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UNITED STATES EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C.

EFFECTS OF MODIFICATIONS TO BATTLESHIP
MODELS ON RESISTANCE AND PROPULSION

EXPERIMENTAL MODEL BASIN
ERECTED 1938
BUREAU OF
CONSTRUCTION AND REPAIR
NAVY DEPARTMENT

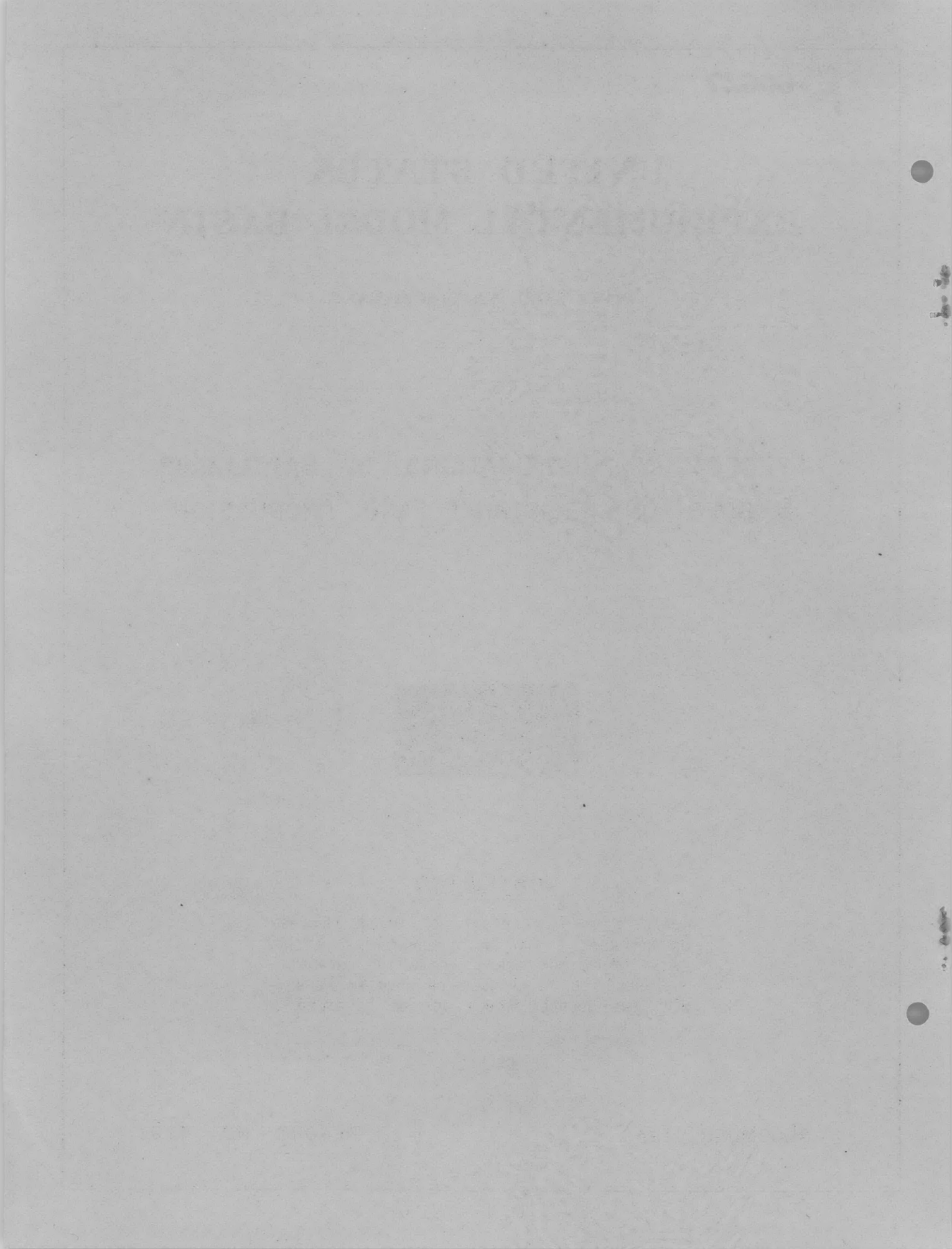
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DECEMBER 1936

REPORT NO. 429



EFFECTS OF MODIFICATIONS TO BATTLESHIP MODELS
ON RESISTANCE AND PROPULSION

U.S. Experimental Model Basin
Navy Yard, Washington, D.C.

December 1936

Report No. 429

EFFECTS OF MODIFICATIONS TO BATTLESHIP MODELS
ON RESISTANCE AND PROPULSION.

Experiments have been conducted on Model No. 3367, representing Battleships 43 to 48, in which eight alterations were made to the bow forward of station #3 on a 40 station basis, and on Model No. 3383 representing tentative battleship of 37,000 tons, 660 feet long, in which three different bows and three different sterns were tested.

The sectional area curves and load water line planes for the three bows and three sterns of Model No. 3383 are on Sheet 1 and their body plans are on Sheets 2 and 3. Curves of E.H.P. for the several combinations of bows and sterns are on Sheet 4.

The altered bow, B_1 and altered flat stern S_1 was run self-propelled with struts and with bossings. The struts and bossings are shown on Sheets 5 and 7, and their self-propulsion results on Sheets 6 and 8. Also, the struts and bossings for the new bow, B_2 and conventional vee stern, S_2 are on Sheets 9 and 11, and their self-propulsion results on Sheets 10 and 12. A summary of propulsion data is given on Sheet 13.

Sheet 14 shows the eight alterations to Model No. 3367, and Sheets 15, 16 and 17 show curves of residuary resistance in pounds on model speed in knots. The lines for test 7, Model 3367 and Model 1817 are identical.

From the curves of residuary resistance for Model 3367, on Sheets 15, 16 and 17 the effects of the alterations at 3.8 knots model speed, corresponding to approximately 21 knots for the vessel, are:

- (a) Increased length reduced the resistance (Sheet 15)
- (b) Increase of length on the load water line is more effective than on lower water lines. (Conditions No. 2 and 3, Sheet 16, compared with conditions 2-A and 4, Sheet 15)
- (c) Successive fining of water line indicated a minimum, beyond which the resistance increased. (Sheet 17)
- (d) At the 32,000 ton displacement the 8 inch (which is equivalent to 20 ft. on the ship) increase in length shows a 33% decrease in residuary resistance and 10% decrease in total resistance.

At higher speeds the rounded bow had lower resistance and successive fining of the bow increased the resistance.

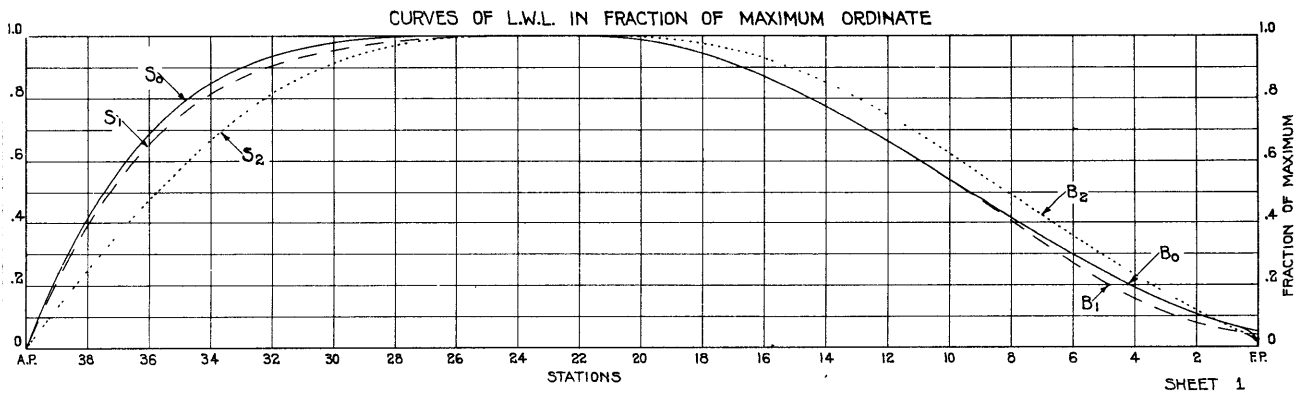
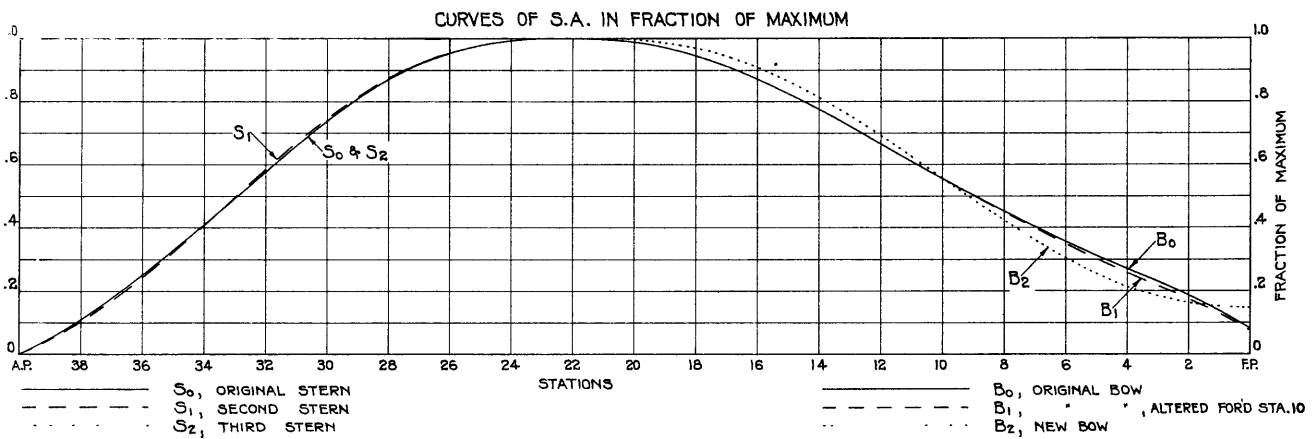
From the summary given in the table on Sheet 13, the results for Model 3383 indicate:

- (a) The flat stern had higher resistance than the vee stern.
- (b) The self-propulsion characteristics are slightly better on the vee stern than on the flat stern.
- (c) The bossings gave better results than the shafts and struts for both

flat and vee sterns, however, in experiments with a model of the U.S.S. MARYLAND, the shafts and struts gave lower power results than the bossings, so it appears there is little choice between shafts and struts and bossings for this type of vessel.

MODEL NO. 3383
 CURVES OF SECTIONAL AREA AND LOAD WATER LINE
 FOR
 ORIGINAL AND MODIFICATIONS

U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD, WASHINGTON, D. C.

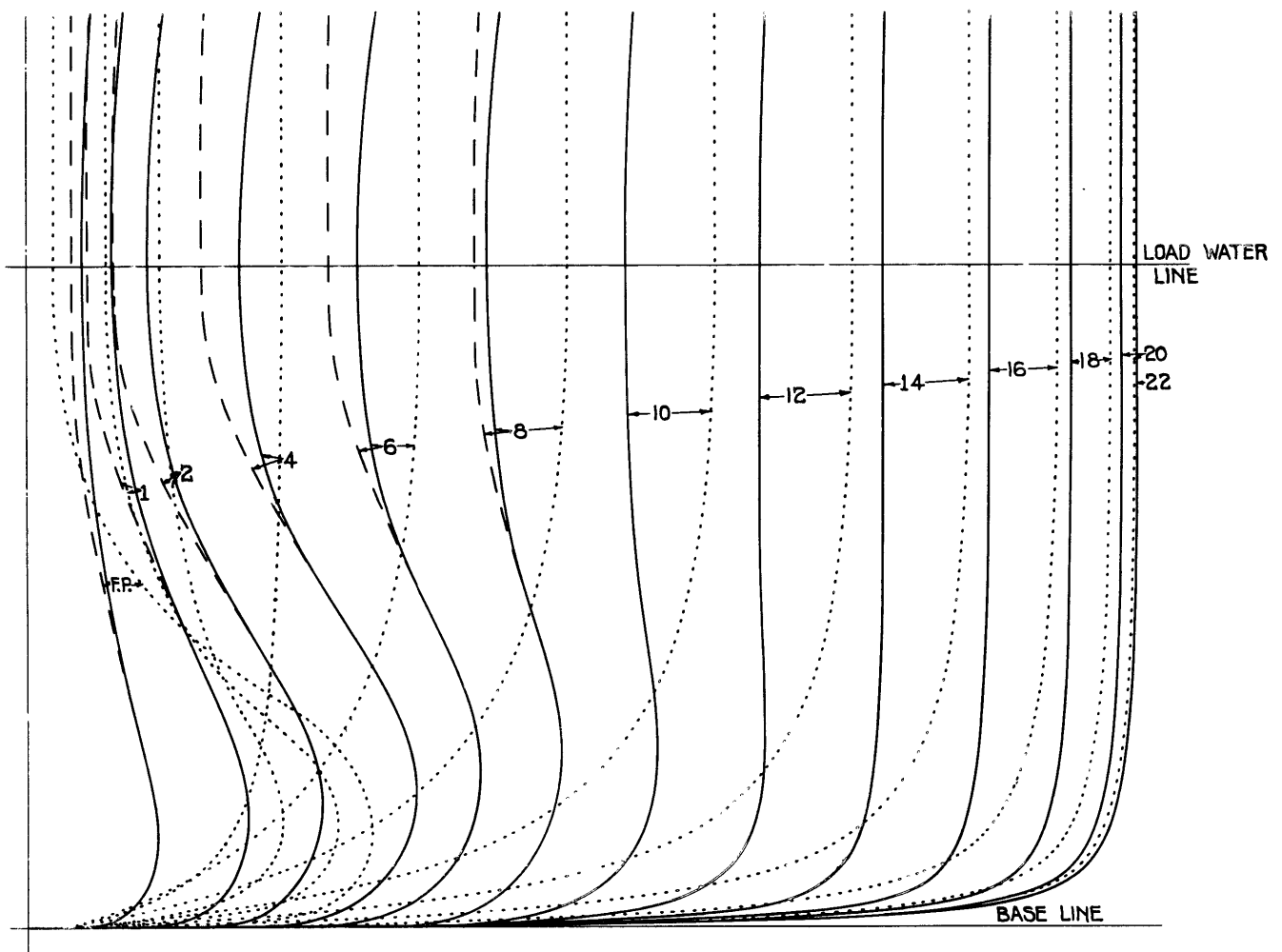


MODEL NO. 3383

BOW BODY PLAN

ORIGINAL & MODIFICATIONS

U.S. EXPERIMENTAL MODEL BASIN
NAVY YARD WASHINGTON, D.C.



——— B_0 , ORIGINAL BOW
- - - B_1 , " " , ALTERED FORD STA. 10
..... B_2 , NEW BOW

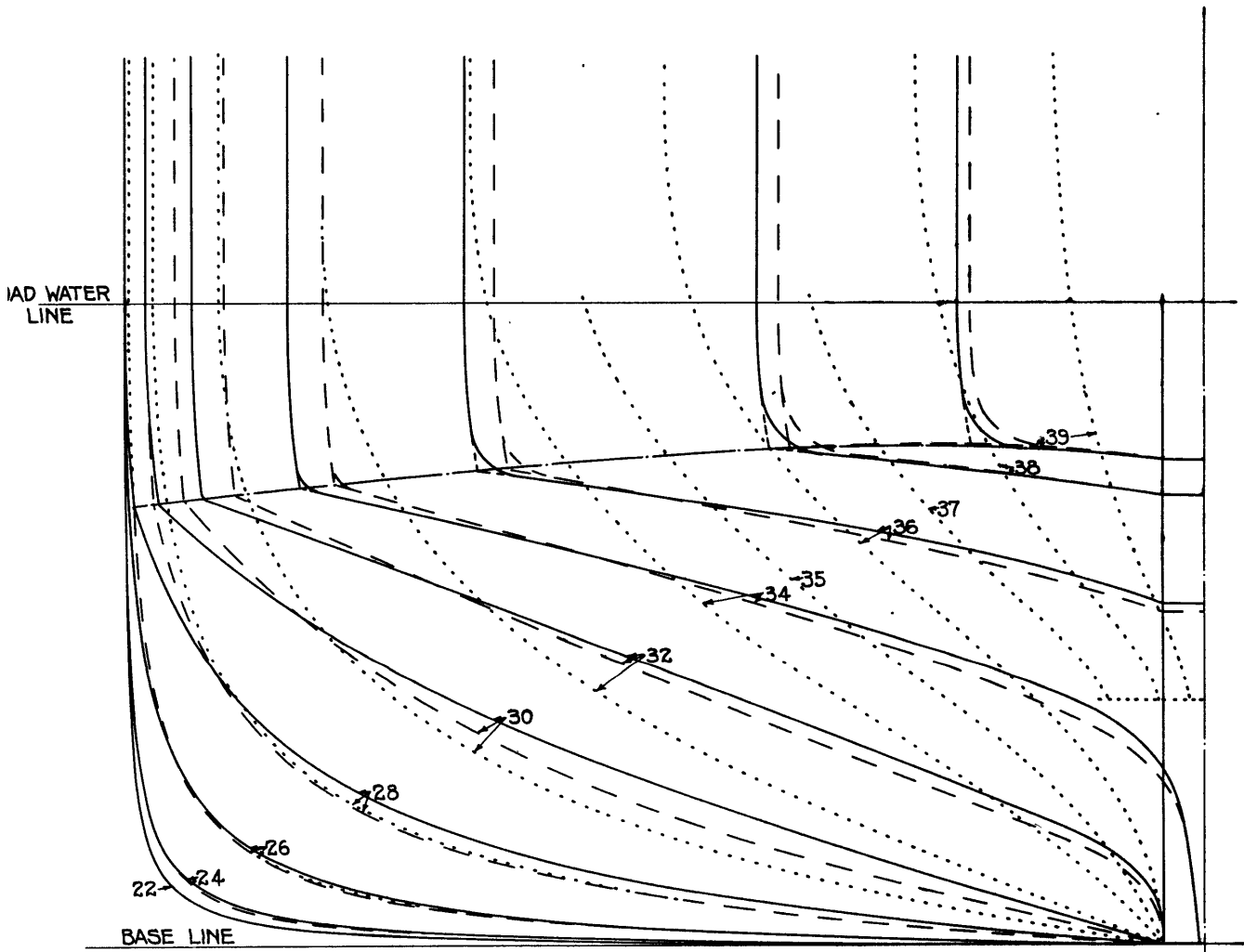
SHEET 2

MODEL NO. 3383

STERN BODY PLAN

ORIGINAL & MODIFICATIONS

U.S. EXPERIMENTAL MODEL BASIN
NAVY YARD WASHINGTON, D.C.

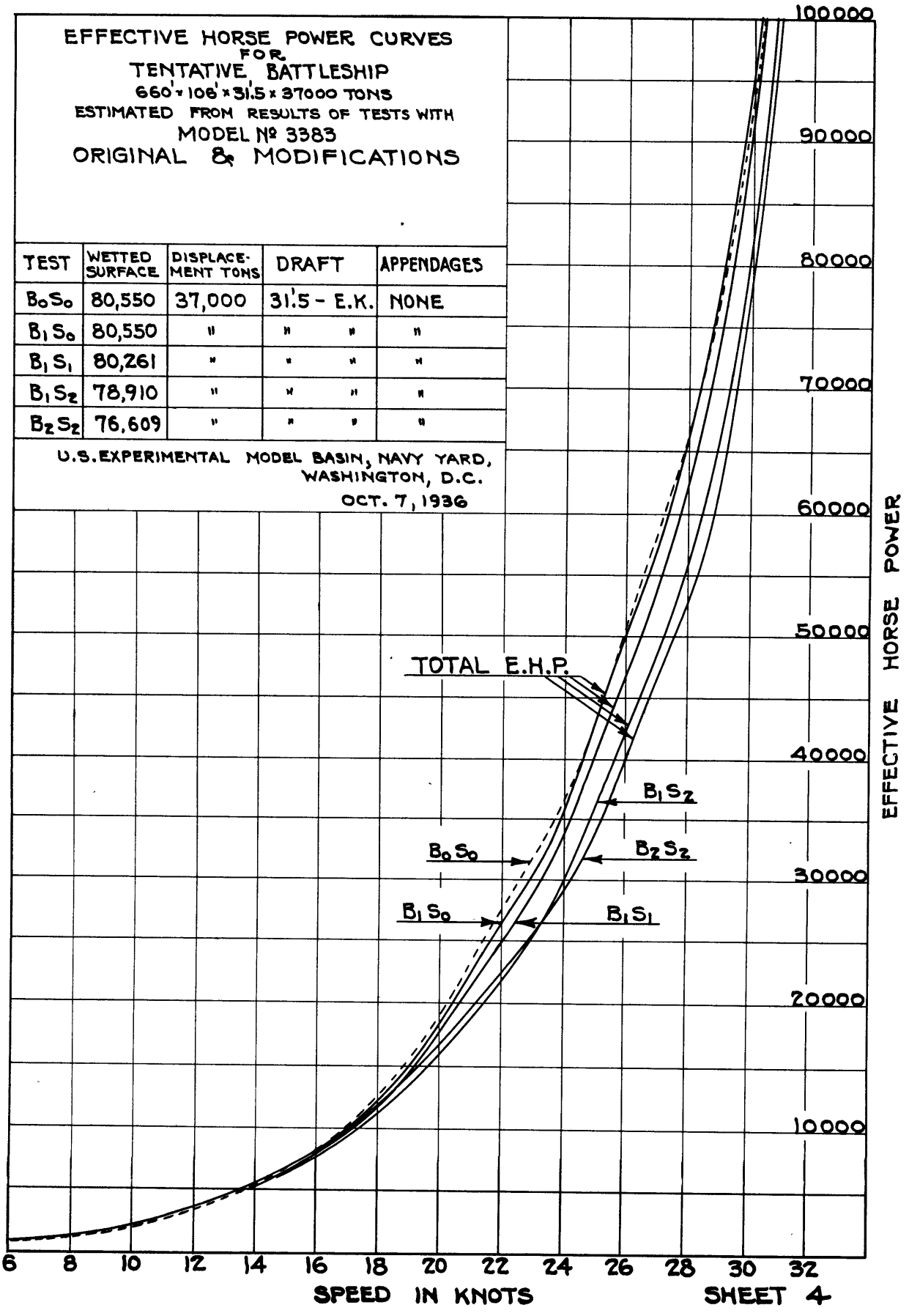


- S₀, ORIGINAL STERN
- - - - - S₁, SECOND STERN
- S₂, THIRD STERN

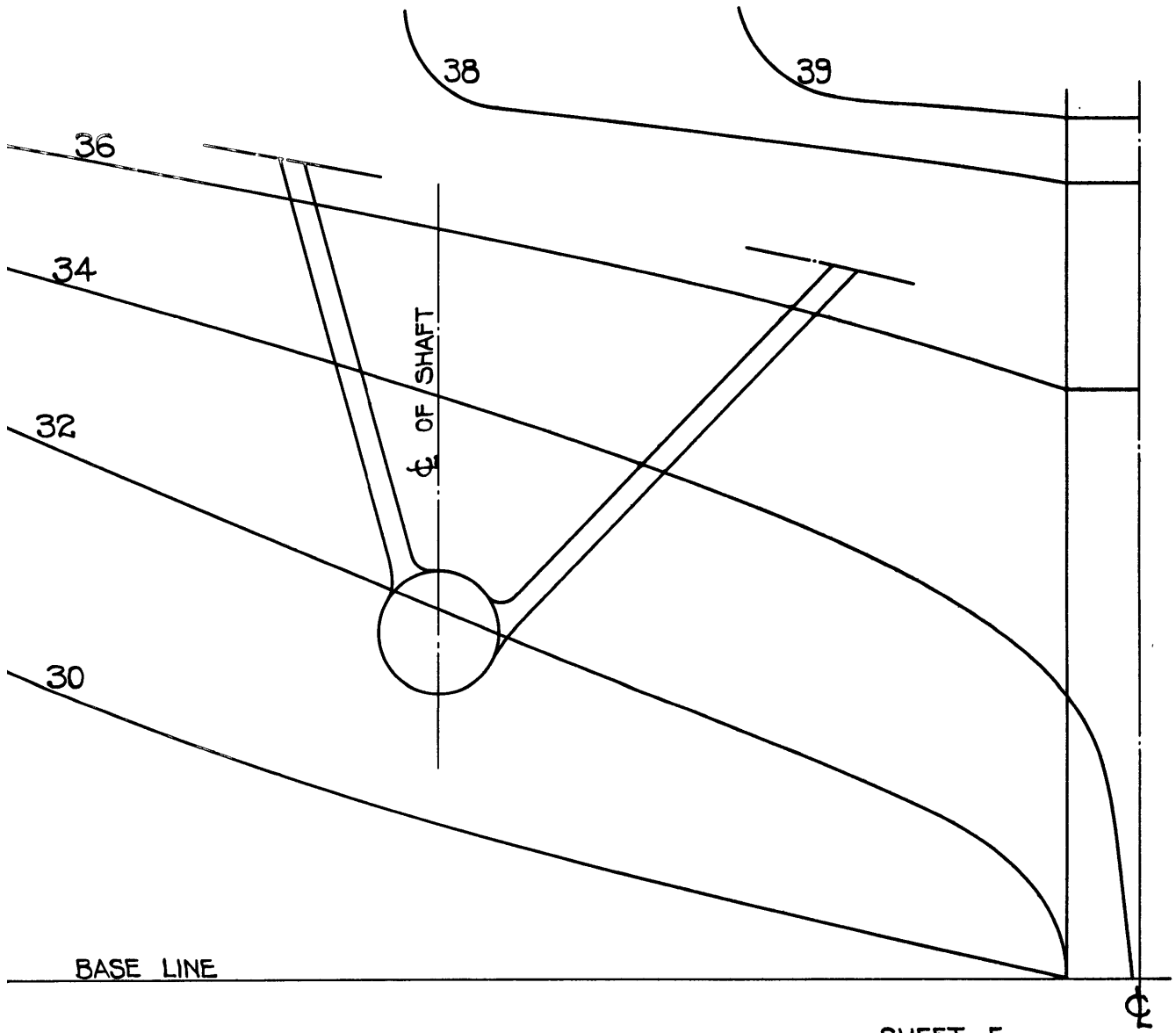
EFFECTIVE HORSE POWER CURVES
 FOR
 TENTATIVE BATTLESHIP
 660' x 106' x 31.5' x 37000 TONS
 ESTIMATED FROM RESULTS OF TESTS WITH
 MODEL NO 3383
 ORIGINAL & MODIFICATIONS

TEST	WETTED SURFACE	DISPLACEMENT TONS	DRAFT	APPENDAGES
B ₀ S ₀	80,550	37,000	31.5 - E.K.	NONE
B ₁ S ₀	80,550	"	"	"
B ₁ S ₁	80,261	"	"	"
B ₁ S ₂	78,910	"	"	"
B ₂ S ₂	76,609	"	"	"

U.S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
 WASHINGTON, D.C.
 OCT. 7, 1936



MODEL NO. 3383
STRUTS- STERN NO. 2 - S₁
EXPERIMENTAL MODEL BASIN
NAVY YARD, WASHINGTON, D.C.



SHAFT HORSE POWER & R. P. M. CURVES
FOR
TENTATIVE BATTLESHIP

ESTIMATED FROM SELF PROPELLED TESTS WITH
MODEL No. 3383-2
 USING PROPELLER No. 1415-1416
 TESTED FOR
U. S. EXPERIMENTAL MODEL BASIN
 CORRESPONDENCE FILE No. _____

DIMENSIONS:

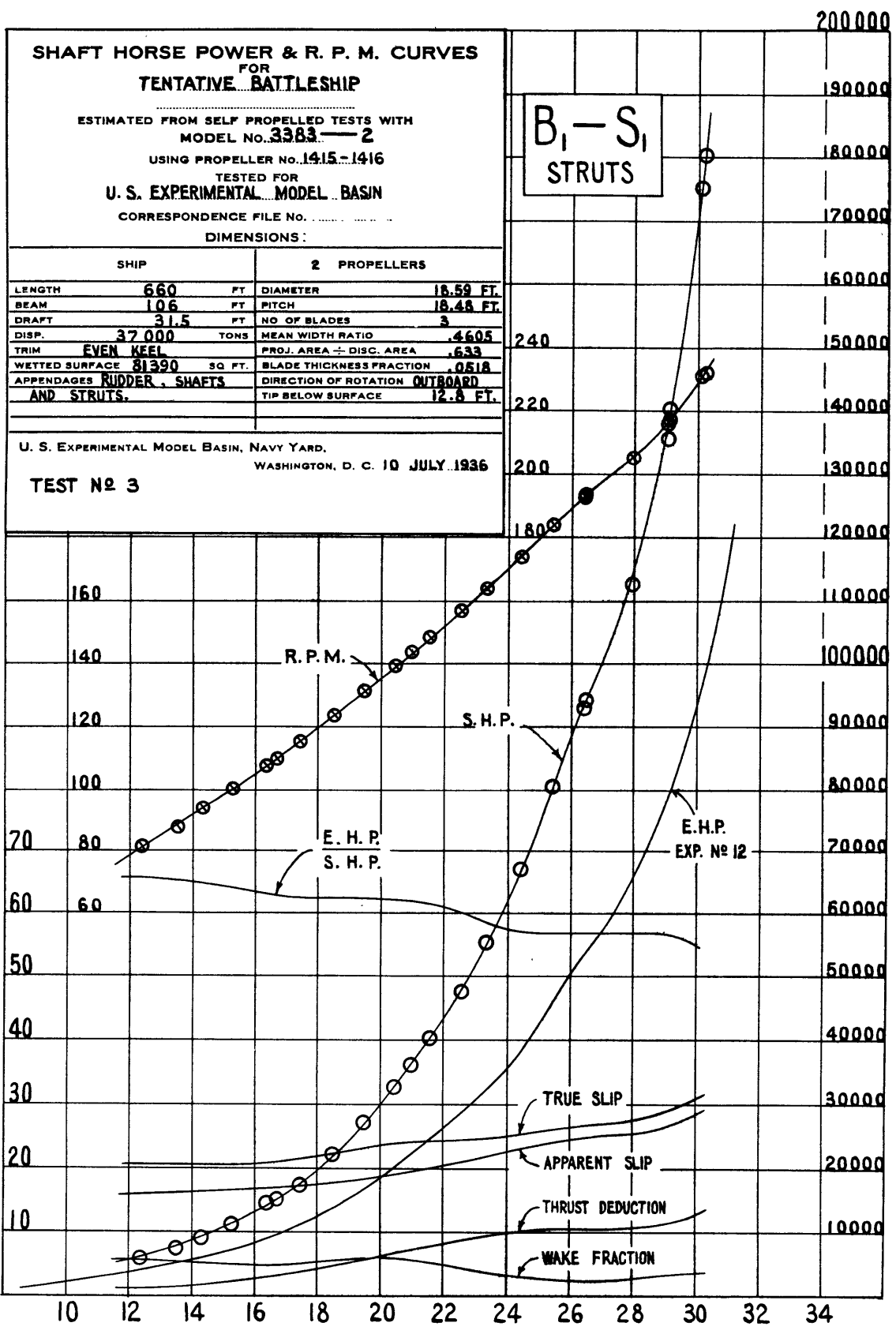
SHIP		2 PROPELLERS	
LENGTH	660 FT.	DIAMETER	18.59 FT.
BEAM	106 FT.	PITCH	18.48 FT.
DRAFT	31.5 FT.	NO OF BLADES	3
DISP.	37,000 TONS	MEAN WIDTH RATIO	.4605
TRIM	EVEN KEEL	PROJ. AREA ÷ DISC. AREA	.633
WETTED SURFACE	81390 SQ. FT.	BLADE THICKNESS FRACTION	.0518
APPENDAGES	RUDDER, SHAFTS AND STRUTS.	DIRECTION OF ROTATION	OUTBOARD
		TIP BELOW SURFACE	12.8 FT.

U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
 WASHINGTON, D. C. 10 JULY 1936

TEST No 3

B₁-S₁
STRUTS

SCALE FOR R. P. M.
 SCALE FOR PERCENTAGES.

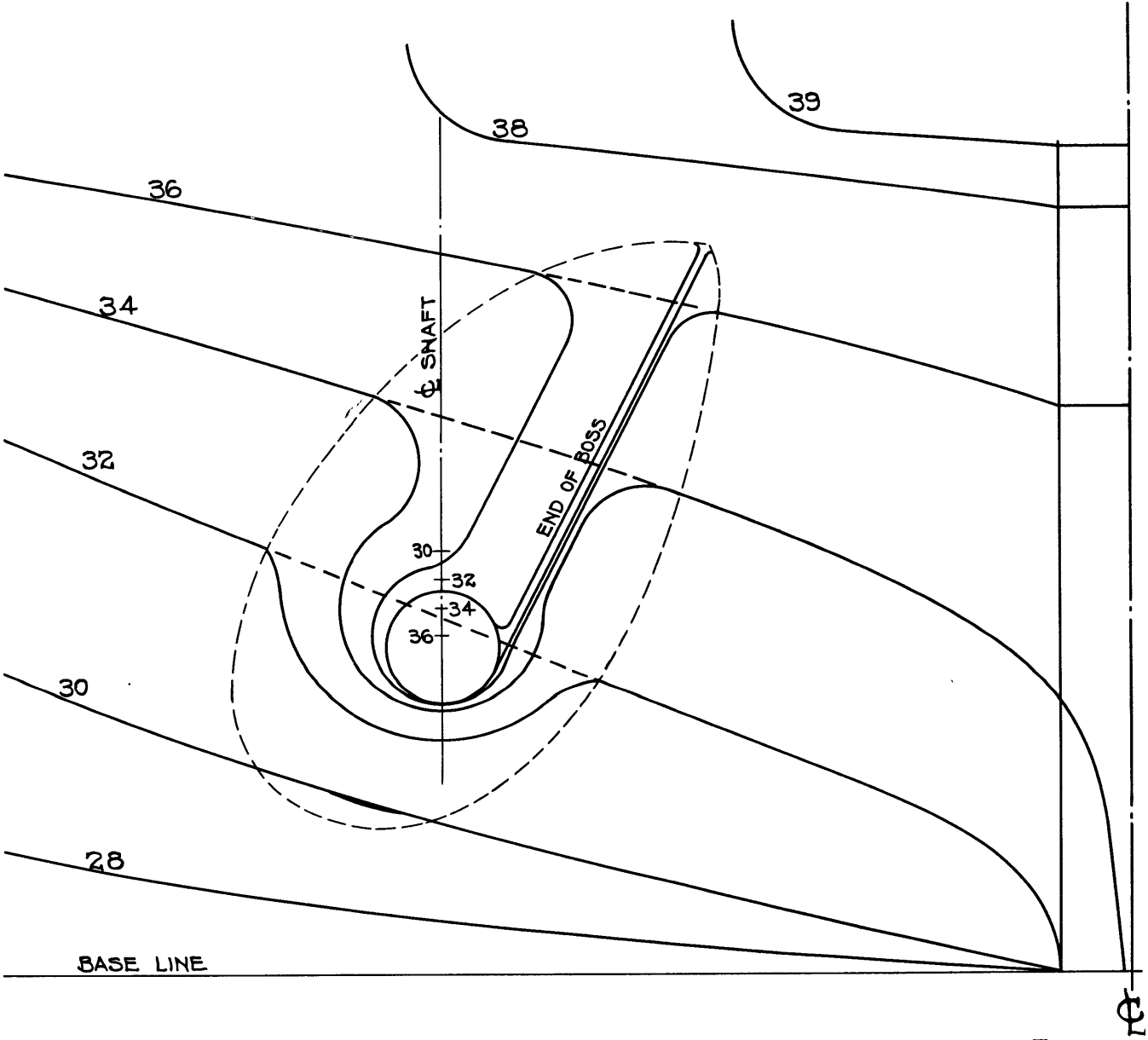


SCALE FOR HORSE POWER

SCALE FOR SPEED IN KNOTS

MODEL NO. 3383
BOSSING- STERN NO.2- S₁

EXPERIMENTAL MODEL BASIN
NAVY YARD, WASHINGTON, D.C.



SHAFT HORSE POWER & R. P. M. CURVES
FOR
TENTATIVE BATTLESHIP

ESTIMATED FROM SELF PROPELLED TESTS WITH
MODEL NO. 3383-2
 USING PROPELLER NO. 1415-1416
 TESTED FOR
U. S. EXPERIMENTAL MODEL BASIN
 CORRESPONDENCE FILE No.

DIMENSIONS:

SHIP		2 PROPELLERS	
LENGTH	660 FT.	DIAMETER	18.59 FT.
BEAM	106 FT.	PITCH	18.48 FT.
DRAFT	31.5 FT.	NO. OF BLADES	3
DISP.	37 000 TONS	MEAN WIDTH RATIO	.4605
TRIM	EVEN KEEL	PROJ. AREA ÷ DISC. AREA	.633
WETTED SURFACE	83 850 SQ. FT.	BLADE THICKNESS FRACTION	.0518
APPENDAGES	RUDDER AND SHAFT BOSSINGS	DIRECTION OF ROTATION	OUTWARD
		TIP BELOW SURFACE	12.6 FT.

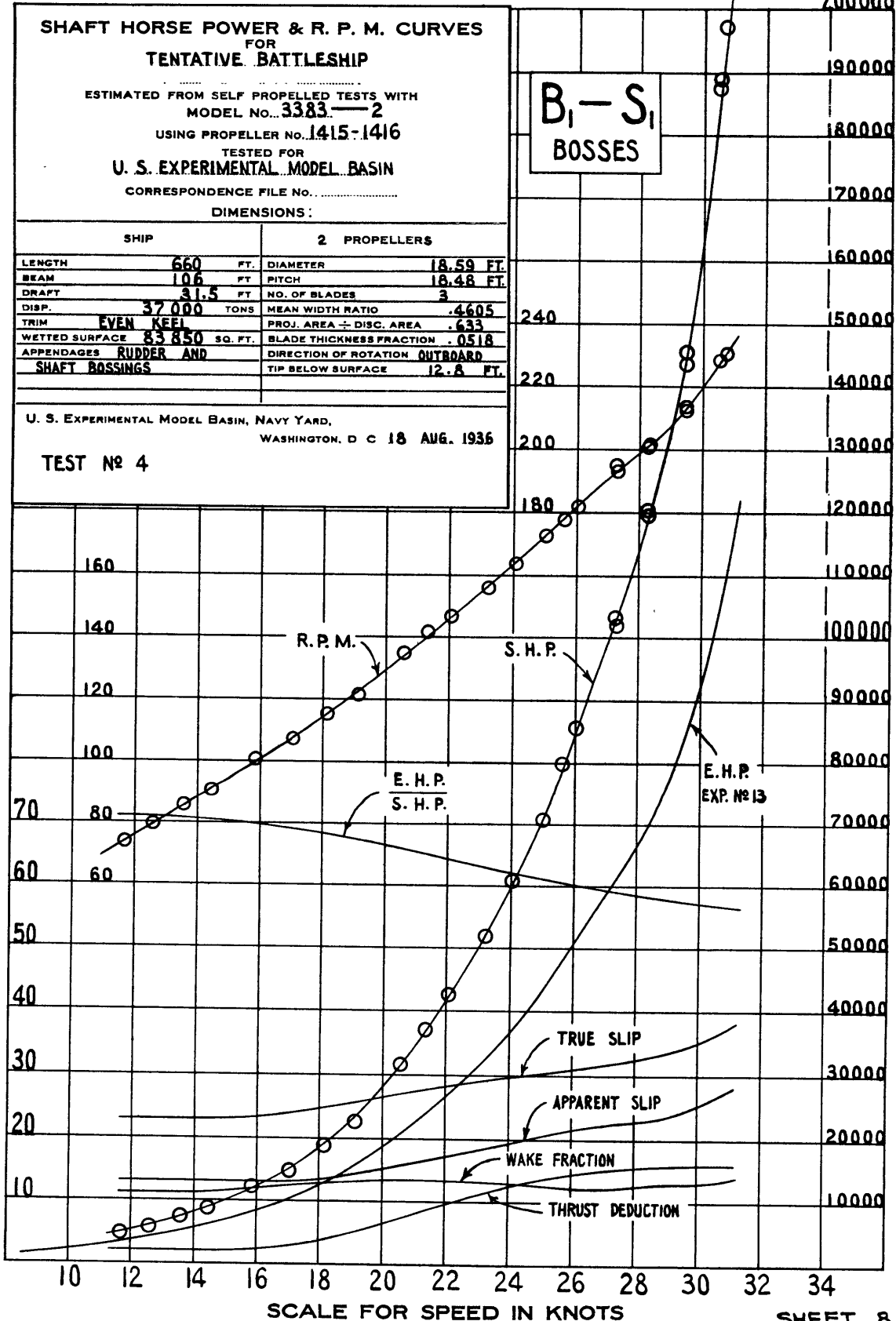
U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
 WASHINGTON, D. C. 18 AUG. 1935

TEST No 4

B₁-S₁
BOSSSES

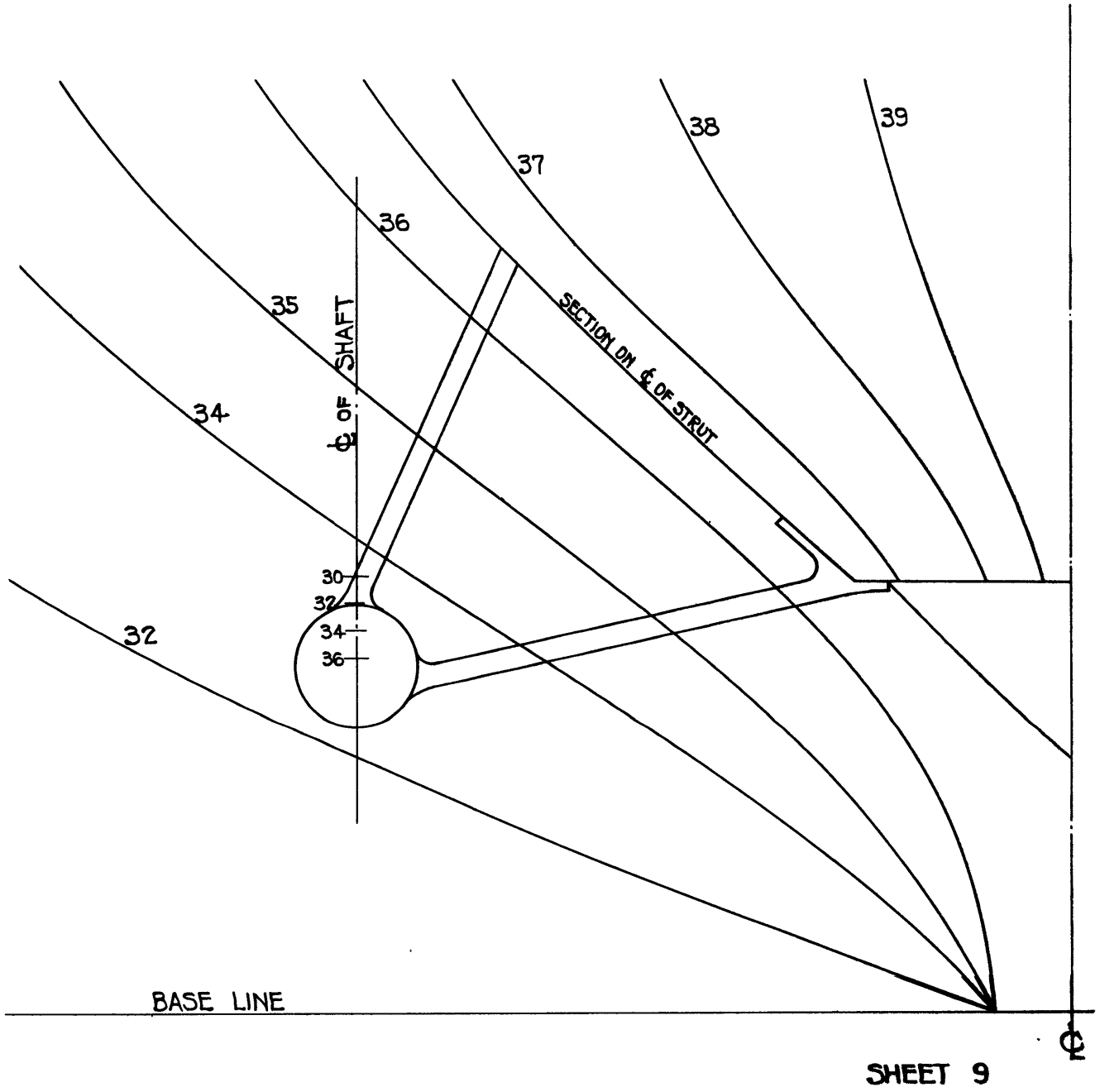
SCALE FOR R. P. M.

SCALE FOR PERCENTAGES



SCALE FOR HORSE POWER

MODEL NO. 3383
STRUTS - STERN NO.3 - S₂
EXPERIMENTAL MODEL BASIN
NAVY YARD, WASHINGTON, D.C.



SHAFT HORSE POWER & R. P. M. CURVES
FOR
TENTATIVE BATTLESHIP

ESTIMATED FROM SELF PROPELLED TESTS WITH
MODEL NO. **3383-4**
USING PROPELLER NO. **1415-1416**
TESTED FOR
U.S. EXPERIMENTAL MODEL BASIN
CORRESPONDENCE FILE NO.

DIMENSIONS:

SHIP		2 PROPELLERS	
LENGTH	660 FT.	DIAMETER	18.89 FT.
BEAM	106 FT.	PITCH	18.48 FT.
DRAFT	31.5 FT.	NO. OF BLADES	3
DISP.	37 000 TONS	MEAN WIDTH RATIO	.4605
TRIM	EVEN KEEL	PROJ. AREA ÷ DISC. AREA	.633
WETTED SURFACE	7737 SQ. FT.	BLADE THICKNESS FRACTION	.0518
APPENDAGES	KUDDER, SHAFTS AND STRUTS.	DIRECTION OF ROTATION	OUTBOARD
		TIP BELOW SURFACE	12.8 FT.

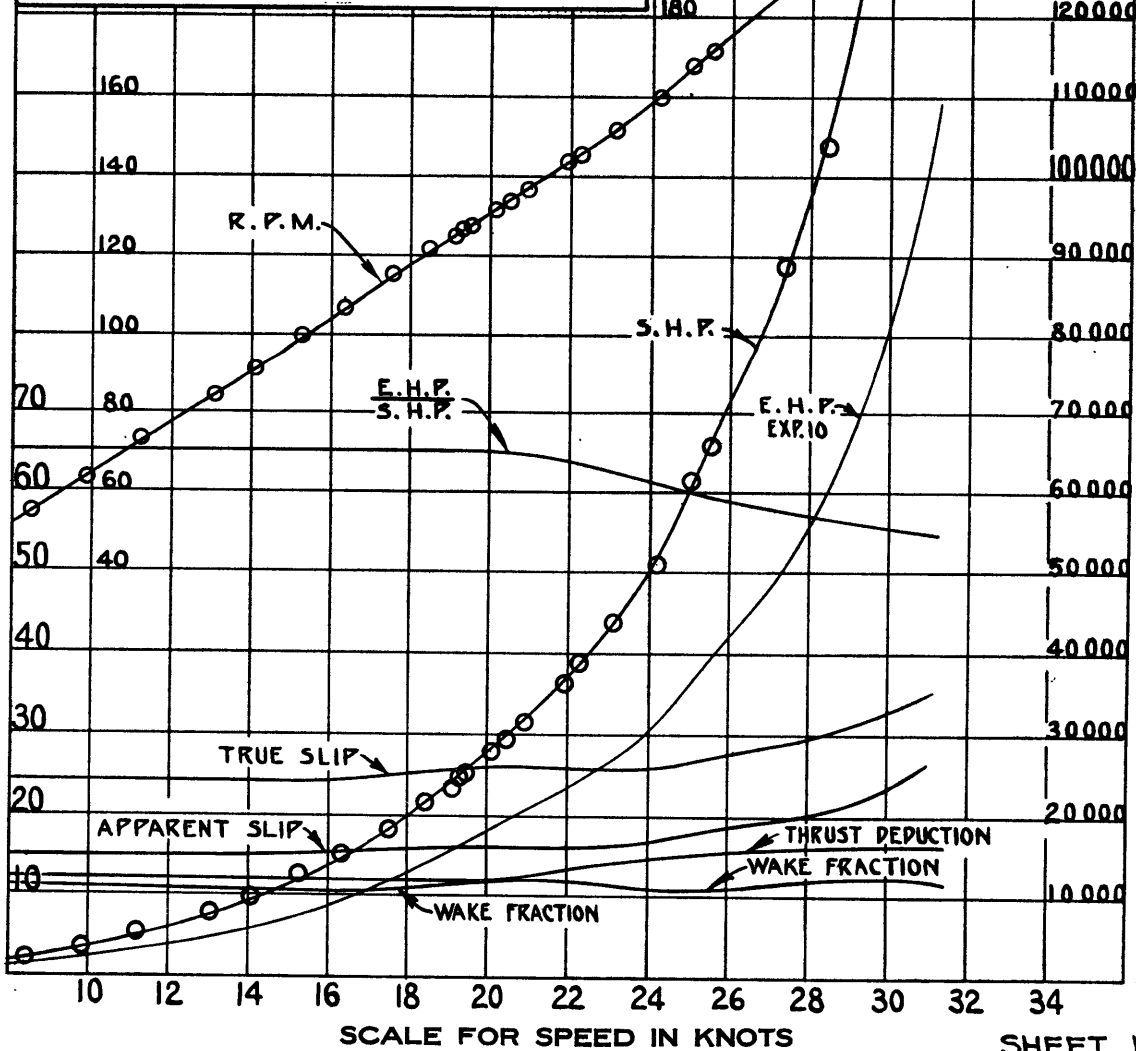
U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
WASHINGTON, D. C. 28 FEB. 1936

TEST NO 1

B₂-S₂
STRUTS

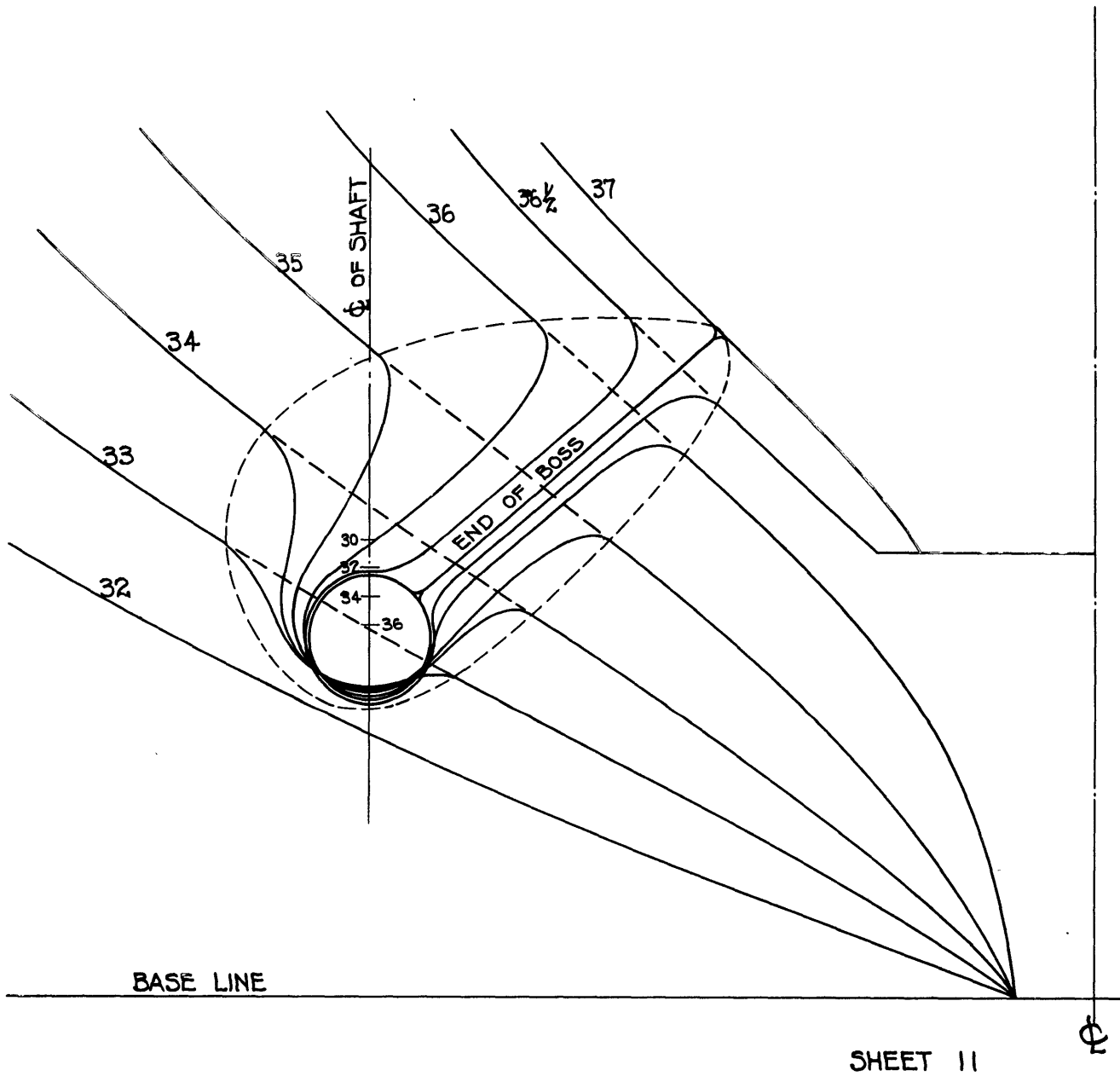
SCALE FOR R. P. M.

SCALE FOR PERCENTAGES.



SCALE FOR HORSE POWER

MODEL NO. 3383
BOSSING - STERN NO.3 - S₂
EXPERIMENTAL MODEL BASIN
NAVY YARD, WASHINGTON, D.C.



SHAFT HORSE POWER & R. P. M. CURVES
FOR
TENTATIVE BATTLESHIP

ESTIMATED FROM SELF PROPELLED TESTS WITH
MODEL No. 3383-4

USING PROPELLER No. 1415-1416

TESTED FOR
U.S. EXPERIMENTAL MODEL BASIN

CORRESPONDENCE FILE No.

DIMENSIONS:

SHIP		2 PROPELLERS	
LENGTH	660 FT.	DIAMETER	18.59 FT.
BEAM	106 FT.	PITCH	18.48 FT.
DRAFT	31.5 FT.	NO. OF BLADES	3
DISP.	37000 TONS	MEAN WIDTH RATIO	.4608
TRIM	EVEN KEEL	PROJ. AREA ÷ DISC. AREA	.633
WETTED SURFACE	79162 SQ FT.	BLADE THICKNESS FRACTION	.0518
APPENDAGES	RUPPER & BOSSES	DIRECTION OF ROTATION	OUTWARD
		TIP BELOW SURFACE	12.8 FT.

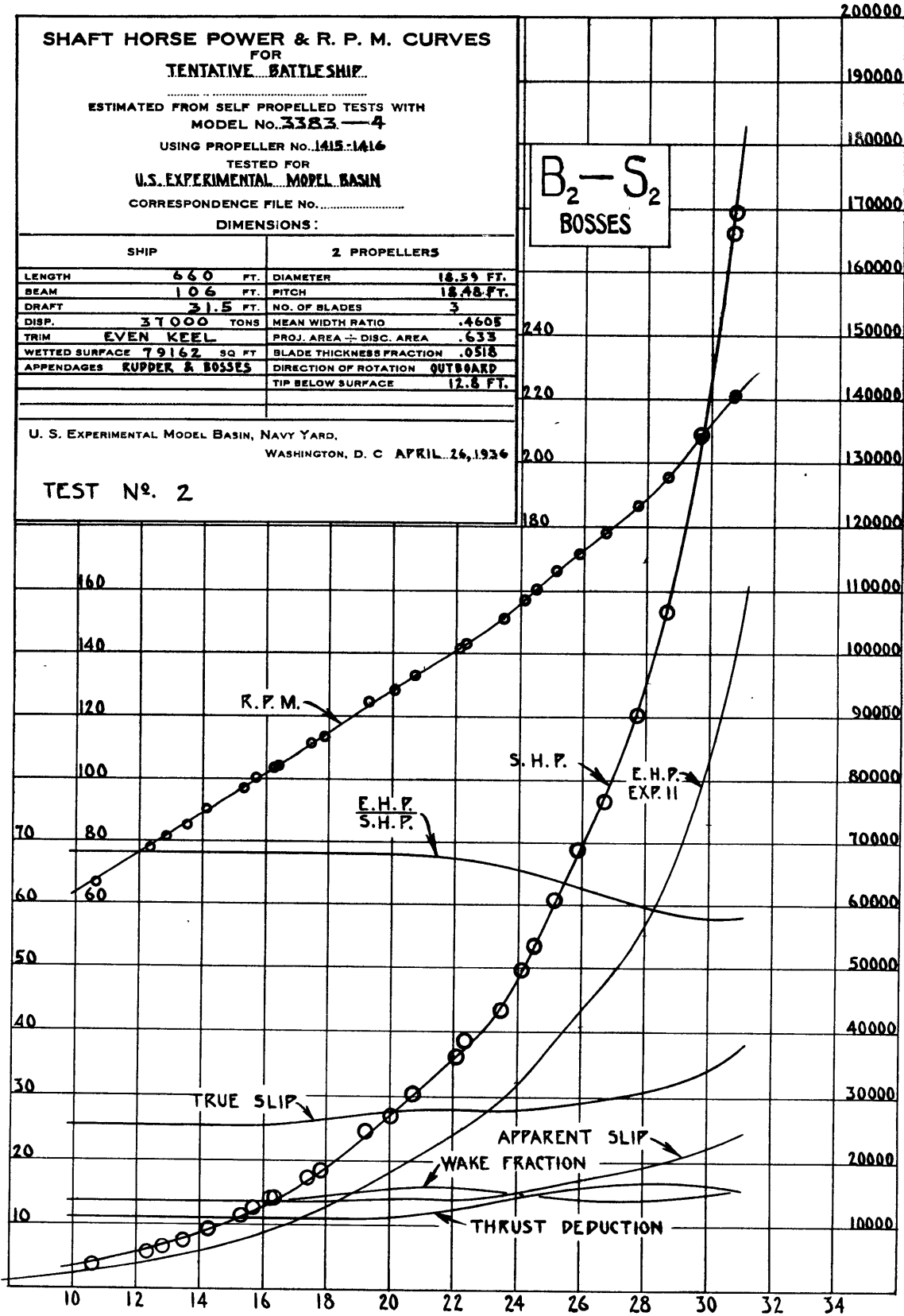
U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
WASHINGTON, D. C. APRIL 26, 1936

TEST No. 2

B₂-S₂
BOSSES

SCALE FOR R. P. M.

SCALE FOR PERCENTAGES



SCALE FOR HORSE POWER

SCALE FOR SPEED IN KNOTS

SUMMARY OF PROPULSION DATA

MODEL NO. 3383

ORIGINAL & MODIFICATIONS

EXPERIMENTAL MODEL BASIN, NAVY YARD, WASHINGTON, D. C.

TYPE	SPEED IN KNOTS	STRUTS OR BOSS- INGS	E.H.P.	S.H.P.	e	1-t	1-w	$\frac{1-t}{1-w}$	St	e _p	$e_p \frac{1-t}{1-w}$	e _{rr}
B ₁ S ₁	21	STRUTS	22,400	36,600	.615	.928	.944	.983	.241	.633	.622	.989
B ₁ S ₁	28	STRUTS	65,400	115,300	.567	.893	.974	.917	.274	.619	.568	.998
B ₁ S ₁	21	BOSS- INGS	22,500	34,500	.652	.920	.867	1.061	.275	.617	.655	.996
B ₁ S ₁	28	BOSS- INGS	66,200	113,500	.583	.844	.875	.965	.324	.592	.571	1.021
B ₂ S ₂	21	STRUTS	20,900	32,300	.647	.873	.880	.992	.260	.625	.620	1.042
B ₂ S ₂	28	STRUTS	55,500	97,600	.569	.840	.881	.954	.293	.609	.581	.979
B ₂ S ₂	21	BOSS- INGS	21,300	31,400	.678	.882	.839	1.051	.280	.615	.646	1.050
B ₂ S ₂	28	BOSS- INGS	56,600	95,400	.594	.831	.859	.967	.309	.600	.580	1.024

NOTES ON e_{rr}

1. PROBABLY TOO FINE CONCLUSIONS SHOULD NOT BE DRAWN.
2. SEEMINGLY, HIGHER WITH V-STEM THAN FLAT STEM.
3. " " HIGHER WITH BOSSINGS THAN STRUTS.

CURVES OF R_R IN POUNDS
FOR

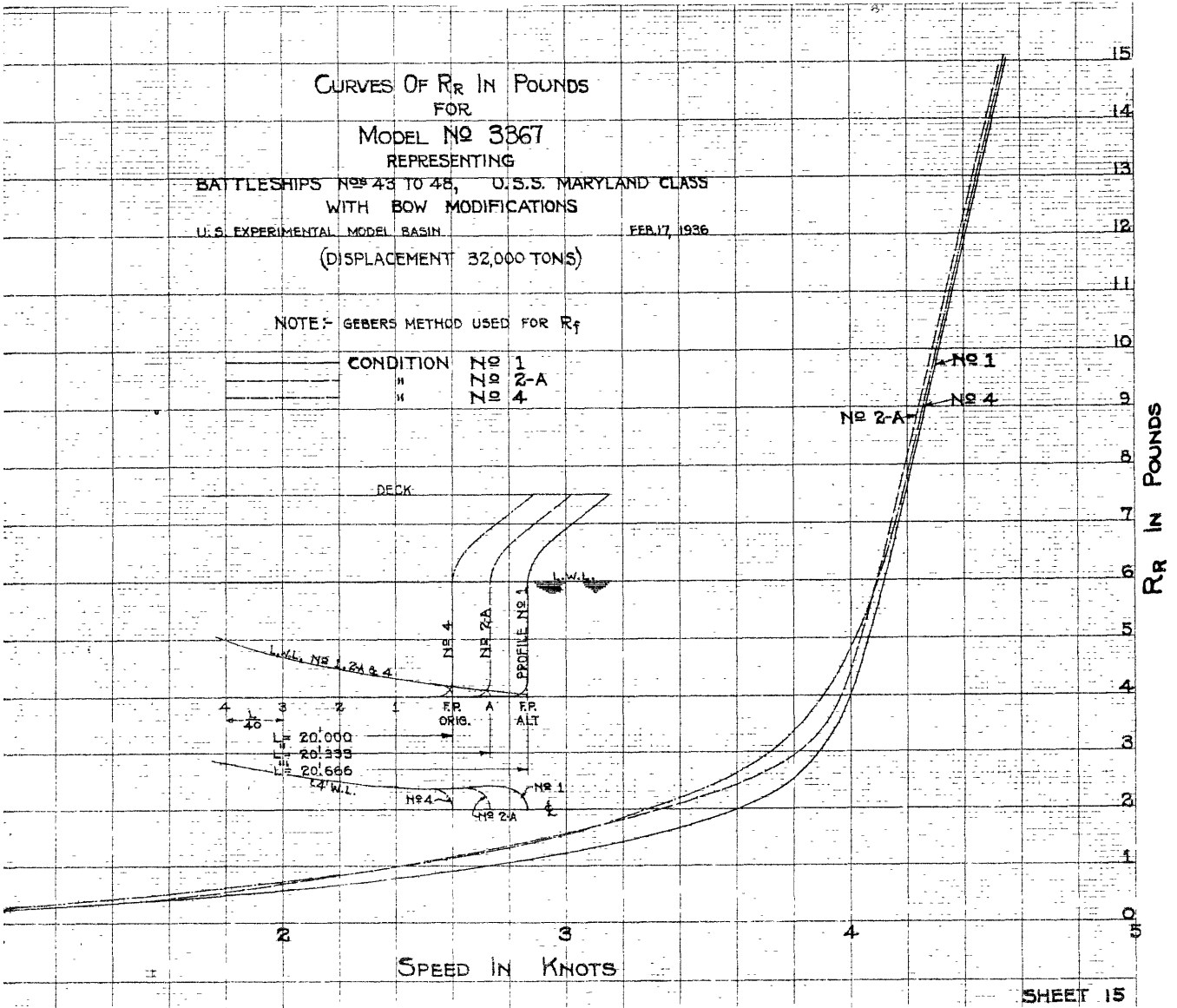
MODEL NO 3867
REPRESENTING

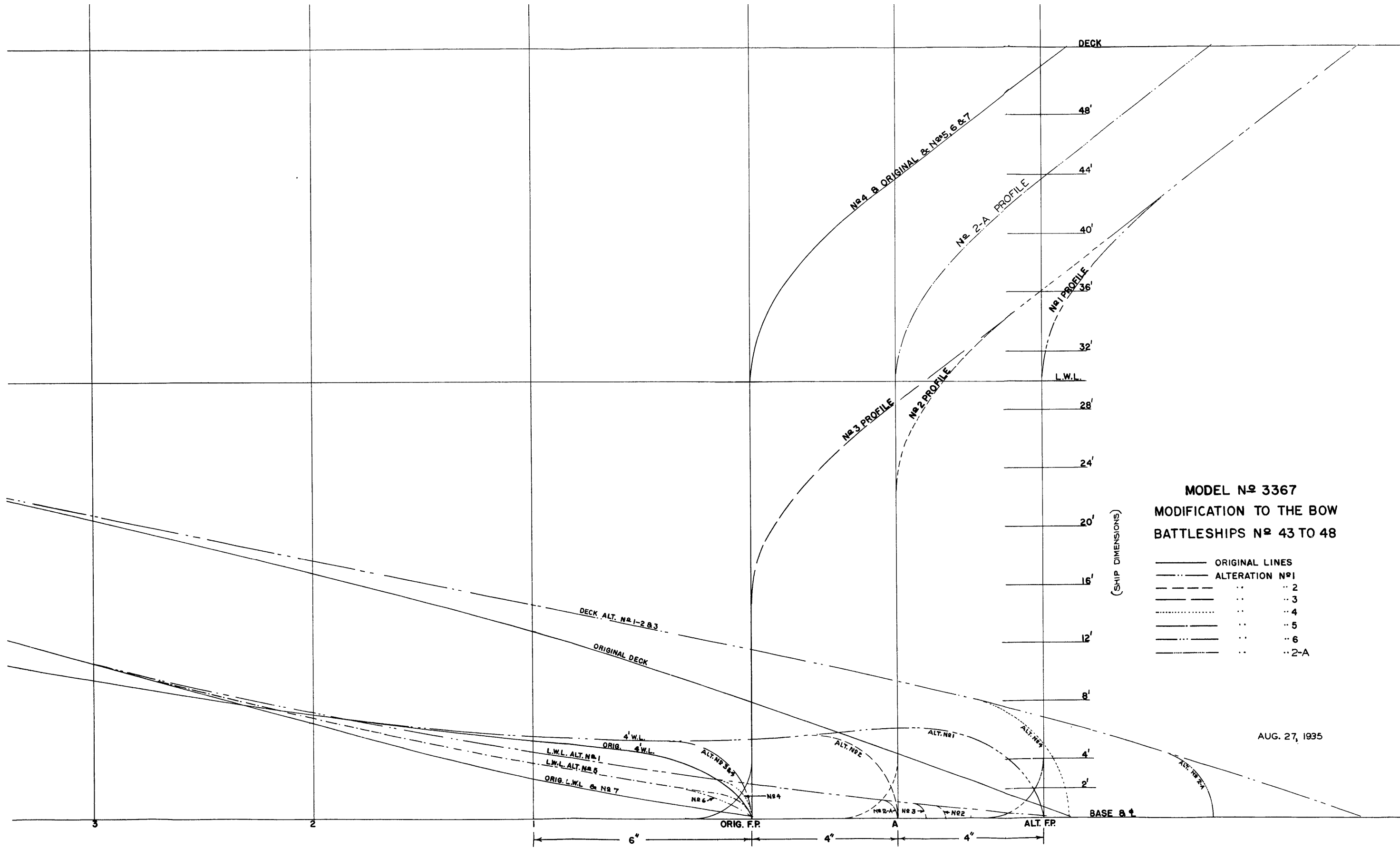
BATTLESHIPS NO 43 TO 48, U.S.S. MARYLAND CLASS
WITH BOW MODIFICATIONS

U. S. EXPERIMENTAL MODEL BASIN FEB. 17, 1936
(DISPLACEMENT 32,000 TONS)

NOTE: GEBERS METHOD USED FOR R_f

CONDITION	Z_{10}	Z_{10}
"	1	2-A
"	4	4





**MODEL No 3367
MODIFICATION TO THE BOW
BATTLESHIPS No 43 TO 48**

Line Style	Description
—	ORIGINAL LINES
- - - -	ALTERATION No 1
· · · · ·	· · · · · No 2
· · · · ·	· · · · · No 3
· · · · ·	· · · · · No 4
· · · · ·	· · · · · No 5
· · · · ·	· · · · · No 6
· · · · ·	· · · · · No 2-A

(SHIP DIMENSIONS)

AUG. 27, 1935

(SHIP DIMENSIONS)

SHEET 14

CURVES OF R_R IN POUNDS
FOR

MODEL NO 3367
REPRESENTING
BATTLESHIPS NOS 43 TO 48, U.S.S. MARYLAND CLASS
WITH BOW MODIFICATIONS

U.S. EXPERIMENTAL MODEL BASIN

FEB. 17, 1936

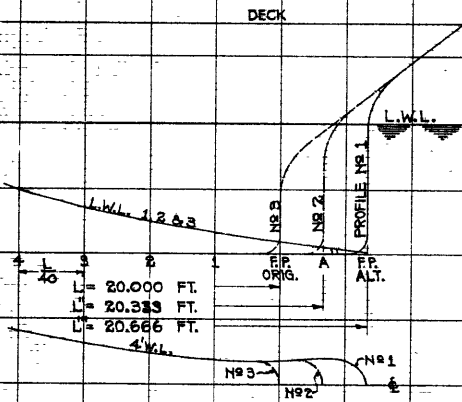
(DISPLACEMENT 32,000 TONS)

CONDITION

	No 1
	No 2
	No 3

NOTE: GEBERS METHOD USED FOR R_f

R_R IN POUNDS



SPEED IN KNOTS

CURVES OF R_R IN POUNDS
FOR

MODEL NO 3367

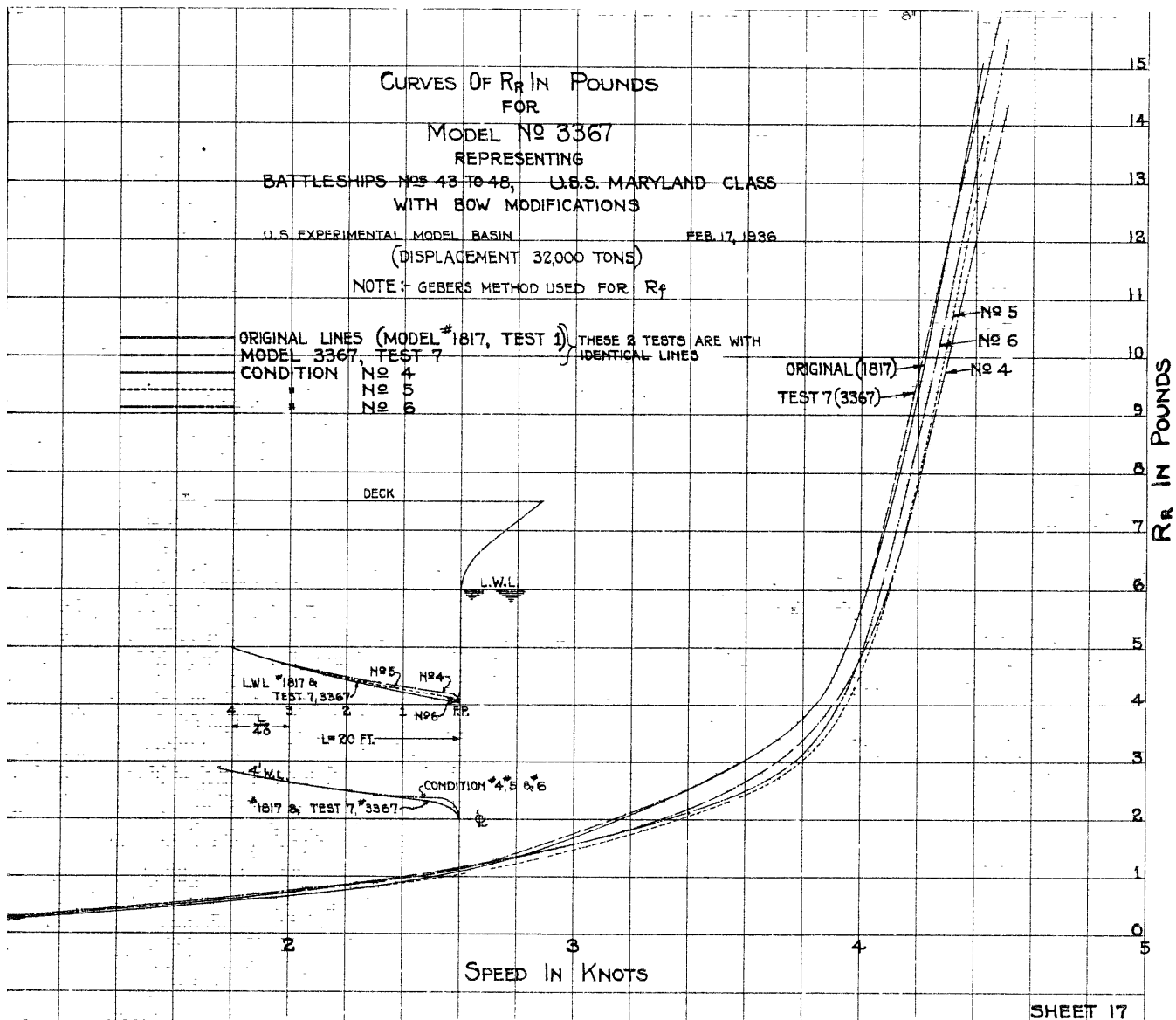
REPRESENTING

BATTLESHIPS NOS 43 TO 48, U.S.S. MARYLAND CLASS
WITH BOW MODIFICATIONS

U.S. EXPERIMENTAL MODEL BASIN FEB. 17, 1936

(DISPLACEMENT 32,000 TONS)

NOTE: GEBERS METHOD USED FOR R_f



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