HYDRAULICS RESEARCH DIVISION

Technical Note

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TITLE: "Stability and Drag Tests on Submerged Floats-Braincon Subsurface Buoy

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REASON FOR REPORT:

Written at the request of the Bedford Institute of Oceanography as part of Hydraulics Research Division Study H77 050 - "Towing Tests - Bedford Institute of Oceanography". This is the fourth in a series of reports related to the above study.

CORRESPONDENCE FILE NO:

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STABILITY AND DRAG TESTS OF SUBMERGED FLOATS

Purpose:

1. To find the drag force as a function of velocity over a range of 0 to 4 knots, acting on a variety of subsurface floats.
2. To determine the stability of all floats throughout the velocity range of 0 to 4 knots.
3. To determine the behaviour of these floats when the current is reversed.

Specifications of Test Apparatus:

1. Towing Mast (see Figure 2) - this was manufactured by CCIW staff using aluminum sailboat mast sections for the main spar. This mast is "L" shaped, has a moveable friction free pivot on the vertical portion of the "L" and has attachment brackets for support and measuring lines. Mast dimensions are: -

Vertical section	- 457.00 cm
Horizontal section	- 153.00 cm
Cross section	- 10.10 cm x 7.60 cm

2. Pivot bearings - Seal Master SF 12-3/4"
3. Strain wire guide pulley bearings - McGill MB 25-5/8"
4. Tension measuring dynamometer - Dillon, 1000 lb. capacity, 5 lb. divisions.
5. Float attachment and tension measuring cable - .100" diameter.
6. Length measuring cable - .030" diameter.
7. Mast level - Sand's Craft No. SC 50.
8. Towing Device - Kempf and Remmers Modified C102 Carriage.

NOTE: Figure 1 is a descriptive drawing showing the test apparatus, as used, plus the symbols and measurements used in the calculations.

Specifications of the Braincon Test Model Subsurface Buoy:

- outside dimensions are scaled to produce a 60% model of full sized units. No attempt was made to scale buoyance or weight of the float.
- skin is fibreglass approximately 1/8" thick as compared to 1/4" of full size unit.

- this buoy is modular in construction as is the full size unit. This allows for several configurations of assembly as follows: Nose and tail sections only, or up to four disc sections between the nose and tail sections.
- Model buoyancy is approximately 150 lbs.
- Diameter = .8165 m
- Tail section has a centrally mounted container for adding ballast if it becomes necessary to adjust the balance point. (Figure 4)

Procedure:

The test apparatus was set up in the following manner:

- The dynamometer was suspended from the carriage mounted hoist.
- The strain wire guide pulley was bolted to the carriage platform.
- The mast assembly was bolted to the rear edge of the carriage so that the mast bottom was approximately 20 cm above the tank bottom and the mast was perpendicular to the water surface.
- The strain wire was attached from the bottom forward edge of the mast through the guide pulley to the bottom of the dynamometer. (See Figure 2).
- The strain wire was slackened and the mast was tilted until the tip of the "L" came to the water surface.
- A premeasured mooring line, 60 cm in length, was attached from this tip of the mast to the mooring point on the underside of the float (See Figures 2 & 3).
- The "length measuring cable" was attached from the float mooring point, through the cable guides, to the top of the mast.
- The carriage mounted hoist was operated to bring the mast to its upright position perpendicular to the water surface and to submerge the float to its test position. This position was maintained throughout the tests with the aid of a level strapped to the upper portion of the mast and adjusting with the hoist.
- The length measuring cable was pulled taut and a reference mark was affixed to it.

Tests were commenced by dragging the float through the water at preselected velocities over the range required. Once the float stabilized at each

speed, a reading was taken from the dynamometer to obtain tension and a measurement made of the taut measuring cable length to provide the remaining information required. Previous trial runs determined that a single or occasionally two runs were sufficient to provide accurate data for calculation of the necessary parameters.

Calculations were then made to compute the drag force on the float, the drag coefficient of the float and the Reynolds Number throughout the tested velocity range.

Calculation of Drag Force

Referring to Figure 1, the sum of moments about the pivot results in the following equation:

$$(1) \ldots\ldots\ldots \quad (D_c \cos\phi) L_1 = D_s L_2 + T \cos(180 - \theta) L_3 + T \sin(180 - \theta) L_4$$

Where D_c	=	tension in the cable measured by the dynamometer
D_s	=	drag force on the towing apparatus
T	=	tension in the cable to the float
L_1, L_2, L_3, L_4	=	fixed distances as given in Figure 1
ϕ , θ	=	angles as specified in Figure 1.

From equation (1)

$$(2) \ldots\ldots\ldots \quad T = \frac{D_c \cos\phi\, L_1 - D_s L_2}{\cos(180 - \theta) L_3 + \sin(180 - \theta) L_4}$$

By measuring the cable length to obtain ℓ_1, Figure 1, and knowing the lengths of ℓ_2 and ℓ_3, the angle θ was calculated using the law of cosines. The drag on the strut, or towing apparatus, was measured in a separate towing test without the float. It can be seen from equation (1) that, when $T = 0$

$$(3) \ldots\ldots\ldots \quad D_s = \frac{F \cos\phi\, L_1}{L_2}$$

Where F is the cable tension measured by the dynamometer when towing the strut alone.

The drag force on the float $D_f = T \cos(180 - \theta)$

The drag coefficient C_D was defined as $C_D = \dfrac{D_f}{\rho A \frac{U^2}{2}}$

Where U = velocity of the float

A = cross-sectional area of the float = .5236 m^2

and ρ = density of the water = 998.8 Kg/m^3 @ temperature of 17^oC

The Reynolds number, Re, was also calculated,

$$Re = \frac{UD}{\gamma}$$

Where D = float diameter = .8165 m

and γ = kinematic viscosity of water = 1.1306×10^{-6} m^2/s

The test results are given in the following text, Plots 1 through 10 plus Tables 1 through 10. It should be noted that these tests were carried out on a model and therefore, for full scale application, the Reynolds Number must be used to select the drag coefficient.

Test #1

Assembly configuration - no discs i.e. nose and tail sections only.

Tow point - between nose and tail sections.

Tow angle at rest approximately 2° tail up.

Data reference - Table 1 and Plot 1.

No attempt was made during these tests to gauge the tow angle during the test runs. The buoy was very stable throughout this test and responded quickly and smoothly to return to prereverse attitude during the current reversing tests.

Test #2

Assembly configuration - no discs i.e. nose and tail sections only

Tow point - between nose and tail sections

Tow angle at rest - tail down 3° with balast added

Data reference - Table 2 and Plot 2

Some lead weights were added to the tail section ballast container to change the balance point. The buoy remained stable throughout this test and responded quickly and smoothly to return to prereverse attitude during the current reversing tests.

Test #3

Assembly configuration - 1 disc plus nose and tail sections
Tow point - in front of disc
Tow angle at rest - 7° tail up
Data reference - Table 3 and Plot 3

The buoy was stable throughout this test but nosed down slightly at the start of the current reversal tests. The buoy responded well during the remainder of the reversal tests to return to prereverse attitude.

Test #4

Assembly configuration - 1 disc plus nose and tail sections
Tow point - behind disc
Tow angle at rest - 13.5° tail down
Data reference - Table 4 and Plot 4

The buoy had a slight tendency to pitch during this test, however, response during the current reversal test was good. It was also noted that the nose came up during the turning process and then settled back to starting attitude quickly and smoothly.

Test #5

Assembly configuration - 2 discs plus nose and tail sections
Tow point - in the middle between the discs
Tow angle at rest - 4° tail down
Data reference - Table 5 and Plot 5

The buoy was very stable throughout this test and responded quickly and smoothly to return to prereverse attitude during current reversing tests.

Test #6

Assembly configuration - 3 discs plus nose and tail sections
Tow point - behind the middle disc
Tow angle at rest - 14° tail down
Data reference - Table 6 and Plot 6

The buoy was very stable during steady speed portions of this test. It was noted, however, that when the speed was changed suddenly, the buoy pitched dramatically but then quickly settled down to a stable condition.

The current reversal tests showed that the buoy reacted slowly to slow direction change and quickly to quick direction changes. It was also noted that when reversed at 3 cm/sec, the float moved around to approximately 45° in relation to the flow direction and continued to tow in this attitude. At 5 cm/sec the towing attitude stopped at approximately 80° in relation to the flow direction. At all higher speeds, the buoy reversed quickly and smoothly to an attitude parallel to the flow direction.

Test #7

Assembly configuration - 3 discs plus nose and tail sections
Tow point - ahead of the middle disc
Tow angle at rest - 6.5° tail up with the tail fin rotated approximately 5° off vertical.
Data reference - Table 7 and Plot 7

The buoy was stable throughout this test but did tow slightly to the side of its at rest centre line up to 35 cm/sec. This off parallel to flow direction attitude straightened out immediately after 35 cm/sec. The buoy responded quickly and smoothly to return to prereverse attitude during current reversing tests.

Test #8

Assembly configuration - 4 discs plus nose and tail sections
Tow point - in the middle of the four discs
Tow angle at rest - 4.5° tail down
Data reference - Table 8 and Plot 8

The buoy was stable throughout this test, responded quickly and smoothly to return to prereverse attitude during current reversing tests and showed identical towing characteristics as seen in Test #7.

Test #9

Assembly configuration - 4 discs plus nose and tail sections
Tow point - in the middle of the four discs
Tow angle at rest - ballast added to balance the buoy at 1° tail up
Data reference - Table 9 and Plot 9

The buoy was stable throughout this test but did tow approximately 2° to the port side of its at rest centre line in relation to parallel with the flow direction.

During current reversing tests the float responded quickly and smoothly to return to prereverse attitude.

Test #10

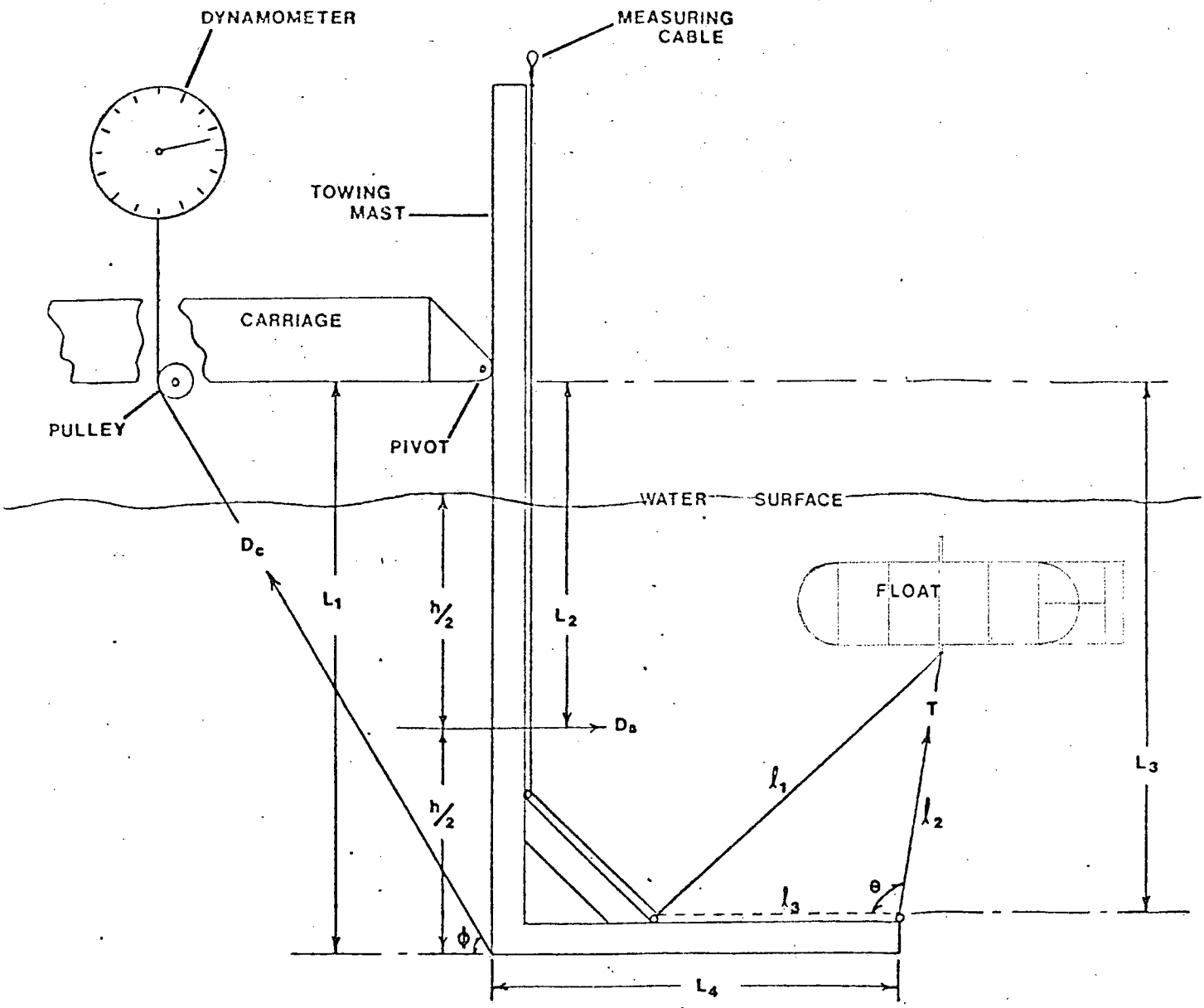
Assembly configuration - 2 discs plus nose and tail sections

Tow point - in the middle between the discs

Tow angle at rest - ballast added to balance the buoy at ½° tail up

Data reference - Table 10 and Plot 10

The buoy was stable throughout this test and parallel to the flow direction up to 200 cm/sec. At 200 cm/sec it took on and maintained a 3° to 5° to port angle off parallel with flow direction and an approximate 5° roll in towing attitude. At 250 cm/sec the off parallel angle remained the same but the roll increased to approximately 15°.



L_1 = 3.038 m
L_2 = 1.9115 m
L_3 = 3.038 m
L_4 = 1.575 m

$h/2$ = 1.2465 m ϕ = 57.5°

Schematic View of Test Apparatus
FIG. 1

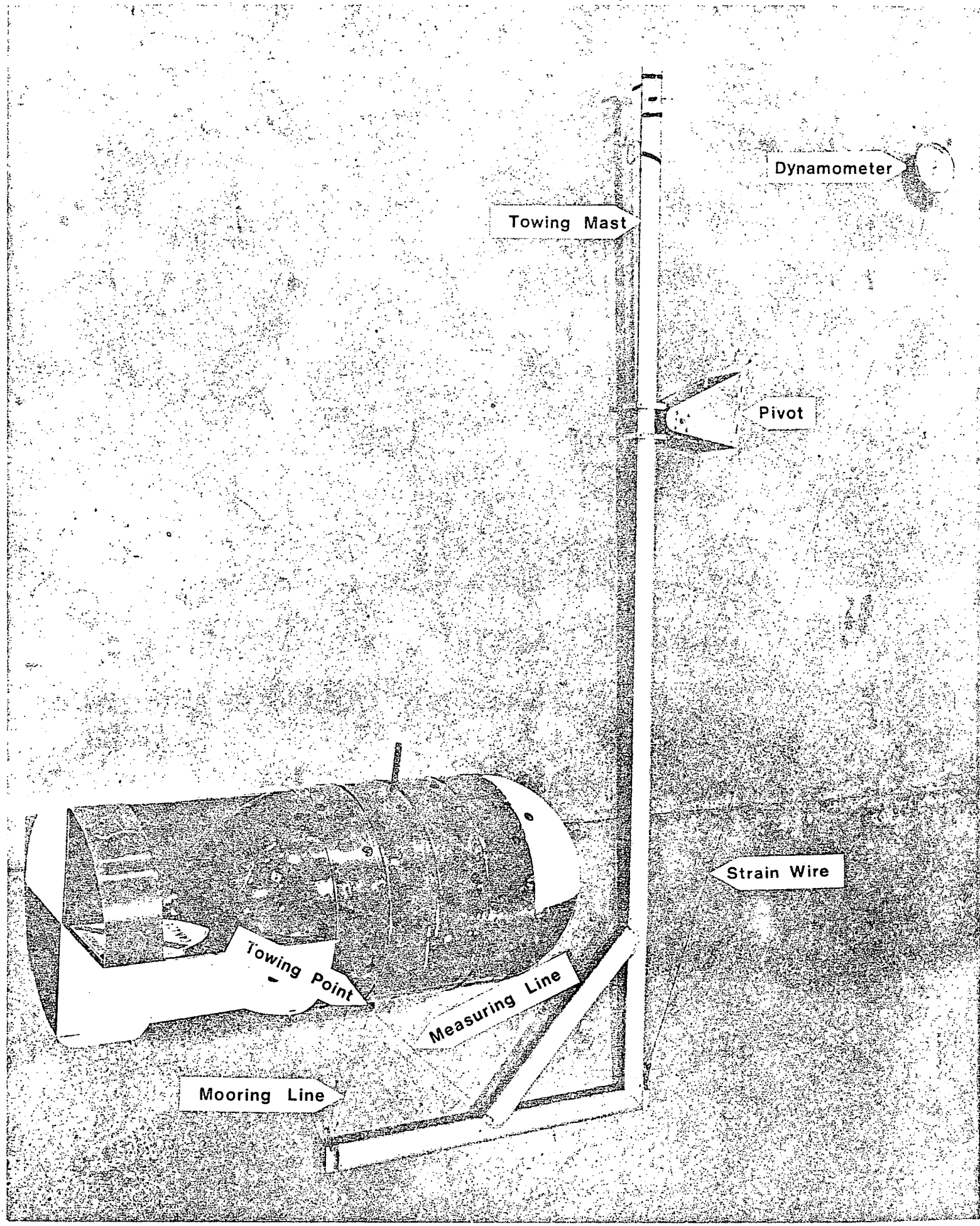

Dynamometer
Towing Mast
Pivot
Strain Wire
Towing Point
Measuring Line
Mooring Line

FIG. 2

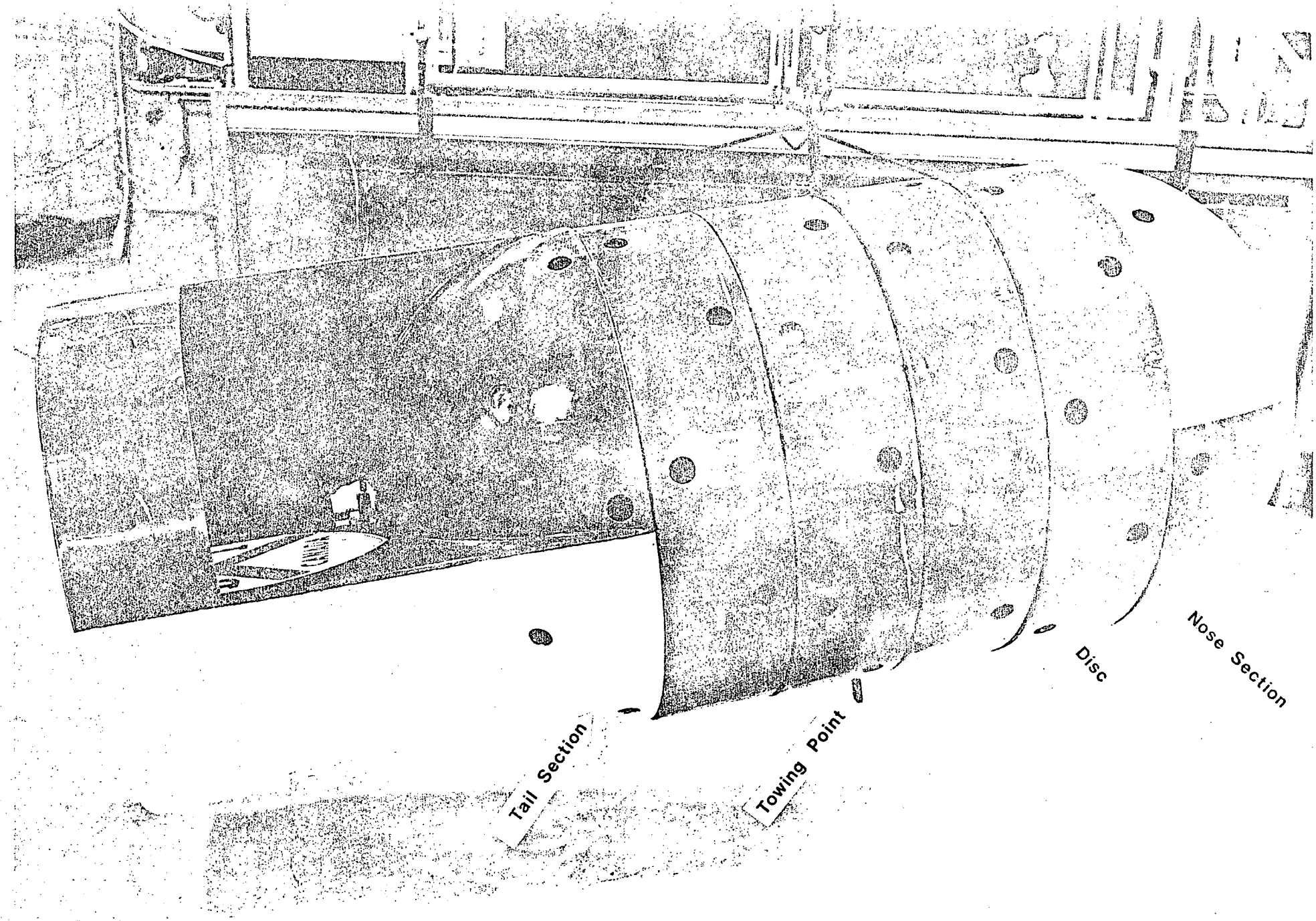


FIG. 3

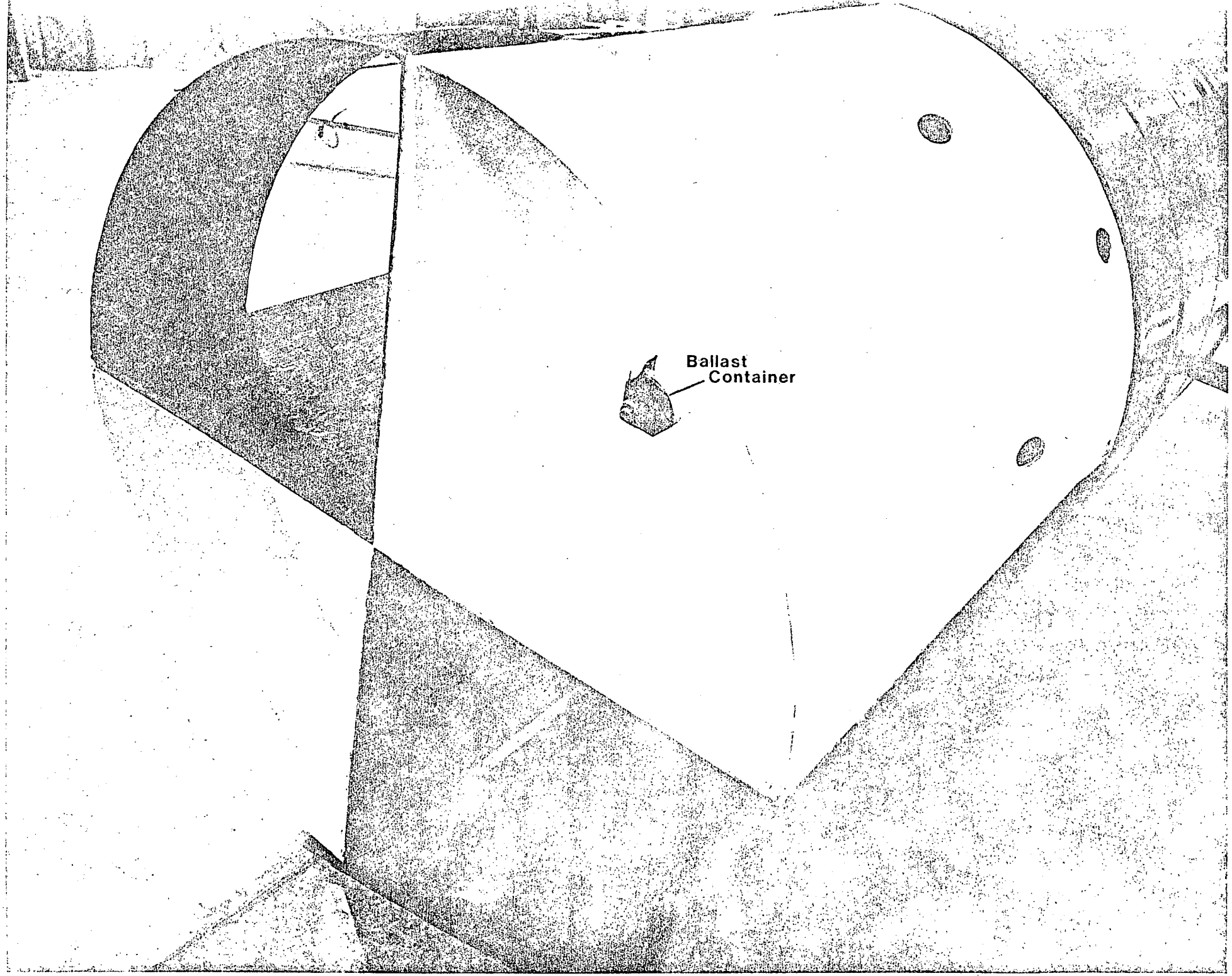


FIG. 4

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	662.785	-.051	92.911	1.83	627.487	31.862	1.950	1.805×10^5
.35	671.681	-.062	93.529	2.90	623.277	38.369	1.198	2.528×10^5
.45	689.474	-.068	93.902	4.22	631.591	42.982	.812	3.250×10^5
.55	711.715	-.072	94.151	5.15	646.493	46.802	.592	3.972×10^5
.65	742.853	-.078	94.464	6.80	667.341	51.939	.470	4.694×10^5
.75	782.887	-.099	95.659	8.52	679.232	66.978	.455	5.416×10^5
.85	814.024	-.118	96.804	10.25	683.971	81.027	.429	6.139×10^5
.95	871.851	-.138	97.961	11.96	710.621	98.415	.417	6.861×10^5
1.15	1005.298	-.181	100.446	13.76	772.913	140.141	.405	8.305×10^5
1.25	1098.710	-.213	102.318	14.64	811.418	173.111	.425	9.027×10^5
1.35	1178.778	-.234	103.541	15.68	848.961	198.780	.417	9.749×10^5

Assembly Configuration - 1
Number of Discs - 0
Tow Point - Between Nose & Tail Sections
Tow Angle - < 2° Tail Up

Notes:

1. Results are in SI units.

TABLE 1

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	542.683	-.055	93.158	1.83	509.660	28.074	1.718	1.805×10^5
.35	560.476	-.062	93.529	2.90	519.564	31.984	.999	2.528×10^5
.45	591.613	-.088	95.028	4.22	524.454	45.968	.868	3.250×10^5
.55	622.751	-.105	96.039	5.15	536.507	56.446	.714	3.972×10^5
.65	662.785	-.116	96.676	6.80	560.270	65.132	.590	4.694×10^5
.75	707.267	-.136	97.831	8.52	579.457	78.956	.537	5.416×10^5
.85	760.646	-.177	100.182	10.25	588.464	104.025	.551	6.139×10^5
.95	796.231	-.195	101.244	11.96	600.504	117.094	.496	6.861×10^5
1.15	969.712	-.262	105.197	13.76	675.447	177.058	.512	8.305×10^5
1.25	1009.746	-.305	107.738	14.64	671.366	204.540	.501	9.027×10^5
1.35	1156.537	-.345	110.207	15.68	738.830	255.207	.536	9.749×10^5

Assembly Configuration - 2
Number of Discs - 0
Tow Point - Between Nose & Tail Sect.
Tow Angle - 3° Tail Down with Ballast

Notes:

1. Results are in SI units.

TABLE 2

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	671.681	-.042	92.418	1.83	645.451	27.231	1.666	1.805×10^5
.35	680.578	-.055	93.158	2.90	638.499	35.171	1.098	2.528×10^5
.45	689.474	-.064	93.653	4.22	636.138	40.536	.766	3.250×10^5
.55	707.267	-.079	94.526	5.15	635.658	50.166	.634	3.972×10^5
.65	725.060	-.092	95.280	6.80	636.658	58.590	.530	4.694×10^5
.75	756.197	-.110	96.293	8.52	644.851	70.688	.481	5.416×10^5
.85	787.335	-.132	97.573	10.25	648.453	85.465	.452	6.139×10^5
.95	831.817	-.156	99.000	11.96	660.684	103.352	.438	6.861×10^5
1.05	894.092	-.179	100.314	12.52	689.207	123.398	.428	7.583×10^5
1.15	951.919	-.204	101.780	13.76	710.134	144.975	.419	8.305×10^5
1.25	1014.194	-.230	103.268	14.64	733.485	168.341	.412	9.027×10^5
1.35	1072.021	-.253	104.642	15.68	754.306	190.667	.400	9.749×10^5
1.45	1156.537	-.269	105.615	15.92	799.653	215.248	.392	1.047×10^6

Assembly Configuration - 3
Number of Discs - 1
Tow Point - Forward of Disc
Tow Angle - 7° Tail Up

Notes:

1. Results are in SI units.

TABLE 3

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	685.026	-.051	92.911	1.83	648.611	32.935	2.015	1.805×10^5
.35	702.819	-.064	93.653	2.90	649.968	41.417	1.293	2.528×10^5
.45	729.508	-.079	94.526	4.22	656.800	51.834	.979	3.250×10^5
.55	796.231	-.094	95.406	5.15	699.152	65.873	.833	3.972×10^5
.65	854.058	-.110	96.293	6.80	731.144	80.148	.725	4.694×10^5
.75	916.333	-.130	97.445	8.52	760.462	98.534	.670	5.416×10^5
.85	991.953	-.156	99.000	10.25	791.651	123.840	.656	6.139×10^5
.95	1072.021	-.177	100.182	11.96	831.632	147.010	.623	6.861×10^5
1.15	1289.984	-.234	103.541	13.76	931.949	218.211	.631	8.305×10^5
1.25	1414.534	-.253	104.642	14.64	1000.355	252.862	.619	9.027×10^5
1.35	1539.084	-.272	105.755	15.68	1065.875	289.415	.607	9.749×10^5

Assembly Configuration - 4
Number of Discs - 1
Tow Point - Aft of Disc
Tow Angle - 13.5° Tail Down

Notes:

1. Results are in SI units.

TABLE 4

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	800.680	-.040	92.295	1.83	772.698	30.945	1.893	1.805×10^5
.35	831.817	-.044	92.541	2.90	795.645	35.273	1.101	2.528×10^5
.45	845.162	-.059	93.405	4.22	786.478	46.716	.882	3.250×10^5
.55	871.851	-.064	93.653	5.15	804.608	51.271	.648	3.972×10^5
.65	920.782	-.072	94.151	6.80	836.253	60.540	.548	4.694×10^5
.75	947.471	-.083	94.777	8.52	843.912	70.281	.478	5.416×10^5
.85	1000.850	-.096	95.533	10.25	871.951	84.067	.445	6.139×10^5
.95	1063.125	-.121	96.932	11.96	891.765	107.621	.456	6.861×10^5
1.05	1112.055	-.127	97.316	12.52	923.739	117.634	.408	7.583×10^5
1.15	1196.571	-.156	99.000	13.76	953.638	149.180	.431	8.305×10^5
1.25	1281.087	-.186	100.712	14.64	981.747	182.474	.447	9.027×10^5
1.35	1370.052	-.200	101.512	15.68	1031.642	205.883	.432	9.749×10^5
1.45	1441.223	-.223	102.860	15.92	1055.283	234.873	.427	1.047×10^6

Assembly Configuration - 5
Number of Discs - 2
Tow Point - In Middle Between Discs
Tow Angle - 4° Tail Down

Notes:

1. Results are in SI units.

TABLE 5

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	929.678	-.040	92.295	1.83	897.521	35.943	2.199	1.805×10^5
.35	956.367	-.053	93.034	2.90	901.825	47.733	1.490	2.528×10^5
.45	987.505	-.064	93.653	4.22	913.089	58.184	1.099	3.250×10^5
.55	1036.435	-.070	94.027	5.15	947.323	66.524	.841	3.972×10^5
.65	1103.159	-.094	95.406	6.80	969.004	91.298	.826	4.694×10^5
.75	1174.330	-.110	96.293	8.52	1006.159	110.295	.750	5.416×10^5
.85	1245.502	-.130	97.445	10.25	1034.939	134.098	.710	6.139×10^5
.95	1316.673	-.145	98.349	11.96	1068.884	155.206	.658	6.861×10^5
1.15	1503.498	-.190	100.978	13.76	1148.503	218.705	.632	8.305×10^5
1.25	1681.427	-.209	102.049	14.64	1255.678	262.115	.642	9.027×10^5
1.35	1823.770	-.243	104.090	15.68	1305.443	318.043	.667	9.749×10^5
1.45	2023.940	-.269	105.615	15.92	1409.168	379.316	.690	1.047×10^6

Assembly Configuration - 6
Number of Discs - 3
Tow Point - Aft of Middle Disc
Tow Angle - 14° Tail Down

Notes:

1. Results are in SI units.

TABLE 6

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	907.437	-.040	92.295	1.83	876.000	35.082	2.147	1.805×10^5
.35	920.782	-.049	92.787	2.90	874.570	42.528	1.328	2.528×10^5
.45	938.574	-.057	93.281	4.22	877.095	50.205	.948	3.250×10^5
.55	943.023	-.064	93.653	5.15	870.746	55.486	.701	3.972×10^5
.65	960.816	-.072	94.151	6.80	872.928	63.195	.572	4.694×10^5
.75	978.608	-.081	94.652	8.52	874.986	70.960	.482	5.416×10^5
.85	1005.298	-.094	95.406	10.25	878.865	82.806	.438	6.139×10^5
.95	1045.332	-.110	96.293	11.96	891.228	97.696	.414	6.861×10^5
1.15	1147.641	-.141	98.090	13.76	934.354	131.489	.380	8.305×10^5
1.25	1192.123	-.156	99.000	14.64	949.217	148.488	.363	9.027×10^5
1.35	1258.846	-.179	100.314	15.68	972.155	174.058	.365	9.749×10^5
1.45	1343.362	-.211	102.183	15.92	996.656	210.337	.383	1.047×10^6
1.55	1427.879	-.230	103.268	17.73	1035.140	237.573	.378	1.119×10^6

Assembly Configuration - 7
Number of Discs - 3
Tow Point - Forward of Middle Disc
Tow Angle - 6.5° Tail Up

Notes:

1. Results are in SI units.
2. Tail Fin Rotated ~5°.

TABLE 7

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	1031.987	-.040	92.295	1.83	996.518	39.908	2.442	1.805×10^5
.35	1067.573	-.046	92.664	2.90	1018.273	47.328	1.478	2.528×10^5
.45	1089.814	-.059	93.405	4.22	1015.475	60.318	1.139	3.250×10^5
.55	1112.055	-.072	94.151	5.15	1013.237	73.352	.927	3.972×10^5
.65	1147.641	-.072	94.151	6.80	1044.075	75.585	.684	4.694×10^5
.75	1183.227	-.088	95.028	8.52	1048.825	91.929	.625	5.416×10^5
.85	1227.709	-.105	96.039	10.25	1057.588	111.268	.589	6.139×10^5
.95	1298.880	-.116	96.676	11.96	1099.340	127.800	.542	6.861×10^5
1.15	1427.879	-.145	98.349	13.76	1158.407	168.205	.486	8.305×10^5
1.25	1516.843	-.163	99.392	14.64	1200.402	195.898	.479	9.027×10^5
1.35	1632.497	-.186	100.712	15.68	1253.739	233.028	.489	9.749×10^5
1.45	1743.702	-.200	101.512	15.92	1316.589	262.750	.478	1.047×10^6

Assembly Configuration - 8
Number of Discs - 4
Tow Point - In Middle
Tow Angle - 4.5° Tail Down

Notes:

1. Results are in SI units.

TABLE 8

U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	1112.055	-.040	92.295	1.83	1073.994	43.011	2.632	1.805×10^5
.35	1125.400	-.046	92.664	2.90	1073.605	49.900	1.558	2.528×10^5
.45	1147.641	-.055	93.158	4.22	1077.420	59.348	1.121	3.250×10^5
.55	1169.882	-.064	93.653	5.15	1081.559	68.919	.871	3.972×10^5
.65	1187.675	-.068	93.902	6.80	1088.471	74.075	.670	4.694×10^5
.75	1218.812	-.077	94.401	8.52	1099.641	84.389	.574	5.416×10^5
.85	1254.398	-.088	95.028	10.25	1110.644	97.347	.515	6.139×10^5
.95	1307.777	-.101	95.786	11.96	1133.109	114.225	.484	6.861×10^5
1.15	1427.879	-.143	98.219	13.76	1162.062	166.134	.480	8.305×10^5
1.25	1499.050	-.154	98.869	14.64	1200.864	185.152	.453	9.027×10^5
1.35	1583.566	-.163	99.392	15.68	1252.836	204.455	.429	9.749×10^5
1.45	1659.186	-.179	100.314	15.92	1285.655	230.188	.419	1.047×10^6

Assembly Configuration - 9
Number of Discs - 4
Tow Point - In Middle
Tow Angle - 1° Tail Up

Notes:

1. Results are in SI units.
2. Tow ~ 2° to Port.

TABLE 9

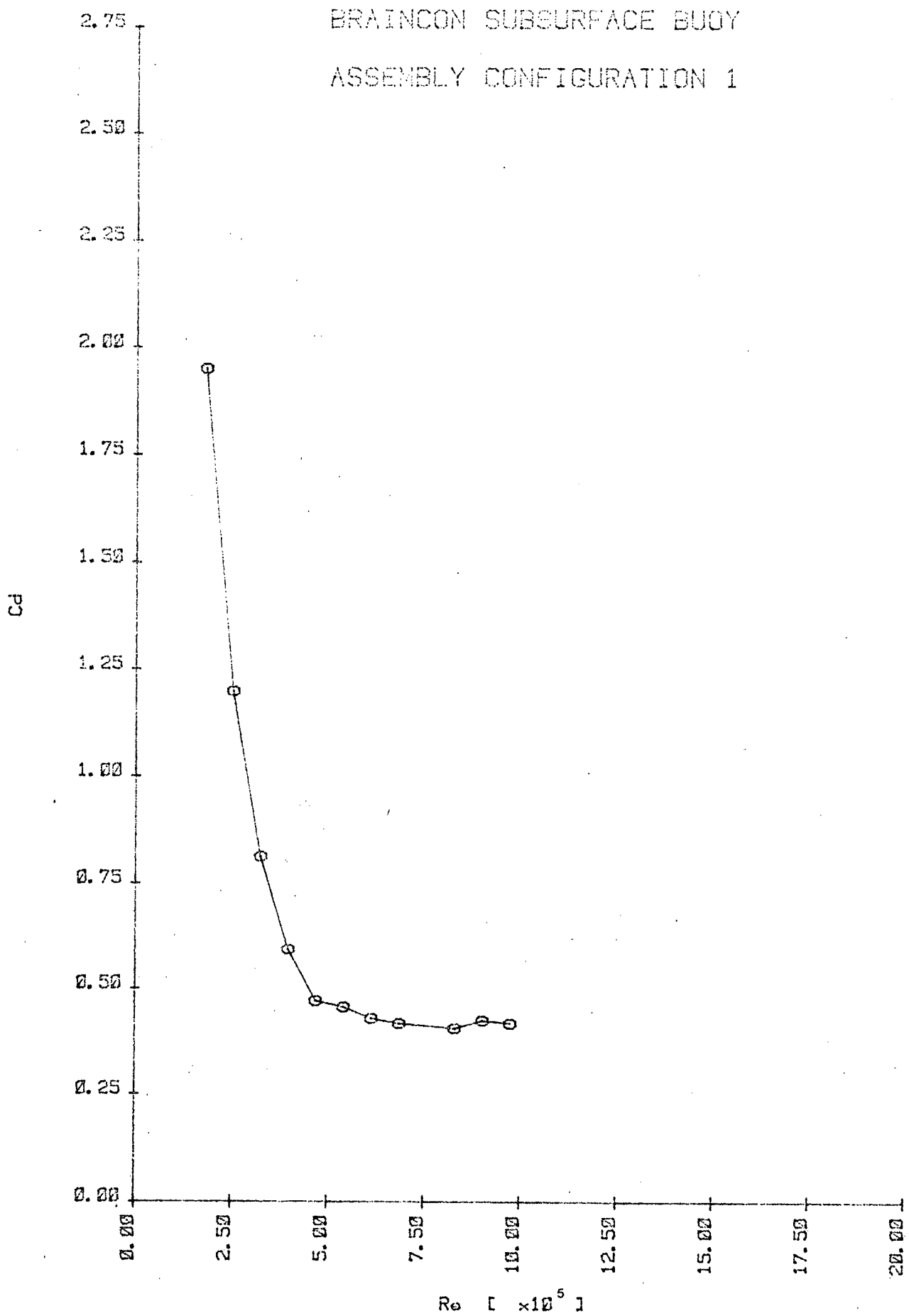
U (m/s)	D_c (N)	Cos θ	θ	D_s (N)	T (N)	D_f (N)	C_d	R_e
.25	880.748	-.044	92.541	1.83	843.836	37.410	2.289	1.805×10^5
.35	894.092	-.057	93.281	2.90	836.753	47.896	1.495	2.528×10^5
.45	907.437	-.064	93.653	4.22	838.684	53.443	1.009	3.250×10^5
.55	934.126	-.077	94.401	5.15	844.253	64.790	.819	3.972×10^5
.65	956.367	-.081	94.652	6.80	856.706	69.478	.629	4.694×10^5
.75	983.057	-.088	95.028	8.52	869.891	76.245	.518	5.416×10^5
.85	1027.539	-.107	96.166	10.25	880.508	94.578	.501	6.139×10^5
.95	1076.469	-.121	96.932	11.96	903.107	108.990	.462	6.861×10^5
1.05	1125.400	-.134	97.702	12.52	925.987	124.107	.430	7.583×10^5
1.15	1178.778	-.154	98.869	13.76	942.177	145.267	.420	8.305×10^5
1.25	1241.053	-.177	100.182	14.64	962.034	170.062	.416	9.027×10^5
1.35	1334.466	-.195	101.244	15.68	1010.336	197.009	.413	9.749×10^5
1.45	1414.534	-.218	102.589	15.92	1041.316	226.957	.413	1.047×10^6
2.00	2068.422	-.358	110.948	28.39	1305.816	466.851	.446	1.444×10^6
2.50	2602.209	-.466	117.779	43.17	1490.176	694.508	.425	1.805×10^6

Assembly Configuration - 10
Number of Discs - 2
Tow Point - In Middle
Tow Angle - 0.5° Tail Up with Ballast

Notes:

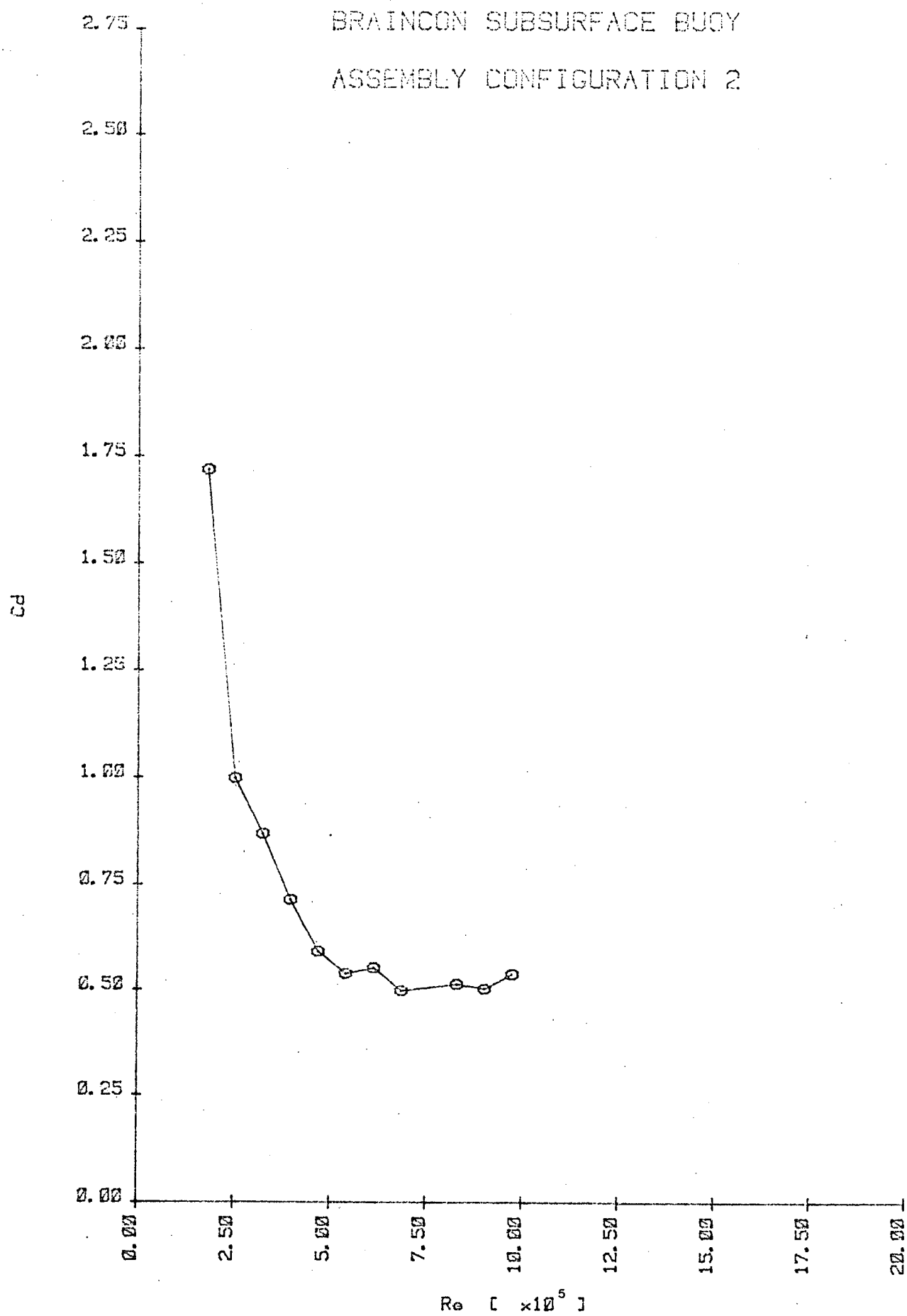
1. Results are in SI units.
2. At 200 m/s float towed ~ 3°-5° to Port & rolled ~5° to one side.
3. At 250 m/s float towed ~3°-5° to Port & rolled ~15° to one side.

TABLE 10



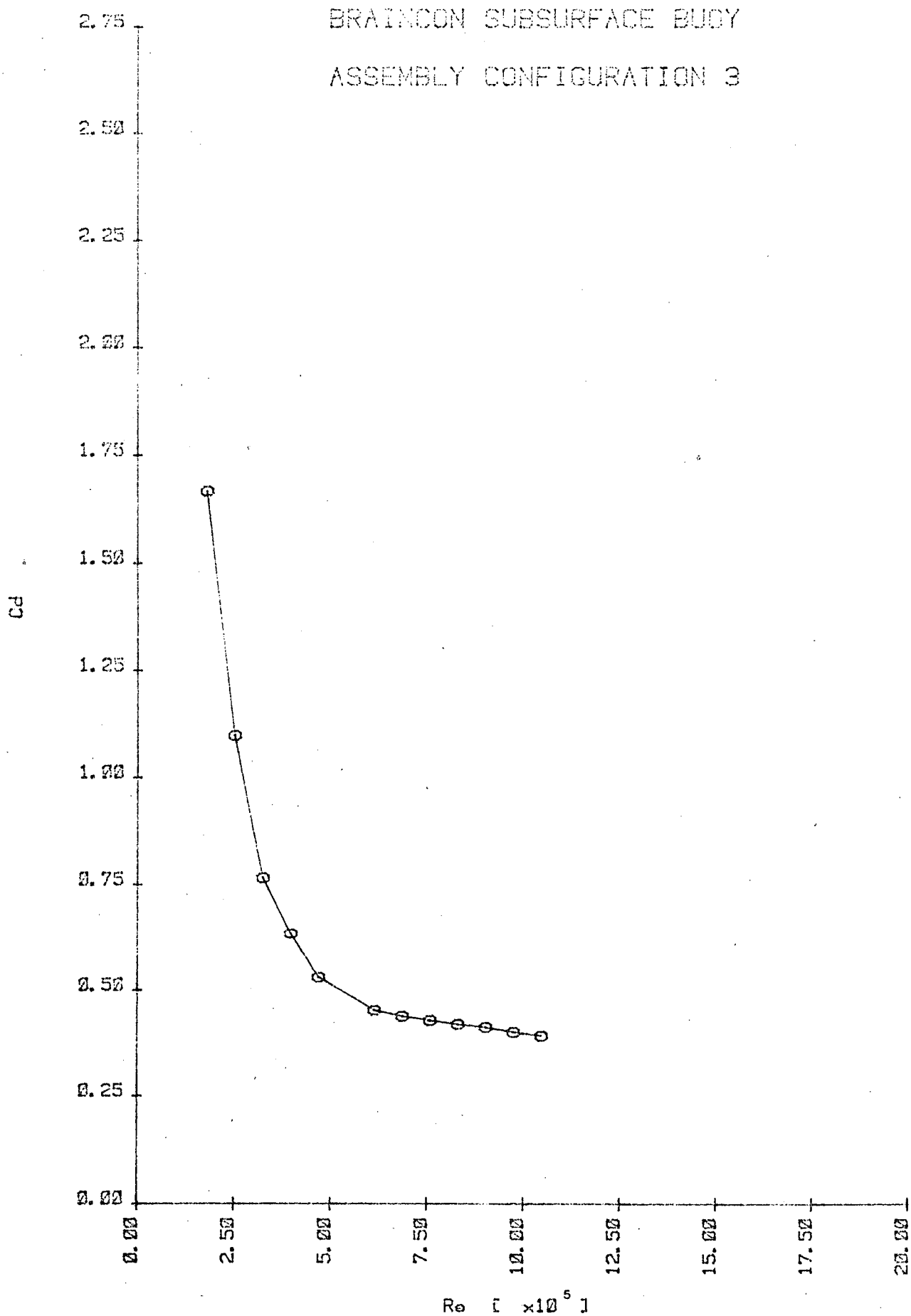
DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 1



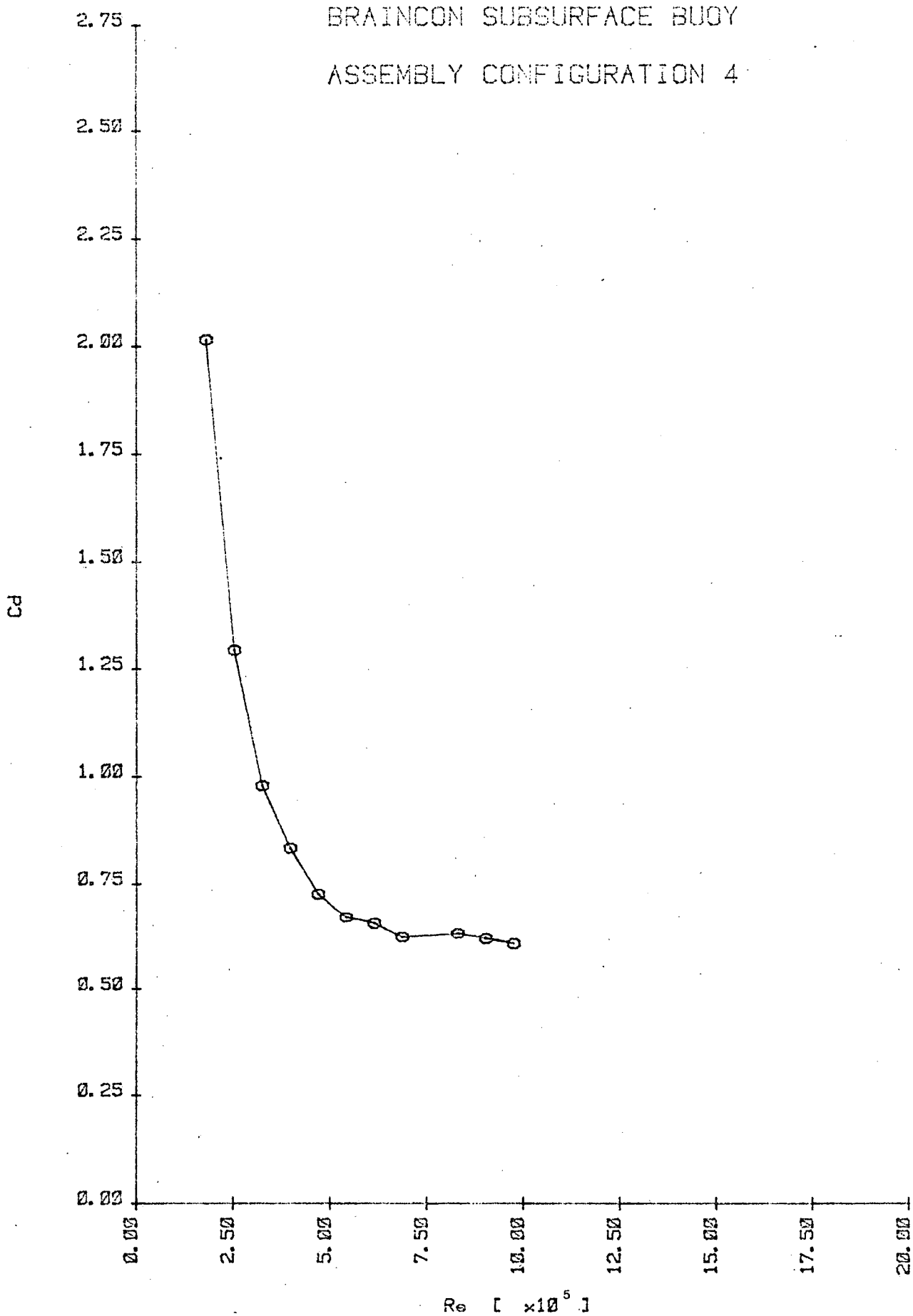
DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 2



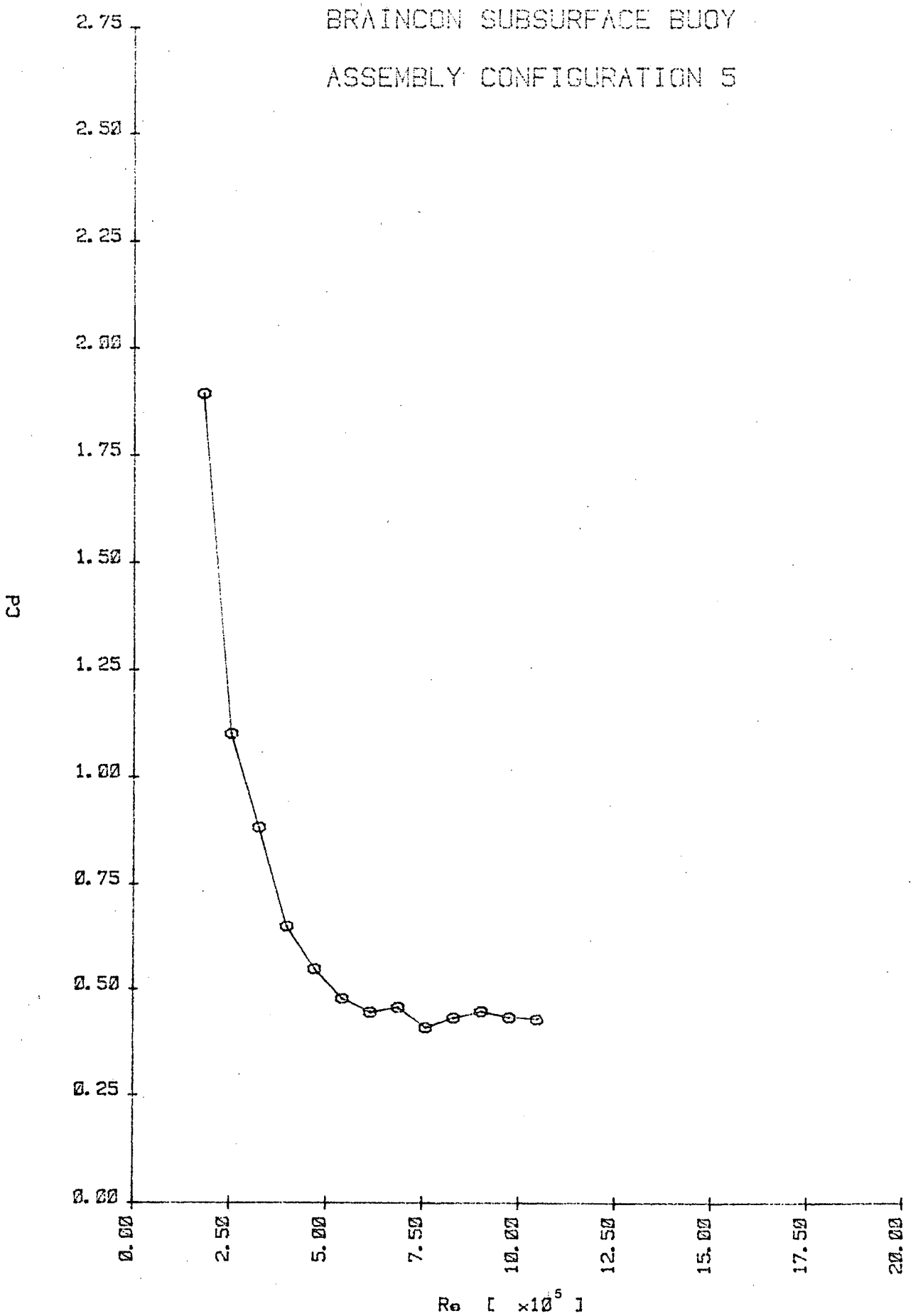
DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 3



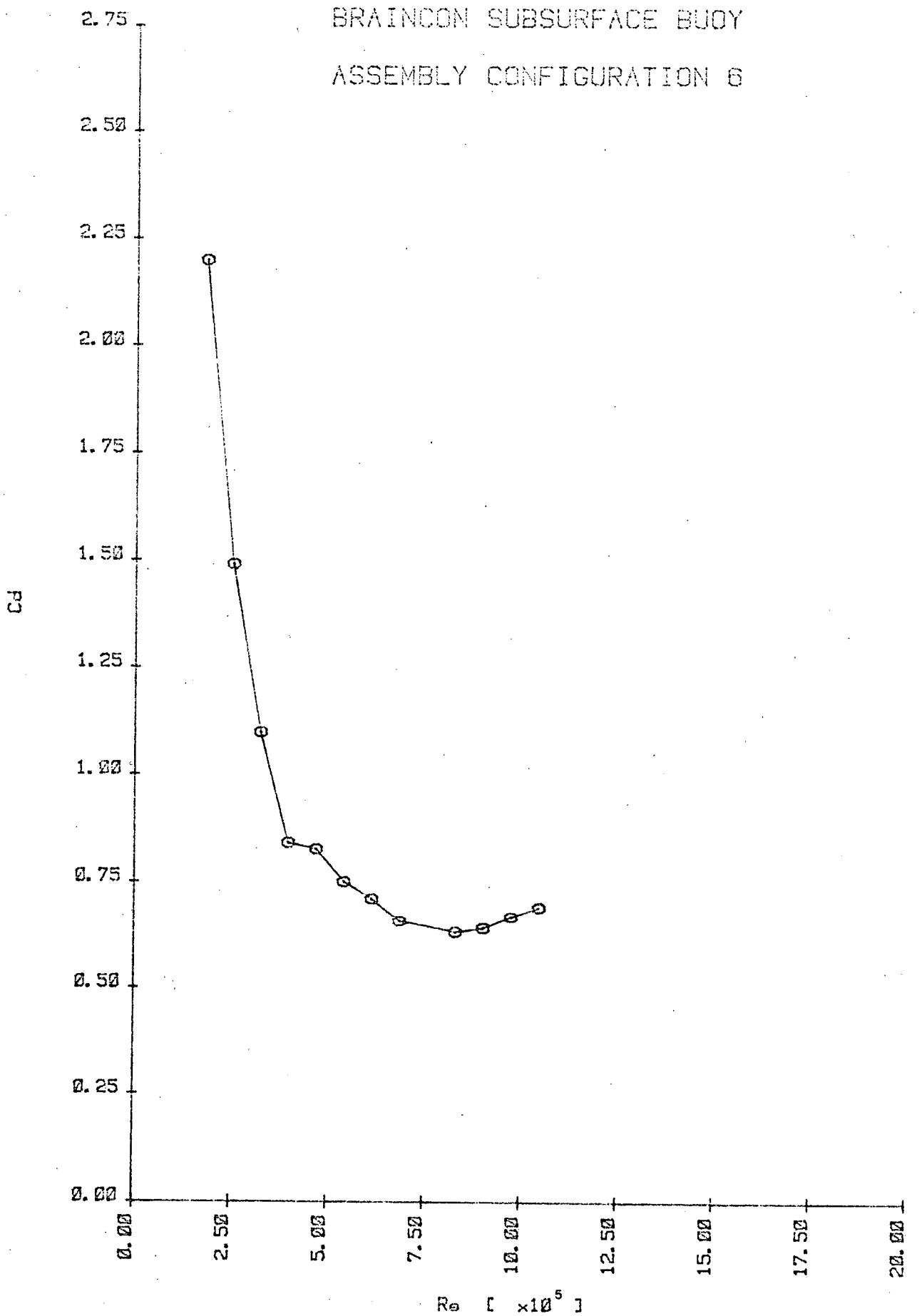
DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 4



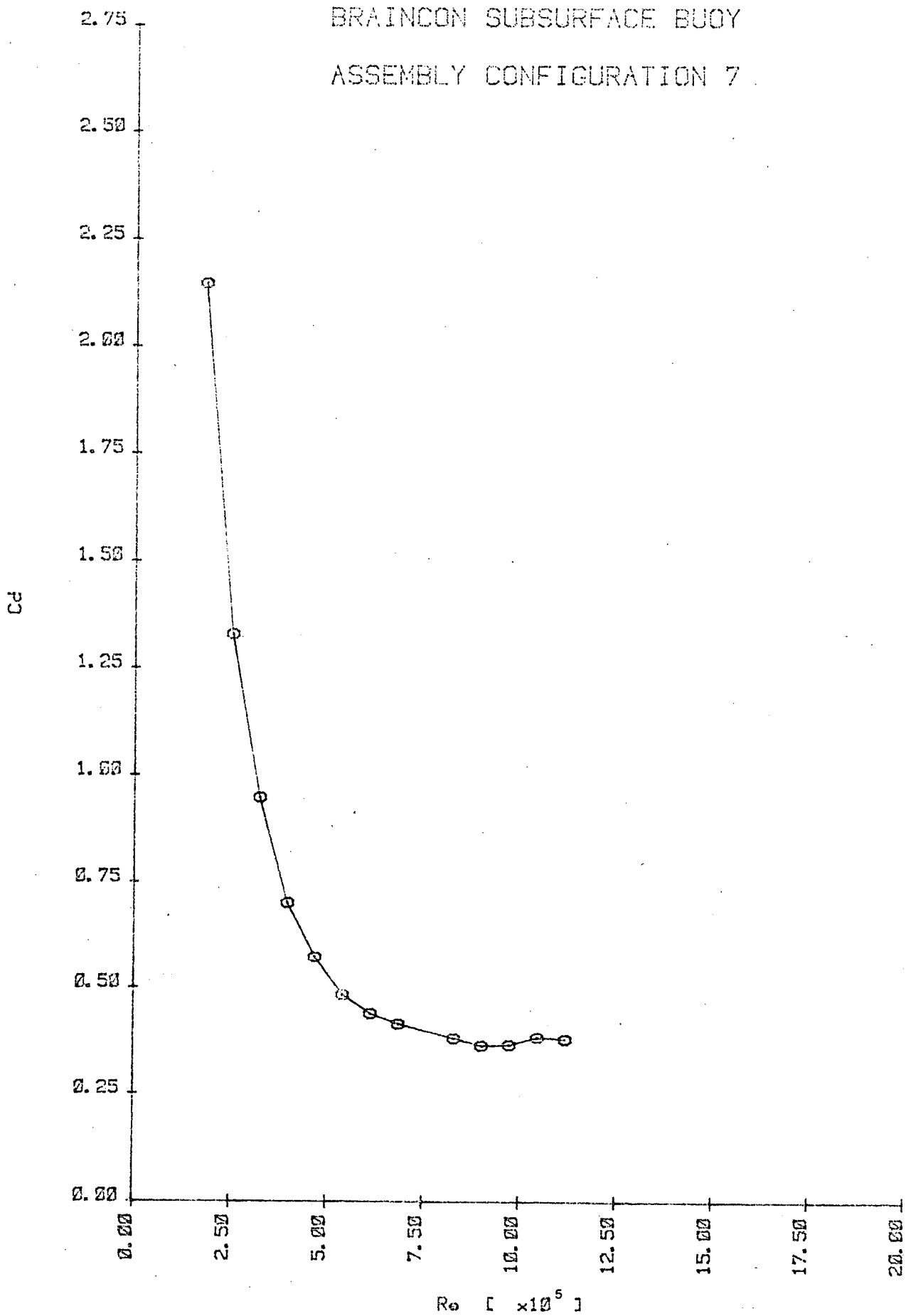
DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 5



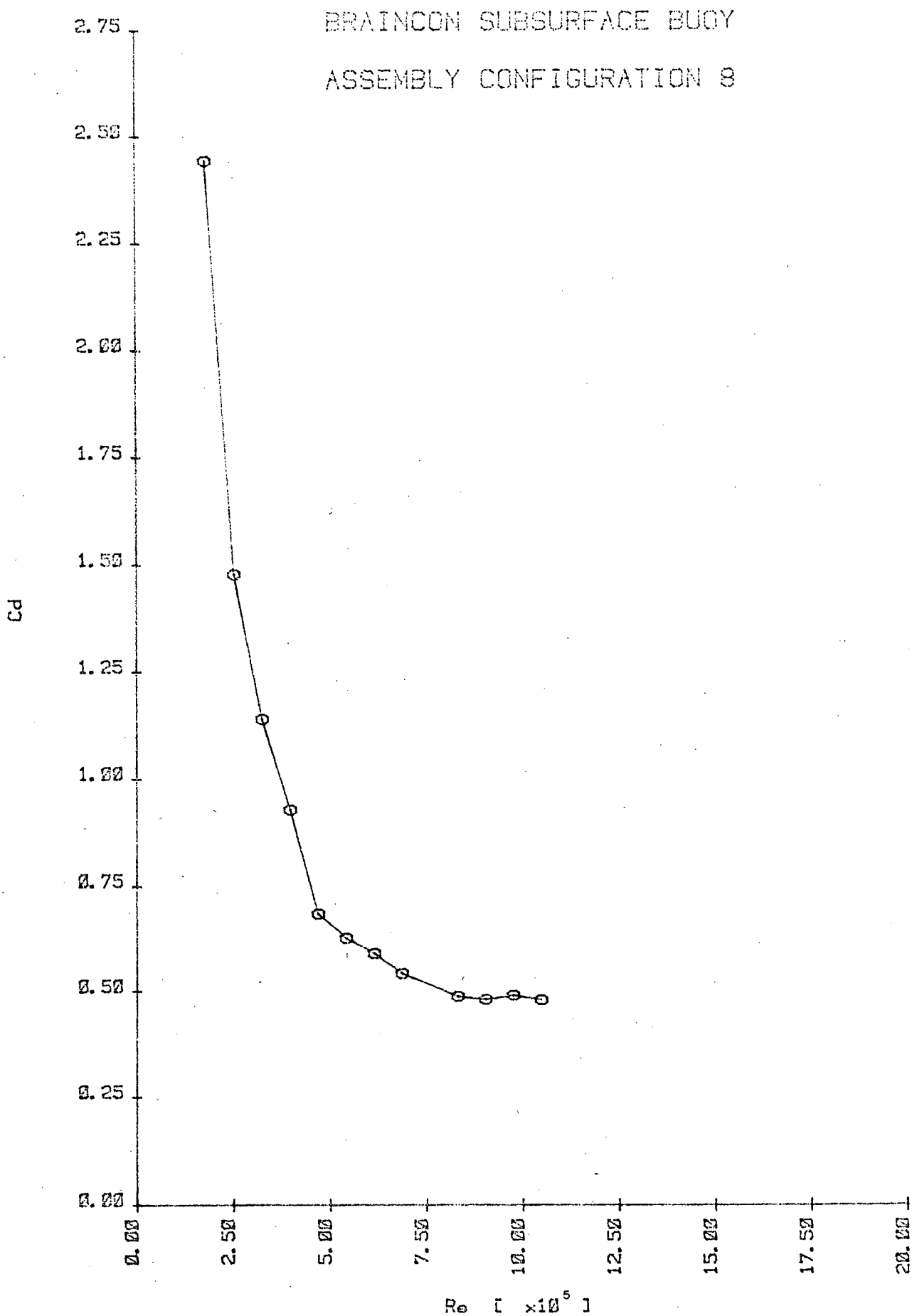
DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 6



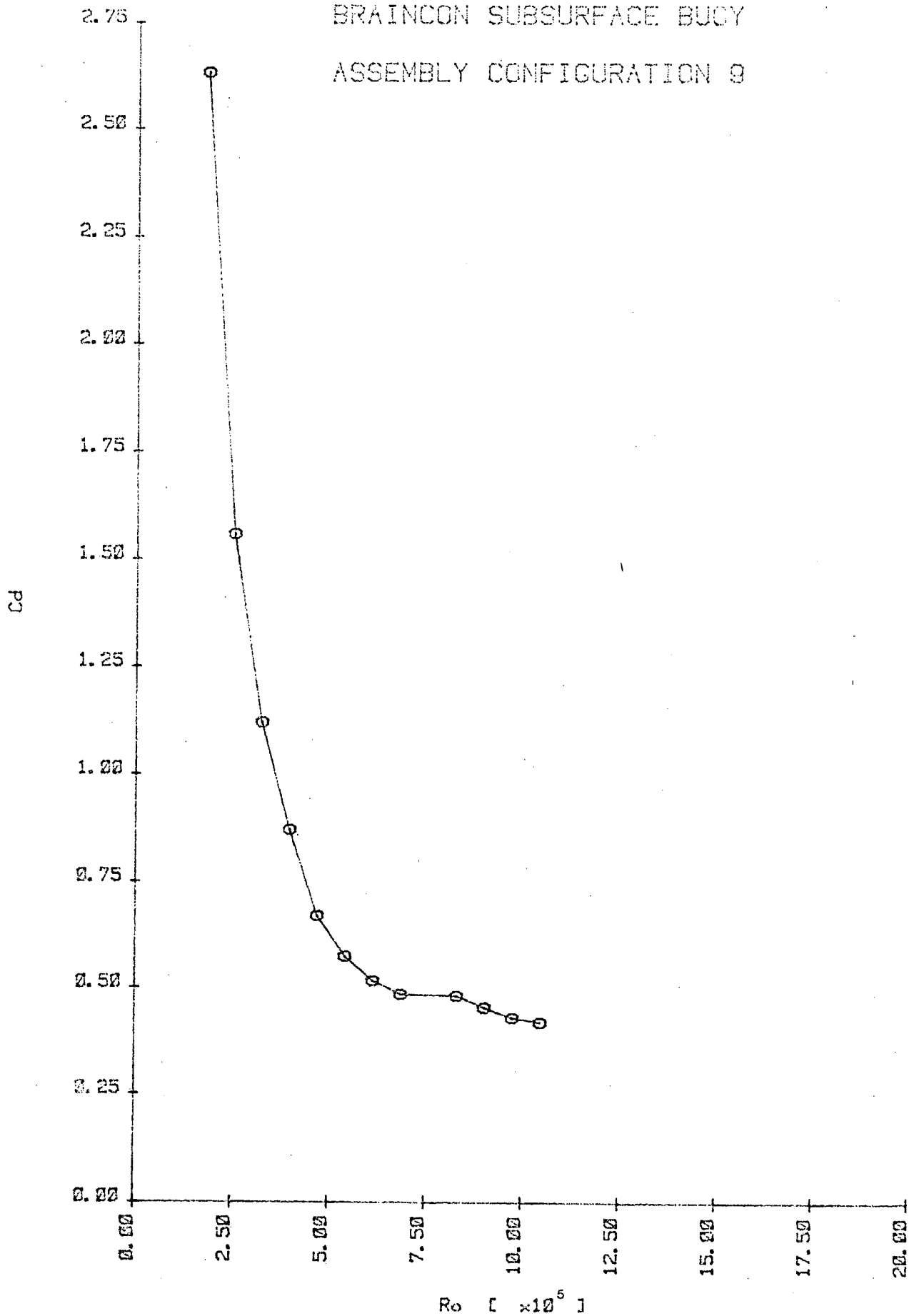
DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 7



DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

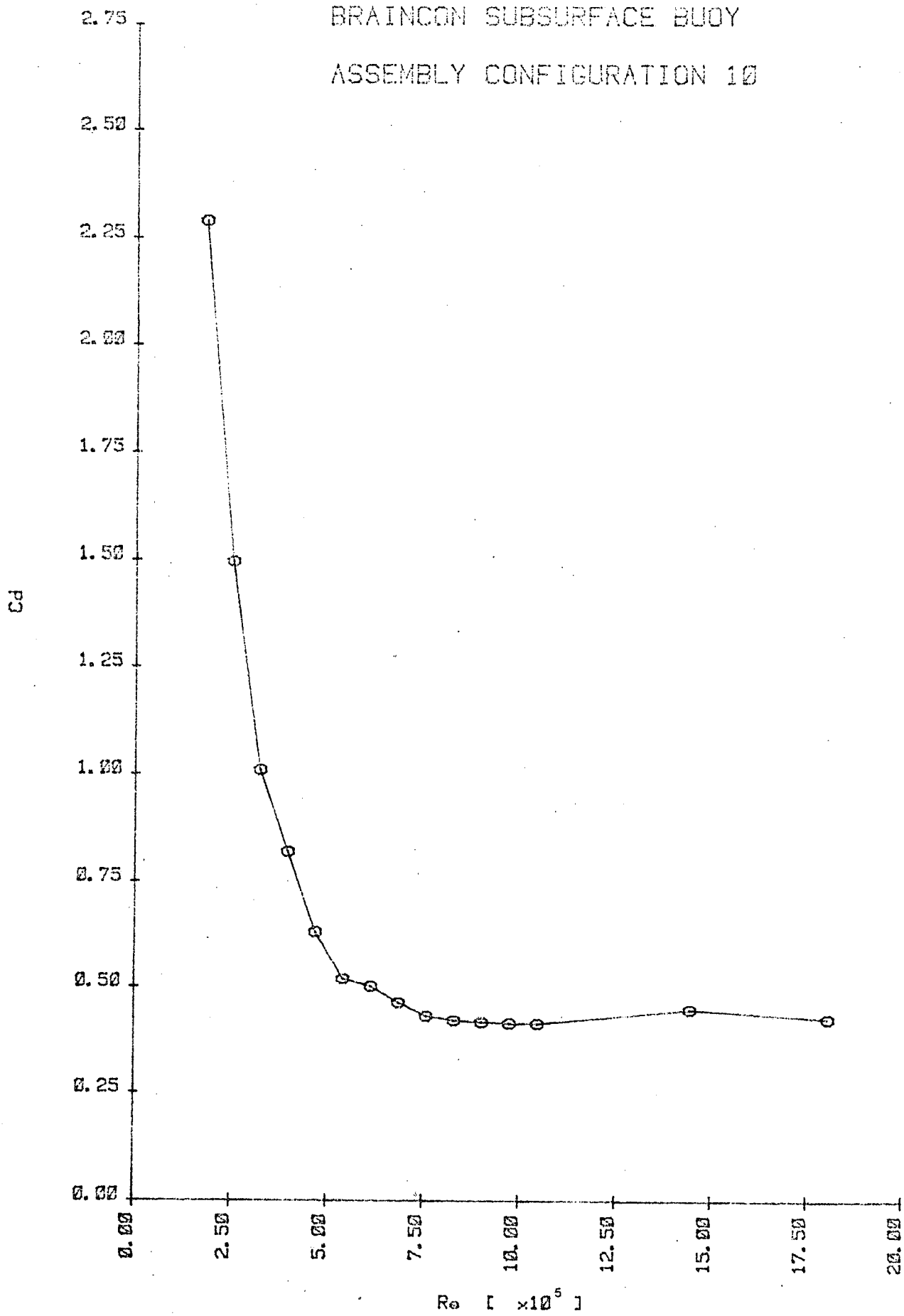
PLOT 8



DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 9

18192



DRAG COEFFICIENT VERSUS REYNOLDS NUMBER

PLOT 10