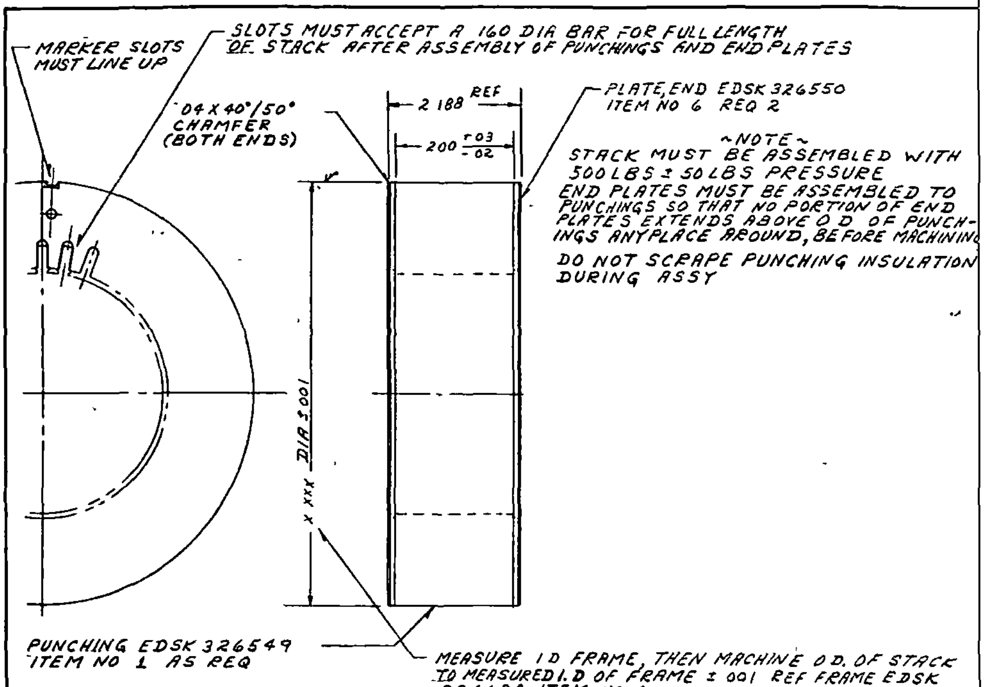
DFTM HGO 1/7/65
DFTM 1-25-65
ENGR
ENGR W.L. Grant

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.

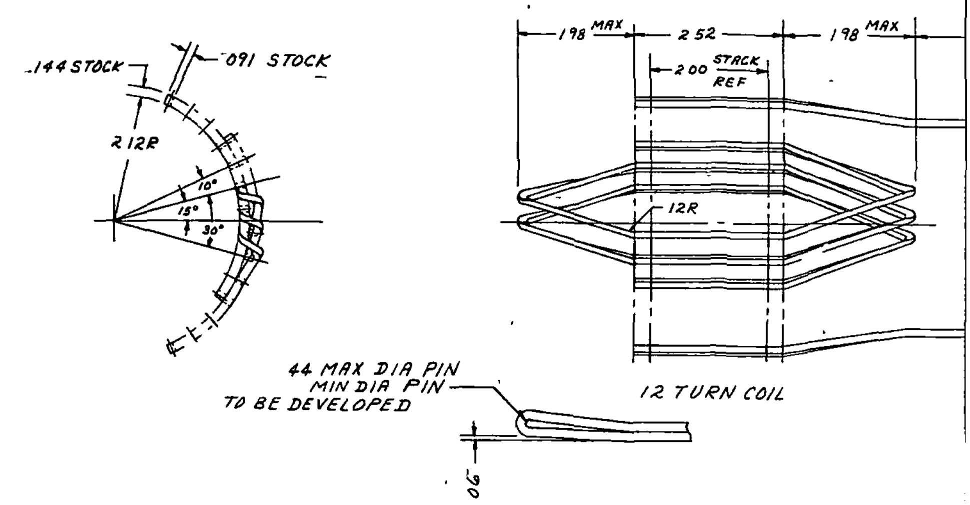
TITLE DETAILS

CODE IDENT NO. 83843 SIZE F DRAWING NO EDSK 326620

SCALE 1/1 WEIGHT SHEET



ASSY NO 1
STACK, STATOR ~ MAKE FROM ITEMS SHOWN

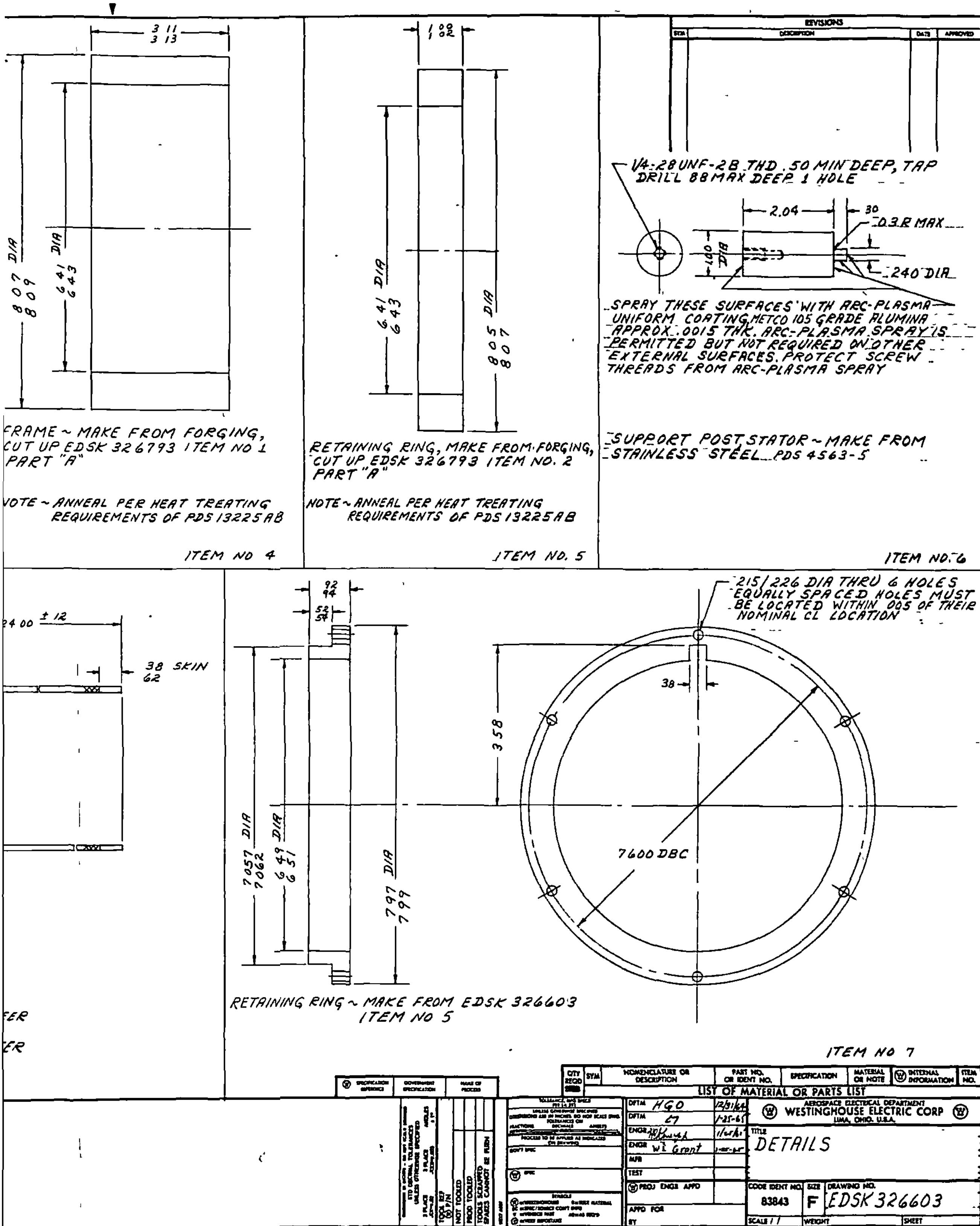


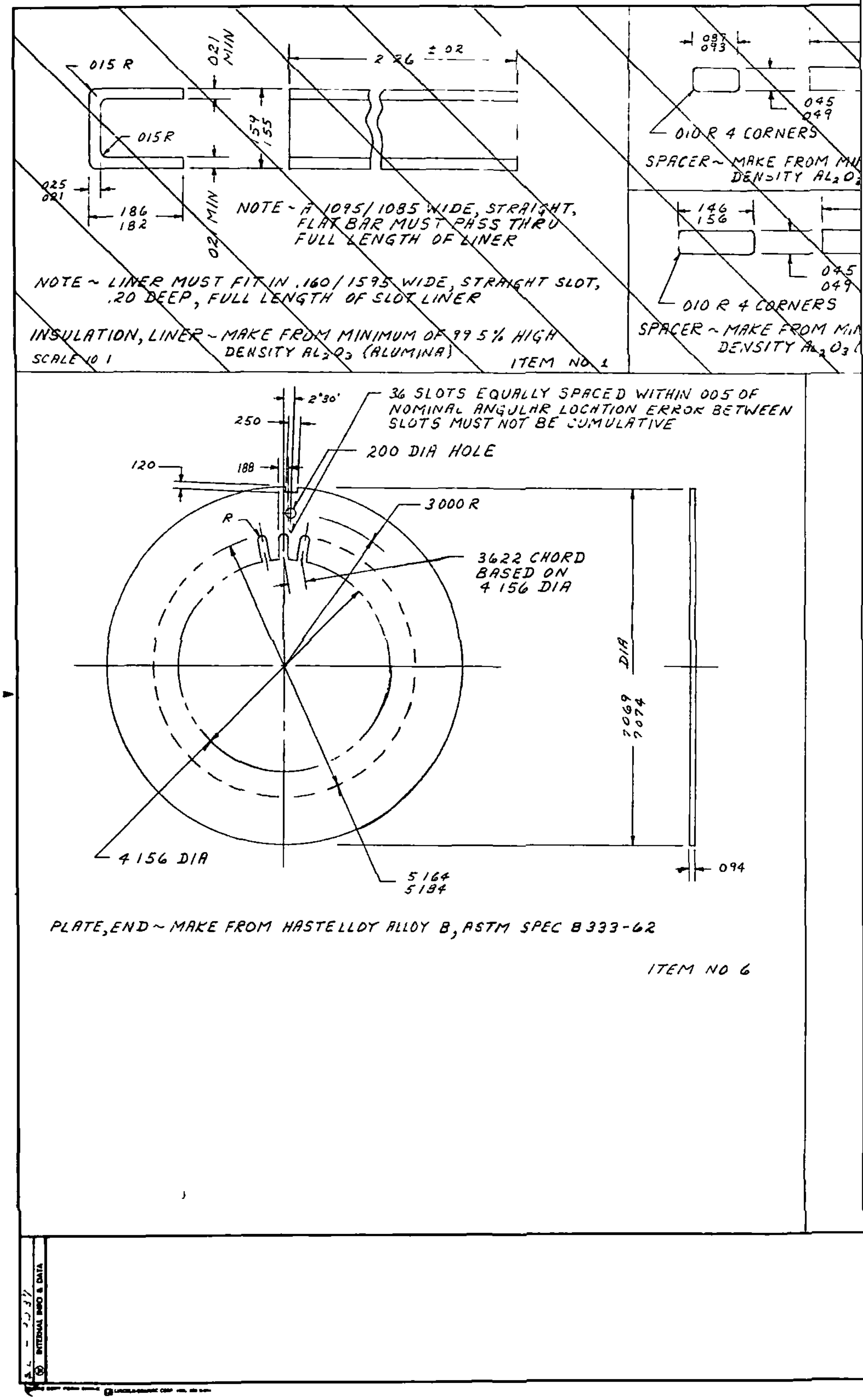
COIL, STATOR ~ ITEM NO 1 MAKE FROM .091 X .144 COPPER WIRE 12903-7

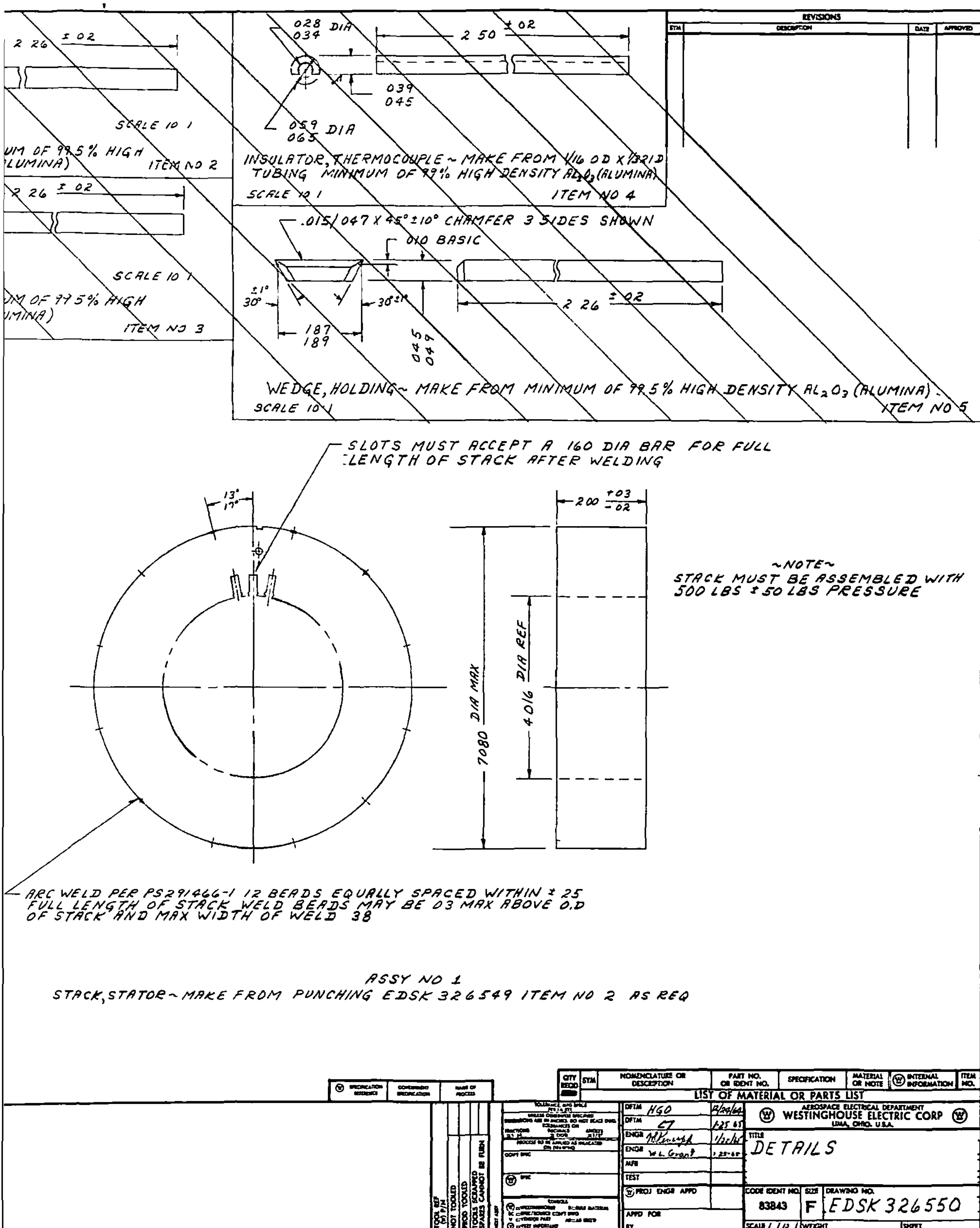
COIL, STATOR ~ ITEM NO 2 MAKE FROM .091 X .144 NICKEL-CLAD SILVER FURNISHED BY ENG

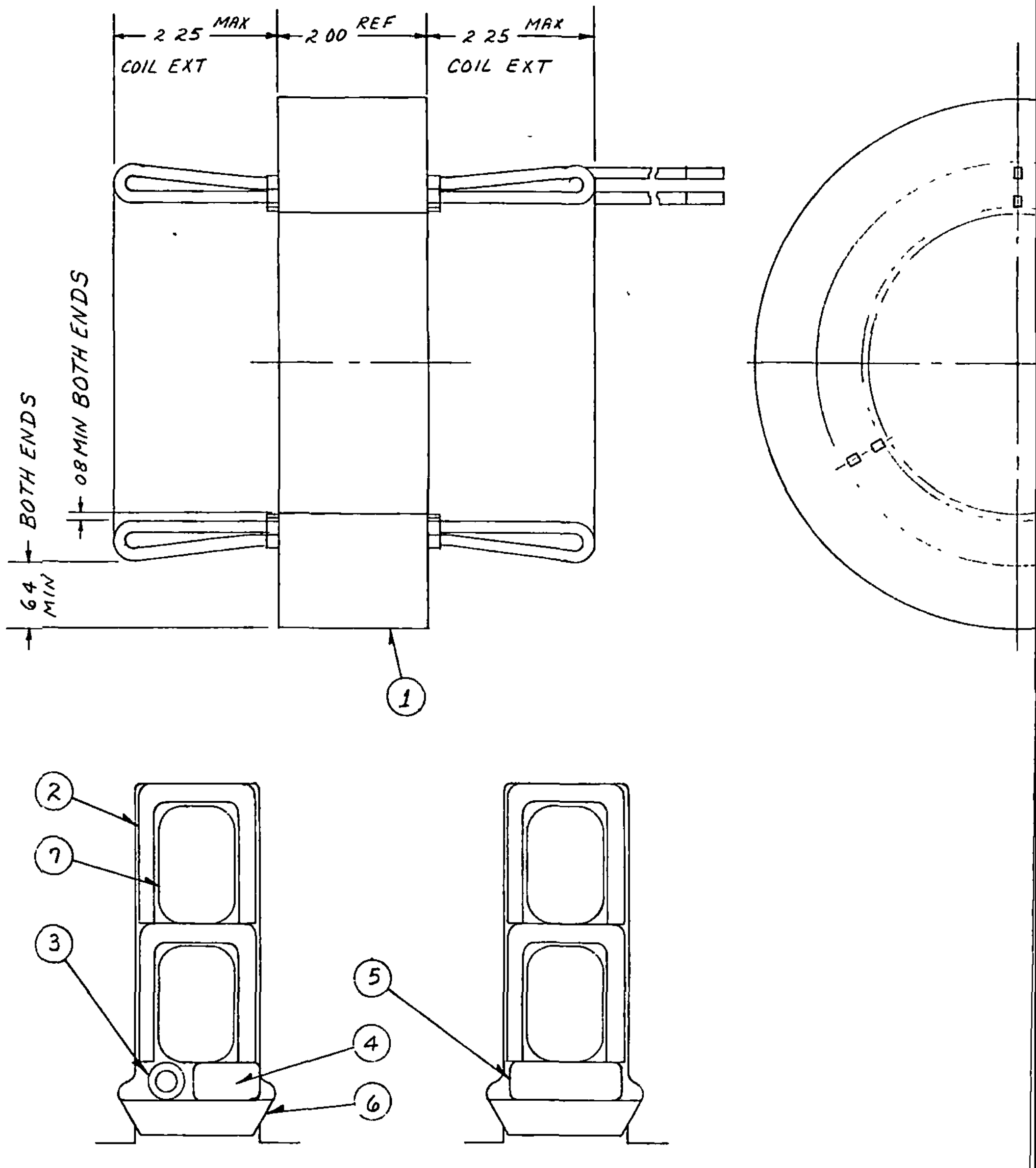
COIL, STATOR ~ ITEM NO. 3 MAKE FROM .091 X .144 INCONEL-CLAD SILVER FURNISHED BY ENG

LYP 19037
INTERNAL INFO & DATA

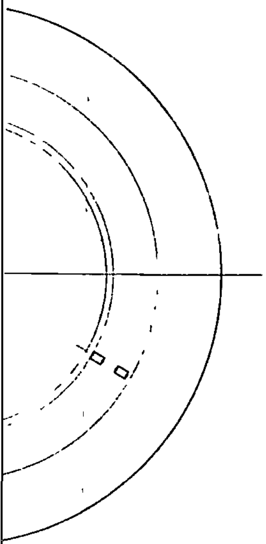

FRAME ~ MAKE FROM FORGING, CUT UP EDSK 326793 ITEM NO 1 PART "A"
NOTE ~ ANNEAL PER HEAT TREATING REQUIREMENTS OF PDS 13225AB
ITEM NO 4
RETAINING RING, MAKE FROM FORGING, CUT UP EDSK 326793 ITEM NO. 2 PART "A"
NOTE ~ ANNEAL PER HEAT TREATING REQUIREMENTS OF PDS 13225AB
ITEM NO. 5
1/4-28 UNF-2B THD .50 MIN DEEP, TAP DRILL .88 MAX DEEP 1 HOLE
SPRAY THESE SURFACES WITH ARC-PLASMA UNIFORM COATING METCO 105 GRADE ALUMINA APPROX .0015 THK. ARC-PLASMA SPRAY IS PERMITTED BUT NOT REQUIRED ON OTHER EXTERNAL SURFACES. PROTECT SCREW THREADS FROM ARC-PLASMA SPRAY
SUPPORT POST STATOR ~ MAKE FROM STAINLESS STEEL PDS 4563-5
ITEM NO. 6
.215/.226 DIA THRU 6 HOLES EQUALLY SPACED HOLES MUST BE LOCATED WITHIN .005 OF THEIR NOMINAL CL LOCATION
7.600 DBC
RETAINING RING ~ MAKE FROM EDSK 326603 ITEM NO 5
ITEM NO 7
LIST OF MATERIAL OR PARTS LIST
AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.
TITLE DETAILS
CODE IDENT NO. 83843
SIZE F
DRAWING NO. EDSK 326603


.015 R
.021 MIN
2.26 ±.02
.015 R
.154
.155
.025
.021
.186
.182
.021 MIN
NOTE ~ A .1095/.1085 WIDE, STRAIGHT, FLAT BAR MUST PASS THRU FULL LENGTH OF LINER
NOTE ~ LINER MUST FIT IN .160/.1595 WIDE, STRAIGHT SLOT, .20 DEEP, FULL LENGTH OF SLOT LINER
INSULATION, LINER ~ MAKE FROM MINIMUM OF 99.5% HIGH DENSITY AL_2O_3 (ALUMINA)
SCALE 10/1
ITEM NO 1
.087
.093
.045
.049
.010 R 4 CORNERS
SPACER ~ MAKE FROM MI
DENSITY AL_2O_3
.146
.156
.045
.049
.010 R 4 CORNERS
SPACER ~ MAKE FROM MI
DENSITY AL_2O_3
2°30'
.250
36 SLOTS EQUALLY SPACED WITHIN .005 OF NOMINAL ANGULAR LOCATION ERROR BETWEEN SLOTS MUST NOT BE CUMULATIVE
.120
.188
.200 DIA HOLE
R
3.000 R
3.622 CHORD BASED ON 4.156 DIA
DIA
7.069
7.074
4.156 DIA
5.164
5.184
.094
PLATE, END ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B 333-62
ITEM NO 6
INTERNAL INFO & DATA


REVISIONS
SYM DESCRIPTION DATE APPROVED
2 26 ± 02
SCALE 10 1
UM OF 99.5% HIGH
LUMINA)
ITEM NO 2
2 26 ± 02
SCALE 10 1
UM OF 99.5% HIGH
UMINA)
ITEM NO 3
028 DIA
034
2 50 ± 02
039
045
059 DIA
065
INSULATOR, THERMOCOUPLE ~ MAKE FROM 1/16 OD X 1/32 ID TUBING MINIMUM OF 99% HIGH DENSITY AL_2O_3 (ALUMINA)
SCALE 10 1
ITEM NO 4
.015/047 X 45° ±10° CHAMFER 3 SIDES SHOWN
010 BASIC
±1° 30°
30° ±1°
187
189
045
049
2 26 ± 02
WEDGE, HOLDING ~ MAKE FROM MINIMUM OF 99.5% HIGH DENSITY AL_2O_3 (ALUMINA)
SCALE 10 1
ITEM NO 5
SLOTS MUST ACCEPT A 160 DIA BAR FOR FULL LENGTH OF STACK AFTER WELDING
13°
17°
200 +03 -02
7080 DIA MAX
4 016 DIA REF
~NOTE~
STACK MUST BE ASSEMBLED WITH 500 LBS ± 50 LBS PRESSURE
ARC WELD PER PS291466-1 12 BEADS EQUALLY SPACED WITHIN ± 25 FULL LENGTH OF STACK WELD BEADS MAY BE 03 MAX ABOVE O.D OF STACK AND MAX WIDTH OF WELD 38
ASSY NO 1
STACK, STATOR ~ MAKE FROM PUNCHING EDSK 326549 ITEM NO 2 AS REQ
QTY REQD
SYM
NOMENCLATURE OR DESCRIPTION
PART NO. OR IDENT NO.
SPECIFICATION
MATERIAL OR NOTE
INTERNAL INFORMATION
ITEM NO.
LIST OF MATERIAL OR PARTS LIST
DFTM HGO
DFTM
ENGR
ENGR W. L. Grant
MFR
TEST
PROJ ENGR APPD
APPD FOR
BY
AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.
TITLE
DETAILS
CODE IDENT NO. 83843
SIZE F
DRAWING NO. EDSK 326550
SCALE
WEIGHT
SHEET
TOOL REF
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED
SPARES CANNOT BE FURN



LYP19037
INTERNAL INFO & DATA
ITEMS 3&4 SPEC REQD
4 ITEM 5 SPEC REQD
32 MERRILL
5#LYP19037 2-2-65
MILLER 2-3-65
VL Grant 2-3-65
1
ADDED 2 NOTES, ITEM
8, AND SPEC REF
2 WL Grant 5-1-65



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

NOTE 1 – USE POTTING COMPOUND ITEM 8 AS REQUIRED TO FILL VOIDS IN SLOTS, CHANNELS AND AROUND WEDGES AND SPACERS EXTEND POTTING OUT APPROX HALF WAY TO THE COIL TURNS

NOTE 2 – AFTER STATOR ASSEMBLY USE THE FOLLOWING SCHEDULE FOR POTTING COMPOUND BAKE-OUT · OVERNIGHT AT 125-150°F FOLLOWED BY 2 HOURS AT 450-500°F

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO
AR	B	POTTING COMPOUND	W-839 (WESTINGHOUSE)				8
3		COIL, STATOR	EDSK 326603 ITEM NO. 1				7
36		WEDGE	EDSK 326626 ITEM NO. 3				6
30		SPACER	EDSK 326626 ITEM NO. 2				5
6		SPACER	EDSK 326626 ITEM NO. 1				4
6		INSULATOR	EDSK 326680				3
72		INSULATION, LINER	EDSK 326625				2
1		STACK, STATOR	EDSK 326550 ASSY NO 1				1

LIST OF MATERIAL OR PARTS LIST

595405-1

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

TOOL REF Ⓦ P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE, MFG SPECS PER LA 831
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG. TOLERANCES ON
FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ =WESTINGHOUSE B=BULK MATERIAL
SC =SPEC/SOURCE CONT DWG
V =VENDOR PART AR=AS REQ'D
⊖ =VERY IMPORTANT

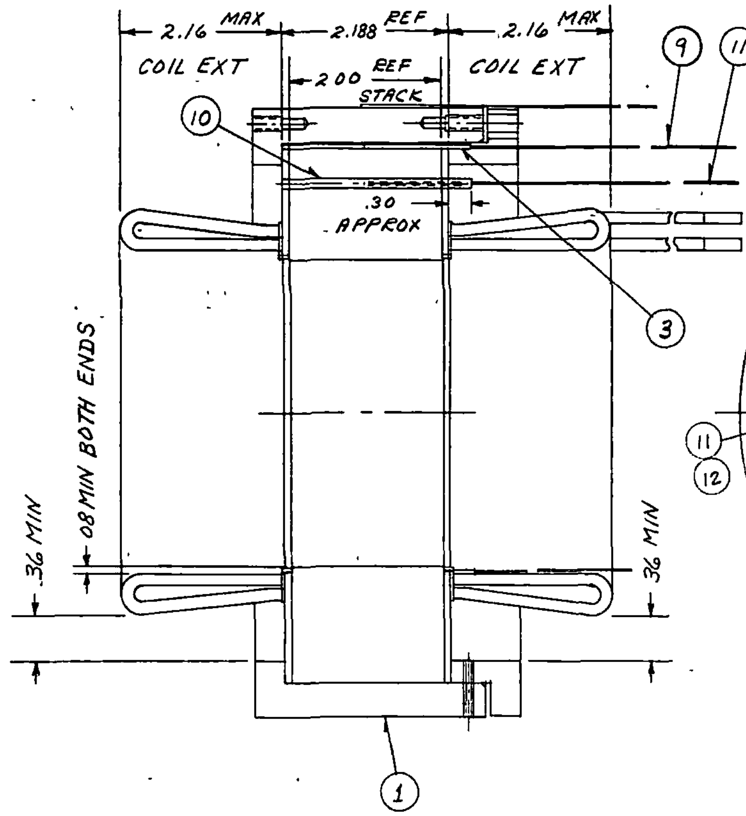
DFTM	HGO	1-6-65
DFTM	GJ	1-25-65
ENGR	H. Kenegy	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR BY		

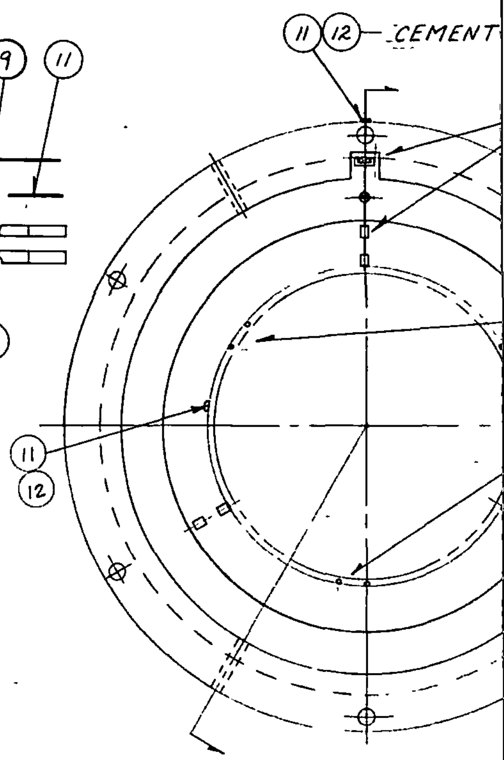
AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.

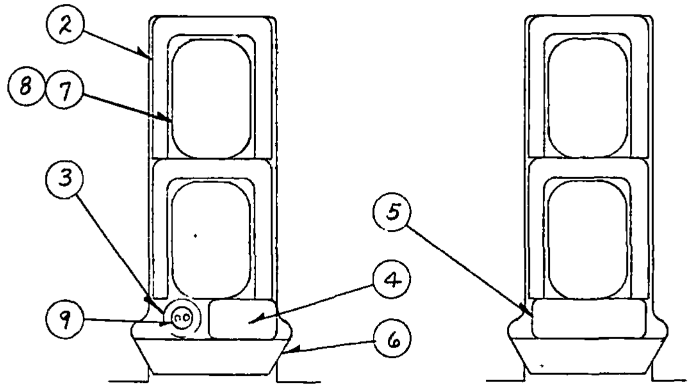
TITLE STACK, STATOR WOUND

CODE IDENT NO	SIZE	DRAWING NO.
83843	D	EDSK 326602
SCALE 1/1	WEIGHT	SHEET

DWG EDSK 326602







~NOTES~

1- ALL THERMOCOUPLE TIPS TO BE
APPROX IN CENTER OF STACK
IN STACK

2- USE POTTING COMPOUND ITEM 13 AS REQ
CHANNELS AND AROUND WEDGES AND SPA
APPROXIMATELY HALF WAY TO THE COIL

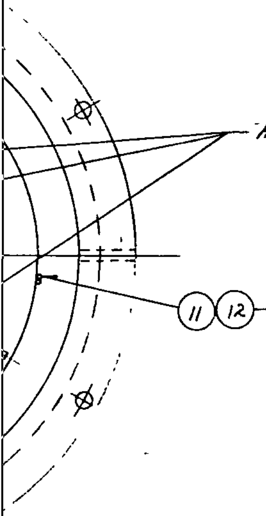
3- AFTER STATOR ASSEMBLY USE THE FO
COMPOUND BAKE-OUT AND SETTING OF
OVERNIGHT AT 125-150°F, 2 HOURS A
800-900°F, ½ HOUR AT 1200-1250°F

S LYP19037
INTERNAL INFO & DATA
CHANGED ITEM 11 FROM 6 TO 8 ADDED ITEM 13 + NOTES 2 + 3 ADDED SPEC REF
1 W.L. Grant 5-3-65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

ERMOCOUPLES TO O.D. WITH PYROCERAM

BRING LEADS OUT IN APPROX POSITION SHOWN IN RELATION TO SLOT SHOWN



APPROX LOCATION OF THERMOCOUPLES IN SLOTS

(11) (12) CEMENT THERMOCOUPLES TO COILS WITH PYROCERAM

ASSEMBLED
HEN USED

ED TO FILL VOIDS IN SLOTS,
RS EXTEND POTTING OUT
ND TURNS.

WING SCHEDULE FOR POTTING
NDUCTOR ANADUR INSULATION.
50-500°F, 2 HOURS AT

QTY REQD PN-2	QTY REQD PN-1	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO
AR	AR	B	POTTING COMPOUND	W-839 (WESTINGHOUSE)				13
AR	AR	B	PYROCERAM					12
8	8		THERMOCOUPLE	EDSK 326796				11
1	1		INSULATOR	EDSK 326794				10
8	8		THERMOCOUPLE	EDSK 326795				9
3	-		COIL, STATOR	EDSK 326603 ITEM NO. 3				8
-	3		COIL, STATOR	EDSK 326603 ITEM NO. 2				7
36	36		WEDGE	EDSK 326626 ITEM NO. 3				6
30	30		SPACER	EDSK 326626 ITEM NO 2				5
6	6		SPACER	EDSK 326626 ITEM NO 1				4
8	8		INSULATOR	EDSK 326680				3
72	72		INSULATION, LINER	EDSK 326625				2
1	1		STACK, STATOR	EDSK 326620 ASSY NO 1				1

LIST OF MATERIAL OR PARTS LIST

DWG EDSK 326618

595405-1

SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

TOOL REF P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE MFG SPECS PER LA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG
TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
SPEC

SYMBOLS
=WESTINGHOUSE B=BULK MATERIAL
SC=SPEC/SOURCE CONT DWG AR=AS REQ'D
V=VENDOR PART
=VERY IMPORTANT

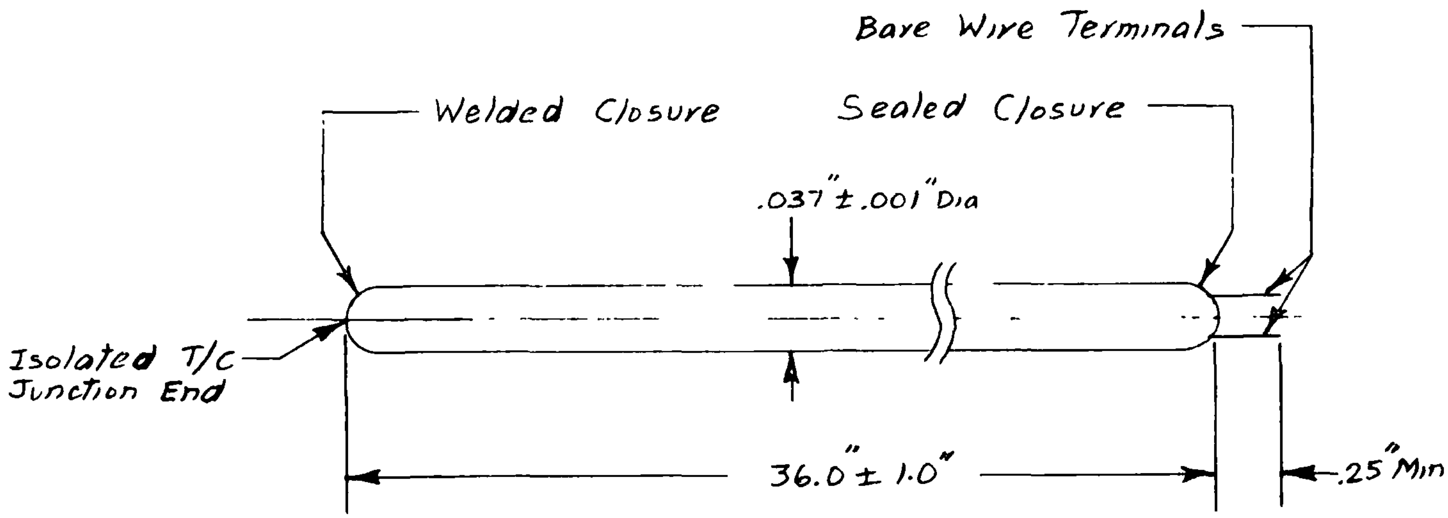
DFTM	HGO	1-8-65
DFTM	LJ	1-25-65
ENGR	[illegible]	1-25-65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO. U.S.A.

TITLE STACK, STATOR WOUND

CODE IDENT NO	SIZE	DRAWING NO
83843	D	EDSK 326618

SCALE 1/1 | WEIGHT | SHEET



Note: Thermocouples are to be Kept straight at all times

SINGLE DIAMETER SHEATHED THERMOCOUPLE

Reference (W) D-Spec # 709747

EDSK 326796

wlg 2-18-65

.250 DIA				
PART NO	A	CATALOG NO	GOVT PART NO. ENGRG REF	APPL
P15C8278-1	7/8	79-048-250-0875	MS171652	Q
-2	3/4	79-048-250-075	MS171650	Q
-3	2	79-048-250-2000	MS171662	Q
-4	3 1/4	79-048-250-3250	MS171667	Q
-5	1 3/8	79-048-250-1375	MS171657	Q
-6	1 1/2	79-048 250-1500	MS171658	Q

062 DIA			
PART NO	A	CATALOG NO	GOVT PART NO. ENGRG REF
P15C8278-18	3/8	79-012-062-0375	MS171434
-19	5/16	79-012-062-0312	MS171433
-20	1/4	79-012-062-0250	MS171432
-21	3/16	79-012-062-0188	MS171431
-22	7/16	52-012-062-0437	
-23	1/2	79 012-062-0500	MS 171436
-24	1/8	52-012-062-0125	

.125 DIA				
PART NO.	A	CATALOG NO.	GOVT PART NO. ENGRG REF	APPL
P15C8278-9	3/8	79-028-125-0375	MS171524	Q
-10	7/16	52-028-125-0437		A
-11	7/16	79-028-125-0437	MS171525	Q
-12	3/4	79-028-125-0750	MS171530	Q
-13	1	79-028-125-1000	MS171534	Q
-14	1 3/8	79-028-125-1375	MS171537	Q
-15	1/4	79-028-125-0250	MS171522	Q
-16	1 3/4	79-028-125-1750	MS171540	Q
-17	5/8	52-028-125 0625		A
-60	9/16	79-028-125 0562	MS171527	Q

188 DIA			
PART NO.	A	CATALOG NO	GOVT PART NO ENGRG REF
P15C8278-26	11/16	79-040-187-0687	MS171589
-27	13/16	79-040-187-0813	MS171591
-28	3/8	79-040-187-0375	MS171584
-29	1 1/8	79-040-187-1125	MS171595
-30	1	79-040-187-1000	MS171594
-31	1 3/8	79-040-187-1375	MS171597
-32	7/16	79 040 187-0438	MS171585

.156 DIA				
PART NO	A	CATALOG NO	GOVT PART NO ENGRG REF	APPL
P15C8278-35	1/2	79-032-156-0500	MS171556	Q
-36	7/16	52-032-156-0437		A
-37	1 1/2	79-032-156-1500	MS171568	Q

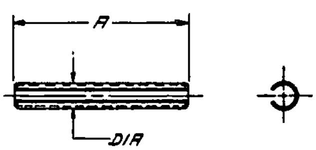
.312 DIA			
PART NO	A	CATALOG NO.	GOVT PART NO ENGRG REF
P15C8278-40	1	52-062-312-1000	

.094 DIA				
PART NO	A	CATALOG NO	GOVT PART NO. ENGRG REF	APPL
P15C8278-45	1/2	79-022-094-0500	MS171496	Q
-46	3/8	79-022-094-0375	MS171494	Q
-47	5/16	79-022-094-03125	MS171493	Q
-48	1/4	79-022-094-0250	MS171492	Q

.219 DIA			
PART NO.	A	CATALOG NO	GOVT PART NO. ENGRG REF
P15C8278-51	1/2	79-048-219-0500	MS171616

-NOTE-

ORDERING INFORMATION FOR Ⓦ INTERNAL COLUMN ORDER Ⓦ PART NO.
FOR GOVT COLUMN ORDER GOVT PART NO. IF AVAILABLE OTHERWISE SPECIFY Ⓦ PART NO. AND NOTE "VENDOR ITEM SEE SPECIFICATION CONTROL DRAWING."



S. # PD18075

Ⓦ INTERNAL INFO & DATA

25	REDRAWN CHANGE PER REV AB S# PD18075
26	PART NO -37 ADDED S# 145230-01 GEISER 10-8-62 10-8-62 R MILBORN 10-8-62
27	CHANGES PER SUB AC LX50509 S# 76151-01 M COURTNEY 6-6-63 R MILBURN 6-17-63
28	CHANGE PER REV AD S 76407-01 LC 1-18-65 R MILBURN 2-3-65 1-17-65
29	CHANGES PER SUB AE S# 20077-01 MERRILL 2-24-65 R MILBURN 3-1-65

ENGRG DEPT FORM 2201-A LINCOLN-GRAPHIC CORP

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED
AB	REDRAWN ADDED "ENGRG REF" TO GOVT PART NO" COL REMOVED "KIT" COL AND ADDED "APPROVAL" COL DRAWING WAS "SOURCE" CONTROL DWG.	9/15/61	[signature]
AC	PART NUMBER -32, -60 & -23 ADDED.	6/7/63	[signature]
AD	PART NO. -6 ADDED	2-2-65	C MILLER
AE	PART NO -24 ADDED	2-26-65	C MILLER

REQUIREMENTS

1. PIN, SPRING
2. DIMENSIONS - NOMINAL DIA AND LENGTH PER TABLE
3. MATERIAL - FOR "MS" NUMBERS - CRES, AMS 5506 OR AISI 420
   - FOR NON-"MS" NO - HIGH CARBON STEEL, AMS 5120 OR AMS 5121
4. FINISH - FOR CRES, PASSIVATE
   FOR HIGH CARBON STEEL, CAD PLATE PER QQ-P-416, TYPE I, CLASS 3
5. PARTS MUST BE IDENTIFIED WITH MFR'S PART NO. PER MIL-STD-130.

QUALIFICATION TESTS

NOT APPLICABLE

LIMA ROUTINE ACCEPTANCE GUIDE

1. DIMENSIONS PER REQUIREMENT NO. 2.
2. PART IDENTIFICATION

~~CERTIFICATION REQUIREMENT-SUPPLIER DESIGNED COMPONENTS~~
~~SIGNED AND DATED CERTIFICATE OF COMPLIANCE TO BE ATTACHED TO PACKING SLIP (NOT APPLICABLE TO APPROVAL X) REQUIRED WITH EACH SHIPMENT STATING:~~
~~A. WESTINGHOUSE P/N ______ SUPPLIER IDENTIFICATION ______~~
~~B. PURCHASE ORDER NUMBER, DATE OF SHIPMENT AND QUANTITY~~
~~C. SUPPLIERS NAME~~
~~D. COMPLIANCE TO REQUIREMENTS SECTION OF THIS DRAWING~~

EXPLANATION OF APPROVAL LETTERS
X=EXPERIMENTAL-NOT AN APPROVED SOURCE TO BE USED FOR ENGRG SAMPLES ONLY. CERTIFICATION NOT REQUIRED.
E=ENGRG APPROVAL-QUALIFICATION INCOMPLETE-APPROVED SOURCE.
Q=QUALIFICATION APPROVAL-APPROVED SOURCE.

SPECIFICATION CONTROL DRAWING FOR ITEMS WITH ONLY CATALOG NUMBERS.

PIN-ELASTIC STOP NUT CORPORATION, UNION, NEW JERSEY CODE IDENT 72962 | BOUGHT OUTSIDE

QTY REQD PN	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	(W) INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

(W) SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

TOOL REF 48A420-7 (W) P/N 969B49 | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE MFG SPECS PER EA 331
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DWG
TOLERANCES ON FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC (NONE)
(W) SPEC
SYMBOLS
(W) = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
(W) = VERY IMPORTANT

DFTM	E B	11/13/61
DFTM	[signature]	11/15/61
ENGR	R MILBURN	11/15/61
ENGR		
MFR		
TEST		
(W) PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
(W) WESTINGHOUSE ELECTRIC CORP (W)
LIMA, OHIO U.S.A.

TITLE
PIN, SPRING
STANDARD APPARATUS

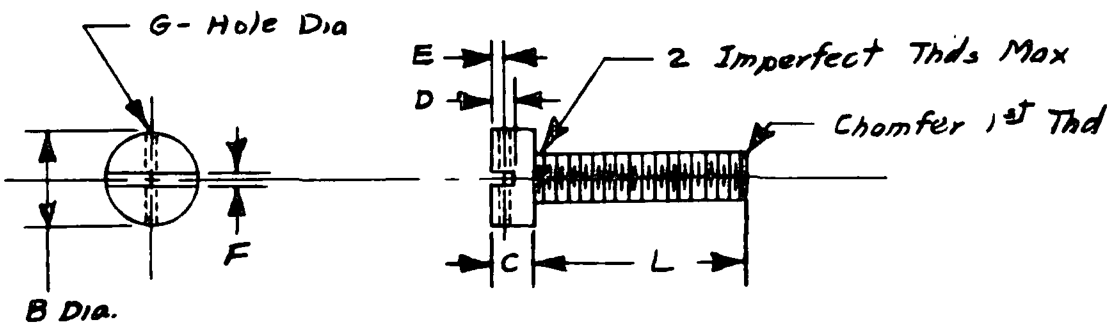
CODE IDENT NO	SIZE	DRAWING NO
83843	D	P15C8278

SCALE NONE | WEIGHT | SHEET

DWG P15C8278

SKETCH SHEET
FORM 28077

WESTINGHOUSE ELECTRIC CORPORATION



Material - Hastelloy Alloy B Rod

Dash No.	Thread	B Dia ±.003	C ±.003	D ±.005	E ±.005	F ±.003	G Dia ±.002	L ±.005	Stock
1	#8 (.164)-32 NC-2A	.270	.156	.078	.050	.062	.040	.500	3/8 Dia
2	" " " "	.270	.156	.078	.050	.062	.040	.750	3/8 Dia
3	#10 (.190)-32 NF-2A	.313	.156	.078	.050	.062	.040	.500	7/16 Dia
4	" " " "	.313	.156	.078	.050	.062	.040	1.00	7/16 Dia
5	1/4-28 UNF-2A	.414	.207	.103	.078	.062	.040	.500	1/2 Dia

SCREW - FLAT FILLISTER HEAD

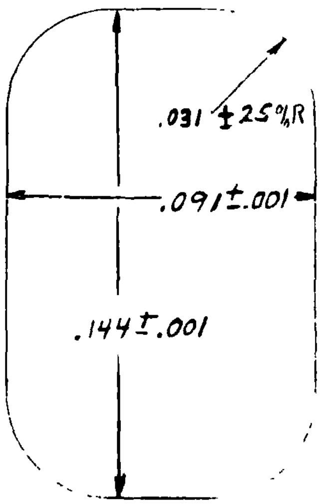
W. L. Groot 4-21-65 EDSK 327502

EDSK 327502

SKETCH SHEET
FORM 28577

WESTINGHOUSE ELECTRIC CORPORATION

Conductor
20% Nickel-Clad Silver



Dimensions in inches
Scale 20:1

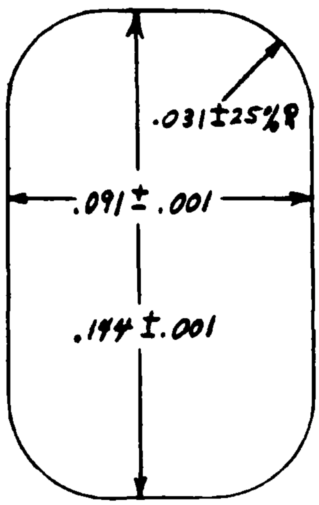
EDSK 326531

H. E. Kenepp 12-17-64

SKETCH SHEET

WESTINGHOUSE ELECTRIC CORPORATION

Conductor
28 % Inconel-Clad Silver



Dimensions in inches
Scale 20:1

EDSK 326532 A

Rev. A - 12-29-64
28% was 20%

H E Keneipp 12-17-64

APPENDIX B

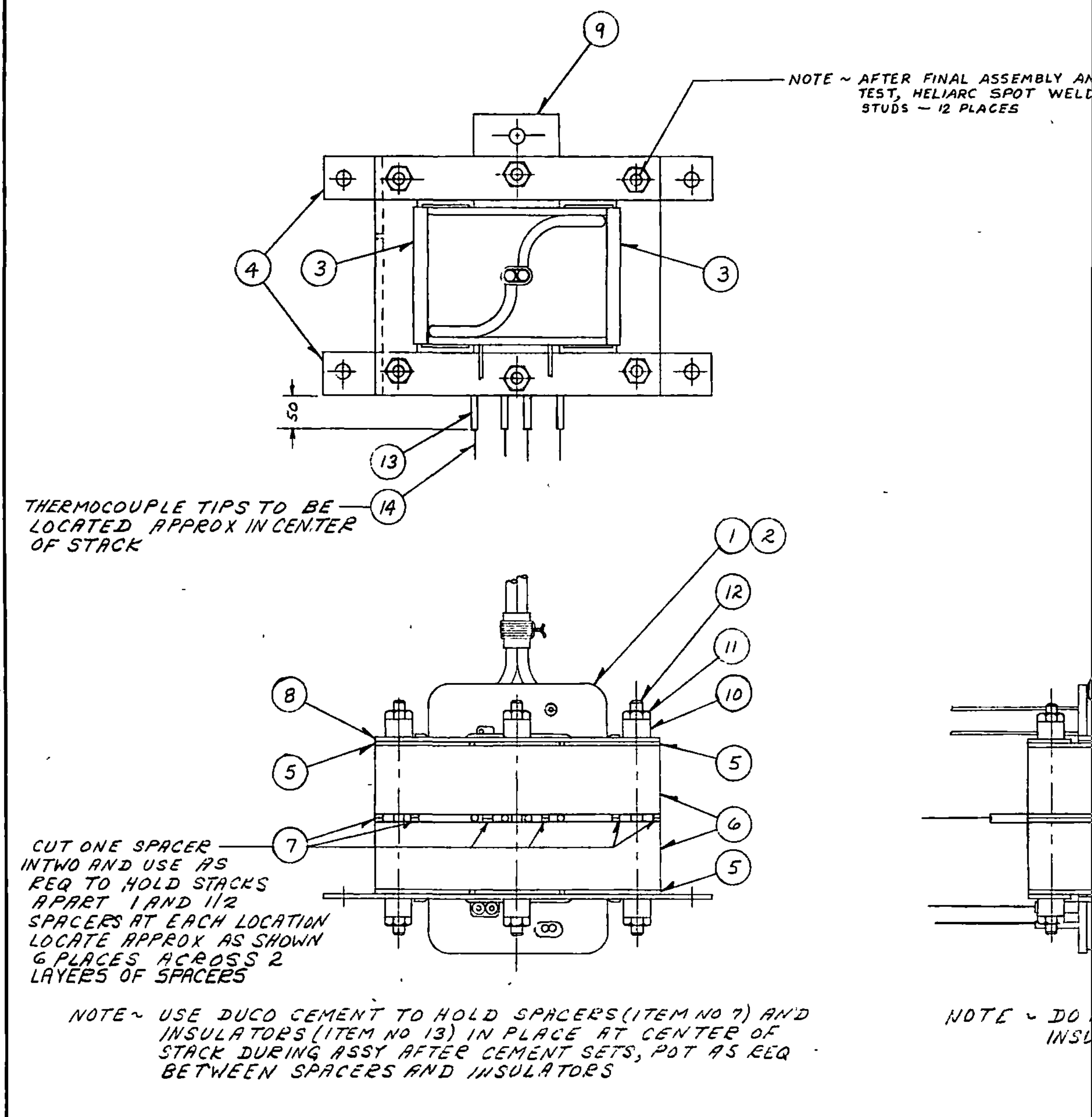
TRANSFORMER MATERIALS SUMMARY

APPENDIX B

TRANSFORMER ASSEMBLY

DRAWING NO.	TITLE	MATERIAL
EDSK 326761	Transformer Assembly	-
EDSK 326760	Winding, Transformer	-
EDSK 326762	Details	See Drawing
EDSK 326756	Punching, Transformer	Hiperco 27 Alloy (27 Co - Fe)
EDSK 326626	Details, Slot	99 Al_2O_3
EDSK 326686	Insulation, Tube	99 Al_2O_3
EDSK 326757	Channel	99.5 Al_2O_3
EDSK 326758	Spool	99.5 Al_2O_3
EDSK 326759	End Plates	99.5 Al_2O_3
EDSK 326786	Spacer	99 Al_2O_3
EDSK 326796	Thermocouple	(Inconel Cladding, Platinel II wire system, Al_2O_3 Insulation)
EDSK 327503	Nut	Hatelloy Alloy B
EDSK 326533	Conductor	Nickel Clad Silver (20% Clad area)(1)
EDSK 326534A	Conductor	Inconel Clad Silver (28% Clad Area)(1)
EDSK 326535	Conductor	Nickel Clad Silver (20% Clad area)(1)
EDSK 326536A	Conductor	Inconel Clad Silver (28% Clad area)(1)

(1) - All conductors insulated with Anaconda's Anadur, a refractory-oxide-filled glass insulation.



S. LYP190-28

INTERNAL INFO & DATA

ITEM 7 SPEC EDSK3 26626, ITEM 2 REQD 9 ITEM 11 SPEC EDSK3 REN 4. ITEM 13 SPEC EDSK3 26680 ITEM 14 SPEC EDSK 326795 ITEM 15 "K" ADDED TO 839, PICTURE CHANGED TO SHOW 2 LAYERS OF SPACERS (ITEM 7). S#LYP190-28 MERRILL 2-4-65 MILLER 2-3-65 W L Grant

1

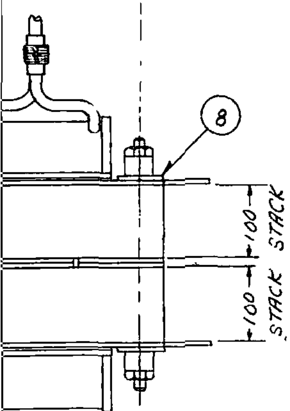
ADDED WELDING NOTE ADDED HOLE TO IT 9 CHANGED ITEM 11 TO EDSK CALL-OUT WL Grant 5-1-65

2

ENGRG DEPT FORM LINCOLN-GRAPHIC CORP

ACCEPTANCE
UTS TO

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



T SCRAPE PUNCHING
ATION DURING ASSY

AR	AR	B	POTTING COMPOUND WESTINGHOUSE W-839				15
4	4		THERMOCOUPLE	EDSK 326796			14
4	4		INSULATOR	EDSK 326686-3			13
6	6		STUD	EDSK 326762 ITEM NO. 7			12
12	12		NUT	EDSK 327503-1			11
12	12		SPACER	EDSK 326786			10
2	2		STRAP, GROUND	EDSK 326762 ITEM NO 4			9
2	2		PLATE	EDSK 326762 ITEM NO. 2			8
18	18		SPACER	EDSK 326626 ITEM NO 1			7
AR	AR		PUNCHING	EDSK 326756			6
4	4		PLATE, SUPPORT	EDSK 326762 ITEM NO 3			5
2	2		PLATE, MOUNTING	EDSK 326762 ITEM NO 1			4
2	2		CHANNEL	EDSK 326757			3
1	-		WINDING	EDSK 326760 PN-2			2
-	1		WINDING	EDSK 326760 PN-1			1
QTY REQD PN-2	QTY REQD PN 1	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	(W) INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

DWG EDSK 326761

(W) SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

TOOL REF (W) P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE MFG SPECS

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG TOLERANCES ON
FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2°

PROCESS TO BE APPLIED AS INDICATED ON DRAWING

GOV'T SPEC

(W) SPEC

SYMBOLS
(W) = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
= VERY IMPORTANT

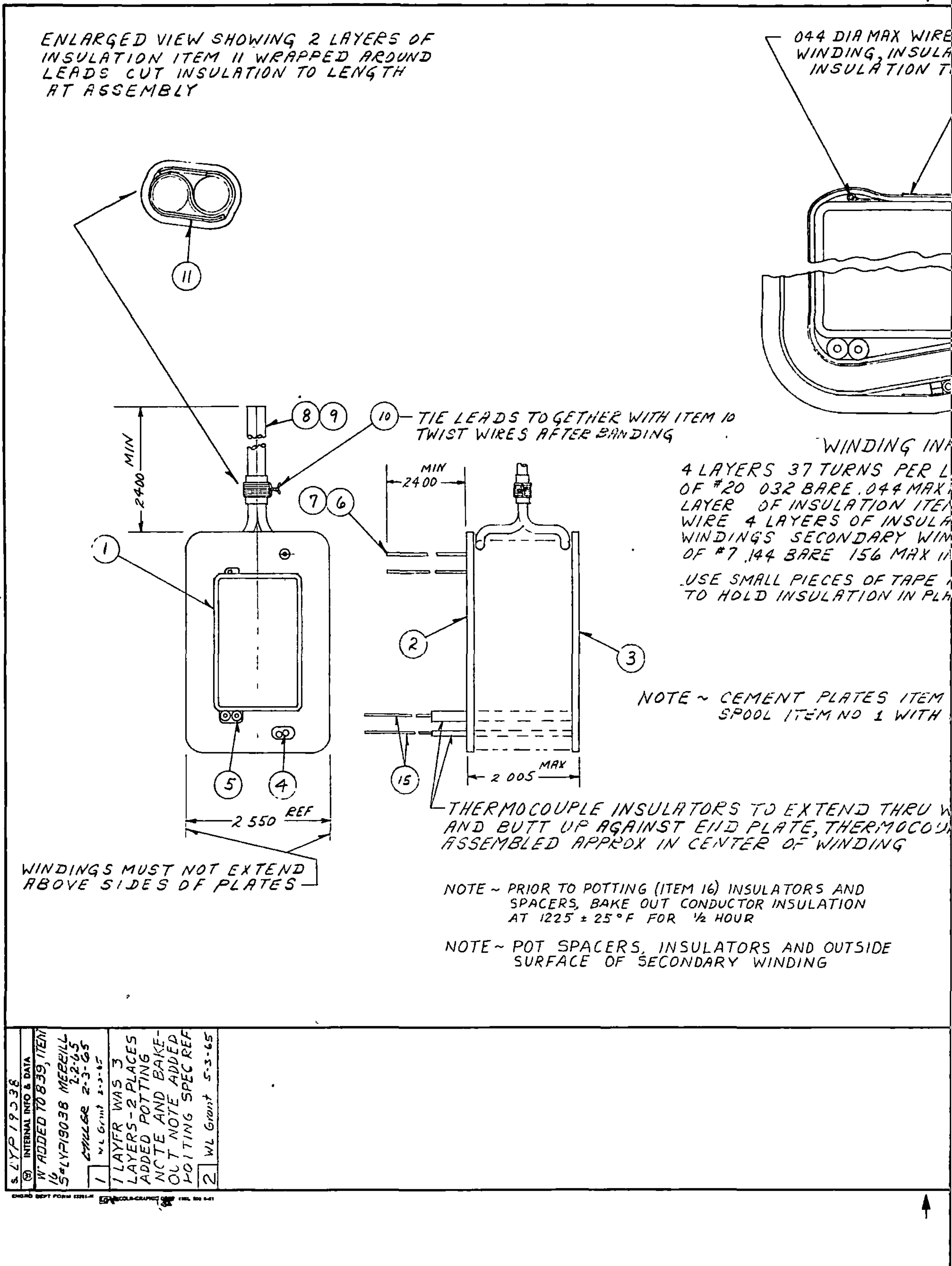
DFTM	HGO	1/19/65
DFTM	CT	1-25-65
ENGR	HCKennedy	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
(W) PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
(W) WESTINGHOUSE ELECTRIC CORP (W)
LIMA OHIO U.S.A.

TITLE
TRANSFORMER

CODE IDENT NO.	SIZE	DRAWING NO
83843	D	EDSK 326761

SCALE 1/1 | WEIGHT | SHEET

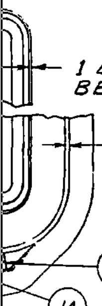


ENLARGED VIEW SHOWING 2 LAYERS OF INSULATION ITEM 11 WRAPPED AROUND LEADS CUT INSULATION TO LENGTH AT ASSEMBLY
11
8 9
10
TIE LEADS TOGETHER WITH ITEM 10 TWIST WIRES AFTER BANDING
MIN
2400
1
7 6
5
4
2 550 REF
2
3
15
2 005 MAX
WINDINGS MUST NOT EXTEND ABOVE SIDES OF PLATES
.044 DIA MAX WIRE
WINDING, INSULA
INSULATION T
WINDING IN
4 LAYERS 37 TURNS PER L
OF #20 .032 BARE .044 MAX
LAYER OF INSULATION ITE
WIRE 4 LAYERS OF INSULA
WINDINGS SECONDARY WIN
OF #7 .144 BARE .156 MAX I
USE SMALL PIECES OF TAPE
TO HOLD INSULATION IN PL
NOTE ~ CEMENT PLATES ITEM
SPOOL ITEM NO 1 WITH
THERMOCOUPLE INSULATORS TO EXTEND THRU W
AND BUTT UP AGAINST END PLATE, THERMOCOU
ASSEMBLED APPROX IN CENTER OF WINDING
NOTE ~ PRIOR TO POTTING (ITEM 16) INSULATORS AND SPACERS, BAKE OUT CONDUCTOR INSULATION AT 1225 ± 25 °F FOR ½ HOUR
NOTE ~ POT SPACERS, INSULATORS AND OUTSIDE SURFACE OF SECONDARY WINDING
S. LYP19338
INTERNAL INFO & DATA
W' ADDED TO 839, ITEM 16
S#LYP19038 MERRILL 2-2-65
MILLER 2-3-65
WL Grant 2-3-65
1
1 LAYER WAS 3 LAYERS-2 PLACES ADDED POTTING NOTE AND BAKE-OUT NOTE ADDED POTTING SPEC REF
WL Grant 5-3-65
2

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

...O GO ACROSS SPOOL BEFORE START OF
...WIRE WITH ONE LAYER OF ITEM 14, CUT
...LENGTH AT ASSEMBLY

...OVERLAP INSULATION ITEM 13 AT TOP
...ON EACH ROW OF WIRE, CUT INSULATION
...TO LENGTH AT ASSEMBLY



1 LAYER OF INSULATION ITEM 13 BETWEEN WIRES

4 LAYERS OF INSULATION ITEM 12 BETWEEN FIRST WINDING AND SECONDARY WINDING

(17) CUT SPACERS TO LENGTH AT ASSY

(14)

...EMATION
...ER, 1 LAYER 26 TURNS
...ULATED WIRE WITH 1
...3 BETWEEN LAYERS OF
...ON ITEM 12 BETWEEN
...NG 1 LAYER 10 TURNS
...ULATED WIRE

...M NO 18 AS REQ
... DURING WINDING

... 2 AND 3 TO
...CO CEMENT

...DING
...E TIPS TO BE

QTY REQD PV 2	QTY REQD PN-1	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.
AR	AR	B	TAPE, ADHESIVE	0025 X .500 9948-3				18
4	4		SPACER	EDSK 326626 ITEM NO 1				17
AR	AR		POTTING COMPOUND WESTINGHOUSE W839					16
4	4		THERMOCOUPLE	EDSK 326796				15
2	2		INSULATION	EDSK 326762 ITEM NO 8				14
4	4		INSULATION	EDSK 326762 ITEM NO. 5				13
1	1		INSULATION	EDSK 326762 ITEM NO. 6				12
1	1		INSULATION	EDSK 326762 ITEM NO 9				11
AR	AR	B	WIRE, SST	.032 DIA 7860-2				10
AR	-	B	WIRE #7 (.144 DIA) INCONEL-CLAD SILVER FURNISHED BY ENGINEER					9
-	AR	B	WIRE #7 (.144 DIA) NICKEL-CLAD SILVER FURNISHED BY ENGINEER					8
AR	-	B	WIRE #20 (.032 DIA) INCONEL-CLAD SILVER FURNISHED BY ENGINEER					7
-	AR	B	WIRE #20 (.032 DIA) NICKEL-CLAD SILVER FURNISHED BY ENGINEER					6
2	2		INSULATOR	EDSK 326686 PN-2				5
2	2		INSULATOR	EDSK 326686 PN-3				4
1	1		END PLATE	EDSK 326759 ITEM NO 1				3
1	1		END PLATE	EDSK 326759 ITEM NO 2				2
1	1		SPOOL	EDSK 326758				1

LIST OF MATERIAL OR PARTS LIST

DWG EDSK 326760

595405-1

SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

TOOL REF P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE W/O SPECS PER LA 351
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG
TOLERANCES ON
FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOVT SPEC
SPEC
SYMBOLS
= WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
= VERY IMPORTANT

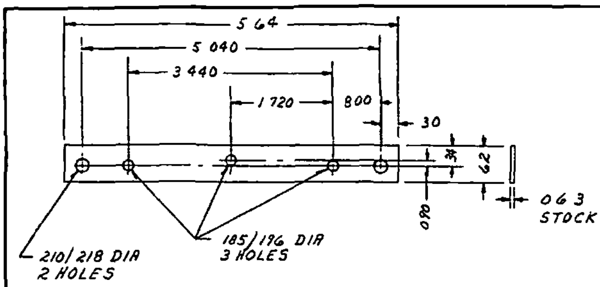
DFTM	HGO	1/18/65
DFTM	[illegible]	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA OHIO U.S.A.

TITLE WINDING, TRANSFORMER

CODE IDENT NO.	SIZE	DRAWING NO
83843	D	EDSK 326760

SCALE 1/1, 2/1 | WEIGHT | SHEET



PLATE, MOUNTING ~ MAKE FROM HASTELLOY ALLOY B,
ASTM SPEC B 333-62

ITEM NO 1

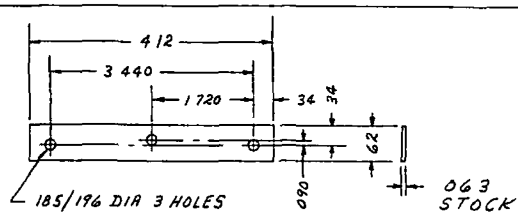
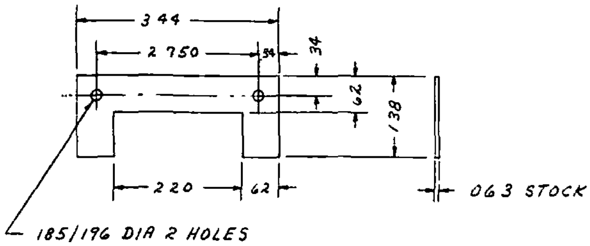


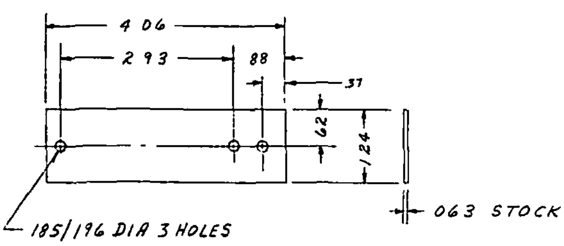
PLATE ~ MAKE FROM HASTELLOY ALLOY B,
ASTM SPEC B 333-62

ITEM NO 2



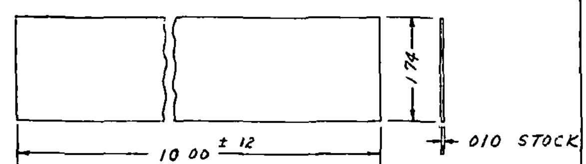
PLATE, SUPPORT ~ MAKE FROM HASTELLOY ALLOY B,
ASTM SPEC B 333-62

ITEM NO 3



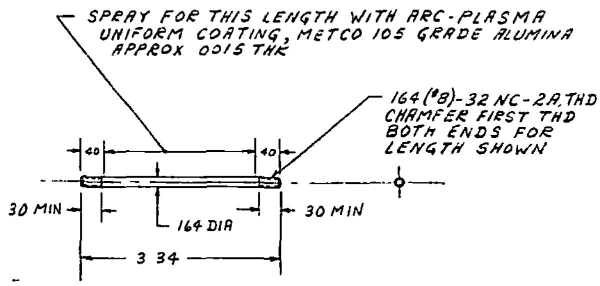
STRAP, GROUND ~ MAKE FROM HASTELLOY ALLOY B,
ASTM SPEC B 333-62

ITEM NO 4



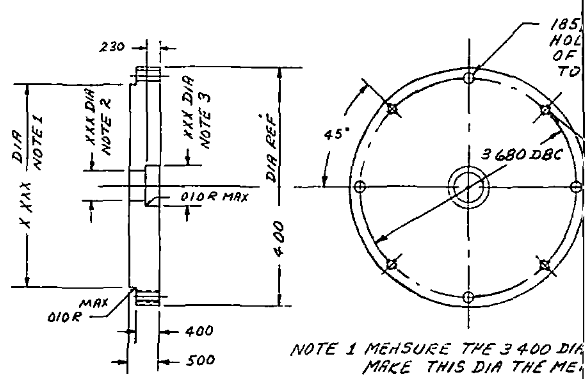
INSULATION ~ MAKE FROM BURNIL CM-2 SYNTHETIC
MICA PAPER

ITEM NO 5



STUD ~ MAKE FROM HASTELLOY ALLOY B, ASTM
SPEC B 335-58T

ITEM NO 7



NOTE 1 MEASURE THE 3 400 DIA
MAKE THIS DIA THE ME

NOTE 2 MEASURE THE 460 DIA
DIA THE MEASURED D

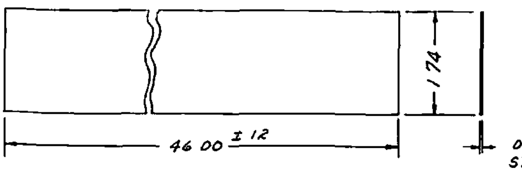
NOTE 3 MEASURE THE .700 DIA
DIA THE MEASURED D

NOTE ~ DIA NOTE 2 AND DIA NOTE 3 MUST BE CONCENTRIC W
DIA NOTE 3 MUST BE CONCENTRIC WITH DIA NOTE 1 W

END BELL ~ MAKE FROM RING EDSK 326688 ITEM NO

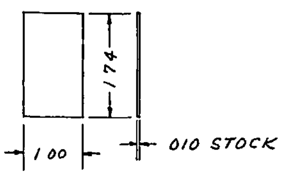
S CPP 17038
INTERNAL INFO & DATA
ITEM ADDED 37
SIMILE ITEM 5-
10:C WAS LB CS C10
WAS CPS ITEMS 5,6
ES-CM-2 WAS CM-1
1 W L Grant 5-1-65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



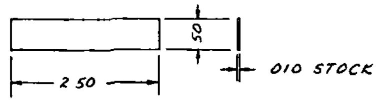
INSULATION ~ MAKE FROM BURNIL CM-2 SYNTHETIC MICA PAPER

ITEM NO 6



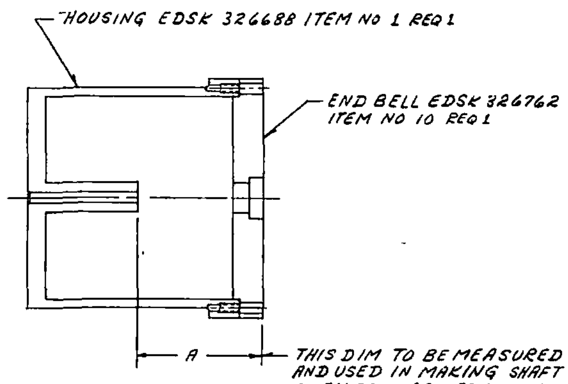
INSULATION ~ MAKE FROM BURNIL CM-2 SYNTHETIC MICA PAPER

ITEM NO. 8



INSULATION ~ MAKE FROM BURNIL CM-2 SYNTHETIC MICA PAPER

ITEM NO 9



ASSY NO 1

HOUSING ASSY ~ MAKE FROM ITEMS SHOWN

DIA 4 HOLES EQUALLY SPACED
MUST BE LOCATED WITHIN .005
IR NOMINAL CL LOCATION DBC
CONCENTRIC WITH DIA AT NOTE 1

.190(#10)-32 NF-2B THD THRU 4 HOLES
EQUALLY SPACED HOLES MUST BE
LOCATED WITHIN .008 OF THEIR
NOMINAL CL LOCATION

HOUSING EDSK 326688 ITEM NO. 1
RED DIA + .000 - .002
BUSHING EDSK 326787 MAKE THIS
+ .040 ± .005
BUSHING EDSK 326787 MAKE THIS
+ .001 + .002
IN .0005 TIR
IN .001 TIR

ITEM NO 10

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

DFTM	HGO 1/21/65
DFTM	CM 1-25-65
ENGR	H.Maxwell 1/25/65
ENGR	W.L. Grant 1-25-65
MFR	
TEST	
PROJ ENGR APPD	
APPD FOR	
BY	

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.

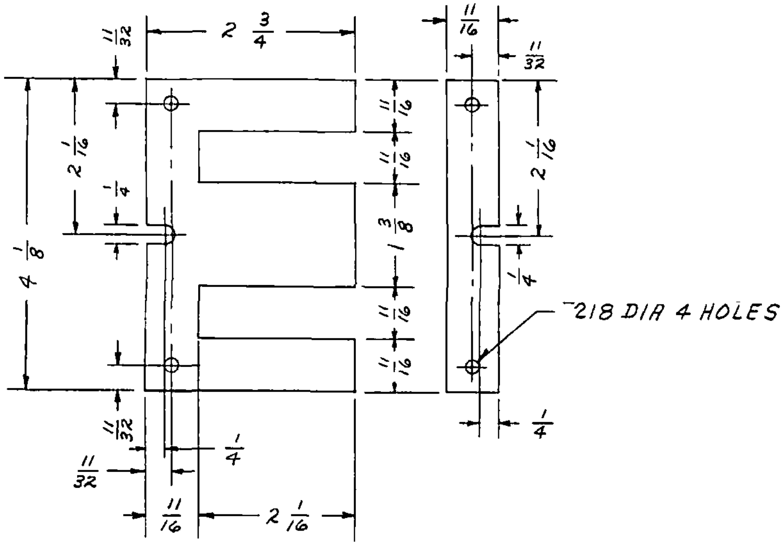
TITLE: DETAILS

CODE IDENT NO.	SIZE	DRAWING NO.
83843	F	EDSK 326762

SCALE | WEIGHT | SHEET

TOOL REF | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED | SPARES CANNOT BE FURN

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG.



ANNEAL PER PDS 80002AK BY MAGNETICS INC, BUTLER, PA CODE 90797
AFTER ANNEALING INSULATE PER INSTRUCTIONS OF ENGINEER

PUNCHING ~ MAKE FROM HIPERCO 27 .008 THK 13202AC
DIMENSIONS PER LAMINATION TYPE 138-EI

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

S LYP19038

INTERNAL INFO & DATA

80002AK WAS 8002AK

1 W L Grant 5-1-65

.218 HOLE DIA WAS .180

2 W L Grant 6-16-65

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

TOOL REF P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE MFG SPECS PER LA 331
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG
TOLERANCES ON FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
SPEC
SYMBOLS
W = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
= VERY IMPORTANT

DFTM	HGO	1/15/65
DFTM		1-25-65
ENGR		1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO U.S.A.

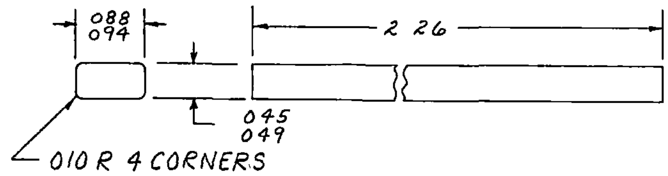
TITLE PUNCHING, TRANSFORMER

CODE IDENT NO	SIZE	DRAWING NO
83843	C	EDSK 326756

SCALE 1:1 | WEIGHT | SHEET

ENGRG FORM LINCOLN-GRAPHIC CORP

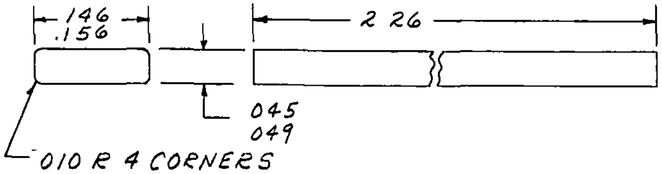
SYM	REVISIONS DESCRIPTION	DATE	APPROVED



NOTE ~ ALL SIDES OF SPACER MUST BE STRAIGHT AND FLAT WITHIN .005 TIR

SPACER ~ MAKE FROM MINIMUM 99 % PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

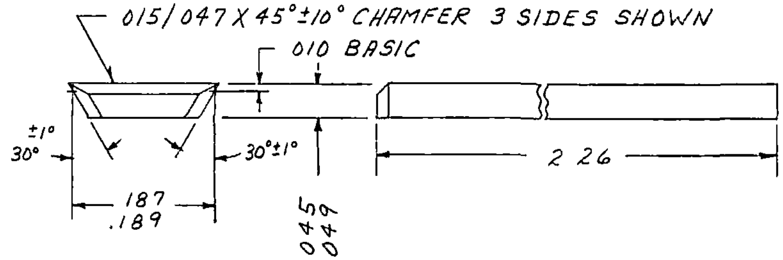
ITEM NO 1



NOTE ~ ALL SIDES OF SPACER MUST BE STRAIGHT AND FLAT WITHIN 005 TIR

SPACER ~ MAKE FROM MINIMUM 99 % PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

ITEM NO. 2



NOTE ~ ALL SIDES OF WEDGE MUST BE STRAIGHT AND FLAT WITHIN 005 TIR

WEDGE ~ MAKE FROM MINIMUM 99 % PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

ITEM NO 3

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

S.LYP19037
Ⓦ INTERNAL INFO & DATA
99 % WAS 99.5 % - 3 PLACES VL Grant 5-1-65
1

DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE XX ±.02 | 3 PLACE XXX ±.005 | ANGLES ±1°

TOOL REF Ⓦ P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE MFG SPECS PER LA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DWG
TOLERANCES ON FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
⊙ = VERY IMPORTANT

DFTM	HGO	1/13/65
DFTM	[illegible]	1-25-65
ENGR	[illegible]	1-25-65
ENGR	WL Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO U.S.A

TITLE
DETAILS, SLOT

CODE IDENT NO	SIZE	DRAWING NO
83843	C	EDSK 326626
SCALE 10 / 1	WEIGHT	SHEET

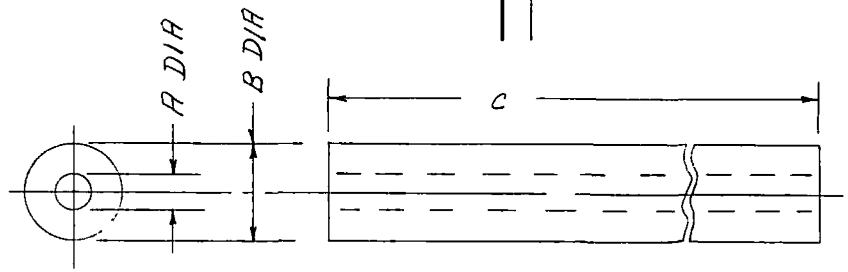
OHIO DEPT FORM ... LINCOLN-GRAPHIC CORP

EDSK 326686

PART NO	DIA A	DIA B	LENGTH C
-1	062	125	.70
-2	062	188	2 50
-3	.044	094	2 50

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED



NOTE ~ STRAIGHTNESS TOLERANCE 1/16 INCH PER FOOT OF LENGTH

INSULATOR ~ MAKE FROM MINIMUM 99% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

DFTM HGO 1/11/65
DFTM 1-25-65
ENGR 1/25/65
ENGR W L Grant 1-25 65
MFR
TEST
Ⓦ PROJ ENGR APPD
APPD FOR
BY

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA OHIO U.S.A

TITLE INSULATOR, TUBE

CODE IDENT NO 83843 | SIZE C | DRAWING NO EDSK 326686
SCALE N-S | WEIGHT | SHEET

TOLERANCE MFG SPECS PER LA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES DO NOT SCALE DWG. TOLERANCES ON
FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
Ⓥ = VERY IMPORTANT

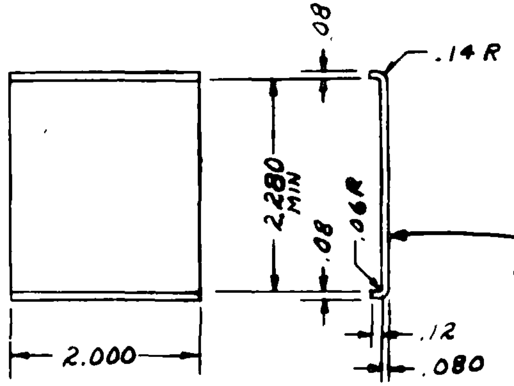
DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES
UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02
3 PLACE .XXX±.005
ANGLES ±1°

TOOL REF Ⓦ P/N
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED
SPARES CANNOT BE FURN
NEXT ASSY

Ⓦ SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

S LYP19039
Ⓦ INTERNAL INFO & DATA

ENGRG DEPT FORM 42598-J LINCOLN-GRAPHIC CORP



NOTE ~ MATERIAL IN THIS PLANE MUST BE FLAT WITHIN .030

CHANNEL ~ MAKE FROM MINIMUM 99.5% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

TOOL REF P/N
NOT TOOLED
PROD TOOLED
TOOLS SCRAPPED
SPARES CANNOT BE FURN

INTERNAL INFO & DATA

5LYP19038

1	2.280 DIM WAS 2.250 5ELYP19038 MERRILL CTILLER 2-3-61 2-2-65 W L Grant 2-3-65
2	ADDED "MIN" TO 2.280 DIM. ADDED FLATNESS NOTE W L Grant 5-1-65

SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

NEXT ASSY

TOLERANCE, INFO SPECS PER LA 2?1
DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES
UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 | 3 PLACE .XXX±.005 | ANGLES ±1°
PROCESS TO BE APPLIED AS INDICATED ON DWG
GOV'T SPEC
SPEC

SYMBOLS
= WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CON'T DWG
V = VENDOR PART AR = AS REQ'D
= VERY IMPORTANT

DFTM	HGO	1/18/65
DFTM		1-25-65
ENGR		1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

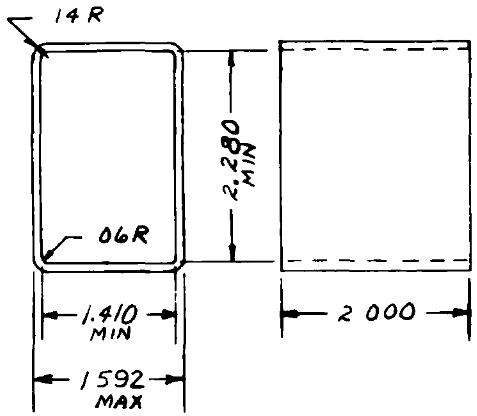
AEROSPACE ELECTRICAL DIVISION
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.

TITLE CHANNEL

CODE IDENT NO.	SIZE	DRAWING NO.
83843	B	EDSK 326757
SCALE 1/1	WEIGHT	SHEET

DWG EDSK 326757

DWG. EDSK 326758



SPOOL ~ MAKE FROM MINIMUM 99.5% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

TOOL REF Ⓦ P/N	
NOT TOOLED	
PROD TOOLED	
TOOLS SCRAPPED SPARES CANNOT BE FURN	

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

Ⓦ INTERNAL INFO & DATA

5 LYP/9038

2.280 DIM WAS 2.230
5 LYP/9038 MERRILL 2-3-65
MILLER 2/3/65
W L Grant 2-3-65

1 — ADDED "MIN" TO 2280 DIM; 1 410 MIN WAS 1 415; ADDED 1592 MAX; DELETED 080 WALL — W L Grant 5-1-65 — 2

NEXT ASSY

TOLERANCE, AND SPECS PER SA 531
DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED

2 PLACE	3 PLACE	ANGLES
XX = ± 02	.XXX = ± 005	± 1°

PROCESS TO BE APPLIED AS INDICATED ON DWG
GOV'T SPEC
Ⓦ SPEC

SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CON'T DWG
V = VENDOR PART AR = AS REQ'D
Ⓥ = VERY IMPORTANT

DFTM	HGO	1/18/65
DFTM	[illegible]	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

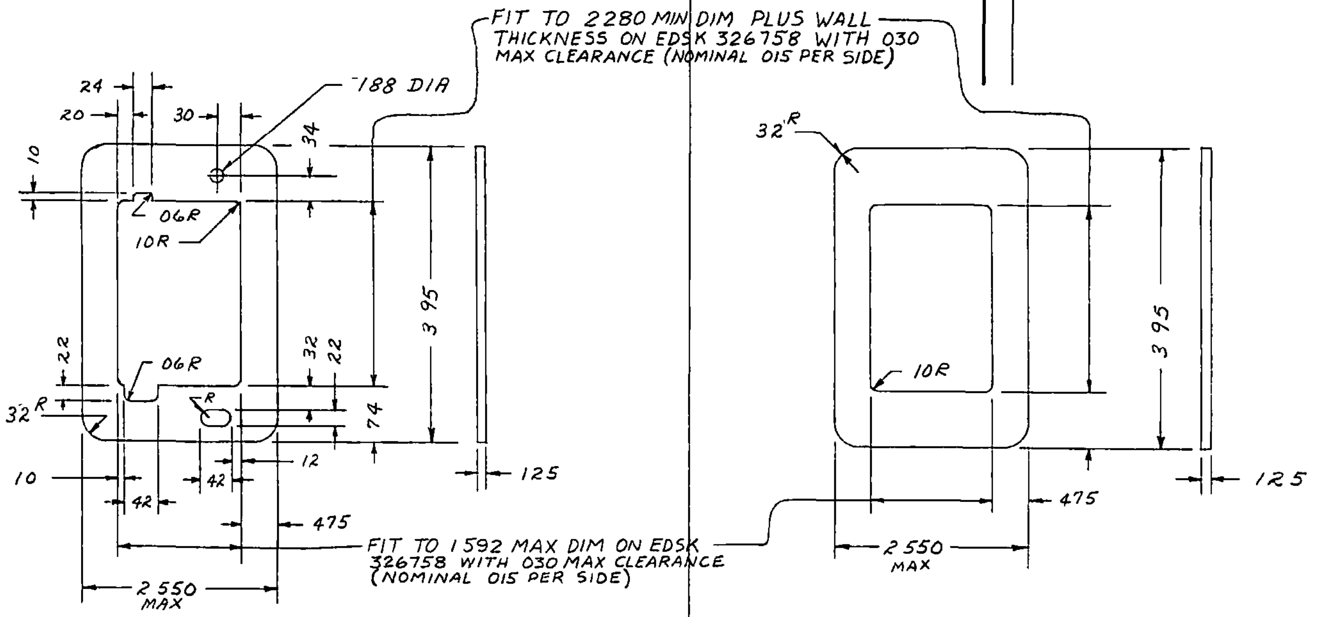
AEROSPACE ELECTRICAL DIVISION
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO. U.S.A.

TITLE SPOOL

CODE IDENT NO.	SIZE	DRAWING NO
83843	B	EDSK 326758

SCALE 1/1 | WEIGHT | SHEET

FORM NO. 16010-4 W FORM NO. 22301-J



END PLATE ~ MAKE FROM MINIMUM ~~OF~~ 99 5% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

ITEM NO 2

END PLATE ~ MAKE FROM MINIMUM ~~OF~~ 99 5% PURITY HIGH DENSITY AL_2O_3 (ALUMINA)

ITEM NO 1

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

S. LYP19038

Ⓦ INTERNAL INFO & DATA

2 470 DIM WAS 2 440
3 95 DIM WAS 3 92
ITEMS 1 & 2
S#LYP19038 MERRILL 2-4-65
MILLER 2-3-65
W L Grant 2-3-65

1 DELETED 1 600 DIM - 2 PLACES ADDED FIT NOTE DELETED 2 470 DIM - 2 PLACES - ADDED "FIT" NOTE ADDED MAX TO 2 550 DIM - 2 PLACES.
2 W.L. Grant 5-1-65

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

DIMENSIONS IN INCHES - DO NOT SCALE DRAWING
STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED
2 PLACE .XX±.02 | 3 PLACE .XXX±.005 | ANGLES ±1°

TOOL REF Ⓦ P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN

NEXT ASSY

TOLERANCE MFG SPECS PER LA 351
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG. TOLERANCES ON
FRACTIONS | DECIMALS | ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOVT SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
K = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
Ⓘ = VERY IMPORTANT

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

DFTM	HGO	1/13/65
DFTM	[illegible]	1 25 65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO U S A

TITLE END PLATES

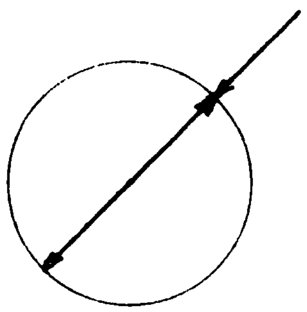
CODE IDENT NO.	SIZE	DRAWING NO
83843	C	EDSK 326759
SCALE 1/1	WEIGHT	SHEET

ENGRG DEPT FORM [illegible] LINCOLN-GRAPHIC CORP

SKETCH SHEET
FORM 28577

WESTINGHOUSE ELECTRIC CORPORATION

Conductor
28% Inconel-Clad Silver



Dimensions in inches
Scale 10:1

EDSK 326536 A

Rev A	12-28-64
28% was 20%	

H.E.Kenaipp 12-31-64

APPENDIX C

SOLENOID MATERIALS SUMMARY

APPENDIX C

SOLENOID ASSEMBLY

DRAWING NO.	TITLE	MATERIAL
EDSK 326788	Solenoid Assembly	-
EDSK 326689	Winding, Solenoid	-
EDSK 326762	Details	See Drawing
EDSK 326688	Details	See Drawing
EDSK 326620	Details	See Drawing
EDSK 326619	Forging	Hiperco 27 Alloy (27 Co - Fe)
EDSK 326793	Forging, Cut Up	Hiperco 27 Alloy (27 Co - Fe)
EDSK 326787	Bushing	99.5 Al_2O_3
EDSK 326687	Solenoid Armature, Guide Rod	99.5 Al_2O_3
EDSK 326686	Insulator, Tube	99 Al_2O_3
EDSK 326685	Insulator, Tube	99 Al_2O_3
EDSK 326684	End Plate	99.5 Al_2O_3
EDSK 326680	Insulator, Tube	99 Al_2O_3
EDSK 326795	Thermocouple	(Inconel Cladding, Platinel II
EDSK 326796	Thermocouple	Wire system, Al_2O_3 Insulation)
EDSK 327502	Screw	Hastelloy Alloy B
EDSK 327503	Nut	Hastelloy Alloy B
EDSK 326533	Conductor	Nickel Clad Silver (20% Clad area)[1]
EDSK 326534A	Conductor	Inconel Clad Silver (28% Clad area)[1]

(1)- All conductors insulated with Anaconda's Anadur, a refractory-oxide-filled glass insulation.

S. LYP 19039

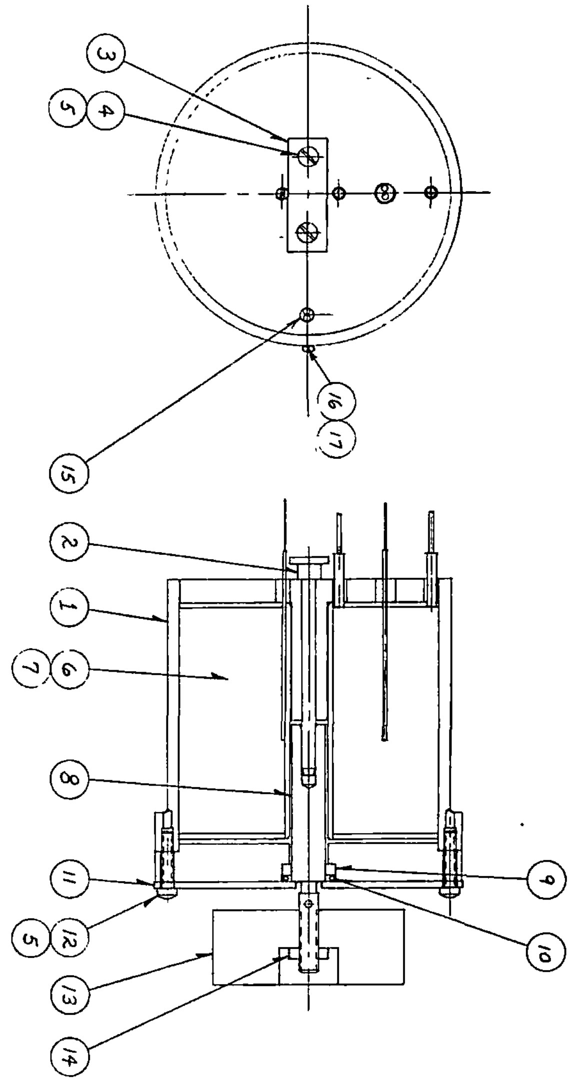
INTERNAL INFO & DATA

HOLE ON HORIZONTAL ℄
WAS ON VERTICAL ℄
ITEMS 4, 12 & 14 RENE 41
WAS RENE 4
S=LYP19039 MERRILL
MILLER 2-3-65 2-2-65

1 WL Grant 2-3-65

ADDED NOTE 1 ADDED
ITEMS 16, 17 & 18
CHANGED ITEMS 4,
12 & 14 TO EDSK
CALL-OUT ADDED
SPEC REF

2 WL Grant 5-1-65



REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

NOTE 1- WINDING POTTING PROCEDURE APPLY FOUR STRIPS OF POTTING COMPOUND W-839 3/8-1/2 INCH WIDE AND LOCATED APPROX 90° APART COATING MUST BE THICK ENOUGH TO PROVIDE CONTACT BETWEEN WINDING AND HOUSING AFTER ASSEMBLY AVOID AREA OCCUPIED BY THERMOCOUPLES ITEM 15

QTY REQD PN-2	QTY REQD PN-1	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO
AR	AR	B	POTTING COMPOUND	W-839 (WESTINGHOUSE) (SEE NOTE 1)				18
AR	AR	B	PYROCERAM					17
2	2		THERMOCOUPLE	EDSK 326796				16
2	2		THERMOCOUPLE	EDSK 326795				15
1	1		NUT	EDSK 327503-2				14
1	1		WEIGHT	EDSK 326688 ITEM NO 4				13
4	4		SCREW	EDSK 327502-2				12
1	1		PLATE	EDSK 326688 ITEM NO 3				11
1	1		STAINLESS STEEL O'RING CAT NO U-8212-00688-NPN UNITED AIRCRAFT PRODUCTS, INC DAYTON, OHIO					10
1	1		BUSHING	EDSK 326787				9
1	1		SHAFT	EDSK 326688 ITEM NO 7				8
1	-		WINDING	EDSK 326689 PN-2				7
-	1		WINDING	EDSK 326689 PN-1				6
AR	AR	B	WIRE, SST	.020 DIA 7860-2				5
2	2		SCREW	EDSK 327502-1				4
1	1		PLATE	EDSK 326620 ITEM NO 4				3
1	1		GUIDE ROD	EDSK 326687				2
1	1		HOUSING ASSY	EDSK 326762 ASSY NO 1				1

LIST OF MATERIAL OR PARTS LIST

Ⓦ SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS
595405-1		

TOOL REF Ⓦ P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE MFG SPECS PER LA 531
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG
TOLERANCES ON
FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
Ⓦ = VERY IMPORTANT

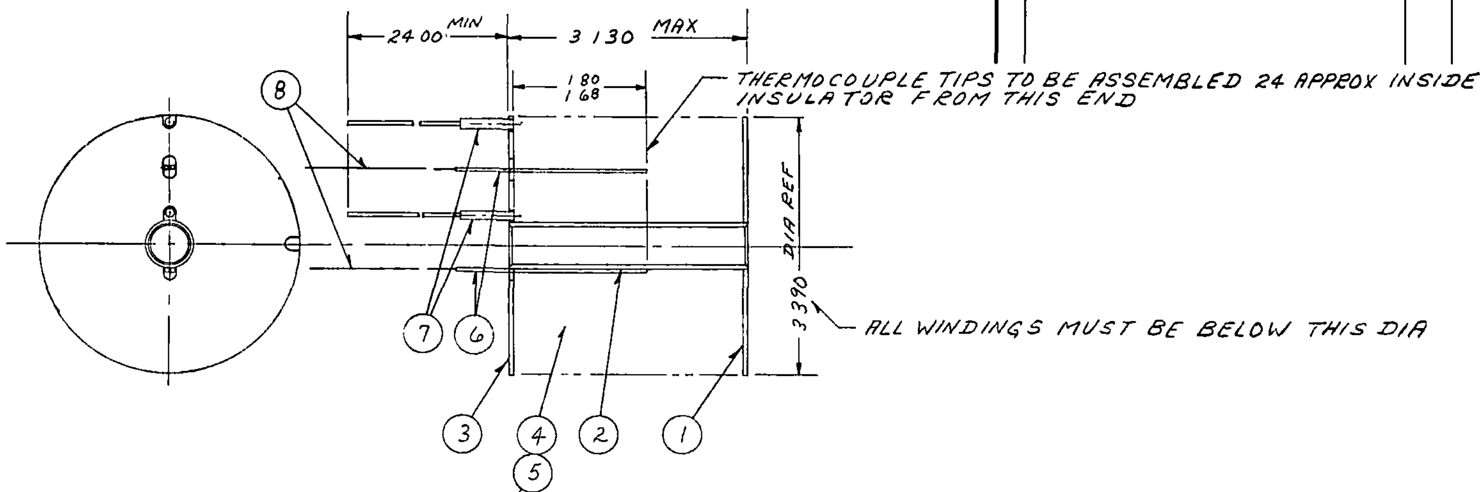
DFTM	HGD	1/21/65
DFTM	MILLER	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO U.S.A.

TITLE SOLENOID

CODE IDENT NO	SIZE	DRAWING NO
83843	D	EDSK 326788

SCALE 1/1 | WEIGHT | SHEET



1860 TURNS PER WINDING

NOTE ~ CEMENT PLATES ITEM NO 1 AND 3 TO TUBE ITEM NO. 2, CEMENT INSULATORS ITEM NO 7 TO PLATE ITEM NO 3 WITH DUCO CEMENT

QTY REQD PN-2	QTY REQD PN 1	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO
4	4		THERMOCOUPLE	EDSK 326795				8
2	2		INSULATOR	EDSK 326686 PN-1				7
4	4		INSULATOR	EDSK 326680				6
AR	-	B	WIRE #20 (032 DIA) INCONEL-CLAD SILVER FURNISHED BY ENGINEER					5
-	AR	B	WIRE #20 (032 DIA) NICKEL-CLAD SILVER FURNISHED BY ENGINEER					4
1	1		END PLATE	EDSK 326634 ITEM NO 2				3
1	1		INSULATOR, TUBE	EDSK 326685				2
1	1		END PLATE	EDSK 326684 ITEM NO 1				1

LIST OF MATERIAL OR PARTS LIST

REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

Ⓦ SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

TOOL REF Ⓦ P/N
NOT TOOLED.
PROD TOOLED
TOOLS SCRAPPED
SPARES CANNOT BE FURN
NEXT ASSY

TOLERANCE MFG SPECS PER LA 551
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG
TOLERANCES ON
FRACTIONS ±1/64 DECIMALS ±.005 ANGLES ±1/2
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOVT SPEC
Ⓦ SPEC
SYMBOLS
Ⓦ = WESTINGHOUSE B = BULK MATERIAL
SC = SPEC/SOURCE CONT DWG
V = VENDOR PART AR = AS REQ'D
Ⓥ = VERY IMPORTANT

DFTM	HGO	1/12/65
DFTM		1-25-65
ENGR		1/25/65
ENGR	W L Grant	1-25-65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA OHIO U.S.A.

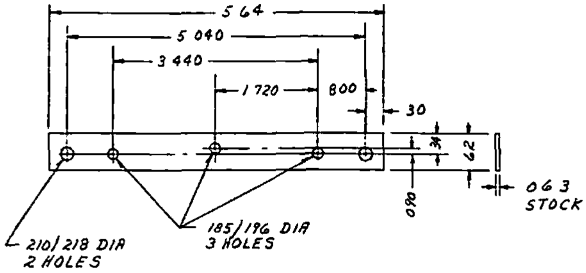
TITLE
WINDING, SOLENOID

CODE IDENT NO. 83843 | SIZE C | DRAWING NO EDSK 326699

SCALE 1/1 | WEIGHT | SHEET

S. LYP 11034
Ⓦ INTERNAL INFO & DATA
SLOT ON HORIZONTAL ℄ WAS LOCATED ON VERTICAL ℄ SLOT WAS SHOWN AS CIRCLE 2-2-65
J#LYP19039 MERRILL
Miller 2-3-65
1 W L Grant 2-3-65

ENGRG DEPT FORM



PLATE, MOUNTING ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B 333-62

ITEM NO 1

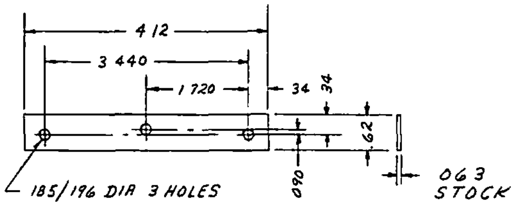
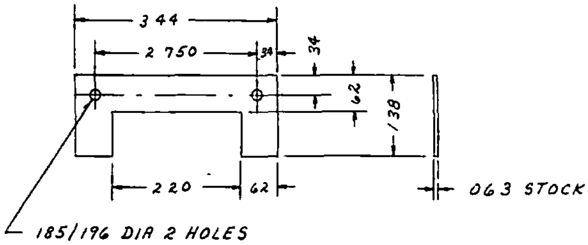


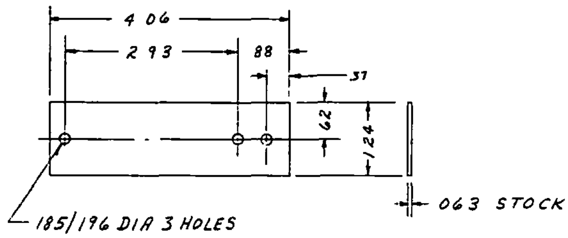
PLATE ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B 333-62

ITEM NO 2



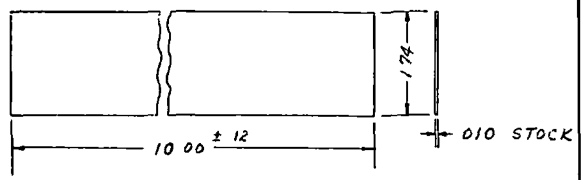
PLATE, SUPPORT ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B 333-62

ITEM NO 3



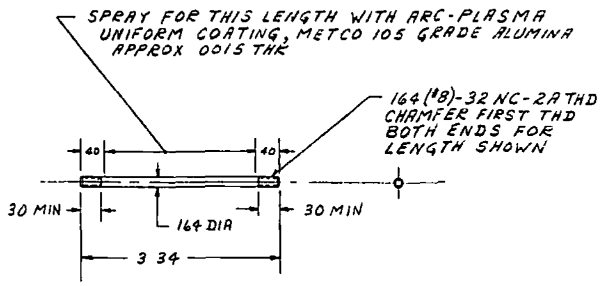
STRAP, GROUND ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B 333-62

ITEM NO 4



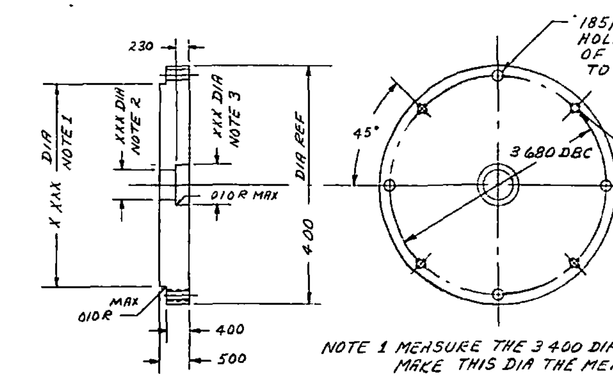
INSULATION ~ MAKE FROM BURNIL CM-2 SYNTHETIC MICA PAPER

ITEM NO 5



STUD ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B 335-58T

ITEM NO 7



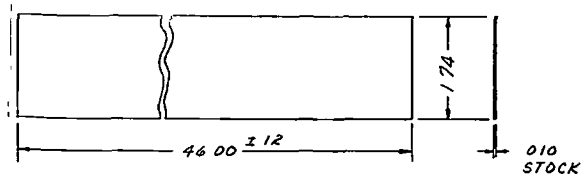
NOTE 1 MEASURE THE 3 400 DIA
MAKE THIS DIA THE ME
NOTE 2 MEASURE THE 460 DIA
DIA THE MEASURED D
NOTE 3 MEASURE THE .700 DIA
DIA THE MEASURED D

NOTE ~ DIA NOTE 2 AND DIA NOTE 3 MUST BE CONCENTRIC WI
DIA NOTE 3 MUST BE CONCENTRIC WITH DIA NOTE 1 W

END BELL ~ MAKE FROM RING EDSK 326688 ITEM NO

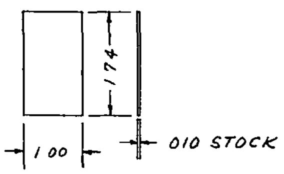
LCP 17038
INTERNAL INFO & DATA
ITEM ADDED 37 DIM HOLE ITEM 5 - ... WAS ... ITEMS 5,6 ... E5 - CM-2 WAS CM-1
1 W L Grant 5-1-65

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



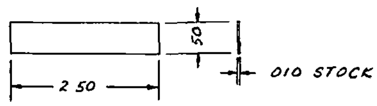
INSULATION ~ MAKE FROM BURNIL CM-2 SYNTHETIC MICA PAPER

ITEM NO 6



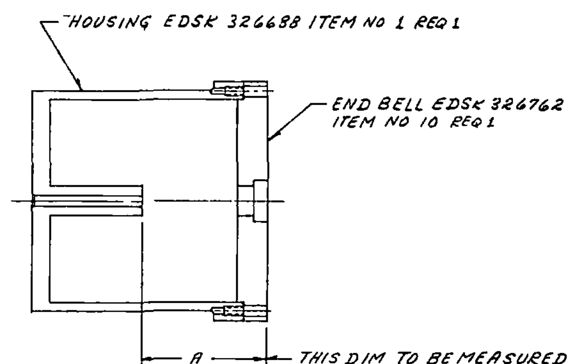
INSULATION ~ MAKE FROM BURNIL CM-2 SYNTHETIC MICA PAPER

ITEM NO 8



INSULATION ~ MAKE FROM BURNIL CM-2 SYNTHETIC MICA PAPER

ITEM NO 9



ASSY NO 1

HOUSING ASSY ~ MAKE FROM ITEMS SHOWN

% DIA 4 HOLES EQUALLY SPACED
MUST BE LOCATED WITHIN 005
IR NOMINAL CL LOCATION DBC
CONCENTRIC WITH DIA AT NOTE 1

190(#10)-32 NF-2B THD THRU 4 HOLES EQUALLY SPACED HOLES MUST BE LOCATED WITHIN 008 OF THEIR NOMINAL CL LOCATION

/ HOUSING EDSK 326688 ITEM NO 1
IRED DIA + 000 - 002
BUSHING EDSK 326787 MAKE THIS
+ 040 ± 005
/ BUSHING EDSK 326787 MAKE THIS
+ 001 + 002

IN 0005 TIR
IN 001 TIR

ITEM NO 10

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.

LIST OF MATERIAL OR PARTS LIST

DFTM	HGO	1/21/65
DFTM	CM	1-25-65
ENGR	[illegible]	1/25/65
ENGR	W.L. Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.

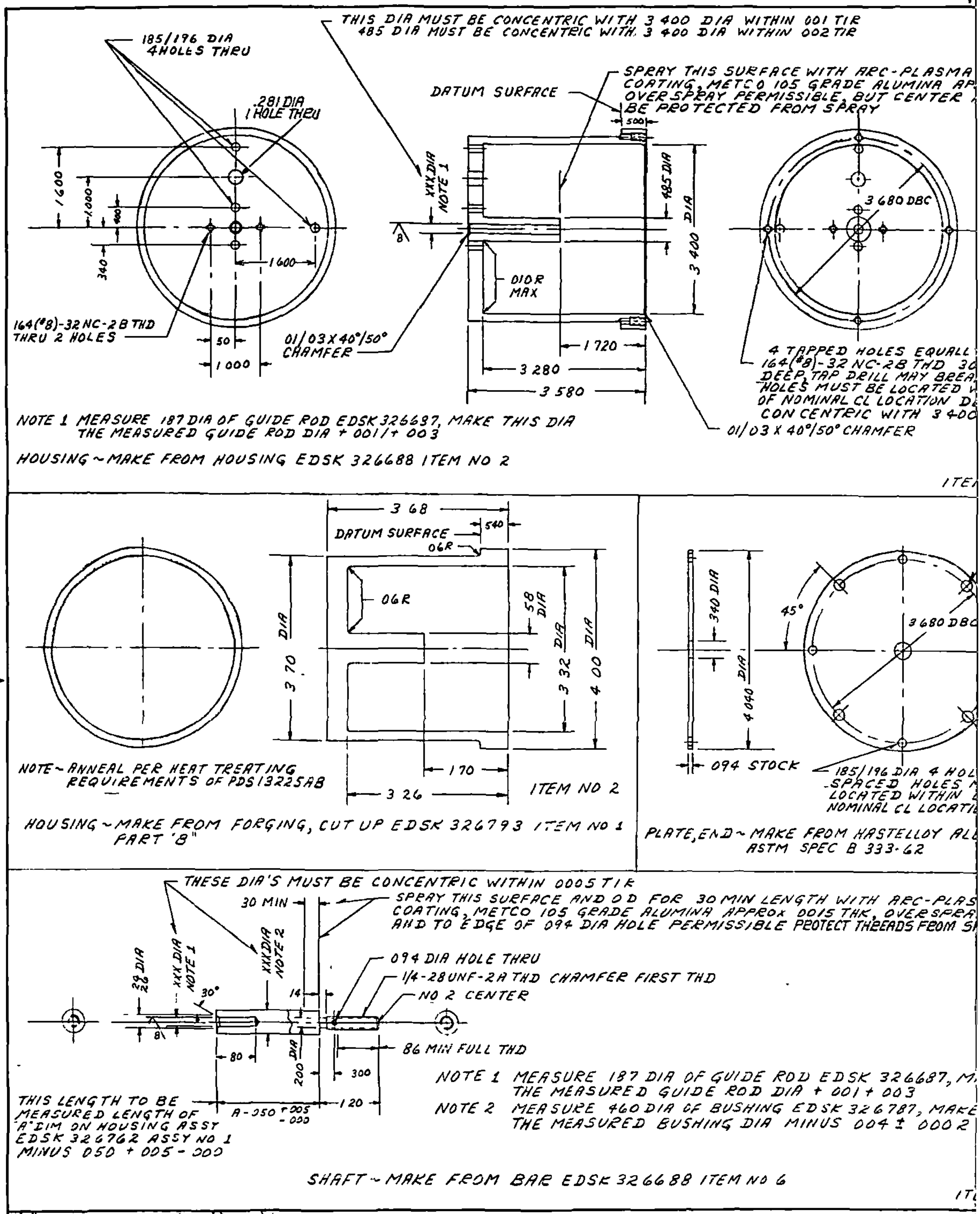
TITLE: DETAILS

CODE IDENT NO.	SIZE	DRAWING NO.
83843	F	EDSK 326762
SCALE	WEIGHT	SHEET

TOLERANCES UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG. FRACTIONS ± 1/64, DECIMALS ± .005, ANGLES ± 1/2°. PROCESS TO BE APPLIED AS INDICATED ON DRAWING.

STD DECIMAL TOLERANCES UNLESS OTHERWISE SPECIFIED: 2 PLACE ±.010, 3 PLACE ±.005, ANGLES ±1°

TOOL REF | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN



LYP 19039
INTERNAL INFO & DATA
ITEM 2 .281 DIA HOLE THRU HAS 185/196 .185/196 DIA HOLE ON HORIZONTAL C WAS LOCATED ON VERTICAL 1.600 DOWN FROM HORIZONTAL ITEM 6 PROTECT THREADS FROM SPRAY ADDED TO NOTE

ITEM 1-RT VIEW CORRECTED PICTURE ITEM 4-ADDED PARA... CONCENTRICITY NOTES DELETED WT... BALANCE NOTES

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED

IFORM
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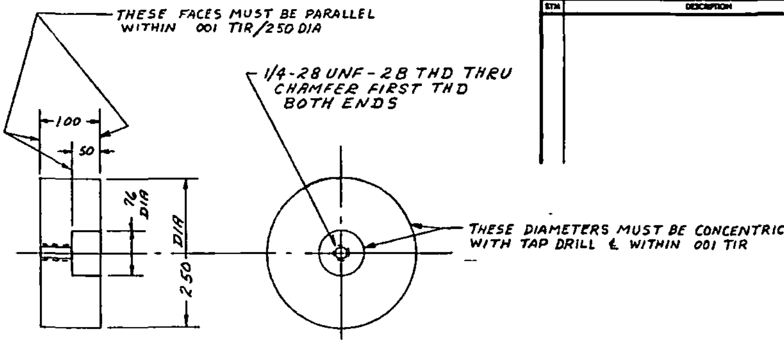
NO 1



WEIGHT ~ MAKE FROM MALLORY 1000 OR FANSTEEL 77

ITEM NO 4

210/218 DIA 4 HOLES
EQUALLY SPACED HOLES
MUST BE LOCATED WITHIN
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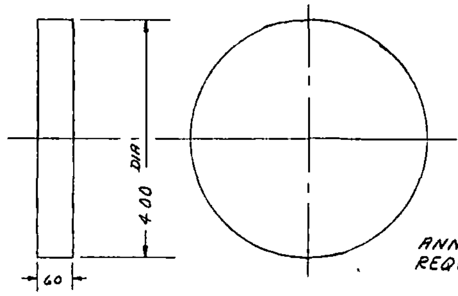
B,

TEM NO 3



~NOTE~
ANNEAL PER HEAT TREATING
REQUIREMENTS OF PDS 13225AB

RING ~ MAKE FROM FORGING, CUT UP EDSK 326793 ITEM NO 2
PART "B"

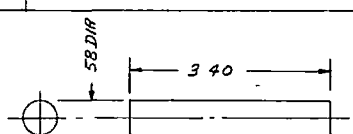
ITEM NO 5

A UNIFORM
N 200 DIA
Y

E THIS DIA

HIS DIA

NO 7



~NOTE~
ANNEAL PER HEAT TREATING
REQUIREMENTS OF PDS 13225AB

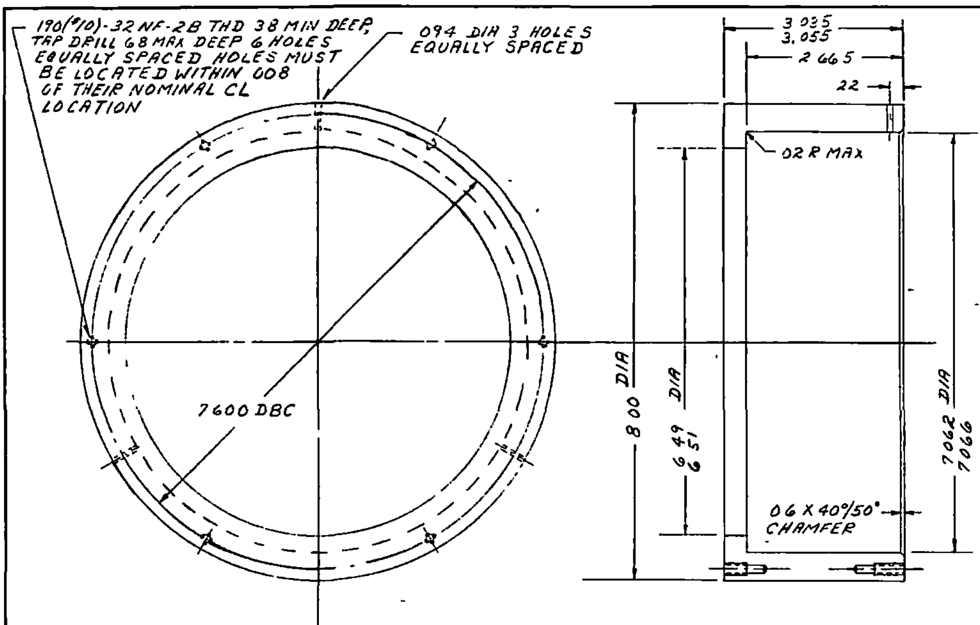
BAR ~ MAKE FROM FORGING, CUT UP
EDSK 326793 ITEM NO 1 PART "C"

ITEM NO 6

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO.

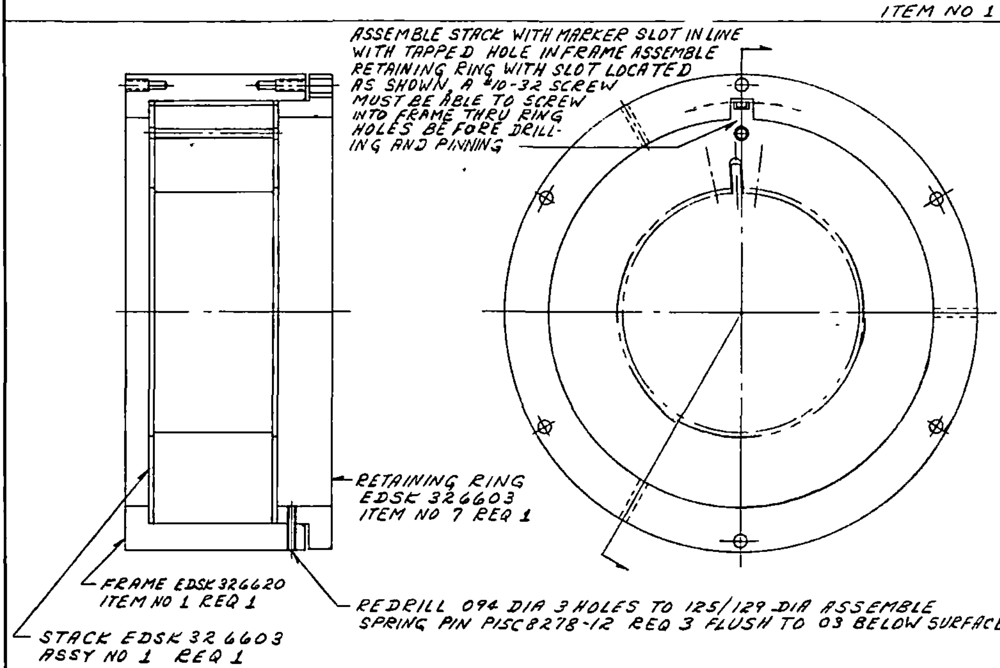
LIST OF MATERIAL OR PARTS LIST

DFTM HGO	1/20/65	AEROSPACE ELECTRICAL DEPARTMENT WESTINGHOUSE ELECTRIC CORP LIMA, OHIO, U.S.A.
DFTM	1-25-65	
ENGR	1/21/65	TITLE DETAILS
ENGR W L Grant	1-26-65	
MFR		
TEST		
PROJ ENGR APPD		CODE IDENT NO. 83843 — SIZE F — DRAWING NO. EDSK 326688
APPD FOR		
BY		SCALE 1/1 — WEIGHT — SHEET



FRAME ~ MAKE FROM EDSK 326603 ITEM NO 4

ITEM NO 1

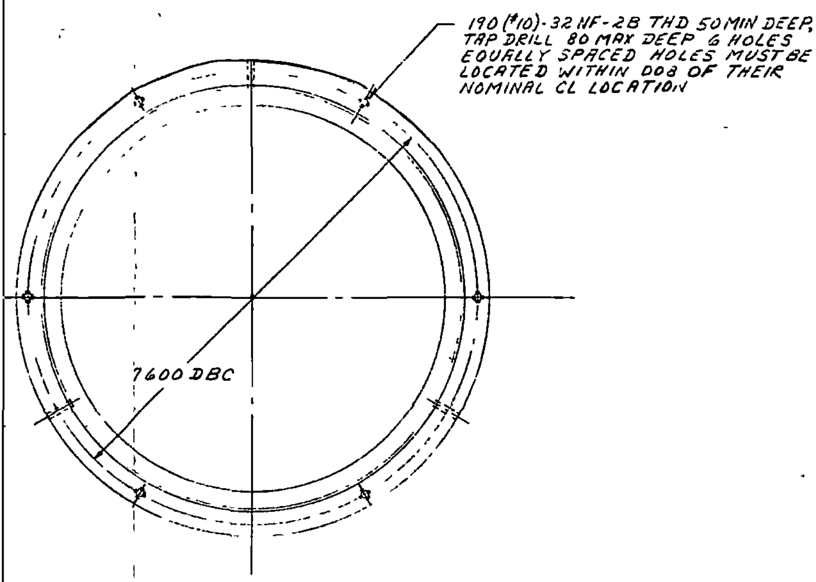


ASSY NO 1

STACK, STATOR ~ MAKE FROM ITEMS SHOWN

INTERNAL INFO & DATA

REVISIONS			
SYM	DESCRIPTION	DATE	APPROVED



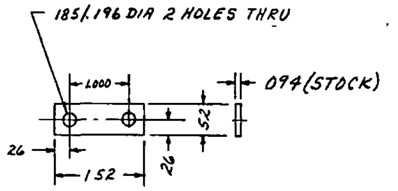
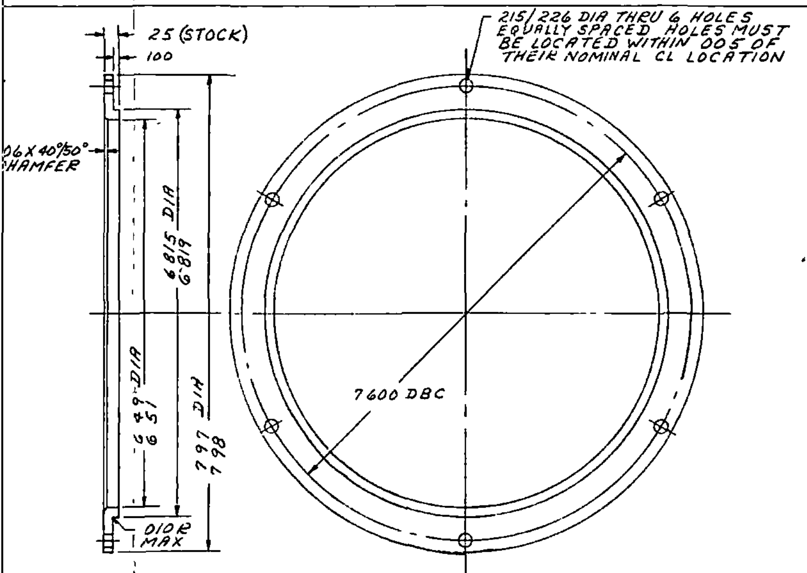


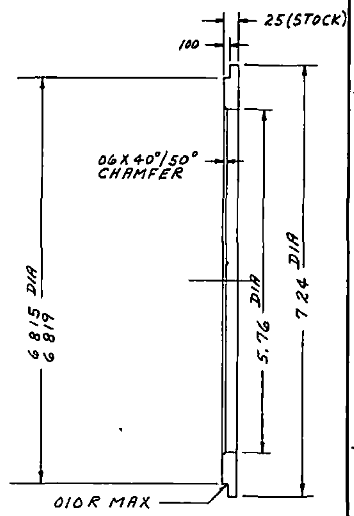
PLATE ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B333-62

ITEM NO. 4



RING ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B333-62

ITEM NO 2



RING ~ MAKE FROM HASTELLOY ALLOY B, ASTM SPEC B333-62

ITEM NO 3

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO. OR IDENT NO.	SPECIFICATION	MATERIAL OR NOTE	INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

SPECIFICATION REFERENCE	GOVERNMENT SPECIFICATION	NAME OF PROCESS

TOOL REF; NOT TOOLED; PROD TOOLED; TOOLS SCRAPPED; SPARES CANNOT BE FURN

TOLERANCES UNLESS OTHERWISE SPECIFIED

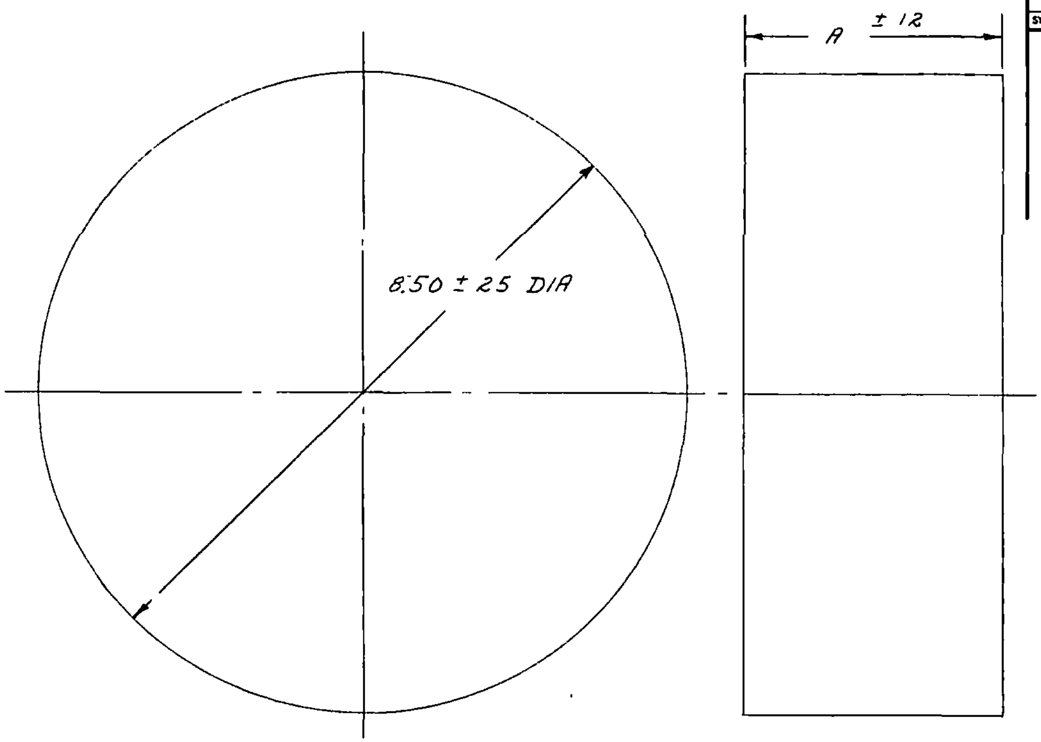
DFTM	HGO	1/7/65
DFTM	ET	1/25/65
ENGR	[illegible]	1/25/65
ENGR	W.L. Grant	1-25-65
MFR		
TEST		
PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
WESTINGHOUSE ELECTRIC CORP
LIMA, OHIO, U.S.A.

TITLE DETAILS

CODE IDENT NO.	SIZE	DRAWING NO.
83843	F	EDSK 326620

SCALE 1/1 WEIGHT SHEET



REVISIONS

SYM	DESCRIPTION	DATE	APPROVED

EDSK 326619	DIM "A"
ITEM NO 1	3.40
ITEM NO 2	1.26
ITEM NO 3	4.00

~NOTE~

MATERIAL SHALL BE MADE TO MEET WESTINGHOUSE PDS 13225AB WITH THE FOLLOWING ADDITIONAL REQUIREMENTS 1. THAT CERTIFICATION OF ACCEPTABLY PASSING ULTRASONIC INSPECTION BE PROVIDED 2. THAT THE MATERIAL BE SHIPPED WITHOUT BEING ANNEALED, HOWEVER IN THE ANNEALED CONDITION SAID FORGING SHALL BE CERTIFIED TO MEET THE MECHANICAL AND MAGNETIC PROPERTIES OF PDS 13225AB

QTY REQD	SYM	NOMENCLATURE OR DESCRIPTION	PART NO OR IDENT NO	SPECIFICATION	MATERIAL OR NOTE	Ⓦ INTERNAL INFORMATION	ITEM NO

LIST OF MATERIAL OR PARTS LIST

Ⓦ SPECIFICATION REFERENCE | GOVERNMENT SPECIFICATION | NAME OF PROCESS

TOOL REF Ⓦ P/N | NOT TOOLED | PROD TOOLED | TOOLS SCRAPPED SPARES CANNOT BE FURN | NEXT ASSY

TOLERANCE MFG SPECS PER LA 331
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. DO NOT SCALE DWG.
TOLERANCES ON FRACTIONS DECIMALS ANGLES
PROCESS TO BE APPLIED AS INDICATED ON DRAWING
GOV'T SPEC
Ⓦ SPEC
SYMBOLS Ⓦ = WESTINGHOUSE B = BULK MATERIAL SC = SPEC/SOURCE CONT DWG V = VENDOR PART AR = AS REQ'D ⊕ = VERY IMPORTANT

DFTM	HGO	12/31/64
DFTM	[illegible]	1-25-65
ENGR	DH [illegible]	1/4/65
ENGR	[illegible]	1/6/65
MFR		
TEST		
Ⓦ PROJ ENGR APPD		
APPD FOR		
BY		

AEROSPACE ELECTRICAL DEPARTMENT
Ⓦ WESTINGHOUSE ELECTRIC CORP Ⓦ
LIMA, OHIO U.S.A.

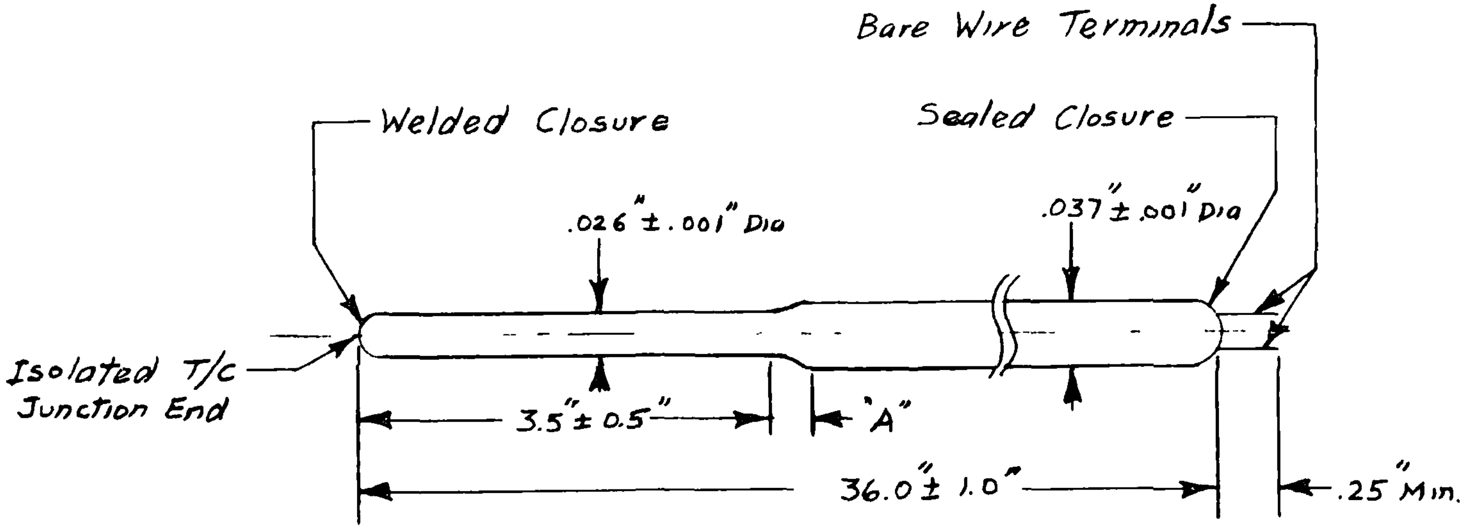
TITLE FORGING

CODE IDENT NO	SIZE	DRAWING NO
83843	C	EDSK 326619

SCALE 1/1 | WEIGHT | SHEET

S. LYP19037 Ⓦ INTERNAL INFO & DATA

ENGRG DEPT FORM 32380-J LINCOLN-GRAPHIC CORP 1961, PRO 5-61



Note: Thermocouples are to be kept straight at all times.

"A" – Dimension as required for forming operation — 10 inch maximum.
OD surface must be continuous thru transition.

DUAL DIAMETER SHEATHED THERMOCOUPLE

Reference (W) D-Spec # 709747

EDSK 326795

wlg 2-18-65

b.) Model 602, Mazur Lapping/Polishing Machine manufactured by Westinghouse Scientific Equipment Division. The machine is equipped with a variable vibrational speed control and timer.

c.) Model 200 B-5 Bench Type Ultrasonic Machine Tool manufactured by Sheffield Corporation.

d.) Model F, Industrial Abrasive Unit manufactured by S. S. White Co.

e.) Model L-300 Ultrasonic Cleaner manufactured by Landsverk Electrometer Co.

f.) Model AST-100 Low Energy Sputtering System (Plasmavac) including a CV-18 Vacuum Evaporator manufactured by Consolidated Vacuum Corporation. The system has an ultimate vacuum of 3.5×10^{-8} torr. Sputtering operations are performed using a novel three electrode technique.

3. Wafer Slicing

The Lucalox rod was sliced into wafers ranging in thickness from 8 to 15 mils. Six wafers were sliced in the 10 mil thickness range. Pyrolytic boron nitride was wafered into 10 to 12 mil thick slices. A yield of five wafers per 1/8 inch thick block was obtained.

Lucalox rod stock and a 1 x 1 x 1/8 inch block of pyrolytic boron nitride was mounted and sliced as follows:

a. MOUNTING FOR SLICING OPERATIONS

A 3/4 inch diameter x 3 inch long Lucalox rod was cemented to a glass plate with LOC-Wax 20 (Geoscience Instrument Co.) and sliced as shown in Figure III-2. A 1 x 1 x 1/8 inch block of pyrolytic boron nitride was also mounted and sliced in a similar manner.

b. SLICING

Slicing Machine: WMSA Precision Wafering Machine

Diamond Wheel: Metal Bonded Diamond Wheel manufactured by Norton Co., Abrasives Div.
Wheel Diameter - 5 inches

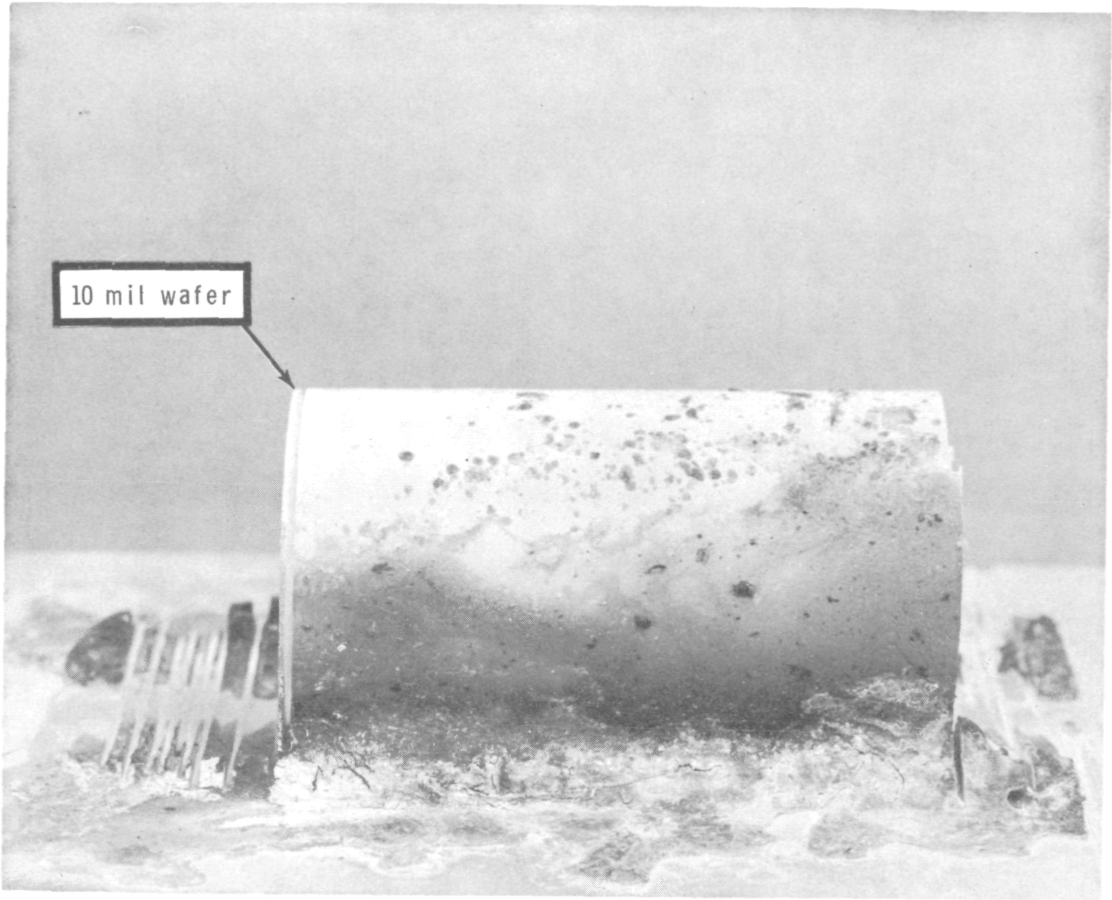


FIGURE III-2. Lucalox Rod Stock With 10 Mil Sliced Wafer Held in LOC-Wax 20 (Geoscience Instrument Co.)

Wheel Thickness - 0.017 inches
Manufacturer's Identification 1-5 x 0.015 x 5/8, D220-N100M-1/8, ME 73082

Travel Speed: Wafers were cut at longitudinal table speeds in the range from 0.059 to 0.111 inches per minute.

Coolant & Wheel RPM: Water was used as a coolant. The wheel was rotated at 3800 rpm during all cutting operations.

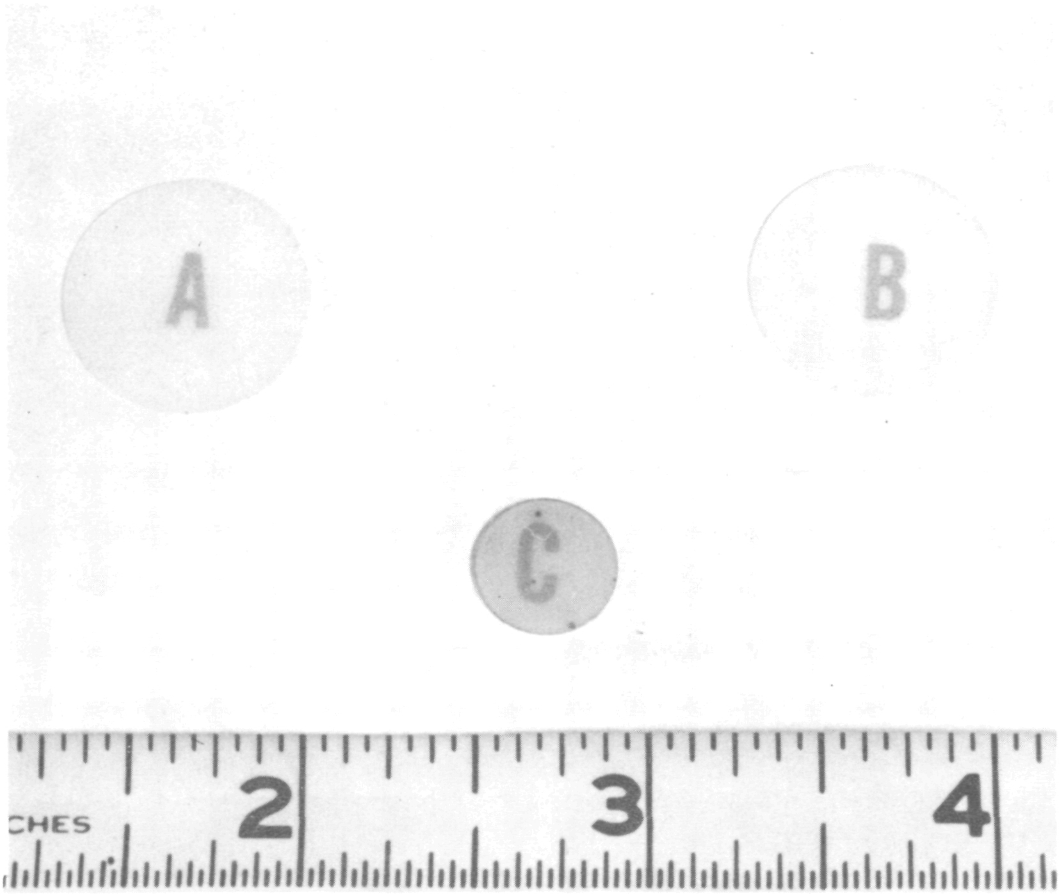
4. Lapping Procedures & Results

The sliced wafers were bonded to a 3 x 3 inch piece of plate glass with a lightly frosted surface to improve adhesion. A black, low melting point wax (Pyseal, Fisher Scientific Co.) was used. The glass plate was heated on a hot plate to the flow temperature of the wax $\sim 158°F$ ($\sim 70°C$). After applying a thin coating of wax, the preheated wafers were positioned on the plate and the excess wax was then squeezed out from under the wafers by applying light and uniform pressure to each individual wafer.

Controlled wafer thickness were achieved by cementing metal (steel) shim strips along two edges of the glass. An epoxy cement was used to permanently bond the shim strips to the glass. A series of glass plates with different thickness shims were made ranging from 2 to 10 mils. Each set of wafers were sequencially lapped by transferring them to thinner shimmed plates until the desired thickness was obtained (2 to 6 mils). Figure III-3 shows two sliced Lucalox wafers lapped to 6 mils. In addition, a 10 mil hot pressed Al_2O_3 disk is also shown. All thickness measurements were made with a hand held micrometer.

Lapping and polishing operations were performed with a Mazur Lapping/Polishing Machine manufactured by Westinghouse Scientific Equipment Department. The machine operation is based on a variable-speed, eccentrically-rotating plate with interchangeable trays that contain different grades of abrasives. Each tray has a plate glass removable base. Lapping and polishing can be done directly on the glass plate or the plate can be covered with a variety of bonded surfacing materials.

Table III-3 shows a lapping and polishing sequence which was found to yield the least number of grain pull outs in Lucalox wafers. In many instances, large areas of the Lucalox wafer surfaces were free from



A & B - 6 Mil Lucalox Wafer Cut and Lapped From 3/4 Inch Rod Stock

C - 10 Mil Hot Pressed Al_2O_3 Prepared Under WAED Contract AF33(615)360

Note the Translucence of the Materials.

FIGURE III-3. Dielectric Materials

TABLE III-3. Lapping and Polishing Operations

Operation Sequence	Abrasive	Lapping Fluid	Lap Plate Surface	No. of Wafers Per Holder and Applied Pressure	Machine Speed (Dial Setting)	Comments
Lucalox Wafers: 10 to 12 mil starting material, 3/4 inch diameter						
1	600 Grit Boron Carbide (Norton Co.)	Elgin Watch Company (Dymo)	Plate glass	6 wafers 3 lbs.	2	Lapped to ~6 mils
2	30 micron diamond (Geoscience Instrument Co.)	same	same	same	same	pre-finish 1/2 hr. each side
3	15 micron diamond	same	same	same	same	same
4	same	same	Pre K, bonded surface material (Geoscience Instrument Co.)	same	3	rough polish 1/2 hr. each side
5	6 micron diamond	same	Fine K bonded surfacing material (Geoscience Instrument Co.)	same	4	final polish 1 hr. each side
6	1 micron diamond	same	Fine K	same	4	remove scratches 1 hr. each side
Pyrolytic Boron Nitride: 10 to 12 mil starting material, 1 x 1 inch square						
1	600 Grit Boron Carbide	Elgin Watch Company (Dymo)	Plate glass	One wafer 1 in^2, 1 lb.	2	Lapped to ~3 mils
2	15 micron diamond	same	Pre K	same	2	Lapped to 2 mils
3	6 micron diamond	same	Fine K	same	2	Lapped and polished to final thickness 1 to 1.5 mils. No pin holes visible

pull outs; however, occasional grain voids were found in all wafers when their surfaces were completely scanned at high magnification. In general, the highest concentration of voids or pull outs were found in the central area of a wafer. Wafers that were lapped to 2 mils had voids that penetrated the entire thickness of the wafer resulting in pin holes. It appears, at present, that 5 to 6 mil wafers can be produced free of pin holes and these wafers could be electroded and tested.

Although the measured thickness of these wafers is in the range of 5 to 6 mils their effective thicknesses (due to large grain pull outs) after electroding might be in the 4 to 5 mil range. In addition, surface voids would contribute to high voltage stress concentrations during electric strength tests causing premature breakdown.

A pyrolytic boron nitride wafer has been lapped and polished with relative ease to a measured thickness that varied from 1 to 2 mils across the wafer surface (Table III-3 shows the lapping sequence). This wafer exhibited an unusually high degree of flexibility (about equivalent to mica sheet or paper in the same thickness range). No visible pin holes or pull outs could be seen. At this stage, pyrolytic boron nitride appears very promising.

Mechanical stresses that occur during machining of brittle materials cannot be entirely eliminated but they can be minimized. Table III-4 contains a listing of possible causes of grain pull outs together with appropriate corrective actions.

5. Dielectric Measurements

It is not planned to make extensive high-temperature dielectric measurements until an inventory of qualified, single-wafer capacitors are accumulated. Room temperature measurements will be made to determine test sample qualification as follows:

a.) Dielectric constant and Tan δ @ 1 KC

b.) Insulation resistance

c.) Voltage Test: 500 to 1000 VDC

Preliminary designs are being considered for constructing a small cold-wall vacuum furnace capable of heating test specimens to 1100°F in a

TABLE III-4. Possible Causes of Grain Pull Outs in Machined Lucalox Wafers

Cause	Corrective Actions
1. a) Excessive mechanical stress as a result of wafering operations b) Surface initiated fractures due to abrasion damage c) Frictional heating	a) Improve coolant efficiency at cutting interface (higher flow rates, direct impingment of coolant at cutting surface) b) Increase cutting wheel rpm c) Decrease feed rate d) Use smaller grain size diamonds in slicing wheel e) Anneal wafers after slicing or heat and quench
2. a) Mechanical stress exceeding cohesive strength of individual crystallites during lapping and polishing operations. b) Abrasion surface damage-excessive stress concentrations at point contacts between abrasive and wafer surface c) Frictional heating-thermal stress gradients	a) Use smaller grain size abrasives for all stock removal and polishing operations b) Determine best compromise between stock removal rates, abrasive size and type, applied pressure and lap speed c) Determine if hardness of lap surface is a significant factor (glass vs. metal and cloth) d) Investigate low amplitude, high frequency lap motion e) Maintain high abrasive concentrations at wafer-lap plate interface and minimize frictional heating
3. a) Non-uniform grain size material with a large number of excessively large grains b) High mean grain size - decreased grain boundary stresses with decreasing grain size c) Non-uniform density distribution from center to outer edges of wafer d) High internal stresses due to crystal anisotropy in expansion coefficients and elastic moduli	a) Obtain smaller mean grain size material b) Investigate hot pressed material with controlled-uniform grain size. The microstructure of hot pressed Al_2O_3 shows that the long axis of individual crystallites lie in a direction parallel to wafer surfaces. Thus, an occasional grain pull out would result in a more shallow surface depression

vacuum in the 10^{-7} - 10^{-8} torr range. The vacuum pumping unit (Model CV18) presently combined with our sputtering unit can evacuate an 18-inch glass bell jar into the 10^{-8} torr range.

C. PROGRAM FOR NEXT QUARTER.

1.) Fabrication of single crystal sapphire wafers will be started.

2.) Lucalox and pyrolytic boron nitride machining and polishing studies will be continued.

3.) Sputtered rhodium and platinum electrodes will be applied to lapped and polished wafers of the candidate dielectric materials.

4.) Dielectric tests will be started including qualification tests and high temperature dielectric measurements.

SECTION IV

PROGRAM III - BORE SEAL DEVELOPMENT AND COMBINED MATERIAL INVESTIGATIONS UNDER A SPACE SIMULATED ENVIRONMENT

The bore seal effort under Task 1 will evaluate promising ceramic-metal sealing systems in potassium and lithium vapor at temperatures to 1600°F for 2000 hours. Elevated temperature seal strength and vacuum tightness will be determined. A four-inch diameter bore seal loaded with potassium will be used in a 5000-hour stator endurance evaluation at temperature and in a high-vacuum environment to confirm data determined on smaller geometries.

Two five-thousand hour tests will be run under Task 2 on a stator which typifies the construction of an inductor alternator or a motor. The first will be run between 800 - 1100°F temperature. The second test will be run with a bore seal at temperatures between 1100 - 1600°F. All will be tested at high vacuum (greater than 10^{-8} torr) under electric and magnetic stresses.

A transformer and two solenoids under Tasks 3 and 4 will be similarly tested under high-vacuum and at elevated temperature. The purpose will be to evaluate the combined effects of electric and magnetic stresses, and high vacuum on combinations of materials suitable for application to advanced space electric power systems. One solenoid test will be under d-c excitation and the other under intermittent excitation so the effects of an invariant electric stress can be investigated.

A. TASK 1 - BORE SEAL DEVELOPMENT.

1. Summary of Technical Progress

a.) The alkali metal loading facility has been undergoing modification to make provisions for manipulative controls through the vacuum chamber walls and for the electron-beam welder which will be used in final closure of the alkali metal corrosion test capsules.

b.) Microhardness surveys were completed across the metal-braze alloy-ceramic seals which survived alkali metal exposure on a previous bore seal program conducted on NAS 3-4162.

c.) Two additional ceramics and six braze alloys have been ordered. Delivery is scheduled for the second quarter.

d.) Tentative design of the model four-inch diameter bore seal has been completed.

2. Discussion

a. FACILITY DESIGN

The chamber which was utilized in performance of the previous contract NAS 3-4162 is being modified to include provisions for loading test capsules with alkali metal in a vacuum of 1×10^{-5} torr and for electron-beam welding of the final closure. This requires manipulative control through the vacuum chamber walls. A schematic layout of the loading chamber is shown in Figure IV-1. The capsule loading techniques which are to be used with the modified equipment have been evaluated. The manipulators for the loading chamber and the electron-beam welder have been delivered. A 1500 ℓ/sec diffusion pump is on order.

The present vacuum system for alkali metal loaded capsule testing furnace is being converted to ion pumps to achieve a vacuum of 10^{-9} torr. The modifications associated with this change are shown in Figure IV-2. The 400 ℓ/sec ion pump and power supply for the dual vacuum environmental test furnaces are on order.

b. BORE SEAL MATERIALS AND SEALING STUDY

The ceramic bodies (low silica 99.8% beryllia and low silica yttria), refractory metal member (low oxygen columbium-1% zirconium),

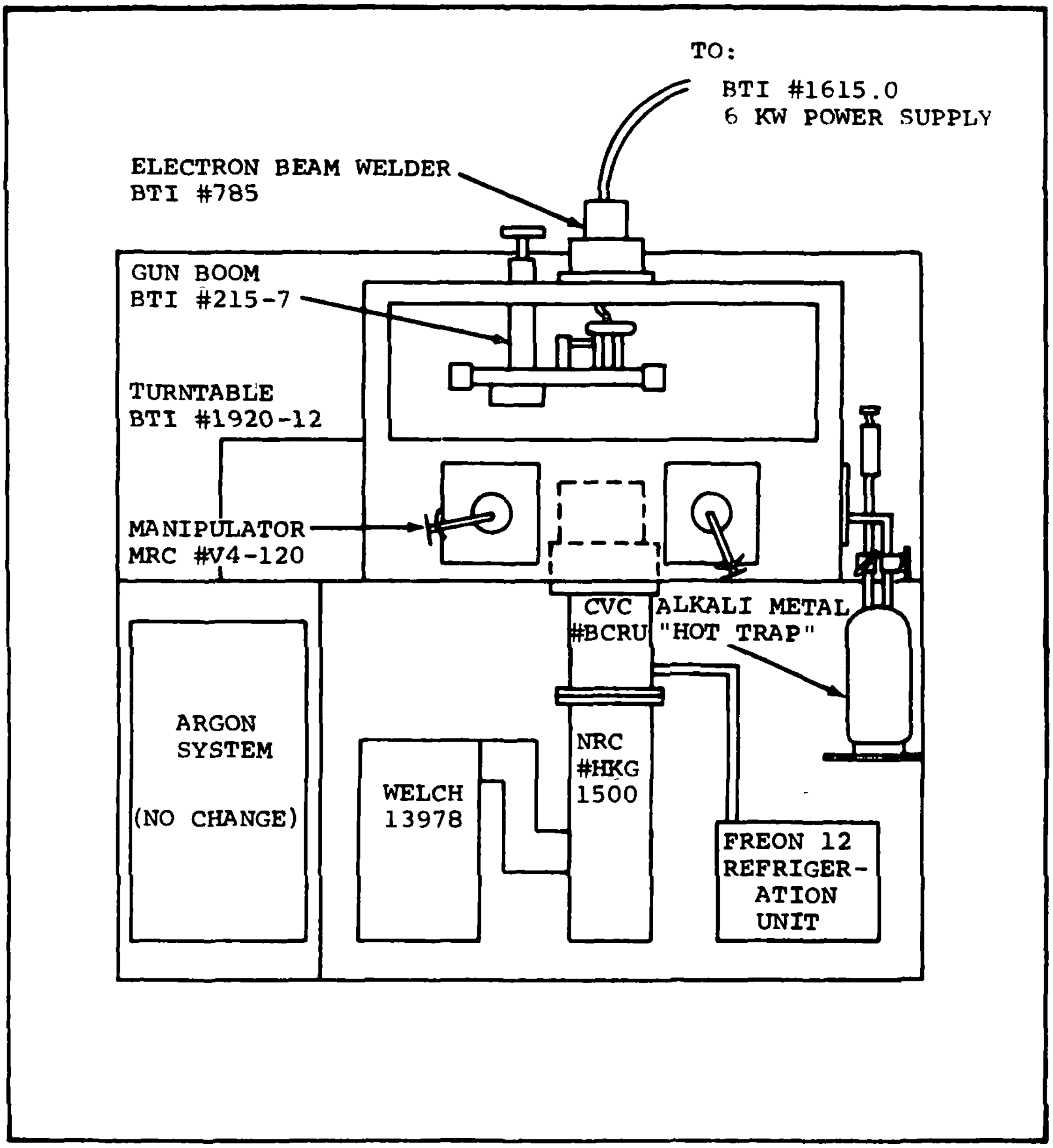


FIGURE IV-1. Schematic of the Capsule Fabrication and Loading Equipment

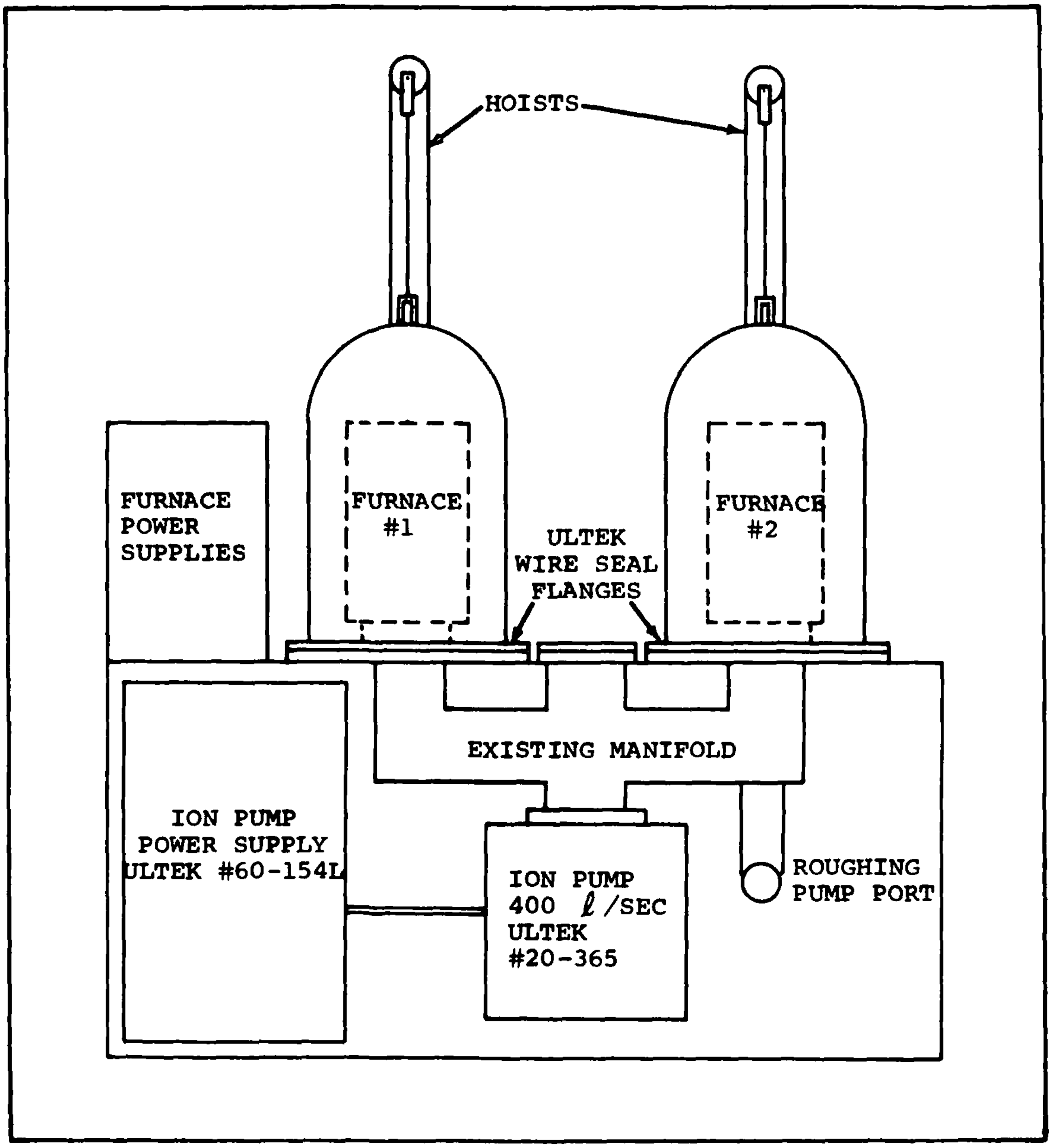


FIGURE IV-2. Schematic of Dual Vacuum Furnace Modifications Using Ion Pumping and special braze alloys required in the bore seal test program are all long lead-time items. Delivery of most of these materials is scheduled in the second quarter. A discussion of the high-temperature seal fabrication program follows.

1) Active Metal Brazing

The evaluation of ceramic-to-metal seals which withstood 500 hour alkali metal exposure at 1600°F on Contract NAS 3-4162 was continued.

Thermalox 998 (99.8% BeO ceramic made by Brush Beryllium Co.) joined to columbium-1% zirconium alloy with active metal braze of composition 56Zr-28V-16Ti exhibited a modulus of rupture strength averaging 11,800 psi after exposure at 1600°F for 500 hours in potassium vapor. This seal system also exhibited a similar strength after exposure to lithium at 1000°F for 500 hours. This seal system will be tested for a period of 2000 hours in high purity potassium and lithium at 1600°F on this program.

Variable joint micro structure of the seals previously tested was attributed primarily to brazing parameters and aging rather than alkali metal exposure.[1]

The effects of 500 hour aging on the active-metal-brazed seals is being determined by microhardness surveys and electron microprobe analyses. Since the ceramic-to-braze interface region is most susceptible to aging effects, emphasis is being placed on the study of this area.

In addition to the 56Zr-28V-16Ti, seals made with 75Zr-19Cb-6Be and 48Zr-48Ti-4Be retained strength after exposure in previous tests.[2] These and several other high-temperature, low-oxygen active metal-braze alloys will be screened.

(1) - Kueser, P. E., et al, Bore Seal Technology, NASA-CR-54093, Contract NAS 3-4162.

(2) - Ibid.

The yttrium-columbium and yttrium-beryllium alloy systems will also be investigated. The Cb - Y alloys are markedly softer than pure Cb; even small additions of Y ($< 1\%$) produce significant reduction in hardness and increases the cold workability of columbium. This effect may be caused by the impurity scavenging of yttrium.[3]

Since corrosion of the active-metal-braze joint proceeds at the ceramic-to-braze interface by reaction with the oxides which are formed, it is desirable to have braze systems which produce reacted oxides having maximum thermodynamic stability. Yttrium oxide and beryllium oxide have such stability. Potential suppliers, including Battelle Memorial Institute, Materials Research Corporation and Rodney Metals, have been contacted to obtain pure, low-oxygen yttrium metal for the braze alloy investigation.

Ceramic-to-metal seals will be made using braze alloys in foil form, when practicable, to minimize oxygen contamination.

Battelle Memorial Institute which supplied active-metal-braze alloys on NAS 3-4162 will supply active braze alloys in the form of foil for those useful compositions which are ductile enough to roll.

2) Alternate Seals

A limited number of seals will be made as a back-up for the active-metal-sealing systems. Ceramic-to-metal seals will be fabricated by utilizing several of the following alternate approaches:

a) Pressure seals or diffusion bonding

b) Evaporated metallizing

c) Gradient seals

(3) - Spedding, F. H. and A. H. Daane, The Rare Earths, John Wiley & Sons, Inc., N. Y. C. 1961.

d) Ion sputtering

e) Combinations of ion sputtering or evaporated metallizing, chemical vapor deposition, and brazing.

In pressure bonding, a metal diffusion plating or washer is bonded at temperature to a metallized ceramic. Pressure may be applied externally or generated through thermal mismatch of ceramic and metal members. The coating on the ceramic is an alkali metal resistant metallizing.

Evaporated metallizings showed promise in the work completed on the previous program.[4] Chemical vapor deposited columbium-1% zirconium or other alkali-metal-resistant deposits will be used. This approach appears most promising as a wetting aid for active-metal brazing of large surface areas.

A gradient seal consists of an integrally bonded composite structure of metal and ceramic which varies from nearly 100 percent ceramic to 100 percent metal in a continuously graduated manner. The metal end (or ends) may then be joined to the electrical apparatus frame by conventional methods. Combinations of ceramic and metal will be chosen from rhenium, columbium, alumina or beryllia, or other appropriate materials.

Ion sputtering of molybdenum or Cb - 1Zr onto a ceramic substrate [5,6] followed by a thicker coating of metal (i. e. Cb - 1Zr) applied by chemical vapor deposition [7] and brazing to a metal member appears promising for seal

(4)- Kueser, P. E., et al, Bore Seal Technology, NASA-CR-54093, Contract NAS 3-4162.
(5)- Mattox, D. M., Sandia Corporation, Reprint, SC-R-64-1330, September 1964.
(6)- Maisset, L. I., and P. M. Schailbe, "Thin Films Deposited by Bias Sputtering", Journal of Applied Physics, Vol. 36, No. 1, p. 237, Jan. 1965.
(7)- Reed, L. and R. McRae, "Evaporated Metallizing", American Ceramic Society Bulletin, January 1965.

fabrication. This method offers the possibility of a clean, highly adherent interface. The system limits oxygen concentration to one highly polarized Be-O-Cb or Be-O-Mo layer [8, 9] which is immune to solution by potassium.

At the present time, methods b, d, and e are preferred and effort on supplementary seal systems will be emphasized in these areas.

c. CERAMIC MATERIALS

The ceramic bodies which survived the 500 hour, 1600°F potassium exposure on the previous program (NAS 3-4162) were:

Thermalox 998 - 99.8% beryllium oxide by Brush Beryllium Co.

Sapphire - 100% alumina by Linde Co.

Lucalox - 99.8% aluminum oxide by General Electric Co.

Experimental results established the desirability of low silica content ($<$ 0.05%) in ceramics intended for potassium exposure at 1600°F.

Sapphire and Lucalox are useful for feedthrough geometries but are not available in large sizes (greater than four-inch diameter) for actual bore seal construction. Coors Porcelain Co., Western Gold and Platinum Co., General Electric Co., Linde Co., Corning Glass Co., Alite Div., and U. S. Stoneware Co. were contacted to determine the availability of fabricable, low-silica ($<$ 0.05%) alumina. Such bodies are not available at the present time. However, several experimental bodies are being developed by Coors Porcelain Co.

(8) - DiStefano, J. R. and A. P. Litman "Effects of Impurities in Some Refractory Metal-Alkali Metal Systems", Corrosion, Vol. 20, No. 12, p. 392, Dec. 1964.

(9) - Weyl, W. A., Coloured Glasses, p. 343, Society of Glass Technology, Sheffield, Rp. Dawson, London.

Table I V-1 shows the spectrographic silica analyses of several Coors experimental alumina bodies, and the U. S. Stoneware (Alite Division) alumina body No. 610. The analyses of several bodies which were used on the previous program are also shown. The results indicate that a number of the Coors alumina bodies have the desirable low-silica content. When available, they will be considered for use as a back-up ceramic.

Two new ceramic bodies will be tested in potassium on the present program. These have been selected as

a) 99.9% beryllium oxide or low silica ($<$ 50ppm SiO_2) 99.8% beryllium oxide (Brush Beryllium Co.)

b) 99+% yttrium oxide (Coors Porcelain Co.)

The rare earth oxides possess good thermodynamic properties. However, experience in fabricating bodies is limited (10 and 11).

The Brush 99.8% beryllia body has been ordered for use on ceramic outgassing and braze alloy screening investigations. In addition, ceramics which survived exposure on the previous program and the new ceramic bodies which withstand 500 hour exposure at 1600°F will be subjected to 2000 hour tests.

3. Program for the Next Quarter

a.) Complete design and construction of loading and test facility.

(10)- Ploetz, G. L., C. W. Krystyniak, H. E. Dumas, "Sintering Characteristics of Rare Earth Oxides", Journal of American Ceramic Society, Vol. 41, No. 12, p. 550, 1958.

(11)- Perez, M., Y. Gorba, F. Queryroux, and R. Collorieques, Bull. Soc. Franc. Min. Crist., Vol. 84 (4), pp. 401-402, 1961.

TABLE IV-1. Spectrographic Silica Analyses of Selected Ceramics

Supplier Designation of Ceramic Body	Nominal Composition	SiO_2 Content [a] (Weight Percent)
Alite #610 Alumina	(c)	1.5
Ei3-3 Alumina (Wesgo)	99.7 Al_2O_3-0.1 SiO_2-0.1 MgO	0.2
Thermalox 998 Beryllia (Brush Beryllium Co.)	99.8% BeO	0.015 [b]
Lucalox Alumina (G. E.)	99.7% Al_2O_3-0.25 MgO	0.02
Sapphire Alumina (Linde)	100% Al_2O_3	0.015
Coors #1 Alumina	(c)	0.005
Coors #2 Alumina	(c)	0.03
Coors ATD 995 Alumina	(c)	0.04
Coors X Alumina	(c)	0.02
Coors Y Alumina	(c)	0.025

(a) Eitel-McCullough, Inc. All data ± 200%

(b) American Spectrographic Laboratories, San Francisco

(c) Compositions were not given by supplier; all are "high alumina".

b.) Complete ordering of materials for screening of ceramic and brazes.

c.) Initiate ceramic outgassing study.

d.) Start experimental work on screening of braze alloys and alternate seals.

B. TASK 2 - STATOR AND BORE SEAL.

1. Summary of Technical Progress

a.) A stator design for the first 5000-hour test has been completed. All long lead time materials are on order.

b.) The two vacuum environmental test furnaces and associated control equipment were ordered. Both furnaces are now under construction and should be delivered by the 3rd week in April.

c.) A design for vacuum furnace test specimen thermocouple feedthroughs which are compatible with special shielded thermocouples has been completed.

d.) A test specimen thermocouple design specification has been released for quotations. (This thermocouple design will be used on Tasks 2, 3, and 4.)

2. Discussion

The assembly and detail drawings which define the components and assemblies that make up the stator are given in Appendix A. A summary of the major materials used in the constructions are also shown in the Appendix. The sequence of drawings begins with the stator assembly, followed by stack assembly drawings, details (several parts to a drawing, identified as items and assemblies) and component parts. Two stator stack drawings are included. EDSK 326602 shows a practice winding stack using plain copper conductors and steel punchings. This assembly will be used to develop coil forming procedures and coil installation techniques before working with the high-temperature conductors.

In some cases the detail drawings show parts that apply to the transformer or solenoid models. In such cases the same drawings are repeated in the drawings covering the subject models.

The stator design is based on the solid-rotor, inductor generator concept using one stack of laminations. It also typifies a motor construction. The excitation coils found in an inductor generator have been eliminated from the design since the winding is similar to the solenoid winding used in Task 4. The stack is made up of Hiperco 27 (27 Co-Fe) laminations, 0.008 inch thick, which are held in place in a Hiperco 27 frame by a bolted and pinned retaining ring. The laminations will be annealed in a hydrogen atmosphere for one hour minimum at a temperature of 1492 to 1672°F. Forgings will be annealed in a rough machined condition in an exotherm gas atmosphere for one hour minimum at a temperature of 1492 to 1672°F.

Ceramic slot liners insulate the conductors from the laminations and from each other. Non-magnetic end bells are attached to each end of the magnetic frame.

The stator windings consist of three 12-turn coils which are installed in the frame in the same manner as in a standard three-phase machine. Thermocouples are located in two of the 12 slots filled by each winding. Additional thermocouples are positioned in the laminations; at the outer edge (OD) of the laminations, and attached to the outside of the magnetic frame and to coil end-turns.

The high-temperature stator to be used in conjunction with the bore seal will be of the same design except that additional members will be required to support the bore seal in position in the stator cavity. In addition, a special high-temperature stator winding and insulation system capable of extended operation at approximately 1400°F has been specified for the bore seal stator. The first stator will operate at 1100°F and will utilize a modified Anaconda Anadur (refractory oxide filled fiber glass) high-temperature insulation system evaluated under NAS 3-4162.

Figure IV-3 is a cutaway drawing of the vacuum furnace which shows the stator installed in the furnace hot zone. Stator thermocouple leads and winding leads are brought up through holes in the top heat shields to their respective feedthroughs in the chamber wall. The chamber is of double wall construction with baffles between the walls to channel cooling water flow. The chamber top cover is also double walled to provide a path for cooling water.

Figure IV-4 is a sketch showing the details of the vacuum furnace thermocouple feedthroughs. The thermocouples pass through the hollow tubes and are brazed to the tubes outside the chamber to form a vacuum-tight seal. An inner ceramic disc provides mechanical support and acts as a thermal radiation shield.

The thermocouple construction consists of two wires in an inconel sheath with Al_2O_3 powder (99%) insulating the wires from each other and from the sheath. The wire system is Platinel II (platinum - rhodium - gold) made by Engelhardt. Final sizing (OD) is done by drawing the complete assembly.

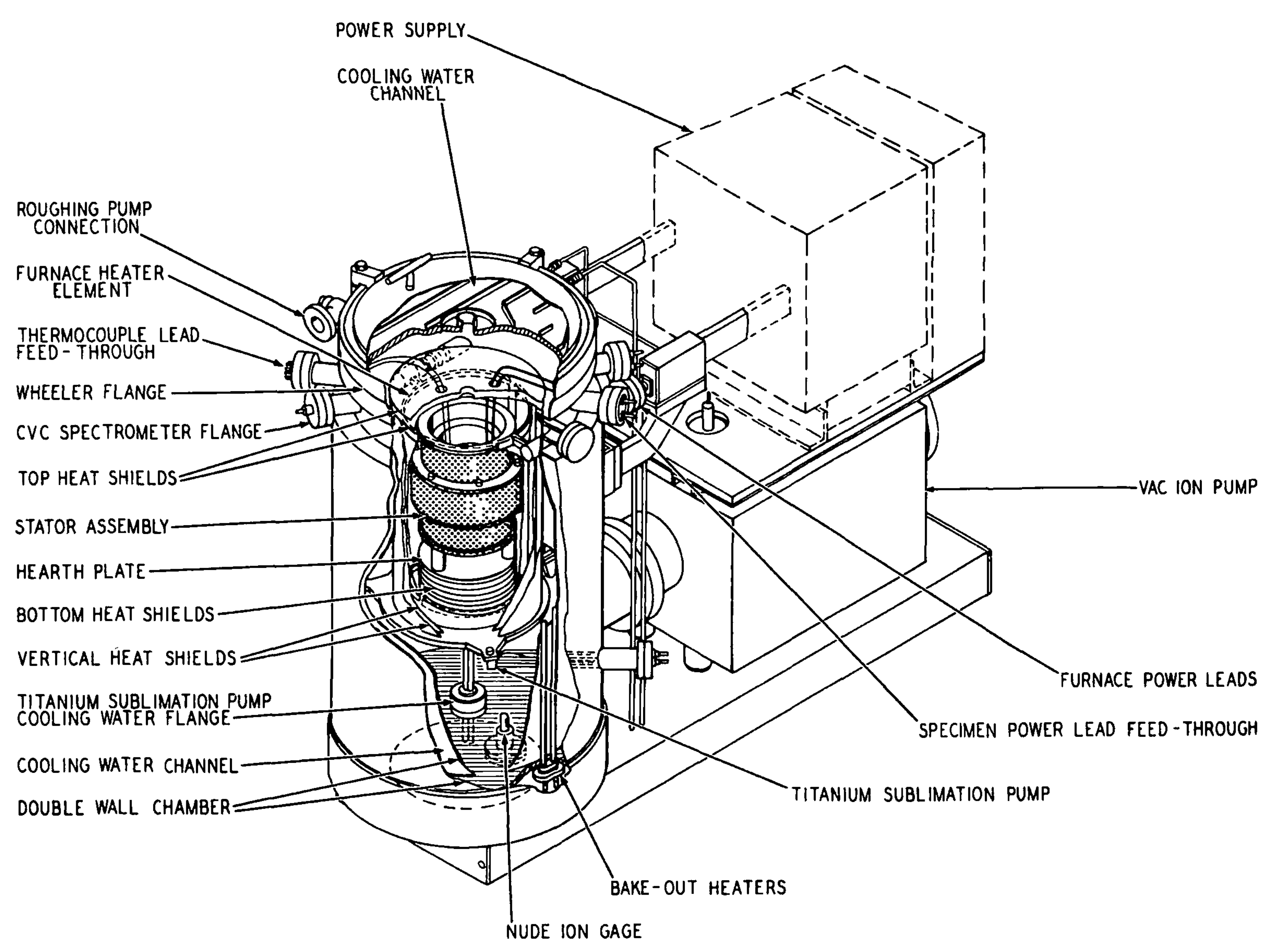


FIGURE IV-3. Cutaway View of Vacuum Furnace Showing the Stator Test Specimen Installed

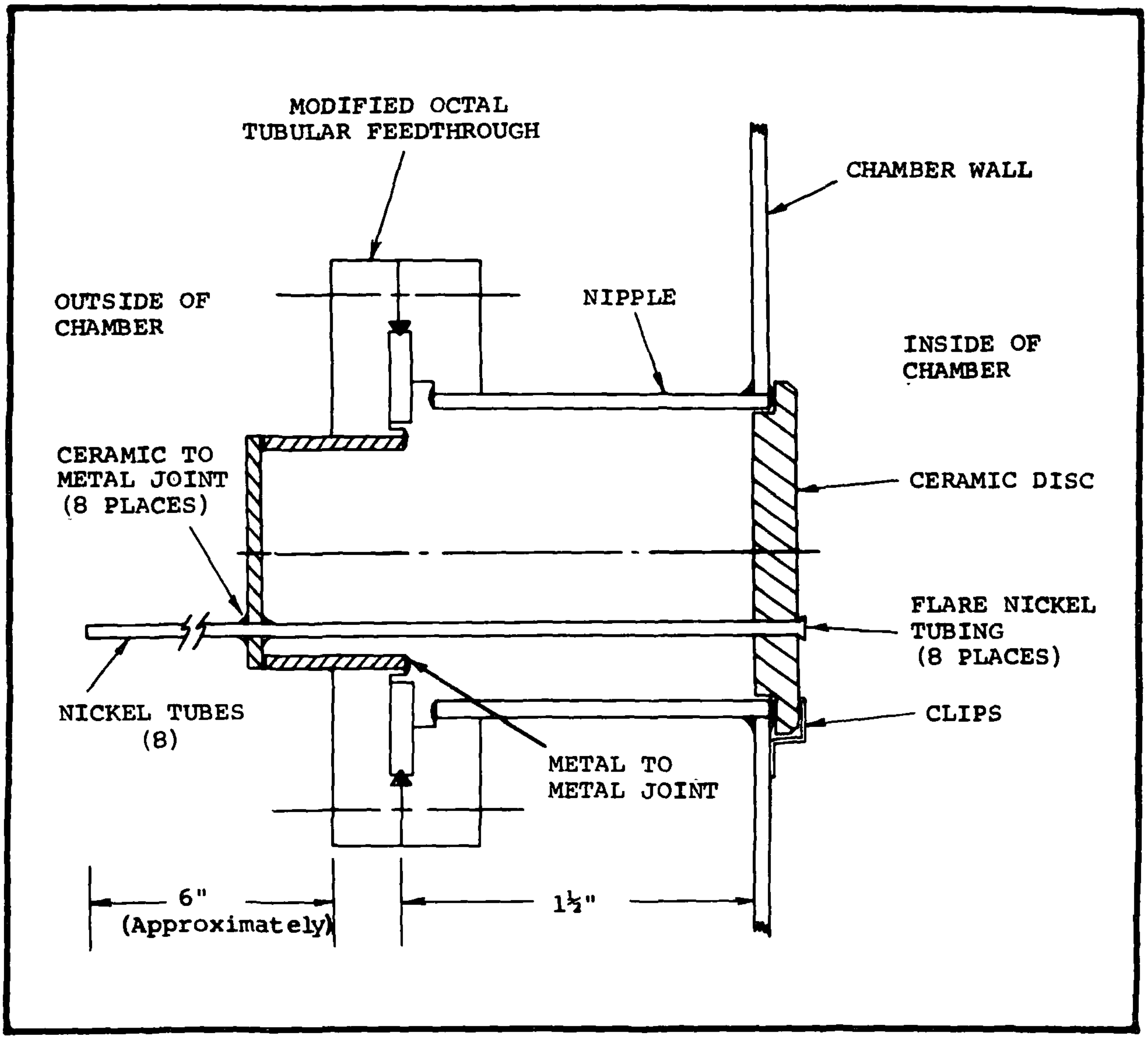


FIGURE IV-4. Details of Thermocouple Feedthrough Flange on the Vacuum Furnace Chamber

3. Program for the Next Quarter

a.) Expedite the procurement of long lead time materials.

b.) Coordinate vacuum furnace delivery, installation and check-out.

c.) Build a practice stator assembly as a check on coil forming techniques.

d.) Continue the manufacture of stator detail parts and begin test specimen assembly.

e.) Evaluate a new high temperature plasma arc sprayed insulation system. The insulation is high purity Linde A (Al_2O_3).

f.) Evaluate Handy & Harmon lithobraz 'BT' and Braze 360 brazing alloys for thermocouple feedthrough brazing.

g.) Continue the 1500°F, 5000-hour vacuum stability tests on Inconel-clad silver.

C. TASK 3 - TRANSFORMER.

1. Summary of Technical Progress

a.) A transformer design has been completed and all long lead time materials are on order.

b.) An engineering model release has been prepared to manufacture the parts in the shop.

2. Discussion

The assembly and detail drawings which define the components and assemblies that make up the transformer are shown in Appendix B. A summary of the major materials used in the constructions are also shown in the Appendix. The sequence of drawings begins with the transformer assembly, followed by the winding assembly, details (several parts to a drawing, identified as items) and component parts.

In some cases the detail drawings show parts that apply to the stator and solenoid models. In such cases the same drawings are repeated in the drawings covering the subject models.

Figure IV-5 is a view of the transformer assembly showing the location of the winding leads and thermocouple leads. This design is rated at 1 KVA with 600 volts on the primary winding and approximately 30 volts at the secondary winding. The core is made from E-I style Hiperco 27 laminations 0.008 inch thick. Evaluation of plasma-arc sprayed insulation is required to confirm the interlaminar insulation system that will be used. The windings are formed around a ceramic spool which provides insulation between the windings and the center leg of the core. Ceramic endplates and channels provide insulation between the winding ends and sides respectively and the laminations.

Pairs of thermocouples are installed between the primary winding and ceramic spool and between the two windings. The core has been divided into two halves by ceramic strip spacers so that four thermocouples can be buried in the core.

Non-magnetic alloy strips are used outside the laminations to provide lamination support. The laminations and support strips are held together by through studs, ceramic washers and lock nuts.

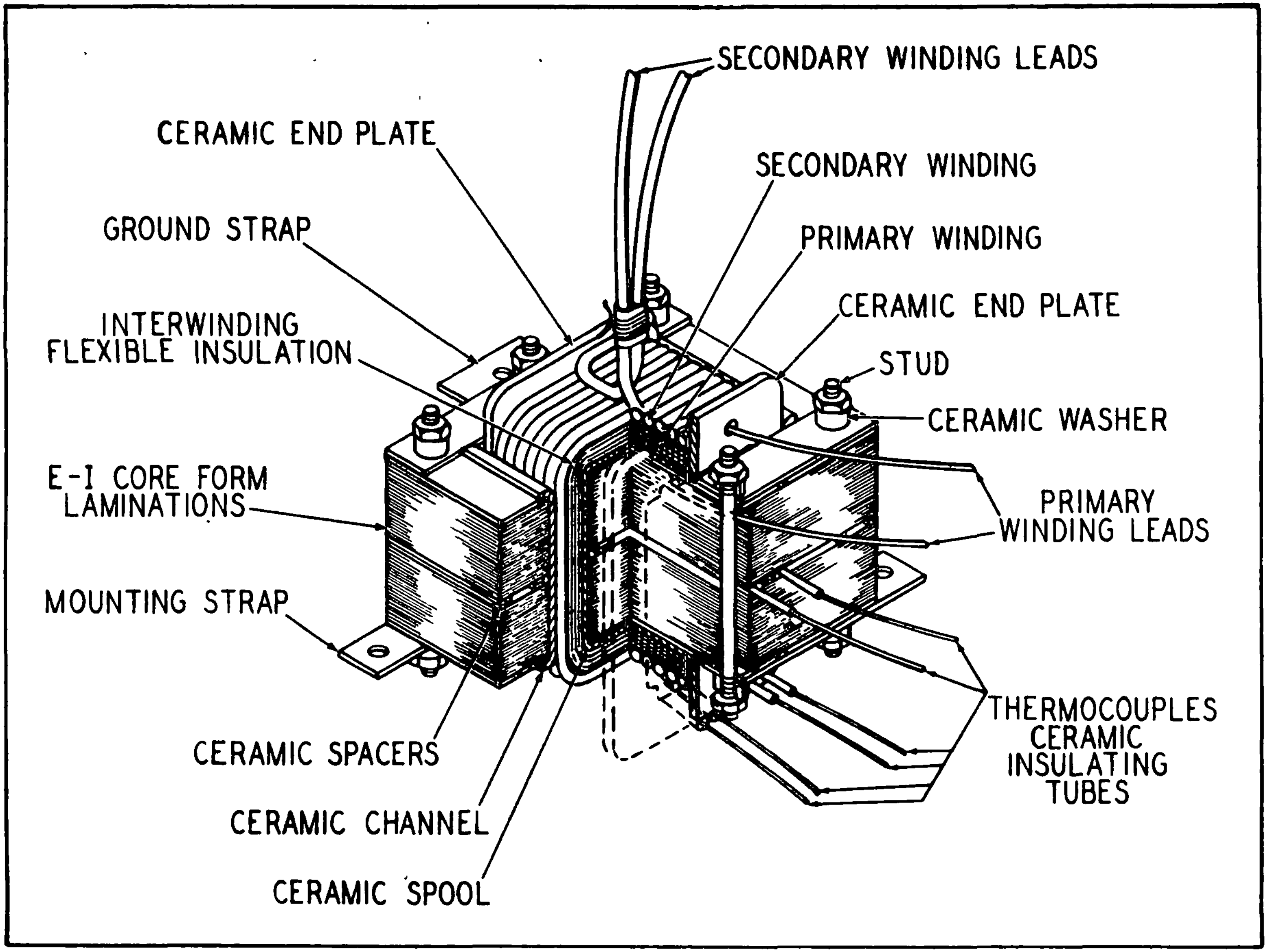


FIGURE IV-5. Cutaway View of Transformer

3. Program for the Next Quarter

a.) Expedite the procurement of long lead time items.

b.) Continue the manufacture of transformer detail parts and begin test specimen assembly.

c.) Evaluate a plasma-arc sprayed Al_2O_3 lamination insulation system.

D. TASK 4 - SOLENOID.

1. Summary of Technical Progress

a.) A solenoid design has been completed and all long lead time materials are on order.

b.) An engineering model release has been prepared to initiate manufacture of the parts.

2. Discussion

Appendix C shows the drawings which define the assemblies and components which make up the solenoid. A summary of the major materials used in the constructions are also given in the Appendix. The sequence of drawings begin with the solenoid assembly, followed by the winding assembly, details (several parts to a drawing, identified as items and assemblies) and component parts.

Figure I V-6 is a view of the external configuration of the solenoid showing the location of the coil leads and thermocouple leads. A weight of approximately three pounds is suspended on the plunger, and when the solenoid is actuated the weight is lifted approximately 0.050 inches and held in that position.

The magnetic solenoid housing, cover and plunger are made from a Hiperco 27 forging. The coil is wound on a ceramic spool which provides insulation between the winding and the plunger and housing center core. Ceramic end plates insulate the sides of the winding from the Hiperco 27 housing and cover. Bearing surfaces for the plunger consist of a ceramic guide rod at one end of the plunger and a ceramic bushing at the opposite end.

Pairs of thermocouples are installed between the coil and the ceramic coil spool, midway between the coil ID and OD, between the coil OD and the housing, and on the outside of the housing.

3. Program for the Next Quarter

a.) Expedite the procurement of long lead time items.

b.) Complete the manufacture of solenoid detail parts and begin test specimen assembly.

c.) Carry out a heat transfer calculation from the inside to the outside of the coil.

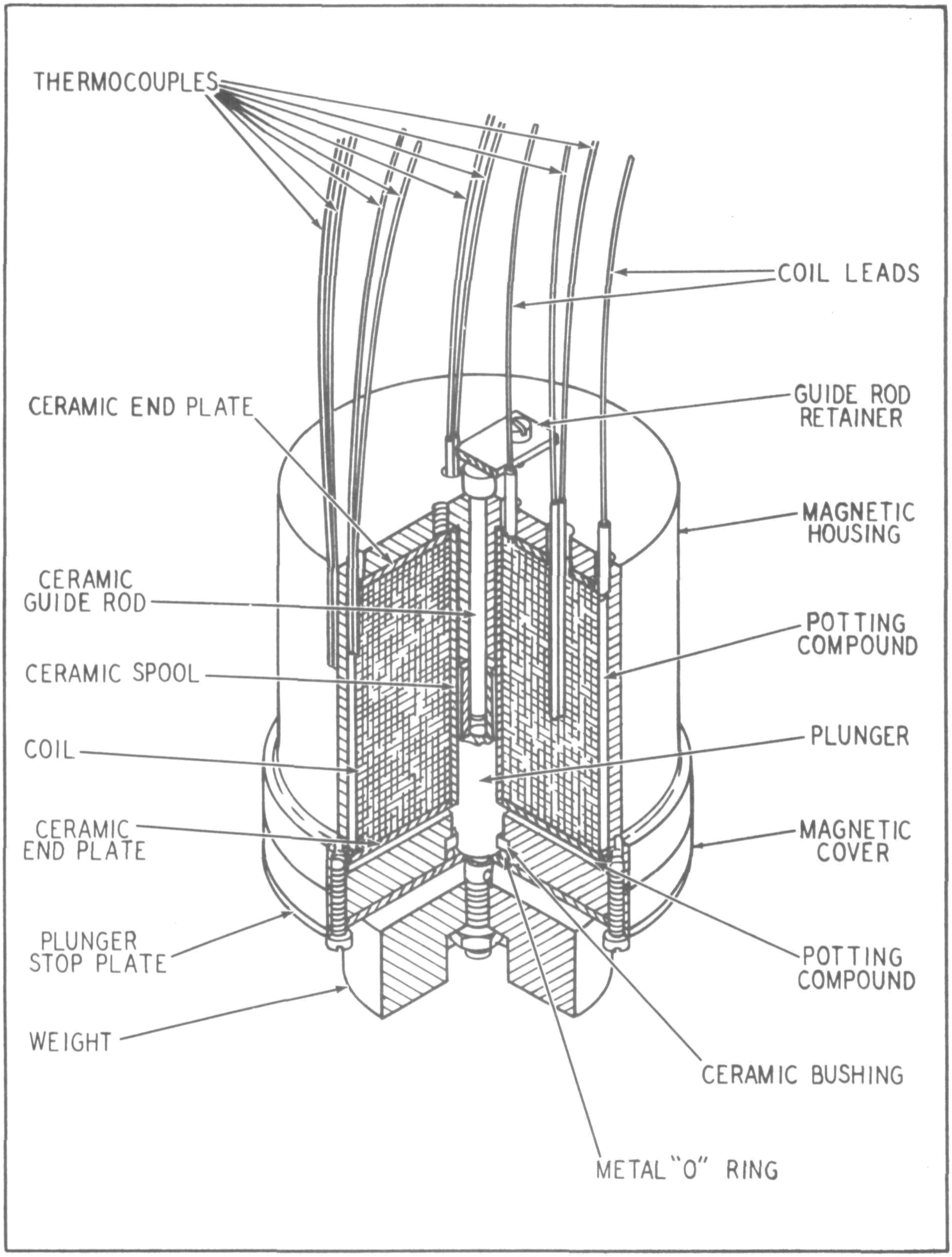


FIGURE IV-6. Cutaway View of Solenoid