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ASTIA

31 May 1956
Report No. 1106
(Final) Volume II
Copy No._____

FC

RESEARCH, DEVELOPMENT, AND TESTING OF UNDERWATER PROPULSION DEVICES

Contract N6ori-10, Task Order I
Project NR 097 003

17598

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31 May 1956

Report No. 1106
(Final)
Volume II

RESEARCH, DEVELOPMENT, AND TESTING OF UNDERWATER PROPULSION DEVICES

Contract N6ori-10
Task Order I
Project NR 097 003

Written by:

M. Bielecki
W. S. De Bear
H. M. Higgins
A. E. Lemke
R. Spies
J. A. Stubstad
R. M. Viney

No. of Pages: 200

Period Covered:

1 January 1946 through 29 February 1956

Approved by:

R. M. Viney
Project Engineer

C. A. Gongwer
Manager
Underwater Engine Division

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AEROJET-GENERAL CORPORATION

Azusa, California

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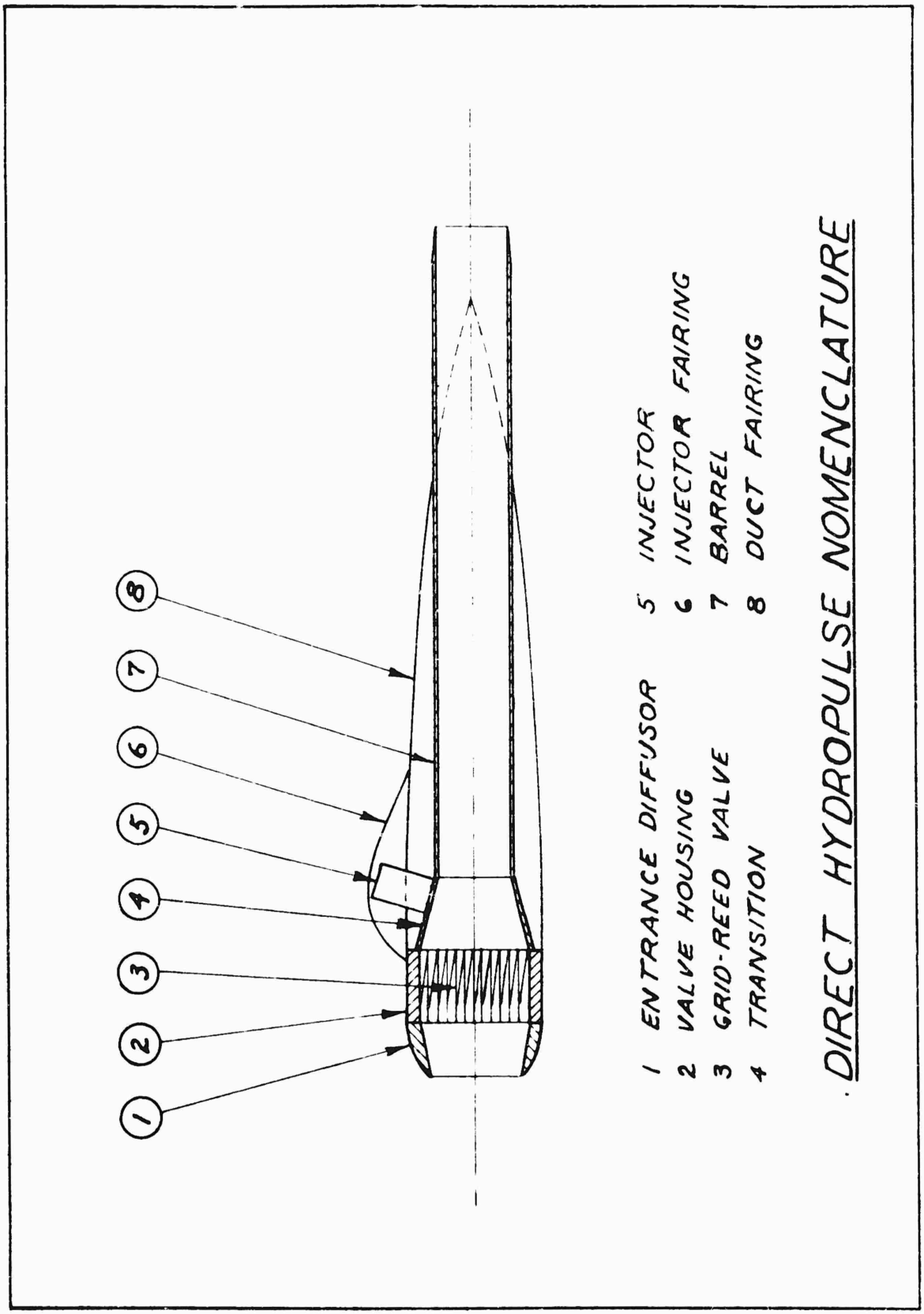

DIRECT HYDROPULSE NOMENCLATURE
1 ENTRANCE DIFFUSOR
2 VALVE HOUSING
3 GRID-REED VALVE
4 TRANSITION
5 INJECTOR
6 INJECTOR FAIRING
7 BARREL
8 DUCT FAIRING
1
2
3
4
5
6
7
8

Figure 1

Chart of Hydropulse Motor Models

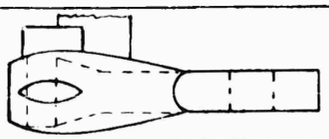
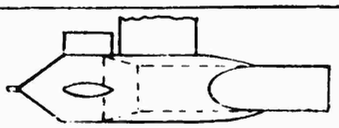
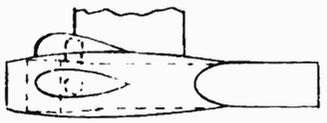
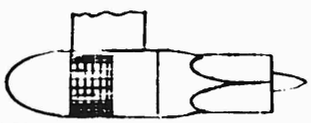
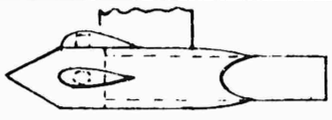
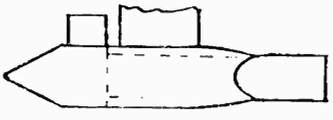
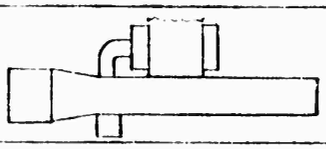
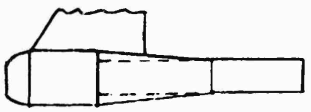
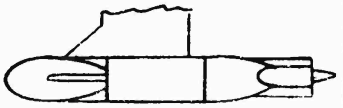
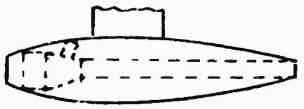
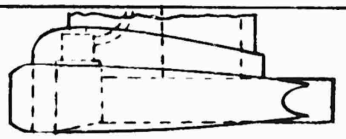
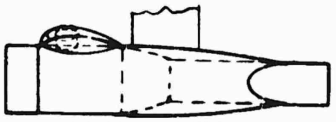
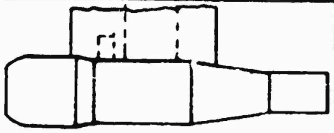
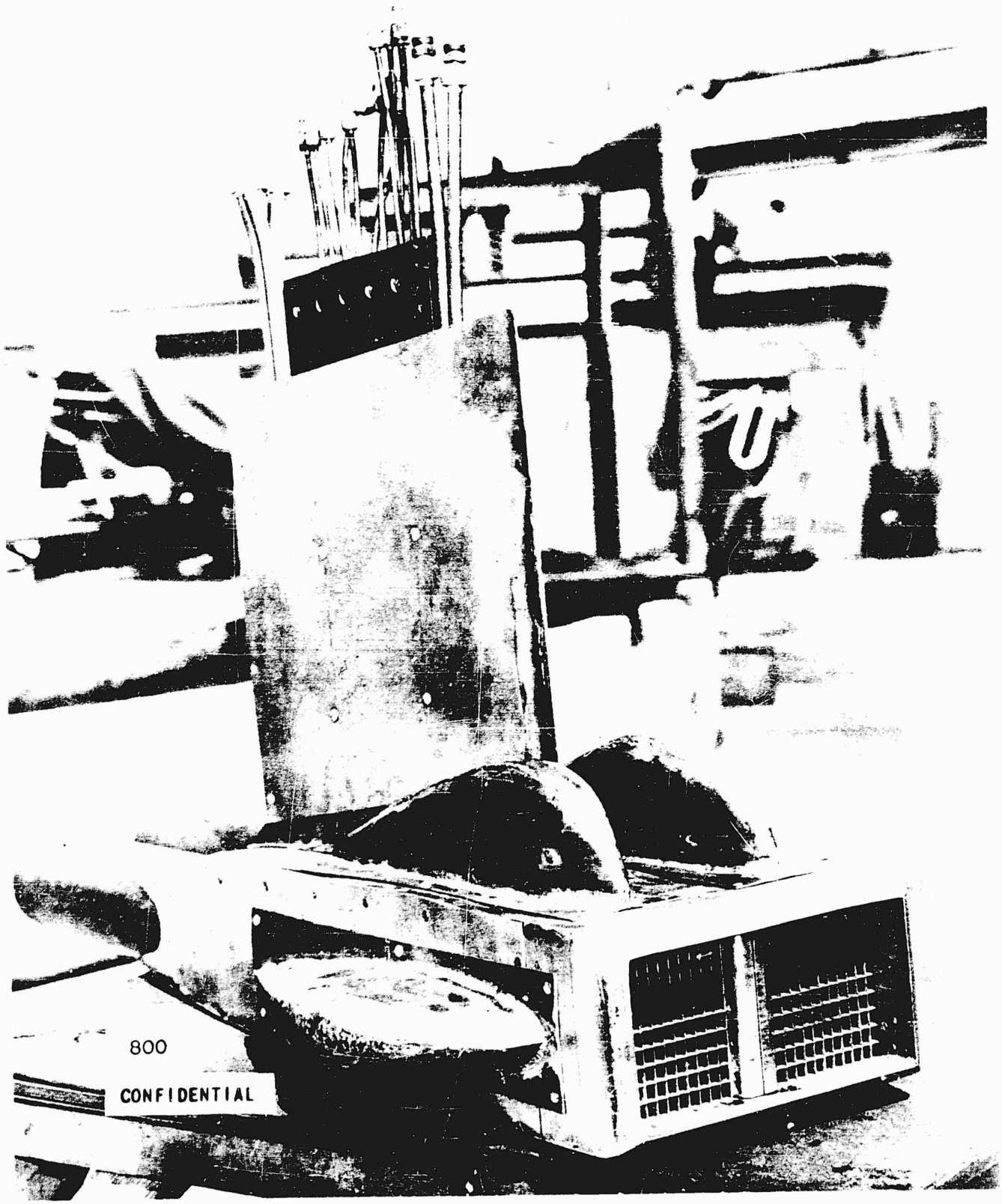
UNIT NO.	SKETCH	INJ./BBL.	BARREL SIZE	DATE 1ST RUN	REMARKS
1		1 & 2	4"x60" TO 4"x18"	9-13-45	SQUARE FACED FRONT ENTRY
2	SAME AS #1	1 & 2	4"x30" 4"x24"	1-14-46	
3	SAME AS #1	2 & 3	4"x30"	2-6-46	
4	SAME AS #1				
5	SAME AS #1	2	4"x36"	3-28-46	
6		2	4"x30" 4"x36"	4-12-46	SLANT VALVE
7	SAME AS #6	2	4"x30" 4"x36"	5-6-46	
8		1 & 2	4"x36"	8-9-46	SQ. FACED FRONT ENTRY— ALSO USED WITH ETHIDE
9	SAME AS #8	1 & 2	4"x48"	8-29-46	
10	SAME AS #8	1	3"x42"	10-8-46	
SEHP MK I		1	#1 3"x36" #2 3"x36" #3 3"x30"	11-26-46 1-3-47	4 BARREL SIDE ENTRY
11		2	4"x36"	12-12-46	HIGH PRESSURE SLANT VALVE
12		1	4"x36"		USED FOR MOLTEN Li
13		1	4"x36"	12-20-46	USED FOR MOLTEN Li

Figure 2

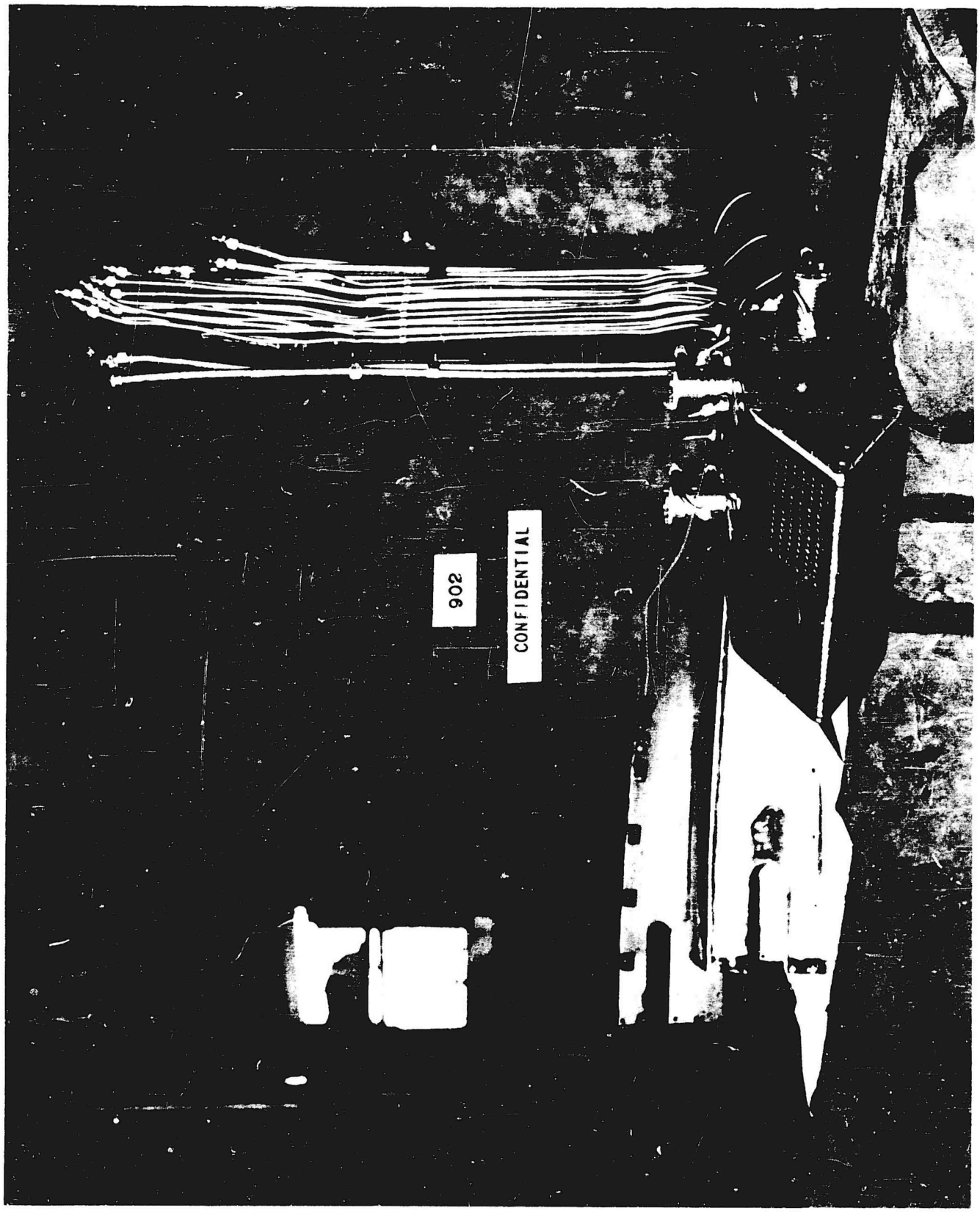
Chart of Hydropulse Motor Models (Cont.)

UNIT NO.	SKETCH	INJ./BBL.	BARREL SIZE	DATE 1ST RUN	REMARKS
14	SAME AS #13	1	4"X36"		USED FOR MOLTEN Li
15		2	4"X48"	3-13-47	INVERTED HYDROPULSE - SOLID SODIUM
16	SAME AS #15	2	4"X48"		
17		1	4"X36"	3-14-47	MULTI-BALL ENTRY VALVE
18		1	4"X36"	4-17-47	CONICAL SPRING ENTRY VALVE
SEHP MK II		1	3"X36" 3"X30"	4-14-47 9-3-47	4 BARREL SIDE ENTRY MARK II
19		1	6"X75"		SINGLE BARREL FRONT ENTRY TORPEDO FOR Li
20	SAME AS #8	1	4"X48"	9-12-47	
21		1	4"X48"	7-22-47	SINGLE BARREL - TO TEST SELF CYCLING INJ.
22		1	4"X48" 4"X42"	1-15-48	SINGLE BARREL - BUILT UP FOR MOLTEN Li
23		1	4X36	1-21-47	ENLARGED DUCT BETWEEN VALVE AND TAIL PIPE
24		1	4X36	12-9-47	GAH-30 CONVERTED FOR USE WITH ALLOY



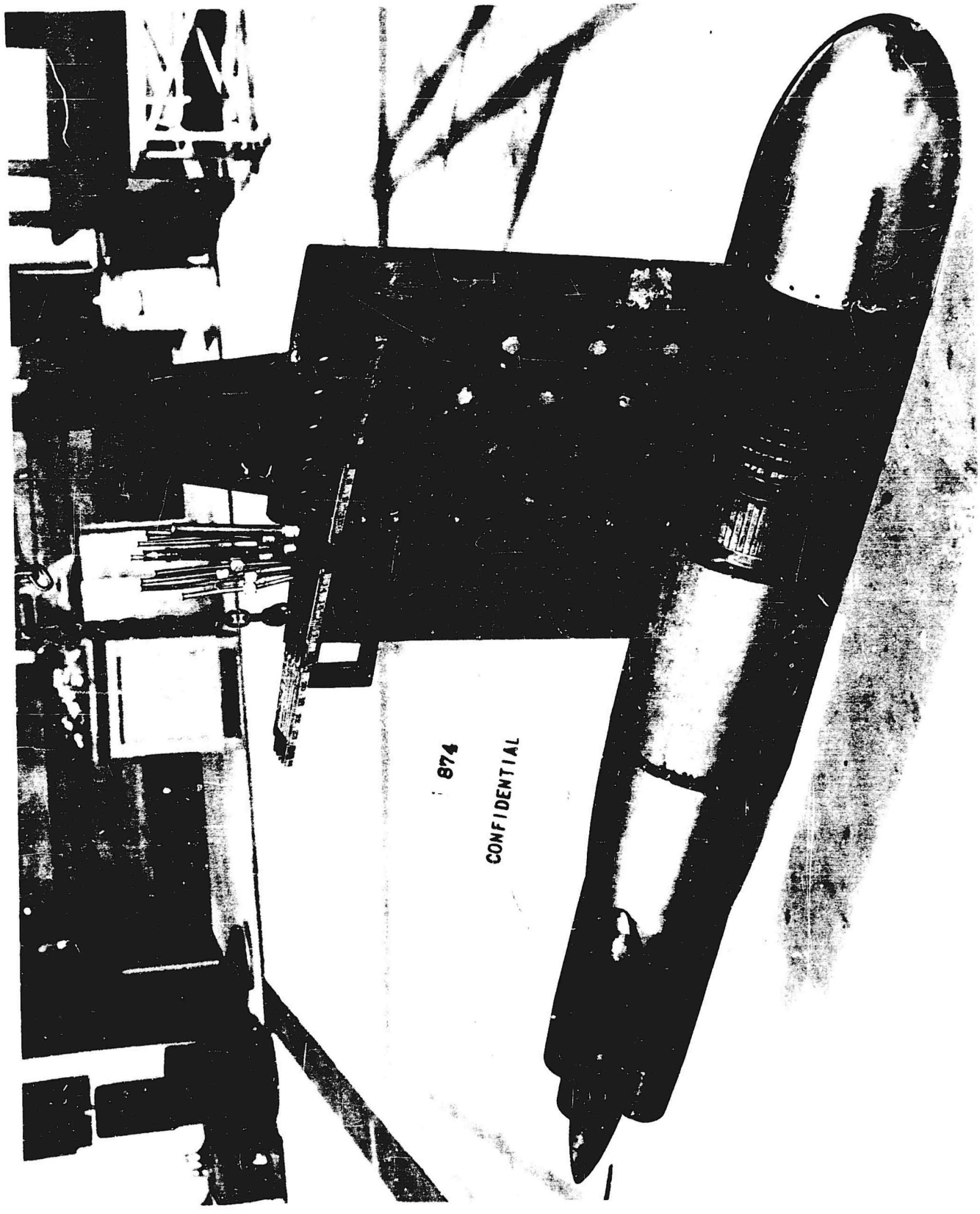
Twin-Barrel Hydropulse Showing Operating Tubing and Injector Housing

Figure 4

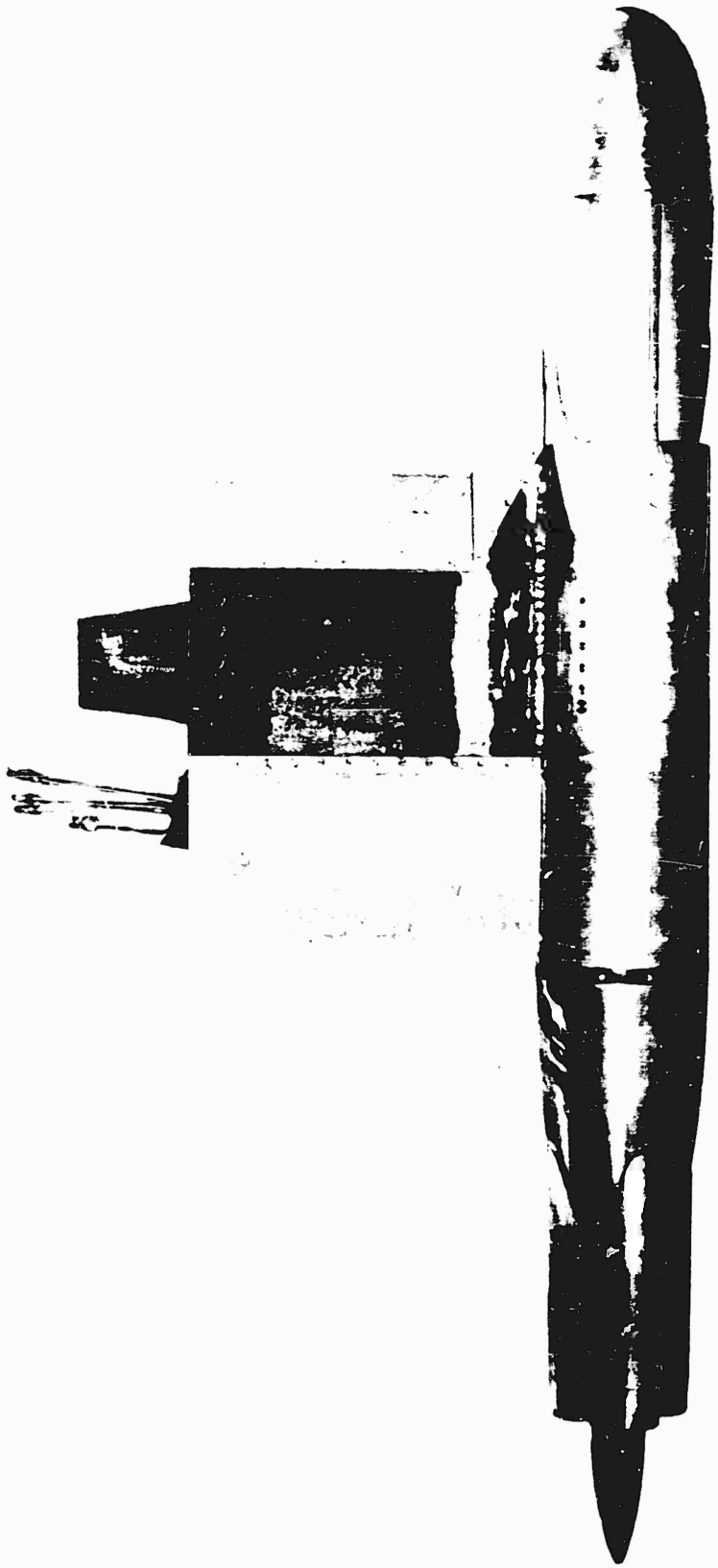


Twin Hydropulse with Fairing Removed, Showing Slant Valve and Injectors

Figure 5

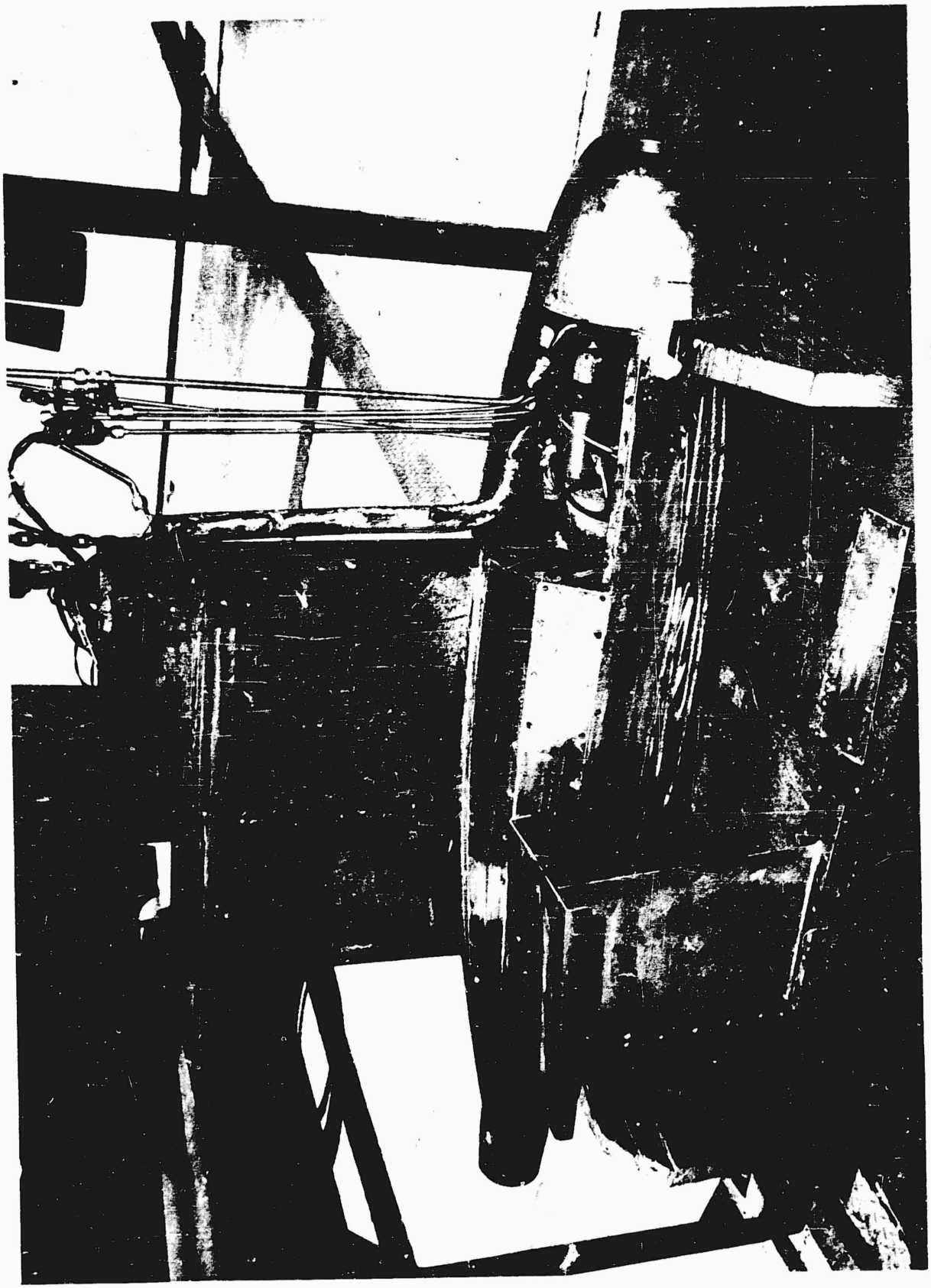


Streamlined Side-Entrance Hydropulse, Four Barrels, 3-in.-dia



R-1048

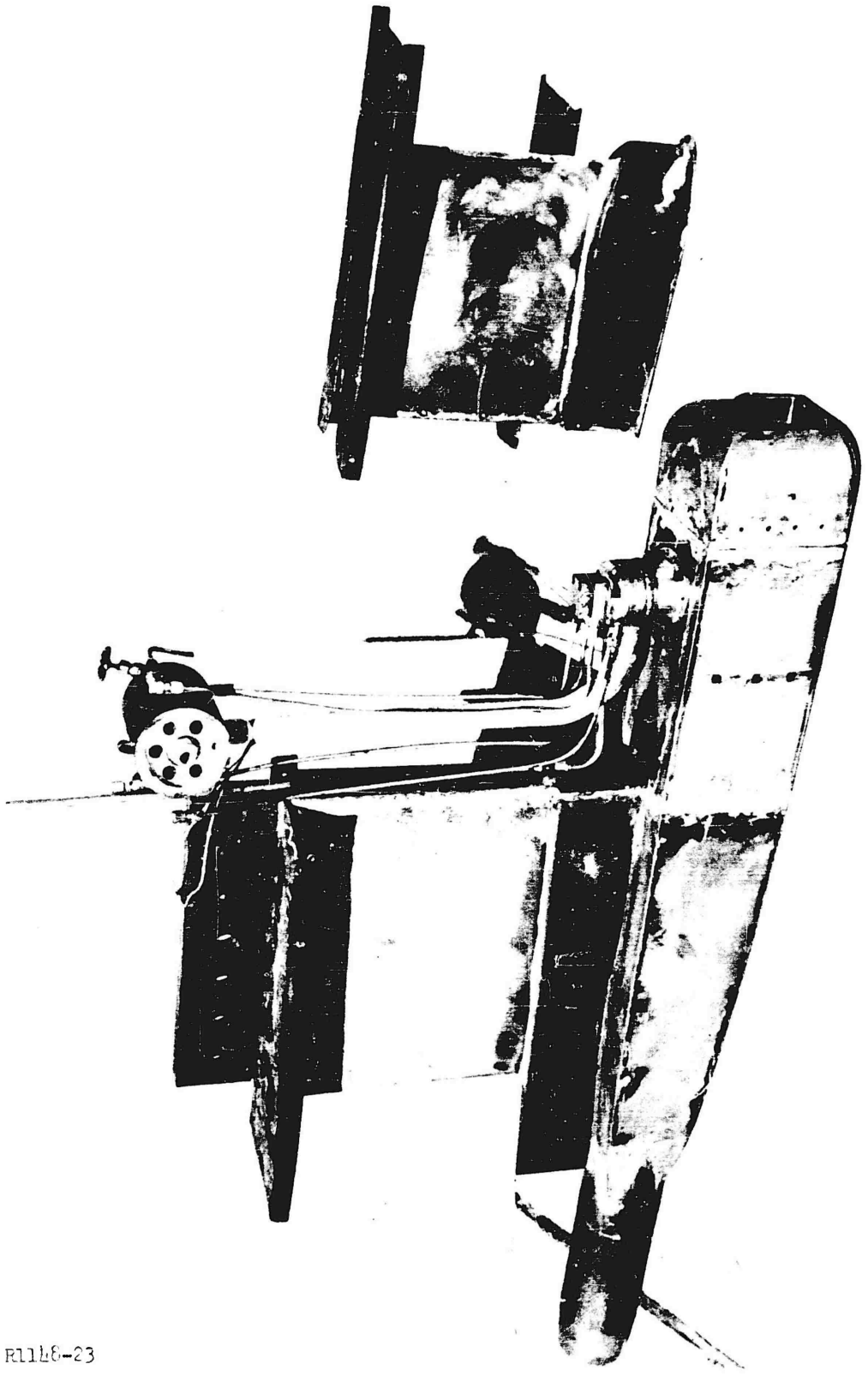
Streamlined Side-Entrance Hydropulse, Mark II, Four Barrels, 3-in.-dia



R749-1

Unit 26 with Hatch Removed to Show Injector, Type 27, in Place

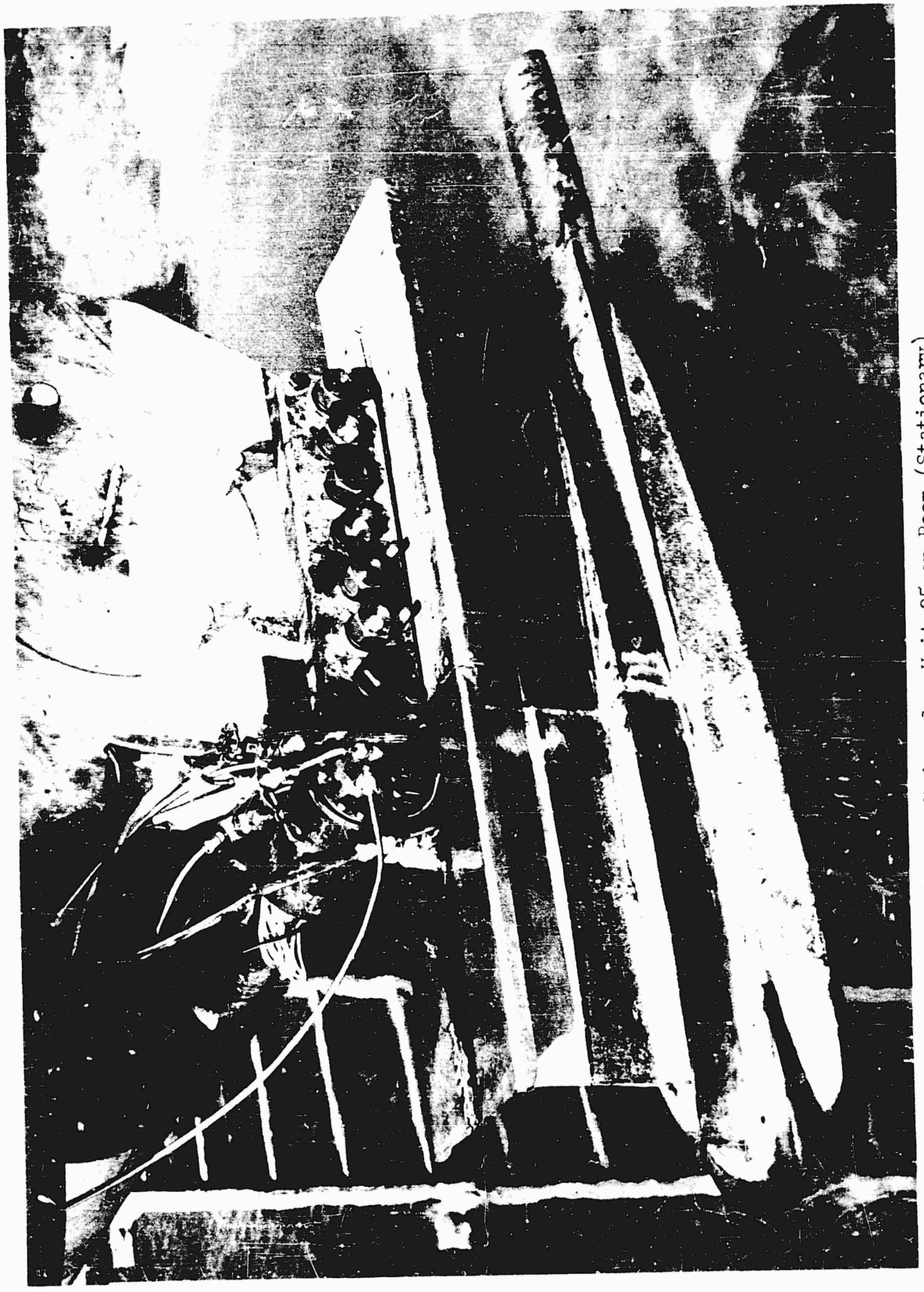
Hydropulse Unit 22-A, Showing Type-22-Injector Plumbing Details



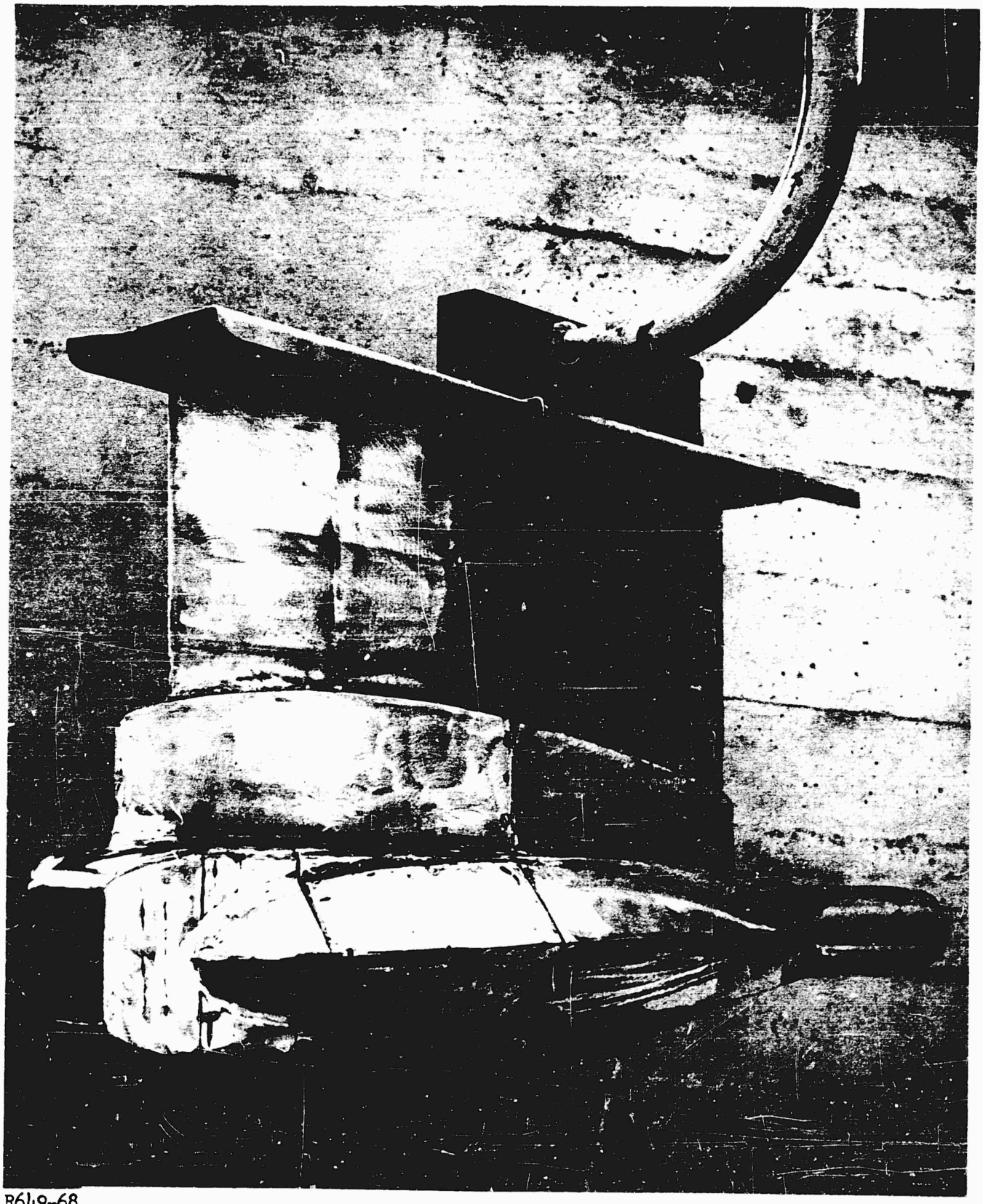
R1148-23

Unit 22-D with Forward Fairing Removed, to Expose the Lithium System

Figure 10

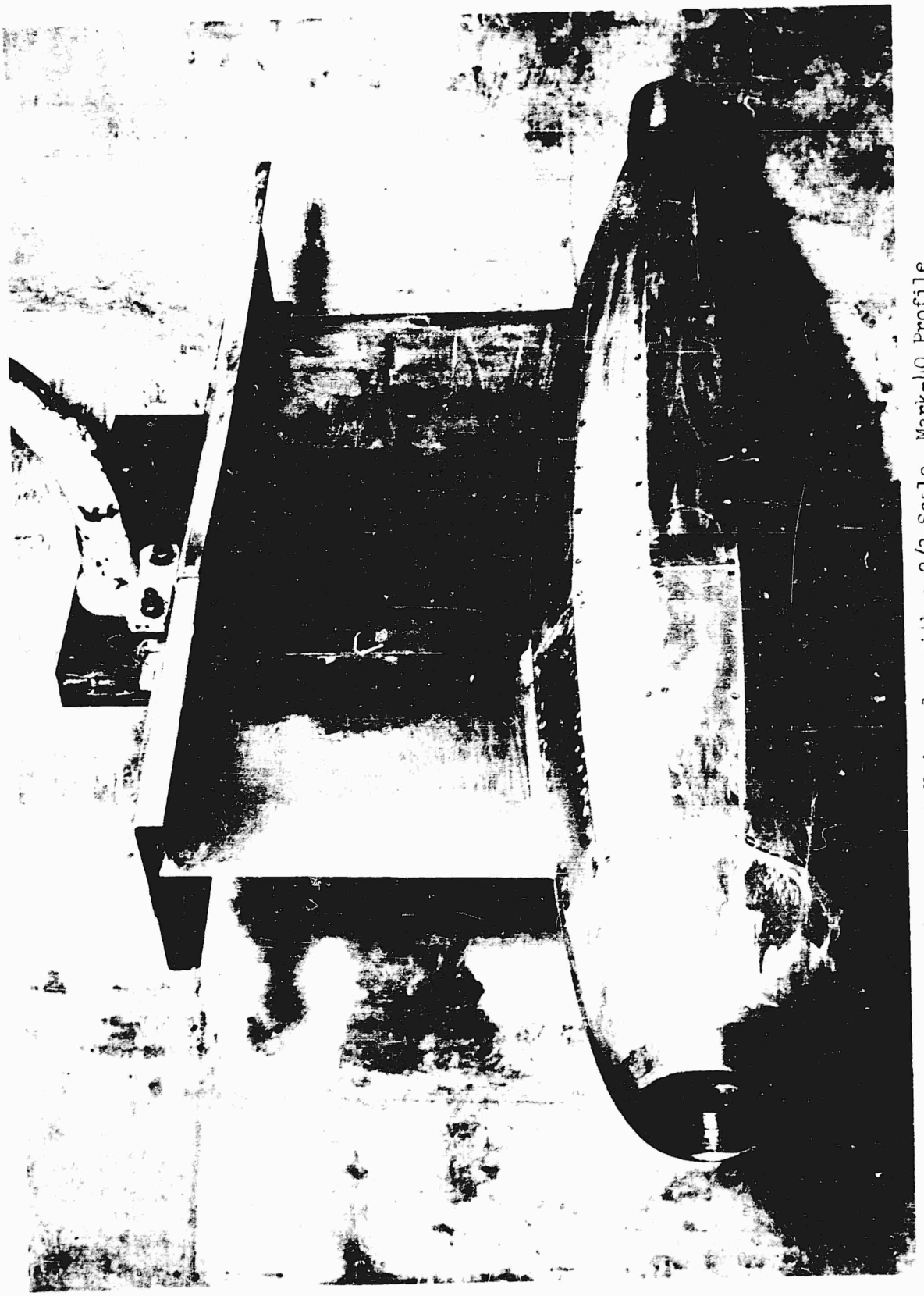


Direct Hydropulse Unit 25 on Boom (Stationary)



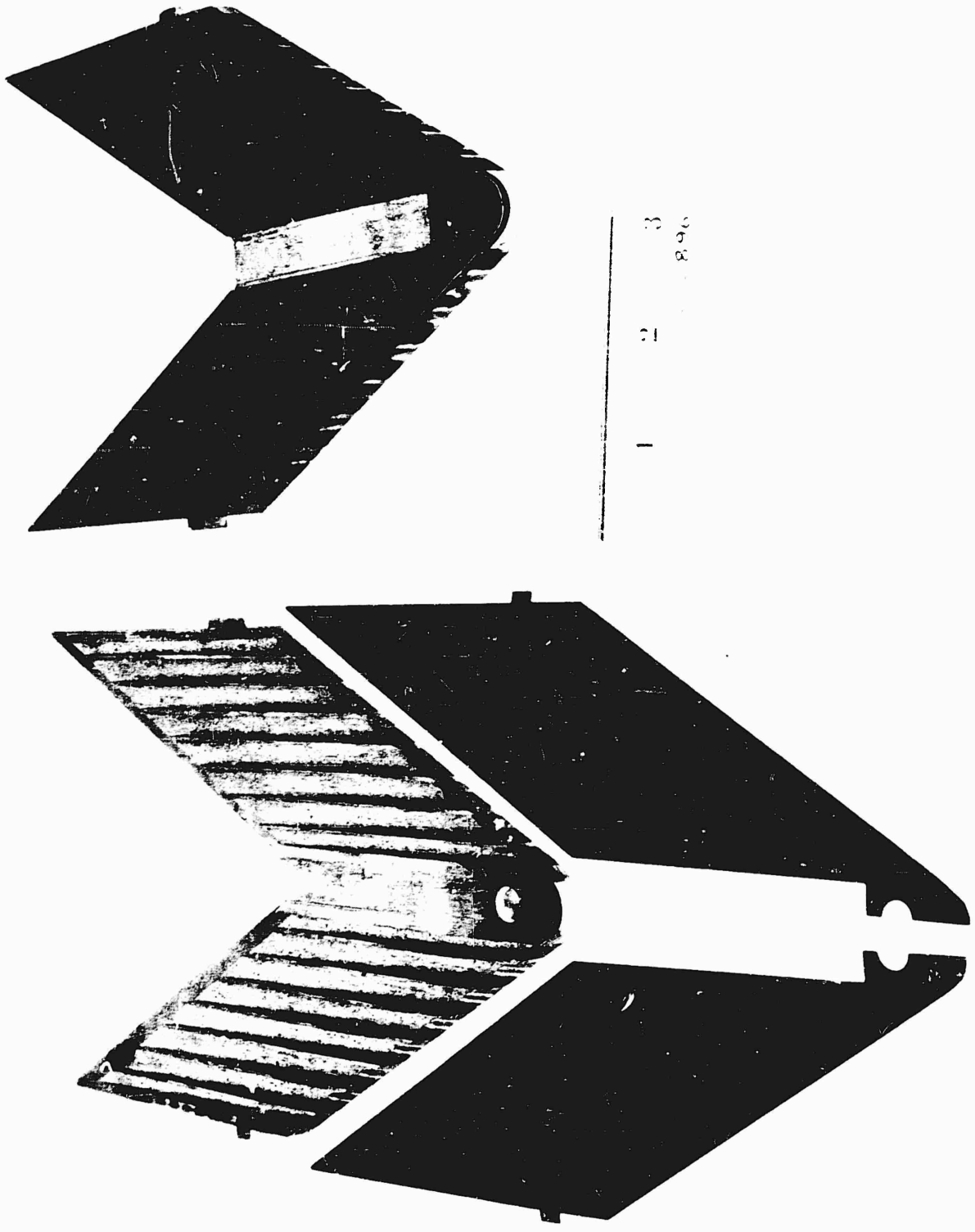
R649-68

Direct Hydropulse Unit 25, 3/4 View



Unit 26, A Direct Hydropulse with a 2/3 Scale, Mark-40 Profile

R6L9-100



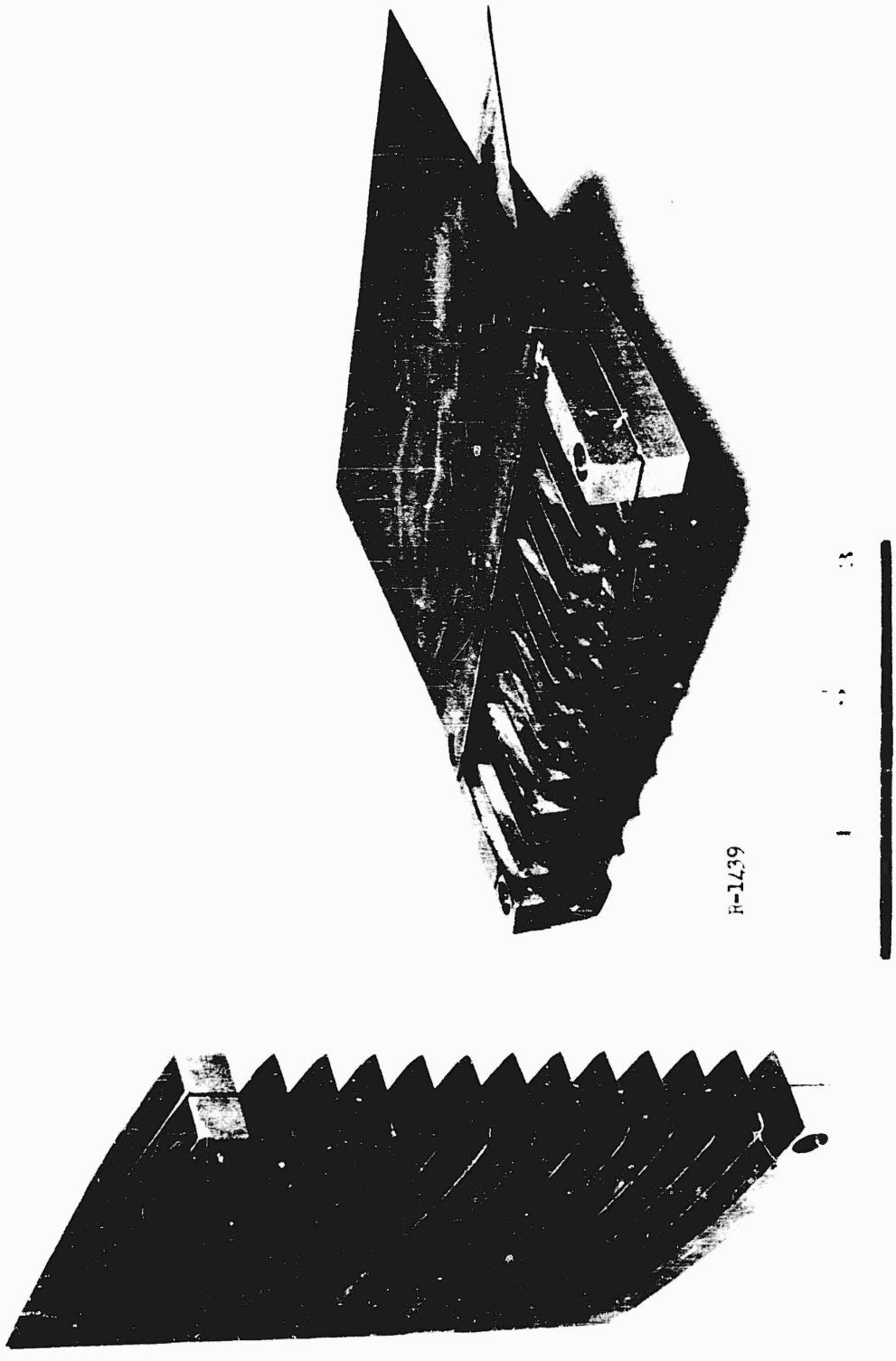
Typical Valve Grid and Reed Arrangement

Details of Entrance Valves and Barrel Arrangement for Streamlined Side Entrance Hydropulse

Figure 15

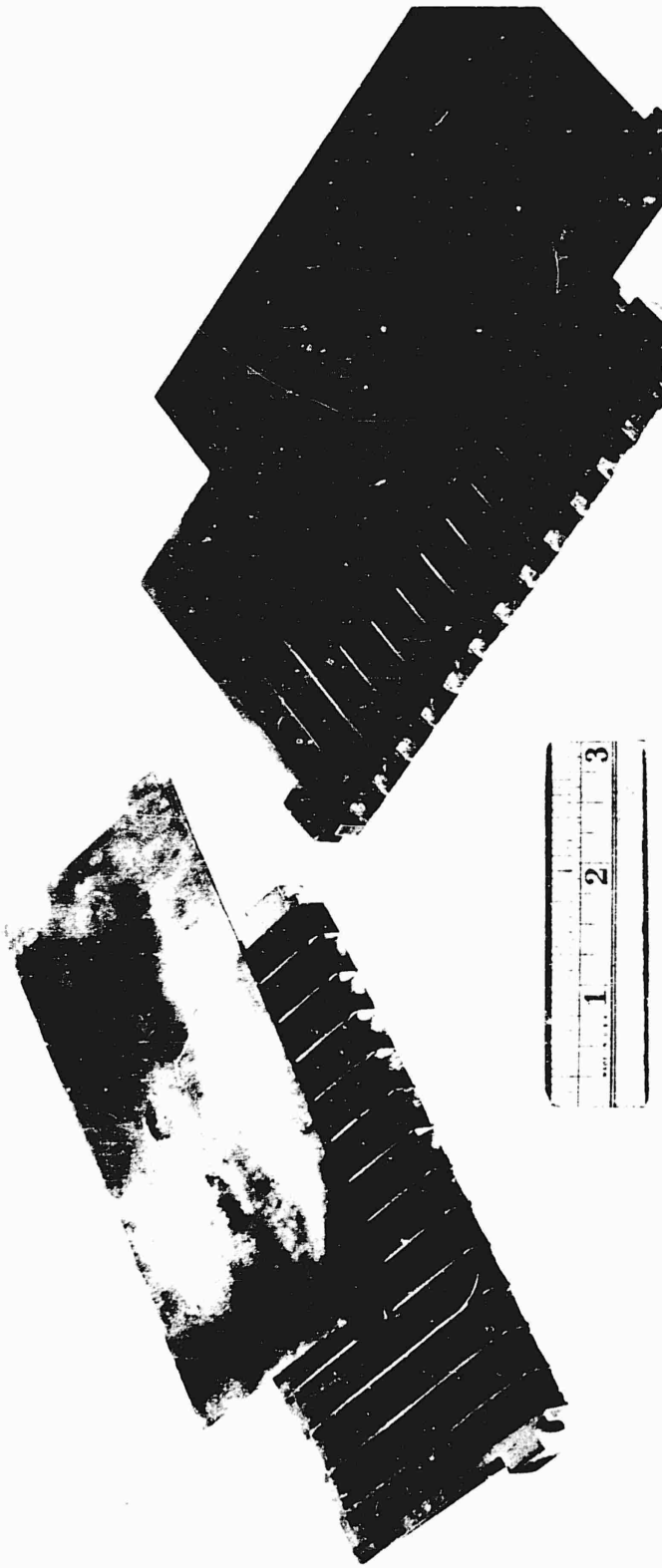
Detail of Reed-Grid Type Entrance Valve of the Side Entrance Hydropulse, Mark II

Figure 16



R-1439

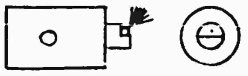
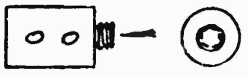
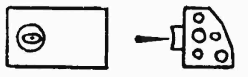
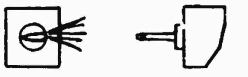
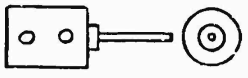
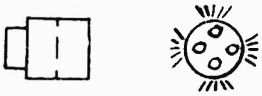
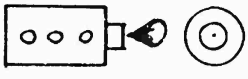
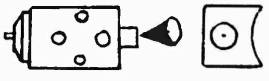
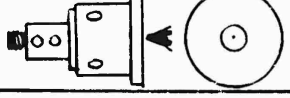
Improved Double-Sided Grids with Flexure Curve Profile



R649-66

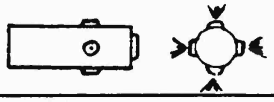
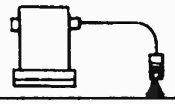
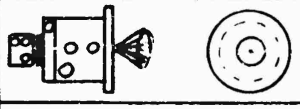
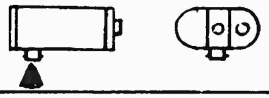
Grids and Reeds for the Shortened Water-Entrance Valve

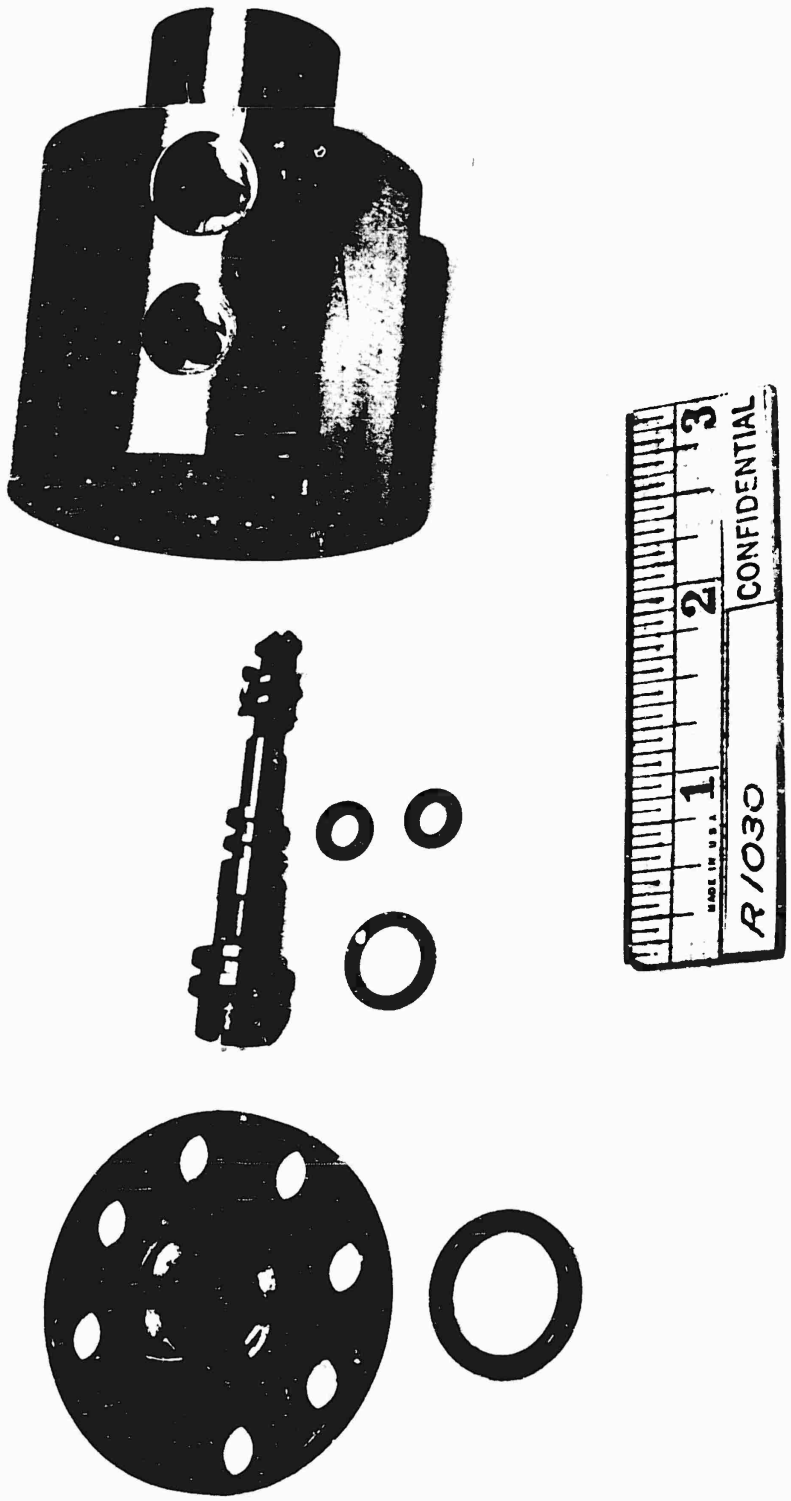
CHART OF INJECTOR TYPES

TYPE	PART NO.	PHYSICAL CHARACTERISTICS	
1	AR4015		CWS* — ONE LATER MODEL MADE WATERLESS (4042)
2	AR4054		IWS **
3	AR4071		DOUBLE IWS - LATER USED AS CWS
4	AR4199		4-a SLOT 4-b SPIRAL PINTLE 4-c EE8W "SPRAYCO" STRUT 4-d E5 "SPRAYCO" STRUT
5	AR4160		CWS FOR SEHP MKI
6	AR4296		WATERLESS SLOTTED STRUT TYPE FOR SEHP MK I
7	AR4180		ACTUATOR ONLY FOR VALVING LITHIUM
8	AR4279		WATERLESS SLOTTED - SINGLE INJ. SERVICES 4 BARRELS
9	AR4045		IWS WITH SPRING DOME LOADING ON PINTLES
10	AR4294		WATERLESS - CONICAL SPRAY SPIRAL PINTLE IN #3 INJ. BODY
11	AR4361		SHORT BODY - WATERLESS SPIRAL PINTLE
12	AR4349		WATERLESS - CONICAL SPRAY SPIRAL PASSAGES
13	AR4344		SELF CYCLING INJ OPERATED BY MOTOR BARREL PRESSURE
14	AR4510		HEATED - BELLOWS TYPE SEAL - USED FOR MOLTEN Li

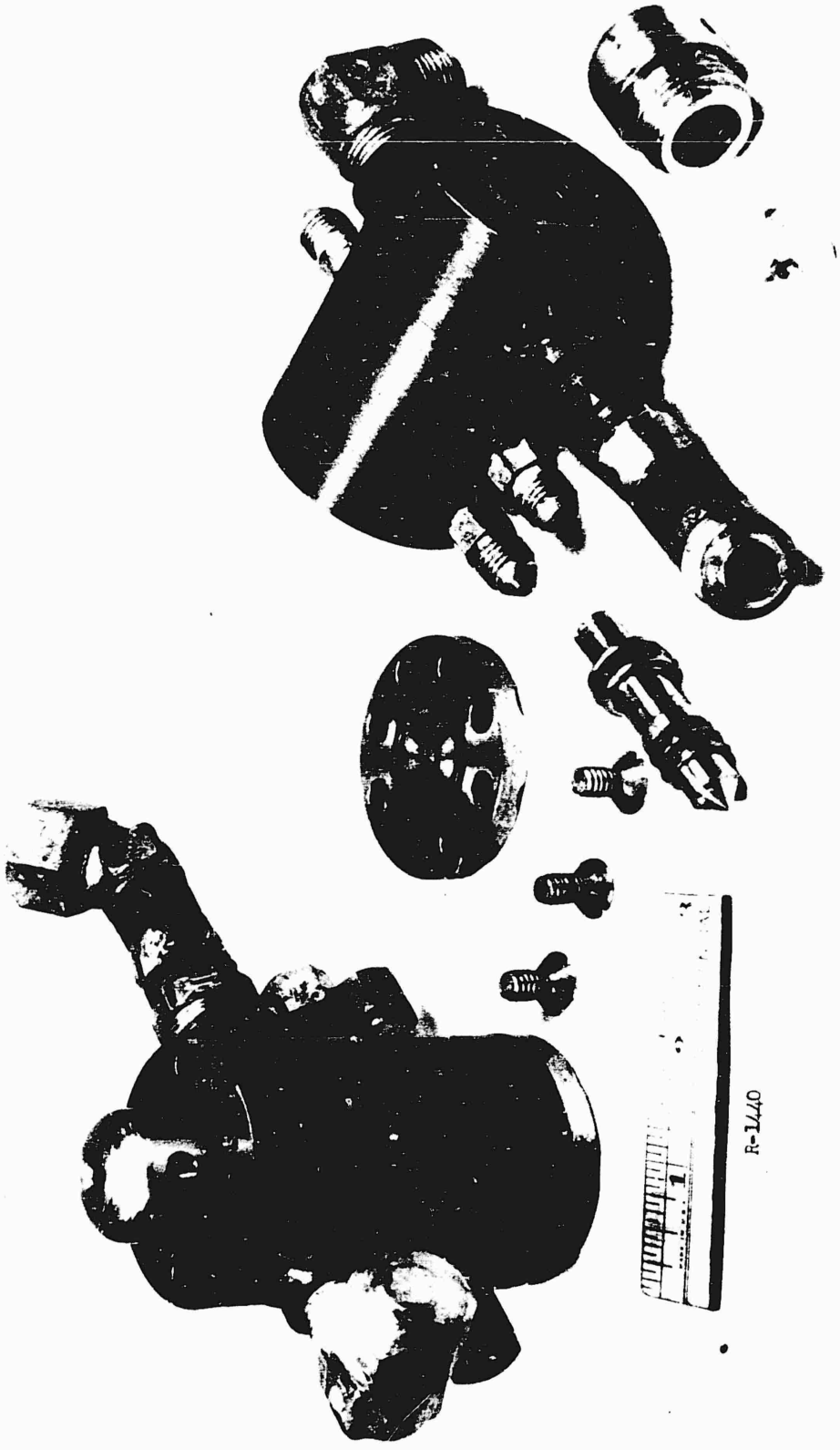
*CONTINUOUS WATER SQUIRT **INTERRUPTED WATER SQUIRT

CHART OF INJECTOR TYPES (CONTINUED)

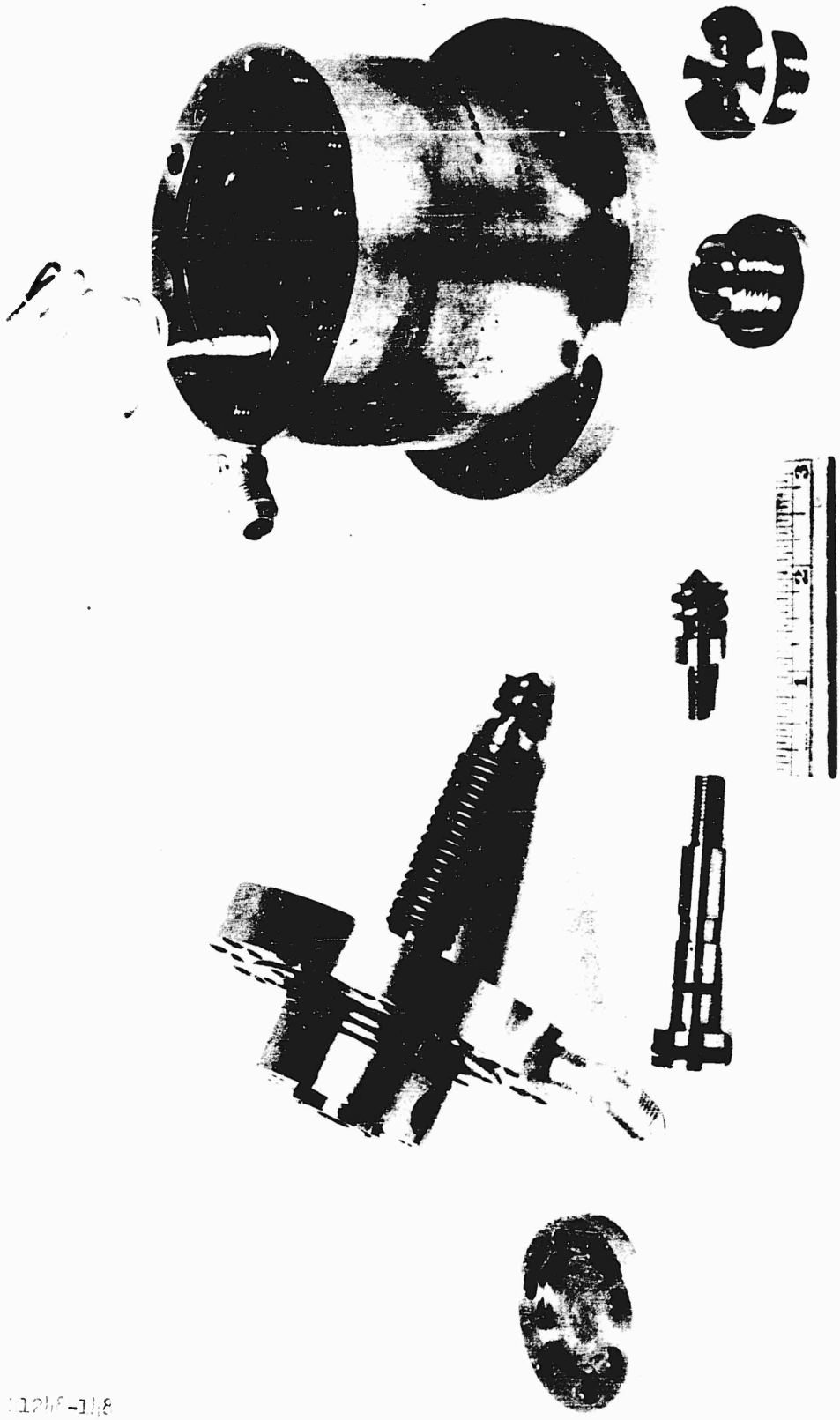
TYPE	PART NO.	PHYSICAL CHARACTERISTICS	
15	AR4586		EXTRA HIGH CAPACITY – 2 FUEL INLETS – "SPRAYCO" NOZZLE
16	AR4410		SELF CYCLING INJ. FOR 4 BARRELED MOTOR
17	AR4570		WATER METERED SELF CYCLING INJ.
18	AR4532		OIL METERED SELF CYCLING INJ.
19	AR4669		FUEL METERED SELF CYCLING INJECTOR
20	AR4719		WATER METERED SELF CYCLER WITH AUX. FUEL SHUTOFF PINTLE
21	AR4734		WATER METERED SELF CYCLER – BALL CHECK – CENTER SPRAY
22	AR4780		A REVISION OF TYPE 14 – ALL TUBE CONNECTIONS FACE AFT.
23	AR4790		"CHATTERING" PINTLE INJECTOR-SELF CYCLING – ALLOY
24	AR4700		LITHIUM CHATTERING SELF CYCLER-BELLOWS ACCUMULATOR ENCLOSED
25	AR4700		CHATTERING SELF CYCLER FOR MOLTEN LITHIUM



Injector, Type-11 Spiral-Tipped Pintle, Produces Hollow-Cone Spray



Double-Capacity Injector, Type-15, with Sprayco Nozzle



Injector Type-26, Details

MECHANISMS FOR PRODUCING THE LITHIUM SPRAY

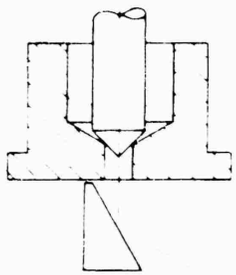
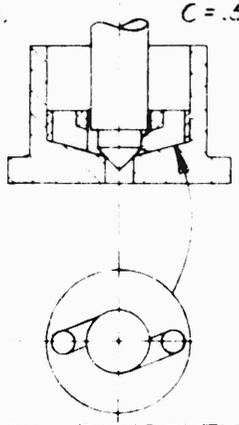
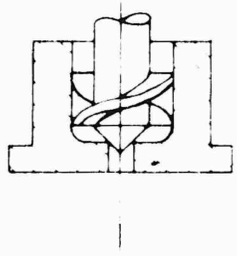
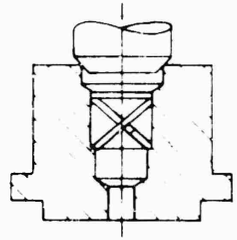
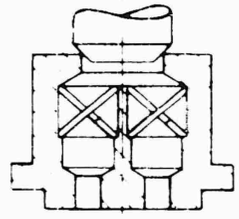
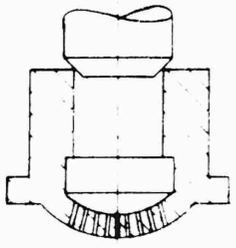
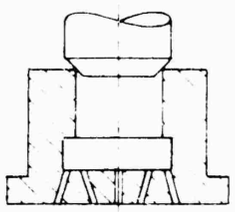
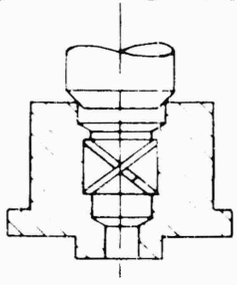
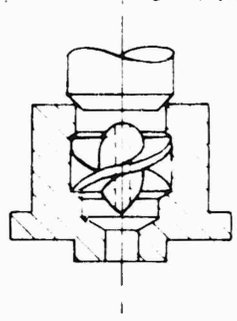
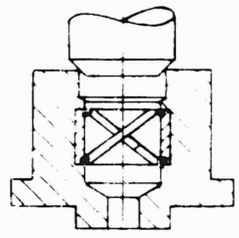
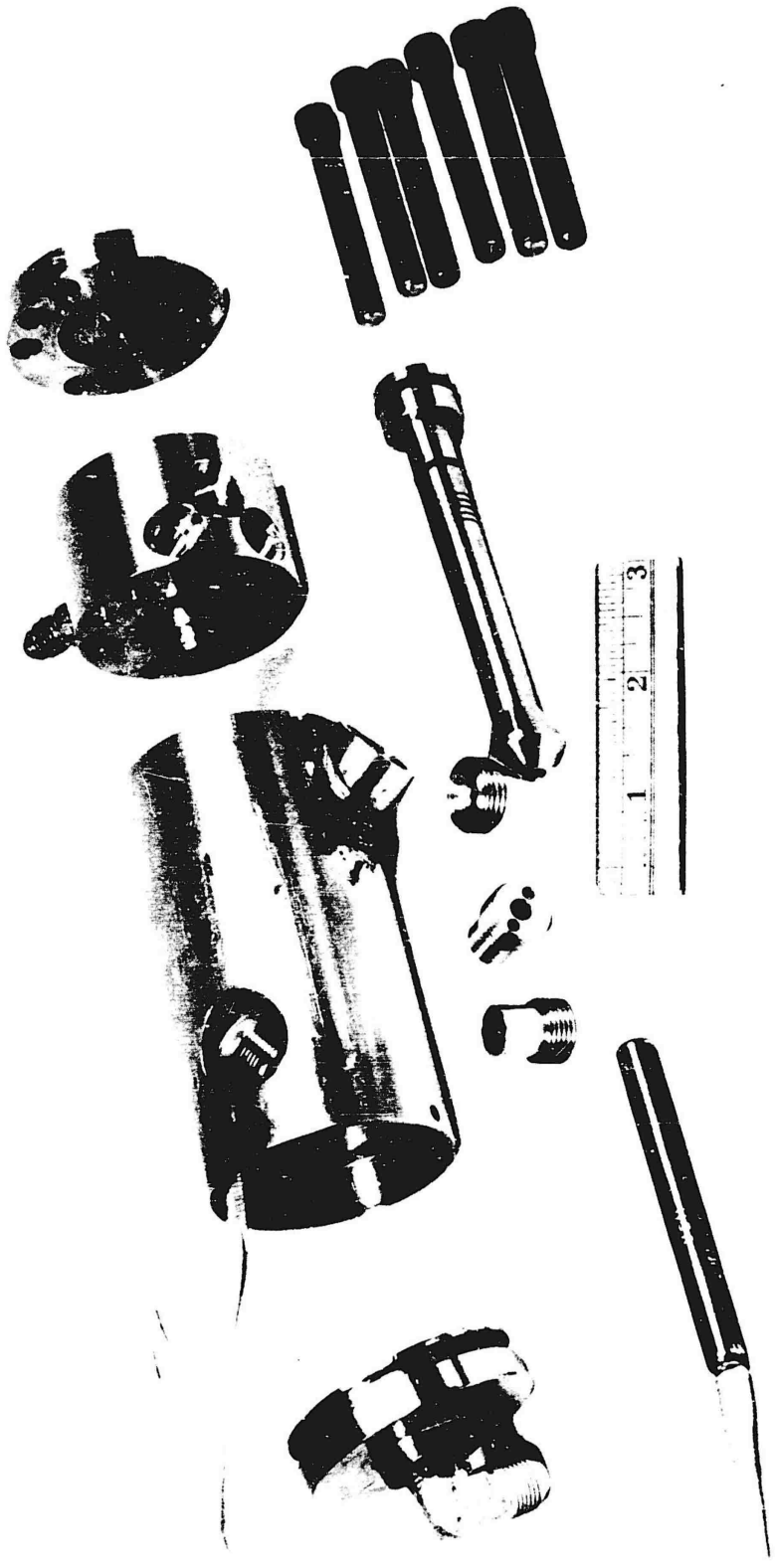
1. C = .73  DEFLECTOR PLATE ORIFICE DIA. - {.082 .128	2. C = .59  TWIN TANGENTIAL PASSAGES ORIFICE DIA. - {.128 .157	3. C = .45  SPIRAL PINTLE ORIFICE DIA. - .157	4. C = .55  #10 SPRAYCO VANE ORIFICE DIA. - .157	5. C = .59  TWIN #10 SPRAYCO VANES TWO .157 DIA. HOLES
6. C = .75  DIVERGING JETS 65 - .028 DIA. HOLES	7. C = .52  IMPINGING JETS 37 - .047 DIA. HOLES	8. C = .58  #15 SPRAYCO VANE ORIFICE DIA. - .182	9. C = .49  SPIRAL SPRAY VANE ORIFICE DIA. - .219	10. C = .55  #15 SPRAYCO VANE (REINFORCED) ORIFICE DIA. - .219

Figure 24



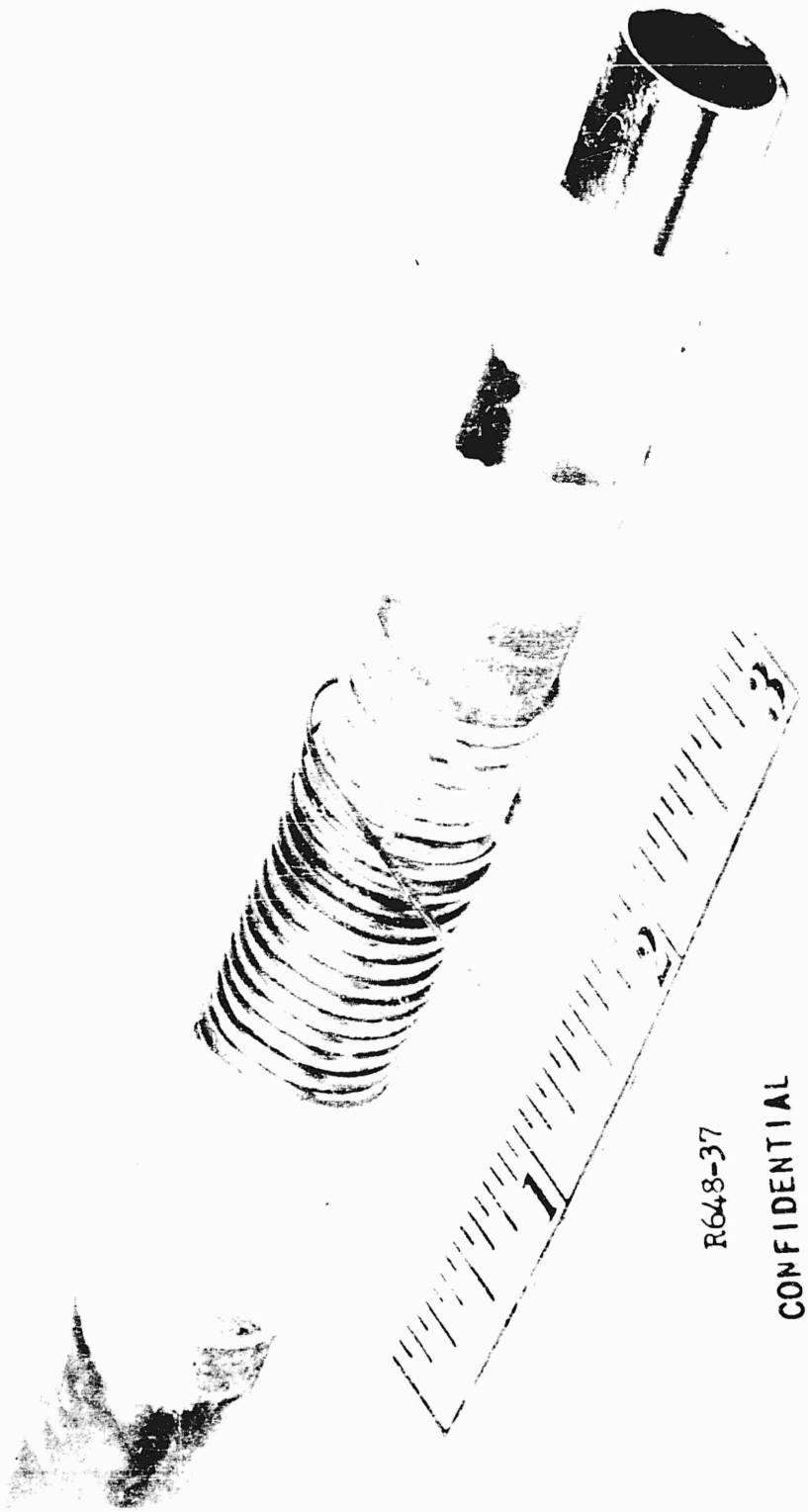
R649-65

Injector, Type-27 Details

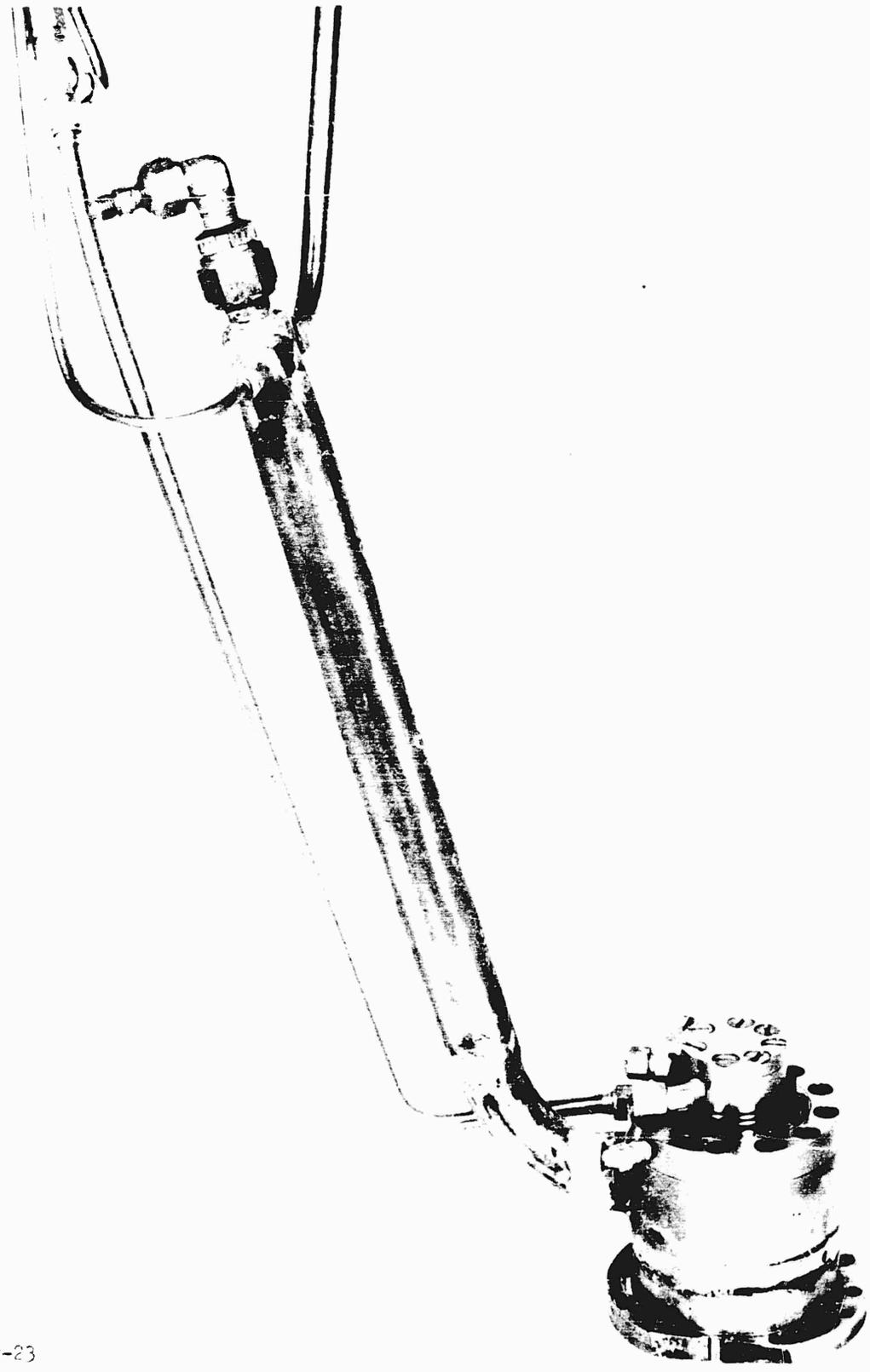
Fuel-Valving Pintle Tips, the Old and th Improved

Direct hydraulic drive, 14 ft. diameter at 14.5 rpm

Figure 27



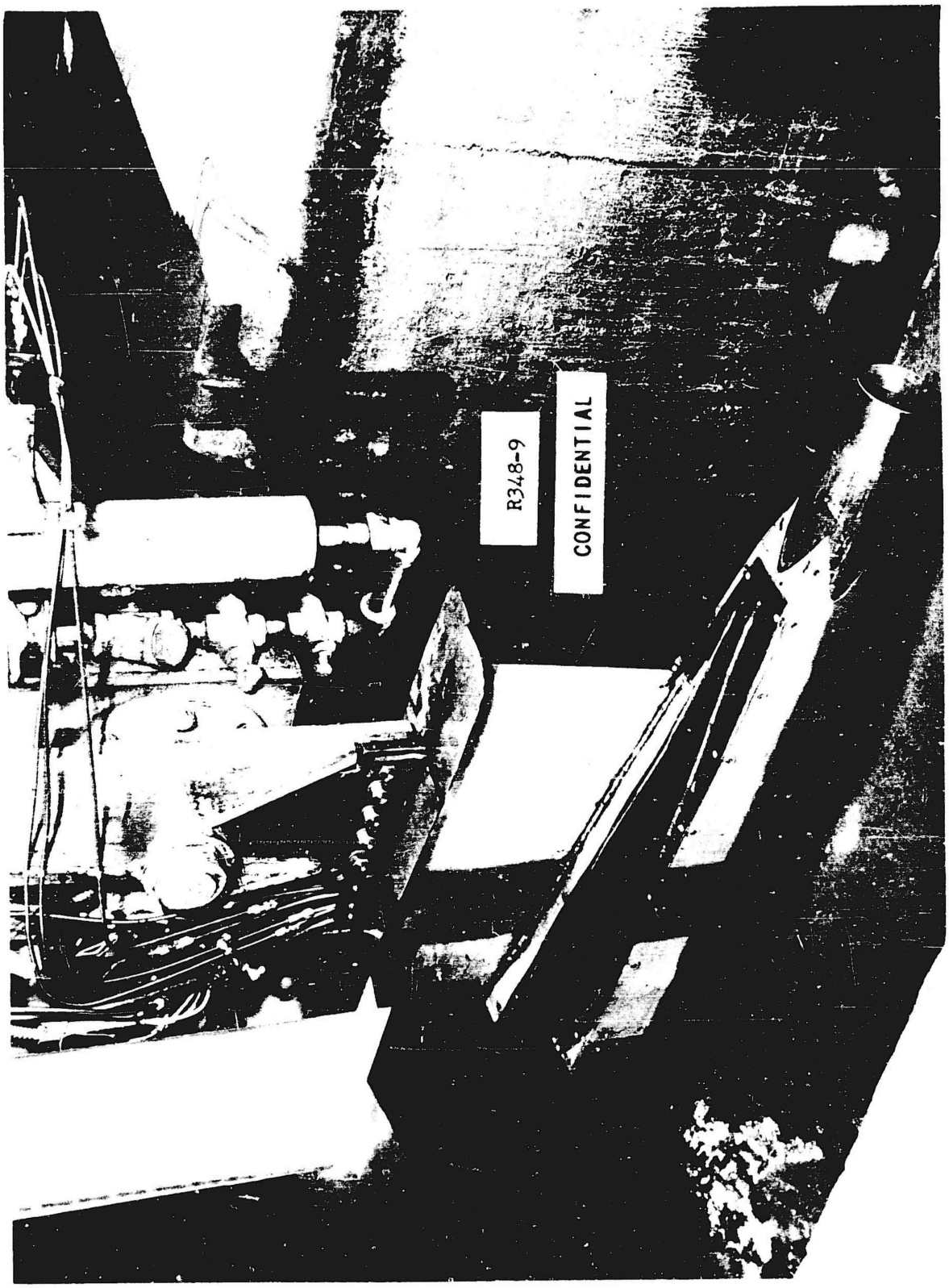
Heated Molten Lithium Fuel Line, Showing Methods of Construction



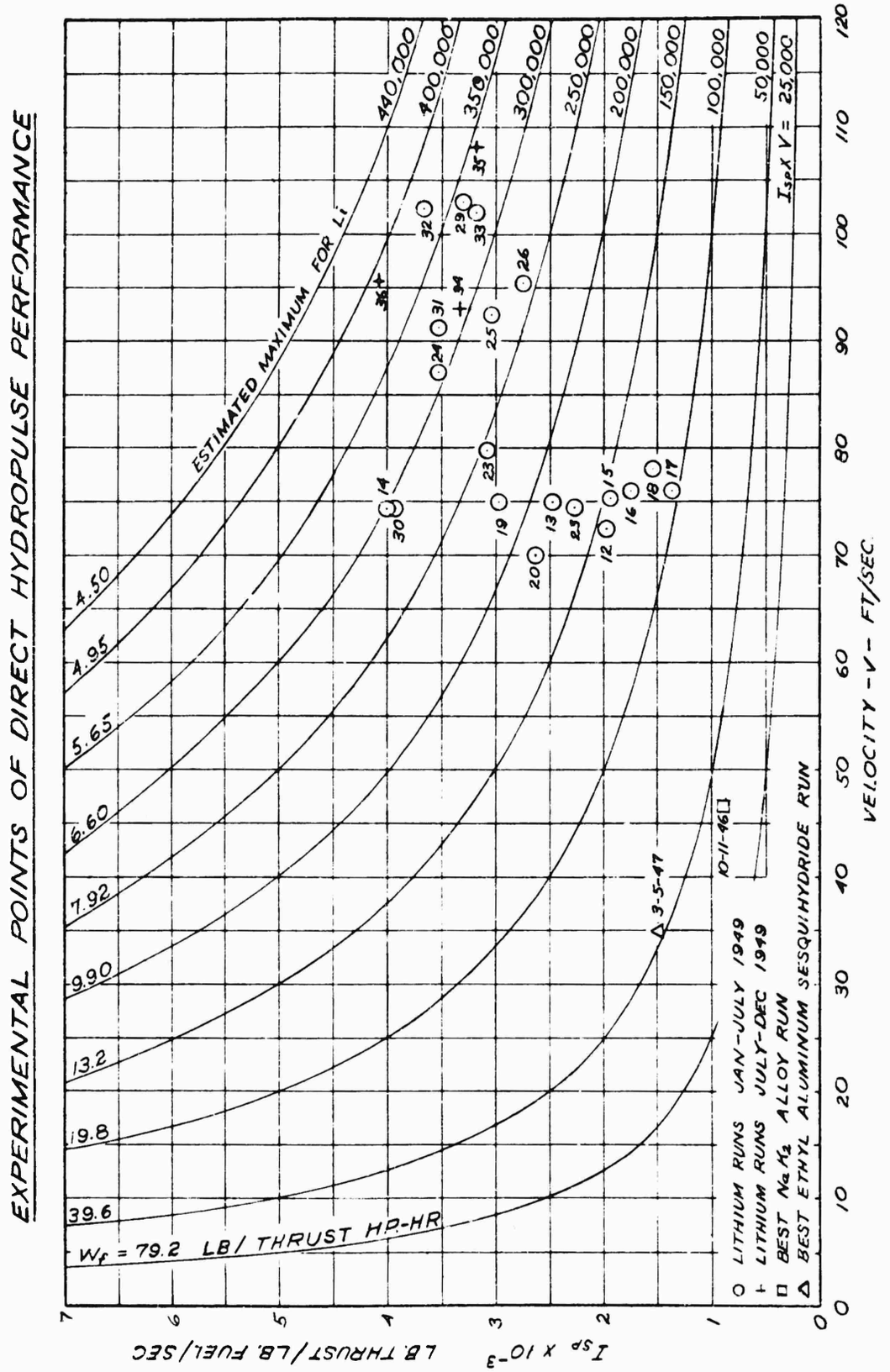
1149-23

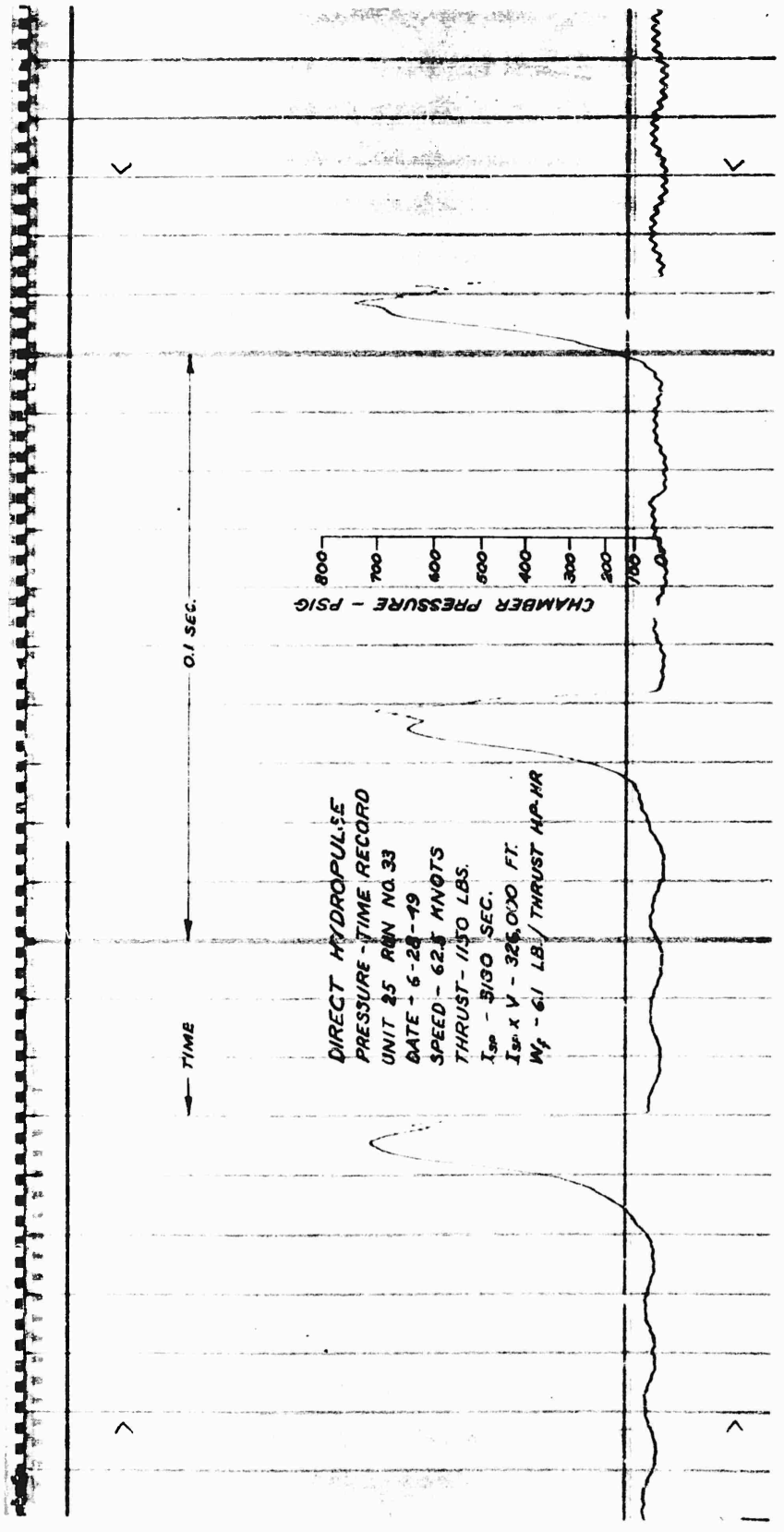
Split-Tube Water Barrier

Figure 29



Hydropulse Unit 22-B, Showing Method of Mounting on Boom


EXPERIMENTAL POINTS OF DIRECT HYDROPULSE PERFORMANCE
CURVE NO. 4022 M. HIGGINS 7-8-49 (REVISED)
ESTIMATED MAXIMUM FOR Li
4.50
4.95
5.65
6.60
7.92
9.90
13.2
19.8
39.6
W_f = 79.2 LB/ THRUST HP-HR
490,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
$I_{sp} V$ = 25,000
10-11-46
3-5-47
○ LITHIUM RUNS JAN-JULY 1949
+ LITHIUM RUNS JULY-DEC 1949
□ BEST NaK_2 ALLOY RUN
△ BEST ETHYL ALUMINUM SESQUIHYDRIDE RUN
$I_{sp} \times 10^{-3}$ LB. THRUST/LB. FUEL/SEC
VELOCITY -V- FT/SEC.


DIRECT HYDROPULSE
PRESSURE - TIME RECORD
UNIT #5 RUN NO. 33
DATE - 6-29-49
SPEED - 62.5 KNOTS
THRUST - 1150 LBS.
Isp - 5130 SEC.
Isp x V - 325,000 FT.
Wf - 6.1 LB / THRUST HP-HR
TIME
0.1 SEC.
CHAMBER PRESSURE - PSIG
800
700
600
500
400
300
200
100
0

CURVE NO. 4028 H.HIGGINS - 7-19-49

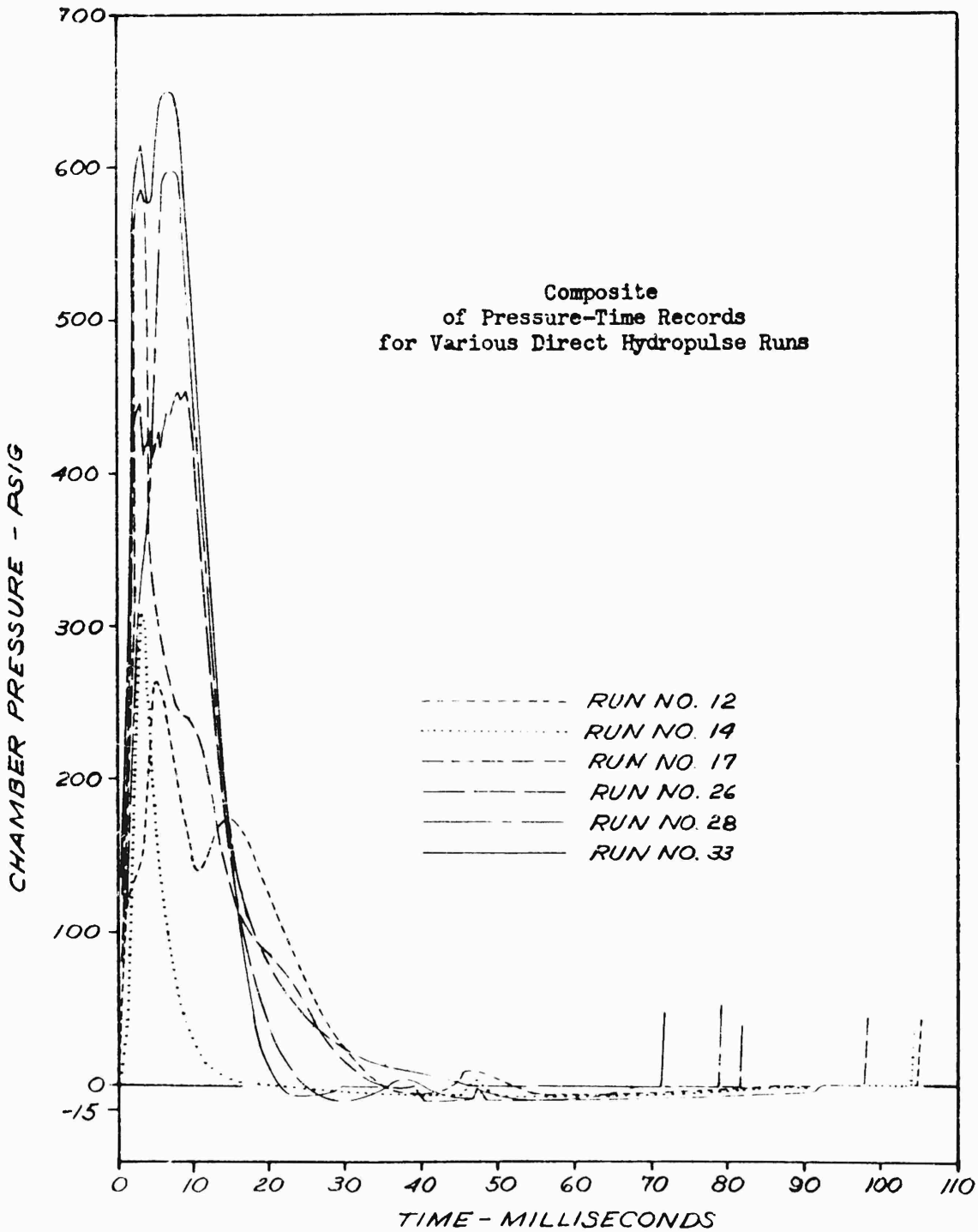


Figure 33

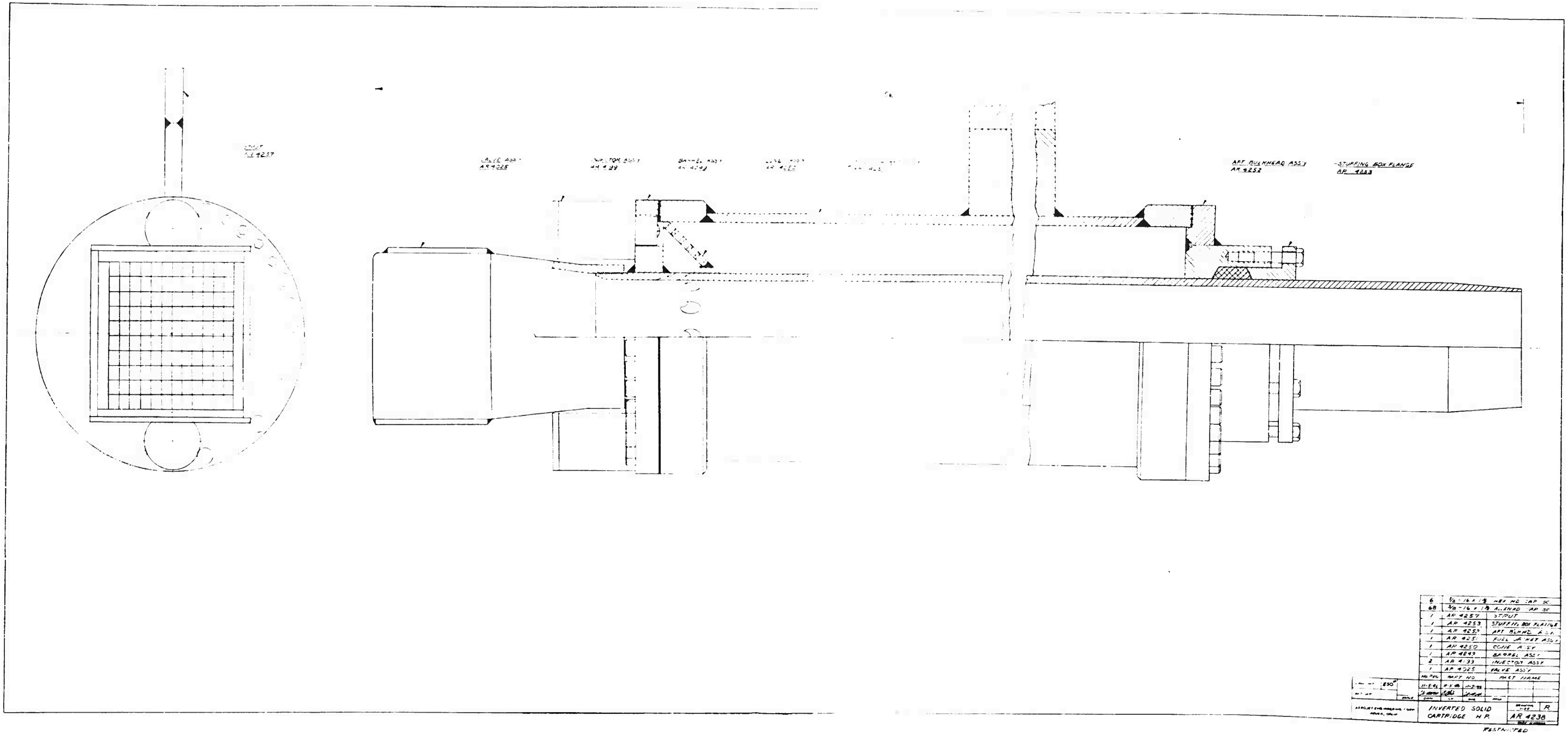
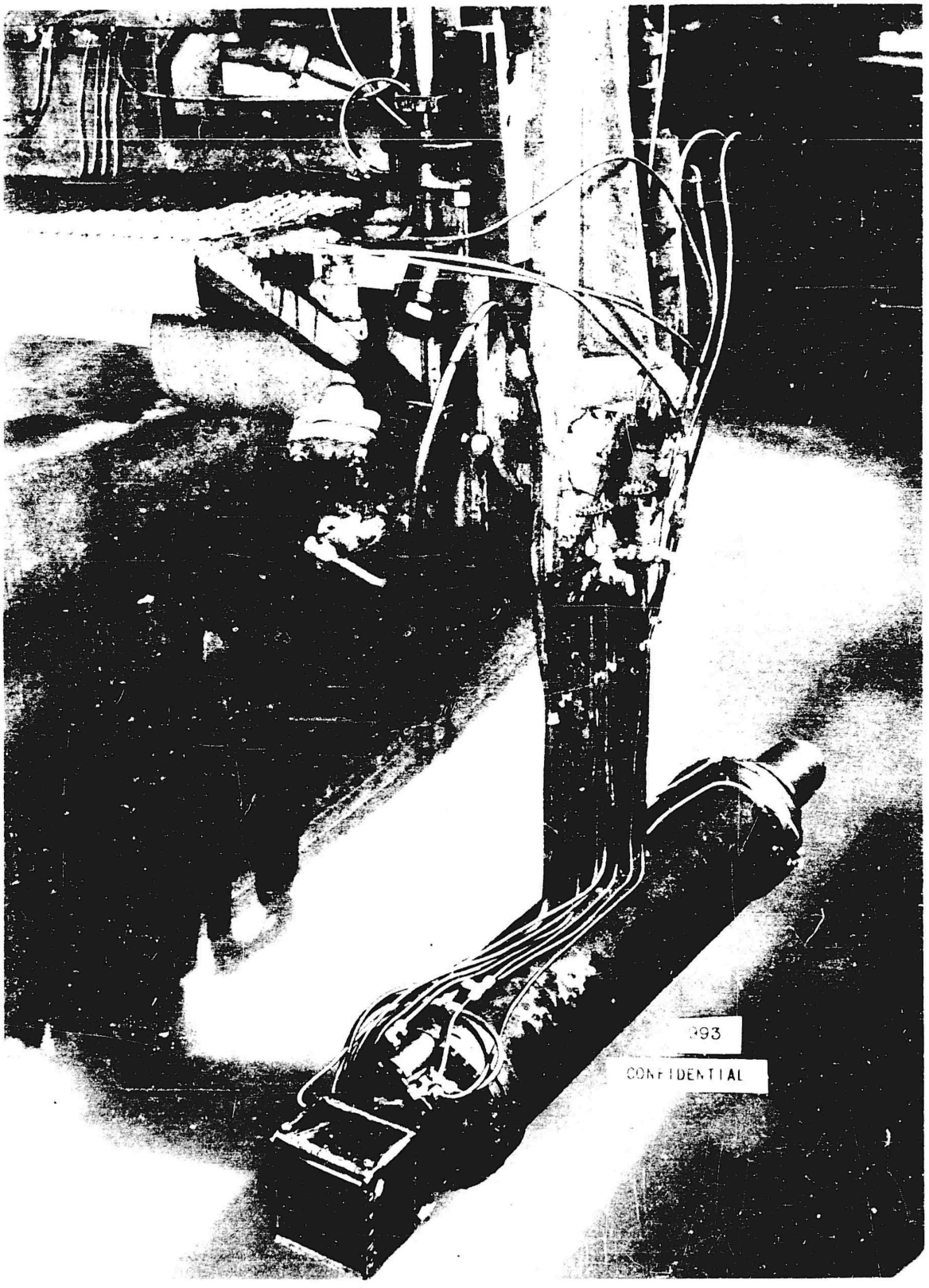
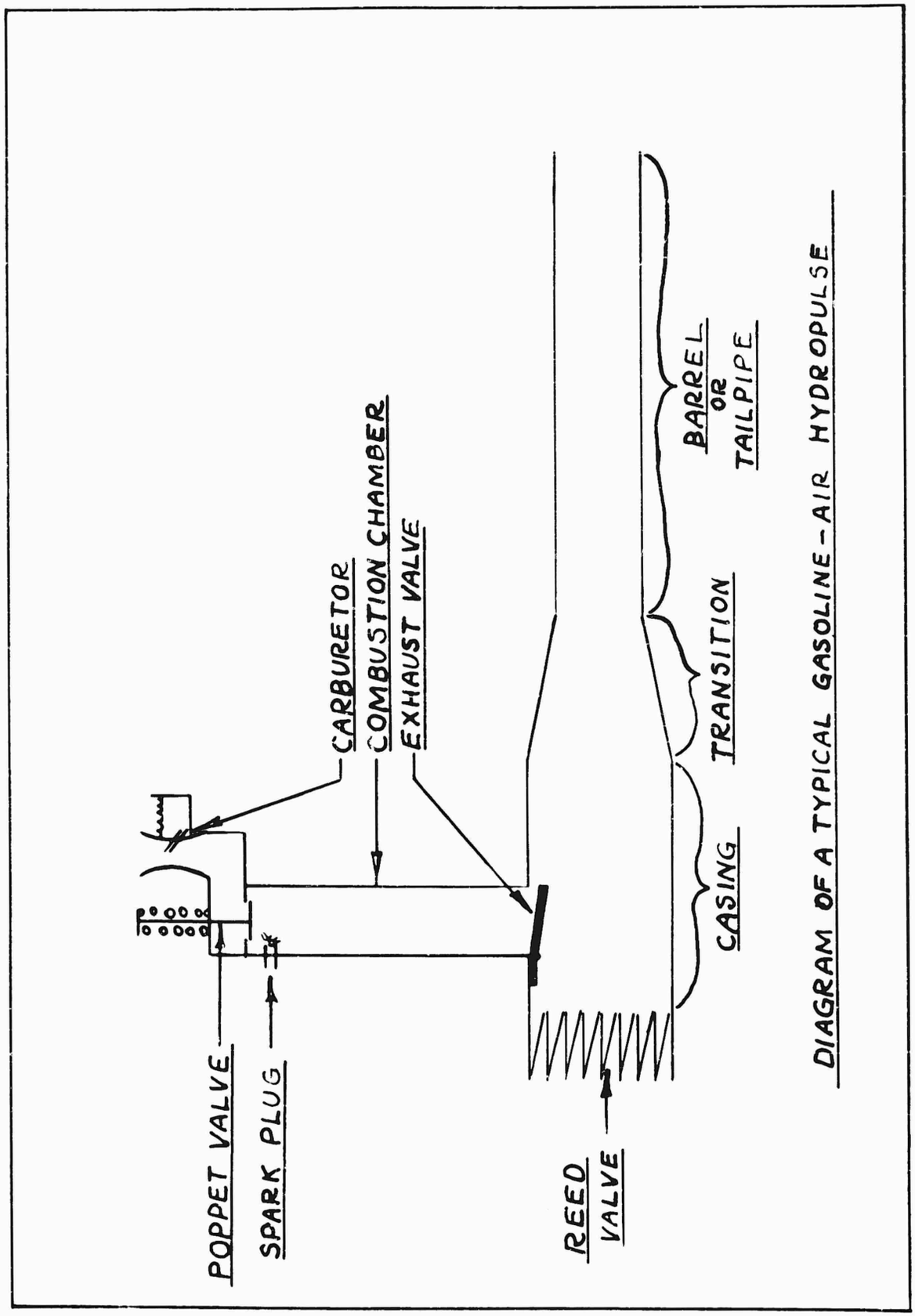


Figure 34

CONFIDENTIAL



Unit 15, Inverted Solid-Sodium Cartridge Hydropulse


POPPET VALVE
SPARK PLUG
CARBURETOR
COMBUSTION CHAMBER
EXHAUST VALVE
REED VALVE
CASING
TRANSITION
BARREL OR TAILPIPE
DIAGRAM OF A TYPICAL GASOLINE-AIR HYDROPULSE

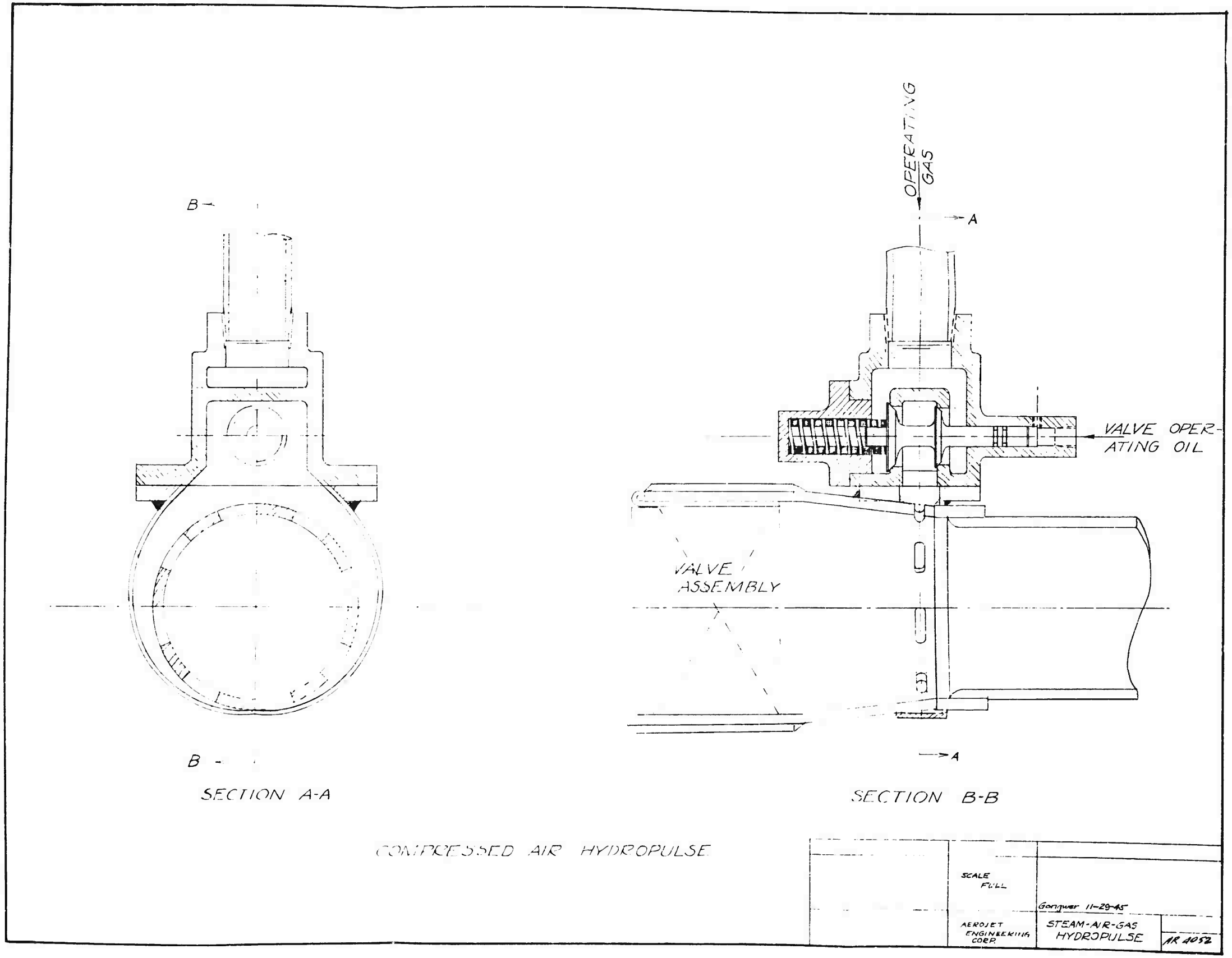
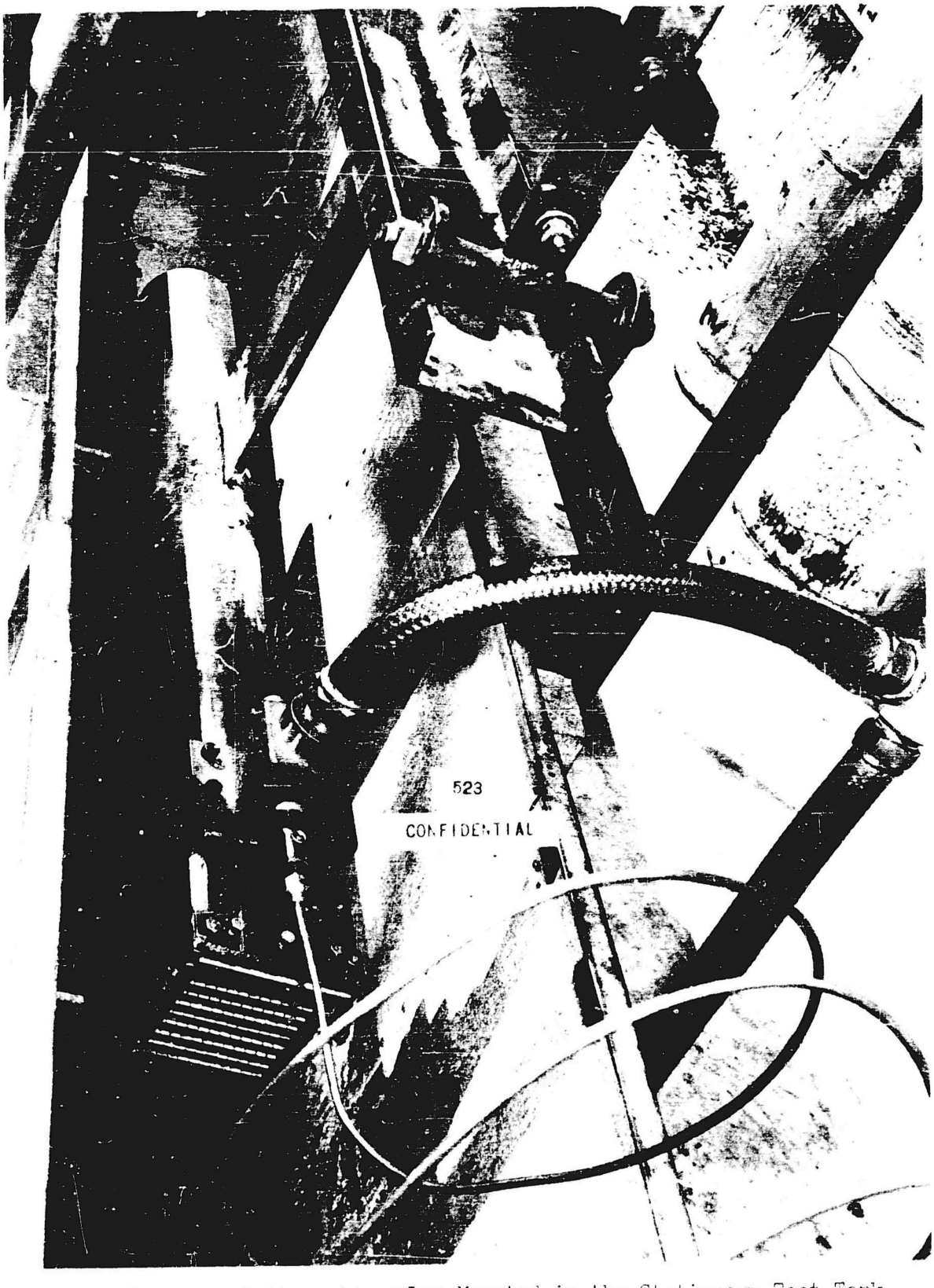
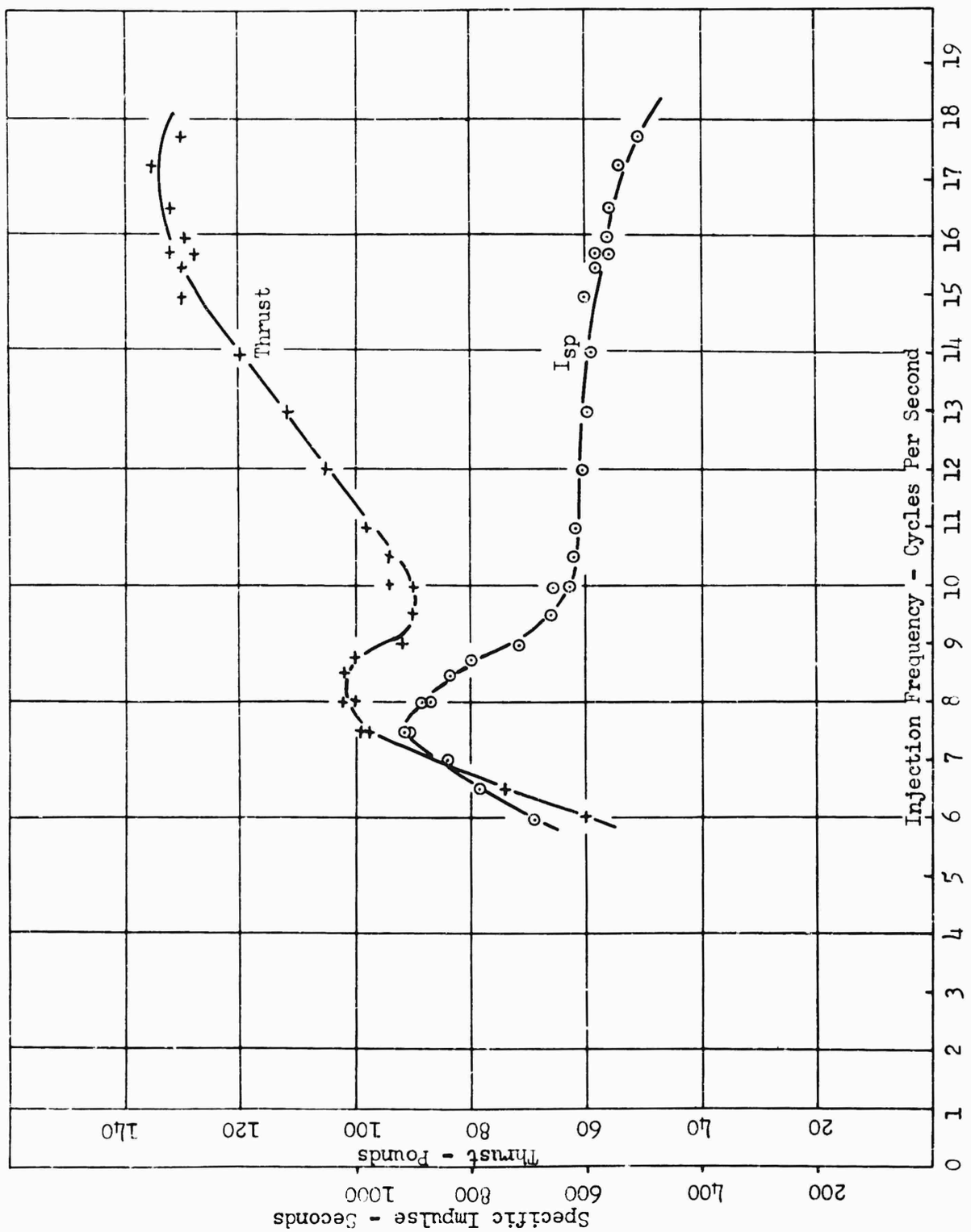

B
B -
SECTION A-A
OPERATING GAS
A
VALVE OPERATING OIL
VALVE ASSEMBLY
A
SECTION B-B
COMPRESSED AIR HYDROPULSE
SCALE FULL
Gorriguer 11-29-45
AEROJET ENGINEERING CORP.
STEAM-AIR-GAS HYDROPULSE
AR 1052

Figure 37

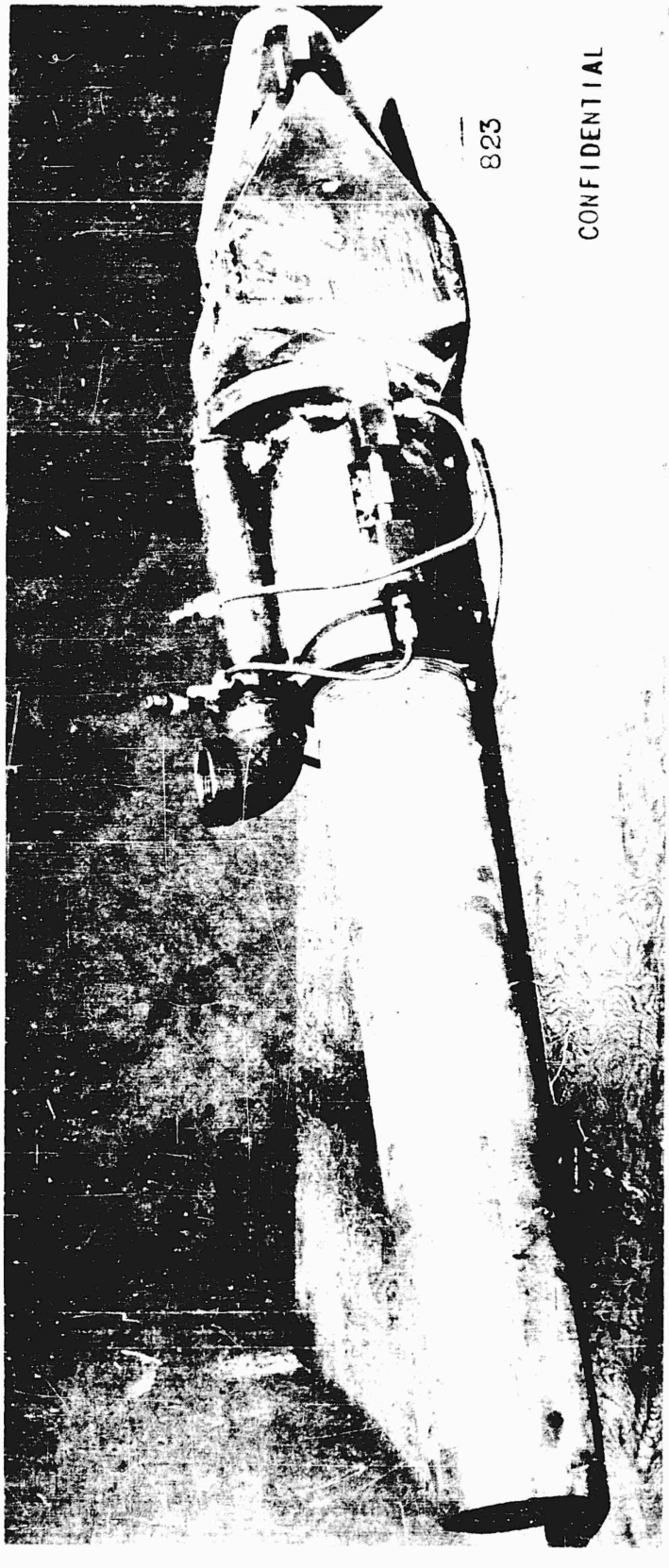


Compressed-Air Hydro-pulse Mounted in the Stationary Test Tank



Performance vs Injection Frequency, Single Barrel, 4" Diameter 3'-0" Long
Inlet Air Pressure 250 Psig, Compressed Air Hydropulse, Zero Speed

Figure 39



Assembly of Nitromethane Gas Hydropulse

Figure 40

Sleeve-Valve Nitromethane Hydropulse Disassembled

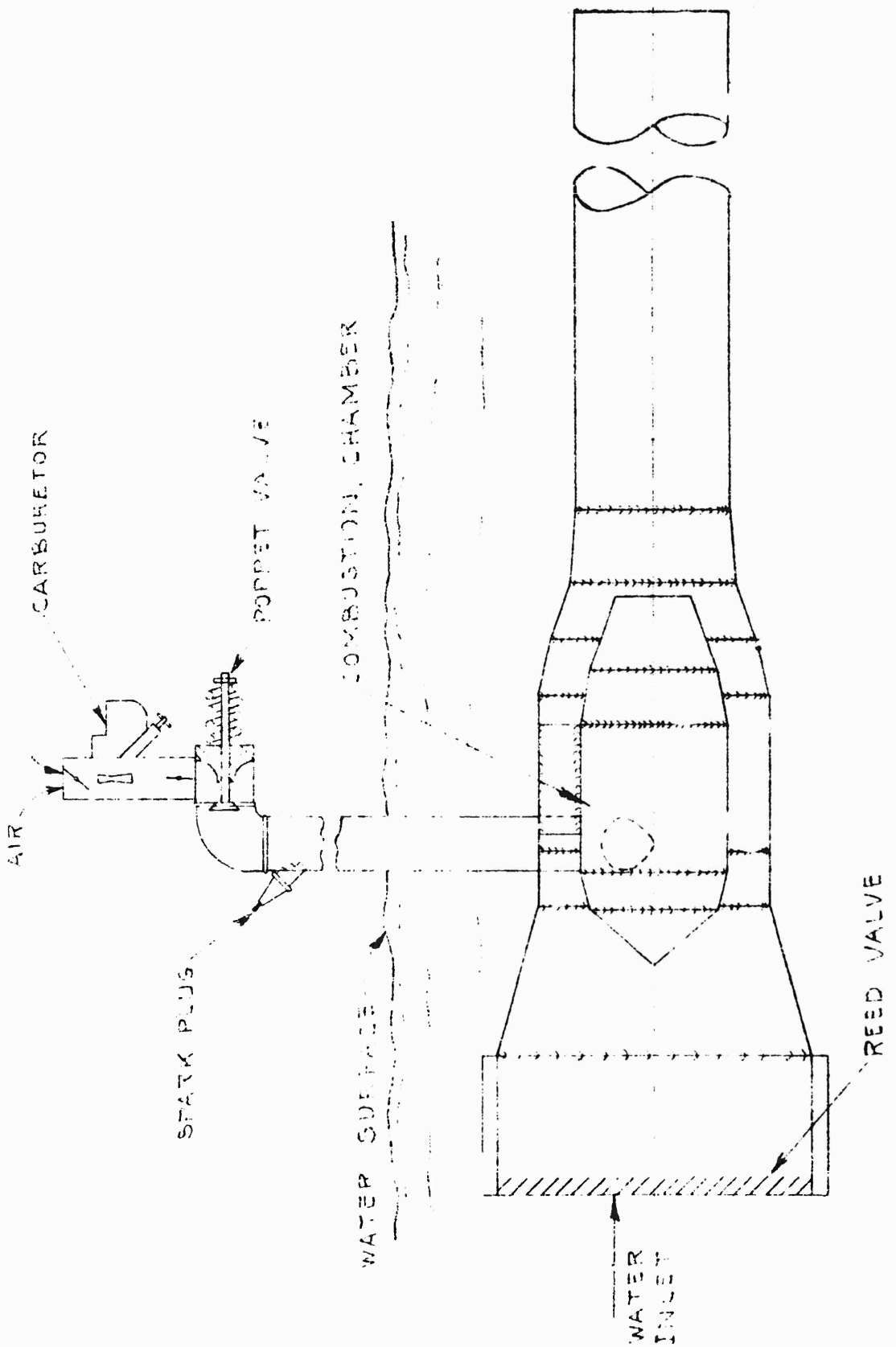


DIAGRAM OF GASOLINE - AIR HYDROPULSE

Figure 42

MISCELLANEOUS G.A.H. MODELS

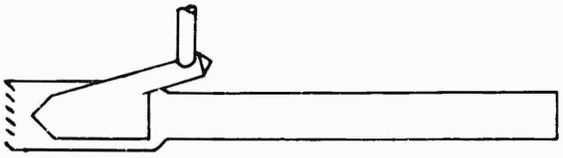
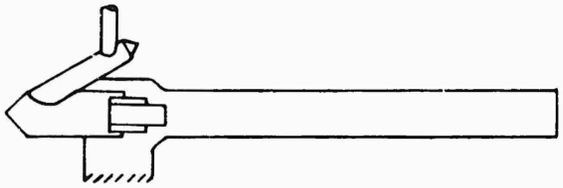
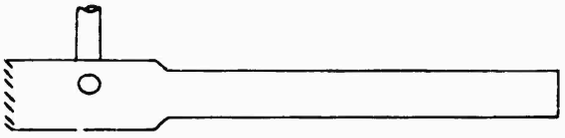
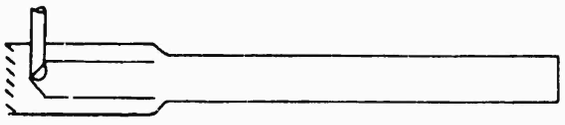
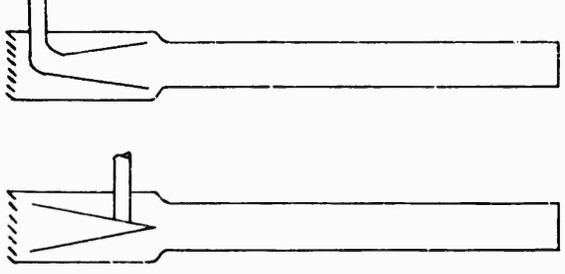
SKETCH	MODEL NO.
	G.A.H.-24
	G.A.H.-31
	G.A.H.-32
	G.A.H.-35
	G.A.H.-36
	G.A.H.-37
	G.A.H.-38
	G.A.H.-39

Figure 43

MISCELLANEOUS G.A.H. MODELS

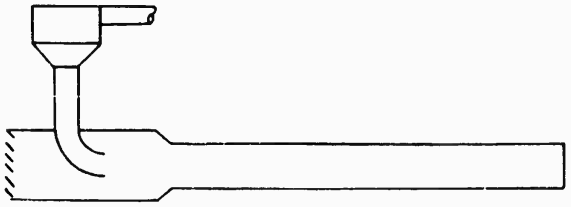
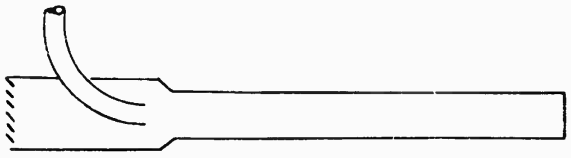
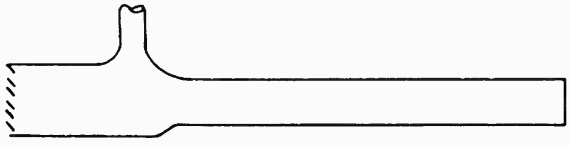
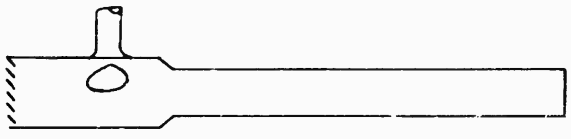
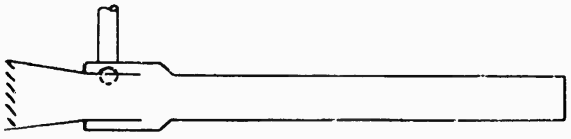
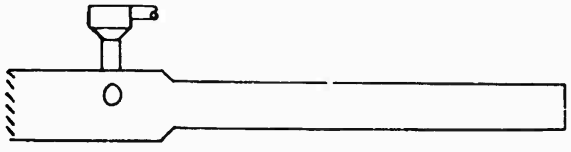
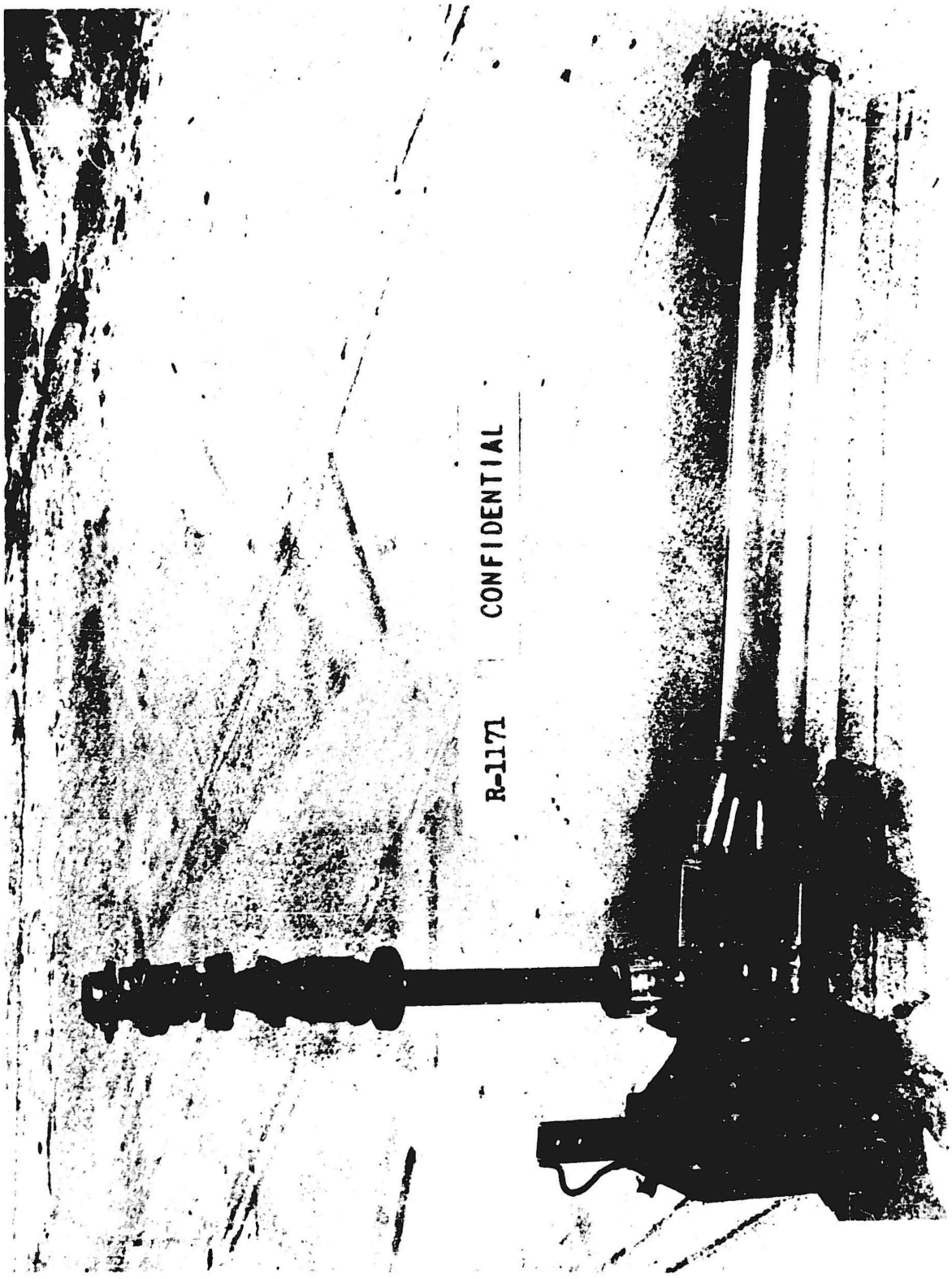
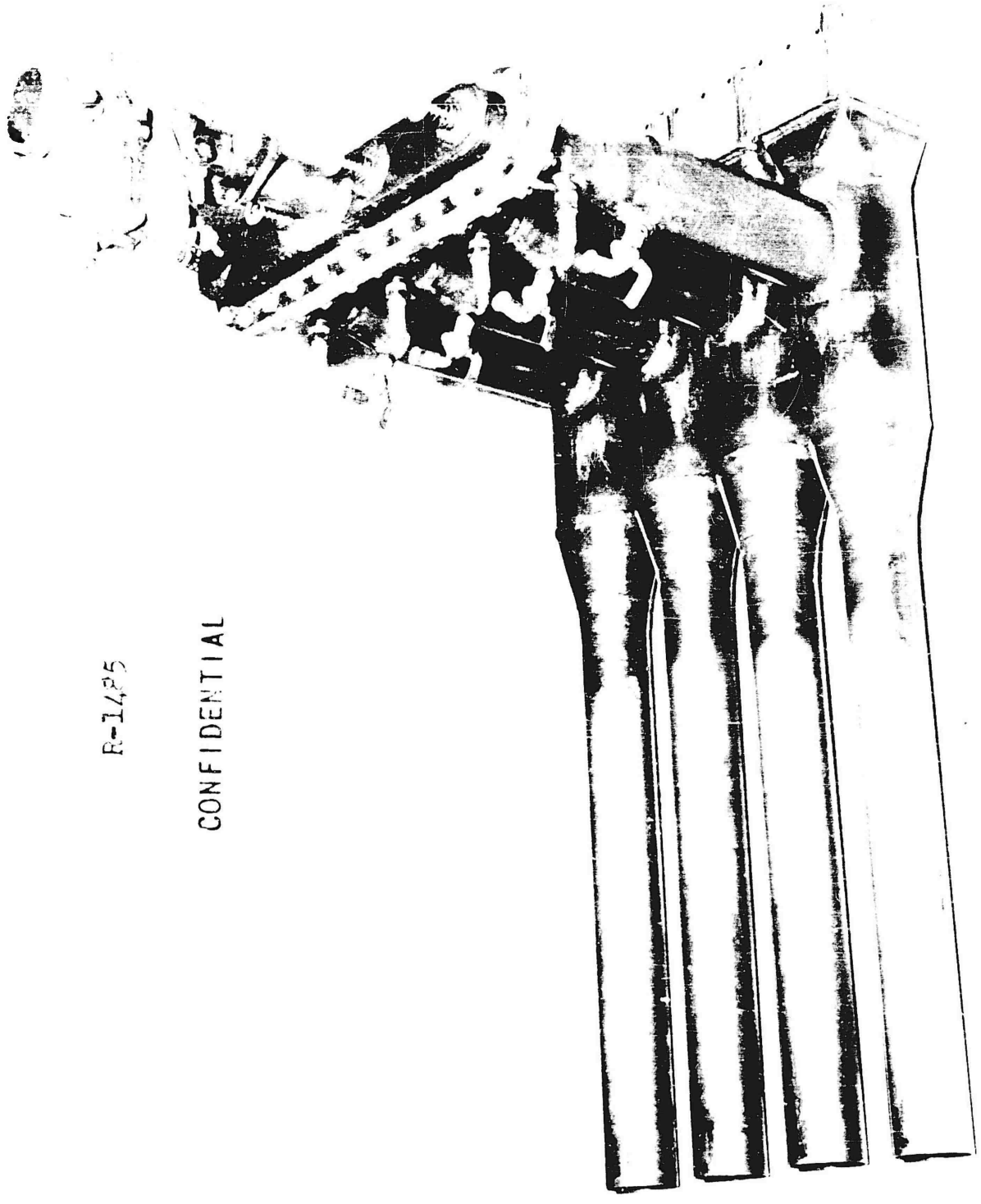
SKETCH	MODEL NO.
	G.A.H.-40
	G.A.H.-41
	G.A.H.-42
	G.A.H.-43
	G.A.H.-44
	G.A.H.-46A

Figure 44



Lucite Model of Gasoline-Air Hydropulse

...rcite Model



R-1485

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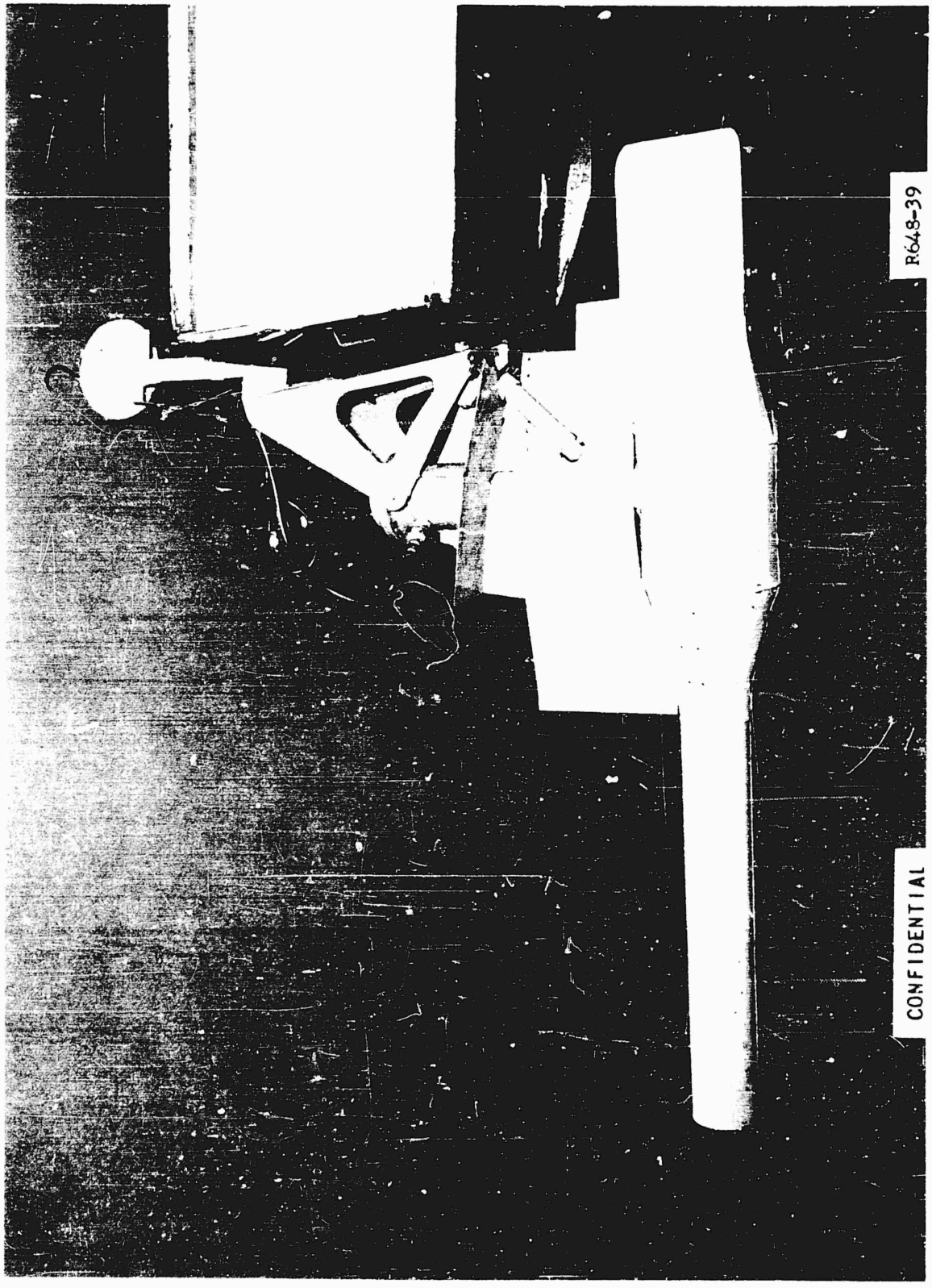
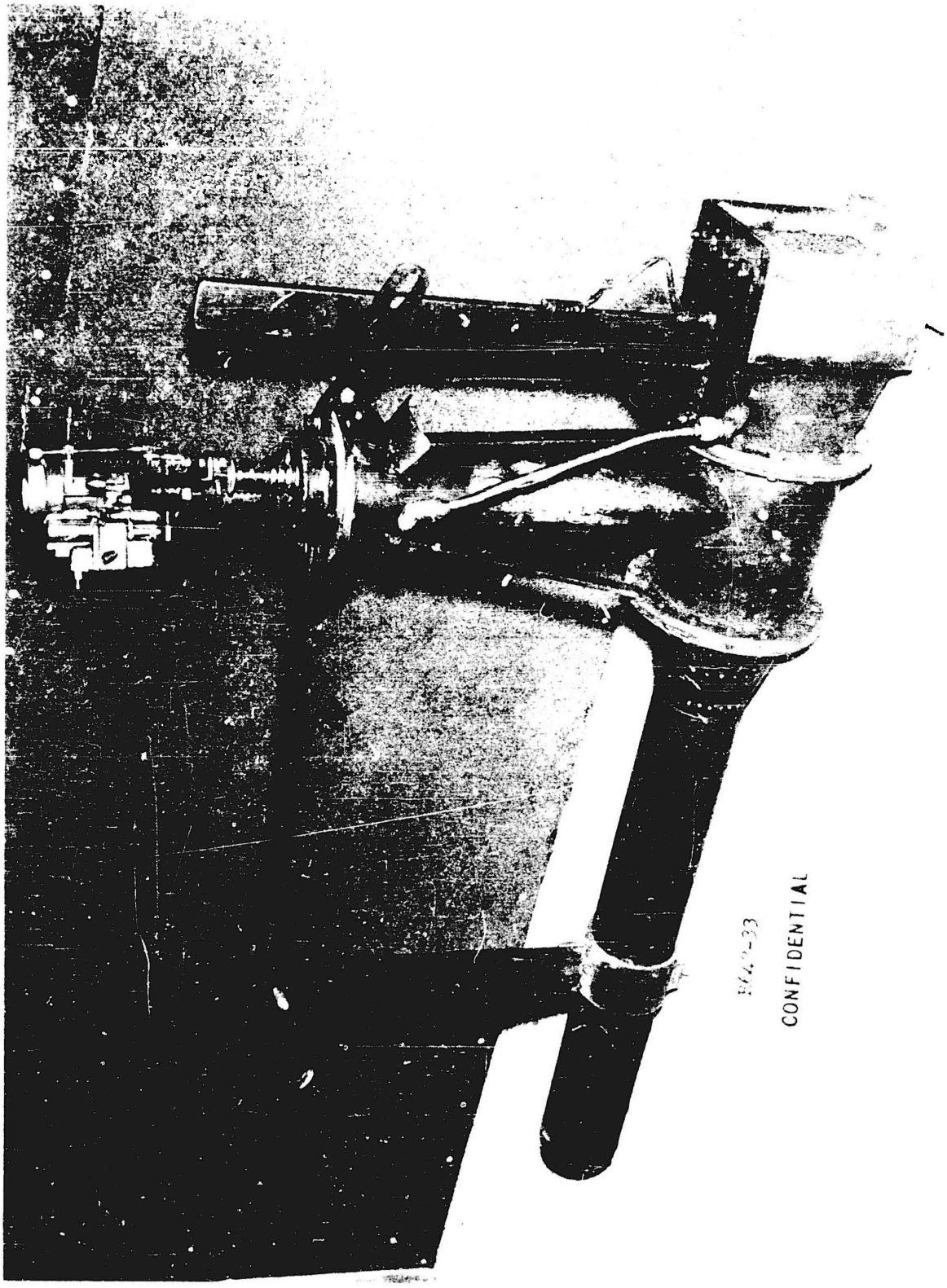
A Four-Ducted Rotor



A Streamlined Unit Mounted on the Skiff for Dynamic Testing



XAH-92 Assembly

M42-33

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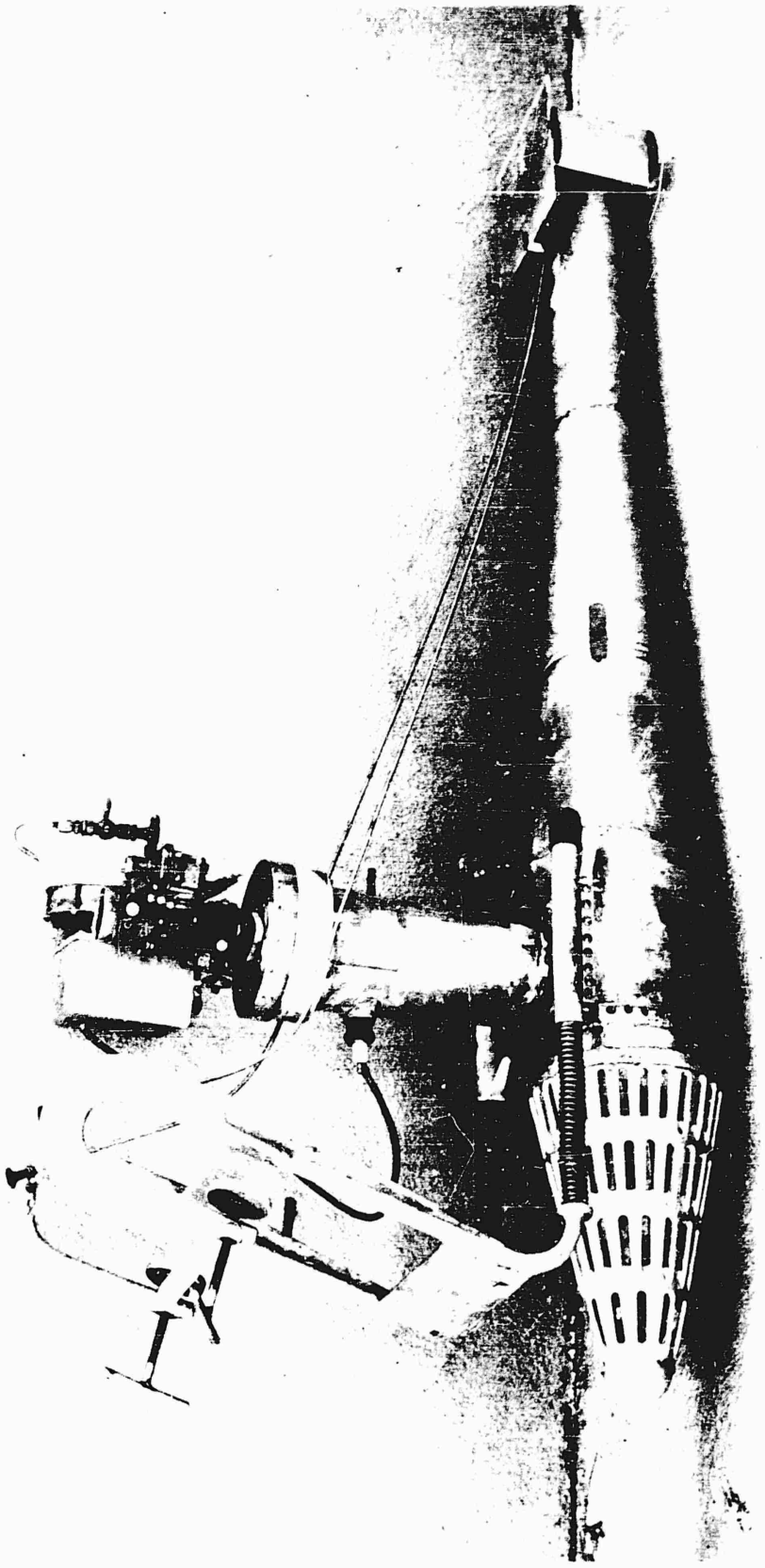
Figure 49

Streamlined model mounted on the 14-ft boat

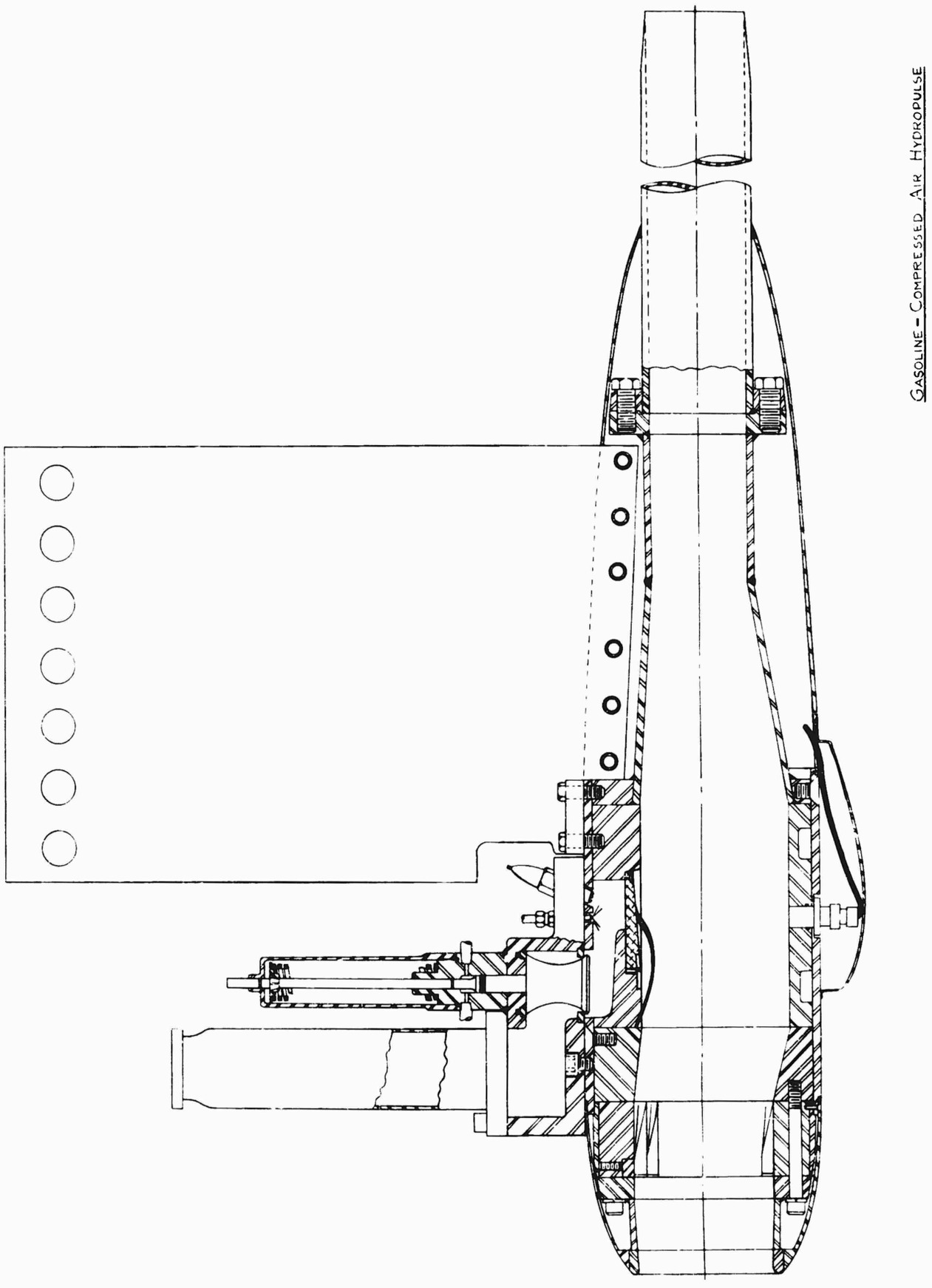


CAE-106 Complete with Magneto

Figure 51

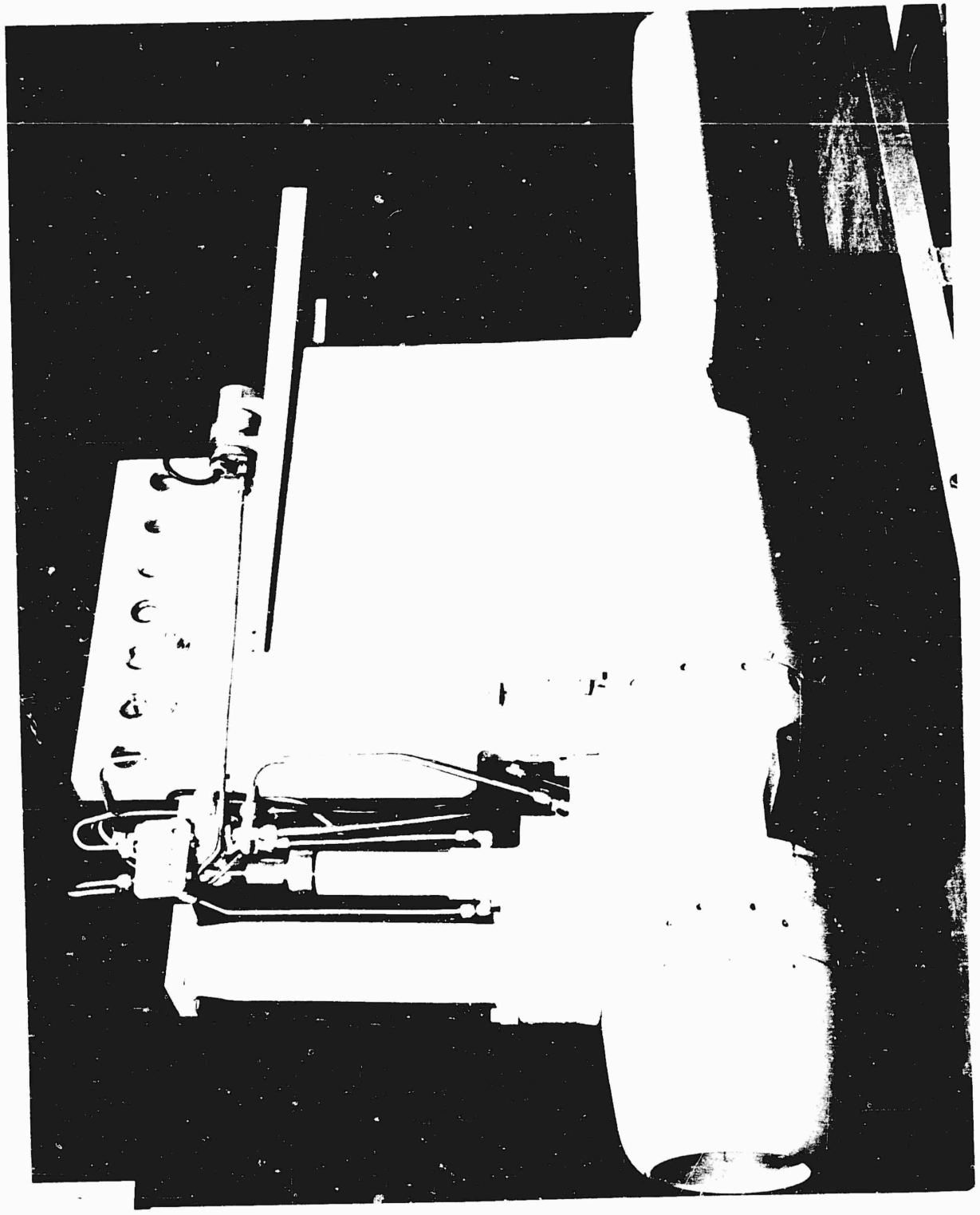
Standard-Grid Reed Valve

87\9-19

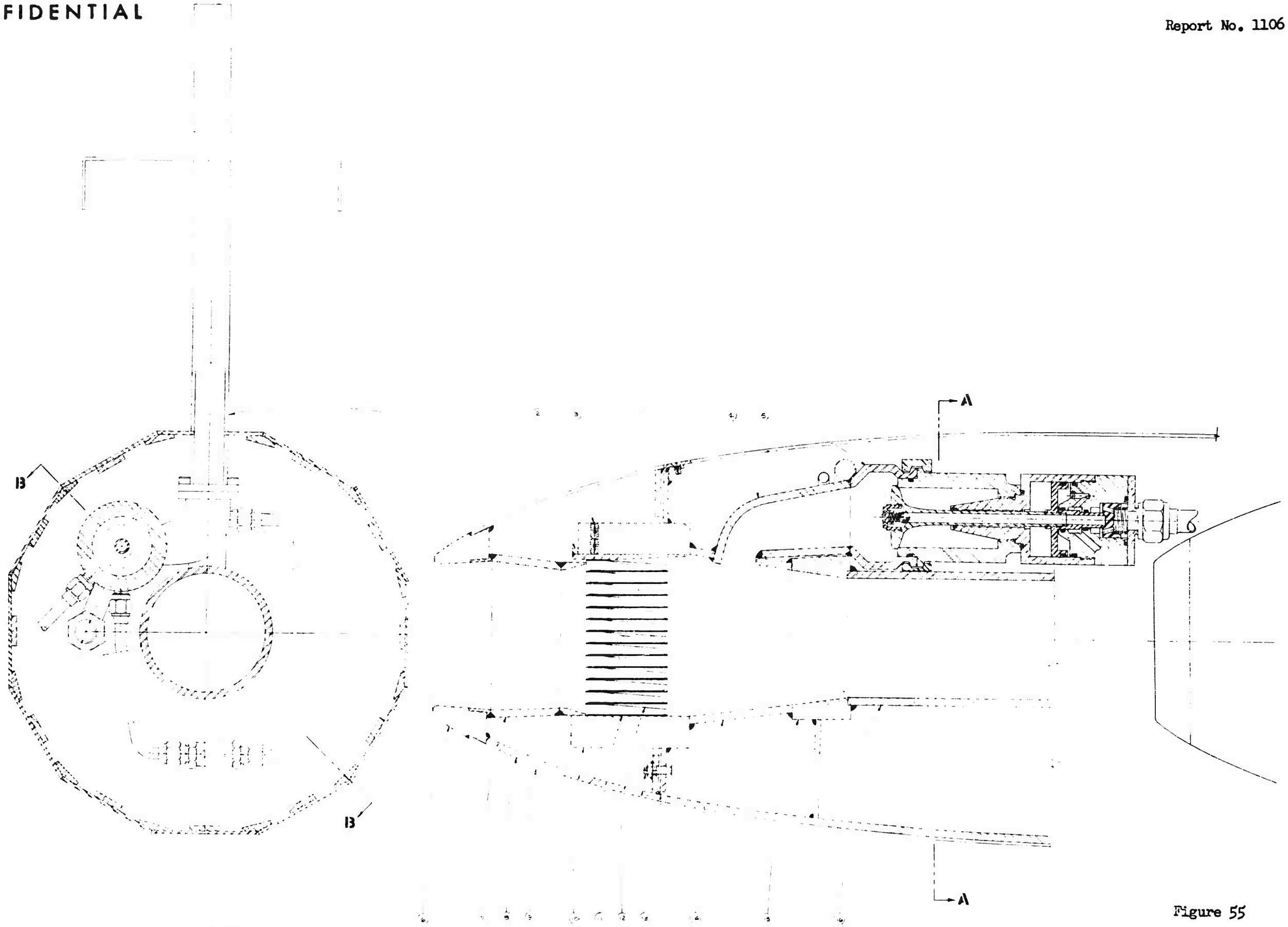


GASOLINE - COMPRESSED AIR HYDROPULSE

Figure 53



View of a Gasoline-Air Hydropulse



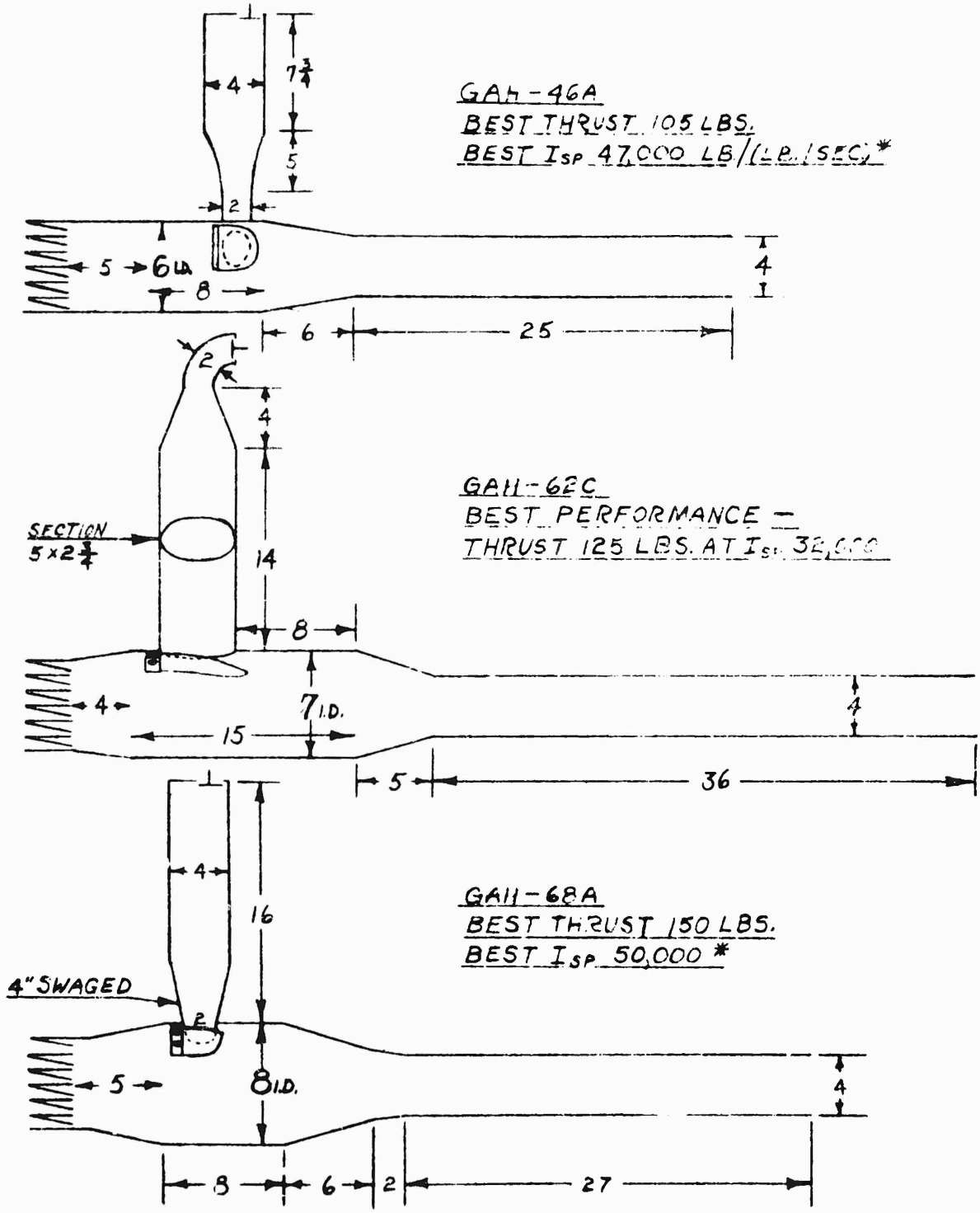
SECTION A-A

SECTION B-B

Figure 55

Mark II Gas-Air Hydropulse

View of AAF-263L Showing the Rubber Flap Valve

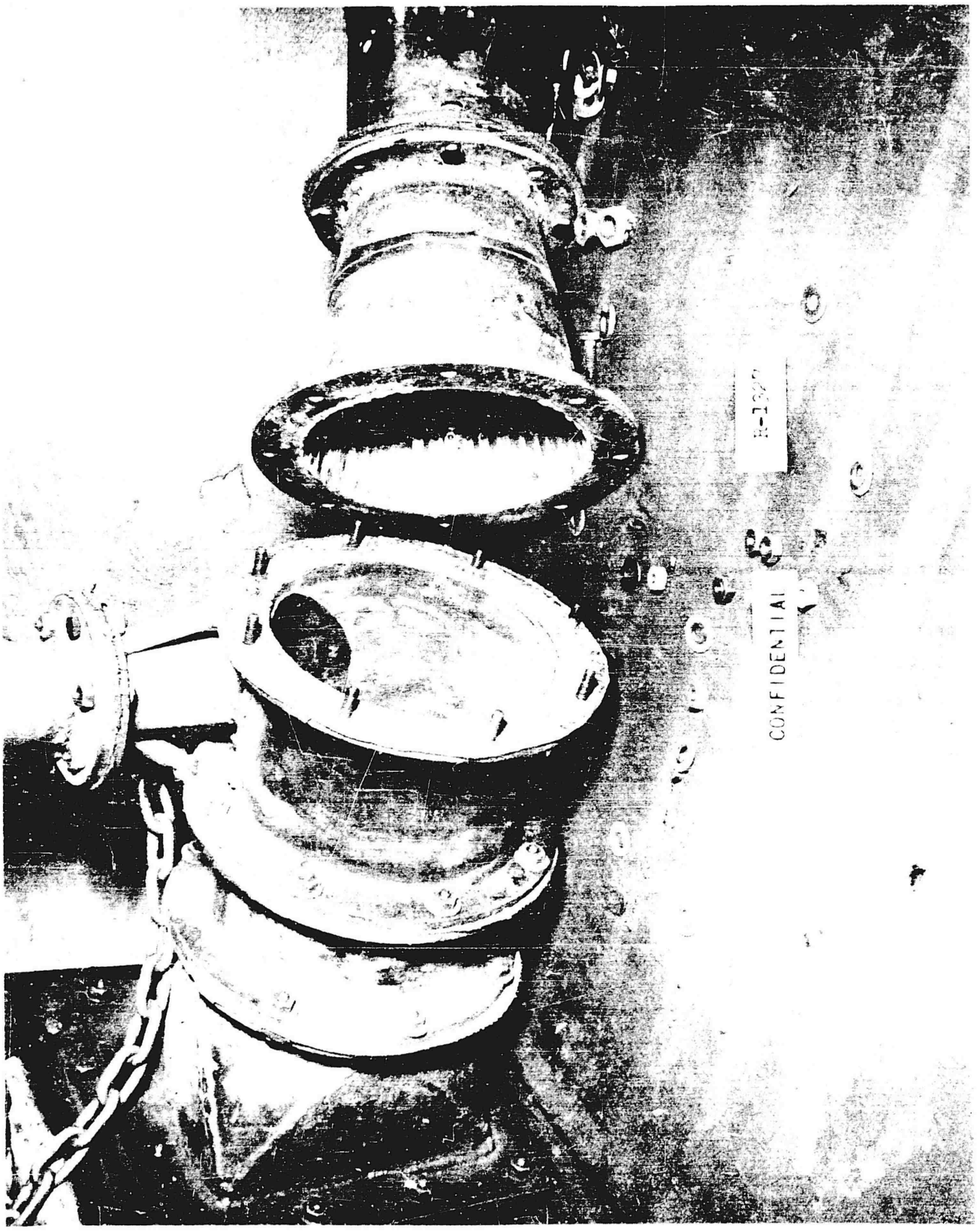


DIAGRAMS OF THE BEST GEOMETRY DETERMINED TO DATE FOR GASOLINE-AIR HYDROPULSES WITH 6", 7", AND 8" CASINGS.

*NOT AT THE THRUST GIVEN.

Most Advantageous Duct Shapes for Gasoline-Air Hydropulse

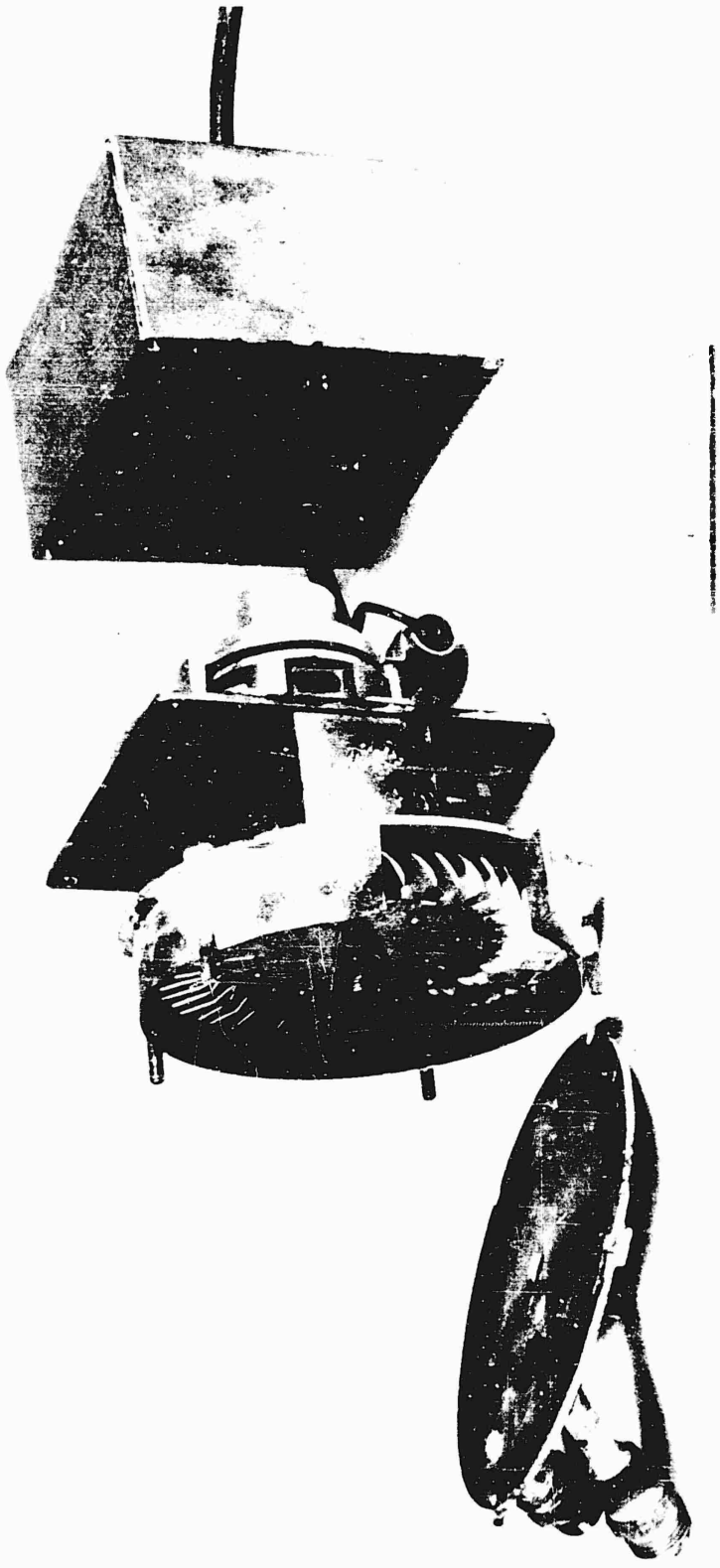
Figure 57



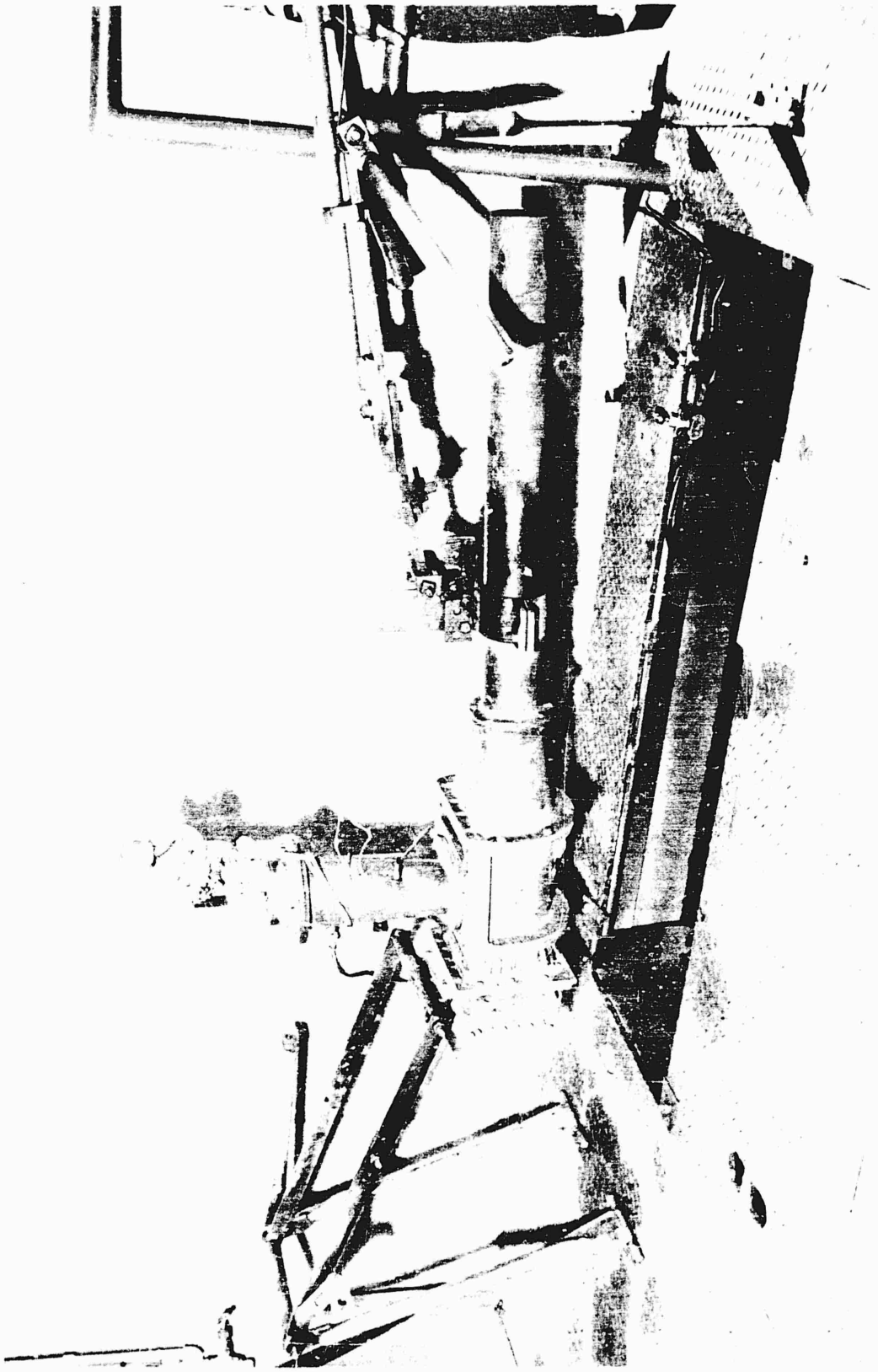
All Transmission Section, Showing Leaf-Spring Check Valves

Figure 18

Details of the Metal Combustion-Chamber Exhaust Valve for XB-47

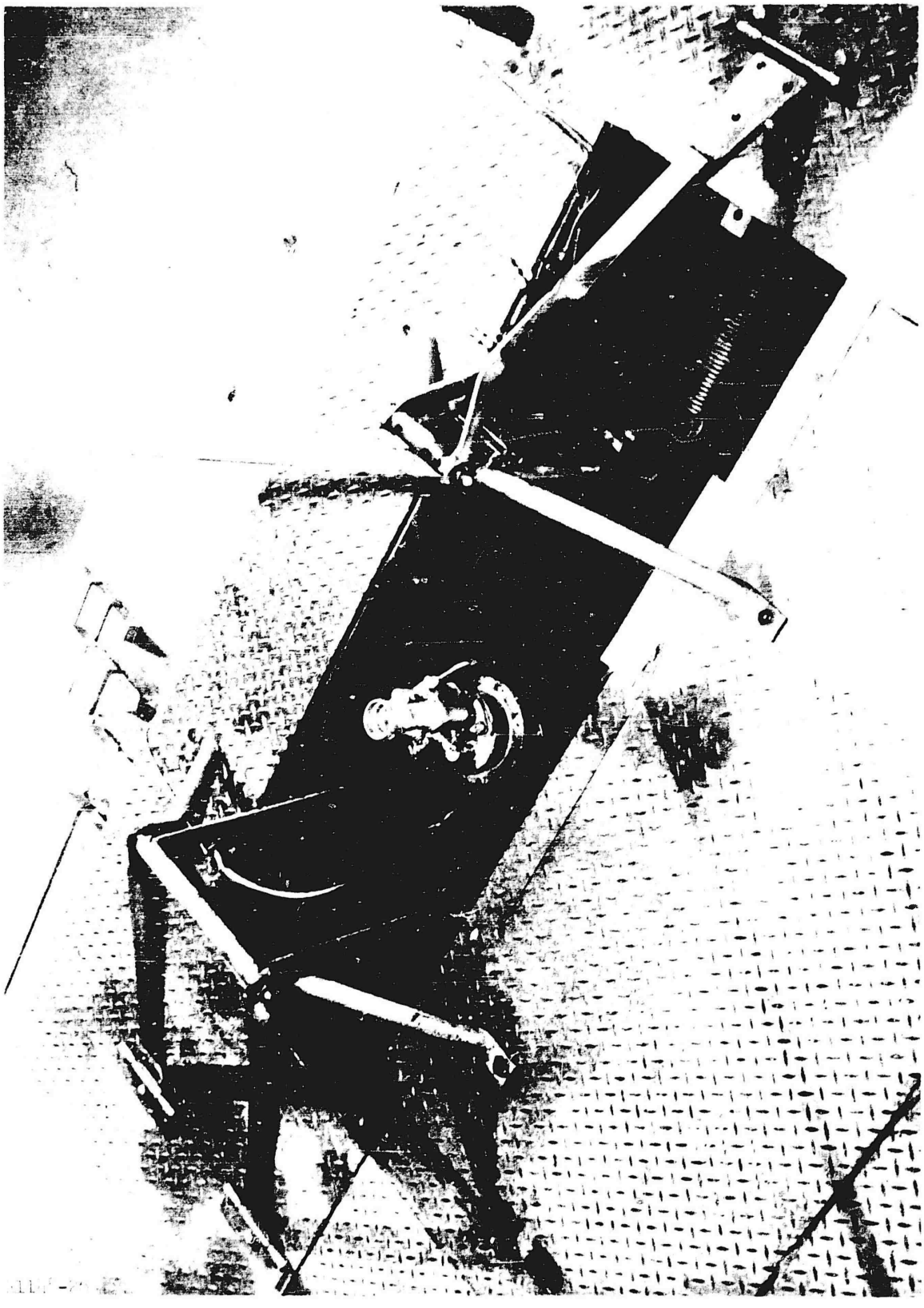


The Turbo-Magneto Ignition



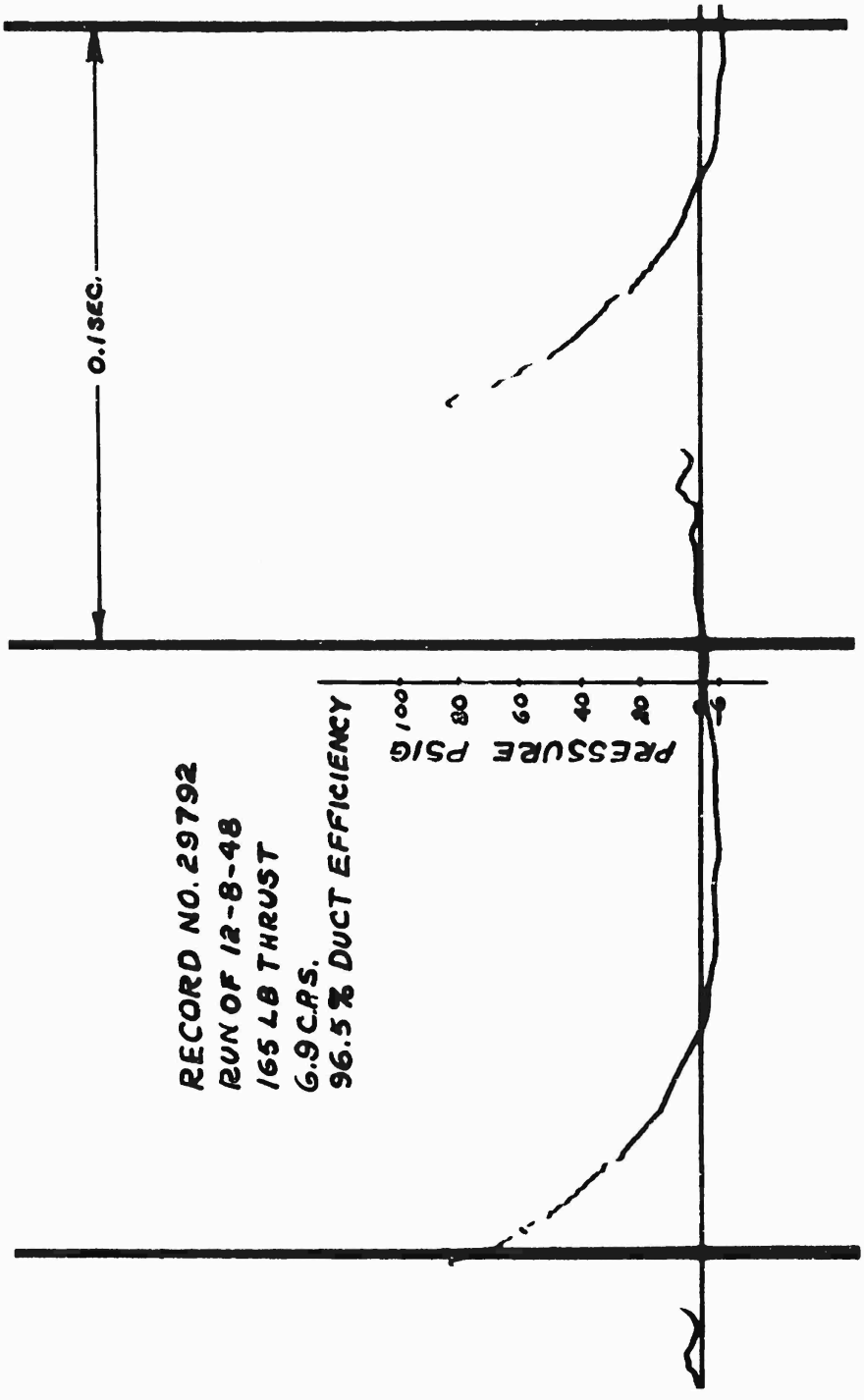
GAM-87 High-Thrust Motor

Figure 62



Parallelogram Thrust Stand for Static Testing of GAH Motors

Skiff-Mounted GAH Testing in the 80-ft Ring Channel



PRESSURE-TIME RECORD OF GAH-97

Figure 65

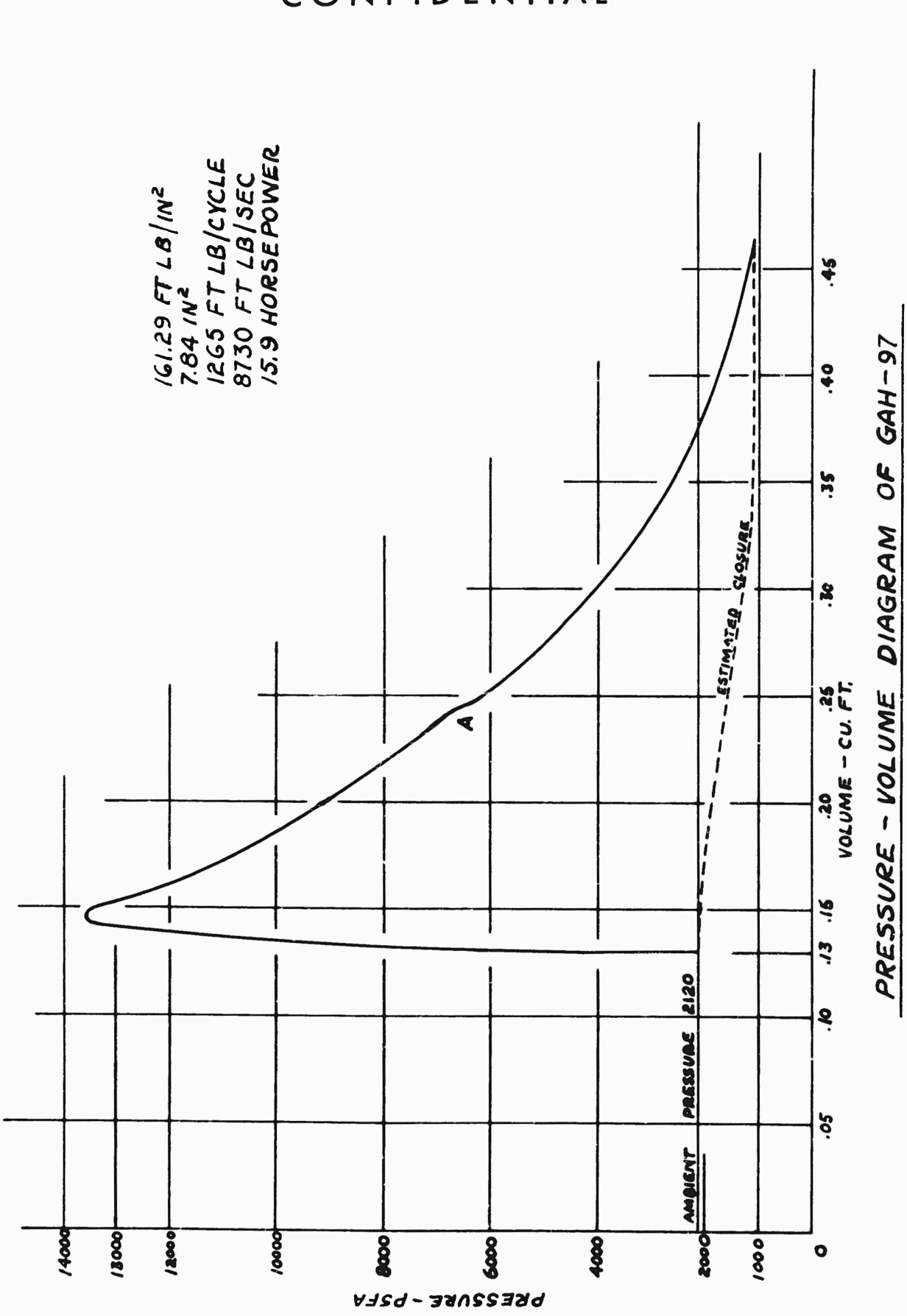

CURVE NO. 4005
161.29 FT LB/IN²
7.84 IN²
1265 FT LB/CYCLE
8730 FT LB/SEC
15.9 HORSEPOWER
PRESSURE - PSFA
14000
13000
12000
10000
8000
6000
4000
2000
1000
0
AMBIENT PRESSURE 2120
.05
.10
.13
.15
.20
.25
.30
.35
.40
.45
VOLUME - CU. FT.
ESTIMATED CLOSURE
A
PRESSURE - VOLUME DIAGRAM OF GAH-97

Figure 66

CURVE No. 4023 W.H. COKE 6-30-49

SEQUENCE OF EVENTS IN THE GASOLINE-AIR HYDROPULSE

SCALE: $\frac{1}{16}$" = 1" FREQUENCY: 5.8 c.p.s. STATIC TEST

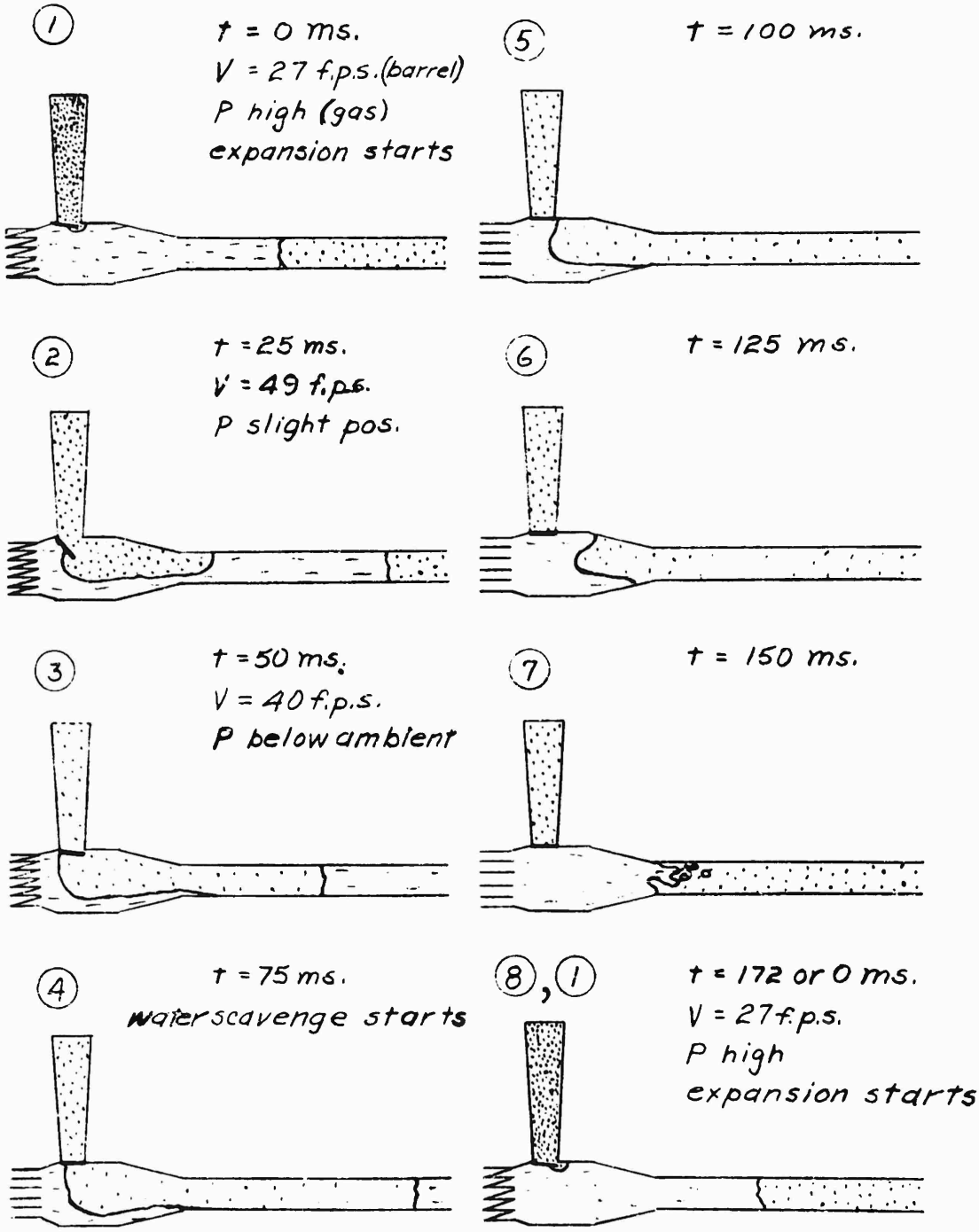
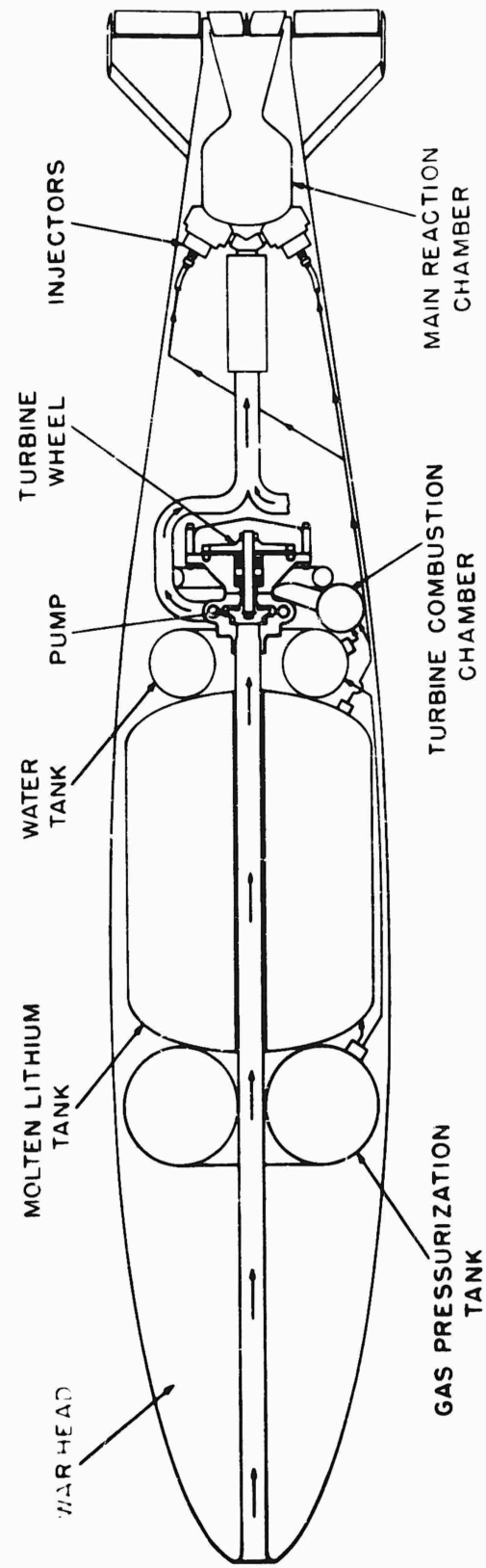


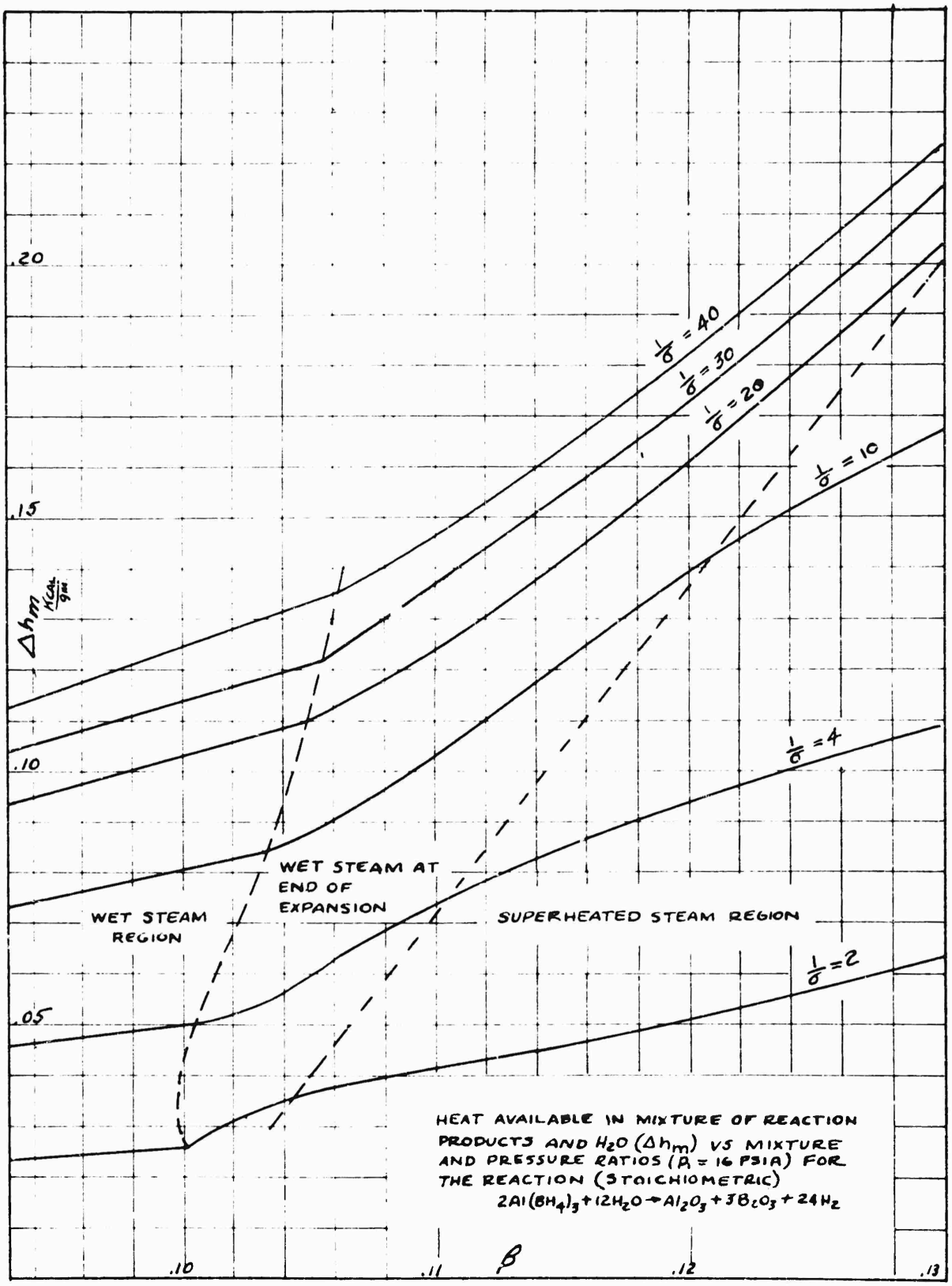
Figure 67



Hydroturbojet Propulsion System

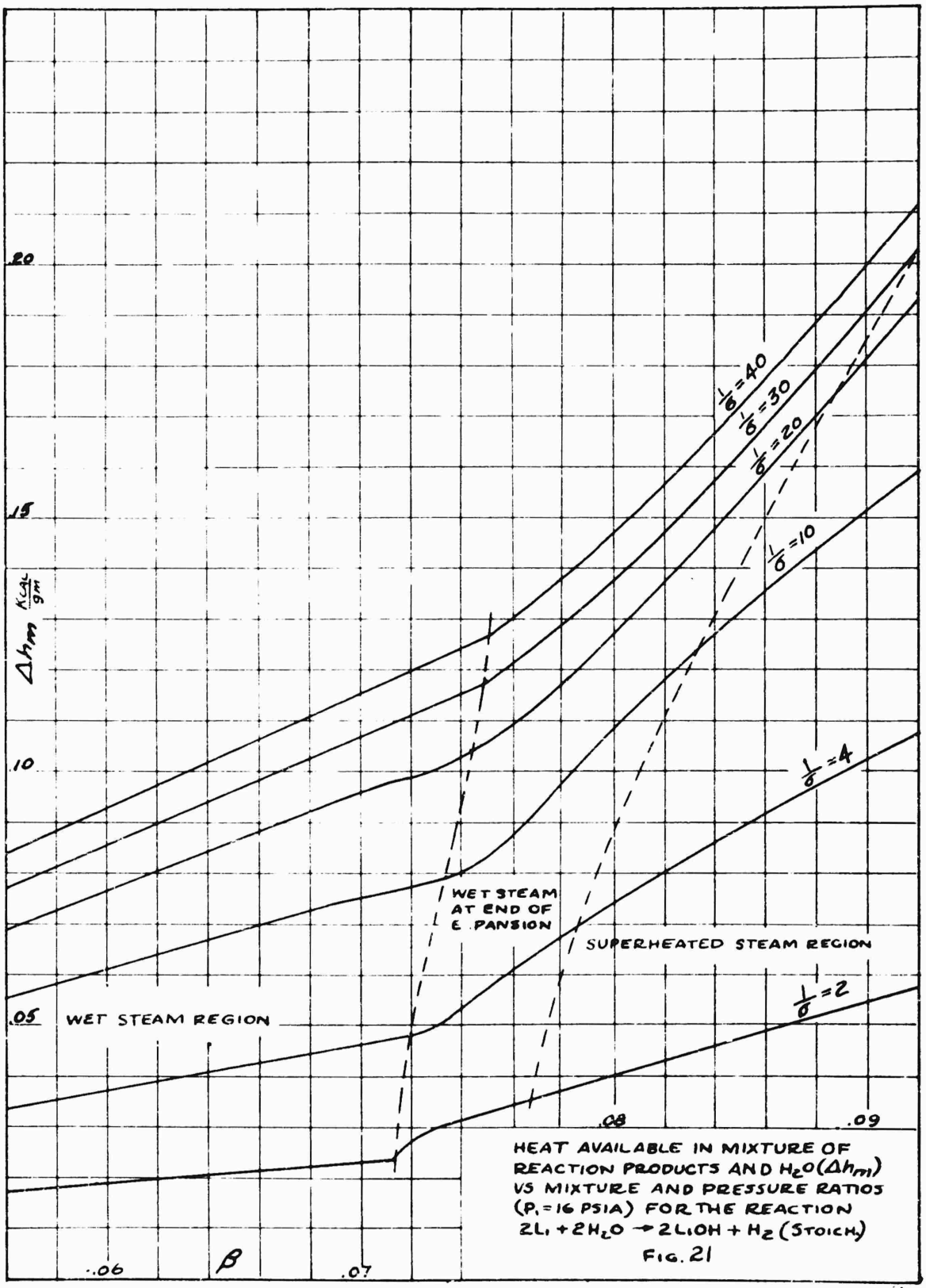
R249-20

Figure 68

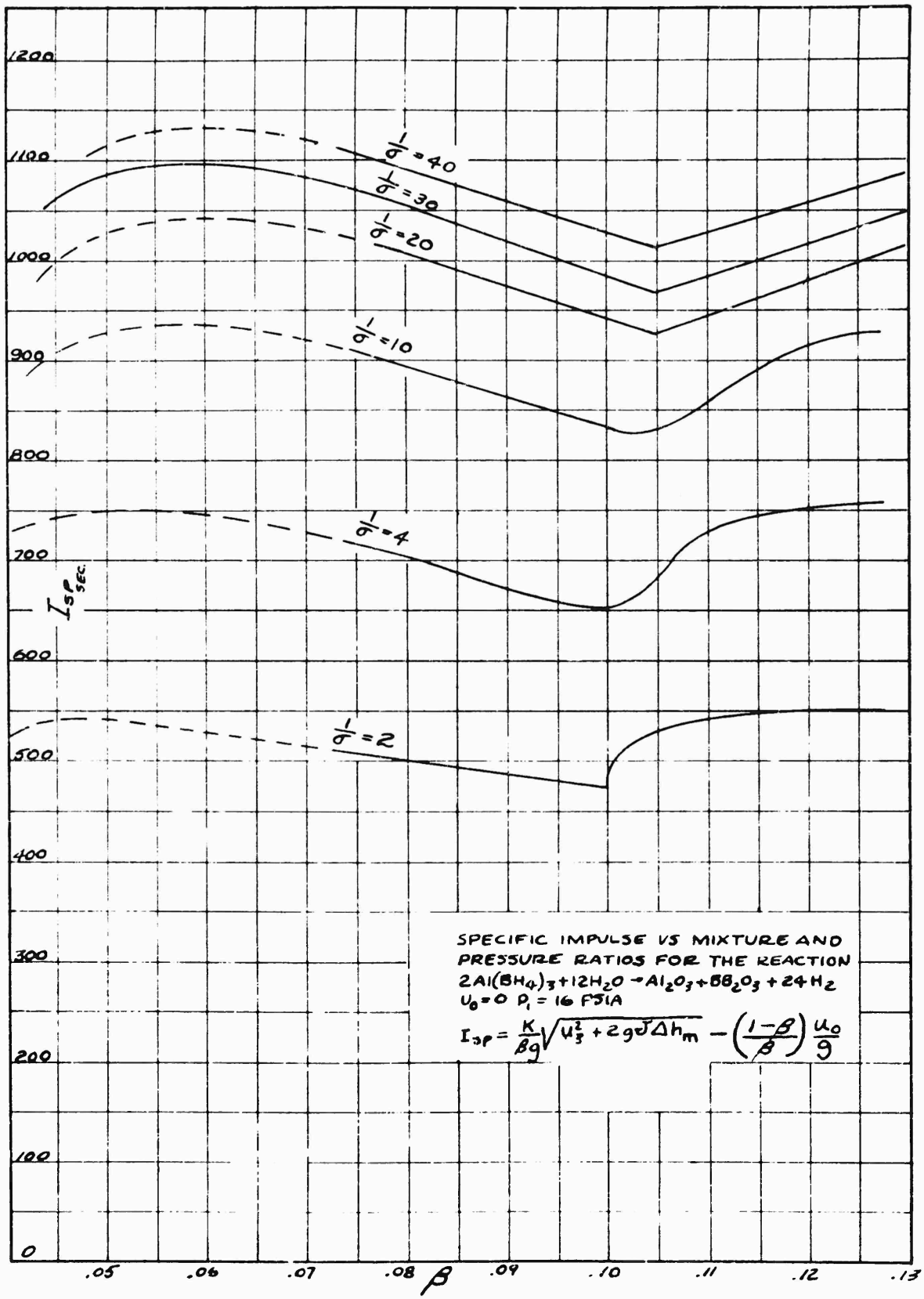


Δh_m vs β for Aluminum Borolydride

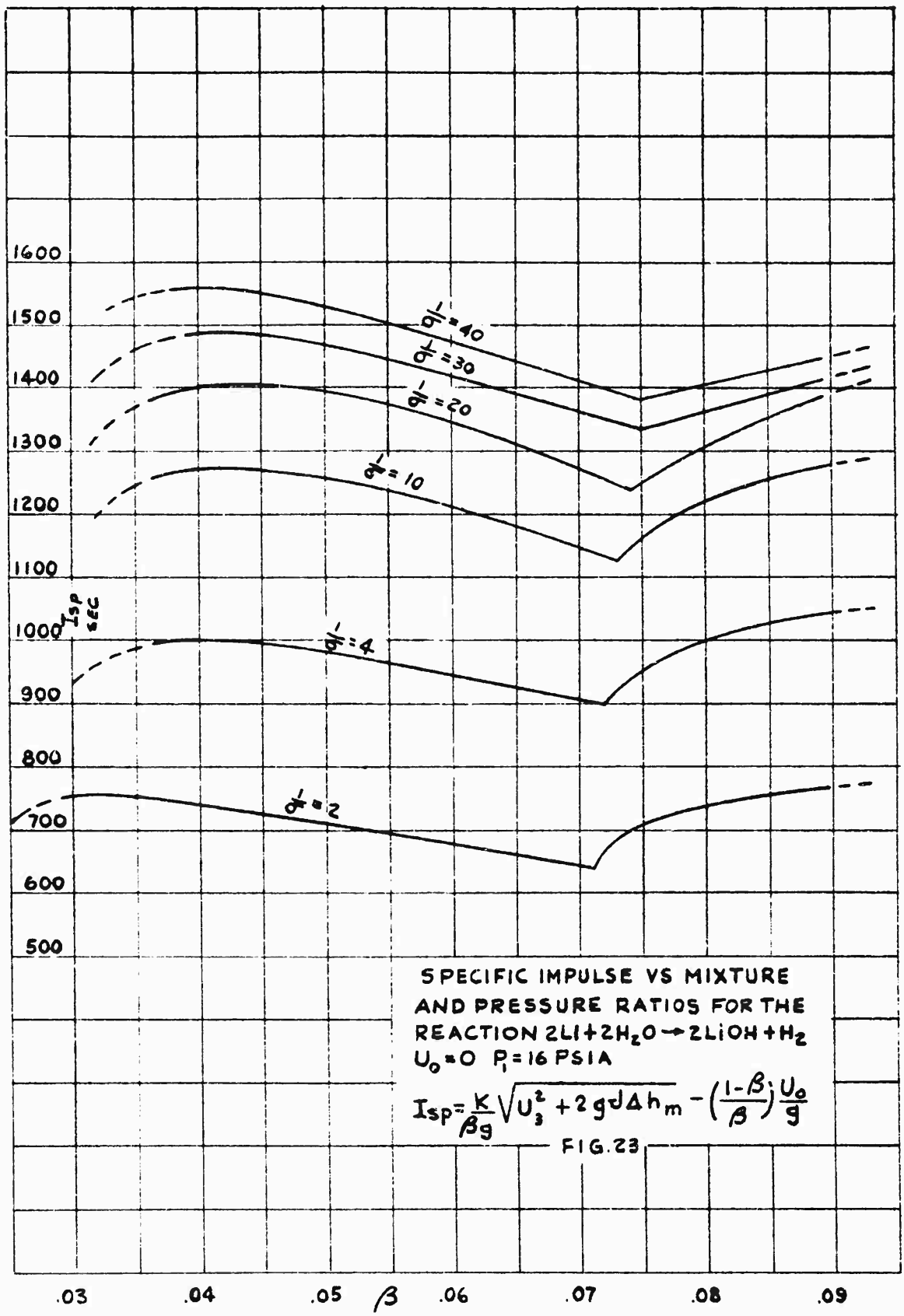
Figure 69



Δh_m vs β for Lithium



I_{sp} vs β for Aluminum Borohydride



I_{sp} vs β for Lithium

Figure 72

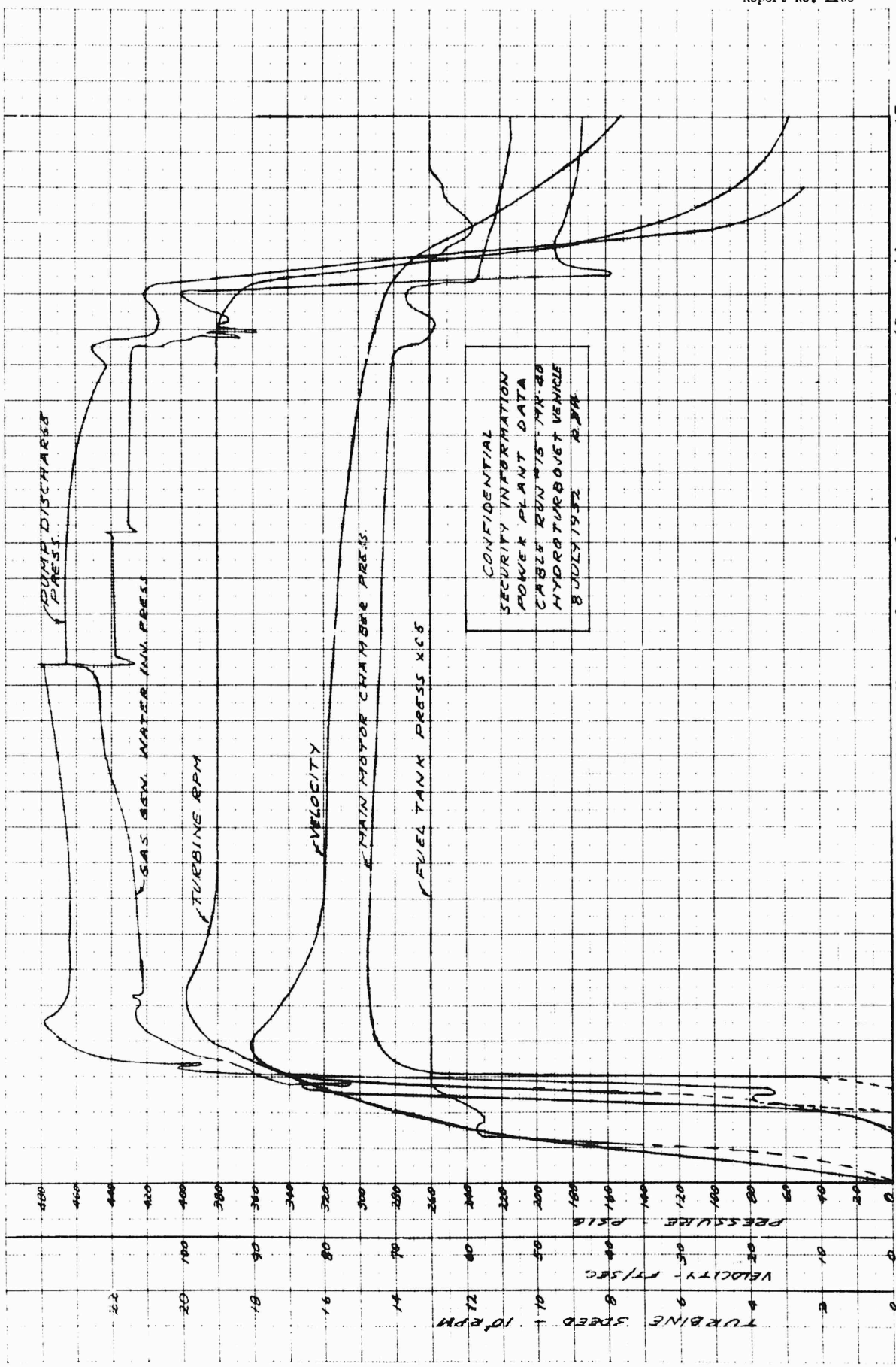

CONFIDENTIAL
SECURITY INFORMATION
POWER PLANT DATA
CABLE RUN #15 - MR. 20
HYDROTURBOJET VEHICLE
8 JULY 1952
PUMP DISCHARGE PRESS.
GAS GEN. WATER INJ. PRESS.
TURBINE RPM
VELOCITY
MAIN MOTOR CHAMBER PRESS.
FUEL TANK PRESS x 0.5
TIME - SEC
PRESSURE - PSIA
VELOCITY - FT/SEC
TURBINE SPEED - 10³ RPM

Figure 73

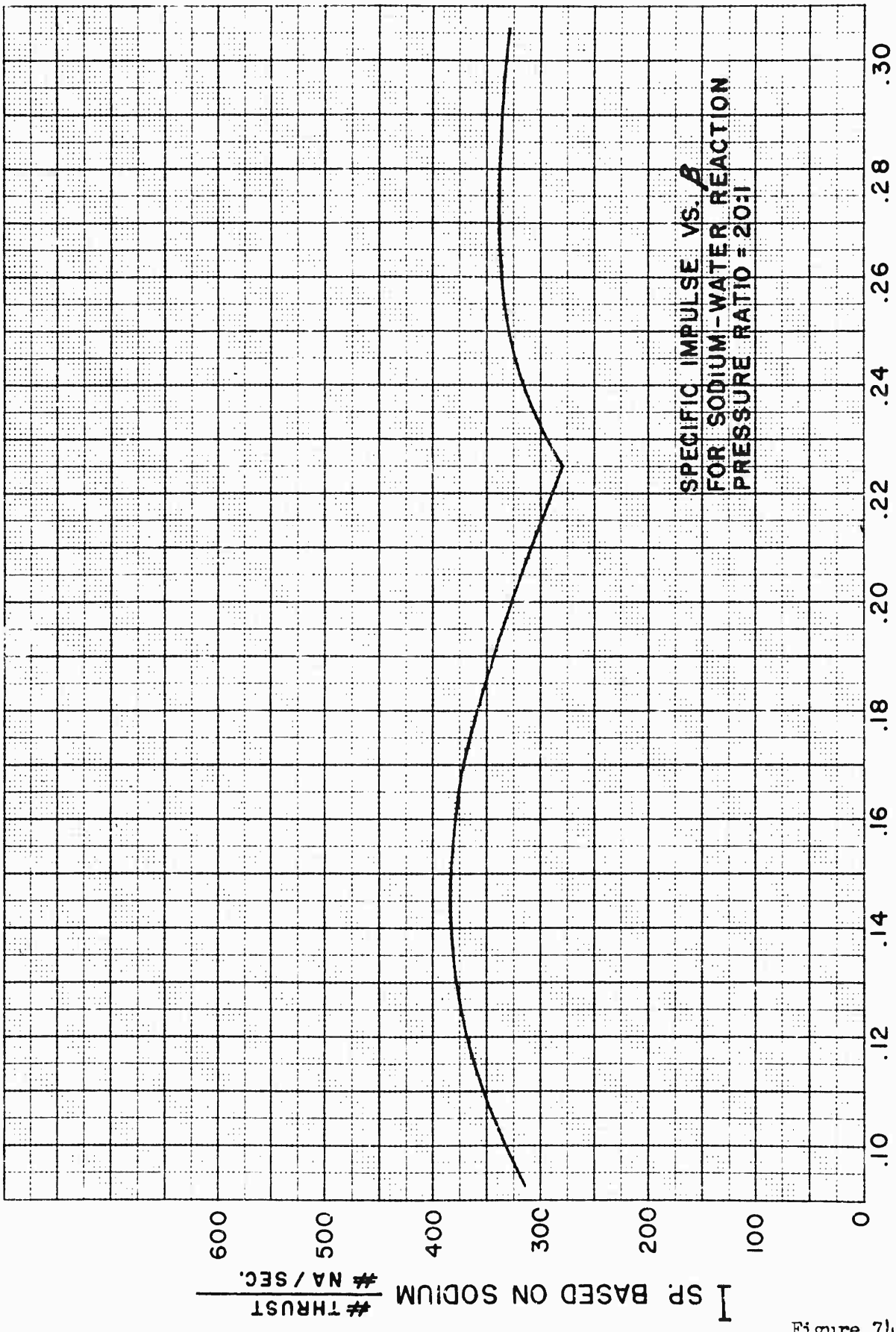

SPECIFIC IMPULSE VS. β
FOR SODIUM-WATER REACTION
PRESSURE RATIO = 20:1
β
.10
.12
.14
.16
.18
.20
.22
.24
.26
.28
.30
0
100
200
300
400
500
600
I SP BASED ON SODIUM # THRUST / # NA / SEC.

Figure 74

CURVE NO. 4005

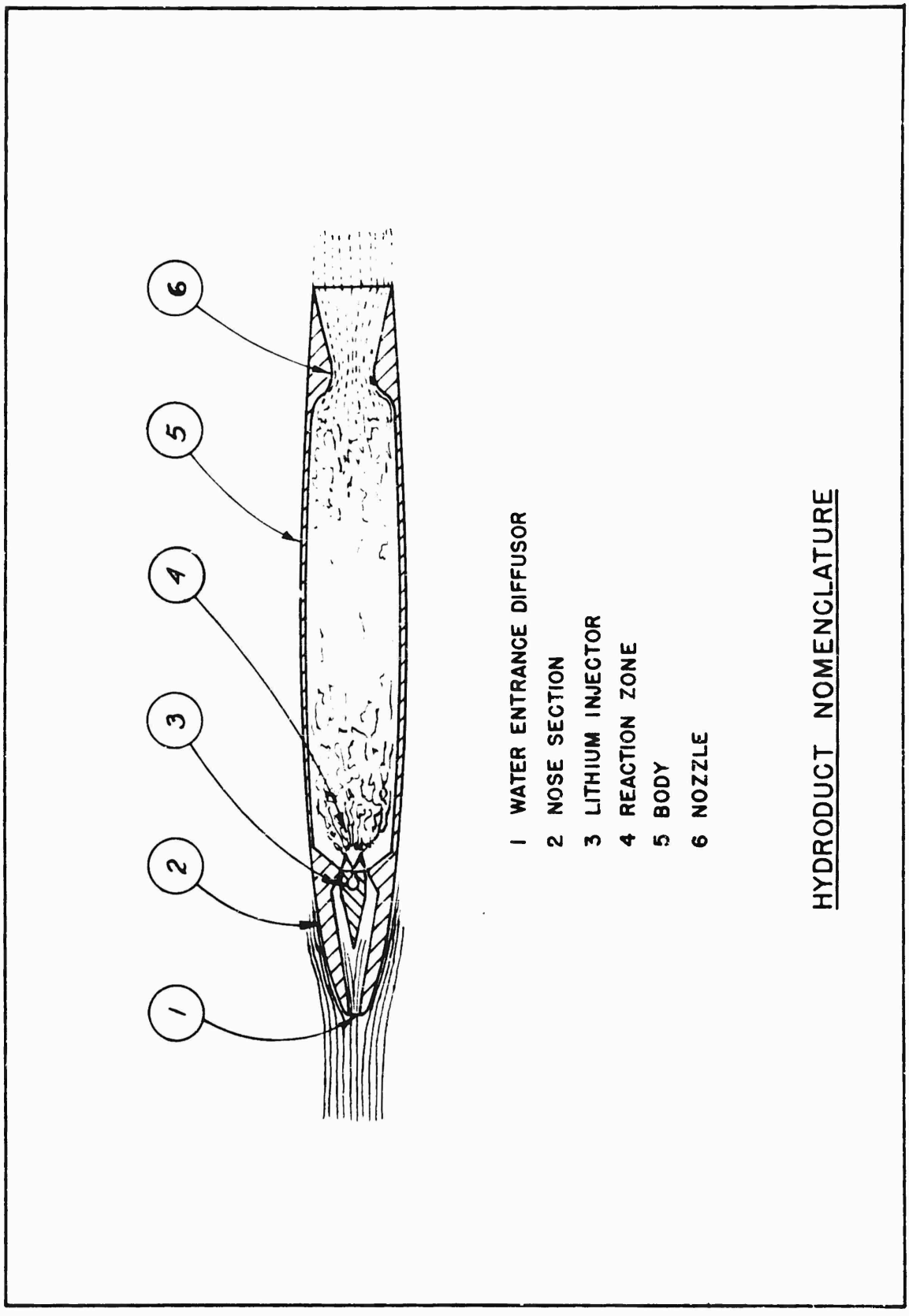
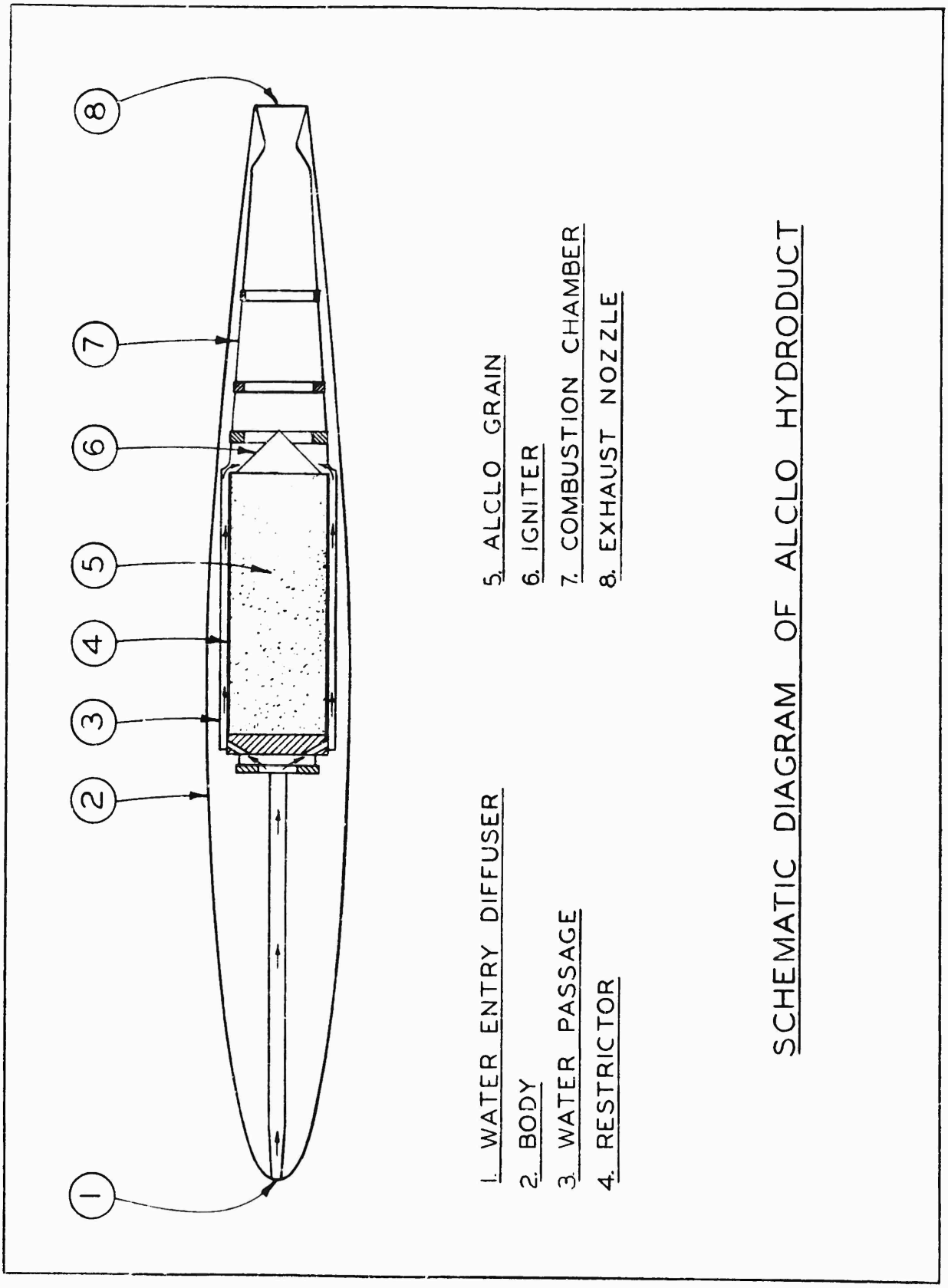


Figure 75

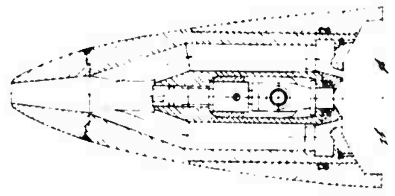
C-4151 12-23-52 BK EGL



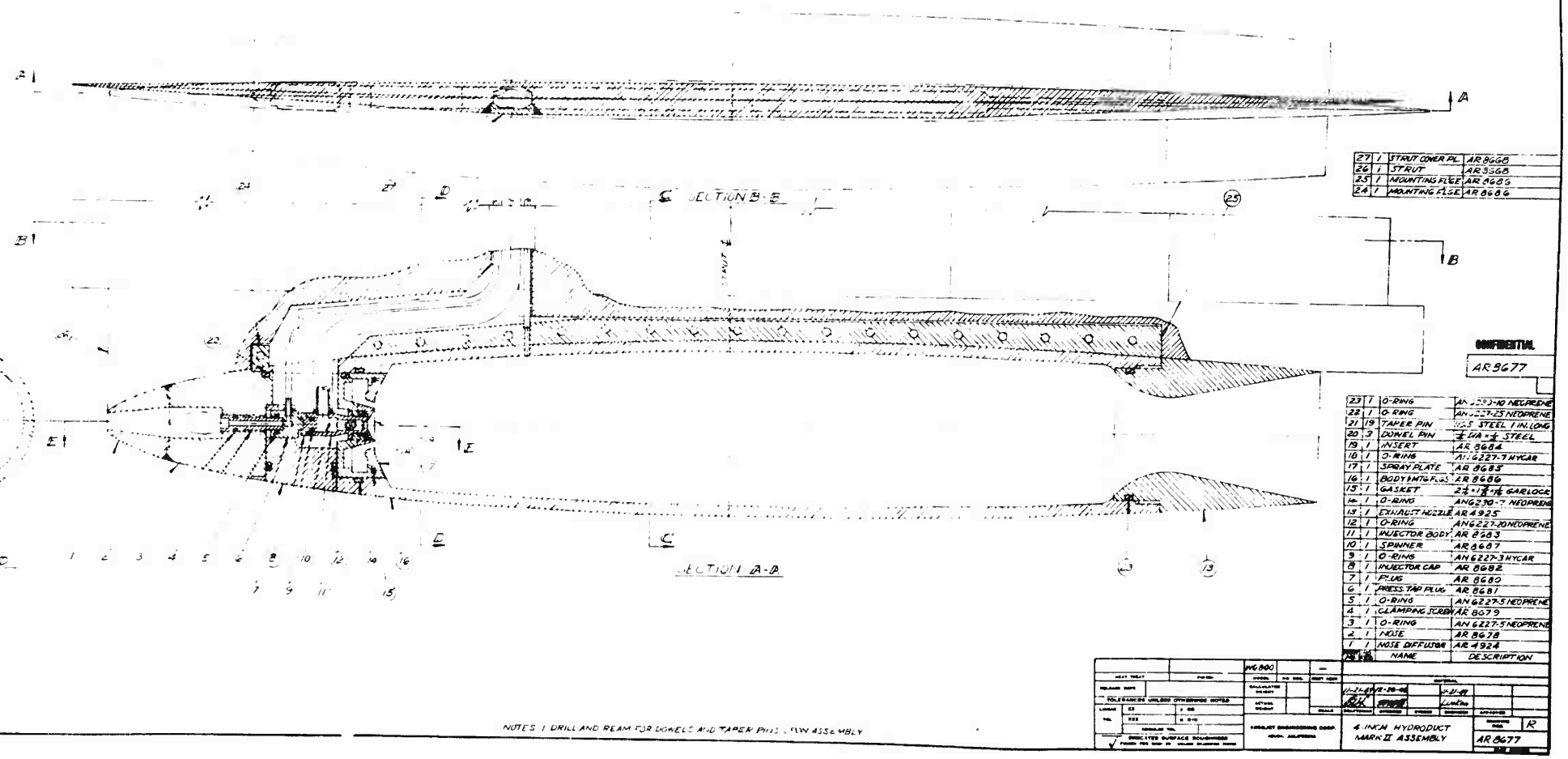
R1248-153

4-in. Hydroduct with Tail Fairing in Place

Figure 77



SECTION E-E



27	1	STRUT COVER PL	AR 8668
26	1	STRUT	AR 8666
25	1	MOUNTING FLGE	AR 8665
24	1	MOUNTING FLGE	AR 8666

CONFIDENTIAL

AR 8677

23	1	O-RING	AN 6227-10 NEOPRENE
22	1	O-RING	AN 6227-25 NEOPRENE
21	19	TAPER PIN	NAS STEEL 1 IN. LONG
20	3	DOWEL PIN	⅜ DIA x ⅝ STEEL
19	1	INSERT	AR 8684
18	1	O-RING	AN 6227-7 HYCAR
17	1	SPRAY PLATE	AR 8683
16	1	BODY MTG FLG	AR 8686
15	1	GASKET	2½-12 5/16 GARLOCK
14	1	O-RING	ANG270-7 NEOPRENE
13	1	EXHAUST NOZZLE	AR 4925
12	1	O-RING	AN6227-20 NEOPRENE
11	1	INJECTOR BODY	AR 8683
10	1	SPINNER	AR 8687
9	1	O-RING	AN 6227-3 HYCAR
8	1	INJECTOR CAP	AR 8682
7	1	PLUG	AR 8680
6	1	PRESS TAP PLUG	AR 8681
5	1	O-RING	AN 6227-5 NEOPRENE
4	1	CLAMPING SCREW	AR 8679
3	1	O-RING	AN 6227-5 NEOPRENE
2	1	NOSE	AR 8678
1	1	NOSE DIFFUSER	AR 4928
PART NO.		NAME	DESCRIPTION

MATERIAL

11-21-49	12-20-49	4-11-49	
CK	[illegible]	[illegible]	

AIRCRAFT ENGINEERING CORP. HAWTHORNE, CALIFORNIA

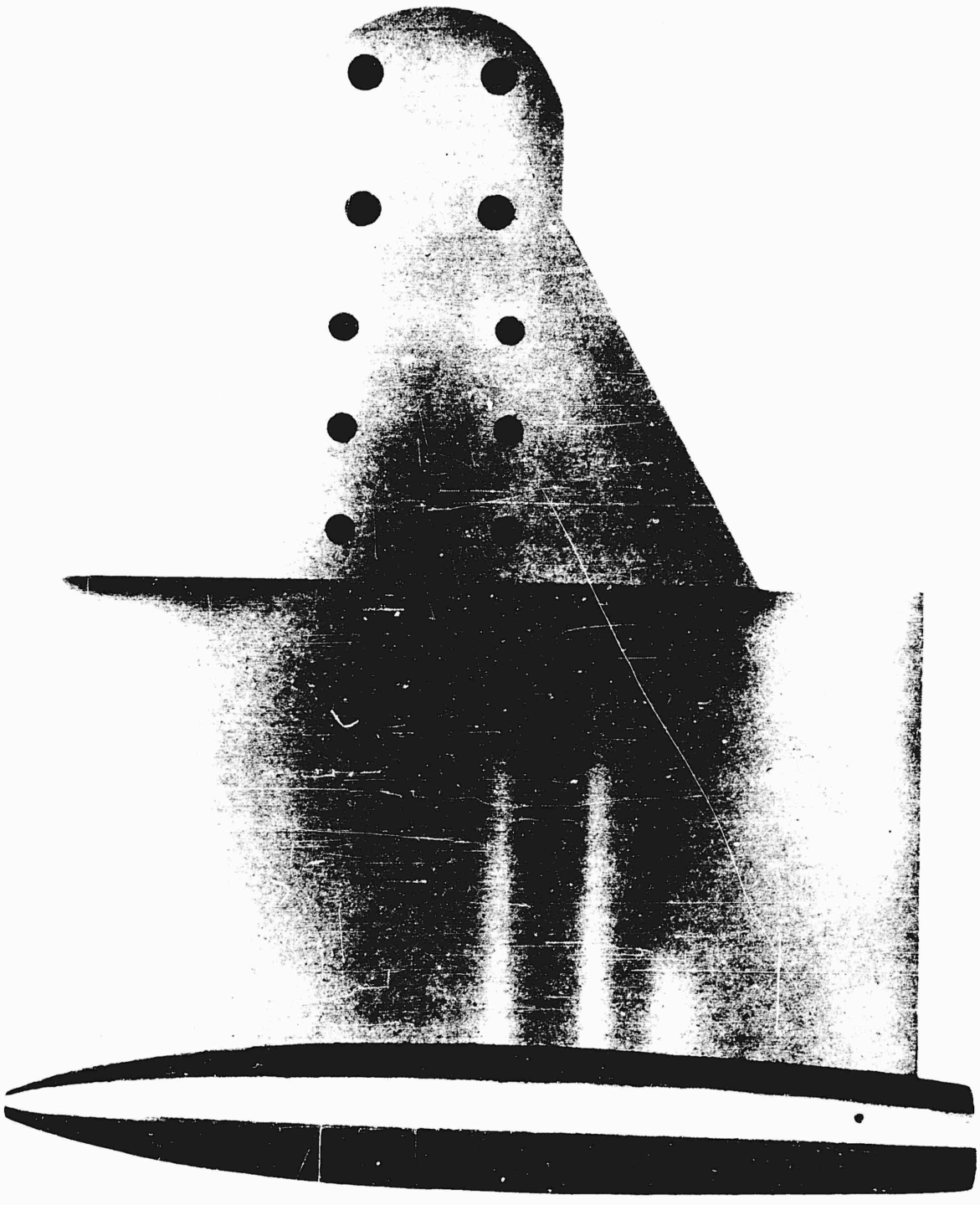
4 INCH HYDROJET MARK II ASSEMBLY

AR 8677

Figure 78

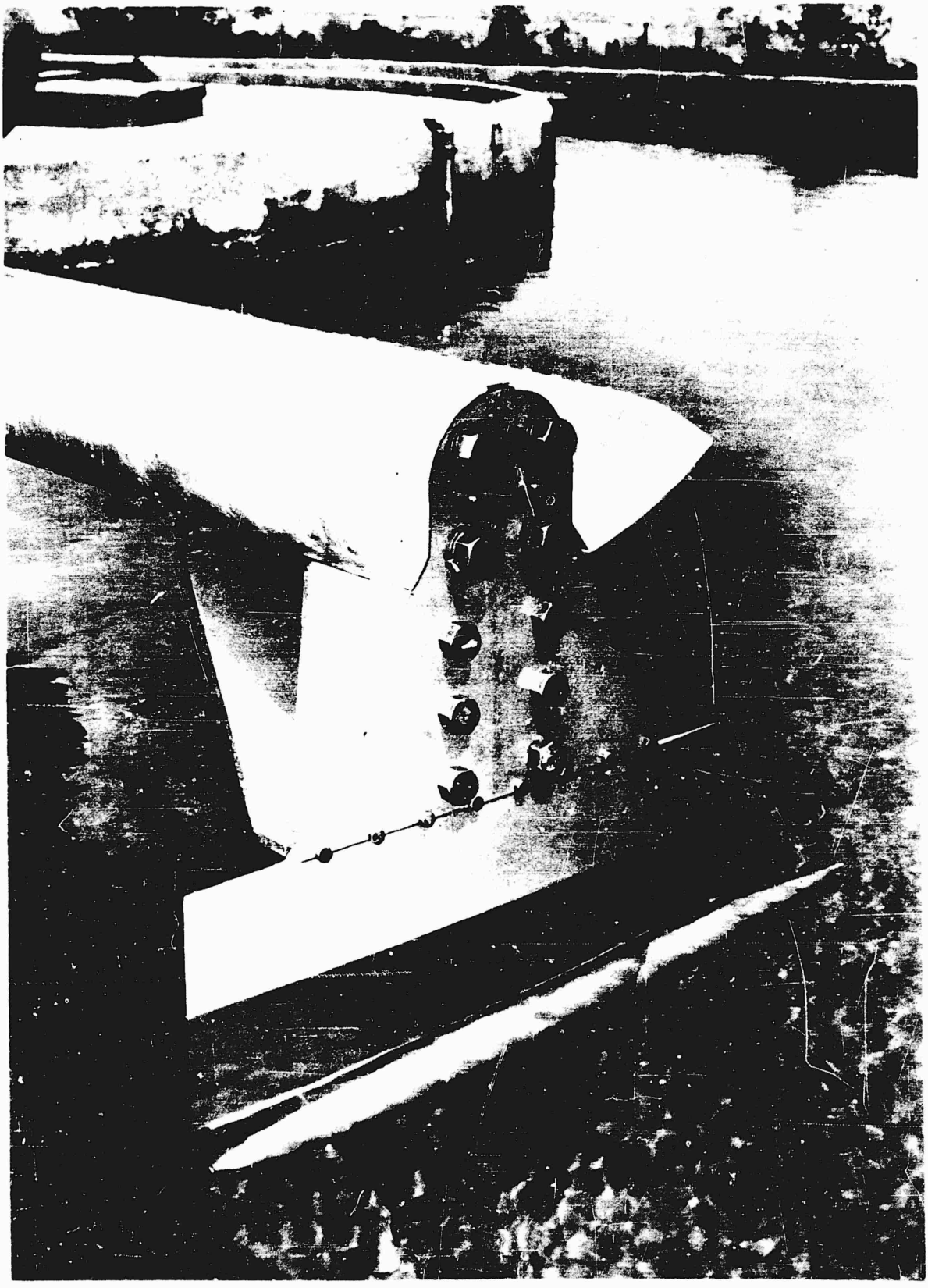
Components of the 4-in. Hydroduct Mark I

12X8-152



P149-63

h-in. Hydroduct with Suspending Strut Attached



Hydroduct Mark II in Position for Drag Testing

Figure 81

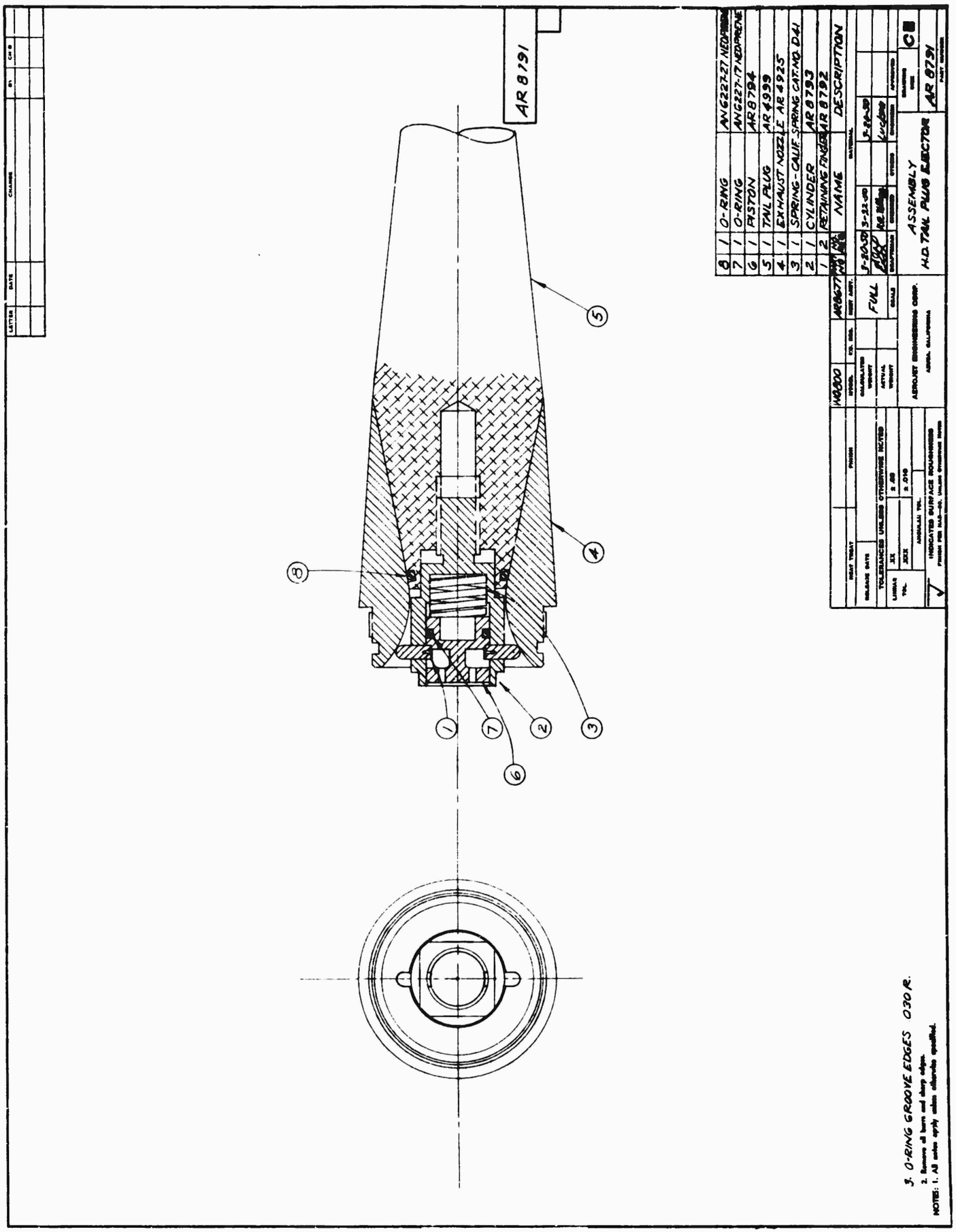
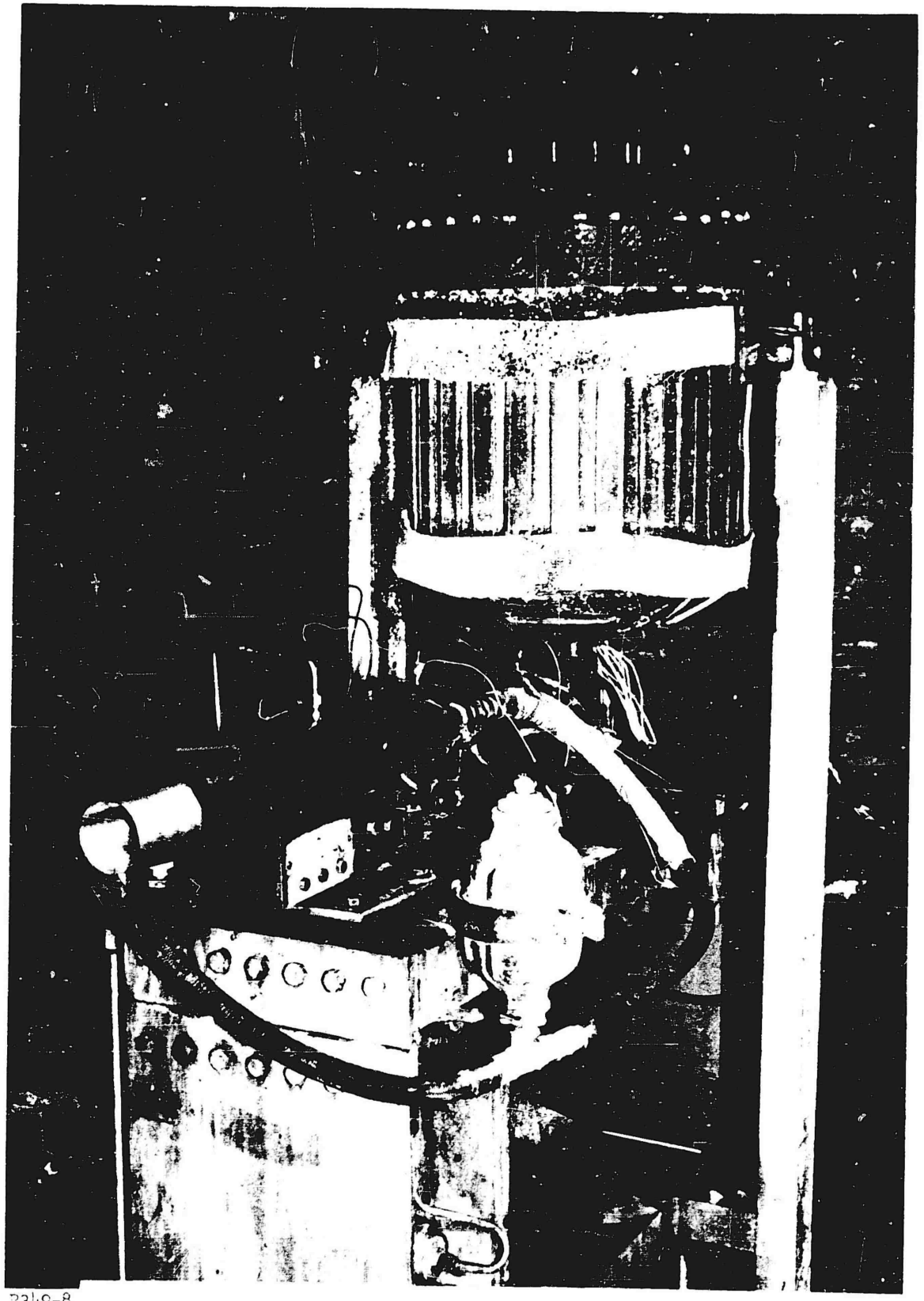

AR 8191
5
4
8
1
7
2
3
6
8 1 O-RING AN6227-27 NEOPRENE
7 1 O-RING AN6227-17 NEOPRENE
6 1 PISTON AR8794
5 1 TAIL PLUG AR4999
4 1 EXHAUST NOZZLE AR4925
3 1 SPRING-CAUF. SPRING CAT. NO. D41
2 1 CYLINDER AR8793
1 2 RETAINING RING AIR 8792
ITEM QTY NAME DESCRIPTION
ASSEMBLY
H.D. TAIL PLUG EJECTOR
AR 8791
3. O-RING GROOVE EDGES 030 R.
2. Remove all burrs and sharp edges.
NOTE: 1. All notes apply unless otherwise specified.

Figure 82



B349-8

4-in. Hydroduct Mark I, Static Test Pit Setup

Figure 83

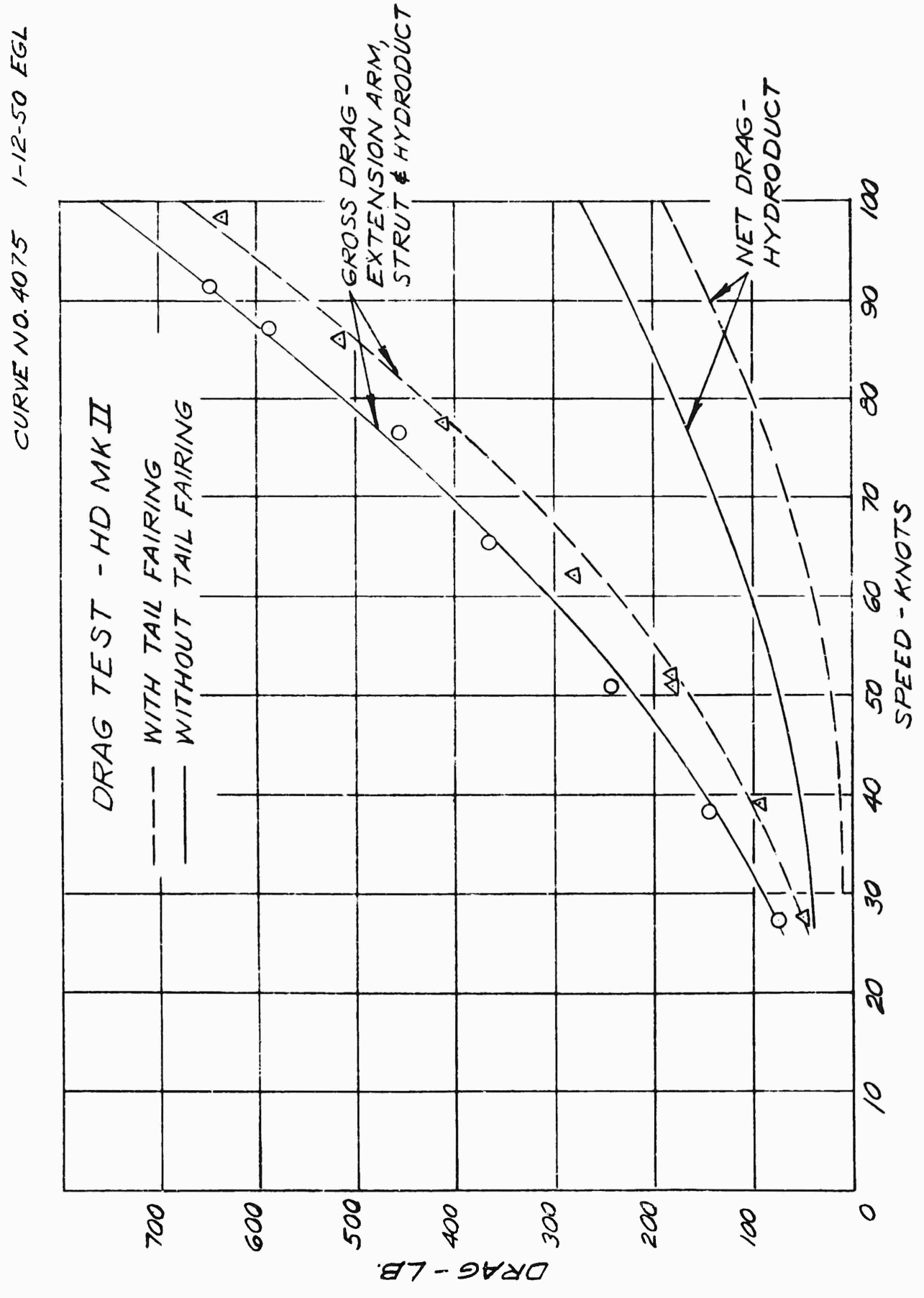
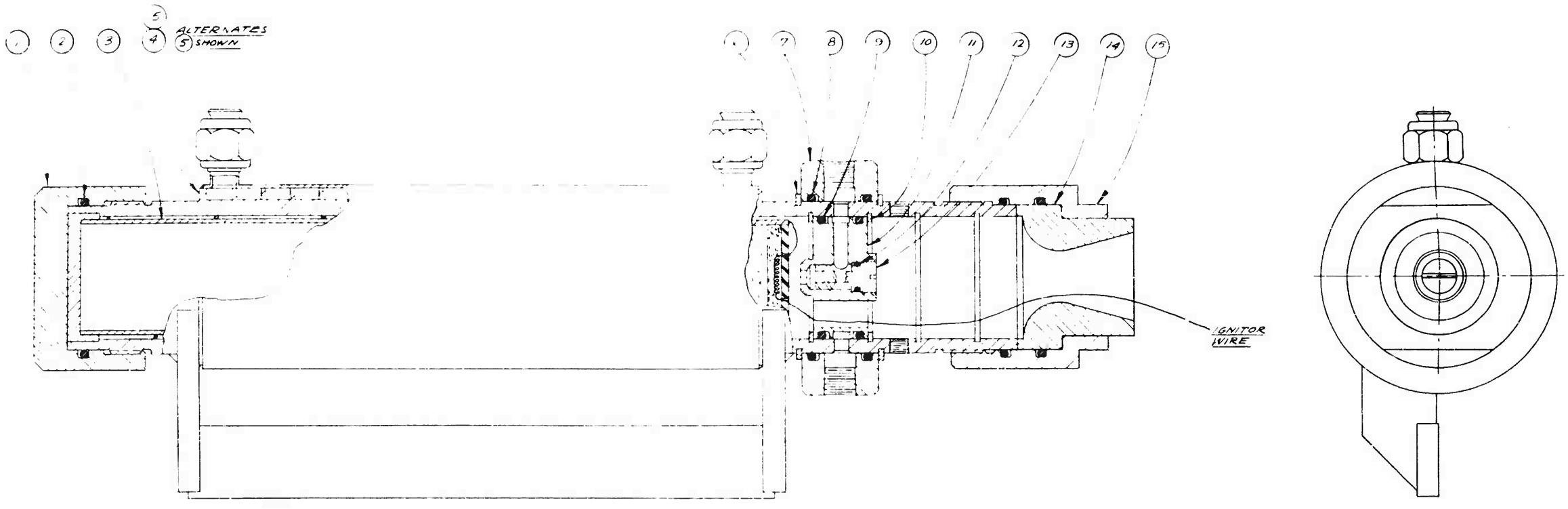

CURVE NO. 4075 1-12-50 EGL
DRAG TEST - HD MK II
--- WITH TAIL FAIRING
—— WITHOUT TAIL FAIRING
GROSS DRAG - EXTENSION ARM, STRUT & HYDRODUCT
NET DRAG - HYDRODUCT
DRAG - LB.
700
600
500
400
300
200
100
0
SPEED - KNOTS
10
20
30
40
50
60
70
80
90
100

Figure 84

LETTER	DATE	CHANGE	BY	CHK'D



AR8928

15	1	NUT	AR 8930-12
14	1	NOZZLE	AR 8930-8
13	1	S.PINNER	AR 8930-11
12	1	'O' RING	MATL NYCAR SIZE AS REQ'D N-209-70 AN6227-7
11	1	SPINNER BODY	AR 8930-9
10	2	SNAP RING	TRUARC #5000-212
9	2	'O' RING	MATL NYCAR SIZE AS REQ'D N-209-70 AN123895
8	2	'O' RING	MATL NYCAR SIZE AS REQ'D N-209-70 AN128891
7	1	ANNULUS	AR 8930-10
6	2	SNAP RING	TRUARC #5100-262
5	1	CHAMBER (COOLED)	AR 8929
4	1	CHAMBER (UNCOOLED)	AR 8931
3	1	ALCLO CHARGE	AR 8930-1
2	3	'O' RING	MATL NYCAR SIZE AS REQ'D N-209-70 AN123890
1	1	CAP	AR 8930-7
PT NO. REQ.		NAME	MATL. & SIZE

ALTERNATES

HEAT TREAT	FINISH	MODEL	NO. REQ.	NEXT ASSY.	MATERIAL	
RELEASE DATE		CALCULATED WEIGHT			2-19-51	2-19-51
TOLERANCES UNLESS OTHERW.SE NOTED		ACTUAL WEIGHT		SCALE	DRAFTSMAN: HUTCHINS	CHECKED: Lucken
LINEAR TOL. .XX ± .03; .XXX ± .010	ANGULAR TOL.	AEROJET ENGINEERING CORP. AZUSA, CALIFORNIA			STRESS	ENGINEER
INDICATES SURFACE ROUGHNESS FINISH PER MAS-20, UNLESS OTHERWISE NOTED					APPROVED	

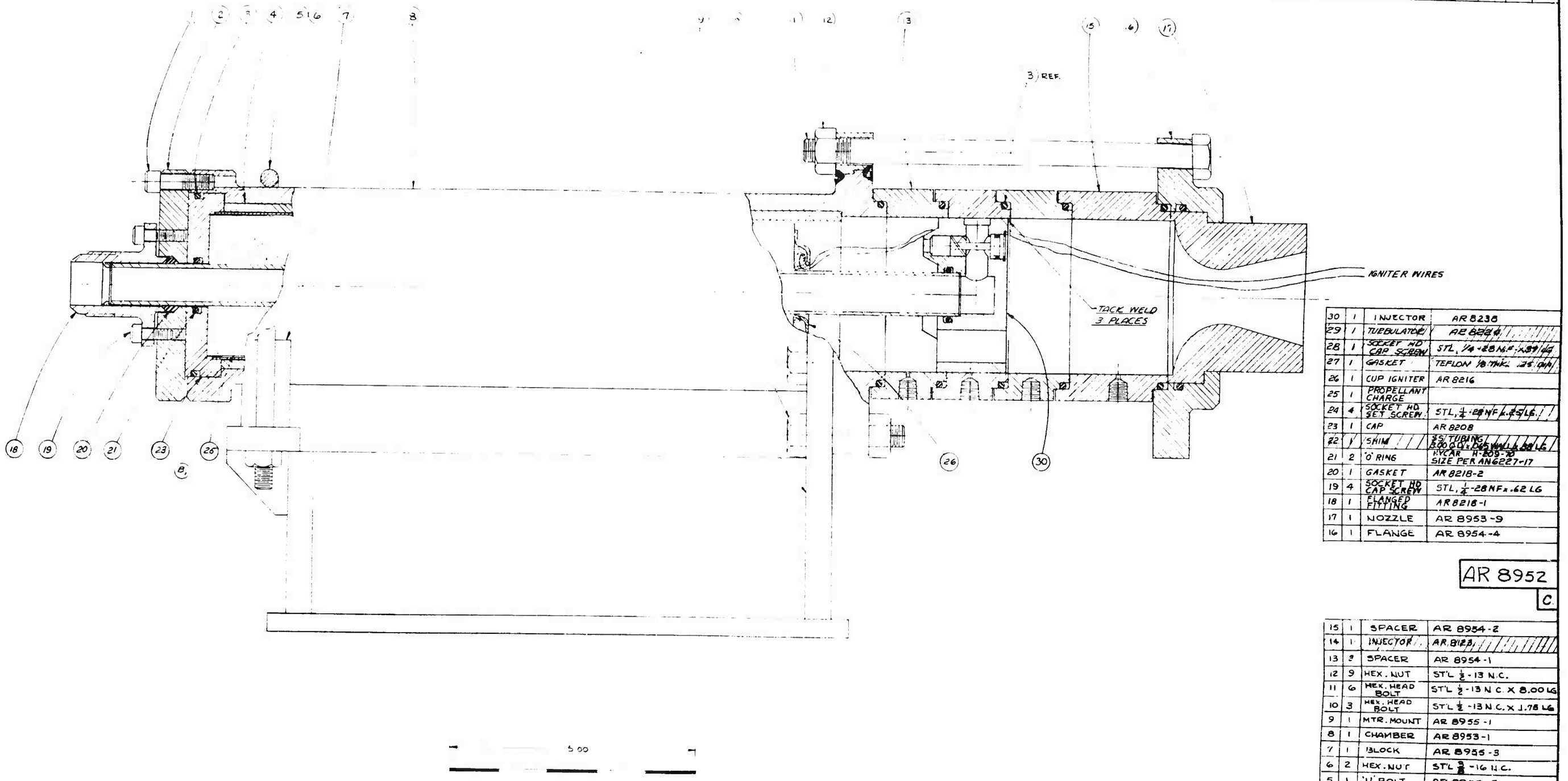
2" DIA ALCLO MOTOR ASSY.

DRAWING SIZE: D

AR 8928 — PART NUMBER

NOTES: 1. Remove all burrs and sharp edges

LETTER	DATE	CHANGE	BY	CHKD	
A	10-5-51	4, 14 & 18 THRU 24 ADDED	BOK	E.S.	
		25, 26 REVISED			
B_2	11/5/51	27 THRU 29 ADDED Re: 23 & 24 DELETED	H.M		
C	1/8/52	ADDED (30) (21) WAS 1 REQ'D	JMC		E.S.
		DELETED 14, 27, 28, 29			



30	1	INJECTOR	AR 8238
29	1	TUBULATOR	AR 8226
28	1	SOCKET HD CAP SCREW	STL, 1/4-28 N.F. x .87 LG
27	1	GASKET	TEFLON 1/8 THK. .25 OPN
26	1	CUP IGNITER	AR 8216
25	1	PROPELLANT CHARGE	
24	4	SOCKET HD SET SCREW	STL, 1/4-28 N.F. x .25 LG.
23	1	CAP	AR 8208
22	1	SHIM	SS TUBING, 3.500 O.D. x .049 WALL x .88 LG
21	2	O RING	HYCAR H-209-70 SIZE PER AN6227-17
20	1	GASKET	AR 8218-2
19	4	SOCKET HD CAP SCREW	STL, 1/4-28 NF x .62 LG
18	1	FLANGED FITTING	AR 8218-1
17	1	NOZZLE	AR 8953-9
16	1	FLANGE	AR 8954-4

AR 8952 C

15	1	SPACER	AR 8954-2
14	1	INJECTOR	AR 8128
13	9	SPACER	AR 8954-1
12	9	HEX. NUT	ST'L 1/2-13 N.C.
11	6	HEX. HEAD BOLT	ST'L 1/2-13 N.C. X 8.00 LG
10	3	HEX. HEAD BOLT	ST'L 1/2-13 N.C. X 1.78 LG
9	1	MTR. MOUNT	AR 8955-1
8	1	CHAMBER	AR 8953-1
7	1	BLOCK	AR 8955-3
6	2	HEX. NUT	ST'L 3/8-16 N.C.
5	1	'U' BOLT	AR 8955-2
4	1	LINER	STL, 3.380 O.D. x 3.00 I.D. x 12.75 LG
3	7	'O' RING	MAT.- HYCAR H-209-70 SIZE PER AN 6230-16
2	1	END PLATE	AR 8954-3
1	6	SOCKET HEAD CAP SCREW	ST'L 5/16-18 N.C. X 1.00 LG
PART NO.	NO. REQ	NAME	MATERIAL & SIZE

NOTES: 1. Remove all burrs and sharp edges.

HEAT TREAT	FINISH	MODEL	NO. REQ.	NEXT ASSY.	
RELEASE DATE		CALCULATED WEIGHT			
TOLERANCES UNLESS OTHERWISE NOTED		ACTUAL WEIGHT		SCALE	
LINEAR .XX ± .03					
TOL. .XXX ± .010					
ANGULAR TOL.		AEROJET ENGINEERING CORP. AZUSA, CALIFORNIA			
INDICATES SURFACE ROUGHNESS FINISH PER MAS—20 Unless Otherwise Noted					

MATERIAL				
4-23-51	4-24-51		4-25-51	
HUGHES				
DRAFTSMAN	CHECKED	STRESS	ENGINEER	APPROVED

3" DIA. ALCLO MOTOR ASS'Y

DRAWING SIZE D

AR 8952

PART NUMBER

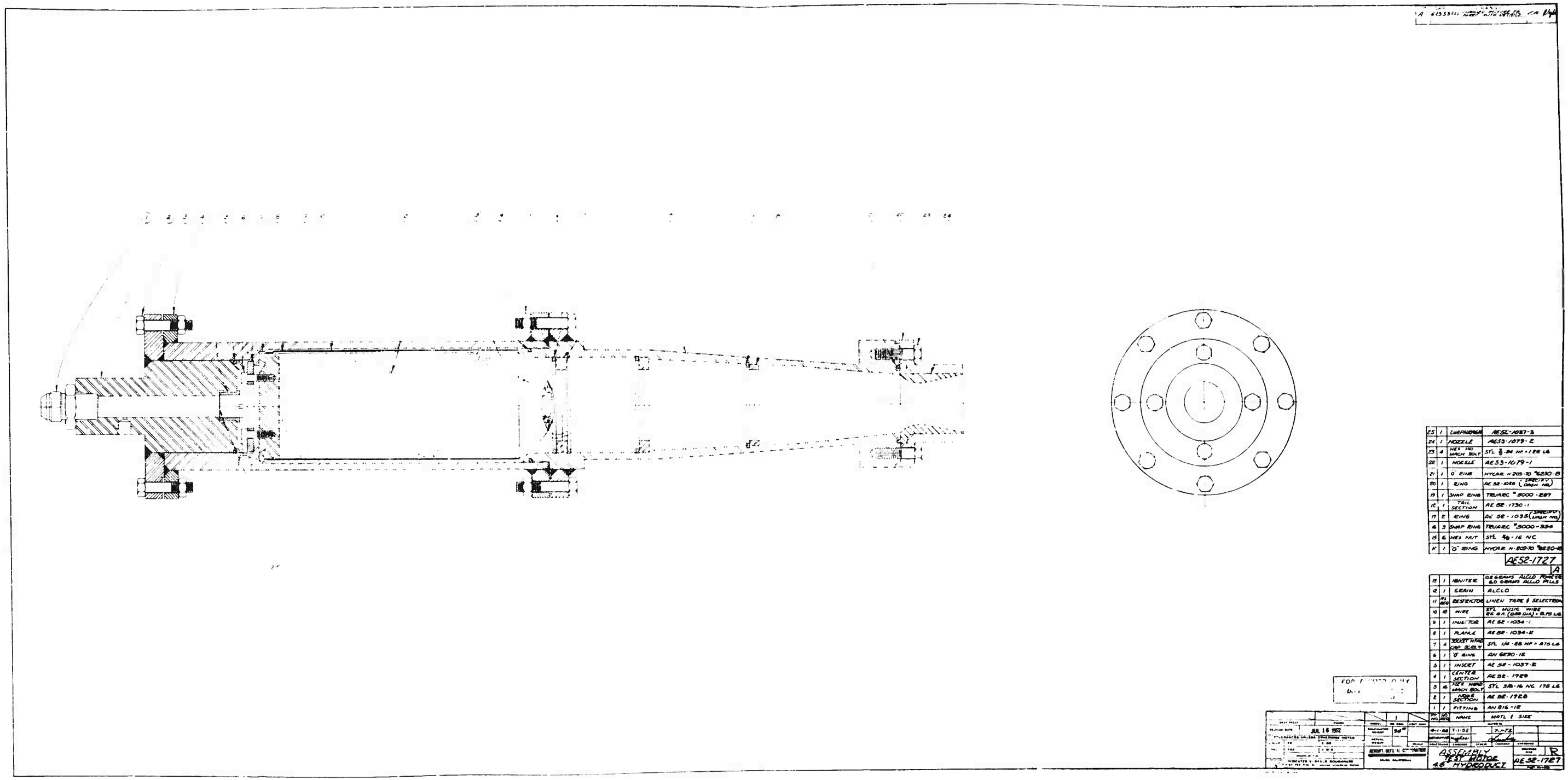
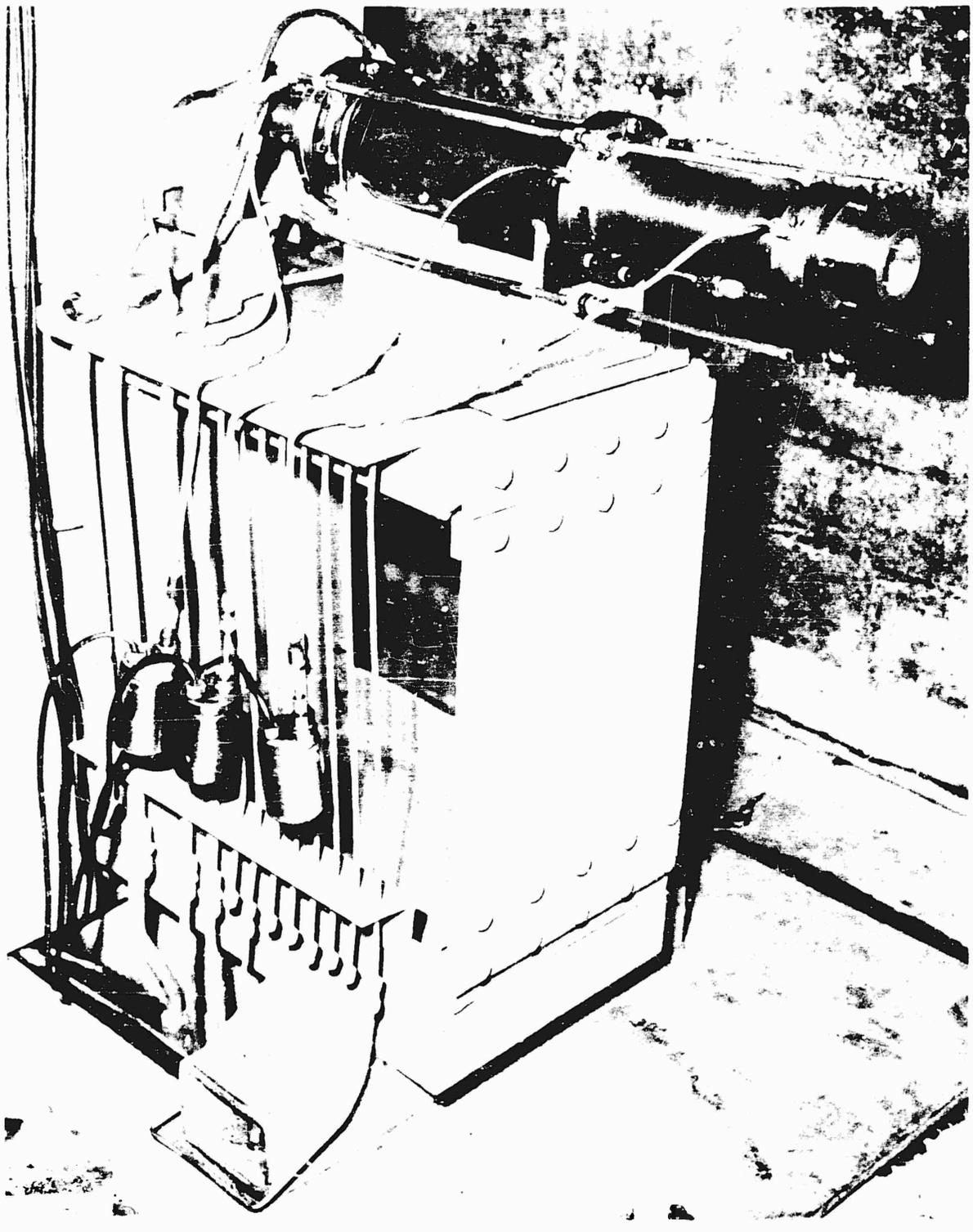

25 1 LIMPWIRE AE5E-1037-3
24 1 NOZZLE AE53-1079-E
23 4 HEX HD MACH BOLT STL 3/8-24 NF x 1.26 LG
22 1 NOZZLE AE53-1079-1
21 1 O RING HYCAR H-203-70 "E230-B
20 1 RING AE 52-1038 (SPECIFY DASH NO.)
19 1 SWAP RING TRW AEC "3000-287
18 1 TAIL SECTION AE 52-1730-1
17 2 RING AE 52-1038 (SPECIFY DASH NO.)
16 3 SWAP RING TRW AEC "3000-334
15 6 HEX NUT STL 3/8-16 NC.
14 1 O RING HYCAR H-203-70 "E230-B
AE52-1727 A
13 1 IGNITER 0.6 GRAMS ALCLO POWDER 6.0 GRAMS ALCLO PELLS
12 1 GRAIN ALCLO
11 AS REQ'D RESTRICTOR LINEN TAPE & SELECTION
10 18 WIRE STL MUSIC WIRE .04 DIA (.039 DIA) = 0.75 LB.
9 1 INSULATOR AE 52-1034-1
8 1 PLANK AE 52-1034-2
7 4 SOCKET HEAD CAP SCREW STL 1/4-28 NF x .875 LG
6 1 O RING AN 6230-12
5 1 INSERT AE 52-1037-E
4 1 CENTER SECTION AE 52-1728
3 16 HEX HEAD MACH BOLT STL 3/8-16 NC 1.75 LG
2 1 NOSE SECTION AE 52-1728
1 1 FITTING AN 816-12
PART NO. NAME MATL & SIZE
FOR APPROVED ONLY
DATE
JUL 16 1952
6-7-52 T-1-52
AERONUTRONIC SYSTEMS INC.
ASSEMBLY TEST NOZZLE 48 HYDROJET
AE 52-1727 R

Figure 87



Alcla Motor Setup for Testing in Static Test Pit

Figure 88

CURVE NO. 4127

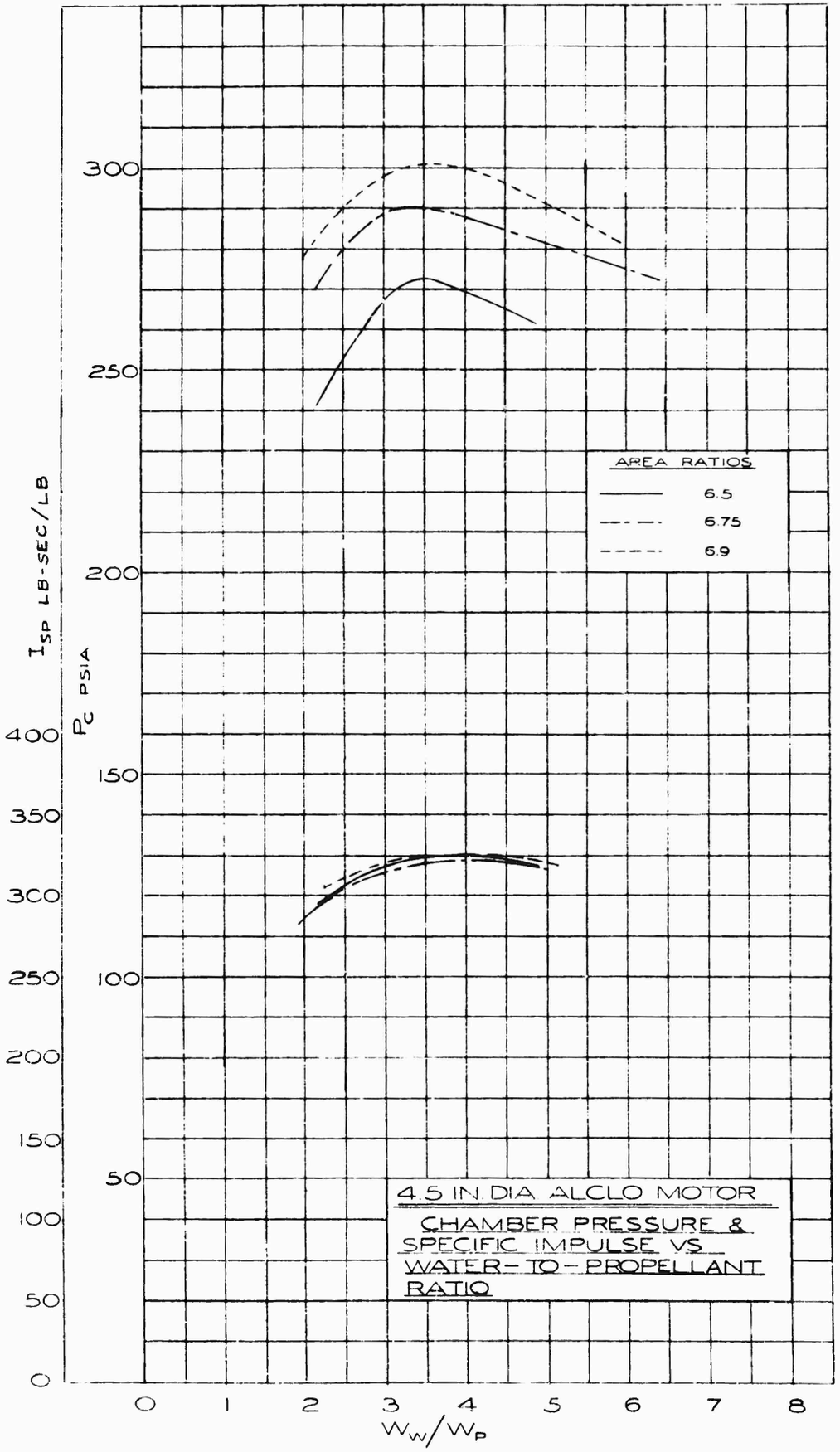
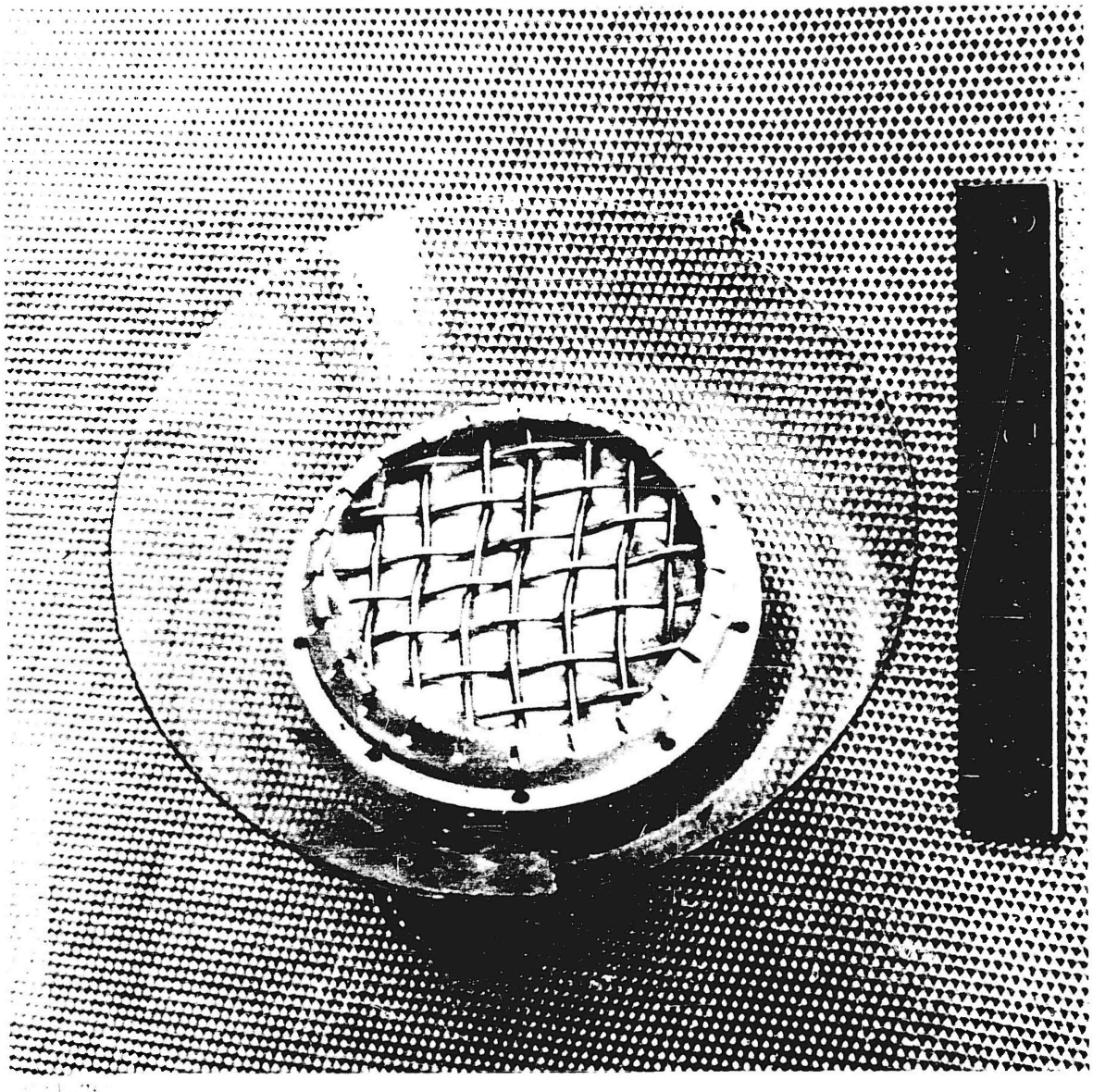


Figure 89



Stand-Off Igniter Mark II

Figure 90

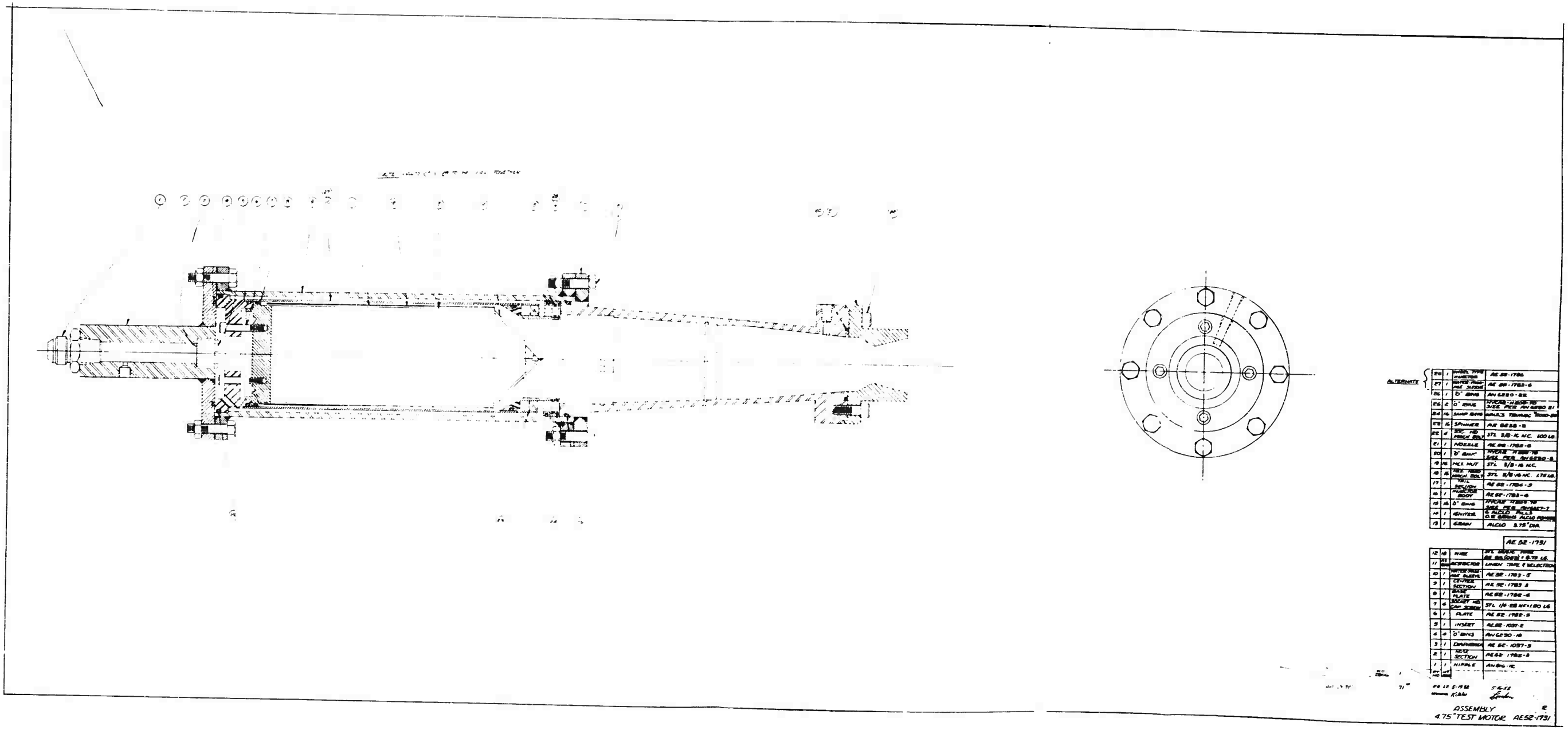


Figure 91

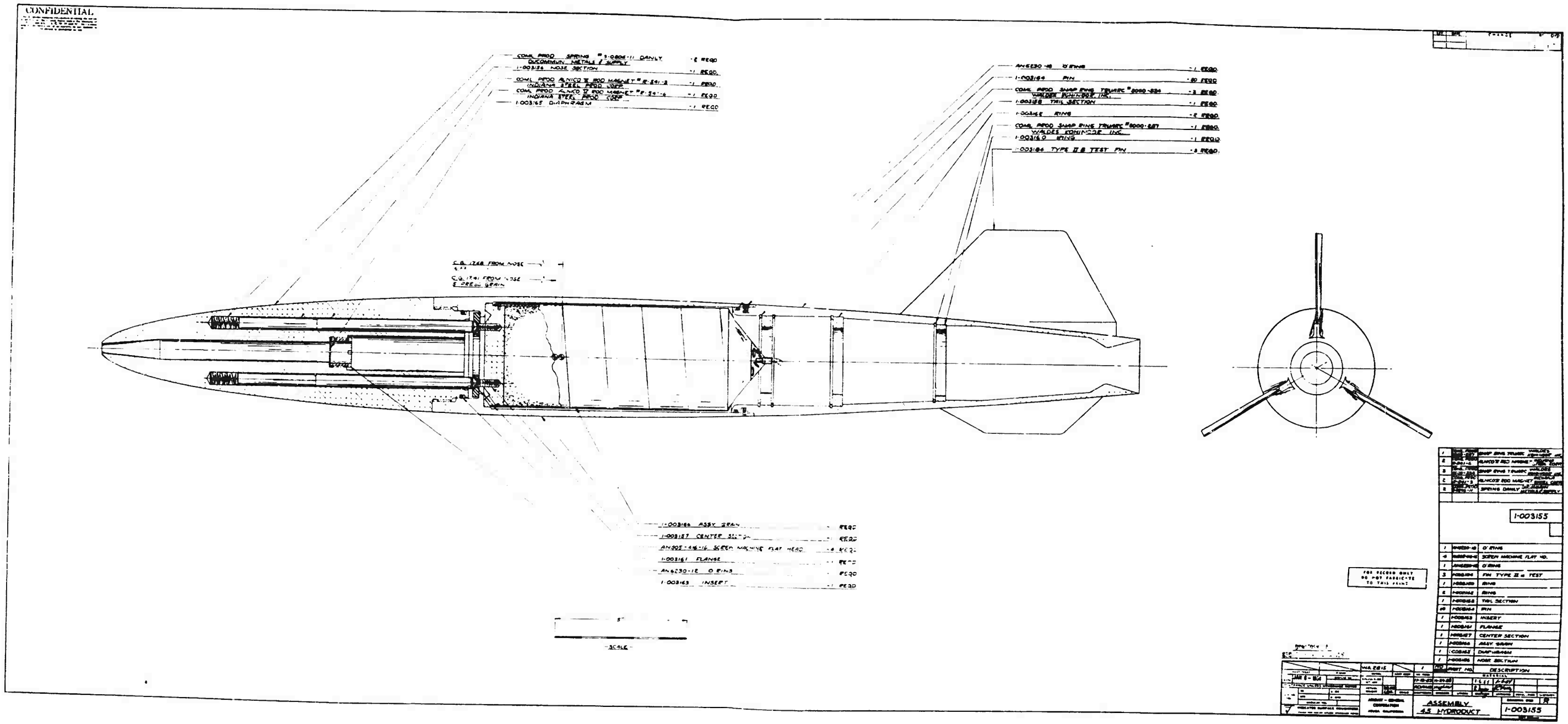
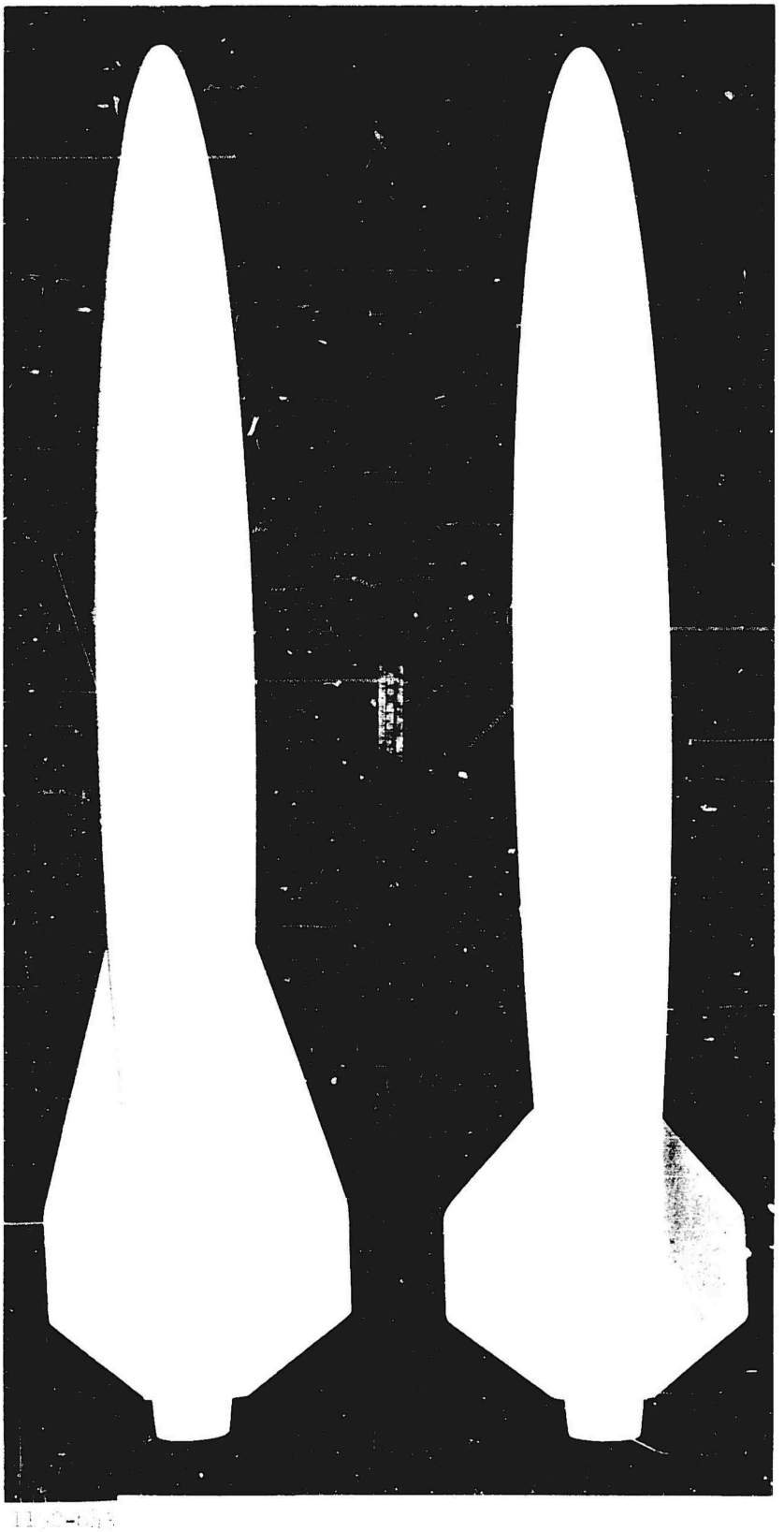

CONFIDENTIAL
1-003155
FOR RECORD ONLY
DO NOT FABRICATE
TO THIS PRINT
ASSEMBLY
45 HYDROJECT
1-003155
SCALE
CONFIDENTIAL

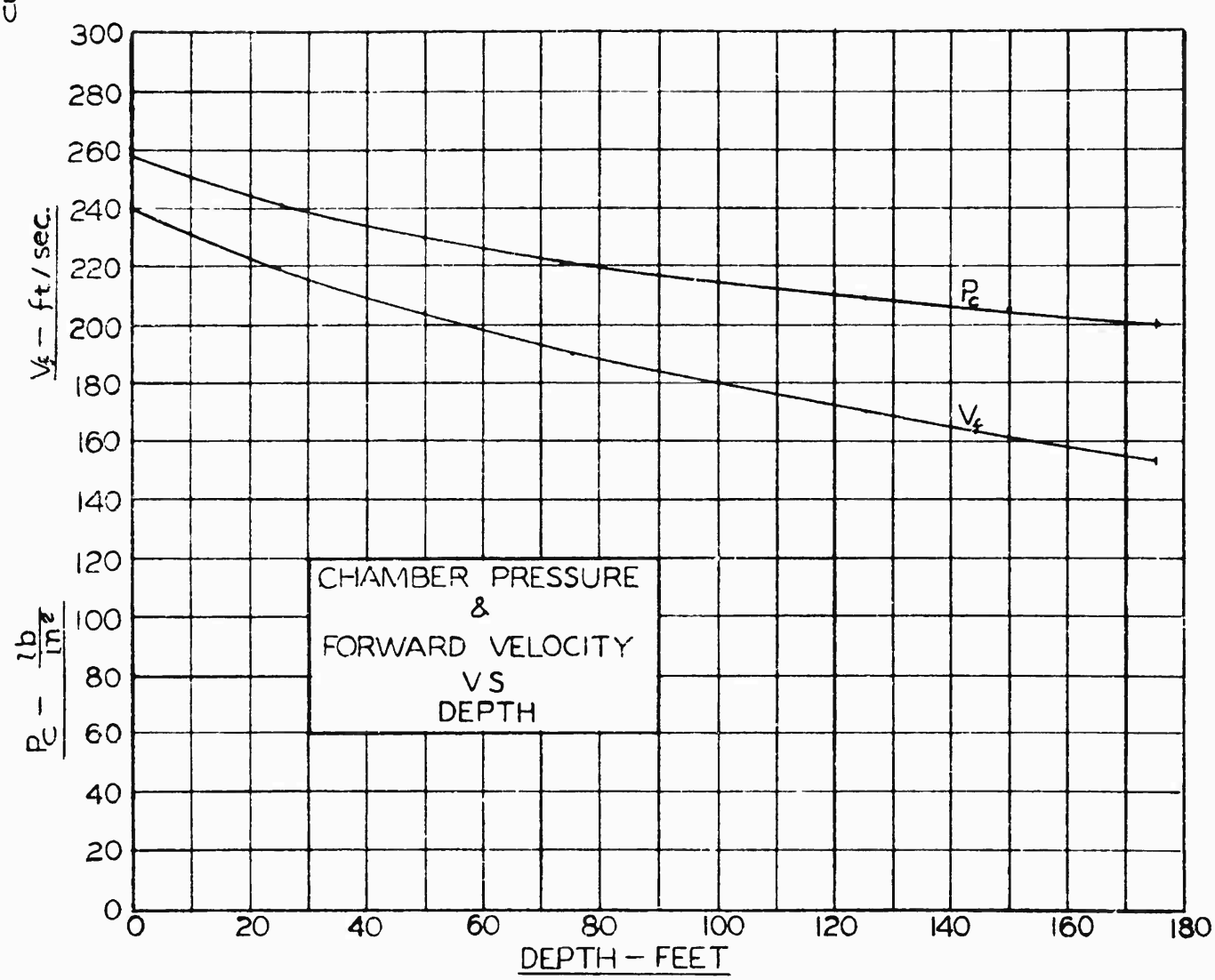
Figure 92



Comparative View of Test Vehicles with Type I and Type II Fins

Figure 93

CURVE NO. 4116



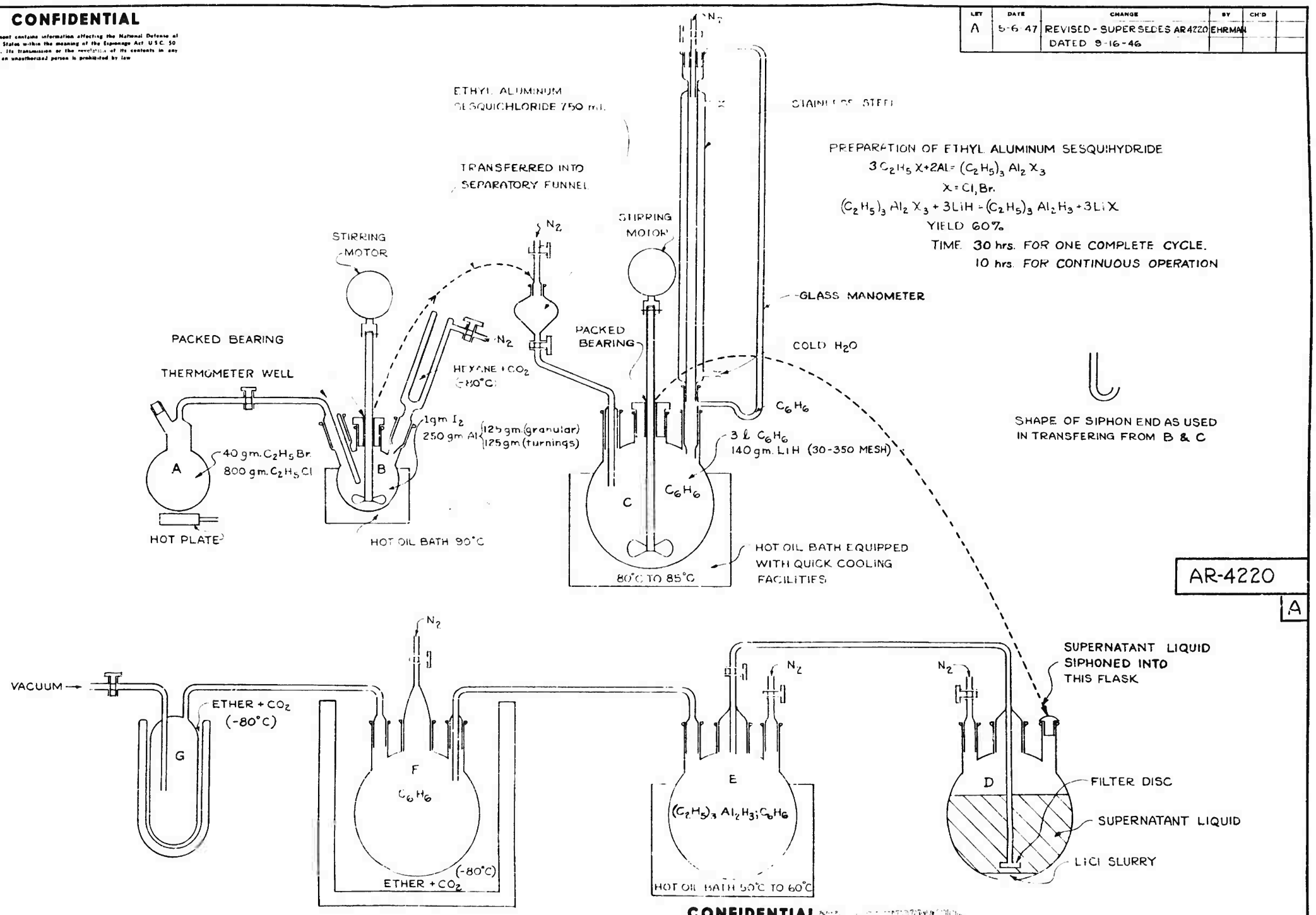
PERFORMANCE OF
4.5 IN. DIA. ALCLO HYDRODUCT

Figure 94

CONFIDENTIAL

This document contains information affecting the National Defense of the United States within the meaning of the Espionage Act, U.S.C. 50 31 and 32. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited by law

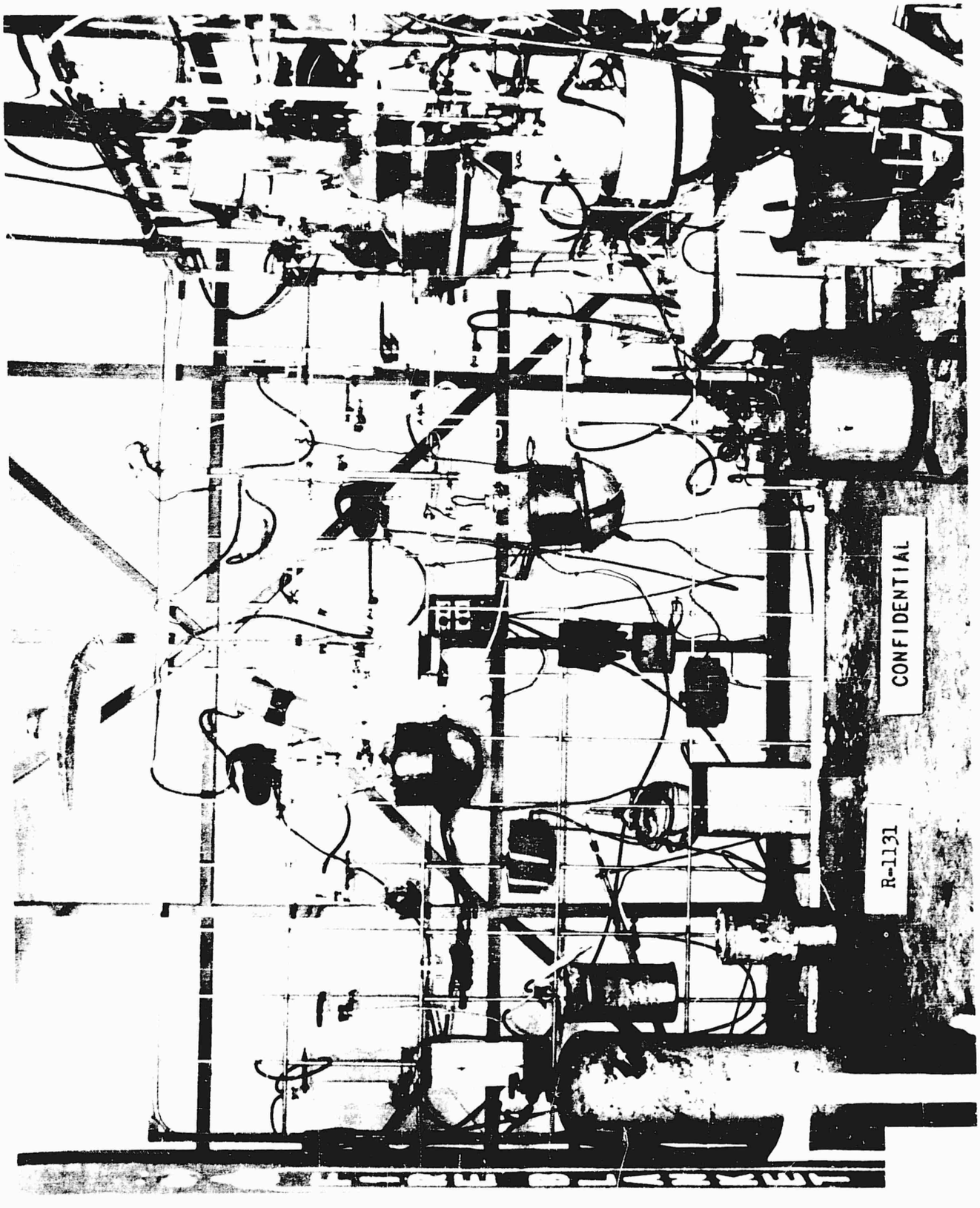
LET	DATE	CHANGE	BY	CH'D
A	5-6-47	REVISED - SUPERSEDES AR4220 DATED 8-16-46	EHRMAN	



CONFIDENTIAL

HEAT TREAT / FINISH	MODEL / NO. REQ. / NEXT ASSY.	MATERIAL		
RELEASE DATE: JUL 3 1952	CALCULATED WEIGHT	5-6-47	5-9-47	
UNLESS OTHERWISE NOTED TOLERANCES ARE FRACTIONS ± 1/32 DECIMALS ± .005 ANGLE ± 1/2°	ACTUAL WEIGHT / SCALE	EHRMAN (DRAFTSMAN)	(CHECKED)	(STRESS)
1 POLISH 2 SMOOTH GRIND 3 SMOOTH MACH. FINISH 4 ROUGH MACH. FINISH 5 ROUGH FILE OR GRIND 6 SAND BLAST	AEROJET ENGINEERING CORP. AZUSA CALIFORNIA			
FINISH ALL SURFACES NOT OTHERWISE NOTED		PREPARATION OF ETHYL ALUMINUM SESQUIHYDRIDE LABORATORY SCALE		
NOTES: 1. ALL NOTES APPLY UNLESS OTHERWISE SPECIFIED 2. REMOVE ALL BURRS AND SHARP EDGES		DRAWING SIZE: D	AR-4220 PART NUMBER	

Figure 95

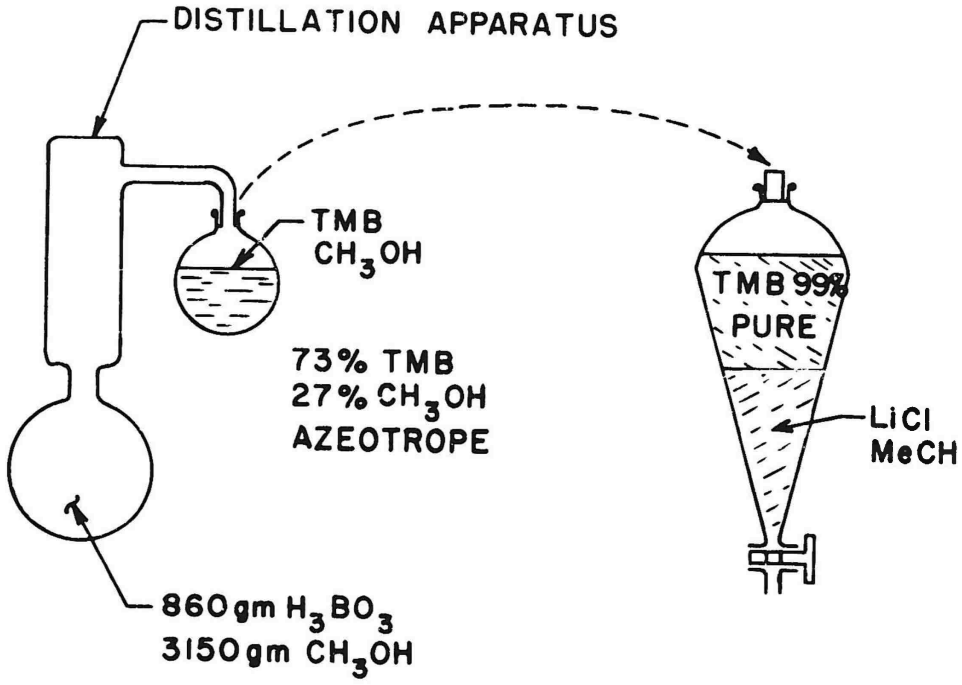


Ethyl Aluminum Sesquihydride Preparation Apparatus

$H_3BO_3 + 8\,CH_3OH = (CH_3O)_3\,B + 3H_2O + 5\,CH_3OH$

YIELD 70% 1010 gm; PURITY 99%

16 hrs.



SYNTHESIS OF ALUMINUM BOROHYDRIDE

STEP I PREPARATION OF TRIMETHYL BORATE

NO. 682
5-27-47

Figure 97

CONFIDENTIAL

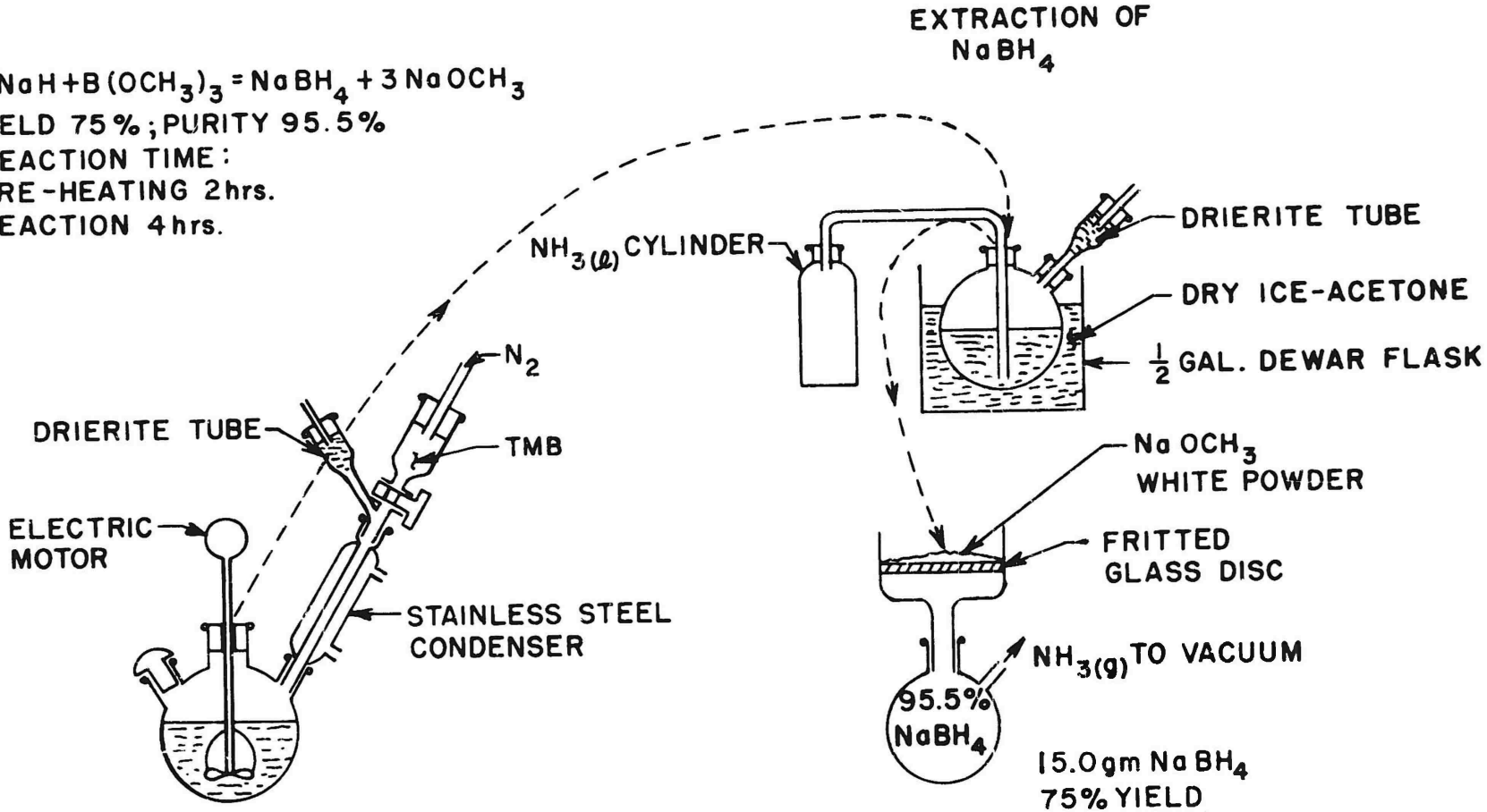
CONFIDENTIAL

CONFIDENTIAL

$4NaH + B(OCH_3)_3 = NaBH_4 + 3NaOCH_3$

YIELD 75%; PURITY 95.5%

REACTION TIME:
PRE-HEATING 2hrs.
REACTION 4hrs.



NaH 52.8gm (10% EXCESS)
TMB 52.0gm; POWDERED GLASS OR UNEXTRACTED PORTION OF PREVIOUS RUN 10.5gm.

15.0gm $NaBH_4$
75% YIELD
PURITY 95.5%

SYNTHESIS OF ALUMINUM BOROHYDRIDE

STEP 2 - PREPARATION OF SODIUM BOROHYDRIDE

NO. 683
5-27-47

Figure 98

CONFIDENTIAL

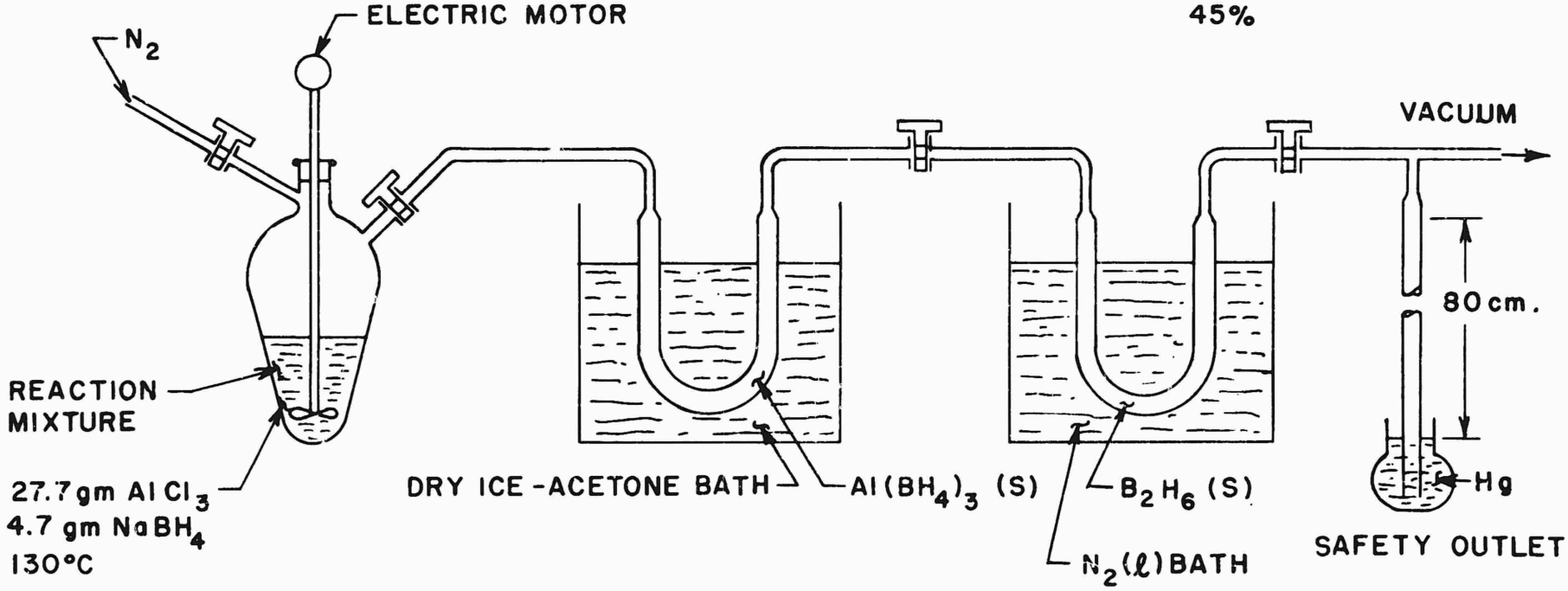
CONFIDENTIAL

$5AlCl_3 + 3NaBH_4 = Al(BH_4)_3 + 4AlCl_3 + 3NaCl$ → 2.5gm; 85% YIELD; 2 hrs.

2.5gm $Al(BH_4)_3$ FINAL PRODUCT

95% PURITY

OVER-ALL EFFICIENCY OF 3 STEP PROCESS; 45%



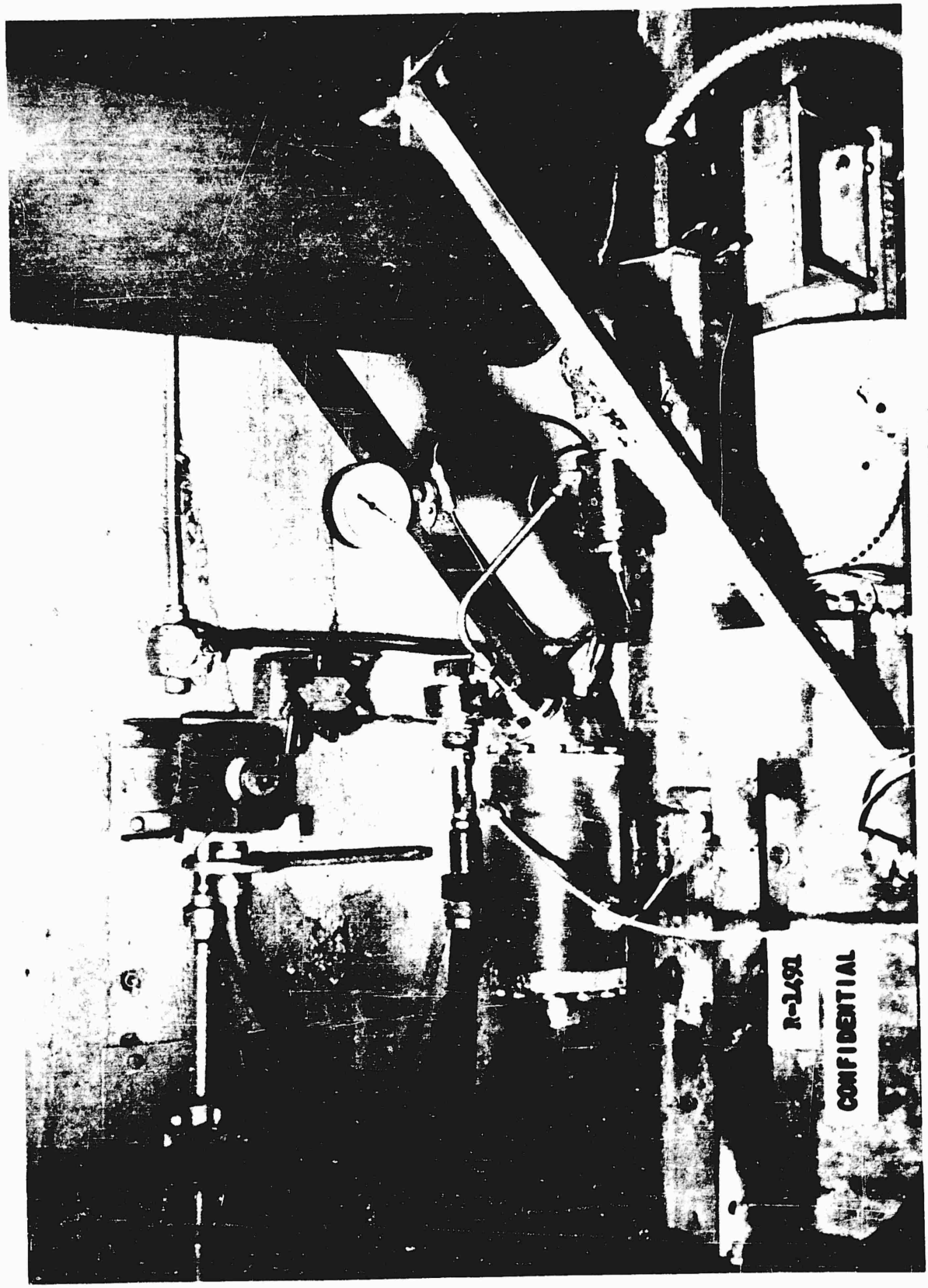
SYNTHESIS OF ALUMINUM BOROHYDRIDE

STEP 3 – PREPARATION OF $Al(BH_4)_3$

NO. 684
5-28-47

Figure 99

Report No. 1106



Molten-Lithium and Water Rocket Motor Installation

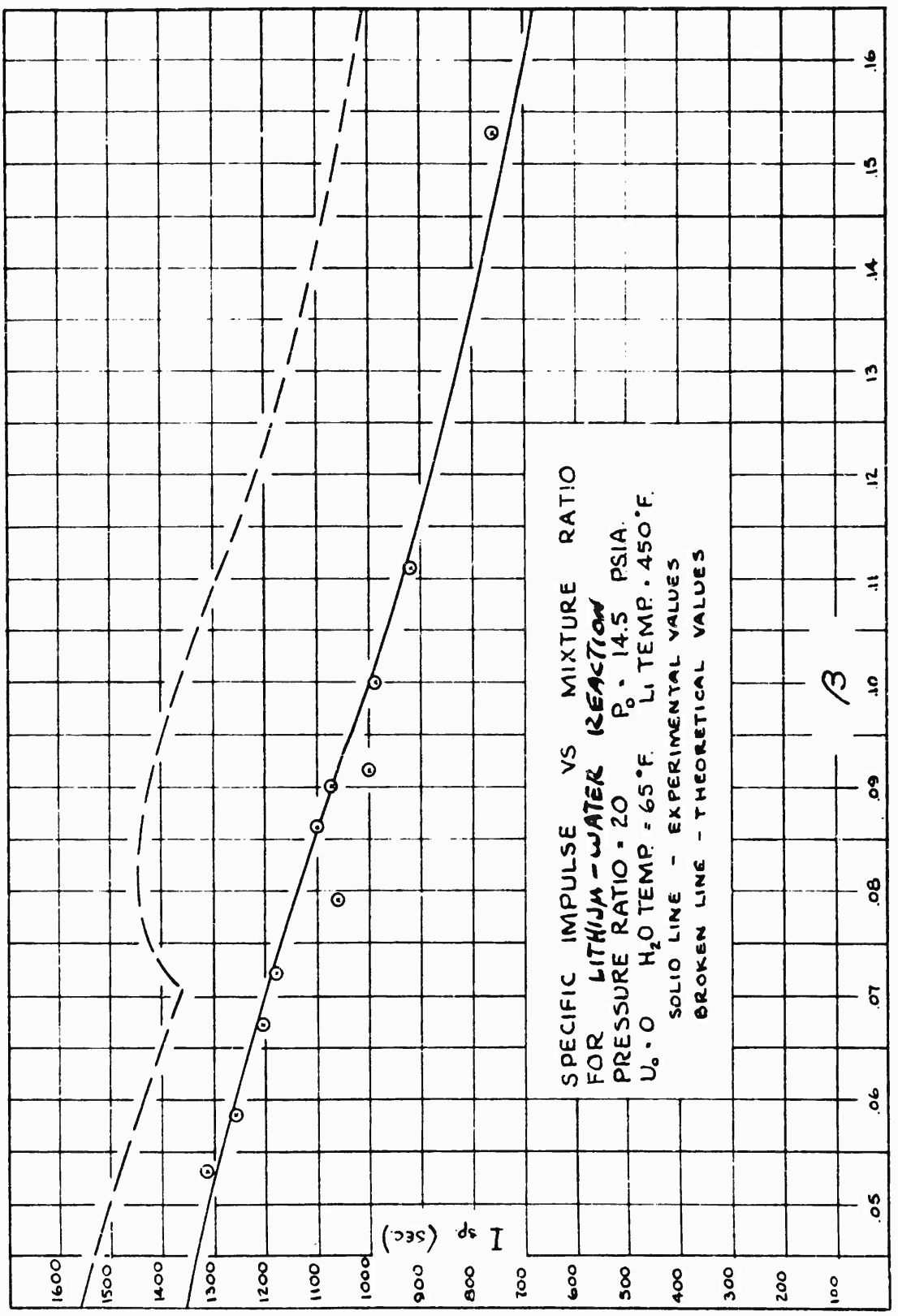
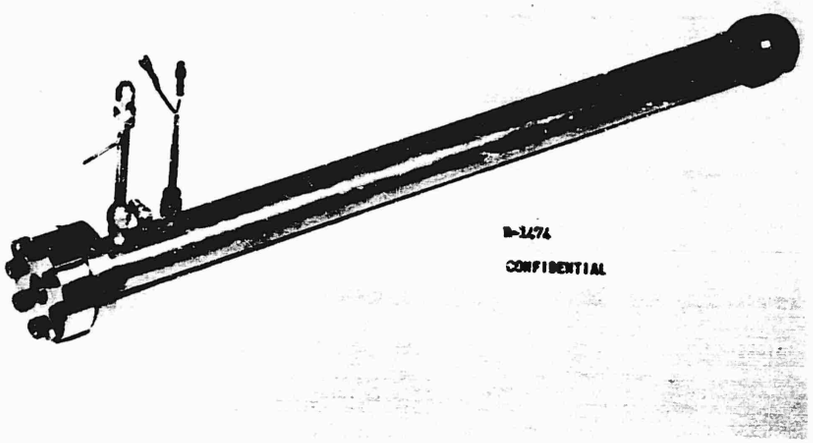
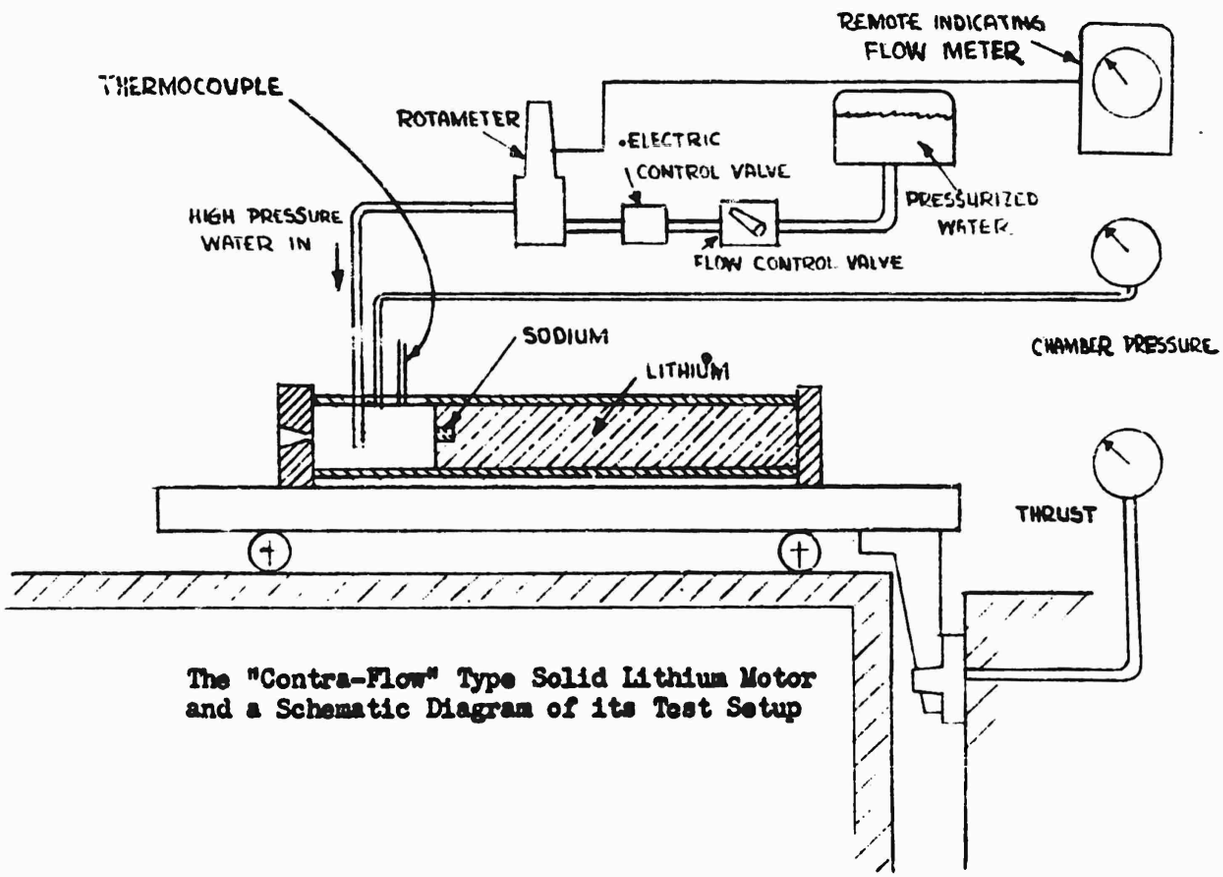
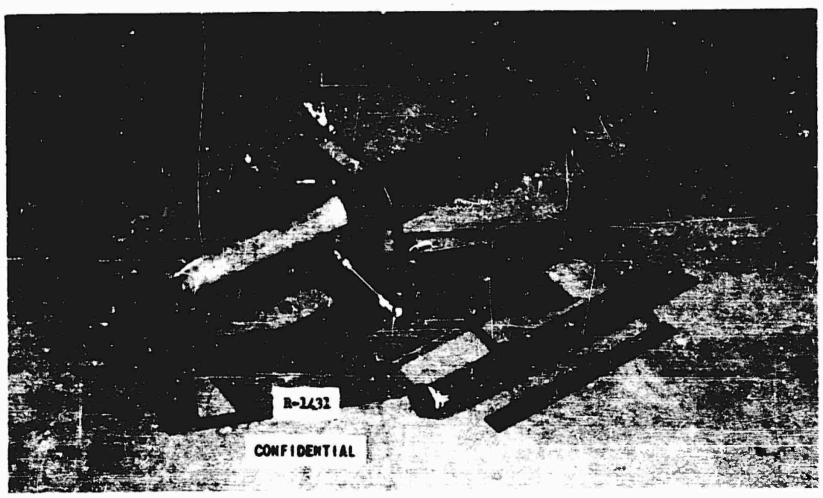

SPECIFIC IMPULSE VS MIXTURE RATIO
FOR LITHIUM-WATER REACTION
PRESSURE RATIO = 20 P_o = 14.5 PSIA.
U_o = 0 H_2O TEMP. = 65°F. Li TEMP. = 450°F.
SOLID LINE - EXPERIMENTAL VALUES
BROKEN LINE - THEORETICAL VALUES
I_{sp} (sec.)
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
.16
.15
.14
.13
.12
.11
.10
.09
.08
.07
.06
.05

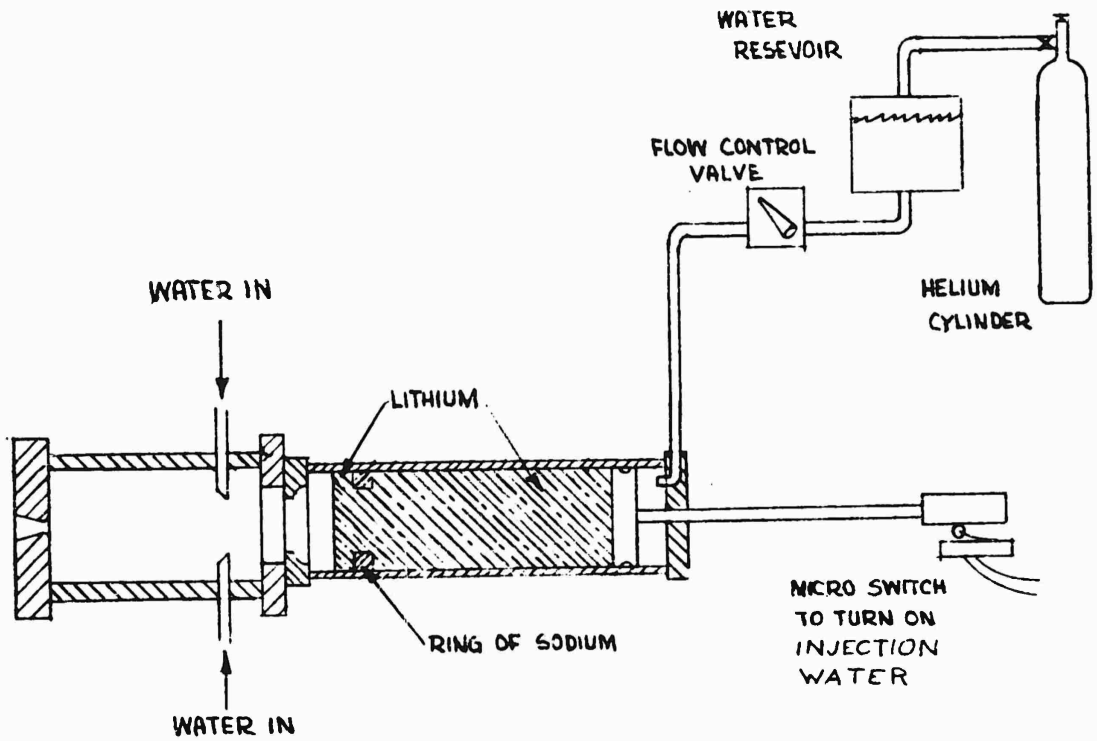
Figure 101



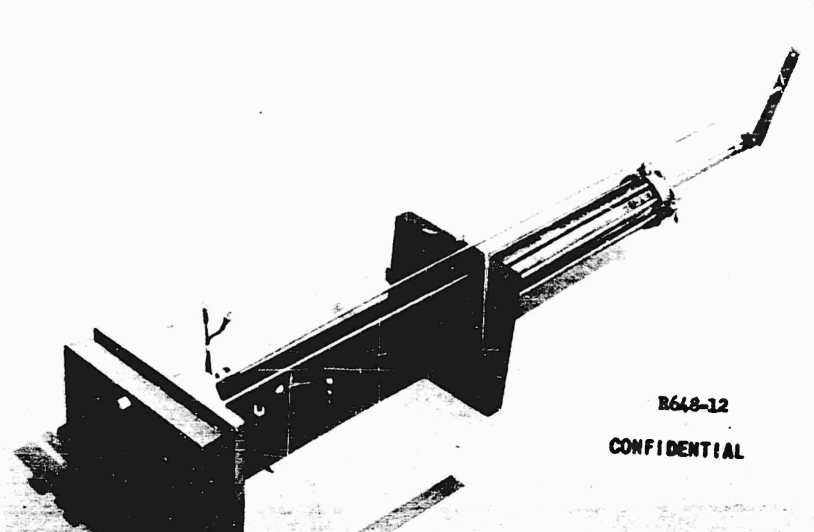


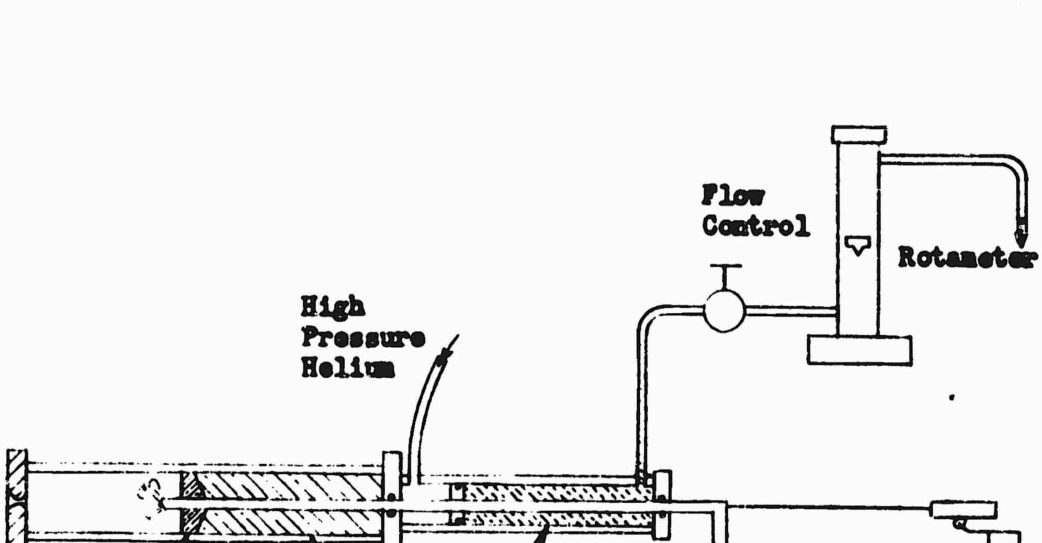
The "Contra-Flow" Type Solid Lithium Motor and a Schematic Diagram of its Test Setup



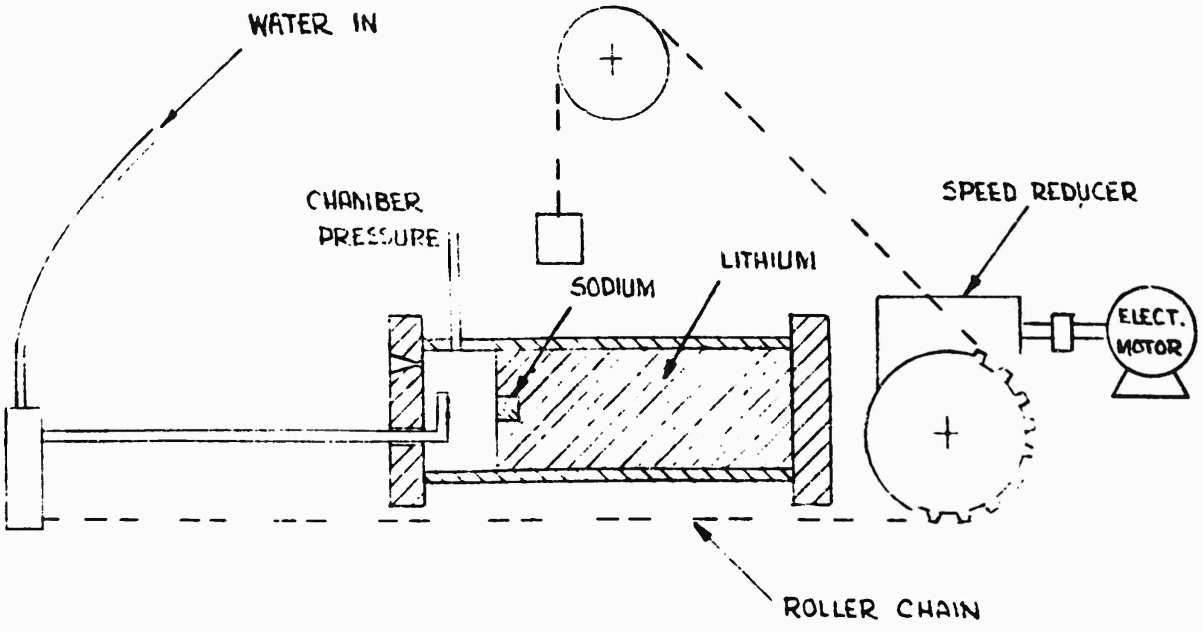


An "Extrusion" Solid Lithium Motor
and a Schematic Diagram of its Test Setup

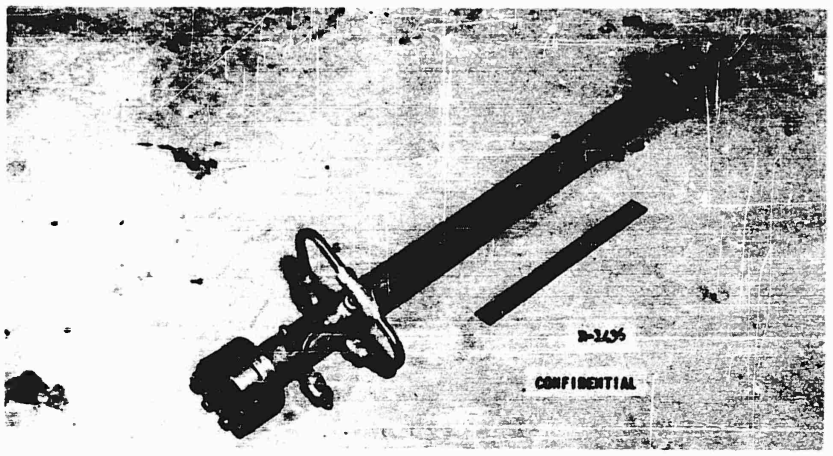


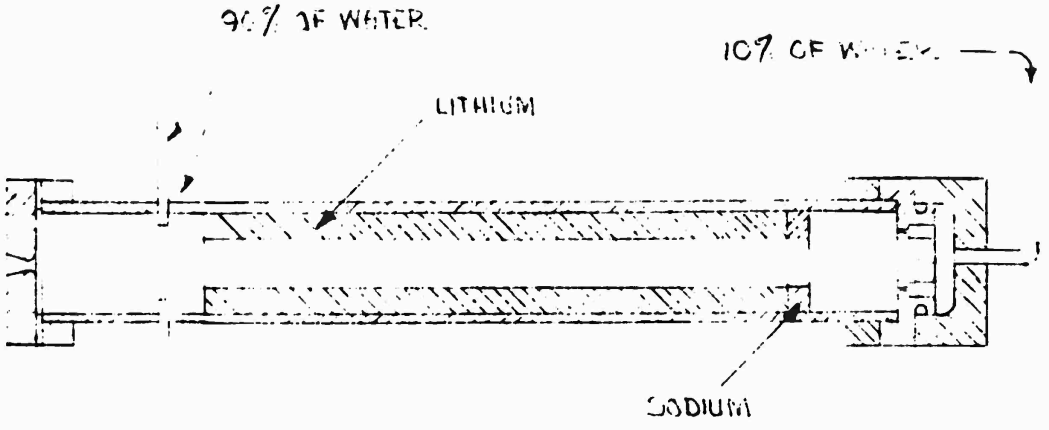


The "Traveling Injector" Solid Lithium Motor and a Schematic Diagram of its Test Setup



A "Traveling-Injector" Second Type Solid-Lithium Motor, and a Schematic Diagram of its Test Setup

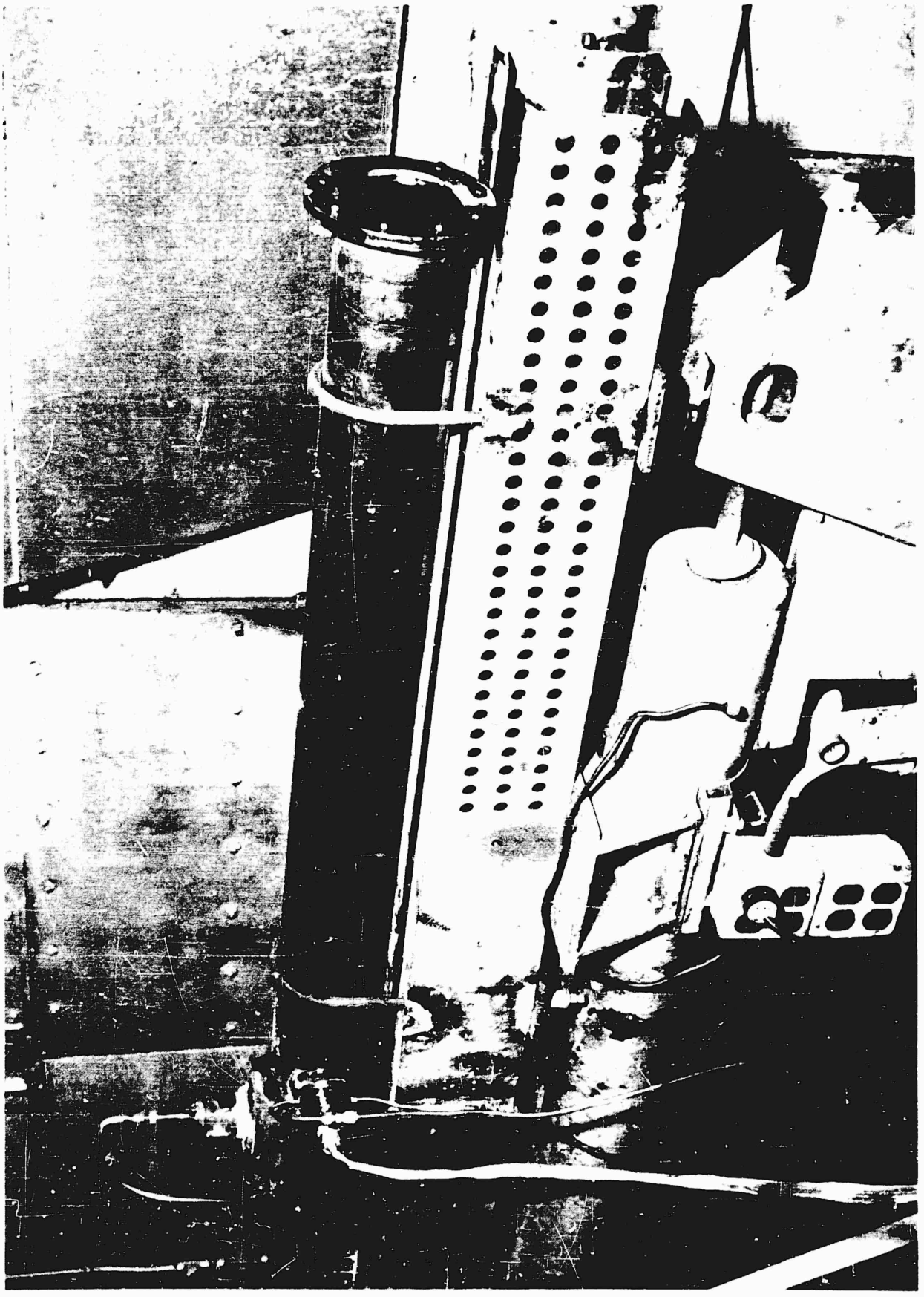




A "Direct Flow" Solid Lithium Motor
and a Schematic Diagram of Its Test Setup

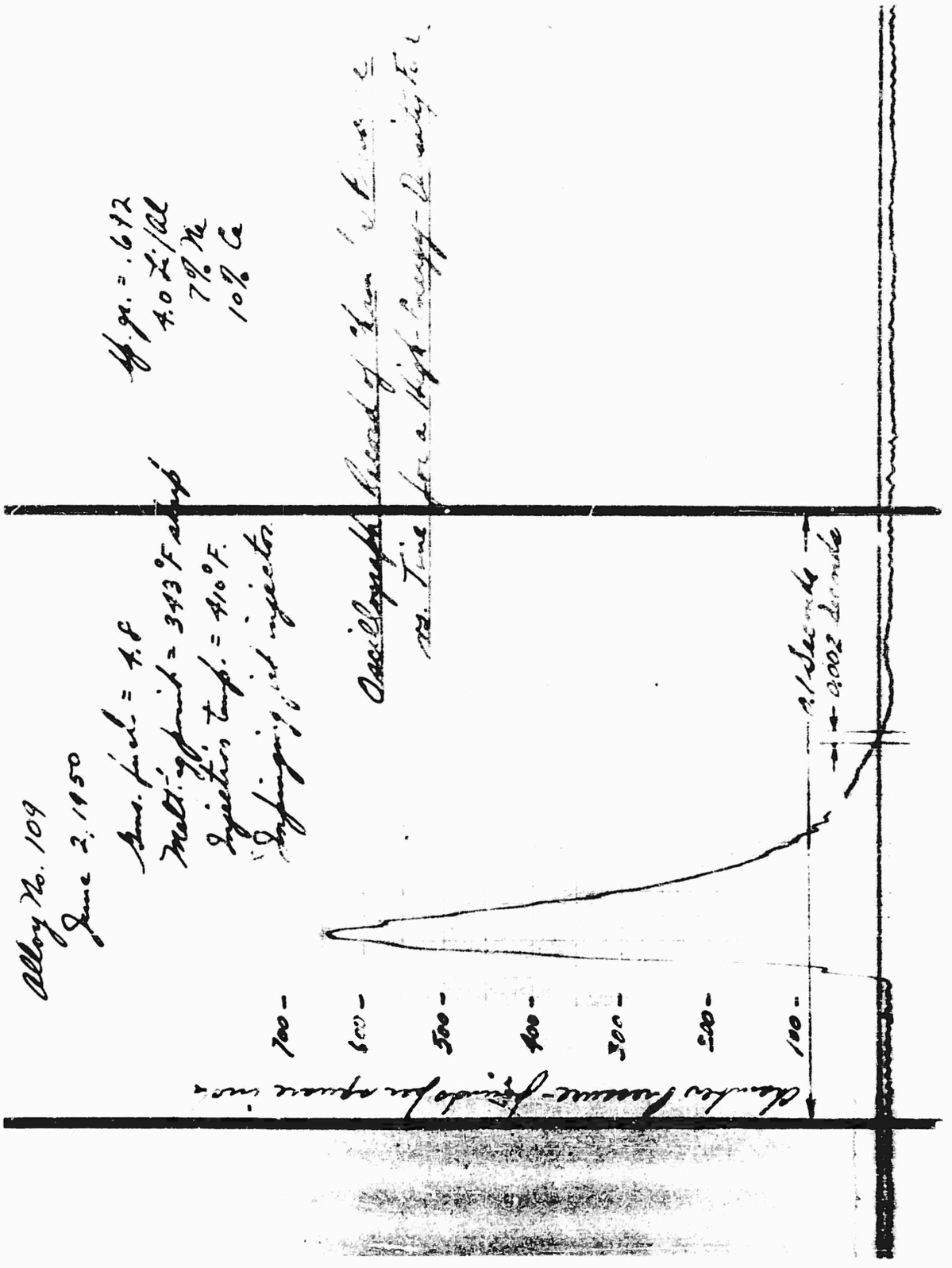
Alloy Melter Components

Figure 107



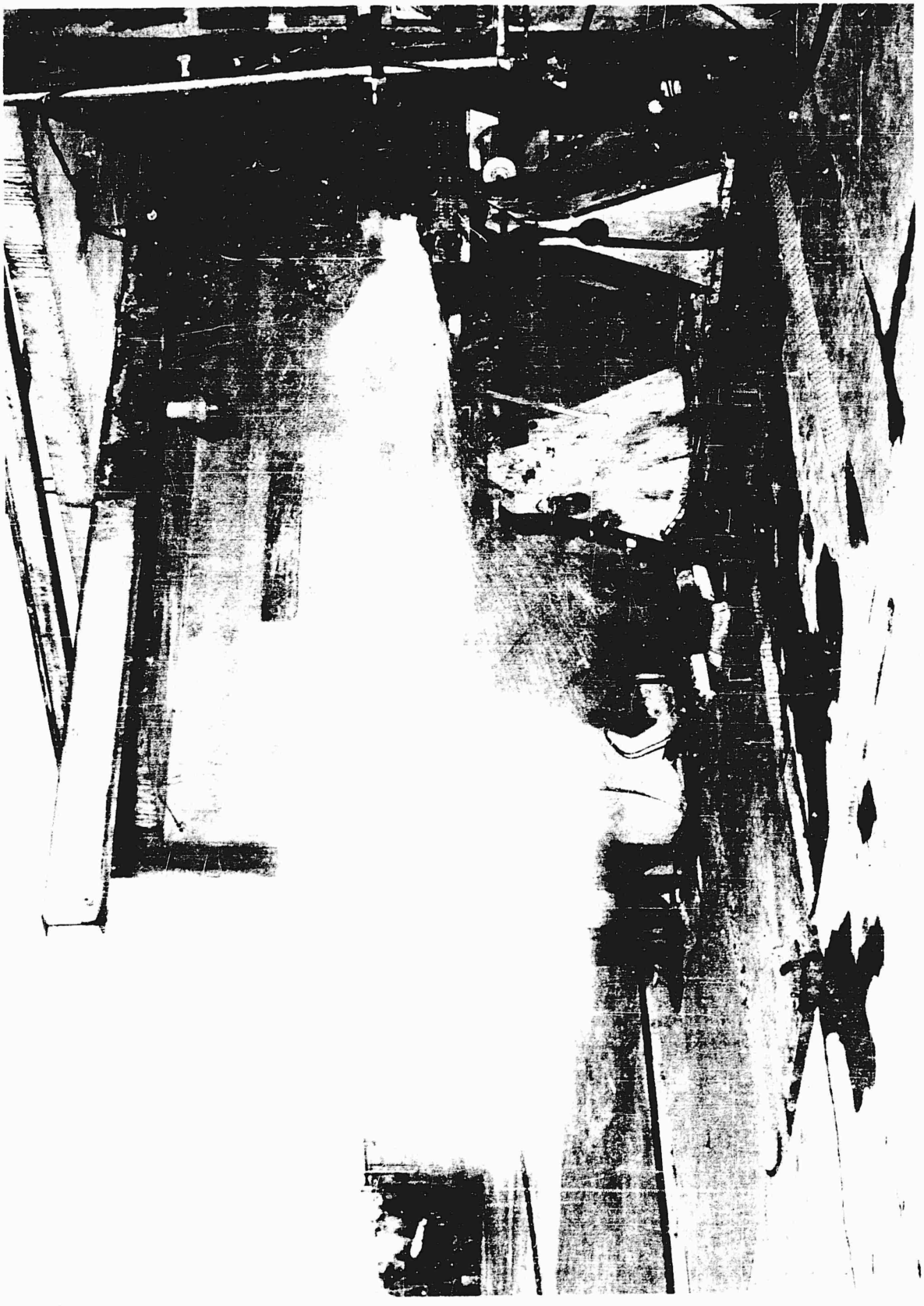
Single-Shot Direct Hydropulse Test Unit

Figure 108



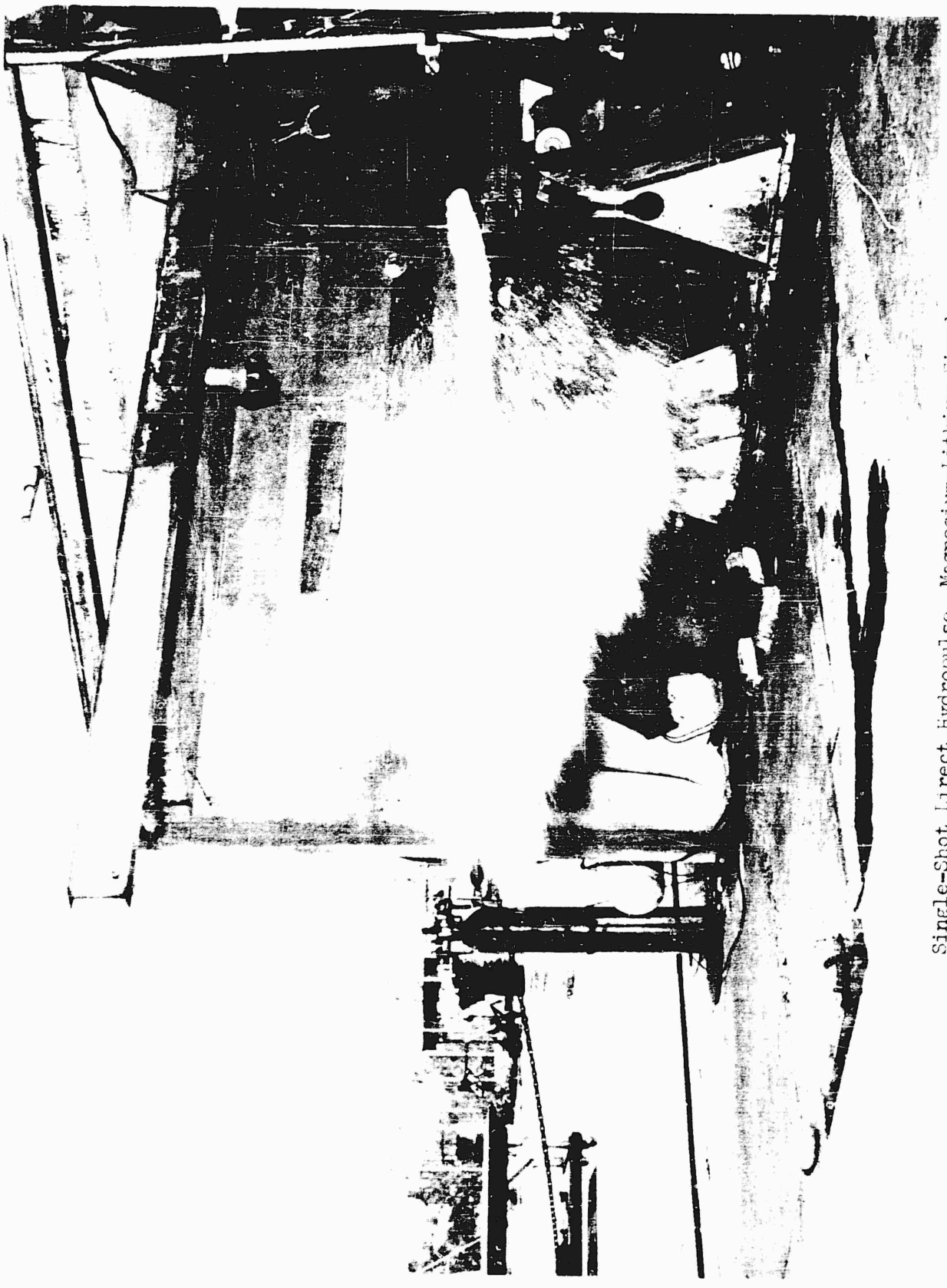
Pressure-Time Trace for a High-Energy-Density Fuel

Figure 109



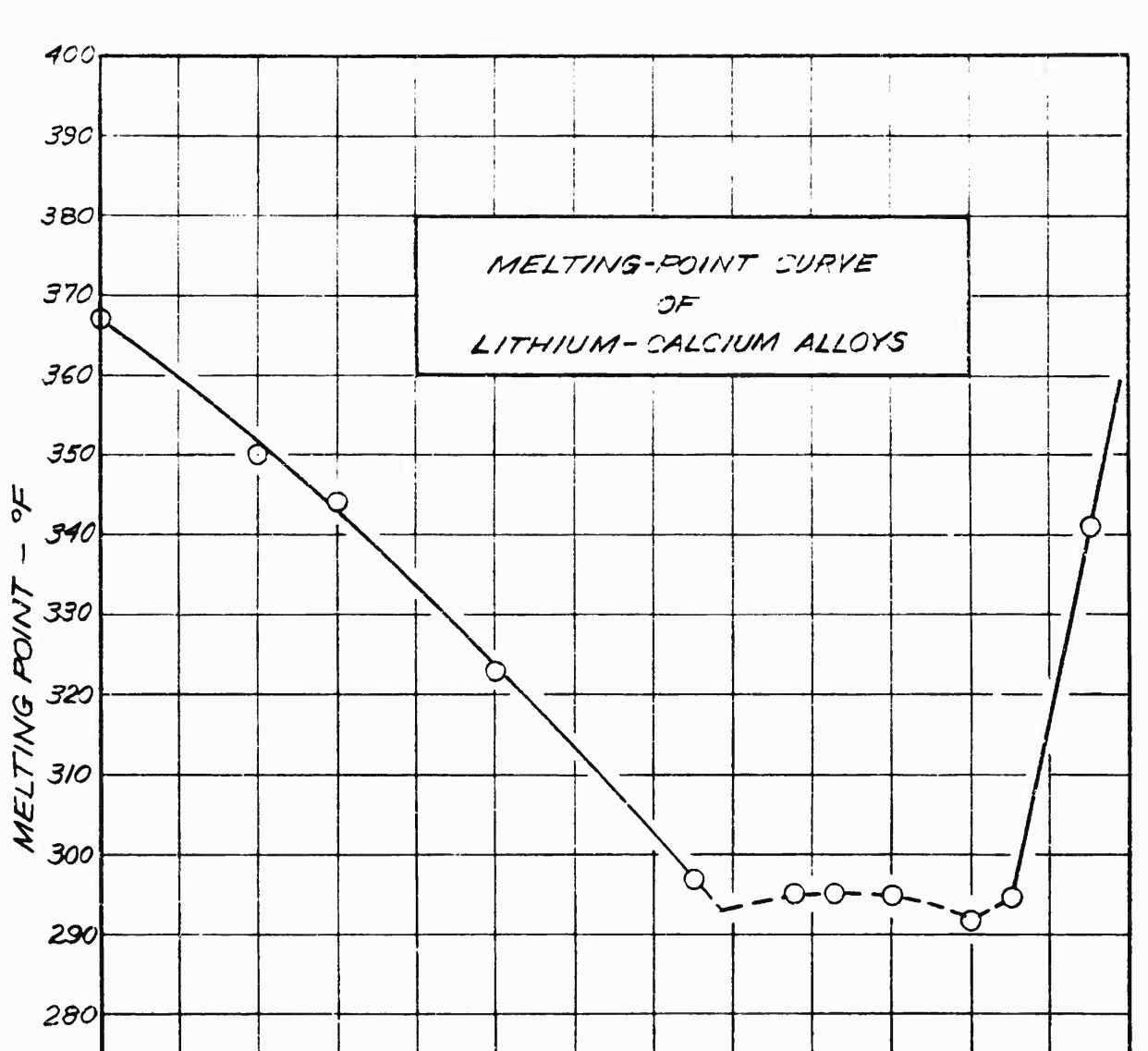
Single-Shot, Direct Hydropulse, Lithium Fired

Figure 110



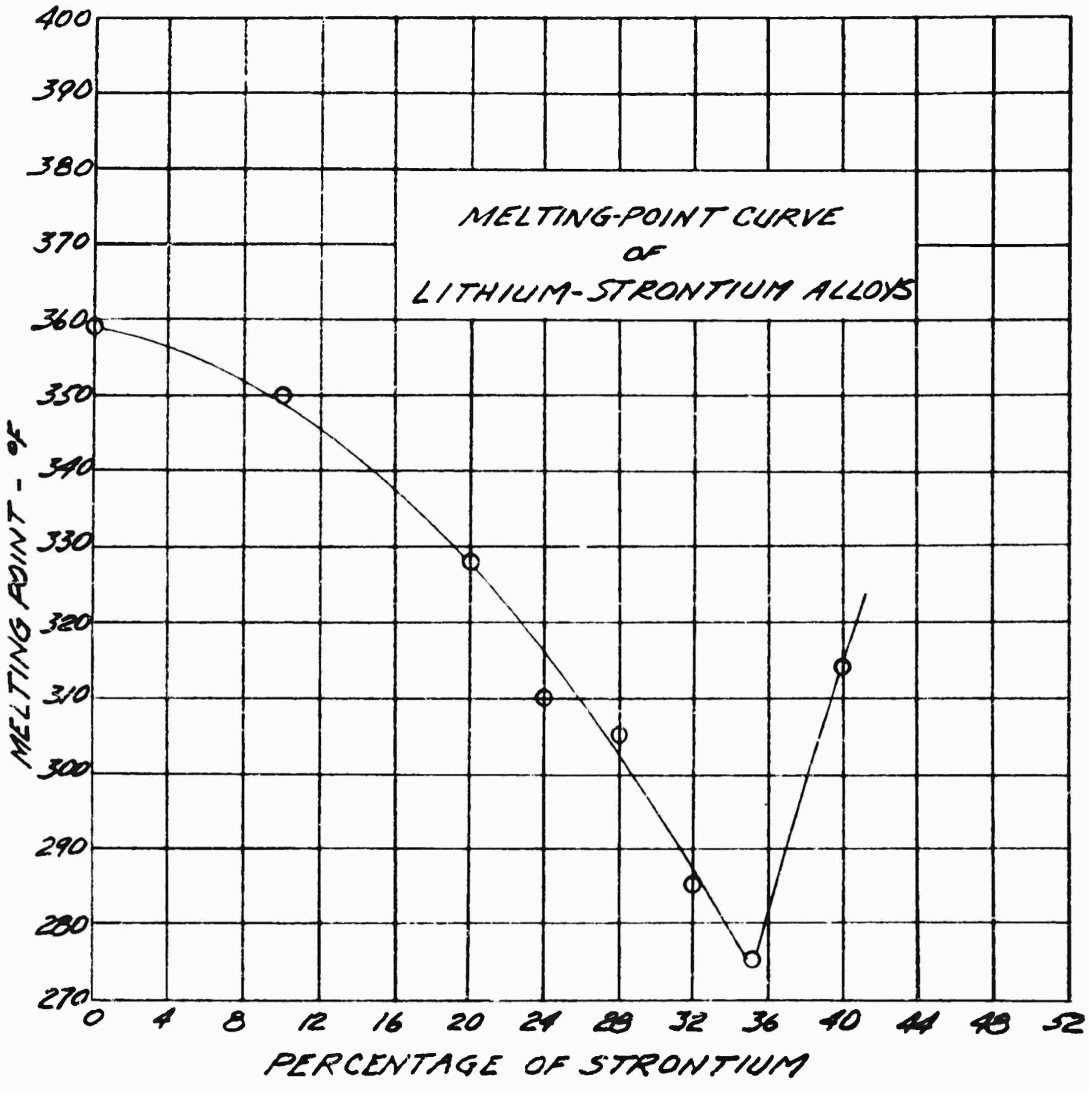
Single-Shot Direct Hydropulse, Magnesium-Lithium Fired

Figure 111



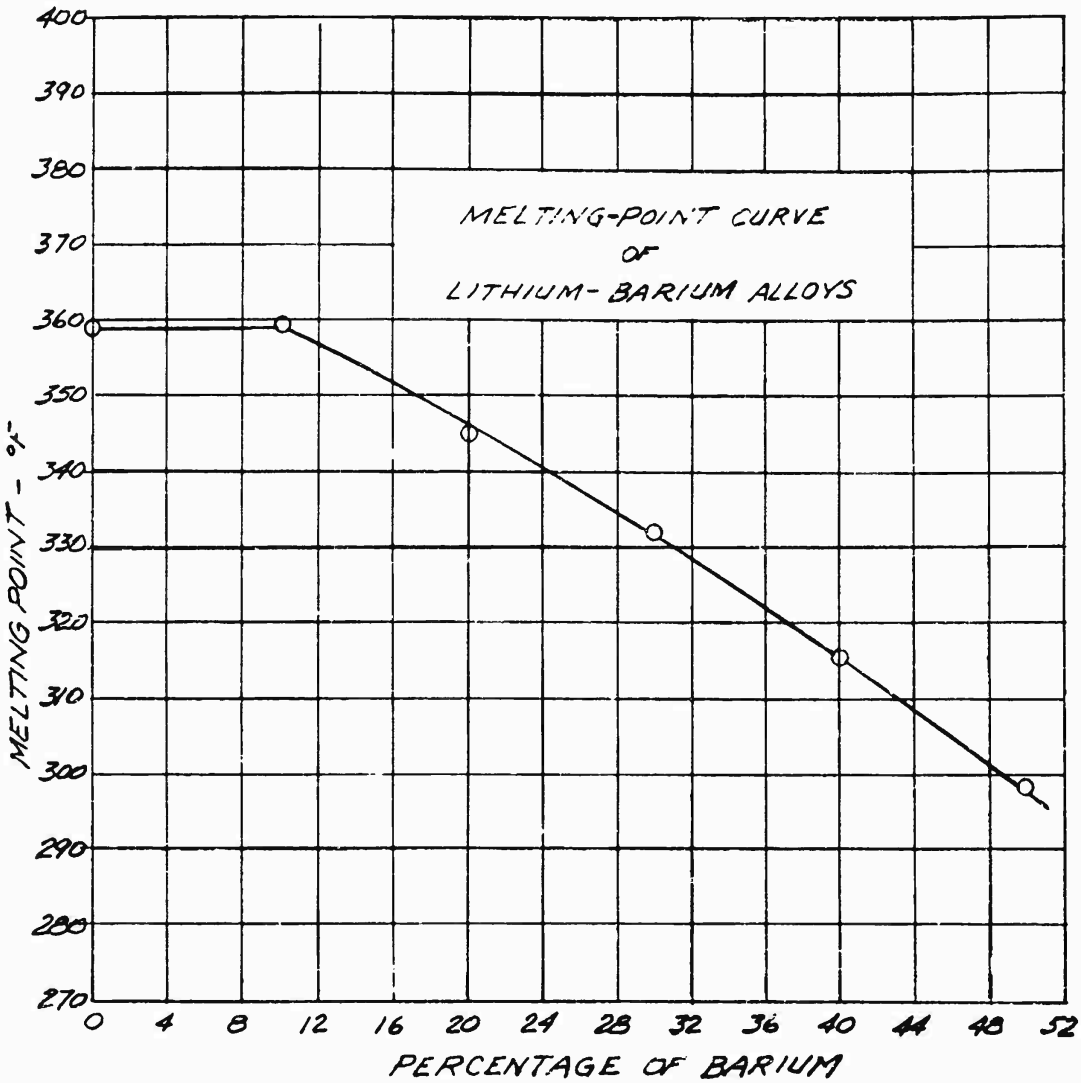
CURVE NO 4054 6-25-50 HIGGINS

Figure 112



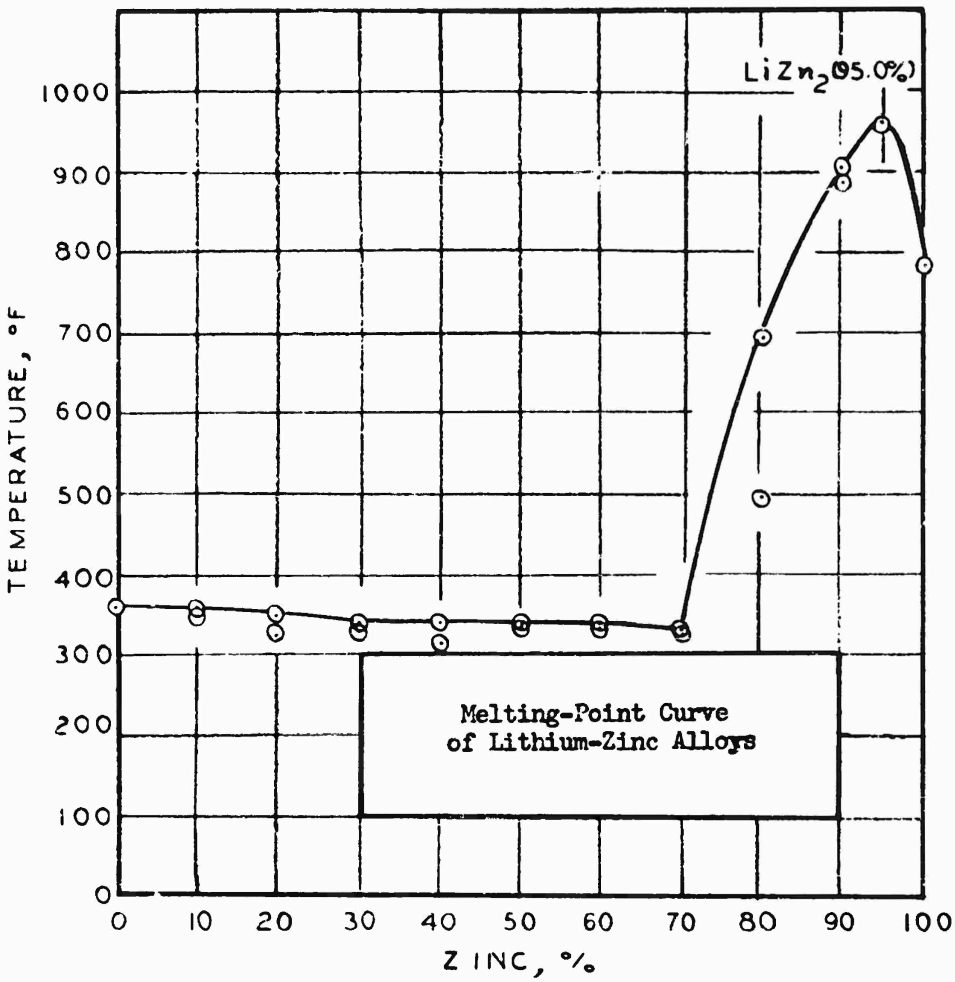
CURVE NO. 4078 12-1-50 COX

Figure 113



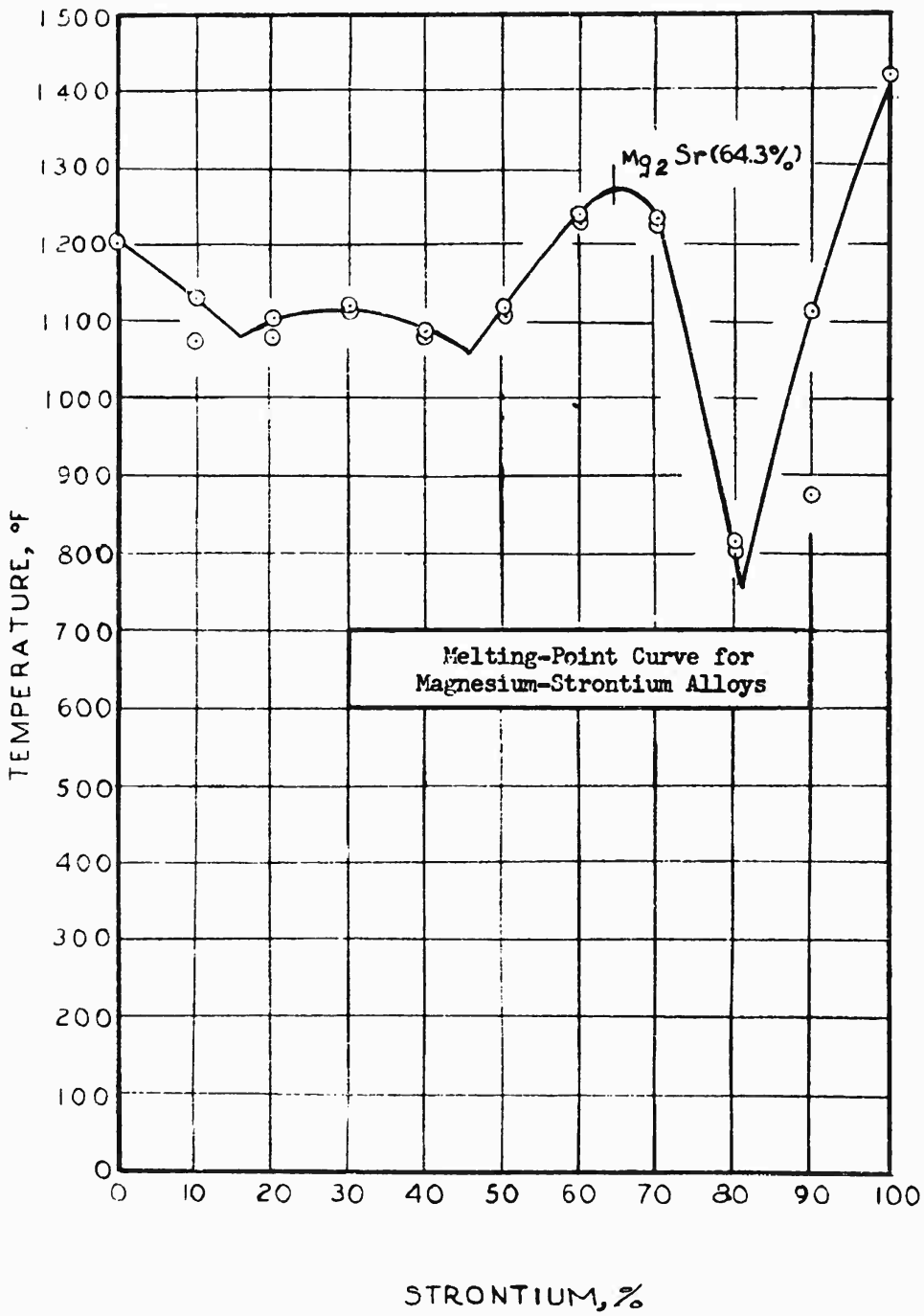
CURVE NO. 4064 12-1-50 COX

Figure 114



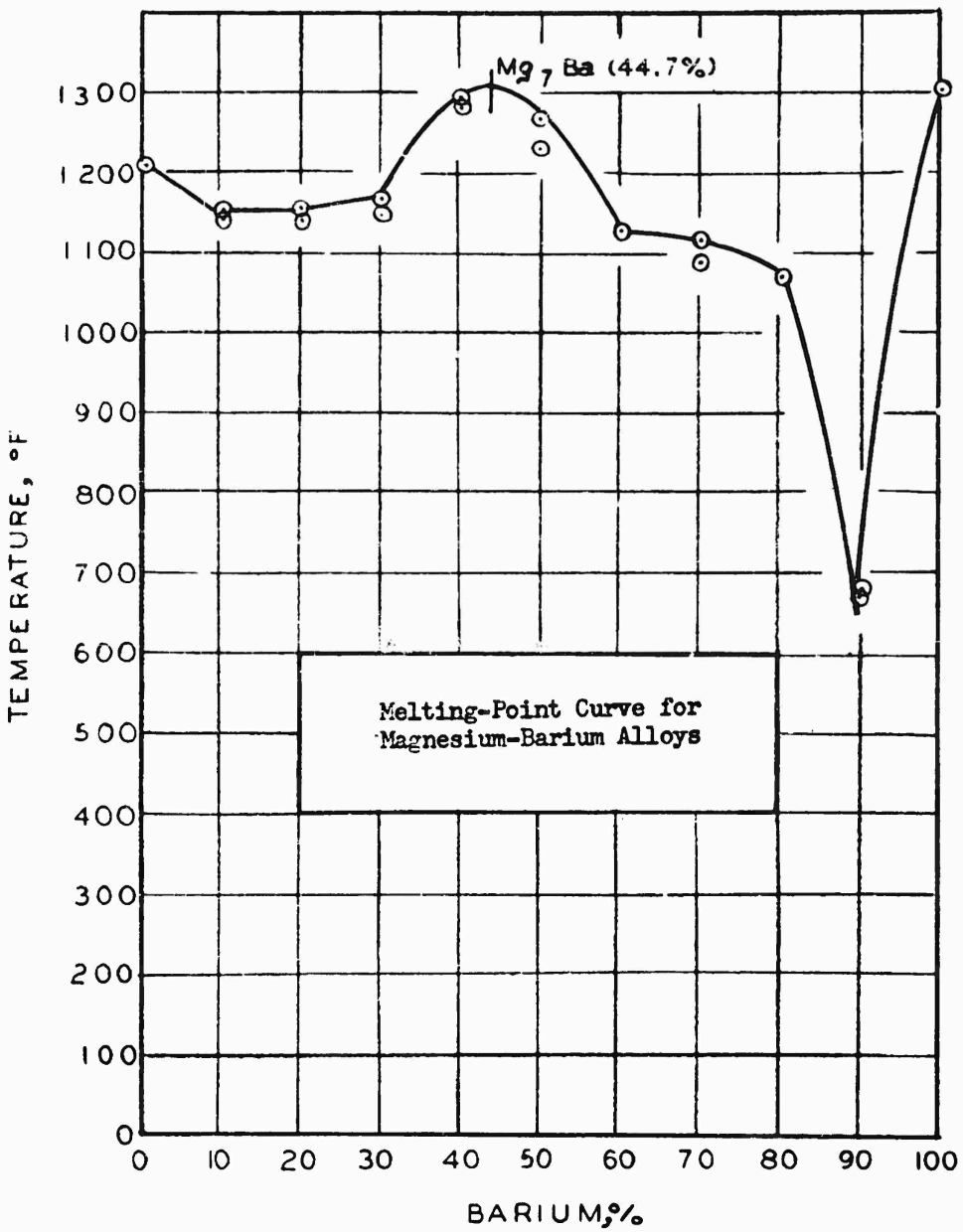
CURVE NO. 4094 6-26-51 R.B. COX/p.s.

Figure 115



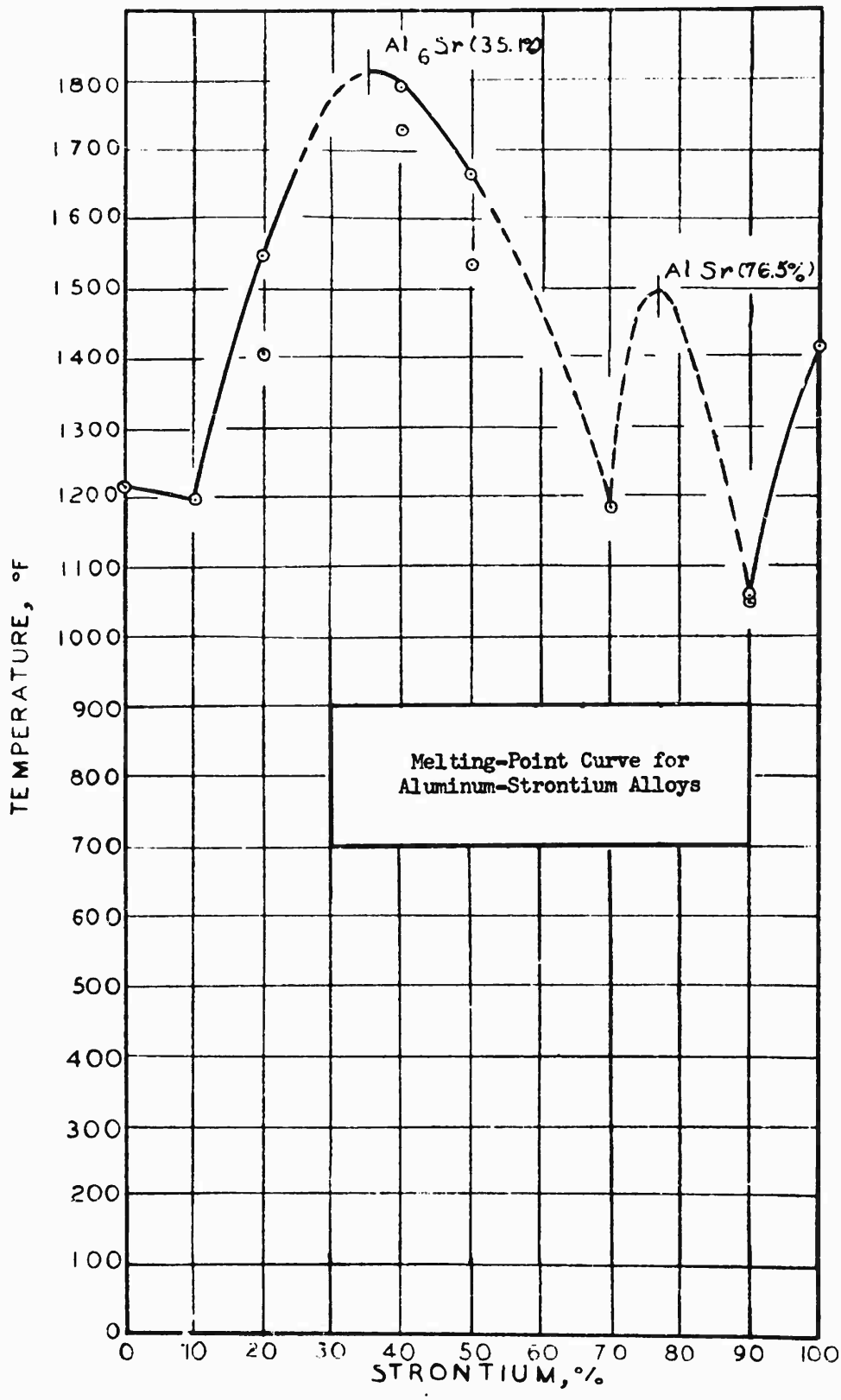
CURVE NO. 4095 6-26-51 R.B. COX/pn

Figure 116



CURVE NO. 4096 6-26-51 R.B. COX

Figure 117



CURVE NO. 4092 6-26-51 R.B. COX/pn.

Figure 118

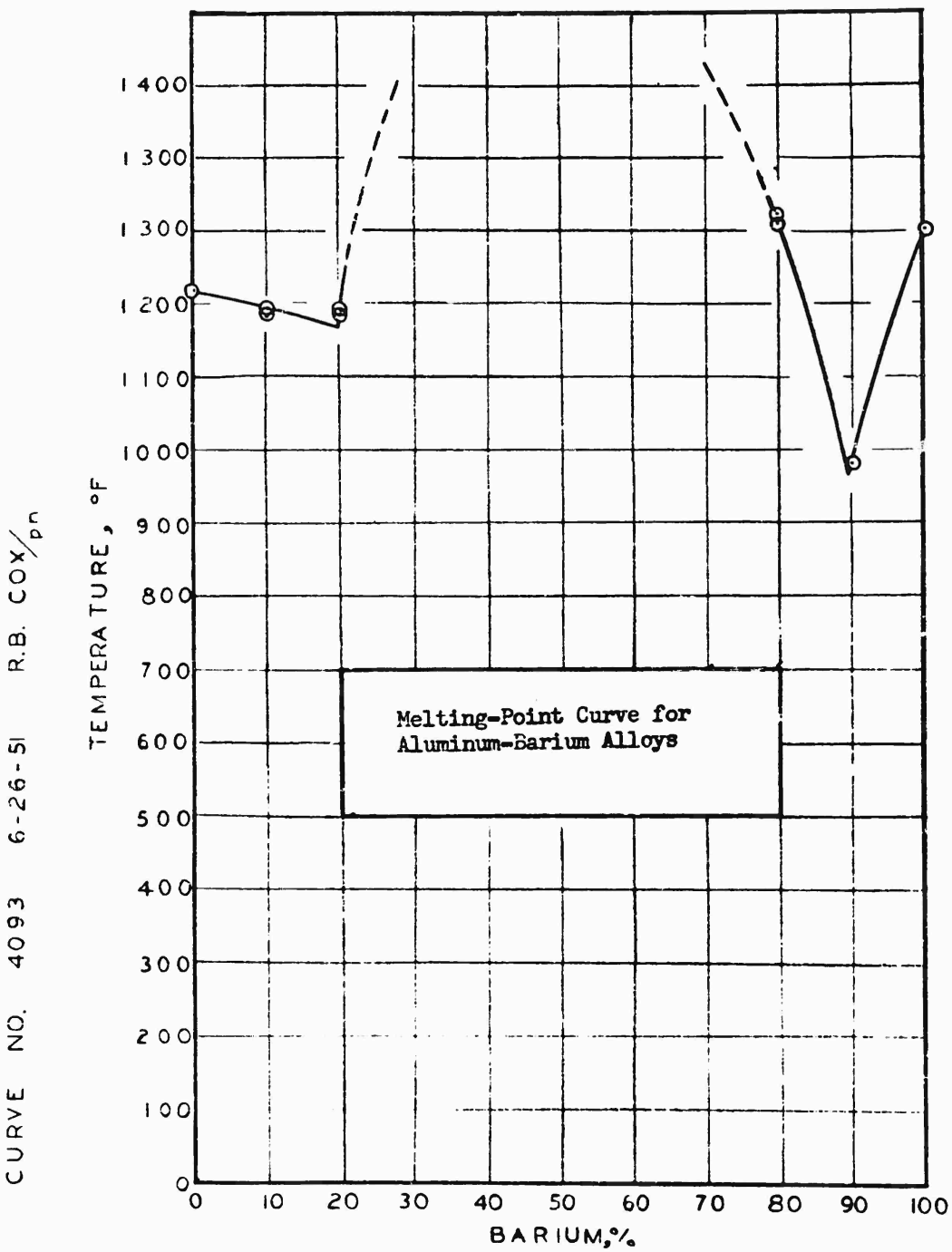

1400
1300
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
TEMPERATURE, °F
0
10
20
30
40
50
60
70
80
90
100
BARIUM,%
Melting-Point Curve for
Aluminum-Barium Alloys
CURVE NO. 4093 6-26-51 R.B. COX/pn

Figure 119

MELTING-POINT CURVE
OF
STRONTIUM-CALCIUM ALLOYS

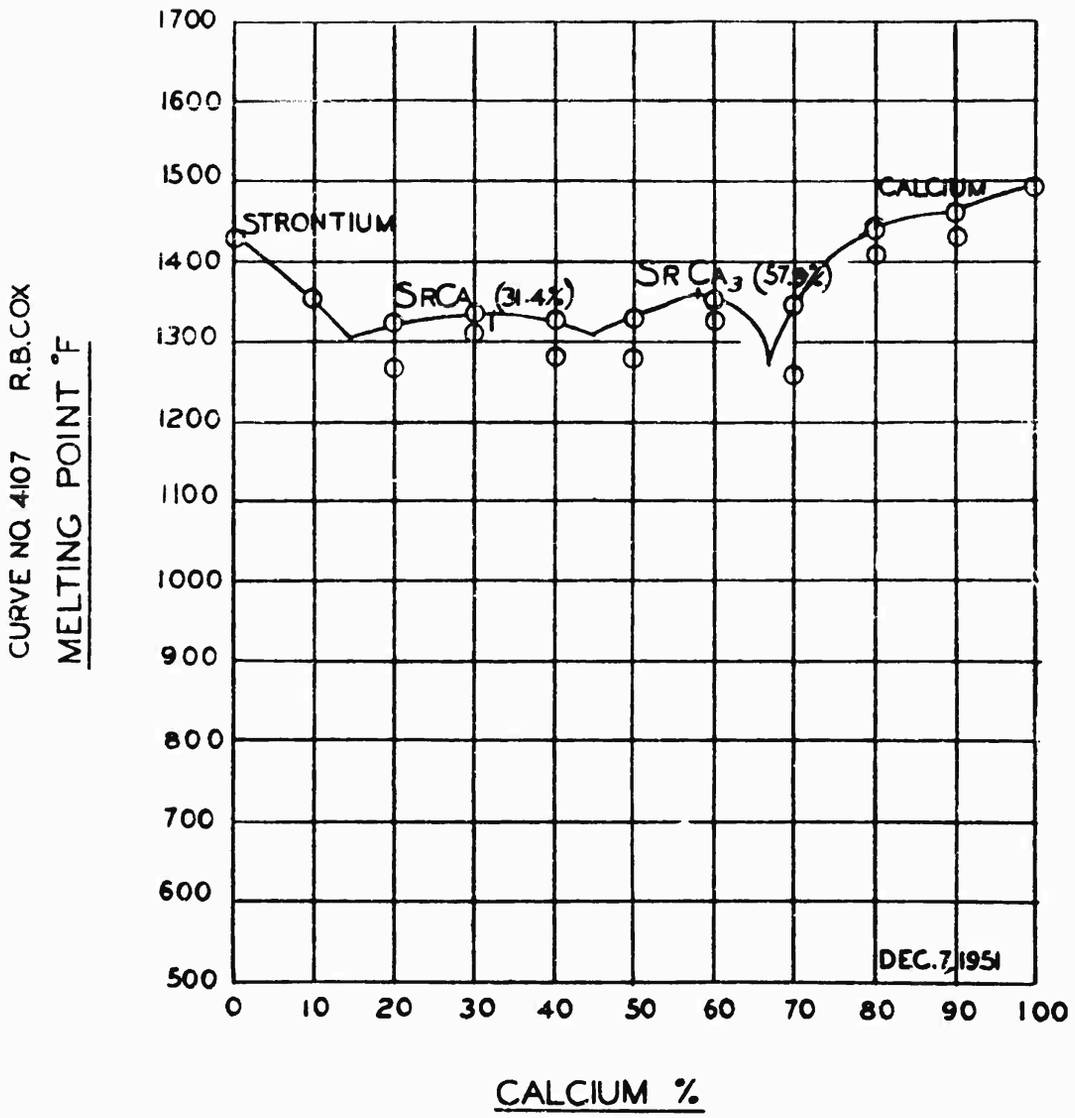
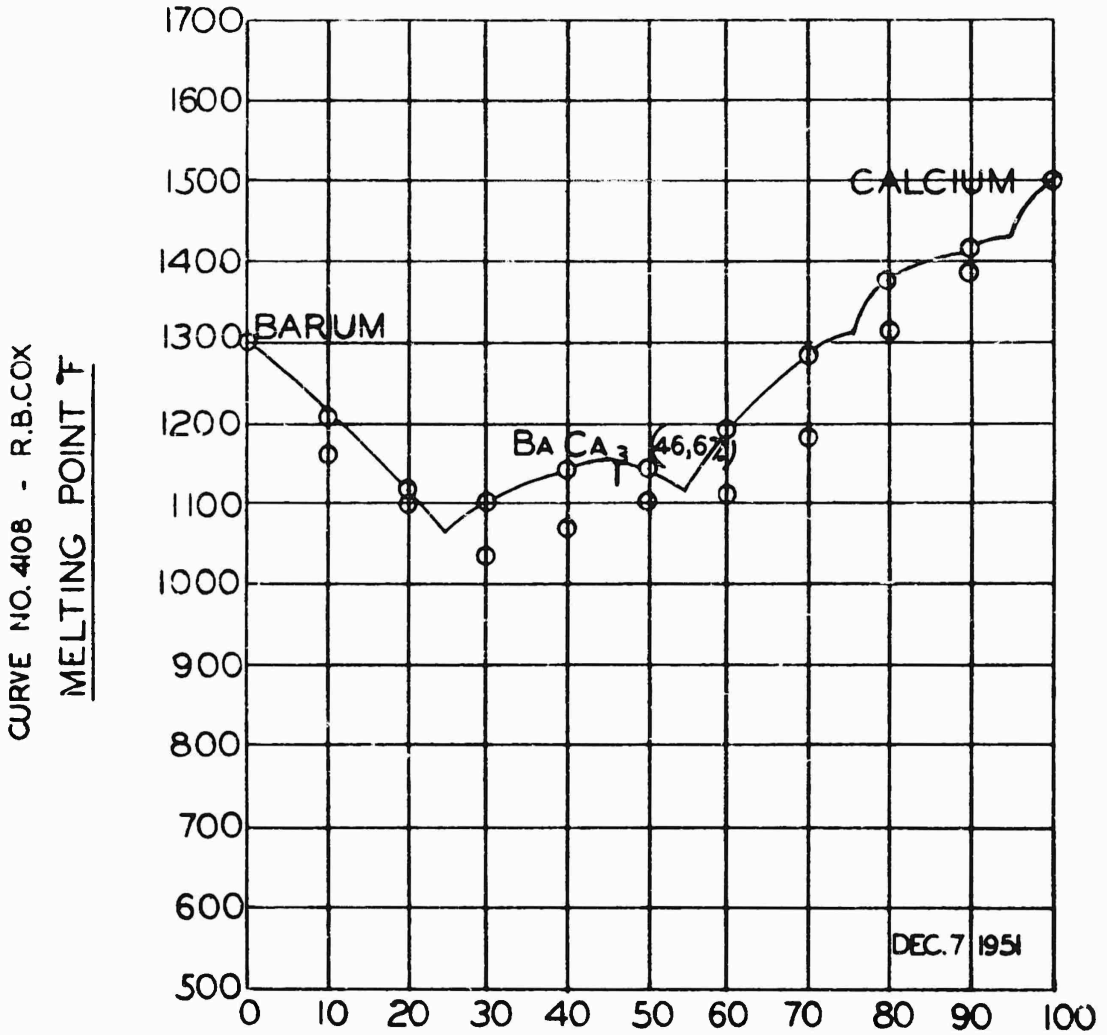
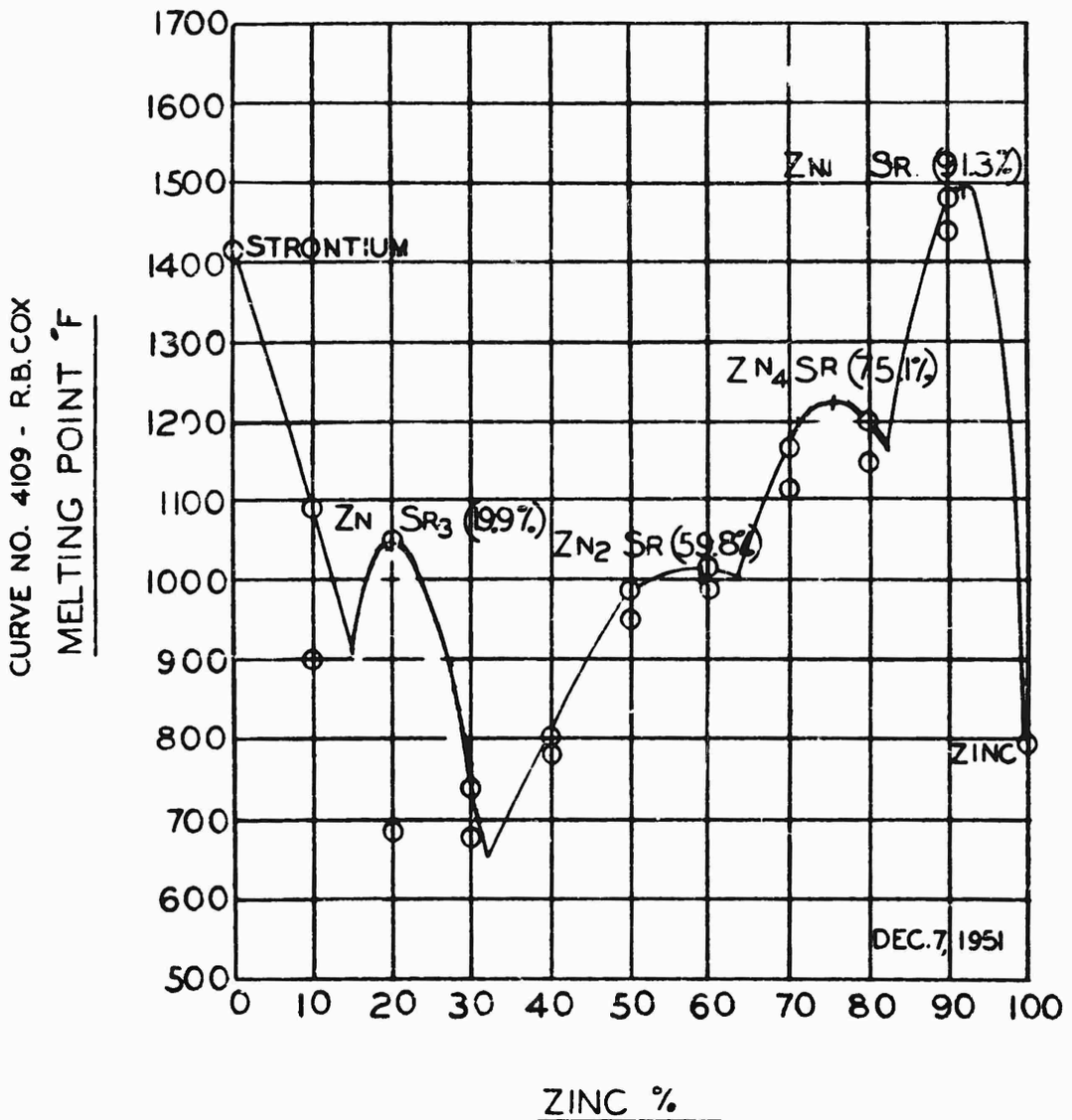


Figure 120

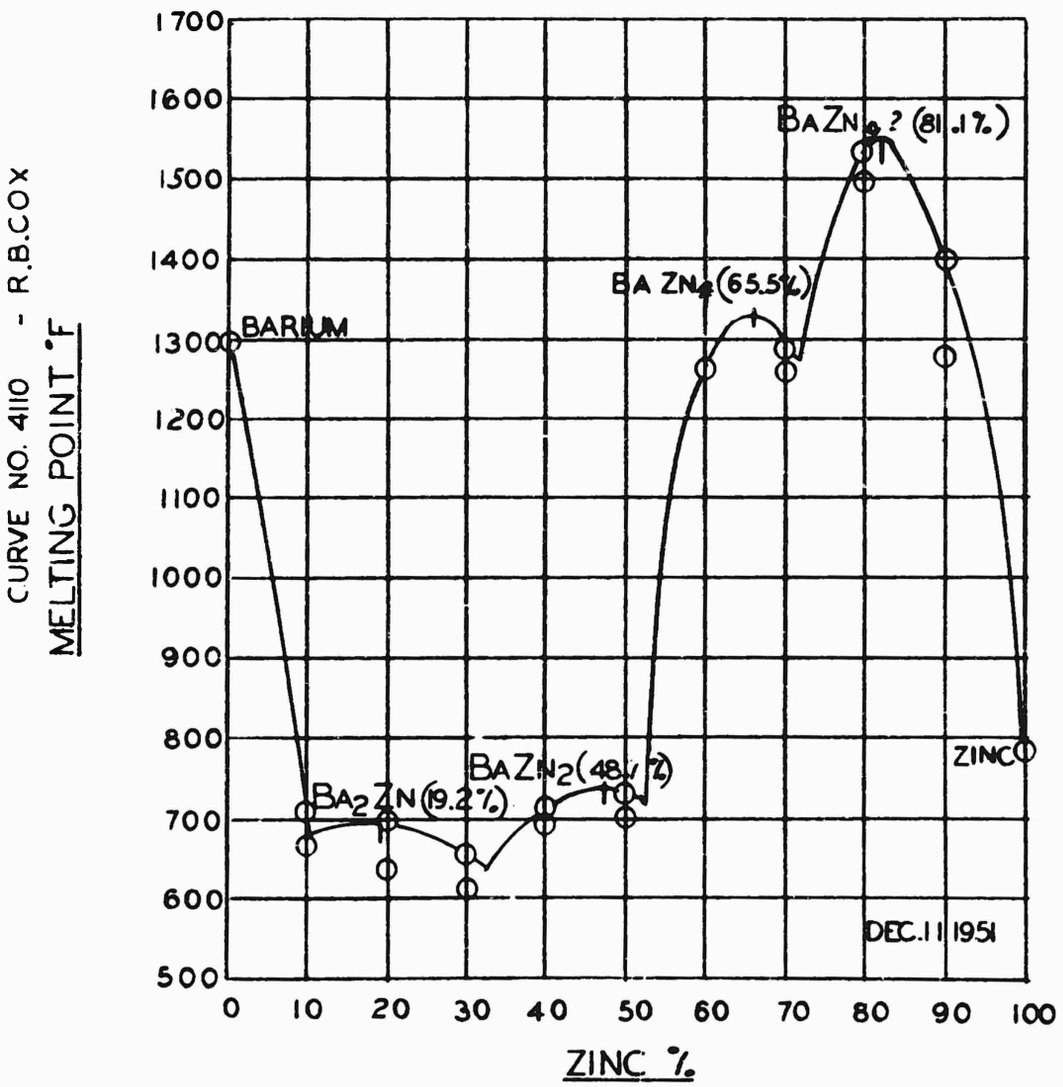
MELTING-POINT CURVE
OF
BARIUM-CALCIUM ALLOYS



MELTING-POINT CURVE OF ZINC-STRONTIUM ALLOYS

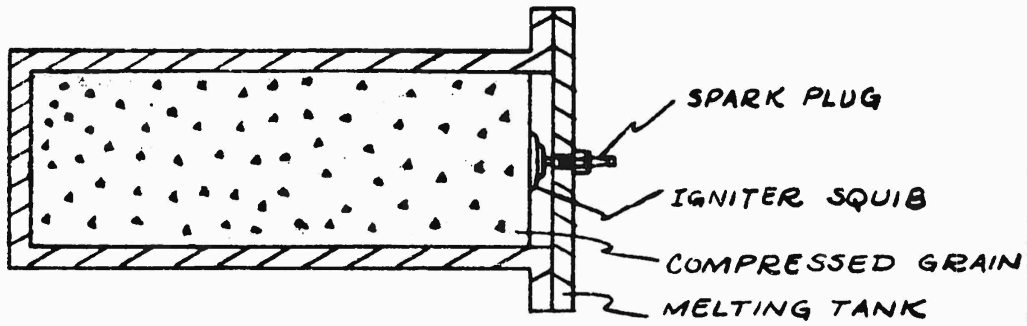


MELTING-POINT CURVE OF ZINC-BARIUM ALLOYS

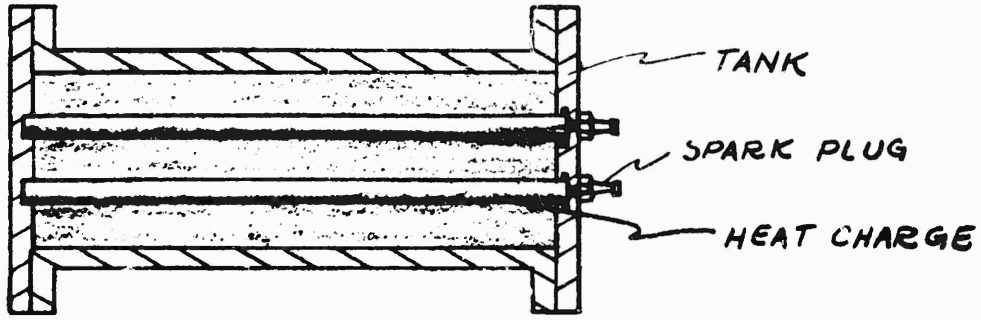


CURVE NO. 4111 1.10.52 BMW

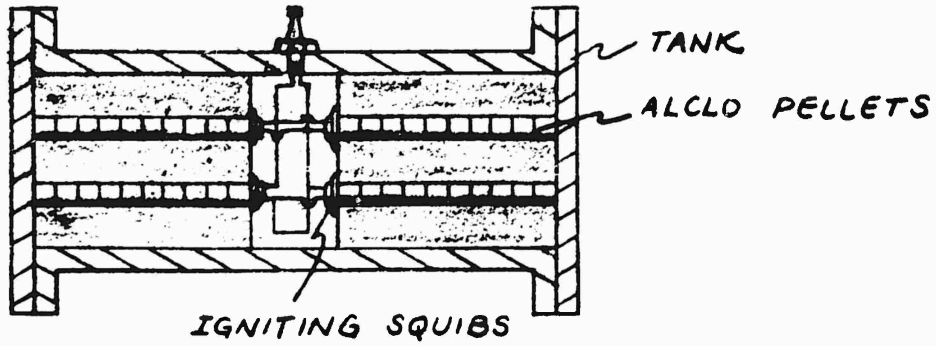
LITHIUM MELTING SYSTEMS



OXIDIZER - POWDERED LITHIUM

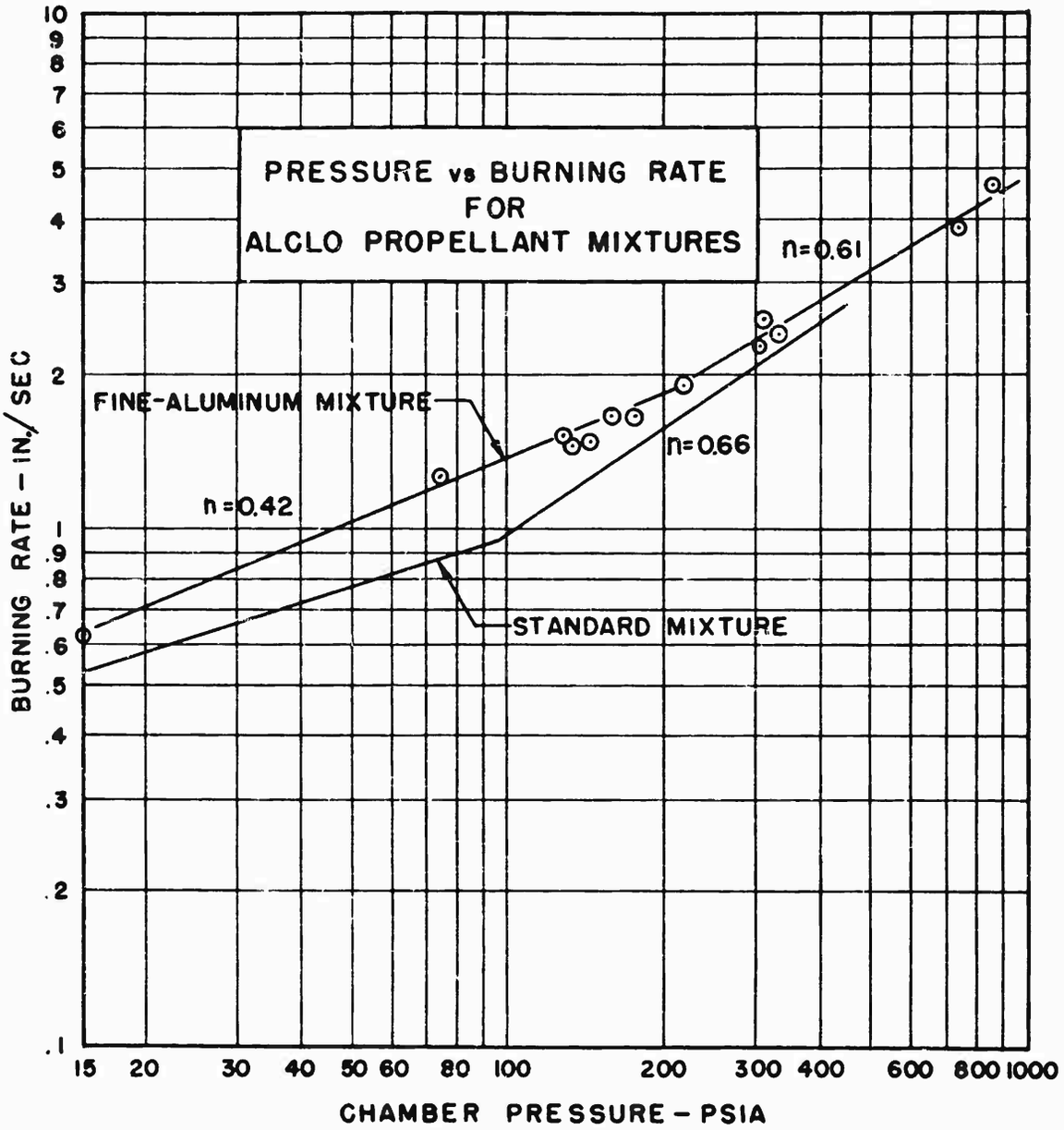


SEALED TUBE HEAT CHARGE



ALCLO HEAT CHARGE

C-4152 12-23-52 BK HMH



FINE-ALUMINUM MIXTURE	
AL #552	31.4 %
KCLO4	55.8 %
Pb	12.8 %

STANDARD MIXTURE	
AL #606	31.4 %
KCLO4	55.8 %
Pb	12.8 %

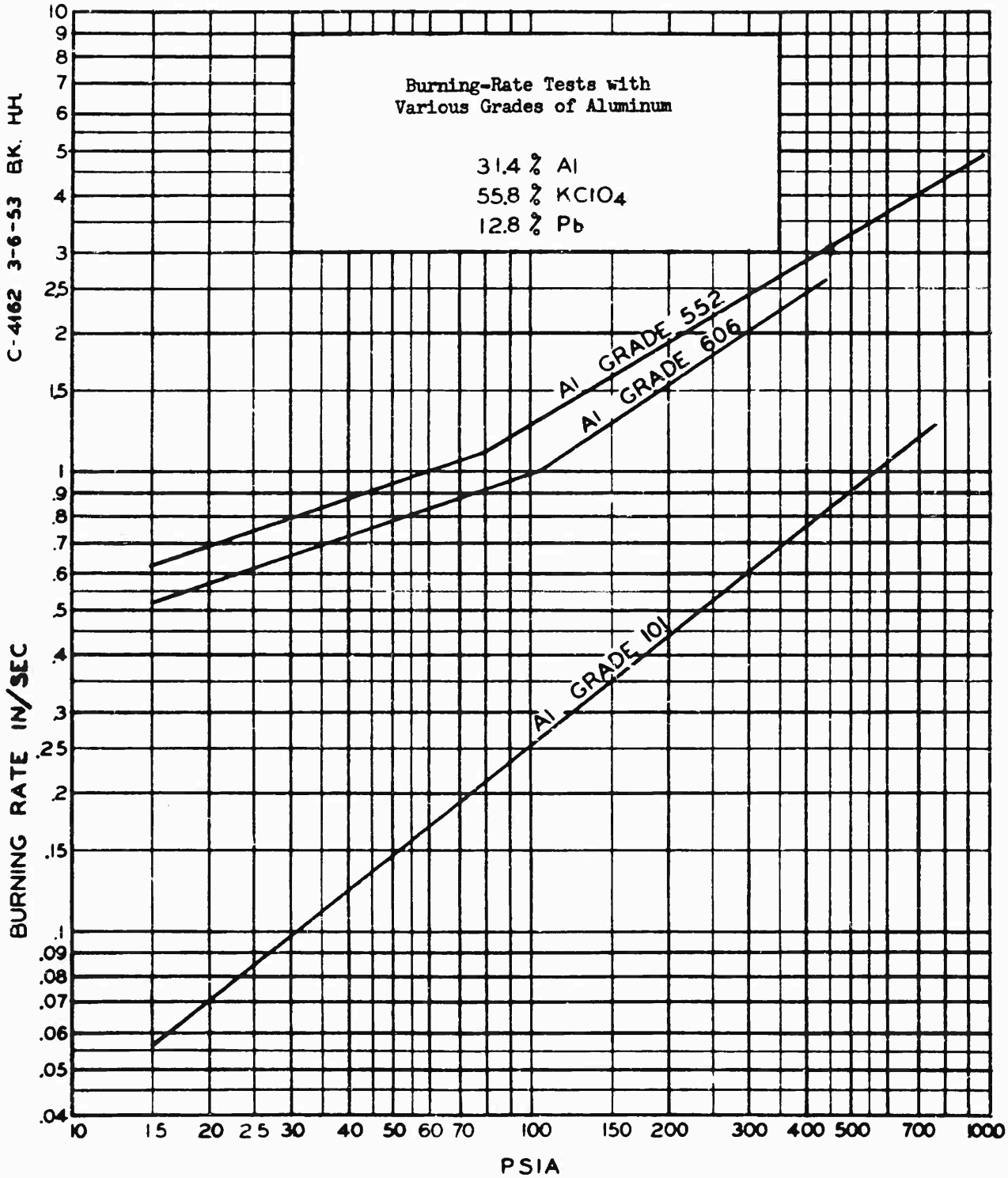
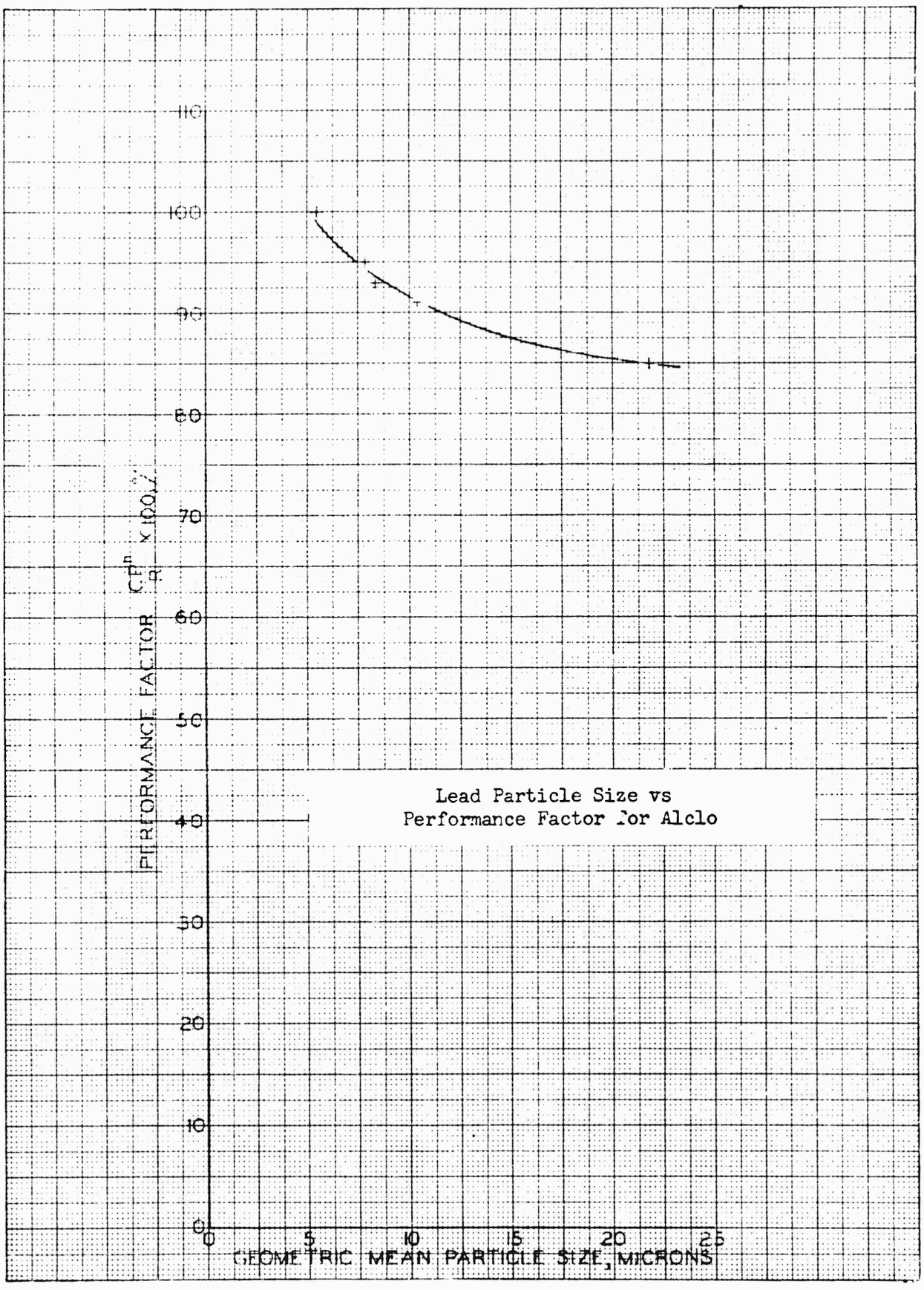
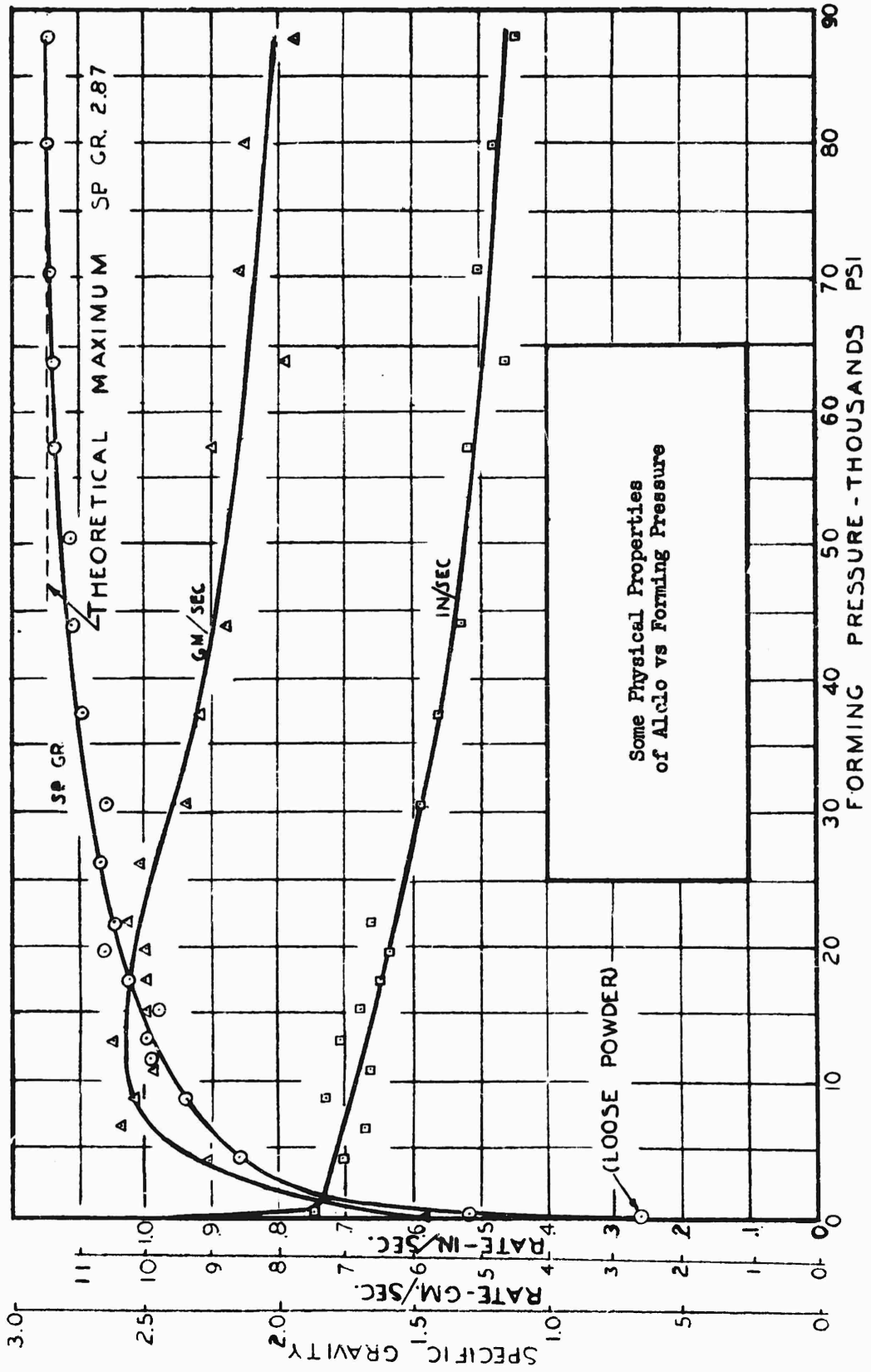

Burning-Rate Tests with
Various Grades of Aluminum
31.4 % Al
55.8 % KClO4
12.8 % Pb
Al GRADE 552
Al GRADE 606
Al GRADE 101
BURNING RATE IN/SEC
PSIA
C-4462 3-6-53 BK. HH

Figure 126

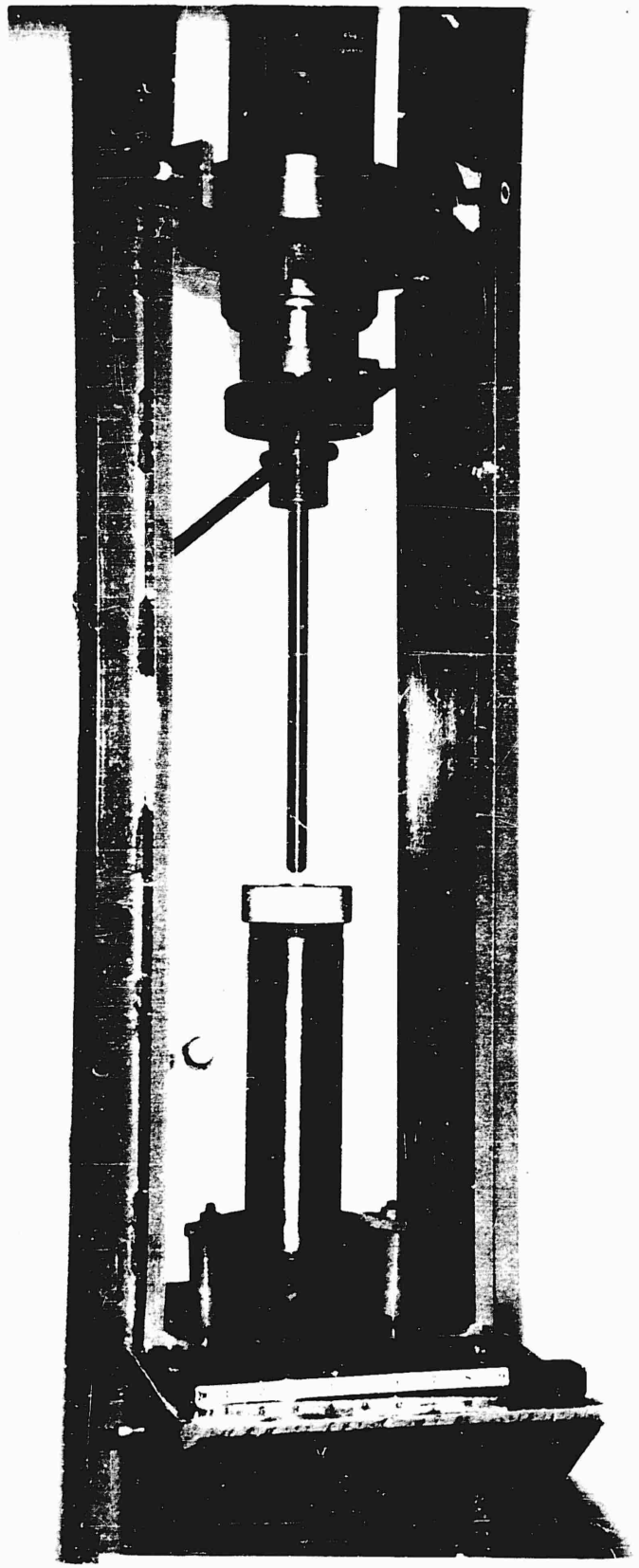


Lead Particle Size vs
Performance Factor for Alclo



CURVE NO. 4097 7-12-51 HIGGINS/pp.

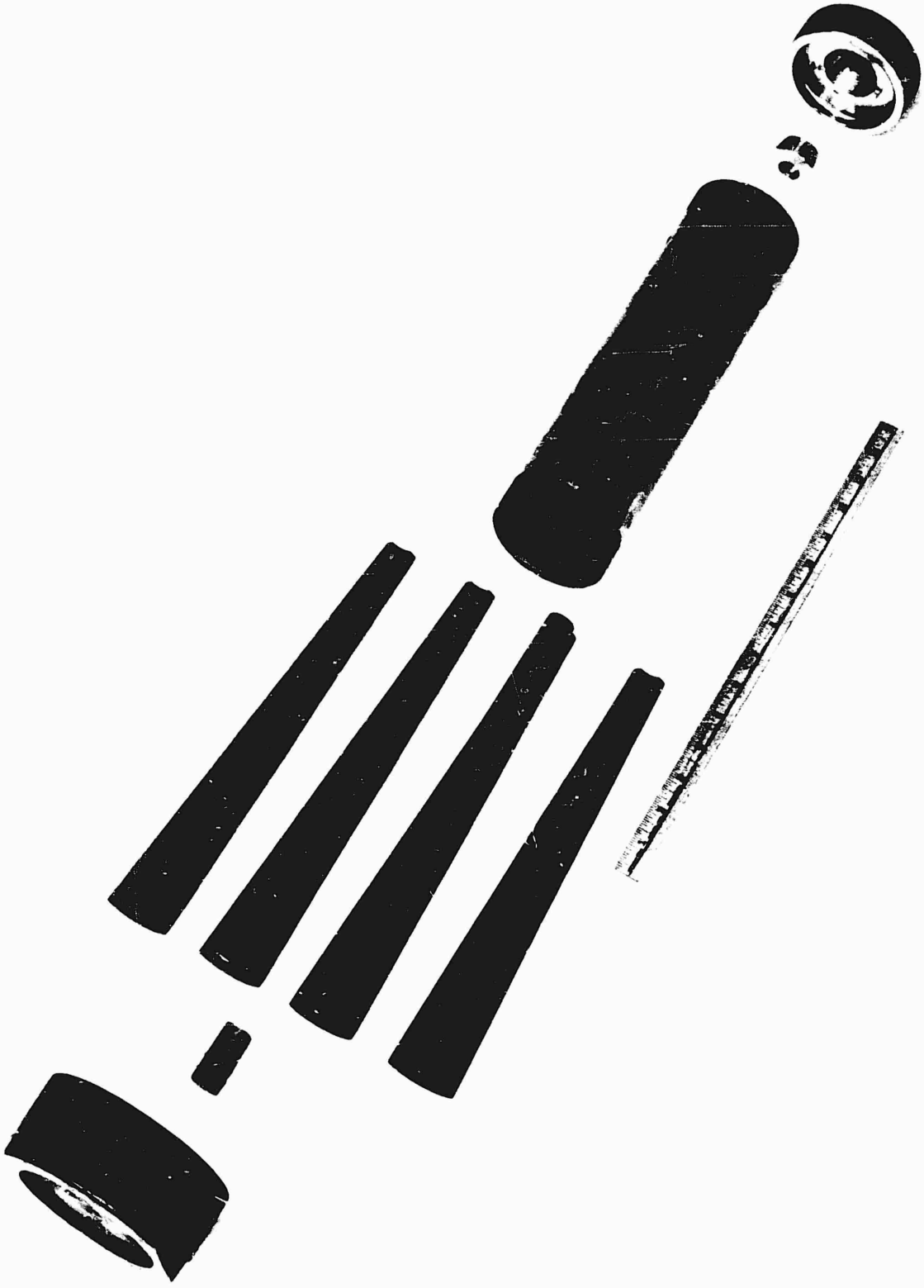
Figure 128



0652-307

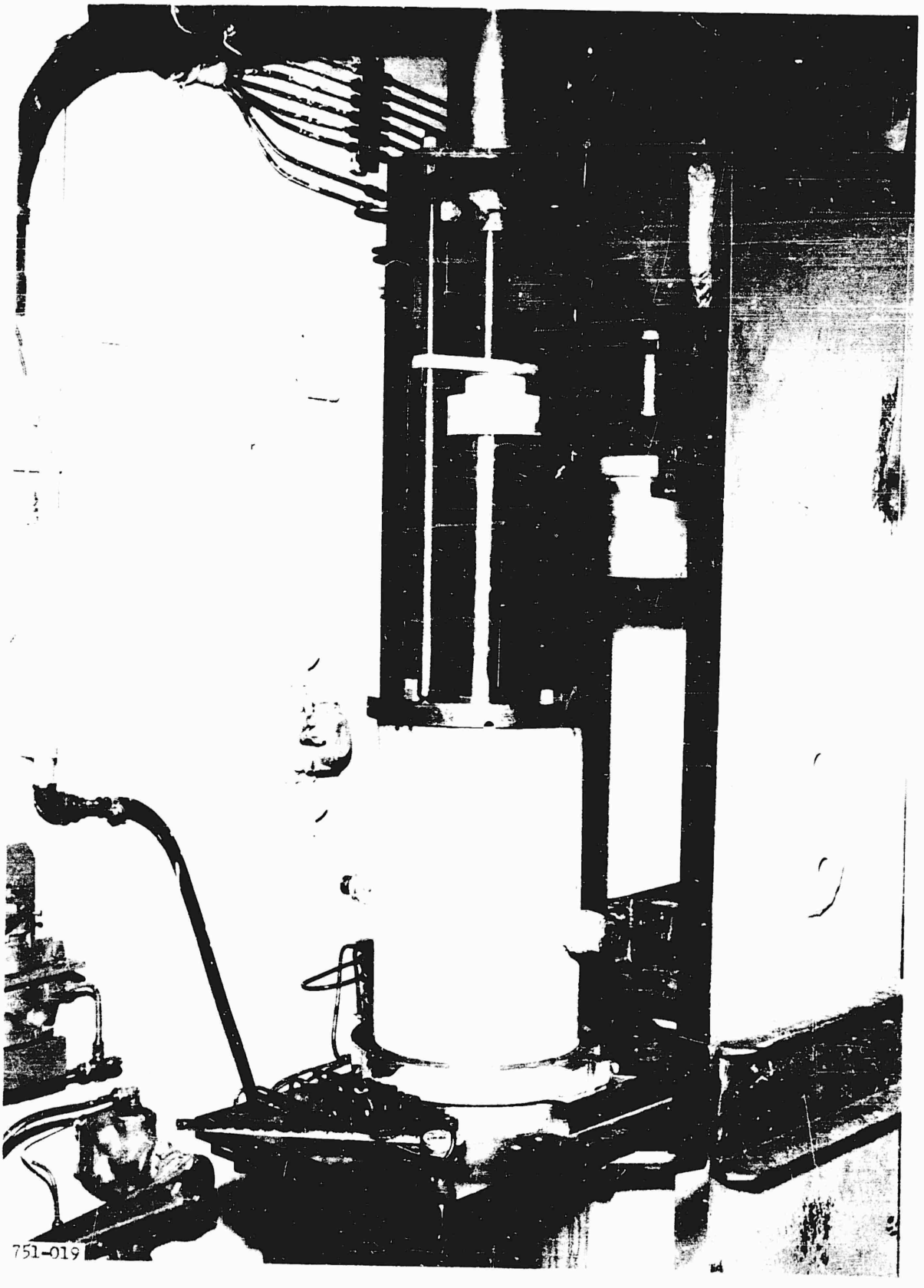
20-Ton Alclo Compaction Press

Figure 129

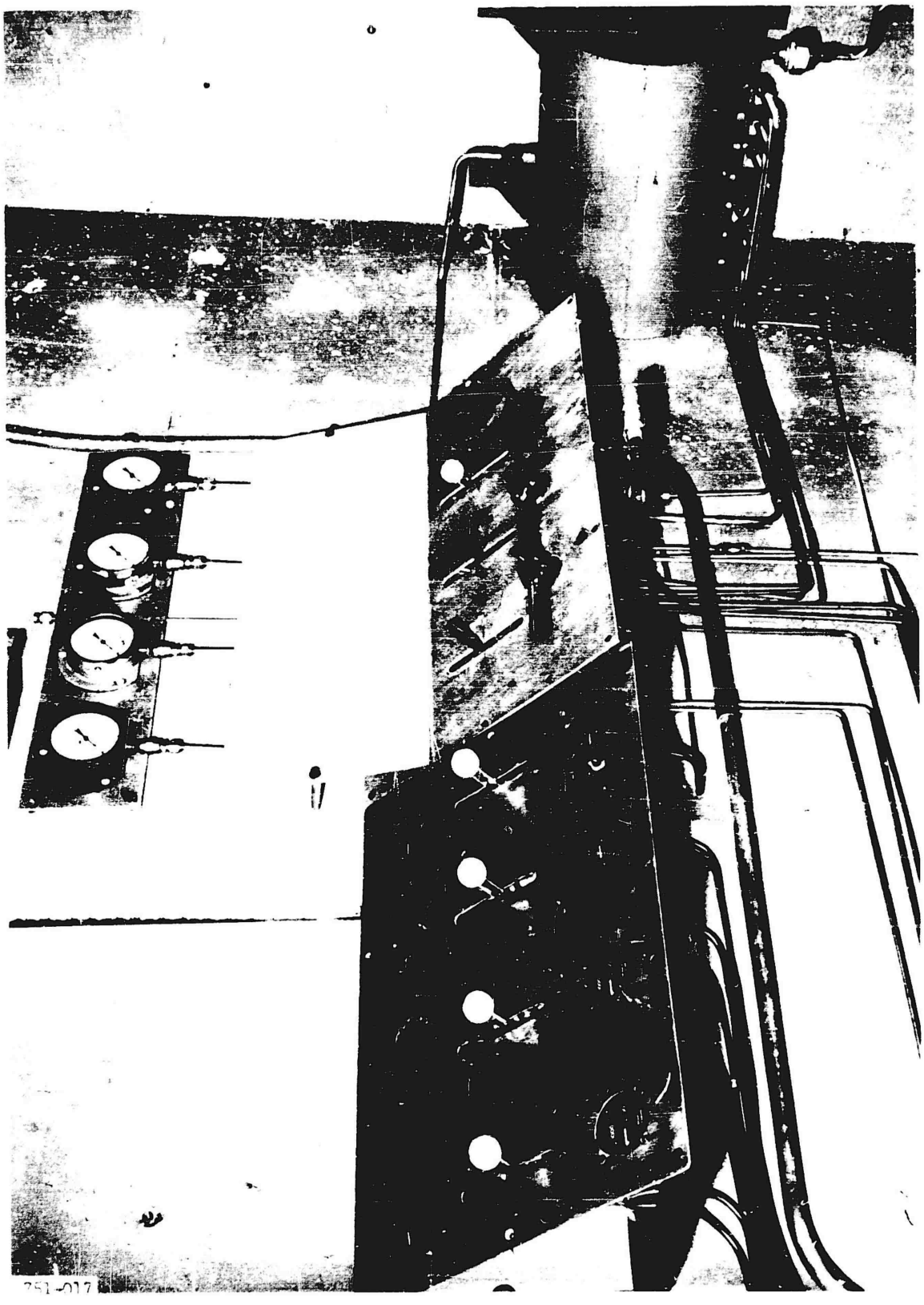


20-Ton Press, Die

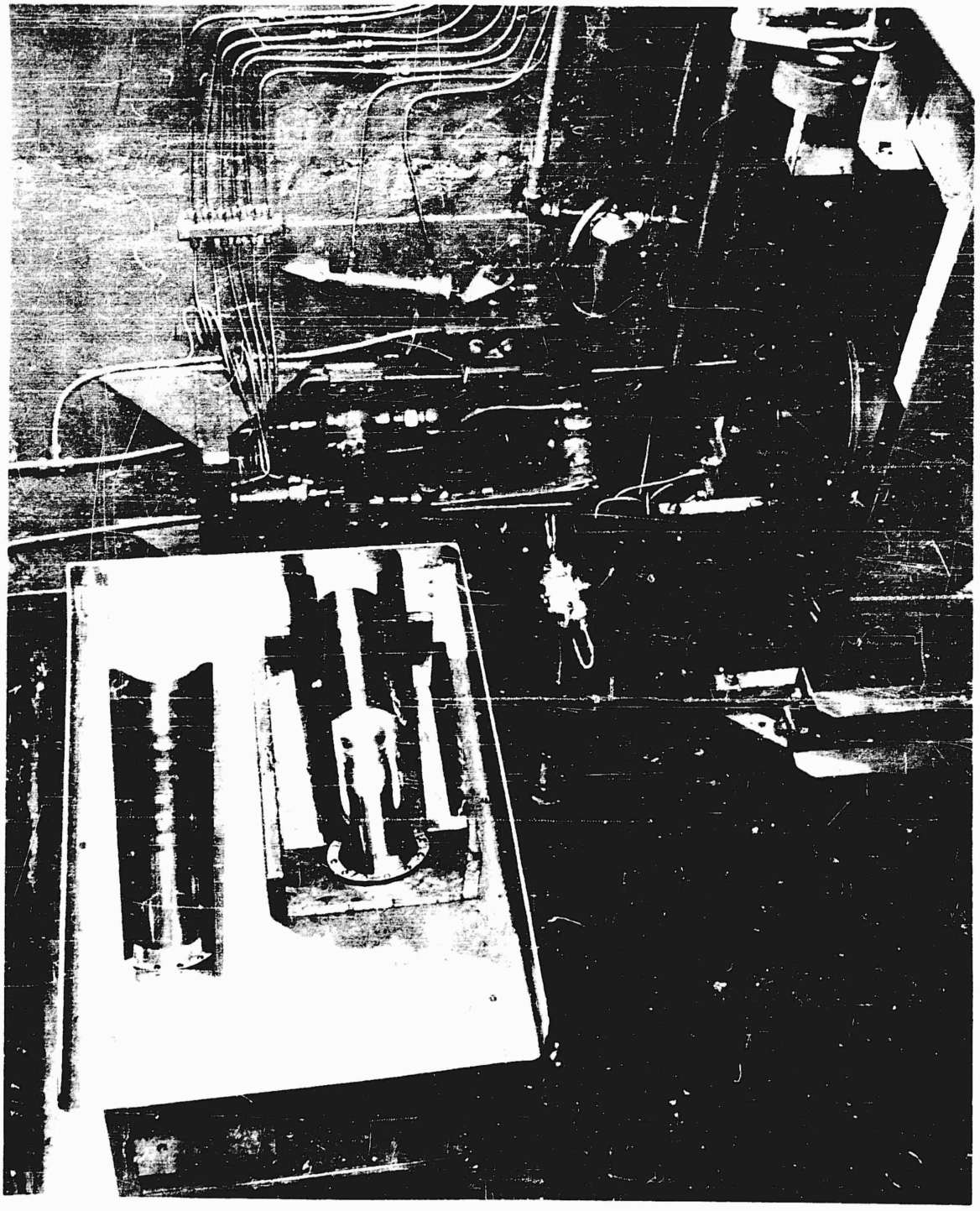
Figure 130



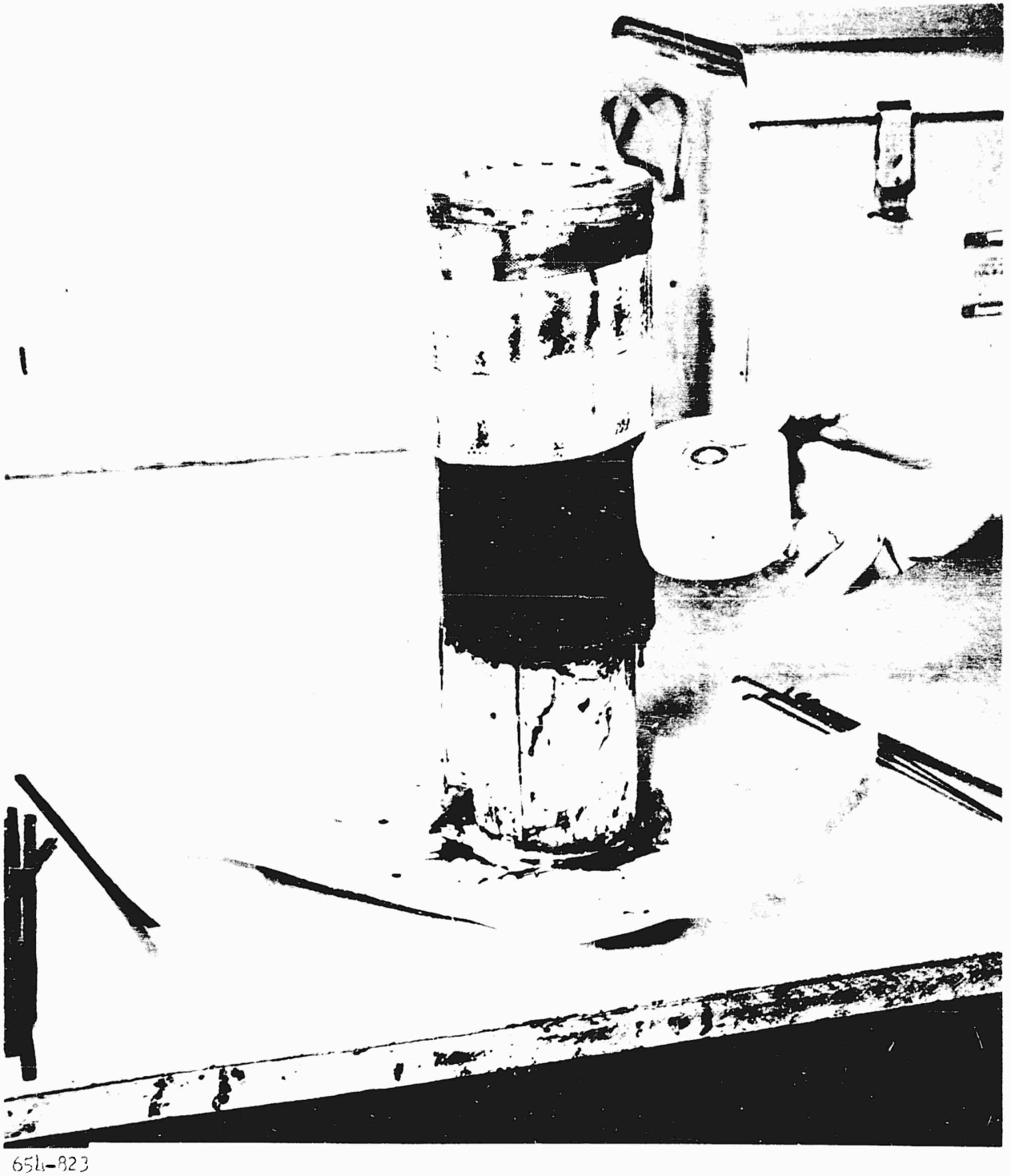
Hydraulic Insertion of 2-in. Plunger



400-Ton Press Control Panel

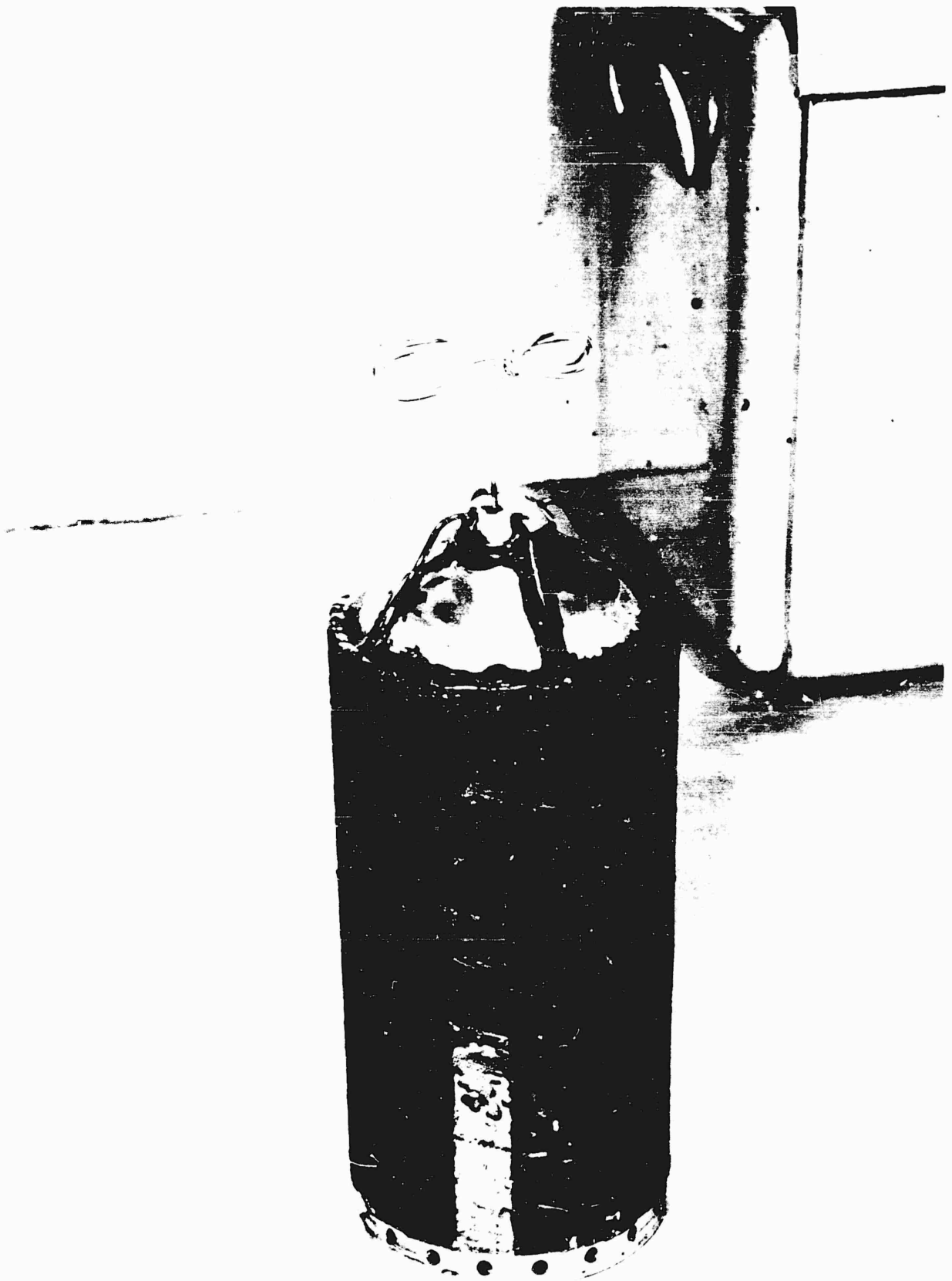


Partial View of Room for 400-Ton Press



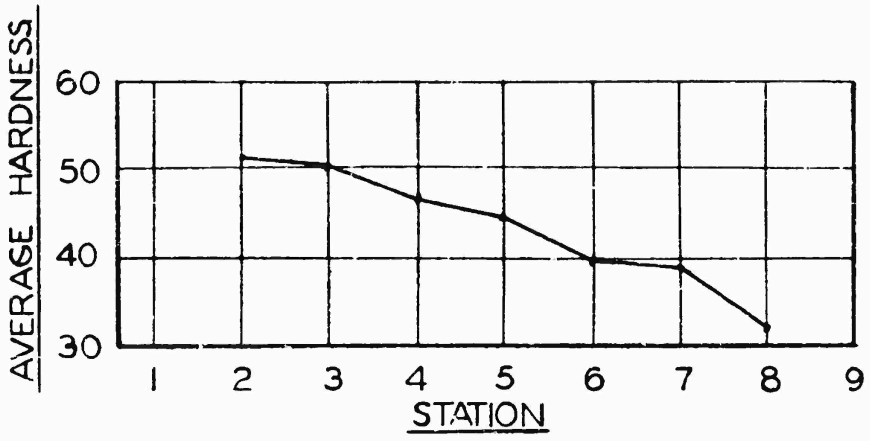
654-823

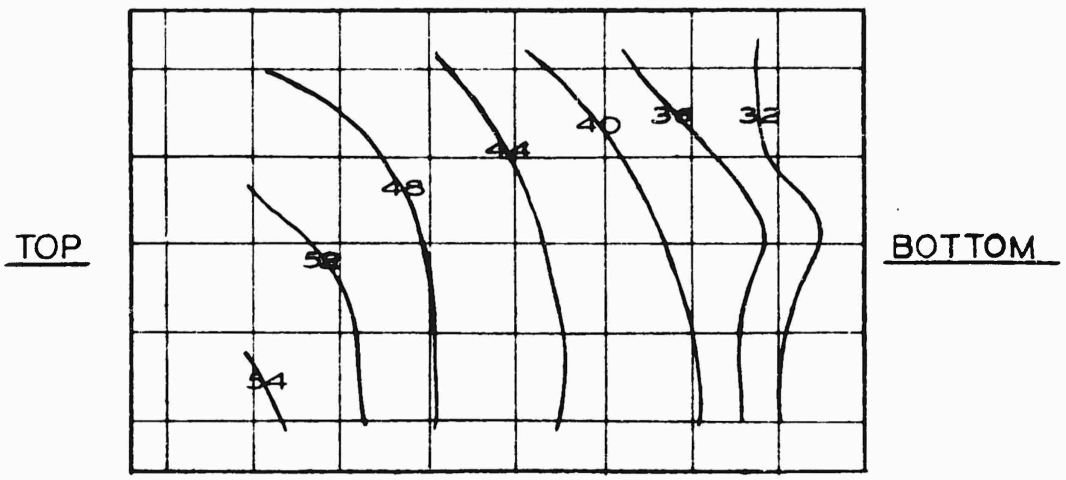
Application of Restriction to the Alclo Grain



Application of Restriction to the Alclo Grain

CURVE NO. 4114





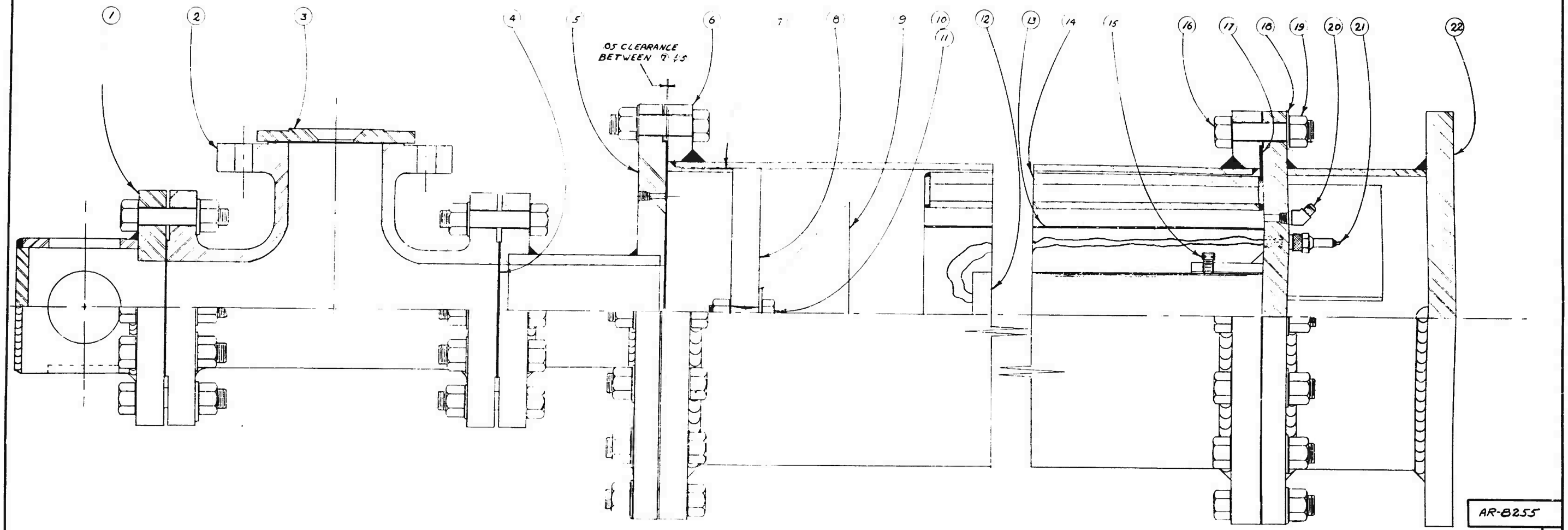
Hardness Contours of 0.75-in. Grain

Components of Vertical Alclo-Fueled Steam Generator, Mark II

Figure 137

UNCLASSIFIED

LETTER	DATE	CHANGE	BY	CHKD



AR-8255

15	1	SOCKET HD. CAP SCREW	ST'L ¢-20 NC x .38
14	1	SPACER ASSY.	AR-8260-1
13	1	SHELL	AR-8251-1
12	1	CHARGE	FURNISHED
11	1	HEX NUT	ST'L ½ X 20 NC
10	1	BOLT (HEX HEAD)	ST'L ½ X 20 NC X 1.75 LG
9	1	CONE ASSY.	AR-8256-1
8	1	TURBULATOR	AR-8256-2
7	1	SPACER	AR-8260-2
6	1	JACKET ASSY	AR-8259
5	1	COVER ASSY.	AR-8258-1
4	2	GASKET	RING TYPE ASBESTOS COMP. .062 X 4.00 I.D. 6.81 O.D.
3	1	ORIFICE PLATE	AR-8256-3
2	1	WALWORTH TEE	WALWORTH CAST ST'L 4.00 NOM S-300-NO 7820
1	1	TRAP ASSY.	AR-8258-2

UNCLASSIFIED

22	1	BASE ASSY.	AR 8257
21	1	SPARK PLUG	10 MM CHAMPION Y-8 OR EQ
20	1	ELBOW	AN 823-2 - ⅜ TUBE O.D. ⅜ NPT-ST'L
19	48	NUT	ALLOY ST'L ¾ -10 NF-2
18	48	WASHER	ST'L, FOR ¾ BOLT
17	1	GASKET	RING TYPE ASBESTOS COMP. 12.001D. X 16.12 O.D.
16	48	HEX HEAD BOLT	ALLOY ST'L ¾-10 NF-2 X 3.50 LG.

ST. NO.	NO. REQ	NAME	MATERIAL ¢ SIZE
		MATERIAL	
		DRAFTSMAN: CANCHOLA	CHECKED: Kibbe
		STRESS:	ENGINEER: W. HAGEMAN
		APPROVED	

HEAT TREAT	FINISH	SO 2806	1
RELEASE DATE	DEC 18 1951	MODEL	NO. REQ. NEXT ASSY.
TOLERANCES UNLESS OTHERWISE NOTED		CALCULATED WEIGHT	
LINEAR .XX ± .03		ACTUAL WEIGHT	SCALE
TOL. .XXX ± .010		11-21-51	12-14-51
ANGULAR TOL.		12-6-51	12-17-51
√ INDICATES SURFACE ROUGHNESS FINISH PER MAS-20, UNLESS OTHERWISE NOTED		AEROJET ENGINEERING CORP. AZUSA, CALIFORNIA	

VERTICAL STEAM GENERATOR ASSY MARK III

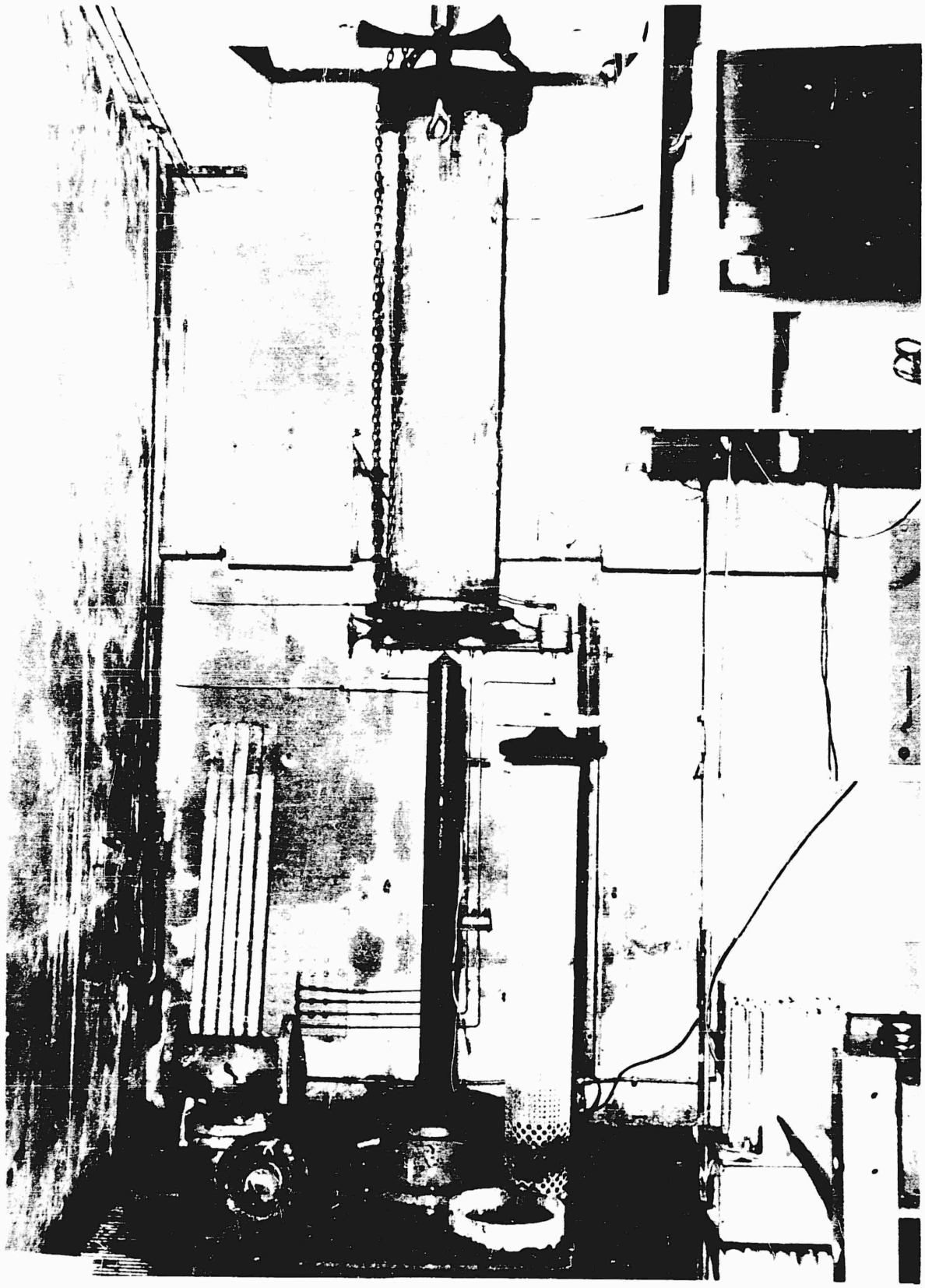
DRAWING SIZE D

AR-8255

PART NUMBER

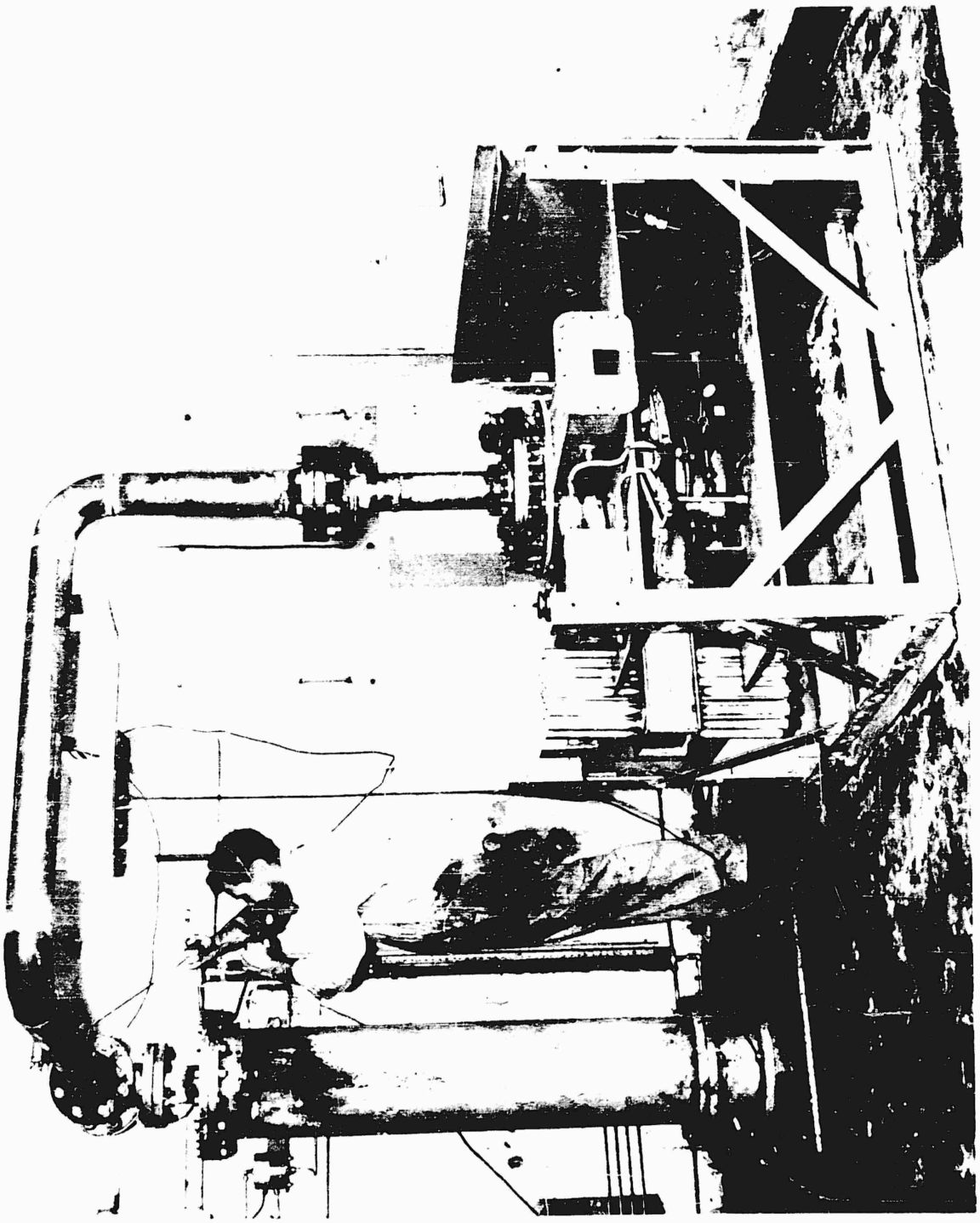
NOTES 1 Remove all burrs and sharp edges

Figure 138



Disassembled View of the Vertical Beam Generator, Mark III

Figure 139



General View of the Vertical Steam Generator, Mark III

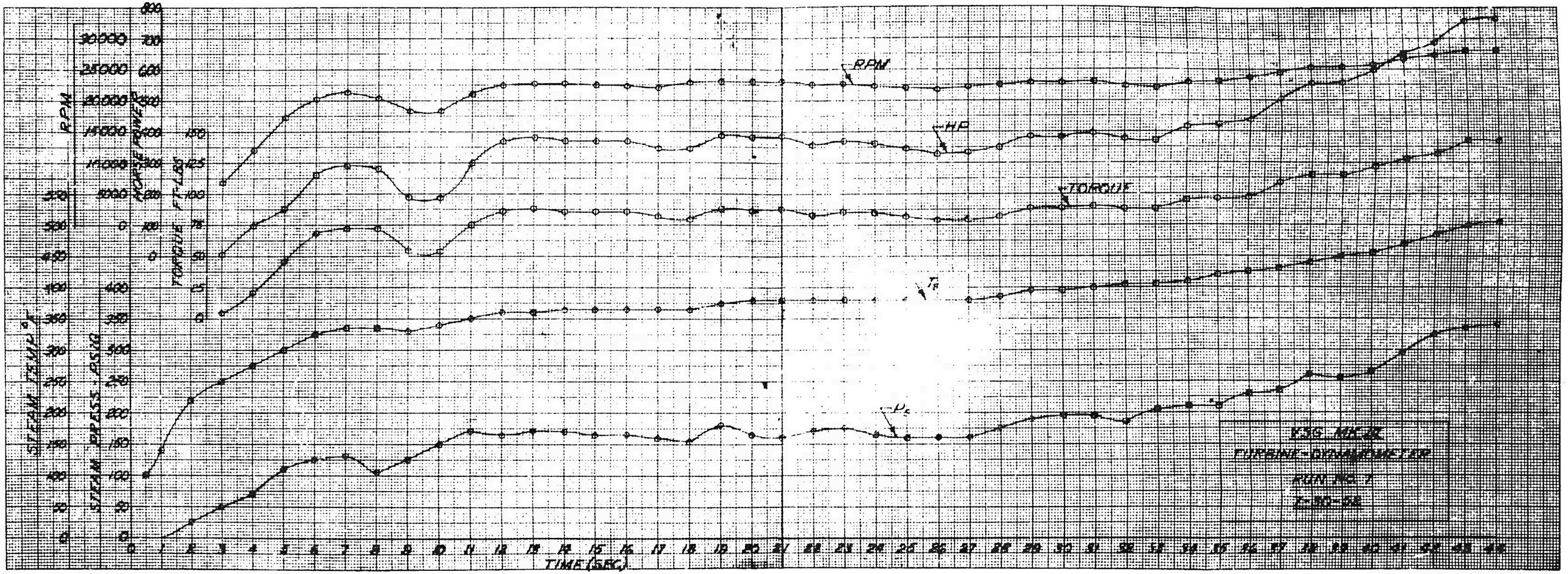

RPM
HP
TORQUE
T_E
P_E
KSG MK 2K
TURBINE-DYNAMOMETER
RUN NO. 7
Z-30-56
TIME (SEC.)
STEAM TEMP °F
STEAM PRESS - PSIG
TORQUE FT-LBS
HORSE POWER
RPM

Figure 1l1

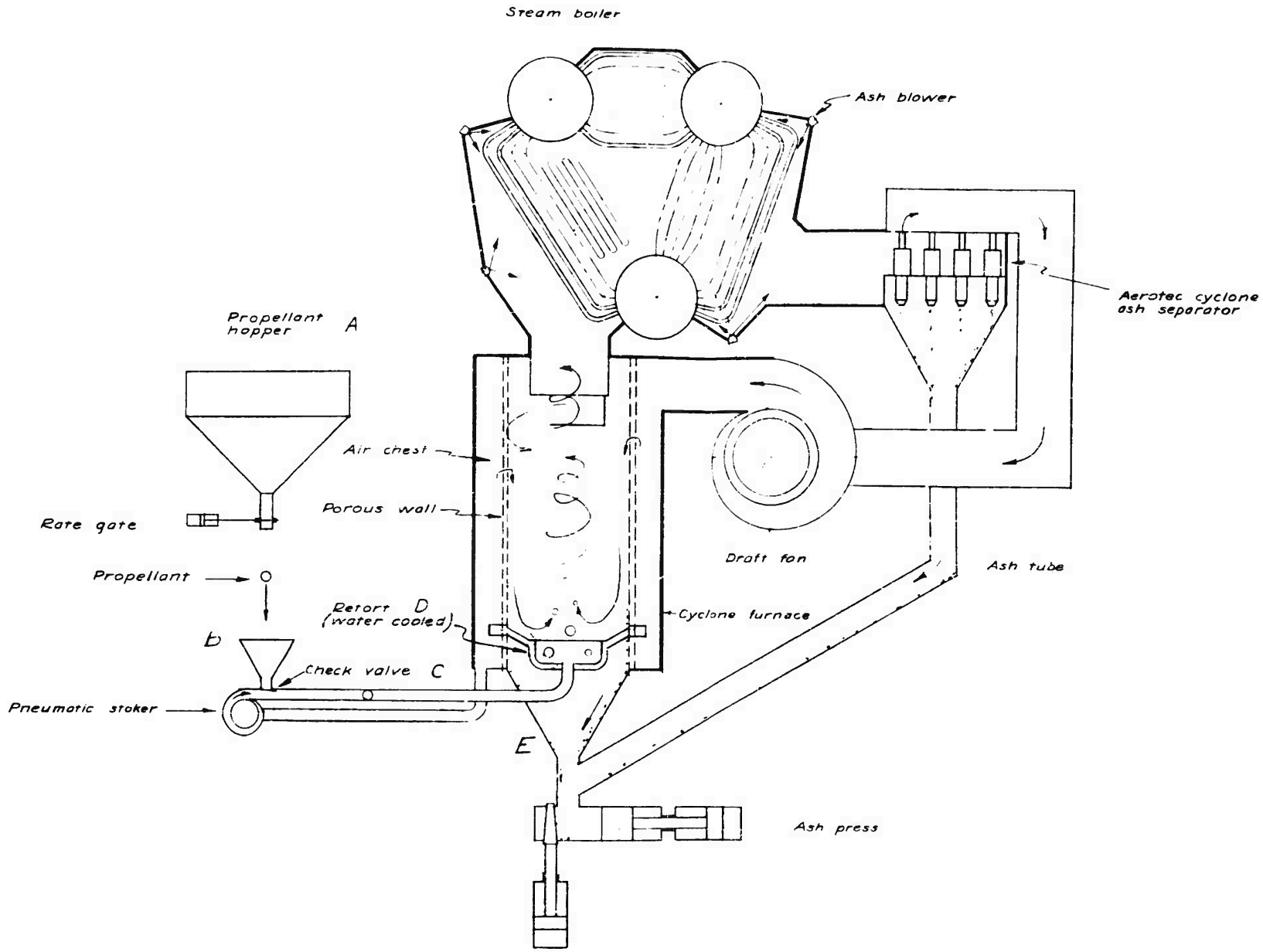
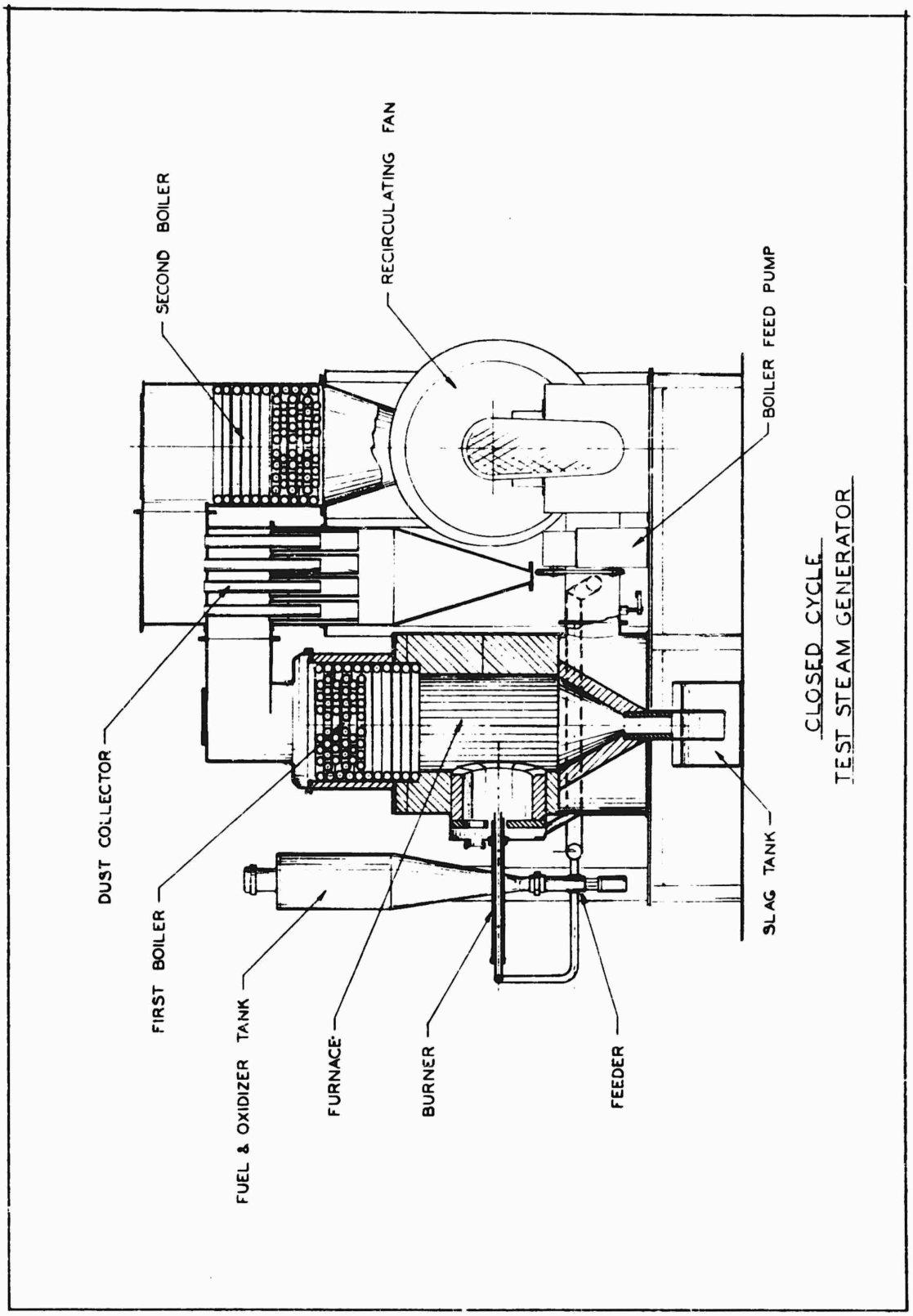


Diagram of an Alclo-Fueled Submarine Power Plant

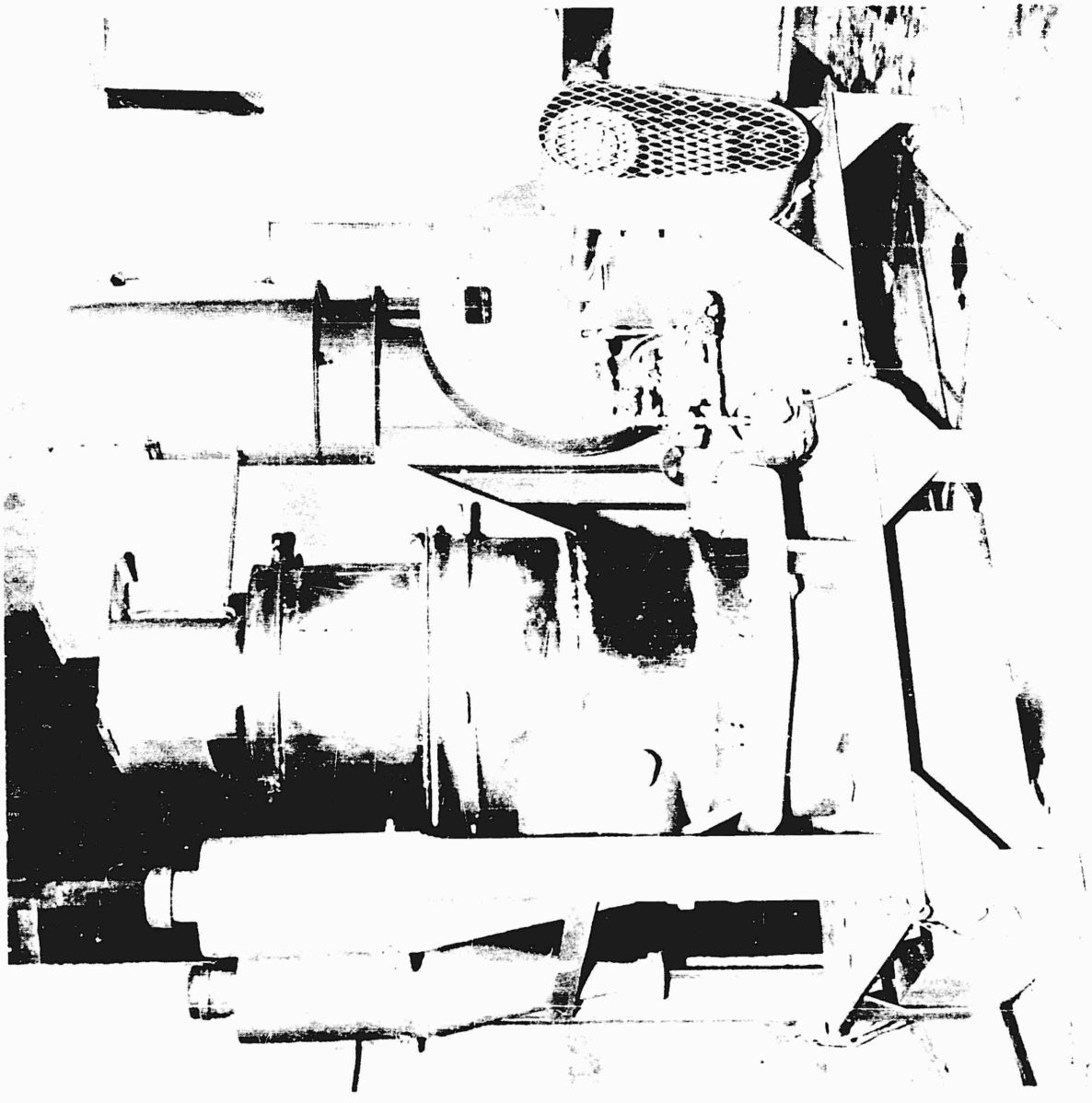
HEAT TREA	FINISH	MODEL	NO. REQ.	NEXT ASSY.
MATERIAL				
CALCULATED WEIGHT				5-2-50
TOLERANCES UNLESS OTHERWISE NOTED		ACTUAL WEIGHT		Bergman
FRACT ±1/64	.X ± .03		SCALE	DRAFTSMAN / CHECKED / STRESS / ENGINEER / APPROVED
TOL.	.XX ± .010	AEROJET ENGINEERING CORP. AZUSA CALIFORNIA		DRAWING SIZE R
	ANGULAR TOL			AR 8812 PART NUMBER
INDICATES SURFACE ROUGHNESS FINISH PER MAS-20 UNLESS OTHERWISE NOTED				

Figure 142

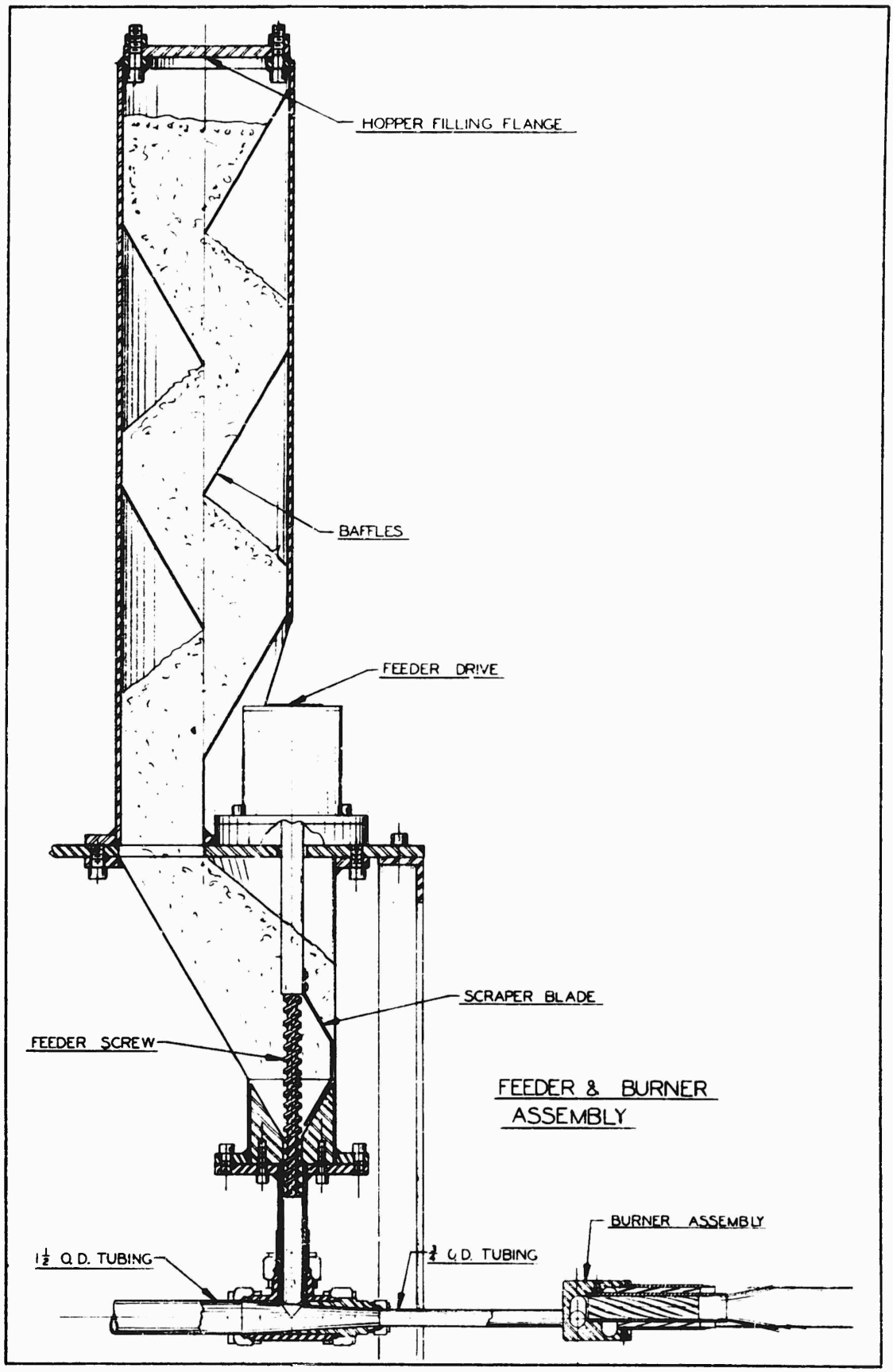
CONFIDENTIAL

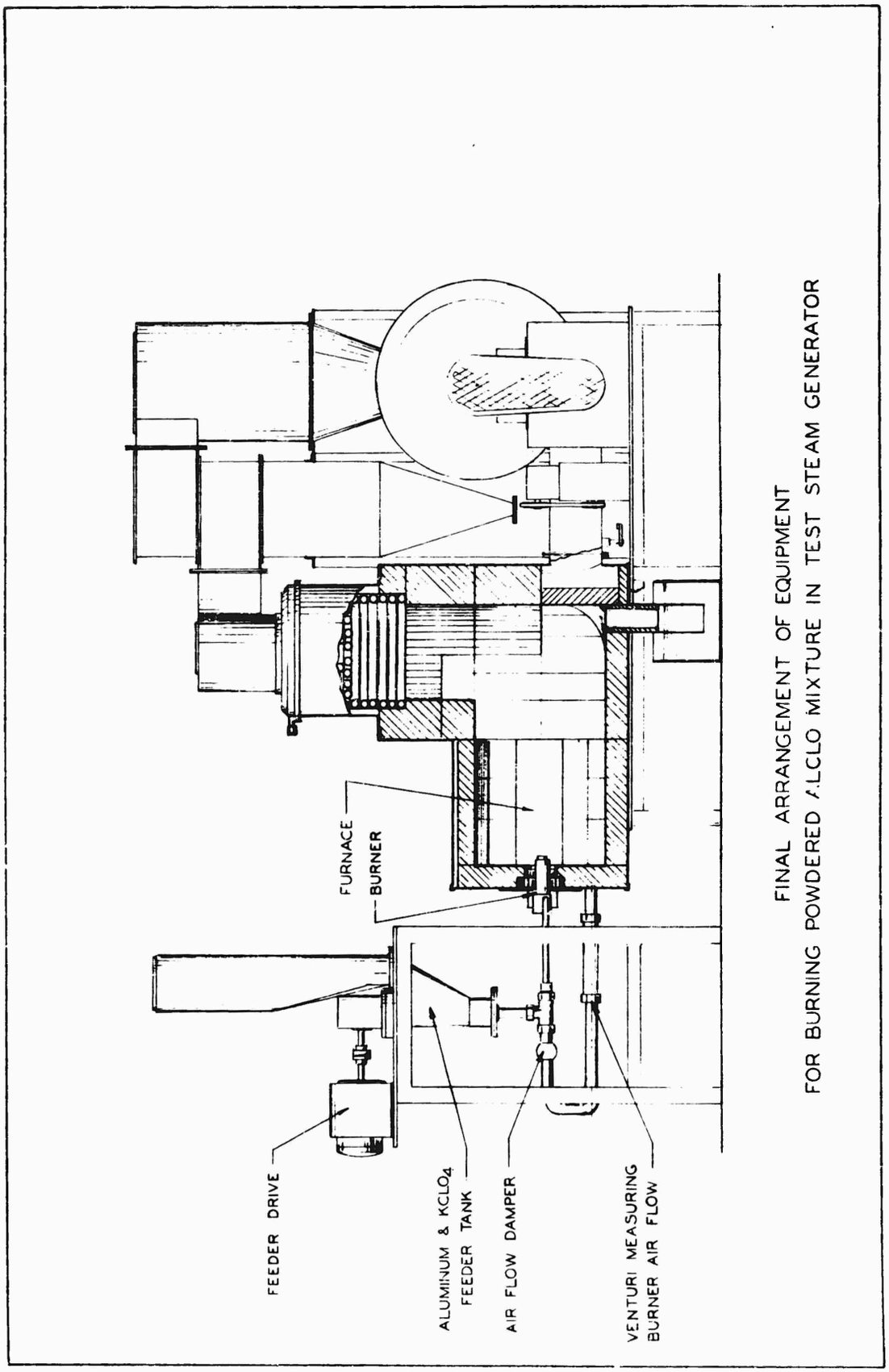


C-4226 9-18-52 MB



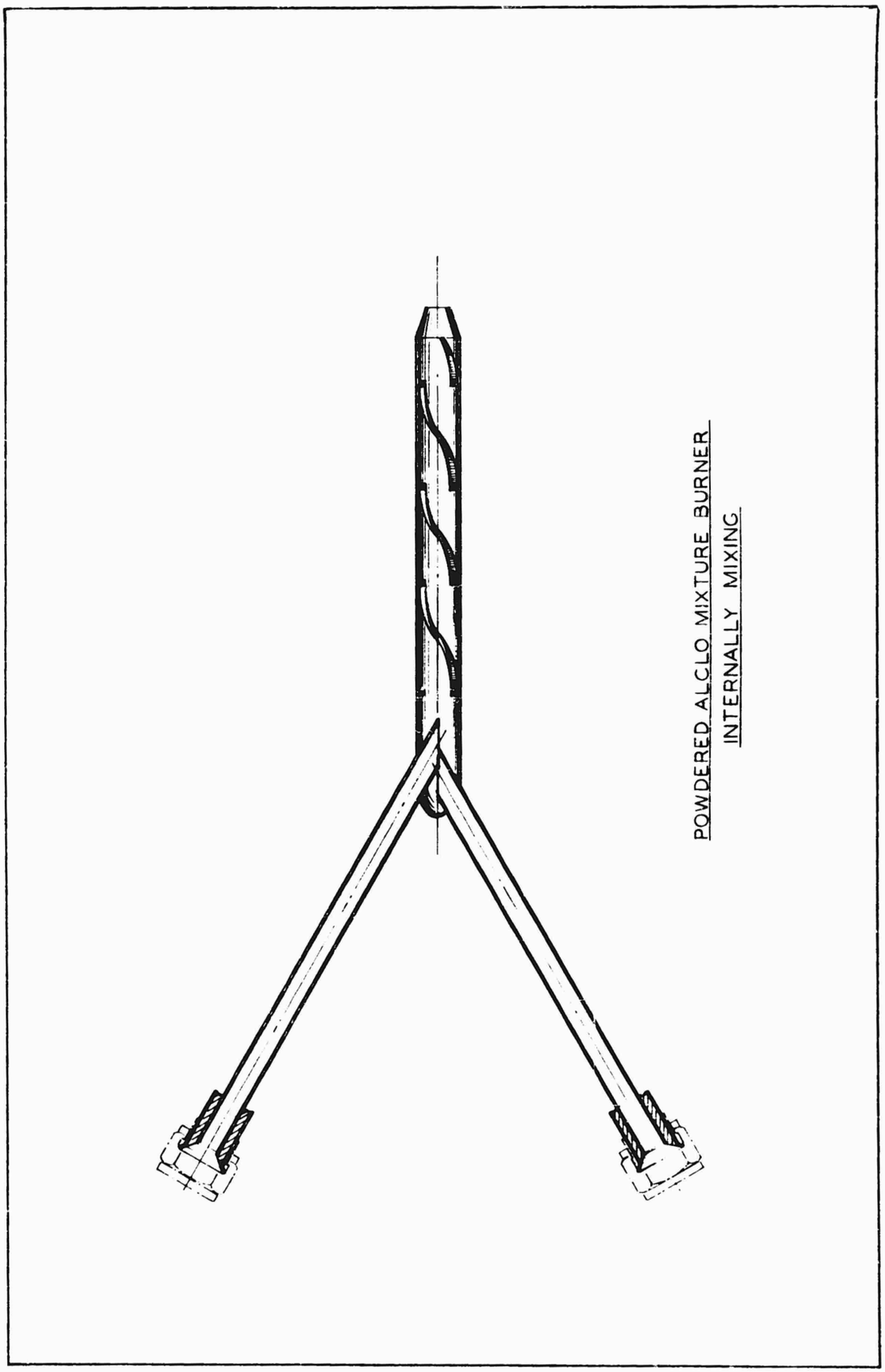
Test Steam Generator


HOPPER FILLING FLANGE
BAFFLES
FEEDER DRIVE
SCRAPER BLADE
FEEDER SCREW
FEEDER & BURNER ASSEMBLY
BURNER ASSEMBLY
1½ O.D. TUBING
¾ O.D. TUBING



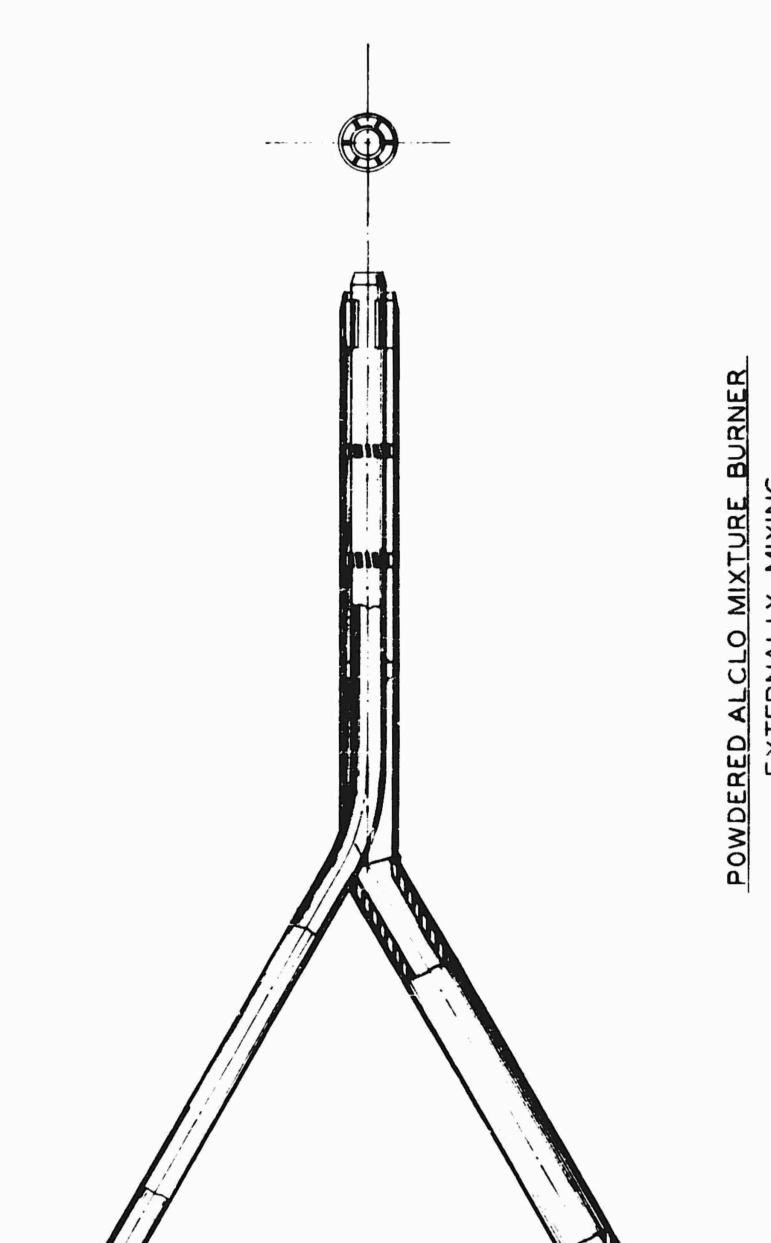
FINAL ARRANGEMENT OF EQUIPMENT
FOR BURNING POWDERED ALCLO MIXTURE IN TEST STEAM GENERATOR

C-4227 9-18-53 MB



C-4228 9-18-53 MB

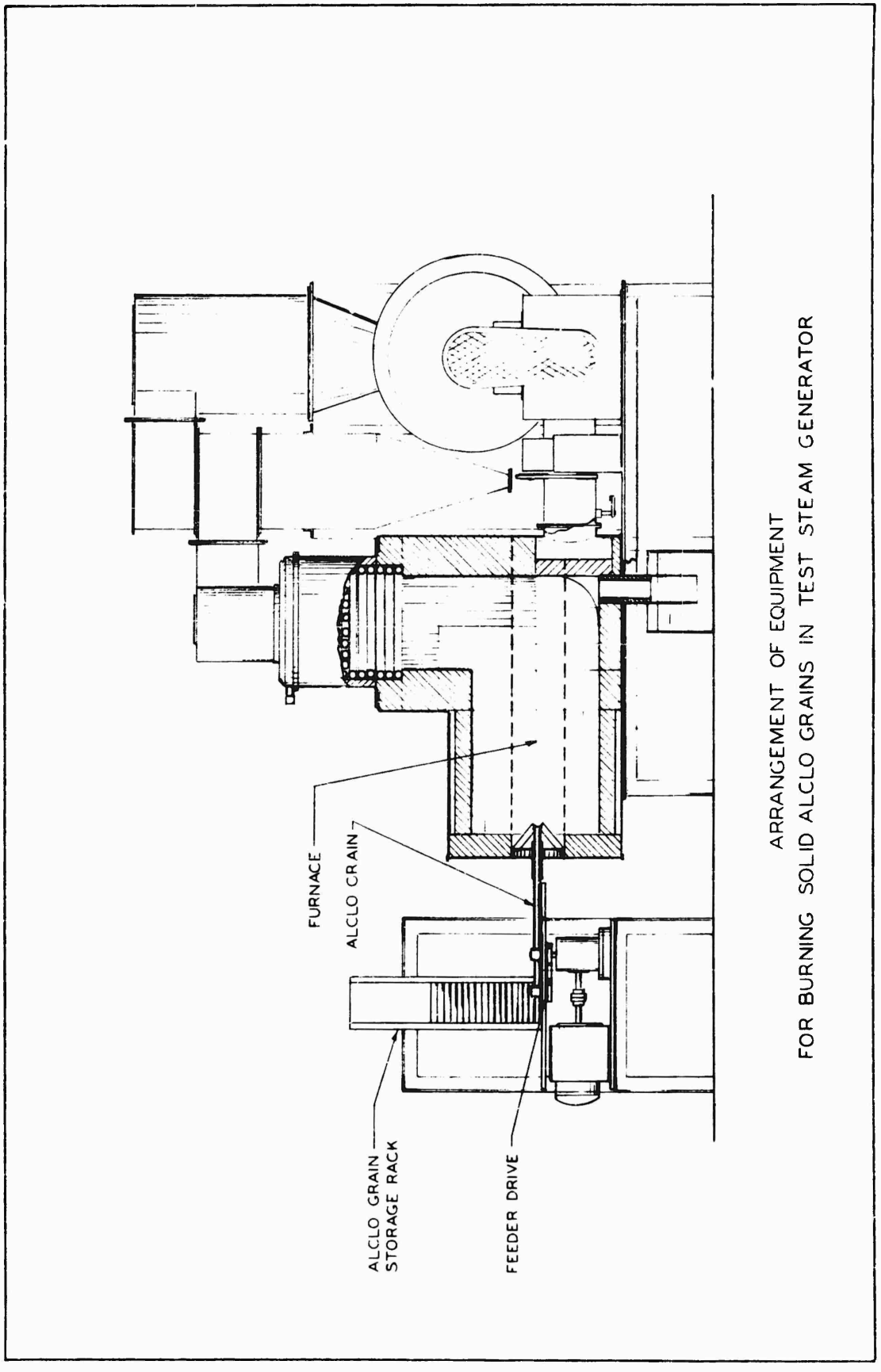
Figure 147



POWDERED ALCLO MIXTURE BURNER
EXTERNALLY MIXING

C-4229 9 18 53 MB

Figure 148



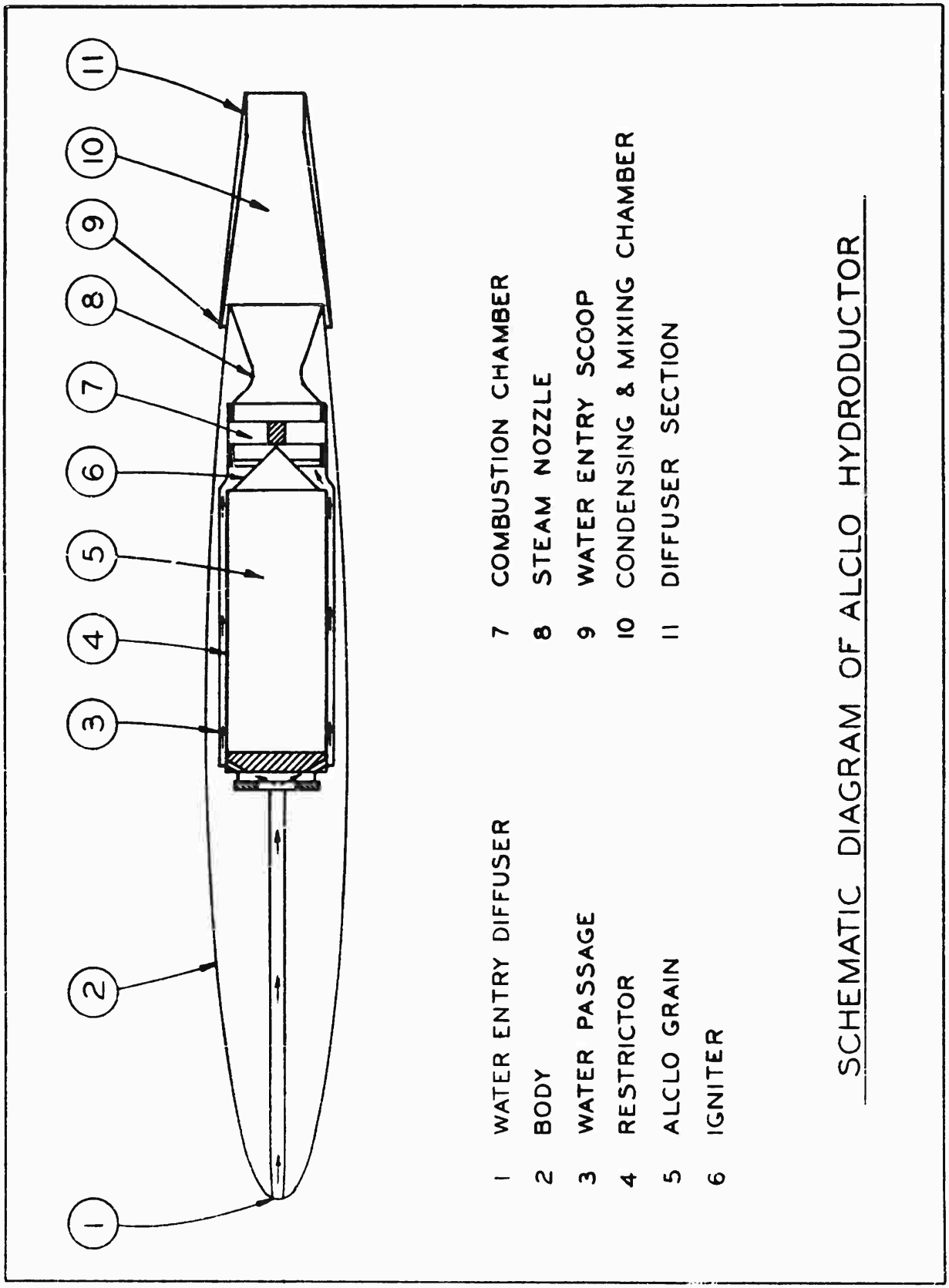
C-4237

ARRANGEMENT OF EQUIPMENT
FOR BURNING SOLID ALCLO GRAINS IN TEST STEAM GENERATOR

Figure 149

CONFIDENTIAL

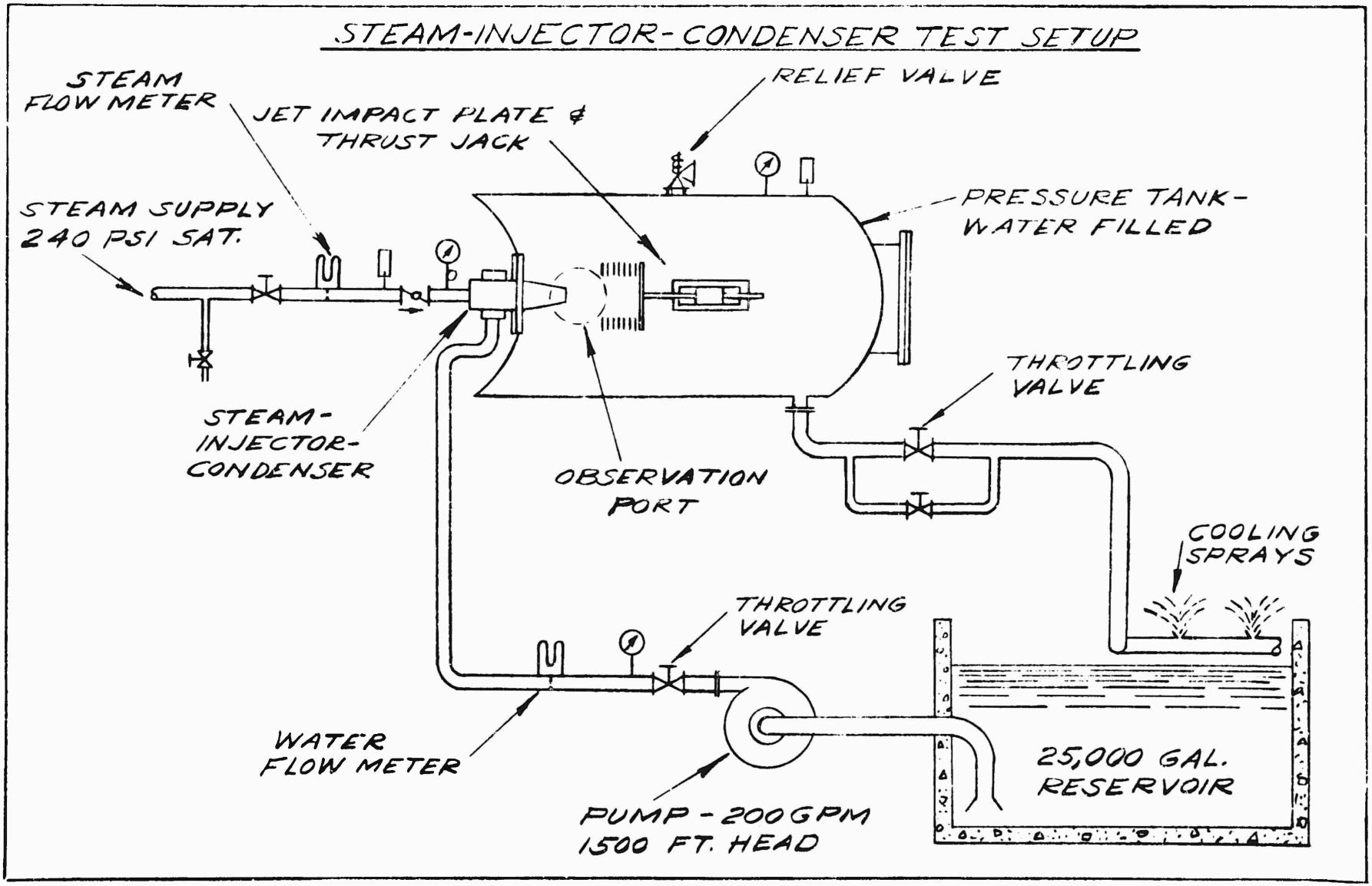
C-4257 6-16-54 EH RS



CONFIDENTIAL

Figure 150

CURVE NO. 4100 7-22-51 EGL

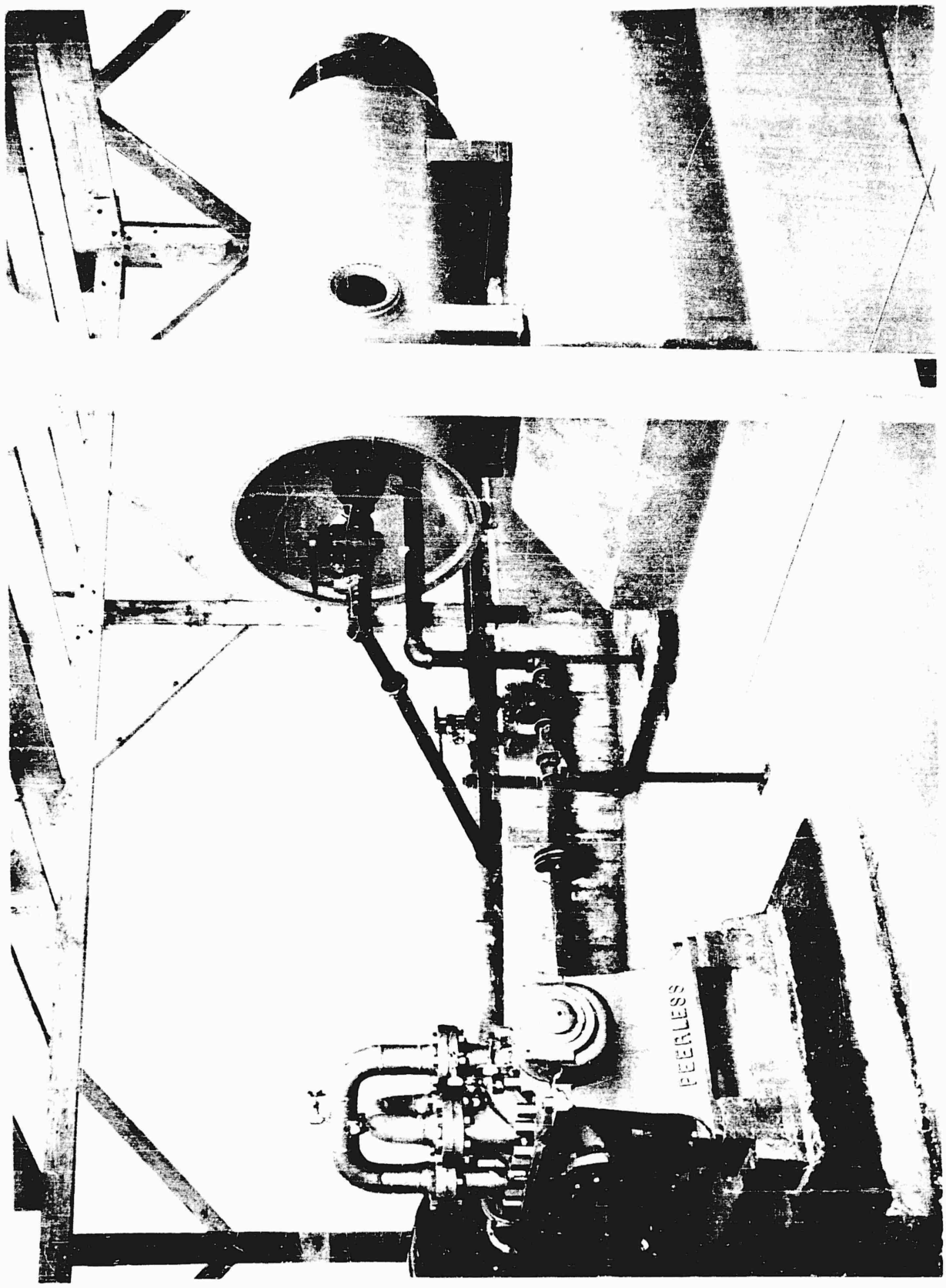


CONFIDENTIAL

CONFIDENTIAL

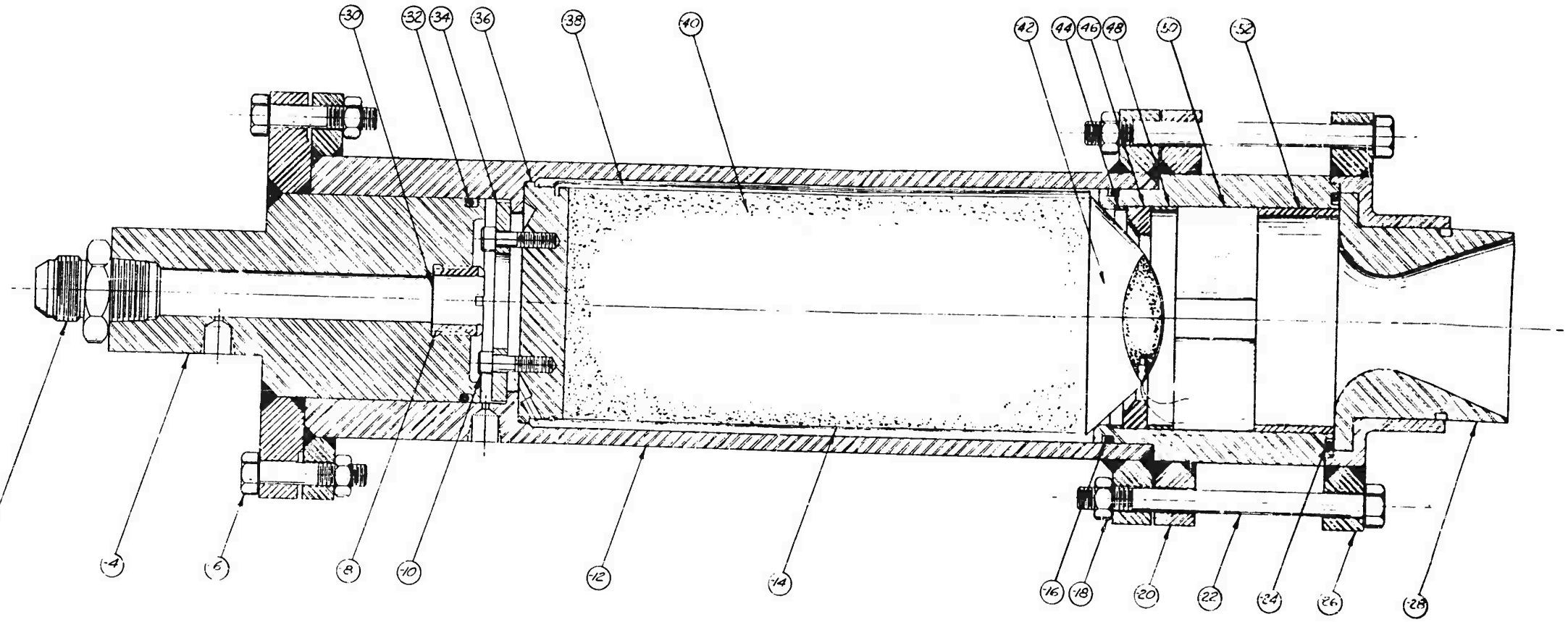
Report No. 1106

Figure 151



General View of Steam-Injector-Condenser Test Setup

LETTER	DATE	CHANGE	BY	CHK'D



PART NO.	REQD.	DESCRIPTION
52	1	SPACER 0-000471-6
50	1	BUTTON 0-000472
48	1	SPACER 0-000471-4
46	1	TURBULATOR RING S-12256
44	1	SPACER 0-000471-2
42	1	CONE AE53-1082
40	1	GRAIN ALCLO
38	18	WIRE S-12276
36	1	INJECTOR AE52-1034-1
34	1	FLANGE AE52-1034-2
32	1	O'RING AN6230-12

0-000469

30	1	DIAPHRAGM AE52-1037-3
28	1	REPLACEABLE NOZZLE S-12280
26	1	NOZZLE FLANGE 0-000470
24	7	O'RING AN6230-18
22	8	BOLT HEX HEAD STL. 3/8-16 NC. X 9.75 LG.
20	1	CHAMBER S-12254
18	16	NUT HEX STL. 3/8-16 NC.
16	1	O'RING AN6230 18
14	AS REQD.	RESTRICTOR LINEN TAPE & SELECTRON
12	1	CENTER SECTION AE52-1729
10	4	SOC. HD. CAP SCREW STL. 1/4-28 NF. X .875 LG.
8	1	INSERT AE52-1037-2
6	8	BOLT HEX HEAD STL. 3/8-16 NC. X 7.5 LG.
4	1	NOSE SECTION AE52-1728
2	1	FITTING AN816-12

DRAWN	6-23-53	6-24-53	6-24-53
CHECKED	6-24-53		
ENGR APPR.			
APPROVED	ADAMS		

ROCKET-GENERAL CORPORATION
AZUSA, CALIFORNIA

3.75 DIA. GRAIN SHORT CHAMBER TEST MOTOR ASSY.

SIZE D

0-XX0469

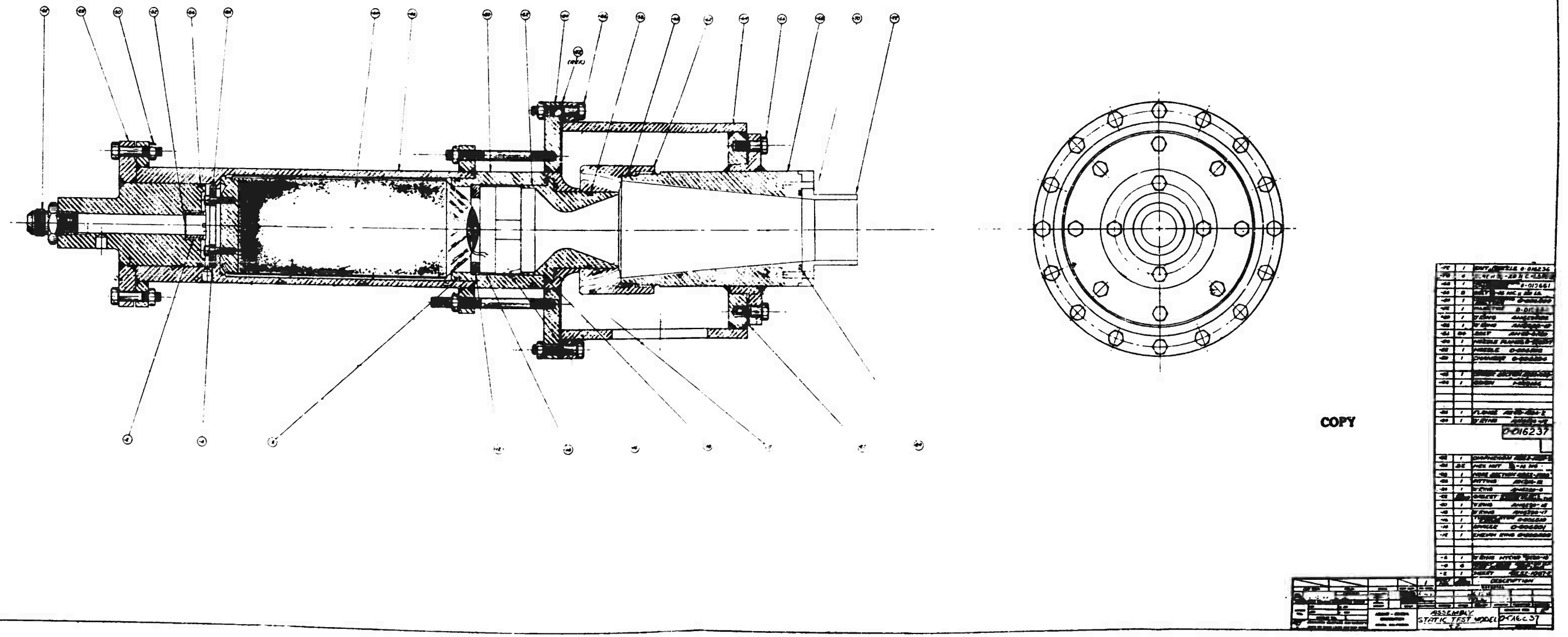
NOTES: 1. Remove all burrs and sharp edges.

Figure 153

C-4148 BW/EH 12-22-52

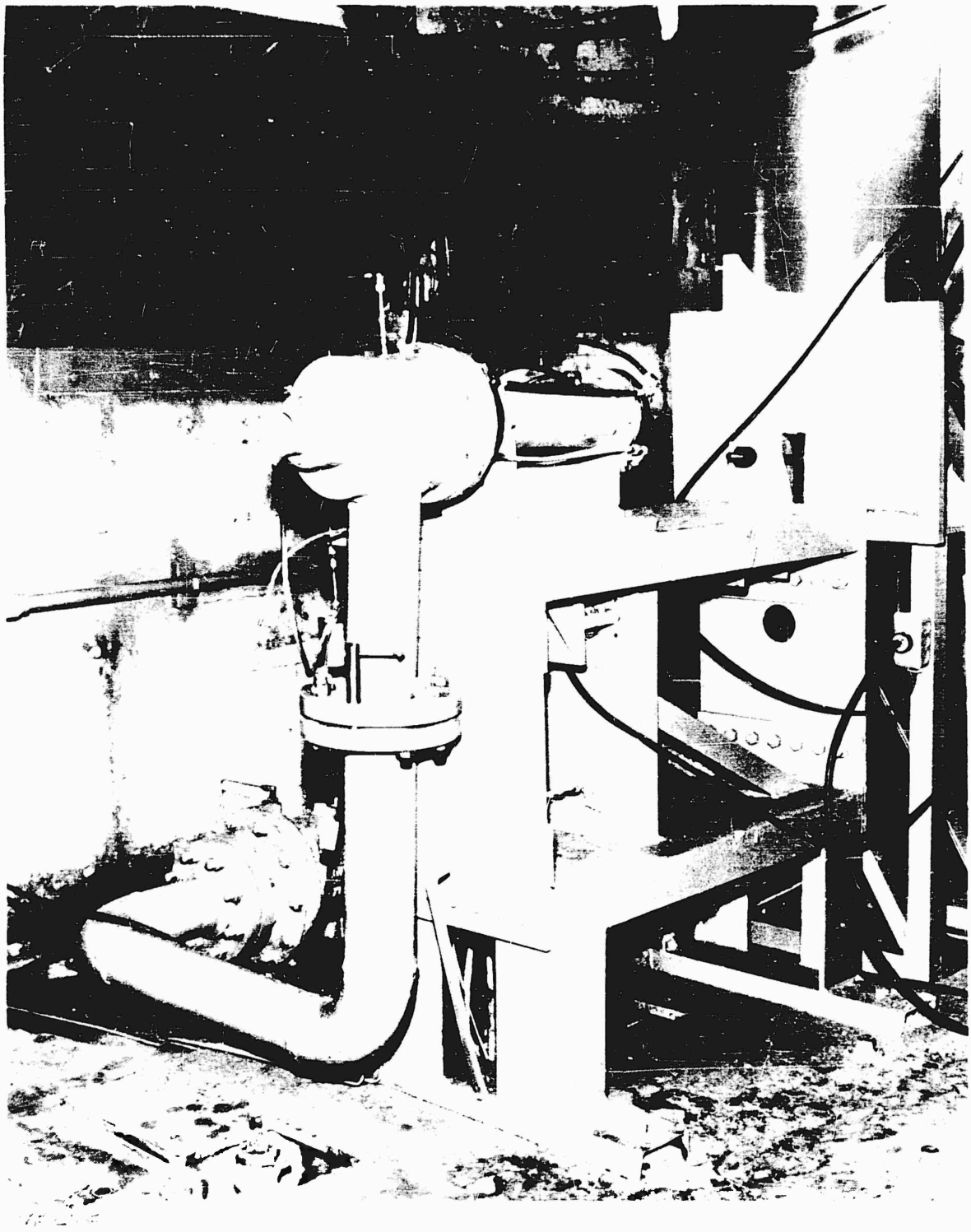
TEST INSTALLATION FOR PROTOTYPE STEAM-JET CONDENSER

Figure 154

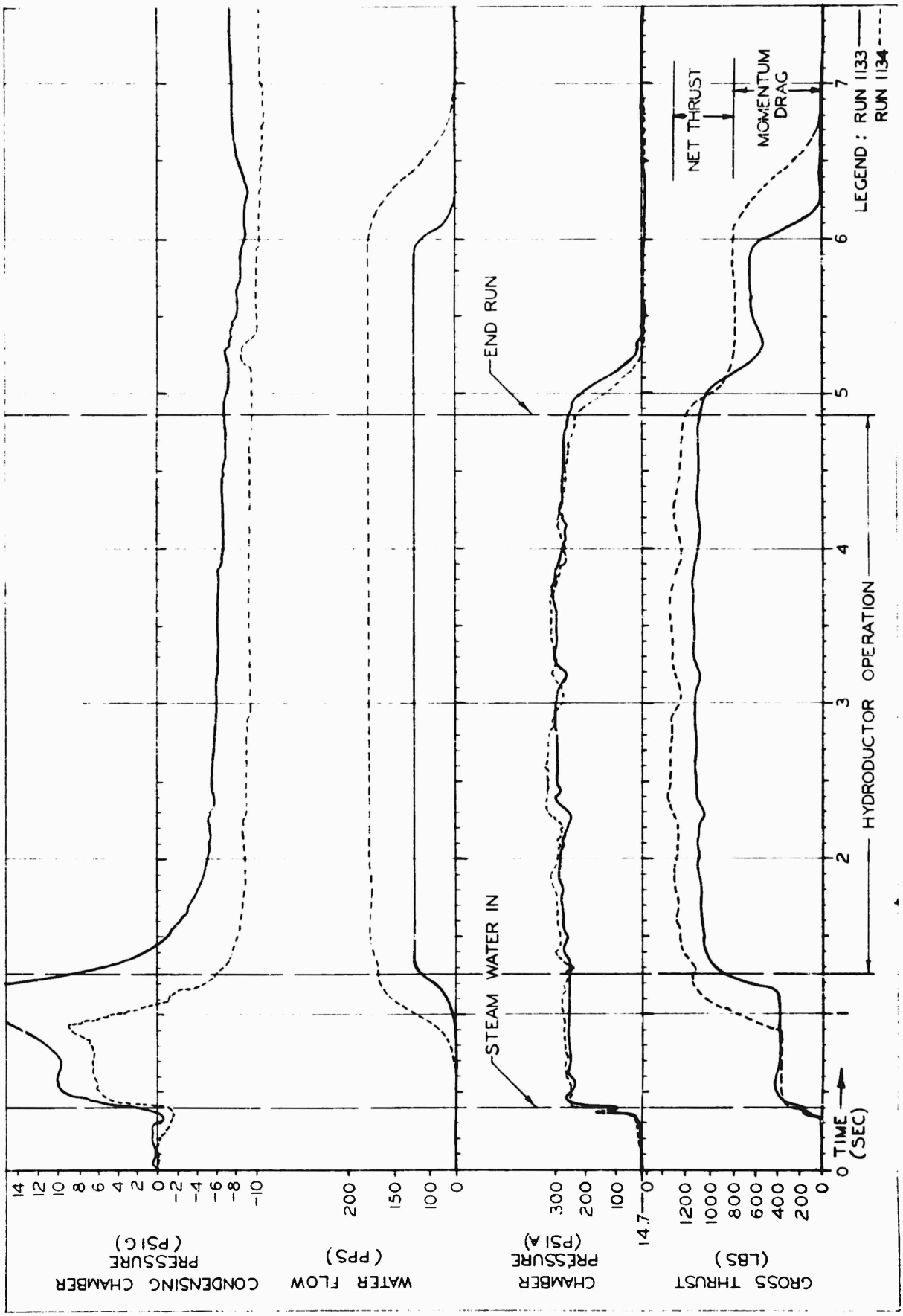


COPY

Figure 155



Hydroductor Test-Pit Setup



Hydroductor Runs No. 1133 and 1134

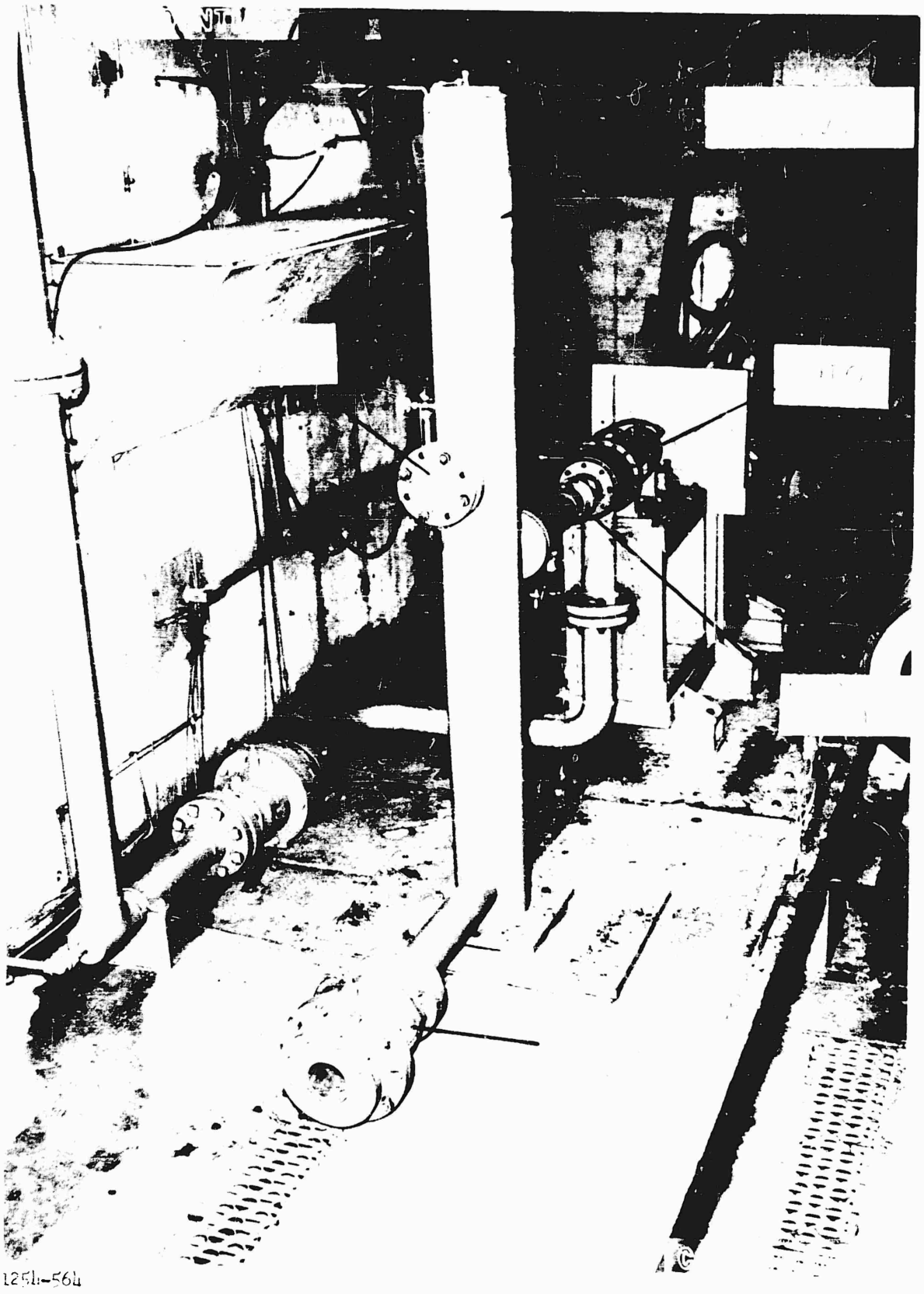
Figure 157

P_C - COMBUSTION CHAMBER PRESSURE
P_{CC} - CONDENSING CHAMBER PRESSURE
P_m - MANIFOLD PRESSURE (TOTAL HEAD OF CONDENSING WATER)
P_b - BACK PRESSURE ON SYSTEM

SCHEMATIC - HYDRODUCTOR BACK-PRESSURE FACILITY

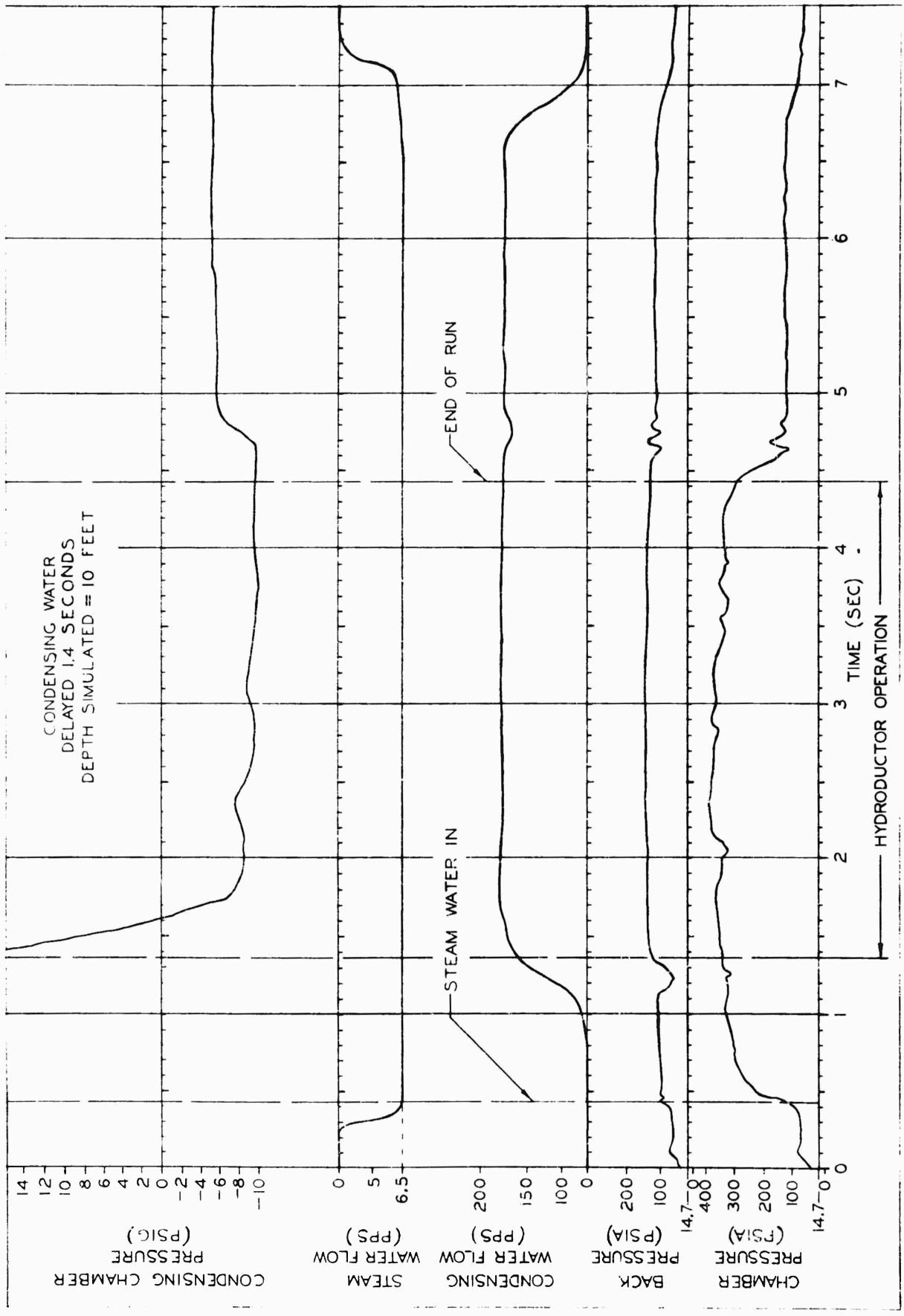
C-415 12-21-54 R.S. eh

Figure 158



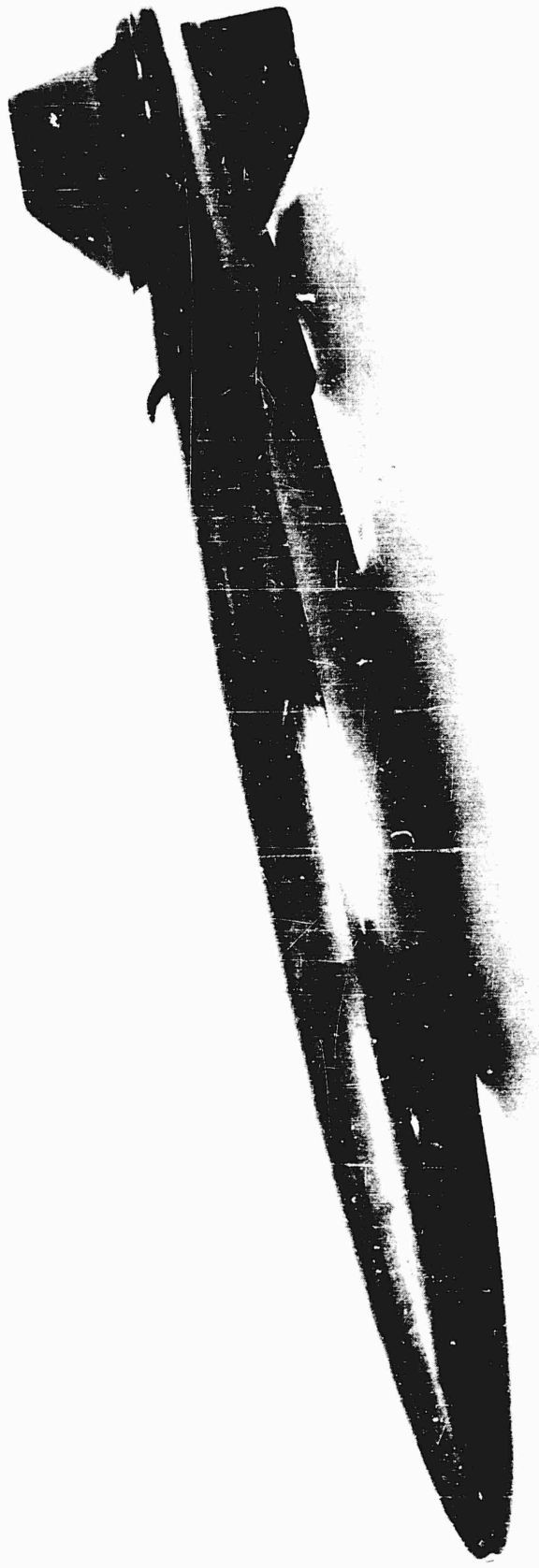
1254-564

Hydroductor Back-Pressure Test Facility



Hydroductor Run No. 1135

Figure 160



Hydroductor No. 1

Figure 161

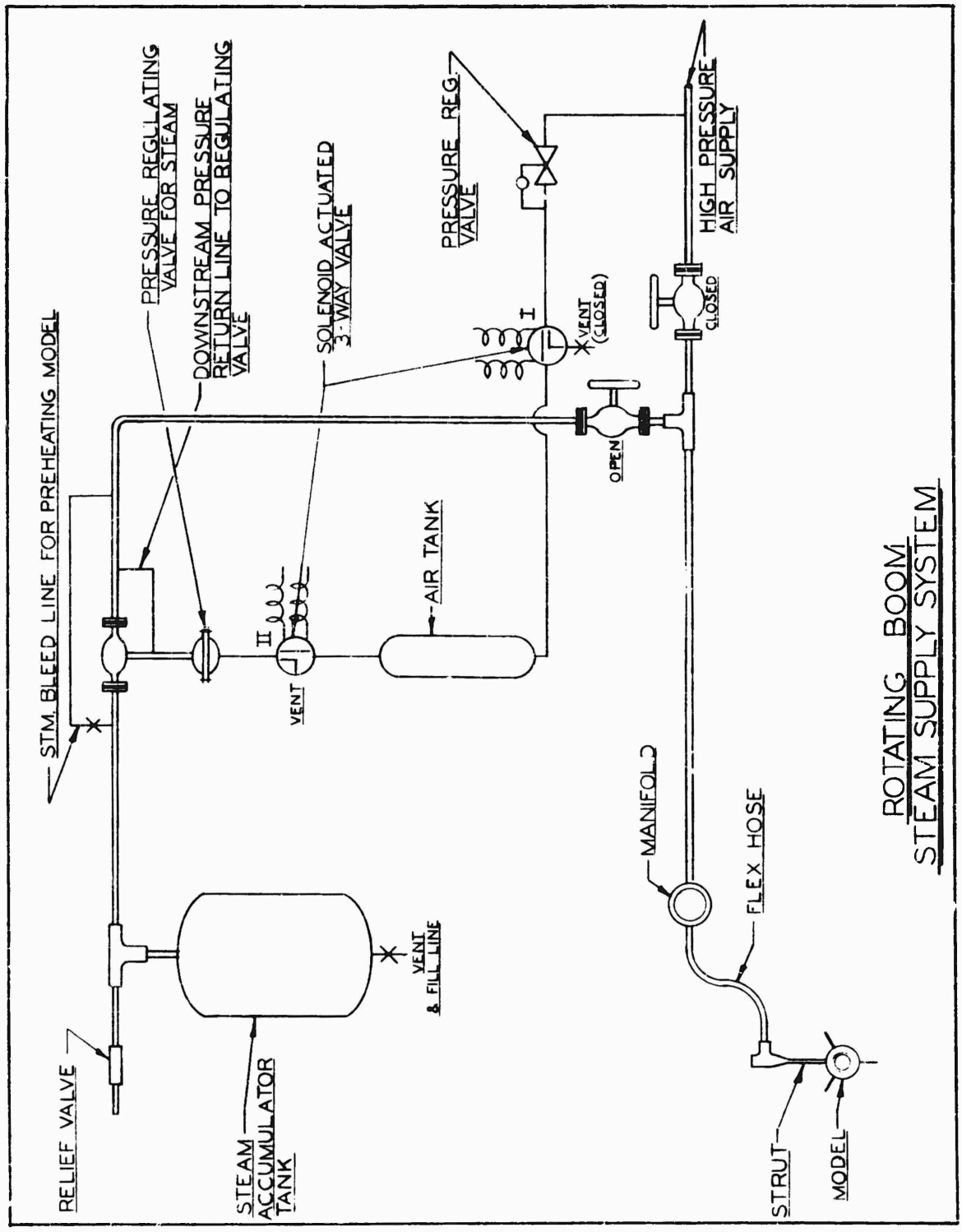
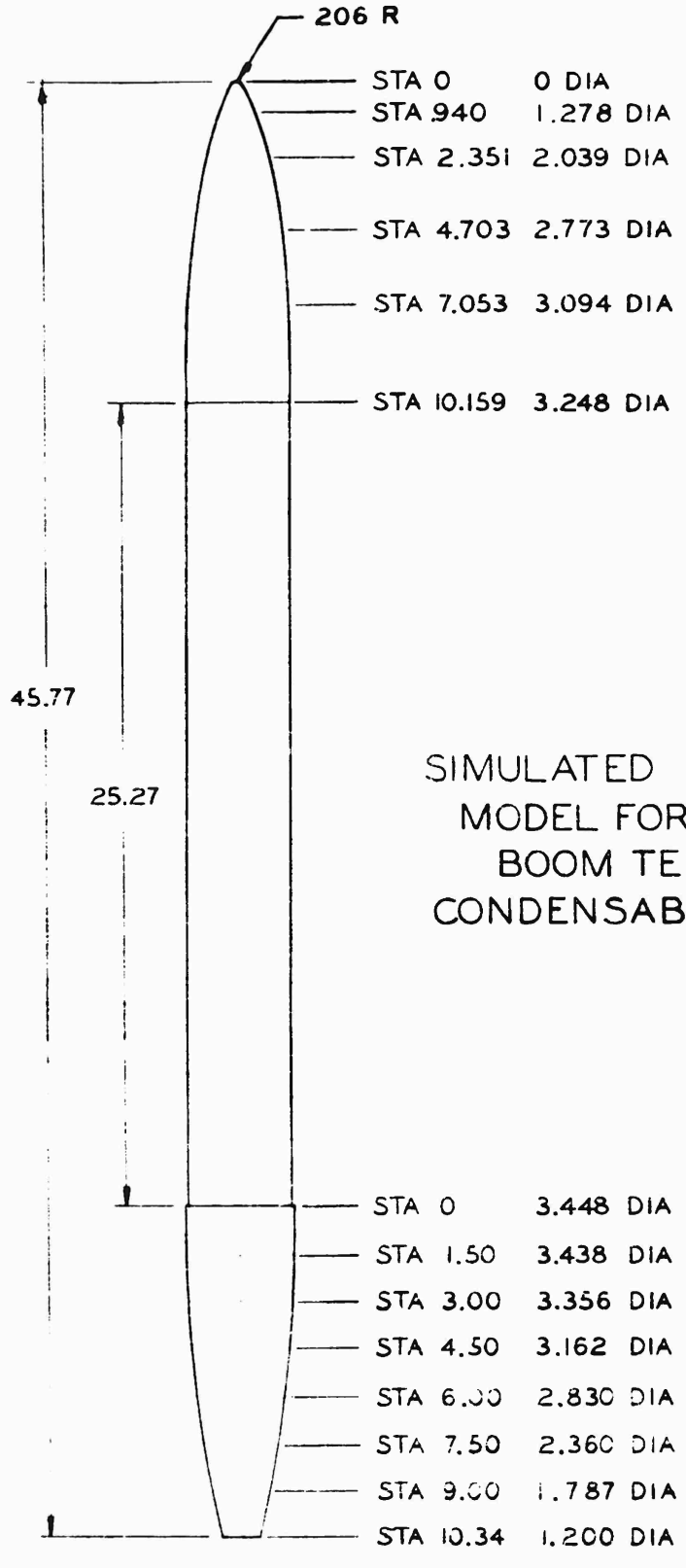
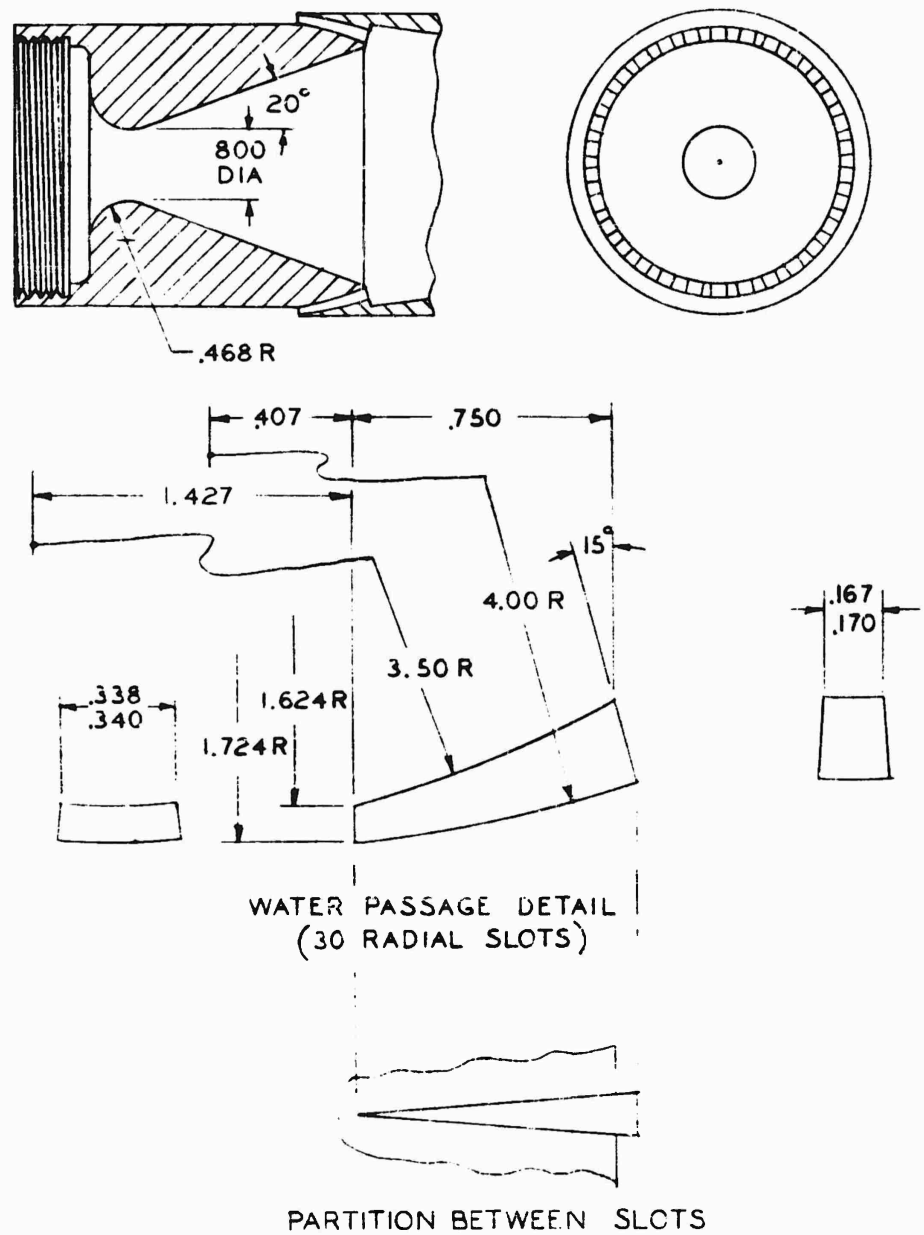

ROTATING BOOM
STEAM SUPPLY SYSTEM
STM. BLEED LINE FOR PREHEATING MODEL
PRESSURE REGULATING VALVE FOR STEAM
DOWNSTREAM PRESSURE RETURN LINE TO REGULATING VALVE
SOLENOID ACTUATED 3-WAY VALVE
PRESSURE REG. VALVE
HIGH PRESSURE AIR SUPPLY
VENT (CLOSED)
CLOSED
OPEN
AIR TANK
VENT
RELIEF VALVE
STEAM ACCUMULATOR TANK
VENT & FILL LINE
MANIFOLD
FLEX HOSE
STRUT
MODEL
C-4236

Figure 162

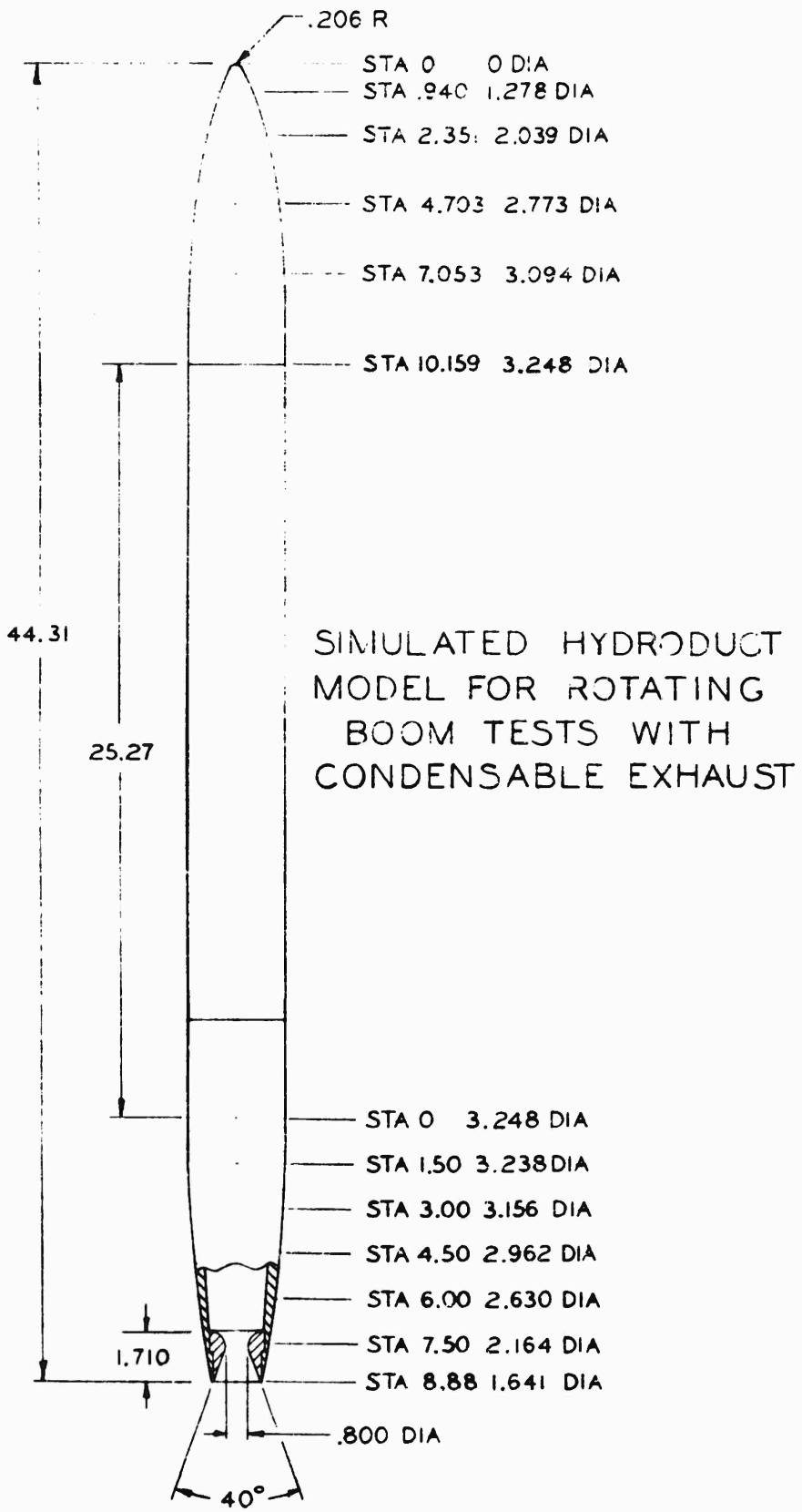


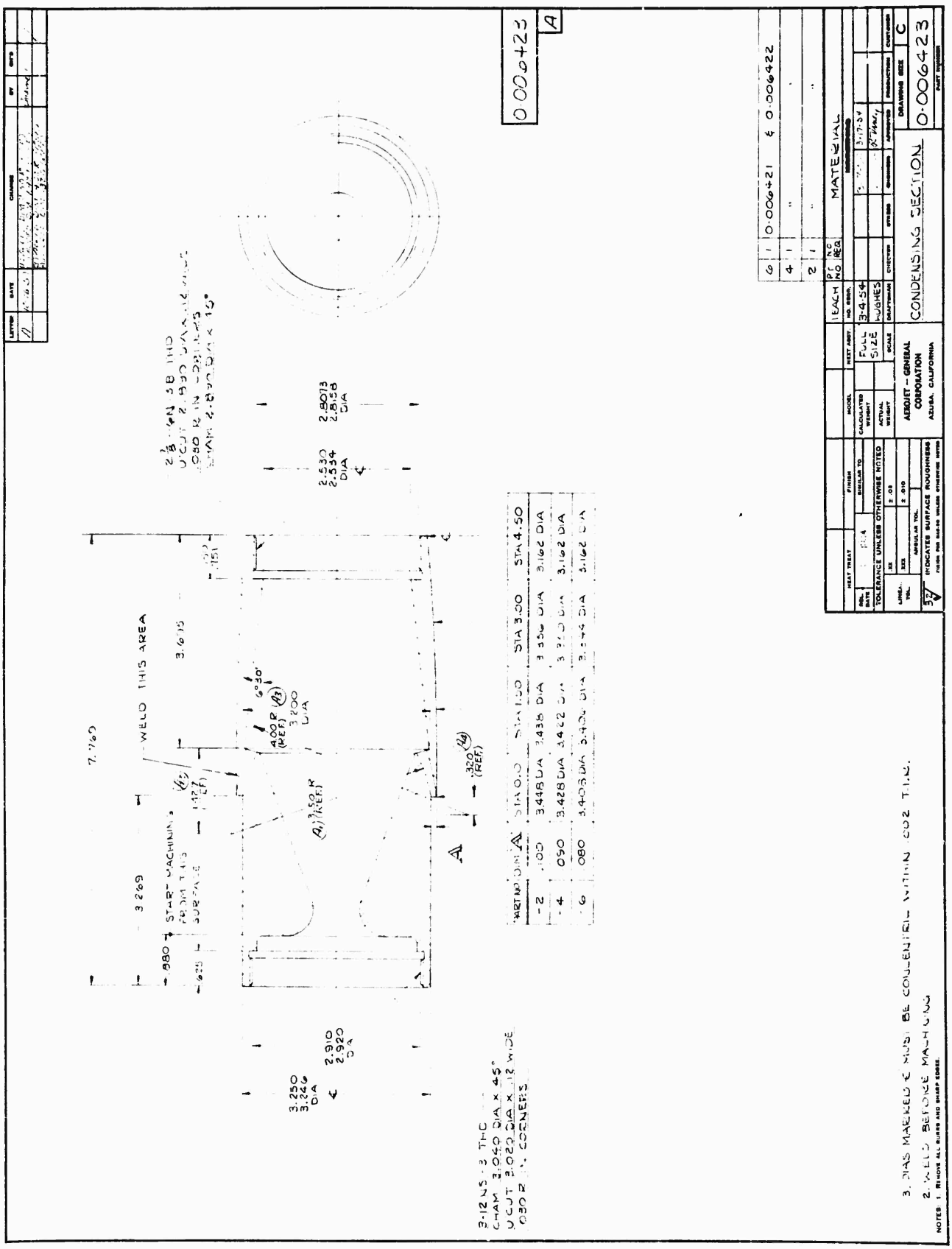
SIMULATED HYDRODUCTOR MODEL FOR ROTATING BOOM TESTS WITH CONDENSABLE EXHAUST

Figure 163



HYDRODUCTOR STEAM NOZZLE
AND SCOOP PASSAGE DETAILS


.206 R
STA 0 0 DIA
STA .940 1.278 DIA
STA 2.35: 2.039 DIA
STA 4.703 2.773 DIA
STA 7.053 3.094 DIA
STA 10.159 3.248 DIA
44.31
25.27
SIMULATED HYDRODUCT MODEL FOR ROTATING BOOM TESTS WITH CONDENSABLE EXHAUST
STA 0 3.248 DIA
STA 1.50 3.238 DIA
STA 3.00 3.156 DIA
STA 4.50 2.962 DIA
STA 6.00 2.630 DIA
STA 7.50 2.164 DIA
STA 8.88 1.641 DIA
1.710
.800 DIA
40°


0.006423
CONDENSING SECTION
0.006423
ASSOCIATED GENERAL CORPORATION
AZUSA, CALIFORNIA
MATERIAL
0.006421 & 0.006422
WELD THIS AREA
7.769
3.269
3.615
2.910
2.920
DIA
3.250
3.240
DIA
2.530
2.534
DIA
2.8073
2.8158
DIA
3.200
DIA
400 R (REF)
320 (REF)
A
A
3.12 NS - 3 THD
CHAM 3.040 DIA x 45°
UCUT 3.020 DIA x .12 WIDE
.030 R ALL CORNERS
STA 0.00
STA 1.00
STA 3.00
STA 4.50
-2 .100 3.438 DIA 3.162 DIA
-4 .090 3.428 DIA 3.162 DIA
-6 .080 3.418 DIA 3.162 DIA
3. DIAS MARKED ¢ MUST BE CONCENTRIC WITHIN .002 T.I.R.
2. WELD BEFORE MACHINING
NOTES: 1. REMOVE ALL BURRS AND SHARP EDGES.

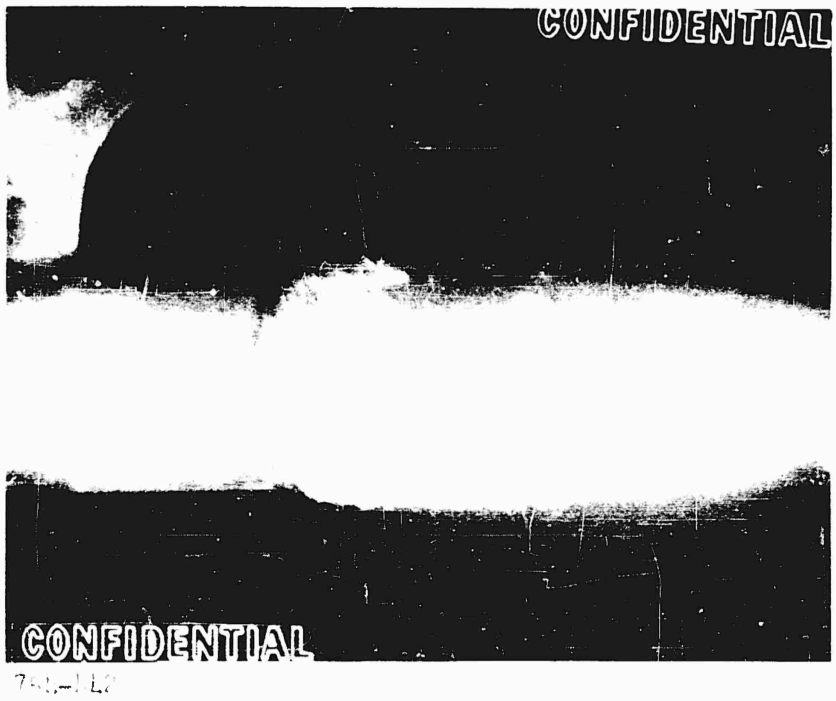


Fig. 167 Constant-Area Scoop, Microflash

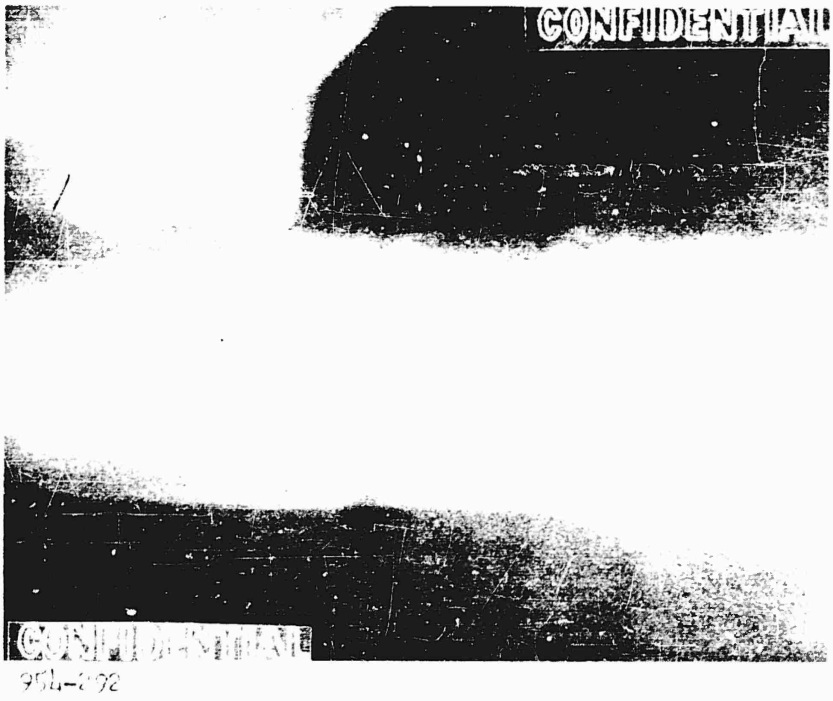


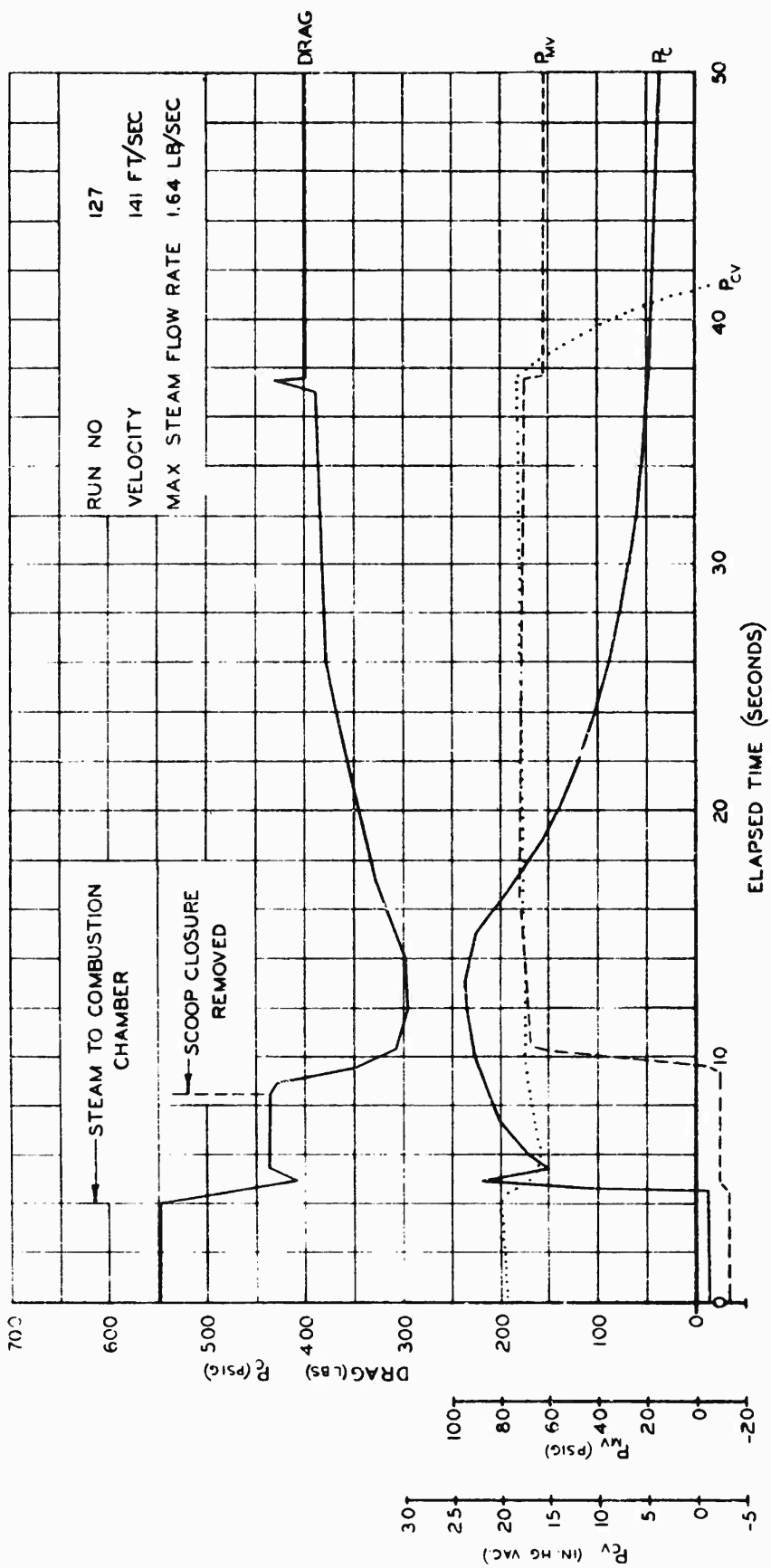
Fig. 168 Improved Constant-Area Scoop, Microflash

1[illegible]L-925

Fig. 169 10%-Increasing-Area Scoop, Microflash

105L-490

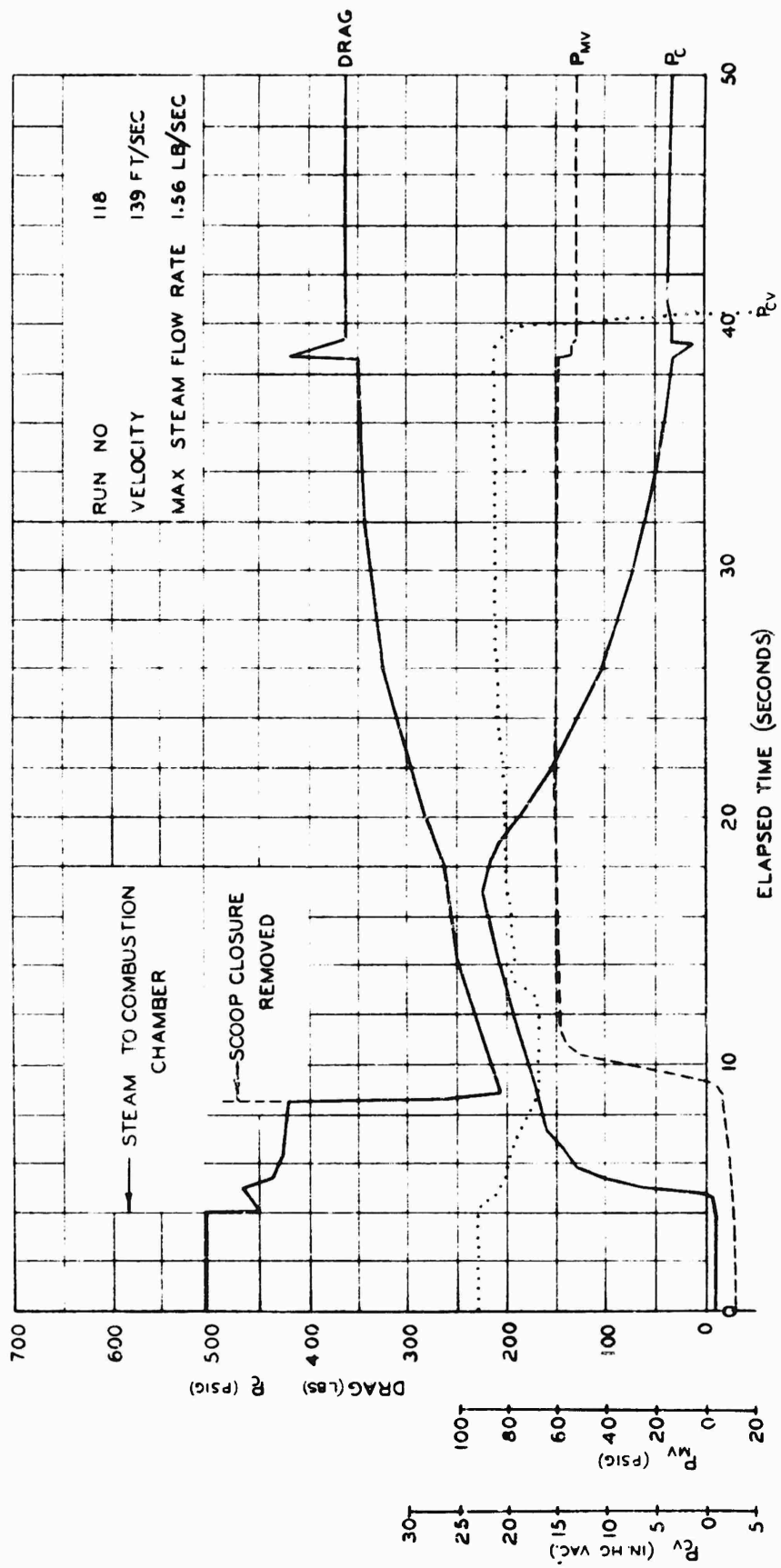
Fig. 170 20%-Increasing-Area Scoop, Microflash



ROTATING BOOM TEST OF HYDRODUCTOR MODEL

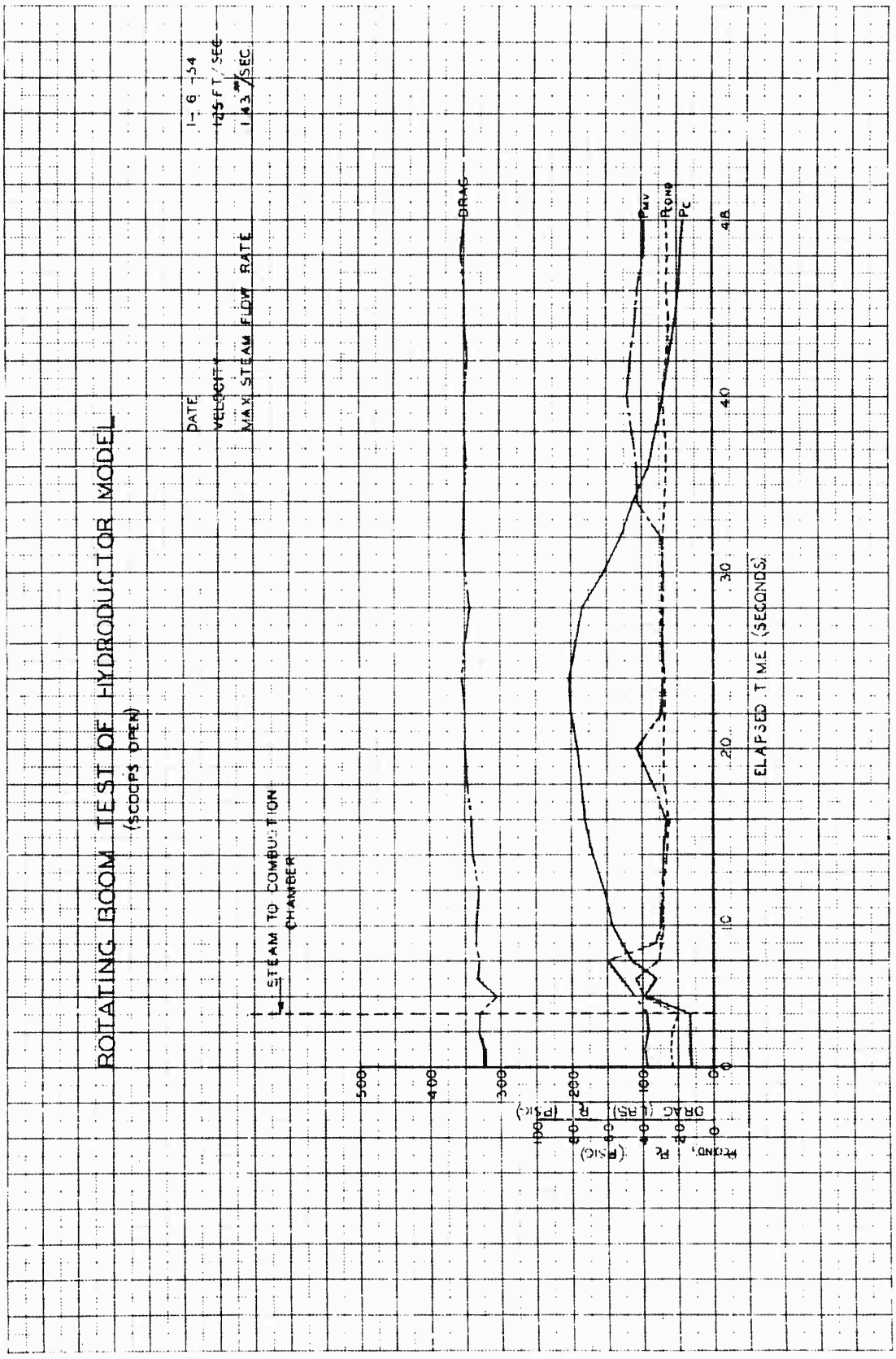
SCOOP HEIGHT = 0.090 INCH AREA RATIO = 0.7

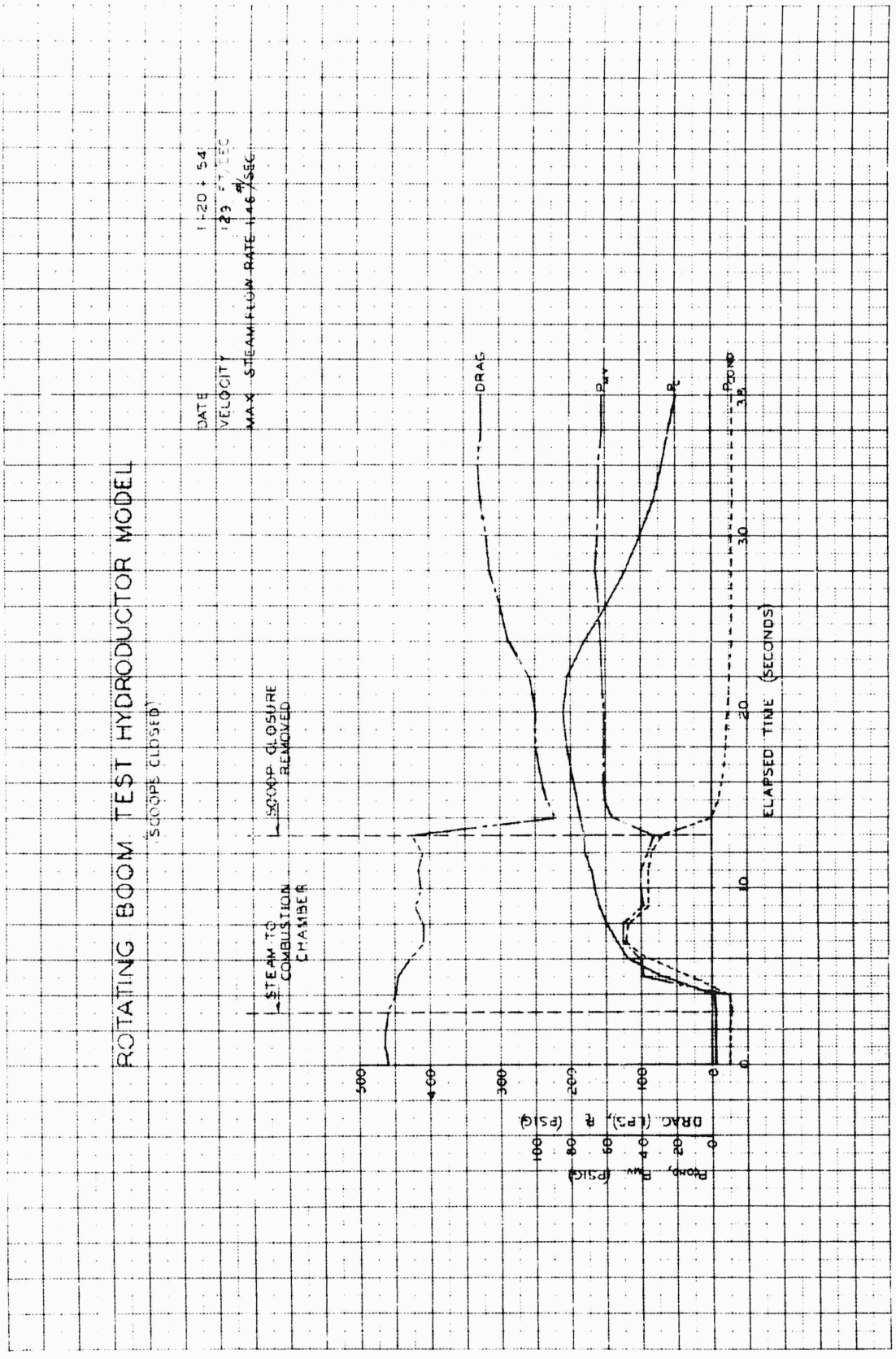
Figure 171



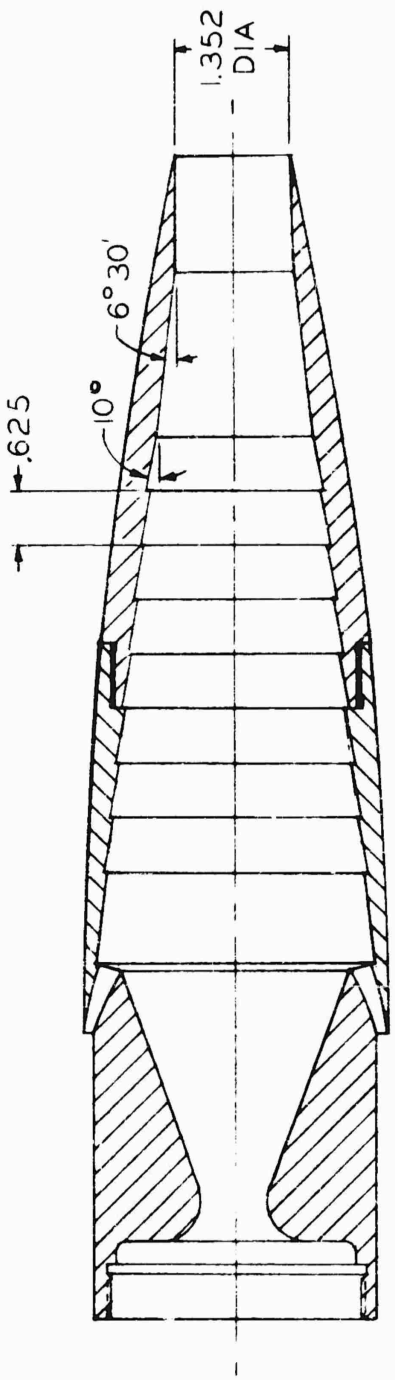
ROTATING BOOM TEST OF HYDRODUCTOR MODEL
SCOOP HEIGHT = 0.100 INCH AREA RATIO = 0.7
(FULLY STEPPED AFTERBODY)

Figure 172


ROTATING ROOM TEST OF HYDRODUCTOR MODEL
(SCOOPS OPEN)
DATE 1-6-54
VELOCITY 125 FT/SEC
MAX STEAM FLOW RATE 1.43 #/SEC
STEAM TO COMBUSTION CHAMBER
DRAG
Pv
RPMD
Pc
ELAPSED TIME (SECONDS)
RPMD
Pc (PSIG)
DRAG (LBS)
Pv (PSIG)

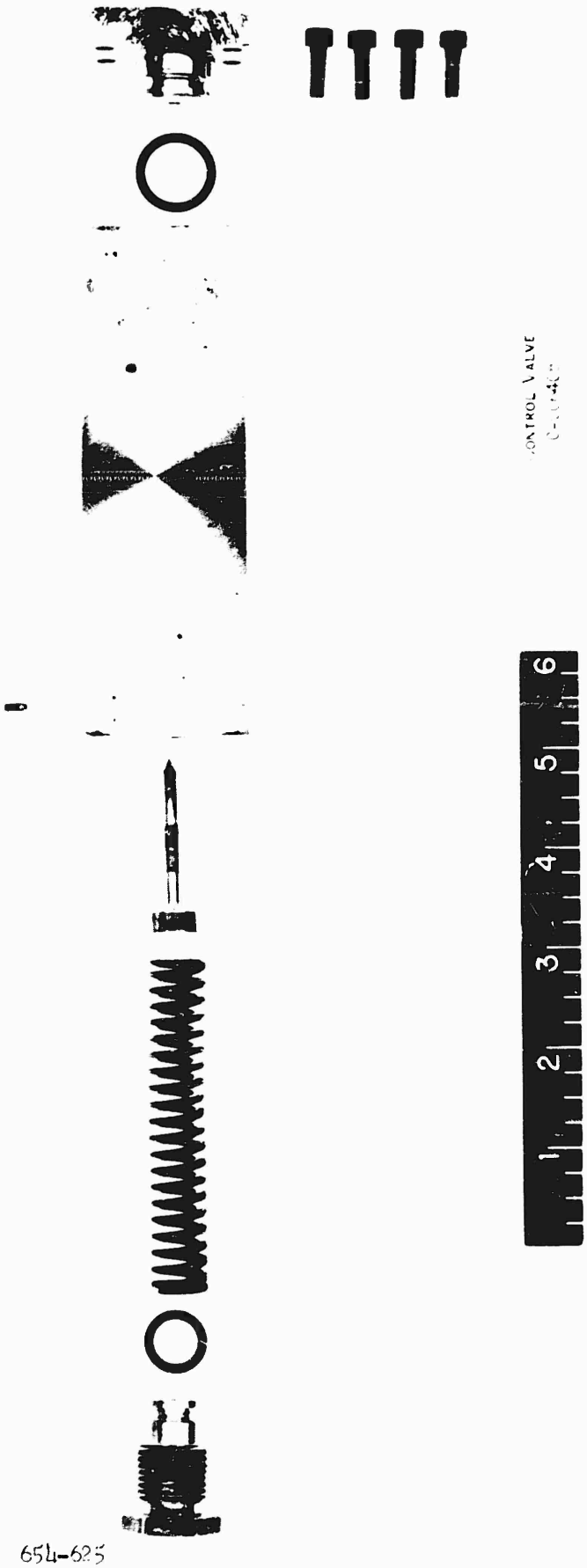

ROTATING BOOM TEST HYDRODUCTOR MODEL
SCOOPS CLOSED
DATE 1-20 + 54
VELOCITY 129 FT/SEC
MAX STEAM FLOW RATE 1.46 #/SEC
STEAM TO COMBUSTION CHAMBER
SCOOP CLOSURE REMOVED
DRAG
P_{HY}
R
P_{COND}
ELAPSED TIME (SECONDS)
DRAG (LBS), R (PSIG)
P_{COMP}, P_{HY} (PSIG)

C-4313 12-7-54 WSD



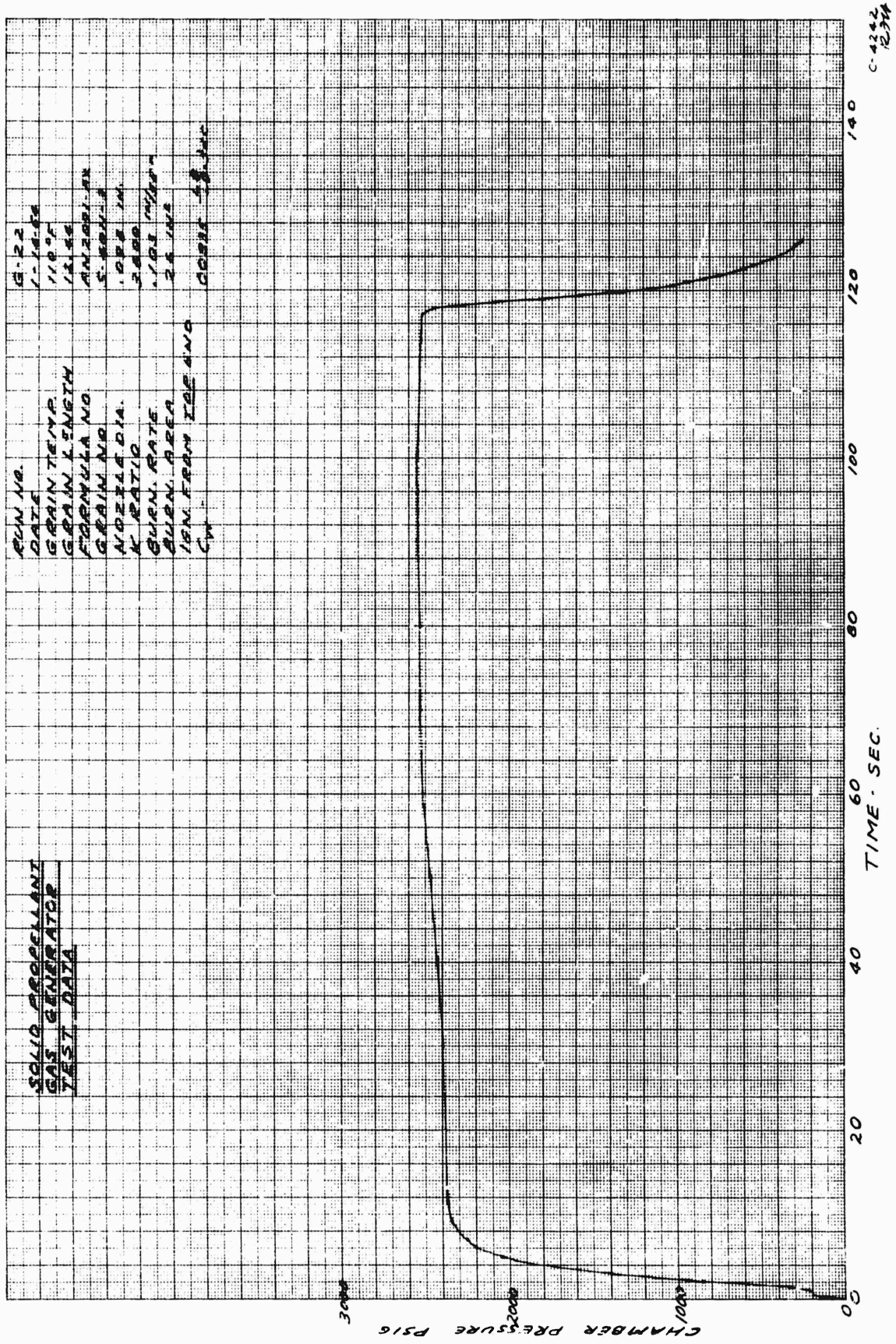
STEPPED CONDENSING SECTION

Figure 175

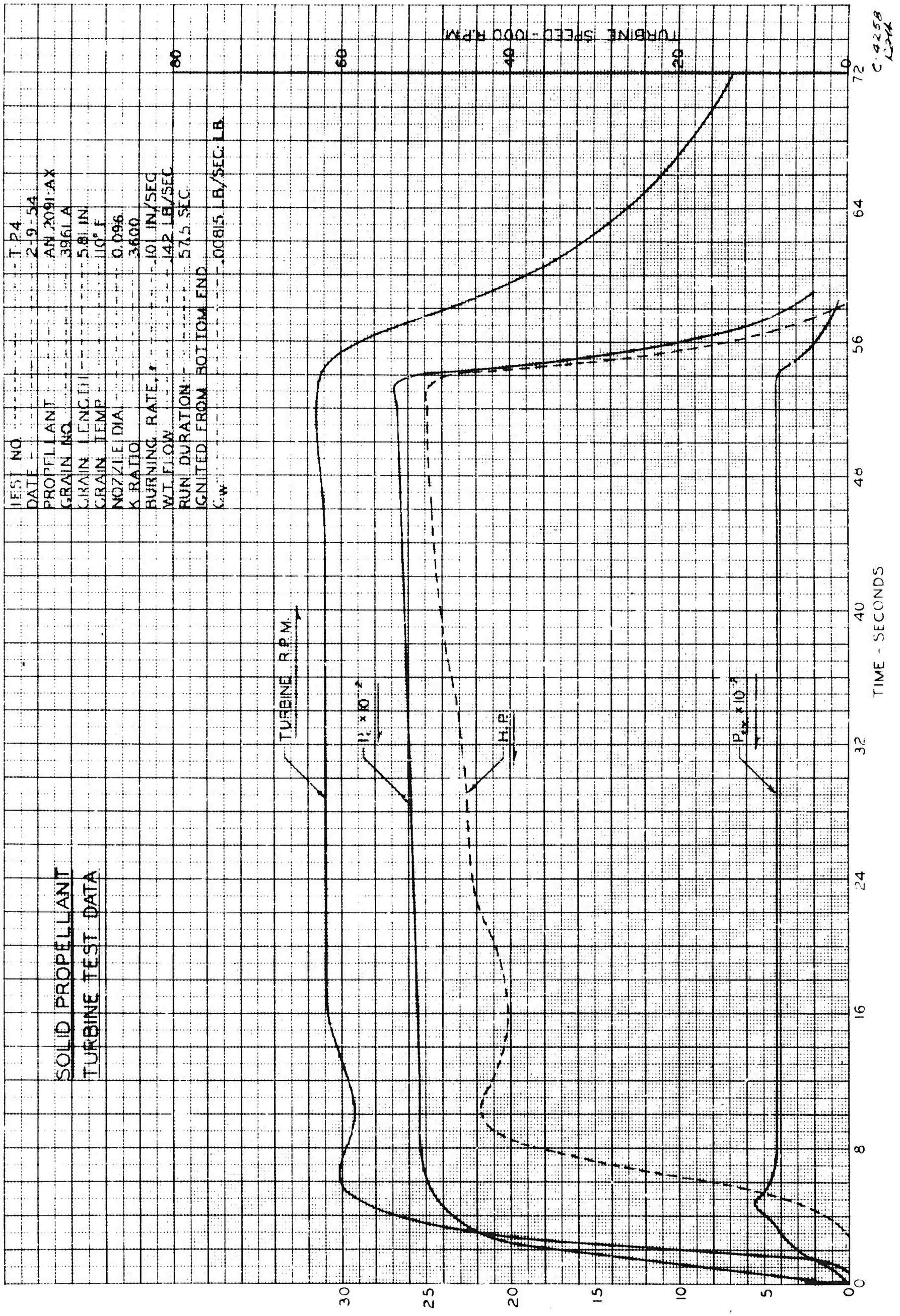


Turbine Speed Controller Components

Figure 176



Pressure-Time Data for 2-Minute Test



CONFIDENTIAL

Figure 178

C-4397 8-12-55 CLG

SCHEMATIC DIAGRAM SPEED CONTROL SYSTEM

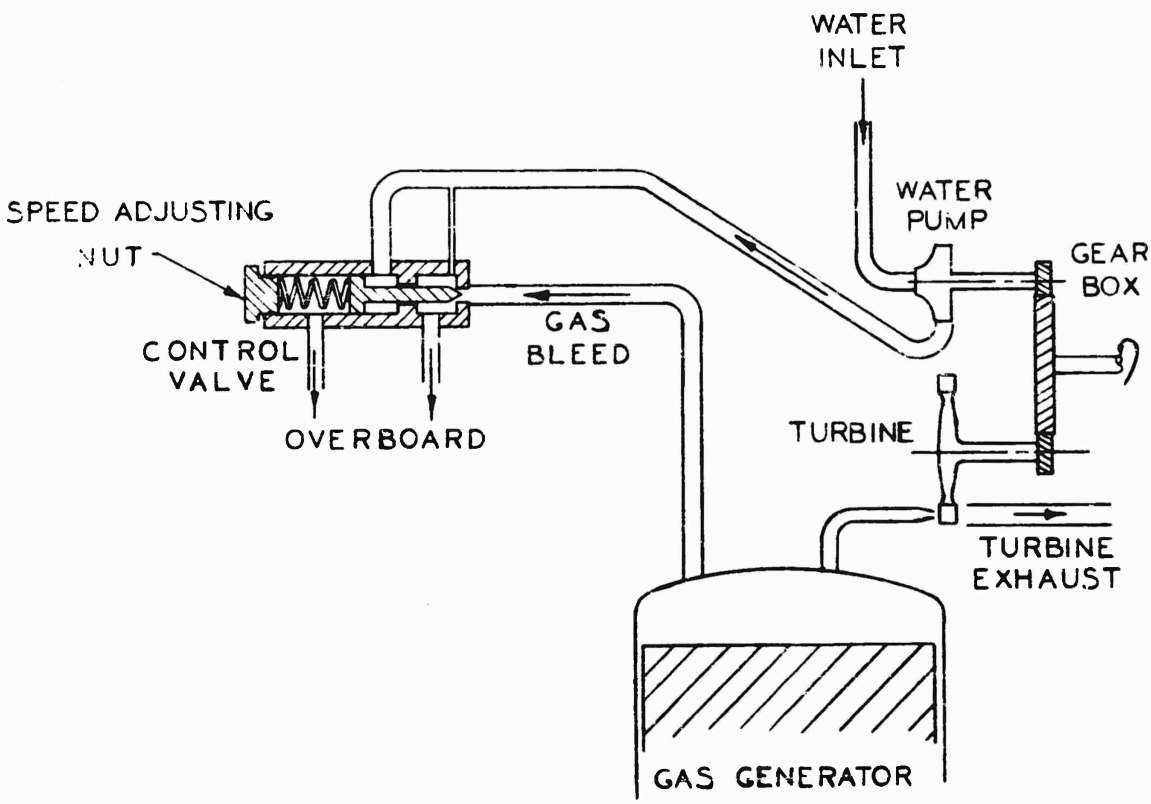
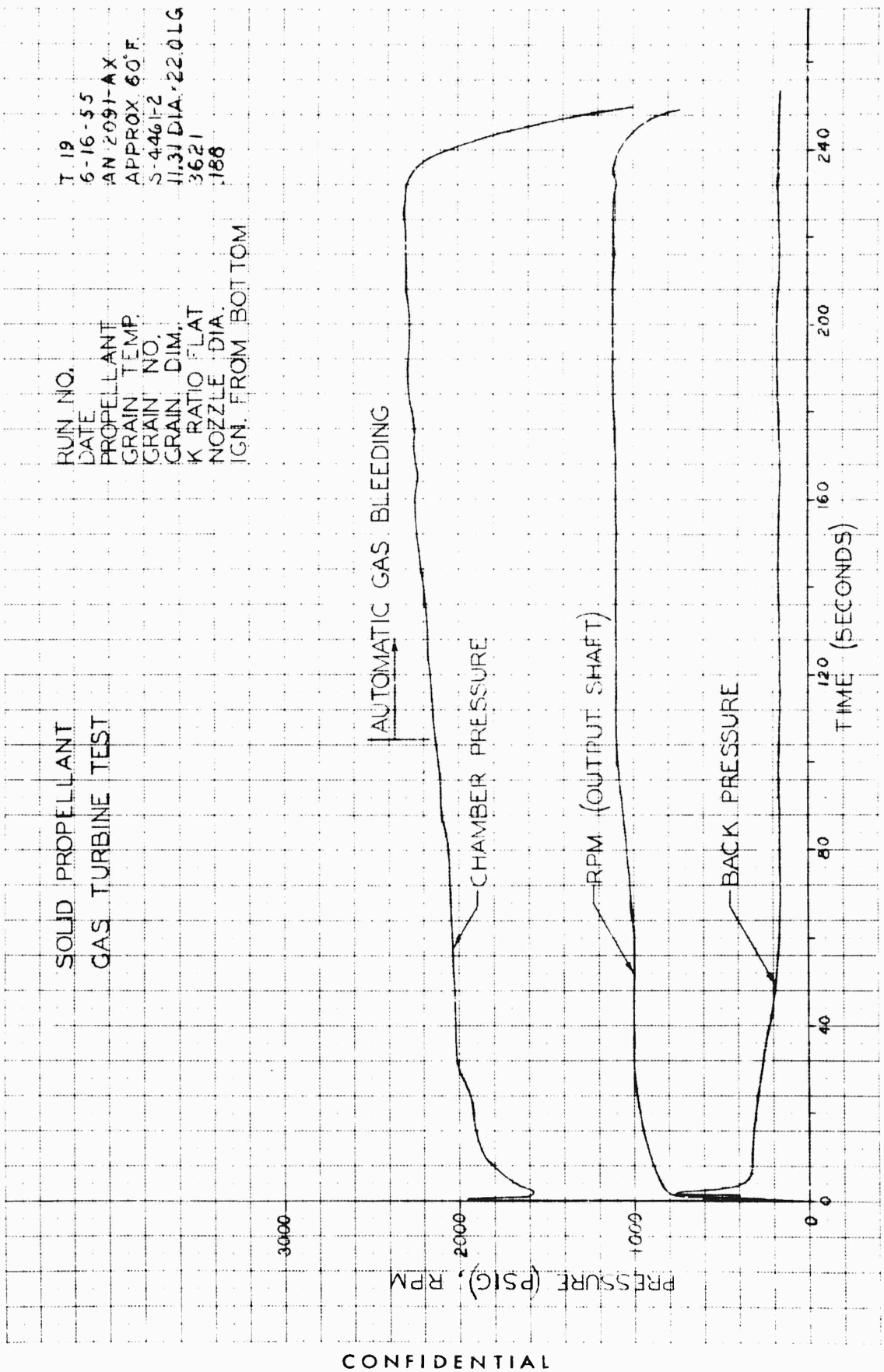


Figure 179

CONFIDENTIAL



CONFIDENTIAL

Figure 180

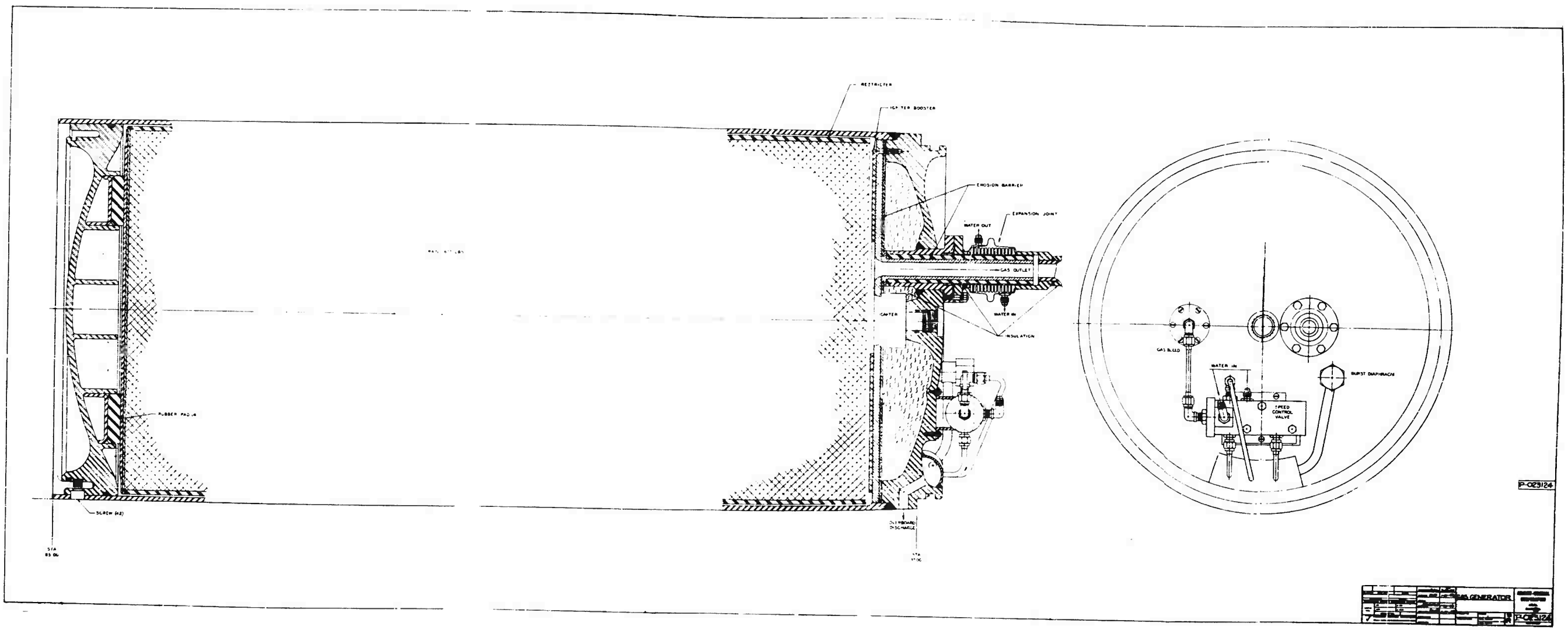
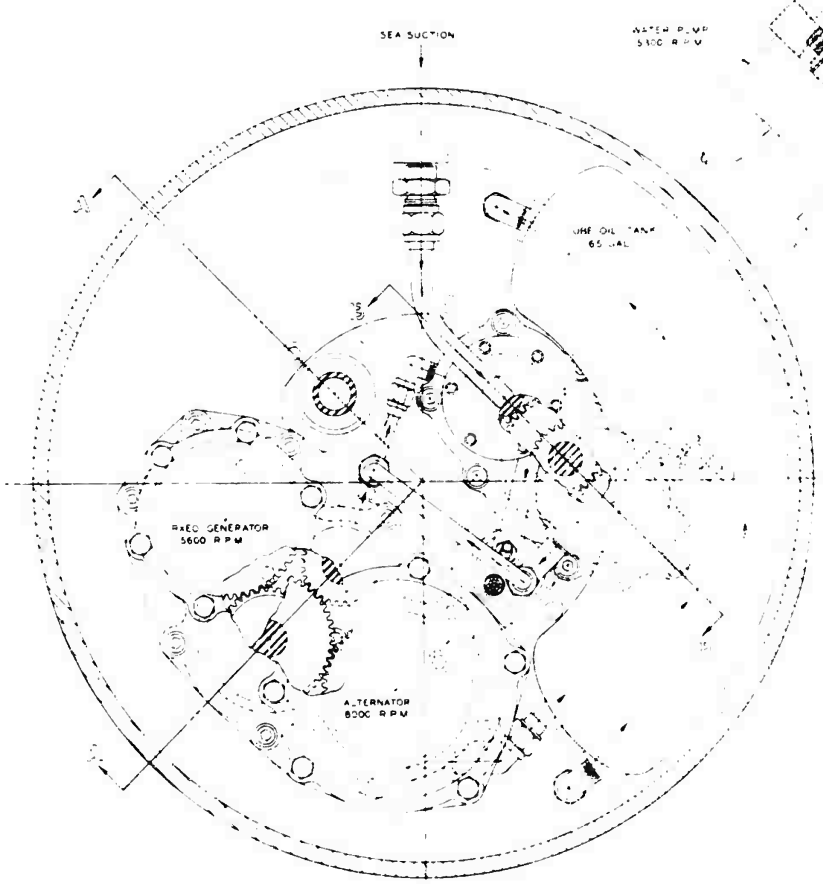
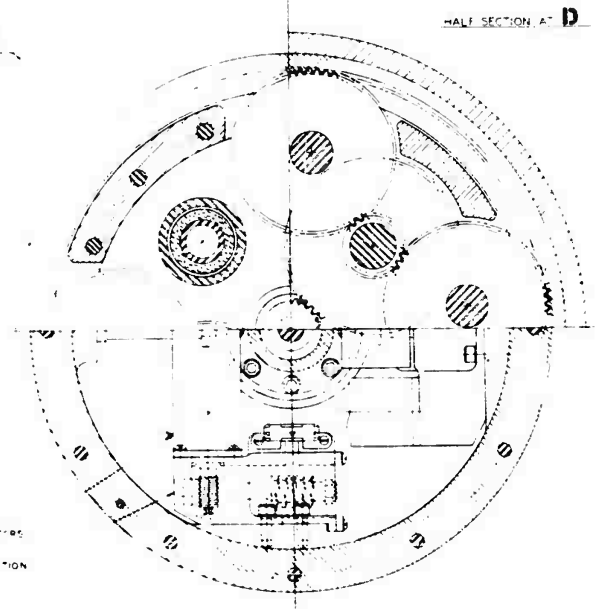

RESTRICTER
IGNITER BOOSTER
EROSION BARRIER
EXPANSION JOINT
WATER OUT
GAS OUTLET
WATER IN
INSULATION
GAS BLEED
WATER IN
BURST DIAPHRAGM
SPEED CONTROL VALVE
RUBBER PAD (4)
SCREW (42)
OVERBOARD DISCHARGE
P-023124
GAS GENERATOR
P-023124

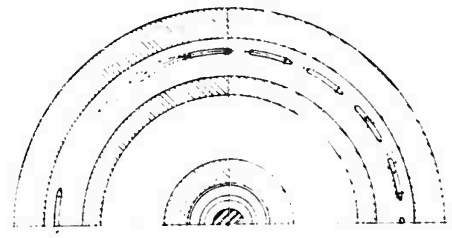
Figure 181

CONFIDENTIAL

1







2

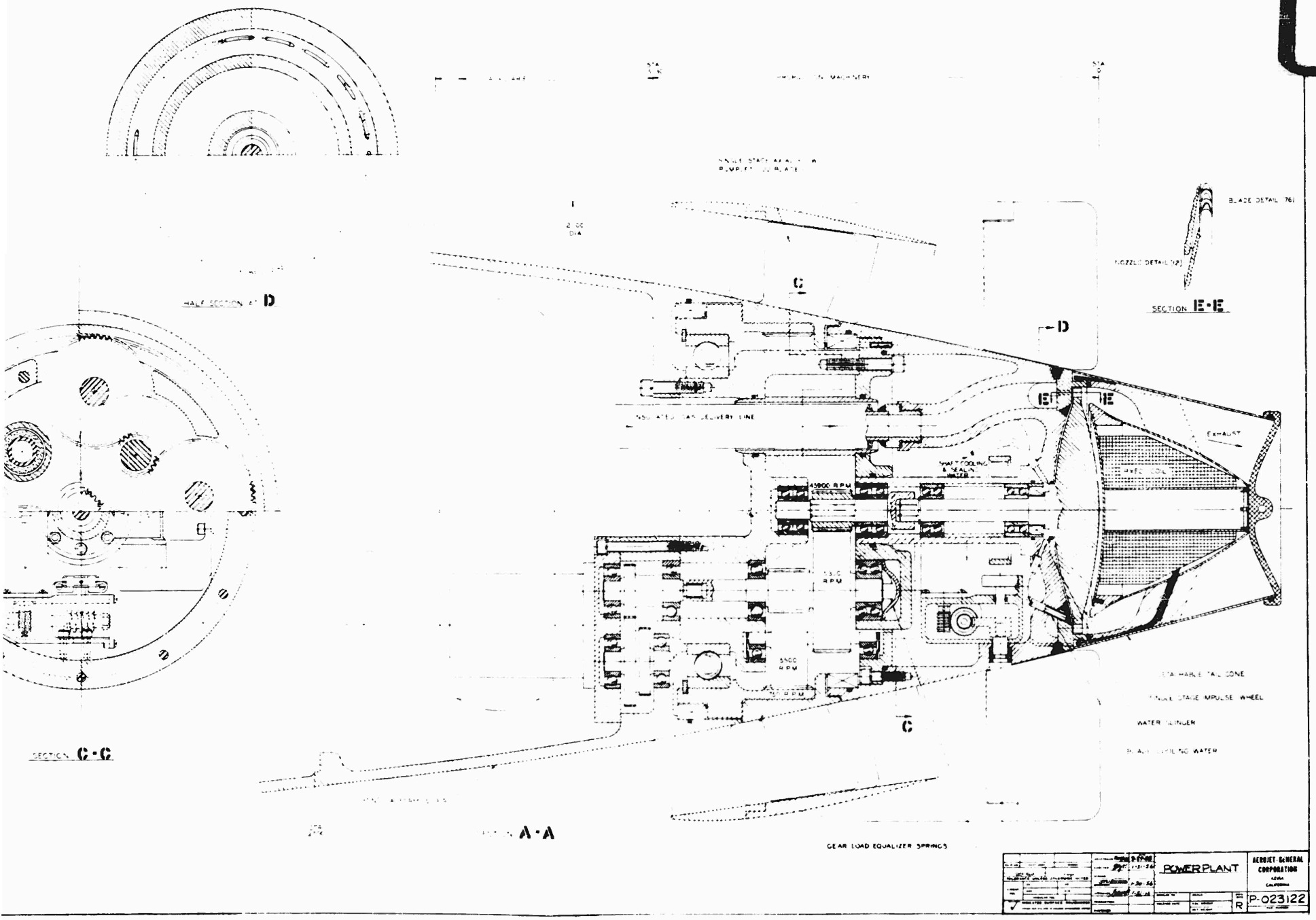
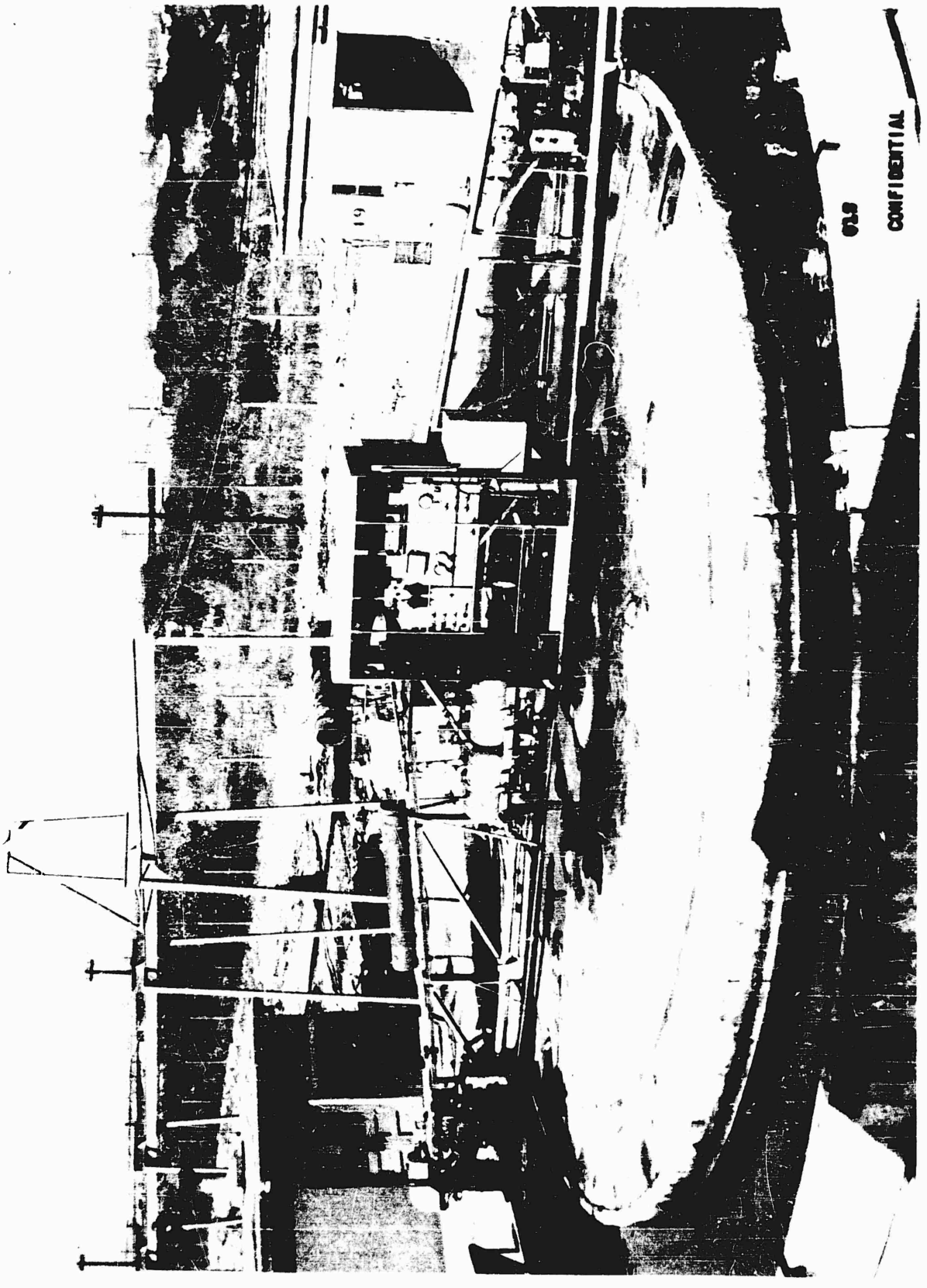
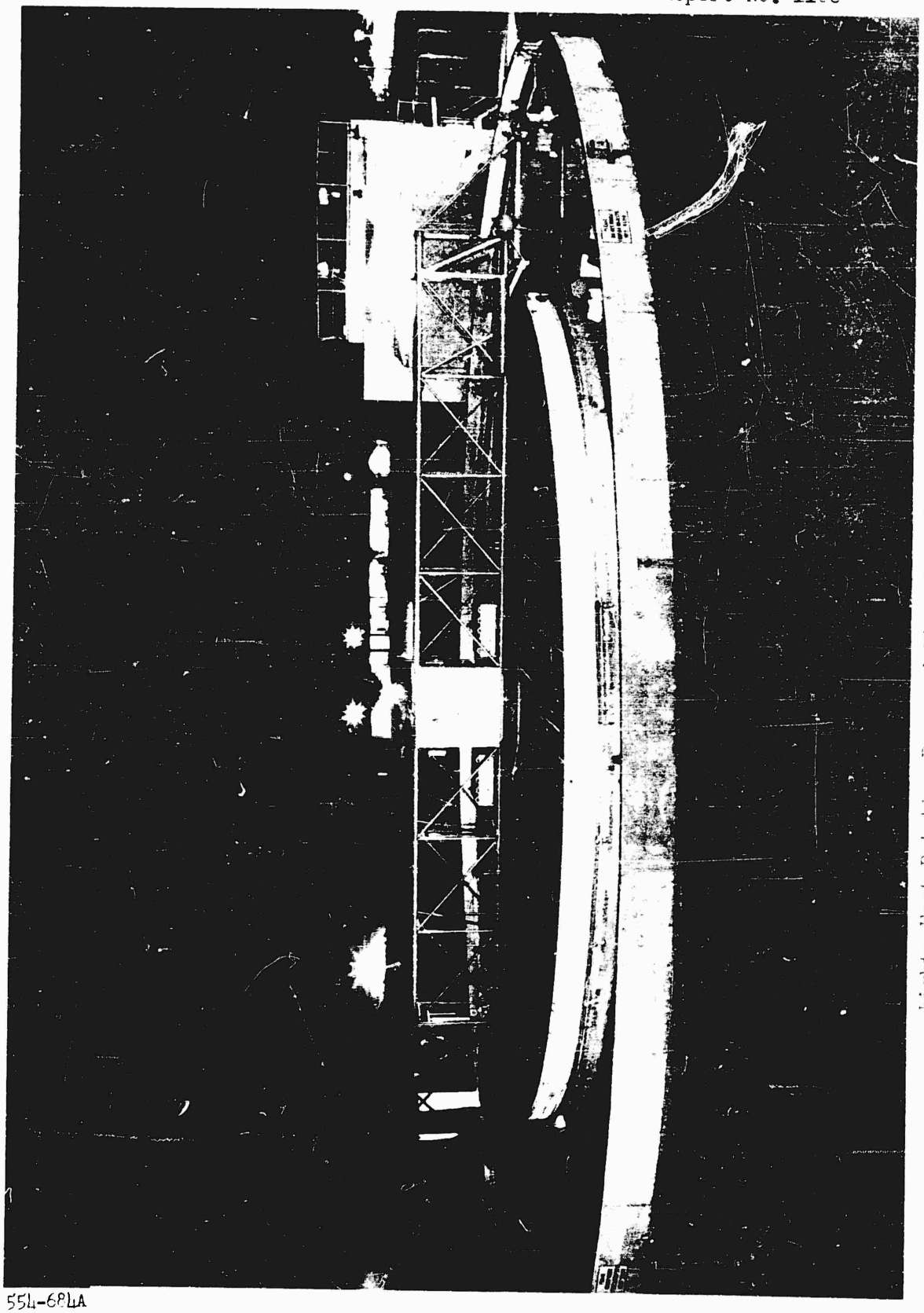


Figure 182

CONFIDENTIAL



Forty Foot Rotating Boom and Ring Channel



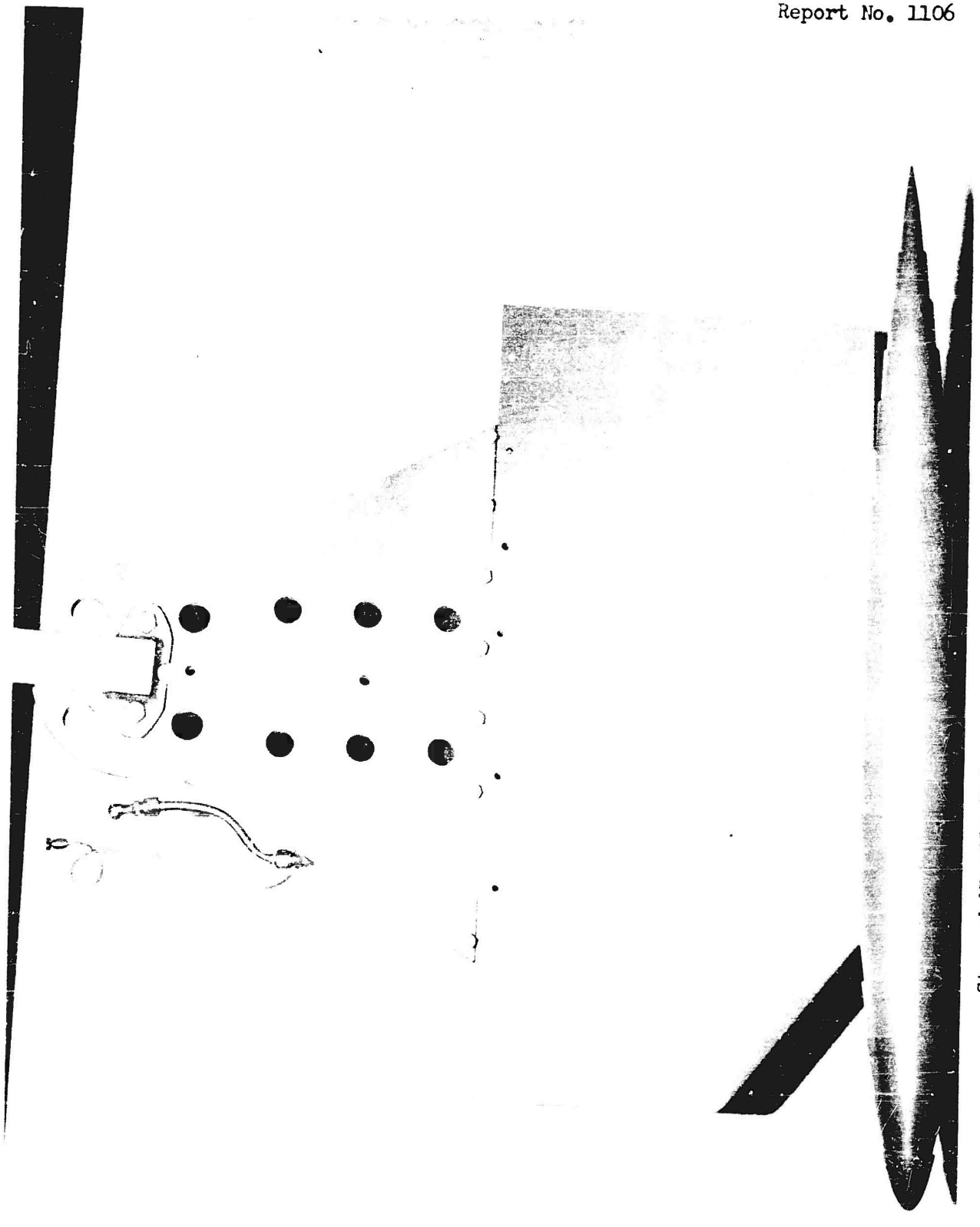
554-684A

Eighty Foot Rotating Boom and Ring Channel Facility

Figure 184

R0750-11

Underwater Missile Body with Stepped Profile



Stepped Missile Body Assembled on Mounting Strut

Figure 186

DRAG TEST

STEPPED MISSILE BODY

1. Stepped Body - Sucking Air
2. Stepped Body - Shut-Off
3. Smooth Body

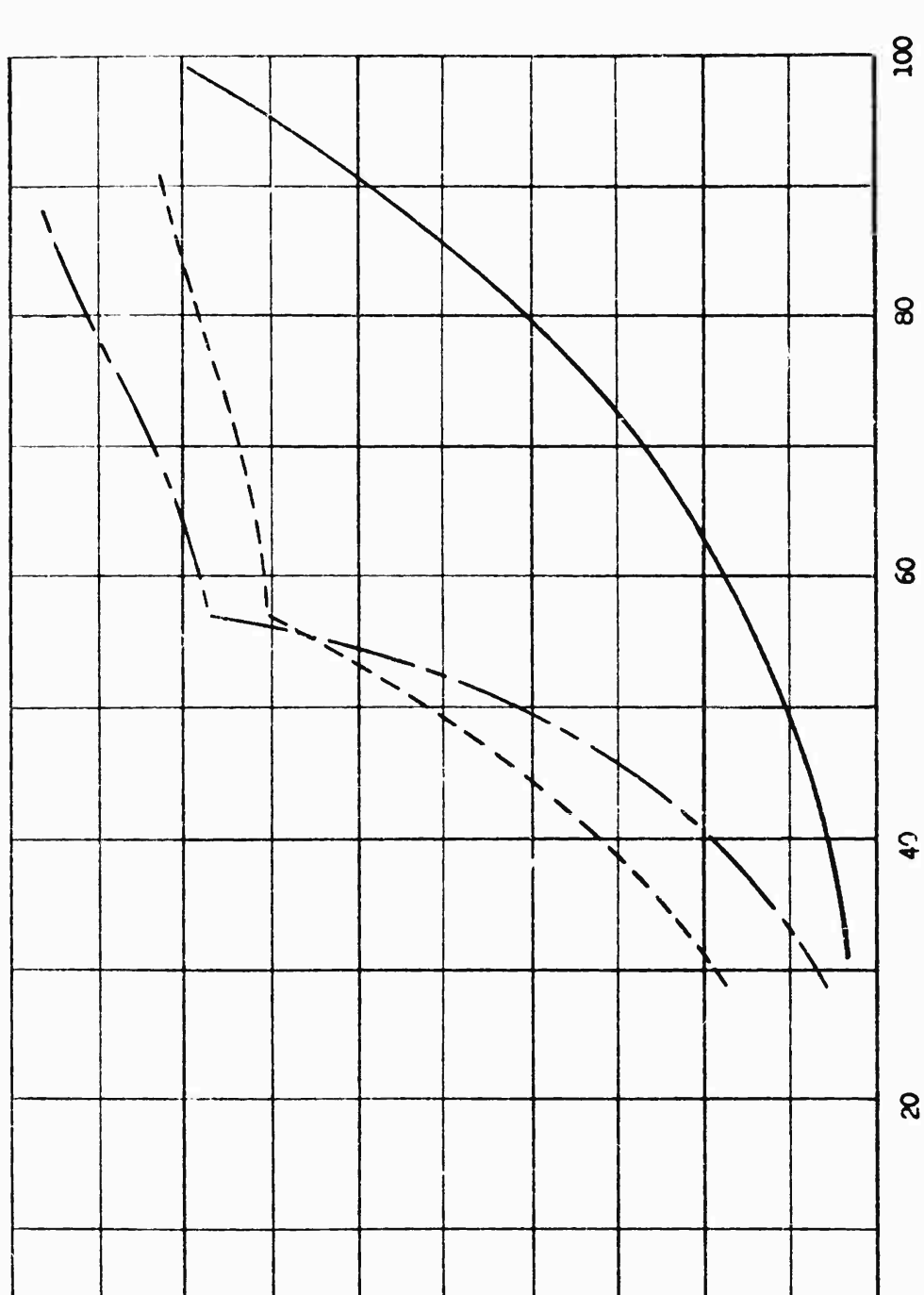
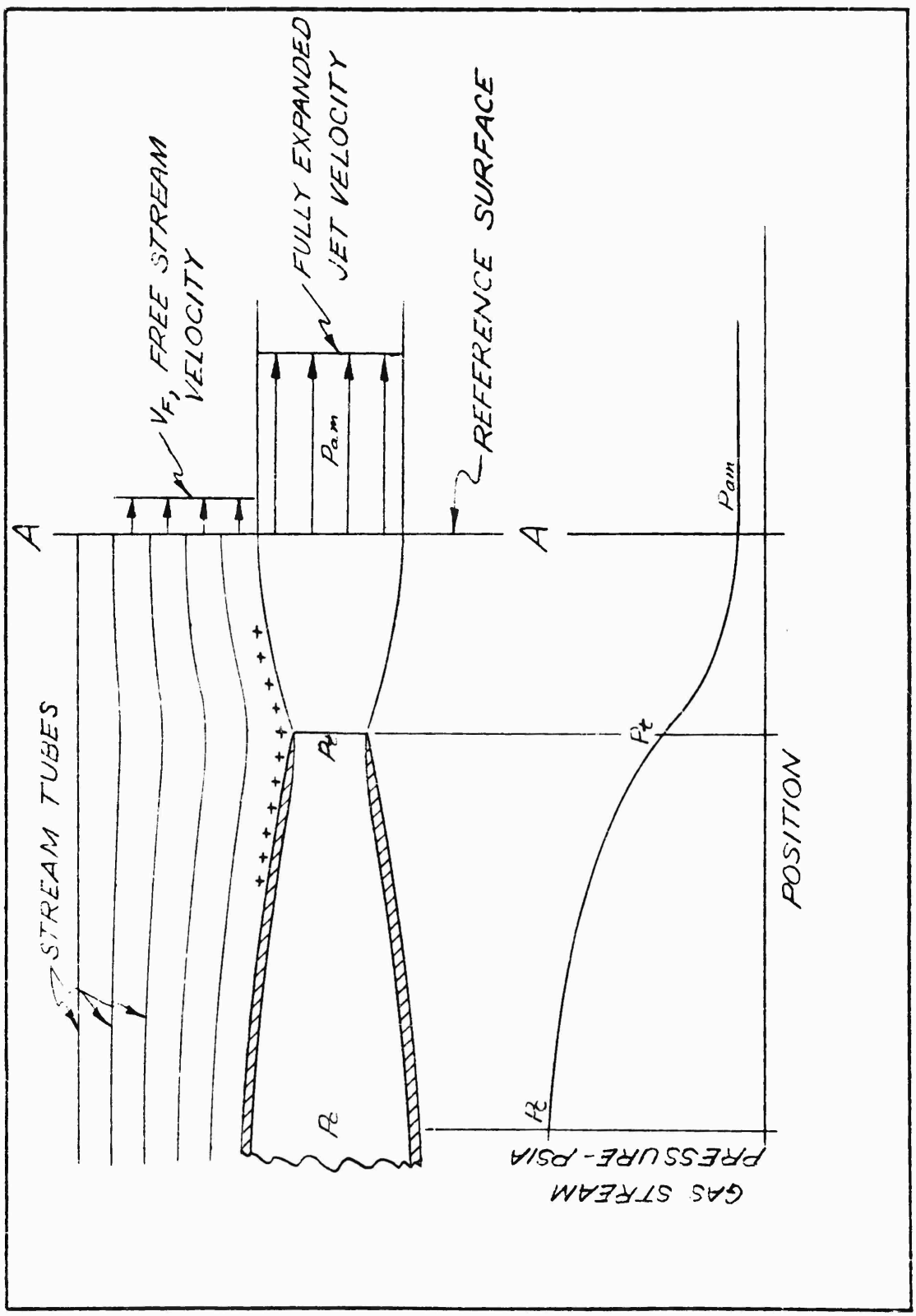


Figure 187



External Flow Confinement of Exhaust Jet Expanding from Critical Pressure

Figure 188

External Expansion of Hydroduct Exhaust from Critical-Pressure Nozzle