June 30, 1942. H. SCOTT-PAINE 2,288,490

HIGH-SPEED MOTORBOAT

Filed April 6, 1940 3 Sheets-Sheet 1

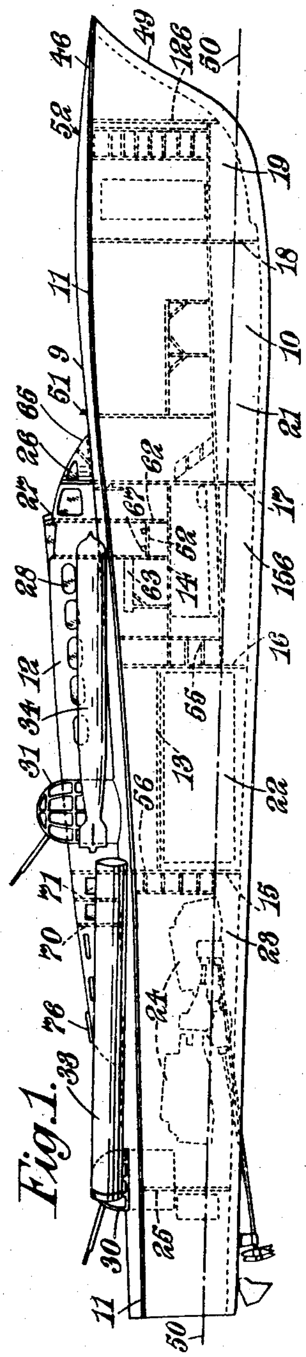

Fig. 1.

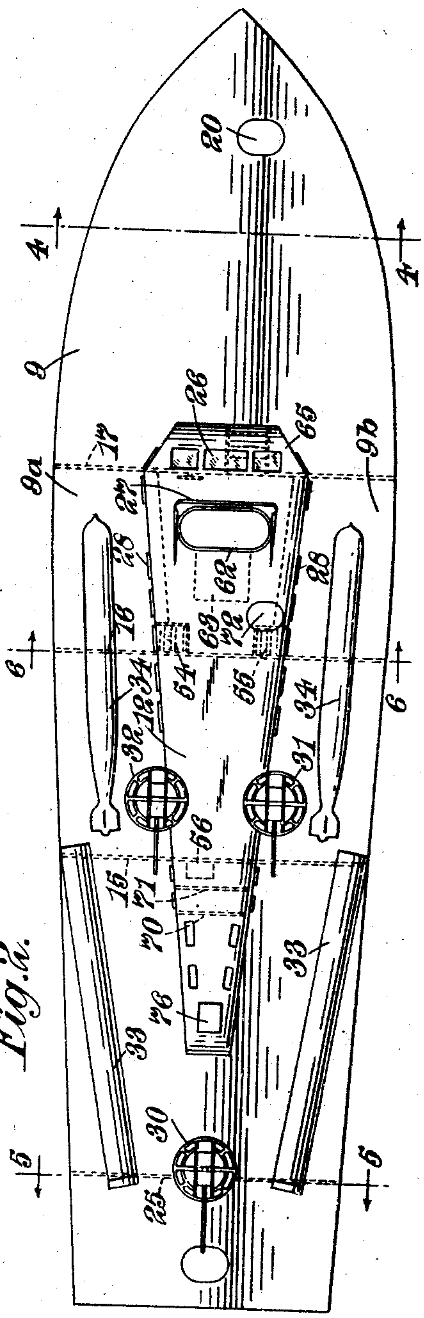

Fig. 2.

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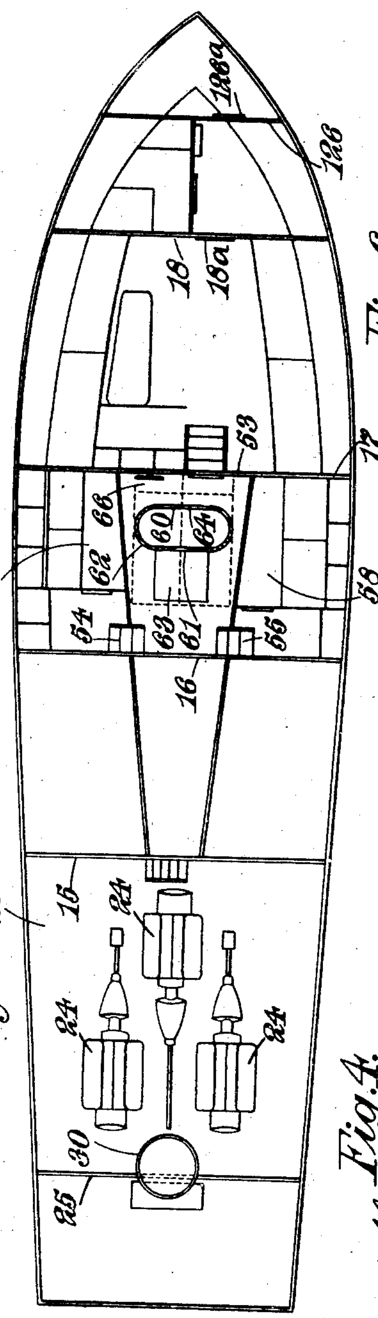

Fig. 3.

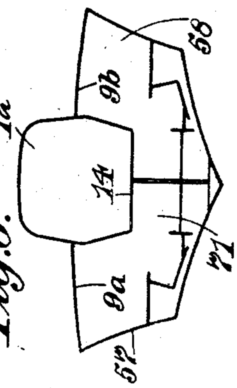

Fig. 6.

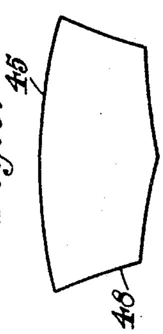

Fig. 5.

Fig. 4.

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HIGH-SPEED MOTORBOAT

Filed April 6, 1940 3 Sheets-Sheet 3

Fig. 7.

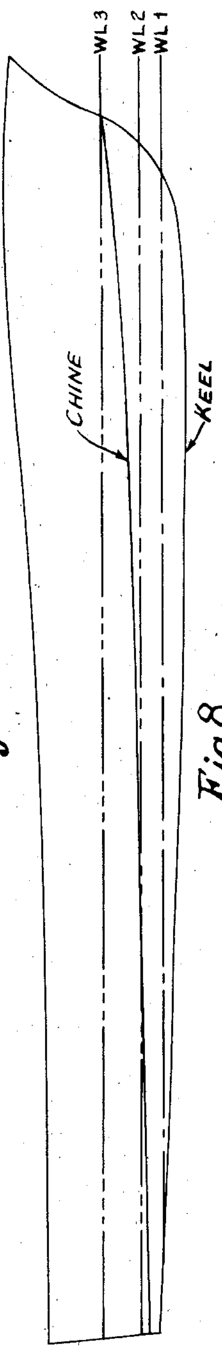


Fig. 8.

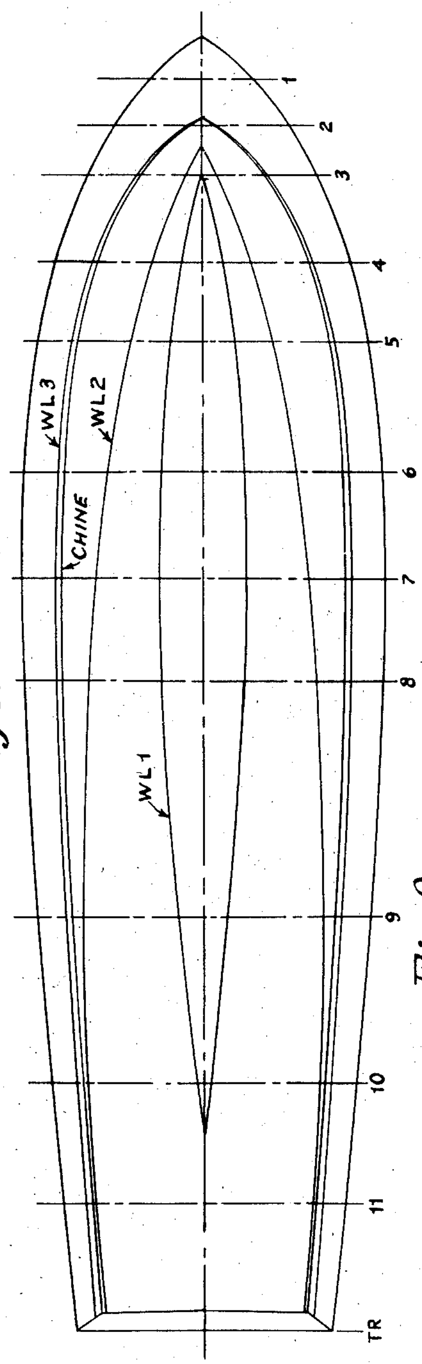
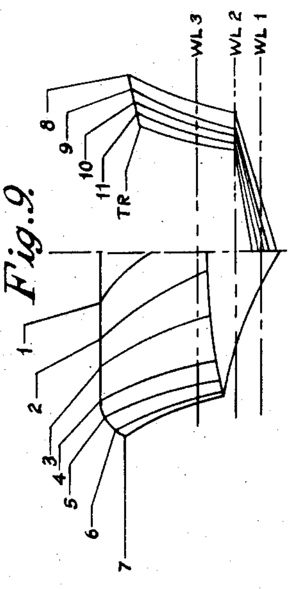


Fig. 9.



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Patented June 30, 1942

2,288,490

UNITED STATES PATENT OFFICE

2,288,490

HIGH-SPEED MOTORBOAT

Hubert Scott-Paine, Hythe, Southampton, England

Application April 6, 1940, Serial No. 328,171
In Great Britain March 25, 1939

25 Claims. (Cl. 114—66.5)

This invention is for improvements in or relating to high-speed motor-boats and has for its object to provide new and improved constructions and arrangements of such craft which are particularly suited for use as war vessels such, for example, as torpedo boats.

One of the most desirable characteristics of such a vessel is that it should be inconspicuous as a target, and in general this is effected by constructing the vessel so that it has a low silhouette; but it is also essential that it should have good sea-keeping qualities in all weathers and also it should be capable of high speeds even in rough seas, and this is attained by the novel hull lines hereinafter described.

Numerous attempts have been made in the past to provide hulls the main purpose of which was to reduce the resistance at high speed by making such hulls of a planing type so that the area of the wetted surface of the hull was reduced at speed by such planing motion. Some of such hulls have been of a planing type with or without steps, and others have been of the partially planing type combining some of the features of a displacement boat. The former types have been unseaworthy in that they lacked longitudinal, lateral and steering stability in a seaway, and had pronounced tendency to dive. The latter type, which may be termed a compromise, may have partially overcome some of the undesirable qualities of the former type, but at the expense of introducing some of the inherent disadvantages of other types of hull.

The present invention has resulted in the provision of a surface or planning type of hull of the hard-chine type with novel characteristics giving improved performance as to manoeuvreability, steerability and seaworthiness at all speeds, and particularly at very high speeds, in comparison with any previously known type of hull, while maintaining at the same time the good qualities of a displacement hull at low speeds. More particularly stated, the invention results in the provision of a hull of the planing type which, by reason of the physical forces brought into use, maintains its longitudinal and lateral stability throughout the speed range, that is, has minimum pitching and rolling irrespective of the direction of the sea; has such excellent directional stability that it does not yaw in a following sea to any objectionable extent; may be driven safely against a head sea at higher speeds than has hitherto been considered safe; and maintains the variations of its longitudinal trim between very narrow limits throughout the speed range; thereby improving the hull as a gun or torpedo firing platform and as a platform from which depth charges, mines and the like may be launched, and contributing to the general seaworthiness of the boat, and increasing the comfort and lessening the fatigue of the crew and passengers.

The hull lines which make possible the advantageous characteristics just mentioned will be hereinafter described in detail, but the following features of the invention may be here mentioned.

The most suitable type of vessel is the well-known hard-chine type, and according to this invention the sheer lines of the hull are such as to provide, with a continuous smoothly curved contour or deck-line, a high free-board forward and a low free-board aft. In the case of a torpedo boat, the after portion of low free-board is of such a length as to provide adequate accommodation for a torpedo tube. The benefits obtained by this construction are:

(a) The extra buoyancy provided by the higher freeboard at the forward part of the vessel prevents it from diving or boring into waves when running at high speed, and improves the general seaworthiness of the vessel.

(b) The after portion of lower freeboard provides a torpedo launching platform which is sufficiently low and near the water level to facilitate the discharge of torpedoes, or if the vessel is used for other war-like purposes it provides a convenient platform for launching depth charges, mines and the like, and

(c) It is possible with this general construction of the hull to provide an adequately seaworthy boat having a very low silhouette and therefore inconspicuous as a target.

In practice it has been found that it is possible to provide a seaworthy boat as above described when the freeboard aft is about one-third to one-half of the freeboard forward.

According to one feature of this invention the inconspicuousness of the boat which has a smoothly continuous deck-line is enhanced by so constructing the boat and its fittings that it presents a completely smooth and unbroken silhouette. This is effected by the omission of all parts such as masts, rigging, hatches, skylights, bollards, which present a broken and sharp-edged silhouette, and further by shaping any outstanding parts, such as deck-houses, so that they merge smoothly into the silhouette lines of the boat.

According to another feature of the invention, the camber of the forward part of the deck is substantially less than that of the after part of the deck. This is possible because in normal service the forward part of the deck is much drier than the after part and a large camber is desirable in the after part adequately to discharge water therefrom, but the flattened camber on the forward part of the deck enables the sight-line forward from the control-positions of the craft, which are arranged somewhat forward of amidships, to be substantially lower than with a high cambered deck, without sacrificing the advantages above-mentioned of extra buoyancy forward.

According to yet another feature of the invention the centre-line of the deck immediately adjacent the bow is sloped slightly downward, for the same purpose of giving a low sight-line forwardly from the control positions.

According to another feature of the invention, the sides of the boat are flared outwards towards the gunwale throughout their entire length. This flaring curvature increases progressively from the transom to the stem and the stem itself is flared forward to secure continuity of this feature. The stem overhangs the forefoot considerably, having in elevation a sloping S-shaped curve up to the deck. By this means considerable up-draught is created and a very dry deck is ensured and a good platform is provided for mooring operations and the like.

It will be appreciated that in view of the general requirement of a low silhouette for the craft, the control-positions which are normally situated in a super-structure or deck-house must also be kept low, and it is for this purpose that the special constructions just mentioned for giving a low sight-line are provided, and according to another feature of the invention, the low silhouette and low height of the control-positions are obtained by constructing the vessel so that the maximum head-room available below the deck is not substantially greater than the height of a man and constructing the wheel-house with its floor below deck level, but of substantially less width than the vessel so as to provide below-deck cabin accommodation which whilst partly of reduced head-room is also partly of the full available head-room. In this way it is possible to provide adequate cabin accommodation whilst maintaining minimum overall height of the vessel. In so far as the cabin accommodation is concerned a sleeping berth or the like is preferably provided near the floor level of the cabin in the space below the floor of the wheel-house.

According to another feature of this invention, there is provided in a vessel as above described, a wheel-house as described in my co-pending application Ser. No. 328,170, now Patent No. 2,268,-425, issued December 30, 1941.

According to yet another feature of this invention, additional armament for a craft as above-described is provided by automatic gun-turrets of the enclosed type now used on aircraft, and these are arranged so that access to the interior is obtained below deck level, so that they are accessible under any weather conditions.

Preferably three such turrets are used, and according to another feature of this invention one of these is disposed as far aft as possible and the other two are arranged one at each side of the after end of the wheel-house; in this way the maximum concentration of fire in any direction, forward, aft or upwards is obtained.

One example of the invention is shown in the accompanying drawings in which:

Figure 1 is a side elevation of the boat,

Figure 2 is a plan view of the boat,

Figure 3 is a plan view of the boat with the deck removed,

Figures 4, 5 and 6 are outline sections on the lines 4—4, 5—5 and 6—6 respectively of Figure 2,

Figure 7 is a side elevation showing the lines of the hull,

Figure 8 is a plan view showing the lines of the hull,

Figure 9 shows the transverse sections of the hull at the various stations indicated in Figure 8.

The vessel is of the hard-chine type consisting of a hull 10, deck 9 and wheel-house 12. The boat is constructed so that the sheer lines 11 provide a high free-board forward and a low free-board aft with a continuous smoothly curved contour or deck-line, as is clearly seen in Figures 1 and 7.

The vessel shown in the drawings is of the order of 70 ft. in length and the line indicated by the reference 50 in Figure 1 is the still water-line. The free-board between this line and the deck at the forward end of the boat is about 8 ft. and at the aft end about half this amount, and, in between, the sheer lines curve smoothly between these limits as may be seen from Figure 1.

The camber of the forward part of the deck is substantially less than that of the after part of the deck, and in this example the camber between the stern of the boat and the point indicated by the reference 51 is about 10'' on the full beam. This camber decreases uniformly from the point 51 up to the stem and near to the stem it is practically nothing, this change being illustrated by the camber 45 in Figure 5 and 44 in Figure 4.

The centre-line of the deck immediately adjacent the bow is sloped slightly downward from the point marked 52 in Figure 1.

The vessel is constructed so that the maximum head-room available below the deck 9 is not substantially greater than the height of a man. The wheel-house is provided with a floor 13, 14 below deck level, but is of substantially less width than the vessel as may be seen from Figures 2 and 6. The wheel-house accordingly projects the minimum amount above the deck. The flattened camber of the forward part of the deck enables the sight-line forward from the wheel-house to be substantially lower than would be possible with a high cambered deck without reducing the free-board forward and the sloping of the centre-line of the deck downward also assists in giving a low sight-line forward from the control positions.

The sides of the boat are flared outwards towards the gunwale throughout their entire length and this curvature increases progressively from the transom to the stem as may be seen from Figures 5, 6 and 4 in which the flare at 48 in Figure 5 increases to the flare shown at 47 in Figure 4; all of which is shown more in detail in Figure 9. In addition, the stem itself is flared forward to secure continuity of this feature. The stem overhangs the forefoot considerably having in elevation a sloping S-shaped curve up to the deck as indicated by the reference 49 in Figure 1.

Hull lines

With the aid of the drawings, the novel hull lines to which the satisfactory performance of the boat from low speeds to very high speeds in substantially all kinds of seas is due, will now be described in detail.

Hereinafter, the terms length-beam ratio, displacement-length ratio, projected keel area and planing area have the following meanings:

Length-beam ratio is the length of the boat in feet divided by the beam of the boat in feet, at either the gunwale or the chine, that is,

$$\frac{L}{B}$$

Displacement-length ratio is the displacement of the hull at rest in long tons divided by the cube of the ratio comprising the length in feet along the load water line divided by 100, that is

$$\frac{D}{\left(\frac{L}{100}\right)^3}$$

Projected keel area is the area of the side elevation of any described under-water longitudinal elevational section through the centre line of the hull.

Planing area means the area of that part of the bottom of the hull in contact with the water when the boat is supported mainly by the resultant force of forward speed and the longitudinal angle of incidence of said bottom, or the area available for such use, as the case may be.

The improved hull which is the subject of the present invention has a length-beam ratio substantially between 3.5 and 4.5, preferably approximately 3.5 to 3.9 at the gunwale and 4.1 to 4.5 at the chine. It has what are commonly known as a "V bottom" and "hard chines" and it will be noted that said bottom has no steps and in transverse section has a dihedral angle on each side of the centre line throughout its length; and that said bottom sections are preferably concave in transverse section throughout the forebody, and are preferably concave or straight in cross section in the afterbody. The sides of the hull above the chines are preferably concave in cross section throughout their length and form stressed members which give most of the longitudinal strength to the hull. The distinctive knuckle or chine formed where the sides meet the bottom is a prominent feature throughout the length of the hull and does not merge at any point into either the sides or the bottom of the hull. The said chine in plan view, as will be obvious from Figures 8 and 9, has its maximum beam located well forward of amidships. The chines converge toward each other from the point of maximum beam to the stern of the boat, and the beam at the chine at the stern of the boat is preferably about 70% of the maximum beam at the chine, though my invention is not limited to this ratio. It will also be noted from Figure 7 that the chines, in longitudinal side elevation, are substantially straight from the stern throughout about ⅔ of the over-all length of the hull; after which they curve upwardly to a slight extent which may be substantially between 6 inches and 12 inches in 40 feet; and that said chines in longitudinal side elevation from the stern throughout about ⅔ of the over-all length of the hull have a relatively small angle to the load water line of the boat. It will also be apparent that said hull in transverse section has an angle between the bottom and the sides, at and adjacent to the chine, which increases only slightly from the stern forward for about ½ of the over-all length of the hull. It will also be apparent from Figures 4, 5, 6 and 9 that the sides of the hull in transverse section flare outwardly throughout the length of the hull and particularly in the forepart of the hull, so as to make the deck in plan similar in shape to the plan of the chines, but with somewhat greater beam and with somewhat greater length along the centre line, as best shown in Figure 8. As best shown in Figures 1 and 7, said hull in longitudinal elevation has a gunwale line characterized by considerable freeboard forward and a relatively lower stern, and with a peculiar sheer which generally may be described as having a convex curve in the forebody and a concave curve in the afterbody and as a whole having a mean angle of incidence to the horizontal of substantially between 2° and 10° depending on the length of the hull. The highest point of the sheer of the gunwale and centre line is approximately 18% of the over-all length of the hull from the bow. It is also a feature of my improved and unique hull that the section of greatest beam is always forward of amidships, and can be at a point between 25% and 45%, of the total over-all length of the hull measuring from the bow.

Forebody.—In my unique hull, the area of the deck forward of the section of widest beam at the chine line, preferably greatly exceeds the area within the chine lines forward of the same section. The maximum beam at the chine is preferably about 80% of the maximum beam at the gunwale. The angle of intersection of the chine lines in plan at the stem post is preferably approximately 105°, but my invention is not limited to this specific angle.

The aforesaid features provide for my hull a buoyancy in the forebody and an amount of planing area at an optimum angle of incidence, which together make it impossible for the hull to dive and substantially impossible for the bottom of the afterbody to leave contact with the water. Another feature of my unique hull is that the projected keel area of the forebody is greater than the projected keel area of the afterbody (which latter may include that provided by the rudders and the propeller brackets) and the relations between these keel areas is substantially maintained throughout the speed range and in variations of sea conditions, this relationship being contributed to by the configuration of the chine line in longitudinal elevation as described, and the large planing area provided in the forebody; all of which combine to decrease yawing in a following sea to a very marked degree in comparison with previous hulls. Furthermore, the propeller and rudders are always in solid water in a seaway. Tests have demonstrated that my unique hull form does in fact provide seaworthiness, manoeuverability, steerability and safety in a seaway at high speed, hitherto unobtainable with any other form of hull.

Afterbody.—It will be noted that the chine lines in the afterbody of my hull converge towards each other in the direction of the stern at a small angle substantially between 8° and 16°. At no point in the afterbody do the chine lines or any of the water lines or the buttock lines have any concavity or reverse curvature, thereby allowing the water a fair flow aft from the point of widest beam of the hull, and insuring an adequate and fair flow of water to the propellers and rudders. It is a valuable characteristic of my hull that at any speed above approximately 15 knots little if any solid water washes the sides of the hull above the chines, thereby preventing wide variations of projected keel area, particularly in the afterbody of the hull.

In planing types of hulls at speed, the lift provided by the pressure on the bottom, resulting from the forward speed and the angle of incidence of the bottom of the hull, to a very considerable degree takes the place of the support of displaced water; and it is a feature of my unique hull that the centre of pressure throughout its speed range is so close to the centre of gravity and moves only within such narrow limits that the longitudinal trim of the hull varies within very narrow limits throughout the speed range, approximately a maximum of 4°.

Sides.—The sides of the hull flare outboard from the chine to the gunwale and are preferably concave in transverse section throughout the length of the hull, such concavity being very pronounced at the bow and gradually reducing towards the stern, as will be apparent from Figs. 4, 5, 6 and 9. The angle formed between the sides and the bottom of the boat adjacent the chine from the stern to about amidships of the hull is preferably substantially between 95° and 115°.

The sides of my hull have considerable freeboard in the forebody where at its maximum it is preferably substantially between 8% and 12% of the over-all length of the hull, although my invention is not confined to such precise limitations of proportion since this proportion may diminish as the size of the vessel increases. The freeboard diminishes towards the stern where it is preferably substantially between 4.5% and 6.5% of the over-all length of the hull, but this proportion may also diminish as the size of the vessel increases.

Bottom surfaces.—It has already been pointed out that, as shown in Figure 9, the bottom of the hull in cross-section is concave on each side of the centre line to the chines throughout the forebody, and from amidships the concavity decreases until the bottom sides are substantially flat near the stern. It will also be noted that the dihedral angles between the bottom sides and a horizontal plane (or dead rise) are large angles at the forward end of the hull, and that they decrease from the bow to approximately the section of maximum beam beyond which they decrease at a less rapid rate. Figure 9 illustrates these features. The characteristics of the bottom sides of the hull, in combination with the length-beam ratio and the other described characteristics of the hull, result in causing the buoyancy of the hull to increase with increased immersion at a much higher rate than in any previous hulls. Moreover, the concave form of the bottom sides in transverse section in the forebody, and the absence of concavity or of reverse curvature of the water lines in plan and of the buttock lines in the afterbody, combine to reduce the amount of wetted surface of the hull and reduce the waves and wake created by the vessel. Furthermore, these forms of the bottom sections in cooperation with other features of the hull increase the righting forces and contribute to lateral stability of the hull at speed.

Balance of keel area.—Another feature of my unique hull which improves its seaworthiness, maneouverability and stability characteristics in a seaway is the disposition of the projected keel area. The problem of maintaining steady longitudinal trim when a high speed boat is being driven against wave formations heading toward it at angles forward of abeam, is a difficult one. A boat of the displacement type, or having certain displacement type characteristics, with or without forward speed and with headseas approaching, has a time lag in responding to the lift on the forebody provided by the added buoyancy as each wave in passing covers with solid water a larger volume of the hull; and this lag encourages the boat, after the wave has passed the forebody and increases the buoyancy of the afterbody, to dive or plunge into the trough of the sea and subsequently into the next wave. Efforts have been made to alleviate this by various means, but a hull operating under displacement characteristics suffers from this inherent disadvantage. In the case of previous known planing types of hulls, driving at a headsea has been dangerous because of pounding and the risk of the boat diving into a sea. With my improved hull, the tendency to dive in a seaway is overcome by the coordination of its various characteristics including the described location of the greatest beam of the hull, the length-beam ratio as described, the provision of a substantial planing area in the forebody at an optimum angle of incidence as determined by the rise in the longitudinal elevation of the chine lines, and by the very large amount of buoyancy provided above the chine lines by the sides of the boat as described. Moreover, in my unique hull, those features contribute effectively to deterring the bottom of the afterbody from breaking contact with the water in a seaway and also contribute to the control of the effective keel area of the hull.

In the case of a hull having displacement type characteristics, in a seaway with the sea either ahead or following, the projected keel areas of the forebody and the afterbody are increased and decreased alternately through wide limits, with the result that in the case of a following sea the stern may be pivoted around the bow or in the case of a head-sea the bow may be pivoted around the stern though to a much lesser extent; these actions being commonly called yawing and broaching and being caused by the lack of control of the alternate changing of the effective projected keel areas of the forebody and afterbody. In my improved type of hull, the projected keel areas of the forebody and afterbody are so disposed and controlled as described, that adequate effective keel area is always maintained in the afterbody whilst in the forebody the maximum projected keel area is limited by the specific characteristics as described irrespective of the amount of rise given to the afterbody in passing over a wave or sea. It is also a characteristic of my improved hull that relative variations in the projected keel areas of the forebody and the afterbody are limited by the described form of the hull throughout its speed range. Tests have shown that this coordination and control of the projected keel areas in the forebody and afterbody provides steering and maneouvering characteristics hitherto unobtainable.

Aerodynamic features.—The sheer of the gunwale of my improved hull in longitudinal elevation, and the longitudinal angle of incidence between the bottom of my hull and the water have been described so far in connection with their direct and indirect hydrostatic and hydrodynamic contributions to seaworthiness. These two features of my hull, however, offer additional advantages by bringing into action certain aerodynamic forces. The sheer of the gunwale, as described herein and shown in the drawings, corresponds generally to the longitudinal elevation of the deck which is kept as free as possible from obstructions and superstructures so that the air-flow over the deck provides a negative pressure and therefore some aerodynamic lift. The sheer line of the gunwale from a position substantially between ⅙ and ⅓ of the length of the hull from the stem should be substantially horizontal or with a slight downward trend towards the stem, and the superstructures on the deck should be suitably streamlined as shown. The relatively small angle of incidence of the bottom of my hull to the water line, the small dead-rise of the chine line in longitudinal elevation, and the low length-beam ratios all cooperate so that throughout the planing-speed range of the hull there is an air cushion between the bottom portion of the forebody and the water which contributes to the longitudinal stability of the boat and to the elimination or reduction of pounding.

Example of typical hull.—A hull typical of my invention, as shown in the drawings, has an over-all length of 70 feet, a load water line length of about 64 feet, a maximum beam of approximately 15 feet, 3 inches at the chine and 19 feet, 8 inches at the gunwale, a beam at the stern of 9 feet, 9 inches at the chine and 11 feet, 8 inches at the gunwale, the maximum beam being located at approximately 40 feet from the stern. The chine in longitudinal elevation is at an angle to the load water line of approximately 2½° at the stern, which increases to a tangential angle of approximately 6° at the bow. The greatest molded depth is about 9 feet, 9 inches and is preferably located at a position about 55 feet forward of the transom measured along the centre line. The molded depth at amidships is about 7 feet, 5 inches, and at the transom is about 5 feet, 1 inch. The freeboard is approximately 8 feet at the point of greatest beam, and is approximately 3 feet, 6 inches at the stern. These dimensions, together with the lines illustrated in the drawings, provide the hull with a substantial well-faired sheer, which together with the described length-beam ratio, and the deck gunwale line in plan provide a configuration that gives the hull an aerodynamic lift.

The centre of gravity of the boat should be located at a point about 26 feet 6 inches from the stern measured along the load water line. The displacement of the boat with the engines, but without the useful and consumable load, should be about 49,000 to 54,000 lbs. Such a hull has a normal fully loaded displacement of about 70,000 lbs. or 31 long tons; but can be loaded in excess of the normal displacement up to a total displacement of about 80,000 lbs. or 36 long tons. Therefore, the displacement-length ratio of such a boat when loaded as mentioned ranges from about 120 to 140. Even when fully loaded, such a hull is able to pass the "hump" of the horse-power speed curve; which means that there is relatively little drop in top speed with said higher displacement as compared with the top speed with the normal displacement.

Teses have shown that my unique hull possesses qualities of seaworthiness and manoeuverability superior to those of any previous type hulls of comparative size and superior to those of many vessels of much larger size. It has been demonstrated that my hull will make a 90° fully stabilized turn to port or starboard at about 50 knots in approximately 8 seconds with a heel or bank inward of the turning circle; and will hold any course in a seaway with the sea in any direction relative to the course, without substantial tendency to yaw.

The wheel-house 12 is provided with a conning bridge as described in my copending patent application Serial No. 328,170, now Patent No. 2,268,425, issued December 30, 1941.

The conning bridge is constituted by a cockpit 62 which opens through the roof of the wheel-house so as to provide a conning position which commands the whole of the boat. The conning bridge is provided with a floor 52 which is above the level of the floor 14 of the wheel-house and scuppers 67 in the floor 52 lead outside the wheel-house so that the cockpit can be cleared of water and although the conning bridge is left open, the water-tight closing of the wheel-house of the vessel is not impaired. Access to the conning bridge is attained from inside the wheel-house by a watertight door 64 (Figure 3) and oral communication is established from the conning bridge with the coxswain stationed inside the wheel-house at 66 by the opening 60, and with a chart room 63 aft of the conning bridge by the opening 61. The openings may be provided with doors or windows and the conning bridge can thus be left open at the top without impairing the watertight closing of the whole vessel. The wheel-house can be entered directly by the hatch 72, Figure 2, which, however, is normally closed when under way.

The wheel-house occupies nearly half the length of the vessel and is arranged approximately in the middle of it. Three water-tight bulk-heads, 15, 16, 17 are provided below the deck-line and underneath the wheel-house. These bulk-heads divide the boat into a compartment 21 constituting the crews quarters, a compartment 156 for officers' accommodation and wireless, a compartment 22 which may contain fuel tanks, and a compartment 23 which constitutes the engine room in which three engines 24 are carried.

The full available head-room beneath the deck 9 is provided in the crew's quarters 21 since the floor of the wheel-house terminates at the forward bulk-head 17. The wheel-house extends slightly further forward than this bulk-head and access to the crew's quarters is obtained from inside the wheel-house by the door 53 on the starboard side of the wheel-house forward of the cockpit.

The next compartment 156 has the floor 14 of the wheel-house in it and sleeping berths are provided under the floor 14 in the part 71 (Figure 6) of reduced head-room. The width of the wheel-house 12, however is less than half the width of the vessel, so that the remainder of the space beneath the parts 9a and 9b of the deck, gives cabin accommodation of full available head-room up to the deck level, and the compartments so formed, indicated at 57 and 58 in Figures 3 and 6, provide respectively accommodation for officers, and a wireless cabin. Access to the compartments 57 and 58 is provided by steps 54 and 55 at the aft end of these compartments.

The next compartment 22 between the bulk-heads 15 and 16 has the floor 13 of the wheel-house in it and is occupied by fuel tanks and the like, and access to the engine room is obtained from the interior of the wheel-house by an opening 56 formed partly in the bulk-head 15 and partly in a continuation of the deck extending from the bulkhead 15 to an instrument panel 70 mounted in the aft part of the wheel-house. Immediately behind the opening 56 is a sound-proof bulk-head 71. The aft part of the wheel-house provides lighting and additional head-room in the engine room. A hatch 76 for access to the engine room directly from the after part of the deck may also be provided.

It will be appreciated therefore that the wheel-house serves the purpose of providing communication under cover between the compartments 21, 23 and 156 without it being necessary to go on to the deck of the boat or to provide doors in the water-tight bulk-heads 15, 16 and 17. Further, the inconspicuousness of the boat is enhanced by the streamlined wheel-house of low height, which, with the boat, presents a completely smooth and unbroken silhouette.

Protection from aircraft or gunfire may be obtained by covering the wheel-house, or the forward part of it, with armour-plate, such protection extending aft at least as far as the after end of the conning bridge, which itself may be protected by an armour-plate sliding roof.

The wheel-house also serves the purpose of providing communication under cover between the parts of the ship, forward and aft of it (for example, the crew's quarters and the engine room) and also to the officers' and wireless operator's accommodation on the port and starboard sides of it.

The aft part of the vessel of low free-board is of sufficient length to provide accommodation for two torpedo tubes 33, and torpedoes 34 are stored on the deck forward of these tubes.

Additional armament for the craft is provided by automatic gun-turrets 30, 31, 32. These are of the enclosed type now used on aircraft.

The turret 30 is disposed as far aft as possible and access to it is obtained below deck level from the engine room 23; the other gun-turrets 31 and 32 are arranged one on each side of the after end of the wheel-house and are accessible from the latter. By this arrangement of the guns the maximum concentration of fire is obtained in any direction. The two forward turrets 31 and 32 are preferably high enough to fire above the roof of the wheel-house and each of them can therefore fire in any direction from directly aft, outboard, forward and across the boat until obstructed by the other turret, giving a horizontal range of nearly 270°. Similarly, the after turret can fire in any direction from directly aft outboard on either side and forward to the point where it is obstructed by the forward turrets, giving a horizontal range of about 330°. Additional bulk-heads 18 and 126 may be provided forward and an additional bulk-head 25 aft, and access to the compartments formed by them is obtained by water-tight doors such as 18*a* and 126*a* (Figure 3).

It will be seen therefore that a vessel constructed in accordance with this invention although very small as compared with ordinary torpedo boats, provides adequate accommodation for the officers and crew and carries adequate armament, and is well suited for high-speed work at sea, being eminently sea-worthy under all conditions of weather. The complete closure of the boat is an important factor for this purpose.

Finally, it may be emphasized that when used for war-like purposes, it is extremely advantageous that the boat should be to the highest degree, inconspicuous as a target and this is achieved, as above described, by the use of an unbroken or continuously curved silhouette; for this purpose all parts which when in use project from the silhouette and present a broken sharp-edged silhouette such as the mast, bollard, towing post and so forth, are arranged to be housed below deck level when not in use. This arrangement also offers the subsidiary advantage of reducing wind resistance which is important in the case of high-speed boats.

I claim:

1. A sea-going boat hull of the hard chine type, capable of high-speed planing operation and having displacement characteristics of moderate resistance at low speeds, having the following characteristics which in combination contribute to improved longitudinal and lateral stability, improved seaworthiness, improved manoeuverability, reduction of wetted surface and high speeds: a length-beam ratio substantially between 3.5 and 4.5, the section of maximum beam being forward of amidships; bottom-sides which in the forebody are concave in transverse cross-section, the angles of deadrise of said bottom-sides decreasing from the bow substantially throughout the length of the hull and being large at the fore part of the hull and small at the transom, top-sides flaring outwardly from the chines at the fore part of the hull, the chines in longitudinal elevation being substantially straight but with a gradual rise from the stern throughout about ⅔ of the over-all length of the hull.

2. A boat hull according to claim 1, in which the length-beam ratio at the gunwale is about 3.6 and at the chine is about 4.2.

3. A boat hull according to claim 1, in which the section of maximum beam is located about 25% to 45% of the over-all length of the hull from the bow.

4. A boat hull according to claim 1, in which the maximum beam at the chine is about 80% of the maximum beam at the gunwale, and the beam at the chine at the stern is about 70% of the maximum beam at the chine.

5. A boat hull according to claim 1, in which the maximum freeboard is in the forebody and is about 8% to 12% of the over-all length of the hull, and the minimum freeboard is at the stern and is about one-half the maximum freeboard.

6. A boat hull according to claim 1, in which the concavity of the bottom-sides extends throughout substantially the length of the hull.

7. A boat hull according to claim 1, in which in still water the angle of incidence to the water of the bottom portion as determined by the chine in longitudinal elevation is substantially between 2° and 10°.

8. A boat hull according to claim 1, in which the concavity of the bottom sides extends substantially throughout the length of the hull, and the angle of incidence to the water of the bottom portion as determined by the chines in longitudinal elevation is substantially between 2° and 10°.

9. A boat hull according to claim 1, in which the top-sides flare outwardly substantially throughout the length of the hull, the flare being more pronounced at the fore part of the hull than at the after part.

10. A boat hull according to claim 1, in which the top-sides are concave in cross-section throughout substantially the length of the hull.

11. A boat hull according to claim 1, in which throughout substantially the length of the hull the top-sides are concave in cross-section and

flare outwardly and the bottom sides are concave.

12. A boat hull according to claim 1, in which the angle between the top-sides and the bottom-sides at and adjacent to the chine varies from about 95° at the stern to about 115° at a point about 80% of the over-all length of the hull from the stern.

13. A boat hull according to claim 1, in which the chines converge from the section of greatest beam toward the stern.

14. A boat hull according to claim 1, in which the sheer lines of the deck slope upwardly from the bow for a distance about 18% of the over-all length of the hull and then slope downwardly to the stern, whereby the flow of air longitudinally over the deck produces a lifting effect on the hull.

15. A sea-going boat hull of the hard chine type, capable of high-speed planing operation and having displacement characteristics of moderate resistance at low speeds, having the following characteristics which in combination contribute to improved longitudinal and lateral stability, improved seaworthiness, improved manoeuverability, reduction of wetted surface and high speeds: a length-beam ratio substantially between 3.5 and 4.5, the section of maximum beam being located about 25% to 45% of the over-all length of the hull from the bow, bottom-sides which are concave in transverse cross-section throughout substantially the length of the hull, the angles of deadrise of said bottom-sides decreasing from the bow throughout the length of the hull and being large at the fore part of the hull and small at the transom, top-sides flaring outwardly throughout substantially the length of the hull, the flare of the top-sides being more pronounced at the fore part of the hull than at the after part, the chines converging from the section of greatest beam toward the stern and in longitudinal elevation being substantially straight but with a gradual rise from the stern throughout about ⅔ of the over-all length of the hull.

16. A boat hull according to claim 15, in which the length-beam ratio at the gunwale is about 3.6 and at the chine is about 4.2.

17. A boat hull according to claim 15, in which the maximum beam at the chine is about 80% of the maximum beam at the gunwale, and the beam at the chine at the stern is about 70% of the maximum beam at the chine.

18. A boat hull according to claim 15, in which the maximum freeboard is in the forebody and is about 8% to 12% of the over-all length of the hull, and the minimum freeboard is at the stern and is about one-half the maximum freeboard.

19. A boat hull according to claim 15, in which in still water the angle of incidence to the water of the bottom portion as determined by the chine in longitudinal elevation is substantially between 2° and 10°.

20. A boat hull according to claim 15, in which the concavity of the bottom sides extends substantially throughout the length of the hull, and the angle of incidence to the water of the bottom portion as determined by the chines in longitudinal elevation is substantially between 2° and 10°.

21. A boat hull according to claim 15, in which the top-sides are concave in cross-section throughout substantially the length of the hull.

22. A boat hull according to claim 15, in which throughout substantially the length of the hull the top-sides are concave in cross-section and flare outwardly and the bottom sides are concave.

23. A boat hull according to claim 15, in which the angle between the top-sides and the bottom-sides at and adjacent to the chine varies from about 95° at the stern to about 115° at a point about 80% of the over-all length of the hull from the stern.

24. A boat hull according to claim 15, in which the sheer lines of the deck slope upwardly from the bow for a distance about 18% of the over-all length of the hull and then slope downwardly to the stern, whereby the flow of air longitudinally over the deck produces a lifting effect on the hull.

25. A boat hull according to claim 15, in which the maximum beam at the chine is about 80% of the maximum beam at the gunwale and the beam at the chine at the stern is about 70% of the maximum beam at the chine, the maximum freeboard is in the forebody and is about 8% to 12% of the over-all length of the hull, the minimum freeboard is at the stern and is about one-half the maximum freeboard, the concavity of the bottom-sides extends substantially throughout the length of the hull, and the angle of incidence to the water of the bottom portion as determined by the chine in longitudinal elevation is substantially between 2° and 10°, throughout substantially the length of the hull the top-sides are concave in cross-section and flare outwardly and the bottom-sides are concave, and the sheer lines of the deck slope upwardly from the bow for a distance about 18% of the over-all length of the hull then slope downwardly to the stern, whereby the flow of air longitudinally over the deck produces a lifting effect on the hull.

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