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RESULTS OF EXPERIMENTS WITH MODELS OF HIGH SPEED TOWING TARGETS INCLUDING ESTIMATES OF FULL-SCALE TARGET DRAG AND CABLE TENSION

by

J. H. Curry and Jack Posner

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TABLE OF CONTENTS

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ABSTRACT

Five models of high-speed towing targets, two flat-bottom sled-types, two vee-bottom boat-types from Bureau of Ships designs, and one vee-bottom toboggan-type David Taylor Model Basin design, were tested at the David Taylor Model Basin and in the Potomac River in an attempt to develop an improved type towing target. The models were towed in the basin (a) by a long cable attached to the dynamometer, and (b) under the towing carriage with load increments applied to simulate various lengths of cable. Subsequent tests were made in the Potomac River to observe the maneuverability of the models when towed in waves. Motion pictures were taken during the latter tests to show the action of the models in a straight run and in turns. Estimates of full-scale target resistance and horizontal cable tension* are given for various speeds and lengths of cable.

It was found that for a given displacement and initial trim, a change in tow-point position, within the limits covered by the tests, has little effect on target resistance or directional stability. The resistances of the two boat-type targets and of the TMB design target were appreciably less when they were towed by a single cable in place of the conventional bridle, but the effect on the directional stability was small. When towed by the single cable the targets had a tendency to be self righting, after deliberately being capsized.

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* The terms horizontal cable tension and horizontal target-plus-cable drag are used synonymously in this report.

During the model basin tests for resistance, without simulated cable load, the boat type targets exhibited undesirable porpoising at speeds above 35 knots full scale. The porpoising was of sufficient severity to make it inadvisable to operate the targets at these speeds. The TMB design did not show any tendency to porpoise, even when violently disturbed.

At high speeds and long cable lengths all of the targets have practically the same horizontal cable tension, with the exception of the revised G-60 sled-type target. For cable lengths of 1500 and 2500 yards full scale and a horizontal cable tension of 60,000 pounds, the estimated maximum speed attainable for the respective cable lengths is practically the same for all targets, with the possible exception of the sled-type target mentioned above.

It is concluded, therefore, that the fundamental factors in the determination of an improved target sled are not the conditions affecting target resistance or the target resistance itself, but the cable drag, the target stability, and the target maneuverability.

INTRODUCTION

In April 1930 the Experimental Model Basin at the Naval Gun Factory, Washington, D. C., conducted experiments on a series of models (1)* for the purpose of developing a

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* Numbers in parentheses indicate references on page of this report.

high-speed towing target for the War Department Coast Artillery. A 25-foot by 12-foot rectangular timber sled was the result of this investigation.

Subsequently, the demand for larger target screens and higher target speeds led to further investigations and the ultimate development of 30-, 40-, and 60-foot sleds (2). The present 60-foot sled is reported to perform the best of the series, however, it is not entirely satisfactory. Because of the high resistance of the target, the relative instability when under tow, and the limited strength of the towing cable, failures have occurred in service.

In order to reduce the cable tension and develop an improved planing-type target, the Bureau of Ships prepared plans for three new designs of targets and requested (3) that the Taylor Model Basin conduct tests on models of the new designs and on a model of the revised 60-foot sled-type target to obtain quantitative data.

In addition to the four models constructed from the Bureau of Ships plans, a fifth model was developed at the Taylor Model Basin. The Bureau of Ships subsequently requested (4) that maneuvering tests of the models be conducted in the Potomac River to observe the effect of varying the fore and aft position of the towpoint.

DESCRIPTION OF MODELS

The TMB model numbers and the corresponding full-scale design designations are given below:

Model	Full-Scale
4024	Revised G-60 sled-type
4025	All-steel sled-type
4026	BuShips design "A", boat-type
4027	BuShips design "B", boat-type
4029	TMB design

Model and full-scale relationships are given in Table 1.

The model of the revised sled-type target was constructed of pine and the other models were made of balsa wood in order to keep the total weights within the limits specified. The models were all constructed to a scale of 1/15 full-size. All models were four feet long. Simulated target screens were installed on the models for the Potomac River tests. Fitting room pictures of the models as tested are shown in Figure 21.

TEST APPARATUS AND PROCEDURE

The test and analysis program was divided into four parts. Part 1 of the program consisted of towing the models by cable in the model basin to determine the comparative resistance characteristics. A 1/32-inch diameter steel cable 400 feet long was used for towing the models. Each model was tested at two initial displacements and at a series of initial trims, positions of towpoint, and speeds, except the TMB design which was towed with a single cable attachment in place of the conventional

bridle used for the other models and for one position of towpoint only. For comparative purposes spot tests were made of the TMB design with conventional bridle and of the BuShips design "B" with single cable attachment. A still camera was set up at a fixed position along the basin for taking pictures of the models while under way.

Part 2 of the program consisted of tests in the model basin to determine the resistance of the targets without cable but with vertical load increments applied to simulate the effect of the weight of various lengths of cable. For this purpose, a special towing bracket was designed which permitted the application of the simulated cable loads at the towpoint. The model was free to trim and rise and the load increments were applied through counterweights. Several increments were applied at each speed to assure a range that was broad enough to cover any full-scale cable loads anticipated. Resistance, trim, rise, and wetted lengths were determined for each model at a series of initial displacements, initial trims, and positions of towpoint for several speeds ranging up to 35 knots full scale. Additional tests, up to a full-scale speed of 60 knots, with zero cable load, were made with the two boat-type and the TMB design targets.

Part 3 of the program included tests in the Potomac River off Indian Head, Maryland, to observe the maneuvering characteristics of the models in turns and in waves at various

speeds, cable lengths, and towpoint positions. For these tests the models were fitted with target screens. The targets were towed by a 1/16-inch diameter steel cable connected to the models by a loop of wire with a breaking strength of about 75 pounds. All turns were 180 degrees with the radius of turn maintained as nearly equal to the length of cable as practicable. All models were towed at the heavy displacement and at the trim which gave minimum resistance in Part 1 of the test program. The BuShips designs were towed both with conventional bridle and with single cable attachment. The TMB design was towed with single cable attachment only. When the Bureau of Ships designs were towed with single cable attachment the point of attachment was located midway between the extreme forward and after locations used for the bridle attachment. Motion pictures were taken of the models in action and a print of the film constitutes a part of this report.

Part 4 of the program consisted of expanding to full scale the data gathered in Part 2 of the program and presenting curves of estimated horizontal drag of the target including simulated cable load and horizontal cable tension with variation of speed and length of cable.

It was not possible in all cases to obtain the trims by the stern specified in Reference (1) without exceeding the specified displacements. In such cases the models were trimmed the maximum practicable with the available ballast.

TEST RESULTS AND ANALYSIS OF DATA

The variation of resistance with initial displacement, initial trim, position of towpoint, and speed, as determined in Part 1 of the program, is shown in Figures 1 to 5. Still pictures showing the corresponding running attitudes and spray formations at a full-scale speed of approximately 35 knots, are included in Figures 7 to 15. Figure 6 is a comparative plot of the resistances of the five models as derived from Figures 1 to 5, at the best trim for each model, that is, the trim for minimum resistance.

The results of the simulated cable load tests, Part 2 of the program, are shown in Figures 16 to 20 at speeds corresponding to 10, 20, and 35 knots full scale. The initial points on the curves, indicated by circles, are the resistances at zero cable load. It should be stated that the initial trims noted correspond to the zero load condition, and were not reset when the simulated cable loads were applied. The curves shown are for the extreme towpoint positions, the intermediate towpoint positions being designated by symbols.

The maneuvering characteristics of the models, Part 3 of the program, are best illustrated by the motion pictures taken during the tests.

The results of the estimated full-scale drag of the targets including simulated cable load, and the estimated full-scale cable tensions, Part 4 of the program, are presented in

Figures 22 to 31. It was assumed that minimum target drag at high speeds would be of most interest, therefore, for each target, only the model condition for each displacement which gave minimum resistance at a full-scale speed of 30 knots was used in estimating the full-scale target drag and cable tension presented in Figures 22 to 31. The cable lengths were determined by computing ϕ, the angle of the cable with the horizontal at the trailing end, from the relationship $\tan \phi = \frac{\text{applied cable load}}{\text{model resistance}}$ and determining the corresponding $\frac{\text{drag (full-scale)}}{\text{cable length (full-scale)}}$ ratio at the various speeds from Figure 32. This figure was computed by the method given in Reference (5). The full-scale target drag was derived from the model data by the use of the Schoenherr frictional resistance formulation. See the appendix for details and a typical example of the computations.

In connection with the possibility of self-propelled targets at high speeds, the tests on the boat-type and the TMB-design targets were extended to a full-scale speed of 60 knots. The results of computations of full-scale target resistances based on these tests are shown in Figures 33 and 34. For speeds up to and including 30 knots full scale, the data were taken from Figures 26 to 31. For full-scale speeds of 35 knots and above, the computations were made using the model conditions that gave minimum resistance at the various speeds.

DISCUSSION

The resistance of the targets at a given speed may be changed by a change in towpoint position, initial trim, and initial displacement. Parts 1 and 2 of the program show that the effect of change of towpoint position on model resistance is small. Therefore, in Part 3, it was decided to test only the extreme forward and after positions of the towpoints. In the course of these tests, no appreciable difference could be observed in the maneuvering characteristics of the models when the towpoint was moved from the extreme forward position to the extreme after position.

Variation in initial trim does have a noticeable effect on the resistance and spray formation of the models. All of the models have more advantageous resistance and spray characteristics at the higher speeds when trimmed by the stern. When trimmed by the bow, all of the models had undesirable and in some cases dangerous spray formations at low speeds.

The models of the two sled-type targets, Model 4024 and Model 4025, exhibited some slight tendency to yaw during the maneuvering tests. Hard pounding in waves was also noticeable. The two boat-type targets heel the most in a cross wind. As accurately as could be detected by eye, the boat-type sleds towed equally well with bridle or with single cable attachment. As had been noted on full-scale tows (2), during the maneuvering

tests the cable tended to rise on starboard turns and sink on port turns due to the lay of the cable. On port turns the target tended to follow inside of the wake of the towing boat.

During the maneuvering tests the boat-type and the TMB-design models were deliberately capsized when towed with both bridle and single cable attachments. With the single cable attachment the models always righted themselves, with some damage to the target screens, whereas, with the bridle attachment, more often than not, the wire loop broke before the models were righted. The estimated full-scale righting forces with the single cable attachment did not exceed the strength of the 1-inch cable used in full-scale tows. In Part 1 it was shown that when towed with a single cable Model 4027 and Model 4029, the only models so tested, had less resistance then when towed with a bridle attachment, see Figure 6.

The full-scale estimates of horizontal target drag with simulated cable load, Figures 22 to 31, show that the two boat-type targets and the TMB design have substantially less drag than the sled-type targets. The same figures show that at high speeds and with long cable lengths the horizontal cable tension is virtually the same for all targets at both displacements, with the exception of the revised G-60 sled. A comparison of the estimated maximum speed attainable with full-scale cable lengths of 1500 and 2500 yards and a full-scale cable tension of 60,000 pounds is given in Table 2.

Figures 33 and 34 indicate that at speeds above 35 knots the two boat-type targets have appreciably less horizontal drag than the TMB design. However, at speeds above 35 knots the TMB design was the only model with adequate stability. No data are shown for the two boat-type targets at a speed of 60 knots full-scale because at this speed both models porpoised violently and uncontrollably. At speeds above 35 knots full scale both boat-type models porpoised if disturbed, the amplitude and period depending upon the severity of the initial disturbance. In some cases slight ripples on the surface of the water, were sufficient to start porpoising. The TMB design did not porpoise at any speed, even when violently disturbed. During the towing tests in the basin with cable, Part 1 of the program, Model 4024, the revised G-60 sled, was the only model which porpoised, and then only when towed from the after tow point with maximum trim by the stern and at a full-scale speed corresponding to approximately 27 knots.

CONCLUSIONS

1. For a given displacement and initial trim, a change in the position of the towpoint causes little change in the resistance or directional stability of the targets.

2. Towing the TMB design and the BuShips design "B" targets by a single cable in place of the conventional bridle results in an appreciable reduction in target resistance but does not

affect the directional stability. With the single cable attachment the boat-type and the TMB-design targets have a tendency to be self-righting when capsized.

3. At full-scale speeds up to 35 knots, the boat-type and the TMB-design targets have towing and resistance characteristics superior to the sled-type targets. At full-scale speeds above 35 knots, the two boat-type targets have better resistance characteristics than the TMB design but they are susceptible to porpoising. The porpoising is of sufficient severity to make it inadvisable to operate the boat-type targets at these speeds. The TMB design does not porpoise at any speed, even when violently disturbed.

4. The estimated full-scale horizontal drag with simulated cable load is less for the two boat-type and the TMB-design targets than for the sled-type targets. With the exception of the revised G-60 sled-type target, all of the targets have, at high speeds with long cable lengths and at both displacements, practically equal horizontal cable tension. Similarly, with the exception of the revised G-60 sled-type target, for 60,000 pounds horizontal cable tension and a given length of cable, within the limits of the tests, the estimated maximum speed attainable with either displacement is practically the same for all of the targets. This leads to the conclusion that the fundamental factors involved in the design of a target with improved towing characteristics are not the conditions

affecting target resistance or the target resistance itself, but the cable drag, the target stability, and the target maneuverability.

REFERENCES

(1) "Experimental Investigation of High Speed Towing Target Design," EMB Report 252, April 1930.

(2) History of sled-type towing targets with enclosed references prepared by BuShips, Structure and Form (443), dated 24 April 1947.

(3) BuShips ltr QT-(3)(442-440) of 24 Feb 47 to TMB, requesting construction and tests of models of towing targets.

(4) BuShips ltr QT-(3)(442-440) of 19 Jun 47 to TMB, requesting maneuvering tests on models of towing targets.

(5) "On the Resistance of a Heavy Flexible Cable for Towing a Surface Float Behind a Ship," by J. G. Thews and L. Landweber, EMB Report 418, March 1936.

APPENDIX

Method of determining full-scale horizontal drag of target with simulated cable load and full-scale horizontal drag of target-plus-cable from model data.

$$D_t = (D \sec \phi + T) \cos \alpha$$

where D_t = full-scale horizontal drag of target-plus-cable, in pounds

D = full-scale horizontal drag of target with simulated cable load, in pounds

ϕ = angle between cable and horizontal at trailing end, in degrees. $\tan \phi = \frac{\delta}{R_m}$

T = cable tension, in pounds. $T = FL$

α = angle between cable and horizontal at forward end, in degrees. $\cos \alpha = \frac{w - \sqrt{w^2 + 4}}{-2}$

δ = applied cable load, in pounds

R_m = model resistance, in pounds

F = tangential friction force in pound/feet $= \frac{1.6}{50} \frac{\rho}{2} dV^2$

$\frac{1.6}{50}$ = arbitrary constant (for all sizes of cable)

ρ = mass density of water, $\frac{\text{lb. sec.}^2}{\text{ft.}^4}$

d = cable diameter, in feet

V = speed, in feet per second

L = cable length, in feet

$w = \frac{W}{R}$

W = weight per unit length of cable in salt water, in pounds = 1.79

R = drag of unit length of cable perpendicular to stream, in pounds = 50 F (for all sizes of cable)

Typical example of a computation.

Model 4029 - TMB-Design Target

Model speed, V = (6.54 fps / 3.87 knots) = (25.3 fps, full scale / 15.0 knots, full scale)

Model resistance, R_m = 5.60 pounds

Wetted length = 3.00 feet

Wetted area = 5.65 feet^2

Applied cable load, δ = 5.00 pounds

$\frac{\text{Mass density of sea water}}{2}$, $\rho/2$ = 0.995 $\frac{\text{lb. sec}^2}{\text{ft}^4}$

$\frac{\text{Mass density of basin water}}{2}$, $\rho/2$ = 0.968 $\frac{\text{lb. sec}^2}{\text{ft.}^4}$

Cable diameter, d = 0.0833 feet

Basin water temperature = 70 degrees Fahrenheit

Sea water temperature = 50 degrees Fahrenheit

1) Determine D from model data by the Schoenherr friction formulation: D = 18,000

2) $\text{Tan } \phi = \frac{5.00}{5.60} = 0.893;\ \phi = 41.8$ degrees

3) From Figure 32, $\frac{D}{L} = 2.16$

4) L = 8320 feet

5) F = 1.70 pounds/foot

6) T = 14,100 pounds

7) R = 85.0 pounds/foot

8) w = 0.0210

9) $\cos \alpha = 0.990$

10) $\sec \phi = 1.34$

11) $D_t = (D \sec \phi + T) \cos$

$= [(18{,}000)(1.34) + 14{,}100]\ 0.990$

$= 37{,}800$

TABLE 1

Model - Full-Scale Relationships

Item	Model	Full Scale
Displacement	21.7 pounds	75,000 pounds
	28.9	100,000
	36.2	125,000
	43.4	150,000
Speed	1.29 knots	5 knots
	2.58	10
	3.87	15
	5.16	20
	6.45	25
	7.75	30
	9.04	35
	15.49	60
Towpoint position forward of stern	17.5 inches	21.9 feet
	19.2	24.0
	20.5	25.6
	22.4	28.0
	24.0	30.0
	25.6	32.0
	28.8	36.0
	33.6	42.0
Initial trim	0.29 inches by bow	0.36 feet by bow
	1.68	2.10
	3.35	4.19
	0.50 inches by stern	0.63 feet by stern
	1.01	1.26
	1.26	1.58
	1.34	1.68
	1.76	2.20
	2.26	2.83
Cable length	300 feet	1500 yards
	400	2000
	500	2500

Linear ratio ship to model, $\lambda = 15$
Speed ratio, $\lambda^{1/2} = 3.87$
Displacement ratio, $1.024\ \lambda^3 = 3456$

TABLE 2

Maximum Speeds Attainable with the Various Towing Targets

for a Horizontal Cable Tension of 60,000 Pounds

Target	Cable Length = 1500 yards: Light Displacement	Cable Length = 1500 yards: Heavy Displacement	Cable Length = 2500 yards: Light Displacement	Cable Length = 2500 yards: Heavy Displacement
Revised G-60 sled-type	33.0 knots	32.0	23.0	20.0
All steel sled-type	34.0	33.5	24.5	23.5
BuShips Design "A"	34.0	34.0	24.5	24.5
BuShips Design "B"	34.0	33.5	24.5	24.0
TMB design	34.5	34.0	24.5	24.0

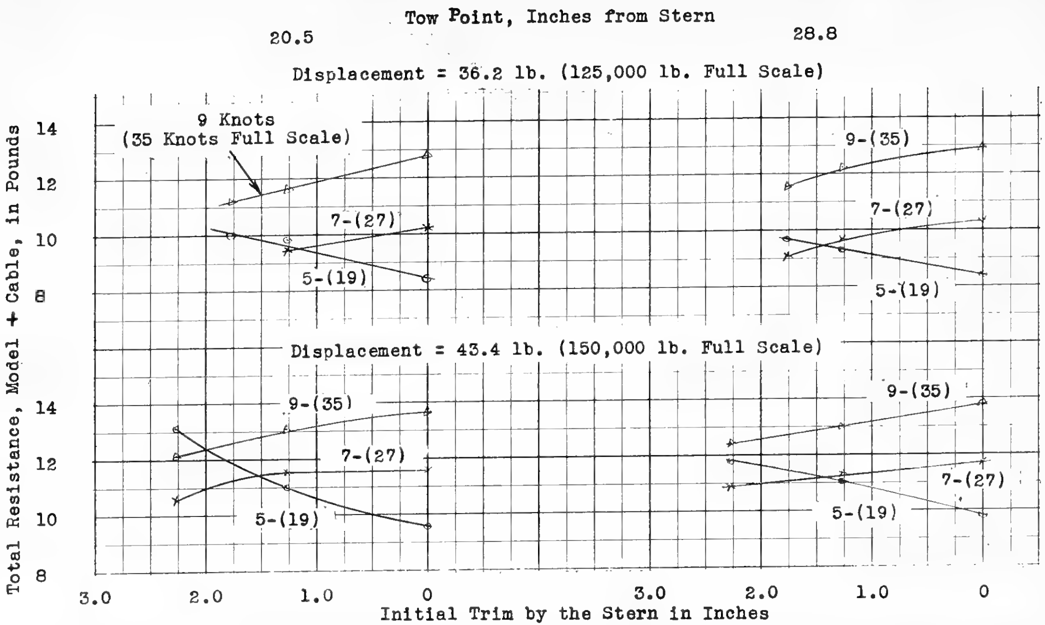


Figure 1 - Model 4024. Revised G-60 Sled-Type Target. Variation of Total Resistance with Displacement, Initial Trim, and Fore and Aft Position of the Tow Point

The Tests Were Conducted in the Model Basin, the Model Being Towed by a 1/32-Inch Diameter Steel Cable 400 Feet Long, with Bridle Attachment to Model.

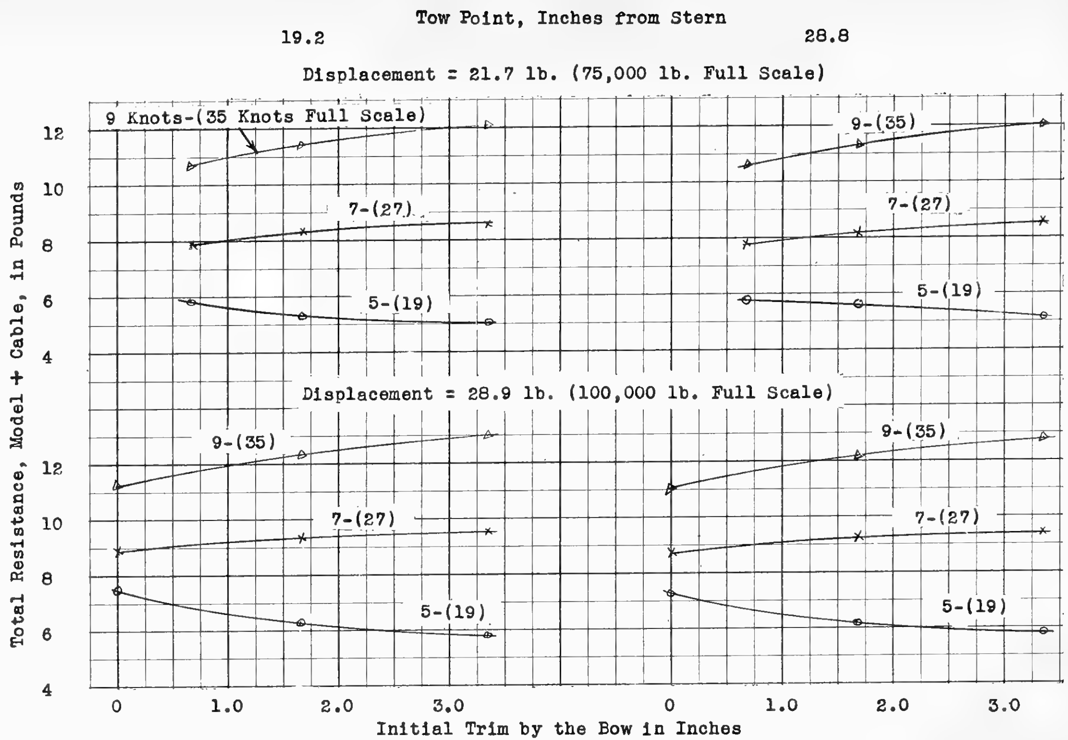


Figure 2 - Model 4025. All- Steel Sled-Type Target. Variation of Total Resistance with Displacement, Initial Trim, and Fore and Aft Position of the Tow Point

The Tests Were Conducted in the Model Basin, the Model Being Towed by a 1/32-Inch Diameter Steel Cable 400 Ft. Long, with Bridle Attached to Model.

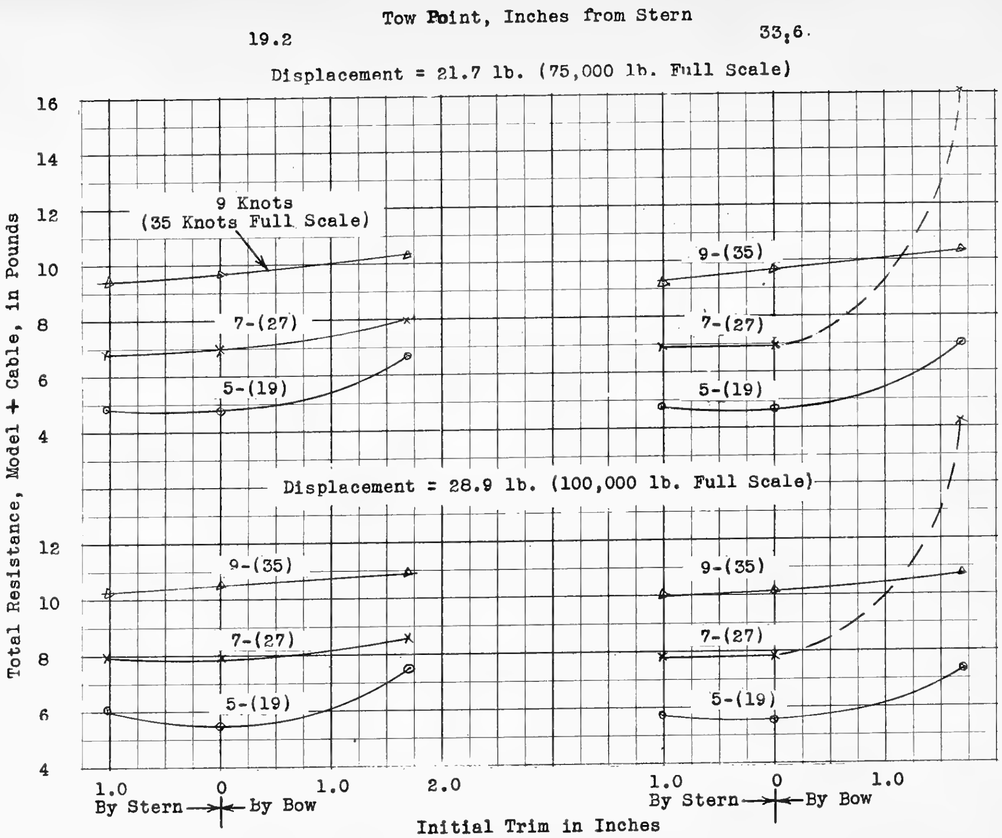


Figure 3 - Model 4026. Design "A" Boat Type Target. Variation of Total Resistance with Displacement, Initial Trim, and Fore and Aft Position of the Tow Point

The Tests Were Conducted in the Model Basin, the Model Being Towed by a 1/32-Inch Diameter Steel Cable 400 Feet Long, with Bridle Attached to Model.

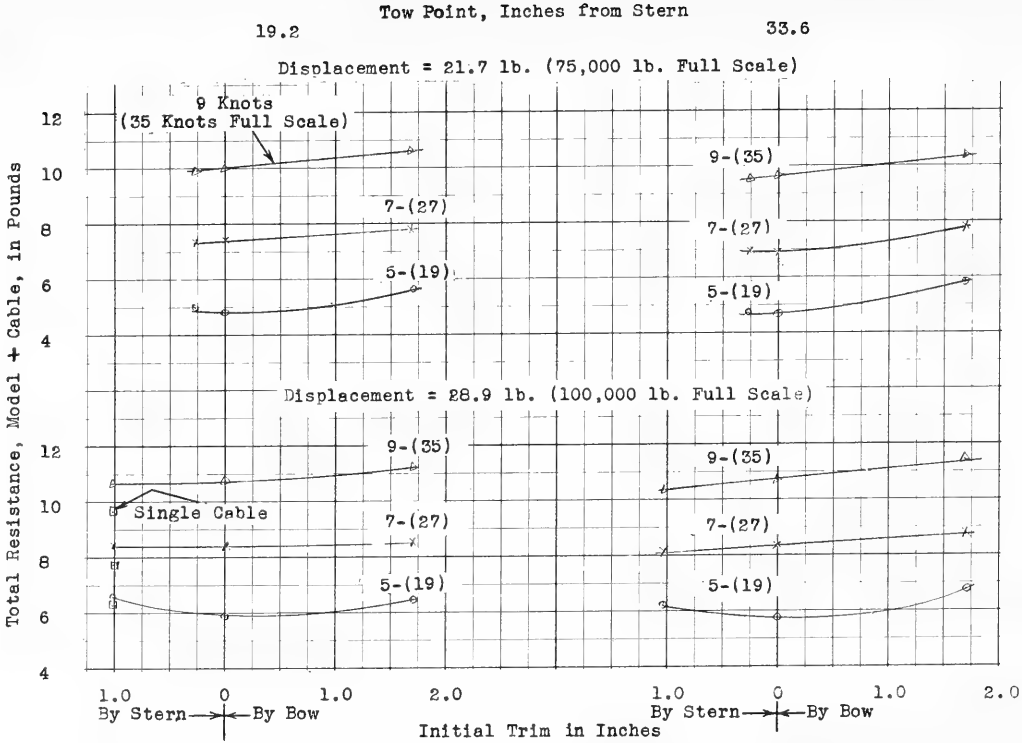


Figure 4 - Model 4027. Design "B" Boat Type Target. Variation of Total Resistance with Displacement, Initial Trim, and Fore and Aft Position of the Tow Point

The Tests Were Conducted in the Model Basin, the Model Being Towed by a 1/32-Inch Diameter Steel Cable 400 Feet Long, with Bridle Attachment to Model except Where Noted.

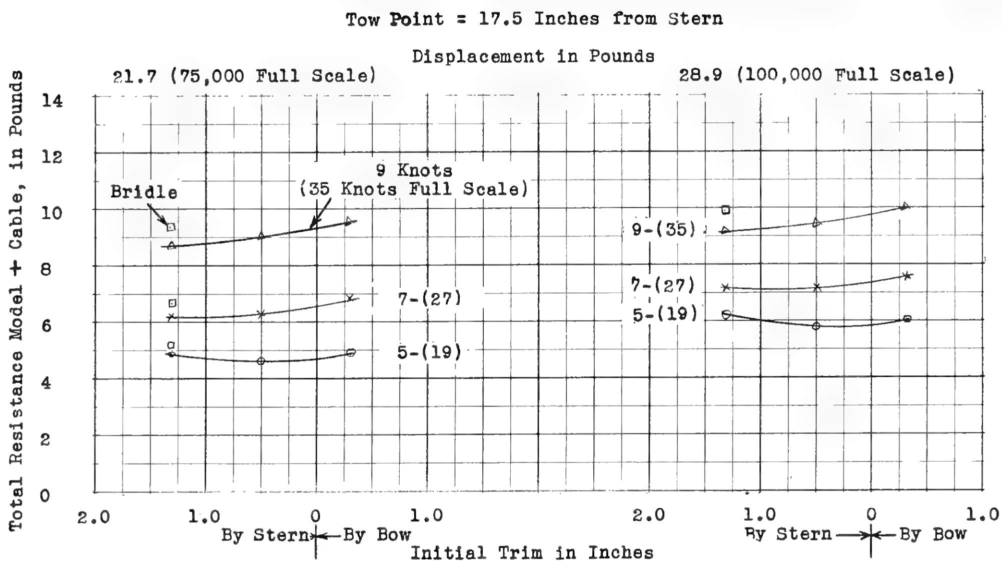


Figure 5 - Model 4029. TMB Design Target. Variation of Total Resistance with Displacement and Initial Trim

The Tests Were Conducted in the Model Basin, the Model Being Towed by a 1/32-Inch Diameter Steel Cable 400 Feet Long, with Single Cable Attachment to Model except where Noted.

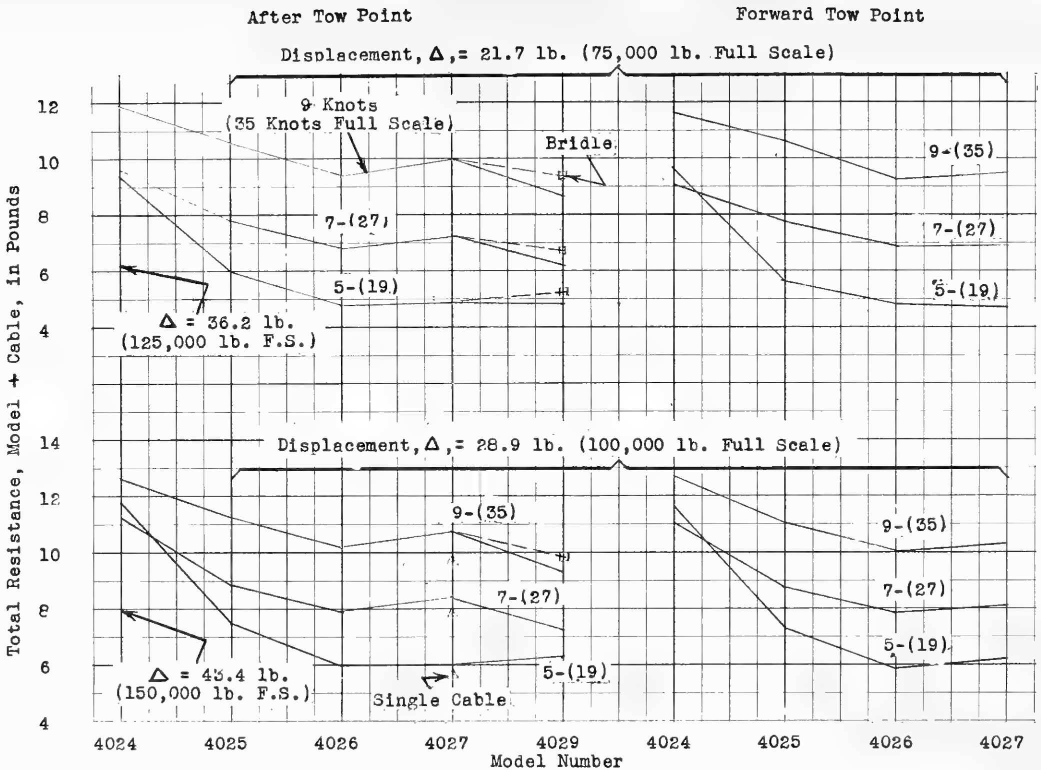


Figure 6 - Models 4024, 4025, 4026, 4027, and 4029. Towing Targets. Comparison of Variation of Total Resistance at Best Initial Trim with Displacement, and Fore and Aft Position of the Tow Point

The Tests Were Conducted in the Model Basin, the Model Being Towed by a 1/32-Inch Diameter Steel Cable 400 Feet Long, with Bridle Attachment to Model except where Noted.

INITIAL TRIM IN INCHES

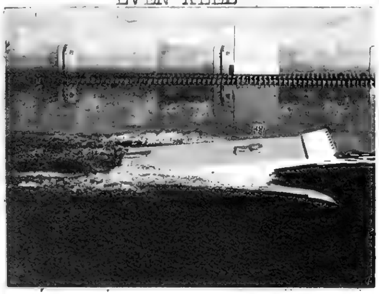
EVEN KEEL

1.26 BY STERN

1.76 BY STERN

DISPLACEMENT = 36.2 LB.

EVEN KEEL



1.26 BY STERN

2.26 BY STERN

DISPLACEMENT = 43.4 LB.

Figure 7.- Model 4024. Effect of Change of Initial Trim and Displacement. Tow Point = 20.5 Inches Forward of Stern; Cable Length = 400 Feet; Speed = 9.04 Knots

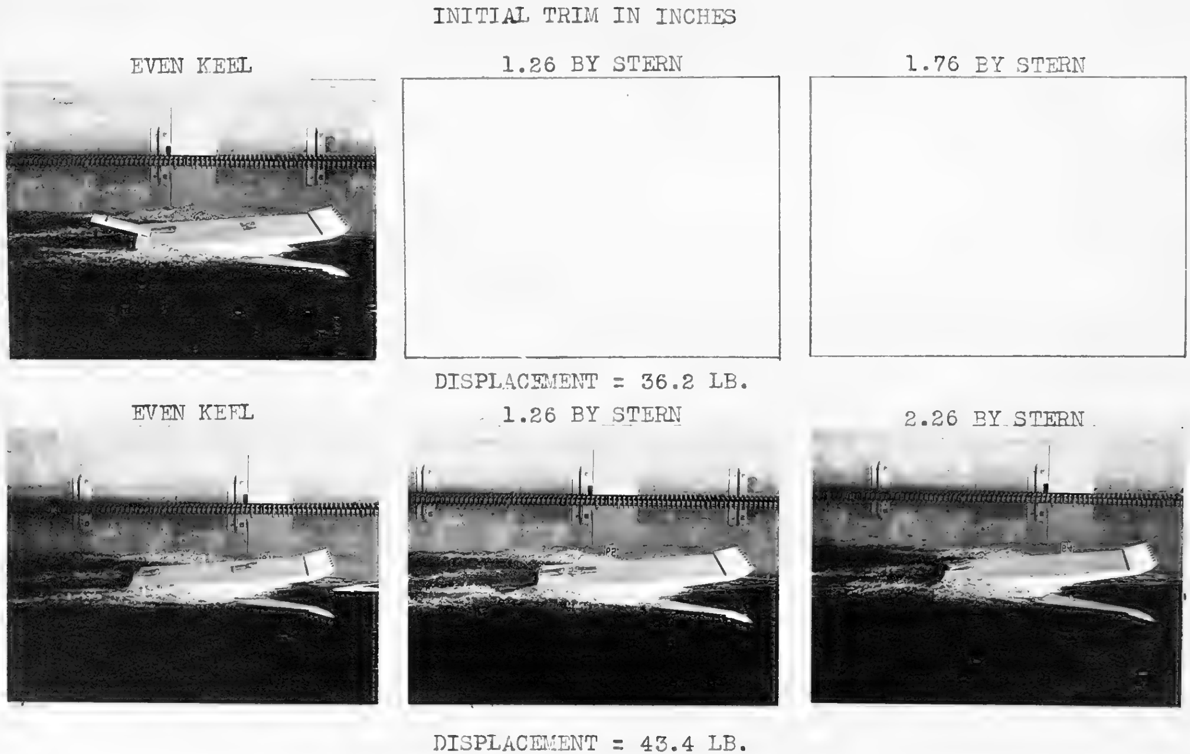
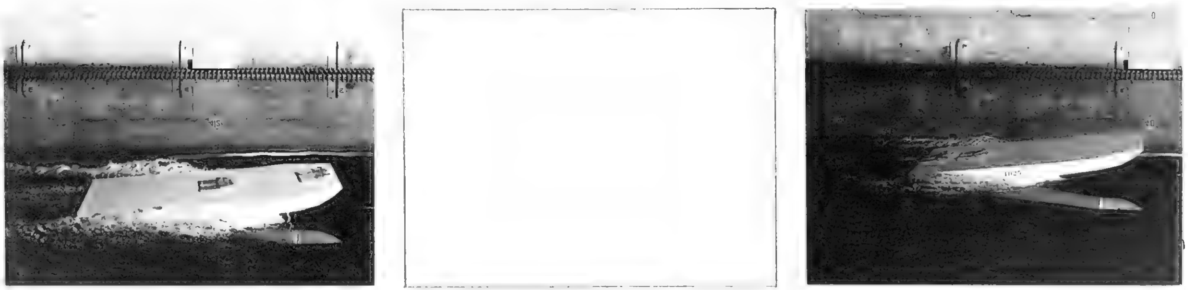


Figure 8.- Model 4024. Effect of Change of Initial Trim and Displacement. Tow Point = 28.8 Inches Forward of Stern; Cable Length = 400 Feet; Speed = 9.04 Knots

INITIAL TRIM IN INCHES

7.35 BY BOW | 1.68 BY BOW | EVEN KEEL

DISPLACEMENT = 21.7 LB.

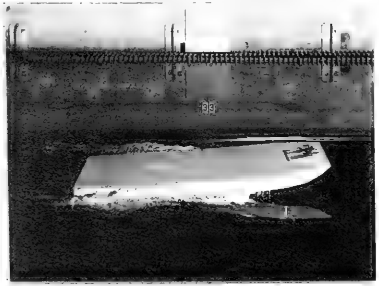


DISPLACEMENT = 28.9 LB.

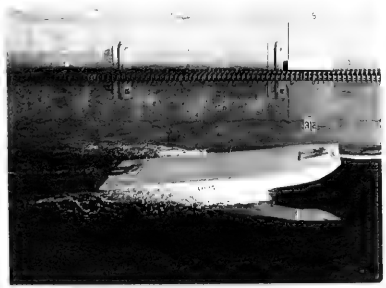
Figure 9.- Model 4025. Effect of Change of Initial Trim and Displacement. Tow Point 19.2 Inches Forward of Stern; Cable Length = 400 Feet; Speed = 9.04 Knots

INITIAL TRIM IN INCHES

3.35 BY BOW	1.68 BY BOW	EVEN KEEL



DISPLACEMENT = 21.7 LB.


DISPLACEMENT = 28.9 LB.

Figure 10- Model 4025. Effect of Change of Initial Trim and Displacement. Tow Point = 28.8 Inches Forward of Stern; Cable Length = 400 Feet; Speed = 9.04 Knots

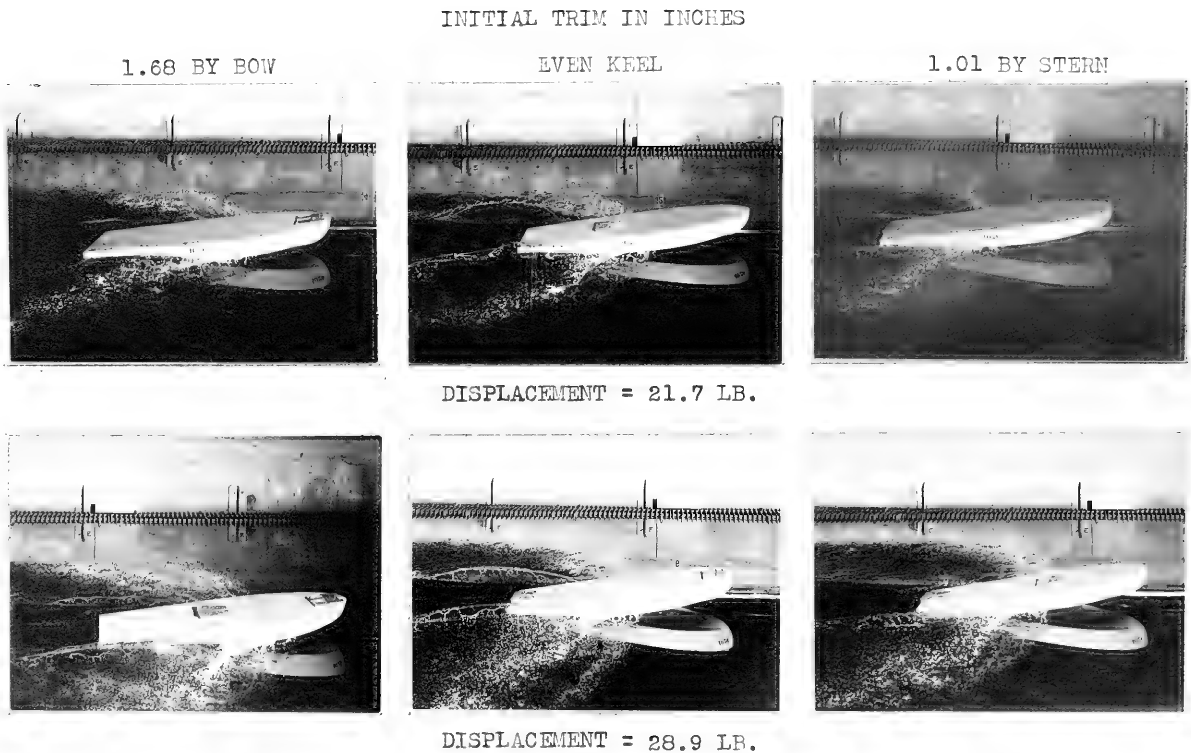
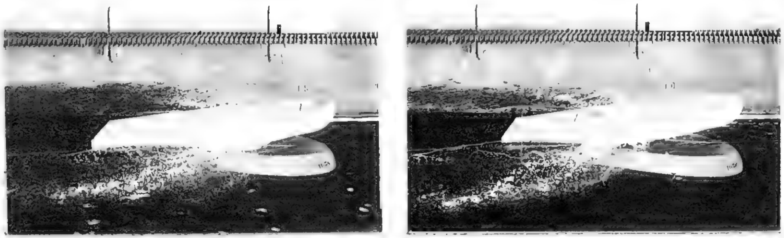


Figure 11- Model 4026. Effect of Change of Initial Trim and Displacement. Tow Point = 19.2 Inches Forward of Stern; Cable Length = 400 Feet; Speed = 9.04 Knots

INITIAL TRIM IN INCHES

1.68 BY BOW | EVEN KEEL | 1.01 BY STERN



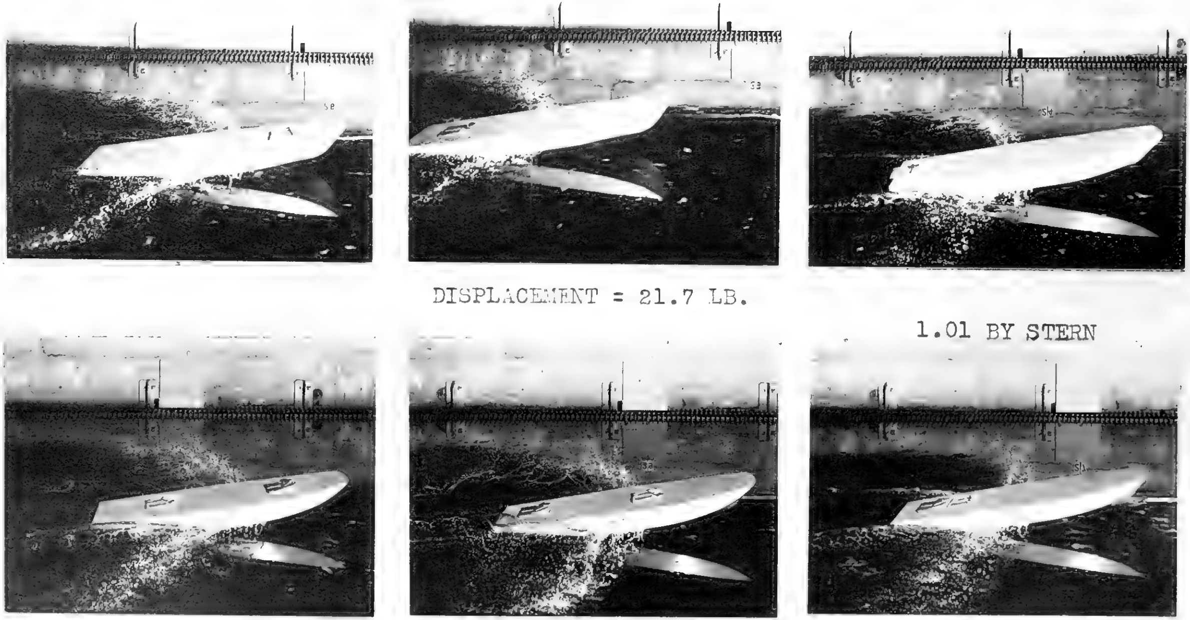
DISPLACEMENT = 21.7 LB.

DISPLACEMENT = 28.9 LB.

Figure 12- Model 4026. Effect of Change of Initial Trim and Displacement. Tow Point = 33.6 Inches Forward of Stern; Cable Length = 400 Feet; Speed = 9.04 Knots

INITIAL TRIM IN INCHES

1.68 BY BOW — EVEN KEEL — 0.29 BY STERN



DISPLACEMENT = 21.7 LB.

1.01 BY STERN

DISPLACEMENT = 28.9 LB.

Figure 13- Model 40[illegible]7. Effect of Change of Initial Trim and Displacement. Tow Point = 19.[illegible] Inches Forward of Stern; Cable Length = 400 Feet; Speed = 9.04 Knots

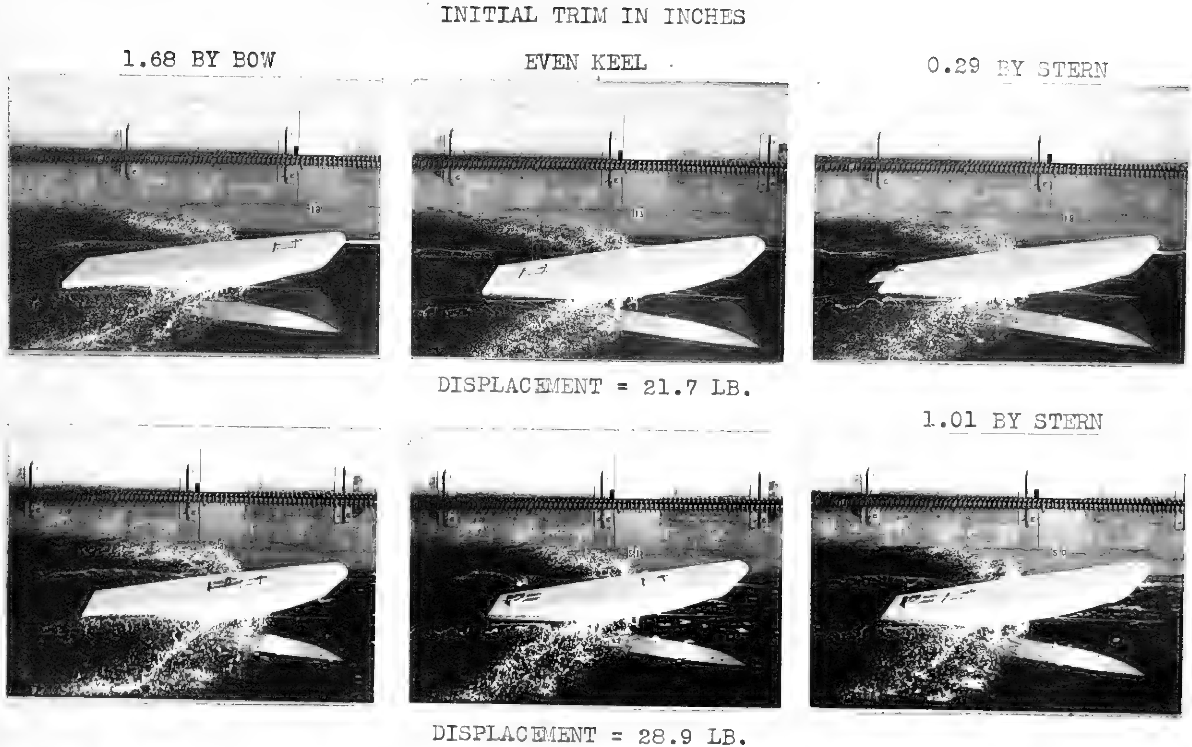
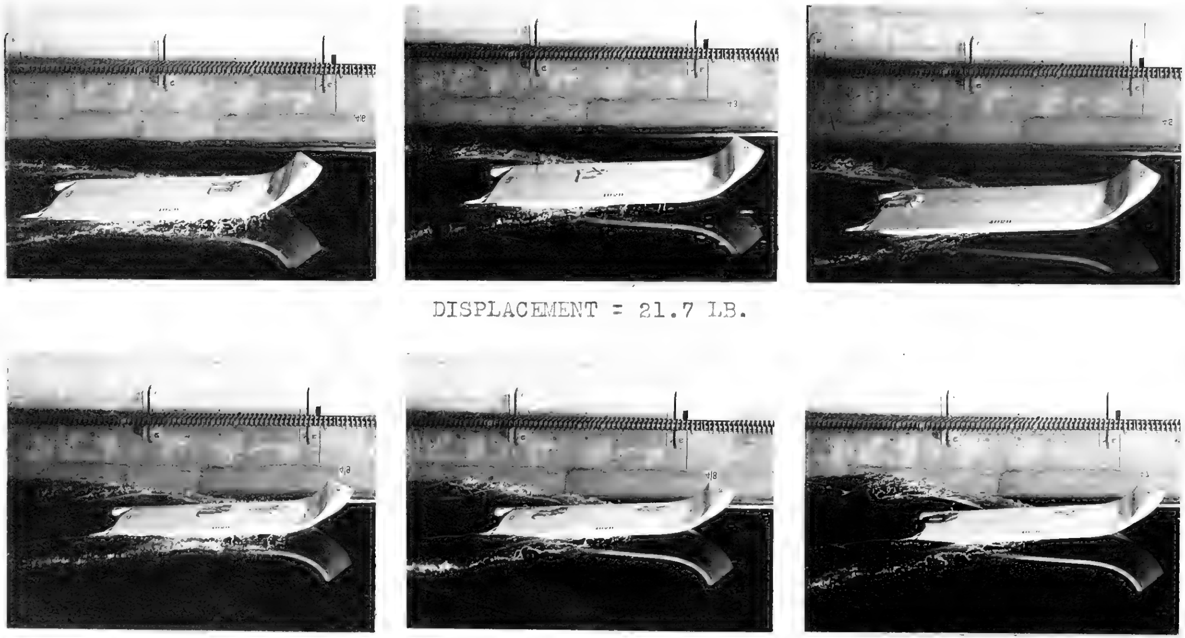


Figure 14- Model 4027. Effect of Change of Initial Trim and Displacement. Tow Point = 33.6 Inches Forward of Stern; Cable Length = 400 Feet; Speed = 9.04 Knots

INITIAL TRIM IN INCHES

0.29 BY BOW | 0.50 BY STERN | 1.34 BY STERN



DISPLACEMENT = 21.7 LB.

DISPLACMENT = 28.9 LB.

Figure 15- Model 4020. Effect of Change of Initial Trim and Displacement. Tow Point = 17.5 Inches Forward of Stern; Cable Length = 400 Feet: Speed = 9.04 Knots

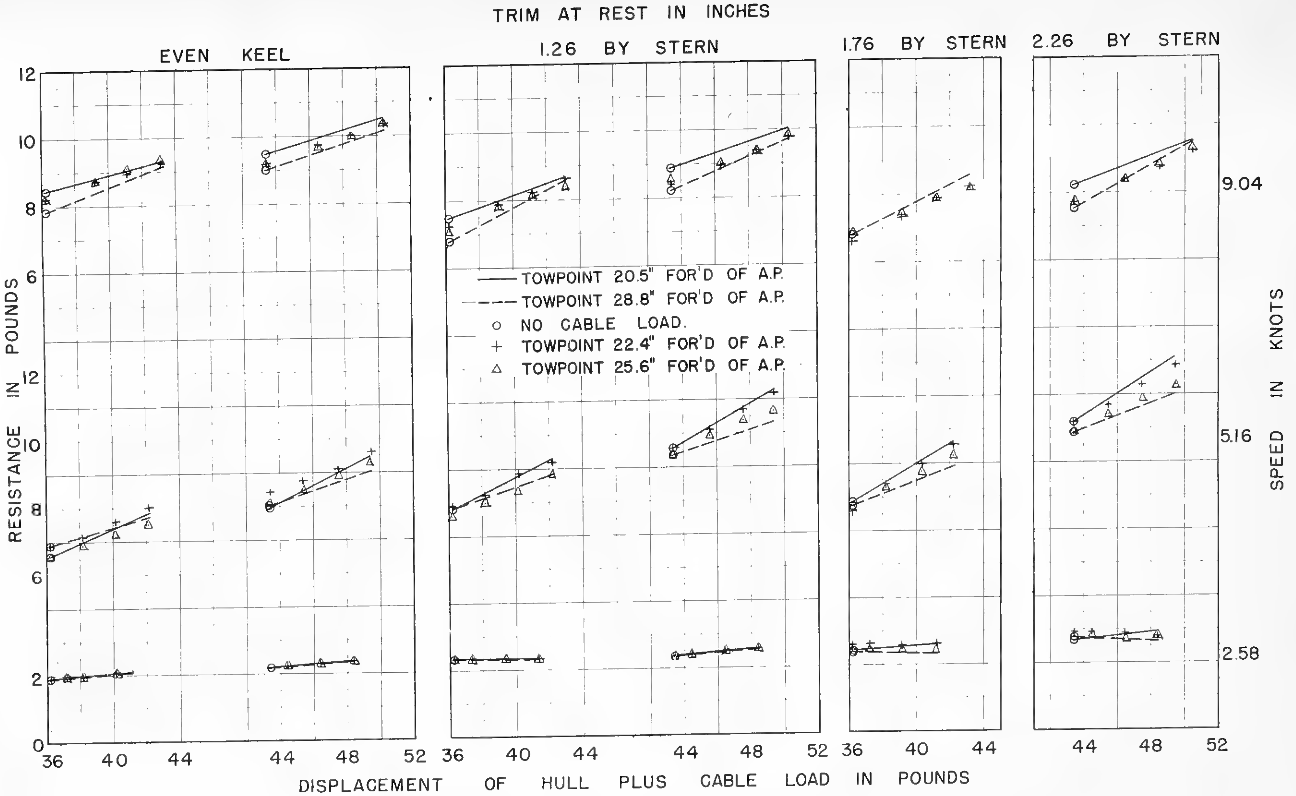


FIGURE 16 – TOWING TARGET MODEL 4024

EFFECT ON RESISTANCE OF DISPLACEMENT TRIM AT REST, POSITION OF TOWPOINT, AND THE ADDITION AT THE TOWPOINT OF LOADS SIMULATING WEIGHTS OF VARIOUS LENGTHS OF TOWING CABLE

NOTE:— TRIM AT REST SET ONLY AT DISPLACEMENT CORRESPONDING TO NO CABLE LOAD.

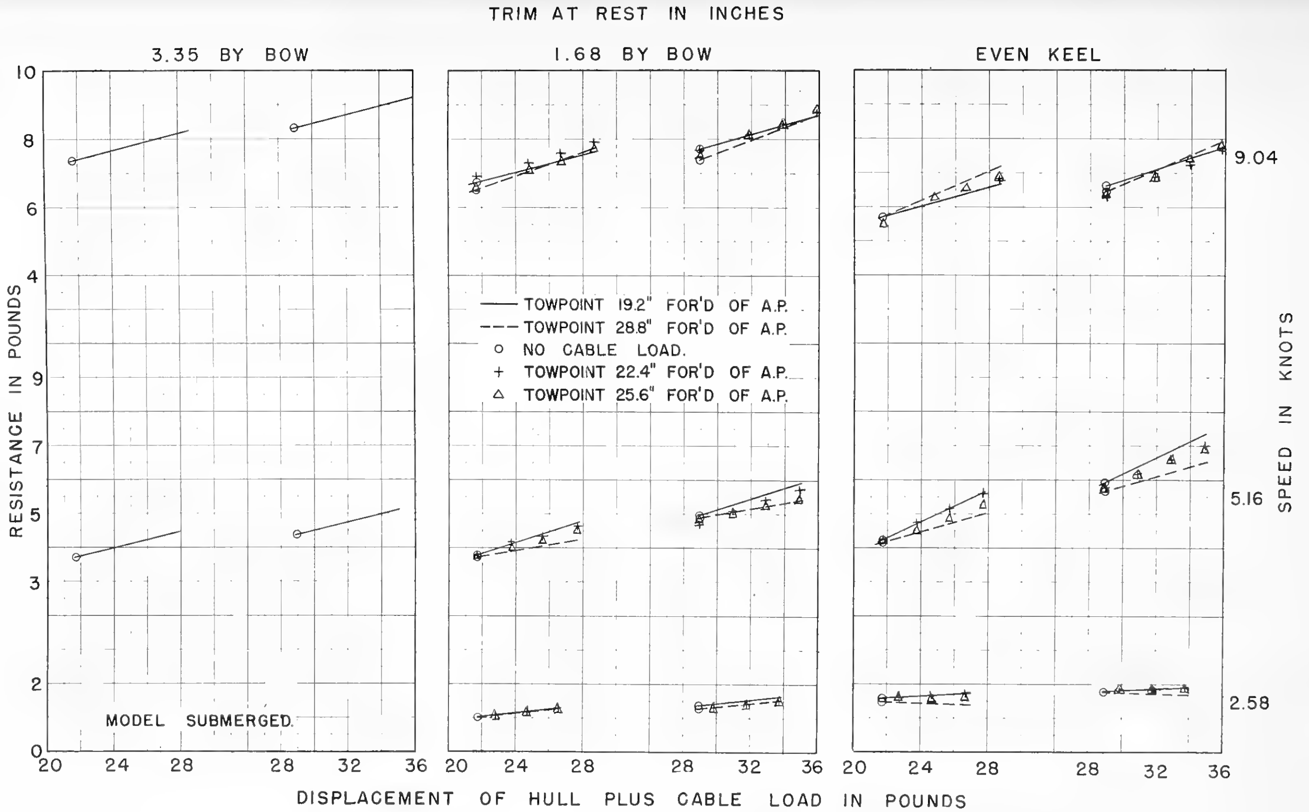


FIGURE 17 — TOWING TARGET MODEL 4025

EFFECT ON RESISTANCE OF DISPLACEMENT, TRIM AT REST, POSITION OF TOWPOINT, AND THE ADDITION AT THE TOWPOINT OF LOADS SIMULATING WEIGHTS OF VARIOUS LENGTHS OF TOWING CABLE

NOTE:— TRIM AT REST SET ONLY AT DISPLACEMENT CORRESPONDING TO NO CABLE LOAD.

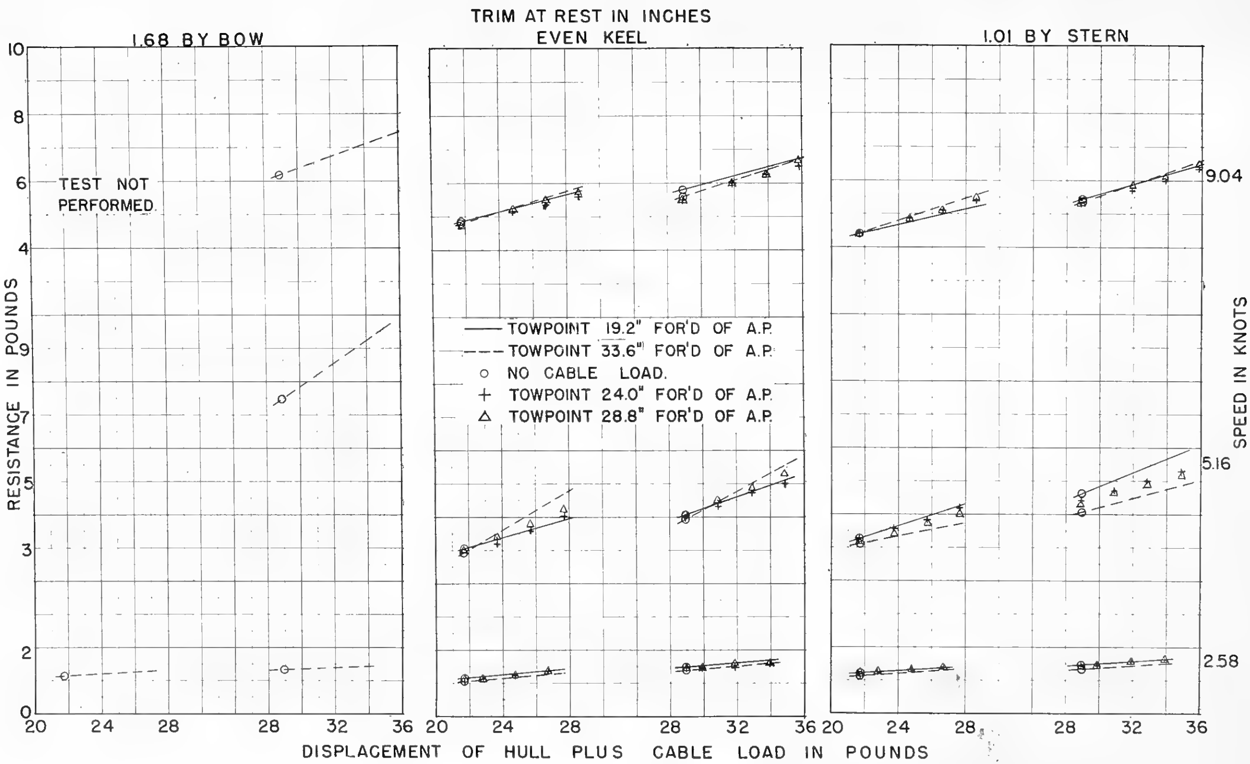


FIGURE 18 – TOWING TARGET MODEL 4026

EFFECT ON RESISTANCE OF DISPLACEMENT, TRIM AT REST, POSITION OF TOWPOINT, AND THE ADDITION AT THE TOWPOINT OF LOADS SIMULATING WEIGHTS OF VARIOUS LENGTHS OF TOWING CABLE.

NOTE:– TRIM AT REST SET ONLY AT DISPLACEMENT CORRESPONDING TO NO CABLE LOAD.

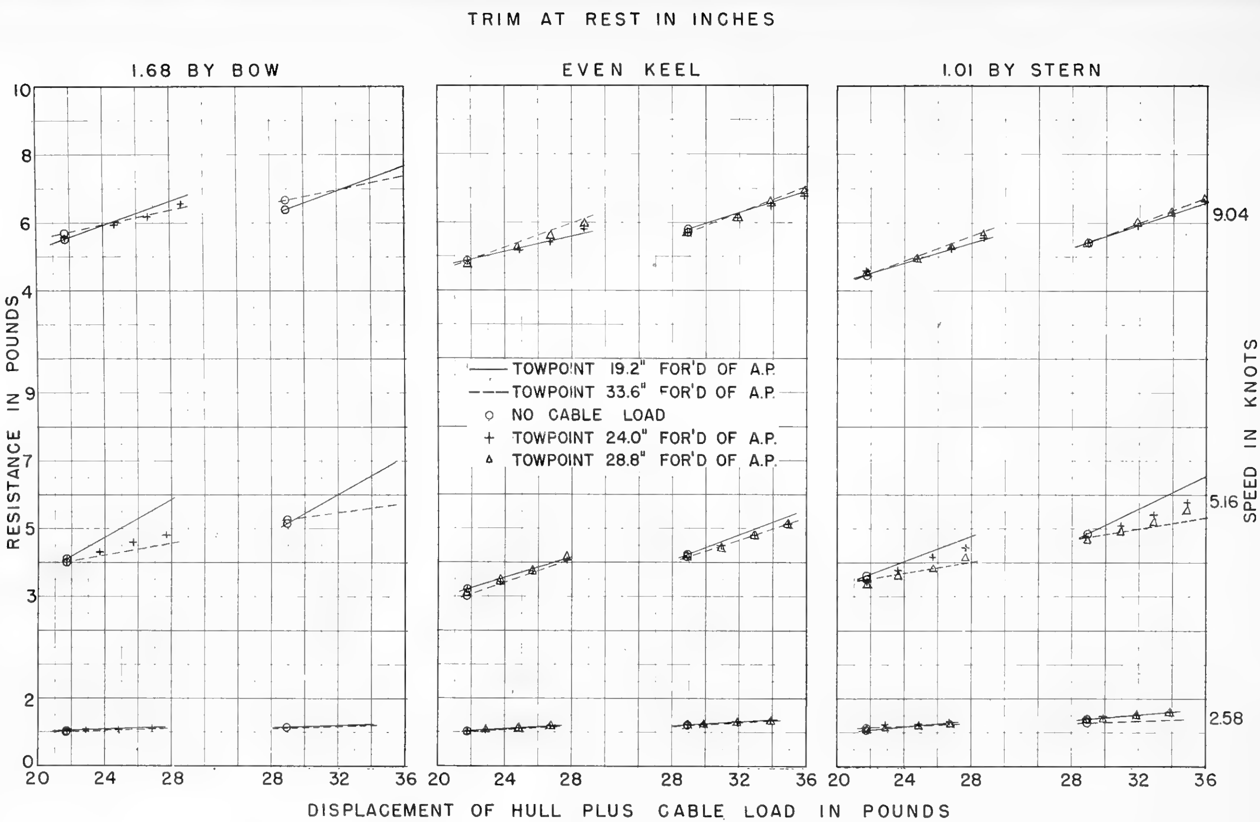


FIGURE 19 — TOWING TARGET MODEL 4027

EFFECT ON RESISTANCE OF DISPLACEMENT, TRIM AT REST, POSITION OF TOWPOINT, AND THE ADDITION AT THE TOWPOINT OF LOADS SIMULATING WEIGHTS OF VARIOUS LENGTHS OF TOWING CABLE.

NOTE:— TRIM AT REST SET ONLY AT DISPLACEMENT CORRESPONDING TO NO CABLE LOAD.

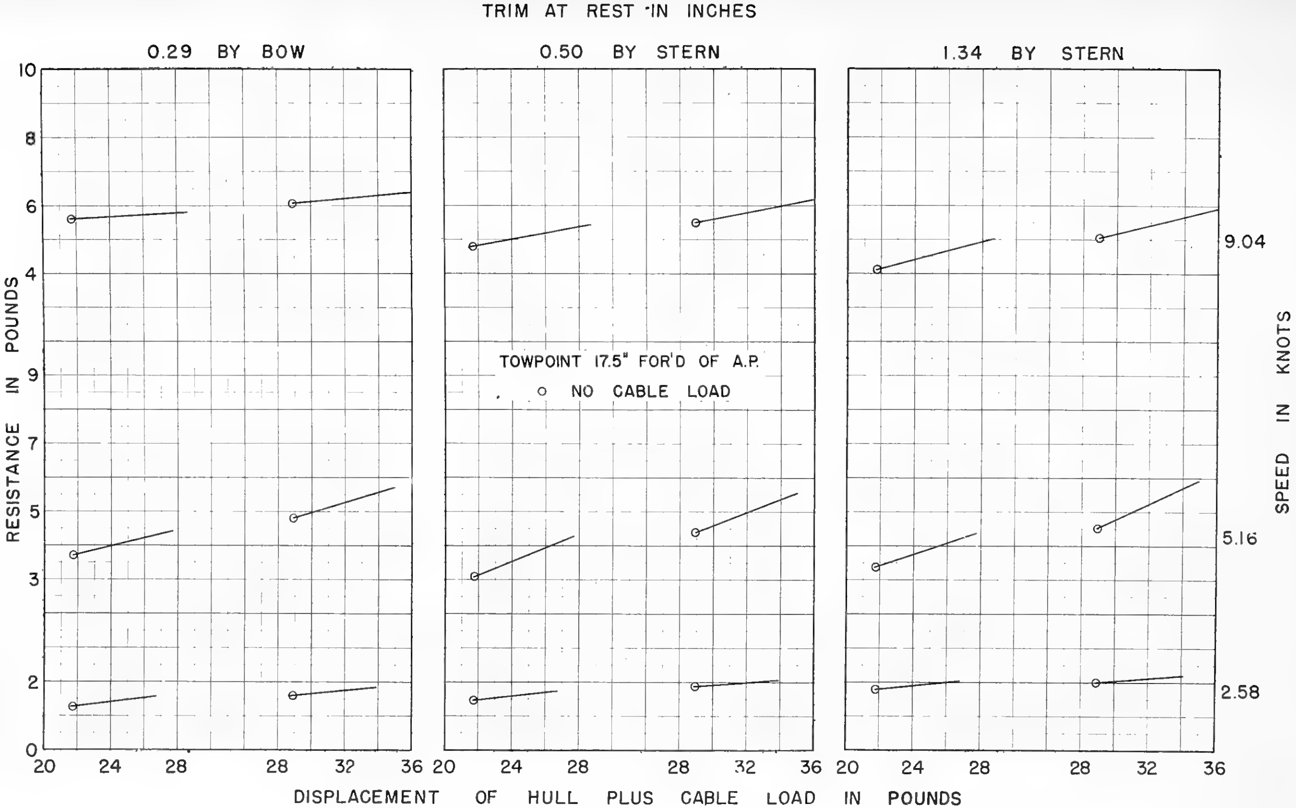
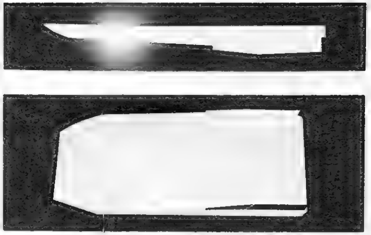


FIGURE 20 — TOWING TARGET MODEL 4029

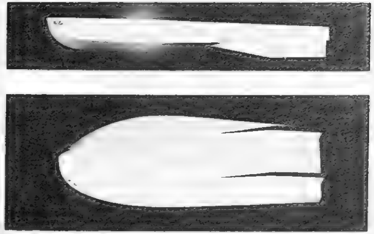
EFFECT ON RESISTANCE OF DISPLACEMENT, TRIM AT REST, POSITION OF TOWPOINT, AND THE ADDITION AT THE TOWPOINT OF LOADS SIMULATING WEIGHTS OF VARIOUS LENGTHS OF TOWING CABLE

NOTE:— TRIM AT REST SET ONLY AT DISPLACEMENT CORRESPONDING TO NO CABLE LOAD.

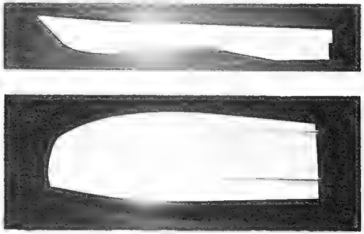
Model 4024 - G-60 Sled Type Target
Revised Design



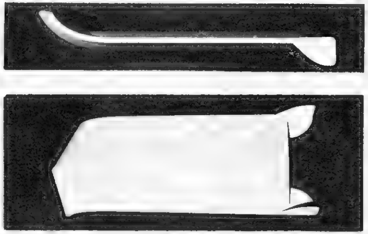
Model 4025 - 60-Foot All Steel
Sled Type Target



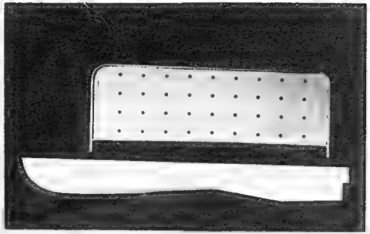
Model 4026 - 60-Foot Boat Type Target
Design "A"



Model 4027 - 60 Foot Boat Type Target
Design "B"



Model 4029 - 60-Foot Towing Target
TMB Design



Screen Fitted for Maneuvering
Tests Only

Figure 21 - Models of High Speed Towing Targets
Linear Ratio = 15

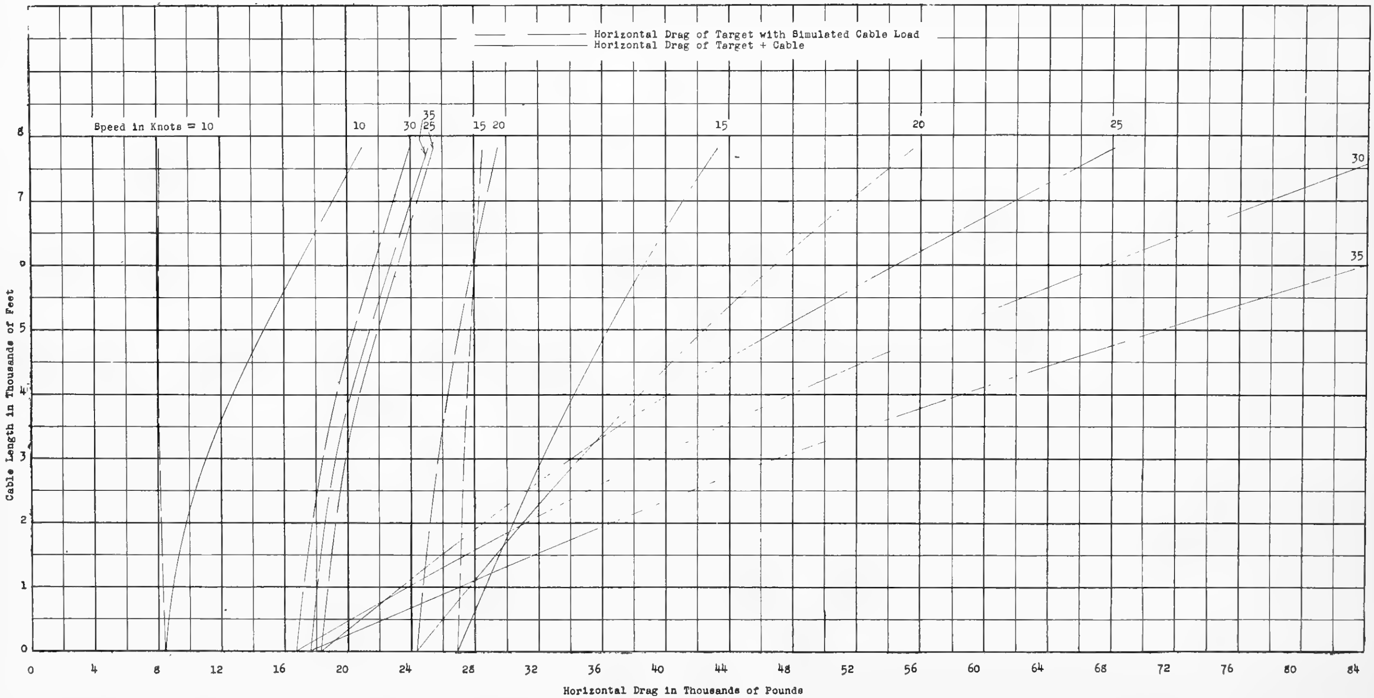


Figure 22 - Revised G-60 Sled-Type Target Represented by Model 4024. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = 2.2 Feet by Stern; Initial Displacement = 125,000 Pounds; Tow Point = 28.0 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

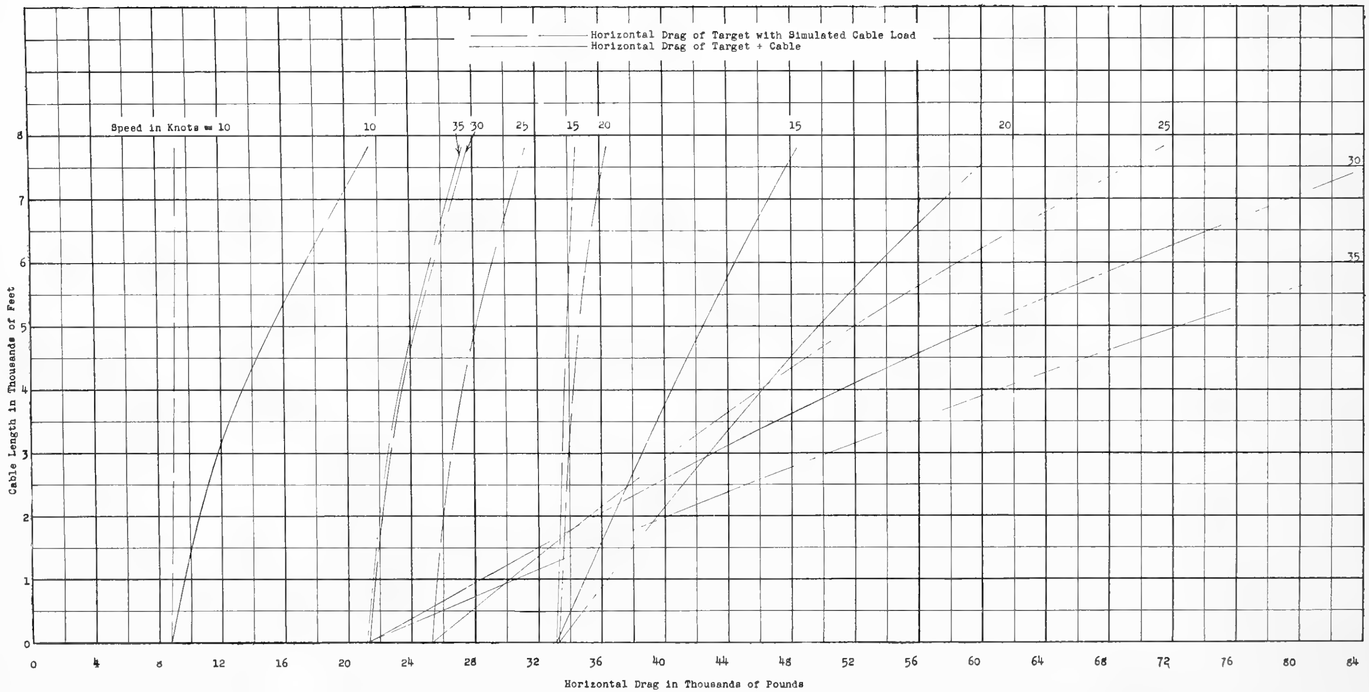


Figure 23 - Revised G-60 Sled-Type Target Represented by Model 4024. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = 2.8 Feet by Stern; Initial Displacement = 150,000 Pounds; Tow Point = 28.0 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

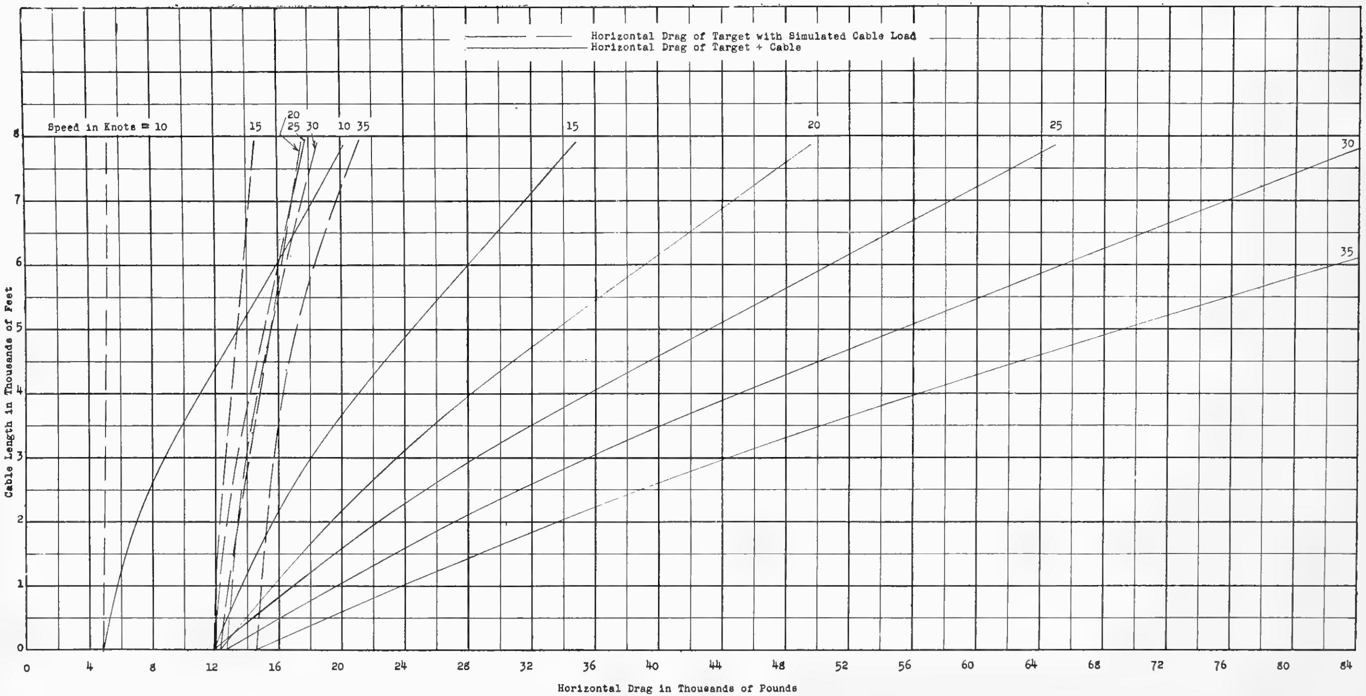


Figure 24 - All-Steel Sled-Type Target Represented by Model 4025. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = Even Keel; Initial Displacement = 75,000 Pounds; Tow Point = 24.0 Feet Forward of Stern

Note---The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

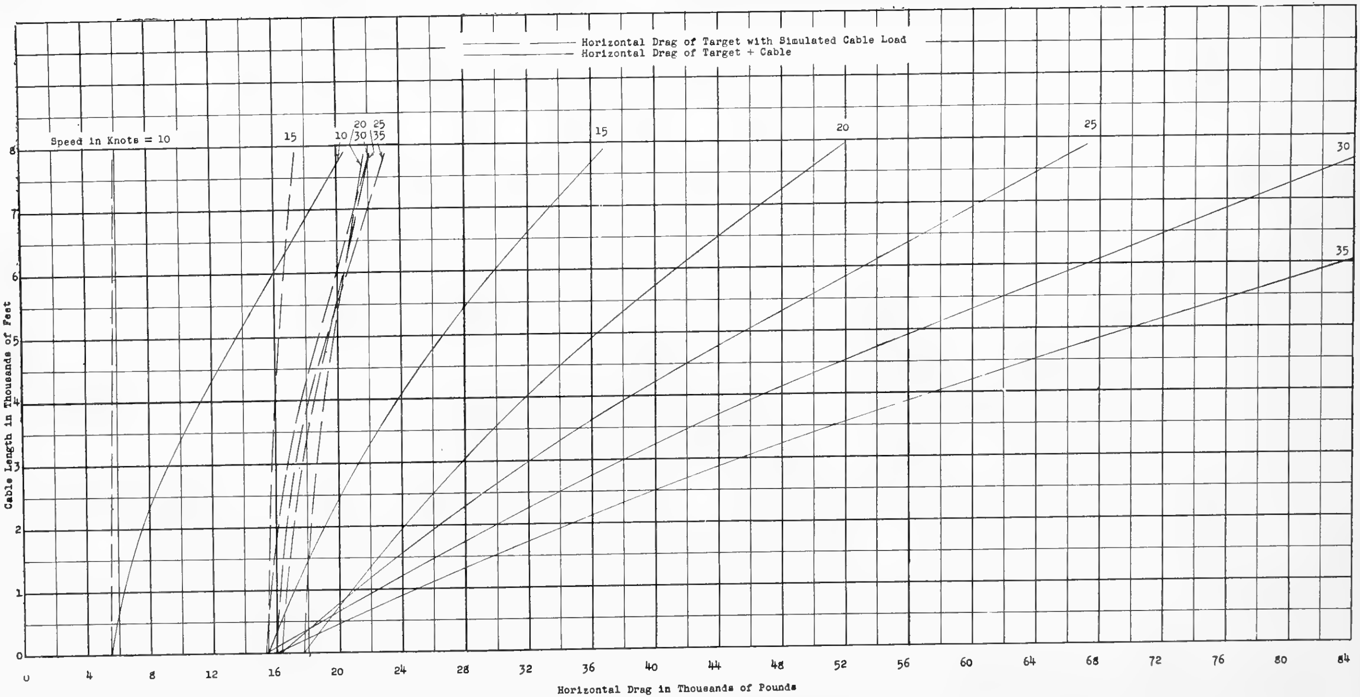


Figure 25 - All-Steel Sled-Type Target Represented by Model 4025. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = Even Keel; Initial Displacement = 100,000 Pounds; Tow Point = 28.0 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

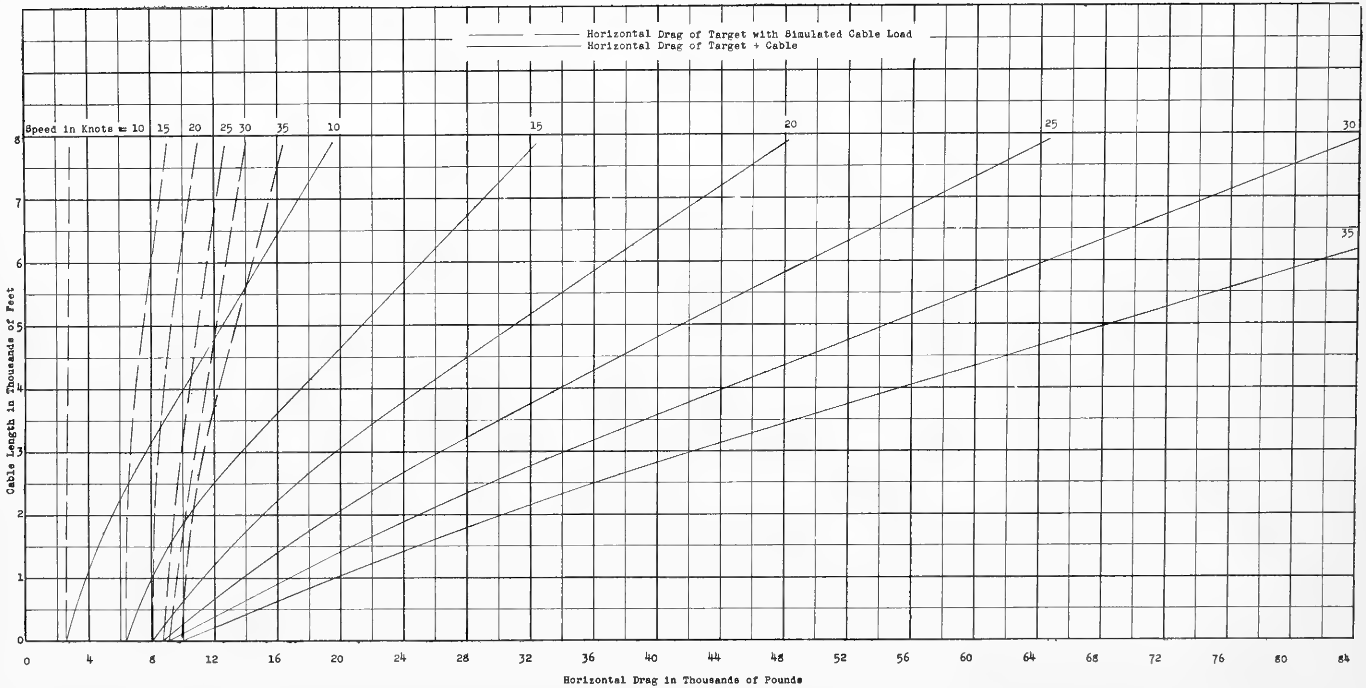


Figure 26 - BuShips Design "A" Boat-Type Target Represented by Model 4026. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = 1.3 Feet by Stern; Initial Displacement = 75,000 Pounds; Tow Point = 42.0 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

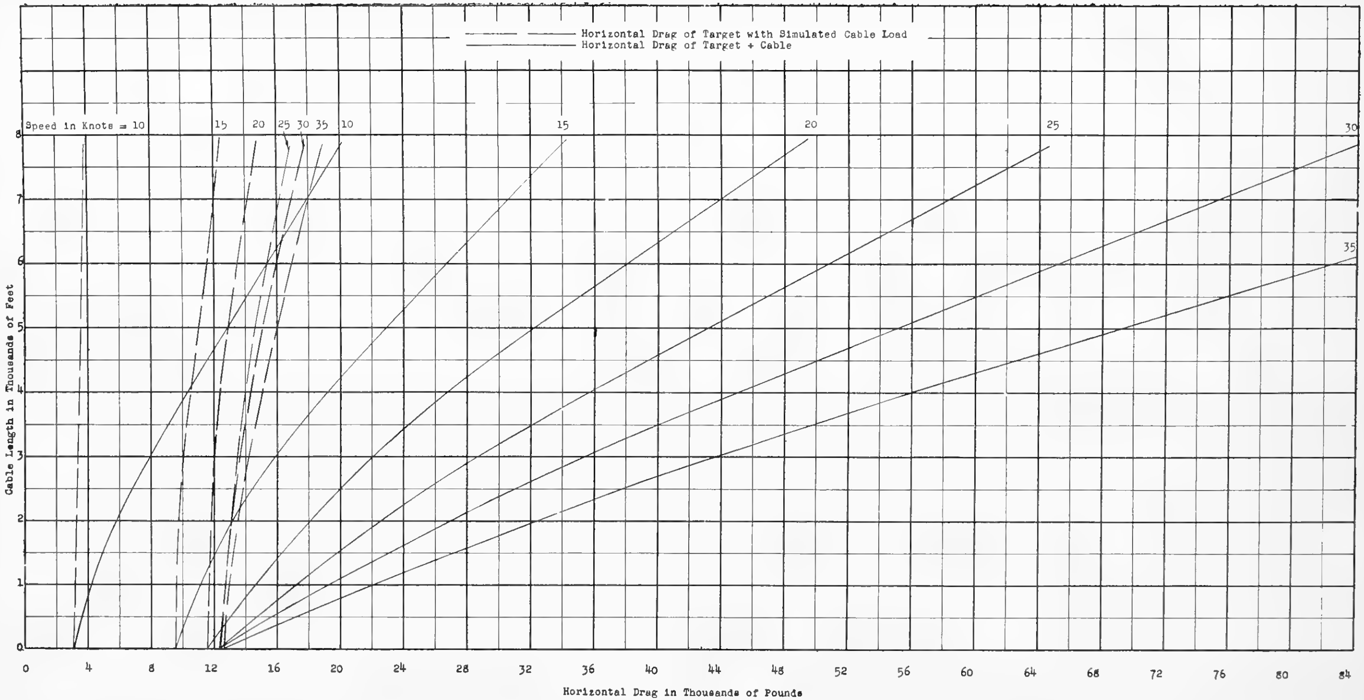


Figure 27 - BuShips Design "A" Boat-Type Target Represented by Model 4026. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = 1.3 Feet by Stern; Initial Displacement = 100000 Pounds; Tow Point = 42.0 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

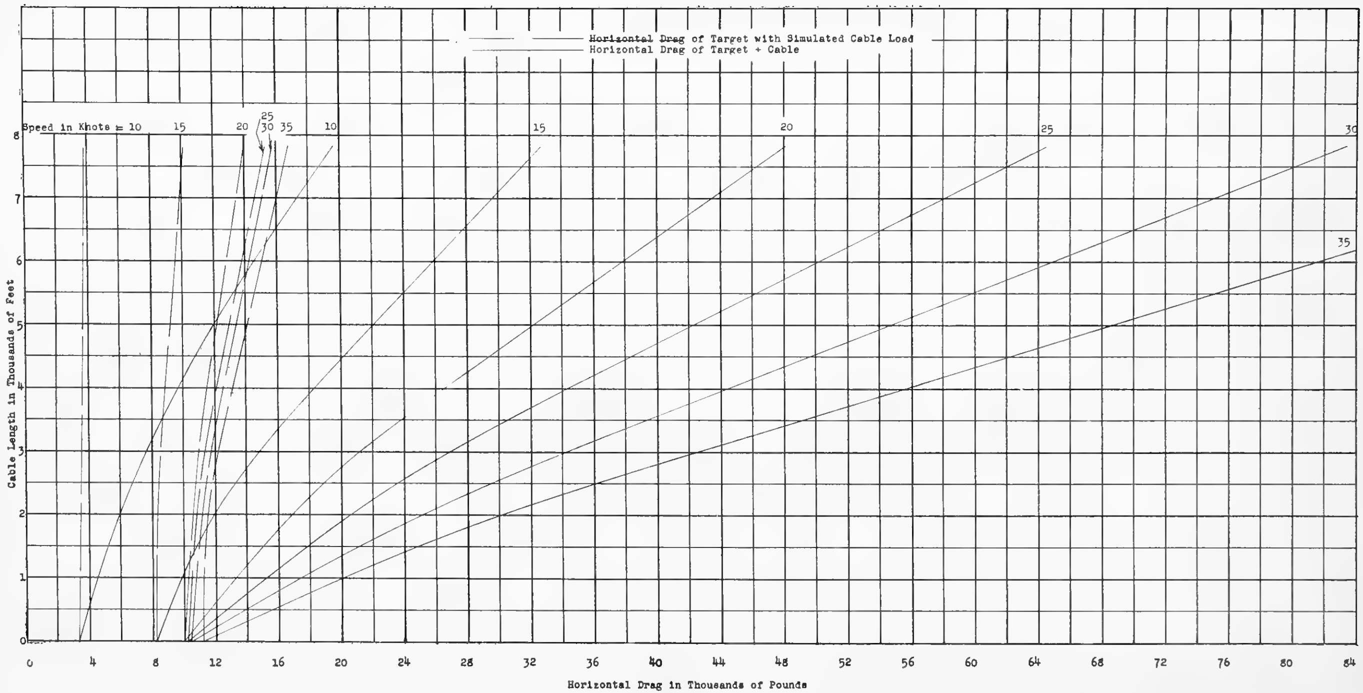


Figure 28 - BuShips Design "B" Boat-Type Target Represented by Model 4027. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = 1.3 Feet by Stern; Initial Displacement = 75,000 Pounds; Tow Point = 30.0 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

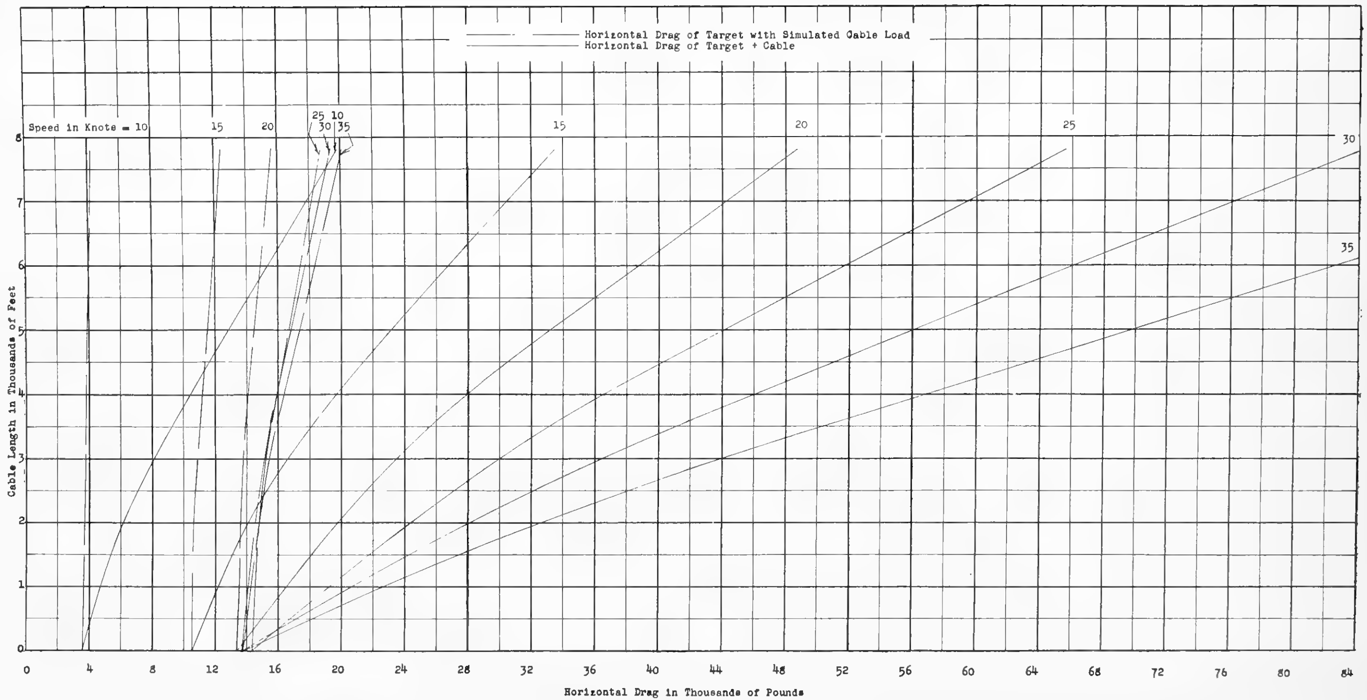


Figure 29 - BuShips Design "B" Boat-Type Target Represented by Model 4027. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = 1.3 Feet by Stern; Initial Displacement = 100,000 Pounds; Tow Point = 42.0 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

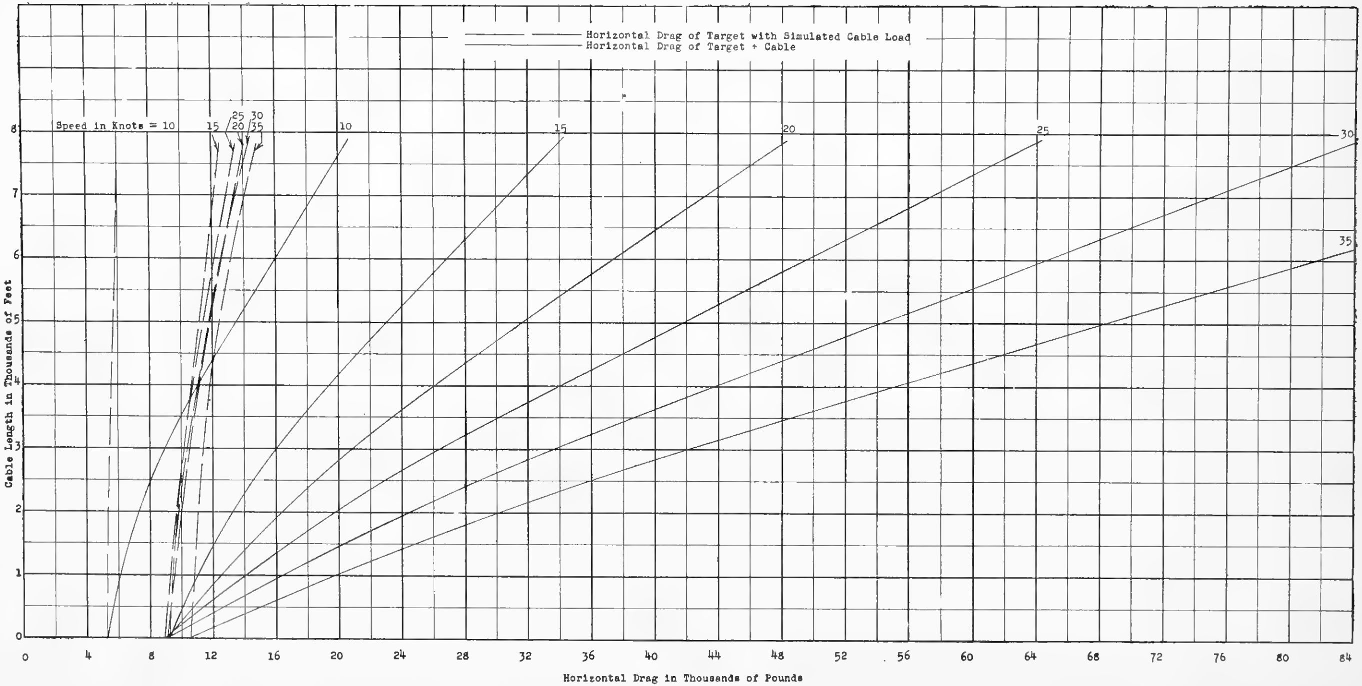


Figure 30 - TMB Design Target Represented by Model 4029. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = 1.7 Feet by Stern; Initial Displacement = 75,000 Pounds; Tow Point = 21.9 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

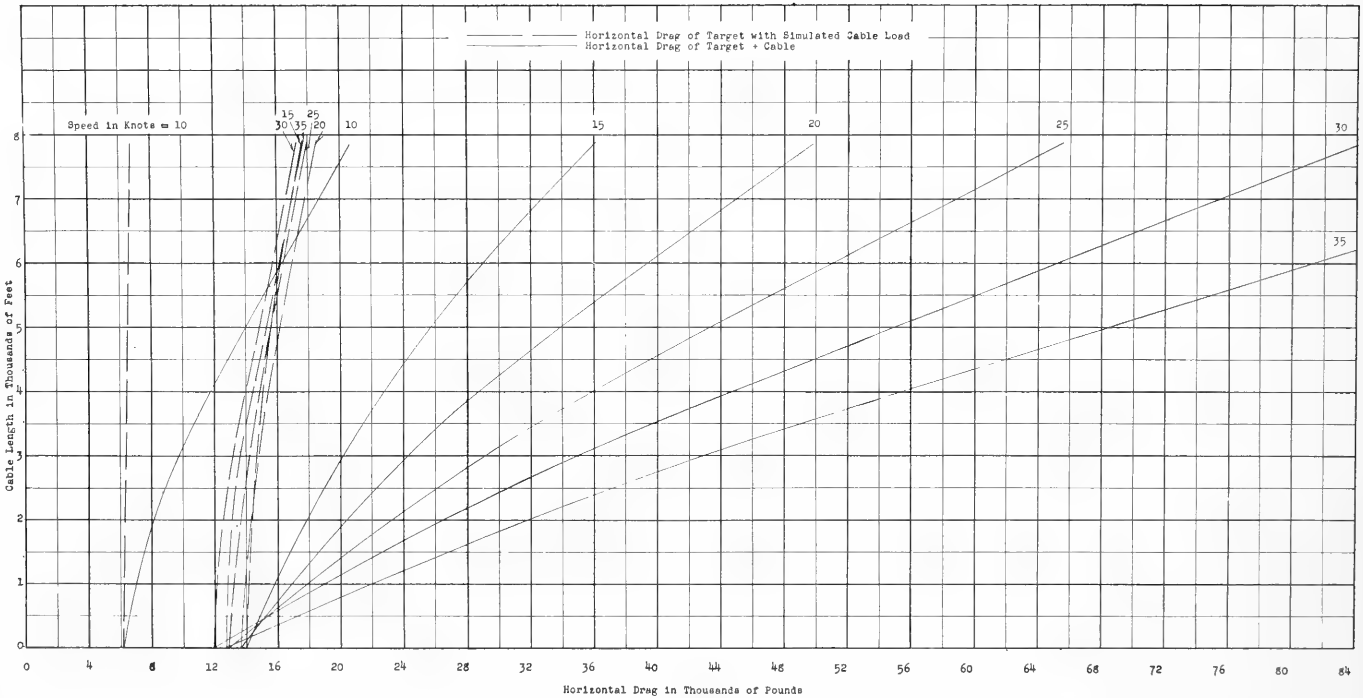


Figure 31 - TMB Design Target Represented by Model 4029. Estimated Variation of Horizontal Drag of Target with Simulated Cable Load, and Horizontal Drag of Target + Cable, with Speed and Cable Length; Initial Trim = 1.7 Feet by Stern; Initial Displacement = 100,000 Pounds; Tow Point = 21.9 Feet Forward of Stern

Note - The curves are based on model data at the condition that gives minimum drag at a speed corresponding to 30 knots.

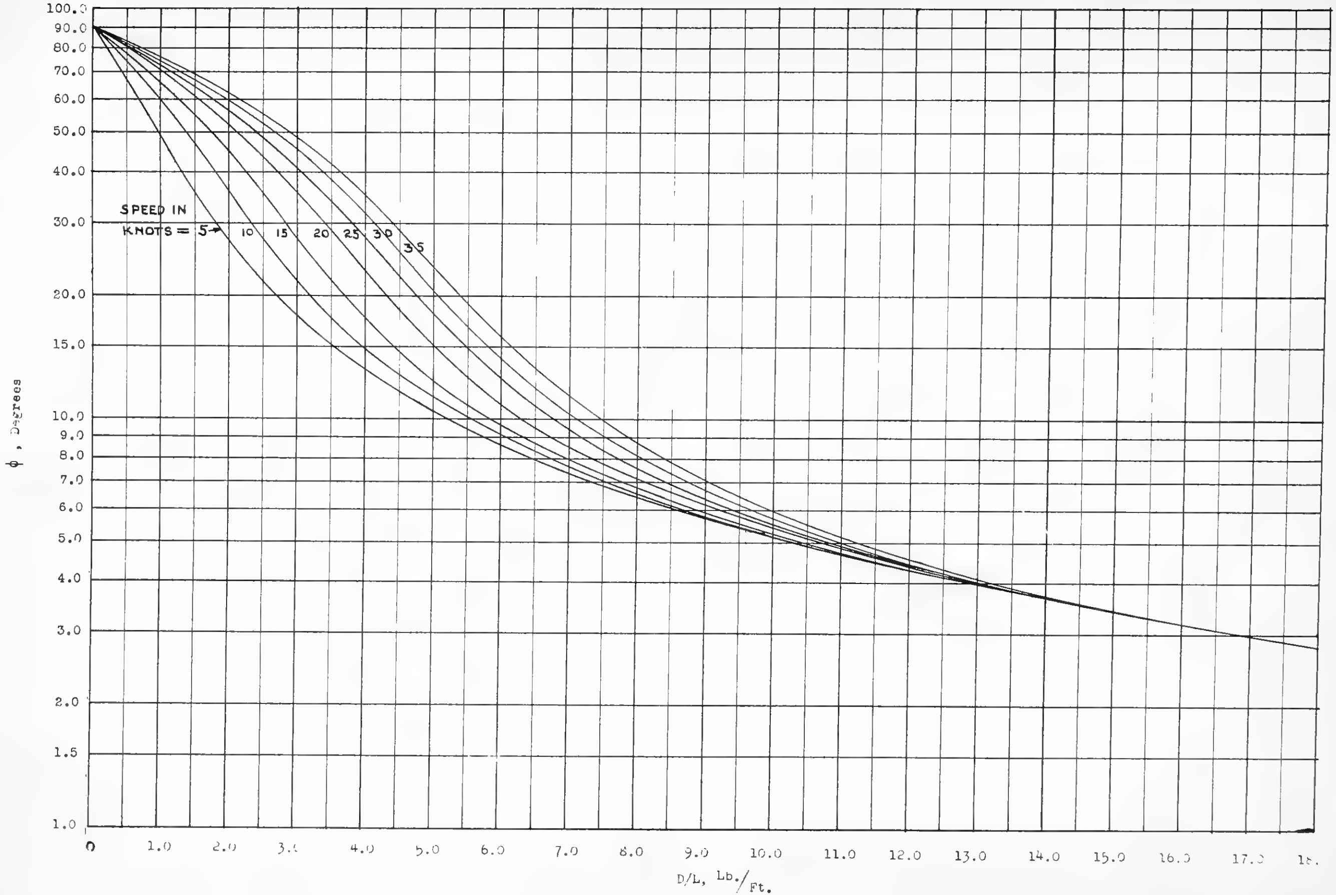


Figure 32- Characteristics of a 1" Stranded Wire Cable Submerged in Salt Water at 50° F with Each End Supported at the Surface. V = Speed of Advance in Knots; L = Cable Length in Feet; D = Superimposed Horizontal Target Drag at the Trailing End of the Cable in the Opposite Direction to V; ϕ = Angle of the Cable with the Horizontal at the Trailing End

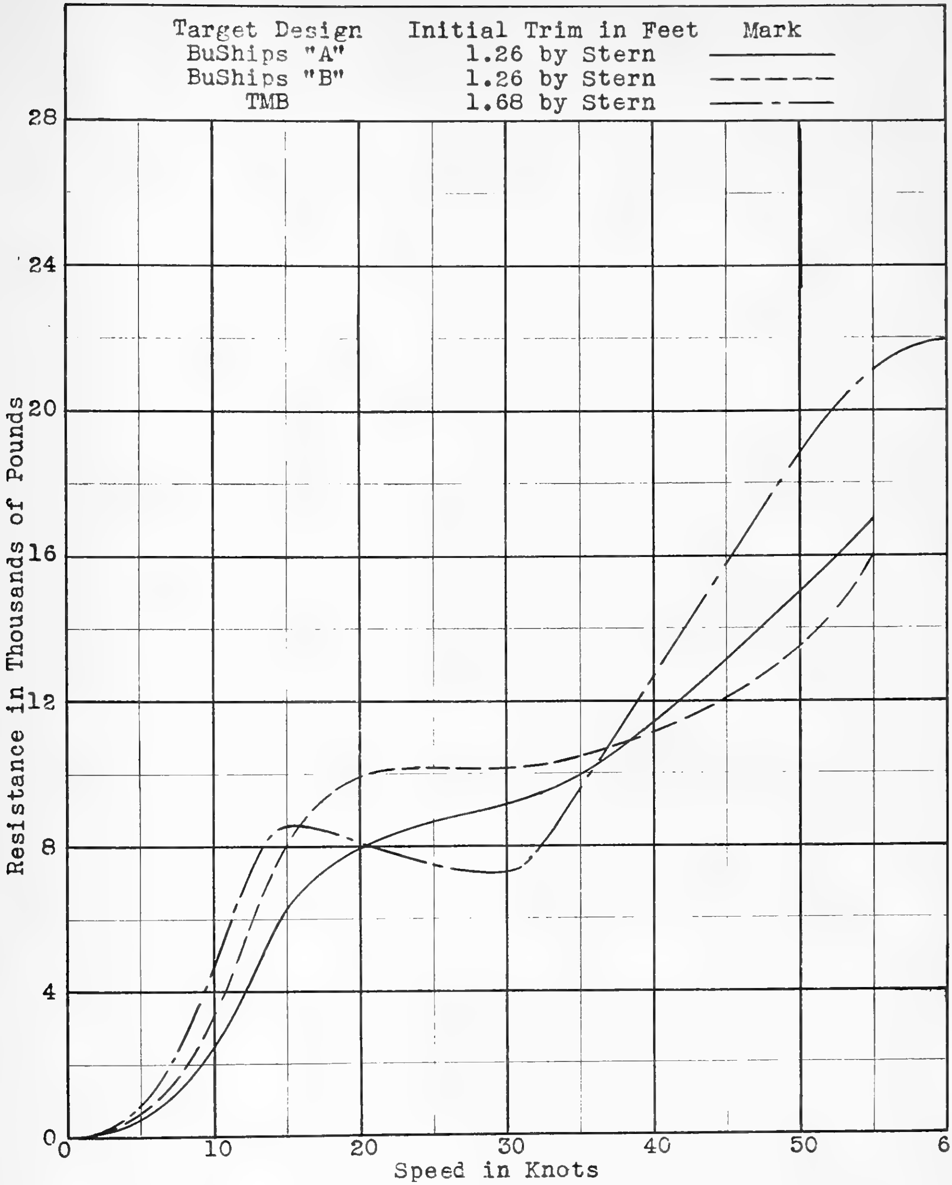


Figure 33 - Variation of Resistance with Speed for TMB Design and BuShips Designs "A" and "B" Towing Targets; No Cable Attached; Displacement = 75,000 Pounds

Note - These conditions give the minimum resistance, as derived from model tests, for speeds of 30 knots and above.

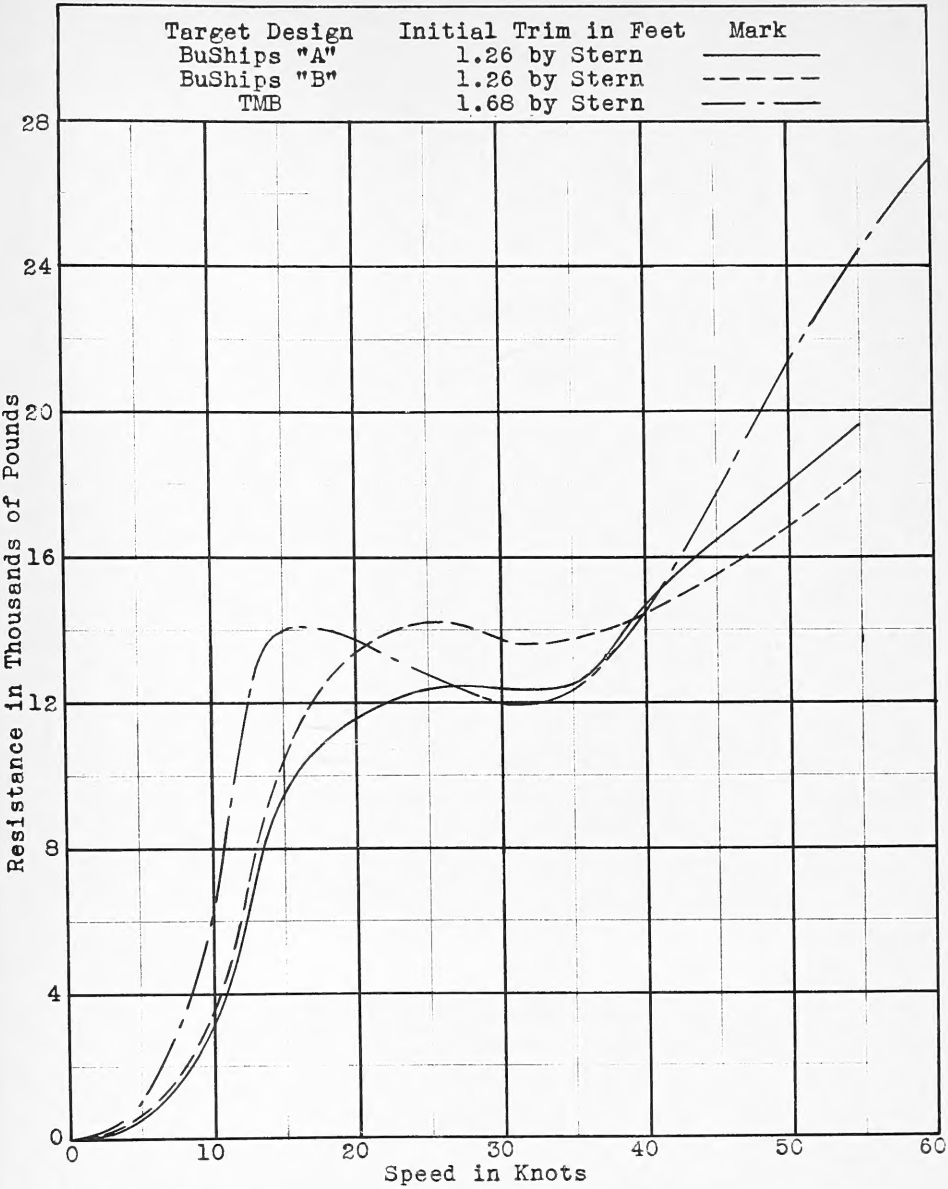


Figure 34 - Variation of Resistance with Speed for TMB Design and BuShips Designs "A" and "B" Towing Targets; No Cable Attached; Displacement = 100,000 Pounds

Note - These conditions give the minimum resistance, as derived from model tests, for speeds of 30 knots and above.