THE 'NEPTUN' BULBOUS BOW

by Dr. Ing Diethard Weicker*

THIS ARTICLE gives details of the characteristics and performance as predicted from model tests of a new type of bulbous bow designated the Neptun bulb. This has been developed by VEB Schiffswerft Neptun, Rostock. The most obvious characteristic of the new bulbous bow is that the bulb is not faired into the ship lines at or slightly below the designed load water line—as is usually the case, but at a height of about the bow wave of the original bulbless ship above the designed load waterline.

The upper part of the bulb, which emerges beyond this waterline is in the form of a wedge which cuts the raised bow wave and makes it flow aside more easily without the formation of spray and without being increased in height at the blunter, above water, stem. By this means the effectiveness of the bulbous bow, especially in loaded conditions of the ship, is essentially increased in comparison with an arrangement below the designed load waterline.

Another advantage of the Neptun-bulb as against other types of bulbous bows is that it is not designed to be effective at the designed draught or light draught condition only, but at the same time for both or even for all important draught conditions of the ship. It is evident that by adopting this design criterion, the sum of the savings of fuel or running-time obtainable through the length of service is substantially increased.

Model tests have proved the above mentioned merits of the Neptun bulb. For a better understanding of the test results, which will be given later, a short explanation of the bulb's method of working is necessary.

The purpose of a bulbous bow is to save power and fuel or to increase the speed by means of diminishing the wave resistance. Savings of power as against the ship without a bulbous bow are physically possible, in so far as by means of fitting a bulbous bow one may succeed in reducing the power which is lost in generating the bow wave.

This is possible on premise that the positive pressure changes, which are caused by the deflection of momentum of water at the bow of the running ship and which in dependence on the ship's shape contributes to the wave resistance, can be efficiently reduced by the bulbous bow. Because such a change in pressure at the bow has its visible result in a respective change of the bow wave, the influence of the bulbous bow upon the height and shape of the bow wave may be considered at least as a qualitative measure for obtaining a reduction in the wave resistance.

Consequently, the bulbous bow can be considered as most effective if it makes the shape of the bow wave long and flat and its surface approximately level. Since the influence of the bulbous bow is in the main confined to the bow wave, a good bulb effect, however, need not be synonymous with an improvement in resistance or with a great gain in power.

The magnitude of the resistance reduction, which can be obtained by a bulbous bow of efficient design, depends —as follows from its manner of working—on the portion of the ship's propulsive power, which is lost in the generation of the bow wave of the original bulbless ship. This portion may be very different for several ships, even if

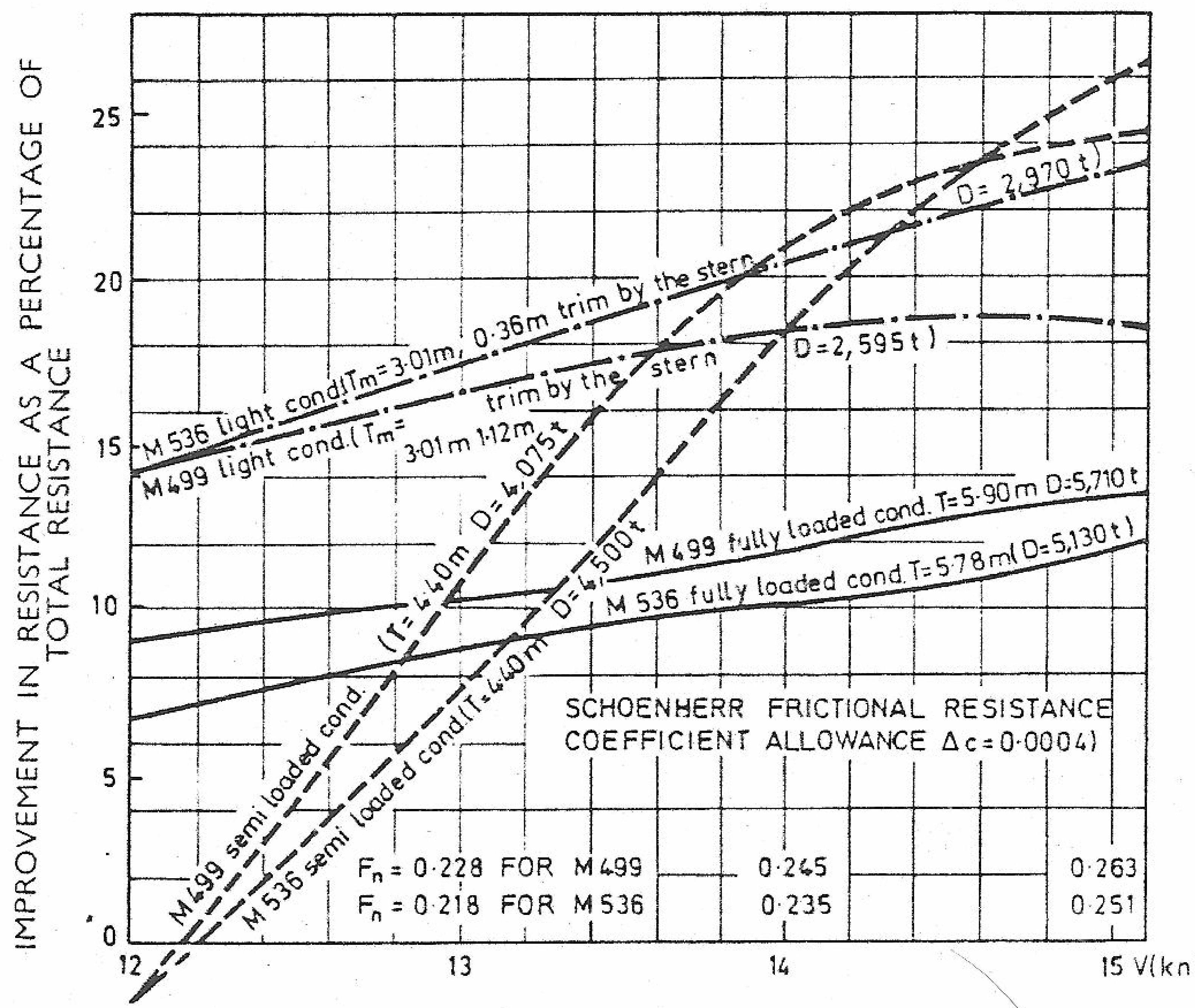

Diagram showing the percentage improvements in resistance obtained for three loading conditions

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the Froude number and the block coefficient are equal, and consequently the same holds also for the maximum obtainable reduction in resistance.

A presupposition of a substantial improvement in wave resistance is, as already mentioned, that the bow wave is levelled by the bulbous bow as much as possible. However, even with an apparently insignificant reduction of the wave height one may succeed in saving a significant portion of the loss of power, which is connected with the generation of the bow wave, because the energy of the wave is proportional to the square of the wave height.

The effect of levelling the bow wave is partly realised by the single addition of the bulb, because by so doing the region of positive pressure change at the bow and consequently also the bow wave is subdivided. Instead of a high bow wave, as in the case of the bulbless ship, there are generated two smaller wave crests by the foremost part of the bulb and by the remainder of the original region of positive pressure changes. These two waves extend into one another and form together a longer and somewhat flatter wave crest, which generally contains less energy. This implies a reduction in wave resistance, it having been obtained almost without any specific adaptation to the ship's lines, and which does, however, represent only a small portion of the improvements which are possible.

Essentially more significant improvements may be obtained by utilising the interference of the waves, which are generated by the bulb and by the ship itself. For this purpose the bulbous bow is to be designed in such a manner, that its first wave trough at the given design conditions coincides with the remainder of the bow wave of the ship. Another presupposition of maximum bulb efficiency is, that the extension and depth of this wave trough should equal the length and height of the remainder of the bow wave.

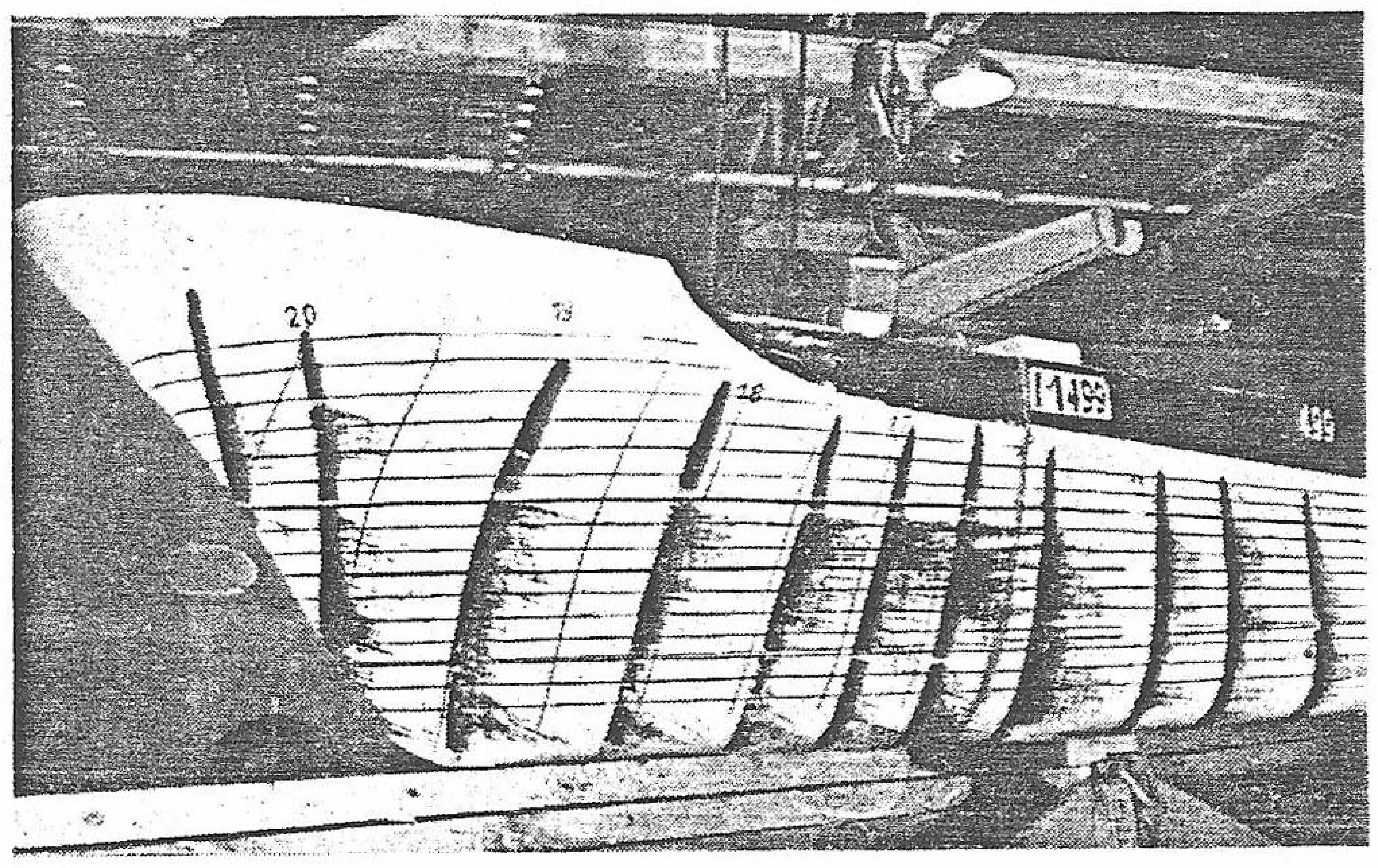
Fig. 1 The shape of the model without the bulbous bow fitted

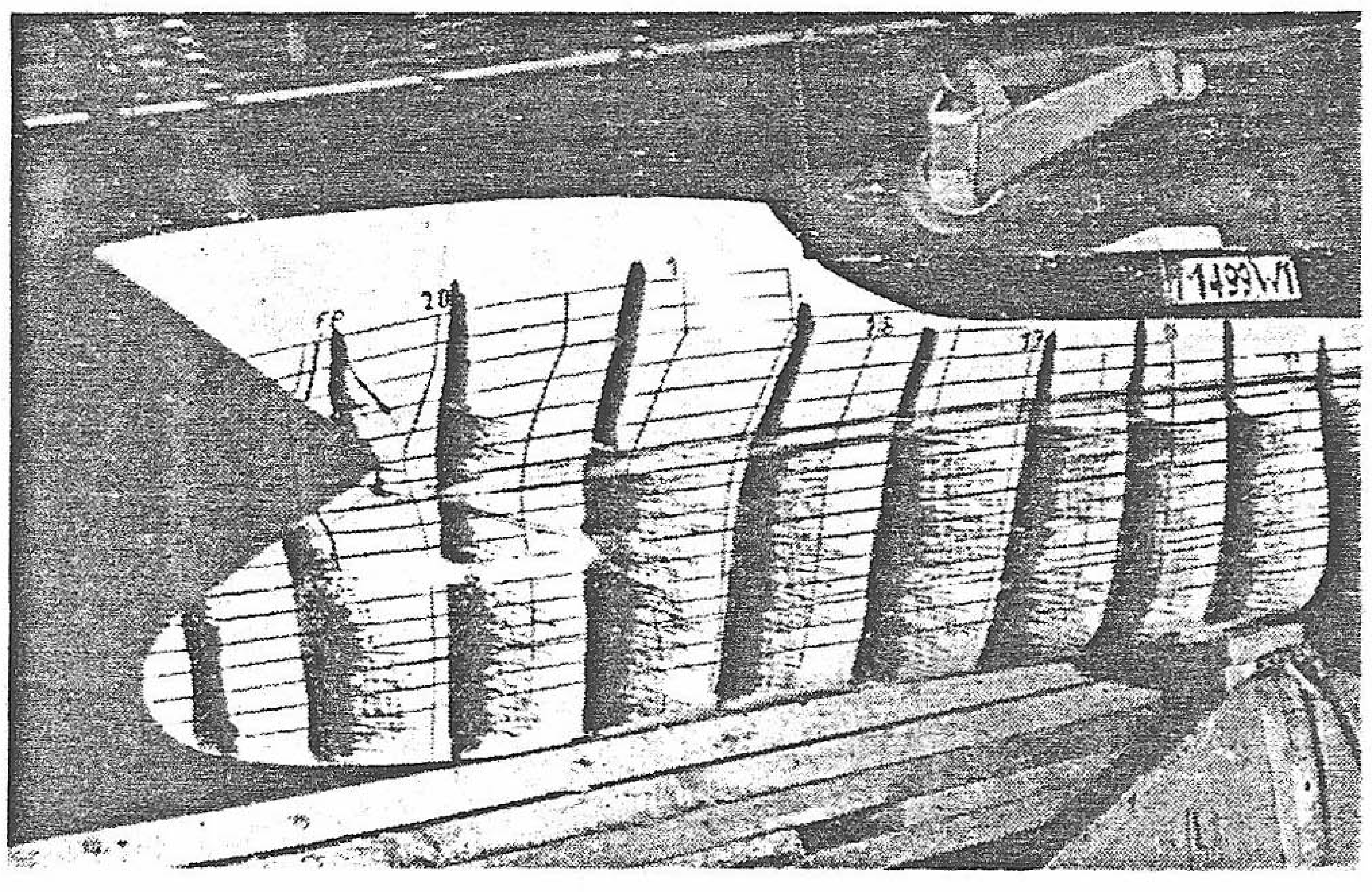
Fig. 2 The same model with 'Neptun' bulb fitted

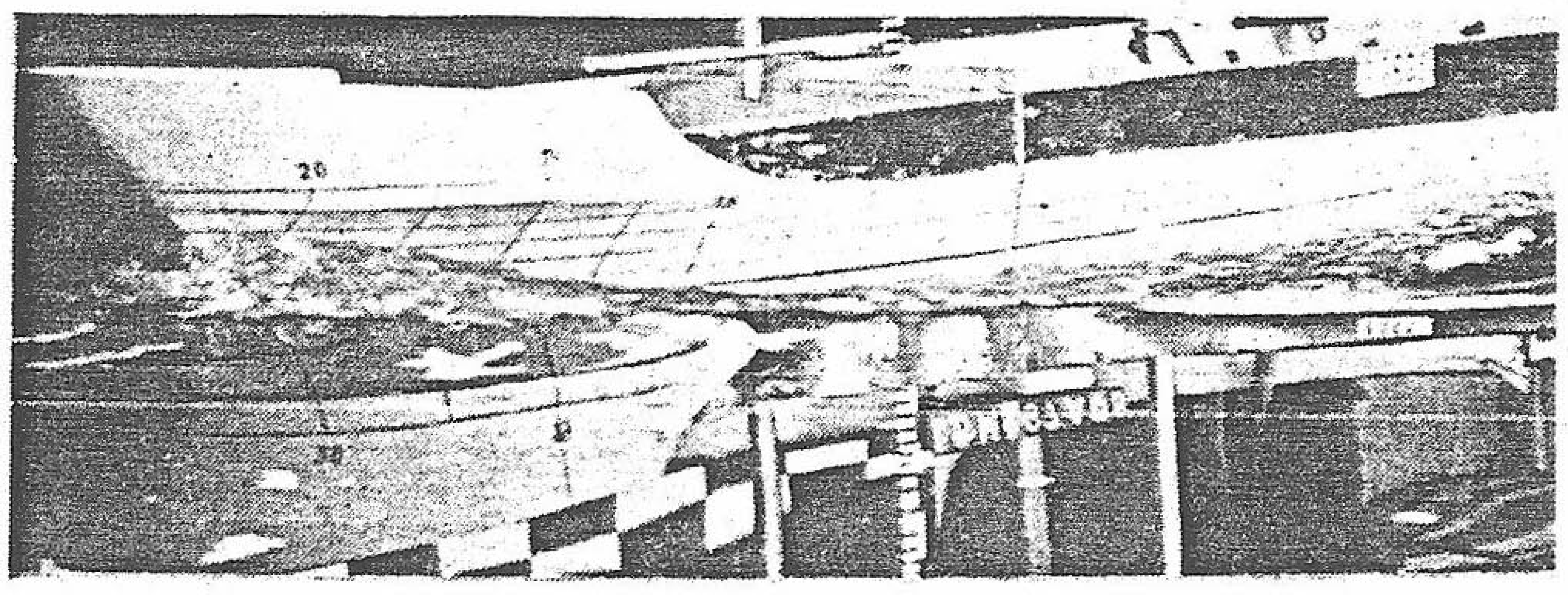
Fig. 3 Bow wave of the model without a bulb, in the designed draught condition

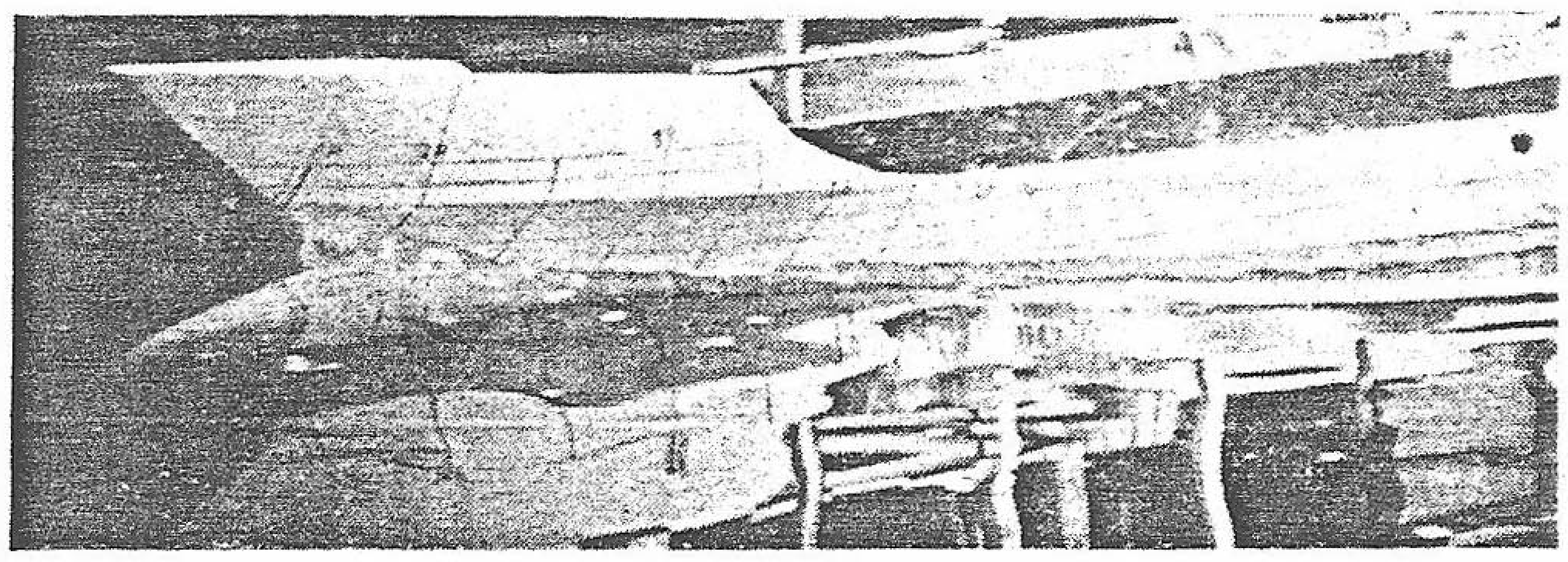
Fig. 4 With the bulb, in the designed draught condition

In principle, the design of a bulbous bow, which is an optimum in this meaning, is rather a problem of the hydrodynamically correct adaptation of the bulb lines to the shape and speed of the respective ship, than a question of choice of the bulbous bow type. Because in practice there is rarely the necessary freedom with respect to the choice of appropriate entrance lines of the ship, and because also the length and breadth of the bulb can't be made as great as one would like, the choice of the type of bulbous bow nevertheless has an important influence on the magnitude of the improvements obtainable.

Thus the Neptun bulb for instance is more suitable to reduce efficiently the relatively high and short bow wave, occurring in the case of the bluntly shaped entrance, than are the hitherto known types of bulbous bows situated completely underneath the designed load waterline. This is because the deep and short wave trough, which is necessary in this case, can only be generated by means of the aforementioned wedge-effect of the Neptun bulb.

Model tests

Models of two ship types of the VEB Schiffswerft "Neptun", Rostock, the lines of which are identical with the exception of a 6.5 metres difference in the length of the parallel middle body, have been tank tested. For both models resistance tests at designed load draught, a half loaded draught and at a light draught condition with trim by the stern were performed, besides propulsion tests at the designed load condition. With the shorter model (M 499) a test to determine the lines of flow at the designed load draught and the corresponding speed of 13 knots was made. The tests, both with and without a bulbous bow, were carried out at the same draught. The displacement with the bulbous bow was therefore about 0.8 per cent greater than without a bulb.

The measured results from these tests are given in the accompanying diagram. Because propulsion tests have only been performed for the designed load draught, the power savings and speed improvements for the other two load conditions have been converted on the base of the results of those tests.

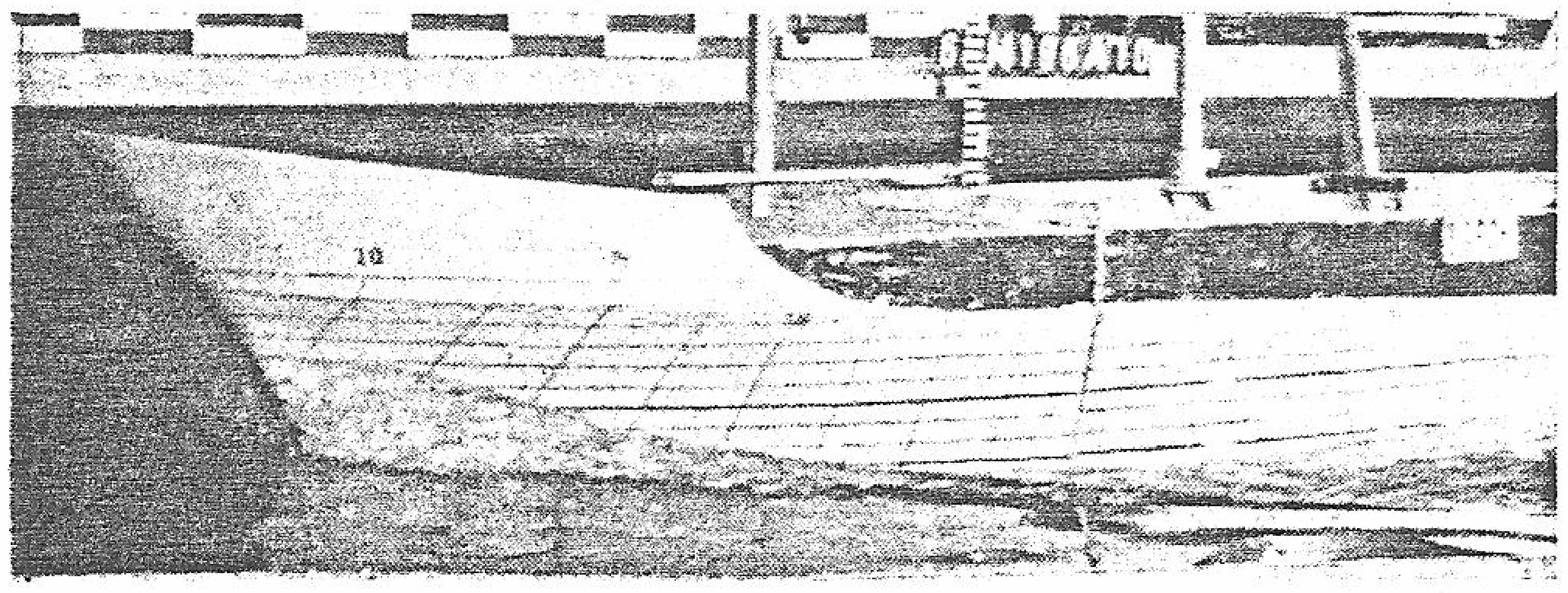

Fig. 5 The half loaded condition bow wave profile

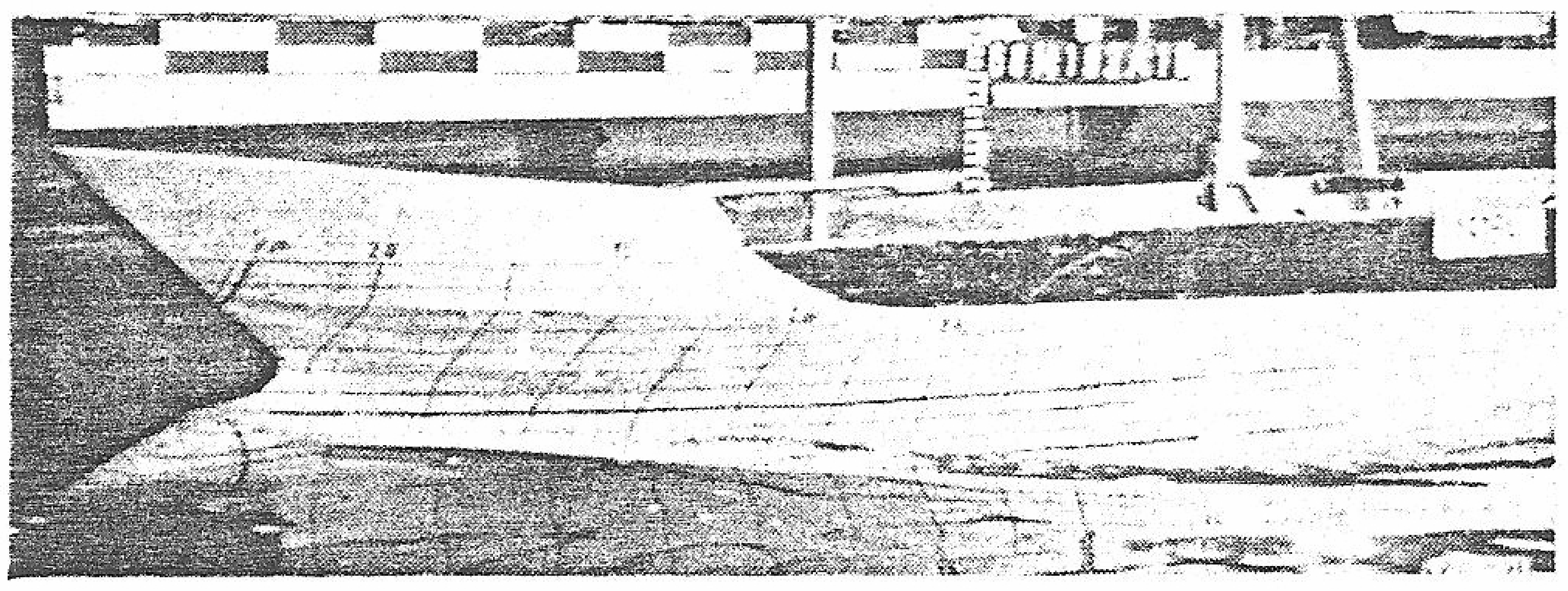

Fig. 6 Effect of the bulb in reducing the bow wave for the half loaded condition

$$\Delta P_D \approx 1.3 \cdot \frac{\Delta P_E}{P_E \text{ without bulb}} \cdot P_D \text{ without bulb}$$

and

$$\Delta V\,[\text{kn}] \approx \Delta P_D\,[\text{h. p.}] \cdot \frac{dV}{dP_D}, \text{ with } \frac{dP_D}{dV} = 1000\,[\text{h. p./kn}]$$

from the measured resistance reductions. The approximate values of speed improvement ΔV, found in this way, are underestimated, since the slope dP_D/dV of the power function is less in these cases, and a certain difference of power therefore corresponds to a greater change of speed, than in the case of the fully loaded ship.

From the theoretical point of view, however, the quantities of power savings or speed improvements, due to the bulbous bow, are not a suitable measure of the efficiency of the bulb, because they depend substantially on the magnitude of the propulsive efficiency $\eta_D = P_E/P_D$ and on the slope of the power function, both of which have nothing to do with the bulb-effect. Physically more correct is a judgement of the efficiency of the bulb by its influence on the bow wave of the ship, as has been stated.

Resistance test results

The results of the resistance tests, given in the diagram, can best be seen from illustrations of bow waves, made during the test runs. Figures 1 and 2 show the shape of the model's entrance without and with the bulbous bow, and further the relative position of the (somewhat thicker painted) waterlines for the tested load conditions of the shorter model M 499. Furthermore it can be seen from these figures, that the bulbous bow has been extended in this case only up to about half the height of the bow wave of the bulbless ship above the designed load waterline, as opposed to the design principle already stated.

This compromise, which is due to construction difficulties, strongly impairs the bulb-effect. As is to be seen from the diagram, in the case of the fully loaded ship therefore only about half as great a resistance improvement could be obtained as in the two cases of smaller draught. The corresponding figures for the bow wave show this different magnitude of bulb-effect very distinctly. (The lengthened model M 536 has the same shape of entrance and therefore also substantially the same bow wave as model M 499). The bow wave of the ship with the bulbous bow is, in the designed draught condition (Fig. 4) substantially reduced as against the case without the bulb (Fig. 3), but in consequence of the mentioned compromise it still swells at the blunter, above water, stem. In contrast to the designed draught the bow wave at the half loaded draught condition is substantially flattened by the bulbous bow (see Figs. 5 and 6).

The different magnitude of the improvements at these two load conditions is an obvious confirmation of the design principle of the Neptun bulb. As can be seen from Figures 5 and 2, the bulb extends in the case of this ship only up to the height of the bow wave of the bulbless ship at the half load draught, which consequently is to be considered as the designed draught of the bulbous bow. The fact, that the bulb in the half load draught condition operates unfavourably at speed values less than about 12 kn, as is to be seen from the diagram, is likewise a consequence of the mentioned compromise in the case of this ship. In order to compensate for the insufficient height of the bulb with respect to the fully loaded ship the upper part of the bulb has been designed rather broad, so that the wedge-effect becomes somewhat too strong for the half loaded condition. This results in a short and deep wave trough, which causes a deterioration in resistance at low speed values, because its position is too far in front of the remainder of the bow wave of the real ship. At the speed of about 14 kn, at this draught condition, its position is at frame 19¼ and operates very favourably. However, the most efficient interference with the remaining bow wave takes place at about 15 kn (see Fig. 6 and diagram).

These results of the resistance tests at half load draught not only illustrate the importance of the problem of wave interference for the design of bulbous bows, but furthermore it shows especially, that the shore-effect of the Neptun bulb makes possible an effective influence on this interference.

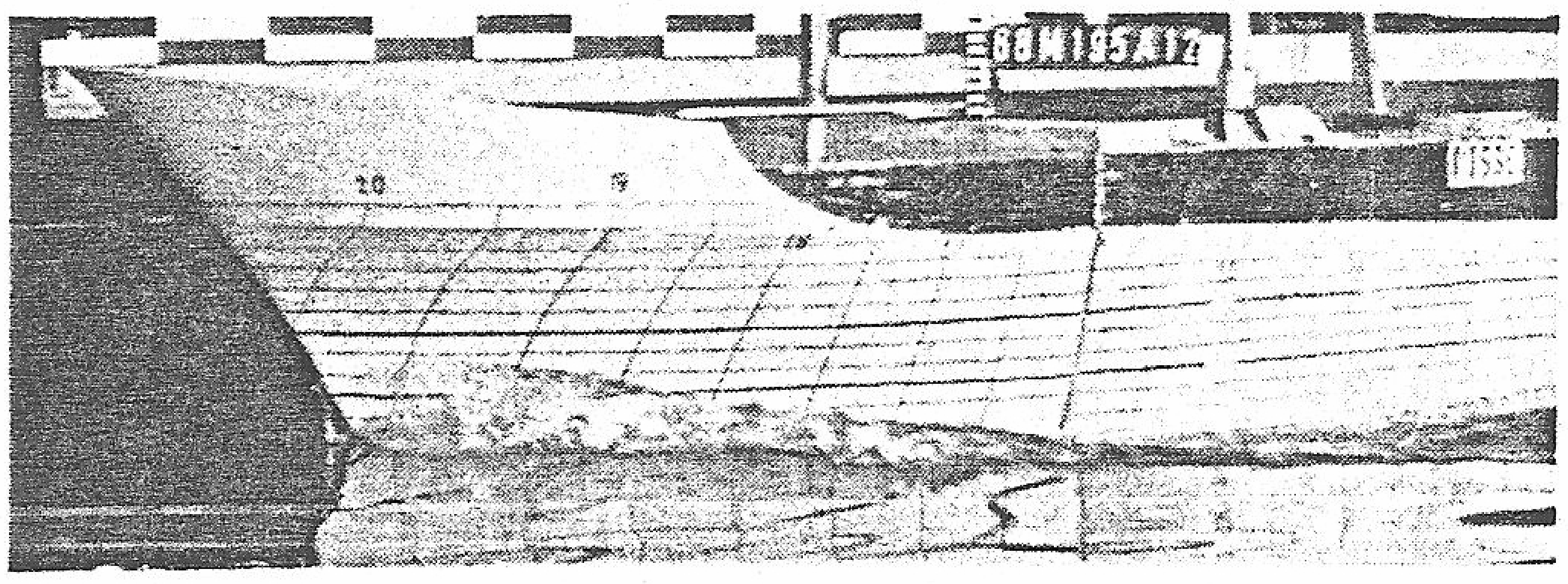

Fig. 7 The bow wave profile for the ballast condition

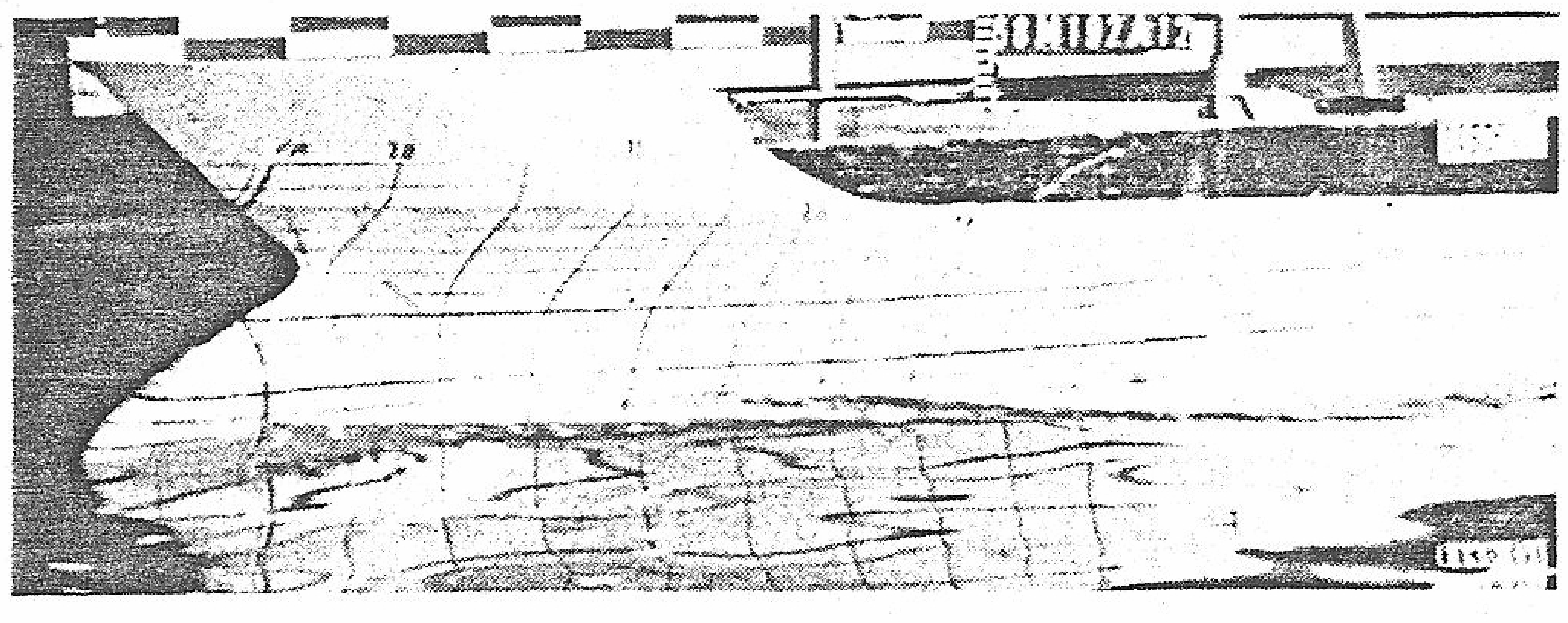

Fig. 8 The model, with bulb fitted, in the ballast condition

For the light draught ballast passage with trim by the stern resistance improvements have been measured of the same order of magnitude as for the half load condition. The respective wave figures show that the bow wave of the bulbless ship (see Fig. 7), being likewise still rather high in the light draught condition, has been almost completely suppressed by the bulbous bow (see Fig. 8). This result of the tests evidently proves that the Neptun-bulb can in fact be designed to operate with equal effect for very different load conditions of the ship.