UNITED STATES EXPERIMENTAL MODEL BASIN

NAVY YARD, WASHINGTON, D.C.

RESISTANCE OF VARIOUS RUDDERS ON A MODEL OF THE U. S. S. PATOKA

EXPERIMENTAL MODEL BASIN
ERECTED 1898
BUREAU OF
CONSTRUCTION AND REPAIR
NAVY DEPARTMENT

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OCTOBER, 1930

REPORT NO. 268

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U.S. Experimental Model Basin
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NOTE

The within report describes a second series of tests made with rudders of various types on a model of the PATOKA class. This second series included a model of a contra rudder developed by the Theo. Goldschmidt Corporation and shown on their plan P-293.

The first model tests on rudders for this class of Navy tankers, with the original plate rudder and with an Oertz rudder, were reported in Officer in Charge Model Basin Memorandum S22 - Patoka and Salinas of 23 November 1929, to the Chief Constructor.

The second series of tests, originally reported in Officer in Charge Model Basin letter S22-1 of 5 September 1930 to the Chief Constructor, were performed in accordance with Bu. C R let. S22-(8)-(5), S22-(8)-(4)(DN) of 12 July 1930.

Prints of four (4) sets of curves for model 2285, giving the results of the second series of tests, are attached, marked Test Nos. 5, 6, 7 and 8.

1. The PATOKA model was tested as requested by the Bureau with a contra-rudder of Goldschmidt's design and also with an ordinary streamline rudder as would be recommended for such a vessel.

2. These tests were carefully made. The previous (1929) tests with plate rudder and Oertz rudder were repeated. The results are none too good in precision, but they are nevertheless fairly definite. The results with the Oertz rudder show a horsepower somewhat reduced from that previously obtained. The horsepower now approaches more nearly to that inferred from the trial trip.

3. Comparison of the separate results can best be made by the tabulation shown below of the results at 12 knots. The tests are arranged in the order of the horsepower required.

Rudder	S.H.P.	R.P.M.	w	t	Rudder Drag	Slip
Plate	3280	78.8	.245	.282	9%	.35
Oertz	2900	75.5	.265	.18	1.5	.34
Fair Form	2740	75.5	.23	.165	-1.9	.31
Contra	2660	75.	.25	.17	-1.4	.32

4. The fairform rudder was similar to the Oertz rudder except that it was one-half as thick and approached very nearly to a strut section of thickness 10% of the width. The Oertz rudder had a thickness ratio of 18%, the contrarudder about 15%.

5. The contrarudder showed the lowest horsepower at this speed, the fair-form being a close second, the Oertz took decidedly more power than the other two,

and, of course, the plate rudder required excessive power. The rudder drag column shows 9% drag for the plate rudder and 1½% for the Oertz rudder. There is not quite so much difference as was found in the previous tests, but it is still of the same order. The fairform rudder and the contrarudder had a negative drag, that is, the resultant force of the water on the rudder was forward instead of aft. This result was not due to error in measurement. There was a clearly defined effort to thrust the rudder forward. The exact amount may be slightly in error, but it is not believed the error is of any great extent.

6. Since it may be difficult to conceive such a result it may be here explained that the water coming from the propeller has a spiral motion which in the upper part of this propeller circle changes the direction of the water to starboard through an angle of about 10 degrees. In the lower part of the circle this direction is to port. This water strikes the fore and aft rudder in the same way as in the case of an airfoil in an inclined stream of air. It produces a lift on the rudder as well as a drag. The drag is in the direction of the water flow, the lift is at right angles to this direction and, therefore, since the flow is 10 degrees from the fore and aft line, the lift has a forward component. The lift component which is forward may exceed the drag which tends aft. In the case of the Oertz rudder, on account of its thickness and full head, the drag exceeds the forward component of the lift and in the case of the plate rudder this is also true. On account of the unfair form of the plate rudder the drag is excessive and the lift much reduced.

7. The result is seen in the column of thrust deductions. The fairform rudder shows slightly less than the contrarudder, the Oertz somewhat more than either. It would seem that this figure for the Oertz rudder should have been slightly larger, about .19. The plate rudder shows a thrust deduction more than ten points greater than any of the others.

8. It might be supposed that the differences in the wake column were accidental. This might be so to a certain extent, but it is to be expected that the Oertz, and to a smaller extent, the contra, would show a larger wake than the other two since the fuller form heads of these rudders produce a wake of appreciable amount. The Oertz being the fullest shows the greatest wake. The fairform being the finest has the smallest wake. This affects the results in the case of the contrarudder, compared to the fairform rudder. If the wakes were the same in the two cases, the fairform which has the greater negative drag should take less power, but the difference in the wake overcomes this gain.

9. The slip column seems to corroborate the variation in the wake. The smallest slip corresponds to the smallest wake and if the wake were the only variable the slip should correspond with it throughout. In the case of the plate rudder this does not apply. The extra drag of the rudder requires more power and more thrust, hence the slip is larger than it would be otherwise. The revolutions agree

with this interpretation.

10. The general result of these tests may be summarized as follows: None of the patented rudders has any appreciable advantage over a rudder of streamline form that is reasonably thin, and a thick rudder, even at the low speed of this vessel, is at a disadvantage. One of the main things is the amount of drag of the rudder in the slip stream and the amount of the forward lift component that can be obtained from the spiral slip stream. In this respect a rudder section that approaches a common airfoil section is not appreciably better than an ordinary streamline rudder if the latter is thin, and a thick rudder should be avoided from the point of view of propulsion. The amount of the lift on the rudder, to starboard at the top, and to port at the bottom, would seem to require consideration, as it is fairly large.

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