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Test of

VERTICAL STEERING CONTROL OF SUBMARINE S-3 USING

VARIOUS STERN HORIZONTAL RUDDERS.

FROM EXPERIMENTS WITH MODEL 1966



U.S. EXPERIMENTAL MODEL BASIN

Navy Yard, Washington, D.C.

April 1919

Report. R-133

Test of
 VERTICAL STEERING CONTROL OF SUBMARINE S-3 USING VARIOUS
 STERN HORIZONTAL RUDDERS

From Experiments with Model 1966

1. The object of the test was to compare the different rudders as to their effectiveness in controlling the submarine when submerged.

2. For the moments and forces due to the submarine itself Model No. 1966 was run submerged at a speed of 2.65 knots, corresponding to a speed of 11.6 knots for the ship, at trims varying from 6° by the bow to 6° by the stern. The results are plotted on Sheet I.

3. The trim of zero moment having been determined as $1/4^{\circ}$ by the bow, the model was run at that trim with each of the several stern horizontal rudders, and the changes in moments and forces obtained were assumed to be due to the rudders. The rudders were set at angles varying from 30° forward edge down to 30° forward edge up by 5° intervals and the results plotted on Sheet II.

4. The rudders to be tested were as follows, the general dimensions being shown on Sheet III.

No.	Designed By	Plan No.	Distance From Axis to A.P.	Position of Rudders
1	Bureau C&R	C&R #70370	23' 4"	Hung on Skeg
2	" Type D "	C&R #70717	28' 6 1/2"	Up on Hull
3	Bureau C&R Type D	C&R #70370-B	9' 9"	Aft of Propellers
4	Portsmouth	C&R #56532-B	28' 6 1/2"	Up on Hull
5	"	Portsmouth's No. 546-107	28' 6 1/2"	Up on Hull

5. Rudder 5 being very similar to Rudder 2 was not tested as it was considered that the difference in results would be within the limit of error of the experimental apparatus.

6. From the results of the test as plotted on Sheet II the rudders rank in their power of controlling the submarine as follows: Numbers 2, 4, 3, and 1, but this does not take into account the action of the propellers on Rudder 3 which would probably, under ordinary conditions, increase its power approximately to that of Rudder 2. It was not possible to test Rudder 3 with the propellers running. It is to be noted that both Rudders 1 and 3 reached the maximum moment when the rear edge is inclined upward at an angle of about 25° , this limit apparently being due to interference between the rudder and the hull. If the race from the propellers extended over the full width of the rudder the steering moment for Rudder 3 would be approximately equal to that of Rudder 2 if the propellers were working at 30% slip. It is to be noted also that if the submarine were diving and beyond control it would be necessary to stop the propellers and in that condition the control from Rudder 3 would be much less than that from Rudder 2. On the whole it appears that about equally satisfactory results may be expected from the use of either Rudder 2 or 3 and that the choice between the two will be determined by seaworthiness on the surface, and maneuvering ability, especially when going alongside the dock.

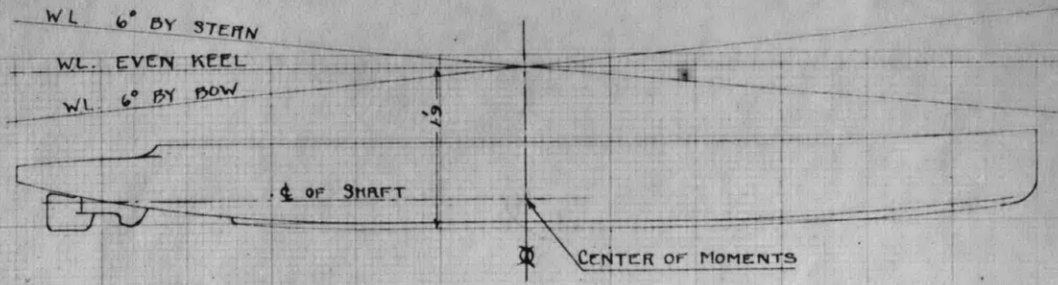
7. From the results obtained, the vertical angular variation from the direction of motion of the submarine

within which each rudder will permit control is as follows, when the rudder may be turned through a total arc of 60° .

For Rudder No.1	$4 \frac{3}{4}^{\circ}$
" " " 2	8° or 9° (Estimated)
" " " 3	$5 \frac{1}{4}^{\circ}$ (Propellers not running)
" " " 4	$5 \frac{1}{4}^{\circ}$

8. Experiments to determine the direction of the stream lines in the vicinity of the rudders were not made. In previous investigations of this kind with the ball ended pitot tube, the results have not been entirely consistent or satisfactory owing to the relatively small size of the model and the proximity of the tube to the hull which interferes with the accuracy of observations. It is assumed that this investigation was desired in order to determine the neutral position for the rudders; that is, the position at which they will exercise no trimming moment on the submarine. It is believed that this point is determined more satisfactorily by the measurement of the moments and from the curves plotted on Sheet II. The point at which the moment curves cross the axis determines the angular setting of the rudder at which it exercises no trimming moment.

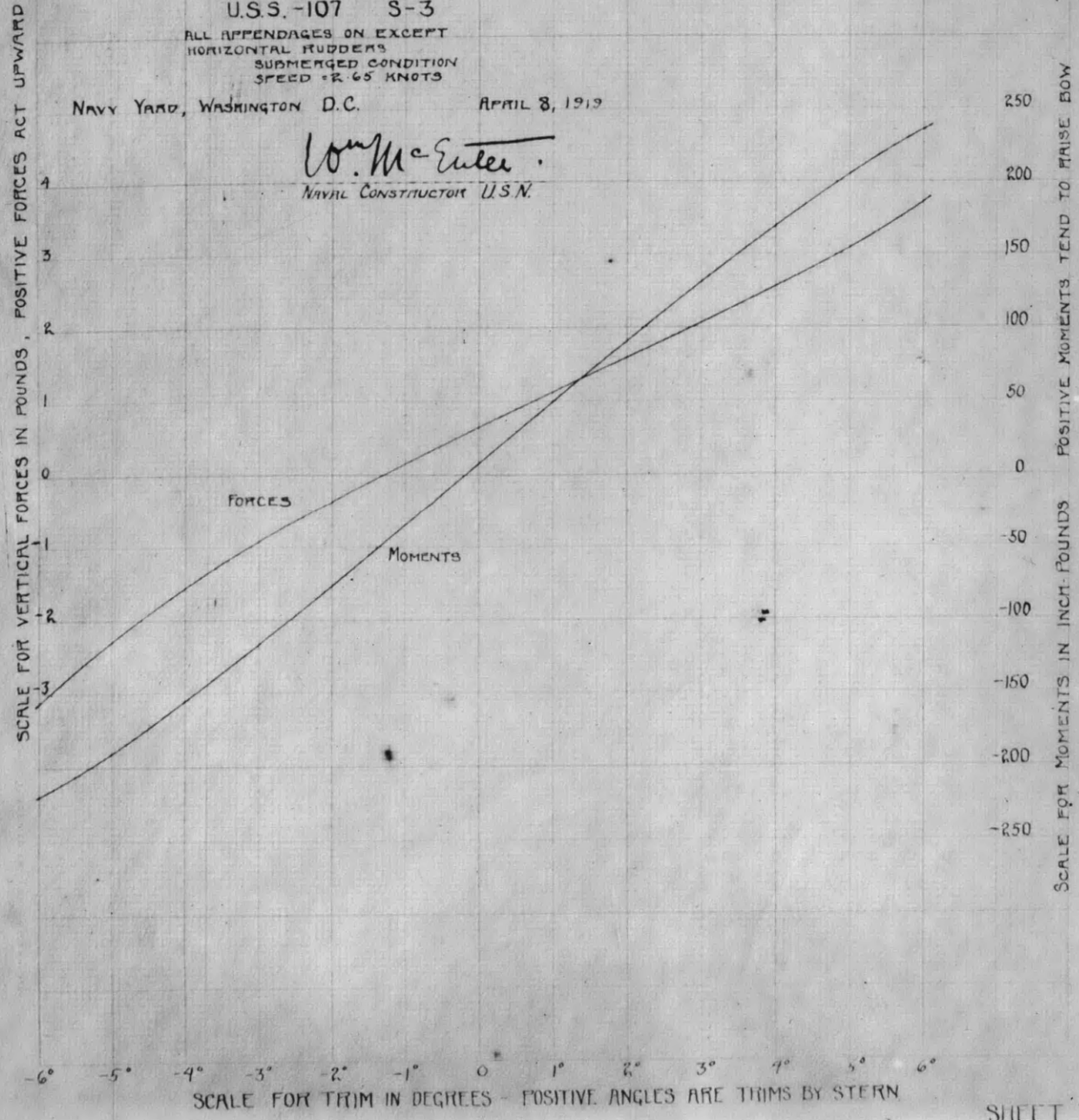
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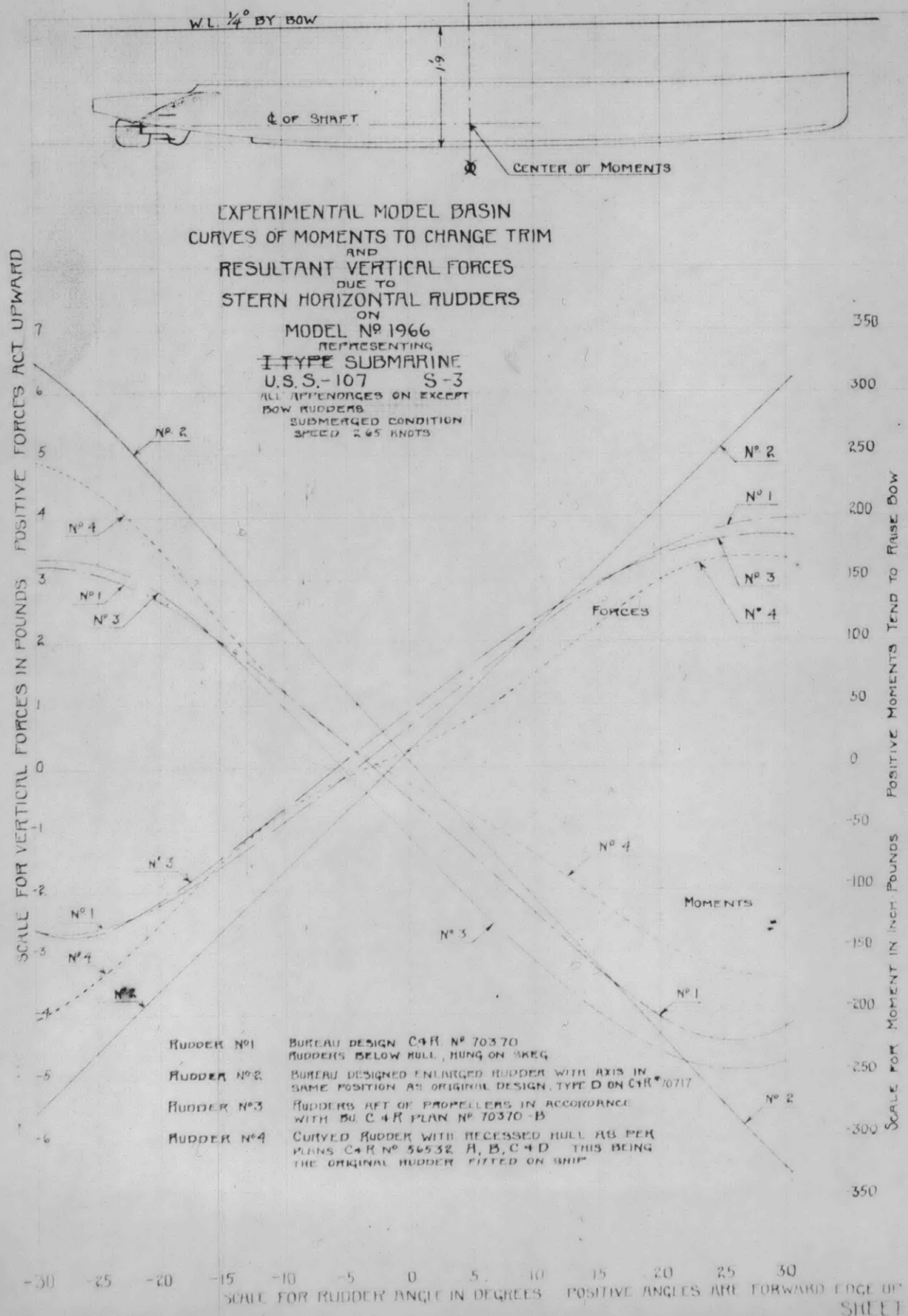
EXPERIMENTAL MODEL BASIN
 CURVES OF MOMENTS TO CHANGE TRIM
 AND
 RESULTANT VERTICAL FORCES
 FOR
 MODEL N° 1966
 WHEN TRIM IS VARIED
 MODEL REPRESENTS
 I-TYPE SUBMARINE
 U.S.S. -107 S-3
 ALL APPENDAGES ON EXCEPT
 HORIZONTAL RUDDERS
 SUBMERGED CONDITION
 SPEED = 2.65 KNOTS

NAVY YARD, WASHINGTON D.C. APRIL 8, 1919

Wm. McEntee
 NAVAL CONSTRUCTOR U.S.N.

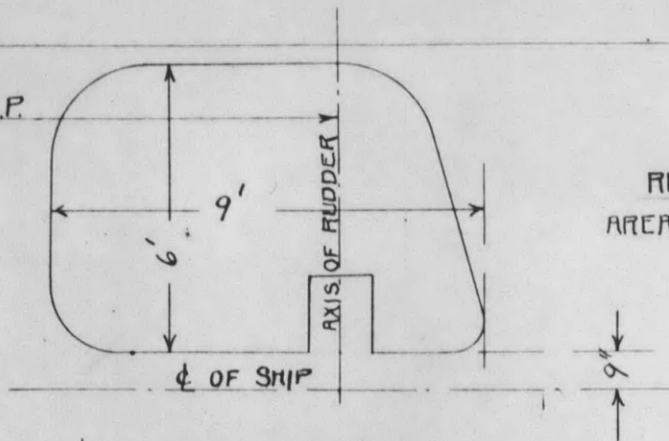


R-153



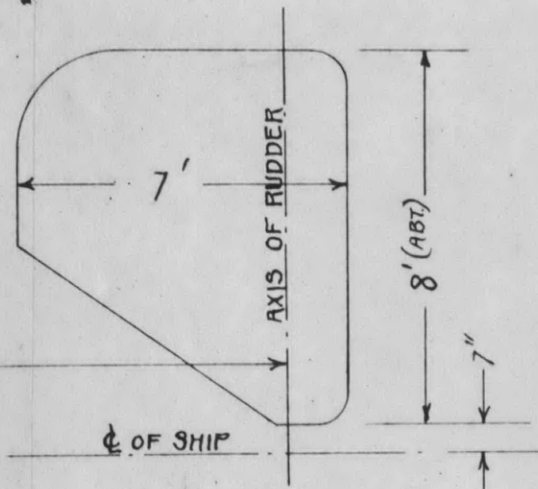
- NOTE -
 DIMENSIONS SCALED
 FROM PRINT OF PLAN
 C+R #70370

23'-4" TO A.P.



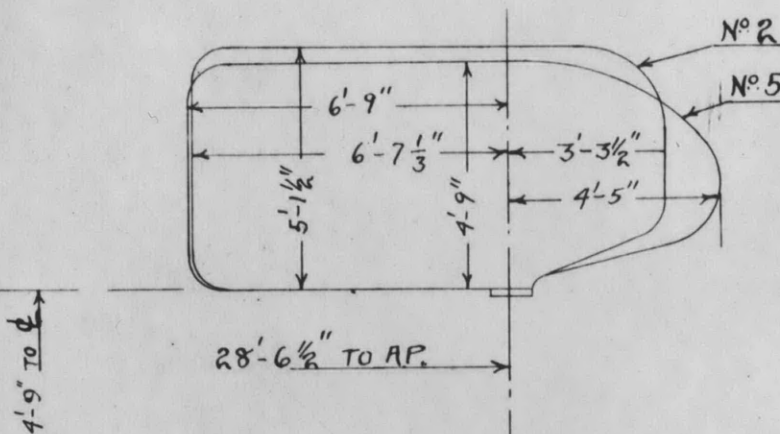
RUDDER N°1
 AREA 50 SQ. FT.

9'-9" TO A.P.



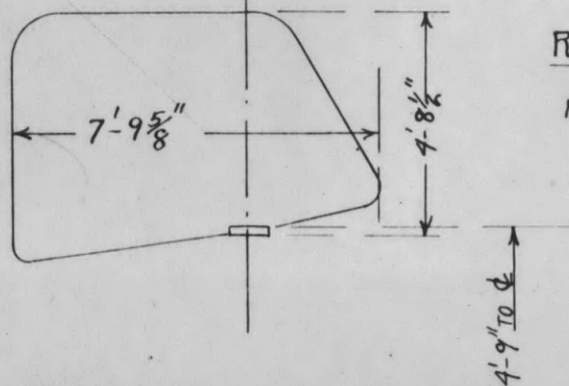
RUDDER N°3
 AREA ABOUT 45 SQ. FT.

- NOTE -
 DIMENSIONS SCALED FROM PRINT
 OF C+R N° 70370-B



RUDDERS N°2+5
 AREAS OF EACH
 47.6 SQ. FT.

GENERAL DIMENSIONS
 OF
 STERN HORIZONTAL RUDDERS
 TESTED ON
 MODEL N° 1966
 REPRESENTING
 U.S. SUBMARINE S-3



RUDDER N°4
 AREA = 34.2 SQ. FT.

