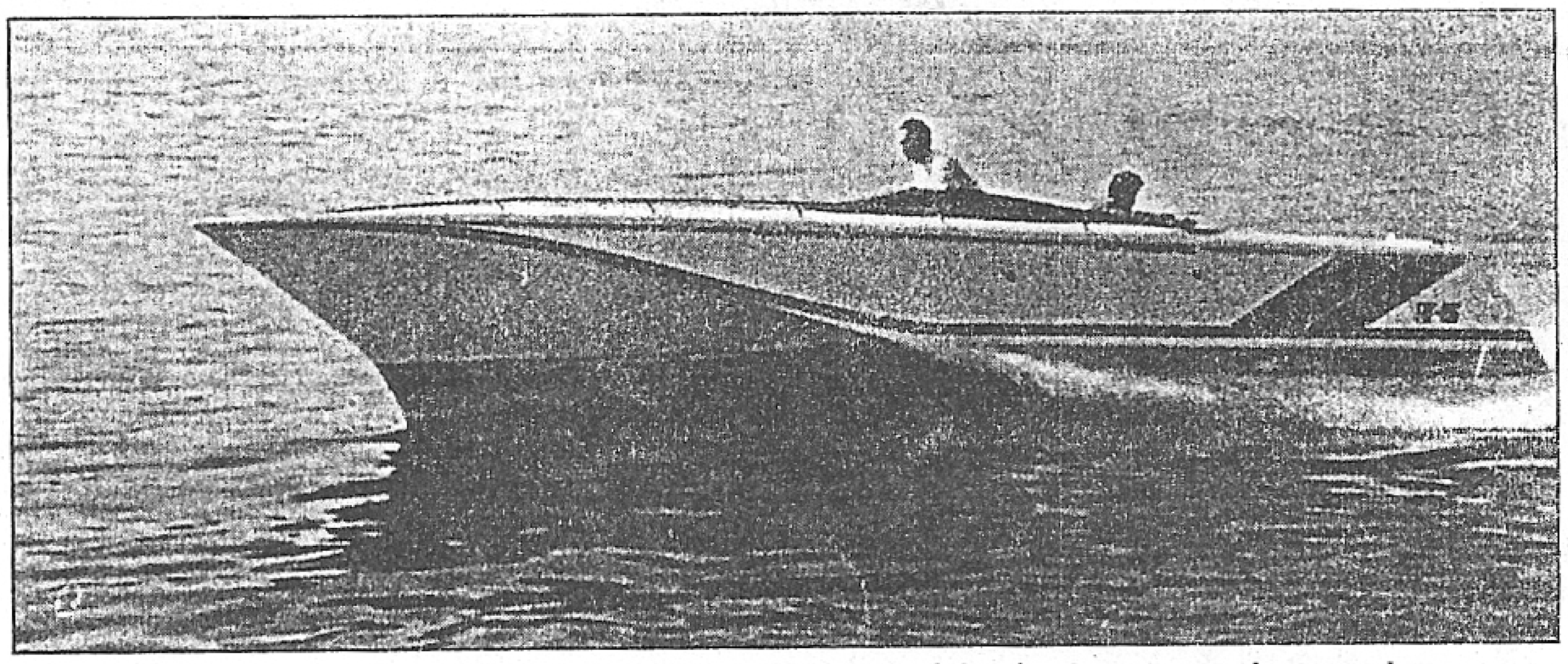
Wrong planing hull forms?

by Erbil H Serter

In this article, Erbil Serter (Dipl-ING) DIC, FRINA, MRAeS, of Hydro Research Systems SA, briefly investigates design features and design characteristics of planing hull forms. Preliminary results indicate that planing hulls have important shortcomings. Indeed, one may have to reconsider entire design formulations of planing hulls; the design of planing hulls as it exists today may even become history.



Author's test boat, E-8, formulated around new planing principles (no hump - no slam - no bow wave and no blister spray).

Introduction

Planing hulls are a waterborne hull form system where the weight of that system is supported by dynamic lift forces generated during forward motion of subject hull form.

Unlike hydrofoils, it may not be possible to support the total weight of a waterborne system by means of lift generated during forward motions; and consequently if more than 50% weight of the waterborne system is supported by hydrodynamic lift forces, and the rest with buoyant hydrostatic forces, a waterborne system may still be classified as a planing hull. In the true sense of 'planing', the complete total weight of any moving waterborne system must only be supported by hydrodynamic lift forces.

Speaking of hydrofoils, contrary to the planing hulls where lift is generated only on the underside of moving surfaces, hydrofoil lift is the sum of lift forces generated under and above their moving foil surfaces. Therefore, hydrofoils are a much more efficient system as far as lift versus resistance is concerned.

Engineering complexities, high investment and maintenance costs of hydrofoil systems have prevented their extensive applications.

Comments

Today, some people still wrongly believe that planing occurs as soon as water clears the transom of a waterborne system.

This event probably happens around Froude number 0.4 depending on trim, beam, and density of water.

Considering the well known lift formula, the lift is always proportional to the square of linear dimensions whereas the weight (or displacement) is proportional to the cube of the same linear dimensions.

Therefore, practical application of planing hulls are extremely limited to relatively smaller displacements due to the limit of lift based on squares of linear dimensions. At present, planing hull form displacements do not exceed 50-70 tonnes within the constraints of cost effectiveness and payloads, where size of power systems, plus fuel capacities, and range are the additional limiting factors.

Indeed, most planing hulls used in the pleasure craft sector have much lighter displacements with very limited payloads and ranges.

After establishing 'size - displacement payload' limitation, which is the first combined shortcoming, planing hulls have other important shortcomings as follows:

I) As established by Professor H.B Squire FRS, of Imperial College (the author was his student), when a planing hull accelerates from rest its transom draught increases. In fact the dynamic forces initially act downward. This dynamic suction at low speeds is so strong that in some cases it prevents a waterborne system from accelerating to the required planing speeds. This behaviour of planing, sometimes called hump effect, has been the source of considerable troubles for planing hull designers, and engine and propeller manufacturers.

Engine torque and propeller characteristics must be very carefully matched to meet the acceleration of planing hulls to the required higher planing speeds.

This is a difficult task unless higher power propulsion systems are formulated for providing high torques at low speeds and low rpm using high thrust propellers. Of course, such solutions may not give time required efficiencies at higher speeds.

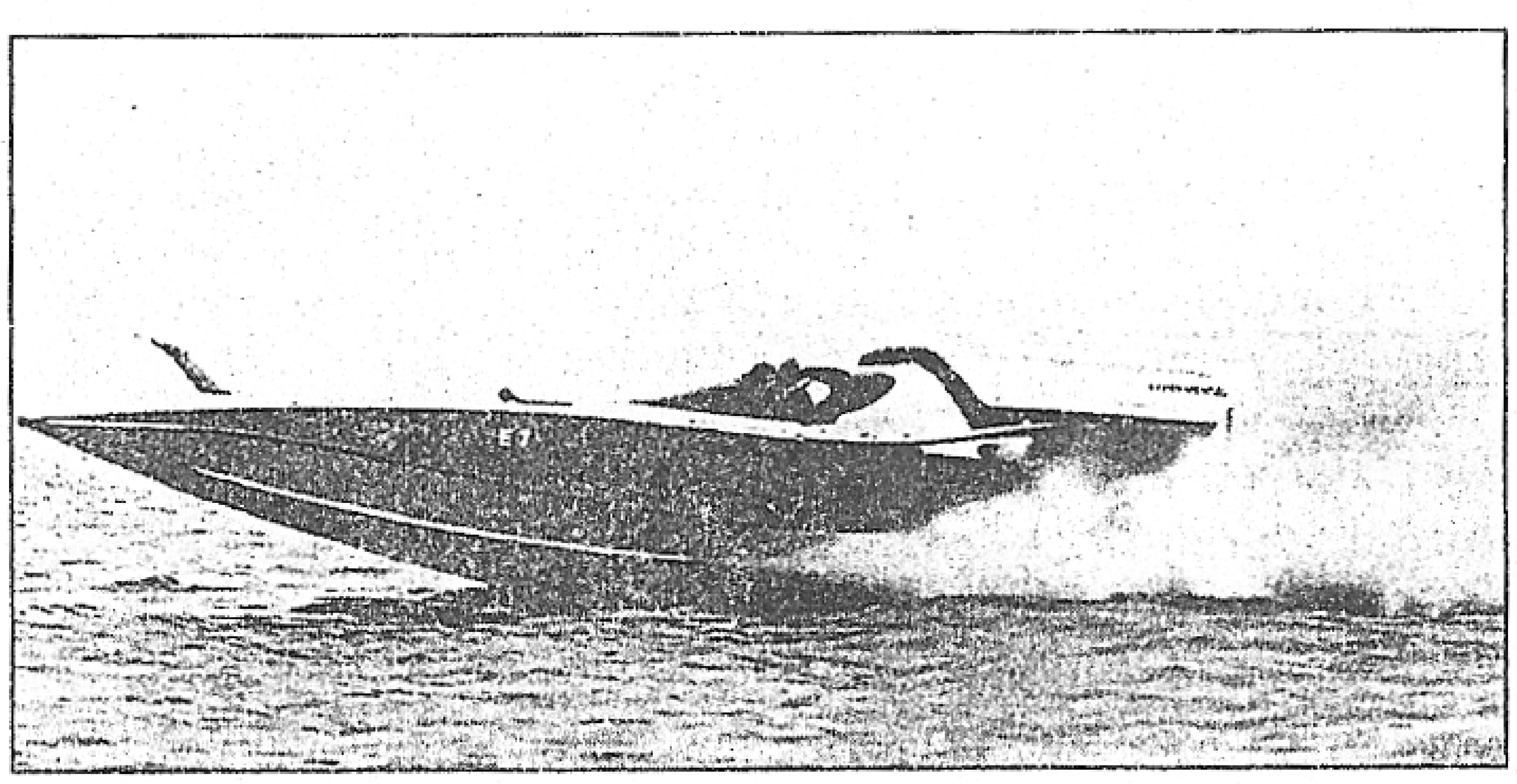
Two-step gearboxes, variable pitch propellers (CCP), torque converters, and special propeller ventilation systems are used to fulfil such requirements in order to overcome this 'hump' effect.

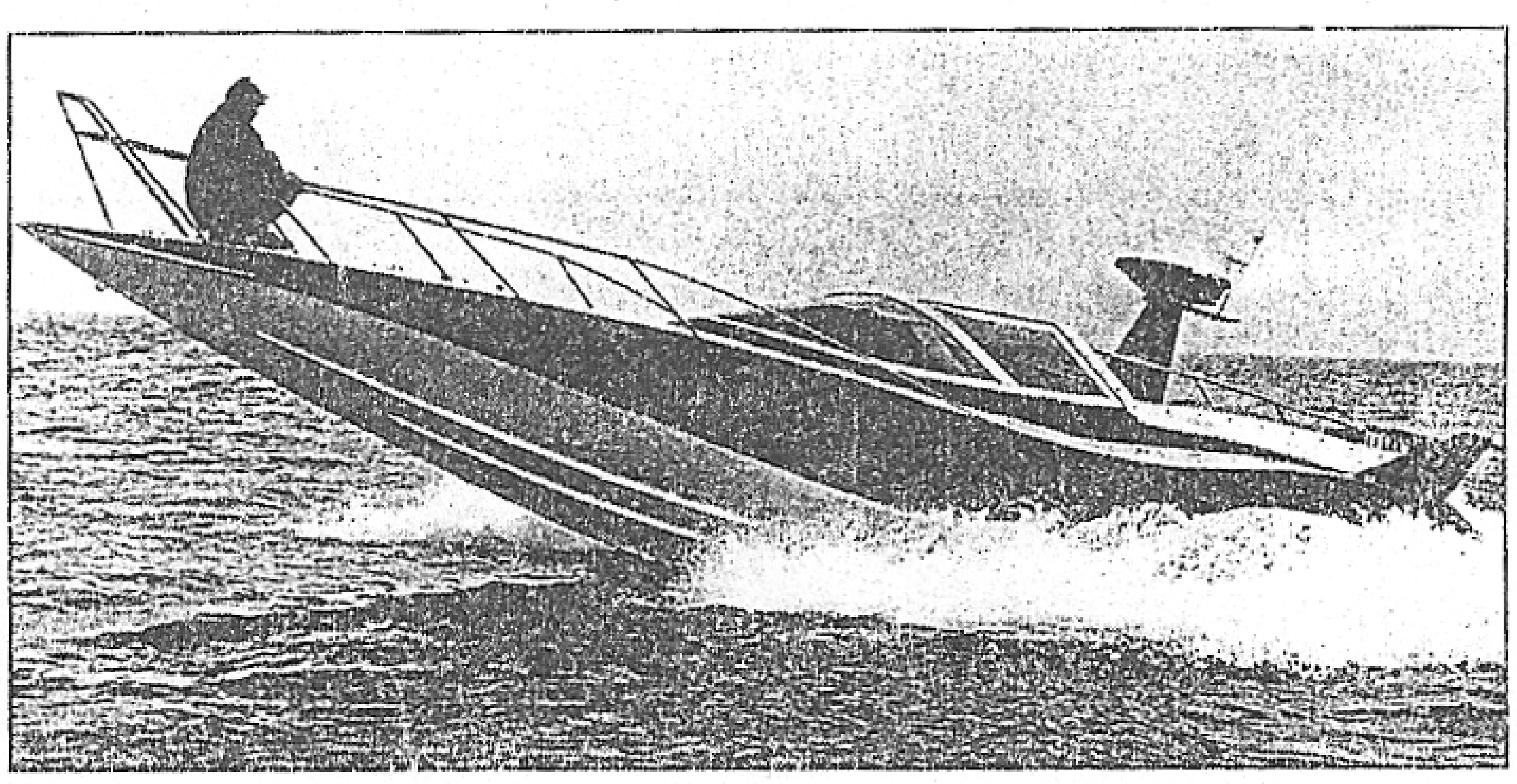
Hydrojets and shaft-adjustable surface propellers may be an answer in providing better solutions, though both systems have lower overall efficiencies at low and medium speeds.

In addition, use of trim tabs and bow ballasts are also used to assist in eliminating this kind of shortcoming of planing hulls.

Therefore, true planing hulls cannot be used with cost effectiveness at low or medium speeds in a way that most operators or boat owners would like to utilise. That is one of the reasons why most true planing hulls are built around small, lightweight hull forms suitable for pleasure craft users where cost effectiveness and payloads are not the

Author's test boats E-7 and E-7A formulated around old planing principles (notice the 'hump effect' before planing in case of boat E-7A).





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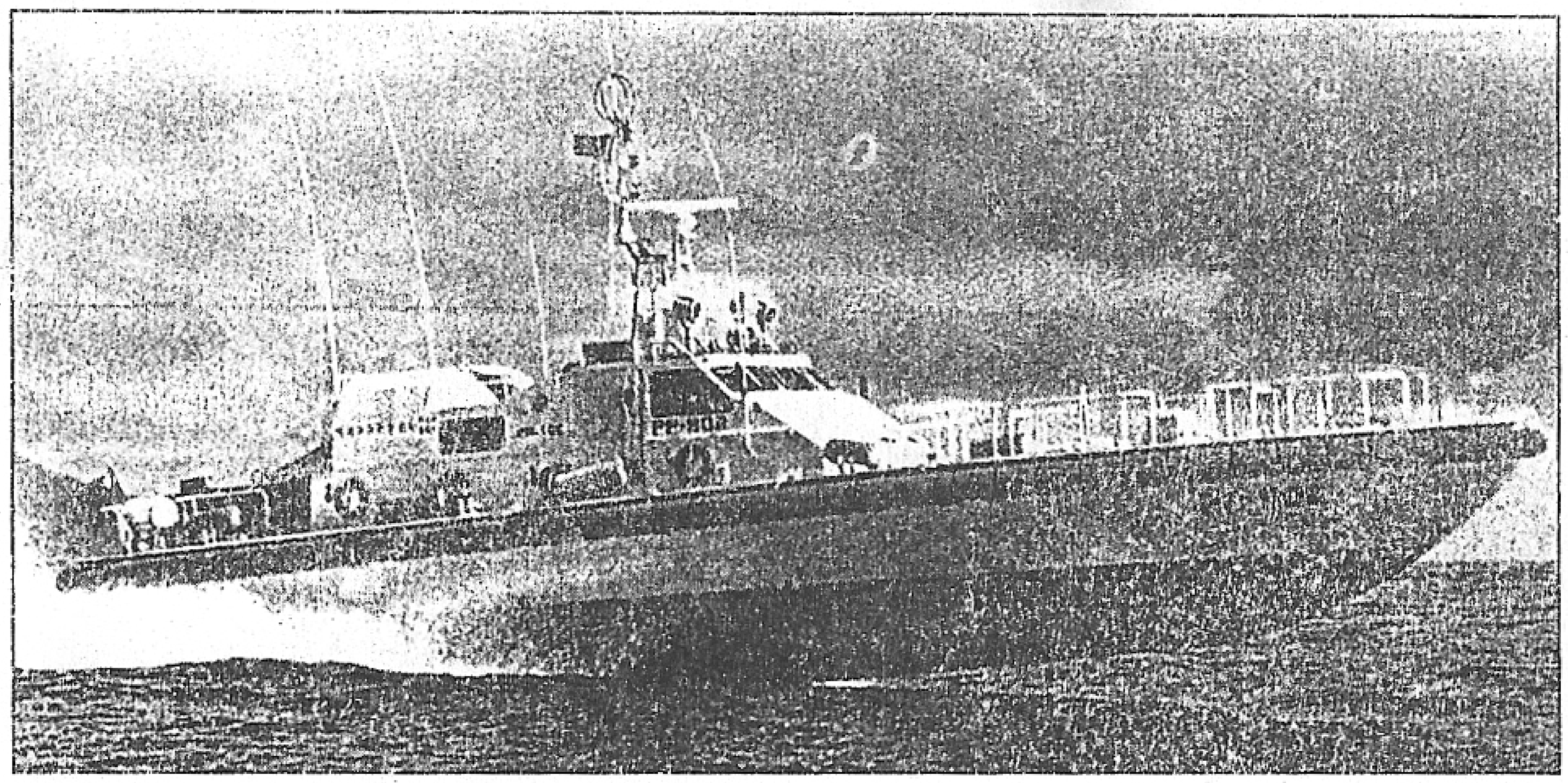
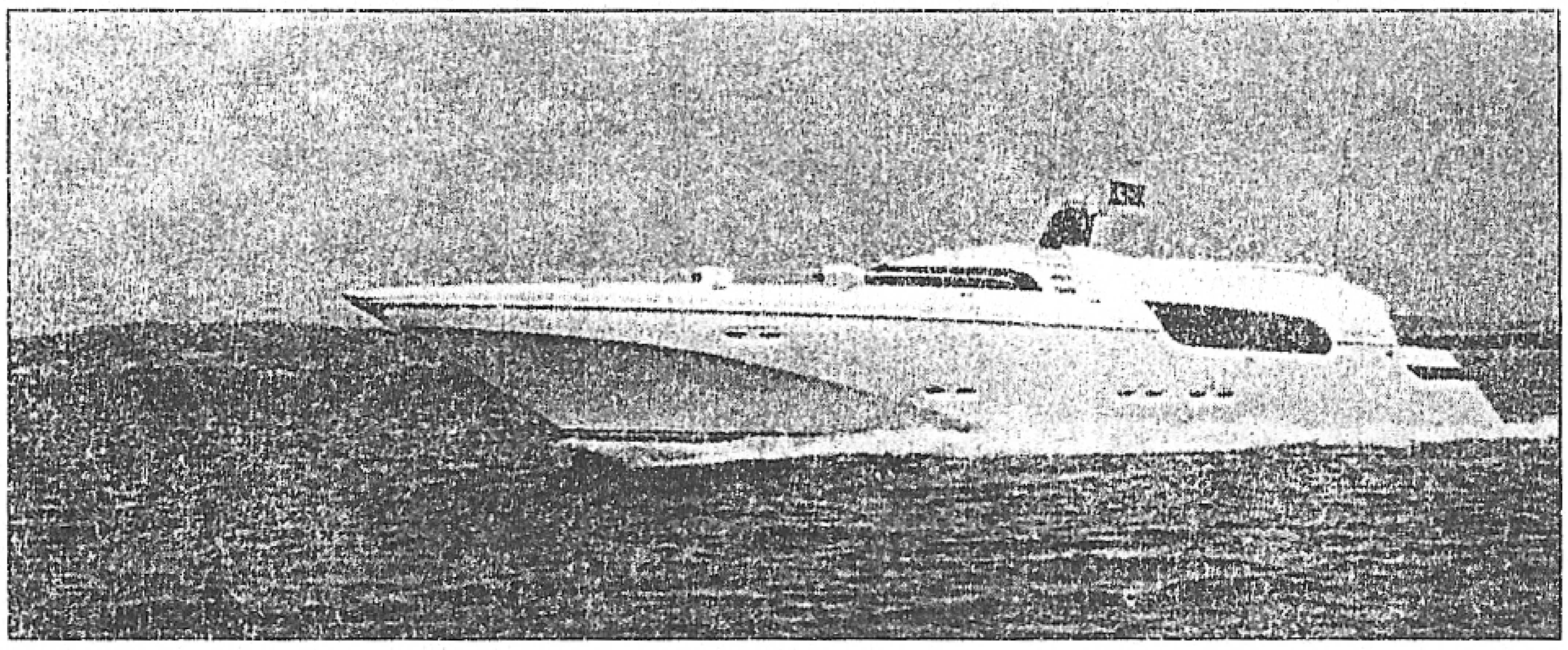


Above: Typical planing hull behaviour (hump effect can be eliminated with CP propellers or hydrojets, but slamming and wetness - porpoising - will still be a big problem). Below: A displacement based 85tonnes deep-vee hull form at 26 knots.



primary requirement.

The very limited research undertaken by the pleasure craft builders on such hull forms has contributed very little in the development of planing hull forms.

Many hull forms designed as planing hulls are actually non-planing displacement or semi-displacement hulls having all the disadvantages of planing hull forms.

I) The resistance of any planing hull in calm water is composed of the following items:

1. Frictional resistance based on wetted areas.
2. Induced-wave making resistance based mostly on horizontal component of lift.
3. Spray resistance due to form of bow's stagnation point-blister spray (this is sometimes confused and incorporated within the induced resistance based spray sheets.)
4. Air resistance
5. Appendage resistance.

The most important advantage claimed by a planing hull is the reductions in wetted areas so that fractional resistance is reduced. This is true, and a close look at this problem will indicate that the shorter the relative wetted waterline length and the less the projected planing area, less is the frictional resistance. On the other hand, the longer the waterline lengths the lower the relative Froude numbers and therefore lower are the wave making and/or the 'apparent induced' resistance characteristics.

Indeed, the induced and wave making resistances are already considerable at higher speeds where Froude numbers exceed 0.5. Accordingly, with relatively short waterlines, very high induced and wave making resistances will be attributed to the planing hull forms. As the induced resistance is the horizontal component of lift force, larger weights mean larger induced resistances that cannot be overcome with cost effective power plants and simple propulsion systems. Any additional weight will simply result with a non-planing situation which is sometimes drastic for planing hulls.

At higher speeds, induced resistance component is more important than frictional resistance component.

Weights and payloads of planing hulls (due to lift = square-weight = cube of linear dimensions rule) are thus limited in terms of range and cost effective propulsion systems. Further blister spray resistance caused by blunt entries (large angle of entry at stagnation point) used in trimmed planing hulls must not be underestimated. As planing efficiency is improved at relatively higher trim angles (higher lift coefficients), another contradictory situation effecting seakeeping, directional stability and 'vision' appears.

III) All waterborne moving systems must have good seakeeping characteristics. The planing hulls have tried to overcome this problem by using high deadrise transverse sections incorporated within hull forms' body plans. In fact, by using deadrise angles in excess of 20deg and using chines, the sea keeping behaviour of planing hulls has improved considerably.

High deadrise angles at mid-sections carried up to the transom have become the basis of a great majority of present planing hull forms. These hull forms are called 'deep-vee' hull forms. Although 'deep-vee' hard chine planing hulls have good seakeeping characteristics under adverse sea states with acceptable roll, heave, surge and swag behaviours, their poor slam motions are the cause of limited operational profiles. Indeed, this poor slamming had been a major problem for all planing hulls.

Further, some pitch and yaw motions for planing hulls at following seas may also be excessive. At so-called efficient planing trim angles the pitch motions of a planing hull may exceed all known limits.

Another shortcoming of planing hulls with vee-shaped hull lines is 'porpoising' and 'leaning'. If the centre of gravity of a planing hull is near the centre of pressure of projected planing areas, slight changes in longitudinal motions due to the smallest wave or swell can

Resistance data (frictional and residual resistances) for planing hulls (from a SNAME publication).