EFFECTS OF
SHAFT STRUTS VERSUS SPECTACLE FRAMES
ON PROPULSION.

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To throw some light on the relative effects of shaft struts versus spectacle frames on propulsion, the 20 ft. model of the Fore River type, 35 knot destroyers of the 186-335 class, was selected for the investigation on account of its availability and the fact that recent tests with struts had been made.

This model was run self-propelled with its designed propellers and fitted in turn with the following appendages.

1. Struts as designed and intended for these vessels.
2. Deadwood added below the shelf aft to better fair the hull.
3. Upper strut arm shortened to keep it under water. Lower strut arm made twice as wide and half as thick.
4. Same as (3) except propeller placed ahead of struts.
5. Symmetrical ended bosses, receding from propeller toward hull.
6. Same as (5) except ends drooped, terminating 10° downward.

7. Same as (6) except bosses lengthened on hull line.

8. New design of bosses to make least streamline disturbances and greater internal accessibility.

9. New design making bosses as nearly horizontal as possible.

10. Check run on (9).

Plans of all these arrangements are appended, and curves showing the results.

Discussion of results:

No. 2 - It was expected to reduce hull cavitation or eddying on the ship but no beneficial effect on the model was discovered.

No. 3 - Thrust and wake factors increased slightly but with no real loss or gain.

No. 4 - Tested only to 26 knots, no material change

No. 5 - Reduced resistance appreciably, but with a loss in hull efficiency so that net gain as shown by RPM and SHP was small.

No. 6 - Drooping ends of bosses; slight increase in both wake and thrust deduction, some reduction in RPM but not in EHP or SHP.

No. 7.- Slight loss in hull efficiency and increase in RPM but no change in EHP or SHP, both of which, however, are lower than with any strut combination.

No. 8 - What differences there are seem inconsistent; EHP up, wake down, SHP and RPM also up a little.

No. 9 - Highest hull efficiency of all; high resistance; some decrease in SHP; a reduction in RPM.

No.10 - The check run generally failed to change the relative results but was not as good as No. 9. On paper the average results of 9 & 10 look very promising. However, this type of bossing cannot be considered for this ship because the water failed to flow over the top of the bossing in sufficient quantity and it is quite certain that additional propeller troubles would be caused thereby. The propeller tips emerged from the water.

Validity of Results:

The above results are what the model tests show. The general results would appear to be nearly negative, but it can be concluded from the tests that bossing, well designed, and in the natural streamflow, would show a small saving in power. There are other sources of information however which will considerably modify such a conclusion. The chief of such sources is the work that has been done on cavitation in the water tunnel recently put into use. This information all points so strongly to the value of bossing that it must be considered carefully.

The lower strut arm is not in the stream flow, departing from it by about seven degrees. It has been shown in the tunnel that the standard strut, at the speed and pressure obtained in these destroyers, when inclined at such an angle, will cavitate heavily. This has been observed in practice. The upper strut arm projects above the water surface. It is not so much out of the stream line, but will cavitate nevertheless. The effect of this cavitation is twofold; first, it sends, into the propeller disc, water that on the average has less density, and therefore takes less thrust from the propeller at the same revolutions, second, it acts by breaking the flow, starting prematurely the cavitation of the propeller. It also causes vibration, from the periodic sudden entry of a propeller blade into this vacuous space. All this the model self-propulsion tests cannot show.

Struts could be designed that would not, in these vessels, produce cavitation. They must be carefully placed so as to be in the stream line. They must be considerably wider than is standard practice. They must be smooth and well shaped, and must fair into the hull and into the hub. The upper arm must be well below the water surface. All these requirements would result in bronze castings, well finished, accurately made. The attachment of the ends to the hull will be difficult. The castings will be delicate and easily damaged, not as rugged as is desirable. Altogether, better results are obtained by using bossing instead.

Any smooth bossing, well designed, without attempt to provide contra-propeller effect, will avoid cavitation of the water forward of the propeller. The water will flow smoothly to the propeller. There should be, in full size, a decided gain in speed at the same power, over that obtained with the present arrangement. The cavitation of the propeller itself will probably be somewhat delayed, thus further increasing the gain. It is not unlikely that there would, with such design, using the same propellers as at present, be a gain of nearly a knot at full power, over the speed attained by any vessel of this class, having the best installation of struts as designed.

There should be no bending down of the fin end of the bossing, with the idea of adding contra-propeller effect by guiding the water into the inboard blades of the screw. The tests show that what is gained in efficiency by such arrangements is lost by greater resistance. What the model cannot show is that in full size, at high speed, such an arrangement would cavitate, and thus lose instead of gain.

<u>Conclusions</u>:

For the destroyer type, bossing such as indicated above, should be used. For the cruisers this is also a valid conclusion. For low speed work struts might be tolerated. They should even then be carefully placed so as to avoid cavitation, which is not confined to high speed work. Better results would be obtained in even low speed classes, by using bossing, and in that case some gain might be expected from drooping the fin ends, provided the speed is low enough, and the immersion great enough. If however the stern is designed for best flow of water, little is to be so gained.

At high speeds, and small immersions, struts cannot be made wide enough to avoid cavitation, if they are not placed in the stream lines, and thus they cannot turn the water to meet the advancing blade of the screw as a contra-propeller should. This applies also to the drooping ends of bossing. There is not time enough for the water to be turned and to remain in contact with the suction side.

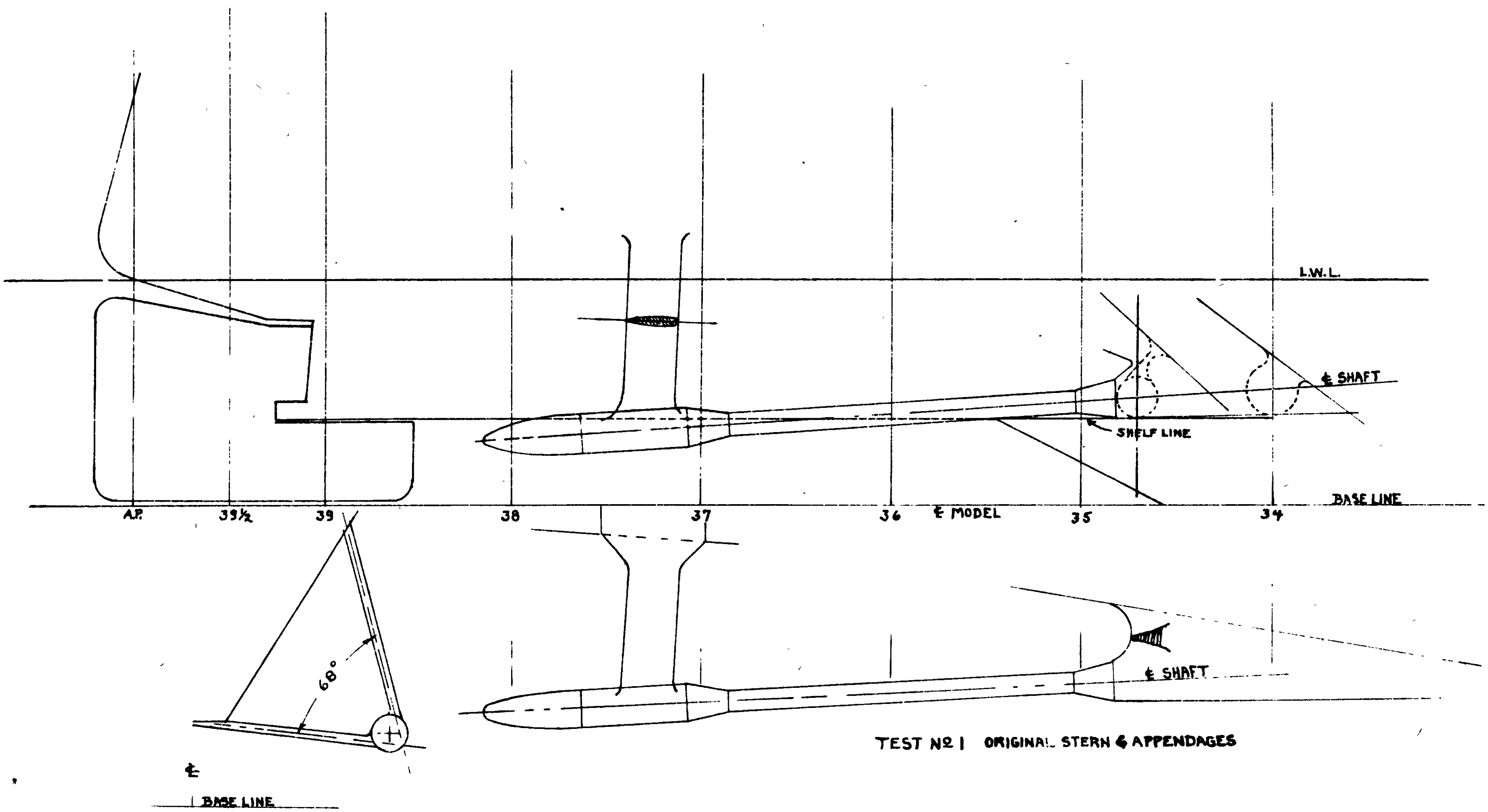
Recommendations:

As an extension of these experiments to full size, a destroyer with power plant, that is capable of working up to full power as designed, should be fitted with well designed and well built bossing, and the effect determi by speed trial before and after the change. In view of the general successful use of bossing in the merchant service and elsewhere, and in view of the above considerations, the use of bossing should be extended to the cruisers now under design.

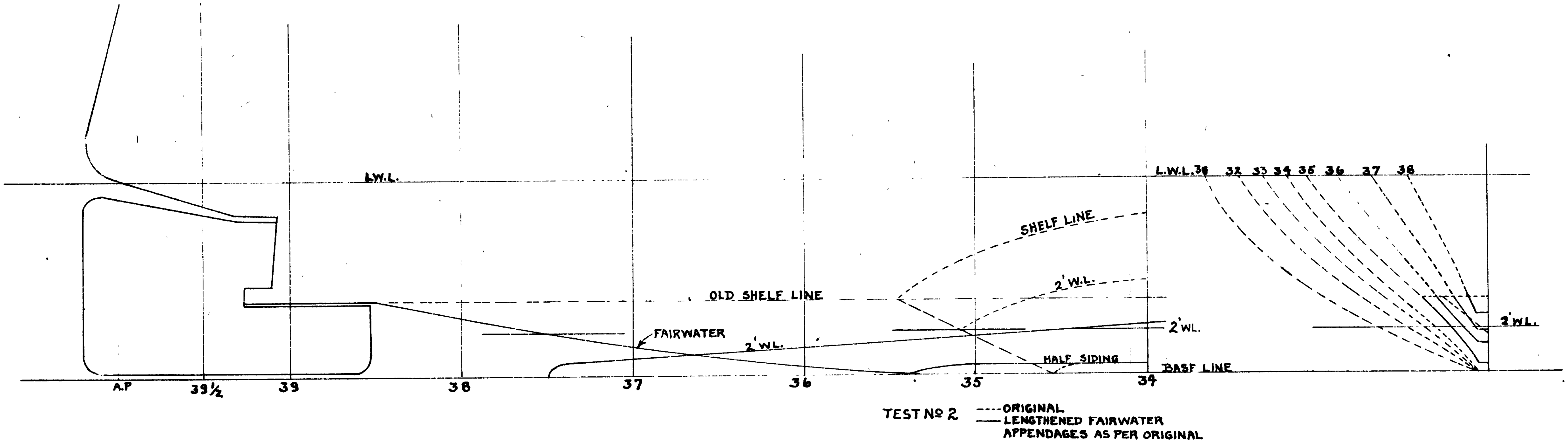
Resumé:

The experiments made on a destroyer model indicate better results to be obtained with spectacle frames or bossings than with struts.

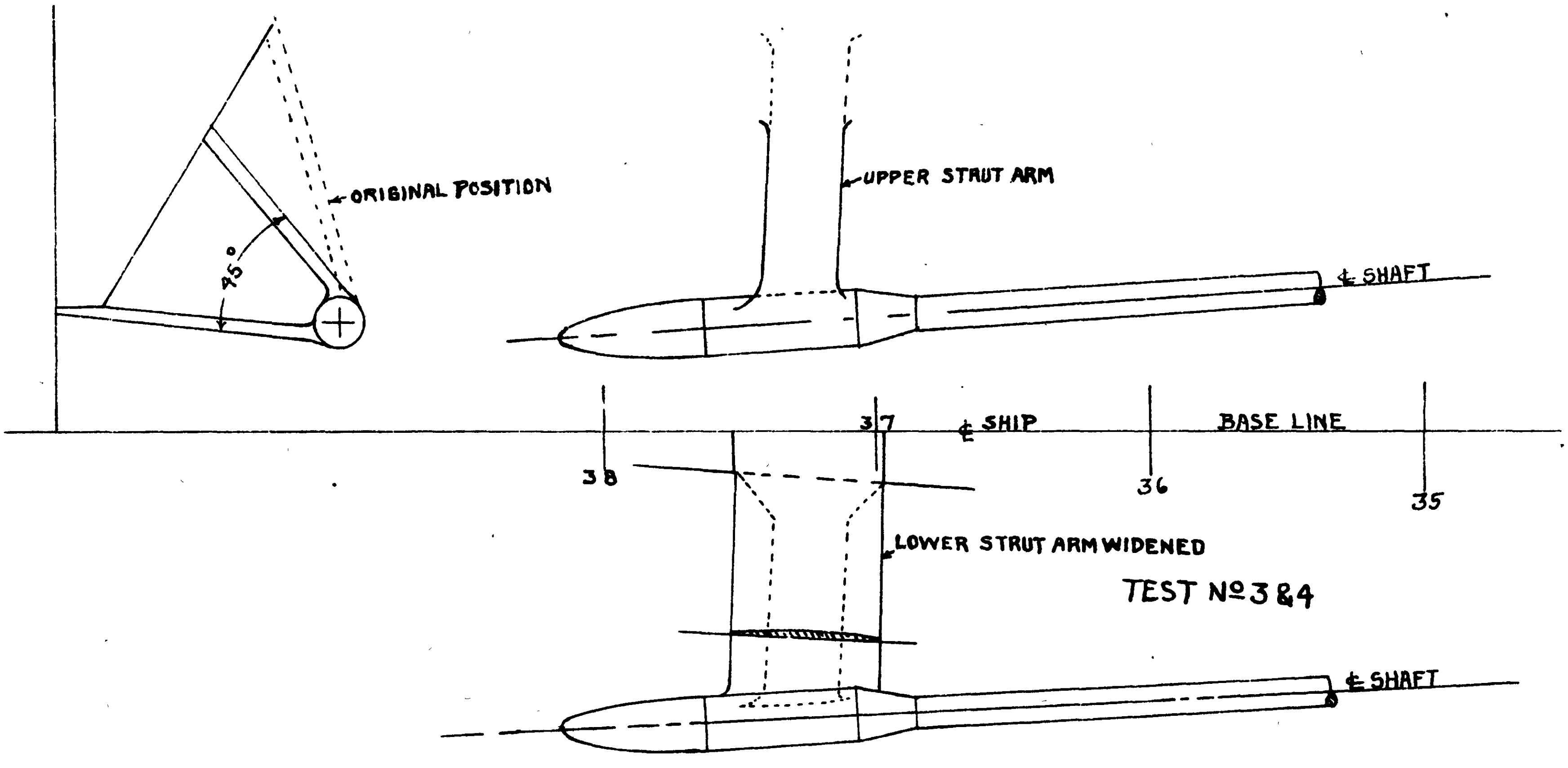
The conclusions drawn are that struts where tolerated should be in the natural stream lines to avoid cavitation and for high speed work the bossings should also be placed in the stream lines and made without contra-propeller effect.

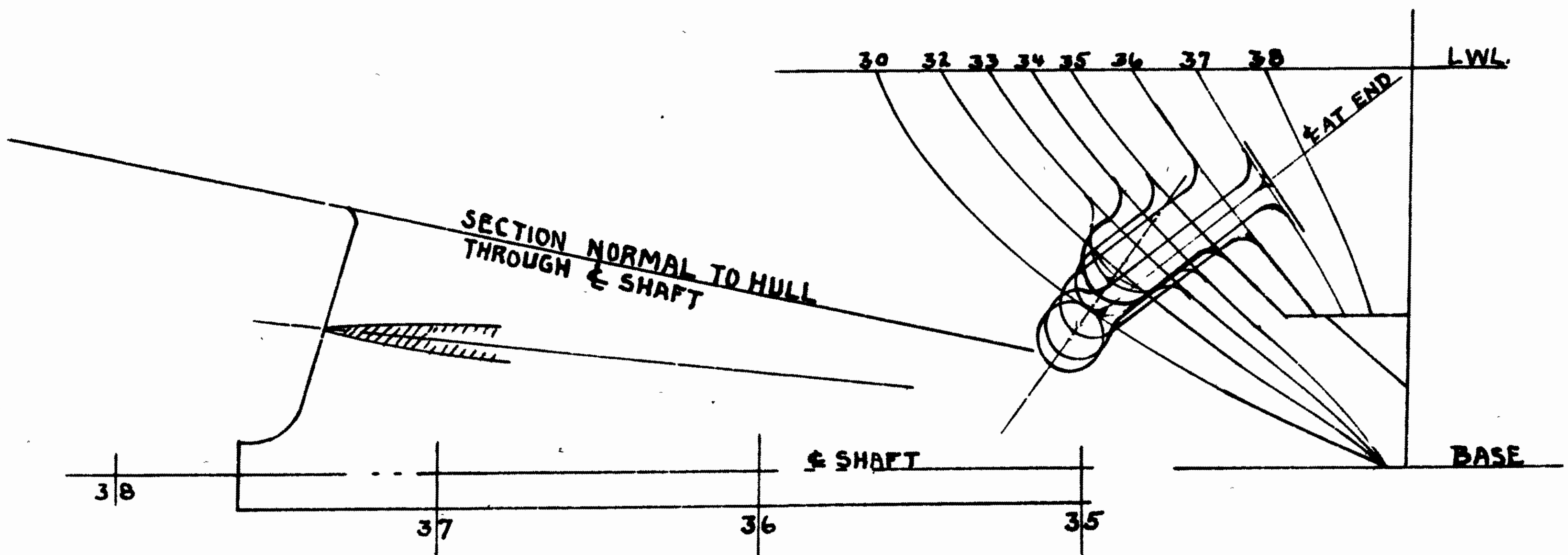


TEST Nº 1 ORIGINAL STERN & APPENDAGES

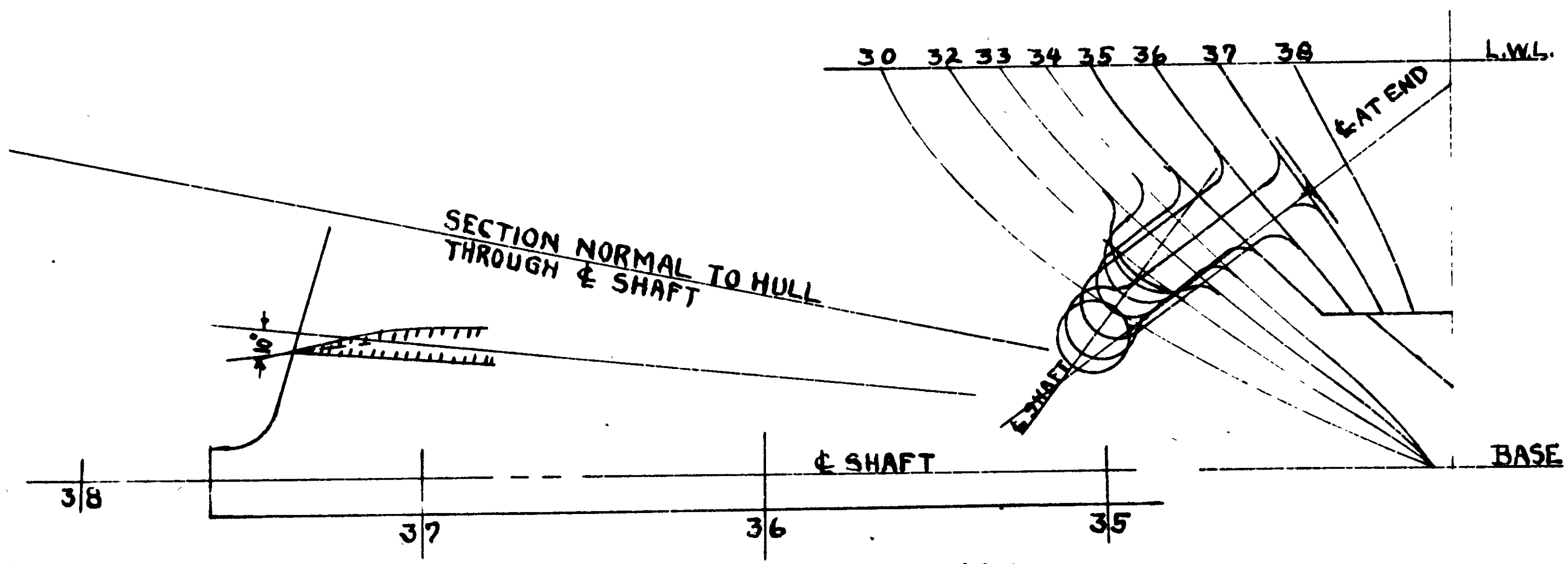


L.W.L.
OLD SHELF LINE
SHELF LINE
2' W.L.
FAIRWATER
2' W.L.
HALF SIDING
2' WL.
BASE LINE
A.P
39½
39
38
37
36
35
34
L.W.L. 31
32
33
34
35
36
37
38
2' W.L.
TEST Nº 2
----ORIGINAL
—— LENGTHENED FAIRWATER
APPENDAGES AS PER ORIGINAL

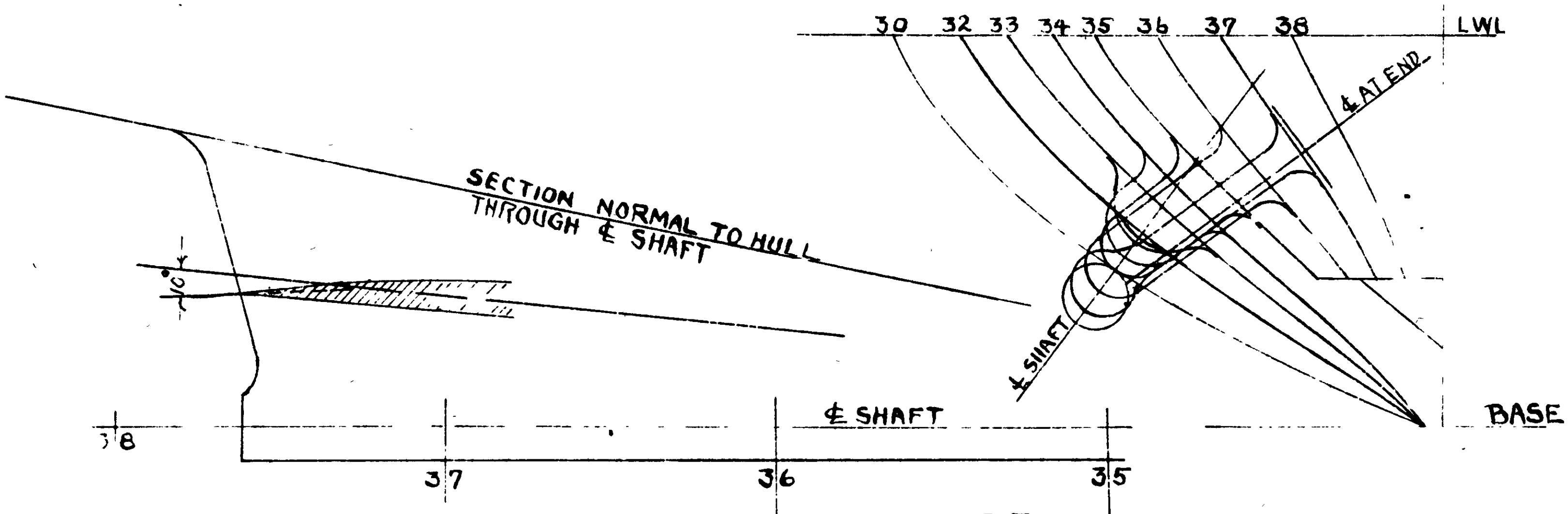

ORIGINAL POSITION
45°
UPPER STRUT ARM
℄ SHAFT
37
℄ SHIP
BASE LINE
38
36
35
LOWER STRUT ARM WIDENED
TEST Nº 3 & 4
℄ SHAFT


30 32 33 34 35 36 37 38
LWL.
℄ AT END
SECTION NORMAL TO HULL
THROUGH ℄ SHAFT
℄ SHAFT
BASE
38
37
36
35

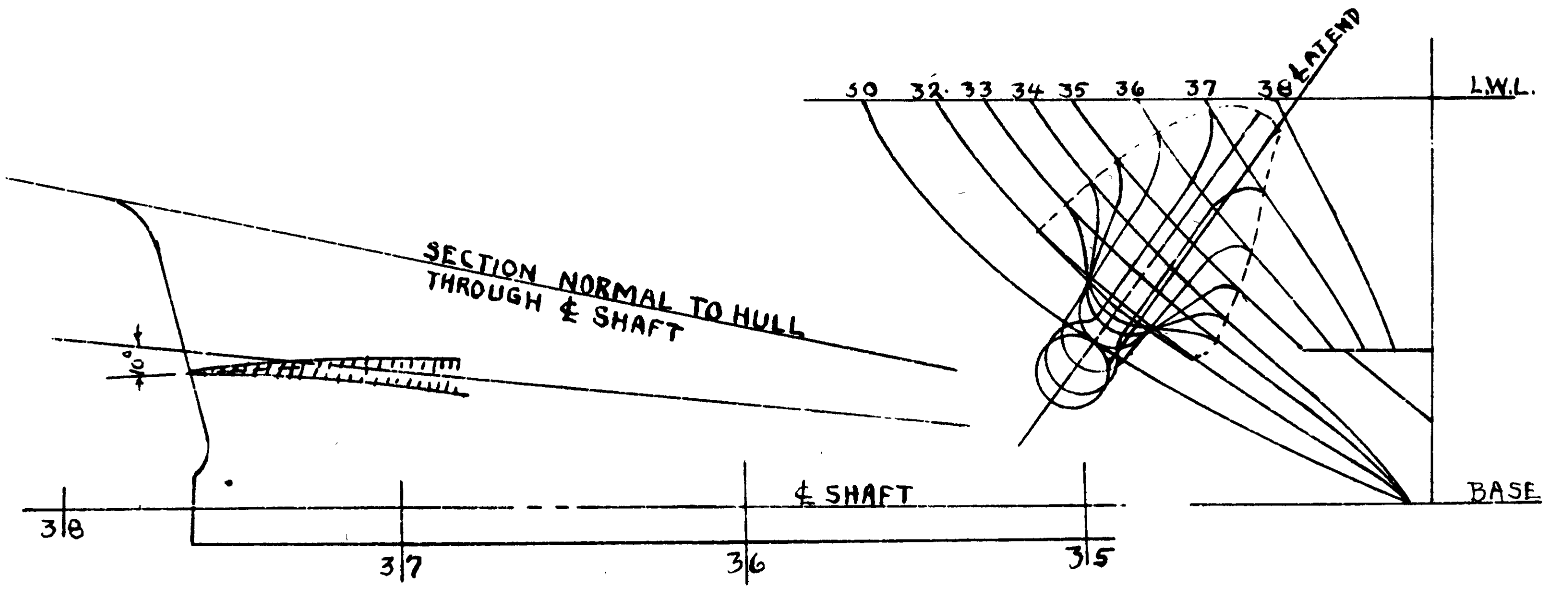
TEST No 5


30 32 33 34 35 36 37 38
L.W.L.
℄ AT END
SECTION NORMAL TO HULL
THROUGH ℄ SHAFT
℄ SHAFT
BASE
℄ SHAFT
38
37
36
35

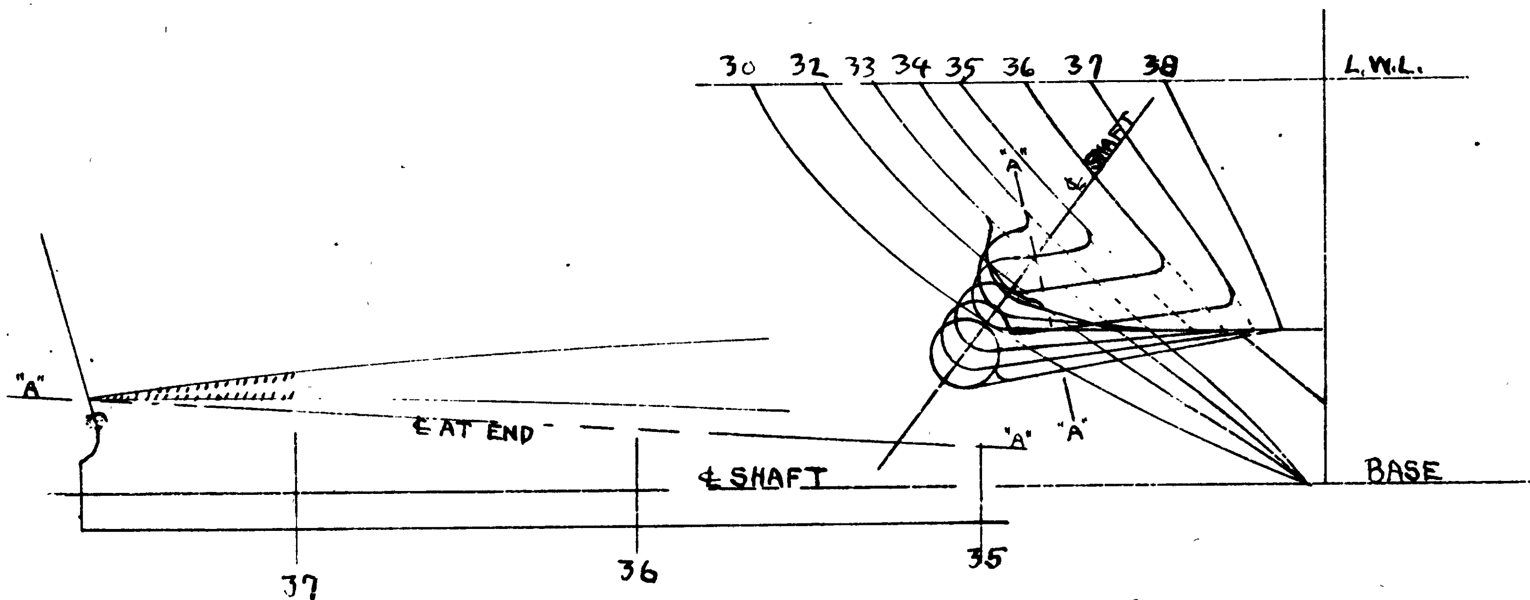
TEST Nº 6


30 32 33 34 35 36 37 38
LWL
℄ AT END
SECTION NORMAL TO HULL
THROUGH ℄ SHAFT
℄ SHAFT
BASE
℄ SHAFT
38
37
36
35

TEST No 7


SECTION NORMAL TO HULL
THROUGH ℄ SHAFT
℄ SHAFT
38
37
36
35
30
32
33
34
35
36
37
38
℄ AT END
L.W.L.
BASE

TEST № 8



TEST Nº 9 & 10