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AN AZIMUTH CURRENT METER TEST FIXTURE

by

S.D. Baird, T. Nugent, H. Savile

Inland Waters Directorate
Direction Générale des Eaux Intérieures

ES 551
Baird (1)
Savile (7)

Study 83-346

AN AZIMUTH CURRENT METER TEST FIXTURE

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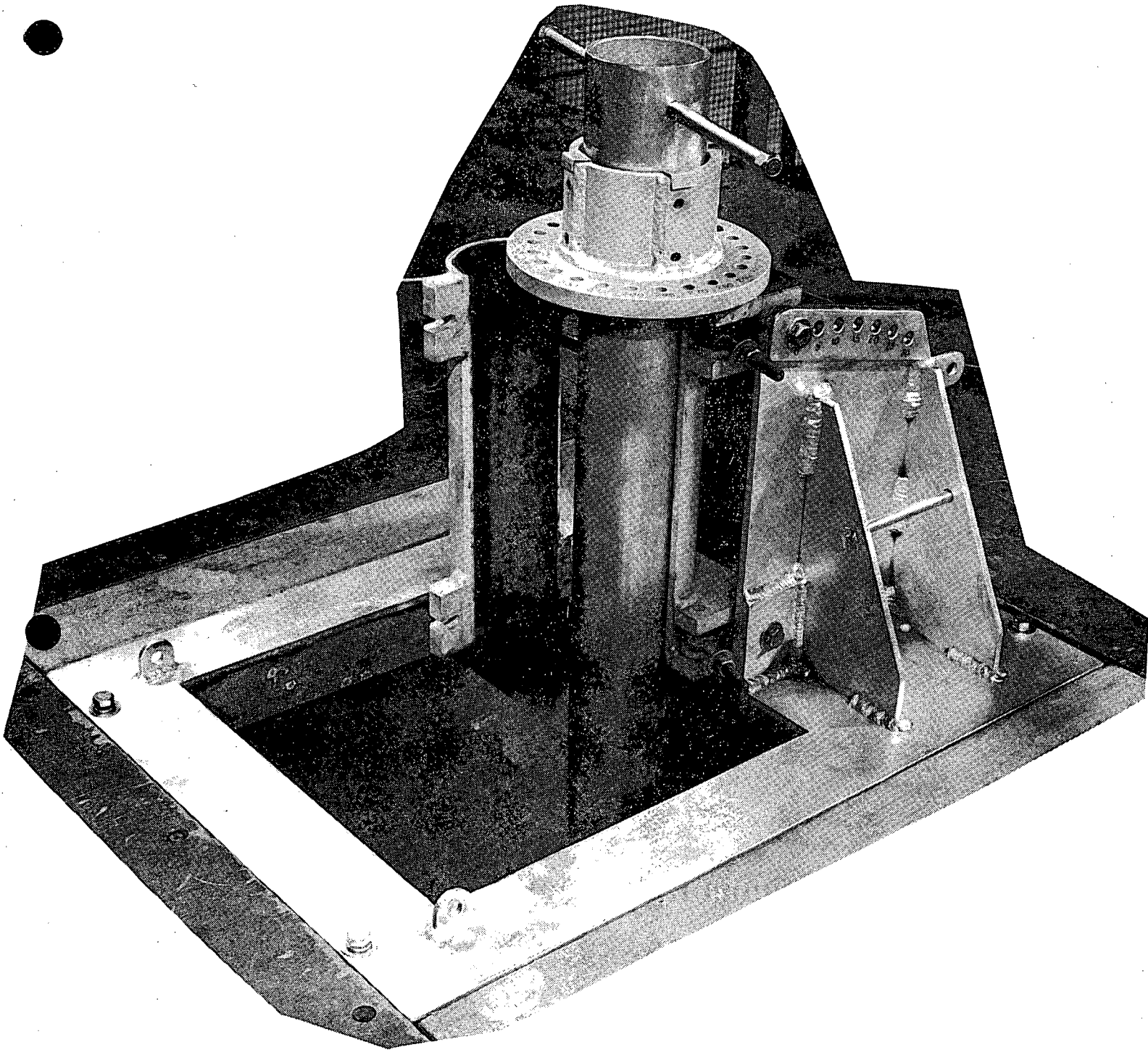
S.D. Baird, T. Nugent, H. Savile

Manufacturing and Technical Development Section
Hydraulics Division
National Water Research Institute

October 1983



AZIMUTHAL CURRENT METER TEST FIXTURE

ABSTRACT

An azimuthal inclinated adjustable current meter test frame has been designed and manufactured for the testing of various current sensing assemblies. The frame provides for azimuthal rotation of the current meter through a full 360° of current attack and may also be inclined through 30° of the flow direction. The frame therefore allows current meters to be tested for horizontal response to varying attack angle flows and further allows for the simulation of instrument drag characteristics by being adjustable in the inclinated axis.

RESUME

On a conçu et fabriqué un cadre d'essai azimutal, inclinable et réglable pour courantomètres afin de mettre à l'épreuve divers montages utilisés pour la mesure des courants. Le cadre permet de faire effectuer une rotation azimutale complète sur 360° aux courantomètres et peut également être incliné de 30° par rapport à la direction de l'écoulement. Il permet donc de vérifier la réponse horizontale des courantomètres à des écoulements suivants des angles d'attaque variables de l'écoulement et, de simuler les caractéristiques de traînée des instruments puisqu'il est réglable en inclinaison.

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1.0 INTRODUCTION

In continuation of the jointly sponsored DFO/DOT energy R&D program; Study No. 5122-604 Gyrocampass Unmanned Profiling Systems (G-UMPS), the Department of Fisheries and Oceans, Central Region, requested MANTEC to perform an analysis, design, and manufacture of a test fixture capable of providing a means to test the horizontal response characteristics of various current meters.

The horizontal response of current sensors is important to identify the capability of these sensors to accurately measure currents attacking the instruments at various attack angles in the horizontal plane. Similarly, it is important to know how this horizontal response reacts to having the instrument inclined as would normally happen on an embilical surface line and/or mooring line due to drag of the lines. The project was undertaken on a cost recovery basis for Mr. E.O. Lewis, Department of Fisheries and Oceans, under study no. 346/6.

2.0 DESIGN CRITERIA

The Current Meter Mounting Frame should meet the following requirements if it is to become a practical and reliable tool for use on the tow tank carriage.

1. It must be able to be mounted in the center hole of the tow tank carriage in order to provide easy access to the current meter.
2. The Mounting Tube must be capable of providing three hundred and sixty degrees of azimuth rotation in fifteen degree increments and inclination from zero to thirty degrees in five degree increments. This would simulate actual field conditions when the meter would be mounted on a cable mooring.
3. The Mounting Tube must have sufficient rigidity to prevent deflection at high speeds and unwanted oscillation due to vortex shedding.
4. The Mounting Tube must be adaptable to any type of meter. The first two meters to be used are the Marsh-McBirney Model 551 Spherical Sensor and the Neil brown Model 3331 3-Axis Acoustic Velocity Sensor.

5. The Current Meter Mounting Tube and Frame should be manufactured of a suitable, corrosion resistant material to withstand up to 250 hours immersion use per year in freshwater with a conductivity of <0.10 ms, for a period of 10 years.

3.0 DESIGN CONCEPT

Several basic designs were considered and after careful review and analysis, the following design concept was chosen.

The Mounting Frame and Tube were constructed of Aluminum 6061-T6. It is a medium strength aluminum structural alloy with good mechanical properties and fair corrosion resistance.

The Mounting Tube is made of 4-inch schedule 40 pipe. Appendix 2 contains calculations showing that this size results in acceptable stress levels at the maximum tow carriage speed. Appendix 3 contains calculations showing that the tow tank carriage is capable of being driven at speeds at which the vortex shedding frequency and natural frequencies intersect. Caution must be taken when towing current meters near these speeds. Figure 1 shows the critical speed ranges. It also must be noted that heavier current meters will reduce the natural frequency of the Mounting Tube assembly, and that non-symmetrical meters may cause unwanted oscillation.

The Mounting Tube has been constructed with an 'O' ring seal in the bottom flange face, which will prevent water from entering the mounting tube, thus enabling the testing of meters which do not have water resistant electrical connectors.

An anti-cavitation plate has been provided which is mounted below the surface of the water. This prevents the downrush of air from the free surface at higher speeds when separation of the boundary layer occurs on the trailing surface of the mounting tube.

Azimuth positioning is made possible with an indexing flange which is fastened to the top of the Mounting Tube. A series of holes in the flange at fifteen degree intervals can be lined up with an indexing pin on the mounting frame. Inclination is obtained by pivoting the pipe clamp

to the appropriate angle and inserting a bolt on each side of the mounting frame.

The Mounting Tube has been electrically insulated from the tow tank carriage by a rubber liner on the inside and top of the pipe clamp. This also helps to isolate the Mounting Tube from any mechanical vibrations which may be caused by tow carriage travel.

4.0 SET UP PROCEDURE

The Current Meter Mounting Frame and Tube has been designed for easy assembly and disassembly. The mounting frame is provided with lifting lugs and bridle slings to be used with the overhead crawl beam crane. The mounting tube is also provided with a nylon sling on one end.

The following is a general procedure for setting up the Current Meter Mounting Frame and Tube.

a) Remove the center floor panel on the tow tank carriage.
b) Lift the Mounting Frame onto the carriage with the overhead crane, and lower it into position as shown in the General Arrangement Drawing (Appendix 4). After lining up the bolt holes, fasten the frame to the tow tank carriage with four half-inch UNC bolts, complete with lock and flat-washers. Cover the remaining portions of the center hole with the precut pieces of three quarter inch thick plywood.
c) Tilt the pipe clamp to the zero inclination position and open the pipe clamp.
d) Install the current meter on the end of the Mounting Tube, using 'O' rings and the appropriate adapting flange. The dotted line running the length of the pipe is aligned with the zero azimuth position. This dotted line should correspond to a reference point on the current meter.
e) After installing an appropriate protection device on the current meter sensor, lift the Mounting Tube and current meter onto the carriage with the overhead crane.

f) Once the meter has been lowered through the opening in the Mounting Frame, remove the sensor protection device.

g) Lower the Mounting Tube until the indexing flange is resting on the top of the pipe clamp and the indexing pin is engaged in the flange. Close the pipe clamp and tighten the nuts on the carriage bolts.

The current meter will be ready for towing after the electrical connections between the meter and the data collecting systems have been made.

5.0 CONCLUSIONS

An acceptable design for the Current Meter Mounting Frame and Tube has been developed. The design meets all the design criteria requirements. Detailed fabrication drawings were made and the fixture was manufactured in the MANTEC Machine Shop.

The Frame and Mounting Tube have been tested successfully on the tow tank using both the Marsh-McBirney Model 551 and the Neil Brown Model 3331 velocity sensors.

6.0 RECOMMENDATIONS

Care must be taken when first towing a new meter in order to observe its hydrodynamic behaviour at speeds where the natural and vortex shedding frequencies coincide.

A protection device should always be installed on a current meter sensor to prevent damage during assembly and disassembly.

7.0 REFERENCES

Martin, G.H. Kinematics and Dynamics of Machines, McGraw-Hull Book Company, Toronto, 1982.

McCormick, M.E. Ocean Engineering Wave Mechanics, John Wiley and Sons, Toronto, 1973.

Shigley, J.E. Mechanical Engineering Design, McGaw-Hill Book Company, Toronto, 1977.

Streeter, V.L. and Wylie, E.B., Fluid Mechanis, McGraw-Hill Book Company, Toronto, 1981.

APPENDIX 1

Flow Drag Calculations

APPENDIX 1

Drag forces are proportional to the square of the velocity, therefore, all the drag force calculations are for the maximum tow tank carriage velocity.

Water Temperature 18°C

ρ	=	density of water	998.74 kg/m^3
μ	=	viscosity	1.06 x 10^{-3} Pa•s
U	=	velocity	6.0 m/s
D	=	pipe diameter	0.114 m

Reynolds Number Calculation

$$Re = \frac{UD\rho}{\mu} \qquad (1.1a)$$

$$Re = 6.44 \times 10^5 \qquad (1.1b)$$

The drag coefficient for a circular cylinder having a Reynolds number between 10^4 and 1.5×10^5 is C_D equal to 1.2

Drag Force Calculation

$$F_D = C_D \rho \frac{U^2}{2} \qquad (1.2a)$$

$$F_D = 2459.3 \text{ N/m of length} \qquad (1.2b)$$

The drag force is 2459.3 N for each meter of submerged pipe at 6 m/s.

APPENDIX 2

Stress and Deflection Calculations for the Mounting Tube

APPENDIX 2

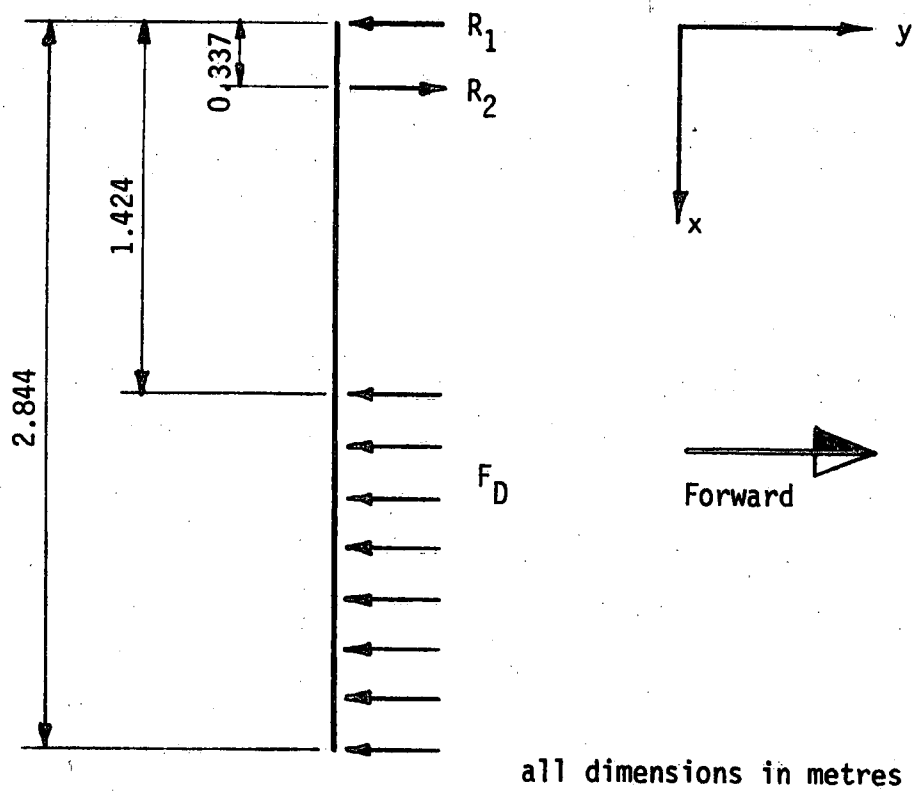
Material Specifications:

Aluminum 6061-T6	
S_u Tensile Strength	303.4 MPa
S_y Yield Strength	282.7 MPa
E Modulus of Elasticity	68.9 GPa

Pipe Specifications:

Nominal 4 inch Schedule 40	
O.D. - Outside diameter	0.114 m
I.D. - Inside diameter	0.102 m
I - Moment of inertia	$3.01 \times 10^{-6} m^4$

Loading Diagram:



all dimensions in metres

The sum of the forces in the y direction equals zero.

$$R_1 + 1.420\ F_D - R_2 = 0 \qquad (2.1)$$

The sum of the moments about R_1 equals zero.

$$0.337\ R_2 - 1.420\ F_D \left(\frac{1.420}{2} + 1.424\right) = 0 \qquad (2.2a)$$

$$R_2 = 8.99\ F_D \qquad (2.2b)$$

From Equation (2.2b) and Appendix 1, the value of R_2 is 22113.85 N.
From Equation (2.1), the value of R_1 is 18621.64 N
The following calculations are based on singularity functions.

Loading Function:

$$q = -R_1 \langle x\rangle^{-1} + R_2 \langle x - .337\rangle^{-1} - F_D \langle x - 1.424.\rangle^{0} \qquad (2.3)$$

Shear Force:

$$V = -R_1\langle x\rangle^{0} + R_2 \langle x - .337\rangle^{0} - F_D \langle x - 1.424\rangle^{1} \qquad (2.4)$$

Bending Moment:

$$M = -R_1\langle x\rangle^{1} + R_2 \langle x - .337\rangle^{1} - \frac{F_D}{2} \langle x - 1.424\rangle^{2} \qquad (2.5)$$

Slope:

$$\frac{dy}{dx} = \frac{1}{EI}\left[\frac{-R_1}{2}\langle x\rangle^{2} + \frac{R_2}{2}\langle x - .337\rangle^{2} - \frac{F_D}{6}\langle x - 1.429\rangle^{3}\right] \qquad (2.6)$$

Deflection:

$$y = \frac{1}{EI}\left[\frac{-R_1}{6}\langle x\rangle^3 + \frac{R_2}{6}\langle x - .337\rangle^3 - \frac{F_D}{24}\langle x - 1.424\rangle^4\right] \quad (2.7)$$

The maximum Bending Moment occurs at x = 0.337.
From Equation (2.5), the Bending Moment is 6275.5 N•m.

Bending Stress Calculation:

$$\sigma = \frac{My}{I} \quad (2.8a)$$

$$\sigma = \frac{6275.5 \times .057}{3.01 \times 10^{-6}} \frac{N \cdot m \cdot m}{m^4} \quad (2.8b)$$

$$\sigma = 118.84 \text{ MPa} \quad (2.8c)$$

The maximum Bending Stress is 118.84 MPa.

Factor of Safety Calculation:

$$F.S. = \frac{Sy}{\sigma} \quad (2.9a)$$

$$F.S. = 282.7 \text{ MPa} \quad (2.9b)$$

$$F.S. = 2.4 \quad (2.9c)$$

The factor of safety is 2.4 for the Mounting Tube.

The maximum deflection occurs at x = 2.844 m. From Equation (2.7) the maximum deflection is 0.06 m. This defleciton would result in a maximum inclination error of 1.4 degrees at maximum speed.

APPENDIX 3

Natural and Vortex Shedding Frequency Calculations
for the Mounting Tube

APPENDIX 3

The natural frequency of a cantilevered structure is given by the following equaton:

$$f_i = \frac{a_i}{2\pi} \left[\frac{EI}{(m + m_w)L^3} \right]^{1/2} \qquad (3.1)$$

E = Young's Modulus 68.9 GPa
I = moment of inertia 3.01×10^{-6} m^4
L = length of pipe 2.844 m
m = mass of pipe 12.75 kg
m_w = added mass of the water 14.48 kg
a_i = modal coefficient has values of 3.52, 22.4, and 61.7 for the first three modes respectively.

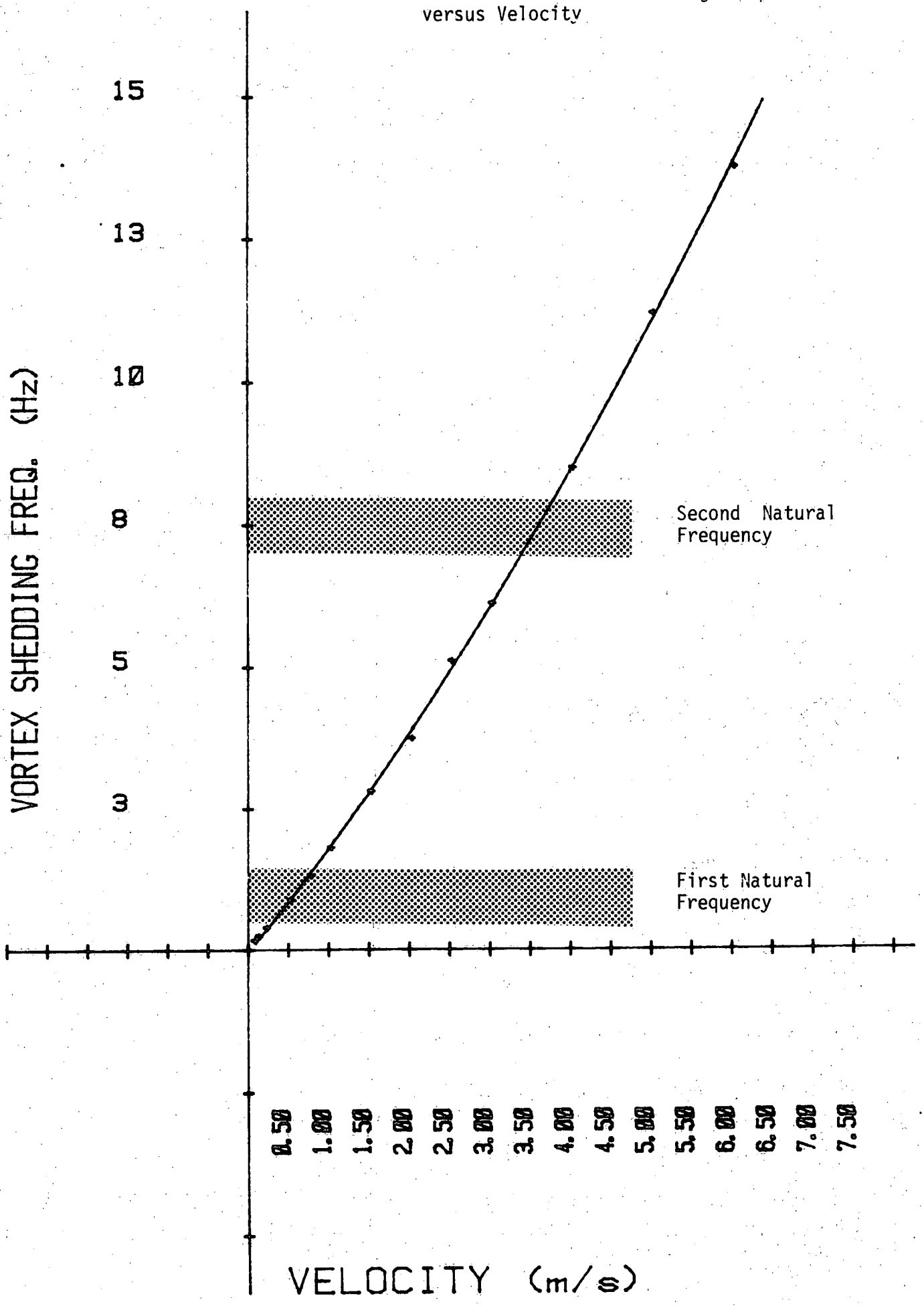
From Equation (3.1), the first three natural frequencies occur at 1.2 Hz, 7.7 Hz, and 21.3 Hz respectively. However, the additional mass of a current meter on the end of the Mounting Tube will decrease the natural frequencies because the mass terms are in the denominator of Equation (3.1).

The vortices shed in the wake of a circular pipe occur at a frequency of f_r which is a function of both the velocity U and the pipe diameter D. This data is represented by the Strouhal Number S, in the following equation.

$$S = \frac{f_r D}{U} \qquad (3.2)$$

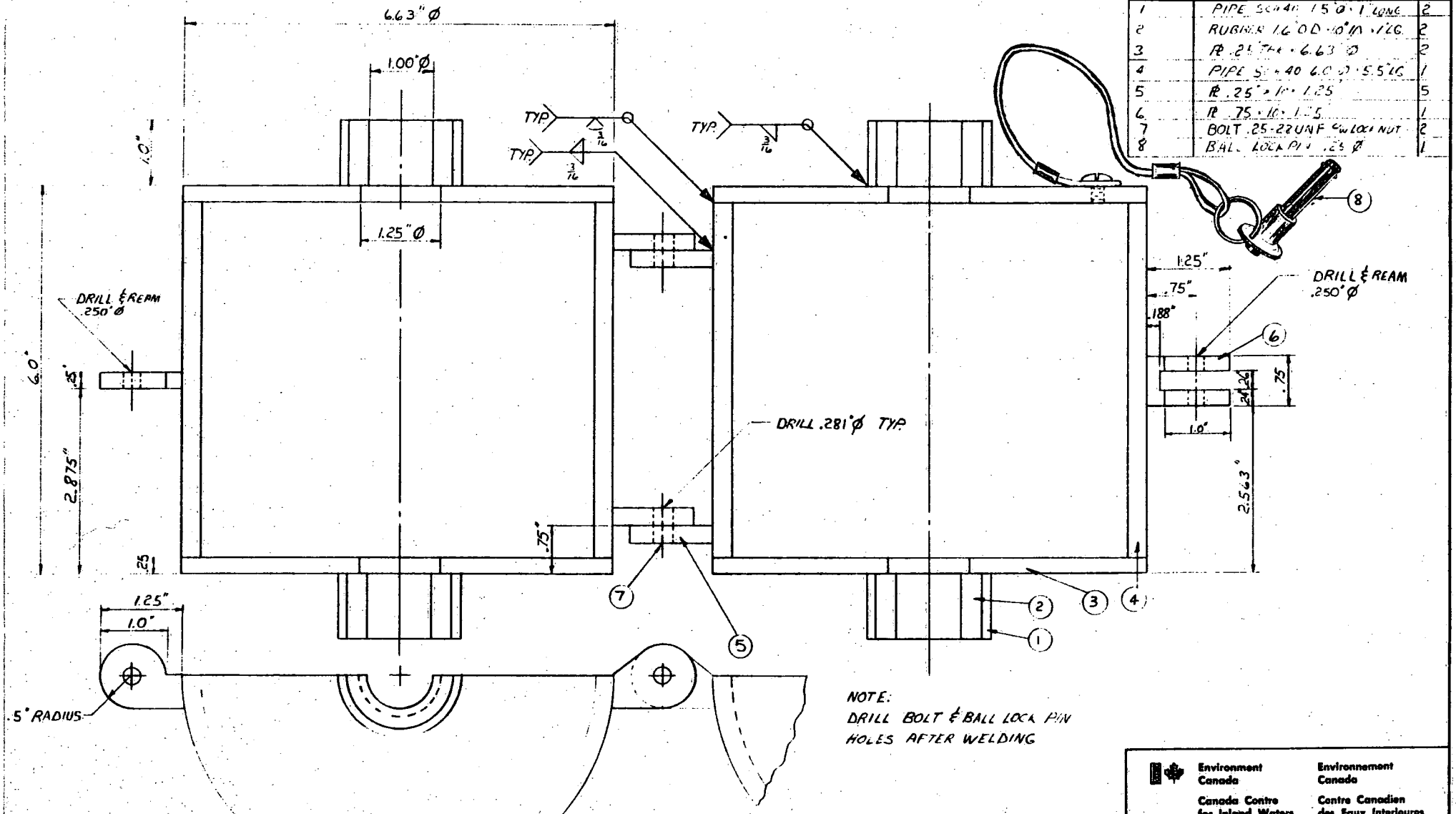
The Reynolds Number was calculated for several velocities in the range of 0 to 6 m/s. Using data presented by Fung (1960), the Strouhal number was obtained and the corresponding vortex shedding frequencies were calculated using Equation (3.2). These results are shown in Figure 1.

FIGURE 1. Natural and Vortex Shedding Frequencies versus Velocity



APPENDIX 4

Detailed Fabrication Drawings



NOTE:
DRILL BOLT & BALL LOCK PIN HOLES AFTER WELDING

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	PIPE SCH 40 1.5" Ø · 1" LONG	2
2	RUBBER 1.6 OD · 10" IN · 1/2 G	2
3	R .25" THK · 6.63" Ø	2
4	PIPE SCH 40 6.0" Ø · 5.5" LG	1
5	R .25" × 1" · 1.25	5
6	R .75 · 1.0 · 1.5	1
7	BOLT .25-22UNF C/W LOCK NUT	2
8	BALL LOCK PIN .25 Ø	1

NO	DATE	DESCRIPTION	DRWN. BY	APPD. BY
		REVISION		

UNLESS OTHERWISE SPECIFIED
TOLERANCE ON THREE PLACE DIMENSIONS ..... ±.001"
TOLERANCE ON TWO PLACE DIMENSIONS ..... ±.01"
TOLERANCE ON ANGLES ..... ±
EXTERNAL CORNER CHAMFER ..... .015 - .025
INTERNAL CORNER RADIUS ..... .010 - .020
SURFACE FINISH ..... AA MICRO INS.

MATERIAL SPECIFICATIONS
ALUMINUM 6061-T6

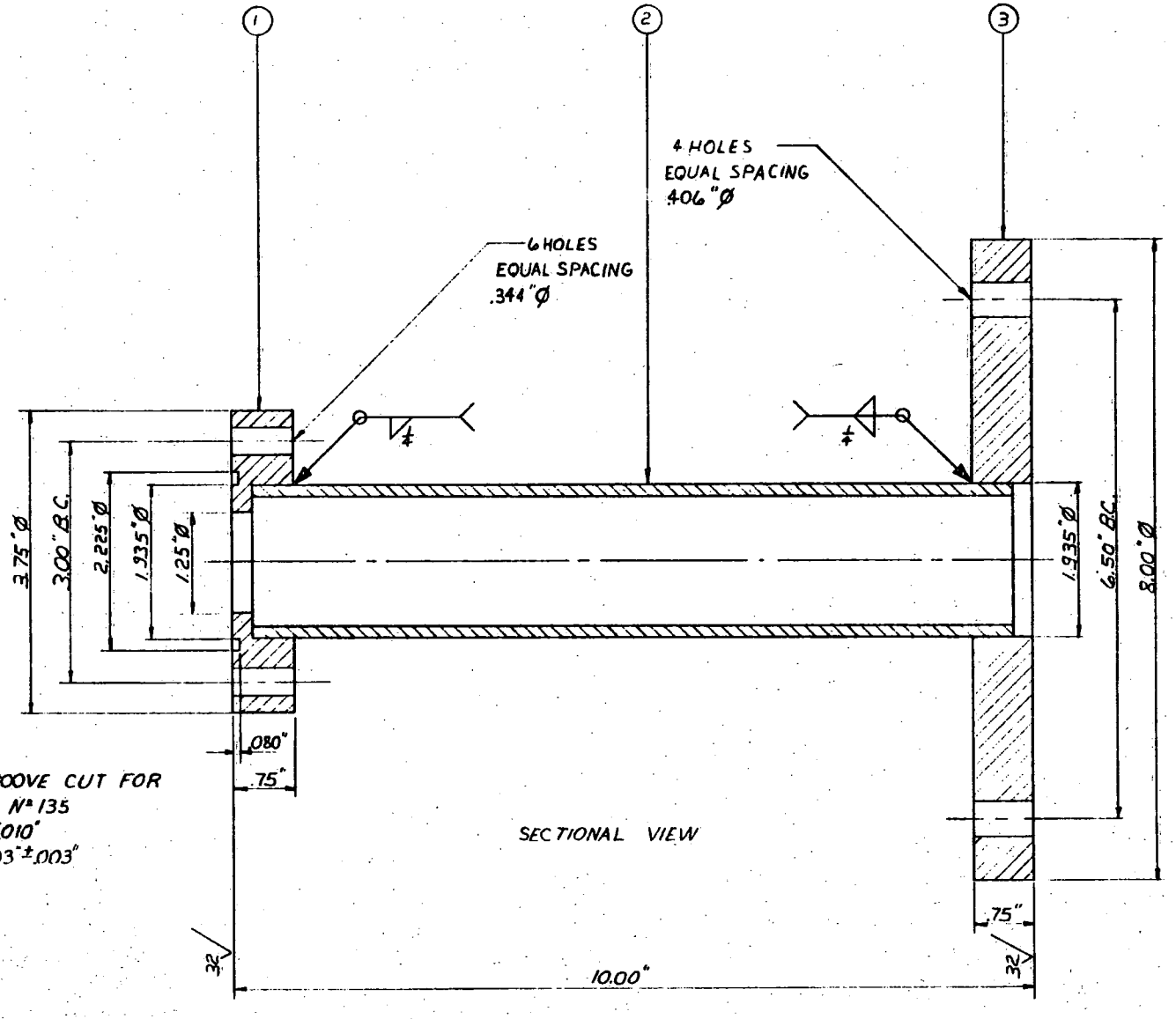
Environment Canada / Canada Centre for Inland Waters
Environnement Canada / Centre Canadien des Eaux Intérieures

TITLE
TOW TANK METER MOUNT
MARSH-McBIRNEY METER CARBON HEAD PROTECTOR

DESIGNED BY T.NUGENT	CHECKED BY SDB	APPROVED BY
DRAWN BY T.NUGENT	CHECKED BY	DRAWING NO. ME5190 3
SCALE FULL	DATE JUNE 23/83	SHEET 1 OF

APP.4-1

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	R .75" THK. x 3.75" Ø	1
2	PIPE SCH 40 1.5" Ø x 9.50"	1
3	R .75" THK x 8.00 Ø	1



SECTIONAL VIEW

'O'-RING GROOVE CUT FOR
PRECISION Nº 135
I.D. 1.925" ±.010"
WIDTH 0.103" ±.003"

NOTE:
MACHINE FLANGE FACES PARALLEL TO EACH OTHER & PERPENDICULAR TO PIPE CENTERLINE

NO.	DATE	DESCRIPTION REVISION	DRWN. BY	APPD. BY

UNLESS OTHERWISE SPECIFIED

TOLERANCE ON THREE PLACE DIMENSIONS	±.001"
TOLERANCE ON TWO PLACE DIMENSIONS	±.01"
TOLERANCE ON ANGLES	±
EXTERNAL CORNER CHAMFER	.018 - .025
INTERNAL CORNER RADIUS	.010 - .020
SURFACE FINISH	AA MICRO INS.

MATERIAL SPECIFICATIONS
ALUMINUM 6061-T6

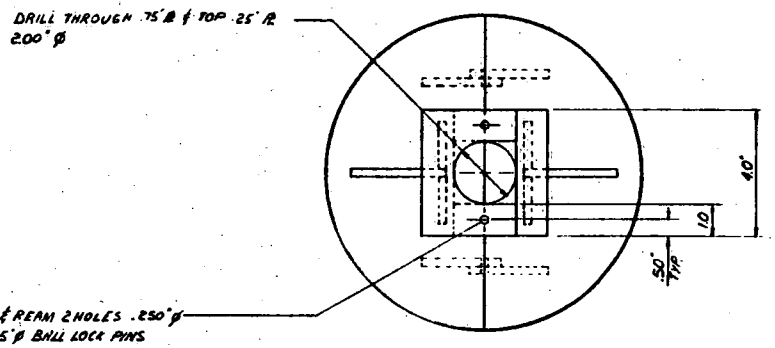
Environment Canada / Environnement Canada
Canada Centre for Inland Waters / Centre Canadien des Eaux Intérieures

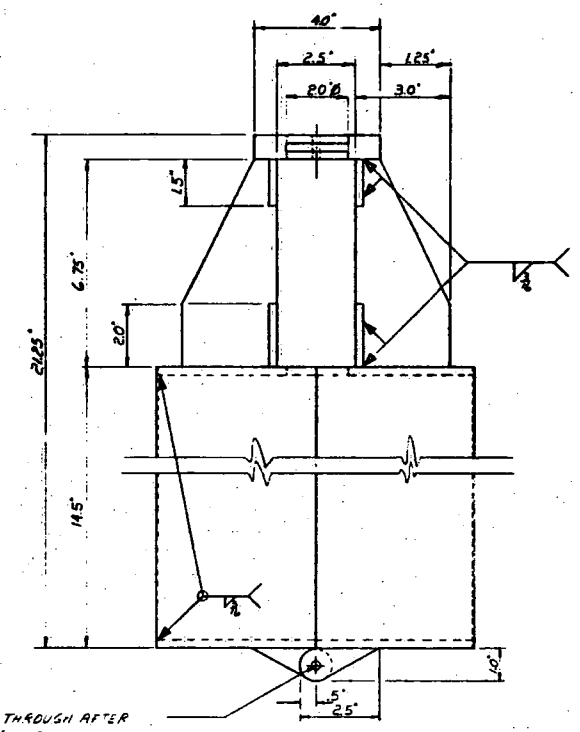
TITLE
TOW TANK METER MOUNT
ADAPTER SPOOL FOR NEIL BROWN CURRENT METER

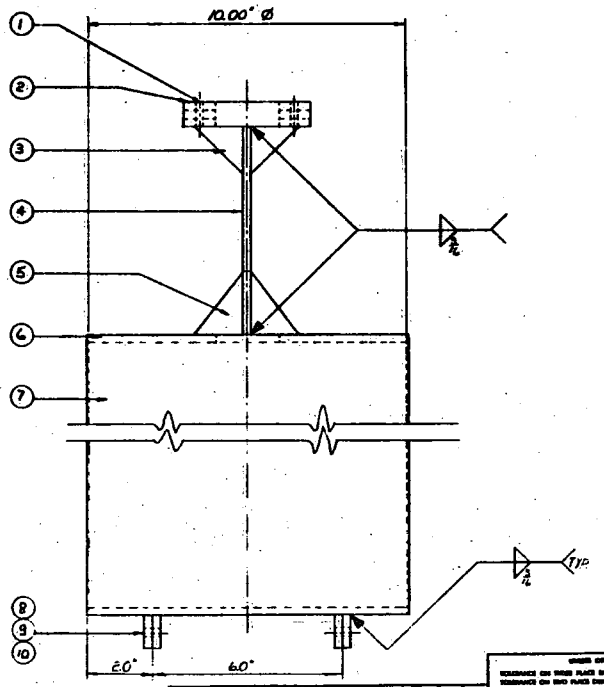
DESIGNED BY T.NUGENT	CHECKED BY SDB	APPROVED BY
DRAWN BY T.NUGENT	CHECKED BY	DRAWING NO. ME 5190-10
SCALE FULL	DATE JUNE 2283	SHEET 1 OF 1

APP. 4-2

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	.25Ø BALL LOCK PIN	2
2	R .75 THK · 3.0 · 4.0	2
3	R .25 THK · 1.5 · 1.5	4
4	R .25 THK · 3.0 · 4.75	2
5	R .25 THK · 2.0 · 3.0	4
6	R .25 THK · 10.00 Ø	2
7	R .063 THK · 14.5 · 31.5	1
8	R .25 THK · 1.0 · 2.5	4
9	BOLT .25-28 UNF · .75	2
10	LOCKNUT .25-28 UNF	2







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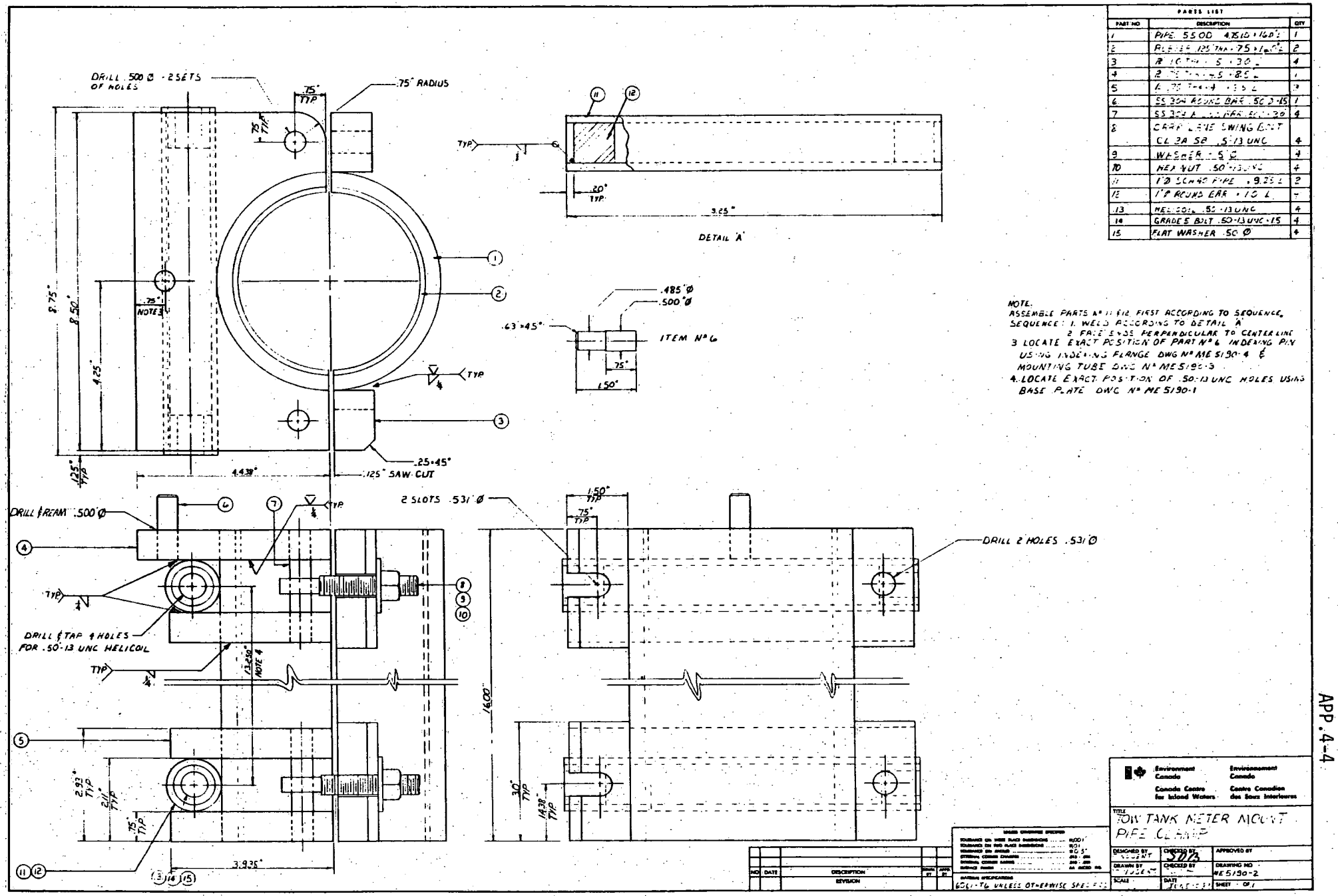
TITLE
TOW TANK METER MOUNT
NEIL BROWN CURRENT METER
BASE PROTOTYPE

DESIGNED BY T.NUGENT	CHECKED BY	APPROVED BY
DRAWN BY T.NUGENT	CHECKED BY	DRAWING NO. ME 5190-12
SCALE	DATE JULY 21	SHEET OF

NO.	DATE	DESCRIPTION REVISION	CHKD BY	APPD BY

UNLESS OTHERWISE SPECIFIED
TOLERANCE ON THREE PLACE DIMENSIONS ±.005
TOLERANCE ON TWO PLACE DIMENSIONS ±.01
TOLERANCE ON ANGLES ±1°
MATERIAL CORNER BREAKS .005 - .020
MATERIAL CORNER RADII .005 - .020
SURFACE FINISH 63 ARCHD. MIL
MATERIAL SPECIFICATIONS
ALUMINUM 6061-T6

APP. 4-3



PARTS LIST		
PART NO	DESCRIPTION	QTY
1	PIPE 5.500 O.D. x .125 W.T. x 16.00" LG	1
2	PLATE .125 THK x 7.5 x 16.00"	2
3	PLATE .125 THK x 5 x 3.0"	1
4	PLATE .125 THK x 5 x 8.5"	1
5	PLATE .125 THK x 4 x 5.5"	2
6	SS 304 ROUND BAR .50 Ø x 4.5"	1
7	SS 304 ANGLE BAR 2" x 2" x .250 x 3.0"	4
8	CARR LANE SWING BOLT CL 2A 5B .5-13 UNC	4
9	WASHER .5"	4
10	HEX NUT .50"-13 UNC	4
11	1" ID SCH 40 PIPE x 9.25" LG	2
12	1" ID ROUND BAR x 1.0" LG	2
13	HELICOIL .50-13 UNC	4
14	GRADE 5 BOLT .50-13 UNC-1.5	4
15	FLAT WASHER .50 Ø	4

NO.	DATE	DESCRIPTION REVISION	DRAWN BY	APPD BY

UNLESS OTHERWISE SPECIFIED
TOLERANCE ON WHERE PLACE DIMENSIONS ..... ±0.01"
TOLERANCE ON PLACE ELEVE DIMENSIONS ..... ±0.1
TOLERANCED DIM. ANGLES ..... ±0.5°
EXTERNAL CORNER CHAMFER ..... .25 x 45°
INTERNAL CORNER RADIUS ..... .250" MAX
SURFACE FINISH ..... 63 MICRO INS
MATERIAL SPECIFICATIONS
6061-T6 UNLESS OTHERWISE SPECIFIED

Environment Canada / Canada Centre for Inland Waters
Environnement Canada / Centre Canadien des Eaux Intérieures

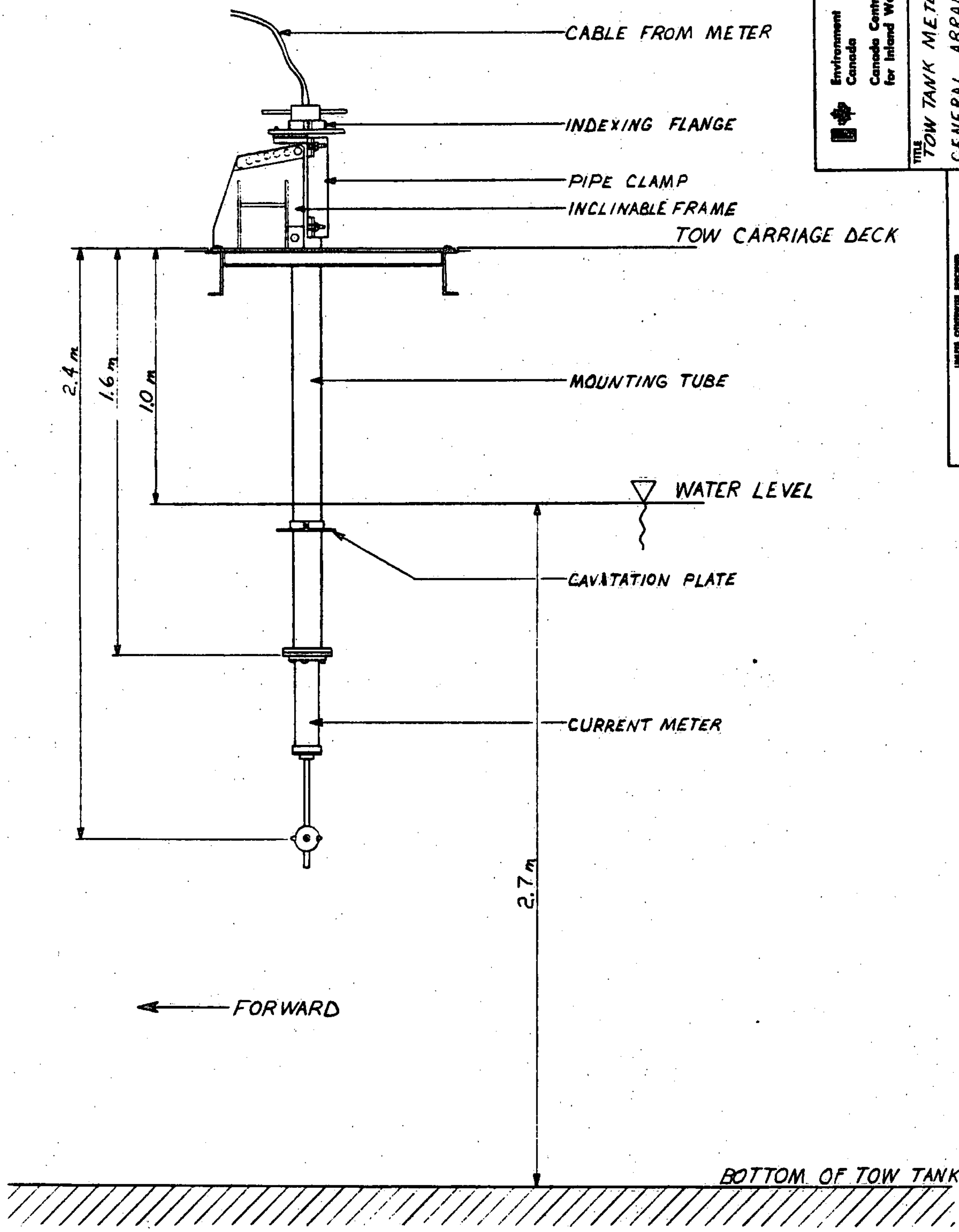
TITLE: TOW TANK METER MOUNT PIPE CLAMP

DESIGNED BY: [illegible]	CHECKED BY: SDB	APPROVED BY:	
DRAWN BY: [illegible]	CHECKED BY:	DRAWING NO: ME 5/90-2	
SCALE:	DATE: [illegible]	SHEET: OF 1	

APP. 4-4

PARTS LIST

PART NO.	DESCRIPTION	QTY.



Environment Canada — Environnement Canada
Canada Centre for Inland Waters — Centre Canadien des Eaux Intérieures

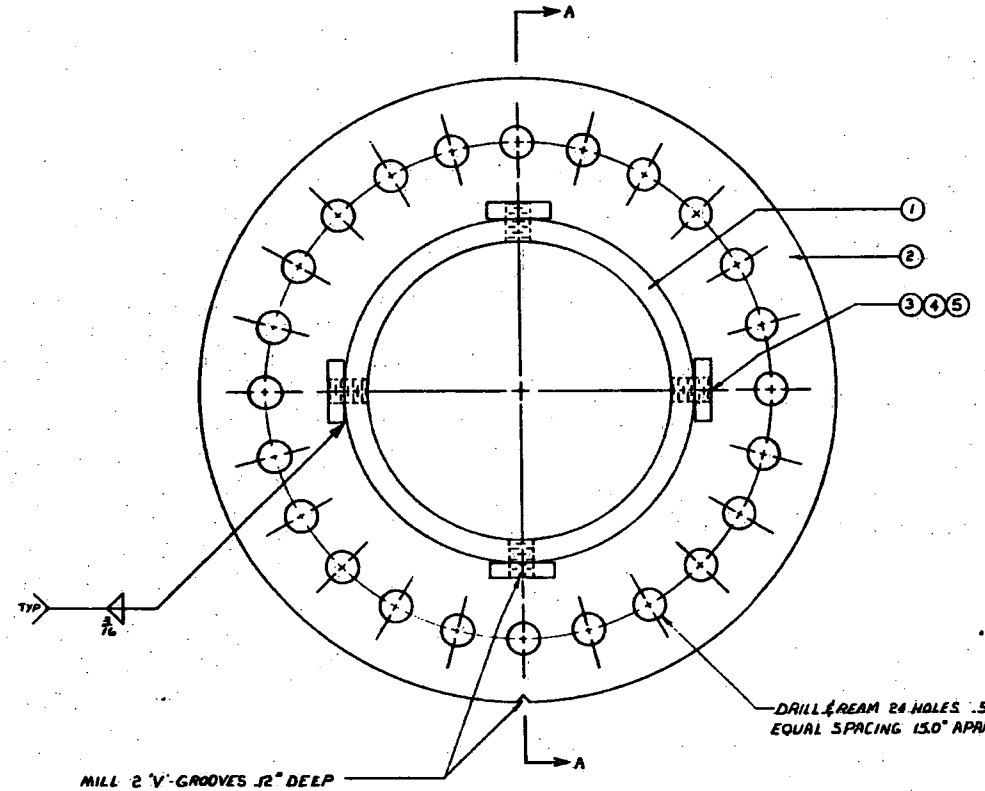
TITLE: TOW TANK METER MOUNT GENERAL ARRANGEMENT

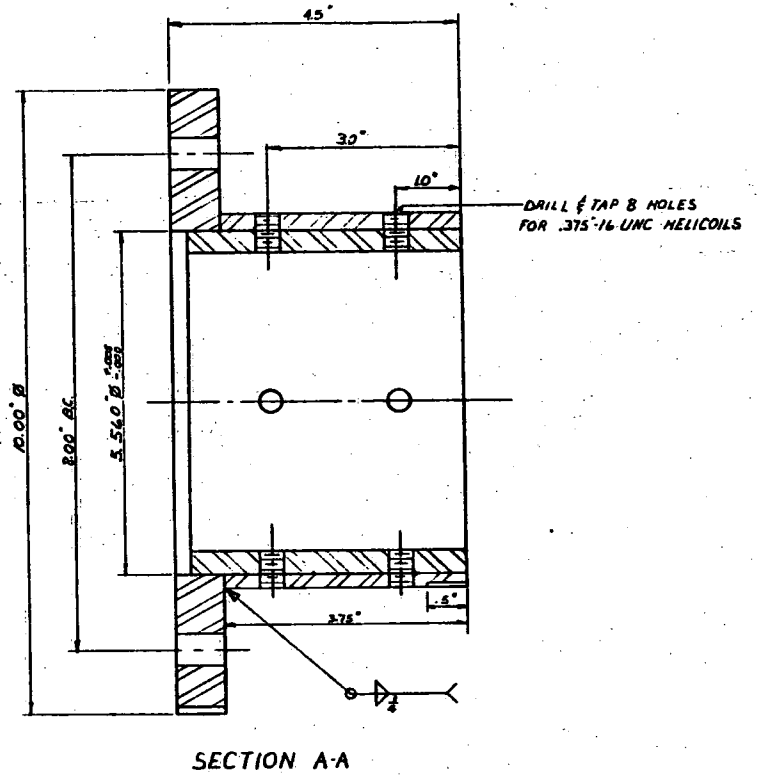
DESIGNED BY	CHECKED BY	APPROVED BY
T. NUGENT	SDB	
DRAWN BY	CHECKED BY	DRAWING NO.
T. NUGENT	[illegible]	ME 5190-13
SCALE	DATE	SHEET
	22-08-83	1 OF 1

UNLESS OTHERWISE SPECIFIED
TOLERANCE ON THREE PLACE DIMENSIONS ±
TOLERANCE ON TWO PLACE DIMENSIONS ±
TOLERANCE ON ANGLES ±
EXTERNAL CORNER CHAMFER .015 - .025
INTERNAL CORNER RADIUS .010 - .020
SURFACE FINISH AA MICRO IN.
MATERIAL SPECIFICATIONS

NO.	DATE	DESCRIPTION	DRWN. BY	APPD. BY
		REVISION		

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	PIPE 5.5 O.D. · 4.75 I.D. · .185" t	1
2	FL .75 THK · 10.0" Ø	1
3	HELICOIL · .375-16 UNC	8
4	SOCKET HEAD SET SCREW .375-16 UNC · .75 LONG	8
5	BAR .25" · I.D. · 3.75"	4





SECTION A-A

NO.	DATE	DESCRIPTION REVISION	DRN BY	APP'D BY

UNLESS OTHERWISE SPECIFIED
TOLERANCES ON WHOLE INCH DIMENSIONS ± .01"
TOLERANCES ON FRACTIONAL DIMENSIONS ± 1/64"
TOLERANCES ON ANGLES ± 0.5°
GENERAL EDGES BROKEN .015 - .035
GENERAL RADII .015 - .035
MATERIAL SPECIFICATIONS 6061-T6

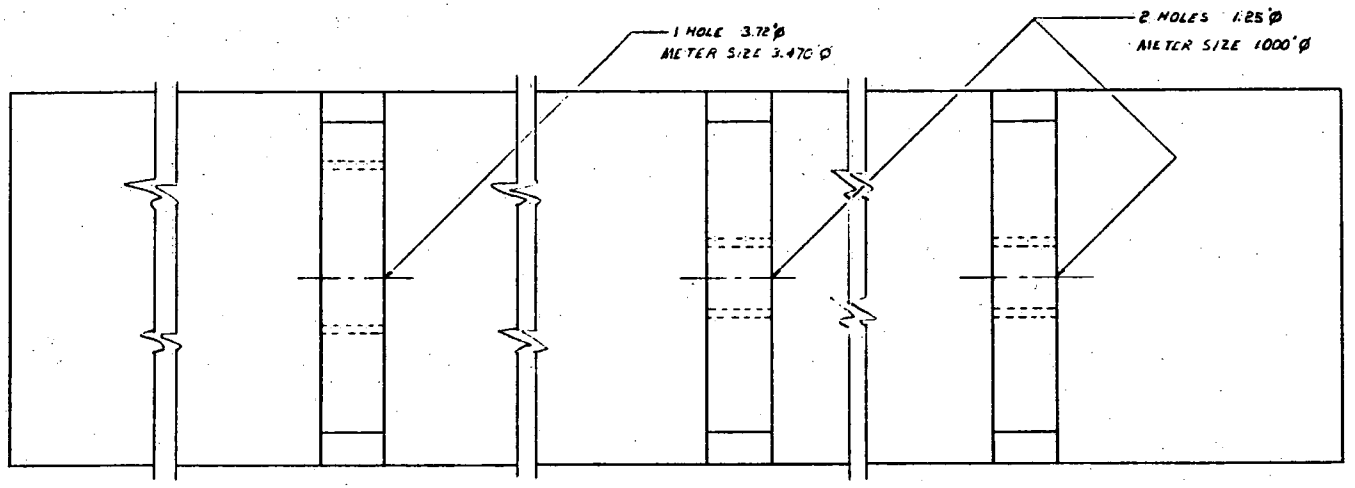
Environment Canada / Canada Centre for Inland Waters
Environnement Canada / Centre Canadien des Eaux Intérieures

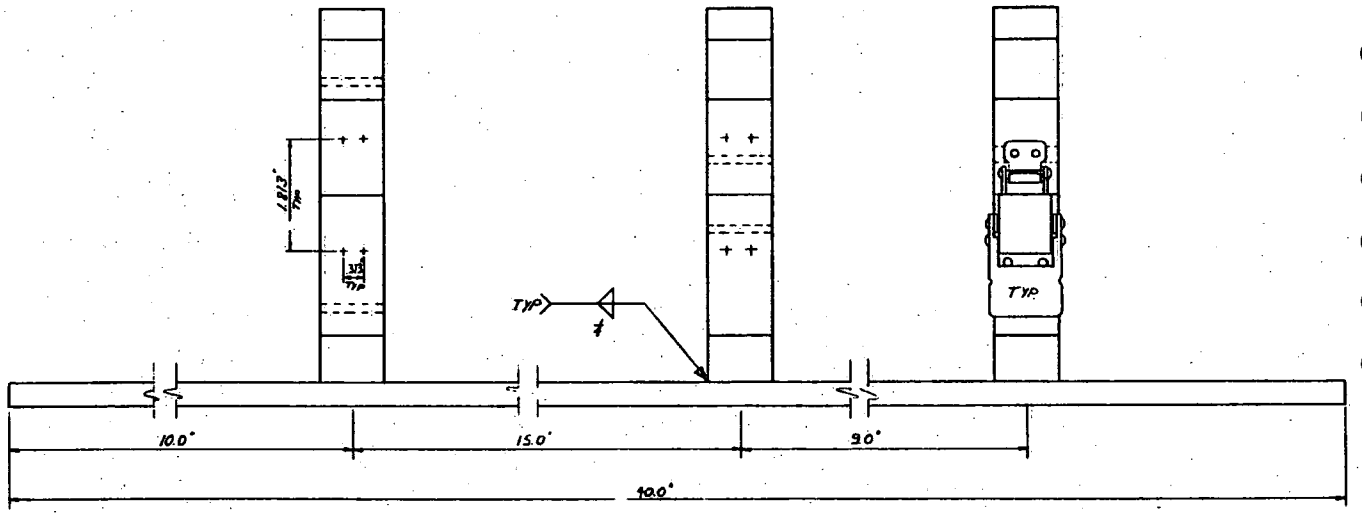
TITLE: TOW TANK METER MOUNT INDEXING FLANGE

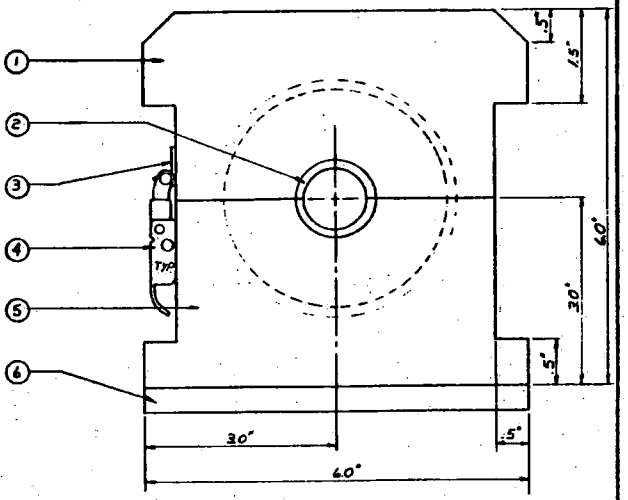
DESIGNED BY: T. VINCENT	CHECKED BY: SBA	APPROVED BY
DRAWN BY: T. VINCENT	CHECKED BY: P.J.	DRAWING NO. ME-5190-4
SCALE: FULL	DATE: JUNE 1993	SHEET 1 OF 1

APP. 4-6

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	R 10"·3.0"·6.0"	3
2	RUBBER .125"×1"WIDE ×20"	1
3	NIELSEN HINGE STRIKE S-B-833/4-ST-18755	6
4	NIELSEN CATCH SC-B-5331/4	6
5	R 10"·3.0"·6.0"	3
6	R .375"×60"×60.0"	1







NO.	DATE	DESCRIPTION REVISION	DRAWN BY	APPR. BY

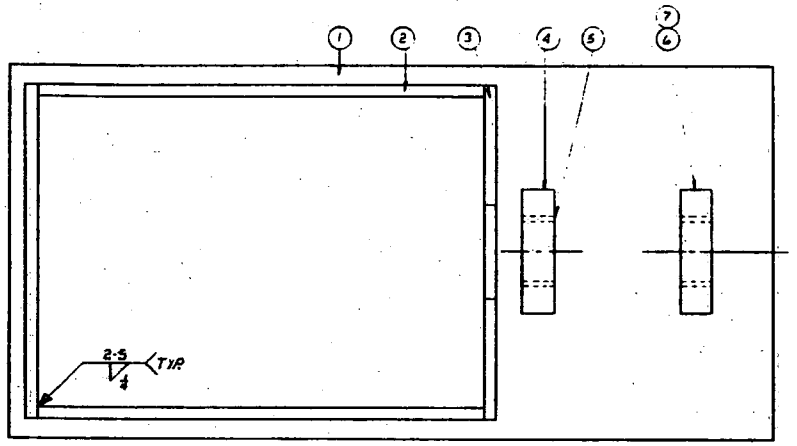
UNLESS OTHERWISE SPECIFIED
TOLERANCE ON THREE PLACE DIMENSIONS ..... ±.010"
TOLERANCE ON TWO PLACE DIMENSIONS ..... ±.0"
TOLERANCE ON ANGLES ..... ±
INTERNAL CORNER CHAMFER ..... .015" - .025"
EXTERNAL CORNER RADII ..... .015" - .025"
DEFINED AREAS ..... 64 MICRO INS.
MATERIAL SPECIFICATIONS
ALUMINUM 6061-T6

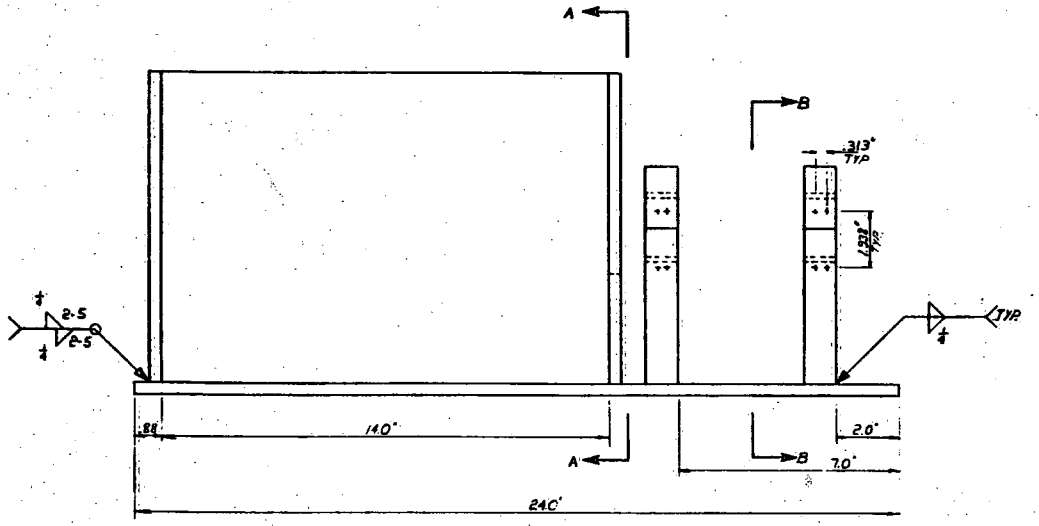
Environment Canada / Environnement Canada
Canada Centre for Inland Waters / Centre Canadien des Eaux Intérieures

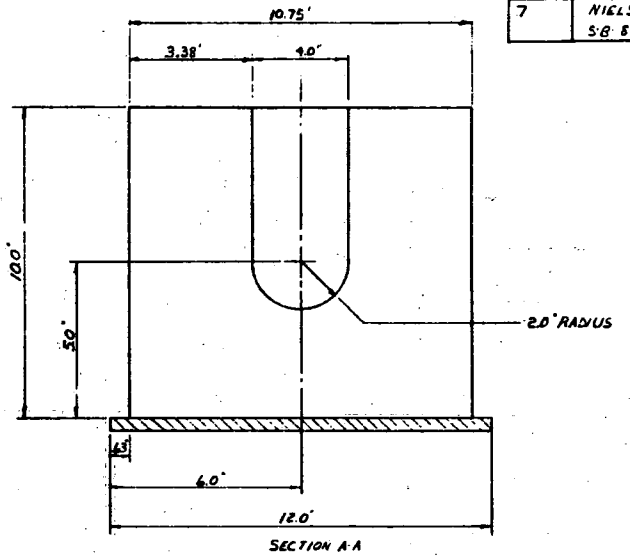
TITLE: TOW TANK METER MOUNT
PROTECTION BASE FOR MARSH-McBIRNEY MODEL 551 METER

DESIGNED BY	CHECKED BY	APPROVED BY
T NUGENT	[illegible]	
DRAWN BY	CHECKED BY	DRAWING NO.
T NUGENT	[illegible]	ME 5190-D
SCALE	DATE	SHEET 1 OF 1
F.	JUNE 2, 1978	

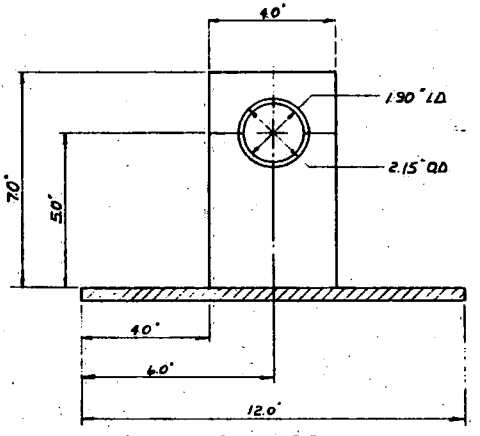
APP. 4-7







SECTION A-A



SECTION B-B

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	R .375 x 12.0" x 24.0"	1
2	R .375 x 10.0" x 14.0"	2
3	R .375 x 12.0" x 10.75"	2
4	R 1.0" x 4.0" x 7.0"	2
5	RUBBER 2.15 OD x 1.90 ID x 1.0	2
6	NIELSON CATCH SC-B-533-[illegible]	4
7	NIELSON STRIKE S-B-533-[illegible]-ST-1675S	4

NO.	DATE	DESCRIPTION REVISION	DRWN BY / CHKD BY

GENERAL SPECIFICATIONS
ALUMINUM 6061-T6

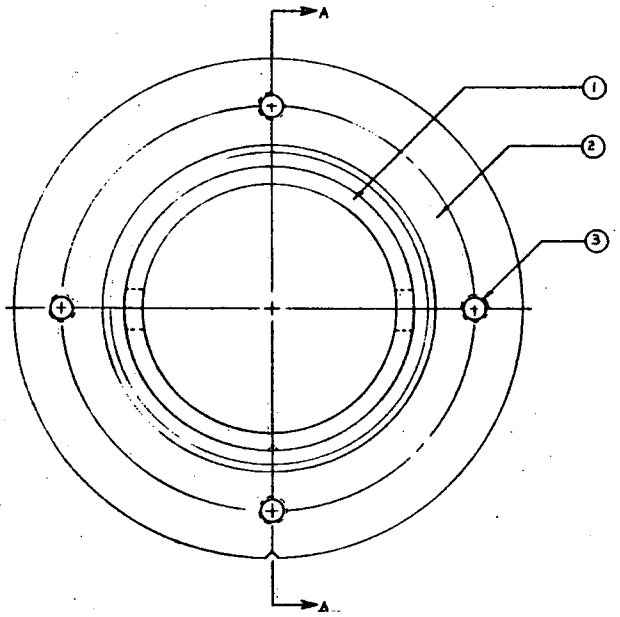
Environment Canada / Canada Centre for Inland Waters
Environnement Canada / Centre Canadien des Eaux Intérieures

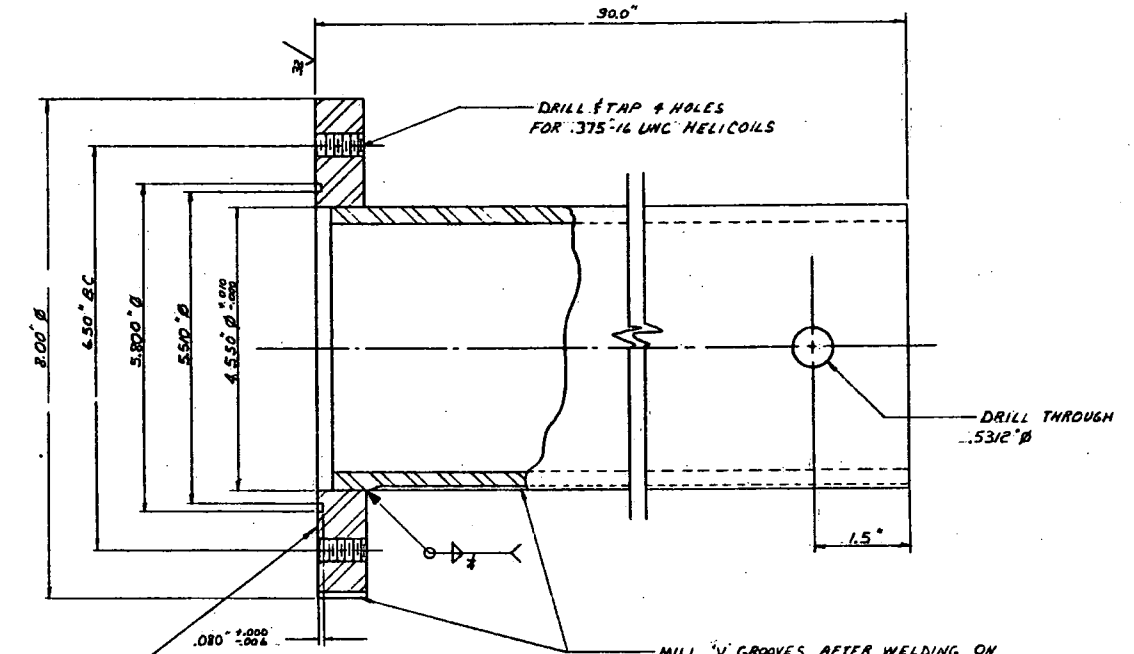
TITLE
TOW TANK METER MOUNT
PROTECTION BASE FOR NEIL BROWN CURRENT METER

DESIGNED BY T.NUGENT	CHECKED BY SDB	APPROVED BY
DRAWN BY T.NUGENT	CHECKED BY [illegible]	DRAWING NO. ME 5190-1
SCALE N.T.S.	DATE JUNE 24 81	SHEET 1 OF

APP.4-8

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	PIPE SCH. 40 · 83.75 LONG	1
2	R .75 THICK · 8.0 Ø	1
3	HELICO - .375-16 UNC	4





SECTION A-A

NOTE:
'O'-RING GROOVE CUT FOR PRECISION SIZE N°161
I.D. 5.487" ±.015
WIDTH .103" ±.003

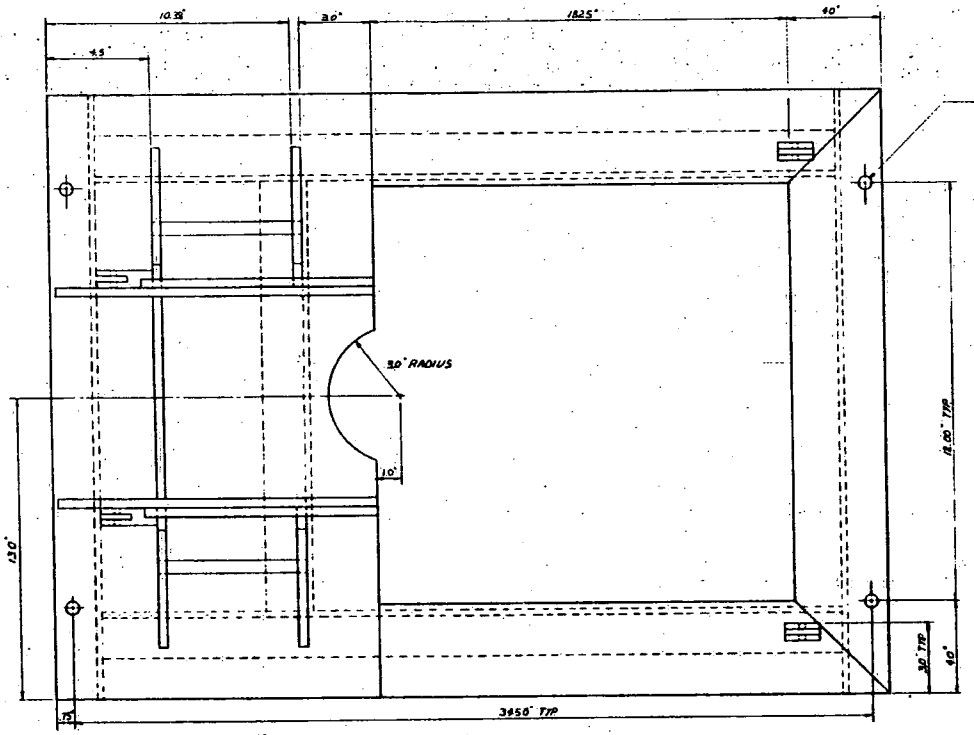
NO.	DATE	DESCRIPTION / REVISION	DRAWN BY	CHECKED BY

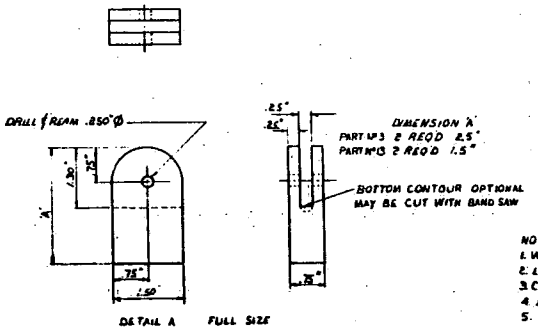
UNLESS OTHERWISE SPECIFIED
TOLERANCE ON THREE PLACE DIMENSIONS ± .001"
TOLERANCE ON TWO PLACE DIMENSIONS ± .01"
TOLERANCE ON ANGLES ±°
FRACTIONAL DECIMALS .xx ± .xxx
DECIMAL DECIMALS .xx ± .xxx
DECIMAL PLACES .xx ± .xxx
MATERIAL SPECIFICATIONS 6061-T6

Environment Canada — Canada Centre for Inland Waters
Environnement Canada — Centre Canadien des Eaux Intérieures

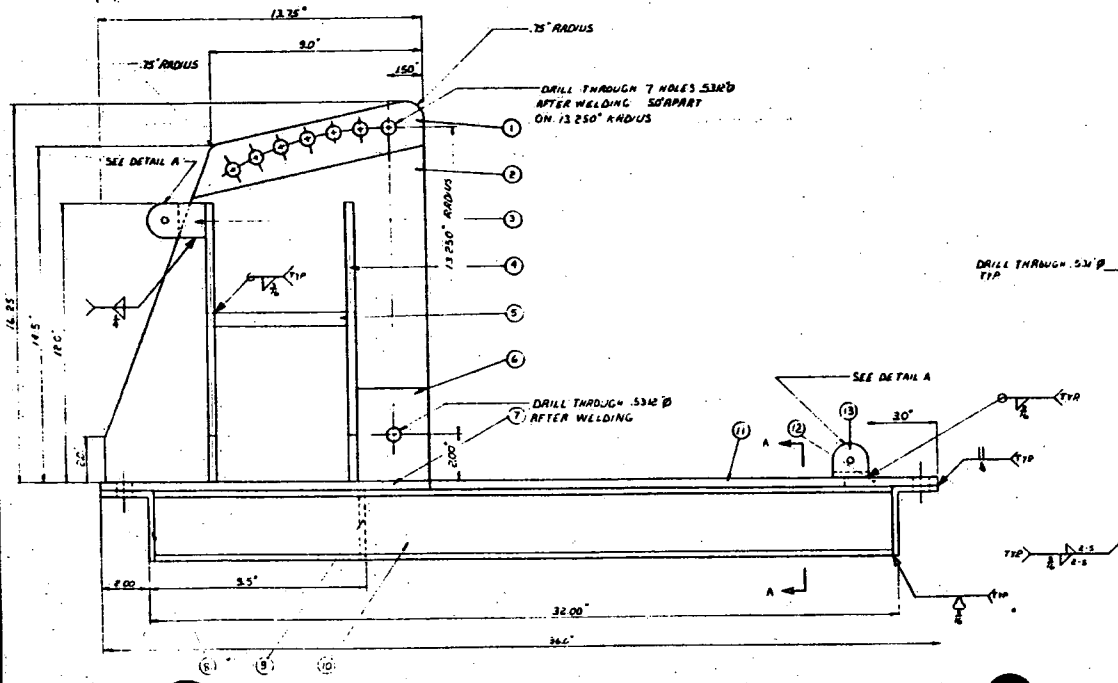
TITLE: TOW TANK METER MOUNT MOUNTING TUBE

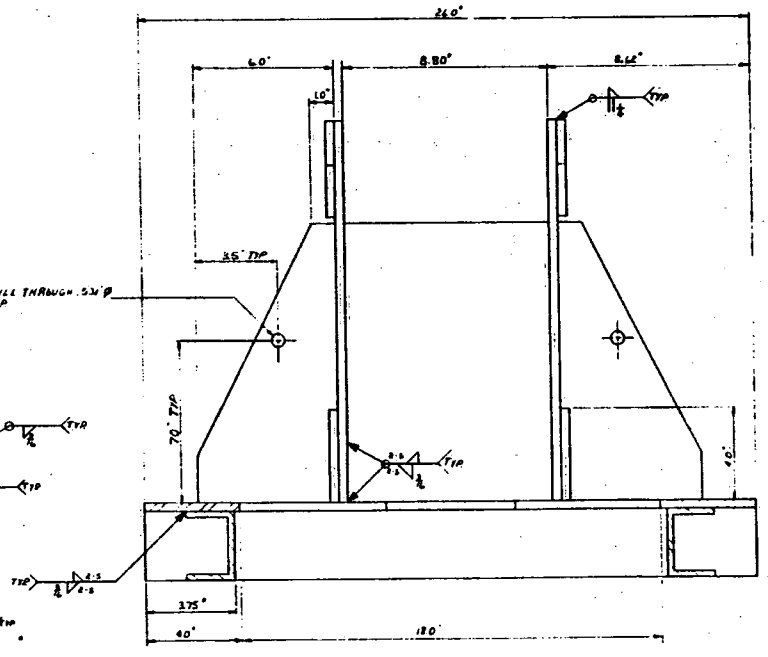
DESIGNED BY	CHECKED BY	APPROVED BY
T. VINCENT	SOB	
DRAWN BY	CHECKED BY	DRAWING NO.
T. VINCENT		MS1-90-3
SCALE	DATE	SHEET OF
	JUNE 10 '91	





NOTE: WELDING SEQUENCE.
1. WELD PARTS Nº1 & Nº10 TO PART 2
2. LAY OUT .5312"Ø HOLES
3. CLAMP PART Nº2 'S BACK TO BACK
4. DRILL 8 HOLES
5. WELD TO FRAME





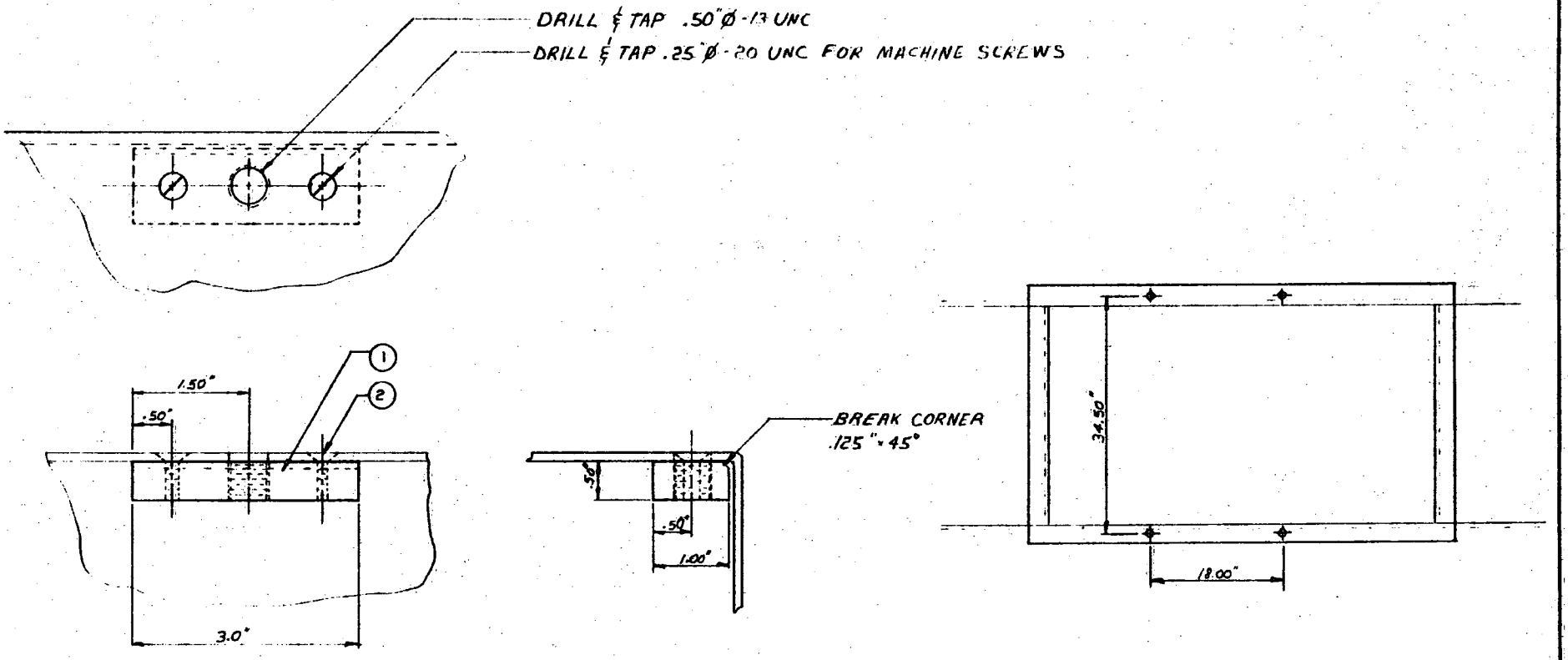
SECTION A-A

PART No.	DESCRIPTION	QTY.
1	BAR .375"×2"×110"	2
2	R .375"×.375"R×25"	2
3	R .75"×15"×2.5"	1
4	R .375"×6"×12"	4
5	ROUND BAR .5Ø×6.5"	4
6	R .375Ø×3"×1"	12
7	R .375"×14"×26"	1
8	ANGLE 3"×3"×.25"×26"	2
9	CHANNEL 2.3"×.85"×18.5"	1
10	CHANNEL 2.3"×.25"×31.50"	2
11	BAR .375"×4"×22.5"	2
12	FLAT .175"×4"×26"	1
13	R .75"×15"×15"	2

TOW TANK METER MOUNT
BASE

APP.4-10

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	BAR .5 × 1 × 3"	1
2	MACHINE SCREW .25Ø × .5"	2



NO.	DATE	DESCRIPTION	DRWN BY	APPD. BY
		REVISION		

UNLESS OTHERWISE SPECIFIED

TOLERANCE ON THREE PLACE DIMENSIONS	±.001"
TOLERANCE ON TWO PLACE DIMENSIONS	±.01"
TOLERANCE ON ANGLES	±
EXTERNAL CORNER CHAMFER	.013 - .025
INTERNAL CORNER RADIUS	.010 - .020
SURFACE FINISH	AA MICRO INS.

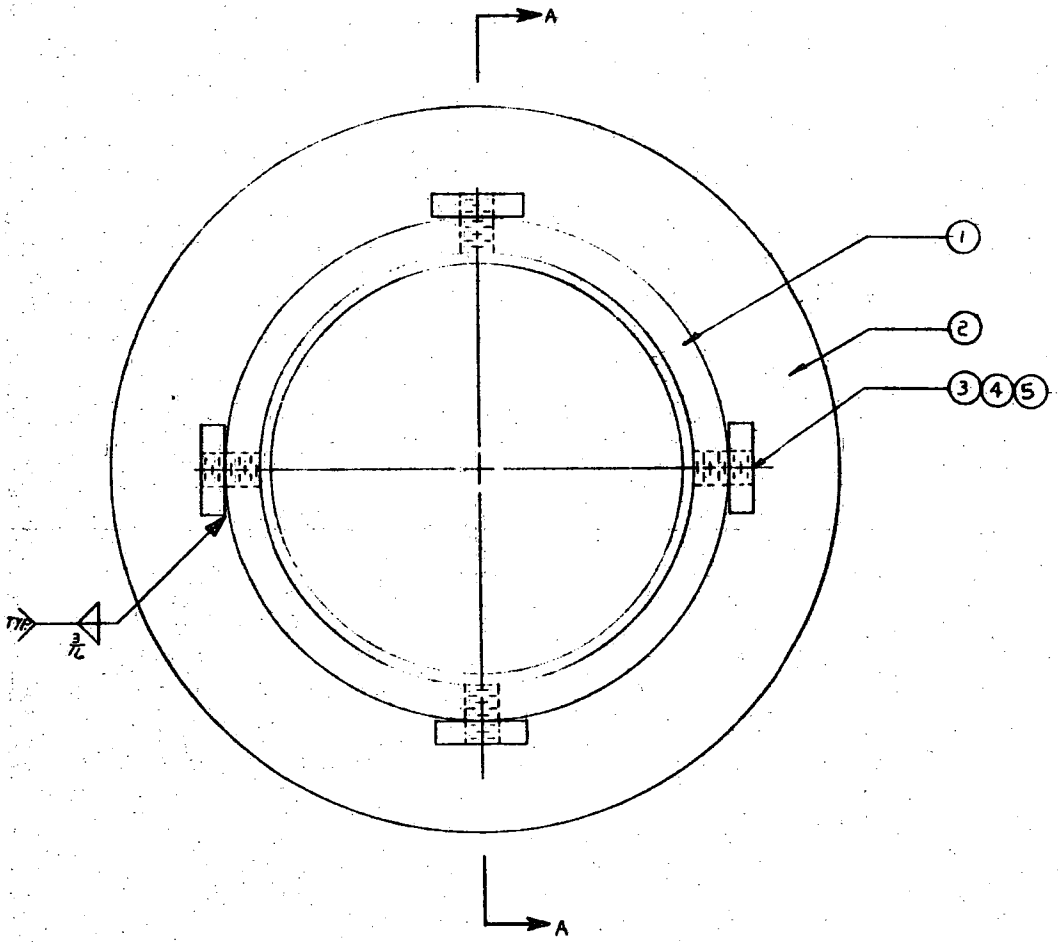
MATERIAL SPECIFICATIONS
SS 304

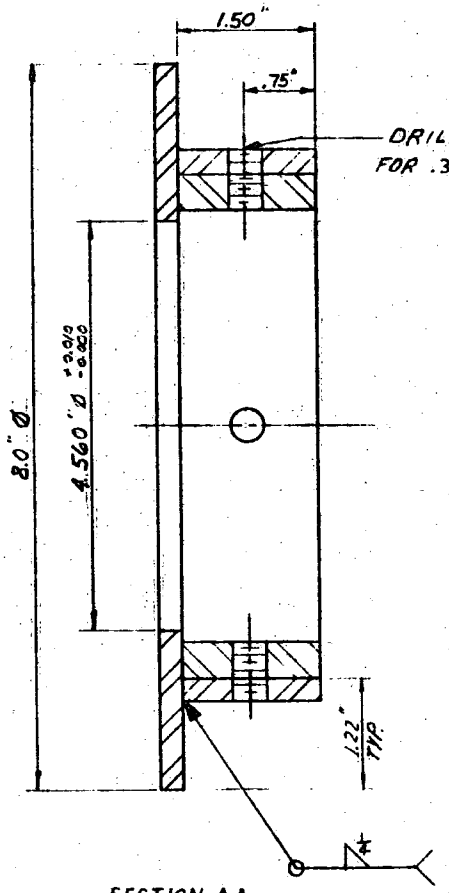
Environment Canada / Environnement Canada
Canada Centre for Inland Waters / Centre Canadien des Eaux Interieures

TITLE
TOW TANK CARRIAGE
BOLT HOLE LOCATION

DESIGNED BY T.NUGENT	CHECKED BY S.D.B	APPROVED BY
DRAWN BY T.NUGENT	CHECKED BY R.D.E.	DRAWING NO. ME 5190-7
SCALE FULL	DATE JUNE 1983	SHEET 1 OF 1

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	PIPE 5.5 OD. × 4.75 ID. × 1.50L	1
2	R .25" THK × 8.0 Ø	1
3	HELICOIL .375-16 UNC	4
4	SOCKET HEAD SET SCREW .375-16 UNC × .75 LONG	4
5	BAR .25 × 1.0 × 1.5	4





SECTION A-A

NO	DATE	DESCRIPTION	DRWN BY	APPD BY
		REVISION		

UNLESS OTHERWISE SPECIFIED

TOLERANCE ON THREE PLACE DIMENSIONS	±0.001"
TOLERANCE ON TWO PLACE DIMENSIONS	±0.01"
TOLERANCE ON ANGLES	±
EXTERNAL CORNER CHAMFER	.015 - .025
INTERNAL CORNER RADIUS	.010 - .020
SURFACE FINISH	AA MICRO INCH

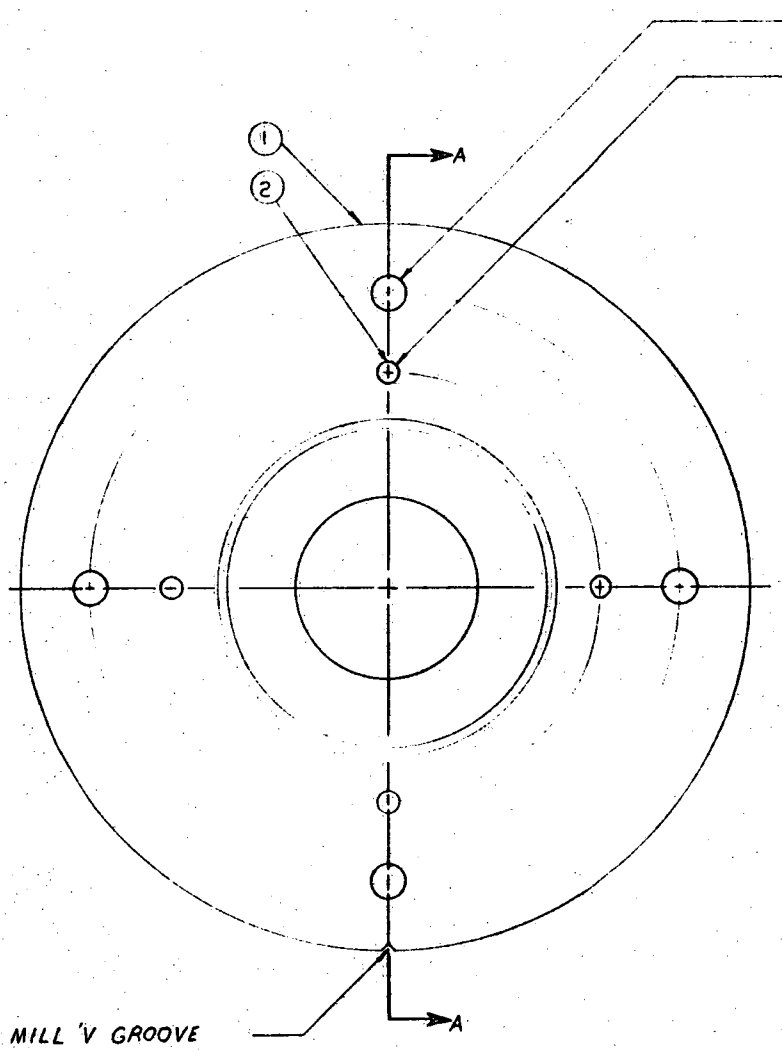
MATERIAL SPECIFICATIONS
6061-T6

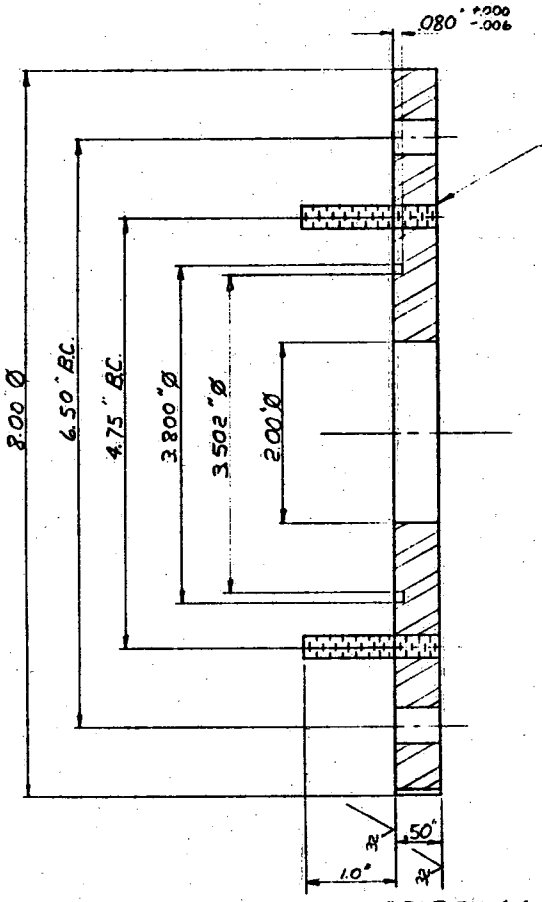
Environment Canada / Environnement Canada
Canada Centre for Inland Waters / Centre Canadien des Eaux Interieures

TITLE
TOW TANK METER MOUNT
CAVITATION PLATE

DESIGNED BY T. NUGENT	CHECKED BY JOE	APPROVED BY
DRAWN BY T.NUGENT	CHECKED BY [illegible]	DRAWING NO. ME 5190-5
SCALE FULL	DATE JUNE 1983	SHEET 1 OF 1

PARTS LIST		
PART NO.	DESCRIPTION	QTY.
1	R .50" THICK x 8.00" Ø	1
2	THREADED ROD .25 - 20 UNC x 1.50"	4





NOTE:
O-RING GROOVE CUT FOR PRECISION
SIZE 153
I.D. 3.487" ± .015 WIDTH .103" ± .003

NO	DATE	DESCRIPTION	DRWN BY	APPD BY
		REVISION		

UNLESS OTHERWISE SPECIFIED
TOLERANCE ON THREE PLACE DIMENSIONS ±.001"
TOLERANCE ON TWO PLACE DIMENSIONS ±.01"
TOLERANCE ON ANGLES ±
EXTERNAL CORNER CHAMFER .010 - .025
INTERNAL CORNER RADIUS .010 - .020
SURFACE FINISH 64 MICRO INS.

MATERIAL SPECIFICATIONS 6061-T6

Environment Canada / Environnement Canada
Canada Centre for Inland Waters / Centre Canadien des Eaux Intérieures

TITLE
TOW TANK METER MOUNT
MARSH-MC BIRNEY ADAPTOR FLANGE

DESIGNED BY T. NUGENT	CHECKED BY SDB	APPROVED BY
DRAWN BY T. NUGENT	CHECKED BY	DRAWING NO. ME 5190-6
SCALE FULL	DATE JUNE/1983	SHEET 1 OF 1

APPENDIX 5

Photographs of Completed Parts

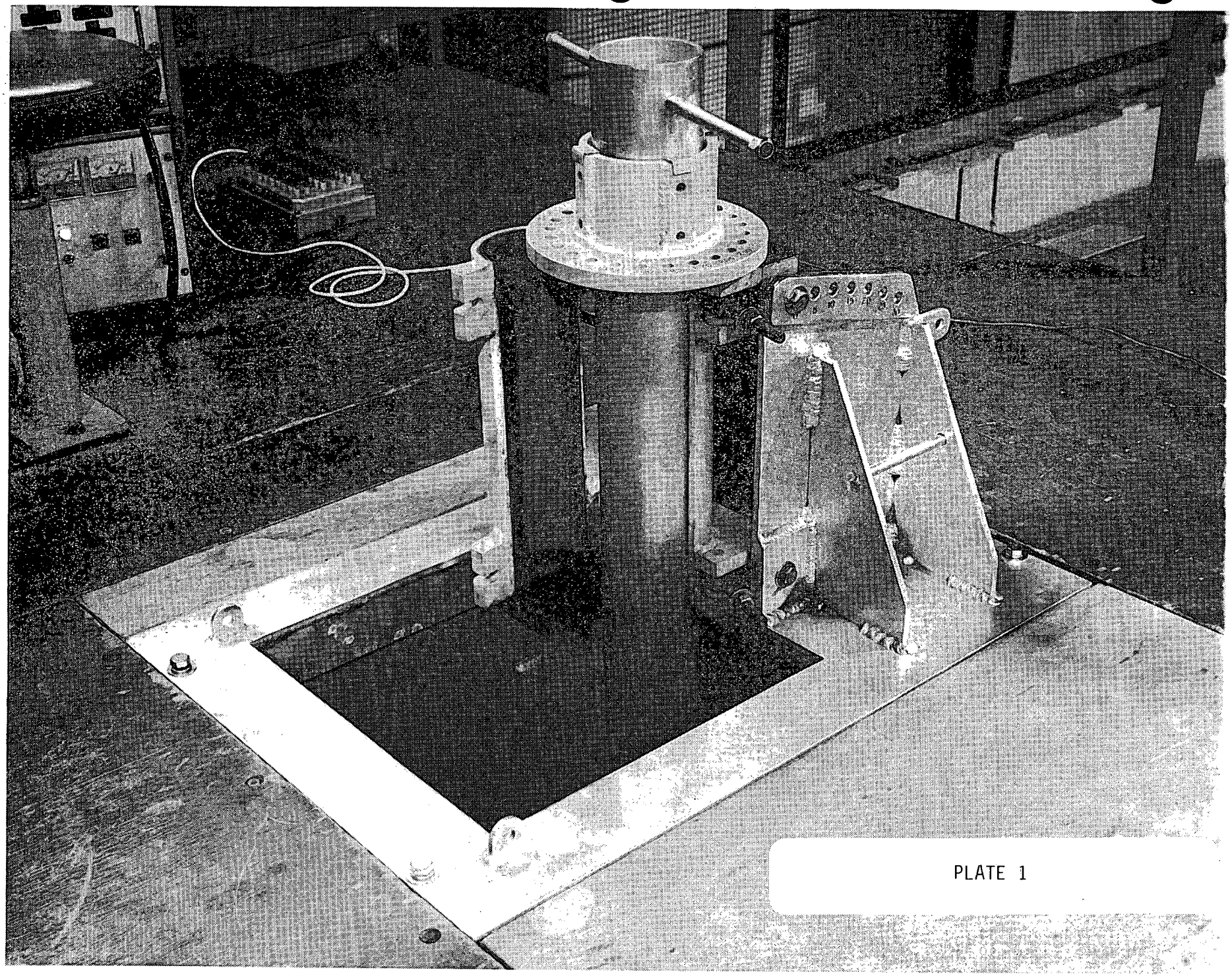


PLATE 1

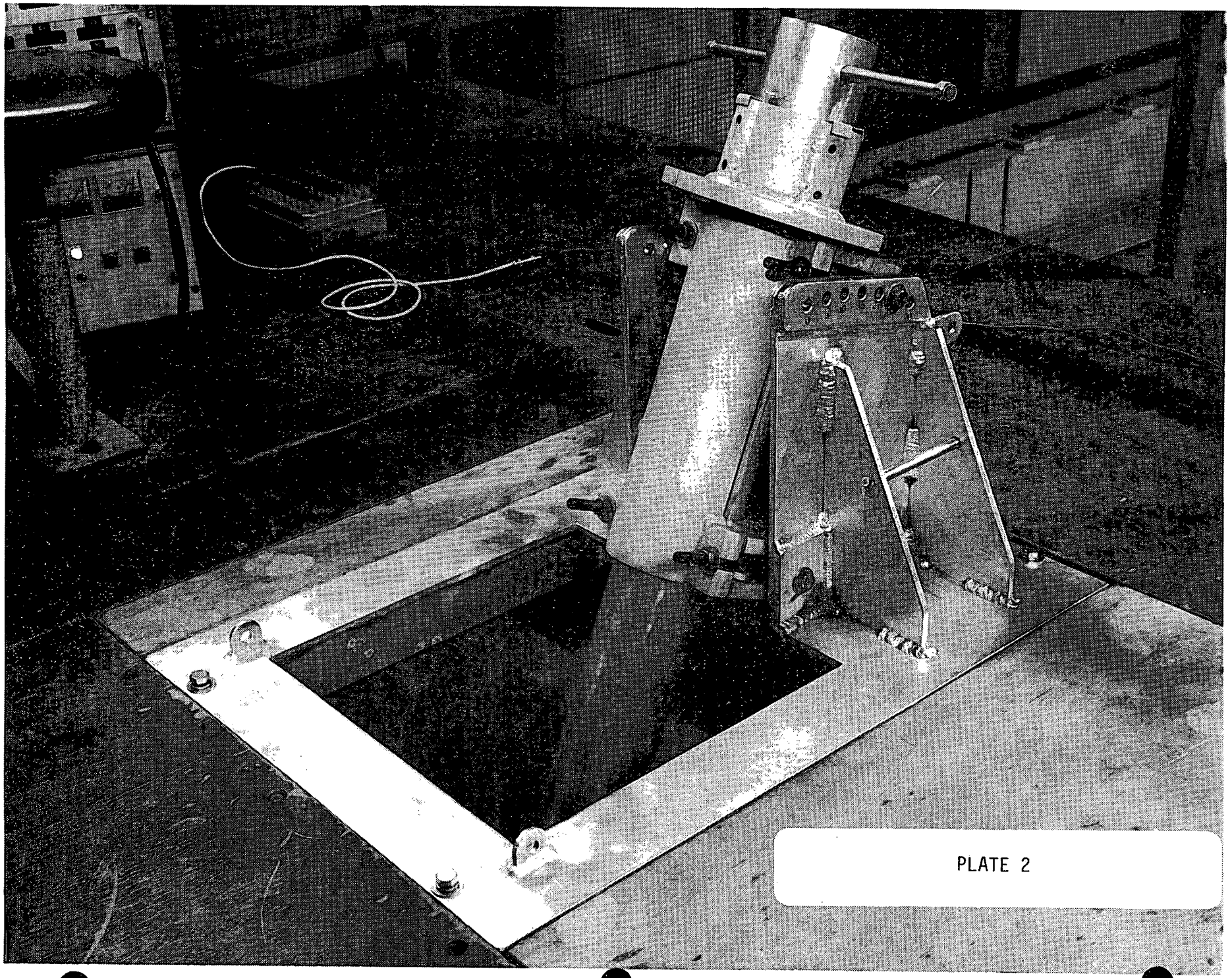


PLATE 2

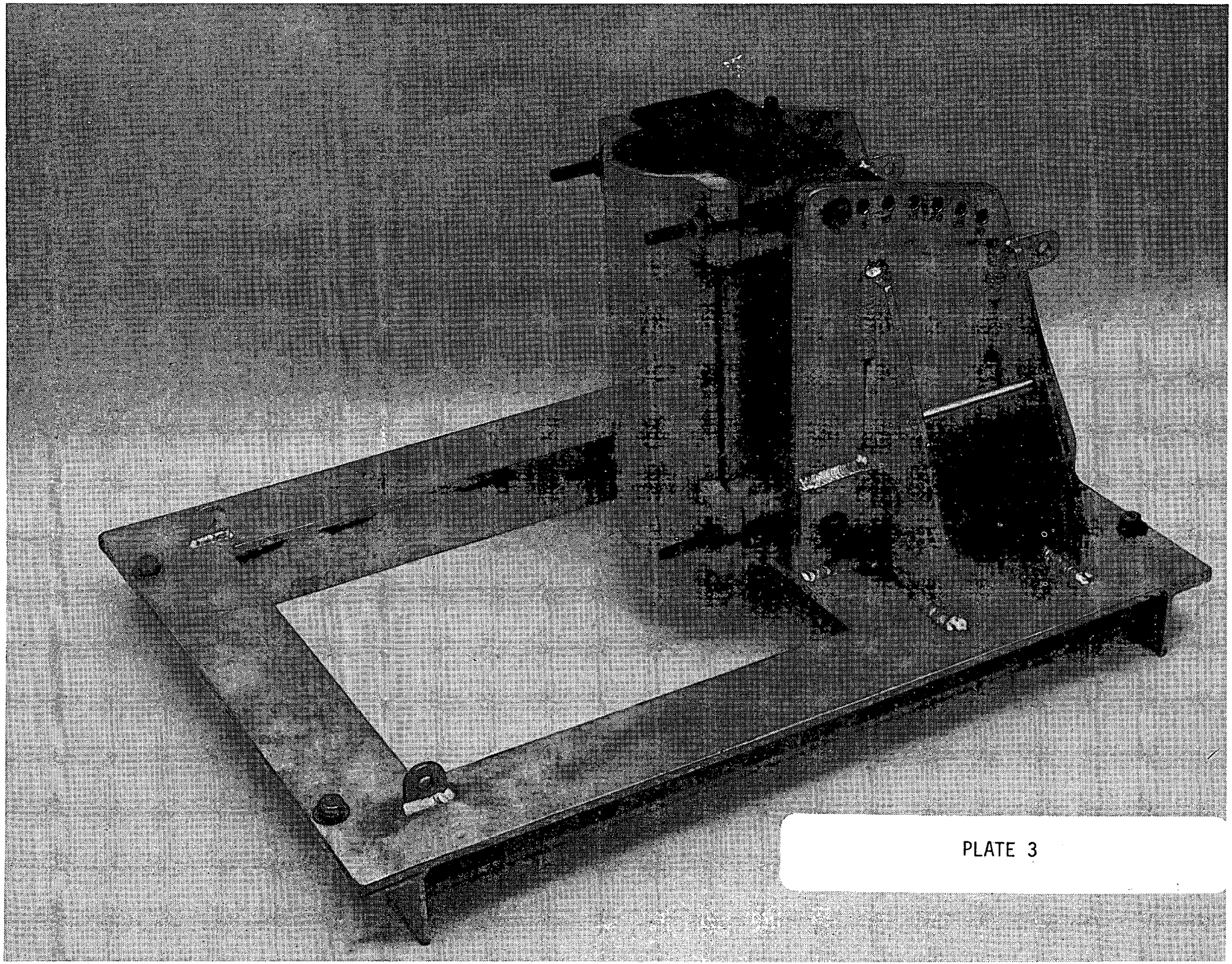


PLATE 3

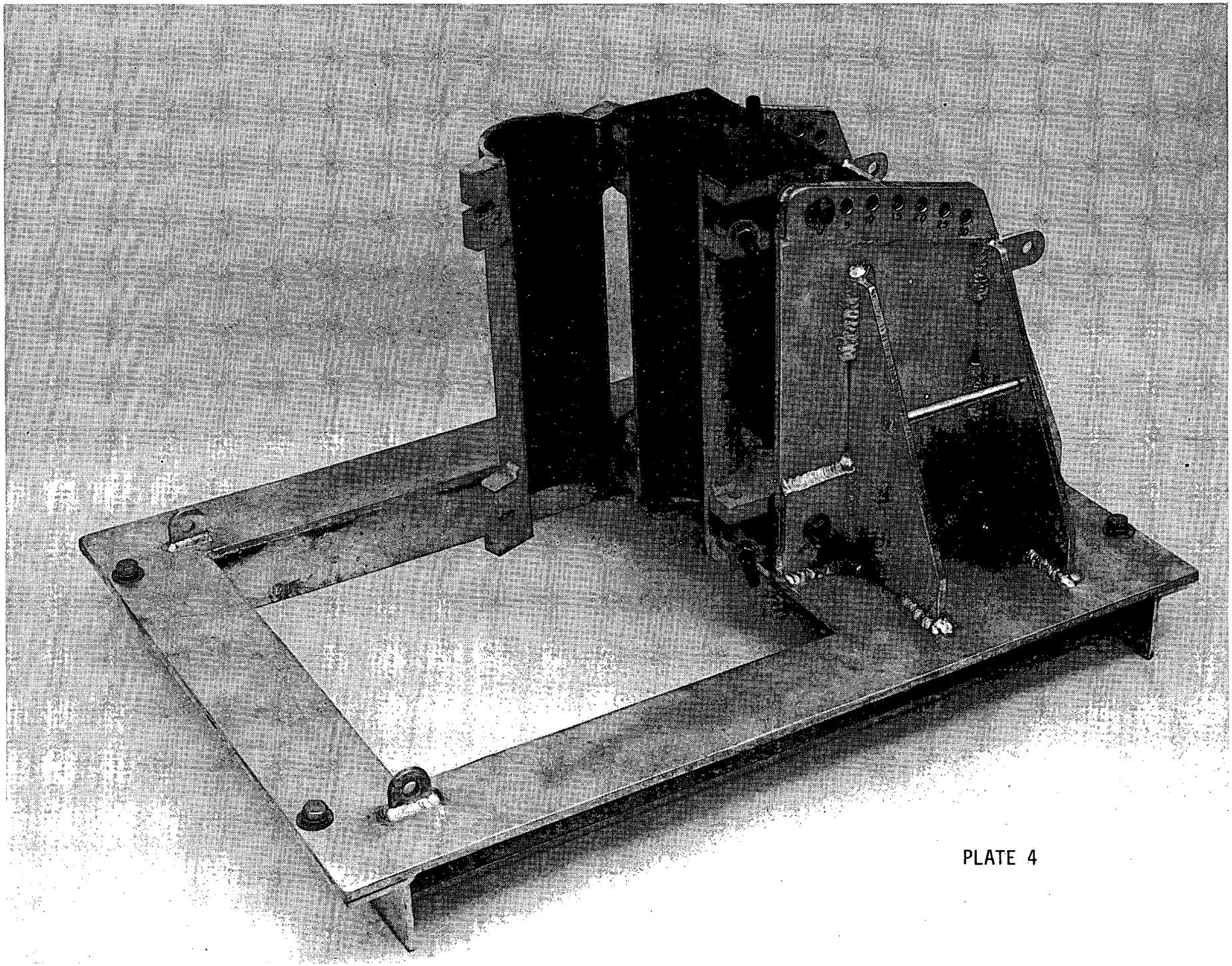


PLATE 4

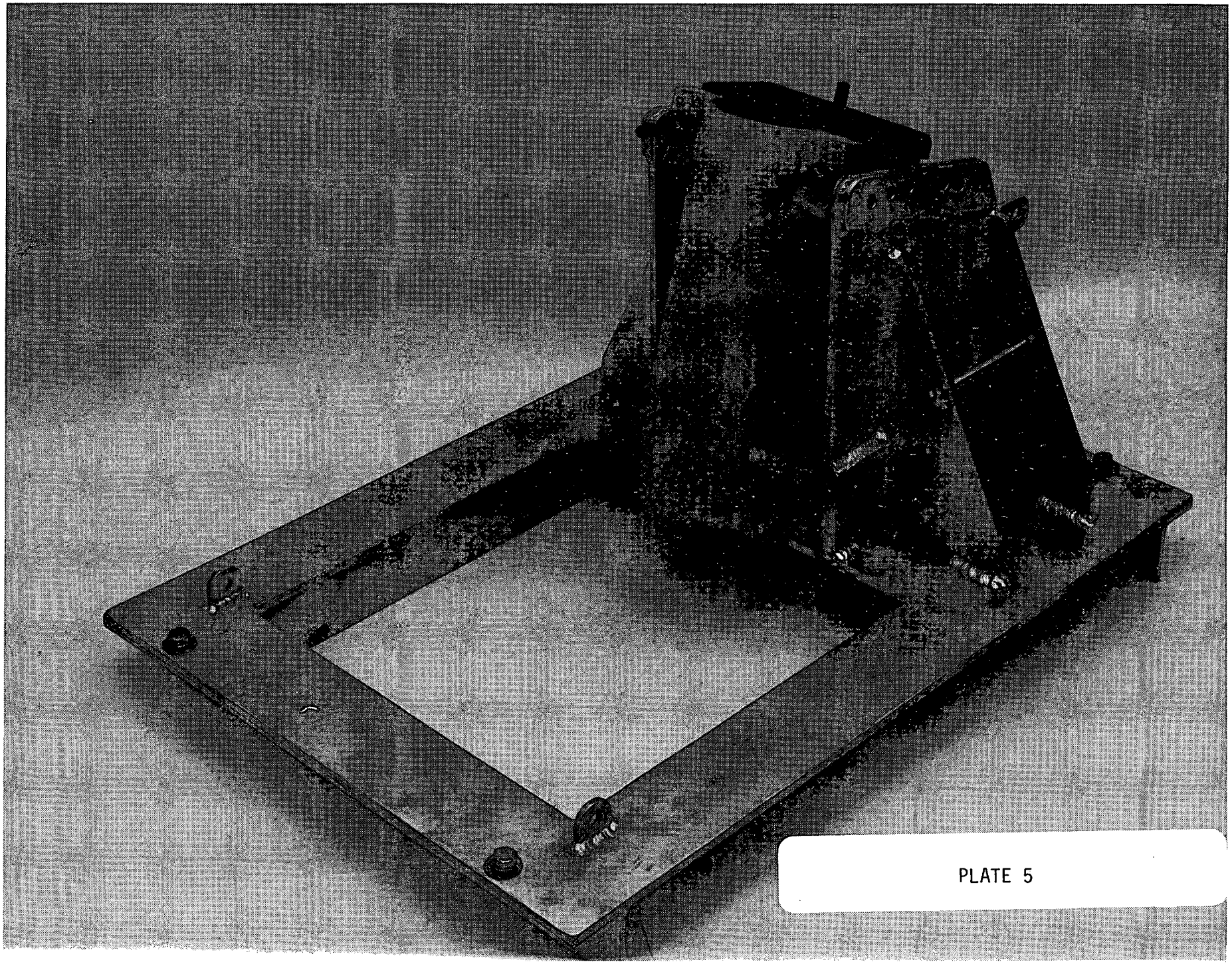


PLATE 5

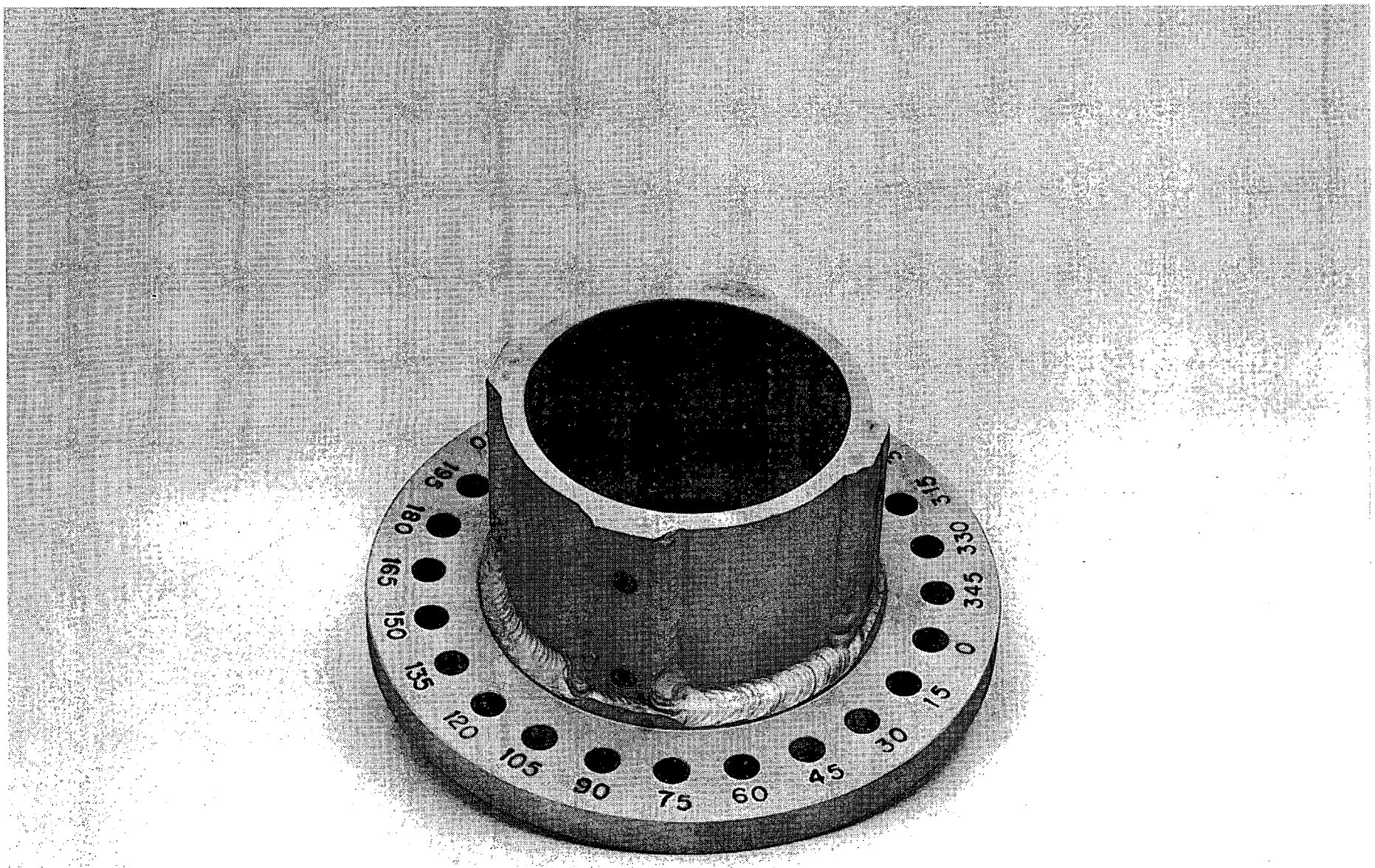


PLATE 6

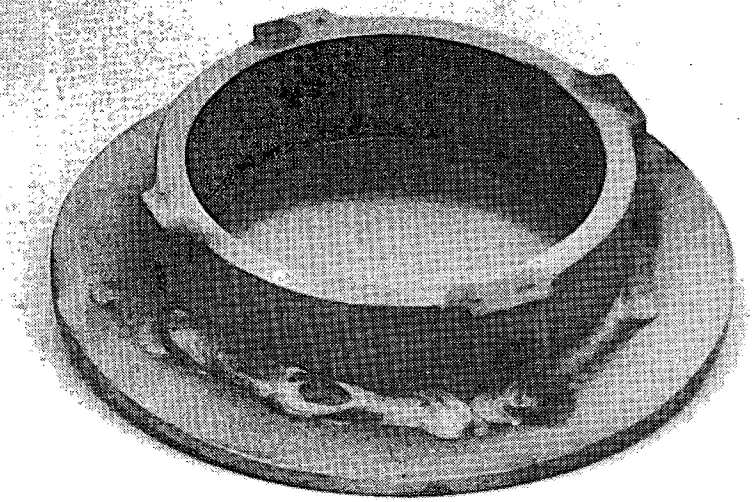


PLATE 7

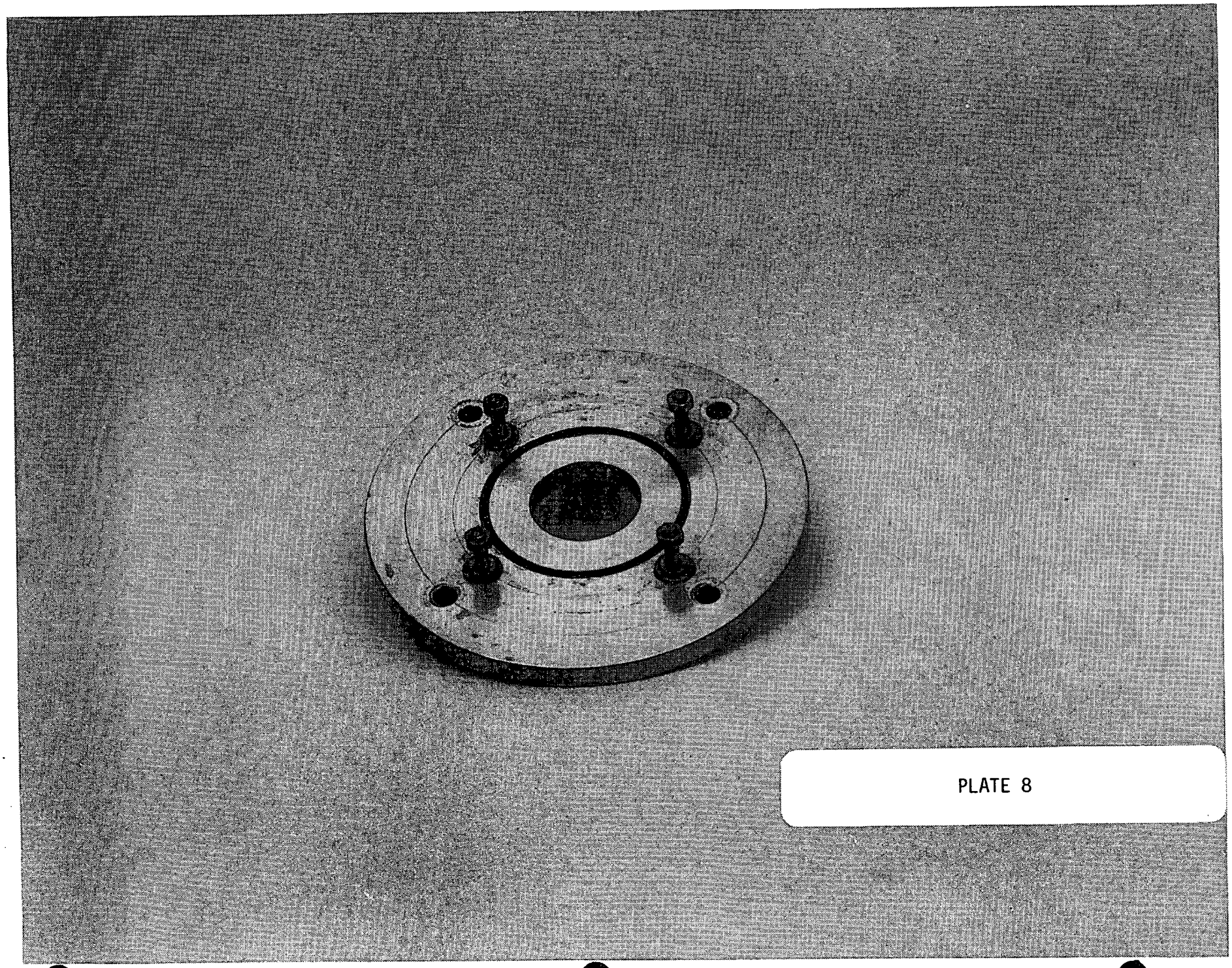


PLATE 8

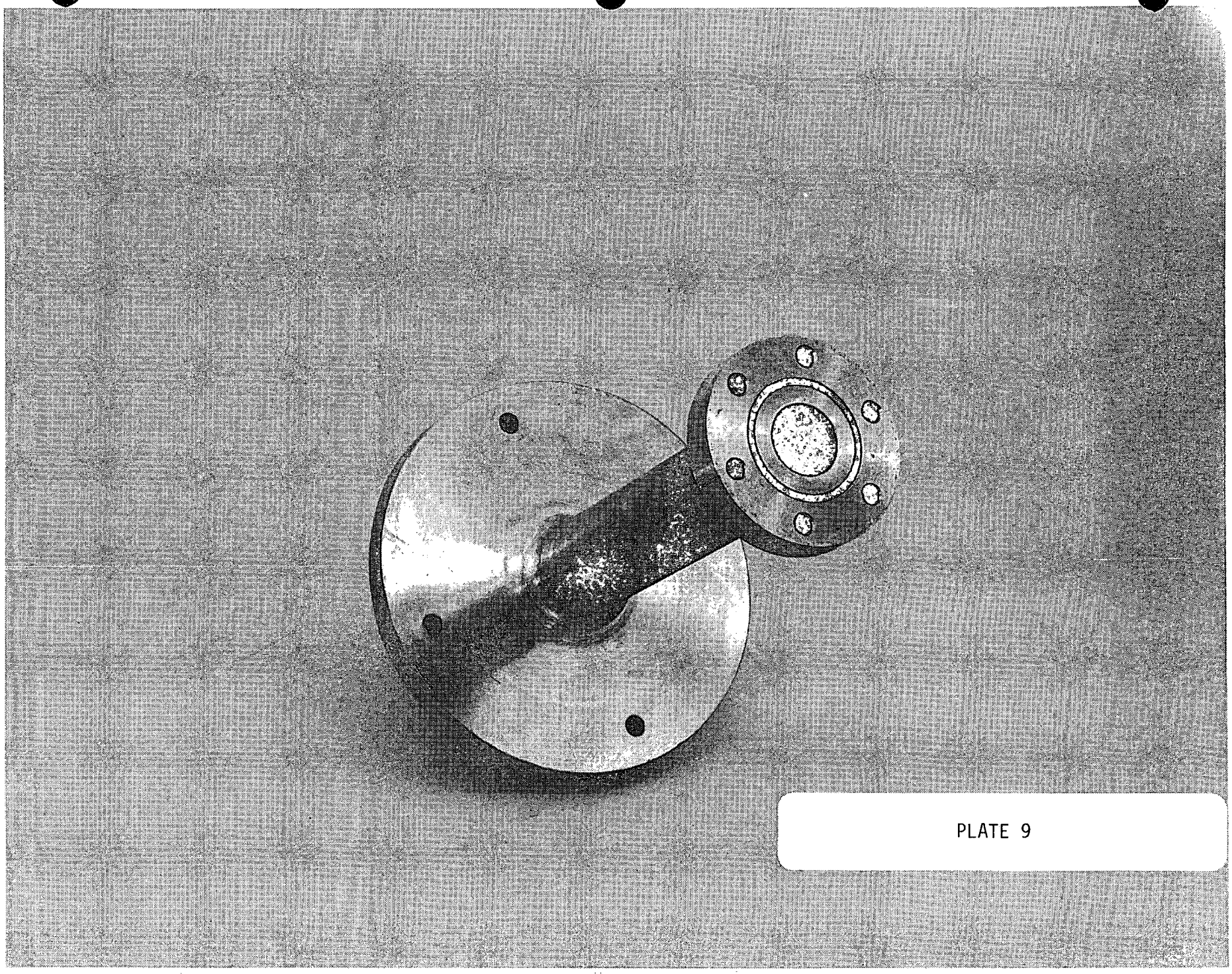


PLATE 9

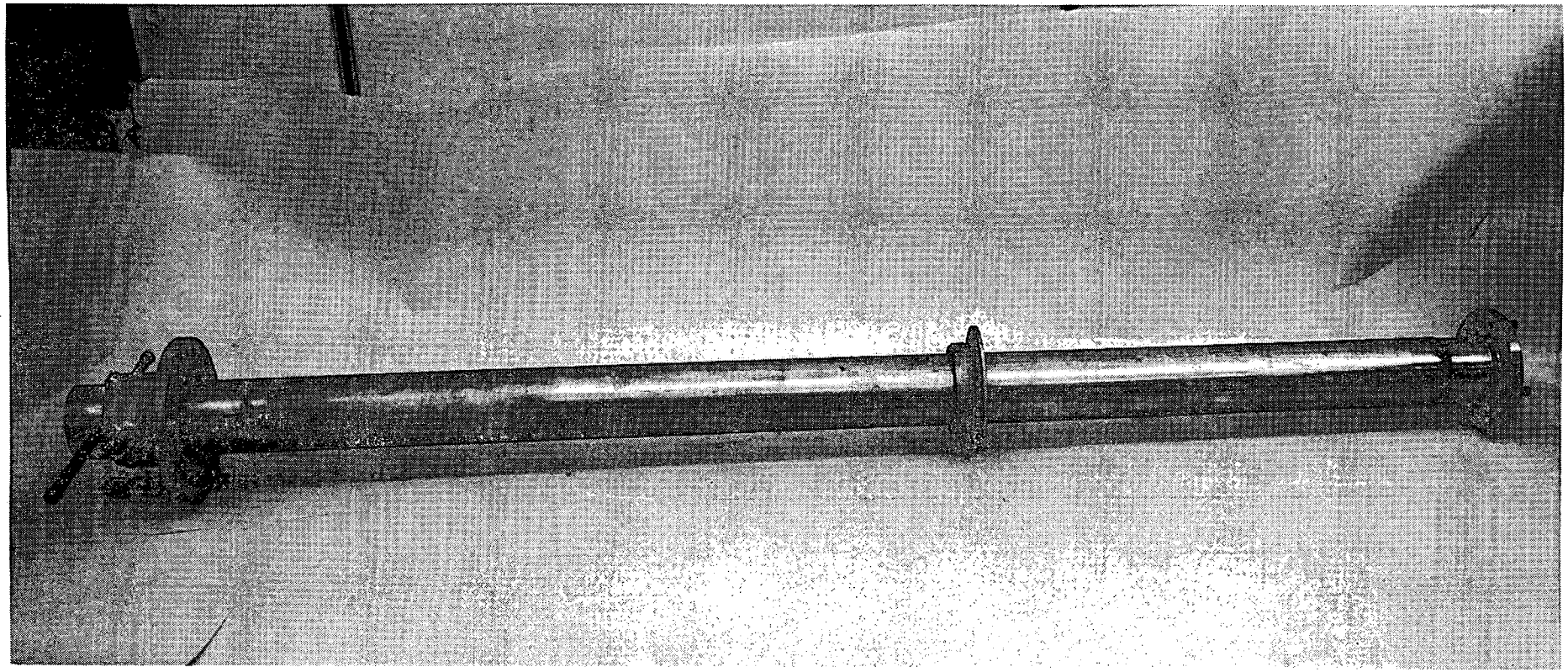


PLATE 10