UNITED STATES

EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C.

ANALYSIS OF

THE STANDARDIZATION TRIAL DATA OF THE

S. S. SANTA ROSA

10 – 12 OCTOBER, 1932.

EXPERIMENTAL MODEL BASIN
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BUREAU OF
CONSTRUCTION AND REPAIR
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JULY, 1933. REPORT NO. 363.

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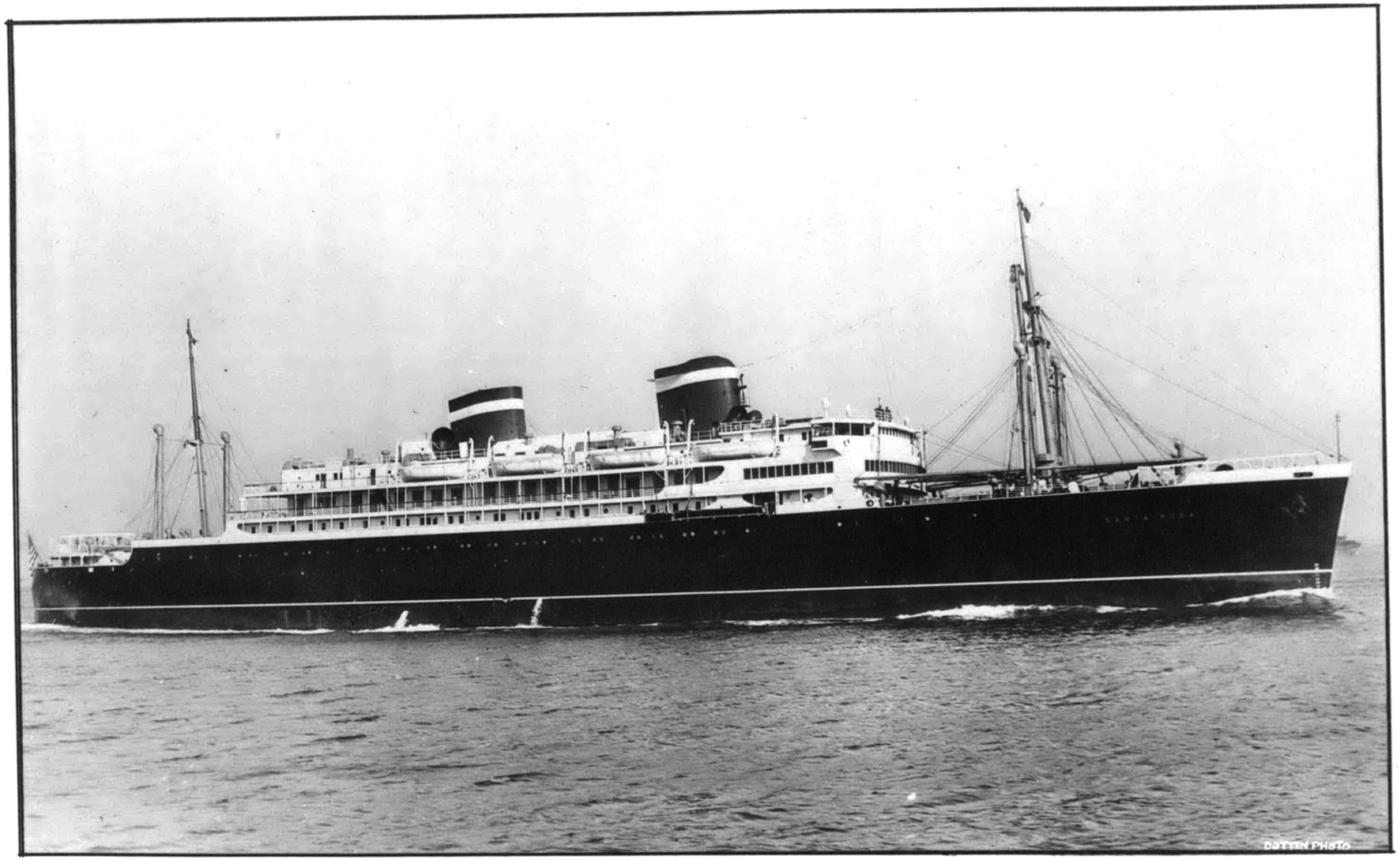


FIG. 1. S.S. SANTA ROSA.

ANALYSIS OF THE STANDARDIZATION TRIAL DATA OF THE S.S. SANTA ROSA 10 - 12 OCTOBER, 1932.

I Abstract

This report contains the complete original data of the standardization trials of the S.S. SANTA ROSA and an analysis of those data by methods in use at the Experimental Model Basin. The performance of the vessel, based on these results is then compared to that predicted from model tests. In conclusion, a discussion of results is given at length.

II Introduction

The S.S. SANTA ROSA is the first of four passenger and cargo liners built by the Federal Shipbuilding and Dry Dock Company for the Panama Mail Steamship Company (Grace Line). These are twin-screw vessels of moderate speed having the following general characteristics:-

Length, overall	508 ft.	Trim	zero
Length, waterline . . .	500 ft.	Displacement	16,102 tons
Beam, molded	72 ft.	Speed, at 12,000 SHP . .	18.5 knots
Draft, mean, loaded . .	25 ft. 3 in.		

The appendages consisted of rudder, bilge keels, and shaft bossings.

These vessels were designed by the firm of Gibbs and Cox, Inc., Naval Architects, and built under certain guaranteed performances as to speed and power, as set forth in Appendix A, which were to be demonstrated by standardizing one vessel of the class over the deep water course at Rockland, Maine. In the course of the design and subsequent construction, numerous tests of models and propellers were made, as a result of which it was decided to carry the propeller shafts in rather steep bossings and to use three-bladed, airfoil-sections, inward-turning propellers.

In view of the interest of all parties concerned in the performance of these vessels, the builders, who were to conduct the trials, decided to use a complete set of special instruments for observing standardization trial data, as is customary for naval vessels. The Experimental Model Basin loaned all the equipment required, including a pressure speed log of its own design for measuring the speed of the vessel through the water.

The services of the Board of Inspection and Survey of the Navy Department were obtained to conduct the trials and to make routine observations as on the trials of naval vessels.

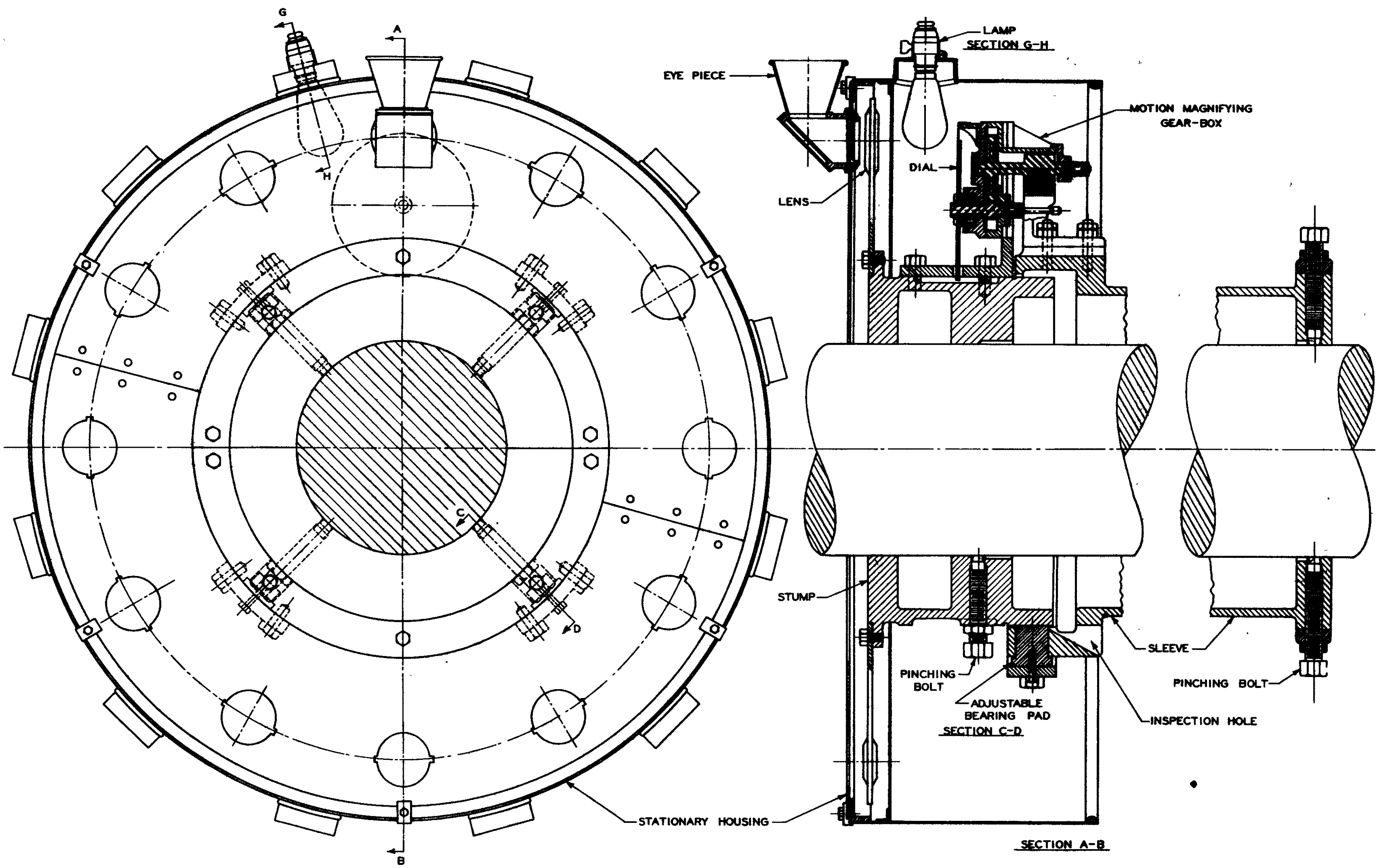


FIG. 2 DENNY-EDGECOMBE TORSIONMETER

GENERAL ARRANGEMENT

III Apparatus and Methods Employed for Observing Trial Data

Briefly, the instruments fitted and the methods of making observations were as follows:-

Speed over the Ground. Elapsed times over the mile were taken by stop watch and by Navy chronograph by three different observers, stationed on the bridge, amidships, and aft. Elapsed times for the forward observer were taken by special (Hamburg) chronograph.

Shaft Horsepower was indicated on each shaft by a Denny-Edgecombe torsionmeter, a diagrammatic arrangement of which is shown in Fig. 2, mounted in the shaft tunnel on the section of line shaft abaft the thrust shaft. There were eight (8) steady bearings abaft the torsionmeter on each shaft. Torsionmeter zeros were obtained (1) by jacking the shaft very slowly in each direction and taking the mean of the readings; (2) by shutting off the power and coasting in each direction (ahead and astern) and taking the mean of the two sets of readings. The mean values thus obtained agreed very closely.

Revolutions of each shaft for the run over the mile were indicated by a Smith-Cummings counter and were recorded by a Taylor printing counter. The former counters were operated by the middle observer and the latter counters by the forward and after observers, giving two sets of readings. Both types of instruments recorded total shaft revolutions for the measured mile.

Individual revolutions on each shaft, for the purpose of studying the variations in revolutions during the run, were recorded by the Hamburg chronograph, actuated by cams and roller contacts on the shaft ring gears.

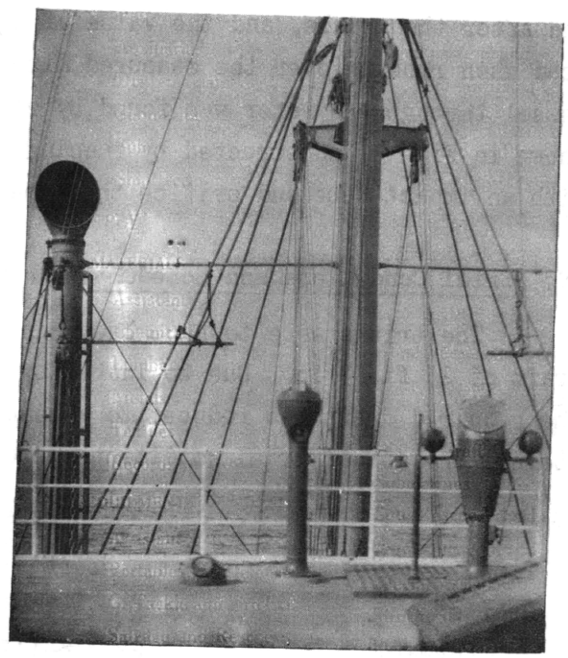


FIG. 3 View of Foremast Showing 3-Cup Anemometer and Wind Vane.

Wind Velocity (relative wind) was recorded (1) by a 3-cup anemometer mounted well up on the foremast, as shown in Fig. 3, and connected to the Navy chronograph; (2) by a 4-cup anemometer mounted on top of the jackstaff and connected to the Hamburg chronograph.

Wind Direction (relative wind) was indicated by a simple wind vane, mounted well up on the foremast, as shown in Fig. 3, and read from the deck below.

Variations from the correct course (0° and 180°) on the measured mile were recorded by a Sperry course recorder. The recorder was set to indicate courses numerically greater than the true courses by 45°, so as to place the records for the north and south headings more nearly in the middle of the chart.

Rudder movements and rudder angles when running the mile were recorded by a Sperry rudder angle recorder loaned to the builders for these trials by the Sperry Gyroscope Company.

Drafts were observed from both outboard marks as well as internal draft gages. No internal draft gage was fitted amidships. The after draft gage was offset 8 feet from the center line.

Speed through the water was indicated and recorded by a pressure speed log, consisting of an impact head or tube mounted on the stem at about the 12 ft. water line, with a small central orifice connected by a small pipe to an indicating gage and a recording gage in the forecastle. This apparatus, shown diagrammatically in Fig. 4, measured static head at the bow plus velocity head due to the speed of the ship; the static head was determined when the vessel was stopped, both before and after the trials, and the value of this head subtracted from the average total head when running over the measured mile to give the net head. The speed of the vessel through the water was found by entering a special calibration curve, as shown in Fig. 5, constructed by running the model self-propelled in the model basin with an impact tube and orifice the same as on the ship.

IV Trial Conditions and Schedule

The trials were to have been run in the normal loaded condition, at a mean draft of 25 ft. 3 in. Due to inability to obtain the necessary cargo as ballast, the required draft was reduced to a mean of 23 feet, with a trim of 1 ft. by the stern. The actual trial conditions were as follows:-

Date of trial	10 October				12 October			
Time	Start		Finish		Start		Finish	
Drafts#	ft.	in.	ft.	in.	ft.	in.	ft.	in.
Forward	22	6-1/4	22	4-7/8	22	4-7/8	Not taken as vessel did not stop.	
Aft	23	7-3/4	23	7-5/8	23	6-3/4		
Mean	23	1	23	0-1/4	22	11-13/16		
Trim, by stern	13-1/2 in.		14-3/4 in.		13-7/8 in.			
Displacement, tons*	14,393		14,340		14,298			
Sp. gravity, sea water	1.0231		1.0225		1.0215			
Temp. sea water, deg. F.	57		58		56			

#All drafts given are with anchors up.

*Displacement is figured at specific gravity as given, and is corrected for trim.

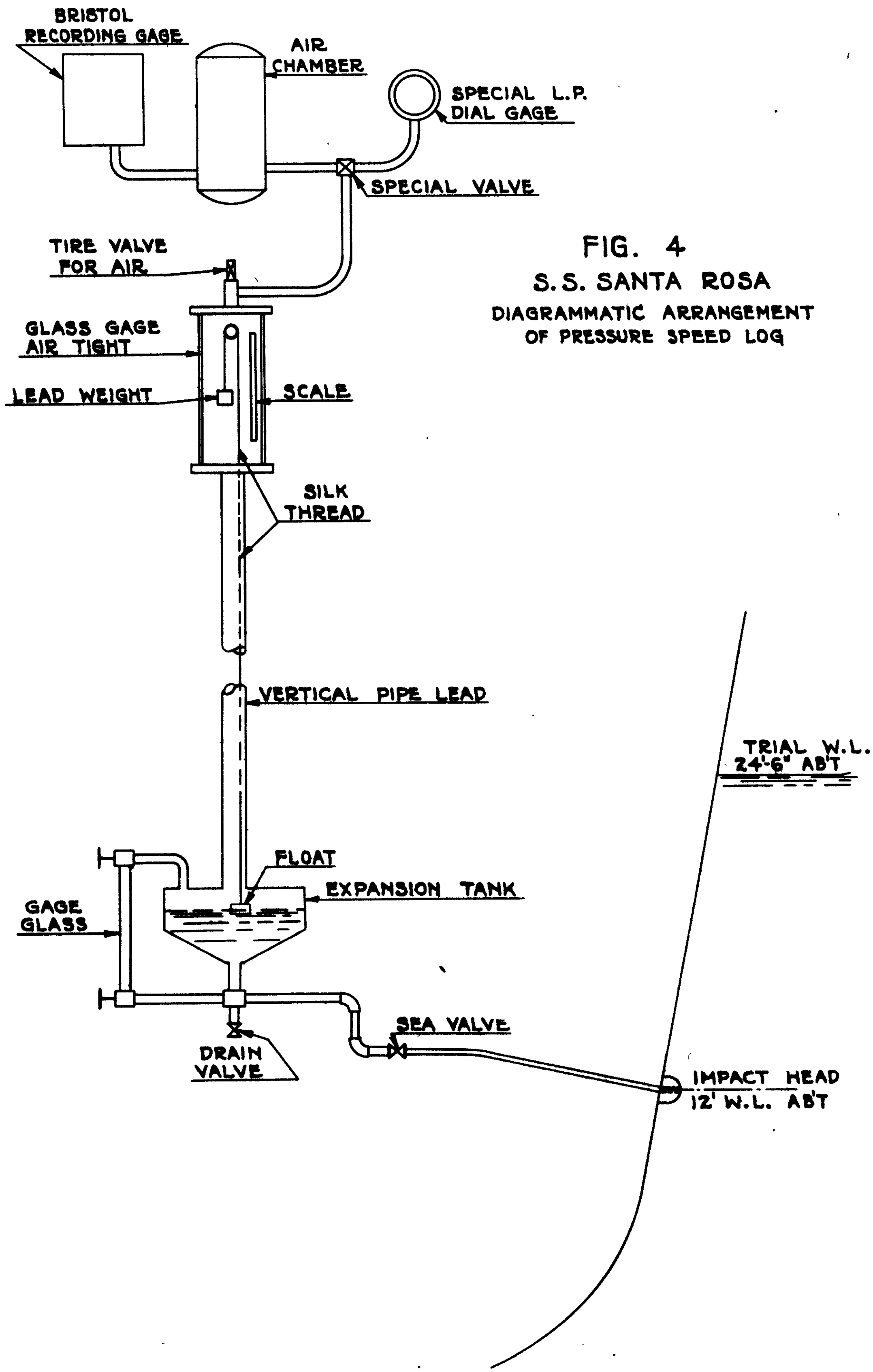


FIG. 4
S. S. SANTA ROSA
DIAGRAMMATIC ARRANGEMENT OF PRESSURE SPEED LOG

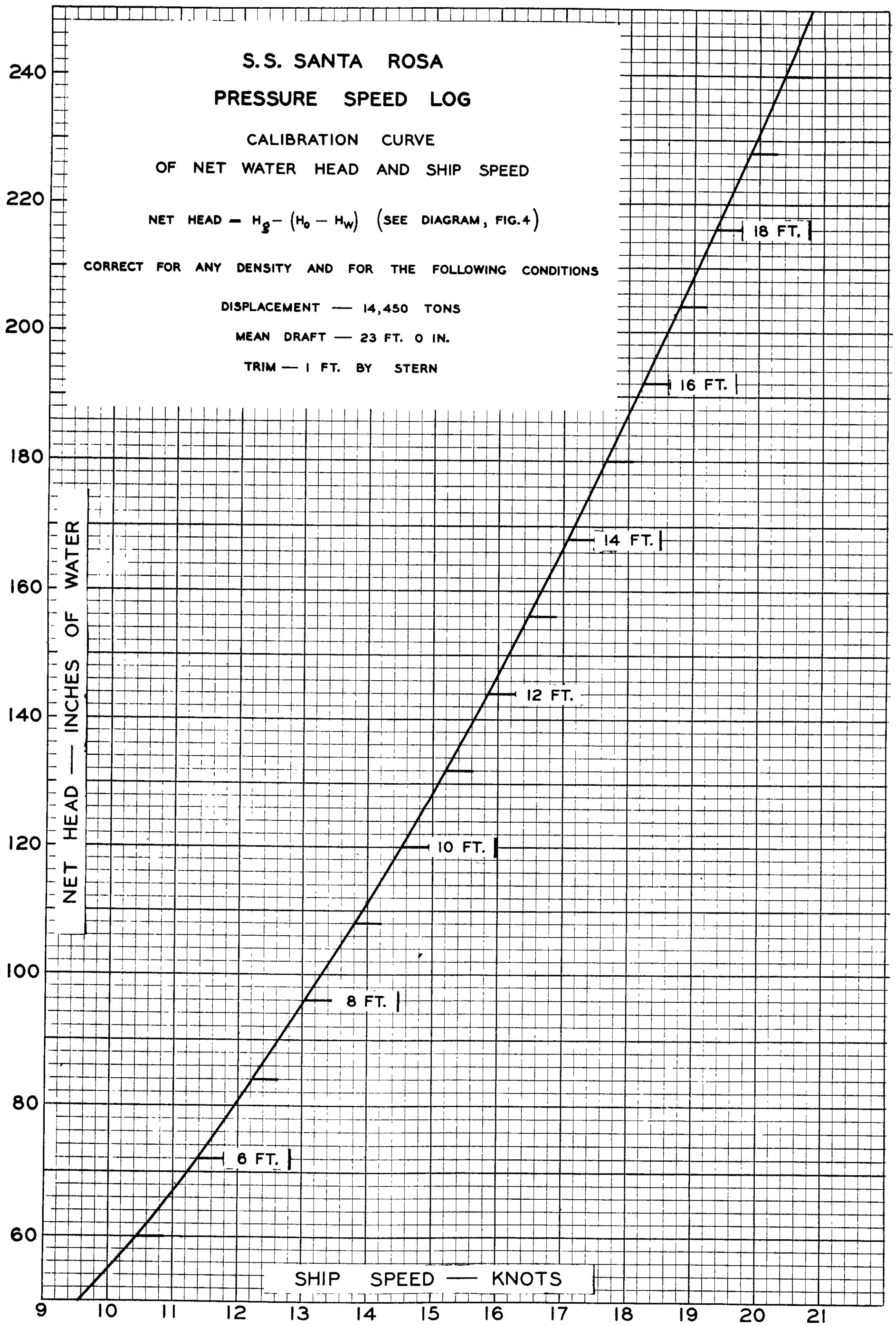

S.S. SANTA ROSA
PRESSURE SPEED LOG
CALIBRATION CURVE
OF NET WATER HEAD AND SHIP SPEED
NET HEAD = $H_s - (H_o - H_w)$ (SEE DIAGRAM, FIG. 4)
CORRECT FOR ANY DENSITY AND FOR THE FOLLOWING CONDITIONS
DISPLACEMENT — 14,450 TONS
MEAN DRAFT — 23 FT. 0 IN.
TRIM — 1 FT. BY STERN
18 FT.
16 FT.
14 FT.
12 FT.
10 FT.
8 FT.
6 FT.
NET HEAD — INCHES OF WATER
SHIP SPEED — KNOTS
240
220
200
180
160
140
120
100
80
60
9
10
11
12
13
14
15
16
17
18
19
20
21

FIG. 5

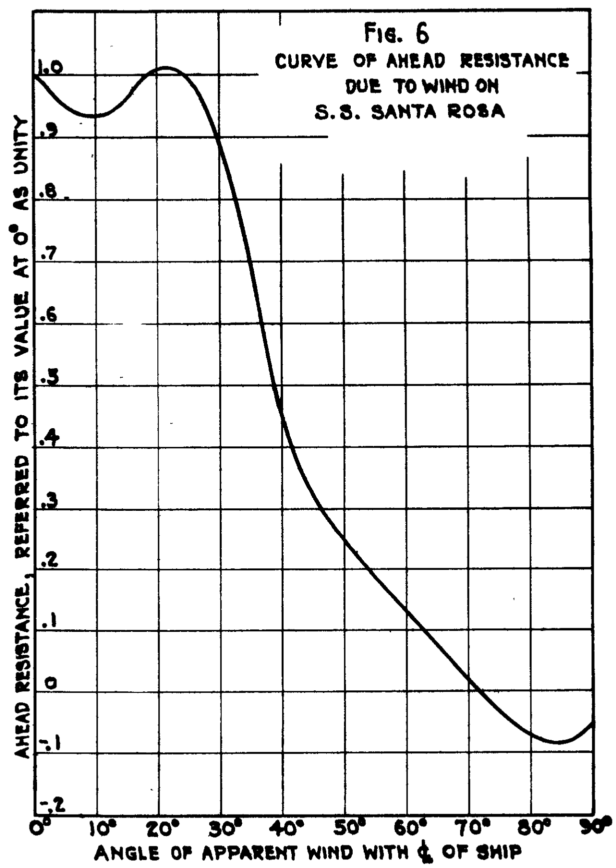
The trial schedule called for three (3) runs each at six pre-determined spots, fixed by propeller revolutions at 50, 65, 77, 87, 94 and at maximum revolutions per minute corresponding to about 14,000 SHP (but in excess of 13,200) at the given displacement and trim.

Due to time lost by reason of thick haze on 10 October, 1932, the spot at 77 RPM was omitted; the others were made in the order named, at the given revolutions specified. Instead of running a single spot at 77 RPM on the next available day, 12 October, three spots were run at 77, 84, and 91 RPM.

The weather on 10 October was partly overcast with variable winds, generally from the S.E. The sea was very nearly smooth with a slight swell from the south. Visibility was only fair.

On 12 October, the wind was fresh from the southwesterly quadrant.

V Correction of Observed Trial Data



The observed trial data are given in sheet 1 of Appendix B.

As there was but meagre information available relative to the wind resistance characteristic of this type of vessel, a wind resistance model, comprising that portion of the vessel above the designed water line, was constructed and tested by towing it inverted in the model basin.

The results of this test did not conform to the anticipated characteristics. Accordingly, additional tests were made as a check. These tests confirmed the results originally obtained. The chief distinguishing characteristic of these results indicated that the vessel, because of its shape, acted somewhat as an airfoil.

As a further confirmation, a smaller model was constructed and tested in the wind tunnel. For angles of relative wind up to 40 degrees, the results of this test agreed remarkably well with those from the basin. Beyond this point, the wind tunnel test showed a greater airfoil effect than the corresponding basin tests. As the model tested in the wind tunnel was relatively smaller, the results of the model basin tests were accepted as the more accurate.

A complete report of these experiments is contained in U.S.E.M.B. Report No. 362. Fig. 6, indicating the wind resistance characteristic is taken from this report and was used in obtaining the correction for wind effect.

Fig. 7 gives the open water characterization of the propellers used in the calculations.

The observed trial data were corrected down to a basis of standard conditions in accordance with methods developed at the U.S. Experimental Model Basin. The calculations are given on sheet 2 of Appendix B.

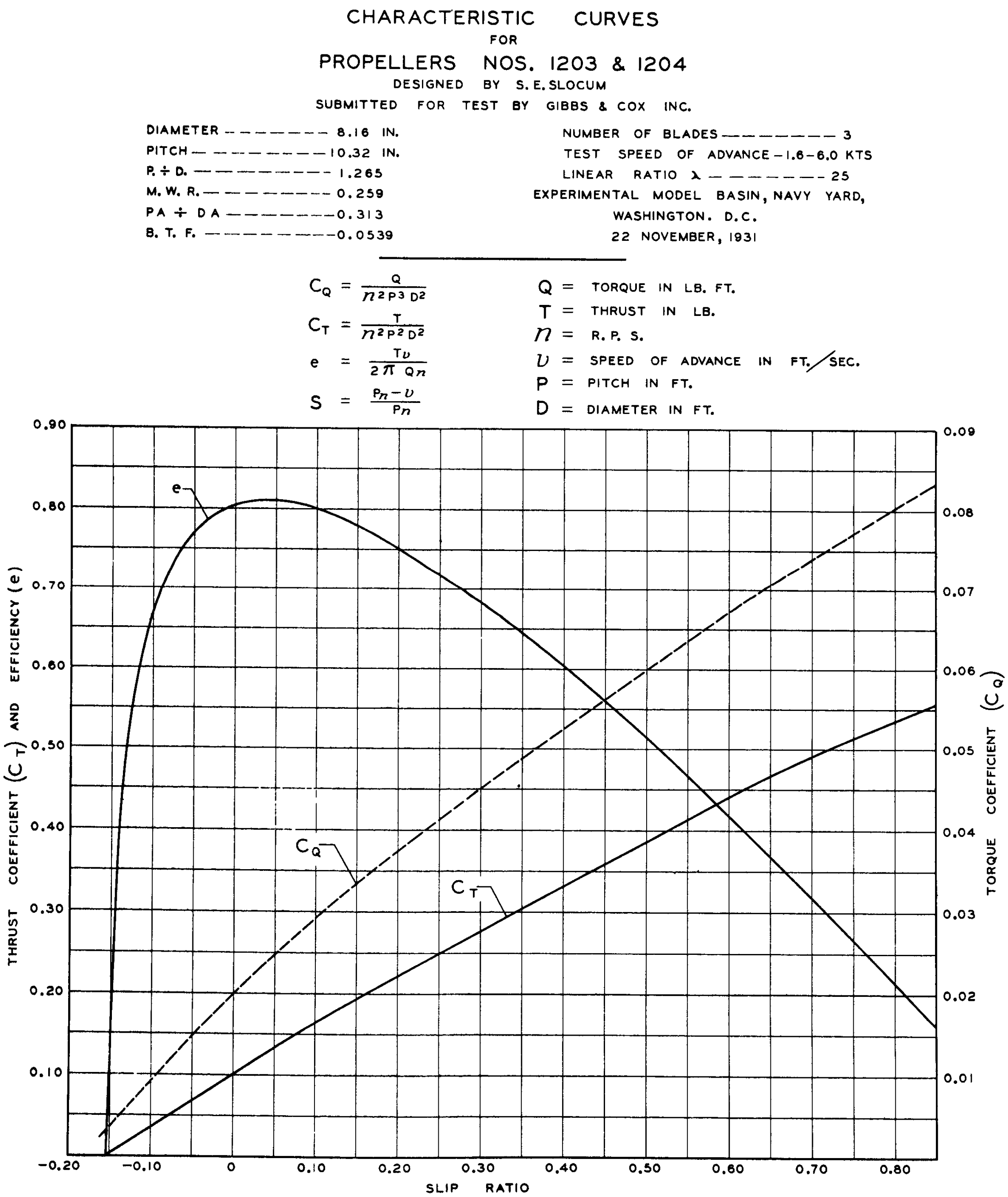


FIG. 7

VI Discussion of Trial Results.

General Comparison

The comparison between actual trial performance, corrected down to standard conditions, and the predicted performance from model tests is given, graphically, in Fig. 8. Table I gives a tabular comparison showing the percentage variation in shaft horse power and revolutions, obtained from the faired curves of Fig. 8, based on model values.

TABLE I

COMPARISON OF TRIAL AND MODEL PERFORMANCE

	SHP			RPM		
Knots	Model	Ship	Per Cent	Model	Ship	Per Cent
10	1300	1360	+4.6	48.0	48.5	+1.04
11	1720	1800	+4.6	52.6	53.2	+1.14
12	2230	2320	+3.9	57.5	58.2	+1.22
13	2850	2980	+4.6	63.4	64.2	+1.26
14	3600	3830	+6.4	67.5	68.6	+1.63
15	4600	4980	+8.3	72.6	74.2	+2.20
16	5790	6150	+6.2	78.0	79.8	+2.30
17	7090	7300	+3.0	83.4	84.6	+0.96
18	8480	8700	+2.6	88.9	89.6	+0.79
19	10300	10550	+2.5	94.6	95.4	+0.85
20	13200	13500	+2.3	101.8	102.6	+0.79

From this table it is seen that up to 13 knots, the shaft horse power characteristic is approximately 4.5 per cent higher for full scale. From 14 to 16 knots there appears a hump which places the trial power approximately 7 per cent higher than the model. Above 17 knots the average increase is slightly more than 2.5 per cent.

The increase in revolutions is, approximately, in agreement with the increase as indicated for the shaft horse power.

Ordinarily a hump would be anticipated at approximately 15 and 18 knots in the case of this vessel. From the model results, this condition was not noticeable, whereas in the full scale only that hump at 15 knots was experienced.

Since no thrust was measured during these trials, it is not possible to develop the performance characteristics of the propellers. Whether the difference in shaft horse power and revolutions between trial and model is due to any variation in frictional resistance or to change in propeller efficiency is impossible to say. However, because of its nature, the frictional resistance characteristic may have suffered the greater variation.

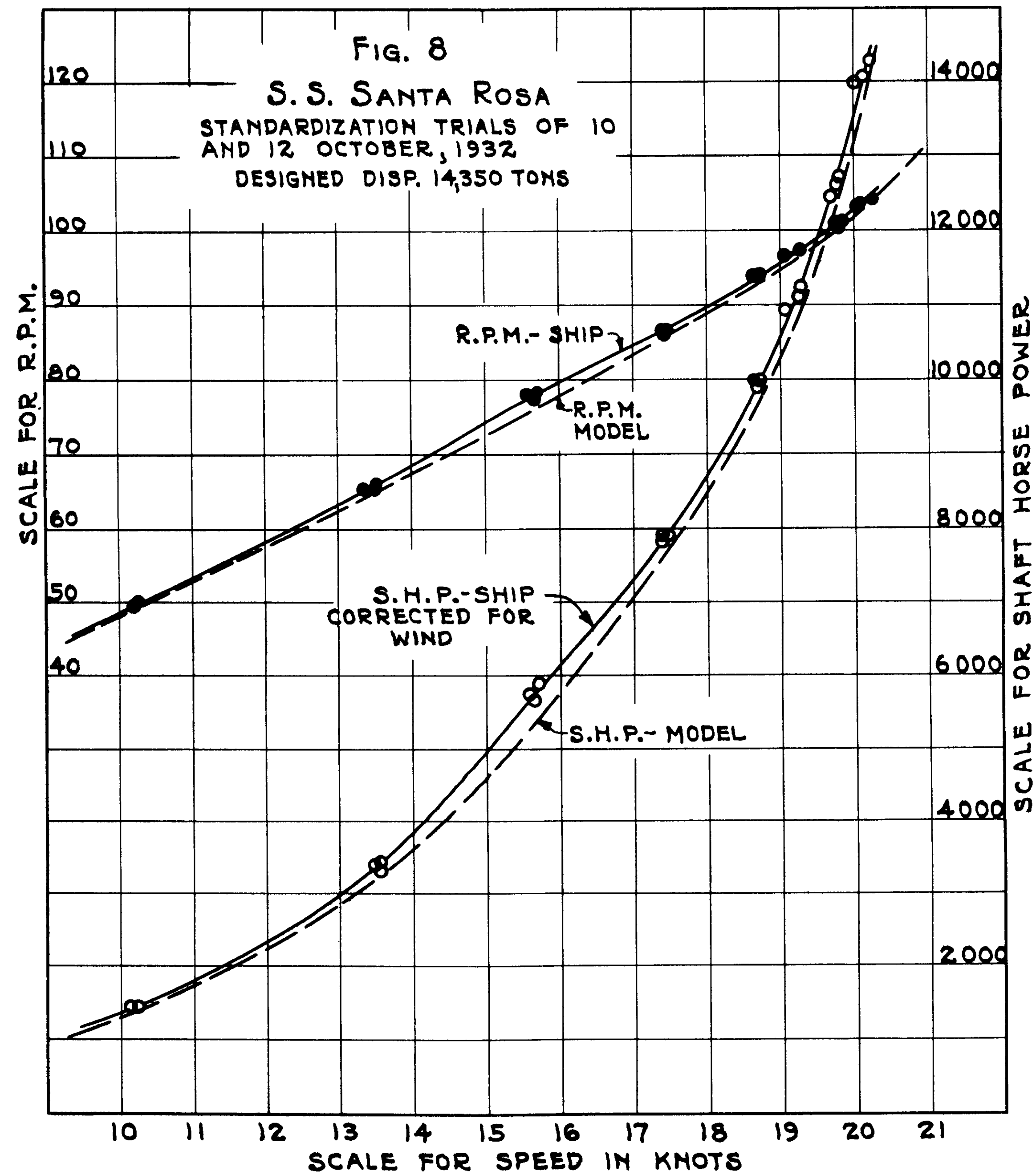


FIG. 8
S. S. SANTA ROSA
STANDARDIZATION TRIALS OF 10 AND 12 OCTOBER, 1932
DESIGNED DISP. 14,350 TONS
R.P.M.- SHIP
R.P.M. MODEL
S.H.P.-SHIP CORRECTED FOR WIND
S.H.P.- MODEL
SCALE FOR R.P.M.
40
50
60
70
80
90
100
110
120
SCALE FOR SHAFT HORSE POWER
2000
4000
6000
8000
10000
12000
14000
10
11
12
13
14
15
16
17
18
19
20
21
SCALE FOR SPEED IN KNOTS

As the vessel was out of dock but 10 days prior to time of trials, there would be a slight addition because of fouling. Assuming an increase in frictional resistance of approximately 0.25 per cent per day—a total of 10 days would result in an increase of about 2.5 per cent which in turn, would increase the E.H.P. approximately about one per cent. This would result in requiring about the same percentage increase in shaft horse power.

From this it is seen that only above eighteen knots would the increase for fouling approximately compensate for the additional trial shaft horse power.

Effect of Rudder

Table II gives the average rudder angle, the maximum rudder angle, and the number of times the rudder was shifted during each run.

TABLE II

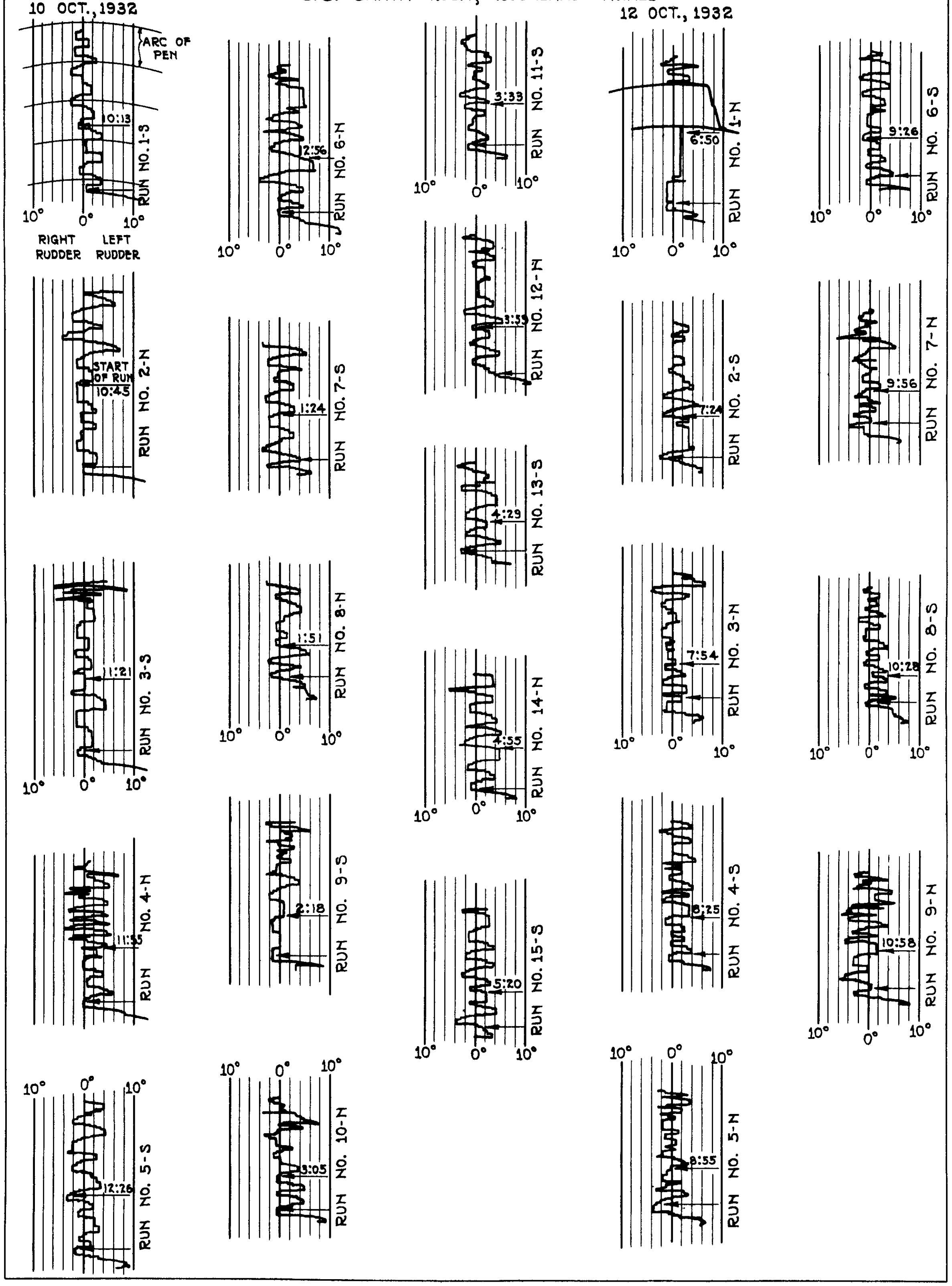
RUDDER ANGLE RECORD

Run No.	Ave. Rudder Angle, Degrees	Maximum Rudder Angle, Degrees	Rudder Shifted
	10 October, 1932		
1S	2.0	4.0	12
2N	0.5	2.4	12
3S	2.0	4.4	10
4N	2.0	5.7	14
5S	2.0	3.2	15
6N	2.6	7.0	11
7S	3.0	4.0	8
8N	3.2	6.0	10
9S	0.7	1.5	6
10N	2.2	4.6	9
11S	1.8	2.2	11
12N	2.0	4.7	10
13S	2.5	5.0	7
14N	3.0	5.0	7
15S	2.5	4.0	8
	12 October, 1932		
1N	1.3	2.3	7
2S	2.2	4.2	9
3N	2.0	3.0	10
4S	1.8	4.0	13
5N	2.0	4.0	10
6S	2.0	4.5	11
7N	2.0	4.0	13
8S	2.0	5.5	9
9N	2.0	5.6	8

This same comparison is given, graphically, in Fig. 9. Just to what extent this condition influenced the increase in resistance is problematical.

FIG. 9

S. S. SANTA ROSA, ROCKLAND TRIALS



Speed Through the Water

Table III gives a comparison between the speed through the water as calculated from the standardization and as measured by means of the pressure speed log.

TABLE III

COMPARISON OF SPEED THROUGH WATER
BY CALCULATION AND BY MEASUREMENT
10 October 1932

Run No.	Speed as calculated Col. 26 Appendix B, knots	Speed as measured, knots	Difference in knots	Difference in per cent
1S	10.09	10.06	+0.03	+0.3
2N	10.19	10.12	+0.07	+0.7
3S	9.97	10.00	–0.03	–0.3
4N	13.52	13.37	+0.15	+1.1
5S	13.12	13.00	+0.12	+0.9
6N	13.50	13.47	+0.03	+0.2
7S	15.47	15.22	+0.25	+1.6
8N	15.68	15.63	+0.05	+0.3
9S	15.36	15.39	–0.03	–0.2
10N	19.23	18.95	+0.28	+1.5
11S	18.77	18.68	+0.09	+0.5
12N	19.24	19.04	+0.20	+1.0
13S	19.93	19.83	+0.10	+0.5
14N	20.19	20.01	+0.18	+0.9
15S	19.89	19.27	+0.12	+0.6
		12 October 1932		
1N	17.30	17.07	+0.23	+1.3
2S	17.13	16.89	+0.24	+1.4
3N	17.34	17.00	+0.34	+1.9
4S	18.49	18.34	+0.15	+0.8
5N	18.58	18.34	+0.13	+0.7
6S	18.49	18.30	+0.19	+1.0
7N	19.68	19.55	+0.13	+0.7
8S	19.49	19.35	+0.14	+0.7
9N	19.81	19.58	+0.23	+1.2

For trials run on 10 October, 1932, the above comparison indicated that the pressure log measurements were on the average 0.60 per cent low. For the runs on 12 October, 1932, the measurements were 1.08 per cent low, or a mean of 0.84 per cent low for all the runs taken as a whole.

Current Characteristics

Fig. 10 shows a comparison of the current curves as calculated and as predicted from lunisolar observations by the Coast and Geodetic Survey. This latter curve has been corrected to include the current caused by the true wind.

It will be noted that the trial curve is displaced, relative to the corrected curve, by an amount of approximately 0.4 to 0.6 knots. This displacement represents not only the river and localized currents present, but also any changes in the predicted and modified curves from those values anticipated. However, since there is good agreement in shape and characteristic between the trial and corrected curves for both days, the indication is that the observed data can be accepted as consistent and as reasonably accurate.

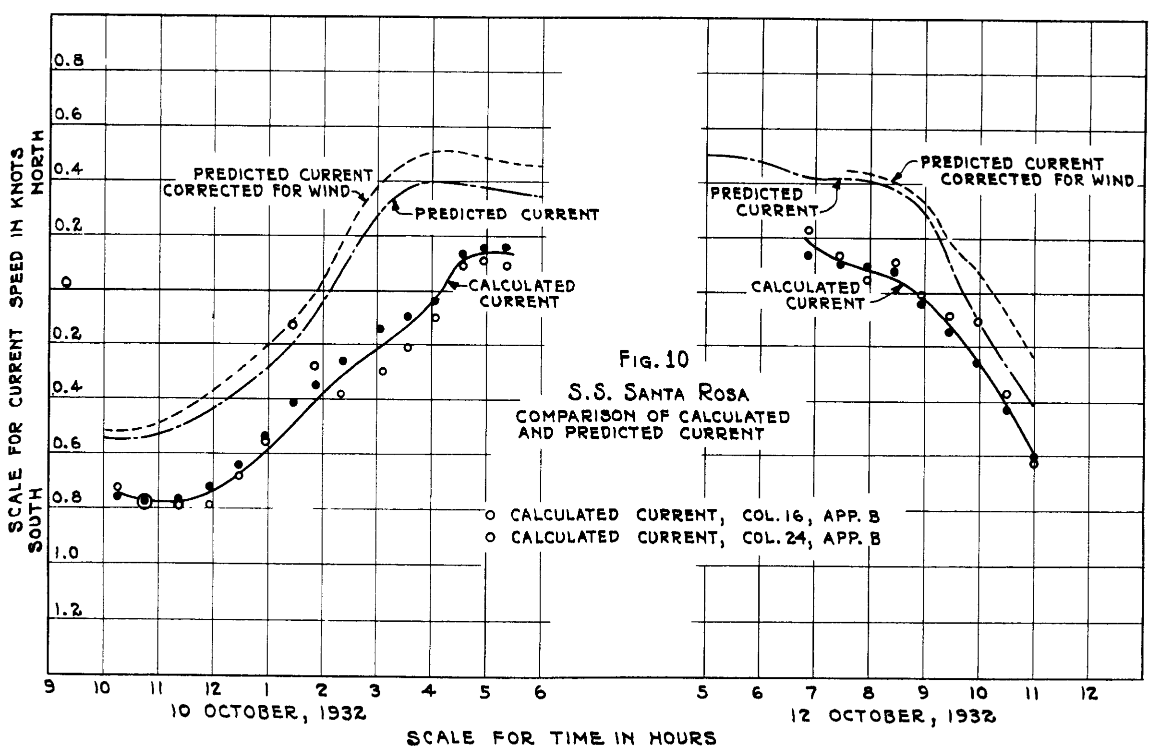


FIG. 10

APPENDIX A

S.S. SANTA ROSA

Contract Requirements Relating to Sea Trials and Standardization Trials

When the work contemplated herein has been substantially completed, each vessel built from these specifications and guidance plans will be put through a sea trial. The first vessel will be put through an extended sea trial including standardization progressive speed trial over the course off Rockland, Me., and fuel consumption trials as specified below

In the case of the first vessel completed in accord with these specifications and guidance plans, it will have all fuel, fresh water and ballast tanks filled with fresh water, ballast and/or fuel oil, except such tank space reserved to add ballast to maintain trim and draft during trials. In addition, the builder will provide and stow on board, in a satisfactory manner fixed ballast and/or cargo, satisfactory and acceptable to the Owner, sufficient to bring the vessel to a mean draft even keel trim when on the standardization trial of 25'-3" and this draft and trim will be substantially maintained by the use of ballast during the fuel consumption runs defined below (a) to (d) inclusive. The sea trial will consist of the following: The vessel will proceed to the deep water trial course off Rockland, Me., and there will carry out a standardization progressive speed trial. This progressive trial will consist of three runs each at approximately 10, 13, 15, and 18 knots and five runs at the maximum speed obtainable. Thereafter, the following fuel consumption and endurance trials will be carried out:-

(a) Four hour continuous maximum power run with the propelling machinery developing not less than 13,200 SHP at about 98 RPM of the propeller.

(b) Four hour run with the propelling machinery developing about 12,000 SHP.

(c) Four hour run with the propelling machinery developing about 9,000 SHP.

(d) Four hour run with the propelling machinery developing about 6,000 SHP.

The fuel consumption for all purposes on these runs will be accurately determined by measuring tanks.

SHEET 1

TRIAL ANALYSIS OF S.S. SANTA ROSA

APPENDIX B

GENERAL DATA

DATE OF TRIALS, 10 & 12 OCT. 1932
LOCATION OF TRIALS, ROCKLAND ME.
DATE OF LAST DOCKING, 2 OCT. 1932
DAYS OUT DOCK,
LOCATION OF SHIP,
LENGTH, 500 FT
BEAM, 72 FT.

TRIAL DATA

ITEM	SHIP	MODEL
DISPLACEMENT,	14353 TONS	14350 TONS
DRAFT,	23 FT. 0 IN.	23·1 FT.
TRIM,	$13\frac{1}{2}$ IN BY STERN	EVEN KEEL
TEMP. OF WATER,	57° & 56°	
SP. G. OF WATER,	1·0228	
APPENDAGES,	RUDDER, BILGE KEELS AND BOSSINGS	
MODEL NO.,		3083
TEST NO.,		19

PROPELLER DATA

DIAMETER, 17 FT 0 IN
PITCH, DESIGNED, 21 FT 6 IN
PITCH, MEASURED,
NO. OF BLADES, 3
M.W.R., .259
B.T.F., .0539
P.A./D.A., .313
DIR. OF ROTATION, INBOARD
TIPS BELOW SURFACE, 4·85 FT (EVEN KEEL)
NO. OF PROPELLERS, 2
MODEL NOS., 1203 & 1204

FORMULAE & COLUMN DESIGNATIONS METHOD I

COL. 9 - THRUST CORRECTED FOR SHAFT DRAG
COL. 10 - $C_T^* = \frac{T}{\rho P^2 D^2 n^2} = --- \frac{T}{N^2}$
COL. 11 - $C_Q^* = \frac{SHP \times 33000 \times 3600}{\rho N^3 \times 2\pi \times P^3 \times D^2} = 6.44 \frac{SHP}{N^3}$
COL. 12 - $S = m\,C_Q - a$ $= 13.40\,C_Q - .30$
COL. 13 - $V_a = \frac{PN(1-S)}{101.33} = .2121\ N(1-S)$
COL. 14 - WAKE, $\omega = \frac{V - V_a}{V}$
COL. 15 - SPEED THRU WATER, $V_1' = \frac{V_a}{1-\omega}$
COL. 16 - CURRENT, $C = V - V_1'$
COL. 17 - K, FROM EXPERIMENT DATA
COL. 18 - INCREMENT OF H.P. FROM WIND, ΔSHP
COL. 19 - FROM $\frac{dEHP}{dV}$ CURVE
COL. 20 - CORRECTED ΔV = COL.18 ÷ COL.19
COL. 21 - CORR. SPEED OVER G'RD, $V'' = V + \Delta V$
COL. 22 - RPM/KNT, COL.3 ÷ COL.21, = N AVE. ÷ V''
COL. 23 - CORR. SP'D THRU WATER, V''' = COL.3/COL.22
COL. 24 - CURRENT, $C = V'' - V'''$
COL. 25 - ACT. SP'D THRU WATER, $V_2' = V''' - \Delta V$
COL. 26 - MEAN SP'D THRU WATER, $V' = (V_1' + V_2') \div 2$
COL. 27 - SPEED THRU WATER, BASIS NO WIND
COL. 28 - TORQUE COEFF., BASIS NO WIND
COL. 29 - SHP, BASIS NO WIND
COL. 30 - THRUST COEFF., BASIS NO WIND
COL. 31 - THRUST H.P., BASIS NO WIND
COL. 32 - THRUST DEDUCTION
COL. 33 - EHP, BASIS NO WIND

* N = REV. PER MIN., T = THRUST (LBS.), n = REV./SEC., P = PITCH, D = DIAM. (FT.), ρ = SPECIFIC GRAVITY OF S.W.

OBSERVED DATA OCT. 10

1 RUN N. & DIR.	2 TIME TO MIDDLE RUN	3 R.P.M. N	4 OBS. SPEED V	5 S.H.P. TOTAL	6 S.H.P. PER PROP.	7 THRUST T	8 APPAR. WIND VEL. Kts.	8 APPAR. WIND DIR.
1-S	10.25	49.80	10·83	1517	758·5		14·2	F
2-N	10.78	49·73	9·42	1485	742·5		6·3	F 10° S
3-S	11.38	49·60	10·75	1521	760·5		16·4	F 15° P
		49·72	10·11	1502				
4-N	11.95	66·05	12·76	3363	1681·5		6·9	F 45° S
5-S	12.47	65·51	13·78	3418	1709		20·8	F 10° P
6-N	12.97	66·20	12·94	3417	1708·5		8·3	F 40° S
		65·82	13·32	3404				
7-S	1.42	77·61	15·74	5627	2813·5		21·5	F 10° P
8-N	1.87	78·58	15 36	5933	2966·5		12·3	F 40° S
9-S	2·32	78·01	15·68	5923	2961·5		20·7	F 20° P
		78·20	15·54	5854				
10-N	3.10	97·29	19·01	11171	5585·5		13·5	F 30° S
11-S	3.57	96·74	18·92	11420	5710		28·0	F 10° P
12-N	4.06	97·55	19·17	11364	5682		14·0	F 35° S
		97·08	19·01	11345				
13-S	4.52	103·89	19·81	14374	7187		25·3	F 20° P
14-N	4.95	104·35	20·32	14373	7187		13·2	F 15° S
15-S	5.37	103·64	19·76	14275	7137·5		25·8	F 10° P
		104·06	20·05	14349				
				OCT. 12				
1-N	6.87	86·59	17·48	7951	3976		17·8	F 35° P
2-S	7.42	86·31	17·01	7917	3959		23·9	F 20° S
3-N	7.93	86·61	17·39	7930	3965		18·5	F 35° P
		86·46	17·22	7929				
4-S	8.45	93·75	18·39	10112	5056		20·8	F 20° S
5-N	8.95	94·03	18·55	10088	5044		16·2	F 25° P
6-S	9·47	93·87	18·61	10156	5078		24·0	F 15° S
		93·92	18·53	10113				
7-N	9·97	101·12	19·50	12878	6439		16·6	F 30° P
8-S	10·50	100·65	19·88	12849	6425		32·7	F 15° S
9-N	11·00	101·03	19·20	12775	6388		19·8	F 70° P
		100·86	19·62	12849				

REDUCTION OF TRIAL DATA — S.S. SANTA ROSA

SHEET 2

APPENDIX B

1	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
				TORQUE METHOD					POWER METHOD										CORRECTED RESULTS						
	CORR. THRUST	C_T	C_Q	S	Va	ω	V_1'	C	K	ΔSHP	$\frac{\Delta SHP}{\Delta V}$	ΔV	V''	$\frac{N_{av.}}{V''}$	V'''	C	V_2'	V'	Vo	C_{Q0}	SHP_0	C_{T0}	THP_0	t	EHP_0
1-S			.0395	.230	8.14		10.10	.73S	1.00	57	340	.17	11.00		10.24	.76S	10.07	10.09	10.26		1,480				
2-N			.0389	.222	8.21		10.19	.77S	.93	11	"	.03	9.45		10.22	.77S	10.19	10.19	10.22		1,470				
3-S			.0401	.237	8.03		9.96	.79S	.98	75	"	.22	10.97		10.20	.77S	9.98	9.97	10.19		1,460				
					8.15	.194							10.22	4.866						.0385					
4-N			.0376	.205	11.15		13.55	.79S	.32	6	640	.01	12.77		13.49	.72S	13.48	13.52	13.53		3,410				
5-S			.0391	.224	10.78		13.10	.68S	.93	149	610	.24	14.02		13.38	.64S	13.14	13.12	13.36		3,330				
6-N			.0379	.209	11.11		13.50	.56S	.45	12	640	.02	12.96		13.52	.56S	13.50	13.50	13.52		3,435				
					10.96	.177							13.44	4.898						.0381					
7-S			.0388	.220	12.85		15.61	.13S	.93	189	890	.21	15.95		15.54	.41S	15.33	15.47	15.68		5,690				
8-N			.0394	.228	12.87		15.64	.28S	.45	30	880	.03	15.39		15.74	.35S	15.71	15.68	15.71		5,910				
9-S			.0402	.239	12.59		15.30	.38S	1.01	187	870	.21	15.89		15.63	.26S	15.42	15.36	15.57		5,780				
					12.79	.177							15.66	4.992						.0393					
10-N			.0391	.224	16.01		19.31	.30S	.89	88	1680	.05	19.06		19.20	.14S	19.15	19.23	19.28		11,110				
11-S			.0406	.244	15.51		18.71	.21S	.93	385	1450	.27	19.19		19.09	.10S	18.82	18.77	19.04		10,940				
12-N			.0394	.228	15.97		19.27	.10S	.70	75	1810	.04	19.21		19.25	.04S	19.21	19.24	19.28		11,230				
					15.75	.171							19.16	5.067						.0389					
13-S			.0413	.253	16.46		19.90	.09N	1.01	364	2320	.16	19.97		20.11	.14N	19.95	19.93	20.09		14,100				
14-N			.0407	.245	17.71		20.21	.11N	.96	95	2340	.04	20.36		20.20	.16N	20.16	20.19	20.23		14,300				
15-S			.0413	.253	16.42		19.85	.09N	.93	346	2250	.15	19.91		20.07	.16N	19.92	19.89	20.04		14.000				
					16.58	.173							20.15	5.165						.0405					
1-N			.0395	.230	14.15		17.25	.23N	.70	108	1035	.10	17.58		17.44	.14N	17.34	17.30	17.40		7900				
2-S			.0397	.232	14.06		17.15	.14N	1.01	280	1040	.27	17.28		17.38	.10N	17.11	17.13	17.40		7820				
3-N			.0394	.228	14.22		17.34	.05N	.70	117	1050	.11	17.50		17.44	.10N	17.33	17.34	17.45		7900				
					14.12	.180							17.41	4.966						.0393					
4-S			.0396	.231	15.30		18.50	.11N	1.01	227	1300	.17	18.56		18.64	.08N	18.47	18.49	18.66		9940				
5-N			.0392	.226	15.35		18.56	.01S	1.00	138	1300	.11	18.66		18.70	.04S	18.59	18.58	18.69		9970				
6-S			.0396	.231	15.32		18.53	.08S	.96	288	1330	.22	18.83		18.67	.16S	18.45	18.49	18.71		9980				
					15.33	.173							18.68	5.029						.0388					
7-N			.0406	.244	16.21		19.60	.10S	.89	136	2100	.07	19.57		19.82	.25S	19.75	19.68	19.75		12650				
8-S			.0406	.244	16.14		19.51	.37S	.96	564	2060	.27	20.15		19.73	.42S	19.46	19.49	19.76		12440				
9-N			.0399	.235	16.39		19.82	.62S	.01	2	2180	0	19.20		19.80	.60S	19.80	19.81	19.81		12710				
					16.22	.173							19.77	5.102						.0394					