RESULT OF TESTS OF MODELS OF A SHALLOW DRAFT RIVER GUNBOAT

U.S. EXPERIMENTAL MODEL BASIN
Navy Yard, Washington, D.C.

July 1923

Report 82

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MODELS AND TOWING EXPERIMENTS

Experiments have been carried out with three models for a shallow draft river gunboat. These three models, numbered respectively 2421, 2422 and 2460, were derived as follows: Model 2421 is in accordance with Bureau C&R Plans 006427 and 006439. In general the bow lines are convex. The model has a tunnel stern.

Model 2422 is similar to Model 2421 as to afterbody but the lines of the forebody are altered to give them in general a "V" section. These lines are from C&R Plans 006475 and 006439.

Model 2460 has the same bow lines as Model 2421, but the afterbody has been changed as required by the fitting of surface propellers. The lines for the afterbody were developed at the Model Basin.

All of the models have the same displacement, 409 pounds, which corresponds to a fresh water displacement of 532 tons for the full sized ship and a linear ratio of 14.128.

All of the models were towed for the determination of their resistance at speeds between 1 and 5 knots. The towing experiments were conducted both in the full depth of the Basin and also over a shallow bottom in depths corresponding to 10 feet, 15 feet and 20 feet, for the full-sized ship, and in the case of Model 2460, the resistance was also determined for a depth of 52.3 feet. The deep water resistance of Model 2421 was measured with shafts and struts and with three and four rudders respectively and also without rudders. The E.H.P. curves for these resistance runs are shown on Sheets 1, 2 and 3. Sheet 3

also shows the curves of E.H.P. for the three shallow water tests.

Comparison of the resistances of Models 2421 and 2422 at shallow drafts showed a superiority for Model 2421, although not as great as reported upon for deep water in a preliminary report made to the Bureau in July 1922. No E.H.P. calculations were made for Model 2422 from the results of the shallow depth runs.

In the case of Model 2460, no appendages were fitted since the shafts come out at the stern above the waterline and the question of a rudder for this design has not been decided. Model 2421 was towed without rudders in order to permit a direct comparison of the hull performance of these two types of hull.

The curves of E.H.P. from Model 2460 are shown on Sheet 4. Contours of Power plotted on speed and log depth for Models 2421 and 2460 are given respectively on Sheets 5 and 6, and Contours of Speed on Power and Depth for the Models 2460, are given on Sheet 7.

SELF PROPULSION EXPERIMENTS

Self Propulsion tests were performed on Models 2421 and 2460. The propellers used in these tests are tabulated below.

No.	Dia. inches	Pitch inches	Pitch Ratio	Mean Width Ratio	No. Blades	Projected Area	Projected Area Ratio
412	6.70	7.00	1.04	0.458	3	20.04	0.568
413	6.70	7.00	1.04	0.461	3	19.91	0.565
458	9.19	8.90	0.968	0.197	4	25.66	0.386
459	9.19	8.90	0.968	0.197	4	25.66	0.386
585	11.34	11.34	1.00	0.250	4	34.47	0.341
586	11.34	11.34	1.00	0.250	4	34.47	0.341

The self propulsion experiments conducted on Model 2421, included one series each in deep water with the Model fitted with three and four rudders respectively, and self propelled runs without rudders, in shallow water in depths corresponding to 10 feet and 20 feet respectively, the model in every case fitted with propellers 412 and 413. Propellers No. 585 and 586 were designed for use as surface propellers with Model 2460. These propellers were tested on this Model in a series of self propulsion tests in depths corresponding to 10 feet, 20 feet and the full depth of the Basin. A series of tests were also made on Model 2460 at full Basin depth using propellers No. 412 and 413 from Model 2421 as well as propellers No. 458 and 459, the latter at two depths of propeller immersion.

The characteristics for propellers 412 and 413 and for 585 and 586 in open water are shown on Sheets 8 and 9 respectively.

The results of these self propulsion tests for Model 2421 are shown on Sheets 10 and 11 for deep water with three and four rudders respectively and on sheets 12 and 13 for depths corresponding to 10 and 20 feet respectively.

The corresponding curves of estimated horsepower for the ship, based on these tests, are shown on Sheets 14 to 17 inclusive.

Similarly, the results of the model tests for Model 2460 with propellers 585 and 586 are shown on Sheet 18 for deep water and on Sheets 19 and 20, for depths corresponding to 10 and 20 feet respectively. On Sheets 21, 22 and 23 are given the results of the tests on this Model with propellers 458 and 459, at two shaft levels and with propellers 412 and 413 used as surface propellers.

Estimated curves of power for the ship based on these self-propulsion tests of Model 2460 are given on Sheet 24 for deep water and Sheet 25 for a depth of 20 feet. The data obtained from the Model test at the depth corresponding to 10 feet were not sufficient to permit the estimate of power for this condition, while the results for the Model in the self propelled tests using propellers other than Nos. 585 and 586 showed such unsatisfactory performances that estimates for the ship were unnecessary.

ANALYSIS OF RESULTS

There are three items to be considered in an analysis of the results of the tests, namely, the comparison of the two types of vessels, the comparison of the performance of the three pairs of propellers on Model 2460, and the effect of the depth of water on the Model performance. The effective horsepower for the two ships in fresh water is tabulated below (without rudders).

Deep Water

Speed	10 knots	16 knots
Tunnel Stern	180	1080
Flat Stern Surface Propeller	160	900

20 feet Depth

Speed	10 knots	125 knots
Tunnel Stern	210	490
Flat Stern Surface Propeller	210	560

10 feet Depth

Speed	9 knots
Tunnel Stern	340
Flat Stern	380

The above figures show a superiority for the flat stern only in the deep water condition; in the other conditions it seems slightly worse off but the results were hard to obtain and are not as reliable as for the deep water condition.

A comparison of Sheets 14 and 18, in deep water and Sheets 17 and 25, in water of 20 feet depth indicate that the efficiency of propulsion for the flat stern is higher than for the tunnel stern, and this, it is believed, would be found to be true for other depths, particularly so if the propellers are sufficiently large.

In the case of Model 2460 three sets of propellers were tried of varying diameters, but the two smaller pairs broke down at or below a speed corresponding to 16 knots, thus increasing the revolutions a prohibitive amount.

While propellers 585 and 586 proved full large for the model and prevented any break-down occurring within the range tested, it is not certain that the full sized propeller will do likewise for the gunboat. If it can be assumed that the ship propeller will not fail below corresponding velocities, then a smaller propeller, say 12 feet 3 inches working at 150 r.p.m. might be attempted, but with more attendant risk of failure than with the larger propellers.

The following table gives the different data to be found on the several sheets, 1 to 25.

Sheet No.	Model	Depth	Propellers	Shows	Remarks
1	2421	Full		E.H.P. Fresh Water	3 rudders
2	2421	Full		E.H.P. S & F	4 rudders
3	2421	Various		E.H.P. F.W.	No rudders
4	2460	Various		E.H.P. F.W.	No rudders
5	2421	Various		Contours E.H.P.	No rudders
6	2460	Various		Contours E.H.P.	No rudders
7	2460	Various		Contours Knots	No rudders
8			412 & 413	Characteristic Curves	
9			585 & 586	Surface Propellers	
10	2421	Full	412 & 413	Self Propelled Model	3 rudders
11	2421	Full	412 & 413	Self Propelled Model	4 rudders
12	2421	10 feet	412 & 413	Self Propelled Model	No rudders
13	2421	20 feet	412 & 413	Self Propelled Model	No rudders
14	2421	Full	412 & 413	Self Propelled (Ship)	3 rudders
15	2421	Full	412 & 413	Self Propelled (Ship)	4 rudders
16	2421	10 feet	412 & 413	Self Propelled (Ship)	No rudders
17	2421	20 feet	412 & 413	Self Propelled (Ship)	No rudders
18	2460	Full	585 & 586	Self Propelled Model	No rudders
19	2460	10 feet	585 & 586	Self Propelled Model	No rudders
20	2460	20 feet	585 & 586	Self Propelled Model	No rudders
21	2460	Full	458 & 459	Self Propelled Model	No rudders CL 4.86 up
22	2460	Full	458 & 459	Self Propelled Model	No rudders CL 5.92 up
23	2460	Full	412 & 413	Self Propelled Model	No rudders CL 4.86 up
24	2460	Full	585 & 586	Self Propelled (Ship)	No rudders as des.
25	2460	20 feet	485 & 685	Self Propelled (Ship)	No rudders as des.

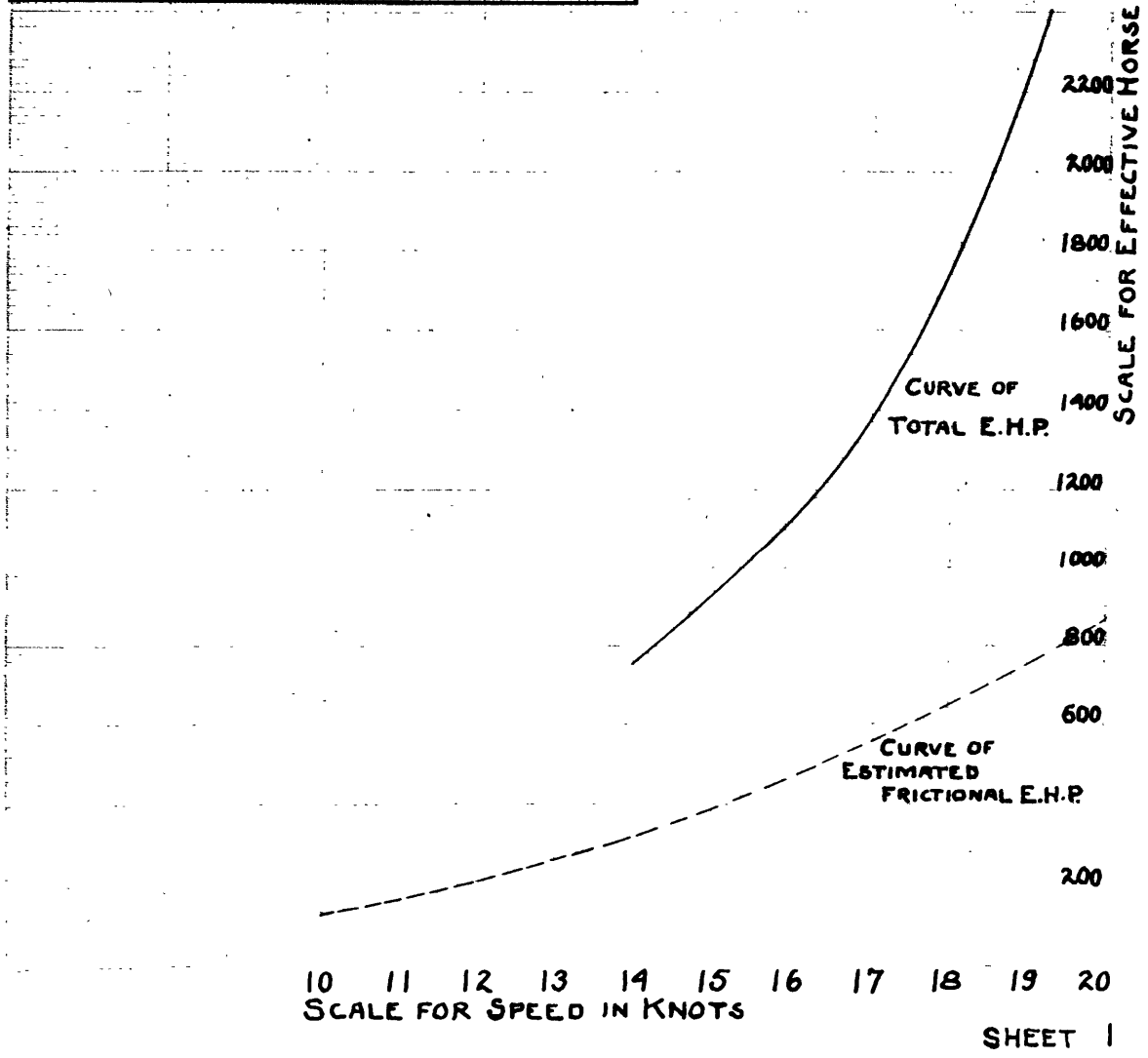
EFFECTIVE HORSE POWER CURVES
FOR
RIVER GUNBOAT 1922
SPOON BOW: TUNNEL STERN
ESTIMATED FROM RESULTS OF TESTS WITH
MODEL No. 2421
LINES No. BU. C&R. Nº 006427
006439
PREPARED BY
BUREAU OF CONSTRUCTION AND REPAIR
CORRESPONDENCE FILE No. R.G.B. N21

CONDITIONS:

TEST	WETTED SURFACE	DISPLACEMENT: TONS	DRAFT			APPENDAGES:
			FOR'D	AFT	MEAN	
1	6384	532	4.5	4.5	4.5	SHAFTS AND STRUTS
						AND THREE RUDDERS

U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
WASHINGTON, D. C. APRIL 4, 1923

NOTE:— E.H.P. CALCULATIONS MADE FOR VESSEL IN FRESH WATER



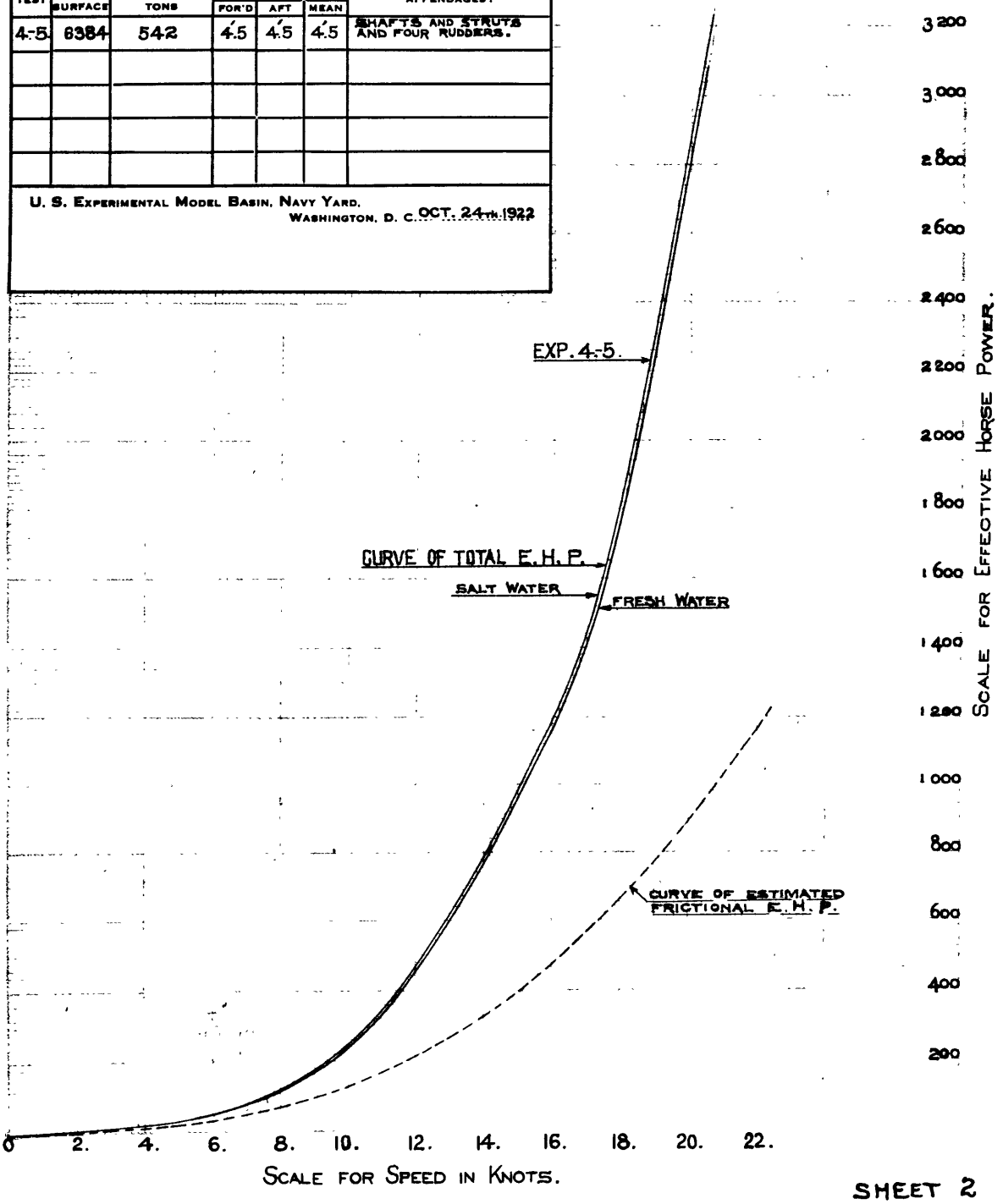
SHEET 1

EFFECTIVE HORSE POWER CURVES
FOR
RIVER GUNBOAT-1922
(SPOON BOW.)
(TUNNEL STERN.)
ESTIMATED FROM RESULTS OF TESTS WITH
MODEL NO. 2421
LINES NO. C.&R. 006427-BOW
006439-STERN
PREPARED BY
BU. OF C. & R.
CORRESPONDENCE FILE NO. R.GB. No 1.

CONDITIONS:

TEST	WETTED SURFACE	DISPLACEMENT: TONS	DRAFT FOR'D	DRAFT AFT	DRAFT MEAN	APPENDAGES:
4-5.	6384	542	4'.5	4'.5	4'.5	SHAFTS AND STRUTS AND FOUR RUDDERS.

U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
WASHINGTON, D. C. OCT. 24th 1922



SHEET 2

EFFECTIVE HORSE POWER CURVES
FOR
RIVER GUNBOAT 1922
SPOON BOW—TUNNEL STERN

ESTIMATED FROM RESULTS OF TESTS WITH
MODEL No. 2421
LINES No. Bu. C&R No. 806427
PREPARED BY
BUREAU OF CONSTRUCTION AND REPAIR
CORRESPONDENCE FILE No. R.G.B. No 1

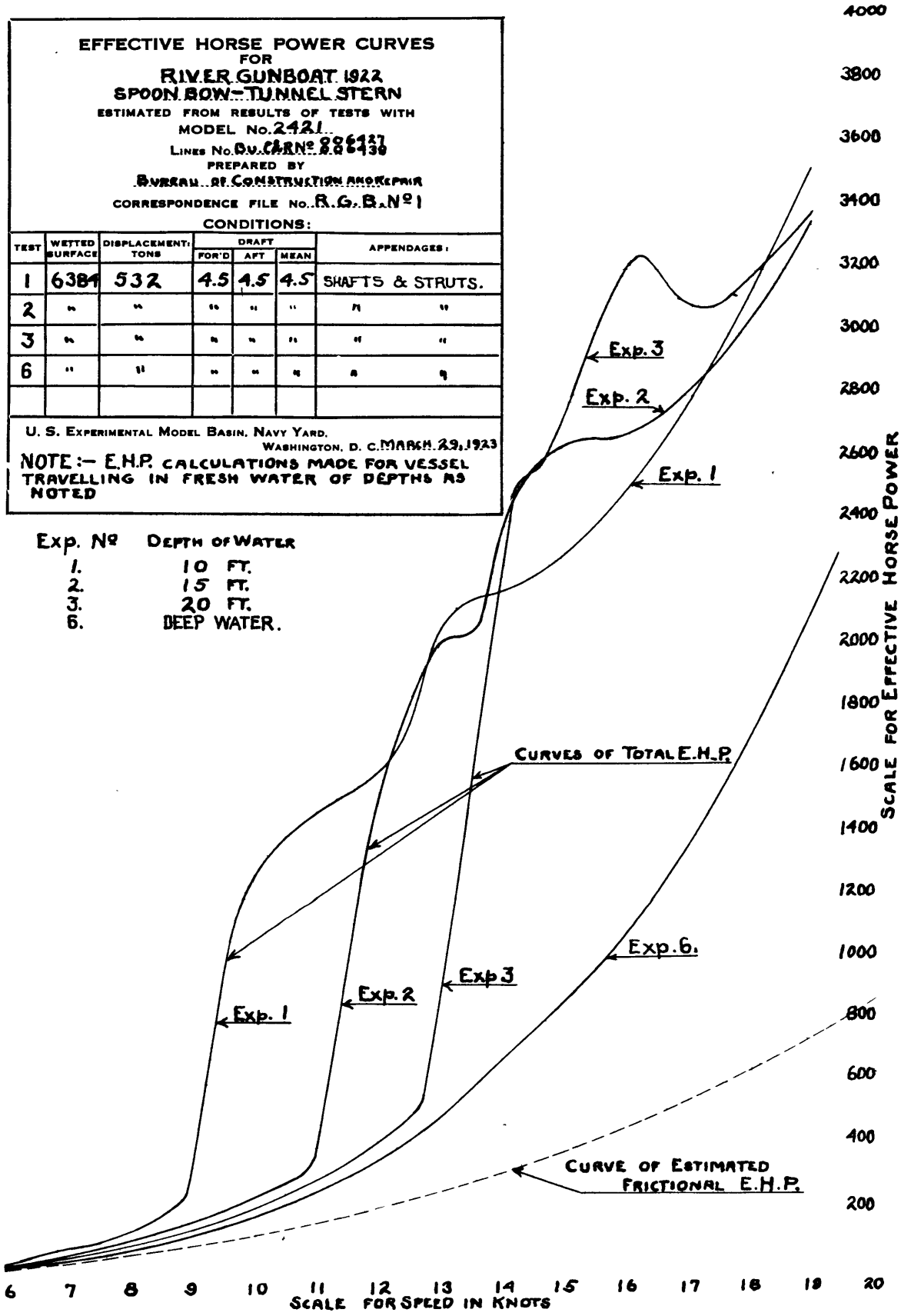
CONDITIONS:

TEST	WETTED SURFACE	DISPLACEMENT: TONS	DRAFT			APPENDAGES:
			FOR'D	AFT	MEAN	
1	6384	532	4.5	4.5	4.5	SHAFTS & STRUTS.
2	"	"	"	"	"	" "
3	"	"	"	"	"	" "
6	"	"	"	"	"	" "

U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
WASHINGTON, D. C. MARCH 29, 1923

NOTE:— E.H.P. CALCULATIONS MADE FOR VESSEL TRAVELLING IN FRESH WATER OF DEPTHS AS NOTED

Exp. No	DEPTH OF WATER
1.	10 FT.
2.	15 FT.
3.	20 FT.
6.	DEEP WATER.



SHEET 3.

EFFECTIVE HORSE POWER CURVES
FOR
RIVER GUNBOAT-1922.
(SPOON BOW)
(FLAT STERN)

ESTIMATED FROM RESULTS OF TESTS WITH
MODEL No. 2460
LINES No. Bu.C.&R. 006427-BOW
EXP. MODEL BASIN-STERN
PREPARED BY
BU. OF C. AND R. AND EXP. MODEL BASIN
CORRESPONDENCE FILE No. R.G.B. № 1

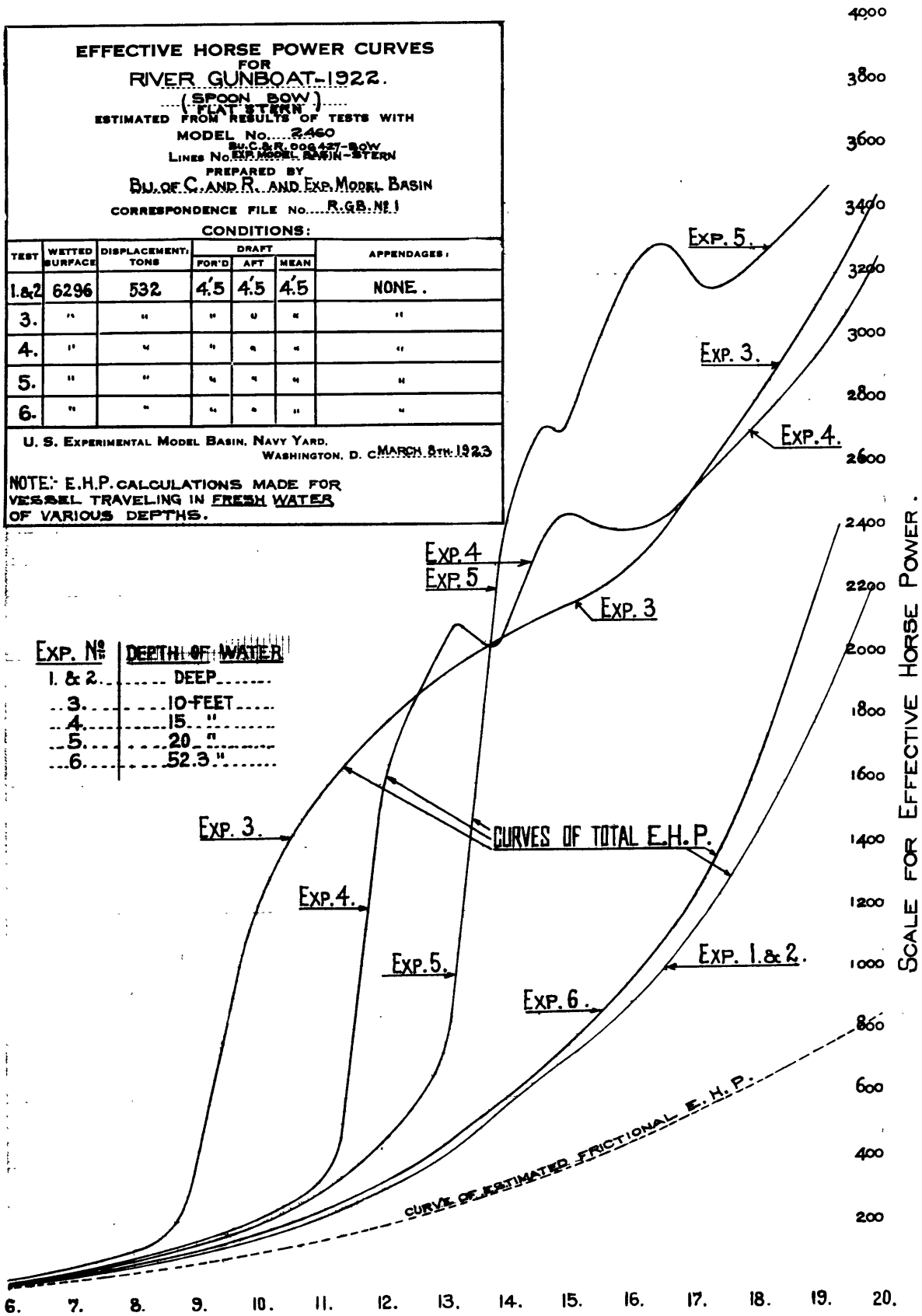
CONDITIONS:

TEST	WETTED SURFACE	DISPLACEMENT: TONS	DRAFT FOR'D	DRAFT AFT	DRAFT MEAN	APPENDAGES:
1.&2	6296	532	4'5	4'5	4'5	NONE.
3.	"	"	"	"	"	"
4.	"	"	"	"	"	"
5.	"	"	"	"	"	"
6.	"	"	"	"	"	"

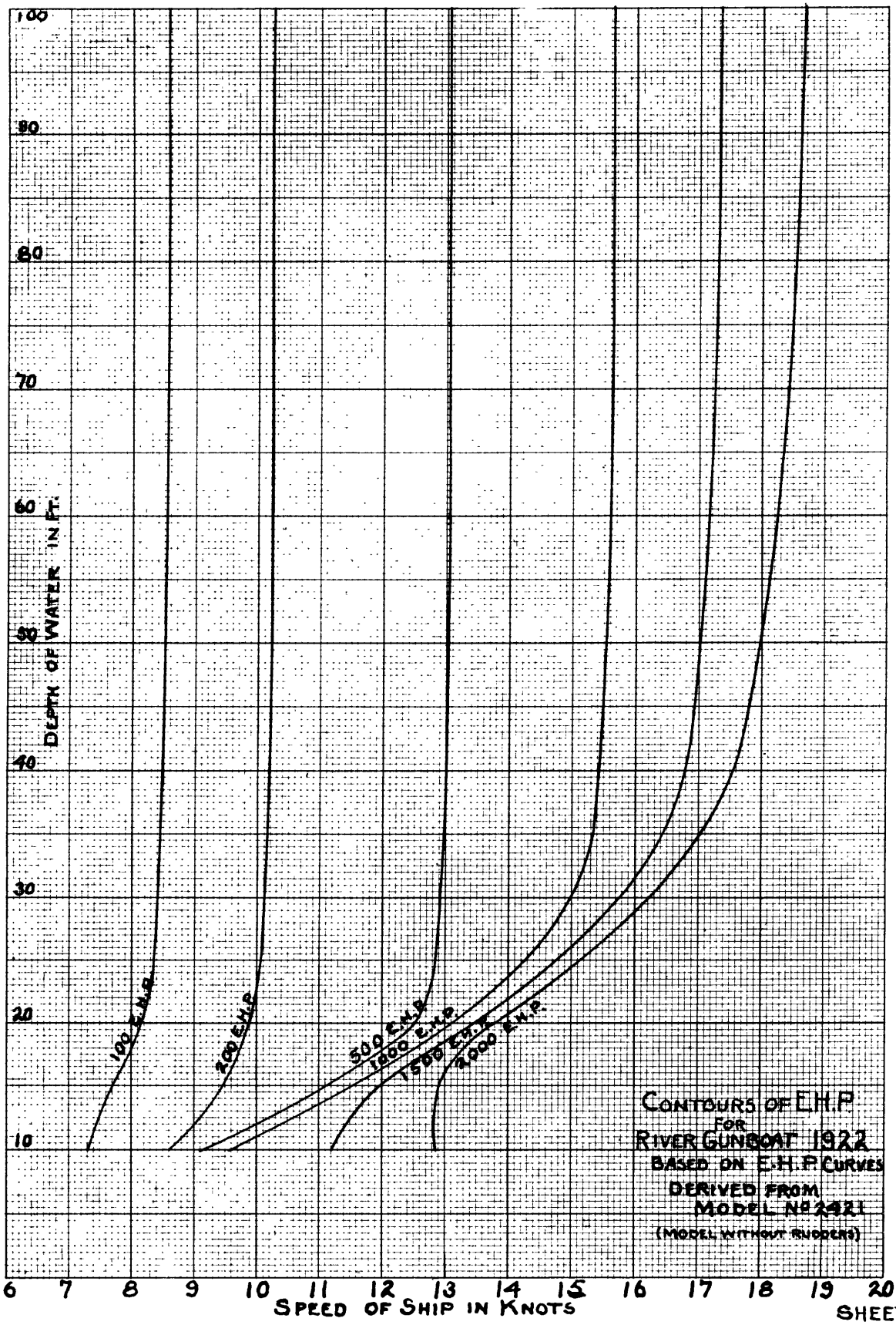
U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD,
WASHINGTON, D. C. MARCH 8TH 1923

NOTE:- E.H.P. CALCULATIONS MADE FOR VESSEL TRAVELING IN FRESH WATER OF VARIOUS DEPTHS.

EXP. №	DEPTH OF WATER
1. & 2.	DEEP
3.	10-FEET
4.	15 "
5.	20 "
6.	52.3 "

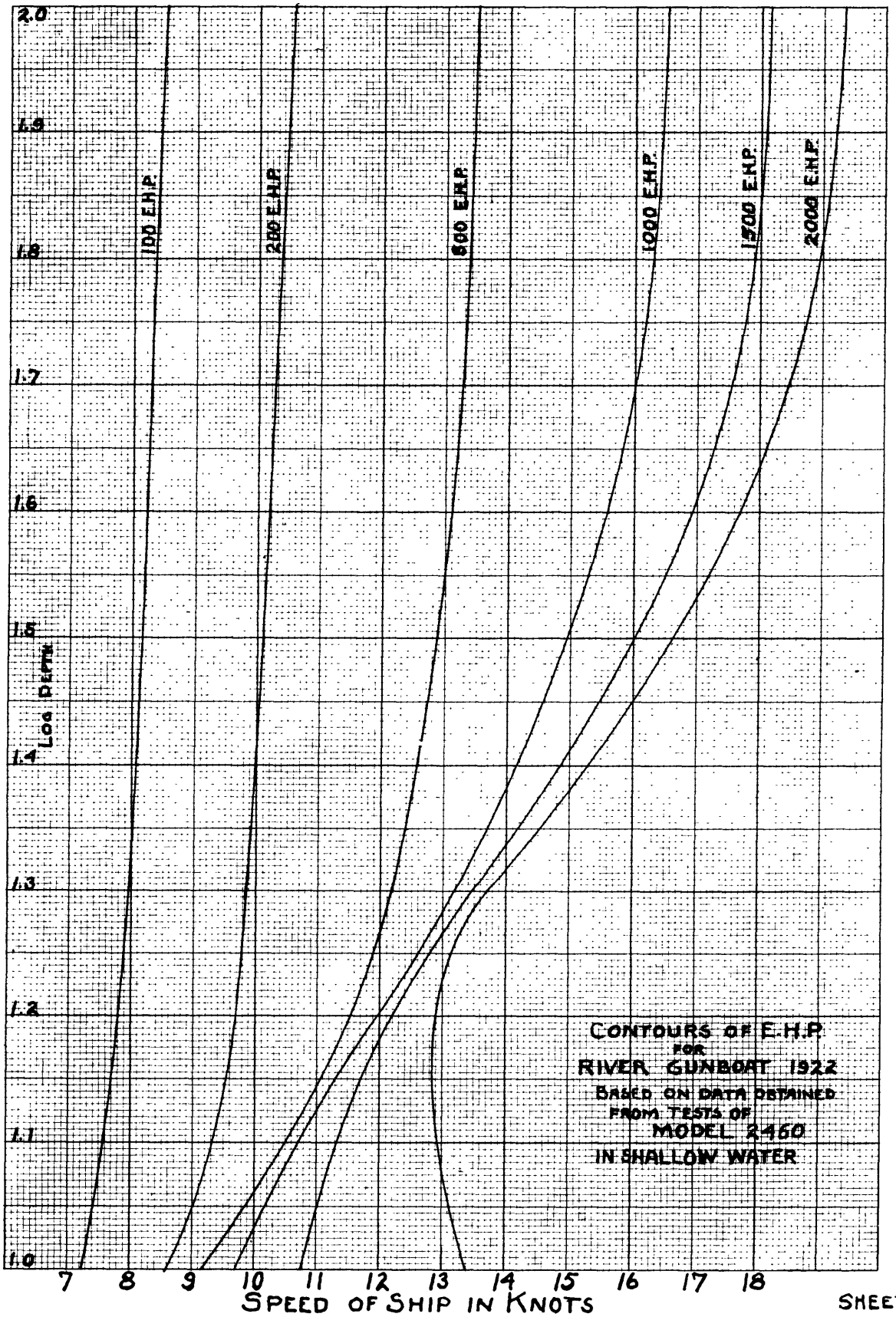


SHEET 4.

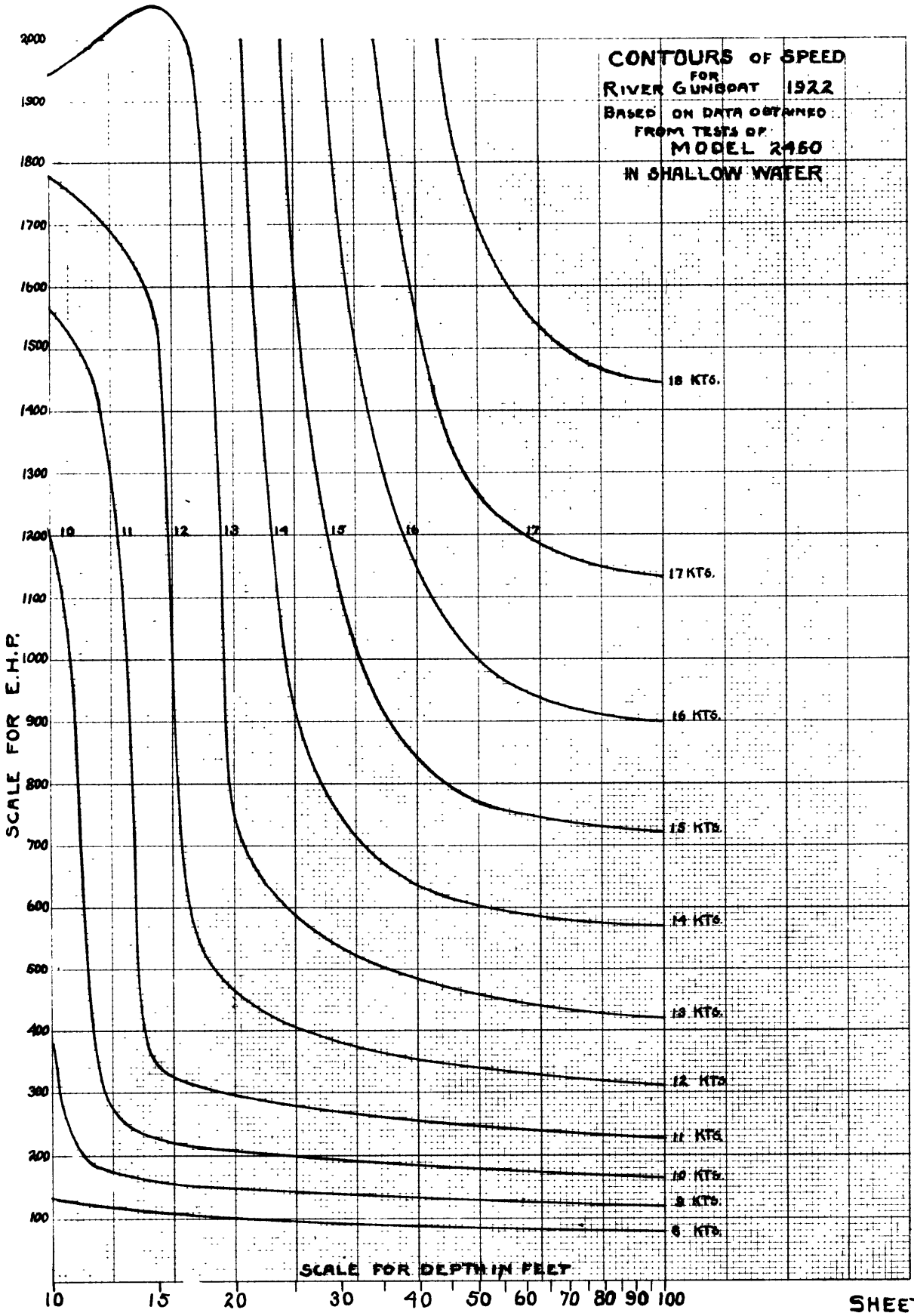


CONTOURS OF E.H.P
FOR
RIVER GUNBOAT 1922
BASED ON E.H.P CURVES
DERIVED FROM
MODEL Nº 2421
(MODEL WITHOUT RUDDERS)

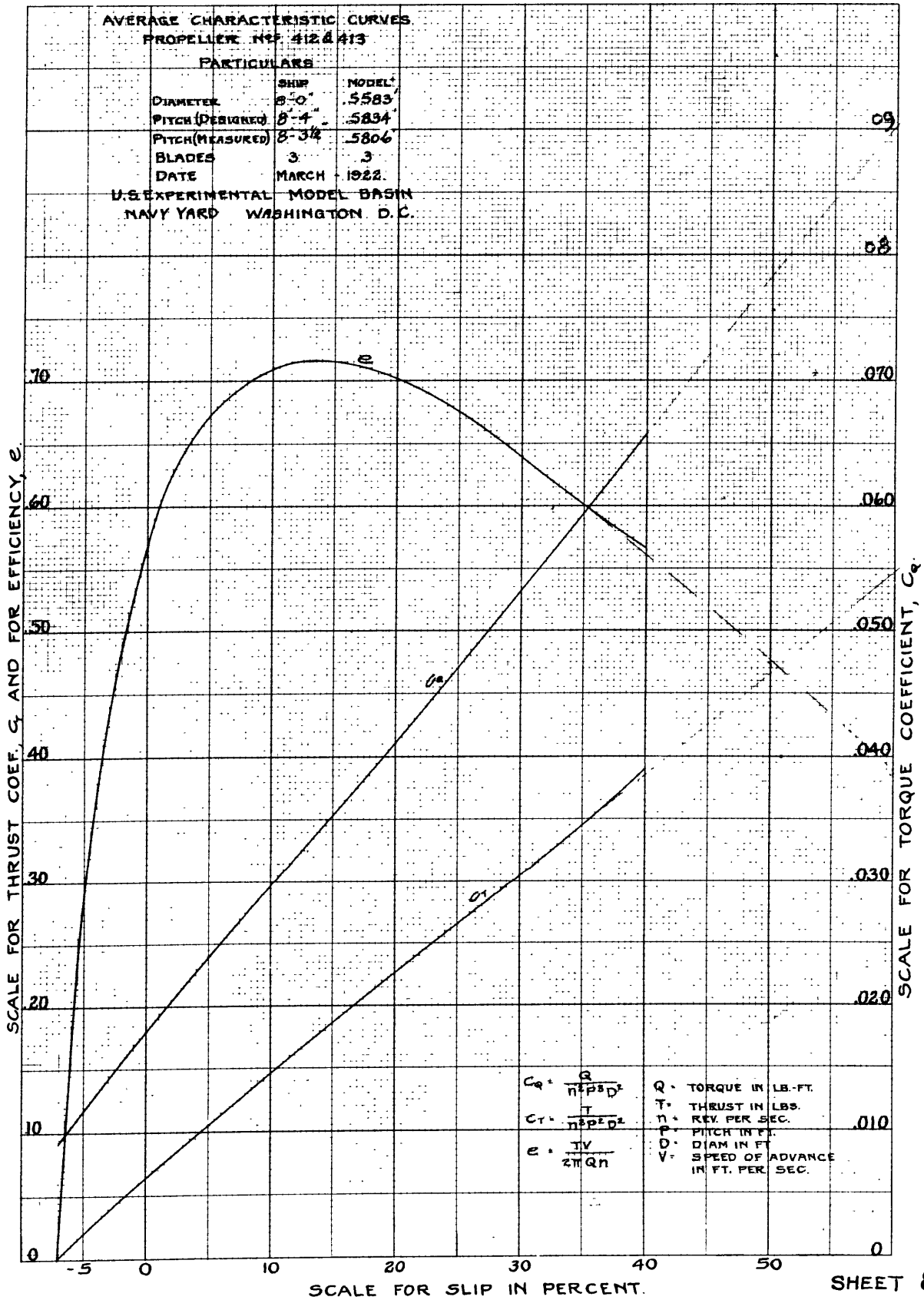
SHEET 5


2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
Log DEPTH
100 E.H.P.
200 E.H.P.
600 E.H.P.
1000 E.H.P.
1500 E.H.P.
2000 E.H.P.
7
8
9
10
11
12
13
14
15
16
17
18
SPEED OF SHIP IN KNOTS
CONTOURS OF E.H.P.
FOR
RIVER GUNBOAT 1922
BASED ON DATA OBTAINED
FROM TESTS OF
MODEL 2460
IN SHALLOW WATER

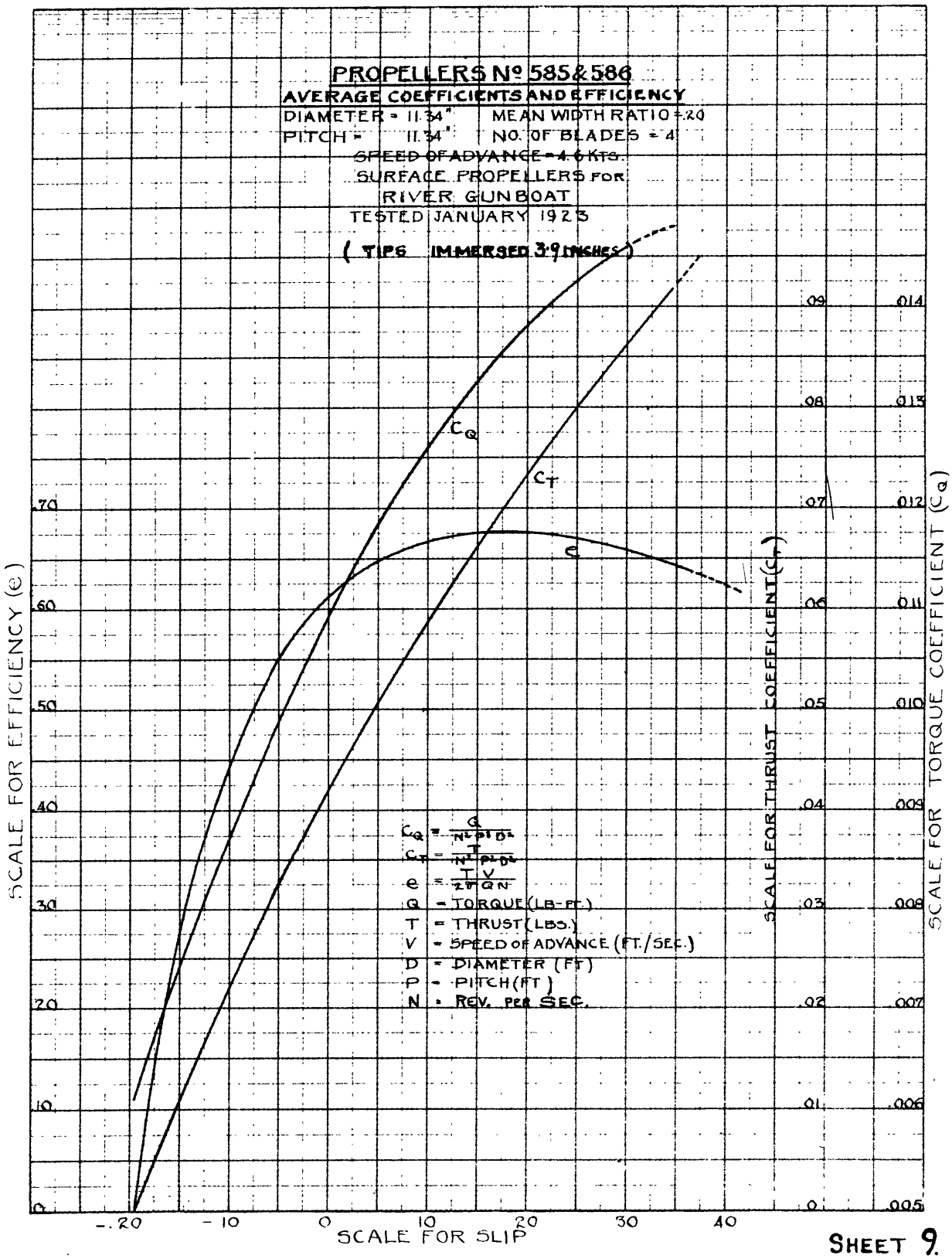
SHEET 6.


CONTOURS OF SPEED
FOR
RIVER GUNBOAT 1922
BASED ON DATA OBTAINED
FROM TESTS OF
MODEL 2460
IN SHALLOW WATER
SCALE FOR E.H.P.
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
10
11
12
13
14
15
16
17
18 KTS.
17 KTS.
16 KTS.
15 KTS.
14 KTS.
13 KTS.
12 KTS.
11 KTS.
10 KTS.
9 KTS.
8 KTS.
SCALE FOR DEPTH IN FEET
10
15
20
30
40
50
60
70
80
90
100

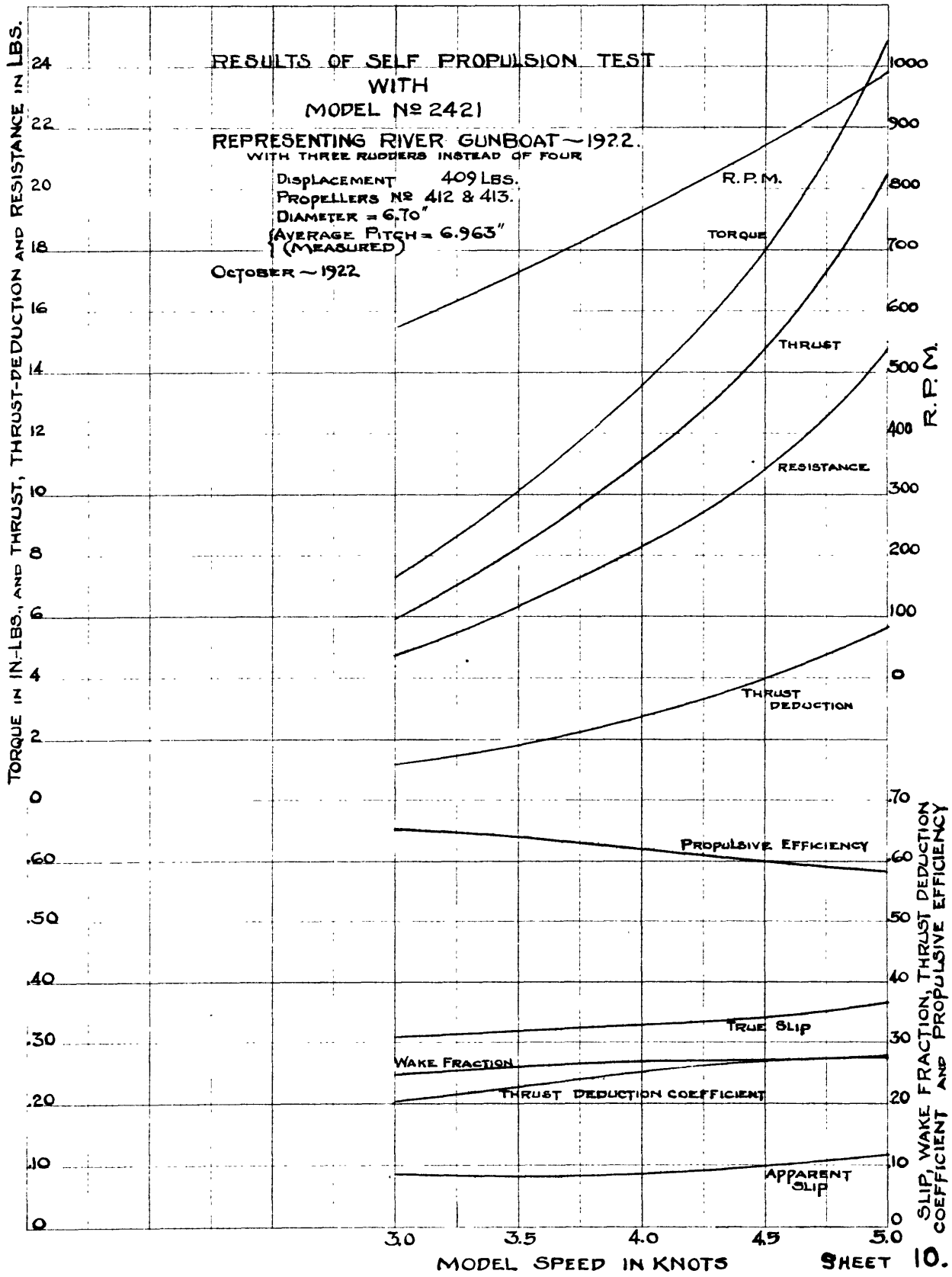
SHEET 7.


AVERAGE CHARACTERISTIC CURVES
PROPELLER Nos 412 & 413
PARTICULARS
SHIP MODEL
DIAMETER 8'-0" .5583'
PITCH (DESIGNED) 8'-4" .5834'
PITCH (MEASURED) 8'-3¼ .5806'
BLADES 3 3
DATE MARCH - 1922.
U.S. EXPERIMENTAL MODEL BASIN
NAVY YARD WASHINGTON D.C.
e
C_Q
C_T
SCALE FOR THRUST COEF. C_T AND FOR EFFICIENCY, e.
SCALE FOR TORQUE COEFFICIENT, C_Q.
SCALE FOR SLIP IN PERCENT.
$C_Q = \frac{Q}{n^2 \rho^3 D^5}$
$C_T = \frac{T}{n^2 \rho^2 D^4}$
$e = \frac{TV}{2\pi Qn}$
Q - TORQUE IN LB.-FT.
T - THRUST IN LBS.
n - REV. PER SEC.
P - PITCH IN FT.
D - DIAM IN FT.
V - SPEED OF ADVANCE IN FT. PER SEC.

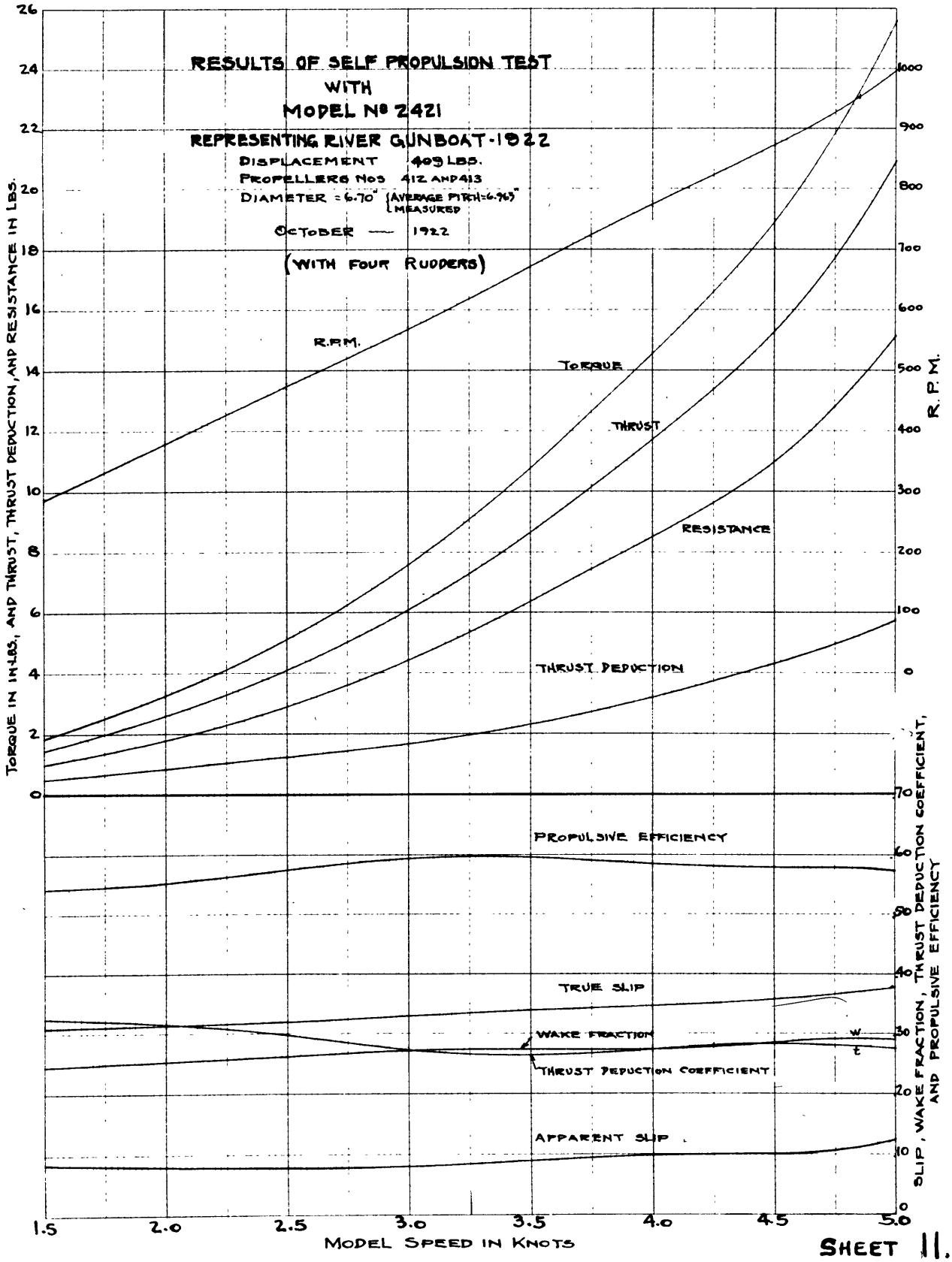
SHEET 8.


PROPELLERS Nº 585&586
AVERAGE COEFFICIENTS AND EFFICIENCY
DIAMETER = 11.34" MEAN WIDTH RATIO = .20
PITCH = 11.34" NO. OF BLADES = 4
SPEED OF ADVANCE = 4.6 KTS.
SURFACE PROPELLERS FOR
RIVER GUNBOAT
TESTED JANUARY 1923
(TIPS IMMERSED 3.9 INCHES)
C_Q
C_T
e
$C_Q = \frac{Q}{N^2 \rho D^5}$
$C_T = \frac{T}{N^2 \rho D^4}$
$e = \frac{TV}{2\pi QN}$
Q = TORQUE (LB-FT.)
T = THRUST (LBS.)
V = SPEED OF ADVANCE (FT./SEC.)
D = DIAMETER (FT)
P = PITCH (FT)
N = REV. PER SEC.
SCALE FOR EFFICIENCY (e)
SCALE FOR THRUST COEFFICIENT (C_T)
SCALE FOR TORQUE COEFFICIENT (C_Q)
SCALE FOR SLIP
.70
.60
.50
.40
.30
.20
.10
.09
.08
.07
.06
.05
.04
.03
.02
.01
0
.014
.013
.012
.011
.010
.009
.008
.007
.006
.005
-.20
-10
0
10
20
30
40

SHEET 9.

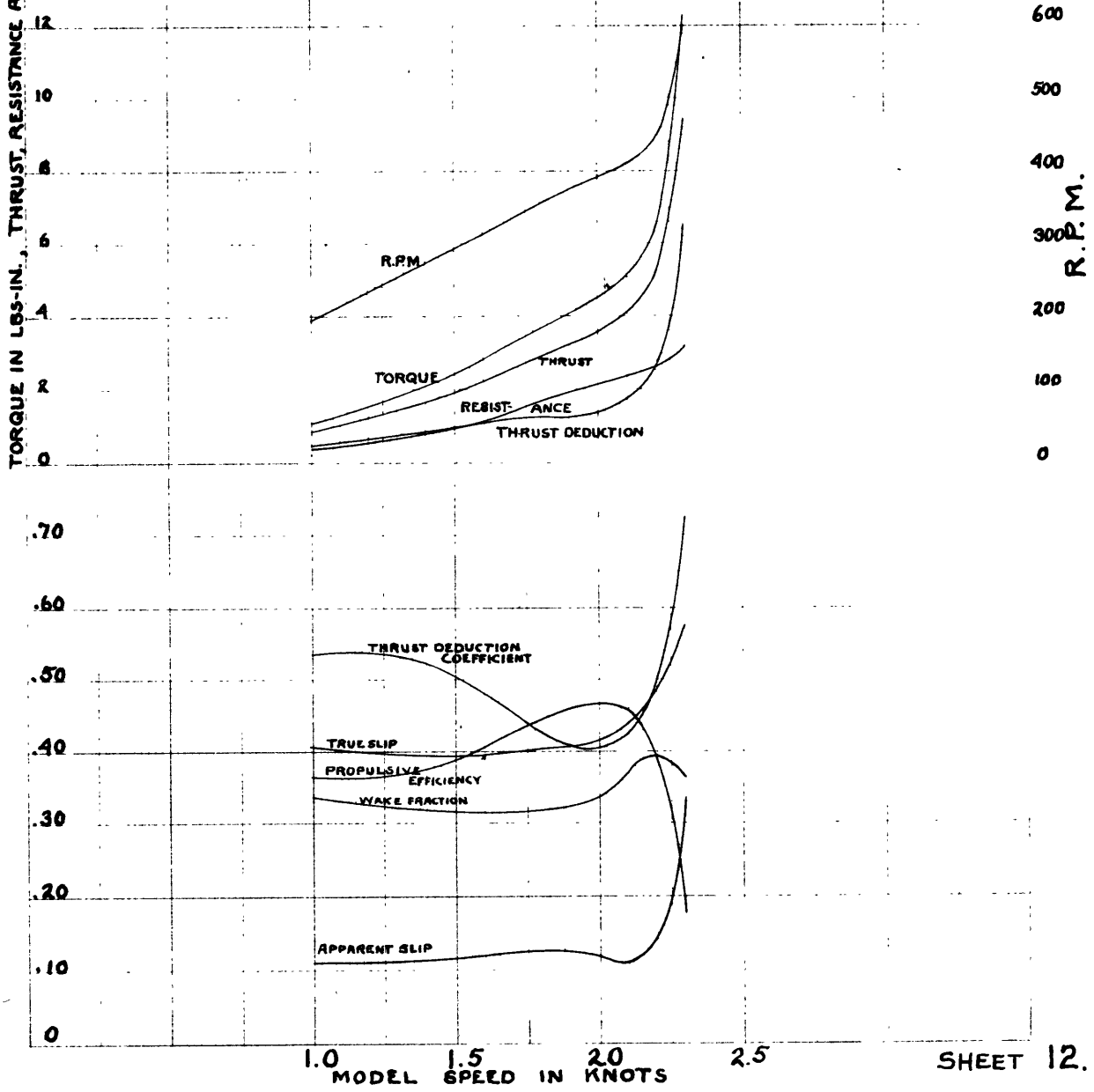

RESULTS OF SELF PROPULSION TEST
WITH
MODEL Nº 2421
REPRESENTING RIVER GUNBOAT ~ 1922.
WITH THREE RUDDERS INSTEAD OF FOUR
DISPLACEMENT 409 LBS.
PROPELLERS Nº 412 & 413.
DIAMETER = 6.70"
AVERAGE PITCH = 6.963" (MEASURED)
OCTOBER ~ 1922.
R.P.M.
TORQUE
THRUST
RESISTANCE
THRUST DEDUCTION
PROPULSIVE EFFICIENCY
TRUE SLIP
WAKE FRACTION
THRUST DEDUCTION COEFFICIENT
APPARENT SLIP
TORQUE IN IN.-LBS., AND THRUST, THRUST-DEDUCTION AND RESISTANCE IN LBS.
R.P.M.
SLIP, WAKE FRACTION, THRUST DEDUCTION COEFFICIENT AND PROPULSIVE EFFICIENCY
MODEL SPEED IN KNOTS
3.0
3.5
4.0
4.5
5.0

SHEET 10.

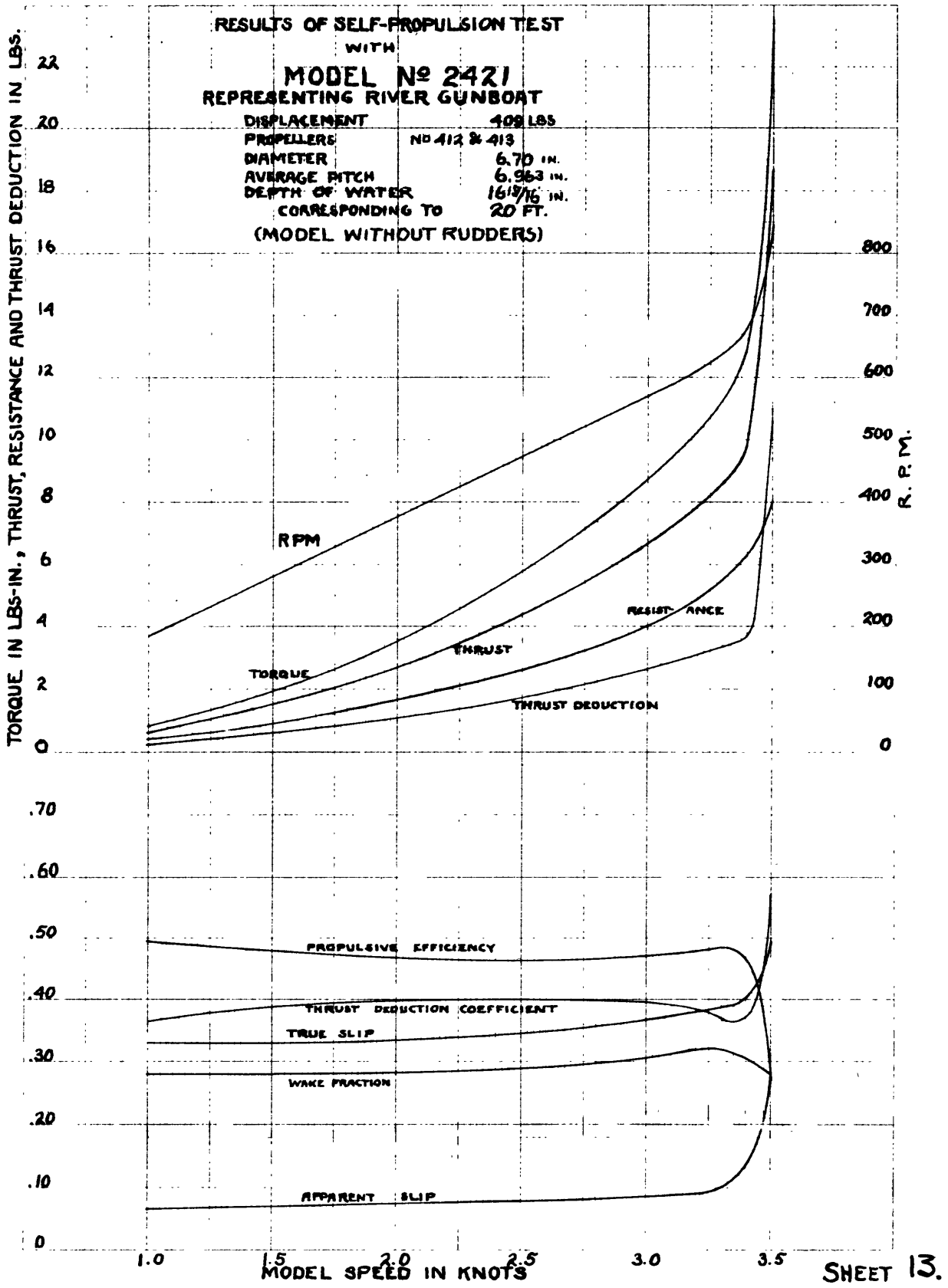

RESULTS OF SELF PROPULSION TEST
WITH
MODEL Nº 2421
REPRESENTING RIVER GUNBOAT-1922
DISPLACEMENT 409 LBS.
PROPELLERS Nos 412 AND 413
DIAMETER = 6.70" (AVERAGE PITCH=6.96" MEASURED
OCTOBER — 1922
(WITH FOUR RUDDERS)
R.P.M.
TORQUE
THRUST
RESISTANCE
THRUST DEDUCTION
PROPULSIVE EFFICIENCY
TRUE SLIP
WAKE FRACTION
w
t
THRUST DEDUCTION COEFFICIENT
APPARENT SLIP
TORQUE IN IN.LBS., AND THRUST, THRUST DEDUCTION, AND RESISTANCE IN LBS.
R.P.M.
SLIP, WAKE FRACTION, THRUST DEDUCTION COEFFICIENT, AND PROPULSIVE EFFICIENCY
MODEL SPEED IN KNOTS
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0

SHEET 11.

RESULTS OF SELF-PROPULSION TEST
WITH
MODEL Nº 2421
REPRESENTING RIVER GUNBOAT
DISPLACEMENT 409 LBS.
PROPELLERS Nº 412 & 413
DIAMETER 6.70
AVERAGE PITCH 6.983
(measured)
DEPTH OF WATER 8 7/8"
CORRESPONDING TO 10 FT.
(MODEL WITHOUT RUDDERS)



SHEET 12.

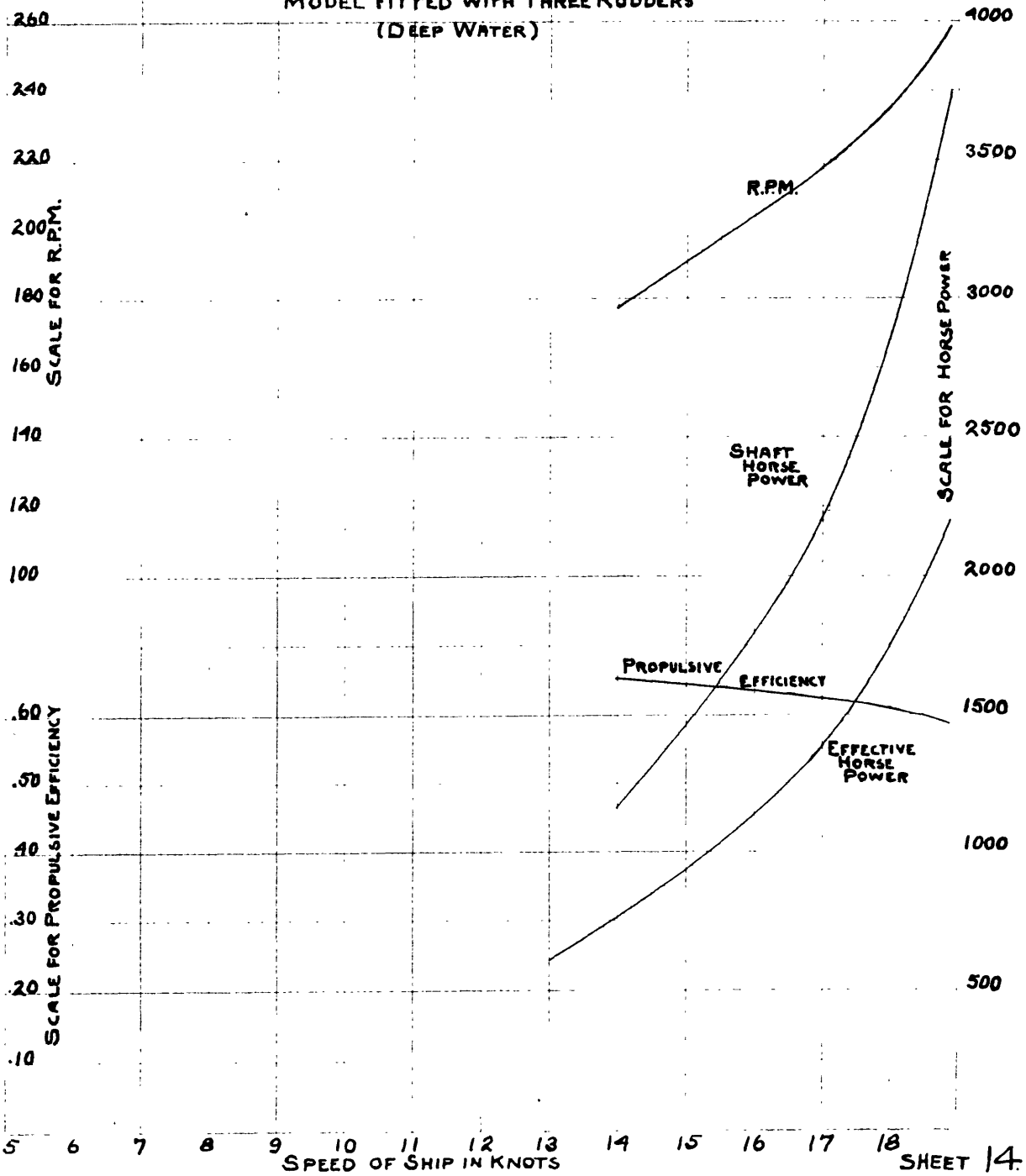

RESULTS OF SELF-PROPULSION TEST
WITH
MODEL Nº 2421
REPRESENTING RIVER GUNBOAT
DISPLACEMENT 409 LBS
PROPELLERS Nº 412 & 413
DIAMETER 6.70 IN.
AVERAGE PITCH 6.963 IN.
DEPTH OF WATER 16 15/16 IN.
CORRESPONDING TO 20 FT.
(MODEL WITHOUT RUDDERS)
TORQUE IN LBS-IN., THRUST, RESISTANCE AND THRUST DEDUCTION IN LBS.
R.P.M.
RPM
RESISTANCE
THRUST
TORQUE
THRUST DEDUCTION
PROPULSIVE EFFICIENCY
THRUST DEDUCTION COEFFICIENT
TRUE SLIP
WAKE FRACTION
APPARENT SLIP
MODEL SPEED IN KNOTS

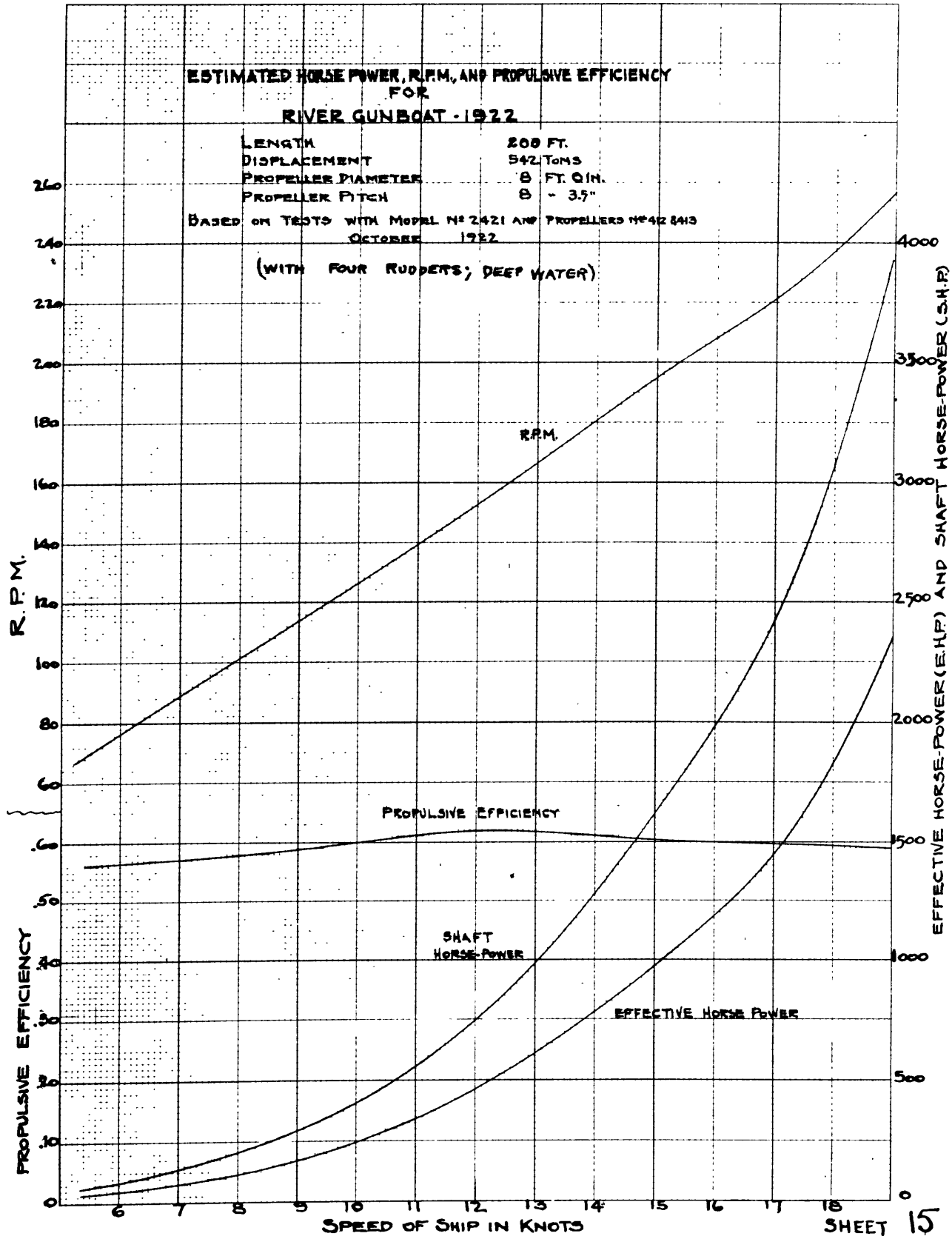
SHEET 13.

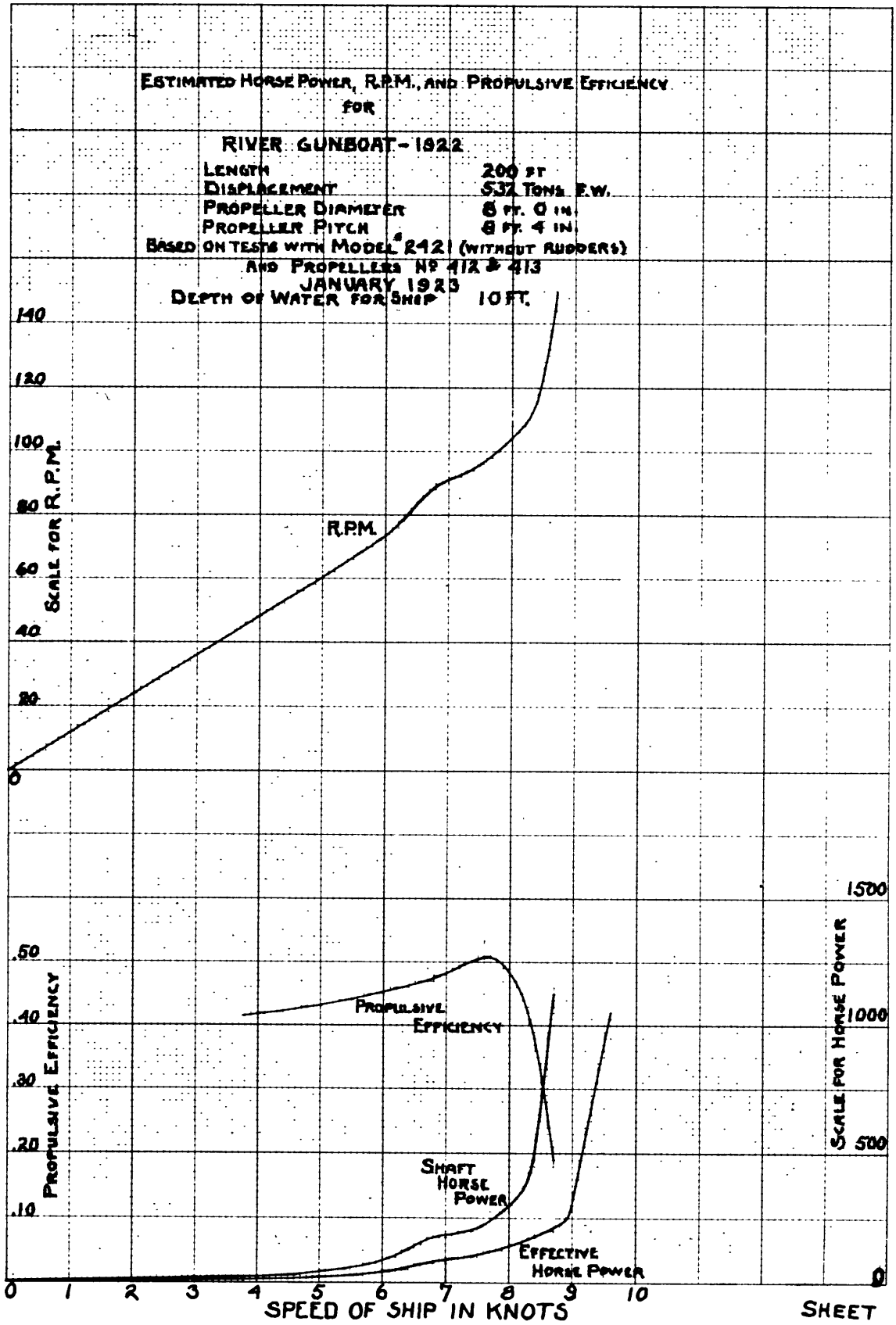
ESTIMATED HORSE POWER, R.P.M. AND PROPULSIVE EFFICIENCY
FOR
RIVER GUNBOAT - 1922

LENGTH	200 FT.
DISPLACEMENT	532 TONS - F.W.
PROPELLER DIAMETER	8 FT. 0 IN.
PROPELLER PITCH	8 FT. 4 IN.

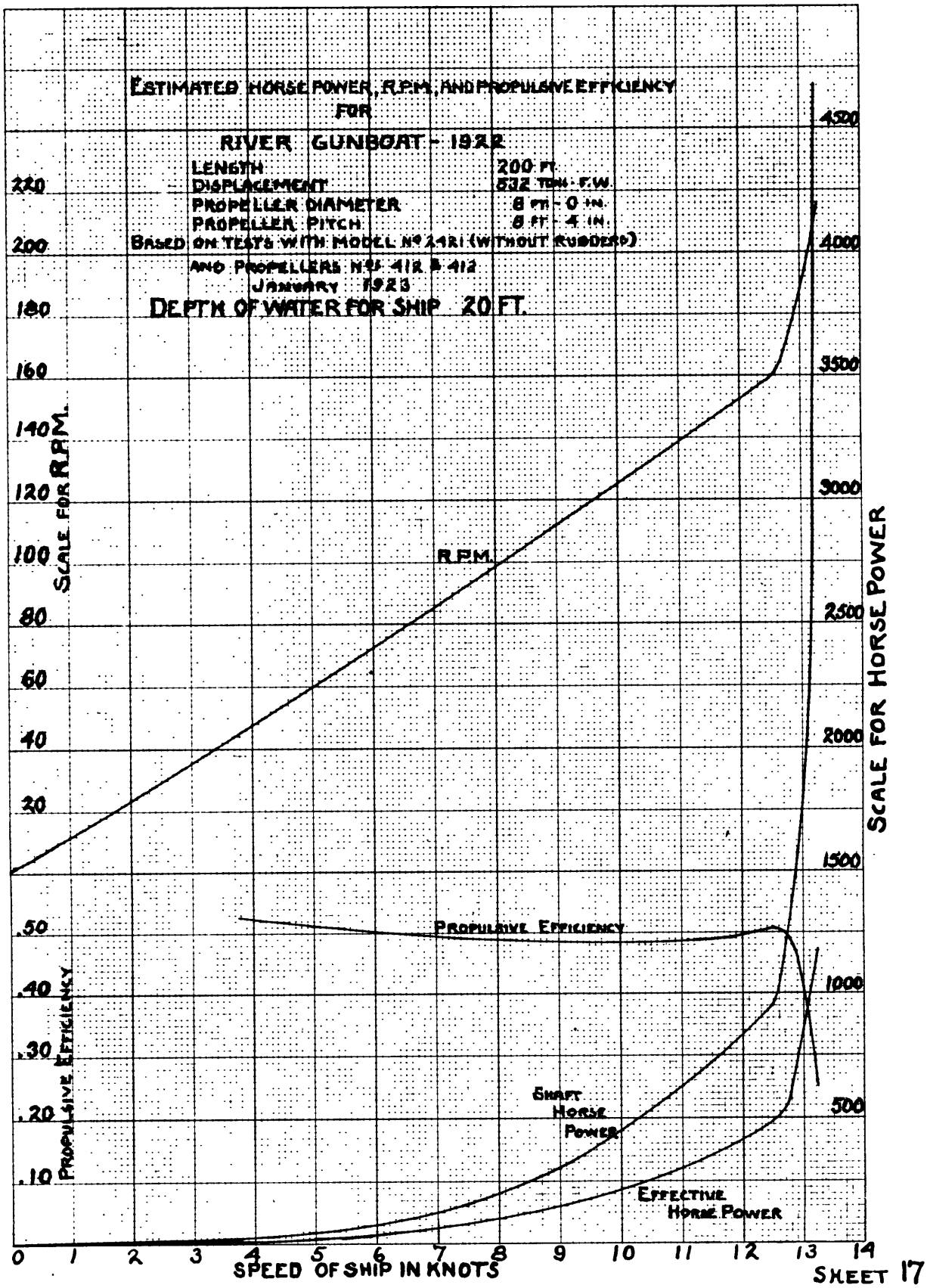
BASED ON TESTS WITH MODEL NO. 2421 AND PROPELLERS 412 & 413
MODEL FITTED WITH THREE RUDDERS
(DEEP WATER)



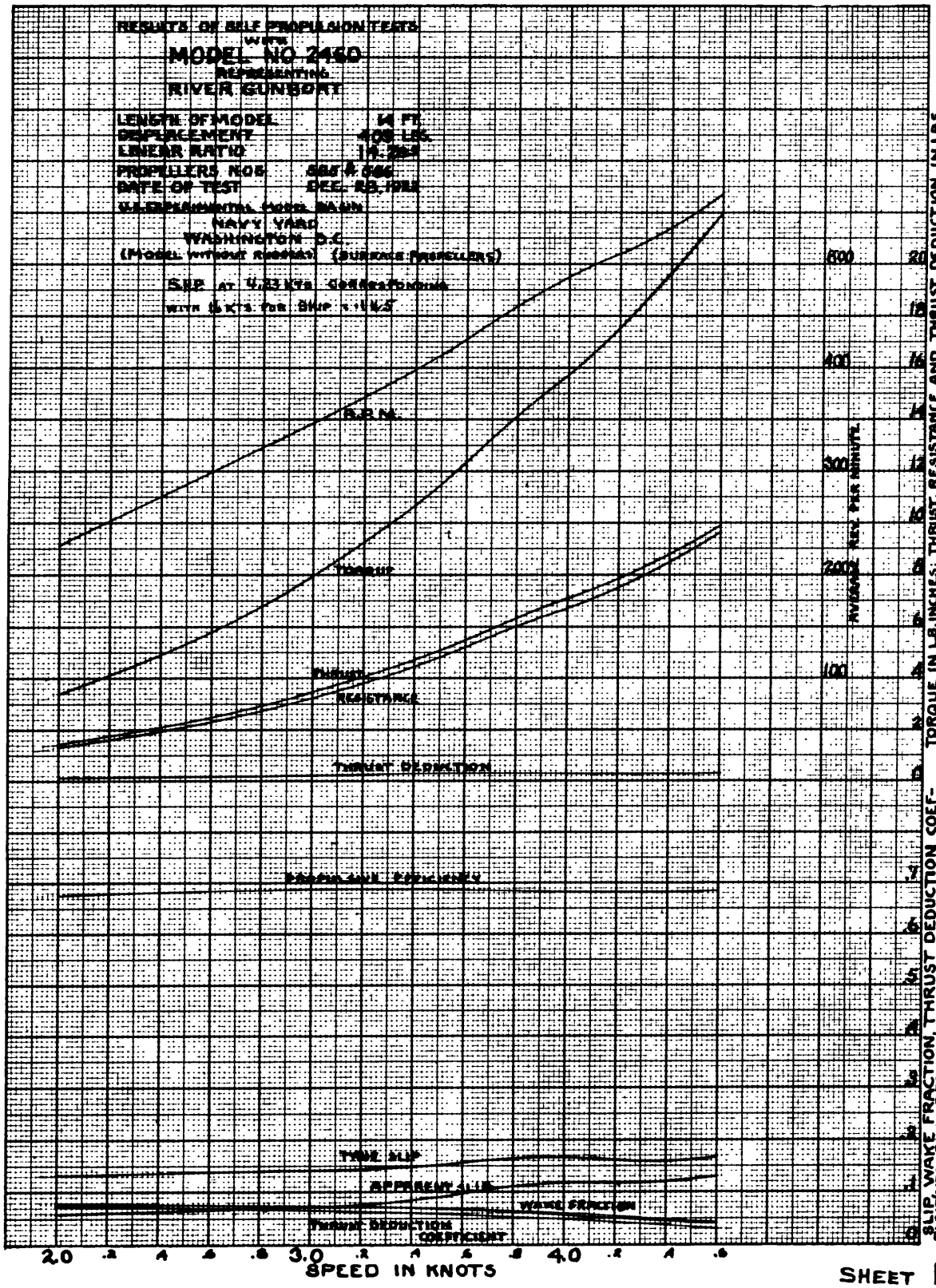

ESTIMATED HORSE POWER, R.P.M., AND PROPULSIVE EFFICIENCY
FOR
RIVER GUNBOAT - 1922
LENGTH 200 FT.
DISPLACEMENT 542 TONS
PROPELLER DIAMETER 8 FT. 0 IN.
PROPELLER PITCH 8 - 3.5"
BASED ON TESTS WITH MODEL Nº 2421 AND PROPELLERS Nº 412 8413
OCTOBER 1922
(WITH FOUR RUDDERS; DEEP WATER)
R.P.M.
PROPULSIVE EFFICIENCY
SHAFT HORSE-POWER
EFFECTIVE HORSE POWER
R.P.M.
PROPULSIVE EFFICIENCY
EFFECTIVE HORSE-POWER (E.H.P.) AND SHAFT HORSE-POWER (S.H.P.)
SPEED OF SHIP IN KNOTS
SHEET 15

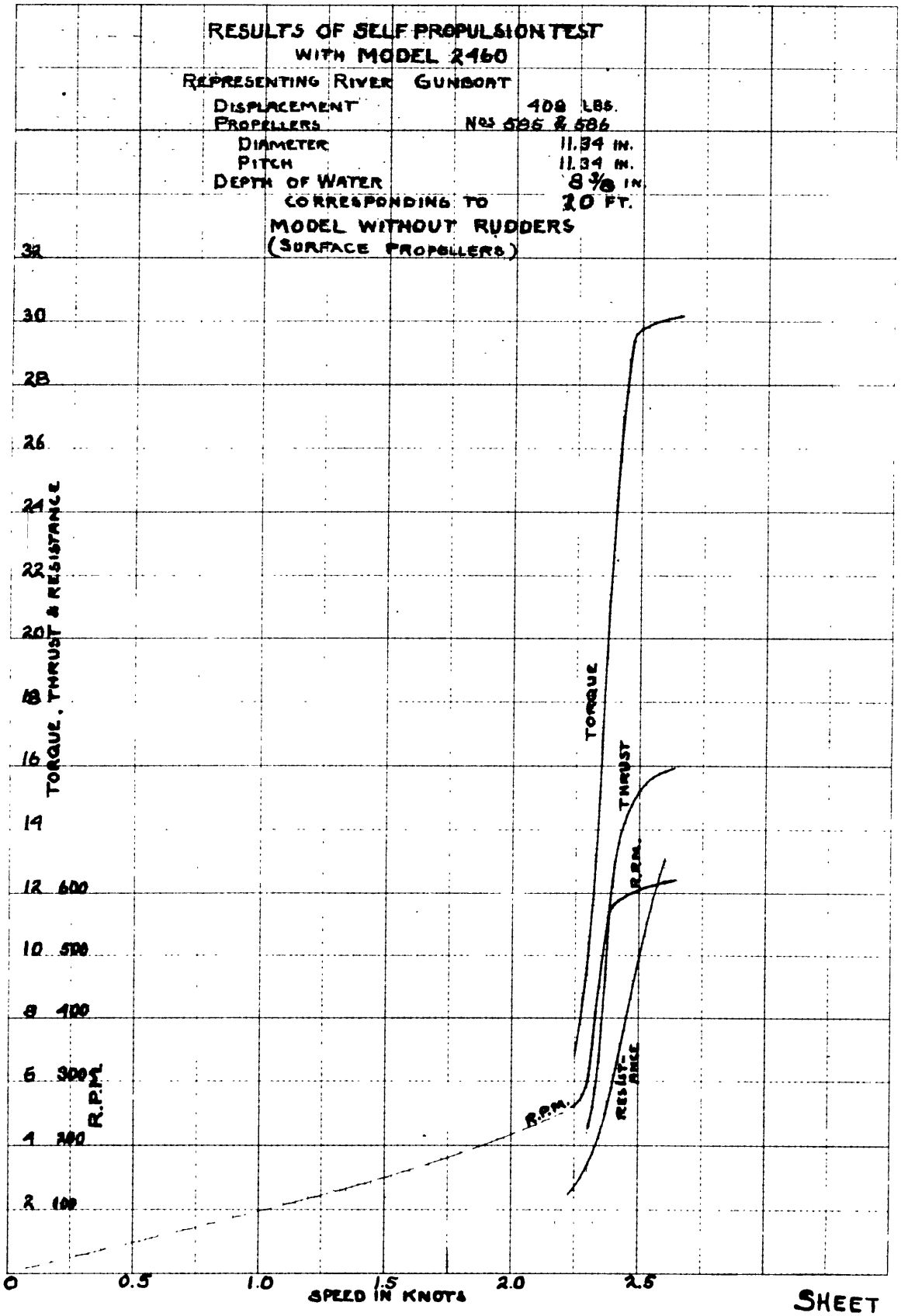

ESTIMATED HORSE POWER, R.P.M., AND PROPULSIVE EFFICIENCY
FOR
RIVER GUNBOAT - 1922
LENGTH 200 FT
DISPLACEMENT 537 TONS F.W.
PROPELLER DIAMETER 8 FT. 0 IN.
PROPELLER PITCH 8 FT. 4 IN.
BASED ON TESTS WITH MODEL 242 (WITHOUT RUDDERS)
AND PROPELLERS Nº 412 & 413
JANUARY 1923
DEPTH OF WATER FOR SHIP 10 FT.
140
120
100
80
60
40
20
0
SCALE FOR R.P.M.
R.P.M.
.50
.40
.30
.20
.10
PROPULSIVE EFFICIENCY
PROPULSIVE EFFICIENCY
SHAFT HORSE POWER
EFFECTIVE HORSE POWER
1500
1000
500
0
SCALE FOR HORSE POWER
0 1 2 3 4 5 6 7 8 9 10
SPEED OF SHIP IN KNOTS

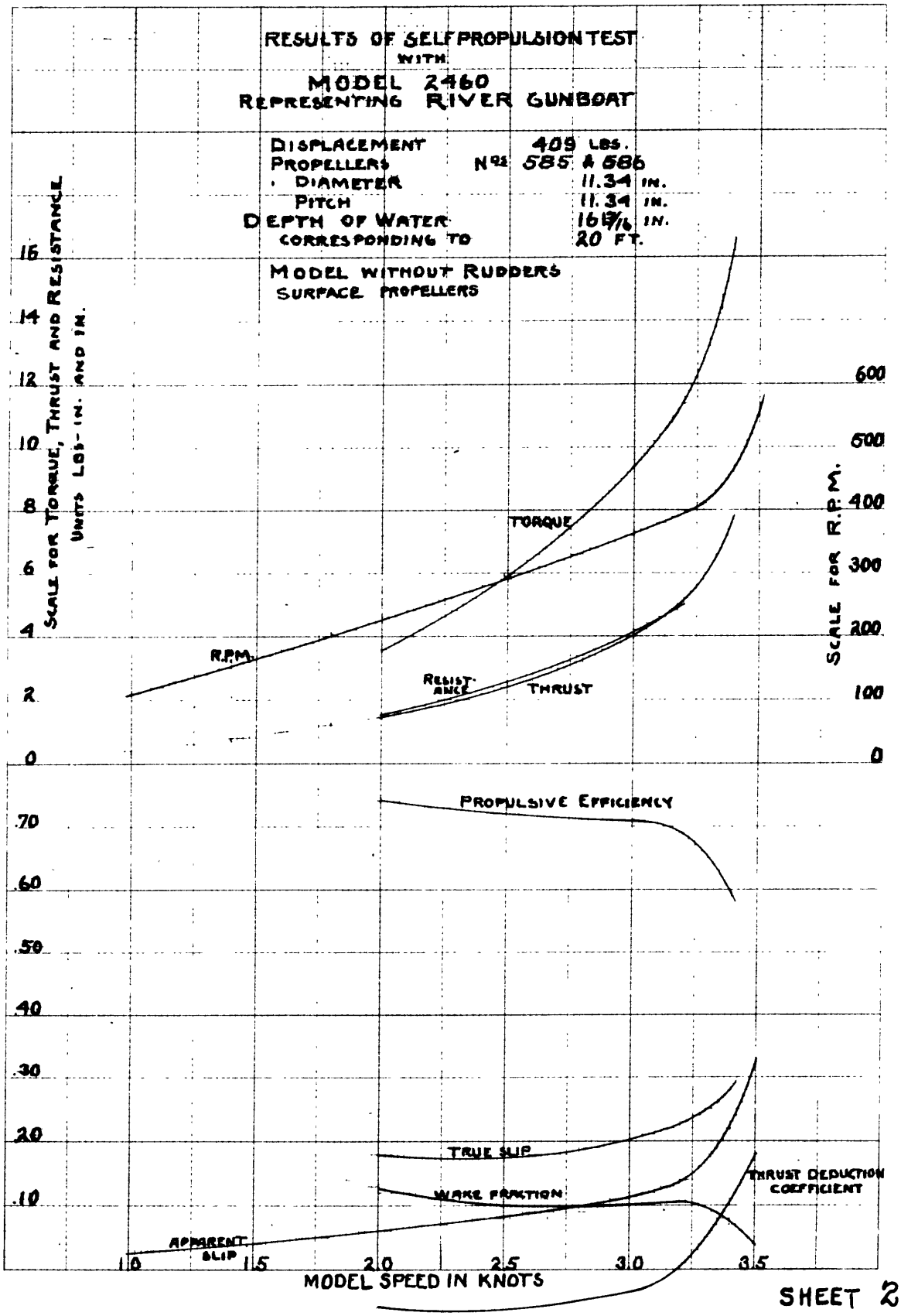
SHEET 16


ESTIMATED HORSE POWER, R.P.M. AND PROPULSIVE EFFICIENCY
FOR
RIVER GUNBOAT - 1922
LENGTH 200 FT.
DISPLACEMENT 532 TONS F.W.
PROPELLER DIAMETER 8 FT - 0 IN.
PROPELLER PITCH 8 FT - 4 IN.
BASED ON TESTS WITH MODEL Nº 241 (WITHOUT RUDDER)
AND PROPELLERS Nºs 412 & 412
JANUARY 1923
DEPTH OF WATER FOR SHIP 20 FT.
SCALE FOR R.P.M.
220
200
180
160
140
120
100
80
60
40
20
R.P.M.
PROPULSIVE EFFICIENCY
.50
.40
.30
.20
.10
PROPULSIVE EFFICIENCY
SHAFT HORSE POWER
EFFECTIVE HORSE POWER
4500
4000
3500
3000
2500
2000
1500
1000
500
SCALE FOR HORSE POWER
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14
SPEED OF SHIP IN KNOTS

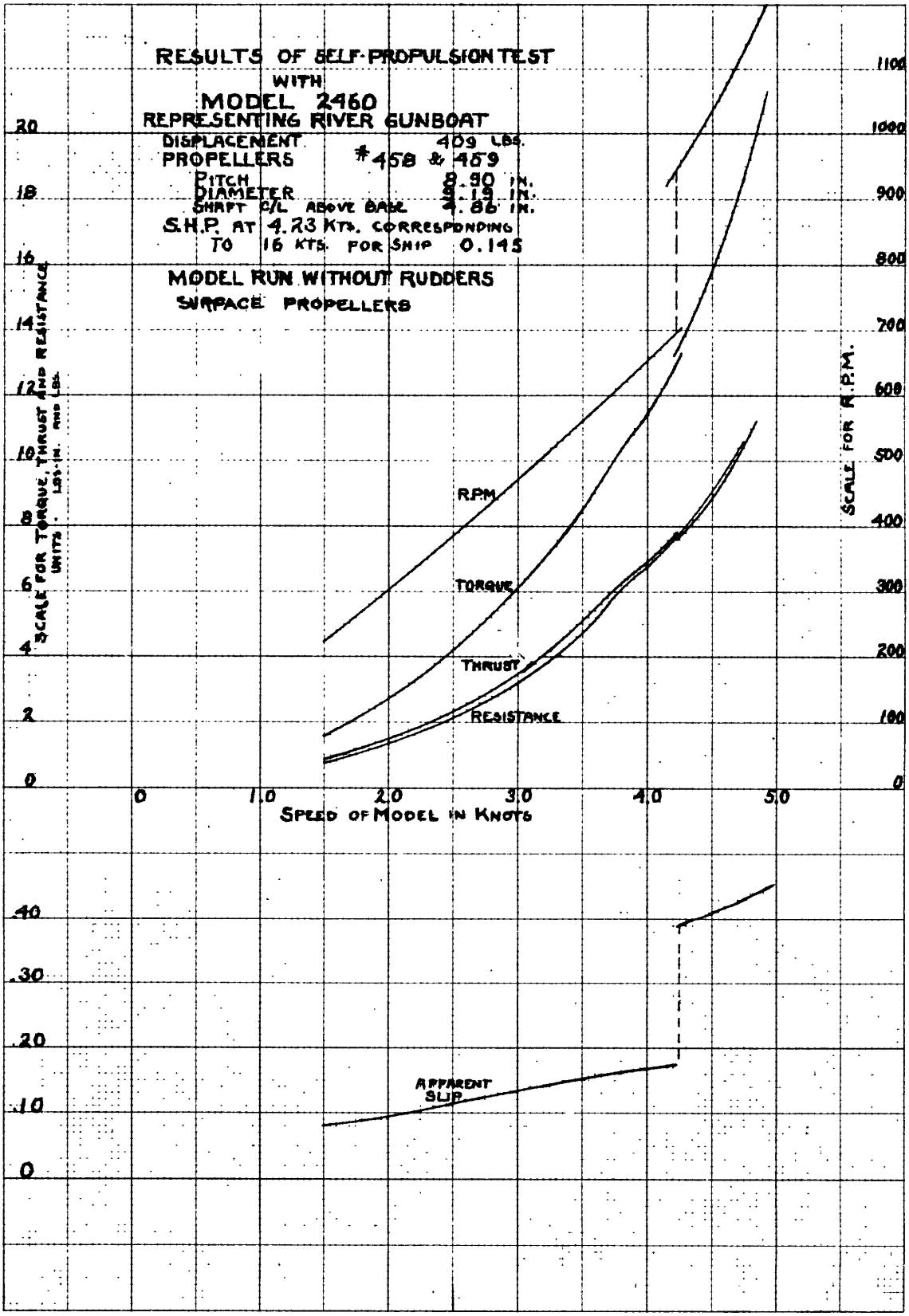
SHEET 17


RESULTS OF SELF PROPULSION TESTS
WITH
MODEL NO 2450
REPRESENTING
RIVER GUNBOAT
LENGTH OF MODEL 14 FT.
DISPLACEMENT 408 LBS.
LINEAR RATIO 16.284
PROPELLERS NOS. 585 & 586
DATE OF TEST DEC. 23, 1918
U.S. EXPERIMENTAL MODEL BASIN
NAVY YARD
WASHINGTON D.C.
(MODEL WITHOUT RUDDER) (BRONZE PROPELLERS)
S.H.P. AT 4.23 KTS. CORRESPONDING
WITH 10 K'TS. FOR SHIP = 11.45
R.P.M.
THRUST
THRUST
RESISTANCE
THRUST DEDUCTION
PROPELLER EFFICIENCY
TRUE SLIP
APPARENT SLIP
WAKE FRACTION
THRUST DEDUCTION
COEFFICIENT
2.0 .2 .4 .6 .8 3.0 .2 .4 .6 .8 4.0 .2 .4 .6
SPEED IN KNOTS
AVERAGE REV. PER MINUTE
SLIP, WAKE FRACTION, THRUST DEDUCTION COEFFICIENT AND EFFICIENCY
TORQUE IN LB. INCHES: THRUST, RESISTANCE AND THRUST DEDUCTION IN LBS.

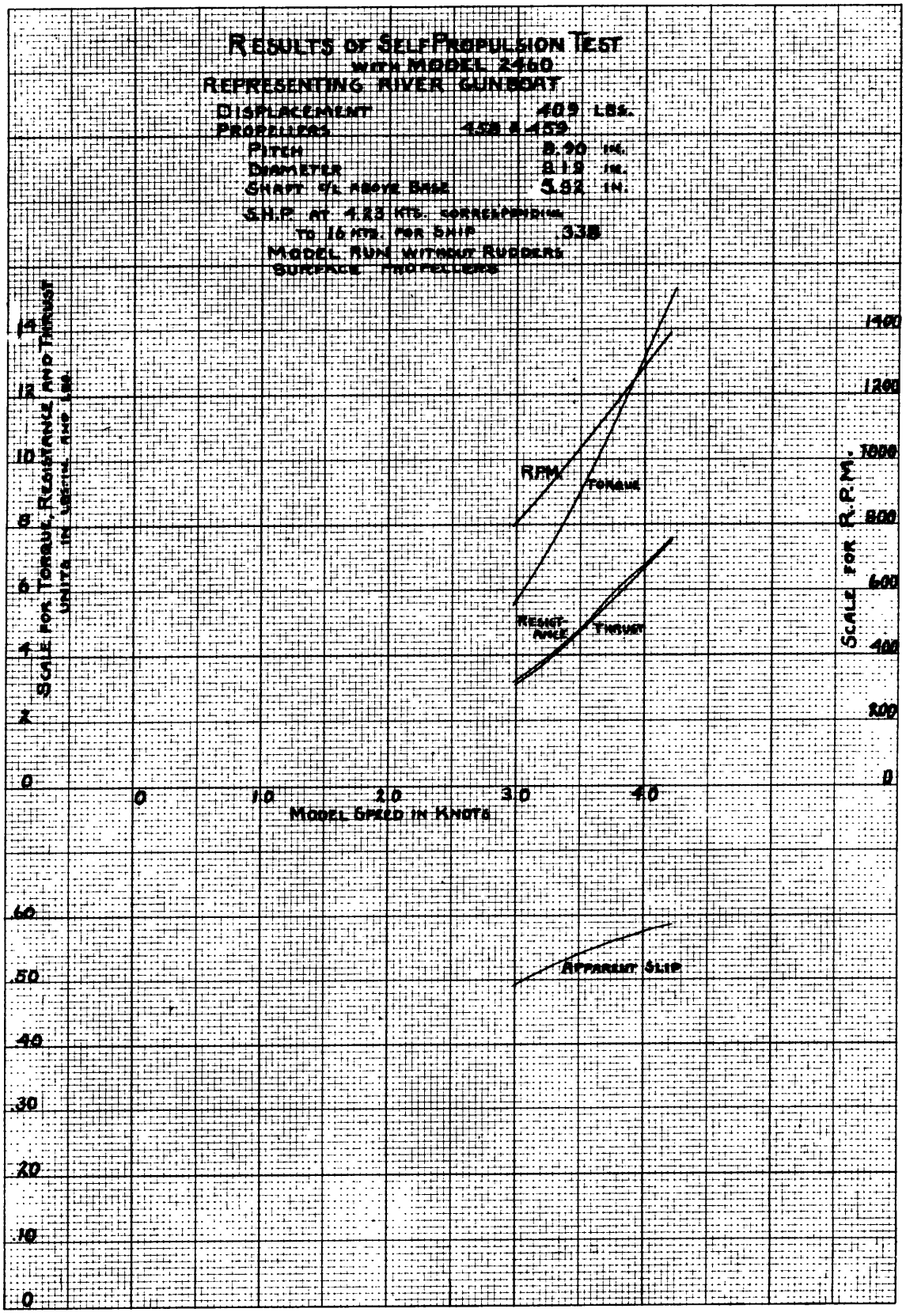

RESULTS OF SELF PROPULSION TEST
WITH MODEL 2460
REPRESENTING RIVER GUNBOAT
DISPLACEMENT 409 LBS.
PROPELLERS Nos 586 & 586
DIAMETER 11.34 IN.
PITCH 11.34 IN.
DEPTH OF WATER 8 3/8 IN.
CORRESPONDING TO 20 FT.
MODEL WITHOUT RUDDERS
(SURFACE PROPELLERS)
TORQUE, THRUST & RESISTANCE
R.P.M.
SPEED IN KNOTS
TORQUE
THRUST
R.P.M.
RESIST-ANCE
0
0.5
1.0
1.5
2.0
2.5
32
30
28
26
24
22
20
18
16
14
12 600
10 500
8 400
6 300
4 200
2 100

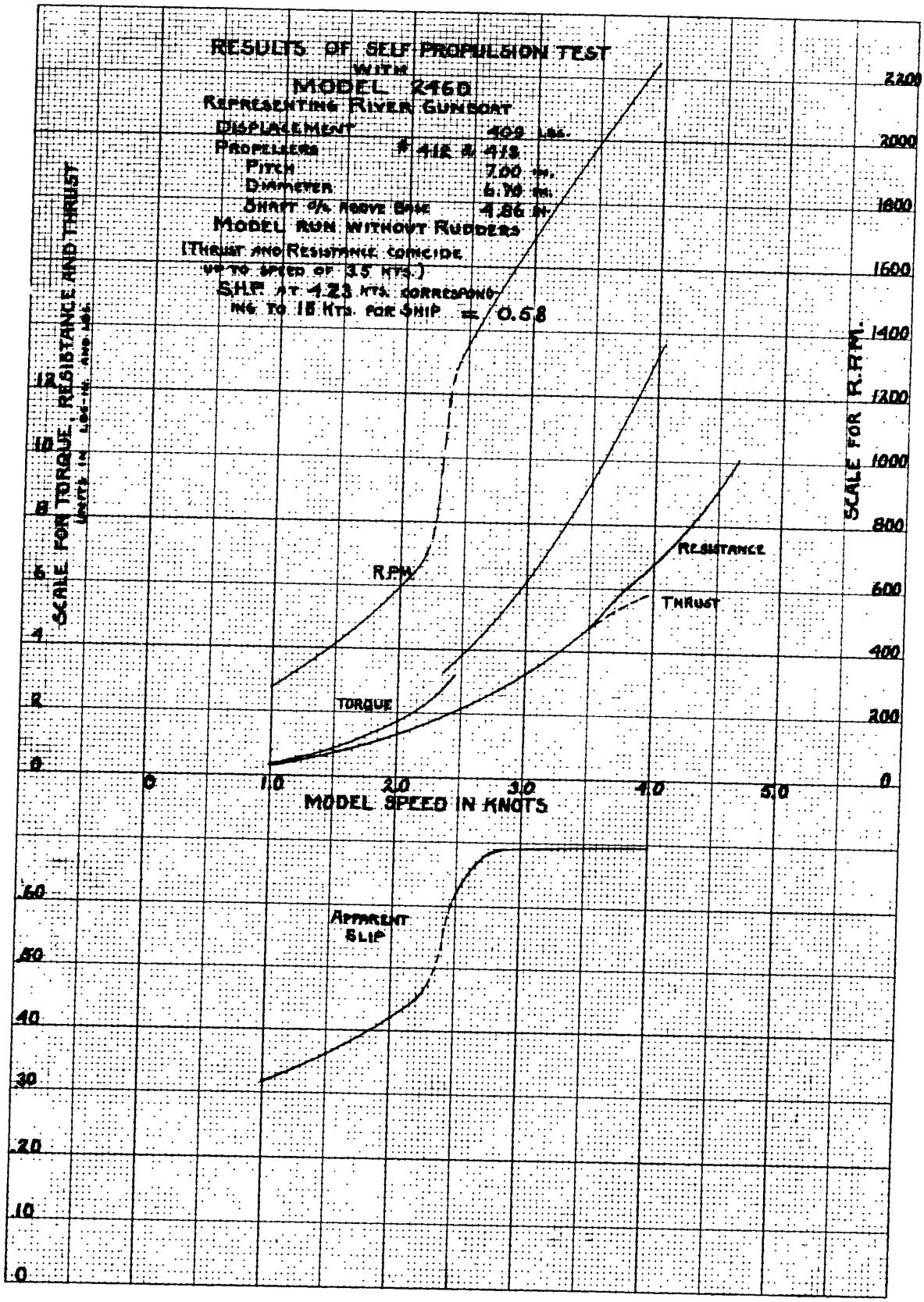

RESULTS OF SELF PROPULSION TEST
WITH
MODEL 2460
REPRESENTING RIVER GUNBOAT
DISPLACEMENT 409 LBS.
PROPELLERS No's 585 & 586
DIAMETER 11.34 IN.
PITCH 11.34 IN.
DEPTH OF WATER CORRESPONDING TO 16 13/16 IN. 20 FT.
MODEL WITHOUT RUDDERS
SURFACE PROPELLERS
SCALE FOR TORQUE, THRUST AND RESISTANCE
UNITS LBS-IN. AND IN.
SCALE FOR R.P.M.
TORQUE
R.P.M.
RESIST-ANCE
THRUST
PROPULSIVE EFFICIENCY
TRUE SLIP
WAKE FRACTION
THRUST DEDUCTION COEFFICIENT
APPARENT SLIP
MODEL SPEED IN KNOTS

SHEET 20

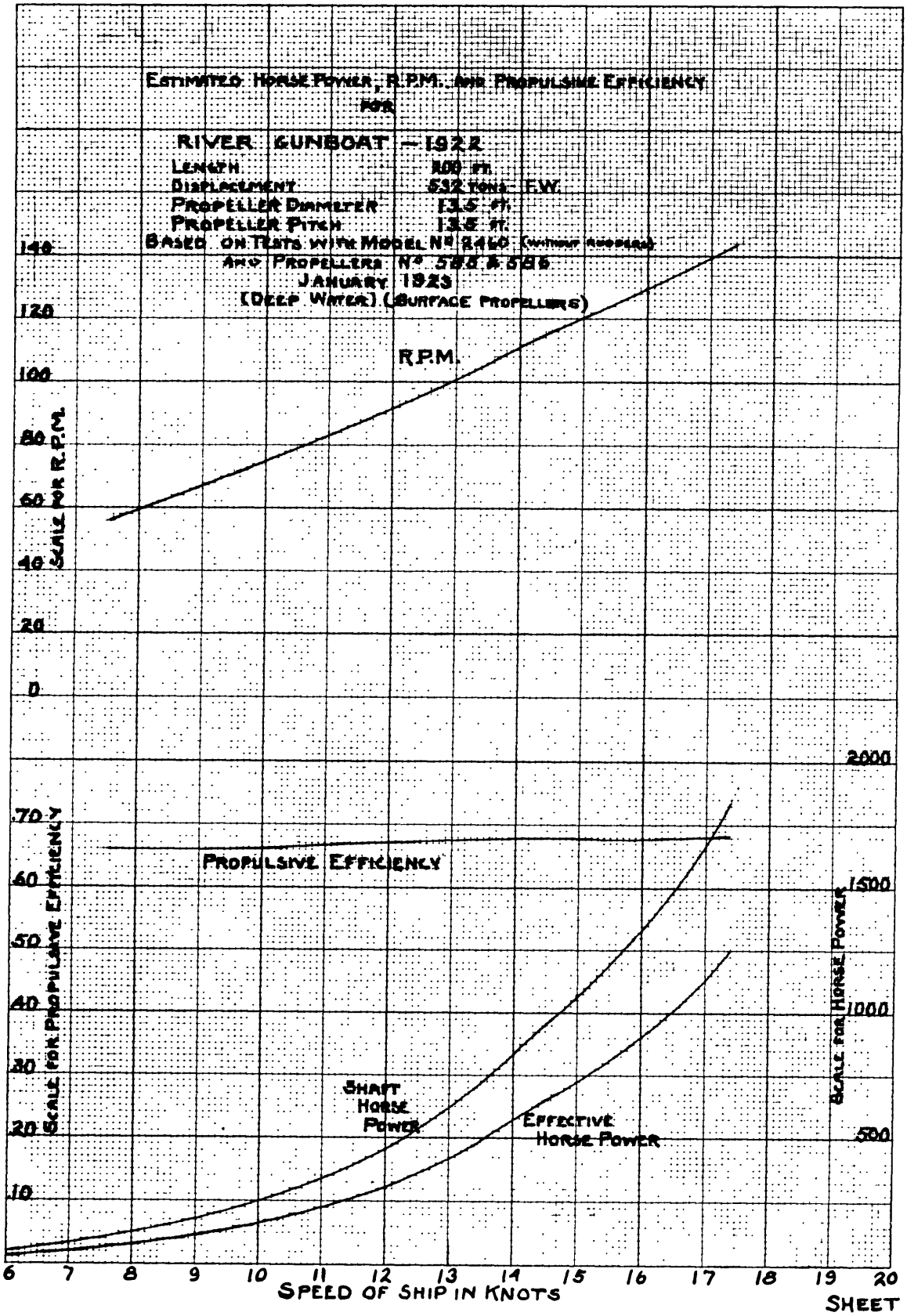

RESULTS OF SELF-PROPULSION TEST
WITH
MODEL 2460
REPRESENTING RIVER GUNBOAT
DISPLACEMENT 409 LBS.
PROPELLERS #458 & 459
PITCH 8.90 IN.
DIAMETER 9.19 IN.
SHAFT C/L ABOVE BASE 4.86 IN.
S.H.P. AT 4.23 KTS. CORRESPONDING
TO 16 KTS. FOR SHIP 0.145
MODEL RUN WITHOUT RUDDERS
SURFACE PROPELLERS
SCALE FOR TORQUE, THRUST AND RESISTANCE
LBS-IN. AND LBS. UNITS
SCALE FOR R.P.M.
R.P.M.
TORQUE
THRUST
RESISTANCE
SPEED OF MODEL IN KNOTS
APPARENT SLIP

SHEET 21

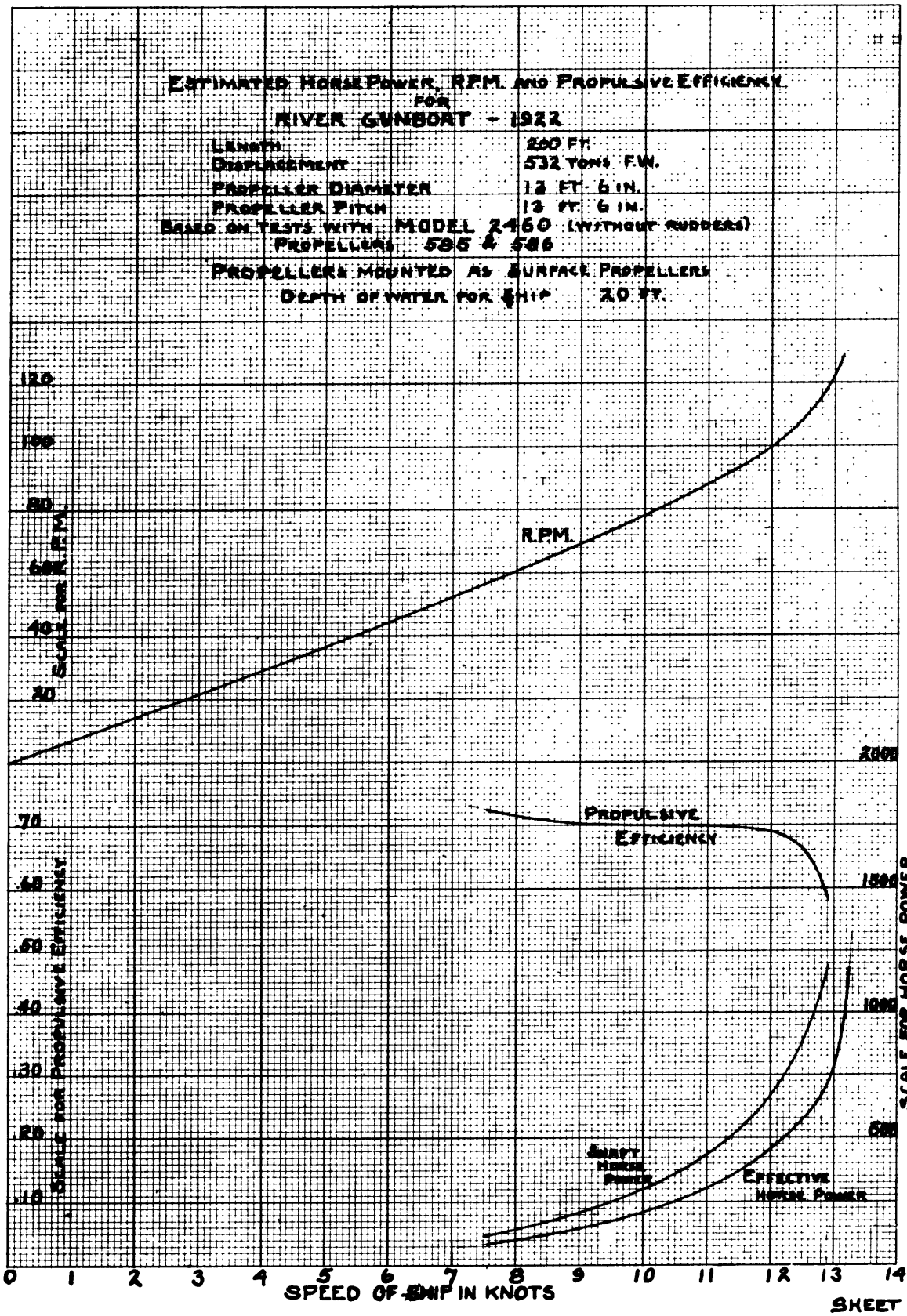

RESULTS OF SELF PROPULSION TEST
WITH MODEL 2460
REPRESENTING RIVER GUNBOAT
DISPLACEMENT 409 LBS.
PROPELLERS 458 & 459
PITCH 8.90 IN.
DIAMETER 8.12 IN.
SHAFT C/L ABOVE BASE 5.82 IN.
S.H.P. AT 4.23 KTS. CORRESPONDING TO 16 KTS. FOR SHIP 338
MODEL RUN WITHOUT RUDDERS SURFACE PROPELLERS
SCALE FOR TORQUE, RESISTANCE AND THRUST UNITS IN LBS. AND LBS.
SCALE FOR R.P.M.
RPM
TORQUE
RESIST-ANCE
THRUST
APPARENT SLIP
MODEL SPEED IN KNOTS
0
1.0
2.0
3.0
4.0
14
12
10
8
6
4
2
0
1400
1200
1000
800
600
400
200
0
60
50
40
30
20
10
0


RESULTS OF SELF PROPULSION TEST
WITH
MODEL 2460
REPRESENTING RIVER GUNBOAT
DISPLACEMENT 409 Lbs.
PROPELLERS # 418 & 419
PITCH 7.00 in.
DIAMETER 6.70 in.
SHAFT C/L ABOVE BASE 4.86 in.
MODEL RUN WITHOUT RUDDERS
(THRUST AND RESISTANCE COINCIDE UP TO SPEED OF 3.5 KTS.)
S.H.P. AT 4.23 KTS. CORRESPONDING TO 15 KTS. FOR SHIP = 0.58
SCALE FOR TORQUE, RESISTANCE AND THRUST
UNITS IN LBS-IN. AND LBS.
SCALE FOR R.P.M.
R.P.M.
RESISTANCE
THRUST
TORQUE
MODEL SPEED IN KNOTS
APPARENT SLIP

SHEET 23.


ESTIMATED HORSE POWER, R.P.M. AND PROPULSIVE EFFICIENCY
FOR
RIVER GUNBOAT — 1922
LENGTH 200 ft.
DISPLACEMENT 532 TONS F.W.
PROPELLER DIAMETER 13.5 ft.
PROPELLER PITCH 13.5 ft.
BASED ON TESTS WITH MODEL Nº 2460 (WITHOUT RUDDER)
AND PROPELLERS Nº 588 & 589
JANUARY 1923
(DEEP WATER) (SURFACE PROPELLERS)
R.P.M.
SCALE FOR R.P.M.
140
120
100
80
60
40
20
0
PROPULSIVE EFFICIENCY
SCALE FOR PROPULSIVE EFFICIENCY
70
60
50
40
30
20
10
SHAFT HORSE POWER
EFFECTIVE HORSE POWER
SCALE FOR HORSE POWER
2000
1500
1000
500
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
SPEED OF SHIP IN KNOTS

SHEET 24


ESTIMATED HORSEPOWER, R.P.M. AND PROPULSIVE EFFICIENCY
FOR
RIVER GUNBOAT - 1922
LENGTH 200 FT.
DISPLACEMENT 532 TONS F.W.
PROPELLER DIAMETER 12 FT. 6 IN.
PROPELLER PITCH 12 FT. 6 IN.
BASED ON TESTS WITH MODEL 2460 (WITHOUT RUDDERS)
PROPELLERS 585 & 586
PROPELLERS MOUNTED AS SURFACE PROPELLERS
DEPTH OF WATER FOR SHIP 20 FT.
R.P.M.
PROPULSIVE EFFICIENCY
SHAFT HORSE POWER
EFFECTIVE HORSE POWER
SCALE FOR R.P.M.
SCALE FOR PROPULSIVE EFFICIENCY
SCALE FOR HORSE POWER
SPEED OF SHIP IN KNOTS
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

SHEET 25