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E. KLINDWORT

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10 Sheets-Sheet 1

Fig. 1

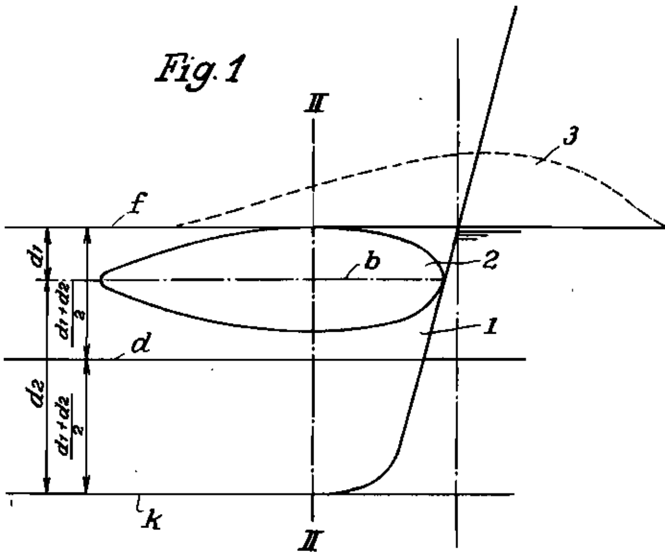

Fig. 2

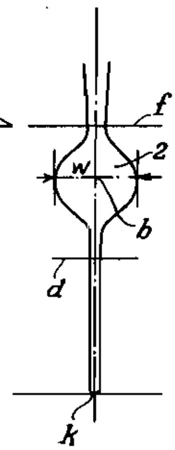

Fig. 3

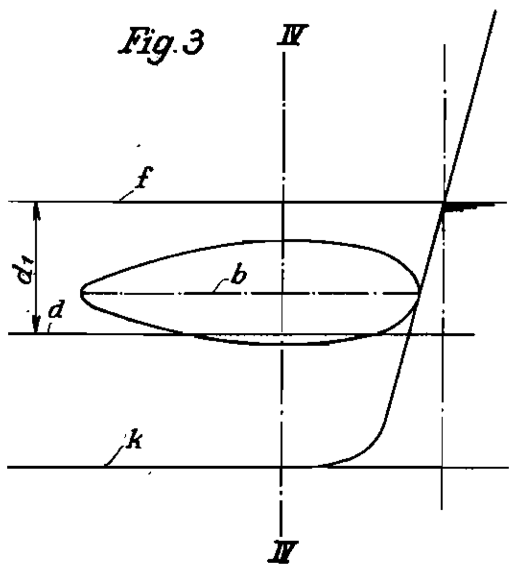

Fig. 4

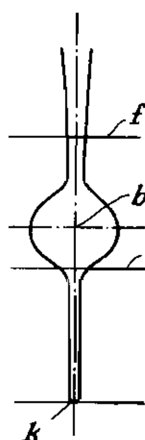

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Fig. 5

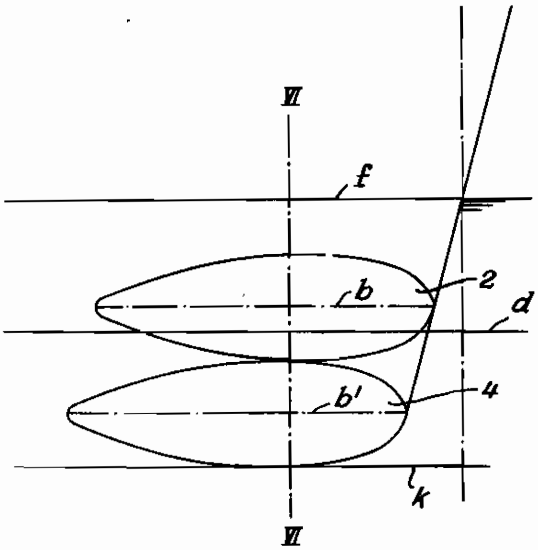

Fig. 6

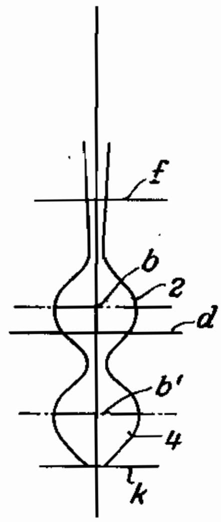

Fig. 7

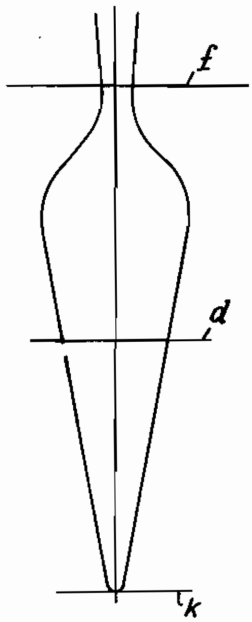

Fig. 8

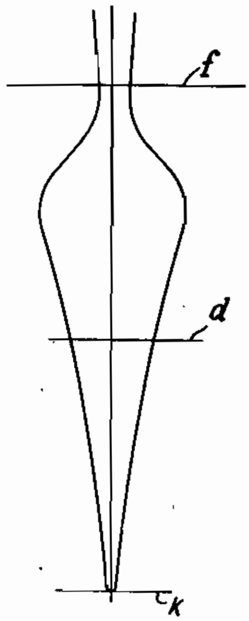

Fig. 9

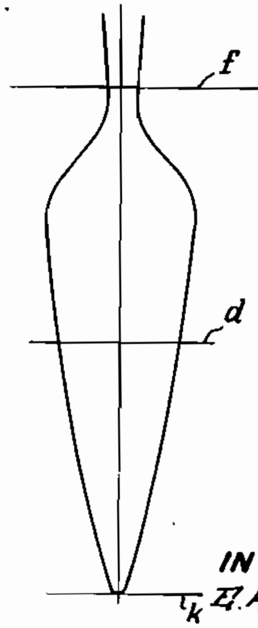

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Fig. 10

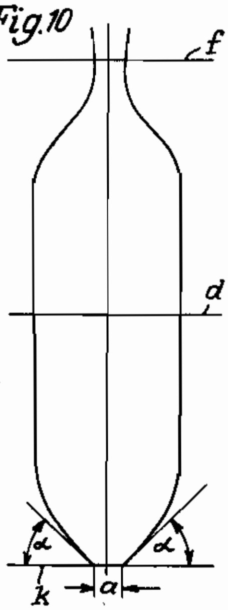


Fig. 11

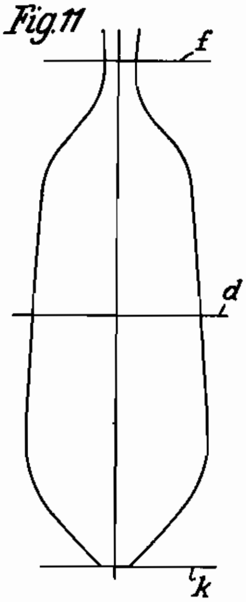


Fig. 12

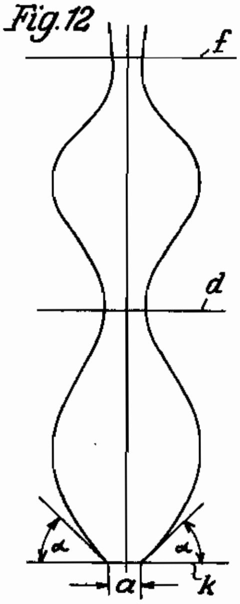


Fig. 13

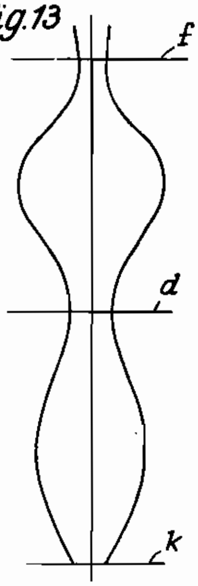


Fig. 14

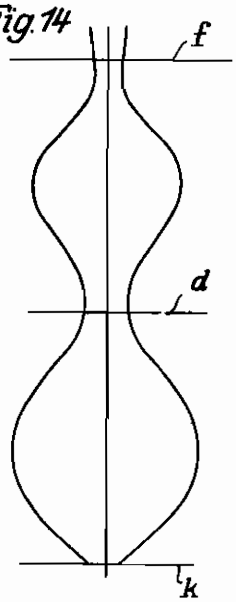
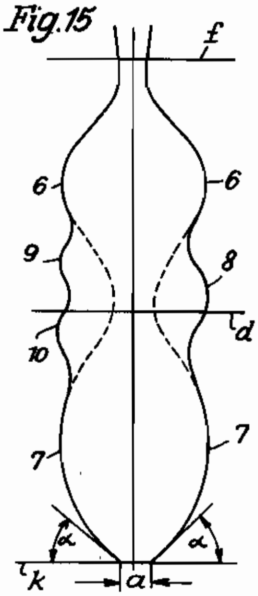


Fig. 15



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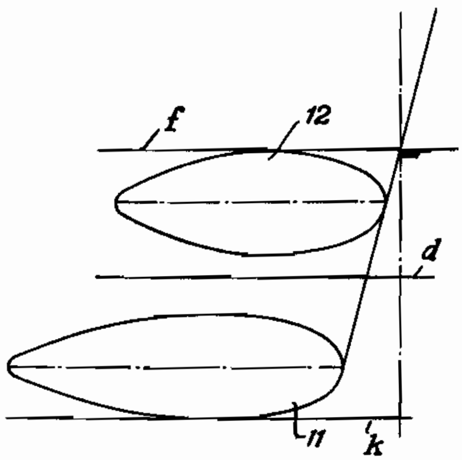

Fig. 16

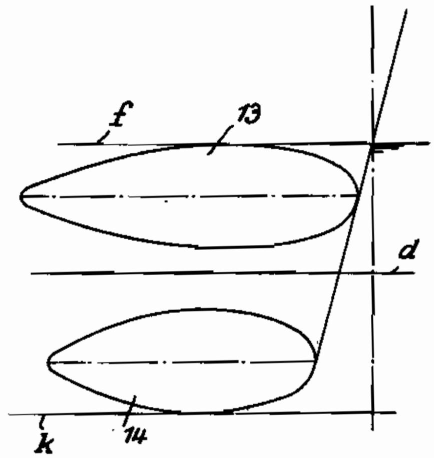

Fig. 17

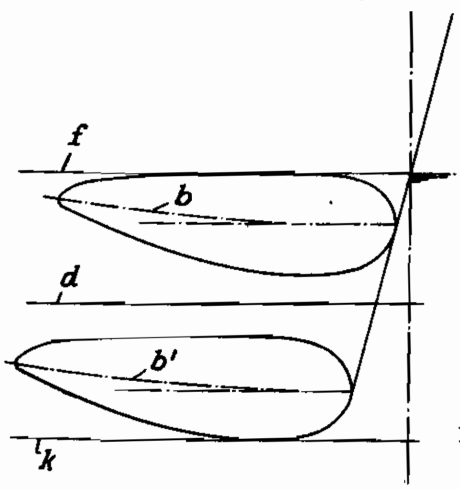

Fig. 18

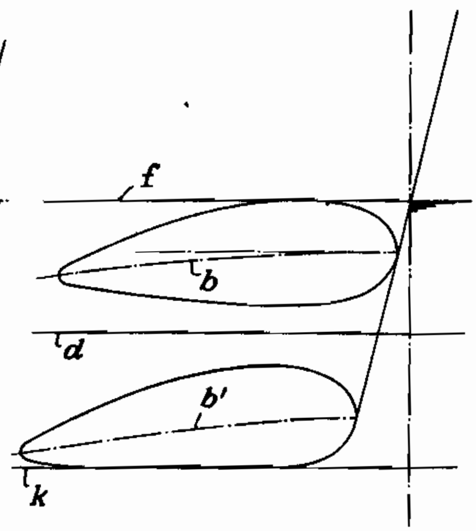

Fig. 19

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Fig. 19a

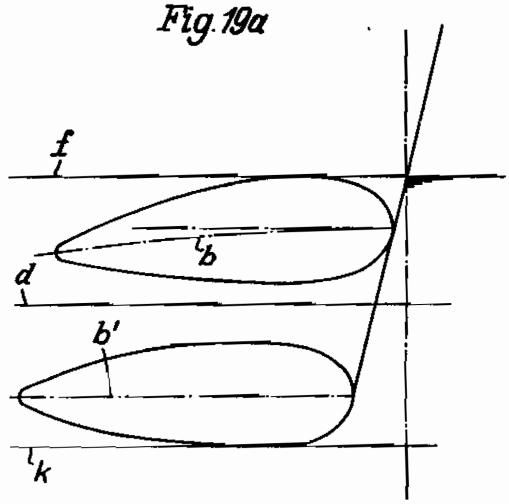

Fig. 19b

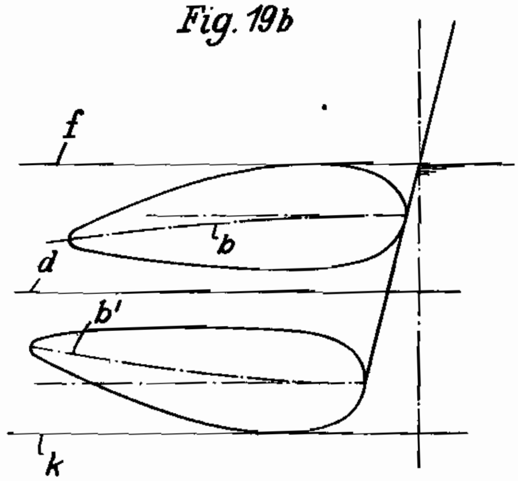

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Fig. 20

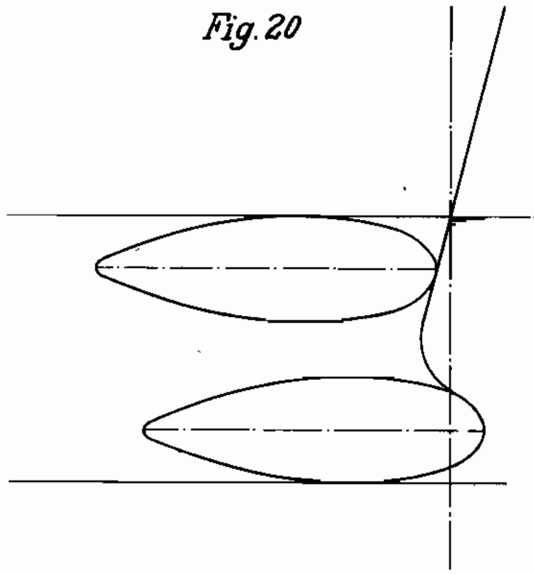
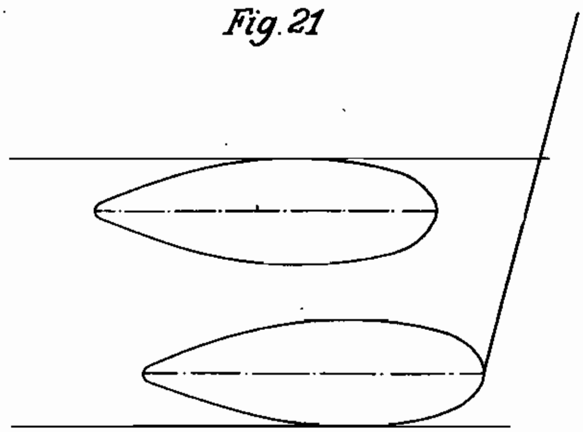


Fig. 21



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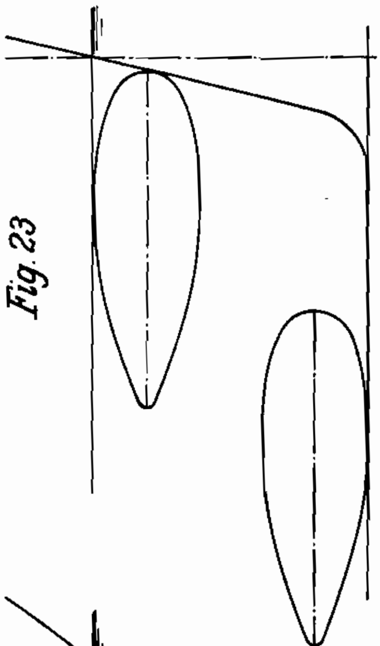

Fig. 23

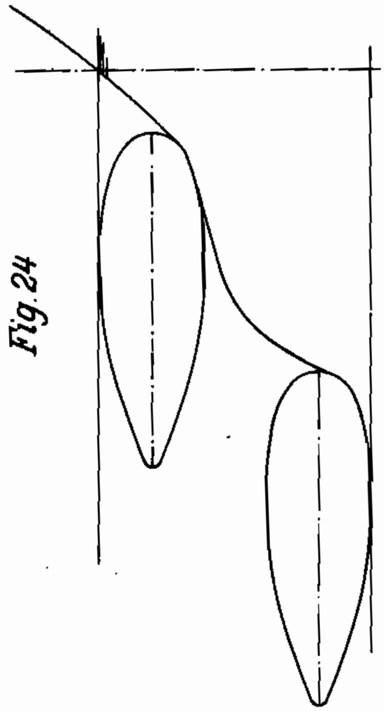

Fig. 24

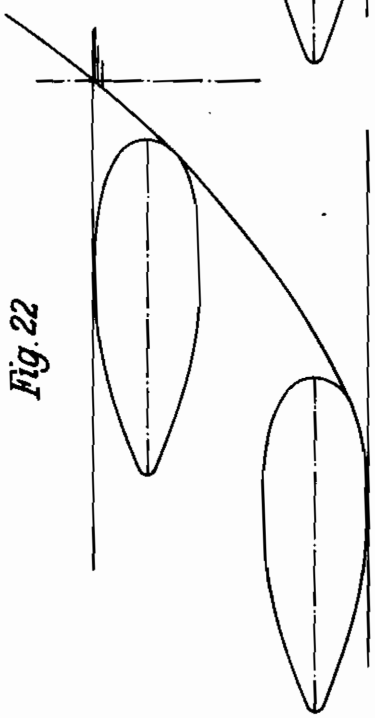

Fig. 22

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Fig. 26

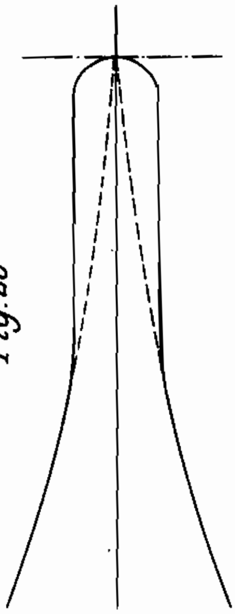

Fig. 27

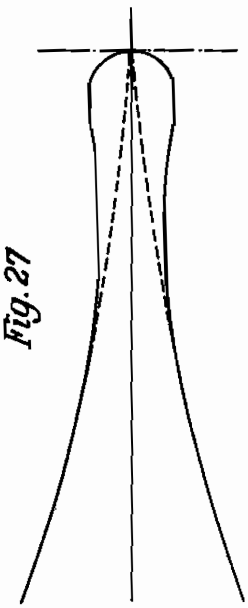

Fig. 29

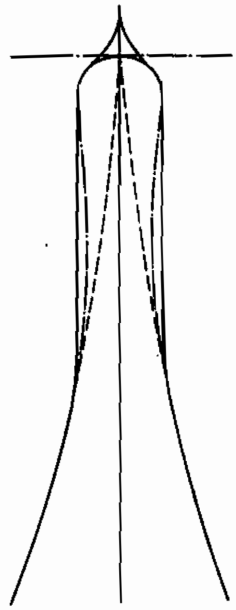

Fig. 25

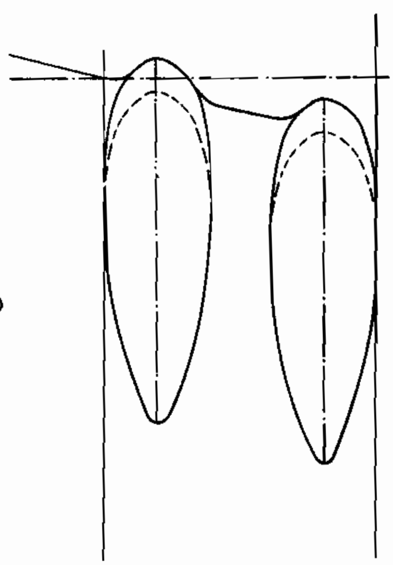

Fig. 28

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Fig. 31

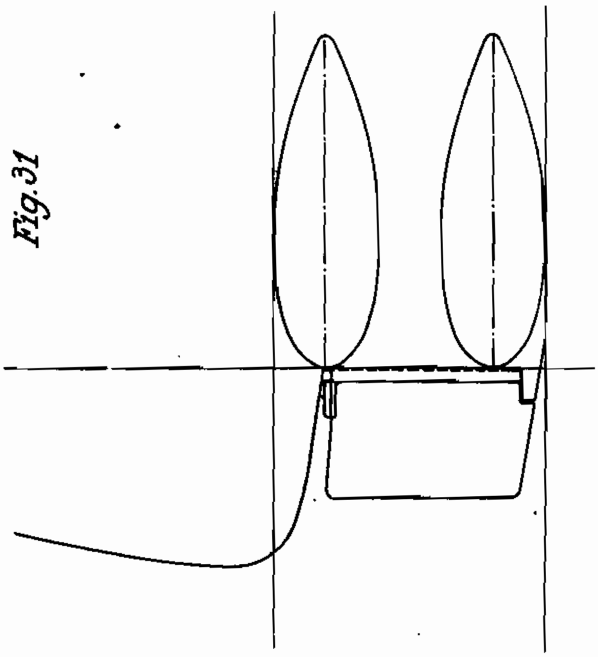

Fig. 30

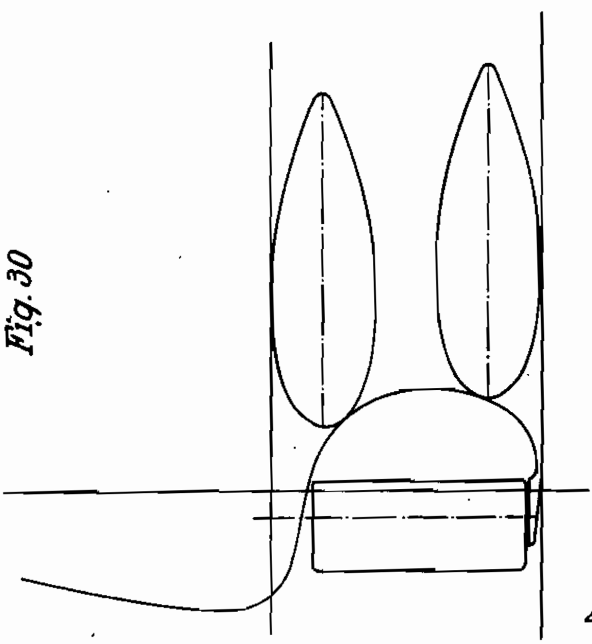

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Fig. 32

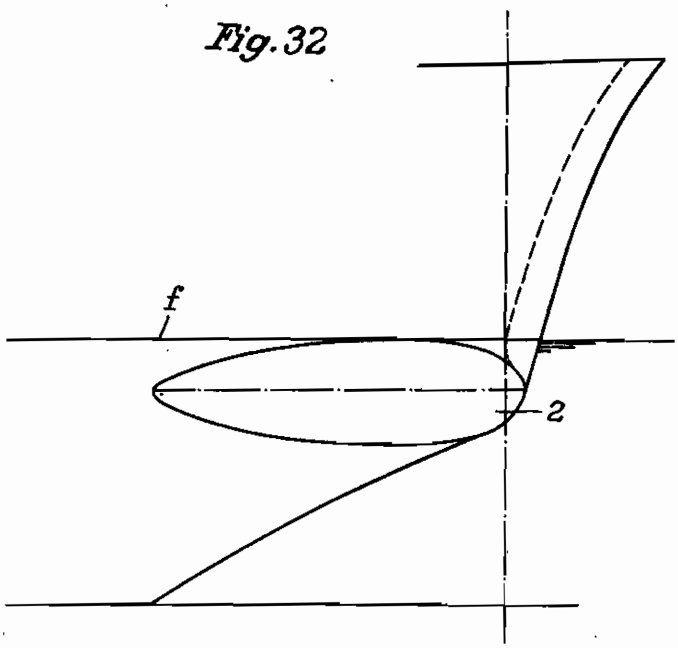
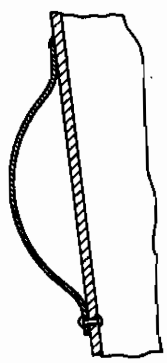


Fig. 33



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ALIEN PROPERTY CUSTODIAN

SHIP FORM

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Application filed March 13, 1941

This invention relates to certain improvements regarding ship forms, of the type having a bulbous bow similar to the so-called "Taylor bulbous bow."

Many types of hulls used in practice have a bulbous portion at the keel of the vessel or in the lower portion of the immersed part of the bow, while according to another proposition a bulb is provided in the region of the constructional water line (C. W. L.). However, the last-mentioned proposition, although suggesting certain improvements regarding the wave-producing resistance, i. e. an increased speed with a given output, does not meet sufficiently with the requirements of practice. More particularly, variations of the draught of the ship and changes of trim, caused by changes of the quantity and weight of the cargo and the consumption during the journey, as well as influences of the waves must be taken into account. Therefore, the actual water line in many instances may be at a lower level than the constructional water line, so that a bulb in the region of the constructional water line will frequently emerge from the water and thus fail to meet its actual purpose. Moreover, it has been found that a bulbous portion in the region of the constructional water line may give rise to heavy spray water phenomenons.

It is an important object of the present invention to provide a shape of the fore-ship which avoids the drawbacks of the said bulbous portions in the constructional water line while being more efficient than the so-called "Taylor-bulb," which has been described, for instance, in an article in "Marine Engineering and Shipping Age" September 1923, on pages 540 to 548.

With this and further objects in view, as may become apparent from the within disclosures, the invention consists not only in the structures herein pointed out and illustrated by the drawings, but includes further structures coming withing the scope of what hereinafter may be claimed.

The character of the invention, however, may be best understood by reference to certain of its structural forms, as illustrated by the accompanying drawings in which:

Fig. 1 is a diagrammatic side view of the bow of a vessel having the invention applied thereto.

Fig. 2 is a diagrammatic section on line II—II of Fig. 1.

Fig. 3 is a view similar to Fig. 1, showing a modification.

Fig. 4 is a diagrammatic section on line IV—IV of Fig. 3.

Fig. 5 is a diagrammatic side view showing a further modification, including two superposed bulbous portions.

Fig. 6 is a diagrammatic section on line VI—VI of Fig. 5.

Figs. 7 to 15 are diagrammatic sections similar to Fig. 6, but showing various modifications.

Figs. 16 to 25 are diagrammatic side views showing further modifications.

Figs. 26 to 29 are diagrammatic horizontal sections of various forms of ship bows having the invention applied thereto.

Figs. 30 and 31 are diagrammatic side views showing the stern of a vessel embodying an additional feature of the invention.

Fig. 32 is a diagrammatic side view of a ship's bow embodying a combination of my novel bulbous bow shape with a rearwardly cut off stem.

Fig. 33 is a fragmentary section showing the subsequent mounting of my bulbs.

Similar characters of reference denote similar parts in the different figures. For the sake of clarity, the sectional views have been indicated by their outer contours only, without hatching or detailed showings.

Referring now to the drawings in greater detail, and first to Figs. 1 and 2, the fore-ship 1 is provided with a bulb 2 disposed below the constructional water line or the load line of the vessel, spaced therefrom by a distance d_1 sufficient to avoid the above mentioned deleterious effects of bulbs in the region of the water line f, but spaced also from the keel k by a distance d_2 sufficient to produce a more intensive effect of the bulb upon the formation of the bow wave indicated at 3 than a so-called Taylor bulb arranged at the keel level. Practically speaking, I arrange the bulb to have its maximum width w at a level above the line d indicating half the total draught of the vessel, whereby the height of the bow wave is substantially reduced even in a speed range where the conventional Taylor bulbous bow would not be effective yet. It will be understood that the line d is at a level which is spaced by the distance

$$\frac{d_1+d_2}{2}$$

from the keel 4 as well as from the water level f, as indicated.

The bulb 2 should be arranged at such a distance d_1 below the line f, indicating the constructional water line, or below the load line, respectively, that the favourable effects of the Taylor keel bulb preventing the formation of spray water with medium height of the waves and with changed trim, as produced by the various customary load conditions, is preserved as much as possible. By the arrangement of my pear-shaped bulb **2** at the level above stated, the bulb under practically any conditions will remain immersed, thus being enabled to produce interference with the normal bow wave system, i. e. to neutralize the normal bow wave, or at least to reduce the same, whereby the output required for propelling the ship is reduced.

Extensive tests have shown that my novel bulbous portion may be constructed in various manners. In the embodiment shown in Figs. 1 and 2 the bulb is shaped similar to a solid generated by rotation about the axis *b*, said solid passing over into the normal bow shape through relatively sharply bent curves.

The shape of fore-ship shown in Figs. 3 and 4 differs from Figs. 1 and 2 merely by the fact that the bulb **2** is arranged at a lower level d_1 from the water line *f*, the maximum width, however, still being in the upper half of the immersed or wetted ship portion, i. e., above the line *d* indicating half the amount of draught.

Towing experiments have shown that my novel bulbous portions produce favourable effects even at relatively low speeds, while the conventional Taylor bulbous bow in the form of a pear-shaped bulb at the keel produces favourable effects at a higher speed only. Therefore, as indicated in Figs. 5 and 6, I contemplate combining my novel bulbous projection **2**, having its maximum width at a point in the upper half of the total draught, with a second bulbous portion **4** of the Taylor type, arranged at keel level, or in the lower half of the immersed portion of the fore-ship, respectively.

Figs. 7 to 15 illustrate various modifications of the combination shown in Figs. 5 and 6.

It has been found that a favourable effect can be attained, for instance, by making the maximum width of the bulb to fade out towards the keel, in the form of a straight or slightly concave or convex curve, as shown in Figs. 7, 8 and 9, respectively. This shape may be advantageous for constructional reasons or in case that it is intended to put the center of gravity of the displacement afore.

The same effect is still more pronounced in a modification in which the maximum width of the bulb is maintained over a larger region of the immersed portion of the fore-ship, in a cross-sectional form similar to a bottle, as shown in Fig. 10, or in which the maximum width of the bulb is even enlarged in width towards the keel, as shown in Fig. 11. The shape shown in Fig. 11 is distinguished from any of the known hulls having a bulbous bow, by the shape of the frames in the upper half of the immersed portion of the fore-ship.

It has been found, moreover, by numerous tests that where two bulbous portions are provided the width of the two bulbous portions influences their effect. With a view to practical requirements, for instance, in anchoring manoevres, it may be desirable to keep the width of the bulbous bow portion within certain limits. In this case it will be suitable to equalize the width of the two bulbous portions, as shown in Fig. 12.

However, in order to reduce the wave formation as much as possible, it may be advantageous to make one bulbous portion thicker than the other one. Therefore, according to a further important feature of the invention, two bulbous portions of different maximum width are provided. In this case, it will depend on the special circumstances whether the upper bulbous portion is made wider, as shown in Fig. 13, or the lower one, as shown in Fig. 14.

According to a further feature of the invention, the connection between the upper and lower main bulb may be formed by a wave line comprising one or more waves. For instance, Fig. 15, right hand half, illustrates a modification in which the connection between the upper and lower bulb **6** and **7** is formed by one wave **8**, while the left hand half of Fig. 15 shows a bow shape with two waves **9**, **10**, between the main bulbs **6** and **7**. These forms will be used especially where it is possible, by carrying out extensive towing experiments, to find out the most favourable pressure conditions for the respective case and thus to secure the optimum reduction of the bow wave which is attainable in the respective case by means of bulbous portions disposed below the constructional water line. Also, it may be desirable to provide several bulbous portions for stabilizing pitching phenomenons.

Generally, care should be taken that the horizontal width "*a*" of the bulbous portions at the keel is not made larger than required for receiving the pressure forces occurring in docking operations. Moreover, the bilge angle α should be chosen so that the formation of spray is avoided as much as possible as the fore-ship is re-immersed after complete emergence in rough sea.

The effect of the bulbous bow is greatly determined by the shape of the upper region of the upper bulbous portion. In all modifications, a characteristic bulb similar to a Taylor bulb is provided above the line *d* of half the total draught, as indicated in Figs. 7 to 15.

Owing to the wide variety of ship hulls to which the invention can be applied, no general figures can be given regarding the dimensions and especially regarding the length of the bulbous portions. In some instances, it may also be useful to provide several bulbous portions of different length, as shown by way of example in Figs. 16 and 17. According to Fig. 16 the lower bulbous portion **11** is made longer than the upper bulb **12** while according to Fig. 17 the upper bulbous portion **13** is made longer than the lower bulb **14**.

Experiments have shown that the pressure effect of the bulbous portions also depends on their construction and arrangement in longitudinal direction of the ship. Depending on the desired efficiency of the bulbs it may be advantageous to arrange the bulbous portions with their center line *b* in horizontal position, as indicated, for instance, in Figs. 1 and 5, or in an inclined position, for instance, rising abaft, as shown in Fig. 18, or sloping abaft, as indicated in Fig. 19. Moreover, where a plurality of bulbs are provided, they may have different slope, as indicated in Figs. 20 and 21, showing an upper bulb with downward slope abaft combined with a lower bulb in horizontal or rearwardly rising position, respectively.

Furthermore, I contemplate arranging the bulbous portions in longitudinally staggered positions. Here again, it depends on the special circumstances of the case whether it is desirable to arrange the upper bulbous portion staggered abaft with respect to the lower one or vice versa. Typical shapes of this type are shown in Figs. 20 to 24, viz:

Fig. 20 shows the upper bulb staggered abaft relatively to the lower one, the stem being made to conform to this staggered arrangement. Fig.

21 shows a similar arrangement, but with a stem of normal, smooth shape. Fig. 22 illustrates an embodiment with the upper bulb arranged afore the lower one, the stem again being made to conform to this arrangement, and Figs. 23 and 24 show similar types, but with modified stem shapes. The shape of Fig. 24 offers the advantage that the wetted surface is small.

Referring now to Fig. 25, it will be noted, that the bulbous portions in this case are made to project forwardly from the stem, whereby a maximum effect of the bulbous bow can be secured in many cases.

Generally, a horizontal section through a Taylor bulbous bow shows a contour which after reaching the normal bulb width underlying the construction runs parallel to the center plane of the ship, as shown in Fig. 26, or passes over into the normal ship hull with a gradually increasing width. My experiments have shown, however, that special advantages can be secured by recontracting or tapering the bulb abaft behind a maximum width, as shown in Fig. 27. In both cases, the dotted line 15 indicates the normal contour of the hull above and below the bulb or bulbs.

It will be understood that the horizontal section shown in Fig. 27 refers to a horizontal bulbous portion. Where the bulb is rising or sloping abaft, as per Figs. 18 to 21, the contours of Fig. 27 would relate to a section on a plane *b* disposed at right angles to the middle plane of the ship and forming the plane of symmetry or the plane of maximum width of the bulb.

The circular shape of the front end of the bulb in Figs. 26 and 27 may be used where emergence of the bulb from the water is not to be expected. With sea-going ships, on the other hand, where emergence of larger portions of the fore-ship will be occasioned it is advantageous to provide a sharp edge with a front angle β of less than 180°, as shown in Fig. 28, or a shape as shown in Fig. 29.

In some instances, for example, where the hull of the ship is sufficiently slim as to permit at the aft-ship reconversion of a considerable portion of the potential energy of flow absorbed by the fore-ship, similar bulbous portions arranged corresponding to those at the bow may be provided at the aft-ship, as shown in Figs. 30 and 31, for reducing the formation of stern waves. Fig. 30 shows two horizontal bulbous portion of about equal length arranged at the stern of a single screw ship, while Fig. 31 shows a similar arrangemen at the stem of a multi-screw ship having an even number of screws.

Fig. 32 illustrates the combination of a bulbous bow portion 2 in the upper half of the total draught combined with a stem which below the bulb is cut off abaft for reducing the size of the frictional area or wetted surface.

I contemplate also combining any of the above described features of my invention with each other in a suitable manner. For example, a plurality of bulbous portions of equal or different maximum width may be arranged at different slope of their center lines, in a staggered relationship. The arrangement adapted to reduce the formation of waves most efficiently must be determined in each case by tests carried out with the ship in question, or with a model thereof, in a model basin, or, at a later date, may be determined by theoretical considerations and computations, basing on the data of the respective ship.

Further, my novel bulbous portions, besides being provided on newly constructed ships may also be fitted subsequently on existing ships. To this end, vaulted sheet iron plates may be welded or riveted to the hull of the ship, as indicated in Fig. 33. Thus, the resistance of the ship can be reduced and as a result the speed can be increased or the output of the engine and the fuel consumption reduced.

The principle of this invention may be applied both to sea-going and inland ships. In the latter case, it is an advantage that pitching motions generally need not be taken into account.

It should be noted that the term "bulb" or "bulbous portion" as used in this specification and in the claims relates to curved projections of the type extending lengthwise on the hull of the ship, preferably in a streamline shape, as illustrated.

The method of the present invention has been described in detail with reference to specific embodiments. It is to be understood, however, that the invention is not limited by such specific reference but is broader in scope and capable of other embodiments than those specifically described and illustrated in the drawing.

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