NAVY DEPARTMENT

THE DAVID W. TAYLOR MODEL BASIN

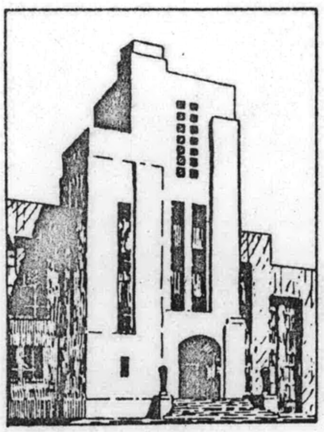
WASHINGTON 7, D.C.

REPORT ON GEOSIM ANALYSIS ACCORDING TO SCHOENHERR LINE

by

W.B. Hinterthan

Report to be submitted to Fall Meeting of
The American Towing Tank Conference, 1956



RESEARCH AND DEVELOPMENT REPORT

July 1956 Report 1064

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ABSTRACT

The report deals with the compilation and analysis of geosim resistance data for use by the Skin Friction Committee of the International Towing Tank Conference in its search for a new "Engineering" friction line. In determining the "Engineering" friction line careful considerations were given to some important points with a view to coordination between model basins to reach international agreement.

The London Conference in 1948 realized the desirability of finding a single friction formulation which would be acceptable to all workers in this field. A Skin Friction Committee was therefore appointed to survey the problem of skin friction and the roughness effects and to recommend a formulation.

Representatives of the various towing basins of the ITTC have been unable to agree on a friction line. The Skin Friction Committee of the International Towing Tank Conference was therefore directed to develop a universally acceptable "Engineering Line" for use in extrapolating from ship models to full-scale. This contribution deals with the compilation of geosim resistance data for use by the Skin Friction Committee of the International Towing Tank Conference in its search for a new friction line. Model resistance data for geosim-series have therefore been compiled and analyzed according to each of several currently proposed friction lines. Resistance data for geosim models tested at TMB have been distributed to other basins (page 15) for analysis according to their methods and TMB analyzed the model data from TMB and other basins using the Schoenherr Formula.

In determining an "Engineering" friction line it appeared to be more accurate to employ geosim models than flat planes from considerations of curvature (three dimensional flow). During this analysis it was found that careful consideration should be given to some important points with a view to coordination between Model Basins to reach international agreement. Some of these points have been considered at conferences but no agreement has been reached or the agreements have not always been observed. Some of the main features that were found during this analysis to influence the model results are:

1. the material, and
2. the method of manufacture of the models,
3. the finish and
4. the roughness of the surface,
5. the stimulation devices used,
6. the size of the basins, and
7. the coefficients and constants used in the various basins.

Further points to be considered for better coordination would be the investigation of the sources of error in testing models which might lead to some revisions of techniques and procedures. These sources of error in any type of testing can be roughly divided into the following items; instrumental equipment, technique and personal idiosyncrasies. The various data presented herewith have not been critically examined, and were plotted without any critical review and without any correction. The results are for a wide range of entirely unrelated ship forms with block coefficients varying from 0.50 to 0.80. The original data were used to calculate each of the test spots, which were then plotted to a base of Reynolds number, the ordinates being values of the total resistance coefficient C_t. The residuary resistance coefficients C_r, determined from the largest model by subtracting the Schoenherr C_f values from the total resistance coefficients C_t are assumed to apply directly to the small models at the corresponding values of $V/\sqrt{L}$. Subtracting these C_r values from the measured C_t values of the smaller models then gives the values of C_f necessary in order to give agreement between the large and small models. It was hoped that by a statistical examination of these spots a smooth frictional line could be deduced in the model range which would be sufficiently accurate from an "Engineering" point of view. The C_t and C_f values are plotted against the Reynolds number in two different scales on each sheet to avoid confusion among the two values at lower Reynolds number. (A-Series: Figs 1-11; B-Series: Figs 12-25)

This method reflects all the experimental inaccuracies, turbulence difficulties and even wall effect. In preparing these charts the following assumptions were made: (a) The flow around the largest model was considered to be fully turbulent, no correction being made for laminar flow influence. (b) The blockage coefficient was considered to be so low that no basin wall interference was expected. (c) Residuary resistance coefficients were considered to be equal at the same $V/\sqrt{L}$ values for different sized geosim models and (d) the Schoenherr friction formulation was used for the large model.

Constant speed-length ratio curves were obtained by connecting the intersection points of the faired C_t values and the corresponding Reynolds number. No temperature corrections are included, i.e. the C_t values of the various geosim models are calculated at the tested temperature, but of course using the correct values of ν.

Tests were not always carried out under conditions as uniform as desirable. The models and the conditions under which they were tested vary and there are many discrepancies in the data. For instance, systematic resistance tests on geosim models were carried out at various drafts but yet at the same stated displacement, the wetted surface was said to be the same with and without rudder, the stern form was changed from a twisted form to a symmetrical form etc.

The models have been grouped into two series A and B. A list of which are given on pp 16 and 41. Particulars of models and ships of the A-series are given on pp 17-27, and corresponding tables B-1 to B-11 of the B-series on pp 42-56. TMB, over the past several years has had the opportunity of comparing a number of tests of small models with tests of 20 and 30 ft models. These are combined in group A while the B group contains geosim model series by other basins.

Figure 26 contains all the spots for all models from the previous geosim plots on a single sheet, showing the inordinate scatter.

In order to eliminate the worst cases of laminar flow at the low Reynolds numbers and the effect of tank wall interference at the high Froude numbers, it was decided to try limiting the data to the speeds in the neighborhood of the design conditions for each ship. Using the Troost formula for service speed $V_S/\sqrt{L_{BP}} = 1.85 - 1.6 \cdot C_p$ the range of plotting was limited to speeds from 10 per cent below to 5 per cent above the Troost speed. The resulting plot is shown in Fig. 27.

Figures 28-30 show the influence of the various stimulating devices. The derived frictional coefficients for models stimulated by studs or trip wires, Fig. 28, as well as for those stimulated by rods, Fig. 29, are scattered around the Schoenherr friction line, especially in the middle and higher Reynolds number range. The sand strips increase the frictional coefficients in the lower Reynolds number range, Fig. 30, while the bare hull test results are low and scattered due to laminar areas on the hull surface.

In examining these deduced frictional spots a number of factors should be borne in mind.

The TMB wood models were rough-cut with station cutters, faired by hand, sanded and sealed. The painting system consisted of one coat of flat white primer, one undercoat and one finishing coat of French Grey Enamel. The models were rubbed smooth between coats.

The wooden model (L = 5.029 ft) of the A-4 series was built at Stevens Institute and finished with four or five coats of clear varnish with a final rubbing with 400 wet or dry paper. The surfaces of new models at this establishment are washed with Murphey's soft soap and then soaked for about five hours in water having the same temperature as the basin. Care is taken that the models are subsequently untouched on the underside. For further tests, models are soaked for one or two hours, depending on the time between tests. If the models show evidence of hand prints, they are washed again with soft soap.

The A-2/3 series was published by Captain H. E. Saunders (1). The evaluation of the Liberty B-1/2 series was based on tests dating back as far as 1947, which confirm the scattering of the present test results. The B-3 results of tests on a series of geosim models of a liner of moderate speed, "SS SIMON BOLIVAR" (2) were carried out in Holland. Seven models have been evaluated in the Victory Ship series. The calculations were based on the NSMB - test results as published by Van Lammeren, Van Manen and Lapp (3). All models were tested in heavy and light conditions with and without stimulation.

The models investigated in the B-10/13 series were made of paraffin and were symmetrical about midships. The straight ends and the symmetry about midships means that the models can be regarded as being intermediate between actual ship models and friction planes (4).

The results of the series B-14 are derived from tests with the destroyer "WRANGEL" as published by H.F. Nordstrom (5).

The main characteristics of the model and ship as well as the controlling form factors $\nabla^{1/3}/L$ and L/H are given on pp 16 and 41.

Analyzing the A-Series, it will be noted that most of the available comparisons occurred between two models: a 20 ft and a 4 to 6 ft model. It is clear that when there are only two geosim in a series it is difficult to derive a friction line. A mean line has been compiled from many tests over several years which in the low and middle range of Reynolds numbers can be approximately represented by the following formulation:

$$C_f = 0.50 \, (\log R)^{-2.58}.$$

As indicated, most of the smaller models have been tested at TMB in basin 4. The dynamometer used in the 140 ft basin is of the gravity type. The electronic interval timer measures the speed of the model to an accuracy of 0.001 knots. Some of the small models have also been towed in the large TMB basin by means of a "dual-force" gage based on strain gage measurements (see A-1)

It should be noted that in a number of cases the smaller geosims have a larger blockage value than the larger models because of the relative sizes of model and basin. An attempt to develop a relation between blockage, size of model and resistance results failed.

Comparison of the B-7/8 series for "LUCY ASHTON" in terms of model size and cross sectional area of the various basins used in the tests indicates that the resistance for the 30 ft geosim in Washington is higher than that in Teddington in spite of the fact that the Washington blockage value is distinctly smaller. Similar discrepancies occurred when comparing the (C) values of the Standard BSRA model ($C_B = 0.75$) as tested in basins of various cross sectional areas at three constant $V/\sqrt{L}$ values; no relation could be obtained between the cross sectional area and the size of models.

An extra large model (L = 29.32 ft) of the NORTH CAROLINA Class (A-3) was built to study wall effect in the Washington EMB basin. Because of the obvious wall effect on this large model at Reynolds numbers above 2.6×10^7 the 25.60 ft model was used as a basis. In general the plottings are self explanatory relative to the type and degree of stimulation.

In some cases a model other than the largest should have been selected as the reference model, bacause of wall effect on the larger ones. However, a standard procedure was adopted and followed throughout, using the largest model in each series as the reference point, so that no personal selection would influence the comparisons.

It is difficult to draw deductions from the plot of C_t since many of the C_t curves do not indicate any leveling out at low speed-length ratios ($V/\sqrt{L}$). Mr. A. B. Murray (8) has carried out a comparison of large and small model results in an endeavor to determine frictional resistance coefficients at low Reynolds numbers. Mr. Murray showed that for the available comparisons between ETT and TMB models, the Schoenherr line was probable as good a mean as could be drawn.

The material of ship models differs widely. The quality of wood and paraffin is not the same in all establishments, Fig. 31, nor is the paint used for brushing or spraying wood models.

According to a report given to the VII. International Conference on Ship Hydrodynamics (6) paraffin models mostly have to be seasoned by keeping them under water for several days before testing. Without such precautions their resistance may be higher by as much as 10 per cent due to saponification or surface electric charge. A seasoning of an equal number of days has been considered necessary before resuming the tests with a model kept out of the water for a certain time. This procedure seems to be of doubtful value, since the basic materials of paraffin differ in the various basins as shown on Fig. 31.

Other basins recommended the treatment of paraffin and wood models with gum lac varnish.

Even the wooden models covered with paint and enamel do not seem to be uneffected by the degree of drying up of the paint or by seasoning. Thus the quality of the material and the seasoning are points of uncertainty that have not been made completely clear, though, when turbulence stimulation devices are used, the problem may be perhaps less evident.

Inconsistency of model roughness influences the analysis of resistance tests. Because frictional resistance in relation to the total resistance is in most cases large, inaccuracies in the calculation of the frictional resistance logically lead to dis-proportionate differences when determining the form resistance. Therefore knowledge of the magnitude of the roughness of ship models, especially in the vicinity of the leading edge, is of the most importance. Measures should be taken to develop a standard procedure and a standard instrument for measuring the roughness of models in all basins.

The roughness of the wetted surface of wood models used in the various basins differs, and also differs when compared with wax models. Model surface roughness measurements are very scarce. The wooden models of the Rome Basin are reported to have a roughness of about 75 to 150 micro inches (about 2 to 4 μ*); which can be compared with a roughness of nearly 30 μ for new steel plates on ships when covered with anti-corrosion paint. The roughness of the model surface using the specially developed wax at TMB has been found to vary between 3 and 7 μ with single values of 2 to 8 μ while the roughness of paraffin models, not including the air bubbles, amounts to 3 to 15 μ. The conclusions reached are that there is no large difference in the magnitude of the roughness of the different blends. Brief check tests between a wax and an identical wood model both 7 ft in length, the hull surface of the latter being sprayed with the standard French grey enamel, gave no significant difference in resistance.

The waviness of paraffin, which originates from the scraping process and depends on tool pressure, is about 50 μ between the crest and the trough. It is suspected that the use of other materials such as wood will give nearly the same conditions, waviness appearing here as a result to the grinding process necessary for priming and varnishing. The logical

* $1\mu = 10^{-6}$m = 3.937×10^{-5} inches.

conclusion is that hand working does not give the required exactness. The model should be worked by machine as much as possible; hand working should be kept to a minimum and tools should be used which are supported over a large area, such as planes etc. Paraffin models have been painted with lacquer in order to compare the varnished surface with a smooth paraffin surface. No substantial difference in resistance was observed.

Careful and extensive research with identical paraffin and wood models, and with paraffin and wax models, painted or not, has shown only minor variation in resistance. Moreover, the fact that a little roughness has no influence at low Reynolds numbers is due to the fact that the grain permissible for models is on the average 5 times greater than that permissible for ships to maintain hydrodynamic smoothness. Thus a moderate amount of model roughness is not necessarily an inconvenience, and it may avoid the laminar flow problem when testing models of $C_B < 0.65$. Models of full ships ($C_B > 0.65$) of about 20-ft length give rise to a serious stimulation problem since laminar or transition flow is present and turbulent stimulation devices should be used.

Stimulation devices are one of the weakest links in the chain of model coordination on geosim model series. The work on turbulence stimulation should be directed towards the adoption of standard devices, and special consideration should be given to the development of techniques for stimulating turbulence especially on the smaller models. In this connection it should be mentioned that no reduction for the drag of the stimulators has been considered, nor are corrections included to balance the resistance difference between laminar and turbulent flow at the forward end at lower Reynolds numbers.

The general question arises whether, with induced turbulence, satisfactory correlation is indeed possible. The devices are mostly attached to the model at $0.05 \cdot L_{BP}$ aft of the forward perpendicular. The first 5 per cent of the model length contains about 2 per cent of the wetted surface. The resistance of the devices is taken to be equal to the reduced resistance forward of the stimulating devices because the flow there is laminar instead of turbulent a very debatable assumptions. In computing the results of tests on different size models with the same type of stimulation, no account has been taken of the fact that turbulent motion has its own descriptive parameters, and that the position of the transition in a turbulent boundary layer depends upon the values of these turbulence parameters as well as upon the size of the model.

<u>Trip Wires</u>

A trip wire 0.039" in diameter (1mm = 0.03937") was generally used at 0.05 L_{BP} aft of the forward perpendicular. But 0.032 and 0.036 inch wires have been used too. In the B-13/14 series the diameter of the wire for the smallest model was reduced from 0.039" to 0.019". The effectiveness of a trip wire as a stimulator varies along the perimeter of the station. The curved parts, developing a thinner boundary layer, will be more effectively stimulated than the straight parts. From an ideal point of view, the diameter of the trip wire should vary. The wire should be guided into the model just above the waterline to avoid variation in parasite resistance due to the dependency of wave formation on speed.

The trip wire should be fitted as close as possible to the model surface and fastened by the least number of staples. The first staple should be located about one inch below the waterline to avoid wave interference. It is recommended that tests be made with the wire cut in half in longitudinal direction so that the flat part faces the surface, in an effort to see if the parasitic resistance can be reduced and still maintain the stimulating effect.

The standard studs used at TMB are 1/8" diameter and 0.1 inch high at 1" spacing. The location of the studs is in most cases in accordance with the recommendations given by Allan and Hughes (7), i.e., the distance aft of the stem depends on the half angle of entrance of the relevant waterline. The cylindrical projections were obtained by cutting brass wire into lengths of 0.30 inches; o.2 inch of the length was reduced to a diameter of 0.02 inches. The thinner part was driven into the model thus automatically giving the required projection height. In a separate test on the B-5 Series, smaller "pins" 0.036" diameter projection 0.028" at 1/4" spacing were used in hope that they might be more effective than studs, but the results do not indicate any advantage.

The standard strut is a rod of 1/8" diameter, extending 1 inch below the bottom line of the model having a forward rake of 20 degrees and located at 0.05 L_{BP} ahead of the leading edge of the model at the load waterline.

Where sand strip stimulation has been used at TMB a standard size of sand grains of 20 to 30 inch mesh has been used for all model lengths. The size of grains is regulated by sifting the sand in standard sieves, so that grains which pass through a number 20 will not run through a number 30 mesh. A 20 mesh corresponds to a grain size of 0.0331 inches, a 30 mesh to 0.0232 inches. These sand granules are sifted on to the prepared surface, distributing them as uniformly as possible. In general the sand is located at 0.05 L_{BP} aft of the forward perpendicular, arranged as a 1/2" wide strip.

Applying a sand strip at the stem influences the form resistance of the model. The small eddies trailing from the individual sand particles are injected into the friction layer to cause instability, but they also cause extra resistance on their own account.

The method of applying sand strips on both sides of the stem and a horizontal strip one inch below the waterline extending back to a point where no bow wave interference could take place, has also been used.

Since the possibility exists of laminar regeneration after the turbulent flow has been stimulated, three or four vertical sand strips are sometimes distributed along the length of the model to maintain turbulent flow. The state of turbulence in the tank water is also of importance in this problem and is affected by the time interval between runs and the speed of return.

In Figs. 32-36 are given the dimensions of the various basins in order to provide a basis for the corrections which might be applied to the measured resistance results to predict the various components of the resistance. The values of a/A given in the analysis are "blockage" values, "a" being the maximum cross sectional area of the model and A the tank cross section area. For the trimmed condition, "a" corresponds to the maximum sectional area.

The existing wall effect on the measurements can be eliminated in various ways. The N.S.M.B. method is based on the well-known "image effect" while other basins are using other methods.

Other points to be considered for better coordination of results are:

1. The <u>nautical mile</u> to be used in the calculations is that adopted by the International Hydrographic Bureau in 1929, and now in general use in the U.S.A. This nautical mile has a length of 1852 m or 6076.1033 ft (see International Meeting of Tank Superintendents, Berlin 1937, page 98-99). According to this definition the conversion factor from knots to feet per second (ft/sec) is 1.6878 and not as commonly used 1.6889.

2. At the 1935 International Conference it was agreed that the kinematic viscosity should be in accordance with the Tables of Lyle and Hosking. In 1942 the American Towing Tank Conference adopted somewhat different values. Pages 84-86 show the various values used in the different basins.

As far as the calculation of Reynolds Number is concerned, the difference is comparatively small, but in the interest of consistency, it would be of advantage to use agreed values.

3. The values for the acceleration due to gravity (g) for mass density (ρ) and kinematic viscosity (ν) used in model displacement calculations at TMB are based on a temperature of 68°F (20°C) and the latitude of Washington, D. C. These values, as adopted by the ATTC in 1942, are given on page 85. If other values are used, it is important to indicate them. Where model test results are reported the actual test temperature should be reported to the nearest half of a degree.

4. The proposal that all calculated ship data should be corrected to a standard temperature of 59°F (15°C) is generally supported. In most cases the salinity is not given. In general the values for the ship are for 3.5 per cent salinity, 45° north latitude and 59°F* (page 87). Agreement should be reached about the average specific salinity of the various oceans or seas. (North Atlantic: 2.5%, Baltic Sea: 2.8, Adriatic Sea: 2.9, Pacific Ocean etc).

5. When using the ATTC data the ratio of the displacements of ship and model becomes:

$$64.043\,\lambda^3/62.2745 = 1.0284\,\lambda^3$$

*Paris Conference 1935.

These values are very important since in most cases the model displacement is calculated from ship displacement.

6. The displacement of the model should be given in cubic feet rather than in pounds. Values in pound include already coefficients which might differ in the various basins. (Fig. 40).

7. The length used in determining the frictional coefficients of model and ship - the Reynolds numbers, etc. - is that on the LWL i.e. model length on the load waterline at design draft. This same length is used for all other model displacement conditions, even though the wetted waterline length in such condition may be different. (In general the length used in speed boats and sail boats does not follow this procedure). In some countries the L_{BP} is preferred on single screw ships. Agreement should be reached upon these discrepancies. The particulars of the ships for the comparative tests should be given in molded dimensions.

8. Since the rake of stem in many recently built ships is rather large it seems to be necessary to give some information about the slope and the form of the stem (round, bar, etc.)

9. L_{BP} is the length on the waterline at design draft measured from the fore side of the stem to the after side of the rudder post, or to the centerline of the rudder stock. The definition of L_{BP} varies in different countries.

10. The Wetted Surface.

Regarding the calculation of the wetted surface the Committee recommended that the mean girth multiplied by the length should be adopted as the wetted surface. No objection was seen in neglecting the small correction for obliquity. The mean girth is to be computed by Simpson's first rule, using 20 equally spaced stations.

The wetted surface is to be computed in two steps: (a) bare hull and (b) appendages.

(a) In some cases there seems to be some doubt whether the rudder is part of the bare hull or not. Whenever the rudder is included in the total wetted hull surface, it should be so stated. It often happens that the resistance without rudder is higher than with rudder, due to the eddy shedding at the blunt stern post. In such cases the special circumstances should be pointed out.

(b) Wetted Surface of Appendages

Procedures vary immensely in this matter. Some basins neglect the wetted surface of struts, intermediate struts and shafts, while other basins add only half the wetted surface area of these appendages to the bare hull wetted surface at rest.

The calculation of the EHP is treated differently with regard to the wetted surface of the rudder. Some basins neglect the rudder area in their calculations, while others include the rudder surface.

CONCLUSIONS

The analysis indicates that more careful consideration should be given to the methods of testing models with a view to obtaining agreement between the results of experiments made in different model basins. Looking at the results from a general point of view, one is led to the conclusion that the accuracy necessary for definite information has not yet been obtained. In endeavoring to determine an "Engineering" line from these data, special care should be paid to the stimulating devices used and to the possible influence of wall effect.

The results would suggest a friction line somewhat steeper than the Schoenherr line within the longer range of Reynolds Numbers, say below 10^7. The desirable trend at higher Reynolds numbers can only be determined by a consideration of full scale ship data.

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INTERNATIONAL TOWING TANK CONFERENCE

SKIN FRICTION COMMITTEE

MODEL RESISTANCE DATA

LABORATORY		MODEL
L_{WL}	BASIN NUMBER	
L_{BP}	SIZE OF BASIN	
B	WATER TEMP.	
H	DATE OF TEST	
Δ	TYPE	
S	MATERIAL	
C_B	MODEL FINISH	
C_P	TRIM	
C_X	APPENDAGES	
$1/2\ \alpha_E$	STIMULATION	

V-ft/sec	R_{tot} - lbs	V-ft/sec	R_{tot} - lbs

A - SERIES

Type	$\frac{\nabla^{1/3}}{L}$	$\frac{L}{H}$
1. Multi Screw Vessel	0.1266	28.00
2. Washington Class Cruiser	0.1588	20.08
3. Armored Cruiser North Carolina	0.1588	20.08
4. Single Screw Ship	0.1640	19.56
5. Multi Screw Vessel	0.1488	34.64
6. Multi Screw Vessel (Ferry)	0.1492	27.27
7. Single Screw Vessel	0.1506	27.20
8. Single Screw Vessel (Rudder and Bilge Keel)	0.1745	18.94
9. Multi Screw Vessel	0.1239	26.50
10. Single Screw Vessel (Series 57)	0.1594	19.01
11. Tanker Series	0.174	19.58

TYPE: MULTI SCREW VESSEL

Model	4507	4007	3878-1	4514
LWL (ft.)	4.494	12.00	20.76	29.46
L_{BP} (ft.)	4.494	12.00	20.76	29.46
B (ft.)	0.480	1.28	2.22	3.14
H (ft.)	0.161	0.43	0.74	1.06
Trim by Stern (ft.)	0.012	0.032	0.054	0.077
∇ (ft.^{3})	0.185	3.517	18.210	52.044
Δ (lbs.)	11.50	219	1134	3241
S (ft.^{2})	2.38	17.00	50.7	102.1
Appendages	None	None	None	None
Material	Wood	Wood	Wood	Wood
Finish	Enamel	Enamel	Enamel	Enamel
Stimul.	0.040"Tr.W.	None	None	None
Temperature	75.0	63.0	62.5	62.5
Test No.	3	5 & 6	35	4
Basin	DTMB 1	DTMB 1	DTMB 1	DTMB 1
A (ft.^{2})	1122	1122	1122	1122
a/A (%)	0.006	0.041	0.121	0.245
C_B	0.525			
C_P	0.634			
C_X	0.827			
$1/2\alpha E$	8.0			
$\nabla^{1/3}/L$	0.1266			
L/H	28.00			

TYPE: ARMORED CRUISER WASHINGTON

Model	2909-1	421-8	2910-1	Ship
λ	19.60	24.70	31.13	
LWL (ft)	25.60	20.33	16.120	502
L_{BP} (ft)	25.60	20.33	16.120	502
B_X (ft)	3.717	2.950	2.340	72.875
H (ft)	1.268	1.007	0.798	25.00
Trim (ft)	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	67.00	33.80	16.89	507,167
Δ (lbs)	4210	2105	1052	--
S (ft^2)	105.01	66.15	41.64	40,355
Append.	½ Rudder	½ Rudder	½ Rudder	½ Rudder
Material	Wood	Wood	Wood	--
Finish	Spar Varnish	Spar Varnish	Spar Varnish	--
Stim.	None	None	None	--
Temp.	62 & 63	72	66	--
Test No.	2909-1	421-8	2910-1	--
Basin	EMB	EMB	EMB	--
A (ft^2)	628	628	628	--
a/A (%)	0.718	0.452	0.285	--
C_B	0.555			
C_P	0.584			
C_X	0.950			
$1/2\alpha_E$	--			
$\nabla^{1/3}/L$	0.1588			
L/H	20.08			

TYPE: ARMORED CRUISER NORTH CAROLINA

Model	3140	3128	3127	3126	Ship
λ	17.13	19.60	24.70	31.13	--
LWL (ft)	29.32	25.60	20.33	16.12	502.00
L_{BP} (ft)	29.32	25.60	20.33	16.12	502.00
B_X (ft)	4.254	3.717	2.950	2.340	72.875
H (ft)	1.459	1.268	1.007	0.798	25.00
Trim (ft)	E.K.	E.K.	E.K.	E.K.	E.K.
∇ (ft3)	101.406	67.604	33.80	16.89	507,167
Δ (lbs)	6315	4210	2105	1052	--
S (ft^2)	137.60	105.01	66.15	41.64	40,355
Append.	½ Rudder	½ Rudder	½ Rudder	½ Rudder	--
Material	Wood	Wood	Wood	Wood	--
Finish	Oil Paint	Oil Paint	Oil Paint	Oil Paint	--
Stim.	None	None	None	None	--
Temp.	59*	78	80	81	--
Test	3140-1	3128-1	3127-1	3126-1	--
Basin	EMB	EMB	EMB	EMB	--
A (ft^2)	628	628	628	628	
a/A (%)	0.940	0.718	0.452	0.285	
C_B	0.555				
C_P	0.584				
C_X	0.950				
$\nabla^{1/3}/L$	0.1588				
L/H	20.08				

* Temp. corrected to 78°F

TYPE: SINGLE SCREW VESSEL

Model	4152-2	4422	1347	Ship
λ	24.175	105.00	105.00	--
LWL (ft)	21.841	5.029	5.029	528.00
L_{BP} (ft)	21.841	5.029	5.029	528.00
B (ft)	3.144	0.724	0.724	76.00
H (ft)	1.117	0.257	0.257	27.00
Trim (ft)	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	46.086	0.563	0.563	651,146 ft^3
Δ (lbs)	2870	35.06	35.06	--
S (ft^2)	83.0	4.40	4.40	48,508
Append.	Rudder & Prop. Hub	Rudder & Prop. Hub	Rudder & Prop. Hub	--
Material	Wood	Wood	Wood	--
Finish	Enamel	Varnish	Varnish	
Stimul.	None	None	None	
Temp.	61	71	68.5	
Test No.	11	1	1	
Basin	DTMB 1	DTMB 4	ETT 2	
A (ft^2)	1122	55	72	
a/A (%)	0.307	0.332	0.253	
C_B	0.600			
C_P	0.612			
C_X	0.981			
$\frac{1}{2}\alpha_E$	7° 15'			
$\nabla^{1/3}/L$	0.164			
L/H	19.56			

TYPE: MULTI SCREW VESSEL

Model	4361	4359	4359	Ship
λ	18.40	64.00	64.00	--
LWL (ft)	22.283	6.406	6.406	410.00
L_{BP} (ft)	22.283	6.406	6.406	410.00
B (ft)	3.37	0.9688	0.9688	62.00
H_{av} (ft)	0.6435	0.1850	0.1850	11.837
Trim (ft)	0.371	0.1067	0.1067	6,829
∇ (ft^3)	36.5	0.87	0.87	227351 ft^3
Δ (lbs)	2273.6	54.008	54.008	--
S (ft^2)	80.967	6.692	6.692	27,412
Append.	None	None	None	
Material	Wood	Wood	Wood	
Finish	Enamel	Enamel	Enamel	
Stimul.	None	½" sand at stem	None	
Temp.	61	80.0	78	
Test No.	2	3	1	
Basin	DTMB 1	DTMB 4	DTMB 4	
A(ft^2)	1122	55	55	
a/A(%)	0.244	0.412	0.412	
C_B	0.746			
C_P	0.759			
C_X	0.983			
$\frac{1}{2} \alpha_E$	35.0			
$\nabla^{1/3}/L$	0.1488			
L/H	34.637			

TYPE: MULTI SCREW VESSEL

Model	4194-1	4193-W	Ship
λ	20.323	62.150	--
LWL (ft)	22.14	7.241	450.00
L_{BP} (ft)	21.40	7.000	435.05
B (ft)	3.44	1.126	69.90
H (ft)	0.81	0.260	16.50
Trim (ft)	E.K.	E.K.	E.K.
∇ (ft^3)	34.52	1.28	303,279 ft^3
Δ (lbs)	2150	79.4	--
S (ft^2)	77.31	8.27	31,931
Append	Rudder	Rudder	
Material	Wood	Wax	
Finish	Enamel	None	
Stim.	None	None	
Temp.	65.0	69	
Test No.	3	1	
Basin	DTMB 1	DTMB 4	
A (ft^2)	1122	55	
a/A(%)	0.231	0.496	
C_B	0.557		
C_P	0.597		
C_X	0.931		
$\frac{1}{2}\alpha_E$	11.0		
$\nabla^{1/3}/L$	0.1492		
L/H	27.27		

TYPE: SINGLE SCREW VESSEL

Model	4480	4460	Ship
λ	23.254	31.00	--
LWL (ft)	29.73	22.30	691.30
L_{BP} (ft)	29.70	22.26	690.06
B (ft)	3.23	2.42	75.00
H (ft)	1.10	0.82	25.42
Trim (ft)	E.K.	E.K.	E.K.
∇ (ft^3)	89.94	37.96	1,130,911 ft^3
Δ (lbs)	5601	2.364	--
S (ft^2)	143.1	80.52	77,380
Append.	Rudder	Rudder	
Material	Wax	Wax	
Finish	None	None	
Stim.	None	None	
Temp.	64	62.5	
Test No.	10	1-B	
Basin	DTMB 1	DTMB 1	
A ft^2	1122	1122	
a/A %	0.314	0.175	
C_B	0.855		
C_P	0.863		
C_X	0.991		
$\frac{1}{2}\alpha_E$	48		
$\nabla^{1/3}/L$	0.1506		
L/H	27.195		

TYPE: SINGLE SCREW VESSEL

Model	4030-1	4395	4395	Ship
λ	29.60	120.00	120.00	--
LWL (ft)	20.267	5.00	5.00	600.00
L_{BP} (ft)	20.000	4.938	4.938	592.56
B (ft)	2.787	0.687	0.687	82.50
H (ft)	1.07	0.2633	0.2633	31.60
Trim (ft)	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	44.24	0.6642	0.6642	1,147,246 ft^3
Δ (lbs)	2755	41.36	41.36	--
S (ft^2)	81.69	4.97	4.97	71,580
Append.	Rudder & B.K.	Rudder & B.K.	Rudder & B.K.	
Material	Wood	Wood	Wood	
Finish	Enamel	Enamel	Enamel	
Stim.	None	None	½" sand strip at 0.05 L_{BP}	
Temp.	64	72	72	
Test No.	D	1	3	
Basin	DTMB 1	DTMB 4	DTMB 4	
A (ft^2)	1122	55	55	
a/A(%)	0.262	0.325	0.325	
C_B	0.739			
C_P	0.731			
C_X	0.989			
$\frac{1}{2}\alpha_E$	15.0			
$\nabla^{1/3}/L$	0.1745			
L/H	18.94			

TYPE: MULTI SCREW VESSEL

3542	4367	4367	4367	4367	4366	4366
26.5	84.8	84.8	84.8	84.8	120	120
20.00	6.25	6.25	6.25	6.25	4.4167	4.4167
20.00	6.25	6.25	6.25	6.25	4.4167	4.4167
1.956	0.6112	0.6112	0.6112	0.6112	0.4319	0.4319
0.708	0.2358	0.2358	0.2358	0.2358	0.1667	0.1667
E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.
15.22	0.46	0.46	0.46	0.46	0.16	0.16
948	28.93	28.93	28.93	28.93	10.21	10.21
46.264	4.518	4.518	4.592	4.592	2.2931	2.2931
None	None	None	Rudder	Rudder	Rudder	Rudder
Wood	Wood	Wood	Wood	Wood	Wood	Wood
Enamel	Enamel	Enamel	Enamel	Enamel	Enamel	Enamel
None	None	½" Sand strip at 0.05 L_{BP}	None	½" Sand strip at 0.05 L_{BP}	None	3/8" San strip at 0.05 L_{BP}
73.0	78.0	80.0	78.0	78.0	79.0	79.0
1	3	4	5	6	1	2
EMB	DTMB 4	DTMB 4	DTMB 4	DTMB 4	DTMB 4	DTMB 4
627.7	55	55	55	55	55	55
0.185	0.220	0.220	0.220	0.220	0.110	0.110
0.503						
0.840						
0.598						
--						
0.1239						
26.50						

TYPE: SINGLE SCREW VESSEL

Model	4200	4368	Ship
λ	20.0	80.0	--
LWL (ft)	20.34	5.084	406.80
L_{BP} (ft)	20.00	5.000	400.00
B (ft)	2.67	0.667	53.40
H (ft)	1.07	0.267	21.40
Trim (ft)	E.K.	E.K.	E.K.
∇ (ft^3)	34.17	0.53	273,375 ft^3
Δ (lbs)	2128	33.2	--
S (ft^2)	68.33	4.256	27,332
Append.	None	None	
Material	Wax	Wood	
Finish	None	Enamel	
Stim.	None	None	
Temp.	65.0	78.0	
Test No.	1	2	
Basin	DTMB 1	DTMB 4	
A (ft)	1122	55	
a/A(%)	0.249	0.317	
C_B	0.600		
C_P	0.613		
C_X	0.979		
$\frac{1}{2}\alpha_E$	8.0		
$\nabla^{1/3}/L$	0.1594		
L/H	19.01		

TYPE: TANKER-SERIES

Model	4396	4057	Ship
λ	120	27.57	1
LWL (ft)	5.00	21.76	600.00
L_{BP} (ft)	4.96	21.57	595.00
B (ft)	0.700	3.046	84.00
H (ft)	0.255	1.111	30.64
Trim	E.K.	E.K.	E.K.
∇ (ft^3)	0.664	54.71	1,147,246.
Δ (lbs)	41.36	3407	32,800 tons
S (ft^2)	4.906	92.88	70,650
Appendages	Rudder	Rudder	
Material	Wood	Wood	
Finish	Enamel	Enamel	
Stimul.	½" wide sand strip at 0.05 x L	None	
Temp. (F)	72	66.5	
Test No.	2	A-1	
Basin	TMB 4	TMB 1	
A (ft^2)	55.0	1122	
a/A (%)	0.322	0.300	
C_B	0.748		
C_P	0.754		
C_X	0.993		
$\frac{1}{2}\alpha_E$	27.33		
$\nabla^{1/3}/L$	0.174		
L/H	19.582		

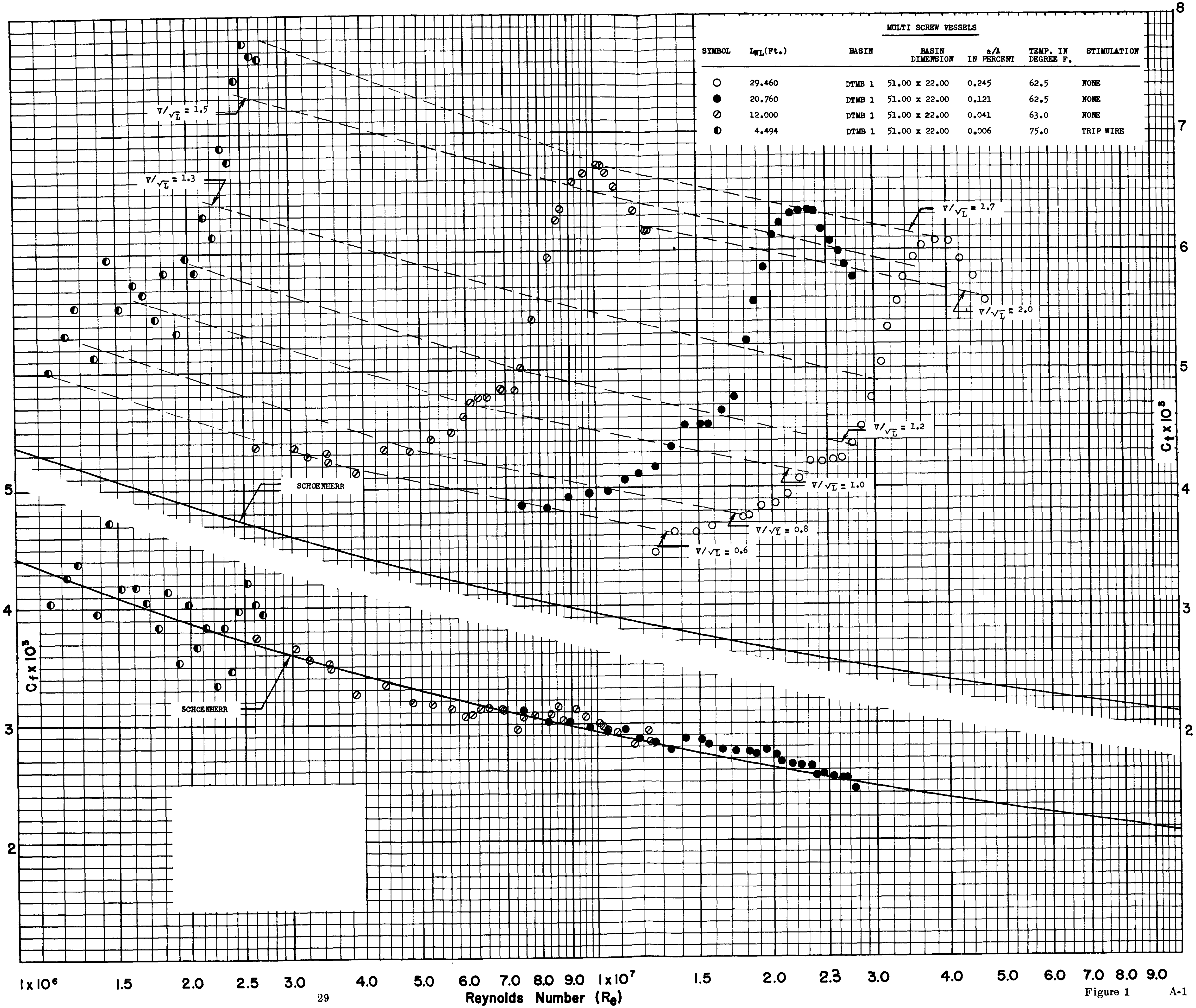

MULTI SCREW VESSELS
SYMBOL | L_WL(Ft.) | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
○ 29.460 DTMB 1 51.00 x 22.00 0.245 62.5 NONE
● 20.760 DTMB 1 51.00 x 22.00 0.121 62.5 NONE
⊘ 12.000 DTMB 1 51.00 x 22.00 0.041 63.0 NONE
◐ 4.494 DTMB 1 51.00 x 22.00 0.006 75.0 TRIP WIRE
V/√L = 1.5
V/√L = 1.3
V/√L = 1.7
V/√L = 2.0
V/√L = 1.2
V/√L = 1.0
V/√L = 0.8
V/√L = 0.6
SCHOENHERR
SCHOENHERR
Ct x 10³
Cf x 10³
Reynolds Number (Re)
1x10⁶
1.5
2.0
2.5
3.0
4.0
5.0
6.0
7.0
8.0
9.0
1x10⁷
2.3

Figure 1

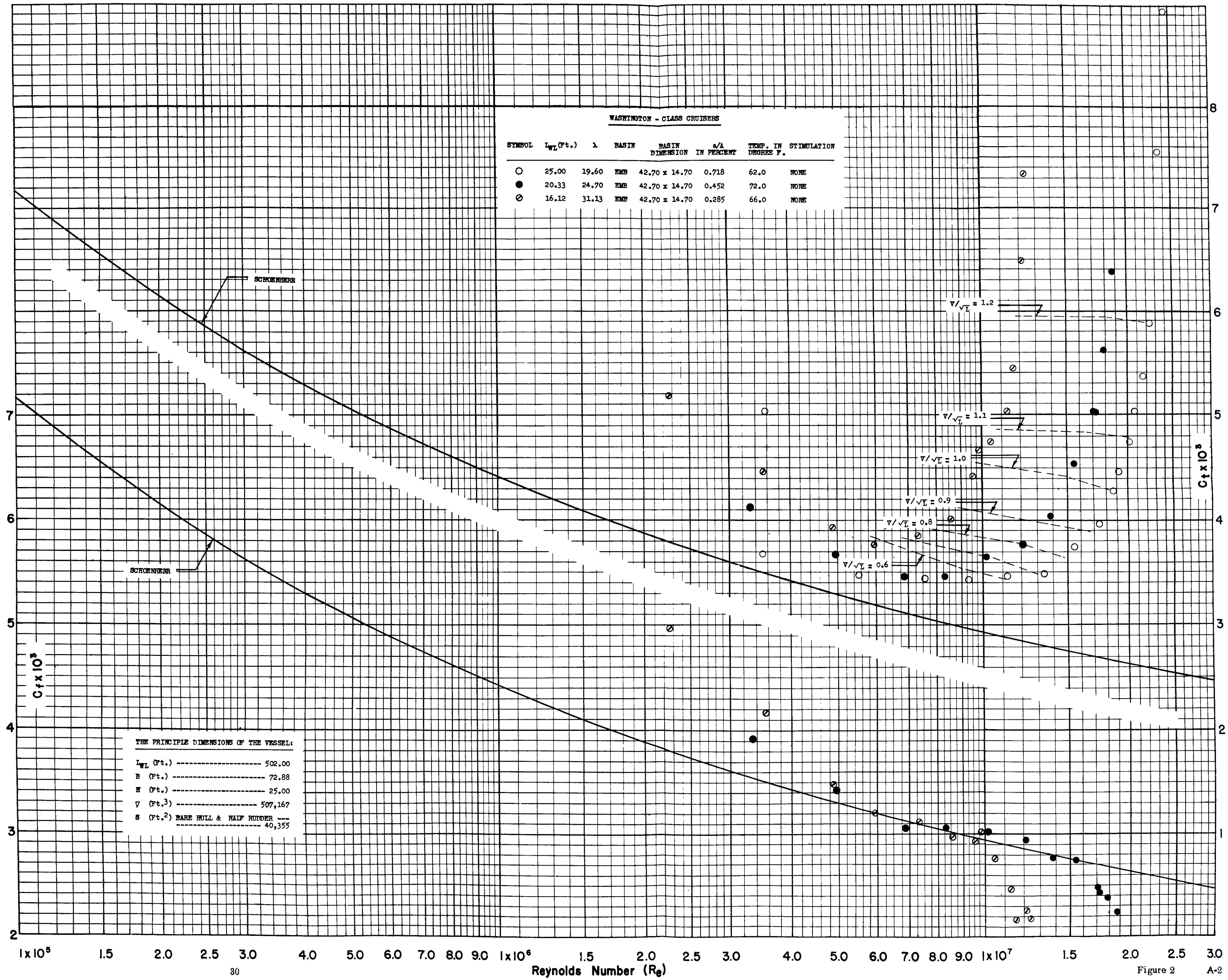
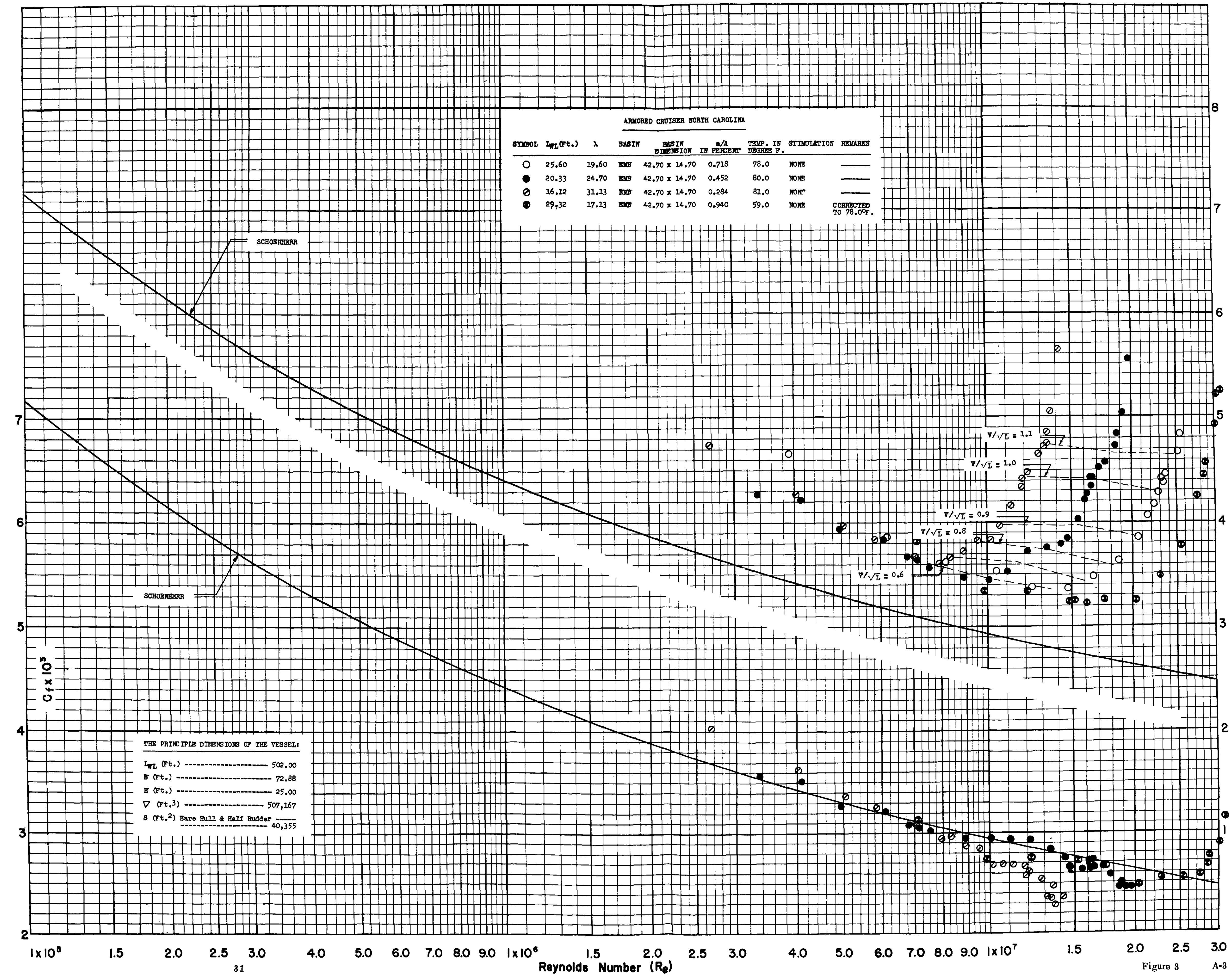

WASHINGTON - CLASS CRUISERS
SYMBOL | L_WL (Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
○ 25.00 19.60 EMB 42.70 x 14.70 0.718 62.0 NONE
● 20.33 24.70 EMB 42.70 x 14.70 0.452 72.0 NONE
⊘ 16.12 31.13 EMB 42.70 x 14.70 0.285 66.0 NONE
THE PRINCIPLE DIMENSIONS OF THE VESSEL:
L_WL (Ft.) ---------------------- 502.00
B (Ft.) ---------------------- 72.88
H (Ft.) ---------------------- 25.00
∇ (Ft.3) ---------------------- 507,167
S (Ft.2) BARE HULL & HALF RUDDER ---
---------------------- 40,355
SCHOENHERR
SCHOENHERR
∇/√L = 1.2
∇/√L = 1.1
∇/√L = 1.0
∇/√L = 0.9
∇/√L = 0.8
∇/√L = 0.6
C_f x 10^3
C_t x 10^3
2
3
4
5
6
7
8
1x10^5 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^6 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^7 1.5 2.0 2.5 3.0
Reynolds Number (Re)

Figure 2



ARMORED CRUISER NORTH CAROLINA
SYMBOL | L_WL(Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
○ 25.60 19.60 EMB 42.70 x 14.70 0.718 78.0 NONE
● 20.33 24.70 EMB 42.70 x 14.70 0.452 80.0 NONE
⊘ 16.12 31.13 EMB 42.70 x 14.70 0.284 81.0 NONE
29.32 17.13 EMB 42.70 x 14.70 0.940 59.0 NONE CORRECTED TO 78.0°F.
SCHOENHERR
SCHOENHERR
V/√L = 1.1
V/√L = 1.0
V/√L = 0.9
V/√L = 0.8
V/√L = 0.6
THE PRINCIPLE DIMENSIONS OF THE VESSEL:
L_WL (Ft.) ---------------------- 502.00
B (Ft.) ------------------------ 72.88
H (Ft.) ------------------------ 25.00
▽ (Ft.3) ---------------------- 507,167
S (Ft.2) Bare Hull & Half Rudder -----
---------------------- 40,355
Cf x 10³
8
7
6
5
4
3
2
1
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0
Reynolds Number (Re)

Figure 3

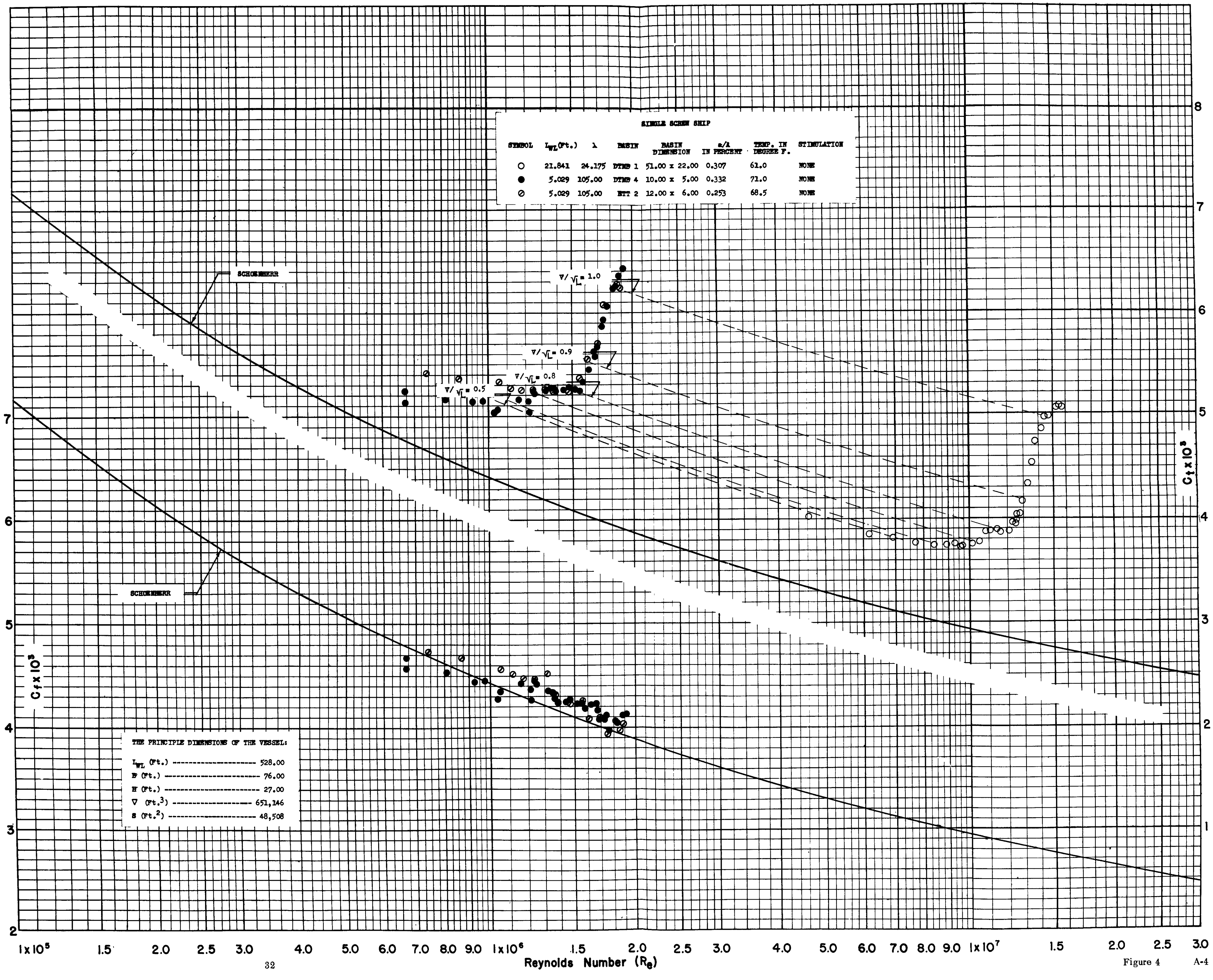

SINGLE SCREW SHIP
SYMBOL | L_WL (Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
○ 21.841 24.175 DTMB 1 51.00 x 22.00 0.307 61.0 NONE
● 5.029 105.00 DTMB 4 10.00 x 5.00 0.332 71.0 NONE
⊘ 5.029 105.00 ETT 2 12.00 x 6.00 0.253 68.5 NONE
SCHOENHERR
SCHOENHERR
∇/√L = 1.0
∇/√L = 0.9
∇/√L = 0.8
∇/√L = 0.5
THE PRINCIPLE DIMENSIONS OF THE VESSEL:
L_WL (Ft.) ---------- 528.00
B (Ft.) ---------- 76.00
H (Ft.) ---------- 27.00
∇ (Ft.³) ---------- 651,146
S (Ft.²) ---------- 48,508
C_f x 10³
C_t x 10³
Reynolds Number (R_e)
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0

Figure 4

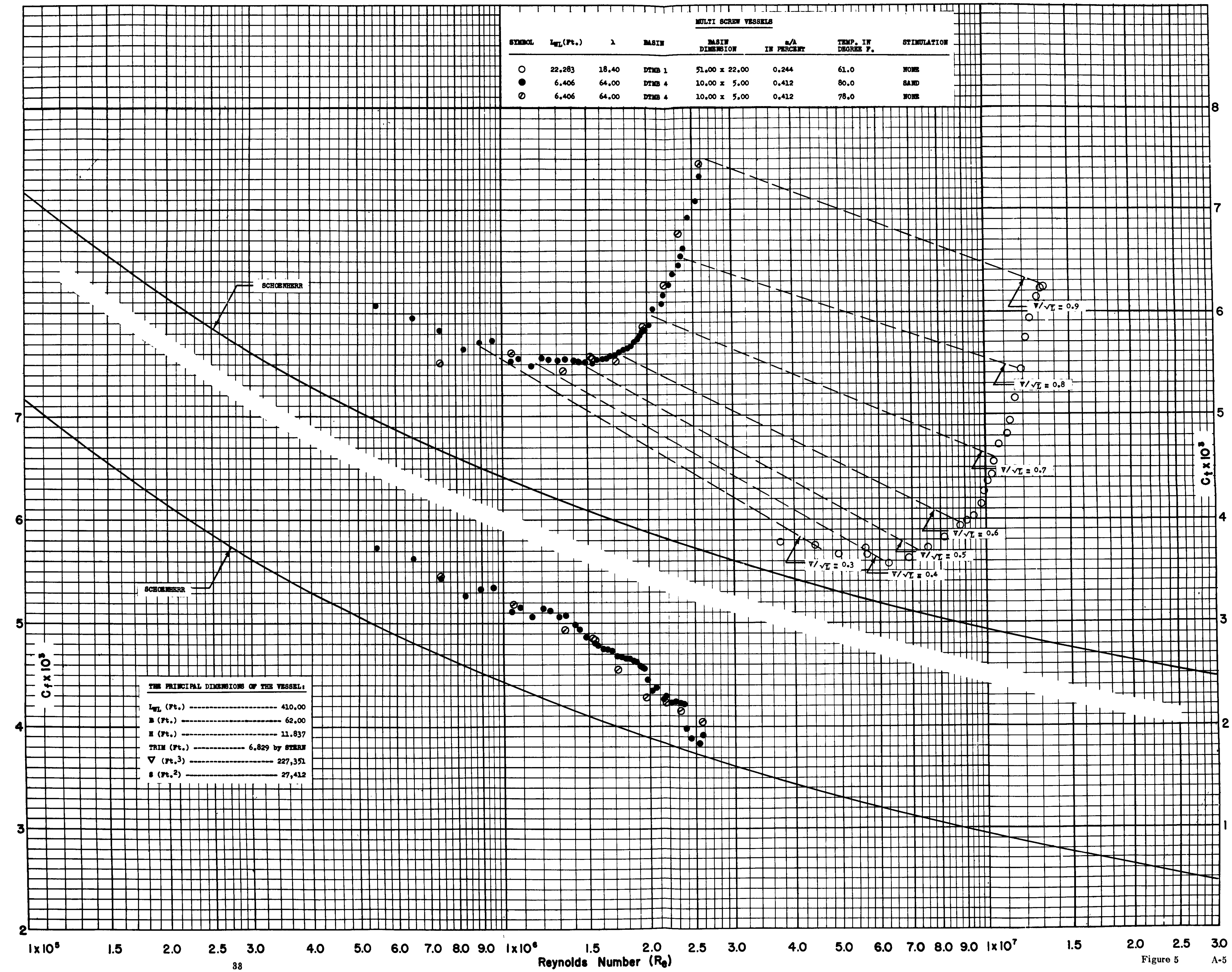
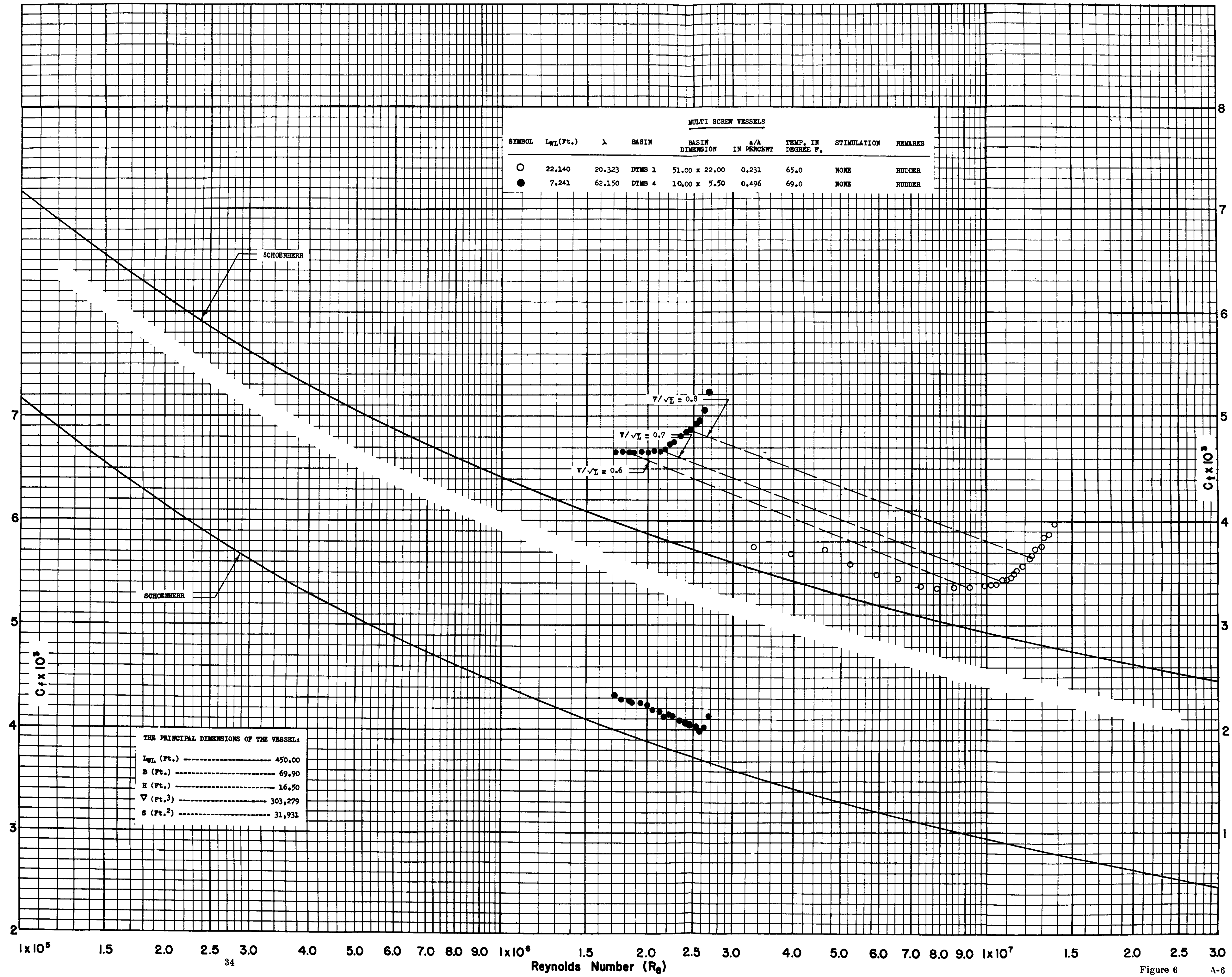

MULTI SCREW VESSELS
SYMBOL | L_WL (Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
○ | 22.283 | 18.40 | DTMB 1 | 51.00 x 22.00 | 0.244 | 61.0 | NONE
● | 6.406 | 64.00 | DTMB 4 | 10.00 x 5.00 | 0.412 | 80.0 | SAND
⊘ | 6.406 | 64.00 | DTMB 4 | 10.00 x 5.00 | 0.412 | 78.0 | NONE
SCHOENHERR
SCHOENHERR
∇/√L = 0.9
∇/√L = 0.8
∇/√L = 0.7
∇/√L = 0.6
∇/√L = 0.5
∇/√L = 0.4
∇/√L = 0.3
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_WL (Ft.) ---------- 410.00
B (Ft.) ---------- 62.00
H (Ft.) ---------- 11.837
TRIM (Ft.) ---------- 6.829 by STERN
∇ (Ft.3) ---------- 227,351
S (Ft.2) ---------- 27,412
Cf x 10³
Ct x 10³
Reynolds Number (Re)
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0
7 6 5 4 3 2
8 7 6 5 4 3 2 1

Figure 5



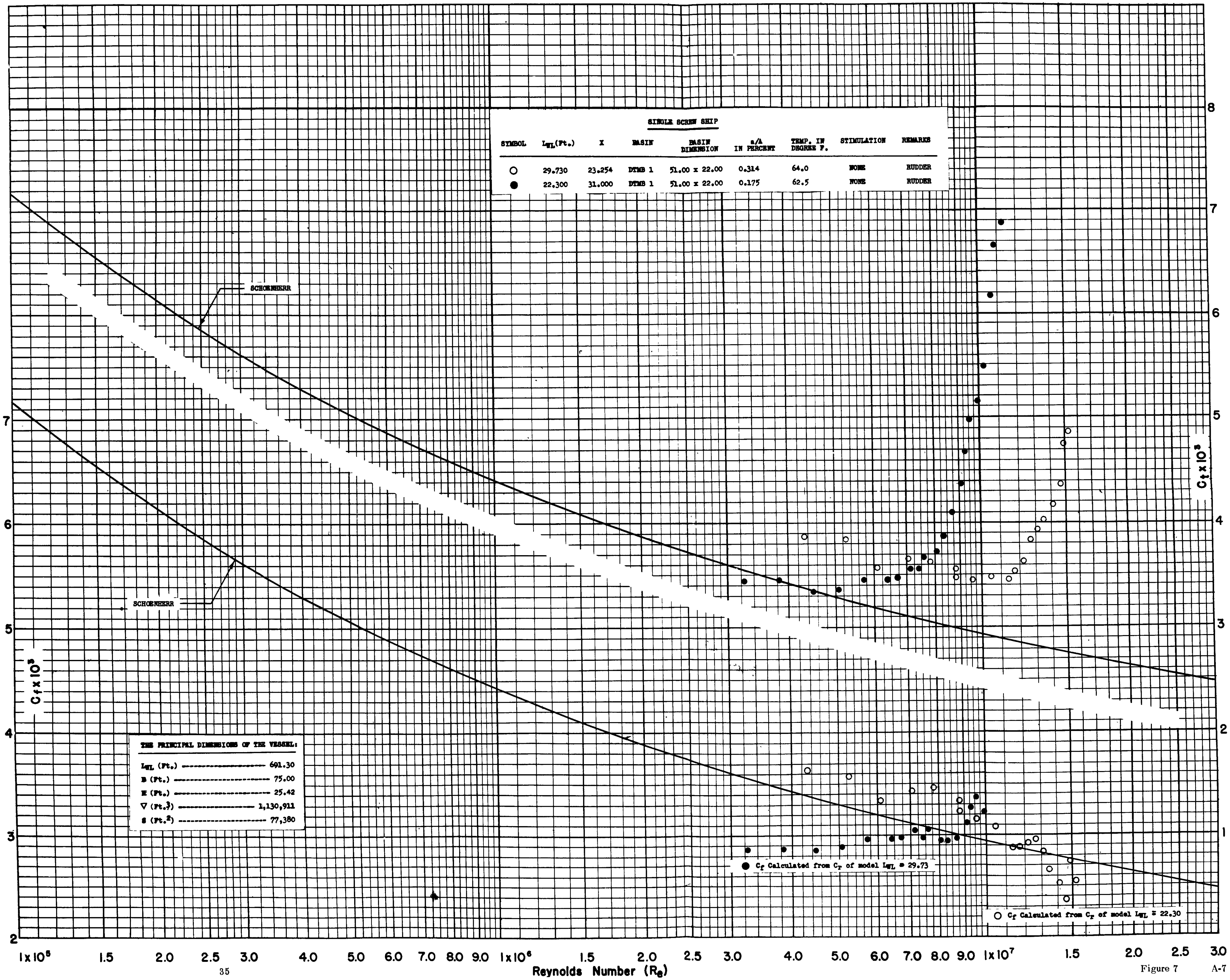
MULTI SCREW VESSELS

SYMBOL	L_{WL}(Ft.)	λ	BASIN	BASIN DIMENSION	a/A IN PERCENT	TEMP. IN DEGREE F.	STIMULATION	REMARKS
○	22.140	20.323	DTMB 1	51.00 x 22.00	0.231	65.0	NONE	RUDDER
●	7.241	62.150	DTMB 4	10.00 x 5.50	0.496	69.0	NONE	RUDDER

THE PRINCIPAL DIMENSIONS OF THE VESSEL:

L_{WL} (Ft.)	450.00
B (Ft.)	69.90
H (Ft.)	16.50
∇ (Ft.^{3})	303,279
S (Ft.^{2})	31,931

Figure 6



SINGLE SCREW SHIP
SYMBOL | L_{WL}(Ft.) | X | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
○ 29.730 23.254 DTMB 1 51.00 x 22.00 0.314 64.0 NONE RUDDER
● 22.300 31.000 DTMB 1 51.00 x 22.00 0.175 62.5 NONE RUDDER
SCHOENHERR
SCHOENHERR
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) 691.30
B (Ft.) 75.00
H (Ft.) 25.42
▽ (Ft.^{3}) 1,130,911
S (Ft.^{2}) 77,380
● C_f Calculated from C_r of model L_{WL} = 29.73
○ C_f Calculated from C_r of model L_{WL} = 22.30
$C_f \times 10^3$
$C_f \times 10^3$
1x10^5 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^6 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^7 1.5 2.0 2.5 3.0
Reynolds Number (R_e)

Figure 7

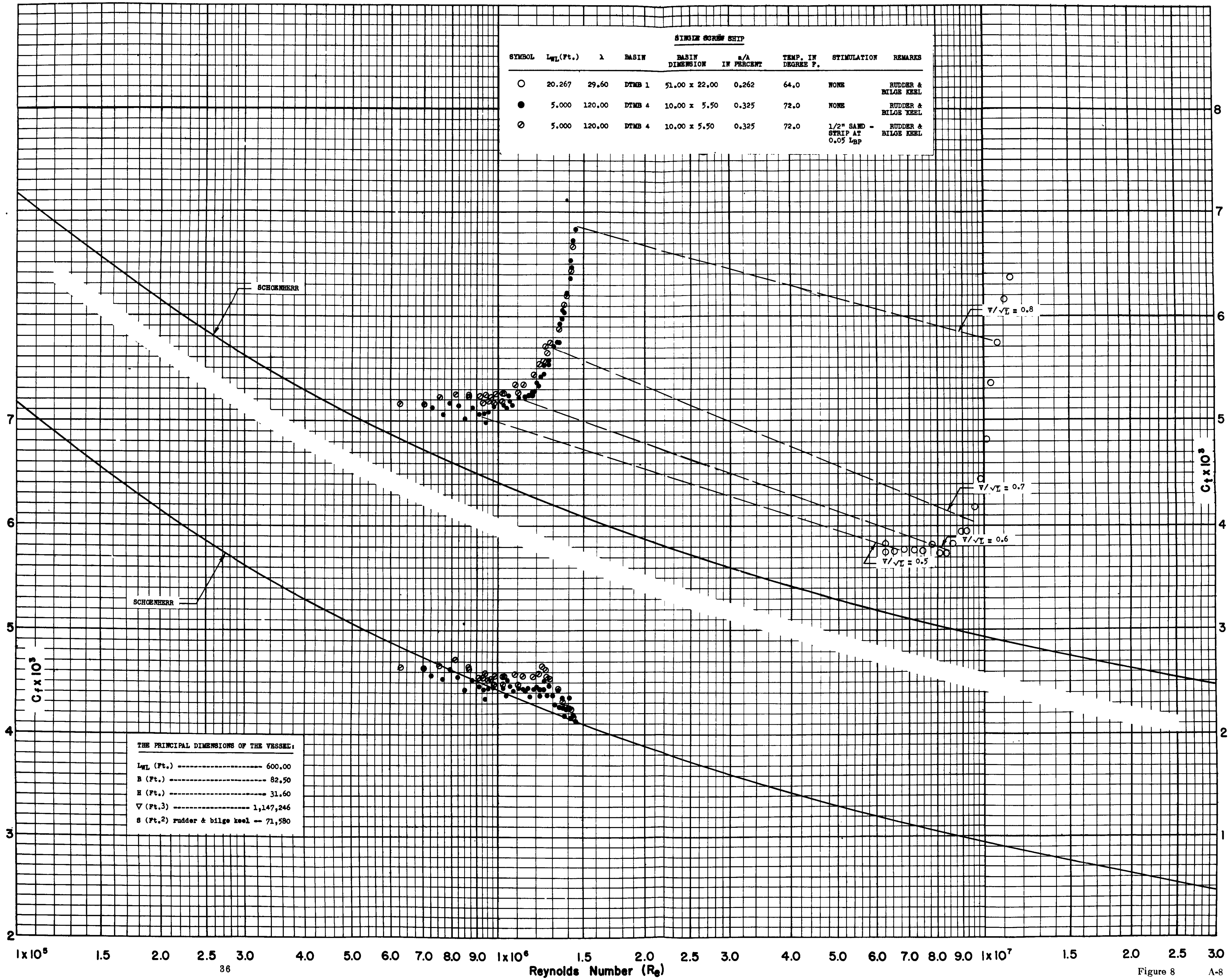

SINGLE SCREW SHIP
SYMBOL | L_WL (Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
○ 20.267 29.60 DTMB 1 51.00 x 22.00 0.262 64.0 NONE RUDDER & BILGE KEEL
● 5.000 120.00 DTMB 4 10.00 x 5.50 0.325 72.0 NONE RUDDER & BILGE KEEL
⊘ 5.000 120.00 DTMB 4 10.00 x 5.50 0.325 72.0 1/2" SAND - STRIP AT 0.05 L_BP RUDDER & BILGE KEEL
SCHOENHERR
SCHOENHERR
∇/√L = 0.8
∇/√L = 0.7
∇/√L = 0.6
∇/√L = 0.5
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_WL (Ft.) 600.00
B (Ft.) 82.50
H (Ft.) 31.60
∇ (Ft.3) 1,147,246
S (Ft.2) rudder & bilge keel 71,580
Cf x 10³
Ct x 10³
Reynolds Number (Re)
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0

Figure 8

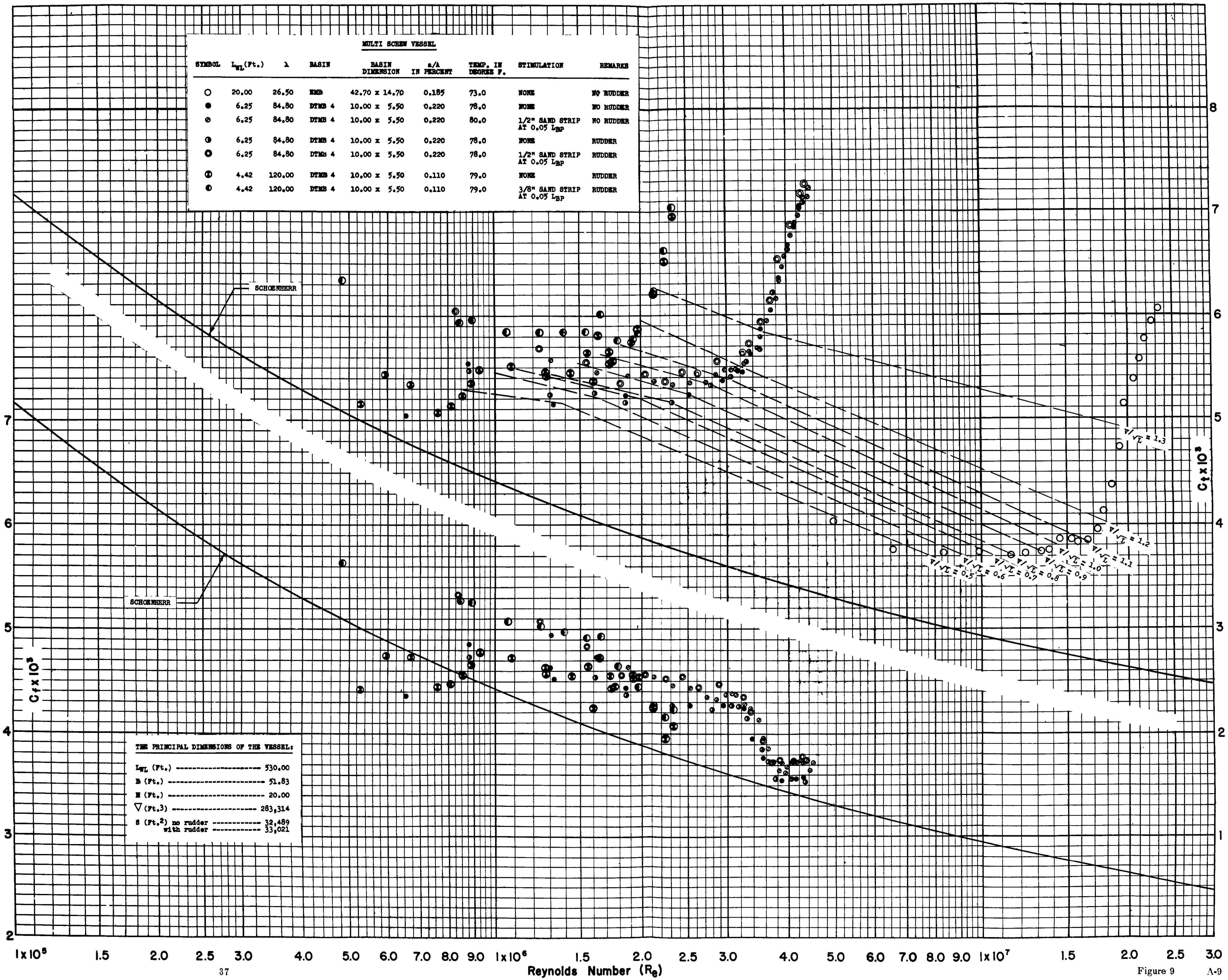

MULTI SCREW VESSEL
SYMBOL | L_{WL}(Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
○ | 20.00 | 26.50 | EMB | 42.70 x 14.70 | 0.185 | 73.0 | NONE | NO RUDDER
● | 6.25 | 84.80 | DTMB 4 | 10.00 x 5.50 | 0.220 | 78.0 | NONE | NO RUDDER
⊘ | 6.25 | 84.80 | DTMB 4 | 10.00 x 5.50 | 0.220 | 80.0 | 1/2" SAND STRIP AT 0.05 L_{BP} | NO RUDDER
◑ | 6.25 | 84.80 | DTMB 4 | 10.00 x 5.50 | 0.220 | 78.0 | NONE | RUDDER
◉ | 6.25 | 84.80 | DTMB 4 | 10.00 x 5.50 | 0.220 | 78.0 | 1/2" SAND STRIP AT 0.05 L_{BP} | RUDDER
⊗ | 4.42 | 120.00 | DTMB 4 | 10.00 x 5.50 | 0.110 | 79.0 | NONE | RUDDER
◐ | 4.42 | 120.00 | DTMB 4 | 10.00 x 5.50 | 0.110 | 79.0 | 3/8" SAND STRIP AT 0.05 L_{BP} | RUDDER
SCHOENHERR
SCHOENHERR
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) ---------- 530.00
B (Ft.) ---------- 51.83
H (Ft.) ---------- 20.00
▽ (Ft.3) ---------- 283,314
S (Ft.2) no rudder ---------- 32,489
with rudder ---------- 33,021
$\nabla/\sqrt{L}$ = 1.3
$\nabla/\sqrt{L}$ = 1.2
$\nabla/\sqrt{L}$ = 1.1
$\nabla/\sqrt{L}$ = 1.0
$\nabla/\sqrt{L}$ = 0.9
$\nabla/\sqrt{L}$ = 0.8
$\nabla/\sqrt{L}$ = 0.7
$\nabla/\sqrt{L}$ = 0.6
$\nabla/\sqrt{L}$ = 0.5
$C_f \times 10^3$
$C_t \times 10^3$
2
3
4
5
6
7
1
2
3
4
5
6
7
8
1×10^5 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1×10^6 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1×10^7 1.5 2.0 2.5 3.0
Reynolds Number (R_e)

Figure 9

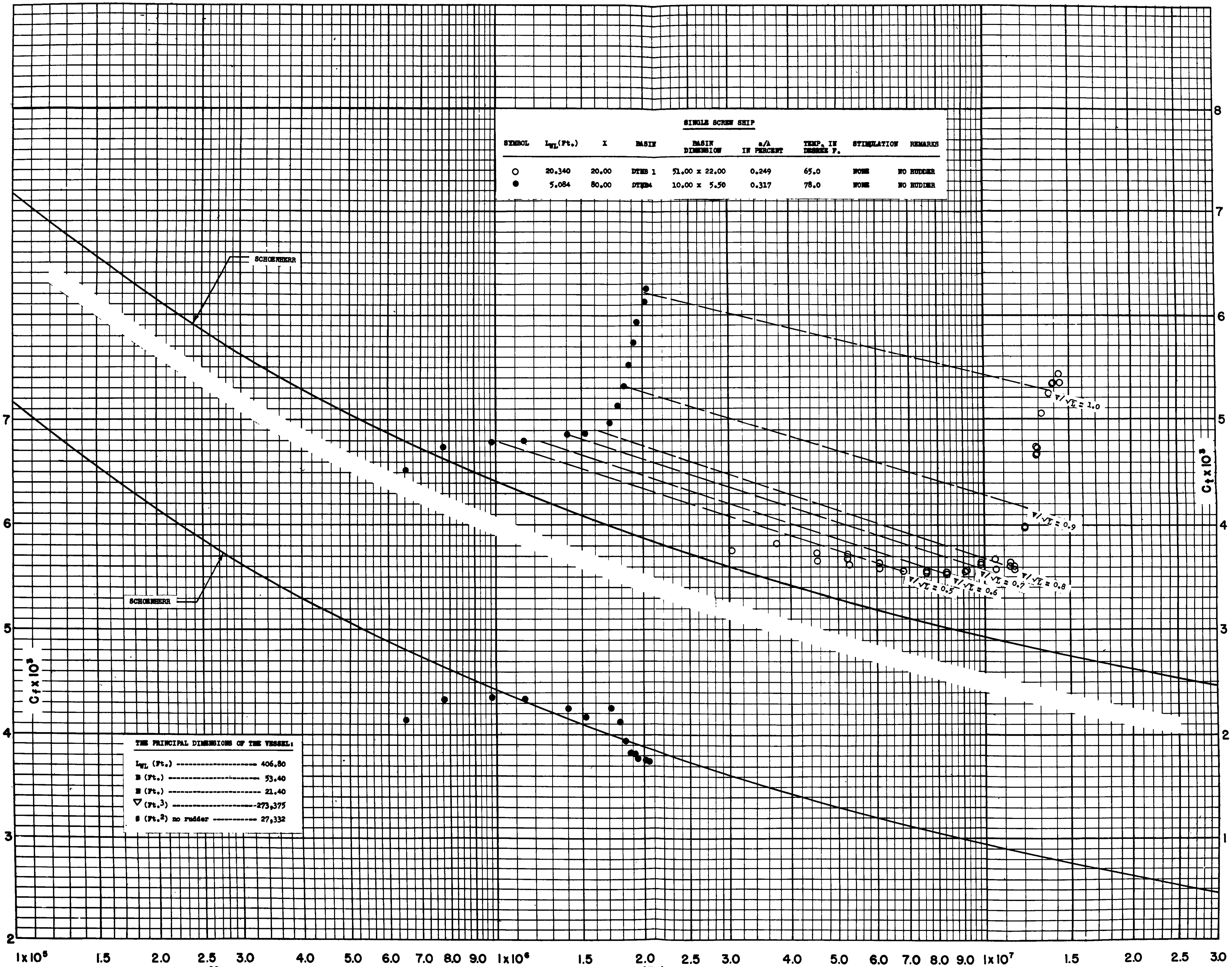

SINGLE SCREW SHIP
SYMBOL | L_WL (Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
○ 20.340 20.00 DTMB 1 51.00 x 22.00 0.249 65.0 NONE NO RUDDER
● 5.084 80.00 DTMB4 10.00 x 5.50 0.317 78.0 NONE NO RUDDER
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_WL (Ft.) ---------- 406.80
B (Ft.) ---------- 53.40
H (Ft.) ---------- 21.40
∇ (Ft.³) ---------- 273,375
S (Ft.²) no rudder ---------- 27,332
SCHOENHERR
SCHOENHERR
∇/√L = 1.0
∇/√L = 0.9
∇/√L = 0.8
∇/√L = 0.7
∇/√L = 0.6
∇/√L = 0.5
Cf x 10³
Cf x 10³
Reynolds Number (Re)
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0
2 3 4 5 6 7
1 2 3 4 5 6 7 8

Figure 10

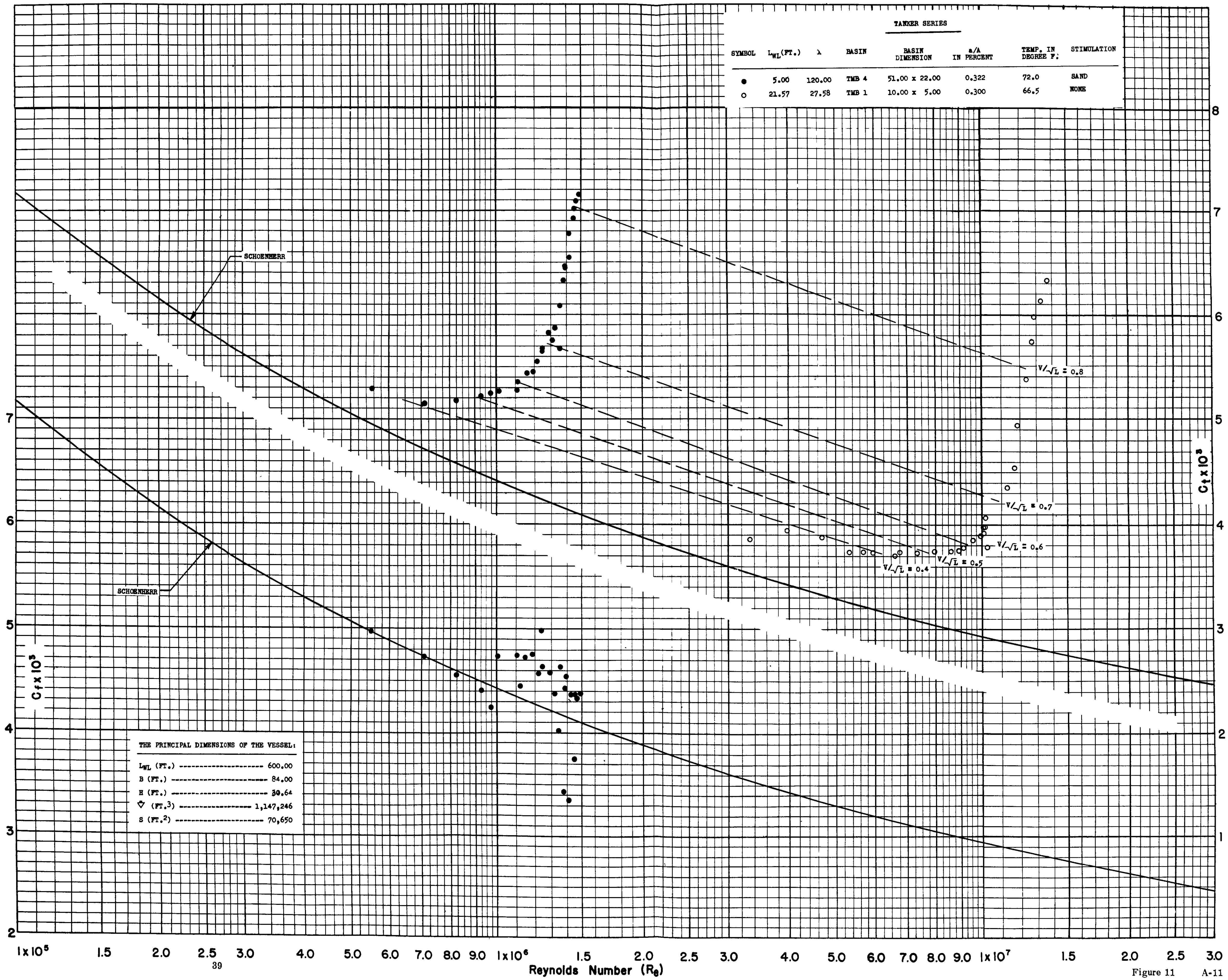

TANKER SERIES
SYMBOL | LWL(FT.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
● 5.00 120.00 TMB 4 51.00 x 22.00 0.322 72.0 SAND
○ 21.57 27.58 TMB 1 10.00 x 5.00 0.300 66.5 NONE
SCHOENHERR
SCHOENHERR
V/√L = 0.8
V/√L = 0.7
V/√L = 0.6
V/√L = 0.5
V/√L = 0.4
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
LWL (FT.) 600.00
B (FT.) 84.00
H (FT.) 30.64
▽ (FT.3) 1,147,246
S (FT.2) 70,650
Cf x 10³
Cf x 10³
Reynolds Number (Re)

Figure 11

B - SERIES

Type		$\frac{\nabla^{1/3}}{L}$	$\frac{L}{H}$
1.	Liberty Ship Series (with and without stimulation)	0.1835	15.83
2.	Liberty Ship Series (1/8" Rod)	0.1835	15.83
3.	Simon Bolivar	0.1775	18.02
4.	San Francisco	0.1772	17.92
5.	Victory Ship Heavy Displ. (with stimulation)	0.1819	15.61
6.	Victory Ship Light Displ. (with stimulation)	0.1660	19.91
7.	Lucy Ashton (without stimulation)	0.1254	40.97
8.	Lucy Ashton (with stimulation)	0.1254	40.97
9.	Tina Onassis	0.1664	21.42
10.	Goteborg (no stimulation) C_p = 0.60	0.1646	17.75
11.	Goteborg (with stimulation) "	0.1646	17.75
12.	Goteborg (no stimulation) C_p = 0.80	0.1812	17.75
13.	Goteborg (with stimulation) "	0.1812	17.75
14.	Wrangel - Series (Goteborg)	0.1057	37.39
15.	Tanker - Series (Kloess)	0.1738	18.26

TYPE: LIBERTY SHIP SERIES

Model	3748-1	3748-1	3748-2	3748-2	3748-3	3748-3	3748-4	3748-5	3748-6	Ship
λ	14.228	14.228	21.342	21.342	28.456	28.456	42.683	60.032	74.679	--
LWL (ft)	30.032	30.032	20.022	20.022	15.016	15.016	10.011	7.118	5.640	427.30
L_{BP} (ft)	29.240	29.240	19.490	19.490	14.620	14.620	9.750	6.930	5.497	416.03
B (ft)	4.00	4.00	2.67	2.67	2.00	2.00	1.33	0.949	0.752	56.896
H (ft)	1.90	1.90	1.26	1.26	0.95	0.95	0.63	0.450	0.357	27.00
Trim (ft)	E.K.	E.K.	E.K.	EK.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	167.38	167.38	49.60	49.60	20.92	20.92	6.20	2.23	1.11	481,800
Δ (lbs)	10,424	10,424	3089	3089	1303	1303	386	139	69.3	--
S (ft^2)	186.3	186.3	82.79	82.79	46.57	46.57	20.70	10.47	6.59	37,709
Append.	Contra Rudder	Contra Rudder	Contra Rudder	Contra Rudder	Contra Rudder	Contra Rudder	Contra Rudder	Contra Rudder	Contra Rudder	--
Material	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Wood	Wood	--
Finish	Enamel	Enamel	Enamel	Enamel	Enamel	Enamel	Enamel	Enamel	Enamel	--
Stimul.	None	0.036" Tr. W.	None	0.036" Tr. W.	None	0.036" Tr. W.	None	None	None	--
Temp.	65.5	65.5	65.5	66.0	65.0	65.0	61.5	66.0	74.0	--
Test No.	9	11	17	19	6	7	3	1	1	--
Basin	DTMB 1	DTMB 1	DTMB 1	DTMB 1	DTMB 1	DTMB 1	DTMB 1	DTMB 1	DTMB 4	--
A (ft^2)	1122	1122	1122	1122	1122	1122	1122	1122	55	--
a/A (%)	0.745	0.745	0.295	0.295	0.166	0.166	0.074	0.037	0.048	--
C_B	0.734									
C_P	0.747									
C_X	0.982									
$\frac{1}{2}\alpha_E$	38.0									
$\nabla^{1/3}/L$	0.1835									
L/H	15.826									

TYPE: LIBERTY SHIP SERIES

Model	3748-1	3748-2	3748-3	3748-4	3748-5	Ship
λ	14.228	21.342	28.456	42.683	60.032	--
LWL (ft)	30.032	20.022	15.016	10.011	7.118	427.30
L_{BP} (ft)	29.24	19.49	14.62	9.75	6.930	416.03
B (ft)	4.00	2.67	2.00	1.33	0.949	56.886
H (ft)	1.900	1.26	0.95	0.63	0.450	27.000
Trim (ft)	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	167.38	49.60	20.92	6.20	2.23	481,800
Δ (lbs)	10,424	3,089	1,303	386	139	--
S (ft^2)	186.3	82.79	46.57	20.70	10.47	37,709
Append	Contra Rudder	Contra Rudder	Contra Rudder	Contra Rudder	Contra Rudder	
Material	Wood	Wood	Wood	Wood	Wood	
Finish	Enamel	Enamel	Enamel	Enamel	Enamel	
Stim.	1/8" rod	1/8" rod	1/8" rod	1/8" rod	1/16" rod	
Temp.	65.5	72.0	65.0	61.5	66.0	
Test No.	2	10	10	4	2	
Basin	DTMB 1	DTMB 1	DTMB 1	DTMB 1	DTMB 1	
A (ft^2)	1122	1122	1122	1122	1122	
a/A (%)	0.745	0.295	0.166	0.074	0.037	
C_B	0.734					
C_P	0.747					
C_X	0.982					
$\frac{1}{2}\alpha_E$	38.0					
$\nabla^{1/3}/L$	0.1835					
L/H	15.826					

TYPE: SIMON BOLIVAR

Model	60	198	37	67	29	38	33	Ship
λ	15	15	18	21	25	36	50	--
LWL (ft)	28.126	28.126	23.438	20.090	16.876	11.719	8.438	421.894
L_{BP} (ft)	28.00	28.00	23.334	20.000	16.80	11667	8.400	420.01
B (ft)	3.922	3.922	3.269	2.802	2.353	1.634	1.177	58.835
H (ft)	1.600	1.600	1.333	1.143	0.960	0.667	0.480	23.410
Trim (ft)	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	124.59	124.59	72.10	45.40	26.91	9.013	3.364	420,488
Δ (lbs)	7.759	7,759	4,490	2,827	1,676	561.26	209.5	--
S (ft^2)	154.851	154.85	107,54	79.00	55.75	26.884	13.936	3,484.2
Append.	Rudder	Rudder	Rudder	Rudder	Rudder	Rudder	Rudder	--
Material	Wood	Paraffin	Paraffin	Paraffin	Paraffin	Paraffin	Paraffin	
Finish	Enamel	None	None	None	None	None	None	
Stim.	None	None	None	None	None	None	None	
Temp.	59.9	55.4	50.7	54.7	52.9	58.5	50.4	
Test No.	--	--	--	--	--	--	--	
Basin	NSMB	NSMB	NSMB	NSMB	NSMB	NSMB	NSMB	
A (ft^2)	620	620	620	620	620	620	620	
a/A (%)	0.986	0.986	0.684	0.503	0.355	0.171	0.089	
C_B	0.7061							
C_P	0.7245							
C_X	0.9745							
$\frac{1}{2}\alpha_E$								
$\nabla^{1/3}/L$	0.1775							
L/H	18.02							

TYPE: SAN FRANCISCO

Model	3572-1	3572-2	3572-3	3572-4	Ship
λ	14.3	20.00	39.00	55.0	--
LWL (ft)	30.52	21.82	11.19	7.934	436.4
L_{BP} (ft)	30.00	21.45	11.00	7.80	429.0
B (ft)	4.125	2.95	1.513	1.072	59.0
H (ft)	1.704	1.218	0.625	0.443	24.37
Trim (ft)	0.16	0.11	0.06	0.04	2.25
∇ (ft^3)	158.594	57.974	7.819	2.786	463,500
Δ (lbs)	9876.3	3610.3	486.9	173.5	--
S (ft^2)	188.6	96.42	25.35	12.75	38,570
Append	Rudder	Rudder	Rudder	Rudder	
Material	Wood	Wood	Wood	Wood	
Finish	Enamel	Enamel	Enamel	Enamel	
Stim.	None	None	None	None	
Temp.	44	48	60.5	60.5	
Test No.	--	1	D	A	
Basin	EMB	EMB	DTMB 1	DTMB 1	
A (ft^2)	627.7	627.7	1122	1122	
a/A (%)	1.10	0.56	0.083	0.042	
C_B	0.739				
C_P	0.750				
C_X	0.985				
$\frac{1}{2}\alpha_E$	26.0				
$\nabla^{1/3}/L$	0.1772				
L/H	17.91				

TYPE: VICTORY SHIP
(Heavy Displacement)

Model							Ship
λ	18	23	30	40	50	60	
LWL (ft)	24.710	19.338	14.826	11.120	8.895	7.413	444.779
L_{BP} (ft)	24.251	18.979	14.550	10.912	8.730	7.275	436.494
B (ft)	3.444	2.6956	2.0666	1.550	1.240	1.0333	62.00
H (ft)	1.5834	1.2395	0.9502	0.7126	0.5699	0.4751	28.50
Trim (ft)	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	90.951	43.595	19.647	8.289	4.245	2.454	530,420
Δ (lbs)	5663.87	2714.84	1223.50	516.177	264.360	152.852	--
S (ft^2)	122.49	75.022	44.097	24.804	15.8747	11.024	39,687
Append.	None	None	None	None	None	None	None
Material	Paraffin	Paraffin	Paraffin	Paraffin	Paraffin	Paraffin	
Finish	None	None	None	None	None	None	
Stim.	0.039" Tr. W.	0.039" Tr. W.	0.039" Tr. W.	0.039" Tr. W.	0.039" Tr. W.	0.039" Tr. W.	
Temp.	61.0	56.0	61.0/53.8	53.8	54.1	55.2	
Test No.	11186	11492	11180/ 11459	11454	11470	11480	
Basin	NSMB	NSMB	NSMB	NSMB	NSMB	NSMB	
A (ft^2)	620	620	620	620	620	620	
a/A (%)	0.869	0.532	0.313	0.176	0.113	0.078	
C_B	0.6876						
C_P	0.6960						
C_X	0.9879						
$\frac{1}{2}\alpha_E$	12.0						
$\nabla^{1/3}/L$	0.1819						
L/H	15.606						

TYPE: VICTORY SHIP
(Light Displacement)

λ	60	50	40	30	23	18	6	1
LWL (ft)	7.413	8.895	11.120	14.826	19.338	24.710	74.130	444,779
L_{BP} (ft)	7.275	8.730	10.912	14.550	18.979	24.251	72.749	436.494
B (ft)	1.033	1.240	1.550	2.067	2.696	3.444	10.333	62.00
H (ft)	0.372	0.447	0.559	0.745	0.971	1.241	3.724	22.340
Trim by stern (ft)	0.121	0.146	0.1821	0.243	0.317	0.405	1.214	7.284
∇ (ft^3)	1.859	3.212	6.274	14.873	32.990	68.855	1,859.00	401,560
Δ (lbs)	115.767	200.024	390.707	926.201	2,054.419	4,287.876	11,576.737	--
S (ft^2)	9.4607	13.623	21.287	37.843	64.382	105.119	946.070	34057
Append.	None	None	None	None	None	None	Rudder*	
Material	Paraffin	Paraffin	Paraffin	Paraffin	Paraffin	Paraffin	Steel	
Finish	None	None	None	None	None	None	Smooth	
Stim.	0.039" Tr. W.	0.039" Tr. W.	0.039" Tr. W.	0.039" Tr. W.	0.039" Tr. W.	0.039" Tr. W.	None	
Temp.	55.2	54.3	56.8	61.0/53.8	56.0	57.0	75.2/75.5	
Test No.	11481	11471	11552	11181/ 11460	11493	11547	84	
Basin	NSMB	NSMB	NSMB	NSMB	NSMB	NSMB		
A (ft^2)	620	620	620	620	620	620		
a/A (%)	0.061	0.088	0.138	0.245	0.417	0.681		
$\nabla^{1/3}/L$	0.166							
L/H	19.910							

* Total resistance has been corrected for the resistance of the rudder.

TYPE: LUCY ASHTON (Without Stimulation)

Model										Ship
λ	6.350	6.350	7.938	9.525	11.906	15.875	21.167	31.750	47.625	--
LWL (ft)	30.00	30.00	24.00	20.00	16.00	12.00	9.00	6.00	4.00	190.50
L_{BP} (ft)	30.00	30.00	24.00	20.00	16.00	12.00	9.00	6.00	4.00	190.50
B (ft)	3.317	3.317	2.653	2.211	1.769	1.327	0.995	0.663	0.442	21.06
H (ft)***	0.7323	0.7323	0.5858	0.4882	0.3906	0.2929	0.2197	0.1465	0.0976	465
Trim (ft)	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	35.35	35.35	27.31	15.80	8.093	3.414	1.442	0.4265	0.1264	136.50
Δ (lbs)	3322.69	3322.69	1700.7	983.93	503.98	212.60	89.799	26.56	7.871	--
S (ft^2)	108.01	108.01	69.12	48.01	30.72	17.28	9.720	4.320	1.9201	4355
Append	Rudder	Rudder	Rudder	Rudder	Rudder	Rudder	Rudder	Rudder*	Rudder*	
Material	Paraffin	Wax	Paraffin	Paraffin	Paraffin	Paraffin	Paraffin	Wood	Wood	
Finish	None	None	None	None	None	None	None	Varnish	Varnish	
Stim.	0.032" Tr. W.	None	None	None	None	None	None	None	None*	
Temp.	56.0	69.0**	52.0	52.0	52.0	61.0	60.0	75.7	76.5	
Test No.	--	2	--	--	--	--	--	--	--	
Basin	NPL 1	DTMB	NPL 1	NPL 1	NPL 1	NPL 1	NPL 1	MIT	MIT	
A (ft^2)	324	1122	324	324	324	324	324	34.32	34.32	
a/A (%)	0.715	0.210	0.458	0.318	0.203	0.114	0.064	0.275	0.122	
C_B	0.685									
C_P	0.705									
C_X	0.972									
$\frac{1}{2}\alpha_E$	12.5									
$\nabla^{1/3}/L$	0.1254									
L/H	40.97									

* Extrapolated to bare hull condition.
** Corrected to 56°F
*** Sag of keel according to BSRA Rep. 107

TYPE: LUCY ASHTON
(with Stimulation)

Model								Ship
λ	6.350	6.350	7.938	9.525	11.906	15.875	21.167	--
LWL (ft)	30.00	30.00	24.00	20.00	16.00	12.00	9.00	190.50
L_{BP} (ft)	30.00	30.00	24.00	20.00	16.00	12.00	9.00	190.50
B (ft)	3.317	3.317	2.653	2.211	1.769	1.327	0.995	21.06
H (ft)	0.7323	0.7323	0.5858	0.4882	0.3906	0.2929	0.2197	4.65
Trim (ft)	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	35.35	35.35	27.31	15.80	8.093	3.414	1.442	13650
Δ (lbs)	3322.69	3322.69	1700.7	983.93	503.98	212.60	89.799	--
S (ft^2)	108.01	108.01	69.12	48.01	30.72	17.28	9.720	4,355
Append	Rudder	Rudder	Rudder	Rudder	Rudder	Rudder	Rudder	Rudder
Material	Paraffin	Wax	Paraffin	Paraffin	Paraffin	Paraffin	Paraffin	
Finish	None	None	None	None	None	None	None	
Stim.	0.032" Tr. W.	0.036" Tr. W.	0.032" Tr. W.	0.032" Tr. W.	0.032" Tr. W.	0.032" Tr. W.	0.032" Tr. W.	
Temp.	56.0	69.0	52.0	52.0	52.0	61.0	60.0	
Test No.	--	1	--	--	--	--	--	
Basin	NPL 1	DTMB 1	NPL 1	NPL 1	NPL 1	NPL 1	NPL 1	
A (ft^2)	324	1122	324	324	324	324	324	
a/A (%)	0.715	0.210	0.458	0.318	0.203	0.114	0.064	
C_B	0.685							
C_P	0.705							
C_X	0.972							
$\frac{1}{2}\alpha_E$	12.5							
$\nabla^{1/3}/L$	0.1254							
L/H	40.97							

TYPE: TINA ONASSIS

Model	321	414	413	412	Ship
λ	32	40	60	80	--
LWL (ft)	23.024	18.419	12.280	9.209	736.76
L_{BP} (ft)	22.556	18.045	12.031	9.022	721.79
B (ft)	2.974	2.379	1.586	1.189	95.10
H (ft)	1.077	0.861	0.575	0.431	34.80
Trim (ft)	E.K.	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	56.308	28.830	8.542	3.604	1845.151
Δ (lbs)	3,515.1	1,799.73	533.25	224.966	--
S (ft^2)	95.189	60.921	27.076	15.230	97468
Append.	Rudder	Rudder	Rudder	Rudder	
Material	Paraffin	Paraffin	Paraffin	Paraffin	
Finish	None	None	None	None	
Stim.	0.0354" Tr. W.	0.0354" Tr. W.	0.0354" Tr. W.	0.0354" Tr. W.	
Temp.	72.0	72.0	71.8	72.0	
Test No.	1431/1812	1806	1801	1798	
Basin	Madrid	Madrid	Madrid	Madrid	
A (ft^2)	873.30	873.30	873.30	873.30	
a/A (%)	0.365	0.234	0.104	0.058	
C_B	0.7796				
C_P	0.7833				
C_X	0.9952				
$\frac{1}{2}\alpha_E$	32°35'				
$\nabla^{1/3}/L$	0.1664				
L/H	21.42				

TYPE: SWEDISH VESSEL* (GOTEBORG

Model	346	332	345	Ship
λ	15	20	40	--
LWL (ft)	26.668	20.000	10.000	400.00
L_{BP} (ft)	26.668	20.000	10.000	400.00
B (ft)	3.609	2.707	1.355	54.14
H (ft)	1.503	1.129	0.564	22.54
Trim (ft)	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	84.654	35.705	4.464	285,747
Δ (lbs)	5,271.74	2,223.49	277.99	--
S (ft^2)	123.431	69.428	17.362	27,771
Append.	None	None	None	
Material	Paraffin	Paraffin	Paraffin	
Finish	None	None	None	
Stim.	None	None	None	
Temp.	57.0/57.9	56.7/56.8/ 57.2/59.4	56.7/55.0	
Test No.	30	17	25	
Basin	Goteborg	Goteborg	Goteborg	
A (ft^2)	544	544	544	
a/A (%)	0.971	0.547	0.137	
C_B	0.585			
C_P	0.600			
C_X	0.975			
$\nabla^{1/3}/L$	0.1646			
L/H	17.75			

* All models are symmetrical about midships.

TYPE: SWEDISH VESSEL*

(With Stimulation)

Model	346	332**	345	Ship
λ	15	20	40	1
LWL (ft)	26.668	20.000	10.000	400.00
L_{BP} (ft)	26.668	20.000	10.000	400.00
B (ft)	3.609	2.707	1.355	54.14
H (ft)	1.503	1.129	0.564	22.54
Trim (ft)	E.K.	E.K.	E.K.	E.K.
∇(ft^3)	84.654	35.705	4.464	285,747
Δ(lbs)	5,271.74	2,223.49	277.99	--
S (ft^2)	123.431	69.428	17.362	27,771
Appendages	None	None	None	None
Material	Paraffin	Paraffin	Paraffin	
Finish	None	None	None	
Stimul.	0.039" Tr.W.	0.039" Tr.W.	0.039" Tr.W.	
Temp.	59.4 57.7	56.7 57.0	57.7	
Test No.	31	18	26	
Basin	Goteborg	Goteborg	Goteborg	
A (ft^2)	544	544	544	
a/A (%)	0.971	0.547	0.137	
C_B	0.585			
C_P	0.600			
C_X	0.975			
$\nabla^{1/3}/L$	0.1646			
L/H	17.75			

* All models are symmetrical about midships.
** With normal and raked stem.

TYPE: SWEDISH VESSEL*

Model	334	352	Ship
λ	20	40	1
LWL (ft)	20.00	10.00	400.00
L_{BP} (ft)	20.00	10.00	400.00
B (ft)	2.707	1.355	54.14
H (ft)	1.129	0.564	22.54
Trim (ft)	E.K.	E.K.	E.K.
∇ (ft^3)	47.642	5.954	381,000
Δ(lbs)	2966.85	370.78	--
S (ft^2)	81.16	20.29	32,464
Appendages	None	None	None
Material	Paraffin	Paraffin	
Finish	None	None	
Stimul.	None	None	
Temp.	57.7 56.8	62.4	
Test No.	1	10	
Basin	Goteborg	Goteborg	
A (ft^2)	544	544	
a/A (%)	0.547	0.137	
C_B	0.78		
C_P	0.80		
C_X	0.975		
$\nabla^{1/3}/L$	0.1812		
L/H	17.75		

* All models are symmetrical about midships.

TYPE: SWEDISH VESSEL*

(With Stimulation)

Model	334	352	Ship
λ	20	40	1
LWL (ft)	20.00	10.00	400.00
L_{BP} (ft)	20.00	10.00	400.00
B (ft)	2.707	1.355	54.14
H (ft)	1.129	0.564	22.54
Trim (ft)	E.K.	E.K.	E.K.
∇ (ft^3)	47.642	5.954	381,000
Δ(lbs)	2,966.85	370.78	--
S (ft^2)	81.16	20.29	32,464
Appendages	None	None	
Material	Paraffin	Paraffin	
Finish	None	None	
Stimul.	0.039" Tr.W.	0.039" Tr.W.	
Temp.	58.0 57.0	62.2 62.0	
Test No.	2	11	
Basin	Goteborg	Goteborg	
A (ft^2)	544	544	
a/A (%)	0.547	0.137	
C_B	0.78		
C_P	0.80		
C_X	0.975		
$\nabla^{1/3}/L$	0.1812		
L/H	17.75		

* All models are symmetrical about midships.

TYPE: WRANGLE-DESTROYER

Model	441	425	425	Ship
λ	50	10	10	1
LWL (ft)	4.564	22.819	22.819	228.194
L_{BP} (ft)	--	--	--	--
B (ft)	0.432	2.159	2.159	21.589
H (ft)	0.122	0.610	0.610	6.103
Trim (ft)	E.K.	E.K.	E.K.	E.K.
∇ (ft^3)	0.112	14.056	14.056	14,056
Δ(lbs)	6.975	875.32	875.32	--
S (ft^2)	1.890	47.254	49.192	4,725.4
Appendages	Rudder	Rudder	Rudder & Append.	
Material	Wood	Paraffin	Paraffin	
Finish	Not published	None	None	
Stimul.	0.019" Tr.W.	0.039" Tr.W.	0.039" Tr.W.	
Temp.	61.0	53.6	56.8	59.0
Basin	Goteborg	Goteborg	Goteborg	
A (ft^2)	544	544	544	
a/A (%)	0.0075	0.188	0.188	
C_B	0.471			
C_P	0.619			
C_X	0.761			
$\nabla^{1/3}/L$	0.1057			
L/H	37.39			

TANKER - SERIES (KLOESS)

Model	1642	1641	1640	1639	Ship
λ	55	45	35	25	1
LWL (ft)	10.260	12.540	16.123	22.573	564.33
L_{BP} (ft)	10.023	12.248	15.749	22.048	551.21
B (ft)	1.344	1.654	2.129	2.979	74.48
H (ft)	0.561	0.686	0.883	1.237	30.91
Trim (ft)	E.K.	E.K.	E.K.	E.K.	E.K.
$\nabla (ft^3)$	5.682	10.376	22.052	60.508	945,425
Δ(lbs)	353.841	645.595	1373.27	3768.08	--
Append.	Rudder	Rudder	Rudder	Rudder	Rudder
Material	Wax	Wax	Wax	Wax	
Stimul.	Tr.W. None	Tr.W. None	Tr.W. None	Tr.W. None	
Temp. F	48.7 49.1	48.2 48.2	59.0 59.0 / 48.2	59.4 / 58.8 59.9	
Test No.	50 53	46 49	61 62 / 45	38 / 49 53	
Basin	Berlin	Berlin	Berlin	Berlin	
A (ft^2)	370	370	370	370	
a/A (%)	0.204	0.304	0.504	0.988	
C_B	0.728				
C_P	0.734				
C_X	0.992				
$\nabla^{1/3}/L$	0.1738				
L/H	18.26				

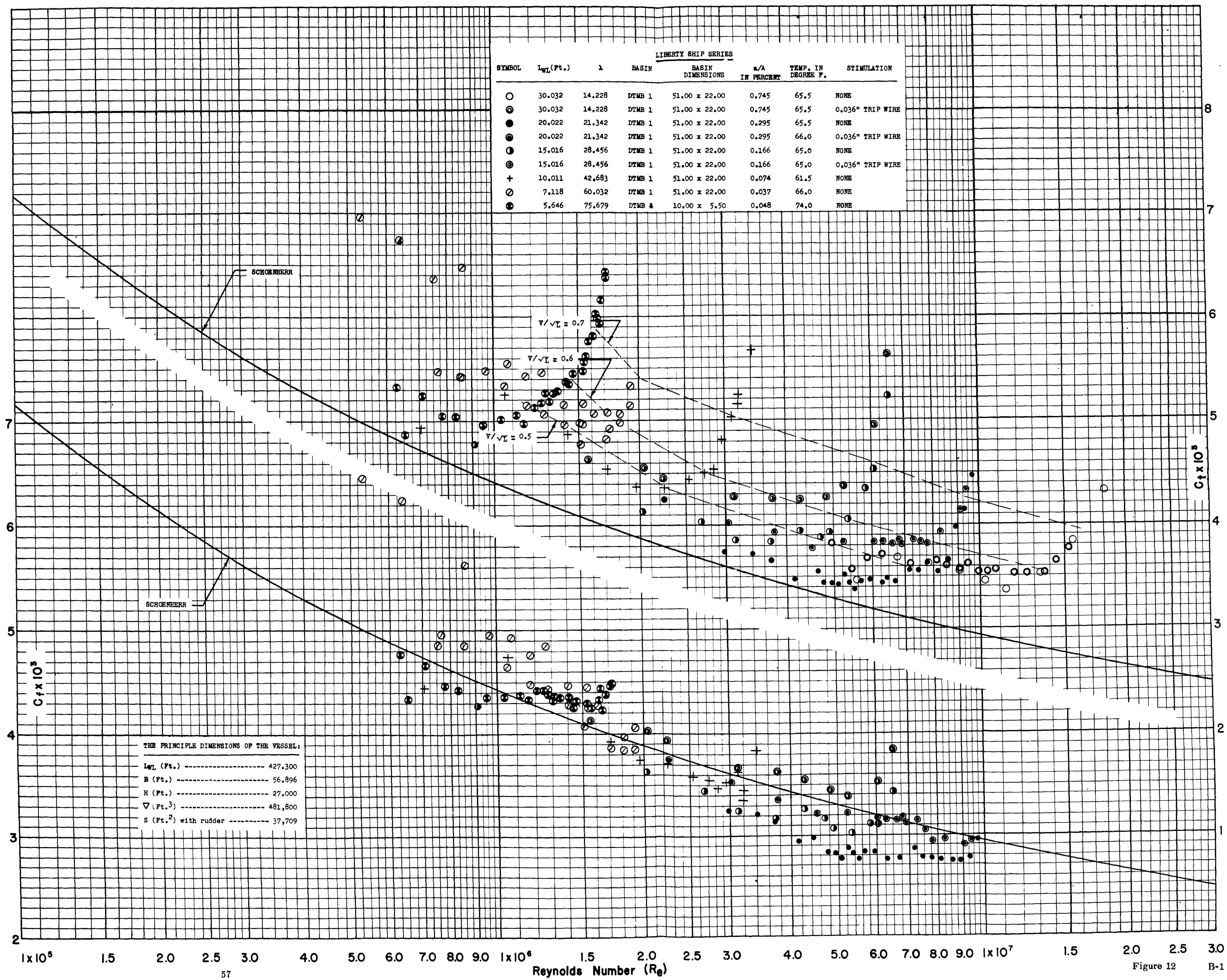
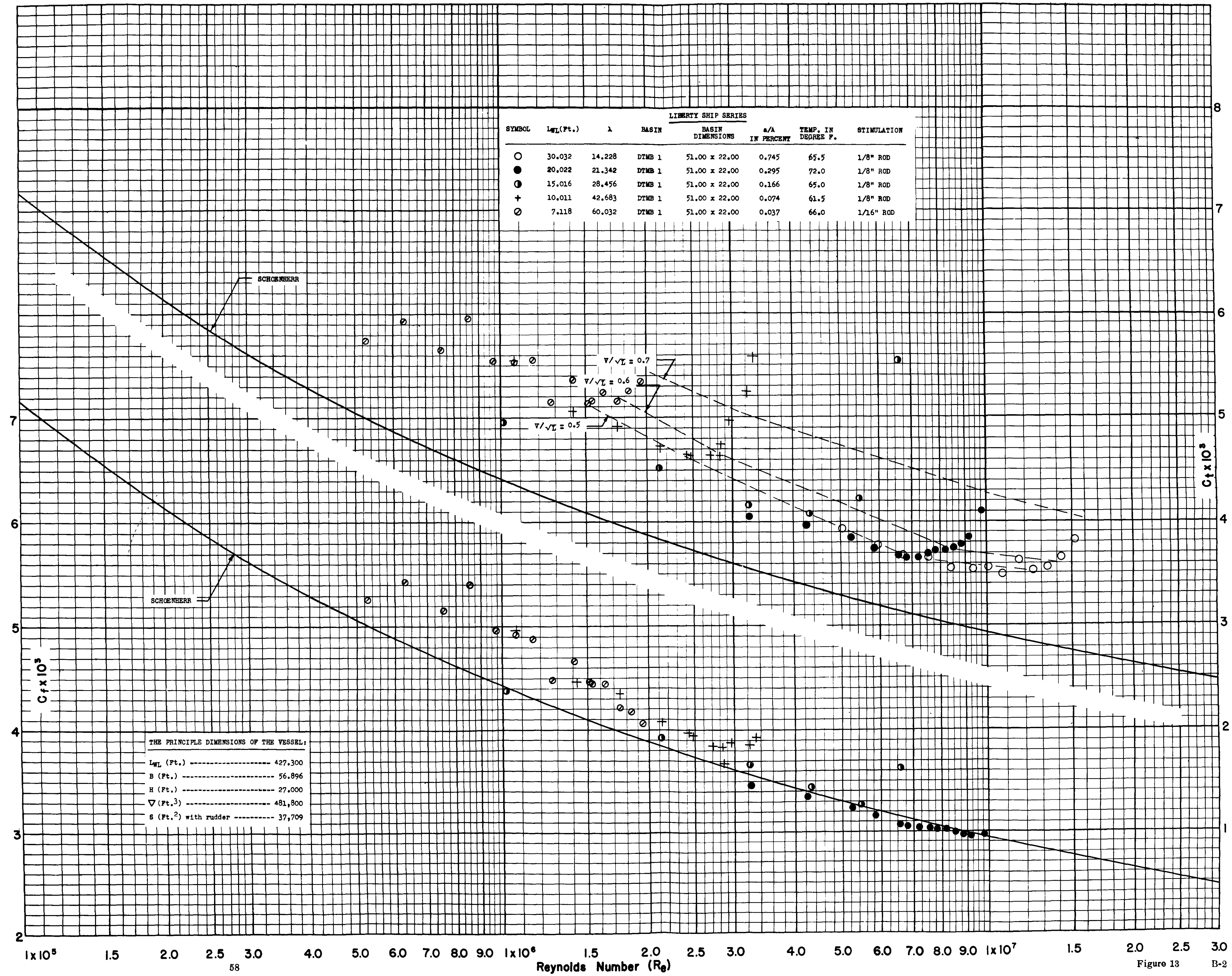

LIBERTY SHIP SERIES
SYMBOL | L_{WL}(Ft.) | λ | BASIN | BASIN DIMENSIONS | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
30.032 | 14.228 | DTMB 1 | 51.00 x 22.00 | 0.745 | 65.5 | NONE
30.032 | 14.228 | DTMB 1 | 51.00 x 22.00 | 0.745 | 65.5 | 0.036" TRIP WIRE
20.022 | 21.342 | DTMB 1 | 51.00 x 22.00 | 0.295 | 65.5 | NONE
20.022 | 21.342 | DTMB 1 | 51.00 x 22.00 | 0.295 | 66.0 | 0.036" TRIP WIRE
15.016 | 28.456 | DTMB 1 | 51.00 x 22.00 | 0.166 | 65.0 | NONE
15.016 | 28.456 | DTMB 1 | 51.00 x 22.00 | 0.166 | 65.0 | 0.036" TRIP WIRE
10.011 | 42.683 | DTMB 1 | 51.00 x 22.00 | 0.074 | 61.5 | NONE
7.118 | 60.032 | DTMB 1 | 51.00 x 22.00 | 0.037 | 66.0 | NONE
5.646 | 75.679 | DTMB 4 | 10.00 x 5.50 | 0.048 | 74.0 | NONE
SCHOENHERR
SCHOENHERR
$V/\sqrt{L}$ = 0.7
$V/\sqrt{L}$ = 0.6
$V/\sqrt{L}$ = 0.5
THE PRINCIPLE DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) ---------- 427.300
B (Ft.) ---------- 56.896
H (Ft.) ---------- 27.000
∇ (Ft.^{3}) ---------- 481,800
S (Ft.^{2}) with rudder ---------- 37,709
$C_f \times 10^3$
$C_t \times 10^3$
Reynolds Number (R_e)
1x10^5 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^6 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^7 1.5 2.0 2.5 3.0

Figure 12



LIBERTY SHIP SERIES
SYMBOL | L_{WL}(Ft.) | λ | BASIN | BASIN DIMENSIONS | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
○ 30.032 14.228 DTMB 1 51.00 x 22.00 0.745 65.5 1/8" ROD
● 20.022 21.342 DTMB 1 51.00 x 22.00 0.295 72.0 1/8" ROD
◑ 15.016 28.456 DTMB 1 51.00 x 22.00 0.166 65.0 1/8" ROD
+ 10.011 42.683 DTMB 1 51.00 x 22.00 0.074 61.5 1/8" ROD
⊘ 7.118 60.032 DTMB 1 51.00 x 22.00 0.037 66.0 1/16" ROD
SCHOENHERR
SCHOENHERR
$V/\sqrt{L}$ = 0.7
$V/\sqrt{L}$ = 0.6
$V/\sqrt{L}$ = 0.5
THE PRINCIPLE DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) ---------- 427.300
B (Ft.) ---------- 56.896
H (Ft.) ---------- 27.000
∇ (Ft.^{3}) ---------- 481,800
S (Ft.^{2}) with rudder ---------- 37,709
$C_f \times 10^3$
$C_f \times 10^3$
Reynolds Number (R_e)

Figure 13

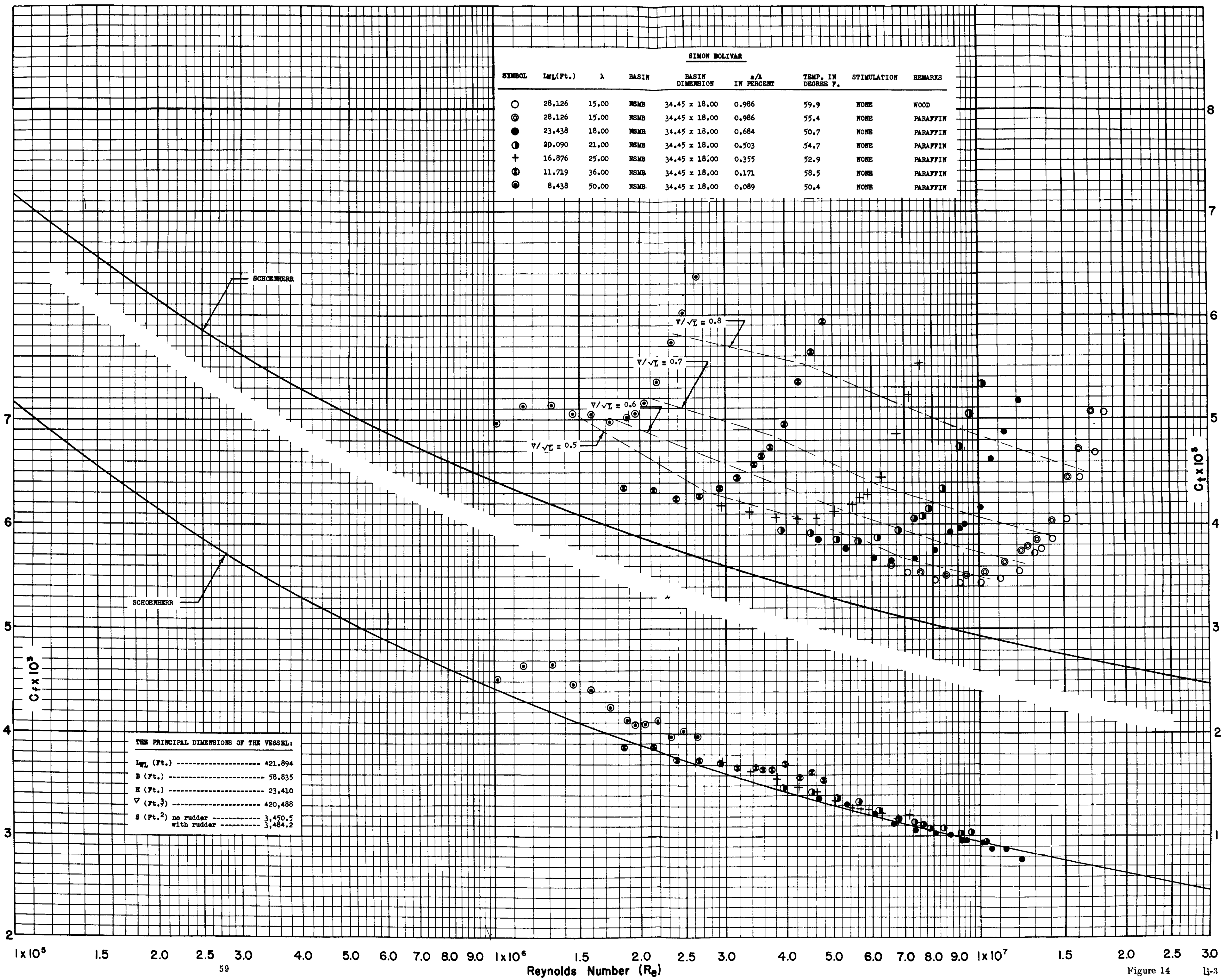
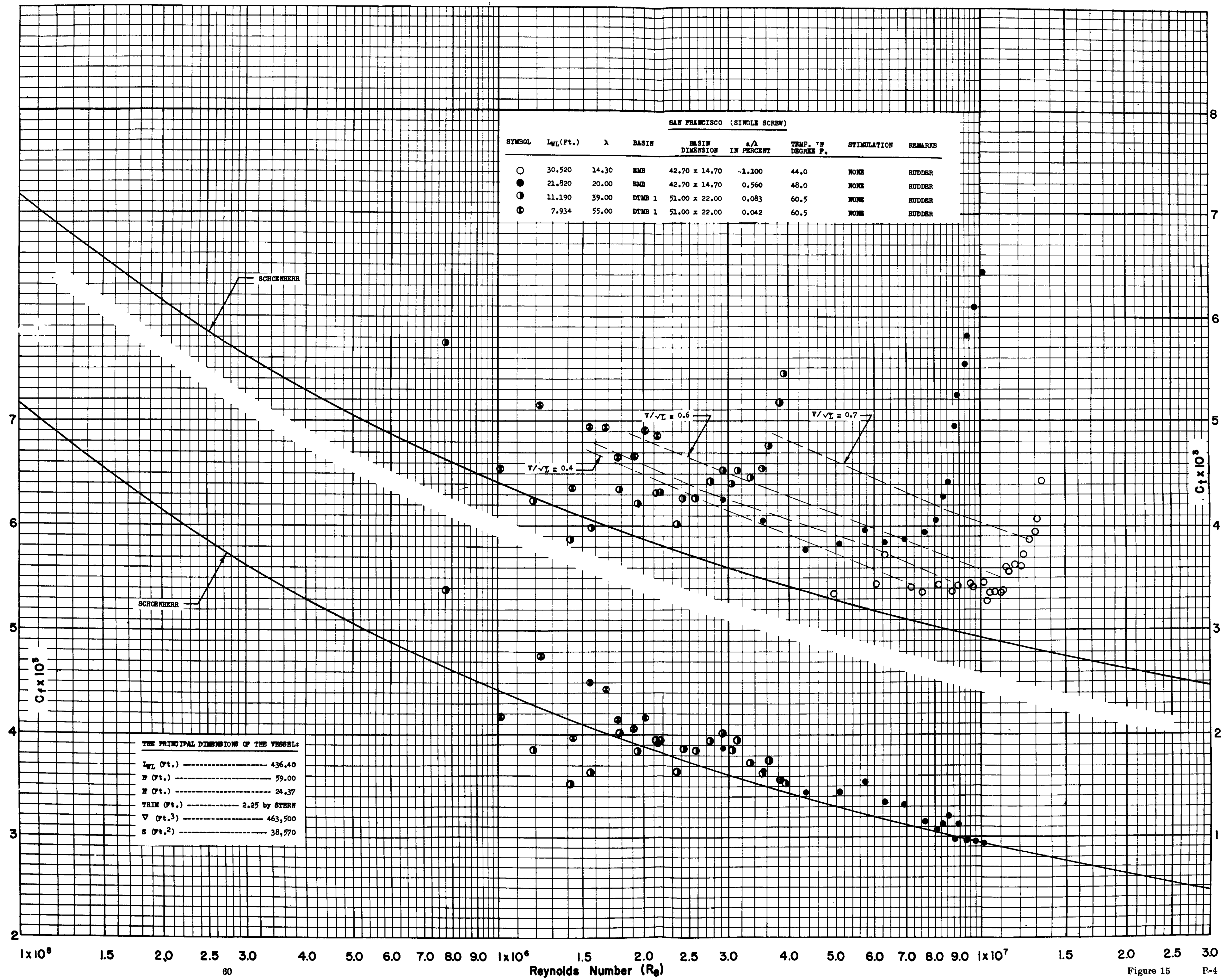

SIMON BOLIVAR
SYMBOL LWL(Ft.) λ BASIN BASIN DIMENSION a/A IN PERCENT TEMP. IN DEGREE F. STIMULATION REMARKS
○ 28.126 15.00 NSMB 34.45 x 18.00 0.986 59.9 NONE WOOD
◎ 28.126 15.00 NSMB 34.45 x 18.00 0.986 55.4 NONE PARAFFIN
● 23.438 18.00 NSMB 34.45 x 18.00 0.684 50.7 NONE PARAFFIN
◑ 20.090 21.00 NSMB 34.45 x 18.00 0.503 54.7 NONE PARAFFIN
+ 16.876 25.00 NSMB 34.45 x 18.00 0.355 52.9 NONE PARAFFIN
⊗ 11.719 36.00 NSMB 34.45 x 18.00 0.171 58.5 NONE PARAFFIN
◉ 8.438 50.00 NSMB 34.45 x 18.00 0.089 50.4 NONE PARAFFIN
SCHOENHERR
SCHOENHERR
∇/√L = 0.8
∇/√L = 0.7
∇/√L = 0.6
∇/√L = 0.5
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
LWL (Ft.) ------------------------ 421.894
B (Ft.) -------------------------- 58.835
H (Ft.) -------------------------- 23.410
∇ (Ft.3) ------------------------- 420,488
S (Ft.2) no rudder ------------ 3,450.5
with rudder ---------- 3,484.2
Cf x 10³
Cf x 10³
2
3
4
5
6
7
8
1
2
3
4
5
6
7
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0
Reynolds Number (Re)

Figure 14



SAN FRANCISCO (SINGLE SCREW)
SYMBOL | L_{WL}(Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
○ | 30.520 | 14.30 | EMB | 42.70 x 14.70 | -1.100 | 44.0 | NONE | RUDDER
● | 21.820 | 20.00 | EMB | 42.70 x 14.70 | 0.560 | 48.0 | NONE | RUDDER
◑ | 11.190 | 39.00 | DTMB 1 | 51.00 x 22.00 | 0.083 | 60.5 | NONE | RUDDER
⦶ | 7.934 | 55.00 | DTMB 1 | 51.00 x 22.00 | 0.042 | 60.5 | NONE | RUDDER
SCHOENHERR
SCHOENHERR
$V/\sqrt{L}$ = 0.4
$V/\sqrt{L}$ = 0.6
$V/\sqrt{L}$ = 0.7
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) ---------- 436.40
B (Ft.) ---------- 59.00
H (Ft.) ---------- 24.37
TRIM (Ft.) ---------- 2.25 by STERN
∇ (Ft.^{3}) ---------- 463,500
S (Ft.^{2}) ---------- 38,570
$C_f \times 10^3$
$C_f \times 10^3$
2
3
4
5
6
7
1
2
3
4
5
6
7
8
1x10^5 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^6 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^7 1.5 2.0 2.5 3.0
Reynolds Number (R_e)

Figure 15

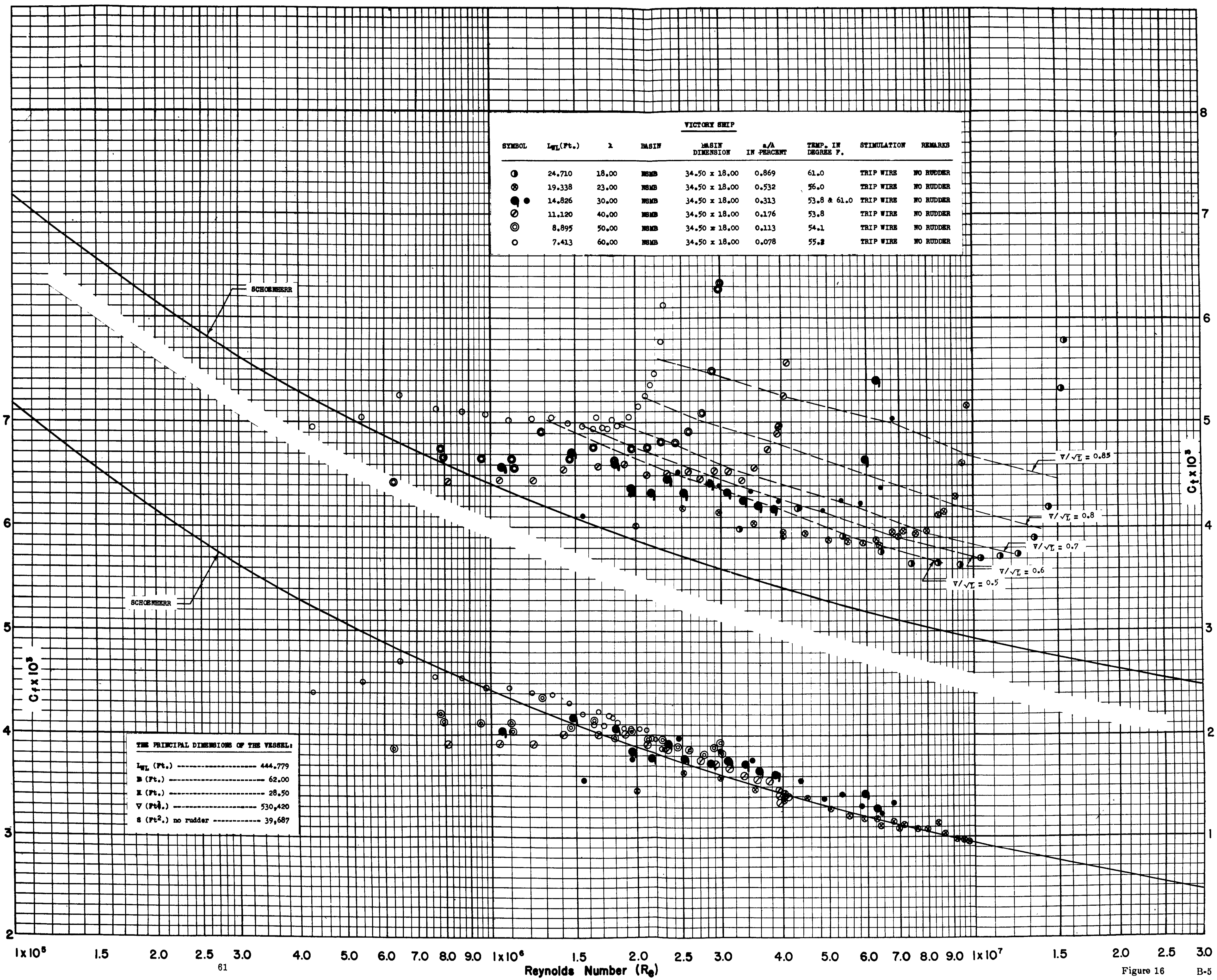

VICTORY SHIP
SYMBOL | L_{WL}(Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
24.710 | 18.00 | NSMB | 34.50 x 18.00 | 0.869 | 61.0 | TRIP WIRE | NO RUDDER
19.338 | 23.00 | NSMB | 34.50 x 18.00 | 0.532 | 56.0 | TRIP WIRE | NO RUDDER
14.826 | 30.00 | NSMB | 34.50 x 18.00 | 0.313 | 53.8 & 61.0 | TRIP WIRE | NO RUDDER
11.120 | 40.00 | NSMB | 34.50 x 18.00 | 0.176 | 53.8 | TRIP WIRE | NO RUDDER
8.895 | 50.00 | NSMB | 34.50 x 18.00 | 0.113 | 54.1 | TRIP WIRE | NO RUDDER
7.413 | 60.00 | NSMB | 34.50 x 18.00 | 0.078 | 55.2 | TRIP WIRE | NO RUDDER
SCHOENHERR
SCHOENHERR
∇/√L = 0.85
∇/√L = 0.8
∇/√L = 0.7
∇/√L = 0.6
∇/√L = 0.5
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) ---------- 444.779
B (Ft.) ---------- 62.00
H (Ft.) ---------- 28.50
∇ (Ft³.) ---------- 530,420
S (Ft².) no rudder ---------- 39,687
C_f x 10³
C_t x 10³
Reynolds Number (R_e)
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0
2 3 4 5 6 7
1 2 3 4 5 6 7 8

Figure 16

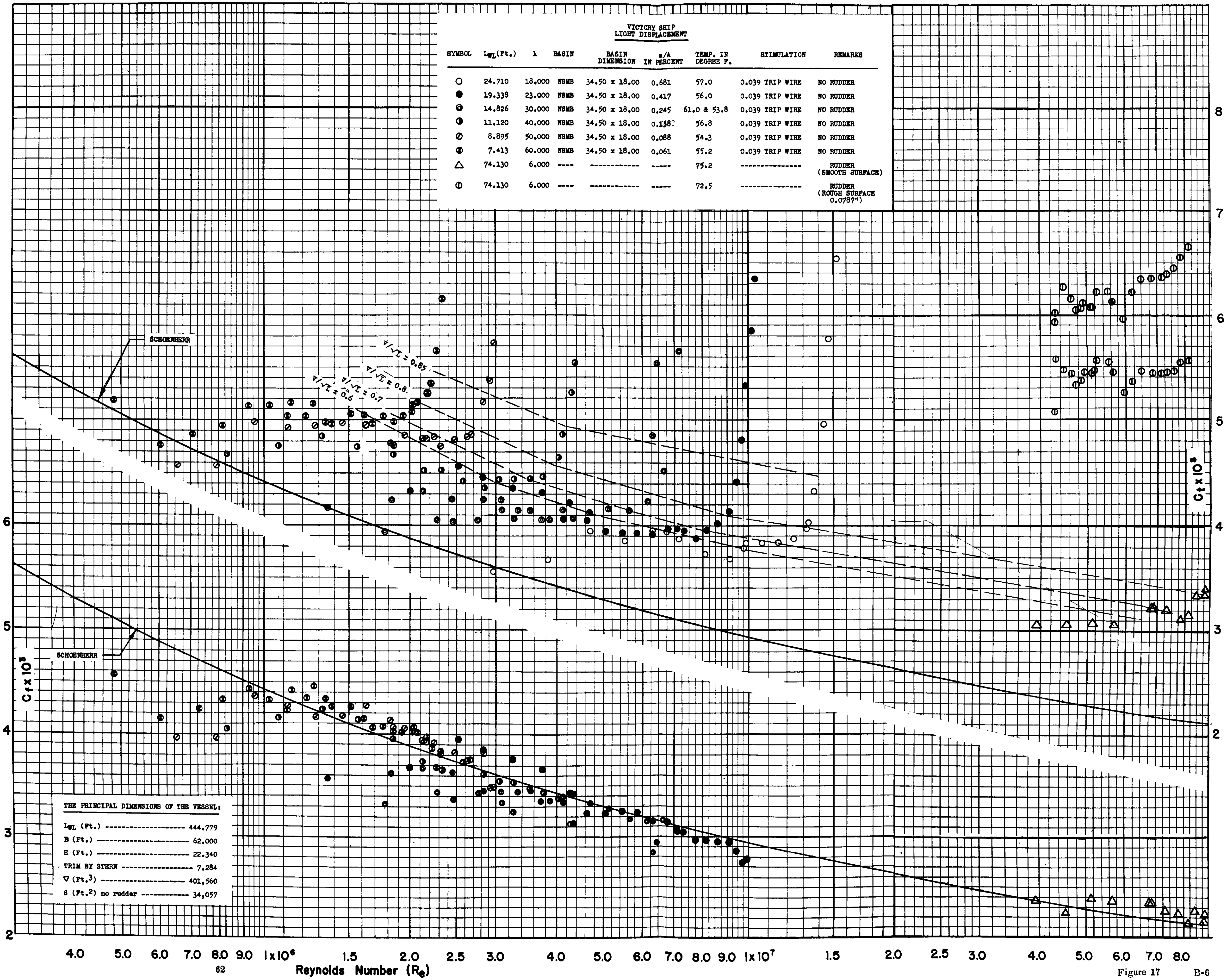

VICTORY SHIP
LIGHT DISPLACEMENT
SYMBOL | LWL (Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
○ 24.710 18.000 NSMB 34.50 x 18.00 0.681 57.0 0.039 TRIP WIRE NO RUDDER
● 19.338 23.000 NSMB 34.50 x 18.00 0.417 56.0 0.039 TRIP WIRE NO RUDDER
14.826 30.000 NSMB 34.50 x 18.00 0.245 61.0 & 53.8 0.039 TRIP WIRE NO RUDDER
11.120 40.000 NSMB 34.50 x 18.00 0.138 56.8 0.039 TRIP WIRE NO RUDDER
8.895 50.000 NSMB 34.50 x 18.00 0.088 54.3 0.039 TRIP WIRE NO RUDDER
7.413 60.000 NSMB 34.50 x 18.00 0.061 55.2 0.039 TRIP WIRE NO RUDDER
△ 74.130 6.000 ---- ------------ ----- 75.2 --------------- RUDDER (SMOOTH SURFACE)
74.130 6.000 ---- ------------ ----- 72.5 --------------- RUDDER (ROUGH SURFACE 0.0787")
SCHOENHERR
SCHOENHERR
∇/√L = 0.85
∇/√L = 0.8
∇/√L = 0.7
∇/√L = 0.6
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
LWL (Ft.) ---------------------- 444.779
B (Ft.) ------------------------ 62.000
H (Ft.) ------------------------ 22.340
TRIM BY STERN ------------------ 7.284
∇ (Ft.3) ----------------------- 401,560
S (Ft.2) no rudder ------------- 34,057
Cf x 10³
Cf x 10³
2
3
4
5
6
2
3
4
5
6
7
8
4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0
Reynolds Number (Re)

Figure 17

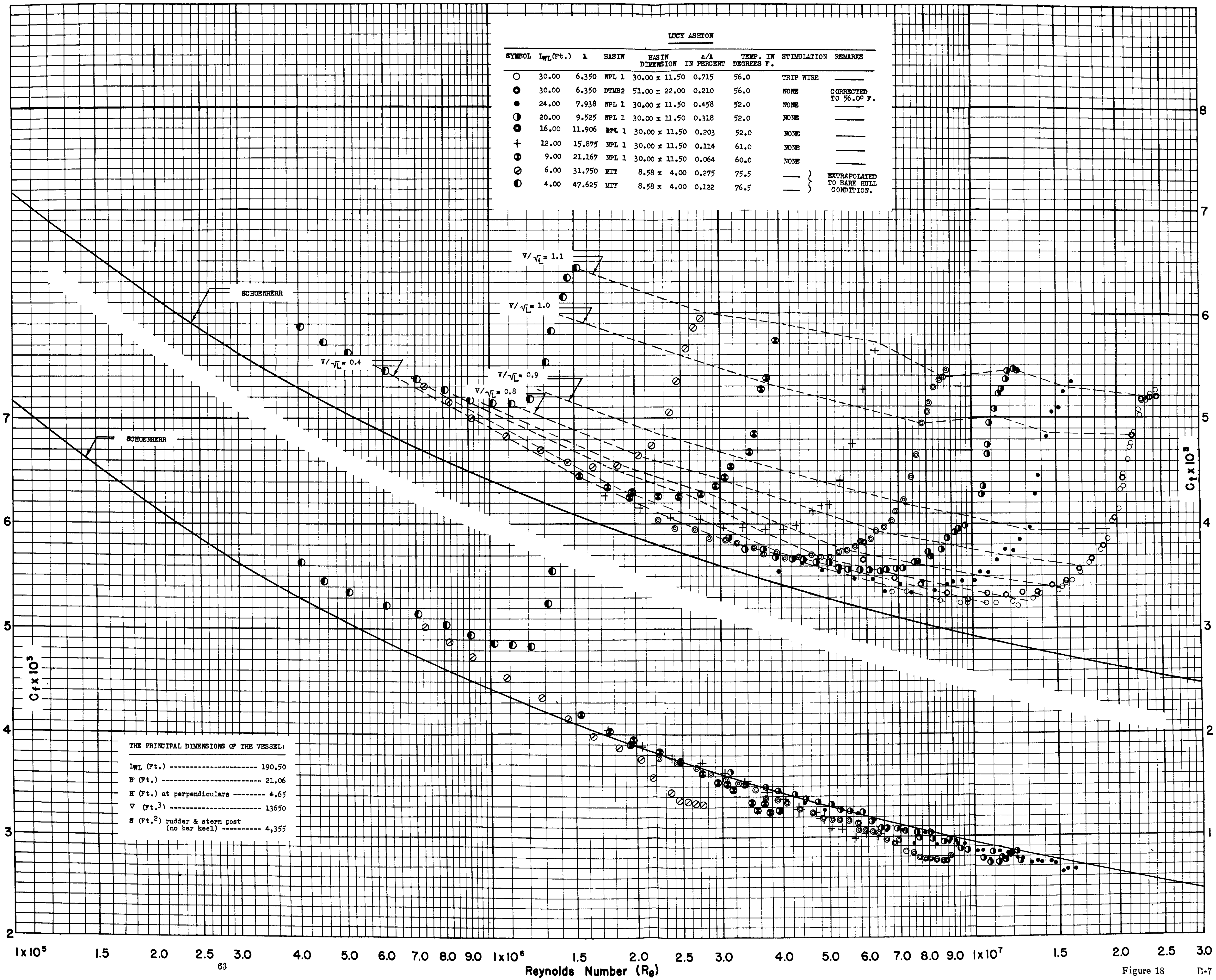

LUCY ASHTON
SYMBOL | LWL(Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREES F. | STIMULATION | REMARKS
○ 30.00 6.350 NPL 1 30.00 x 11.50 0.715 56.0 TRIP WIRE
30.00 6.350 DTMB2 51.00 x 22.00 0.210 56.0 NONE CORRECTED TO 56.0° F.
● 24.00 7.938 NPL 1 30.00 x 11.50 0.458 52.0 NONE
20.00 9.525 NPL 1 30.00 x 11.50 0.318 52.0 NONE
16.00 11.906 NPL 1 30.00 x 11.50 0.203 52.0 NONE
+ 12.00 15.875 NPL 1 30.00 x 11.50 0.114 61.0 NONE
9.00 21.167 NPL 1 30.00 x 11.50 0.064 60.0 NONE
6.00 31.750 MIT 8.58 x 4.00 0.275 75.5
4.00 47.625 MIT 8.58 x 4.00 0.122 76.5
EXTRAPOLATED TO BARE HULL CONDITION.
V/√L = 1.1
V/√L = 1.0
V/√L = 0.9
V/√L = 0.8
V/√L = 0.4
SCHOENHERR
SCHOENHERR
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
LWL (Ft.) ---------------------- 190.50
B (Ft.) ------------------------ 21.06
H (Ft.) at perpendiculars -------- 4.65
∇ (Ft.3) ----------------------- 13650
S (Ft.2) rudder & stern post (no bar keel) ---------- 4,355
Cf x 10³
Ct x 10³
2
3
4
5
6
7
8
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0
Reynolds Number (Re)

Figure 18

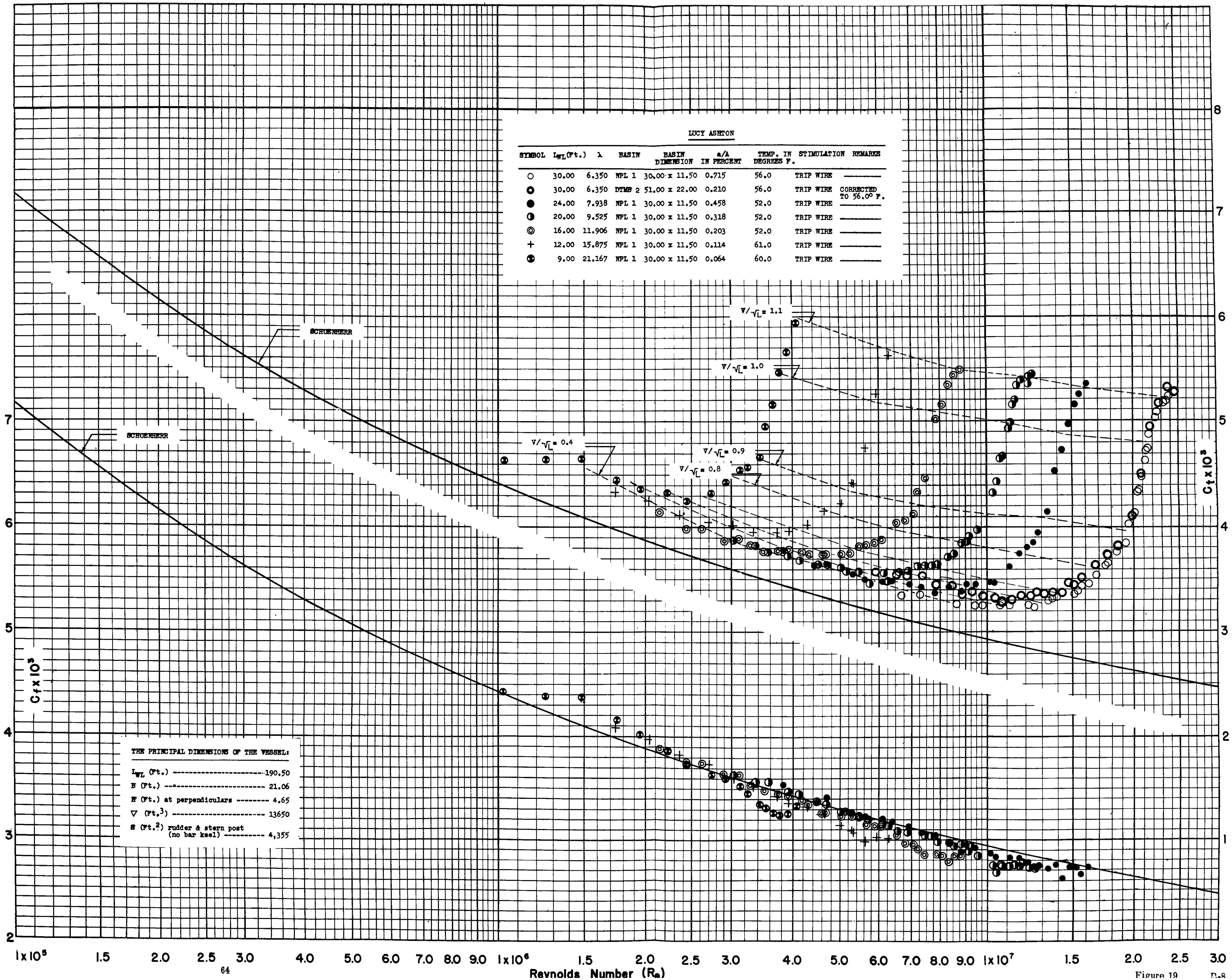
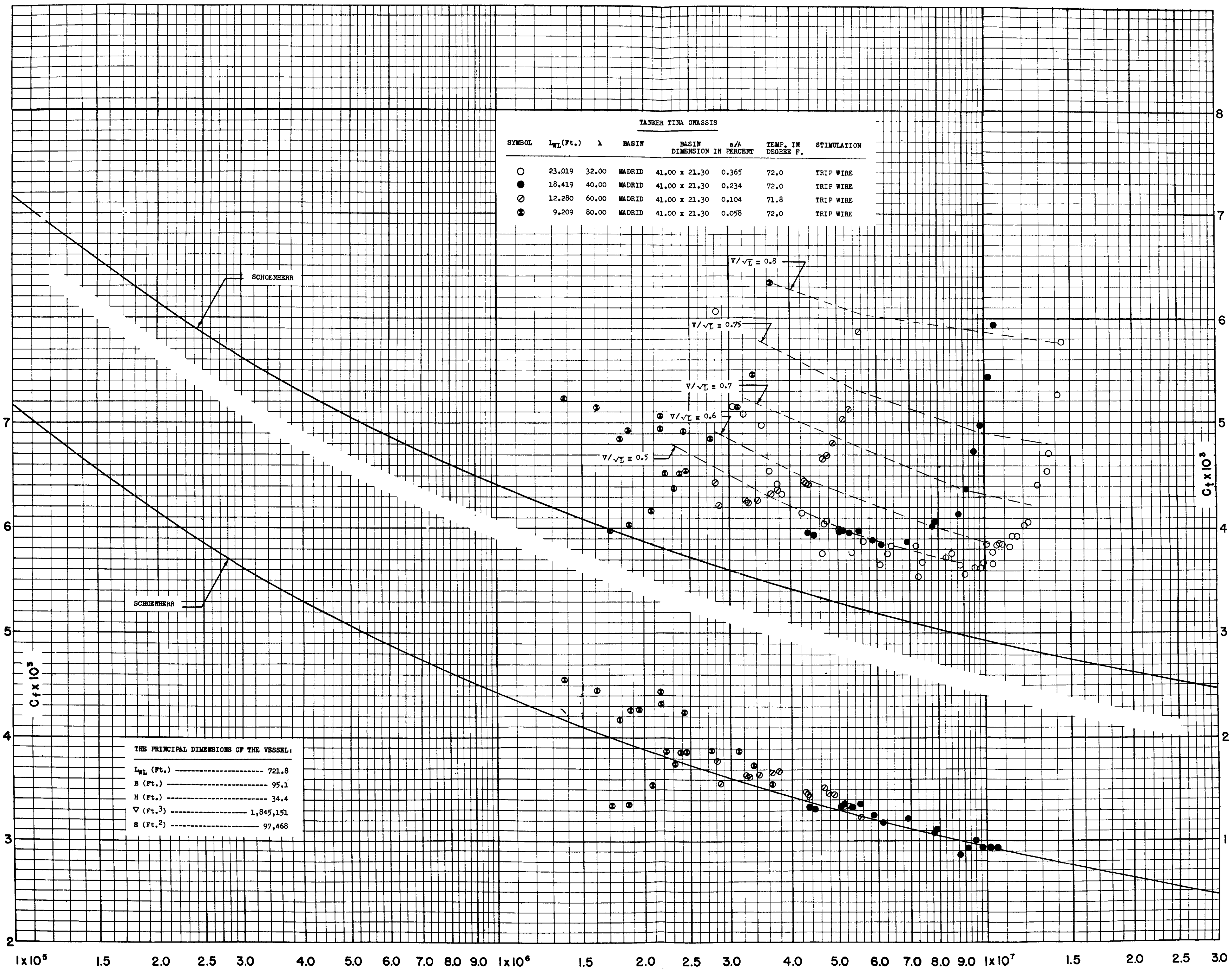

LUCY ASHTON
SYMBOL | LWL (Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREES F. | STIMULATION | REMARKS
○ 30.00 6.350 NPL 1 30.00 x 11.50 0.715 56.0 TRIP WIRE
30.00 6.350 DTMB 2 51.00 x 22.00 0.210 56.0 TRIP WIRE CORRECTED TO 56.0° F.
● 24.00 7.938 NPL 1 30.00 x 11.50 0.458 52.0 TRIP WIRE
◑ 20.00 9.525 NPL 1 30.00 x 11.50 0.318 52.0 TRIP WIRE
◎ 16.00 11.906 NPL 1 30.00 x 11.50 0.203 52.0 TRIP WIRE
+ 12.00 15.875 NPL 1 30.00 x 11.50 0.114 61.0 TRIP WIRE
9.00 21.167 NPL 1 30.00 x 11.50 0.064 60.0 TRIP WIRE
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
LWL (Ft.) ---------------------- 190.50
B (Ft.) ------------------------ 21.06
H (Ft.) at perpendiculars -------- 4.65
▽ (Ft.3) ----------------------- 13650
S (Ft.2) rudder & stern post (no bar keel) ---------- 4,355
SCHOENHERR
SCHOENHERR
V/√L = 1.1
V/√L = 1.0
V/√L = 0.9
V/√L = 0.8
V/√L = 0.4
Cf x 10³
Ct x 10³
Reynolds Number (Re)
1x10⁵
1.5
2.0
2.5
3.0
4.0
5.0
6.0
7.0
8.0
9.0
1x10⁶
1x10⁷
2
3
4
5
6
7
8

Figure 19



TANKER TINA ONASSIS
SYMBOL | L_{WL}(Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
○ | 23.019 | 32.00 | MADRID | 41.00 x 21.30 | 0.365 | 72.0 | TRIP WIRE
● | 18.419 | 40.00 | MADRID | 41.00 x 21.30 | 0.234 | 72.0 | TRIP WIRE
⊘ | 12.280 | 60.00 | MADRID | 41.00 x 21.30 | 0.104 | 71.8 | TRIP WIRE
⊗ | 9.209 | 80.00 | MADRID | 41.00 x 21.30 | 0.058 | 72.0 | TRIP WIRE
$V/\sqrt{L}$ = 0.8
$V/\sqrt{L}$ = 0.75
$V/\sqrt{L}$ = 0.7
$V/\sqrt{L}$ = 0.6
$V/\sqrt{L}$ = 0.5
SCHOENHERR
SCHOENHERR
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) ---------------------- 721.8
B (Ft.) ------------------------- 95.1
H (Ft.) ------------------------- 34.4
∇ (Ft.^{3}) ------------------ 1,845,151
S (Ft.^{2}) ---------------------- 97,468
$C_f \times 10^3$
$C_t \times 10^3$
2
3
4
5
6
7
8
1
2
3
4
5
6
7
1x10^5 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^6 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^7 1.5 2.0 2.5 3.0
Reynolds Number (R_e)

Figure 20

B-

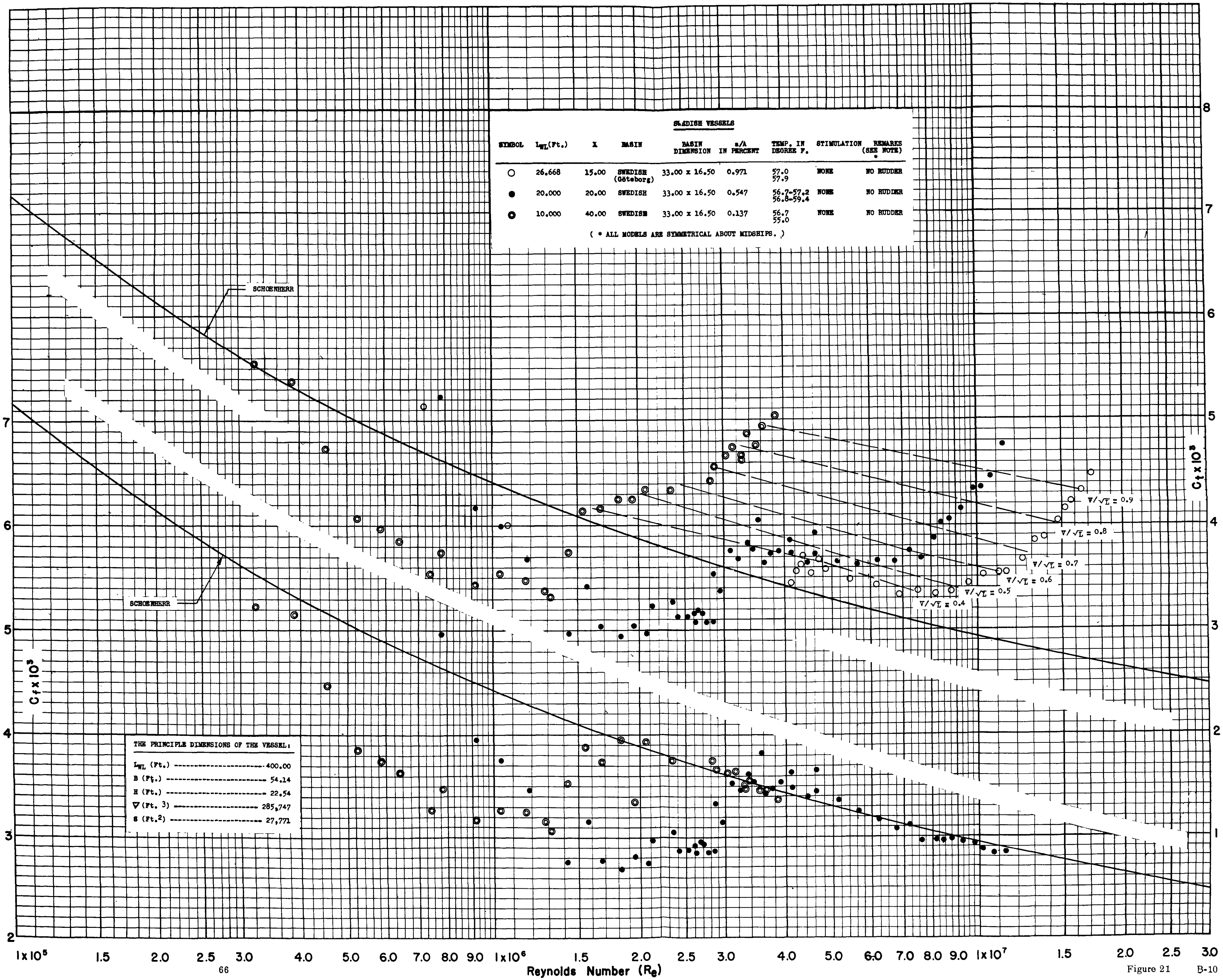

SWEDISH VESSELS
SYMBOL | LWL (Ft.) | X | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS (SEE NOTE) *
○ 26.668 15.00 SWEDISH (Göteborg) 33.00 x 16.50 0.971 57.0 57.9 NONE NO RUDDER
● 20.000 20.00 SWEDISH 33.00 x 16.50 0.547 56.7-57.2 56.8-59.4 NONE NO RUDDER
◉ 10.000 40.00 SWEDISH 33.00 x 16.50 0.137 56.7 55.0 NONE NO RUDDER
(* ALL MODELS ARE SYMMETRICAL ABOUT MIDSHIPS.)
SCHOENHERR
SCHOENHERR
∇/√L = 0.9
∇/√L = 0.8
∇/√L = 0.7
∇/√L = 0.6
∇/√L = 0.5
∇/√L = 0.4
THE PRINCIPLE DIMENSIONS OF THE VESSEL:
LWL (Ft.) ---------- 400.00
B (Ft.) ---------- 54.14
H (Ft.) ---------- 22.54
∇ (Ft. 3) ---------- 285,747
S (Ft.2) ---------- 27,771
Cf x 10³
Ct x 10³
2
3
4
5
6
7
8
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0
Reynolds Number (Re)

Figure 21

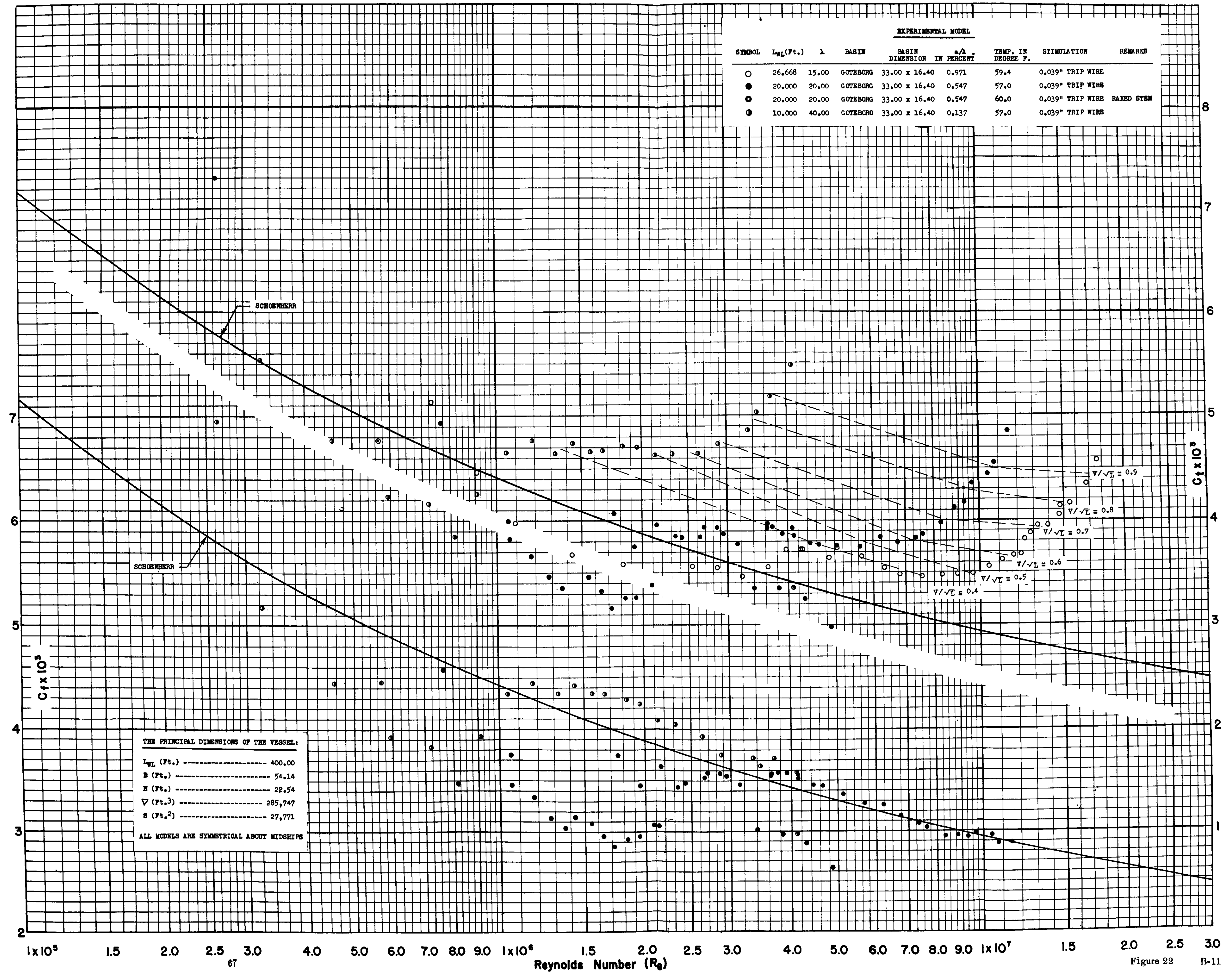
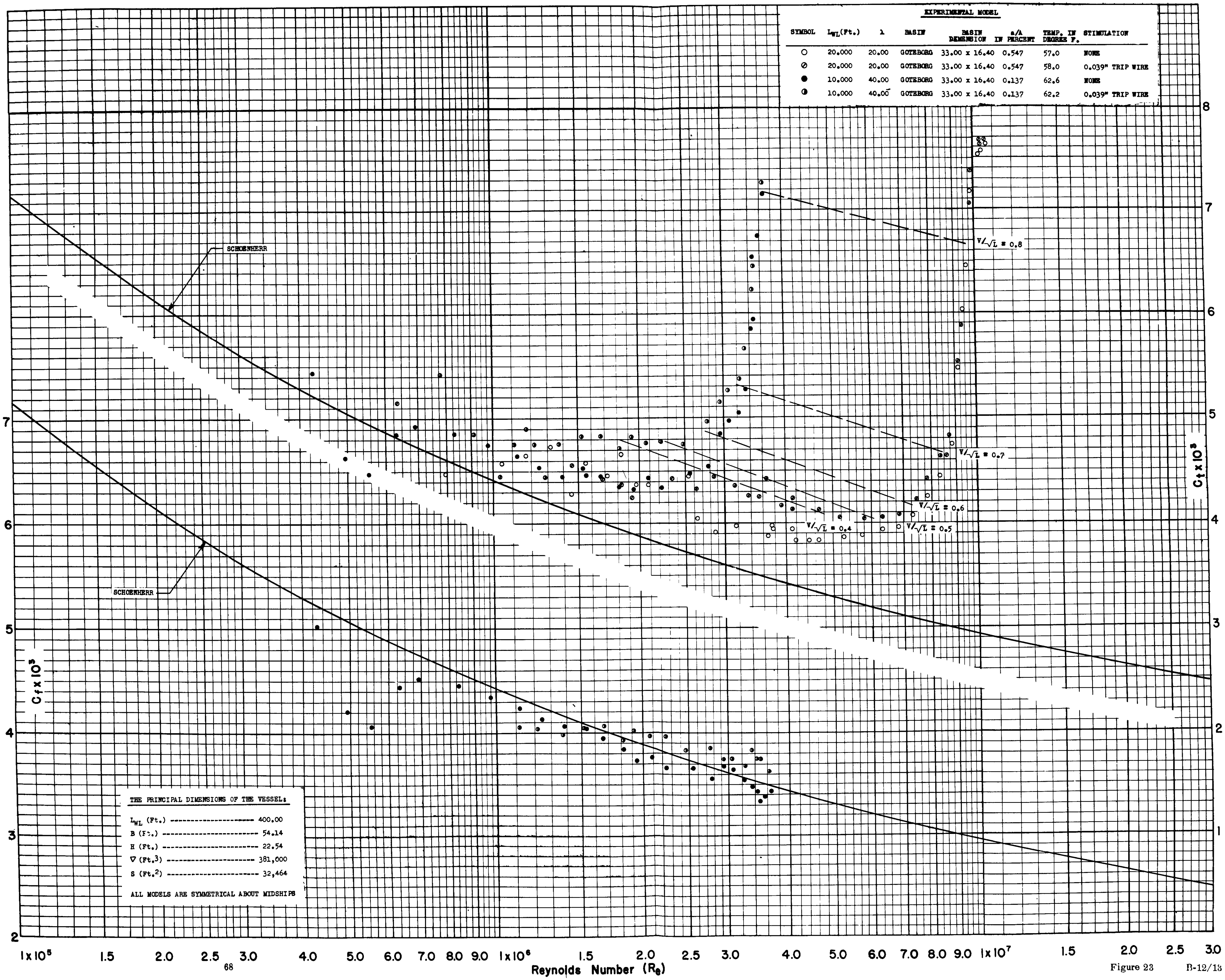
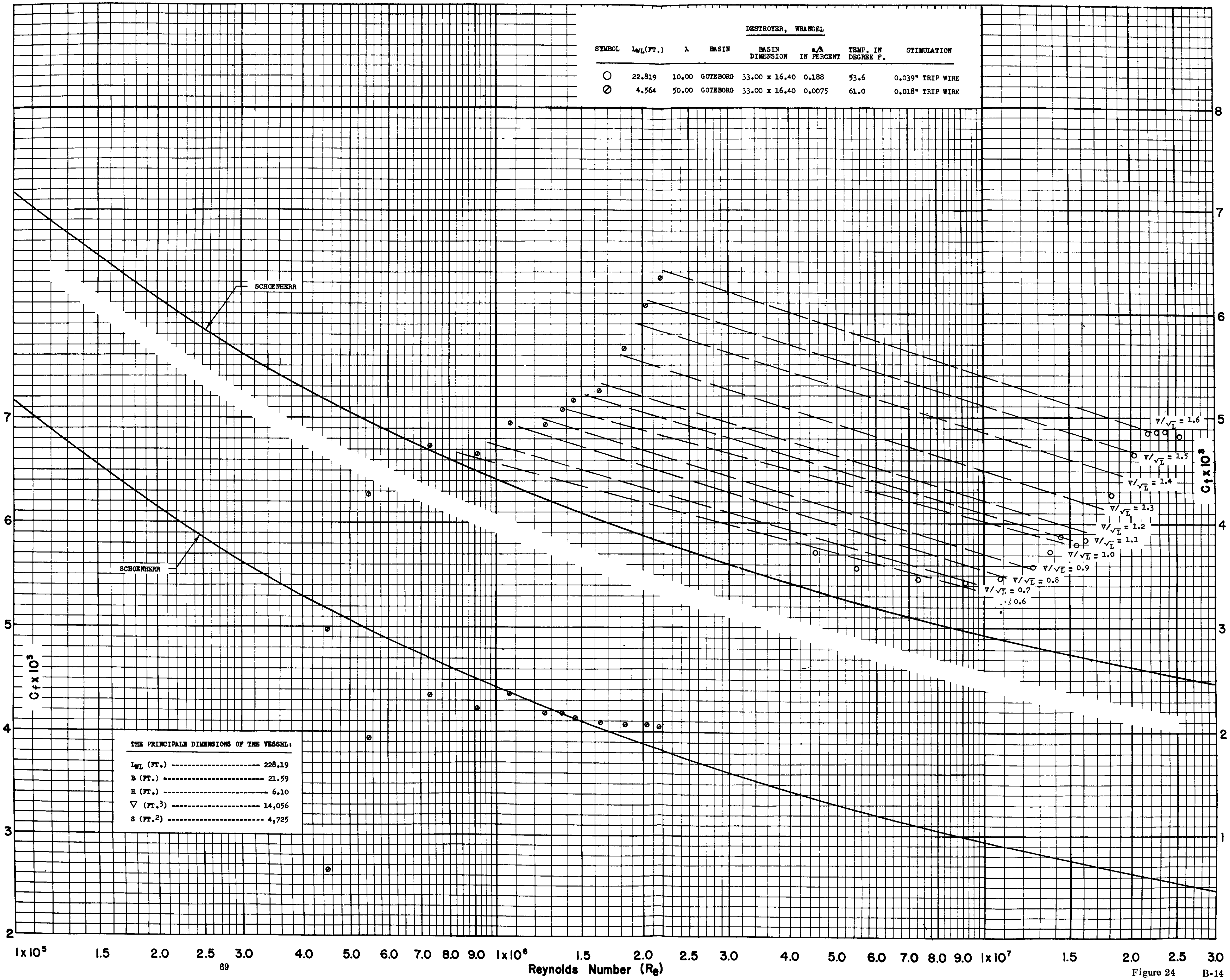

EXPERIMENTAL MODEL
SYMBOL | L_{WL}(Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARKS
○ | 26.668 | 15.00 | GOTEBORG | 33.00 x 16.40 | 0.971 | 59.4 | 0.039" TRIP WIRE |
● | 20.000 | 20.00 | GOTEBORG | 33.00 x 16.40 | 0.547 | 57.0 | 0.039" TRIP WIRE |
⊙ | 20.000 | 20.00 | GOTEBORG | 33.00 x 16.40 | 0.547 | 60.0 | 0.039" TRIP WIRE | RAKED STEM
◐ | 10.000 | 40.00 | GOTEBORG | 33.00 x 16.40 | 0.137 | 57.0 | 0.039" TRIP WIRE |
SCHOENHERR
SCHOENHERR
$\nabla/\sqrt{L}$ = 0.9
$\nabla/\sqrt{L}$ = 0.8
$\nabla/\sqrt{L}$ = 0.7
$\nabla/\sqrt{L}$ = 0.6
$\nabla/\sqrt{L}$ = 0.5
$\nabla/\sqrt{L}$ = 0.4
$C_f \times 10^3$
$C_f \times 10^3$
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) ---------- 400.00
B (Ft.) ---------- 54.14
H (Ft.) ---------- 22.54
∇ (Ft.^{3}) ---------- 285,747
S (Ft.^{2}) ---------- 27,771
ALL MODELS ARE SYMMETRICAL ABOUT MIDSHIPS
1x10^5 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^6 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^7 1.5 2.0 2.5 3.0
Reynolds Number (R_e)

Figure 22



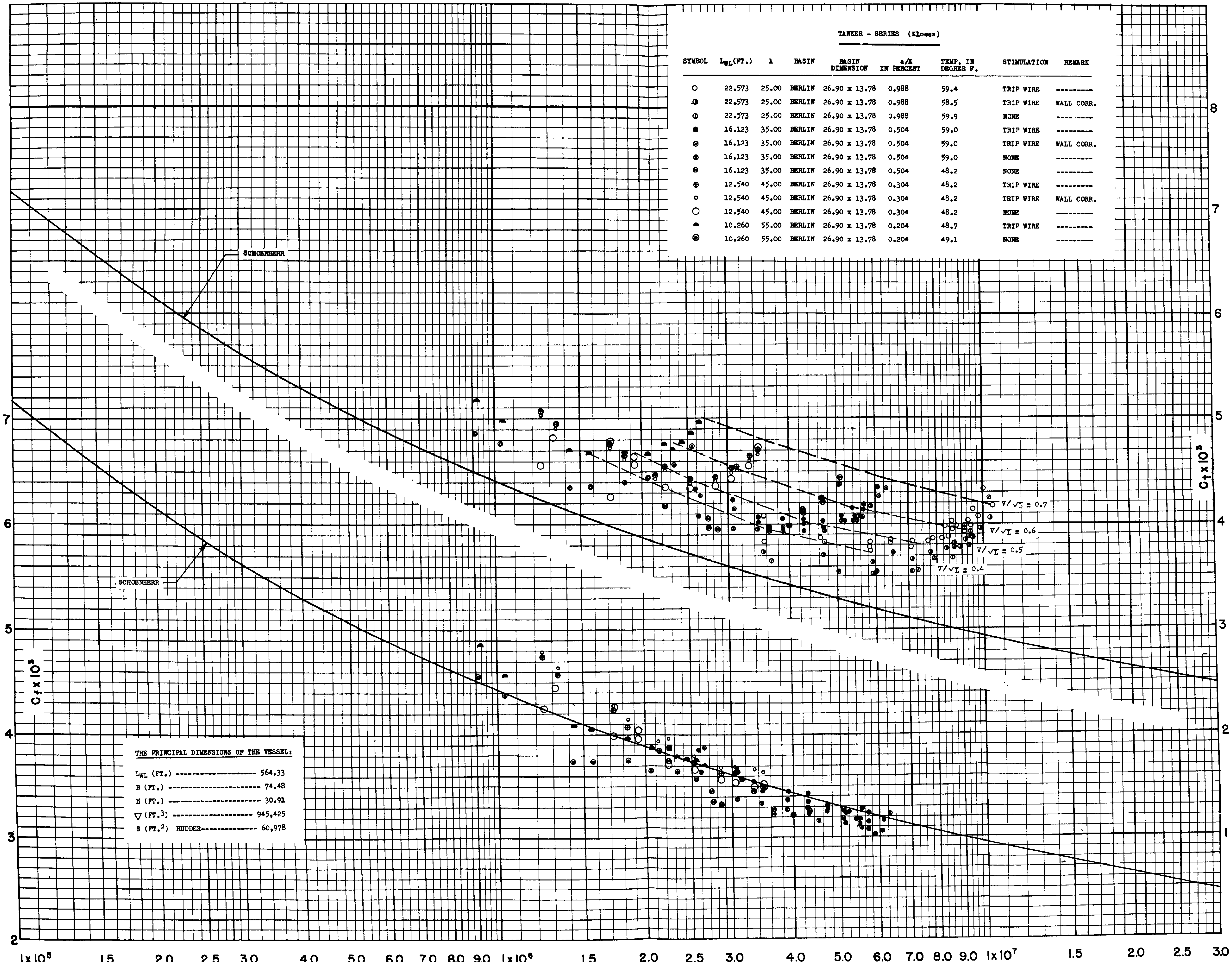
EXPERIMENTAL MODEL
SYMBOL | L_{WL}(Ft.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
○ | 20.000 | 20.00 | GOTEBORG | 33.00 x 16.40 | 0.547 | 57.0 | NONE
⊘ | 20.000 | 20.00 | GOTEBORG | 33.00 x 16.40 | 0.547 | 58.0 | 0.039" TRIP WIRE
● | 10.000 | 40.00 | GOTEBORG | 33.00 x 16.40 | 0.137 | 62.6 | NONE
◑ | 10.000 | 40.00 | GOTEBORG | 33.00 x 16.40 | 0.137 | 62.2 | 0.039" TRIP WIRE
SCHOENHERR
SCHOENHERR
V/√L = 0.8
V/√L = 0.7
V/√L = 0.6
V/√L = 0.5
V/√L = 0.4
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
L_{WL} (Ft.) ---------------------- 400.00
B (Ft.) ------------------------- 54.14
H (Ft.) ------------------------- 22.54
∇ (Ft.^{3}) ---------------------- 381,000
S (Ft.^{2}) ---------------------- 32,464
ALL MODELS ARE SYMMETRICAL ABOUT MIDSHIPS
$C_f \times 10^3$
$C_f \times 10^3$
7
6
5
4
3
2
8
1
1x10^5 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^6 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10^7 1.5 2.0 2.5 3.0
Reynolds Number (R_e)

Figure 23



DESTROYER, WRANGEL
SYMBOL | L_{WL}(FT.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION
○ 22.819 10.00 GOTEBORG 33.00 x 16.40 0.188 53.6 0.039" TRIP WIRE
⊘ 4.564 50.00 GOTEBORG 33.00 x 16.40 0.0075 61.0 0.018" TRIP WIRE
SCHOENHERR
SCHOENHERR
∇/√L = 1.6
∇/√L = 1.5
∇/√L = 1.4
∇/√L = 1.3
∇/√L = 1.2
∇/√L = 1.1
∇/√L = 1.0
∇/√L = 0.9
∇/√L = 0.8
∇/√L = 0.7
0.6
THE PRINCIPALE DIMENSIONS OF THE VESSEL:
L_{WL} (FT.) ---------- 228.19
B (FT.) ---------- 21.59
H (FT.) ---------- 6.10
∇ (FT.3) ---------- 14,056
S (FT.2) ---------- 4,725
$C_f \times 10^3$
$C_f \times 10^3$
Reynolds Number (R_e)

Figure 24



TANKER - SERIES (Kloess)
SYMBOL | LWL(FT.) | λ | BASIN | BASIN DIMENSION | a/A IN PERCENT | TEMP. IN DEGREE F. | STIMULATION | REMARK
○ 22.573 25.00 BERLIN 26.90 x 13.78 0.988 59.4 TRIP WIRE ---------
22.573 25.00 BERLIN 26.90 x 13.78 0.988 58.5 TRIP WIRE WALL CORR.
22.573 25.00 BERLIN 26.90 x 13.78 0.988 59.9 NONE ---------
● 16.123 35.00 BERLIN 26.90 x 13.78 0.504 59.0 TRIP WIRE ---------
⊗ 16.123 35.00 BERLIN 26.90 x 13.78 0.504 59.0 TRIP WIRE WALL CORR.
16.123 35.00 BERLIN 26.90 x 13.78 0.504 59.0 NONE ---------
16.123 35.00 BERLIN 26.90 x 13.78 0.504 48.2 NONE ---------
⊕ 12.540 45.00 BERLIN 26.90 x 13.78 0.304 48.2 TRIP WIRE ---------
○ 12.540 45.00 BERLIN 26.90 x 13.78 0.304 48.2 TRIP WIRE WALL CORR.
○ 12.540 45.00 BERLIN 26.90 x 13.78 0.304 48.2 NONE ---------
10.260 55.00 BERLIN 26.90 x 13.78 0.204 48.7 TRIP WIRE ---------
◎ 10.260 55.00 BERLIN 26.90 x 13.78 0.204 49.1 NONE ---------
SCHOENHERR
SCHOENHERR
∇/√L = 0.7
∇/√L = 0.6
∇/√L = 0.5
∇/√L = 0.4
Cf x 10³
Cf x 10³
THE PRINCIPAL DIMENSIONS OF THE VESSEL:
LWL (FT.) ---------------------- 564.33
B (FT.) ------------------------- 74.48
H (FT.) ------------------------- 30.91
∇ (FT.³) ---------------------- 945,425
S (FT.²) RUDDER--------------- 60,978
1x10⁵ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁶ 1.5 2.0 2.5 3.0 4.0 5.0 6.0 7.0 8.0 9.0 1x10⁷ 1.5 2.0 2.5 3.0
2 3 4 5 6 7
1 2 3 4 5 6 7 8

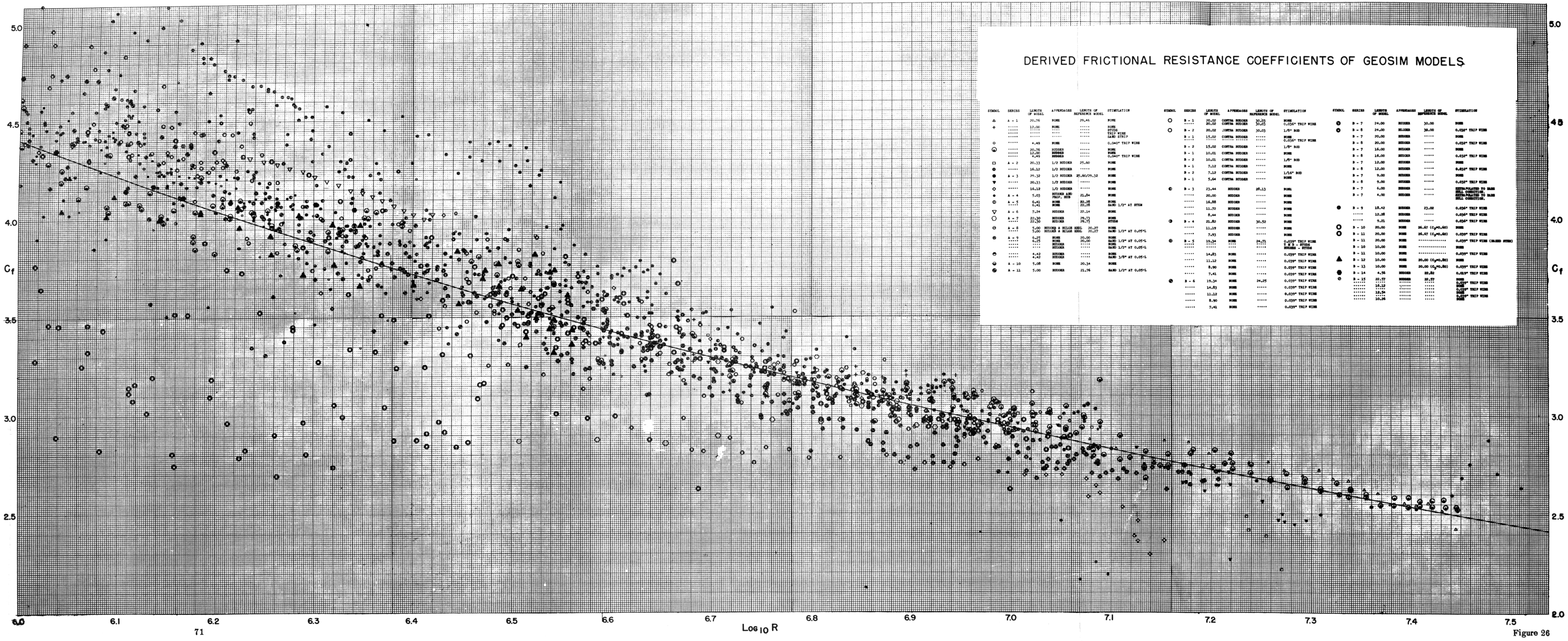
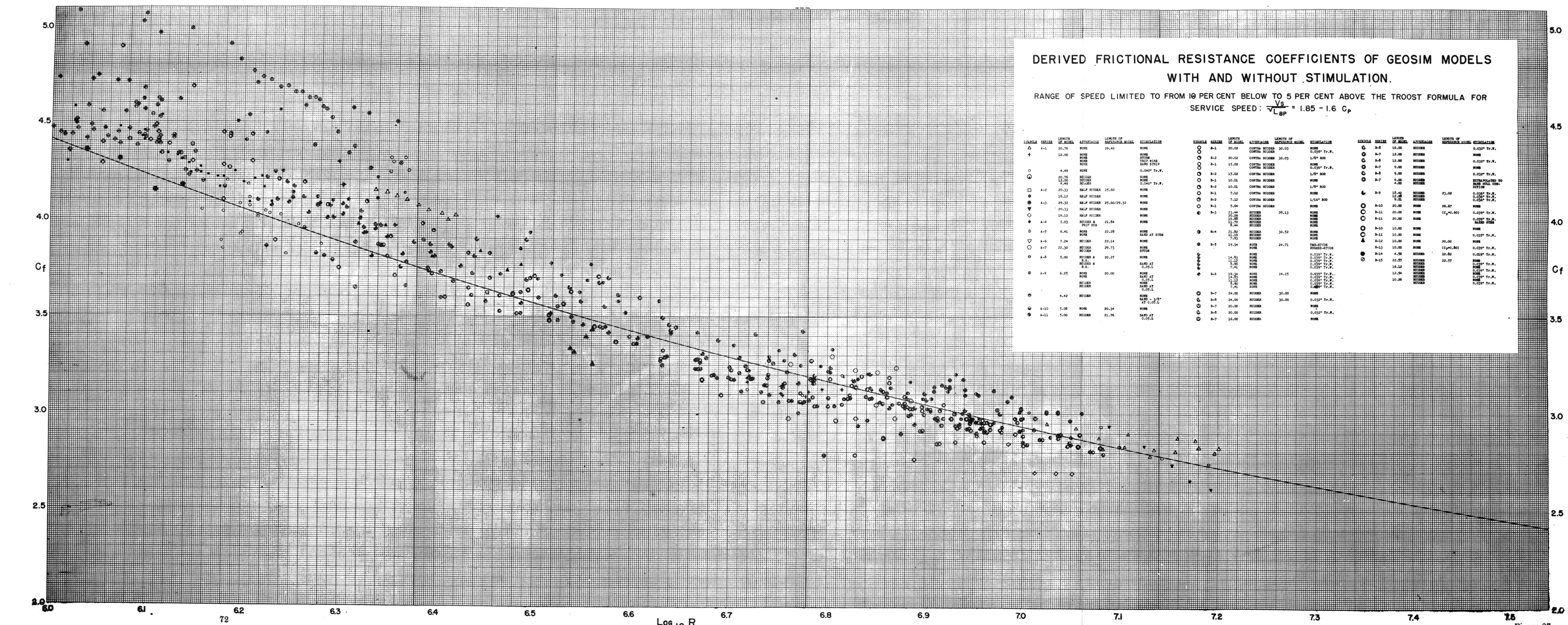

DERIVED FRICTIONAL RESISTANCE COEFFICIENTS OF GEOSIM MODELS
SYMBOL | SERIES | LENGTH OF MODEL | APPENDAGES | LENGTH OF REFERENCE MODEL | STIMULATION
A - 1 | 20.76 | NONE | 29.46 | NONE
..... | 12.00 | NONE | ..... | NONE
..... | ..... | .... | ..... | STUDS
..... | ..... | .... | ..... | TRIP WIRE
..... | ..... | ..... | ..... | SAND STRIP
..... | 4.49 | NONE | ..... | 0.040" TRIP WIRE
..... | 20.76 | RUDDER | ..... | NONE
..... | 12.00 | RUDDER | ..... | NONE
..... | 4.49 | RUDDER | ..... | 0.040" TRIP WIRE
A - 2 | 20.33 | 1/2 RUDDER | 25.60 | NONE
..... | 16.12 | 1/2 RUDDER | ..... | NONE
A - 3 | 29.32 | 1/2 RUDDER | 25.60/29.32 | NONE
..... | 20.33 | 1/2 RUDDER | ..... | NONE
..... | 16.12 | 1/2 RUDDER | ..... | NONE
A - 4 | 5.03 | RUDDER AND PROP. HUB | 21.84 | NONE
A - 5 | 6.41 | NONE | 22.28 | NONE
..... | 6.41 | NONE | 22.28 | SAND 1/2" AT STEM
A - 6 | 7.24 | RUDDER | 22.14 | NONE
A - 7 | 22.30 | RUDDER | 29.73 | NONE
..... | 22.30 | RUDDER | 29.73 | STUDS
A - 8 | 5.00 | RUDDER & BILGE KEEL | 20.27 | NONE
..... | 5.00 | RUDDER & BILGE KEEL | 20.27 | SAND 1/2" AT 0.05·L
A - 9 | 6.25 | NONE | 20.00 | NONE
..... | 6.25 | NONE | 20.00 | SAND 1/2" AT 0.05·L
..... | .... | RUDDER | ..... | NONE
..... | .... | RUDDER | ..... | SAND 1/2" AT 0.05·L
..... | 4.42 | RUDDER | ..... | NONE
..... | 4.42 | RUDDER | ..... | SAND 3/8" AT 0.05·L
A - 10 | 5.08 | NONE | 20.34 | NONE
A - 11 | 5.00 | RUDDER | 21.76 | SAND 1/2" AT 0.05·L
SYMBOL | SERIES | LENGTH OF MODEL | APPENDAGES | LENGTH OF REFERENCE MODEL | STIMULATION
B - 1 | 20.02 | CONTRA RUDDER | 30.03 | NONE
..... | 20.02 | CONTRA RUDDER | 30.03 | 0.036" TRIP WIRE
B - 2 | 20.02 | CONTRA RUDDER | 30.03 | 1/8" ROD
B - 1 | 15.02 | CONTRA RUDDER | ..... | NONE
..... | ..... | .... | ..... | 0.036" TRIP WIRE
B - 2 | 15.02 | CONTRA RUDDER | ..... | 1/8" ROD
B - 1 | 10.01 | CONTRA RUDDER | ..... | NONE
B - 2 | 10.01 | CONTRA RUDDER | ..... | 1/8" ROD
B - 1 | 7.12 | CONTRA RUDDER | ..... | NONE
B - 2 | 7.12 | CONTRA RUDDER | ..... | 1/16" ROD
B - 1 | 5.64 | CONTRA RUDDER | ..... | NONE
B - 3 | 23.44 | RUDDER | 28.13 | NONE
..... | 20.00 | RUDDER | ..... | NONE
..... | 16.88 | RUDDER | ..... | NONE
..... | 11.72 | RUDDER | ..... | NONE
..... | 8.44 | RUDDER | ..... | NONE
B - 4 | 21.82 | RUDDER | 30.52 | NONE
..... | 11.19 | RUDDER | ..... | NONE
..... | 7.93 | RUDDER | ..... | NONE
B - 5 | 19.34 | NONE | 24.71 | 0.039" TRIP WIRE
..... | ..... | .... | ..... | T M B - STUDS
..... | ..... | .... | ..... | HUGHES - STUDS
..... | 14.83 | NONE | ..... | 0.039" TRIP WIRE
..... | 11.12 | NONE | ..... | 0.039" TRIP WIRE
..... | 8.90 | NONE | ..... | 0.039" TRIP WIRE
..... | 7.41 | NONE | ..... | 0.039" TRIP WIRE
B - 6 | 19.34 | NONE | 24.25 | 0.039" TRIP WIRE
..... | 14.83 | NONE | ..... | 0.039" TRIP WIRE
..... | 11.12 | NONE | ..... | 0.039" TRIP WIRE
..... | 8.90 | NONE | ..... | 0.039" TRIP WIRE
..... | 7.41 | NONE | ..... | 0.039" TRIP WIRE
SYMBOL | SERIES | LENGTH OF MODEL | APPENDAGES | LENGTH OF REFERENCE MODEL | STIMULATION
B - 7 | 24.00 | RUDDER | 30.00 | NONE
B - 8 | 24.00 | RUDDER | 30.00 | 0.032" TRIP WIRE
B - 7 | 20.00 | RUDDER | ..... | NONE
B - 8 | 20.00 | RUDDER | ..... | 0.032" TRIP WIRE
B - 7 | 16.00 | RUDDER | ..... | NONE
B - 8 | 16.00 | RUDDER | ..... | 0.032" TRIP WIRE
B - 7 | 12.00 | RUDDER | ..... | NONE
B - 8 | 12.00 | RUDDER | ..... | 0.032" TRIP WIRE
B - 7 | 9.00 | RUDDER | ..... | NONE
B - 8 | 9.00 | RUDDER | ..... | 0.032" TRIP WIRE
B - 7 | 6.00 | RUDDER | ..... | EXTRAPOLATED TO BARE HULL CONDITION.
B - 7 | 4.00 | RUDDER | ..... | EXTRAPOLATED TO BARE HULL CONDITION.
B - 9 | 18.42 | RUDDER | 23.02 | 0.036" TRIP WIRE
..... | 12.28 | RUDDER | ..... | 0.036" TRIP WIRE
..... | 9.21 | RUDDER | ..... | 0.036" TRIP WIRE
B - 10 | 20.00 | NONE | 26.67 (Cp=0.60) | NONE
B - 11 | 20.00 | NONE | 26.67 (Cp=0.60) | 0.039" TRIP WIRE
B - 11 | 20.00 | NONE | .... | 0.039" TRIP WIRE (RAKED STEM)
B - 10 | 10.00 | NONE | .... | NONE
B - 11 | 10.00 | NONE | .... | 0.039" TRIP WIRE
B - 12 | 10.00 | NONE | 20.00 (Cp=0.80) | NONE
B - 13 | 10.00 | NONE | 20.00 (Cp=0.80) | 0.039" TRIP WIRE
B - 14 | 4.56 | RUDDER | 22.82 | 0.019" TRIP WIRE
B - 15 | 22.57 | RUDDER | 22.57 | NONE
...... | ..... | ...... | ..... | 0.039" TRIP WIRE
...... | 16.12 | ...... | ..... | NONE
...... | ..... | ...... | ..... | 0.039" TRIP WIRE
...... | 12.54 | ...... | ..... | NONE
...... | ..... | ...... | ..... | 0.039" TRIP WIRE
...... | 10.26 | ...... | ..... | NONE
Cf
5.0
4.5
4.0
3.5
3.0
2.5
2.0
6.0
6.1
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
7.0
7.1
7.2
7.3
7.4
7.5
71
Log10 R

Figure 26



DERIVED FRICTIONAL RESISTANCE COEFFICIENTS OF GEOSIM MODELS
WITH AND WITHOUT STIMULATION.
RANGE OF SPEED LIMITED TO FROM 10 PER CENT BELOW TO 5 PER CENT ABOVE THE TROOST FORMULA FOR
SERVICE SPEED: $\frac{V_S}{\sqrt{L_{BP}}} = 1.85 - 1.6\ C_P$
C_f
5.0
4.5
4.0
3.5
3.0
2.5
2.0
6.0
6.1
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
7.0
7.1
7.2
7.3
7.4
7.5
Log_{10} R

Figure 27

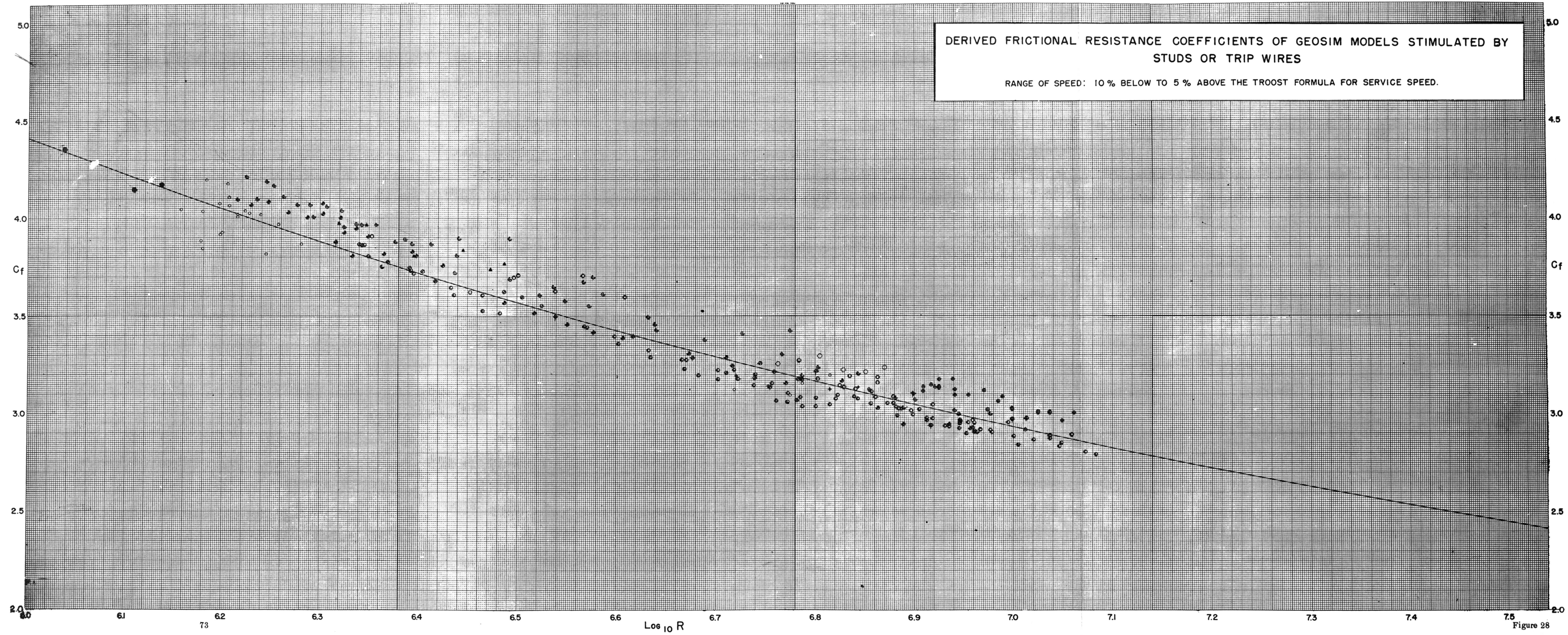
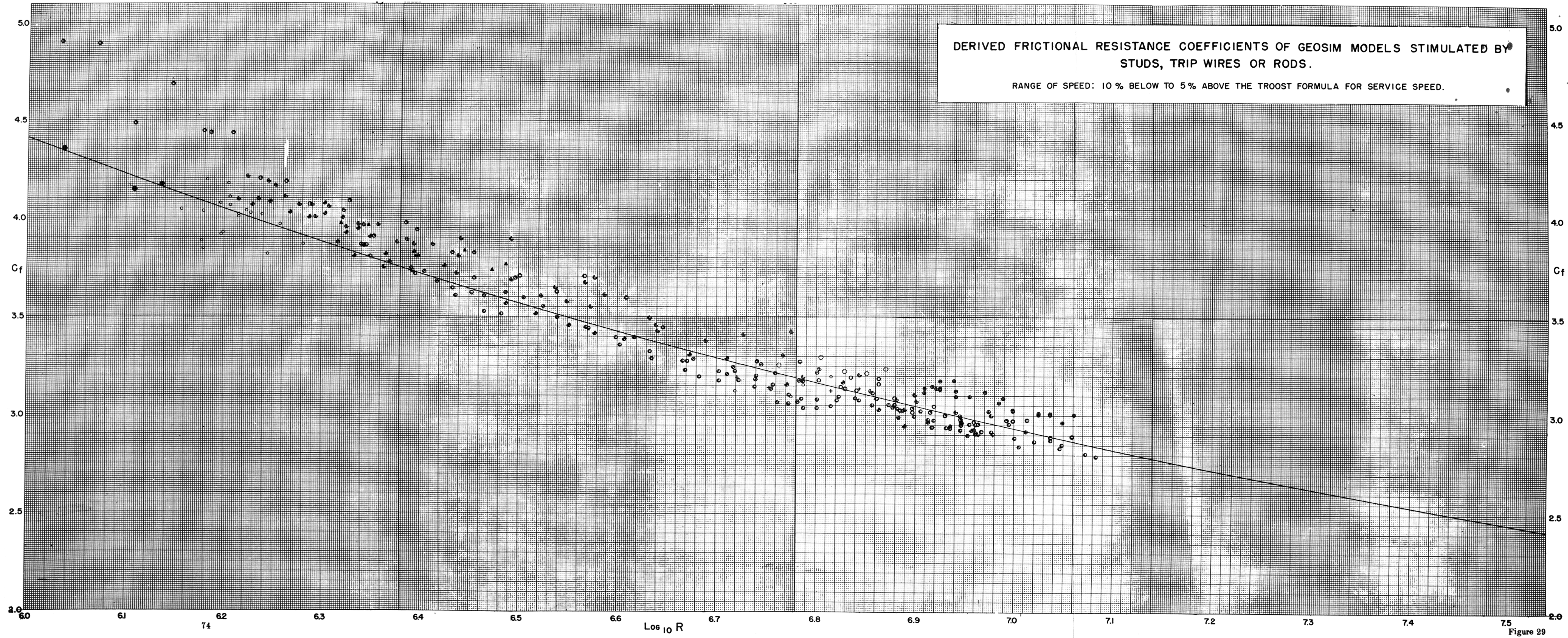

DERIVED FRICTIONAL RESISTANCE COEFFICIENTS OF GEOSIM MODELS STIMULATED BY STUDS OR TRIP WIRES
RANGE OF SPEED: 10 % BELOW TO 5 % ABOVE THE TROOST FORMULA FOR SERVICE SPEED.
Cf
Log 10 R
5.0
4.5
4.0
3.5
3.0
2.5
2.0
6.0
6.1
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
7.0
7.1
7.2
7.3
7.4
7.5

Figure 28


DERIVED FRICTIONAL RESISTANCE COEFFICIENTS OF GEOSIM MODELS STIMULATED BY STUDS, TRIP WIRES OR RODS.
RANGE OF SPEED: 10 % BELOW TO 5 % ABOVE THE TROOST FORMULA FOR SERVICE SPEED.
Cf
Log 10 R
5.0
4.5
4.0
3.5
3.0
2.5
2.0
6.0
6.1
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
7.0
7.1
7.2
7.3
7.4
7.5

74

Figure 29

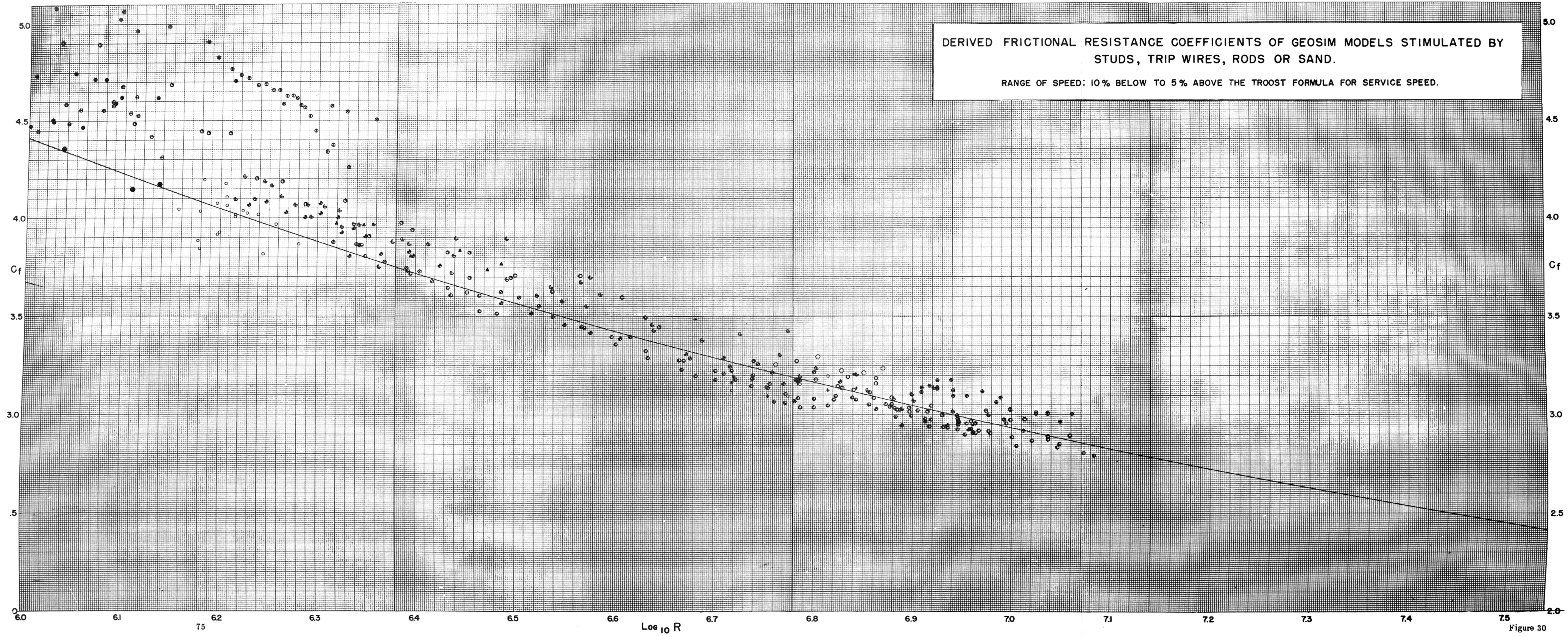

DERIVED FRICTIONAL RESISTANCE COEFFICIENTS OF GEOSIM MODELS STIMULATED BY STUDS, TRIP WIRES, RODS OR SAND.
RANGE OF SPEED: 10% BELOW TO 5% ABOVE THE TROOST FORMULA FOR SERVICE SPEED.
Cf
Cf
5.0
4.5
4.0
3.5
3.0
.5
0
2.5
2.0
6.0
6.1
6.2
6.3
6.4
6.5
6.6
6.7
6.8
6.9
7.0
7.1
7.2
7.3
7.4
7.5
Log 10 R

Figure 30

WAX COMPOSITION USED IN VARIOUS BASINS

Basin	Refined Paraffin %	Bee's Wax %	Ceresin %	Winnothene %	Assam Paraffin %	Yellow Micro-crystalline Wax	Cire D'Abeille	Lucite 44	Stearin	Aristo	Assam	Opal	Melting Temp.	Casting Temp.
Vienna	98.00	2.00											140-144	158
Ottawa	Wood												--	--
Haslar	87.50	3.5	9.0										130	160
NPL	98.00	1.0		1.0									145-150	165
Vickers-Armstrong		2½			95.0	2½							135-140	165-170
W. Denny & Brothers	99.5	0.5											135	165
Paris	90.00						10.00							140
Hamburg	91.00	3.0							6				136-140	160
Wageningen	97.00	3.0											140-144	158
Rome	90.00	2.0							8					176
Trondheim	64.00	4.00	32.0										150-158	162-176
Madrid	97.00	3.00											145	151
Goteborg		2.10								84.9	13.0		145	152
DTMB								37.5		30.0		32.5	195	280
Michigan	Wood													
MIT	Wood													
Yugoslavia	Wood													

Figure 31

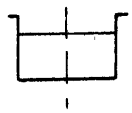
	Year of Construction	Length Ft.	Width Ft.	Depth Ft.	Cross Section Ft²	Year of Destruction
AUSTRIA						
VIENNA	1919	590.00	32.80	16.40	527.44	------
BRAZIL						
IPT SAO PAULO	Under	43.0	3.3	2.30		
	Construct.	197.00	12.14	7.55		-------
CANADA						
OTTAWA	1930	350.73	9.00	6.00		Old Basin
OTTAWA	1951	450.15	25.00	9.81	245.00	
NRC						
ENGLAND						
CLYDEBANK	1908	400.29	19.69	9.51		
DUMBARTON	1884	275.60	25.92	9.84		
HASLAR I(AEW)	1887	400.00	20.00	8.67	167.5	
II	1932	890.00	40.00	18.00	673.0	
KING'S COLLEGE	1952	130.00	11.81	4.92		
VICKERS-ARMSTRONG						
ST. ALBANS	1912	384.86	20.20	11.25	219.00	
TEDDINGTON I	1911	550.00	30.00	12.00	324.00	
II	1932	678.18	20.00	9.16	178.00	
TORQUAY	1871	278.23	36.09	9.84		
WM.DENNY BR.		330.00	22.30	8.38	187.00	
FRANCE	Large					
PARIS	1906	525.00	33.00	13.00	430.00	
	Small	62.00	12.00	3.60		
TOULCUSE	1952	3937.20	18.37	9.19		
	New	593.00	42.5	13.1		
		(721)				
		(1050)				
GERMANY						
UBIGAU	1892	203.42	26.25	9.84		1904
BREMERHAVEN	1900	475.75	19.69	10.50		1912
BERLIN	1902	547.93	26.90	13.78	370.28	
HAMBURG I	1912-13	541.37	26.25	14.76		1945
II	1912-13	606.99	52.50	21.98		1945
III	1932	1148.35	16.41	8.20		1945
HAMBURG		656.00	59.00	19.70		
		262.00	16.40	10.00		
		246.00	13.00	2.60		
		(82 ft x 10 ft)				
DUISBURG						
BERLIN(EAST)						
HOLLAND						
DELFT	1938	131.24	8.86	4.27		
DELFT	1955	31.86	13.78	8.86		
NSMB	1932	826.81	34.45	18.00	620.00	

Figure 32

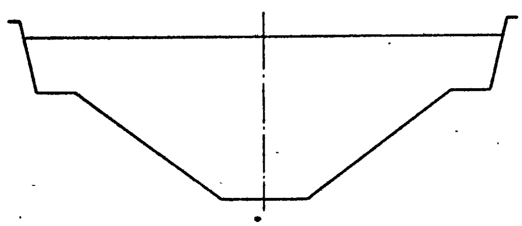
	Year of Construction	Length Ft.	Width Ft.	Depth Ft.	Cross Section Ft^2	Year of Destruction
INDIA		500.00	12.00	9.00		
JAPAN						
MITSUBISHI	1953	935.00	41.01	21.33		
		541.37	20.00	12.00		
		394.00				
TOKYO UNIV	1910	902.27	19.69	11.81		
ITALY						
LA SPEZIA	1889	492.15	19.69	9.84		
ROMA	1930	902.28	41.00	20.00	820.00	
GENOA	1947	157.49	9.19	5.25		
NORWAY						
TRONDHEIM		557.00	34.45	18.05	622.00	
		88.5	8.20	3.00		
RUSSIA						
LENINGRAD	1891	374.03	21.65	9.19		
MOSCOW	1933	557.77	---	21.32		
SPAIN						
EL PARDO	1932/46	1050.00	41.01	21.33	829.15	
SWEDEN						
GOTEBORG	1940	853.00	32.80	16.40	535.00	
U.S.A.						
EMB, WASH.	1898	470.00	42.70	14.70	628.00	Decom.
DTMB, CARDEROCK	1940	2775.00	51.00	22.00	1122.00*	
1		963.00	51.00	22.00	1122.00	
2		1812.00	51.00	22.00	1122.00	
3		1168.00	21.00	10.00	210.00	
4		140.00	10.00	5.50	55.00	
5		303.00	51.00	varies	----	
MICHIGAN	1904	360.00	22.00	10.00	185.00	
NEWPORT NEWS	1933	56.11	7.87	3.94		
ETT STEVENS INST.	1935	109.00	9.00	4.50	31.80	
II	1944	313.00	12.00	6.00	72.00	
		(75 ft.^{2} x 4.5 ft.)				
MIT	1951	108.00	8.50	4.00	34.40	
WEBB INST.	--	92.85	9.84	4.92		
ILLINOIS		75.00	8.8	8.00		
YUGOSLAVIA						
DEEP TANK I	1956		40.00	21.33	875.00	
HIGH SPEED II	1956		16.41	11.32	186.00	
SMALL TANK III	1956		9.84	8.69	85.57	
NATIONAL ADVISARY		2920.00	24.00	12.00		
COMMITTEE		1880.00	18.00	6.00		
	Impact Basin	330.00	24.00	8.00		

* J-shaped (95 x 15.5 x 3.0)

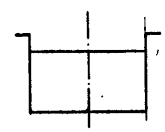
Figure 32 (continued)



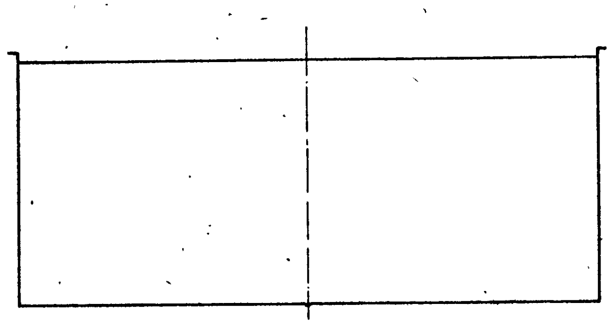
MASSACHUSETTS INSTITUTE OF TECHNOLOGY
SHIP MODEL TOWING TANK
MASSACHUSETTS U. S. A.



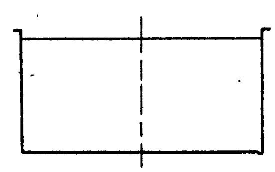
U. S. EXPERIMENTAL MODEL BASIN
WASHINGTON D.C. U. S. A.



NO. 4 TANK



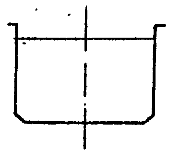
NO. 1 AND NO. 2 TANK



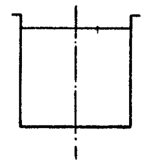
NO. 3 TANK

THE DAVID TAYLOR MODEL BASIN
CARDEROCK MD.
U. S. A.

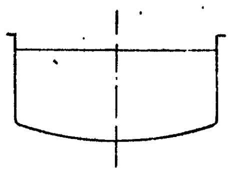
Figure 33



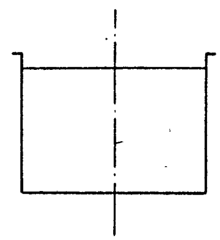
INSTITUTO DE PESQUIZAS TECHNOLOGICAS
SAO PAULO BRAZIL



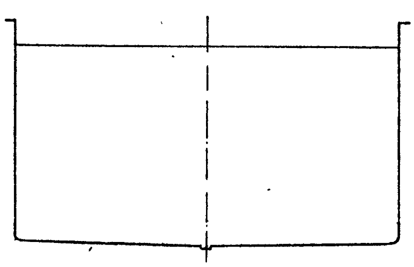
NO. 3 TANK
BRODARSKI INSTITUT
ZAGREB YOGOSLAVIA



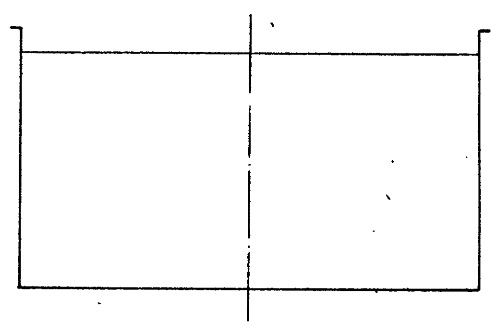
TOULOUSE
FRANCE



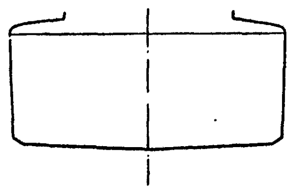
NO. 2 TANK
BRODARSKI INSTITUT
ZAGREB YOGOSLAVIA



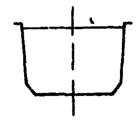
TRONDHEIM
NORWAY



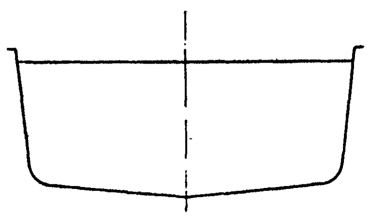
NO. 1 TANK
BRODARSKI INSTITUT
ZAGREB YOGOSLAVIA



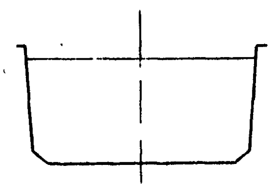
NATIONAL RESEARCH COUNCIL
OTTAWA CANADA
(NEW BASIN)



NATIONAL RESEARCH COUNCIL
OTTAWA CANADA
(OLD BASIN)

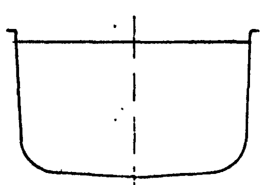


NO. 1 TANK

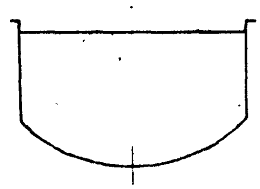


NO. 2 TANK

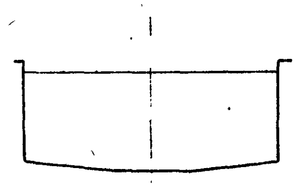
TEDDINGTON
ENGLAND



VICKERS-ARMSTRONGS LTD
SHIP MODEL EXPERIMENT TANK
ST. ALBANS ENGLAND

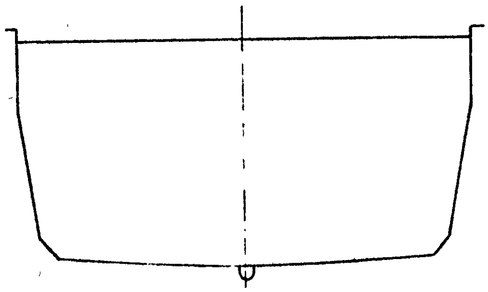


HASLAR I
ENGLAND

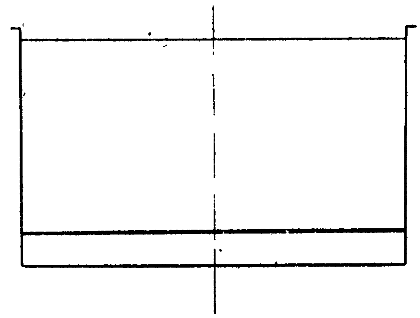


WILLIAM DENNY & BROTHERS LTD.
DUMBARTON
ENGLAND

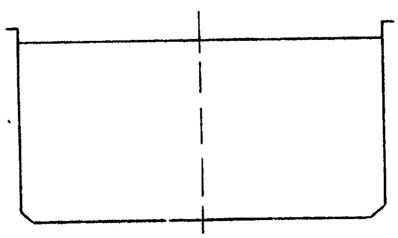
Figure 35



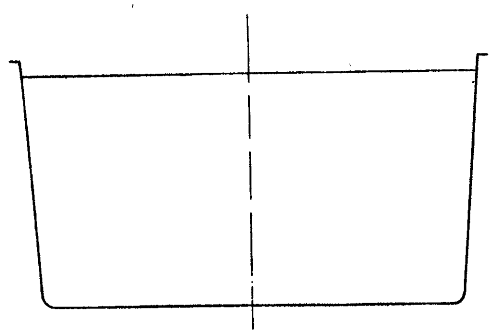
ROME
ITALY



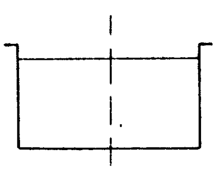
WAGENINGEN
NETHERLANDS



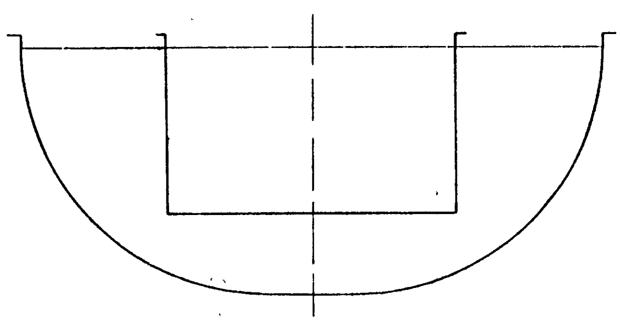
GÖTEBURG
SWEDEN



EL PARDO
SPAIN



NO. 3 TANK



HAMBURG
GERMANY

Figure 36

Basin location	Basin Water Specific Weight kg/m³	Basin Water Specific Weight lbs/ft³	Basin Water Density kg·s²/m⁴	Basin Water Density lbs·s²/ft⁴	Sea Water Specific Weight kg/m³	Sea Water Specific Weight lbs/ft³	Sea Water Density kg·s²/m⁴	Sea Water Density lbs·s²/ft⁴	Salinity	Acceleration m/s²	Acceleration ft/s²	Coefficient used
Vienna	----	------	102.00	------	----	------	104.60	------	------	----	------	Paris 1935
Canada	----	------	------	------	----	------	------	------	------	----	------	S N A M E
W. Denny & Brothers	997	------	------	------	1023	------	------	------	------	----	------	A T T C 1939
Vickers-Armstrong	----	62.40	------	------	----	64.00	------	------	------	----	------	S N A M E
Haslar	----	62.43	------	------	----	------	------	------	------	-----	------	A T T C
Teddington	----	62.40	------	------	----	64.00	------	------	------	------	------	A T T C
Paris	1000	------	------	------	1026	------	------	------	------	------	------	Paris 1935 Lyle & Hosking
Wageningen	----	------	101.90	------	----	------	104.50	------	------	-----	------	A T T C 1939
Rome	1000	------	------	------	1025	------	------	------	------	-----	------	Lyle & Hosking
Trondheim	----	------	102.00	------	-----	------	104.60	------	------	-----	------	A T T C 1939
Spain	1000	------	101.94	1.936	1026	64.049	104.59	1.9901	3.5%	9.81	32.186	About Lyle & Hosking Paris 1935
Goteborg	----	------	102.00	------	----	------	104.50	------	------	-----	------	Various **
Michigan	----	------	------	1.9367 (68°)	----	------	------	1.9905 (59°)	------	-----	------	A T T C
	----	------	------	1.9384 (59°)	----	------	------	1.9924 (50°)	------	-----	------	
	----	------	------	1.9396 (50°)	----	------	------	------	------	-----	------	
M I T	----	62.274	------	1.9367	----	64.043	------	1.9905 (59°)	------	-----	------	S N A M E
T M B	----	62.274	------	1.9367 (68°)	----	64.043 (59°)	------	1.9905 (59°)	3.5 %	-----	32.155 (model)	A T T C
	----	------	------	------	----	------	------	-------	------	-----	32.174 (ship)	
Yugoslavia	1000.8	------	102.00	------	----	------	105.00 (Adriatic Sea)	-------	------	9.806	------	A T T C

** Bingham - Jackson, Bulletin of the Bureau of Standards 14 p.75 1919

Figure 37

APPENDIX 1

Table of Density of Water

These values were adopted by the American Towing Tank Conference in 1942.
The fifth significant figures are doubtful.

Density of Fresh Water ρ lb × sec^2/ft^4	Temperature degree F	Density of Sea Water ρ_s lb × sec^2/ft^4	Density of Fresh Water ρ lb × sec^2/ft^4	Temperature degree F	Density of Sea Water ρ_s lb × sec^2/ft^4
1.9399	32	1.9947	1.9381	61	1.9901
1.9399	33	1.9946	1.9379	62	1.9898
1.9400	34	1.9946	1.9377	63	1.9895
1.9400	35	1.9945	1.9375	64	1.9893
1.9401	36	1.9944	1.9373	65	1.9890
1.9401	37	1.9943	1.9371	66	1.9888
1.9401	38	1.9942	1.9369	67	1.9885
1.9401	39	1.9941	1.9367	68	1.9882
1.9401	40	1.9940	1.9365	69	1.9879
1.9401	41	1.9939	1.9362	70	1.9876
1.9401	42	1.9937	1.9360	71	1.9873
1.9401	43	1.9936	1.9358	72	1.9870
1.9400	44	1.9934	1.9355	73	1.9867
1.9400	45	1.9933	1.9352	74	1.9864
1.9399	46	1.9931	1.9350	75	1.9861
1.9398	47	1.9930	1.9347	76	1.9858
1.9398	48	1.9928	1.9344	77	1.9854
1.9397	49	1.9926	1.9342	78	1.9851
1.9396	50	1.9924	1.9339	79	1.9848
1.9395	51	1.9923	1.9336	80	1.9844
1.9394	52	1.9921	1.9333	81	1.9841
1.9393	53	1.9919	1.9330	82	1.9837
1.9392	54	1.9917	1.9327	83	1.9834
1.9390	55	1.9914	1.9324	84	1.9830
1.9389	56	1.9912	1.9321	85	1.9827
1.9387	57	1.9910	1.9317	86	1.9823
1.9386	58	1.9908			
1.9384	59	1.9905			
1.9383	60	1.9903			

Figure 38

APPENDIX 2

Table of Kinematic Viscosity of Water

These values were adopted by the American Towing Tank Conference in 1942. The fifth significant figures are doubtful.

Kinematic Viscosity of Fresh Water $\nu \times 10^5$ ft^2/sec	Temperature degree F	Kinematic Viscosity of Sea Water $\nu_s \times 10^5$ ft^2/sec	Kinematic Viscosity of Fresh Water $\nu \times 10^5$ ft^2/sec	Temperature degree F	Kinematic Viscosity of Sea Water $\nu_s \times 10^5$ ft^2/sec
1.9291	32		1.1937	61	1.2470
1.8922	33		1.1769	62	1.2303
1.8565	34		1.1605	63	1.2139
1.8219	35		1.1444	64	1.1979
1.7883	36		1.1287	65	1.1822
1.7558	37		1.1133	66	1.1669
1.7242	38		1.0983	67	1.1519
1.6935	39		1.0836	68	1.1372
1.6638	40		1.0692	69	1.1229
1.6349	41	1.6846	1.0552	70	1.1088
1.6068	42	1.6568	1.0414	71	1.0951
1.5795	43	1.6298	1.0279	72	1.0816
1.5530	44	1.6035	1.0147	73	1.0684
1.5272	45	1.5780	1.0018	74	1.0554
1.5021	46	1.5531	0.98918	75	1.0427
1.4776	47	1.5289	0.97680	76	1.0303
1.4538	48	1.5053	0.96466	77	1.0181
1.4306	49	1.4823	0.95276	78	1.0062
1.4080	50	1.4599	0.94111	79	0.99447
1.3860	51	1.4381	0.92969	80	0.98299
1.3646	52	1.4168	0.91850	81	0.97172
1.3437	53	1.3961	0.90752	82	0.96067
1.3233	54	1.3758	0.89676	83	0.94982
1.3034	55	1.3561	0.88621	84	0.93917
1.2840	56	1.3368	0.87586	85	0.92873
1.2651	57	1.3180	0.86570	86	0.91847
1.2466	58	1.2996			
1.2285	59	1.2817			
1.2109	60	1.2641			

Figure 39

EXPLANATORY NOTES FOR MODEL RESISTANCE DATA SHEET

1. The nautical mile to be used in the calculation is that adopted by the International Hydrographic Bureau in 1929, and now in general use in the U. S. A. This has a length of 1852m or 6076.1033 feet.

2. The conversion factor from knots to ft/sec is 1.687806.

3. The values for the acceleration of gravity (g) and for mass density (ρ) for model displacement calculations are based on a temperature of 68°F or 20°C and latitude of Washington, D. C.

$g = 32.155$ ft/sec^2

$\rho = 1.9367$ slugs per cubic foot

weight per ft^3 = 62.2745 pounds

ft^3 per ton = 35.9697

4. The values for the ship are for 3.5 per cent salinity, 45° north latitude and 59° F or 15° C and are as follows:

$g = 32.174$ ft/sec^2

$\rho = 1.9905$ slugs per ft^3

weight/ft^3 = 64.043

ft^3/ton = 34.977

5. The ratio of the displacements, ship to model, then becomes

$$64.043 \cdot \lambda^3 / 62.2745 = 1.0284 \cdot \lambda^3$$

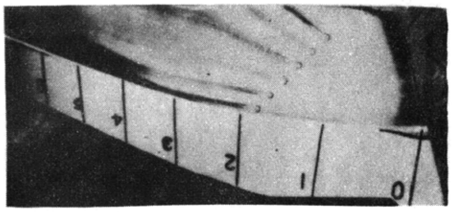
6. L.W.L. = Model length on the waterline at design draft. This same length is used for all model conditions, even though the wetted waterline length in such conditions may be different.

7. L_{BP}, is the length on the waterline at design draft from the fore side of the stem to the after side of the rudder post, or to the centerline of the rudder stock.

ON A 7 FT. LIBERTY SHIP MODEL

MODEL SPEED

KNOTS



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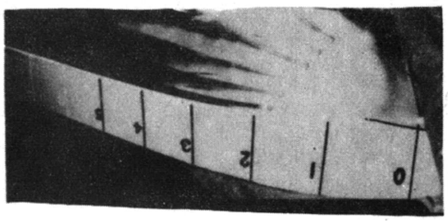

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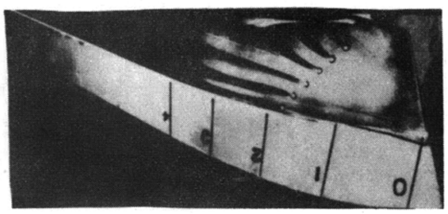

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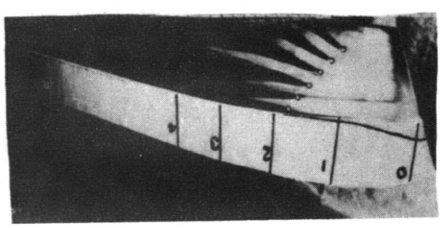

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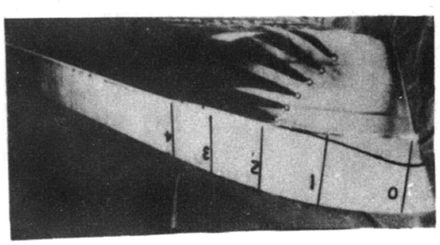

1.69

Figure 41

David W. Taylor Model Basin. Rept. 1064.
REPORT ON GEOSIM ANALYSIS ACCORDING TO SCHOENHERR LINE, by W.B. Hinterthan. July 1956. 88 p. incl. figs., tables, refs. (Report to be submitted to Fall Meeting of The American Towing Tank Conference, 1956)
UNCLASSIFIED

The report deals with the compilation and analysis of geosim resistance data for use in the search for a new "Engineering" friction line. In determining the "Engineering" friction line careful considerations were given to some important points with a view to coordination between model basins to reach international agreement.

1. Ship models – Resistance – Statistical analysis
2. Ship models – Resistance – Test results
3. Resistance data – Statistical analysis
4. Skin friction – Mathematical analysis
I. Hinterthan, Werner B.

David W. Taylor Model Basin. Rept. 1064.
REPORT ON GEOSIM ANALYSIS ACCORDING TO SCHOENHERR LINE, by W.B. Hinterthan. July 1956. 88 p. incl. figs., tables, refs. (Report to be submitted to Fall Meeting of The American Towing Tank Conference, 1956)
UNCLASSIFIED

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