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ROCKET FLARES

A Final Report - Contract OEM-sr-968

By

THE BUDD WHEEL COMPANY
ENGINEERING DEPARTMENT
ROCKET DIVISION

Submitted on: Nov. 14, 1945

By

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20061030004

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PREFACE

The rockets described in this report are pertinent to the project designated by the War Department Liaison Officer as OD-170 and to the project designated by the Navy Department Liaison Officer as NO-252. Engineering of the metal components and production of test models were performed by the Budd Wheel Company. Most of the testing was done at the Jet Propulsion Research Laboratory, Indian Head, Maryland. This work was under the supervision of Section H, National Defense Research Committee. When the laboratory operations of Section H were transferred to Cumberland, Maryland, the testing was done by the Allegany Ballistics Laboratory. This laboratory was operated for Section H by The George Washington University under contract OEMsr-273. All of the testing work is described in the final report by the Allegany Ballistics Laboratory ("Rocket Flares", O.S.R.D. 5778). This project was referred to in their files as W-50.

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ABSTRACT

Three Rocket Flare models were engineered and manufactured for Section H, Division 3, of the National Defense Research Committee, by the Budd Wheel Company. These were known as the IF3-M1, IF3-M2, and IF3-M3 models. All were $3\frac{1}{4}$ " diameter inductively heat-treated rocket motors. The heads were of two sizes and contained a black powder charge which at the proper time expelled the Navy parachute flare from the rocket.

INTRODUCTION

In the fall of 1942 the project of developing a rocket motor for propelling a Naval parachute flare was undertaken by Section H of Division A of the National Defense Research Committee. The purpose of this development was to provide a means of silhouetting a submarine or vessel on the water's surface. The Budd Wheel Co. was requested to design and construct the test models.

IF3-M1 Flare Rocket

The original conception of this rocket is illustrated in the Indian Head Jet Propulsion Research Laboratory Drawing 146 dated September 14, 1942, see page 11. The subsequent designs developed conformed fundamentally to this proposal. This drawing shows:

1. In the front of the rocket is a 2-1/2" outer diameter casing which contains a Navy parachute flare.
2. Propelling the flare is a 3 1/4" rocket with integral Venturi. For stability of flight, a folding fin assembly is attached to the end of the rocket.
3. The flare casing and the rocket chamber are joined together by means of a threaded adaptor.
4. In order to provide a time delay between the ignition of the rocket powder and the ignition of the flare expulsion charge, a powder train is incorporated between the rocket chamber and the flare container.
5. Electrical squib ignition is at the front of the rocket propulsion charge. Contacts are provided by a tapered plug similar to that used in the Army T-22 rocket.
6. The rocket chamber was specified by the National Defense Research Committee to be capable of withstanding 6000 p.s.i. internal pressure. 81 mm hot rolled trench mortar tubing was available and in order to meet the pressure specification, the rocket tube was heat-treated. The method of manufacture of this rocket chamber was similar to that of the T-5 and T-6 3-1/4" Ordnance Rockets, and the details are reported in Budd Wheel Company's Investigation #M-3, a final report on Ordnance Contract under date of January 21, 1944. The critical points of consideration in the production of these chambers, as well as any other heat-treated and machined rocket chambers, are:

- a. Where the body wall is heat-treated before hot Venturi forming then the heat for forming the Venturi must not be allowed to extend into the full body diameter section; otherwise, a weakened annealed band occurs in the rocket body.
- b. The body must be properly stress-relieved after cold working operations. In this rocket this operation was necessary after shrinking in the upset end of the tube.
- c. The annealed band for the safety groove must be correctly positioned so that the subsequent machining of the safety groove is at the weakened section.

Indian Head Drawing 146 was submitted to the Budd Wheel Company for design proposal and study by Dr. C. N. Hickman shortly after its completion. At that time, Budd Wheel Company was being engaged by the Ordnance Department to develop their 3-1/4" T-5 and T-6 experimental rockets and it was thought that by engineering compromise a propulsion motor could be developed for all three rockets. With this in mind, in January of 1943 layouts were made by the Budd Wheel Company in an effort to combine the specifications for all three rocket chambers.

In the production of the T-5 and T-6 3-1/4" Ordnance rocket chambers, the design had, in order to keep weight to a minimum, incorporated a .093" chamber wall thickness. This was found impractical in production because of the excessive warpage that resulted from the heat treat process. Therefore, the Budd Wheel Company suggested to the National Defense Research Committee that a .125" rocket chamber wall thickness be allowed in their model. This was agreed upon and it became the basis of design for the ensuing 3-1/4" flare rocket chamber. The first 50 samples of this model rocket were produced according to Budd Wheel Drawing 47087 as shown on pages 14 and 15. Also, see Photographs 1 and 2 on pages 21 and 22. Drawing 47087 followed substantially the original design as outlined in the description of Indian Head Drawing 146. From an engineering viewpoint it was refined by the Budd Wheel Company, in that:

- (1) The threaded end of the rocket chamber was upset to provide the same strength in the threaded joint as in the body itself.
- (2) The powder was supported on an integral trap assembly supported from a machined ledge in the upset section instead of by the individual worm head wires as shown in the Indian Head Drawing.
- (3) The flare and delay train were revised upon engineering consultation between Dr. A. Kossiakoff of the

National Defense Research Committee and the Naval Ordnance Plant of Baldwin, Long Island, New York. Details of the flare design are shown in Navy sketch 64426 on page 12.

- (4) The safety groove was provided in the upset section of the rocket chamber instead of at the rear of the chamber as shown in the Indian Head Drawing.

After approval of the drawings approximately 300 samples were produced and delivered for tests in March through May of 1943. After the testing of this initial experimental production, a re-interest was shown in this project by the Services. Therefore, 826 additional assemblies were ordered and these were delivered from October 23, 1943 to March 6, 1944. Differences between this production and the prior production of these flare rockets were of a minor order and therefore are not embodied in this report.

IF3-M2 Flare Rockets

Twenty-five 3-1/4" rocket assemblies were produced in October 1942, conforming to Drawing 50196, page 18. It will be noted that this assembly is identical to the IF3-M1 model already described except that the flare case on the IF3-M2 is 3-1/4" outside diameter instead of 2-1/2". This provided room enough for a larger Navy flare with approximately twice the candle-power of the IF3-M1 model. Drawing 50061 is the sub-assembly of the casing and nose and is shown on page 17. See Photographs 3 and 4 on pages 23 and 24.

IF3-M3 Flare Rockets

This 3-1/4" rocket flare was identical to the IF3-M2 model except that no trap system was originally required. Consequently the chamber did not incorporate an upset shoulder for support of a trap plate. The chamber is illustrated on Drawing 51076, page 19. After the chambers were built, however, the Budd Wheel Company was requested to add a special powder trap. The special trap consisted of a three legged spider which was welded inside of the chamber at the Venturi end to support the single grain of cast powder, known as the "Alternate Propellant". Drawing 51086, page 20, shows the trap installation.

Sixty of these models were manufactured for experimental purposes and delivered in June 1944. Twenty were made with a 1" diameter Venturi throat, twenty with a 1.09" diameter throat, and twenty with a 1.18" diameter throat. Photograph 5, page 25, illustrates the completed assembly.

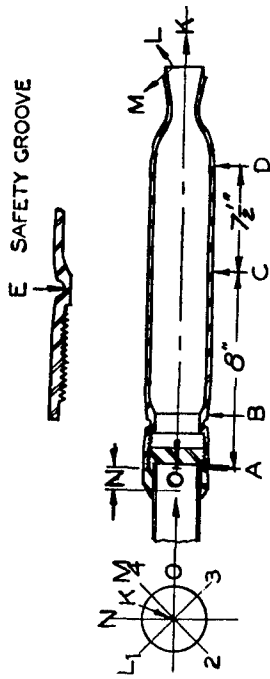
HYDROSTATIC TEST OF 3-1/4" FLARE ROCKETS

During the development and in the production of these rockets, hydrostatic tests were used to check the chamber strength. Test 428-A-B is included in this report and is representative of these tests. (see pages 7 through 10.) It will be observed in this test that the safety groove failed at 6,600 p.s.i. and that the body had not failed at 12,000 p.s.i. Other hydrostatic tests applying to these rockets are Budd Wheel Tests 337, 350, 359, 360, 361, 420, 429, 444, 445, 474, 484, 497, 498, 499, 516, 531, 540, 541, 567, 574, 575, 583, 608 and 620. These tests are available for reference in the Budd Wheel Company's Engineering files.

The rockets were subjected to firing tests at the Jet Propulsion Research Laboratory, Indian Head, Maryland. Results of these tests are covered in O.S.R.D. Report 5778, prepared by the Allegany Ballistics Laboratory.

APPENDIX

<u>Tests</u>	<u>Title</u>	<u>Page</u>
428	A - Determine Strength of $3\frac{1}{4}$ " IF3-M1 Safety Groove	7 - 8
	B - Determine Strength of $3\frac{1}{4}$ " IF3-M1 Chamber	9 - 10
 <u>Drawings</u>		
	<u>Indian Head</u>	
146	Identification Rocket Flare	11
	<u>U. S. Navy</u>	
64426	Rocket Flare	12
	<u>Budd Wheel Company</u>	
47013	IF3-M1 Chamber	13
47087	IF3-M1 Assembly (Issue "Original" through Issue "P")	14
47087	IF3-M1 Assembly (Issue "Q")	15
47226	IF3-M1 Casing and Nose Assembly	16
50061	IF3-M2 Casing and Nose Assembly	17
50196	IF3-M2 Assembly	18
51076	IF3-M3 Chamber	19
51086	IF3-M3 Ring, Fin and Chamber Assembly	20
 <u>Photographs</u>		
1	IF3-M1 Rocket Flare Assembly	21
2	IF3-M1 Rocket Flare - Half Section	22
3	IF3-M2 Rocket Flare Assembly	23
4	IF3-M2 Rocket Flare - Half Section	24
5	IF3-M3 Rocket Flare Assembly	25



PHYSICAL PROPERTIES

	HARDNESS "C", ROCKWELL	THICKNESS	HARD- NESS DEPTH	TENSILE
A				
B				
C				
D				

EXPERIMENTAL: PRODUCTION: X.
TYPE OF TEST SAMPLE 3-1/4" Assembly.
SAMPLE SUBMITTED BY: Elder DATE 10-25-43.
PART NO. 47037-D. (ASSY. #E-562)
TYPE OF TEST: Internal hydraulic pressure.
PURPOSE OF TEST: Determine strength of production.

PRES-SURE (psi)	READINGS										
	A	B	C	D			K	L	M	N	O
1000	.0005 3 .0005 .0005		.0005 .0015 .0005	.0015 .0015 .0015	.0015 .0015 .0015						
2000	.0005 .0005 .0005		.0005 .003 .0005	.0025 .0025 .0025	.003 .003 .003						
3000	.0015 .0015 .0015		.0005 .004 .0005	.0035 .0035 .0035	.004 .004 .004						
4000	.0025 .0025 .0025		.000 .0045 .0005	.0035 .0035 .004	.005 .005 .0055						
5000	.0035 .0035 .0035		.001 .0055 .001	.0045 .0045 .0045	.006 .006 .006						
5500	.0045 .0045 .0045		.001 .006 .0005	.0055 .0055 .009	.007 .007 .0085						
6000	.005 .005 .005										
6500	.006 .006 .006										
6600		Safety grooves failed.									

ANALYSIS

C	MN				
---	----	--	--	--	--

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REMARKS:

Safety groove: .040"
Shake in thread: .015"
Thread overlap: .067"
Pilot clearance: .003" P- .0335"

Assembly was placed in test fixture and held in place by means of a split bushing engaging head. Hydraulic pressure was then applied through hole in plug welded in at venturi end of chamber.

Readings were taken as per above sketch.

At 6600 psi safety groove failed.

Dia.	A	B	C	D
Before	3.250	3.252	3.251	3.251
After	.267	.240	.252	.252
Set	.007	.008	.001	.001

CONCLUSIONS: Chamber and safety groove 0. K₂

REFER TO TEST NOS.:
 RUN BY: J. Aylsworth.
 REPORTED BY: C. A. Temple.
 CONDUCTED BY: J. Bortman.

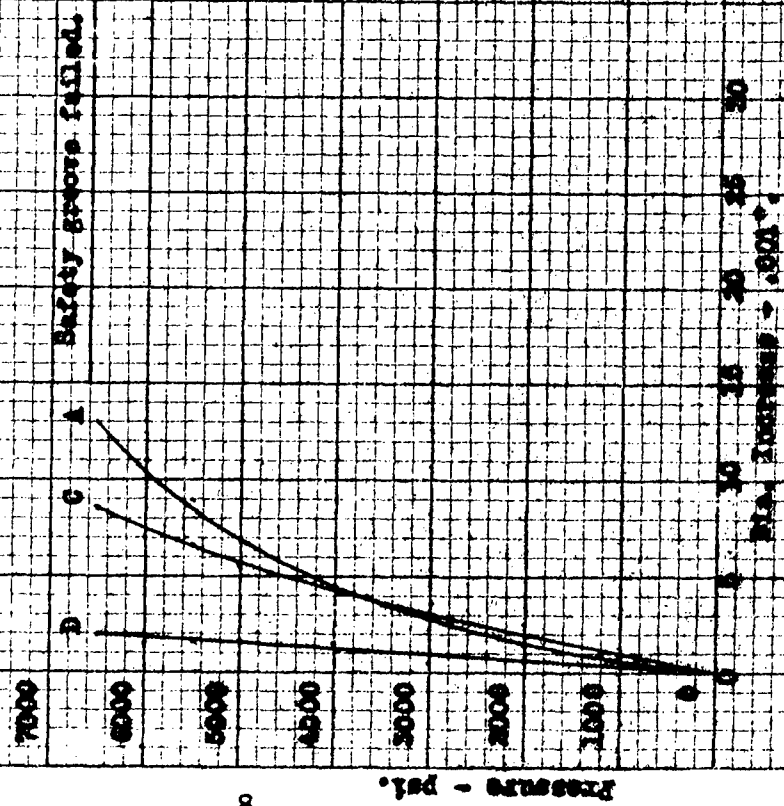
PRESSURE TEST.

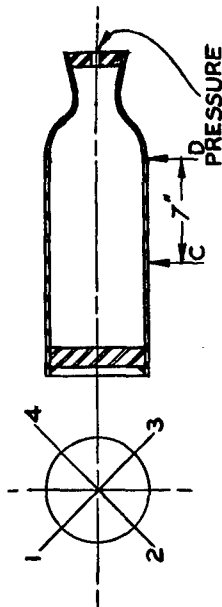
Test #023-1

Date: 10-26-43.

Pla. Increased:

Failure:





PHYSICAL PROPERTIES

HARDNESS "C." ROCKWELL	THICKNESS	HARD- NESS DEPTH	TENSILE
A			
B			
C			
D			

EXPERIMENTAL: PRODUCTION: X.
TYPE OF TEST SAMPLE: 3 1/2" Chamber.
SAMPLE SUBMITTED BY: Elder DATE: 10-25-43
PART NO.: 47013-E (Assy. #P-562)
TYPE OF TEST: Internal hydraulic pressure.
PURPOSE OF TEST: Determine strength of production.

READINGS

PRES- SURE (PSI)	A	B	C	D	K	L	M	N	O
1000			.000	.000					
2000			.0005	.000					
3000			.001	.001					
4000			.001	.002					
5000			.0015	.0025					
6000			.0015	.0035					
7000			.002	.004					
7500			.002	.005					
8000			.0025	.0065					
8500			.0025	.006					
9000			.0025	.0065					
9500			.003	.007					
12000			No failure.						

ANALYSIS

C	Mn				

REMARKS:

This chamber was previously used in Test # 428-A. Safety groove failed at 6600 psi.

After chamber failed in Test #428-A a 4" section was cut off the threaded end. A solid plug was then welded into chamber, and chamber was placed in test fixture and held in place by means of a split bushing engaging chamber at the welded-in plug.

Hydraulic pressure was applied through venturi end of chamber and readings were taken of radial increase by means of dial indicators, as per above sketch.

At 9500 psi the seal leaked slightly but hydraulic pump was worked until 12000 psi was reached. Test was then discontinued. No failure.

CONCLUSIONS:

Chamber O.K.

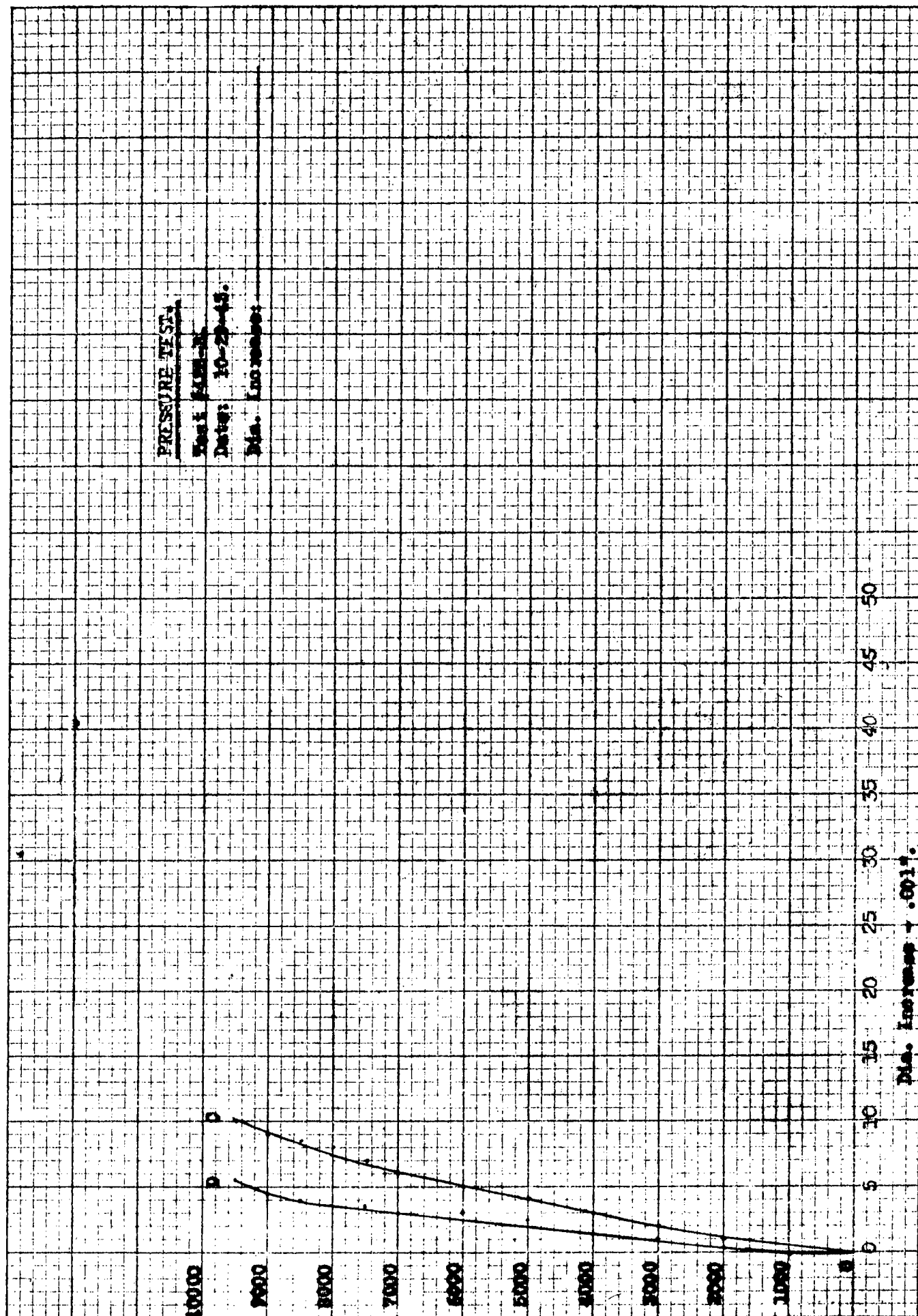
REFER TO TEST Nos.:
RUN BY: J. Aylsworth
REPORTED BY: C. A. Temple
CONDUCTED BY: W. J. Portman

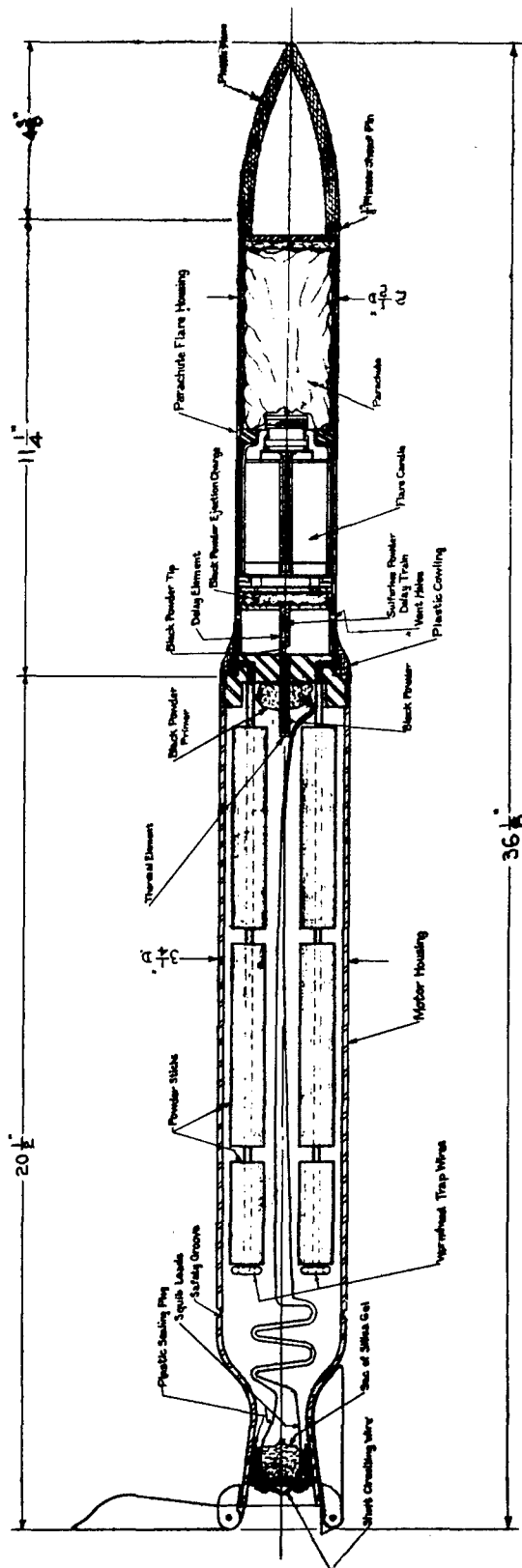
PRESSURE TEST

Test #100-20

Date: 10-20-45.

Dis. Increase:



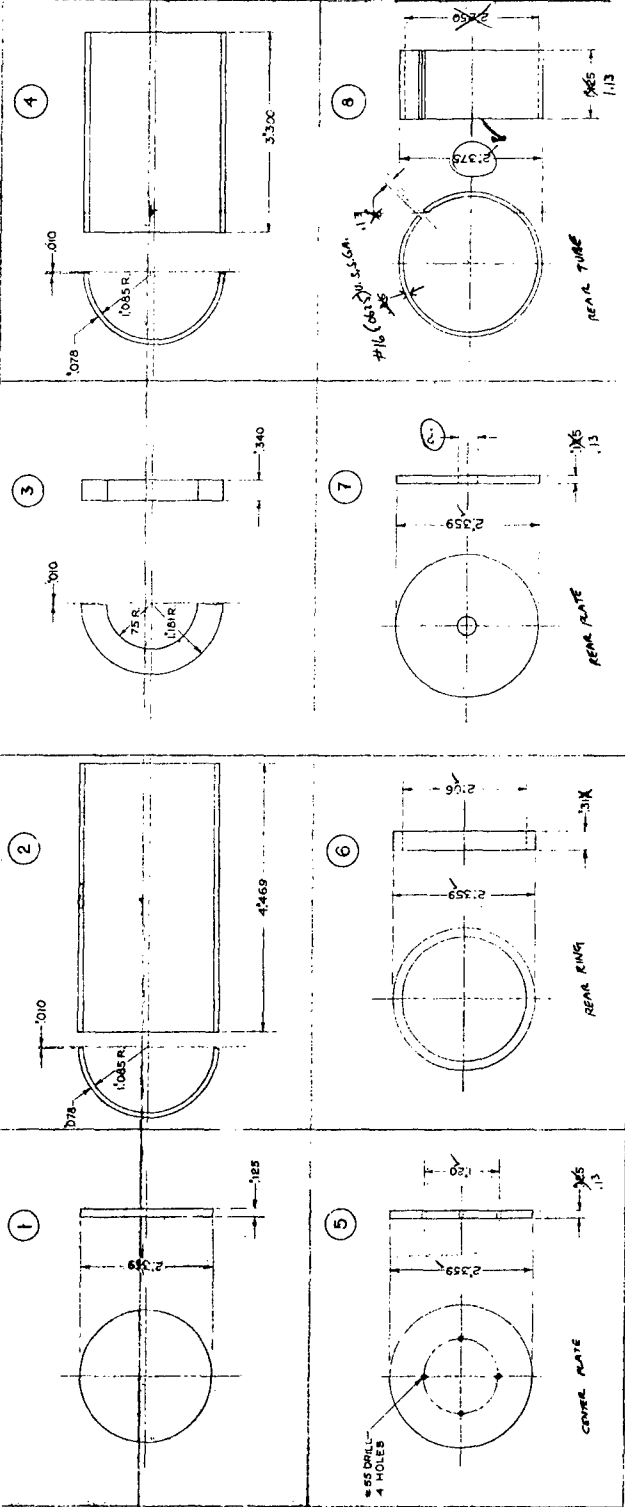
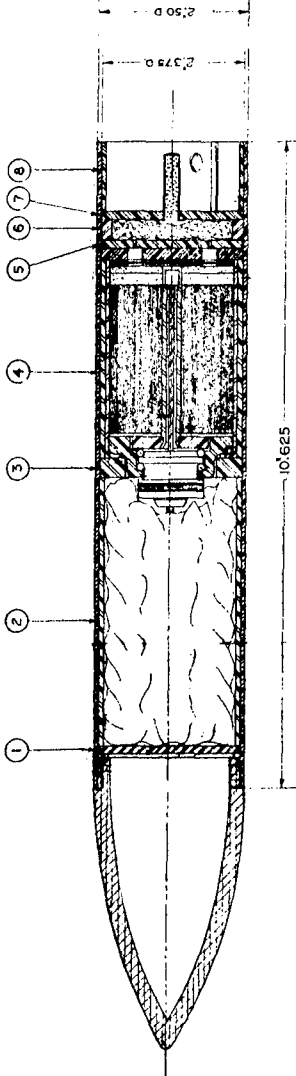


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CHECKED BY: [illegible]	DATE: [illegible]

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REV	NO	DESCRIPTION	DATE	BY	CHKD	APPROV
1	1	UPPER WASHER				
2	2	UPPER SUPPORT				
3	3	SPLIT WASHER				
4	4	LOWER SUPPORT				
5	5	BAFFLE				
6	6	POWDER SPACER				
7	7	LOWER WASHER				
8	8	SPLIT SPACER				

REVISIONS

REV	NO	DESCRIPTION	DATE	BY	CHKD	APPROV
1	1	UPPER WASHER				
2	2	UPPER SUPPORT				
3	3	SPLIT WASHER				
4	4	LOWER SUPPORT				
5	5	BAFFLE				
6	6	POWDER SPACER				
7	7	LOWER WASHER				
8	8	SPLIT SPACER				

EXPERIMENTAL

ROCKET FLARE

SCALE: 1" = 1"

U.S. ARMY ORDNANCE PLANT
 BALDWIN, L. I., N. Y.

CLASSIFICATION: EXPERIMENTAL

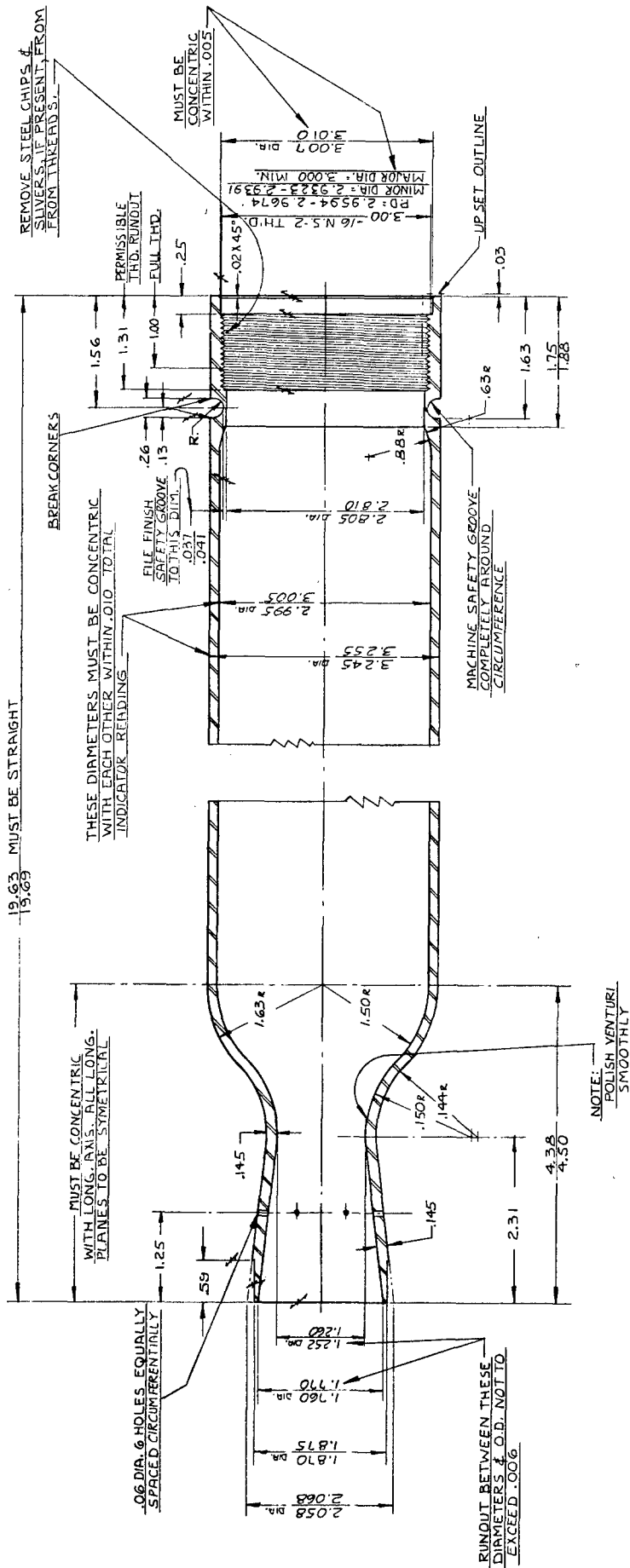
SKETCH NO: 64426

DATE: 1/13

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S.A.E #1035

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ACID PROOF BLACK PAINT

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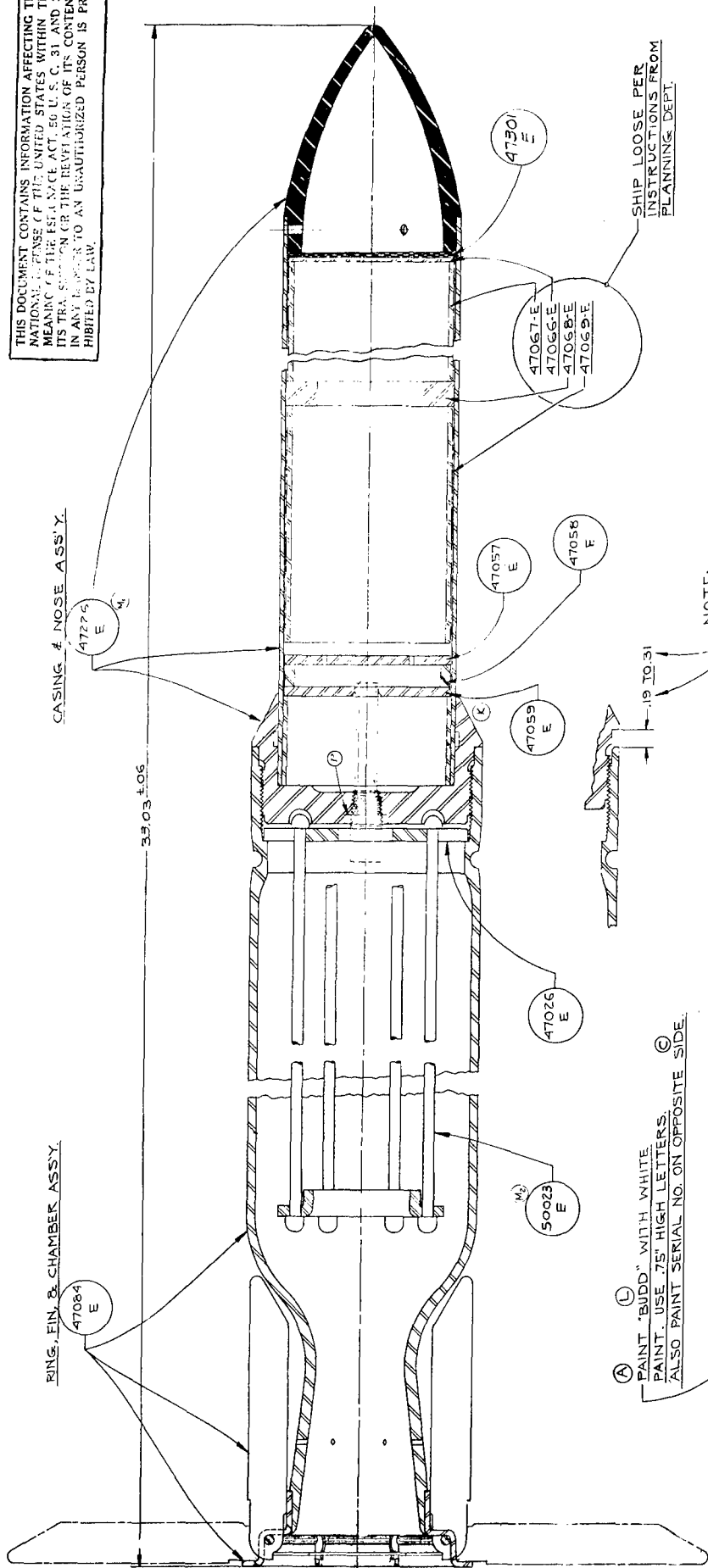
47087 D

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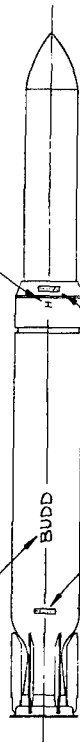
RING, FIN. & CHAMBER ASSY.

CASING & NOSE ASSY.



PAINT "BUDD" WITH WHITE.
PAINT USE .75" HIGH LETTERS.
ALSO PAINT SERIAL NO. ON OPPOSITE SIDE.

STAMP "H" (HEAVY SIDE) HERE
IN LINE WITH SERIAL NO. ON HEAD.



STAMP SERIAL NO. 2 PLACES
AS SHOWN.

NOTE:
FOR SHIPMENT ASSEMBLE AS
SHOWN TO FACILITATE DISASSEMBLY
FOR LOADING.

SHIP LOOSE PER
INSTRUCTIONS FROM
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BY CHANGE NO. 25098
DATE 3-8-44

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1		HEAD REVISED PER DETAIL	11-22-43
2		N WAS "K.C." MODEL	10-28-43
3		M "REVISED" A PER C.D.	9-15-43
4		M WAS "WOL. ATOM."	9-14-43
5		L WAS "BUDD EMPTY"	9-14-43
6		K VENT HOLES REMOVED	9-7-43
7		J WAS OBSOLETE-NOW REINSTATED	7-14-43
8		H CHAMBER REVISED PER DETAIL	4-14-43
9		G OVERALL LENGTH WAS 33.00	4-6-43
10		F PART NR 47301-E ADDED	3-14-43
11		E CASING & NOSE ASSY. WAS 47086	3-10-43
12		D NOSE ADDED	2-2-43
13		C PAINTING OF SERIAL NO. ADDED	2-2-43
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15		A NOTE ADDED	2-15-43

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BUDD WHEEL CO.
DETROIT, MICHIGAN
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47087 D

32.97
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RING, FIN, & CHAMBER ASSY

47084
E

CASING & NOSE ASSY

47226
E50023
E47026
E47059
E47058
E47057
E47067-E
47066-E
47068-E
47069-E47301
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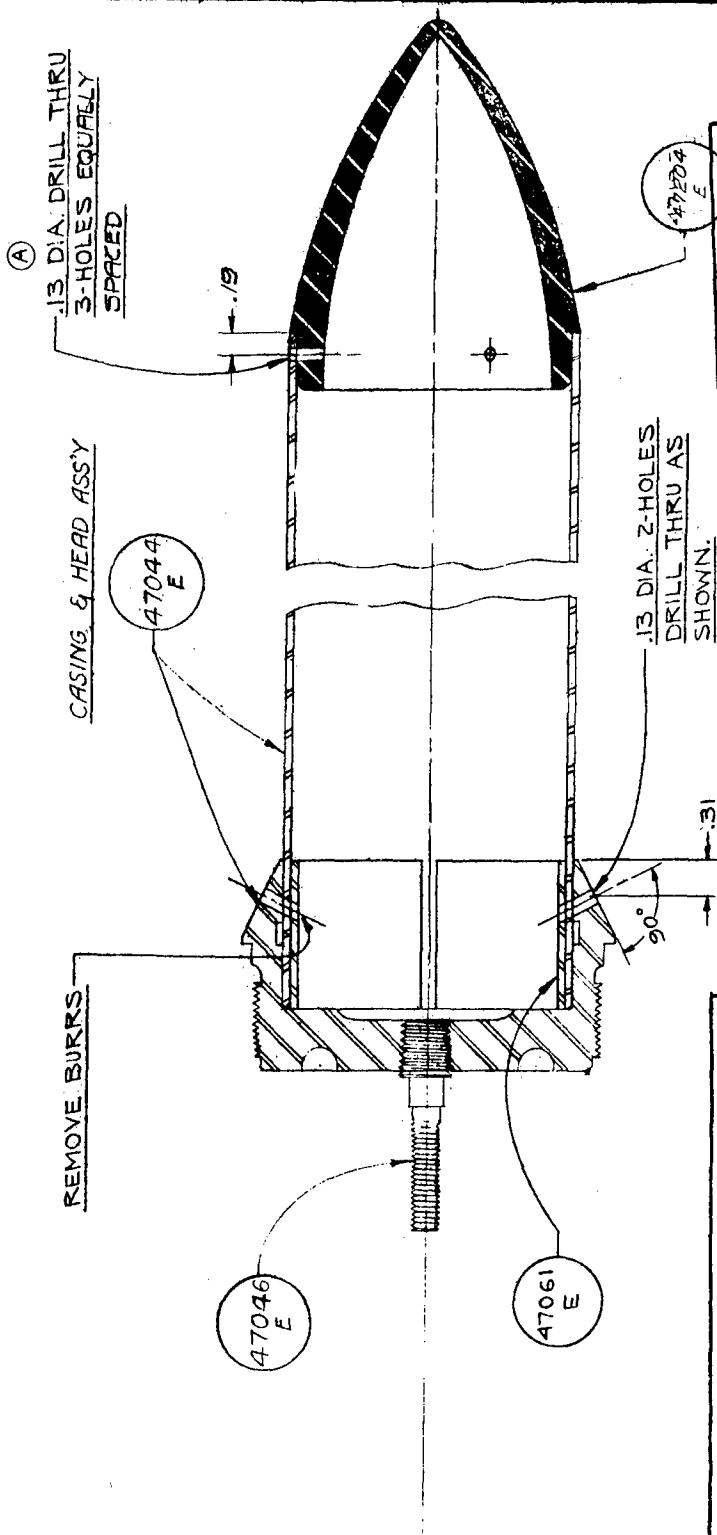
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MAT. APP. 10/11/49	DATE 3-6-44	SUP. ISSUE "P"	
CK. CHGE. 26094	DESCRIPTION REDRAWN NO CHANGE	BUDD WHEEL CO.	
REL # 14267	SCALE: FULL	DETROIT, MICHIGAN	
		47087 D	

PAINT OUTSIDE SURFACES OF CHAMBER, HEAD,
AND CASING WITH BLACK LACQUER ENAMEL

472226

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DATE	3-25-43	
CK. CHGE	11/23/43	
DESCRIPTION	CASING & NOSE ASSY	
3 1/4 NC. MODEL		
AFTER 12/1/57		
SUP. BY		
BUDD WHEEL CO		47226
DETROIT, MICHIGAN		E

REL-14279

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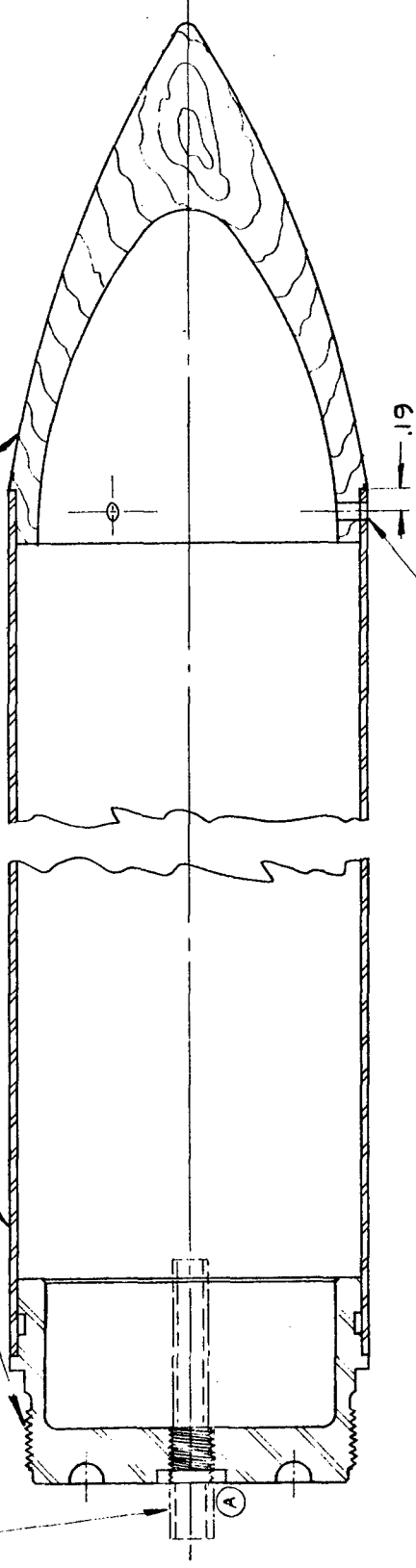
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CASING & HEAD ASSY.

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50059 E

50060 E

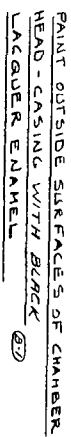


27 (.1440) DRILL THRU
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GOEHMANN		
CHKD.		
APPVD.	9-21-43	
W. J. P. G. R. L.		
MAT. APP.		
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CHGE		
SUP. BY		
BUDD WHEEL CO.		X-50061
DETROIT, MICHIGAN		E



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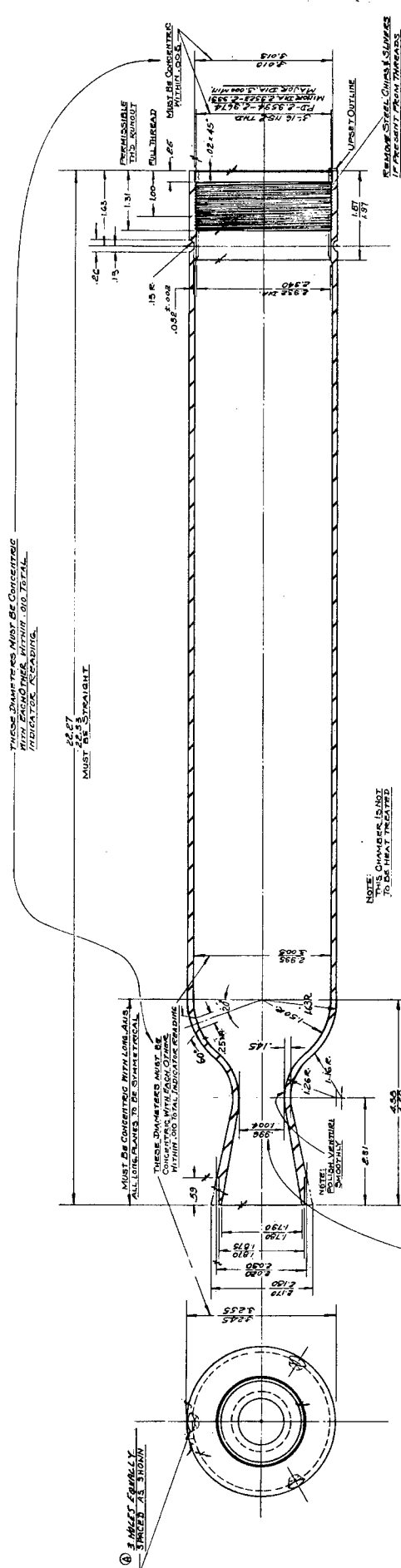
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SUP. BY	X 50
---------	------

D

MACH DIMS TO HAVE TOL OF ± 0.10
UNLESS OTHERWISE SPECIFIED.



IMPORTANT:-
MUST BE UNIFORM IN DIA. WITHIN .004.
CONCENTRIC WITH 3.245 / 3.255 DIA.
WITHIN .014 TOTAL INDICATOR READING

MATERIAL-
SEAMLESS STEEL TUBING
S.A.E. #1035

PAIN'T ALL INTERIOR SURFACES, EXCEPT THREAD
Ø 3/10-5/13 DIA. WITH ONE (1) COAT OF SYNTHETIC
LACQUER RESISTING PRIMER (GOVT. SPEC. # AYS-946.)
FOLLOWED WITH ONE COAT OF OLIVE DRAB LUSTERLESS

CONFIDENTIAL

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[illegible]

E 51086-X

MACH. DIMS. TO HAVE TOL. OF $\pm .010$
UNLESS OTHERWISE SPECIFIED.

FINS MUST MOVE FREELY
FROM VERTICAL TO HORIZONTAL POSITION
BY VIRTUE OF THEIR OWN WEIGHT.

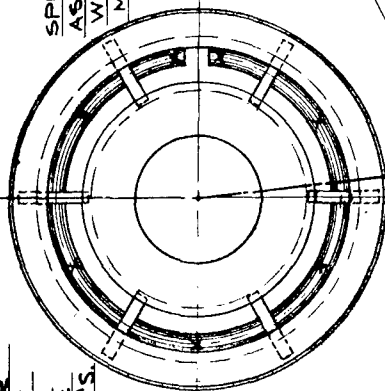
INSERT IN PLACE
AFTER SPINNING
OPERATION.

53008
D
CHAMBER & TRAP PLATE
ASSY. (WELDED)

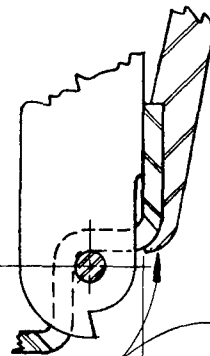
47071
E
RING & FIN ASSY.

A
AFTER SPINNING OPERATION
IS COMPLETED, SPIN OVER
PORTION OF CHAMBER
MUST BE TOUCHED UP
WITH OLIVE DRAB
LUSTERLESS LACQUER
ENAMEL GOVT. SPEC'S.
#3-67E GRADE I).

SPINNING MUST PRODUCE
ASSEMBLY CAPABLE OF
WITHSTANDING 1000#
MIN. TENSILE PULL



SPIN CHAMBER OVER
AROUND ENTIRE CIRCUM-
FERENCE SECURELY. DO
NOT EXCEED DIMENSION AS SHOWN.



DOUBLE SIZE

SECTION AA

SPIN OVER SECURELY AROUND
ENTIRE CIRCUMFERENCE.

1.02 OUT SIDE EDGES OF FINS
.05 MUST BE HELD WITHIN THESE LIMITS.

CONFIDENTIAL

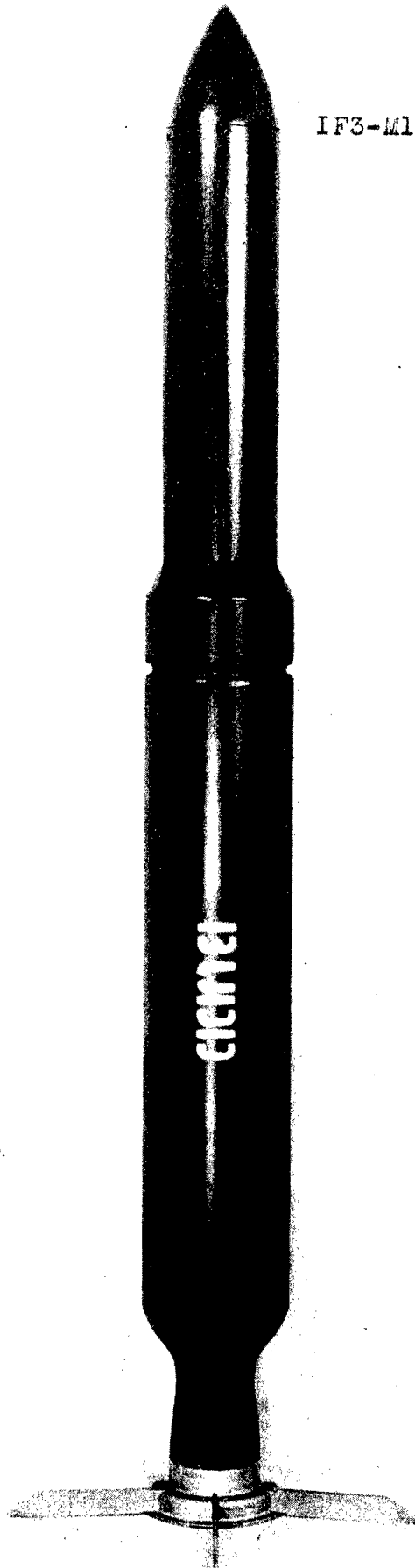
NOTE: SPINNING OPERATION MUST PRODUCE
A TIGHT CONNECTION BETWEEN FIN ASSY.
& CHAMBER WITH NO SLIPPAGE
BETWEEN PARTS PERMITTED.

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MEANING OF THE ESPIONAGE ACT, 50 U. S. C. 31 AND 32.
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IN ANY MANNER TO AN UNAUTHORIZED PERSON IS PRO-
HIBITED BY LAW.

REPORT ERRORS & CHANGES TO ENGINEERING		DO NOT SCALE	
DRAWN 11-28-44	Blair	RING-FIN & CHAMBER ASSEMBLY	
CHKD. 12-16-44	KIDER		
APPROV. 12-22-44	MMT		
MAT. APP.			
REL	CK. CHGE	DESCRIPTION	DATE
		A REVISED PER DET'S (3-1) WAS 51085-B	7-28-14
		SCALE: FULL	SUP. BY
		BUDD WHEEL CO. X-51086 E	
		DETROIT, MICHIGAN	

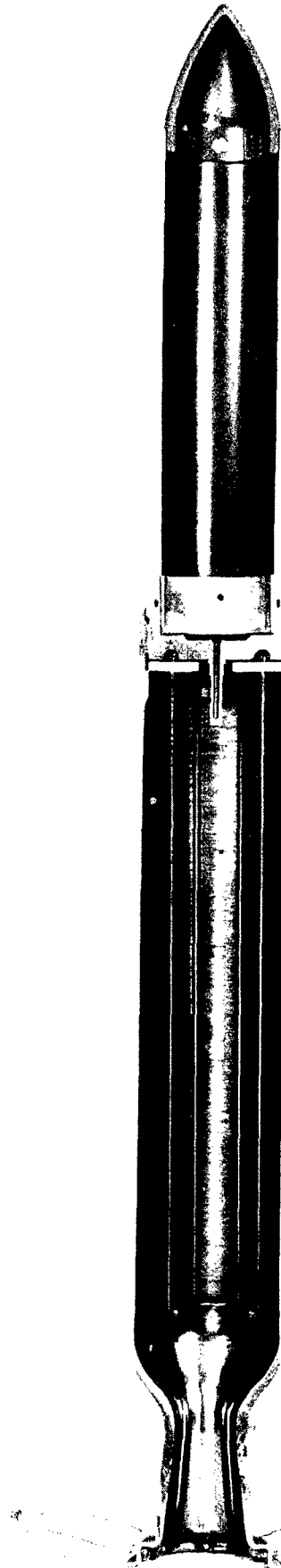
PHOTOGRAPH 1

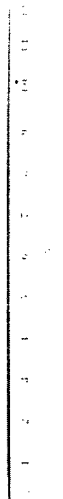
IF3-M1 Rocket Flare Assembly



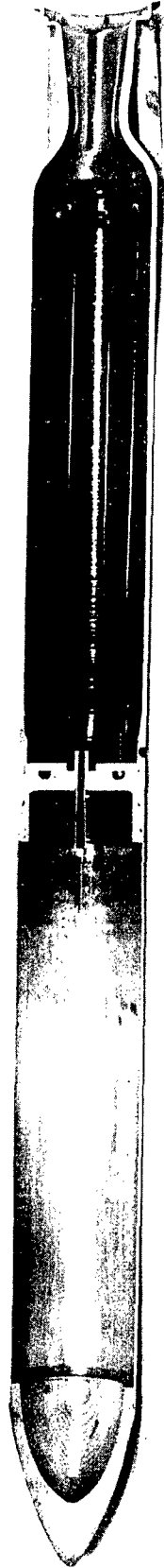
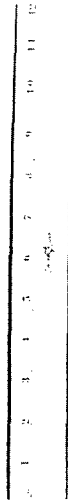
PHOTOGRAPH 2

IF3-M1 Rocket Flare - Half
Section





PHOTOGRAPH 3
IF3-M2 Rocket Flare Assembly



PHOTOGRAPH 4
IF3-M2 Rocket Flare - Half
Section

PHOTOGRAPH 5

IF3-M3 Rocket Flare Assembly



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Efforts to Standardize T-5, T-6 and IF3-M1 Rocket Chambers - W. W. Farr - January 20, 21, 1943 - Budd File NE-34.

Final Design Approval IF3-M1 Conference - Dr. C. N. Hickman, Dr. R. E. Gibson and Dr. A. Kossiakoff - January 30, 1943 - Budd File NE-34.

Receipt of Flare Details - Dr. A. Kossiakoff - February 5, 1943 - Budd File NE-34.

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Design and Production Required - Dr. R. E. Gibson - May 31, June 7, 1943 - Budd File NE-43.

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Production Release of IF3-M3 Rocket of Budd Wheel Company - February 21, 1944 - W. B. Pope.

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Annapolis, Maryland

FORM 100-9 (10 FEB 47) Budd Wheel Co.		57 C-22-11-73		ATI- 18734	
DIVISION: Ordnance and Armament (22)		ORG. AGENCY NUMBER			
SECTION: Chemicals and Incendiaries (11)		O.S.R.D.-6135			
CROSS REFERENCES: Flares (37720)		REVISION			
AUTHOR(S)					
AMER. TITLE: Rocket flares					
FORG'N. TITLE:					
ORIGINATING AGENCY: O.S.R.D., N.E.R.C., Div. 3, Washington, D. C.					
TRANSLATION:					
COUNTRY	LANGUAGE	FORG'N. CLASS	U. S. CLASS.	DATE	PAGES
U.S.	Eng.		Conf'd'l	Oct '45	35
					ILLUS.
					19
					FEATURES
					photos, graphs, dwgs
ABSTRACT					
Three rocket flare models known as the IF3-M1, IF3-M2, and IF3-M3 were engineered and manufactured by the Budd Wheel Company. All contained inductively heat-treated rocket motors 3½ inches in diameter. The heads were of two sizes and contained a black powder charge which at the proper time expelled the Navy parachute flare from the rocket. Drawings are included showing assembly procedure for each of the flare models. Safety groove failure occurred at 6500 psi in hydrostatic tests of the chamber strength, although the body withstood pressures of 12,000 psi. Fire tests results are given in O.S.R.D. 5778.					
T-2, HQ, AIR MATERIEL COMMAND		AIR TECHNICAL INDEX		WRIGHT FIELD, OHIO, USAAF	
				WF-O-11 MAR 47 12M	

31

Reclassified per Auth OSRD List # 31
 dtd Aug 5-9, 1946 by HR Jackson, WACO
 on 9 Aug 49