Report of Rolling Experiments

on

MODEL NO. 2300

representing

U.S. AEROPLANE CARRIER LANGLEY

(FORMERLY U.S. COLLIER JUPITER)

U.S. Experimental Model Basin,

Navy Yard, Washington, D. C.

September 1920

Report 18

REPORT OF ROLLING EXPERIMENTS ON MODEL NO. 2300, REPRESENTING U.S. AIRCRAFT CARRIER LANGLEY, (FORMERLY U.S. COLLIER JUPITER)

1. In continuation of the rolling experiments made under the Bureau's instructions on the model of the U.S.S. JUPITER, (now U.S.S. LANGLEY), to determine the roll quenching capacity of bilge keels the results of which were reported to the Bureau in March 1920, it was considered desirable to investigate the possibility of using a gyro-stabilizer.

2. The experiments had for their object a comparison of the quenching powers of bilge keels and of a gyro-stabilizer so far as may be determined by model tests. As the "LANGLEY" is being refitted to carry aeroplanes which are both to fly from and to land on her deck, it appears that the prevention of excessive rolling is a matter of greater importance than for other vessels. As an incident to the tests the increase of the towing resistance of the model when rolling was measured and the corresponding increase in effective horsepower required for the ship estimated with interesting results.

3. For use in the tests a small gyro-stabilizer shown on Photographic Sheet VIII was obtained from the Sperry Gyroscope Co. This was an exhibition stabilizer on hand and as it was not designed especially to suit the model it was larger than necessar Also the speed of the precession motor was not well adapted to the period of the model to give most efficient results. The designed stabilizing moment of the twin gyros when running at 7000 RPM is 57.4 lbs-ft., but during the tests the speed was cut down as far as possible to about 2300 RPM, reducing the stabilizing moment to about 20 lbs-ft. which was still considerably larger

than necessary to quench heavy rolling rapidly.

4. The dimensions of the LANGLEY are, 520' length, 65' beam, 16' draft and 11,000 tons displacement. The model to 1/26t scale was first fitted with bilge keels, representing to scale, keels 15 inches deep by 180 feet in length and rolled in still water to obtain its declining angle curve. The bilge keels were then removed and another declining angle curve obtained. The results are shown on Sheet I, from which the quenching power of the bilge keels may be seen. Thus without bilge keels to reduce the angle of heel from 11° to 3°, required about 54 swings as compare with 8 swings with bilge keels. In making these tests a gyroscopic roll recorder was used so that after the model had been inclined by hand and released a continuous record was obtained showing how the rolling died out in the two cases. Typical curves ar shown in Sheet II. In plotting angles of heel on Sheet I, the swing numbers correspond to successive hollows and crests on thes sinuous curves. In other words, one swing comprises the motion from port to starboard or vice versa.

5. The model was next rolled with and without bilge keel and with the gyro-stabilizer in waves. For this purpose it was held broadside to the waves by single head and stern lines made fast to the model at the water line close to the longitudinal rolling axis. The height and period of the waves could be controlled within limits and could be so adjusted as to produce marked rolling. The results of these tests are shown on Sheet III. In the same system of waves the bilge keels reduce the arc of roll from 26.4° to 9.6°, or about two-thirds, while the gyro-stabilizer reduced it very quickly when cut in, from 34° to 3° or about one-eleventh of the uncontrolled roll which was

somewhat greater than in the two preceding cases, because of bett synchronism between the wave and the natural period of the model.

6. The model was then tested in waves approaching half the period of the model, the resulting records being shown on Sheet IV. With the bilge keels in place, when the wave length was shortened so that the rolling was no longer synchronous, the model stopped rolling almost entirely and no other wave period could be found that would induce rolling to any extent as the typical record on Sheet IV illustrates. When the bilge keels were removed however, it was easy to find a period of wave in the vicinity of the half period of the model, that would cause very heavy rolling. The angle rolled through was so great that it was necessary to use a shorter arm for the pencil of the gyroscope roll recorder, thus changing the scale for angle of roll on the records and running up to at least 48° as shown on Sheet I The last record on Sheet IV shows the effect of the gyro-stabiliz When cut in, the stabilizer almost instantly cut down the maximum of roll to about 2°.

7. As it was apparent from the preceding tests that the roll quenching capacity of the gyro-stabilizer was more than ampl for the model, an investigation was next made to determine its performance in higher waves, the higher waves being attained by increasing the eccentricity of the wave maker while attempting to keep the period of the wave such as to produce maximum rolling. On Sheet V is shown the rolling records for the different waves. In the following table is given the eccentricity of the wave make and the corresponding height, length, and period of the waves for the ship.

TABLE 1

Wave Maker Eccentricity, inches	Approximate Dimensions of Wave for Ship		
	Height, feet	Length, feet	Period, seconds
4	11.9	1391	16.5
5	13.5	1409	16.6
6	17.3	1275	15.8
7	19.5	1357	16.3

It will be seen on Sheet V, that the stabilizer was capable of controlling the roll with the largest wave which the wave maker could produce. In the case of the wave produced by the 6" eccentricity, the stabilized roll was 5^{o} as compared with $2\text{-}1/2^{o}$ for the larger wave, corresponding to a 7" eccentricity. This was due to lack of proper adjustment of the control gyro. The control gyro was adjusted after rolling in the smaller wave and in the larger wave the roll was reduced to 2.5^{o}.

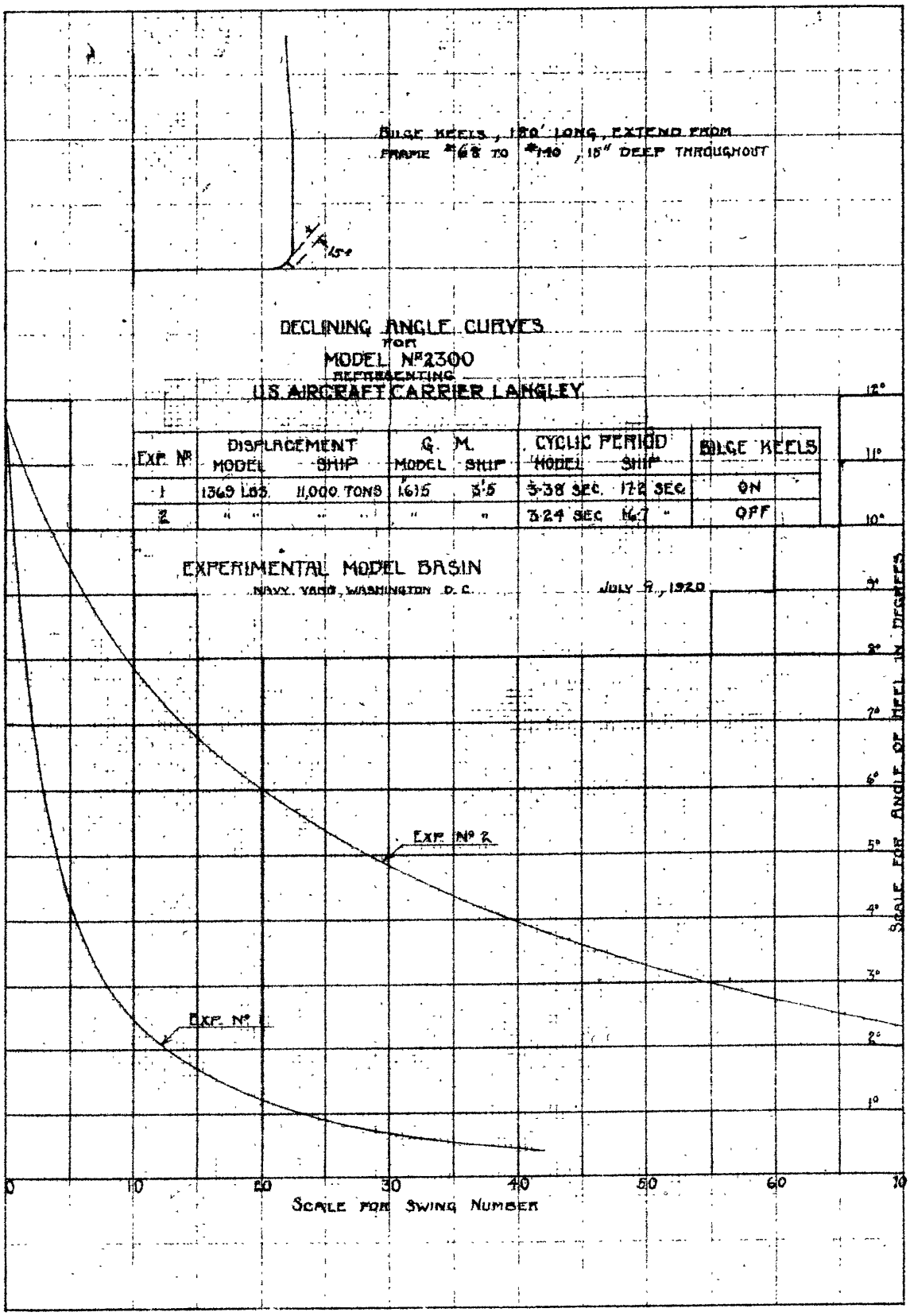
8. The estimated stabilizing moment of the gyro-stabilizer as run during the experiments was 20 lbs. ft. This was the minimum stabilizing moment which could be obtained because the gyro-motors could not be run at any lower speed. To compare the estimated stabilizing moment with a known impressed moment, additional tests were made in which the stabilizer was operated against a rolling moment produced by a weight moving harmonically from side to side in the model through a distance of 8 inches. This weight was actuated by an electric motor placed in the model which was free to roll in still water. By controlling the speed of the motor it was possible to make the harmonic rolling moment agree with the natural period of the model. By varying the weigh

it was possible to increase or decrease the rolling moment. The result of this investigation is shown on Sheet VI. From this it is seen that with a maximum rolling moment of 31.33 lbs. ft., the gyro-stabilizer reduced the roll from 37.5° to 3°. It is to be noted also, that it required several rolls before the angle was so reduced. When the rolling moment was increased to 39.33 lbs.f the roll was reduced by the gyro-stabilizer from 46° to 5° though taking a somewhat greater number of rolls to do so. When still further increase in the rolling moment was made to 47.33 lbs.ft., the capacity of the gyro-stabilizer was clearly insufficient to cope with the same, the roll being reduced from 42° to 34° only. It is apparent from this data and from the action of the gyro-stabilizer when opposed to the rolling moments of waves, that the moments required to produce a given angle of roll in still water is considerably greater than the moment of synchronous waves when causing a similar roll. It is also clear that the gyro-stabilize is capable of controlling a maximum harmonic rolling moment of at least 50% greater than the stabilizing moment exerted by the gyro. Though the disturbing moment may temporarily exceed the stabilizing moment, it apparently does not act for sufficient time to cause much increment in the arc of roll. This appears to confirm certain claims advanced for the so called "Active Gyro-Stabilizer."

9. As a final test an investigation was made of the increase of towing resistence of the model when caused to roll by an harmonic rolling moment applied to the model while being towed in smooth water. The results obtained as reduced to Effective Horsepower Curves for the ship, are shown on Sheet VII. From these it appears that at a speed of 15 knots, the Effective

Horsepower would be increased from 3,000 to 3,300 when the ship is rolling through an arc of 25°, and to 3,600 when rolling throug an arc of 45°, corresponding to an increase in Effective Horsepower of 10% and 20% respectively. It is to be noted that this does not include the loss of power due to decrease in propeller efficiency for a twin screw ship, when the propellers alternately approach the surface, if not actually coming out of the water. Also as the method of towing did not permit free yawing of the model the losses which occur on a ship, because of the increase in rudder resistance as it is moved from side to side in an effort to steer a straight course, were not present. These results confirm experience at sea that loss of speed is found to occur when ships are rolling heavily. Under these circumstances it appears that the power and weight devoted to the means for stabilizing a ship, are more than amply repaid by the saving effected in the power required to drive her.

Wm. McEntee, Commander
Construction Corps, U.S.N.


BILGE KEELS, 120' LONG, EXTEND FROM FRAME #68 TO #140, 15" DEEP THROUGHOUT
45°
DECLINING ANGLE CURVES
for
MODEL Nº2300
REPRESENTING
U.S. AIRCRAFT CARRIER LANGLEY
EXP. Nº | DISPLACEMENT MODEL | DISPLACEMENT SHIP | G. M. MODEL | G. M. SHIP | CYCLIC PERIOD MODEL | CYCLIC PERIOD SHIP | BILGE KEELS
1 | 1369 LBS. | 11,000 TONS | 1.615 | 3.5 | 3.38 SEC. | 17.2 SEC. | ON
2 | " " | " " | " | " | 3.24 SEC. | 16.7 " | OFF
EXPERIMENTAL MODEL BASIN
NAVY YARD, WASHINGTON D. C.
JULY 7, 1920
EXP. Nº 2.
EXP. Nº 1.
12°
11°
10°
9°
8°
7°
6°
5°
4°
3°
2°
1°
SCALE FOR ANGLE OF HEEL IN DEGREES
0
10
20
30
40
50
60
70
SCALE FOR SWING NUMBER

GYROSCOPIC ROLLING RECORDS

RECORDS FOR DECLINING ANGLE CURVES FOR

MODEL Nº 2300

REPRESENTING

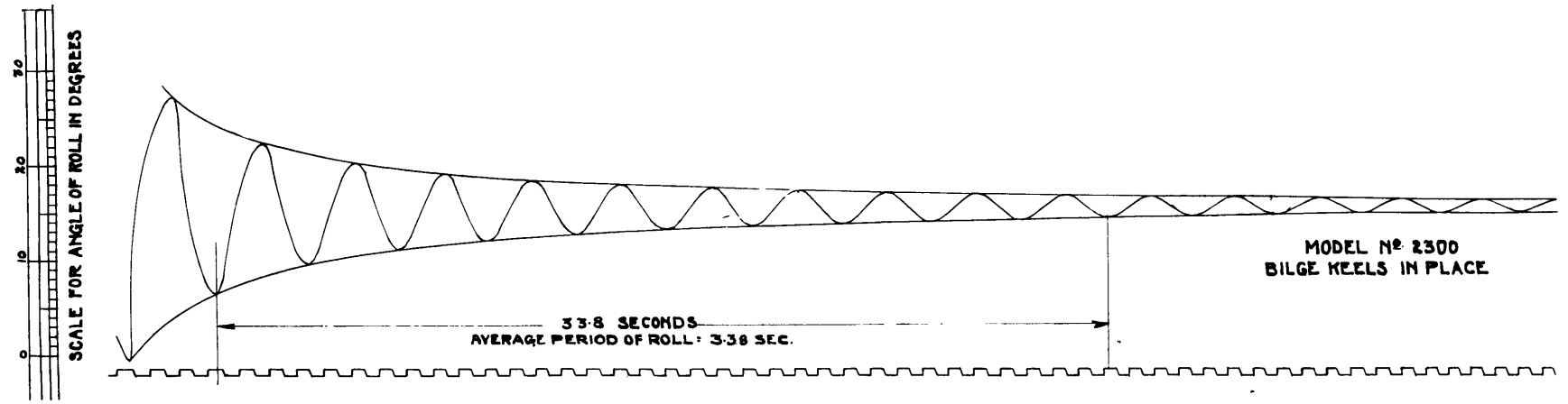
U.S. AIRCRAFT CARRIER LANGLEY

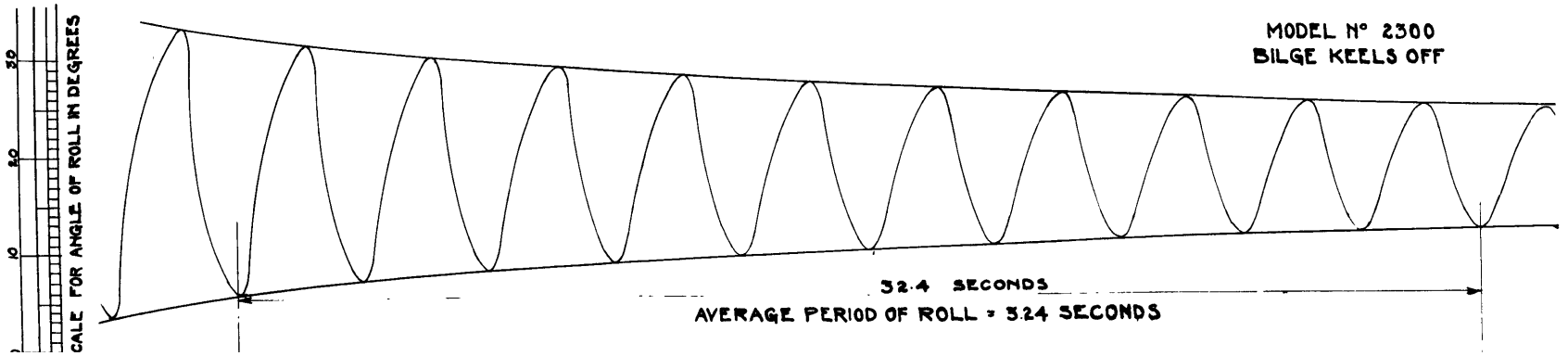
	MODEL	SHIP
G.M.	1·615	3·5
DISPLACEMENT	1369 LBS	11,000 TONS

LINEAR RATIO, SHIP TO MODEL = 26

EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C. JULY 1920





Sheet II

GYROSCOPIC ROLLING RECORDS

MODEL Nº 2300 ROLLING IN WAVES

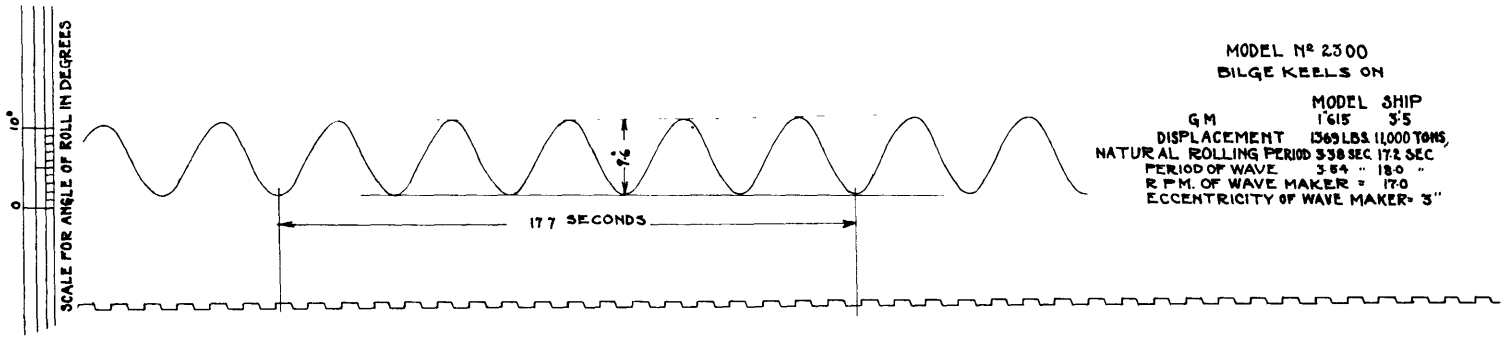
MODEL REPRESENTING

U S AIRCRAFT CARRIER LANGLEY

EXPERIMENTAL MODEL BASIN

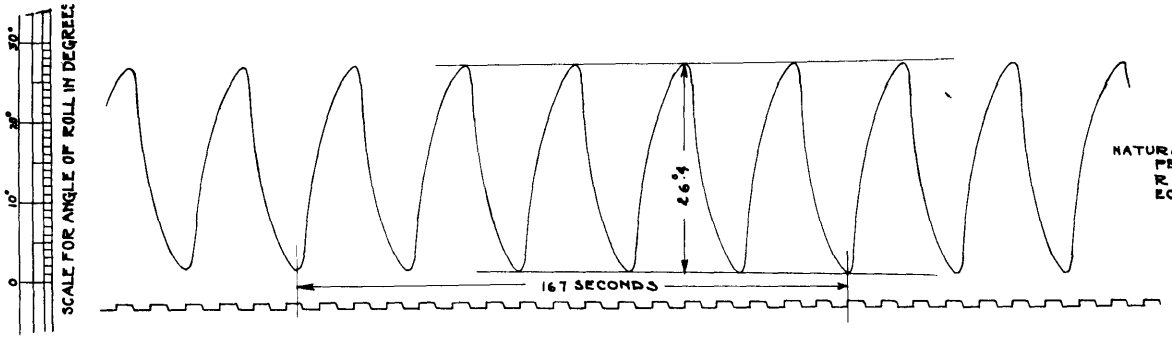
NAVY YARD WASHINGTON, D C

JULY ,1920



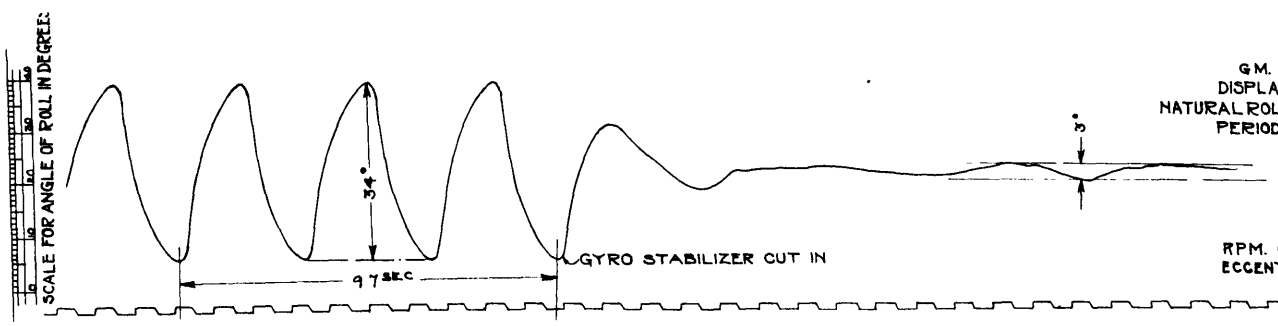
MODEL Nº 2300
BILGE KEELS ON

	MODEL	SHIP
G M	1'615	3'5
DISPLACEMENT	1369 LBS	11,000 TONS
NATURAL ROLLING PERIOD	3.38 SEC	17.2 SEC
PERIOD OF WAVE	3.64 "	18.0 "
R P M. OF WAVE MAKER =	17.0	
ECCENTRICITY OF WAVE MAKER= 3"		



MODEL Nº 2300
BILGE KEELS OFF

	MODEL	SHIP
G.M.	1'615	3'5
DISPLACEMENT	1369 LBS	11,000 TONS
NATURAL ROLLING PERIOD	3.24 SEC.	16.8 SEC.
PERIOD OF WAVE	3.34 "	17.0 "
R.P.M. WAVE MAKER = 17.6		
ECCENTRICITY OF WAVE MAKER= 3"		



MODEL Nº 2300

	MODEL	SHIP
G.M.	1'615	3'5
DISPLACEMENT	1369 LBS	11,000 TONS
NATURAL ROLLING PERIOD	3.24 SEC.	16.5 SEC.
PERIOD OF WAVE	3.23 SEC.	16.5 SEC.

R.P.M. OF WAVE MAKER 18.6
ECCENTRICITY OF WAVE MAKER 3"

Sheet III

GYROSCOPIC ROLLING RECORDS

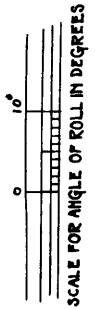
MODEL N° 2300 ROLLING IN WAVES

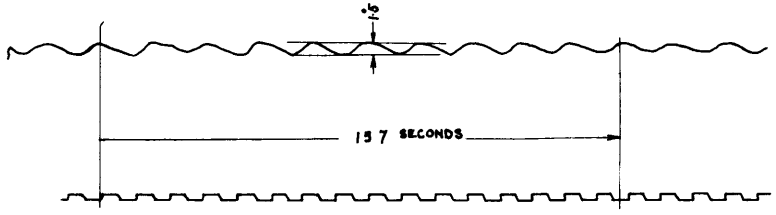
MODEL REPRESENTS

U.S. AIRCRAFT CARRIER LANGLEY

EXPERIMENTAL MODEL BASIN
NAVY YARD, WASHINGTON D.C.

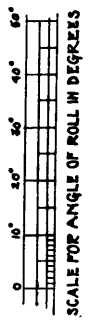
JULY 1920

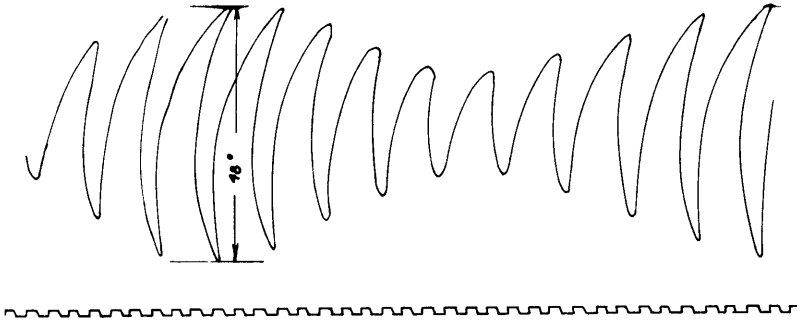




MODEL N° 2300
BILGE KEELS ON

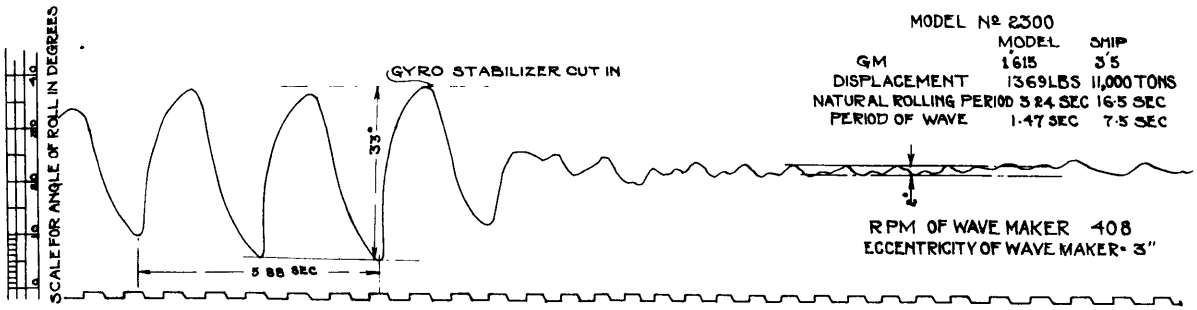
	MODEL	SHIP
G M.	1·615	3·5
DISPLACEMENT	1369 LBS.	11,000 TONS
NATURAL ROLLING PERIOD	3·38 SEC.	17.2 SEC.
PERIOD OF WAVE	1.57 "	8·0 "
R.P.M OF WAVE MAKER	38·2	
ECCENTRICITY OF WAVE MAKER	3"	





MODEL N° 2300
BILGE KEELS OFF

	MODEL	SHIP
G M	1·615	3·5'
DISPLACEMENT	1369 LBS	11,000 TONS
NATURAL ROLLING PERIOD	3·24 SEC	16·8 SEC
PERIOD OF WAVE	1.43 "	7·28 "
R.P.M. OF WAVE MAKER	42	
ECCENTRICITY OF WAVE MAKER	3"	



MODEL N° 2300

	MODEL	SHIP
GM	1·615	3'5
DISPLACEMENT	1369 LBS	11,000 TONS
NATURAL ROLLING PERIOD	3·24 SEC	16·5 SEC
PERIOD OF WAVE	1·47 SEC	7·5 SEC

RPM OF WAVE MAKER 408
ECCENTRICITY OF WAVE MAKER· 3"

Sheet IV

GYROSCOPIC ROLLING RECORDS

MODEL Nº 2300 ROLLING IN WAVES

WITH AND WITHOUT GYRO STABILIZER

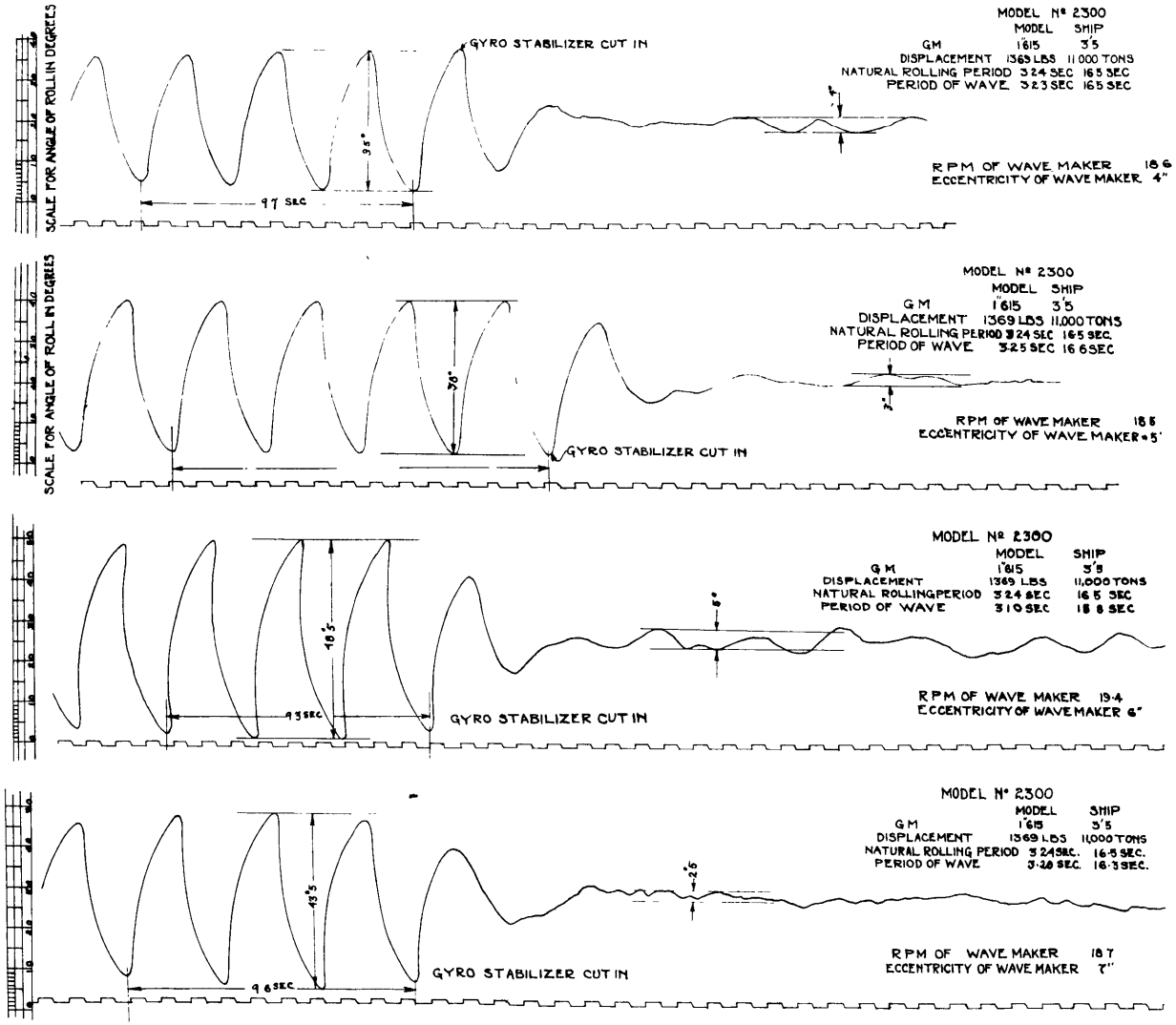
MODEL REPRESENTS

US AIRCRAFT CARRIER LANGLEY

LINEAR RATIO. SHIP TO MODEL = 26

EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C. AUG 1920



Sheet 4

GYROSCOPIC ROLLING RECORDS

MODEL Nº 2300 ROLLED IN STILL WATER

BY WEIGHT SHIFTING GEAR

WITH AND WITHOUT GYRO STABILIZER

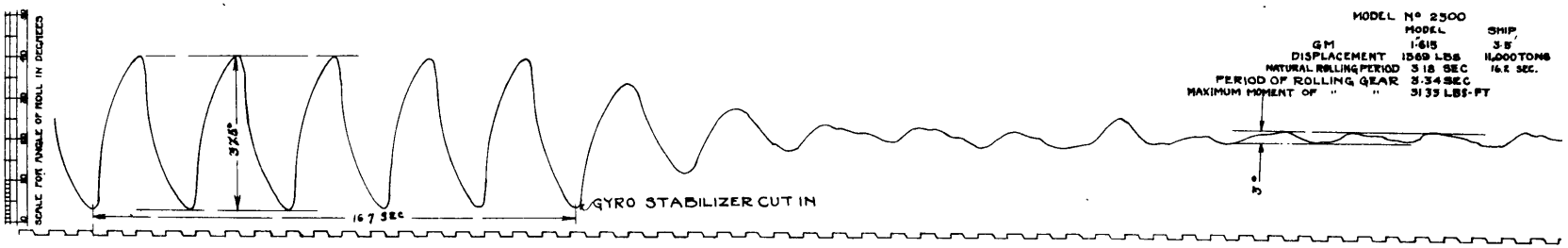
MODEL REPRESENTS

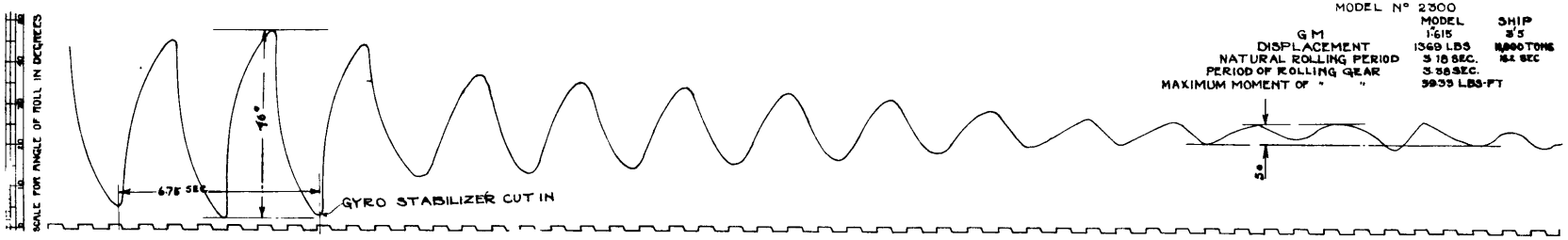
U.S. AIRCRAFT CARRIER LANGLEY

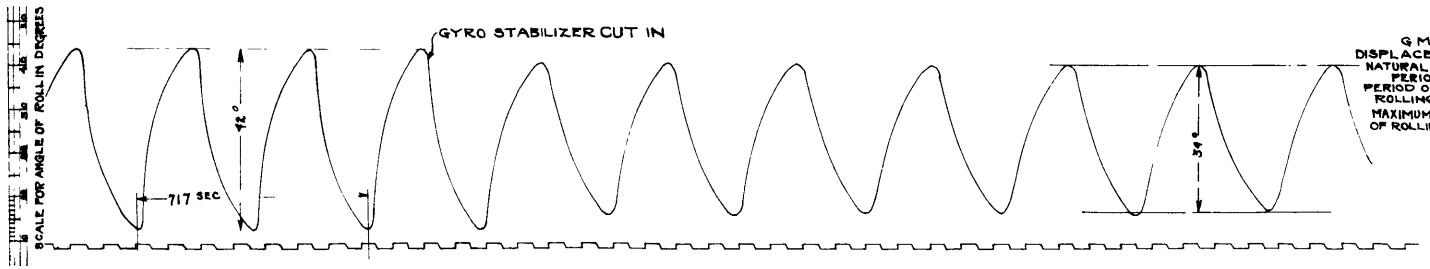
LINEAR RATIO SHIP TO MODEL - 26

EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON D.C. AUG., 1920







Sheet VI

EFFECTIVE HORSE POWER CURVES
FOR
U.S. AIRCRAFT CARRIER LANGLEY

ESTIMATED FROM RESULTS OF TESTS WITH
MODEL No. 5300
SHOWING INCREASE IN EHP CAUSED BY ROLLING
PREPARED BY

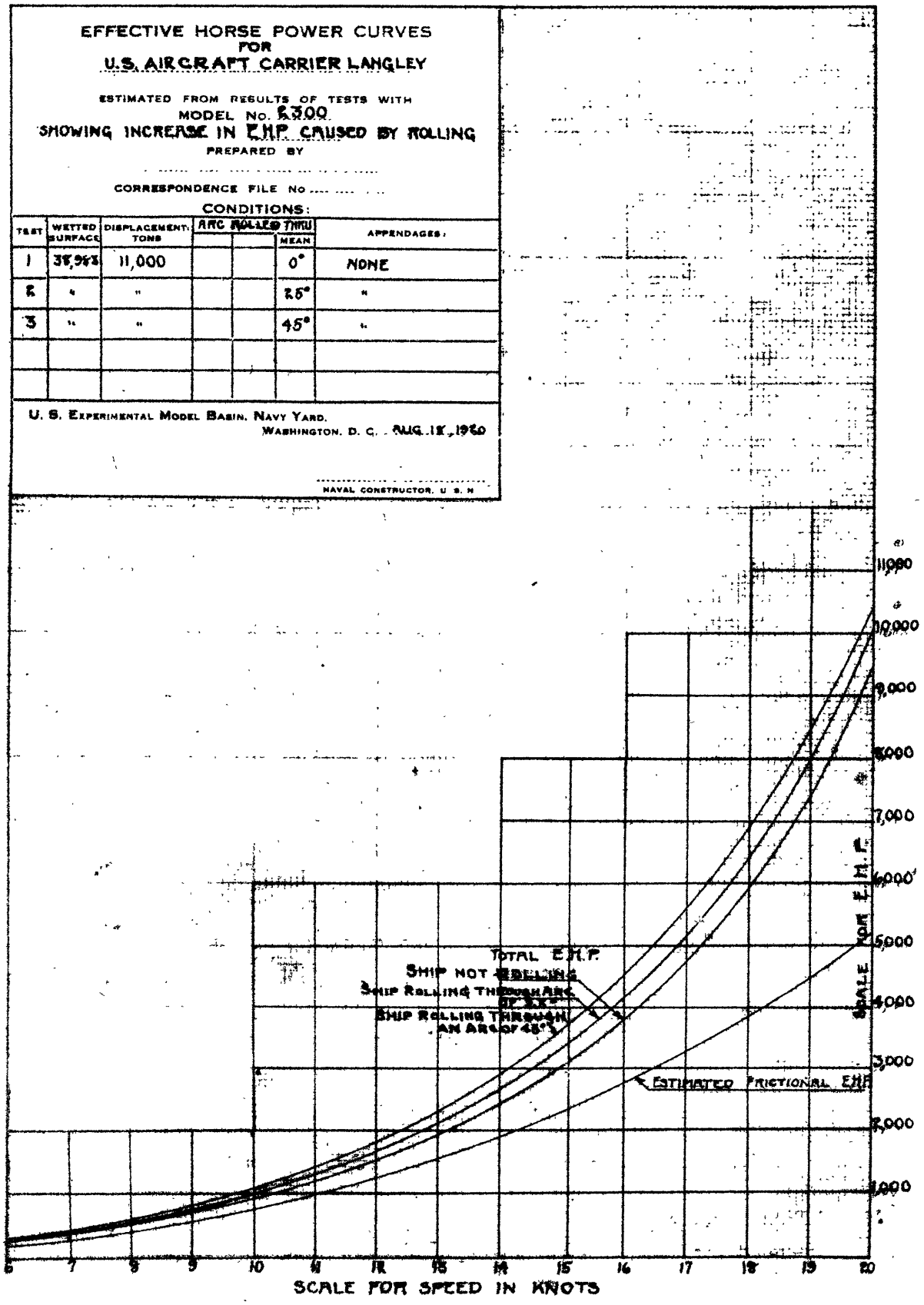
CORRESPONDENCE FILE No .....

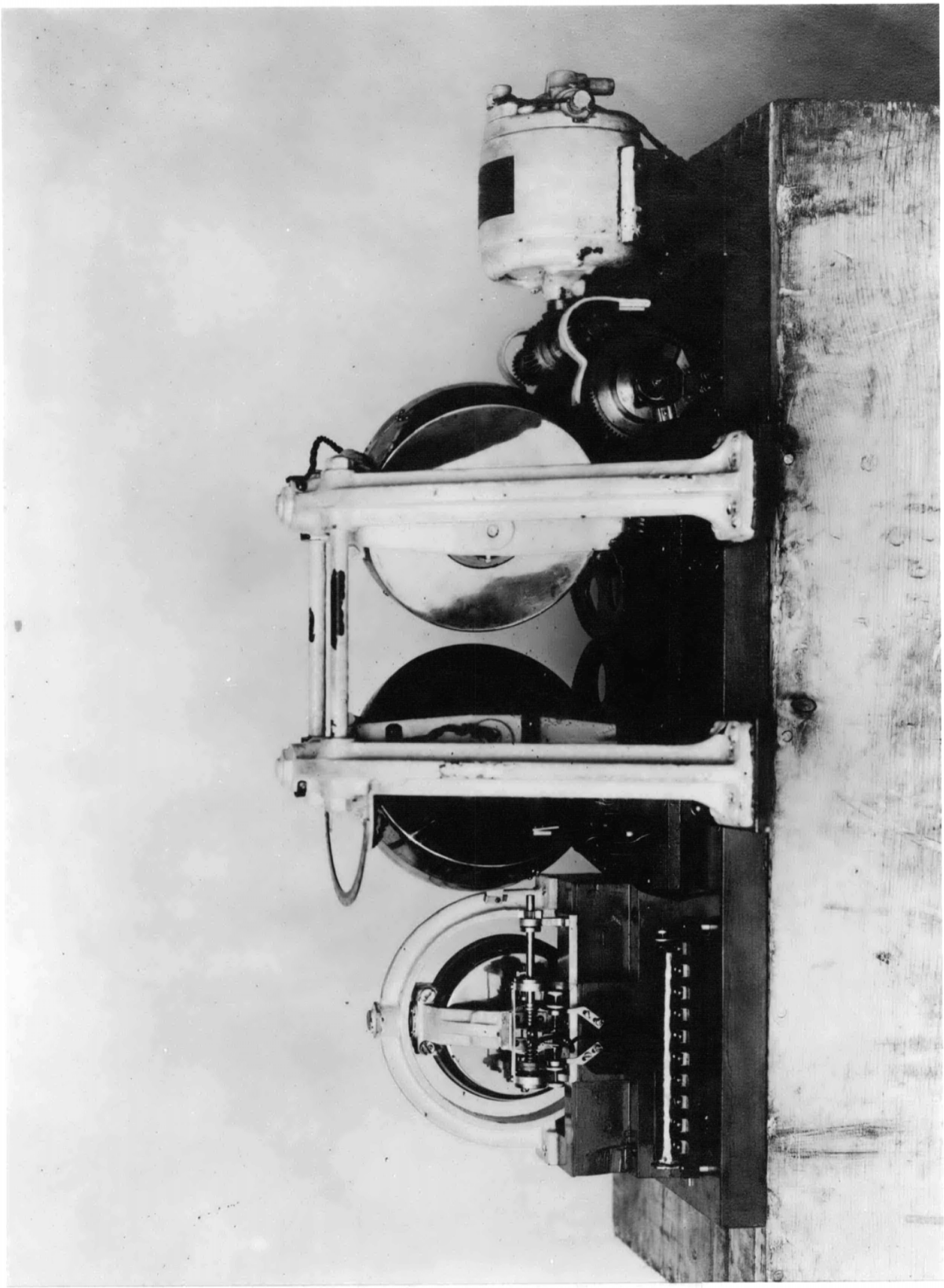
CONDITIONS:

TEST	WETTED SURFACE	DISPLACEMENT TONS	ARC ROLLED THRU			APPENDAGES:
					MEAN	
1	38,943	11,000			0°	NONE
2	"	"			22.5°	"
3	"	"			45°	"

U. S. EXPERIMENTAL MODEL BASIN, NAVY YARD.
WASHINGTON, D. C. AUG. 18, 1930

NAVAL CONSTRUCTOR, U. S. N





Sheet VIII