

JANE'S SURFACE SKIMMER SYSTEMS

Edited by Roy McLeavy

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ADDENDA

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HYDROFOIL MANUFACTURERS

CANADA

De Havilland**THE DE HAVILLAND AIRCRAFT COMPANY OF CANADA, LIMITED**

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W. T. Heaslip, Vice-President, Engineering

F. H. Buller, Engineering Chief Designer

In 1947-49, a 45 ft craft powered by a 1,200 hp Rolls-Royce Merlin was designed by Phillip Rhodes for Cdr D. M. Hodgson RCNR of Montreal for an attempt on the existing water-speed record. At about this time, the Canadian Defense Research Board became interested in the potential operational employment of hydrofoils and Cdr. Hodgson's craft, named the R-100 Massawippi (after Lake Massawippi, Quebec, the site of its construction and initial tests) was built under the Board's direction. Success of the Massawippi, which displaced 7.5 tons and could reach 55 knots, led to an extensive experimental programme involving Massawippi and two subsequent craft, the Bras d'Or and RX. The Bras d'Or, designed and built by Saunders Roe for the Defense Research Board, was delivered in 1957. The RX is a fully instrumented test bed for testing a wide range of new foil designs. De Havilland have used the craft extensively during their design development programme for the FHE-400.

The extensive test experience, together with that gained from the US programmes, led the Naval Research Establishment to prepare proposals for a 200-ton ASW hydrofoil capable of all-weather operation in the North Atlantic. At a tripartite conference in January 1960, a group of specialists from the US and Britain reviewed these proposals and concluded that the extension of NRE's work to a prototype craft was desirable. This led to the design and construction of the FHE (fast hydrofoil escort) 400 by De Havilland Aircraft of Canada as design agent for the Canadian Government.

FHE-400

In early 1961 the Canadian Department of Defence contracted De Havilland Aircraft of Canada Ltd for a feasibility and engineering study, based on the NRE ASW hydrofoil report, which could lead to detailed design and construction of a full-scale craft. The company's recommendations were approved in April 1963. The FHE-400 programme

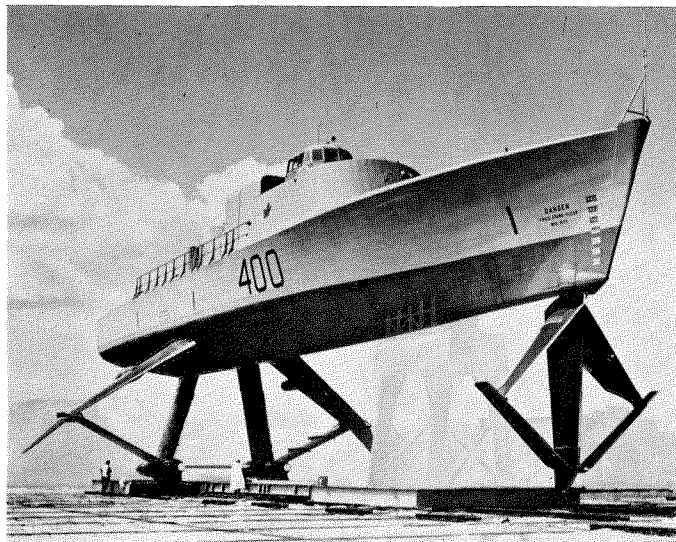
has two fundamental objectives: (a) to establish in practice the feasibility of an ocean-going hydrofoil of the proposed size and characteristics (b) to evaluate the prototype as an ASW system.

It is intended that the prototype shall be capable of being developed into a warship. For operational evaluation the fighting equipment is likely to include variable depth sonar for submarine detection, homing torpedoes for armament and the necessary facilities for navigation, communication, radar, command and control. Tactical use of the FHE-400 is based upon variable depth sonar as the prime means of submarine detection.

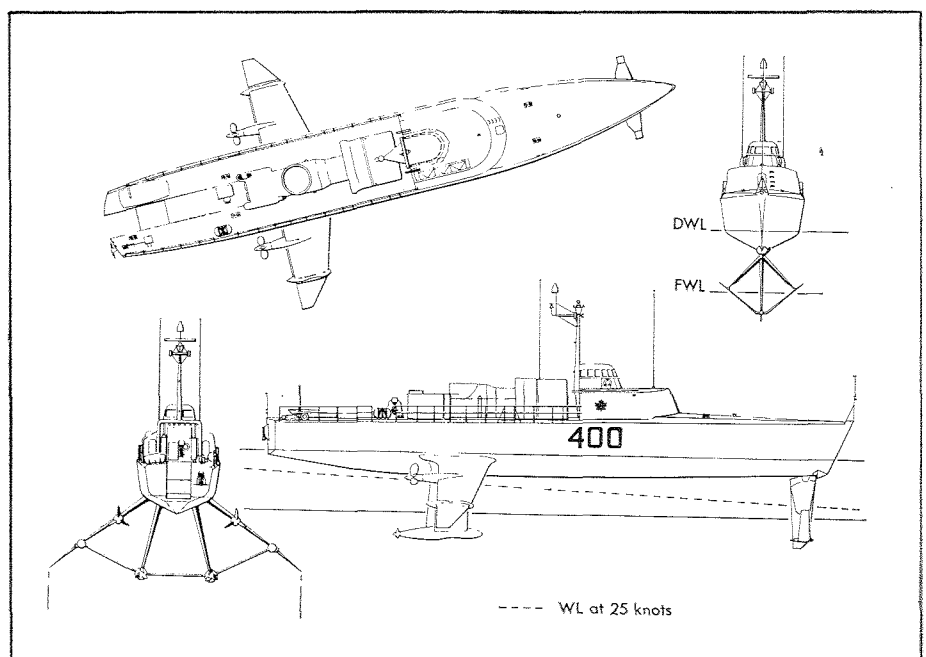
Launching was planned for mid-1968 and completion by mid-1970 after contractor's sea trials, weapon systems installation and systems evaluation.

After commissioning as HMCS Bras d'Or in Quebec City, an RCN crew will operate the ship during contractor's acceptance trials. Rough water and operational trials will then be conducted by the Hydrofoil Evaluation team at Halifax, N.S.

FOILS: The foil system is a canard configuration of the surface piercing type and non-retractable. The steerable foil is supercavitating and designed for good response in a seaway. The subcavitating main foil carries 90% of the static weight and is a combination of surface-piercing and submerged foils. The centre high speed foil section is protected from ventilation by the struts and the dihedral foils have full-chord fences to inhibit ventilation. Anhedral foils provide reserve lift at take-off and their tips provide roll restoring forces at foilborne speeds.



FHE prototype on slipway



De Havilland FHE-400 ocean going ASW warship

HYDROFOIL MANUFACTURERS

Canada: DE HAVILLAND

The struts are a compromise to provide the optimum fin effect in yaw in conjunction with the steerable bow foil. The foils are constructed in maraging steel.

HULL: Hull and superstructure are fabricated from ALCAN D54S, and extensive use is made of large extrusions with integral stringers for the plating.

Strain gauges are attached to critical points in the hull and foil system so that predicted stress levels can be monitored and recorded on oscillograph charts or magnetic tape for analysis ashore.

A crew of twenty will be carried, comprising eight officers and twelve men. In order to maintain crew alertness at all times, comfortable crew quarters and good messing facilities were considered essential features. Both were intensively studied by the Institute of Aviation Medicine. The study included the testing of crew bunks on a motion simulator at NCR Ottawa, and the use of a simulator to assess crew efficiency under foilborne conditions.

POWER PLANT: Continuous search for a useful period demands economical operation in any sea state at displacement speeds and the ability to attack at high speeds. For this reason there are two propulsion systems—the foilborne "free" marinized gas-turbine, a 22,000 shp Pratt & Whitney FT4A-2, and a 2,000 bhp Davey-Paxman 16YJCM diesel engine for hullborne power. The maximum foilborne speed is expected to be about 60 knots and the hullborne speed about 14 knots. The KWM controllable-pitch displacement propellers of 7 ft (21.33 m) diameter are novel, since they will be feathered when the craft is foilborne so as to minimize the appendage drag penalty. Slow speed manoeuvring will be effected by a control of individual propeller pitch settings.

Thrust is provided by twin 4 ft (1.22 m) diameter supercavitating propellers fitted in

Pods at either end of the main foil's fully submerged centre section.

The FT4A-2, a marine version of the shaft-turbine engine developed from the JT4 and 5 gas turbine, is enclosed by a protective cowling aft of the bridge.

Shaft power is transmitted to the inboard gearbox directly aft of the engine exhaust elbow and is then transmitted via dual shafts through each of the two inner struts to the outboard gearboxes in the streamlined pods at the intersection of the struts and foils. The dual shafts are combined at the outboard gearboxes into a single drive, taken through an over-running clutch to each of the two fixed-pitch supercavitating propellers.

A governor prevents overspeed if the propellers leave the water in rough seas.

A Paxman Ventura 16YJCM diesel-engine is sited in the engine room, on the ship's centreline. Power is transmitted to the variable pitch hullborne propellers through a dual output gearbox and thence through shafts to gearboxes located in the pods.

CONTROLS: Diesel power, propeller pitch, main gas turbine speed and individual displacement propeller pitch are all normally controlled by lever from the bridge. Dual wheels are provided to steer the bow foil. An engineer's console is located in the operation room and starting and stopping of all engines is undertaken from this position. Engine and propeller pitch controls duplicating those on the bridge are provided on the console.

SYSTEMS

AUXILIARY POWER: An auxiliary gas turbine, A United Aircraft of Canada ST6A-53 rated at 390 hp continuous at 2,100 rpm is used to power electric generators, hydraulic pumps and a slat-water pump. It can also be used to increase the available displacement propulsion power and for emergency propulsion power at reduced speed.

EMERGENCY POWER: The emergency power unit is an AiResearch GTCP-85-291 shaft-coupled turbine rated at 190 hp continuous. In the event of the auxiliary gas turbine becoming unserviceable or being in use for the displacement propulsion, this turbine will power the ship's system. Alternatively bleed air may be drawn from the compressor for main turbine starting.

ARMAMENT: The FHE 400 will be equipped with a specially designed detection, data processing and weapon delivery system. Primary sensor will be a towed sonar and the armament consists of lightweight homing torpedoes. Canadian Westinghouse Co is the main contractor to the RCN for the weapons system which will be installed on the completion of sea trials. The sonar towed body is being built by Canadian Westinghouse to a design developed as part of the Naval Research Establishment's long term high speed towed sonar programme. Handling gear is a compact, lightweight mechanism developed by Fleet Manufacturing.

DIMENSIONS, EXTERNAL:

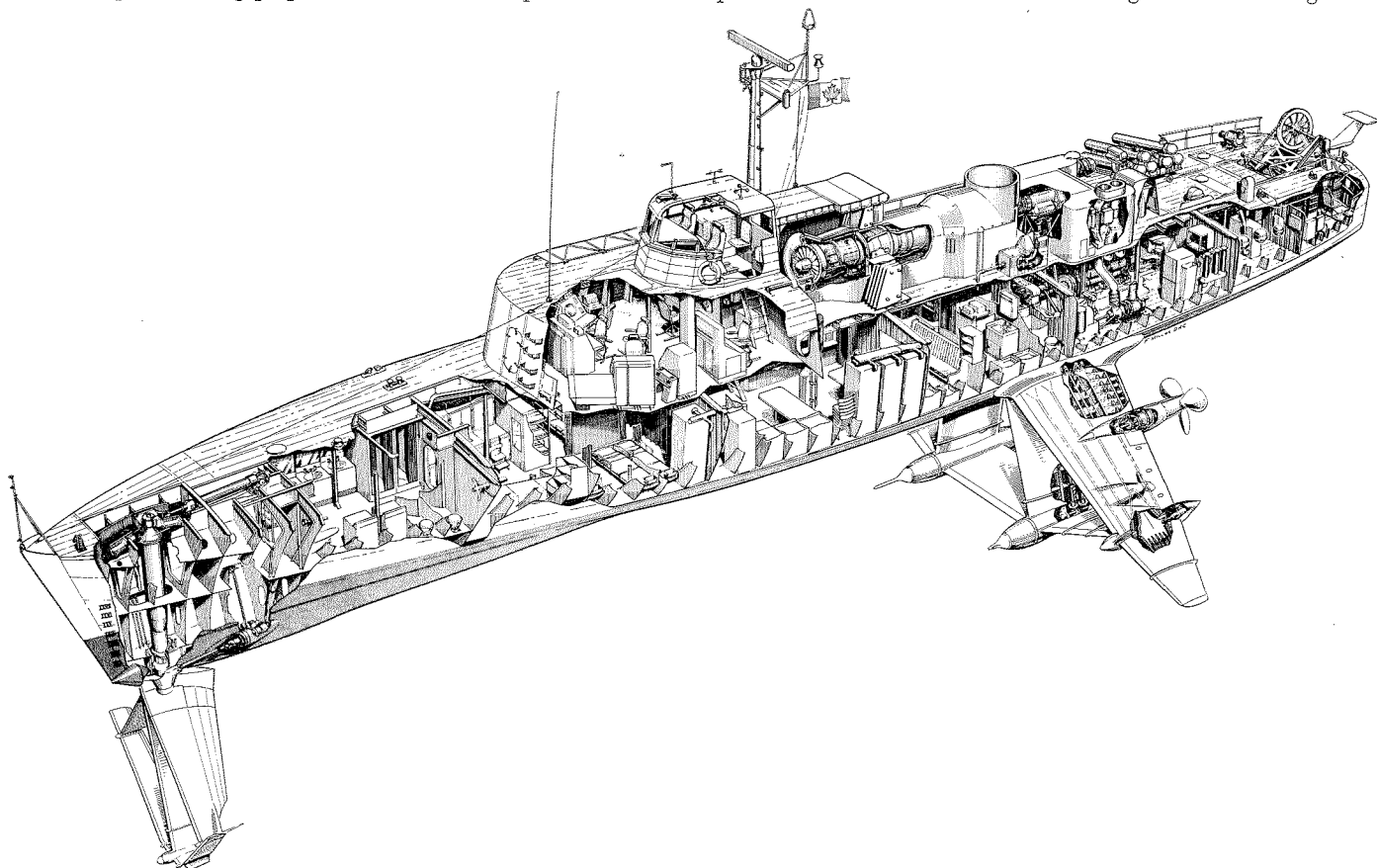
Length overall, hull	151 ft 0 in (45.9 m)
Length waterline, hull	147 ft 0 in (44 m)
Hull beam	21 ft 6 in (6.5 m)
Beam across foils	66 ft 0 in (20 m)
Draft afloat	23 ft 6 in (7.16 m)
Freeboard	11 ft 0 in (3.3 m)

WEIGHTS:

Gross tonnage (normal)	212 tons
Light displacement	165 long tons
Max take-off displacement	235 long tons
Useful load (fuel, crew and military load)	over 70 tons

PERFORMANCE:

Cruising speed, foilborne	50 knots rough water 60 knots calm water
Cruise speed, hullborne	over 12 knots
Sea state capability	Sea State 5 significant wave height 10 ft



Cutaway of the De Havilland FHE-400

HYDROFOIL MANUFACTURERS

WATER SPYDER: Canada

Water Spyder

WATER SPYDER MARINE LTD

HEAD OFFICE AND WORKS:

157 Richard Clark Drive, Downsview, Ontario

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244 5404

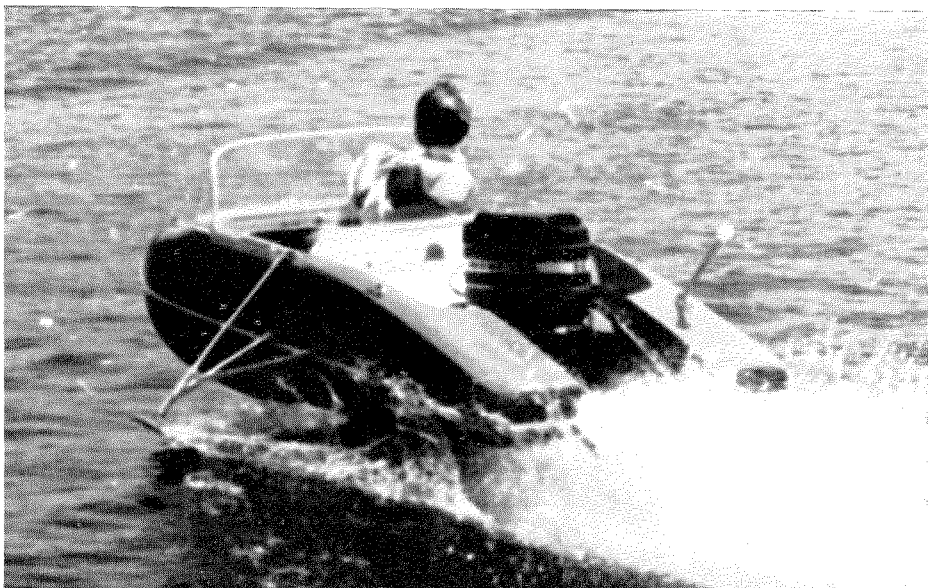
DIRECTORS:

J. F. Lstiburek, President
G. A. Leask, Secretary/Treasurer
A. Lstiburek, Vice President

SENIOR EXECUTIVES:

L. Civiera, Sales Manager
J. F. Lstiburek, Designer

Water Spyder Marine Ltd is a wholly-owned Canadian company operating under charter issued by the Government of the Province of Ontario. It produces two fibreglass-hulled sports hydrofoils, a two-seat sports model and a six-seat family model. Both are available either ready-built or in kit form. Canadian Department of Transport plates were issued in 1966 for both models.



Water Spyder 2-B, a two seat, fibreglass-hulled hydrofoil pleasure craft powered by a 20-30 hp long-shaft outboard motor. The retractable W main foil system carries 98% of the total load

WATER SPYDER 2-B

The Water Spyder 2-B is a two-seat sports hydrofoil powered by a long-shaft outboard of 20-35 hp.

FOILS: The foil system comprises a split W-type surface piercing main foil supporting 98% of the load and an adjustable outriggered trim tab which supports the remaining 2%. The foils and the trim tab assembly are retracted manually for docking and beaching. The main foils are of polished 65ST aluminium and the trim tab is of steel.

HULL: This is a two-piece (deck and hull) moulded fibreglass construction and incorporates buoyancy chambers. Standard fittings include a curved Perspex windshield and regulation running lights, fore and aft.

ACCOMMODATION: The craft seats two in comfortably upholstered seats. Foils and the trim tab assembly are adjustable from inside the cockpit.

POWER PLANT: Any suitable outboard engine of 20-35 hp (Mercury 200L or 350L or Evinrude) with long-shaft extension. Total fuel capacity is 5 gallons.

CONTROLS: Controls include steering wheel with adjustable friction damper, single-lever throttle and gearshift control, and trim tab control.

DIMENSIONS:

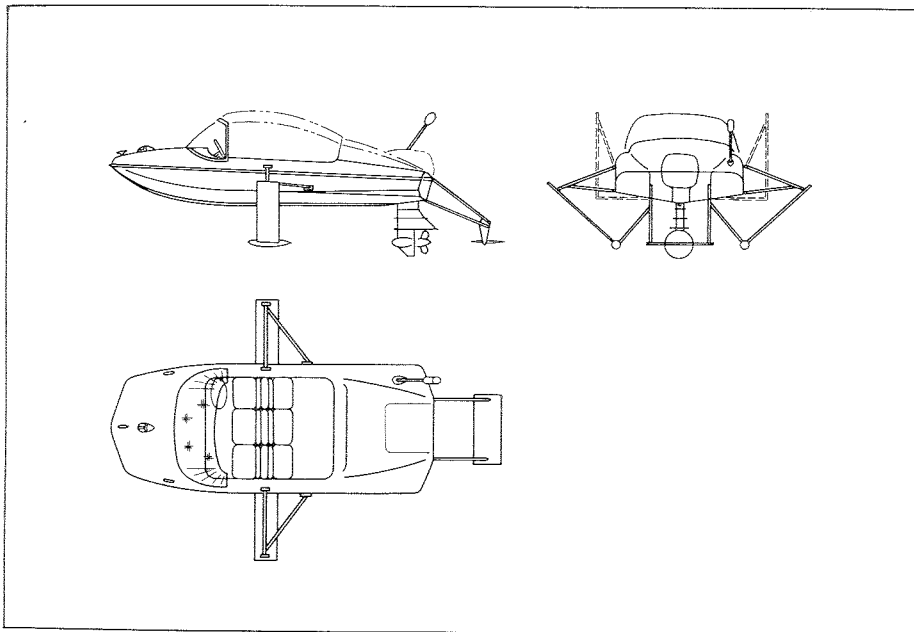
- Length overall, hull 12 ft 0 in (3.6 m)
- Beam overall, foils retracted 5 ft 4 in (1.6 m)
- Beam overall, foils extended 7 ft 4 in (2.2 m)

WEIGHTS:

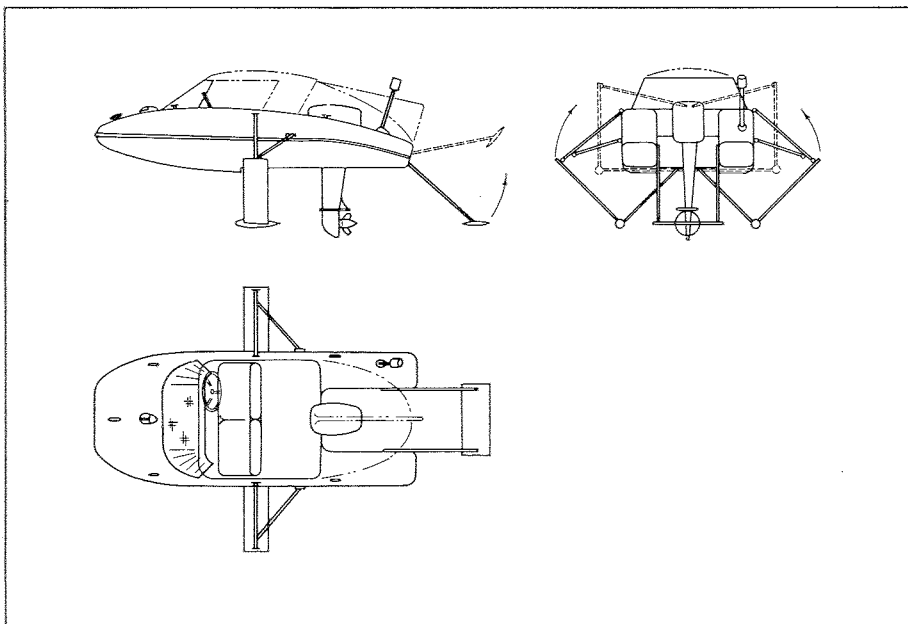
- Weight empty 220 lb (99.7 kg)

PERFORMANCE:

- Max speed up to 40 mph (64 km/h)
- Max permissible wave height in foillborne mode 1 ft 6 in
- Turning radius at cruising speed 10 ft (3 m) app
- Number of seconds and distance to take-off (theor app) 4-6 sec, 15 ft (4.5 m)
- Number of seconds and distance to stop craft (theor app) 4-6 sec, 15 ft (4.5 m)
- Cost of standard craft and terms of payment: US\$970. Terms: Cash. Delivery: 3 weeks from date of order, fob Toronto.



Water Spyder 6-A



Water Spyder 2-B

HYDROFOIL MANUFACTURERS

Canada/ Germany: WATER SPYDER/ BLOHM & VOSS AG

WATER SPYDER 6-A

An enlarged version of the Water Spyder 2, Model 6-A is a six-seat family pleasure hydrofoil boat, with a two-piece moulded fibreglass hull. The foil system is identical to that of the earlier craft except that the foils are retracted with the aid of a crank and winch.

The seats, located immediately over the main foil, are arranged in two rows of three abreast, one row facing forward, the other aft.

Power is supplied by a long-shaft outboard motor of 60-115 hp. Total fuel capacity is 15 gallons.

DIMENSIONS:

Length overall, hull	19 ft 0 in (5.79 m)
Beam overall, foils retracted	8 ft 3 in (2.5 m)
Beam overall, foils extended	13 ft 0 in (3.96 m)
Height overall, foils retracted	4 ft 6 in (1.37 m)
Floor area	30 sq ft (2.78 m ²)

WEIGHTS:

Gross tonnage	1 ton app
Weight empty	980 lb (444 kg)

PERFORMANCE:

Max speed	35-40 mph (56-64 km/h)
Cruising speed	32 mph (51 km/h)
Max permissible wave height in foilborne mode	2 ft 6 in (0.76 m)
Turning radius at cruising speed	20 ft (6.09 m)
Number of seconds and distance to take-off (theoretical, app)	4-6 sec, 15 ft (4.57 m)
Number of seconds and distance to stop craft (theoretical, app)	4-6 sec, 15 ft (4.57 m)

Cost of standard craft and terms of payment: \$US2,200. Terms: cash. Delivery: Three weeks from date of order f.o.b. Toronto.



Water Spyder 6-A is a six-seat hydrofoil. The main foil, trim-tab support and engine fold upward so the craft can be floated on and off a trailer

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Albert Schütt, Shipbuilding Manager
Egbert Müller, Engineering Manager

Under partnership arrangement with Grumman Engineering Corporation, Blohm & Voss undertook the final development and construction of the Grumman Dolphin.

From January 1965 the company's engineers have worked together with Grumman's design staff. The Dolphin prototype was completed in October 1966. The second Dolphin was due for completion in the autumn of 1968 and has been sold to an operator in the United States.

The company is now planning to build the 325-ton Neptune, a passenger/car ferry

similar in design and construction to the AG(EH) experimental hydrofoil designed by Grumman.

NEPTUNE

The Neptune is a design for a fast, seagoing passenger/car ferry, capable of operating in up to Sea State 6. It will have a maximum take-off displacement of 325 tons and a cruising speed of 50 knots (93 km/h).

The standard design will accommodate 302 passengers on the saloon deck and 37 cars on the vehicle deck beneath, but all-passenger layouts will be available.

Foilborne power will be supplied by two General Electric LM 1500 marine gas turbines each rated at 14,200 hp continuous.

FOILS: The foil system is fully submerged and of "airplane" configuration, with 90% of the weight supported by the two bow foils and 10% by the rear foil. The foils are subcavitating and of medium aspect ratio. The stern strut rotates for steering and all three foil struts retract completely clear of the water. Incidence of the three foils is controlled by an autopilot system. Struts and foils will be built in steel.

HULL: The hull will be almost completely built of aluminium and will be of predominantly welded construction. Most of the deck, side and bottom plating will be made from integrally stiffened, aluminium extruded planks.

ACCOMMODATION: The wheelhouse, located forward, provides a 360° view. The first officer and engineer are seated side-by-side, with a third seat for the captain. Immediately aft of the wheelhouse is a chart room/radio cabin. Normally the crew will have ten members, a captain, a first officer, an engineer, an assistant engineer, two deck hands and four stewards.

Passengers are accommodated in three well glazed saloons, a fore compartment seating 68, a central compartment seating 142 and an aft compartment seating 92. Passenger and crew compartments are air-conditioned.

Access to the compartments is through two doors in the forward saloon, port and starboard, or two doors in the aft saloon, port and starboard. Separate doors, port and starboard, are provided for the crew. Four emergency exits are provided, two port, two starboard.

HYDROFOIL MANUFACTURERS**BLOHM & VOSS AG: Germany**

A full range of safety equipment is carried, including fire extinguishers and approved life rafts sufficient for the crew and 302 passengers. Life jackets for adults and children are also provided.

The vehicle deck, designed for up to 37 cars, has two wide doors at the stern which become access ramps for loading and unloading. A turntable at the forward end permits the vehicle to be turned round so that they can be driven straight off.

POWER PLANT: Foilborne propulsion is supplied by two General Electric LM1500 marine gas turbines of 14,000 bhp continuous rating, connected by Z-drives through the main struts to two stainless-steel, supercavitating fixed propellers of 4 ft 4 in (1.3 m) diameter at the end of the propulsion pods on the main foils. The air intake is at the top of the deckhouse. Four integral fuel tanks will give a total fuel capacity of 35 tons. Oil tank capacity will be 4 tons.

Hullborne propulsion is supplied by two MB 835 BB, or equivalent diesels, rated at 1,650 hp at 1,500 rpm, driving two waterjet pumps with moveable nozzles.

NAVIGATION AND COMMUNICATIONS: Radio and radar are standard equipment.

SYSTEMS:

AIR CONDITIONING: Type not yet determined.

ELECTRICAL: Diesel generator 100 kW, 125kVA at 0.8 P.F. for auxiliary power,

lighting system, master warning and monitoring system and autopilot.

HYDRAULICS: 210 atu for strut retraction, foil incidence control and auxiliary power.

APU: 1 emergency gas turbine generator, 30kW.

DIMENSIONS, EXTERNAL:

Length overall, hull	212 ft 8 in (64.85 m)
Length waterline, hull	198 ft 7 in (60.9 m)
Length overall, foils retracted	219 ft 8 in (67.0 m)
Length overall, foils extended	223 ft 0 in (67.97 m)
Hull beam, maximum	41 ft 6 in (12.65 m)
Beam overall, foils retracted	82 ft 9 in (25.2 m)
Beam overall, foils extended	70 ft 9 in (21.57 m)
Draft afloat, foils retracted	7 ft 8 in (2.33 m)
Draft afloat, foils extended	26 ft 1 in (7.95 m)
Draft foilborne	6 ft 7 in (2.0 m)
Freeboard	14 ft 1 in (4.3 m)
Height overall, approx	62 ft 6 in (19.0 m)

DIMENSIONS, INTERNAL:

Superstructure interior, including wheelhouse, chart room, radio cabin, passenger cabins, galley, toilets and air conditioning compartment:

Length	167 ft 5 in (51.0 m)
Max width	33 ft 0 in (10.0 m)

Max height	7 ft 5 in (2.3 m)
Floor area, approx	4,951 sq ft (460 m ²)
Volume, approx	37,432 cu ft (1,060 m ³)

BAGGAGE HOLDS:

Racks for hand luggage in passenger cabin; baggage holds in forepeak.

WEIGHTS:

Light displacement	205 tons
Normal take-off displacement	320 tons
Max take-off displacement	325 tons
Normal deadweight	115 tons
Max deadweight	120 tons
Normal payload	73 tons
Max payload	78 tons

PERFORMANCE:

Max speed foilborne	58 knots (106 km/h)
Max speed hullborne	20 knots (38 km/h)
Max permissible wave height in foilborne mode	14.7-16.4 ft (4.5-5 m)
Cruising speed foilborne	50 knots (93 km/h)
Cruising speed, hullborne	18 knots (32 km/h)
Design range at cruising speed	325 n.m. app

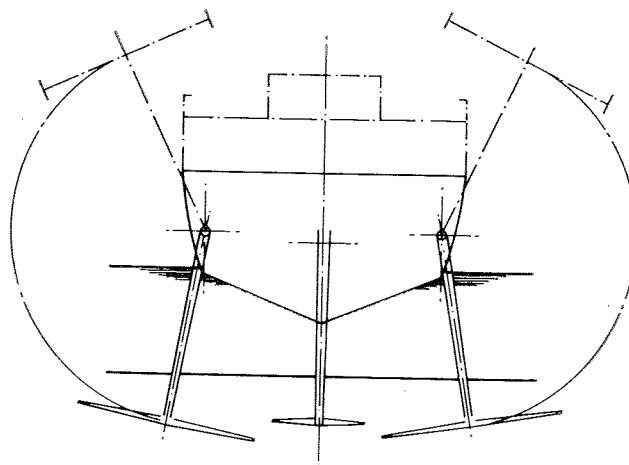
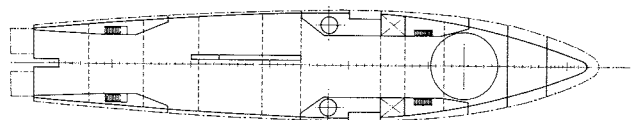
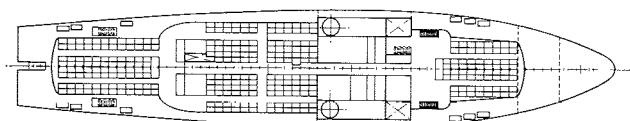
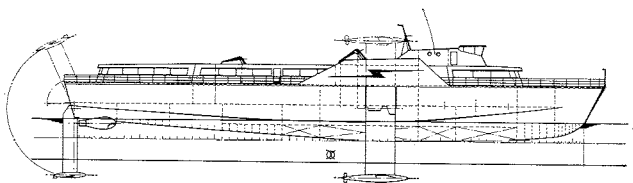
Turning radius at cruising speed
1,148 ft (350 m)

Number of seconds and distance to take-off
35 sec/1,312 ft (400 m)

Number of seconds and distance to stop craft
16 sec/656 ft (200 m)

Fuel consumption at max speed
250.5 gallons per hour

Fuel consumption at cruising speed
255 gallons per hour



General arrangement of the Neptune hydrofoil passenger/car ferry showing outboard profile, passenger and car decks

HYDROFOIL MANUFACTURERSGermany / Italy: **SCHLICHTINGWERFT / RODRIQUEZ****Schlichtingwerft
SCHLICHTINGWERFT****HEAD OFFICE:**

Mecklenburger Landstrasse, Lubeck-Travemunde

MANAGING DIRECTOR:

Alnwick Harmstorf

Schlichtingwerft is constructing the prototype of a 160-ton hydrofoil patrol craft of Supramar design for the Federal German Navy (Bundesmarine). It is generally similar in construction to the proposed gas-turbine powered version of the PT 150.

Details of the gas-turbine version of the PT 150, a 300-seat passenger ferry for routes up to 250 nautical miles, were released by Supramar in 1963. To facilitate calls at smaller ports, the crossing of shallows, docking and slipping, the foils, rudders and propellers are retractable.

A combined surface piercing and submerged foil configuration is employed with two surface piercing foils forward and two submerged foils aft. Initially the gas turbine powered PT 150 was to be fitted with hydraulically-operated stability augmentation flaps on the front foils to give improved

performance in a seaway, and the new Supramar air stabilisation system was to be fitted at a later stage.

The two 4,250 bhp Marine Proteus turbines are located aft, and each transmits power through a mechanical right-angle drive transmission to a propeller at the aft end of a strut-and-pod assembly. For manoeuvring in displacement condition there is an independent 200 hp gas-turbine with its own propeller.

Designed maximum speed of the craft was given as 48 knots, and the cruising speed 45 knots.

ITALY**Advance Marine Systems
ADVANCED MARINE SYSTEMS—
ALINAVI S.p.A.****HEAD OFFICE:**

Via Gramsci 24, Rome, Italy

TELEPHONE:

879 204

DIRECTORS:Dr. Publio Magini (Boeing), President
Airo M. Gonnella (Boeing)

W. J. Kane (Boeing)
Brantz Mayor (Boeing)
Ing. Riccardo Baldini (Finmeccanica)
Ing. Giorgio Bettini (Finmeccanica)
Cav. del Lav. C. Rodriquez (Rodriquez)

EXECUTIVE:

Ing. Francesco Cao, Chief Engineer
This company was formed in 1964 to develop military and commercial advanced marine systems, primarily in Europe and the

Mediterranean areas. Local manufacturing and marketing support will be given to technology from Boeing. At present the company's major activities are confined to the sale and production of military hydrofoil boats and research into hydrofoil design, and advanced marine propulsion systems. The company is jointly owned by The Boeing Company (60%), Finmeccanica (30%) and Carlo Rodriquez (10%).

**Leopoldo Rodriquez
LEOPOLDO RODRIQUEZ SHIPYARD****HEAD OFFICE:**

Molo Norimberga 24, Messina

TELEPHONE:

44801 (PBX)

TELEX:

98030 Rodrikez

DIRECTORS:Cav Del Lavoro Carlo Rodriquez, President
Leopoldo Rodriquez
Franco Rodriquez**SENIOR EXECUTIVES:**Dott. Ing. Leopoldo Rodriquez, General Manager
Capt. Franco Rodriquez, Sales Director
Dott. Ing. Giovanni Falzea, Yard Director
Ing. Frederick Leobau, Design Office Director

The Leopoldo Rodriquez Shipyard was the first in the world to produce hydrofoils in series, and is now the biggest hydrofoil builder outside the Soviet Union. On the initiative of the company's president, Carlo Rodriquez, the Aliscafi Shipping Company was established in Sicily to operate the world's first scheduled seagoing hydrofoil service in August 1956 between Sicily and the Italian mainland.

The service was operated by the first Rodriquez-built Supramar PT 20, Freccia del Sole. Cutting down the port-to-port time from Messina to Reggio di Calabria to one-quarter of that of conventional ferry boats, and completing 22 daily crossings, the craft soon proved the commercial viability of Supramar designs. With a seating capacity of 75 passengers the PT 20 has carried between 800-900 passengers a day and has conveyed a record number of some 31,000 in a single month.

The prototype PT 20, a 27-ton craft for 75 passengers, was built by Rodriquez in 1955 and the first PT 50, a 63-ton craft for 140 passengers, was completed by the yard in 1958.

Since 1956 the company has built forty-one PT 20s and twenty-three PT 50s. Sales have been made to 21 countries. Under construction at the yard at the time of going to press are seven PT 20s, six PT 50s and one PT 150. Apart from building the standard range of Supramar designs (*see Supramar, Switzerland*) the company also produces a number of variants, including the PAT 20 fast naval and police patrol craft, the PT 20/59 Caribe and the PT 50/S which are described below.

PAT 20

Two PAT 20 fast patrol hydrofoils, Camiguin 72 and Siquijor 73, have been built by Rodriquez for the Phillipine Navy. The craft carry one, bow-mounted 12.7 machine gun and have been employed on contraband patrol and coastguard duties since June 1965. Their main patrol area is between the island of Mindanao and the NW coast of Borneo. **FOILS:** Bow and rear foils are of surfacing piercing V configuration and identical to those of the standard PT 20. About 59% of the total weight is borne by the bow foil and 41% by the rear foil. The foils are of hollow ribbed construction and made from medium Asera steel.

Total foil area is 112 sq ft (10.4 m²). The angle of incidence of the forward foil can be varied during flight by means of a hydraulic ram acting on the foil strut supporting tube. **HULL:** The hull is of riveted light alloy construction with Peraluman (aluminium and magnesium alloy) plates and Anticorodal (aluminium, magnesium and silicon alloy) profiles.

ACCOMMODATION: The crew comprises a captain, two officers and eight NCO's and ratings. The pilot's position is on the left of the wheelhouse, with the principal instrumentation; and the radar operator sits on the right with the auxiliary instrumentation. The pilot is provided with an intercom system connecting him with the officer's

cabin, engine room and crew cabin. The internal space has been divided as follows:

- The forward or bow room, subdivided into two cabins, one for the captain, the other for two officers, and including a WC with washstand and a storeroom with a refrigerator.
- The stern room, with eight berths for the NCOs and ratings, a WC with washstand and a galley equipped with a gas stove and an electric refrigerator.
- The deck room, aft of the wheelhouse, with tilting sofa and table for R/T equipment.

Air conditioning is installed in the captain's and officer's quarters.

POWER PLANT: Power is supplied by a supercharged 12-cylinder Mercedes-Benz MB820 Db with a max continuous output of 1,350 hp at 1,500 rpm. Engine output is transferred to a 3-bladed bronze aluminium propeller through a Zahnradfabrik BW 800/S reversible gear. Fuel (total capacity 2,800 kg) is carried in ten cylindrical aluminium tanks located in the double bottom beneath the bow room and the stern room. Dynamic and reserve oil tanks in the engine room give a total oil capacity of 120 kg. An auxiliary engine can be fitted in the stern for emergency operation.

ARMAMENT AND SEARCH EQUIPMENT: Single 12.7 machine-gun mounted above well position in bow, and two searchlights.

SYSTEMS:

ELECTRICAL: 220v, 10 kW, diesel generator with batteries. Supplies instruments, radio and radar and external and internal lights, navigation lights and searchlights.

HYDRAULICS: 120 kp/cm² pressure hydraulic system for steering and varying forward foil incidence angle.

APU: Onan engine for air conditioning when requested.

HYDROFOIL MANUFACTURERS

RODRIQUEZ: Italy



A Rodriquez PAT 20 fast patrol hydrofoil under test off Messina. Two are employed by the Philippine Navy on contraband patrol and coastguard duties.

DIMENSIONS:

Length overall, hull	68 ft 6 in (20.89 m)
Hull beam	15 ft 8½ in (4.79 m)
Beam overall	24 ft 4 in (7.4 m)
Draft afloat	9 ft 1 in (2.76 m)
Draft foilborne	4 ft 0 in (1.20 m)
Height overall:	
hullborne	21 ft 0 in (6.44 m)
foilborne	26 ft 3 in (8.00 m)

WEIGHTS:

Net tonnage	28 tons
Light displacement	26 tons
Max take-off displacement	32.5 tons
Useful load	7.6 tons
Max useful load	8.1 tons

PERFORMANCE:

Max speed foilborne	38 knots
Max speed hullborne	13 knots
Cruising speed foilborne	34 knots
Cruising speed hullborne	12 knots
Max permissible sea state foilborne mode	Force 4

Designed range at cruising speed

540 miles (869 km)

Number of seconds and distance to take-off
20 secs, 328 ft (100 m)

Number of seconds and distance to stop
craft 12 secs, 164 ft (50 m)

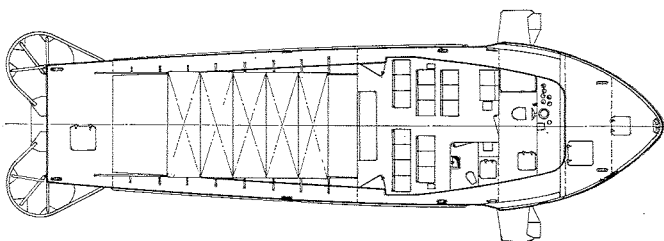
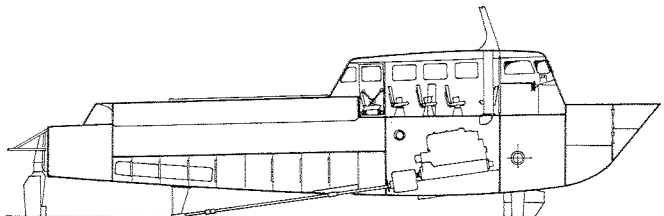
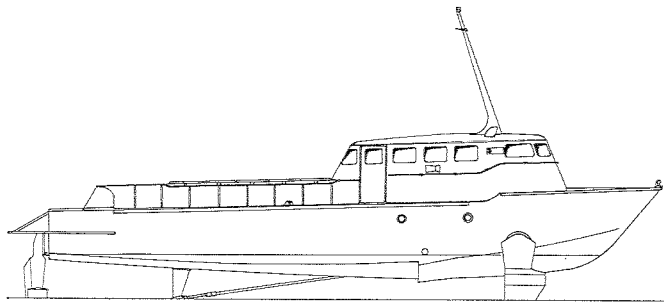
Fuel consumption at cruising speed 145 kg/h

Fuel consumption at max speed 180 kg/h

PT 20/59 CARIBE

This version of the PT 20 was designed originally for services in tropical waters. The bridge and engine room have been arranged in the foreship to give maximum forward vision in areas where there is an influx of driftwood. Tropical conditions have also been taken into consideration in the design and installation of the powerplant.

FOILS: Bow and rear foils are of standard Schertel-Sachsenburg surface-piercing Vee configuration, with about 66% of the weight supported by the bowfoil and 34% by the rear foil. Submerged foil area when foilborne is 67 sq ft (6.2 m²). Each foil, together with its struts and horizontal girder forms a rigid framework which facilitates the ex-



Mixed passenger cargo version of the Caribe with a cargo deck in place of the main passenger cabin

change of the foil structure. The foils are of hollow-ribbed construction and fabricated from medium Asera type steel. The incidence angle of the forward foil can be adjusted hydraulically during operation to counter the effect of large variations in passenger loads.

HULL: The hull is of riveted light metal alloy and framed on a combination of longitudinal and transverse formers. Watertight compartments are provided in the bow and stern and beneath the passenger decks. Some are filled with foam plastic which makes these boats practically unsinkable.

POWER PLANT: The engine is a supercharged Mercedes-Benz MB 820 Db, with a maximum continuous output of 1,100 hp at 1,500 rpm. Engine output is transferred to a 3-bladed, 27.5 in (700 mm) diameter bronze aluminium propeller through a Zahnradfabrik BW 800 H reversible gearbox.

ACCOMMODATION: Fifty-one passengers can be accommodated in the main cabin and fifteen in the small forward cabin. Access to the forward and main compartment is through either of two doors, located port and starboard, to the rear of the wheelhouse superstructure. Steps from the forward



The Rodriguez Caribe, a special class of the PT 20 designed for commercial service in tropical conditions. Fifteen passengers are accommodated in the forward cabin above the engine room and fifty-three in the main cabin. Powered by an MB 820Db diesel rated at 1,350 hp continuous, the craft cruises at 34 knots

compartment lead down to the main cabin. At the aft end of the main cabin is a WC and an emergency exit.

A mixed passenger/cargo version is available, with seats for 19 in a cabin immediately aft of the wheelhouse and a cargo deck in place of the main passenger cabin.

SYSTEMS:

ELECTRICAL: Single phase generator 220 volts, 7.1 kW, 50 c/s and batteries. Supplies instruments, radio, radar and internal and exterior lights.

HYDRAULICS: 120 kp/cm² pressure hydraulic system for rudder and varying incidence angle of bow foil.

APU: Onan engine for air conditioning, when specified.

COMMUNICATIONS AND NAVIGATION:

Radio: VHF radio-telephone, to customer's requirements.

Radar: Decca, Raytheon, etc., to customer's requirements.

DIMENSIONS:

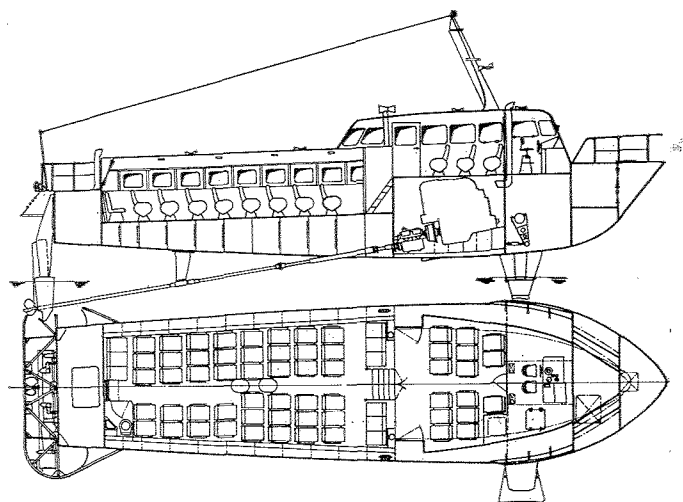
Length overall, hull	64 ft 0 in (19.5 m)
Hull beam	16 ft 7 in (5.06 m)
Width over foils	24 ft 2 in (7.38 m)
Draft afloat	9 ft 1 in (2.77 m)
Draft foiborne	3 ft 10 in (1.16 m)
Height overall, hullborne	20 ft 4 in (6.18 m)
Height overall, foiborne	27 ft 11 in (8.5 m)

WEIGHTS:

Net tonnage	43.31 tons
Light displacement	25.8 tons
Normal take-off displacement	33 tons
Max take-off displacement	33.5 tons
Useful load (fuel, water, passengers, baggage and crew)	7.2 tons
Max useful load	7.7 tons

PERFORMANCE (with normal payload):

Max speed, foiborne	34.5 knots
Max speed, hullborne	12 knots
Cruising speed, foiborne	31 knots
Cruising speed, hullborne	11 knots
Max permissible sea state in foiborne mode	State 5
Designed range at cruising speed	250 n miles



Inboard profile and plan of the Rodriguez PT 20 Caribe

Fuel consumption at max speed

396 lb/h (180 kg/h)

Fuel consumption at cruising speed

320 lb/h (145 kg/h)

PT 50/S

The PT 50/S differs from the standard PT 50 in having the bridge arranged in the foreship. Immediately aft of the wheelhouse is a belvedere (viewing) saloon with seats for 14 and a bar. Companies operating this particular variant include the Port Jackson and Manley Steamship Co of Sydney, Australia, and the Hong Kong-Macao Hydrofoil Co.

FOILS: Bow and rear foils are of surface-piercing vee configuration identical to those of the standard design. About 60% of the total weight is borne by the bow foil and 40% by the rear foil. Hydraulically-operated flaps are fitted at the trailing edge of the bow foil to balance out longitudinal load shifting, assist take-off and adjust the flying height.

HULL: This is of riveted light alloy construction and framed on a combination of longitudinal and transverse formers.

ACCOMMODATION: The PT 50/S carries a crew of 6 and 125 passengers. The main compartment, aft, seats 65, the forward compartment seats 46, and the belvedere saloon, located above the engine, seats 14. Either a dry ice or electric refrigerator of about 150 litre capacity can be fitted in the bar, together with a stainless steel wash basin served with running water. Both the forward and aft saloons have a WC/washbasin unit. Access to the passenger saloons is through either of two doors on the main deck, port and starboard. Separate doors, on either side of the wheelhouse, are provided for the pilot and crew.

POWER PLANT: Power is supplied by two 12-cylinder supercharged MB 820 Dbs, with a maximum output of 1,350 hp at 1,500 rpm. Reverse and reduction gears are manufactured by Zahnradfabrik. The reverse clutches are solenoid operated from the bridge.

SYSTEMS:

AIR CONDITIONING: Genefrigor Genoa, where requested.

ELECTRICAL: Air cooled MWM type AKD412E or similar diesel driving a single

HYDROFOIL MANUFACTURERS

RODRIQUEZ: Italy

phase generator of 220 volts, with batteries. Supplies instruments, radio and radar and external and internal lights.

HYDRAULICS: System to operate rudder and flaps on bow foil, 120 kp/cm².

DIMENSIONS:

Length overall, hull	95 ft 2 in (29 m)
Length waterline, hull	80 ft 1 in (24.8 m)
Hull beam	20 ft 1 in (6.1 m)
Width over foils	33 ft 6 in (10.2 m)
Draft afloat	11 ft 6 in (3.5 m)
Draft foilborne	4 ft 11 in (1.5 m)

Height overall, hullborne 29 ft 7 in (9 m)

Height overall, foilborne 36 ft 2 in (11 m)

WEIGHTS:

Net tonnage	82 tons
Light displacement (with fuel, oil and water)	51.5 tons
Max take-off displacement	64.5 tons
Useful load (fuel, water, passengers, baggage and crew)	13.5 tons
Max useful load	14 tons

PERFORMANCE (with normal payload):

Max speed foilborne 37 knots

Max speed hullborne 18 knots

Cruising speed foilborne 34 knots

Max permissible sea state in foilborne mode State 6

Designed range at cruising speed

250 n. miles

Number of seconds and distance to take-off (theor app) 25 secs, 164 yd (150 m)

Number of seconds and distance to stop craft 18 secs, 88 yd (80 m)

Fuel consumption at max speed 360 kg/h

Fuel consumption at cruising speed 330 kg/h



Flying Flamingo, a Rodriguez-built 125-seat PT 50/S, operated by the Hong Kong Macao Hydrofoil Company. Cruising speed is 34 knots.

Seaflight**SEAFLIGHT S.p.A.****HEAD OFFICE:**

Via della Munizione 3, Messina

TELEPHONE: 46100

TECHNICAL OFFICE:

Villaggio Torre Faro, Messina

TELEPHONE: 50200

The Seaflight series of hydrofoils use a foil system introduced by Guiseppe Guiffrida, who joined this company in 1961. The foil automatically assumes the best angle of incidence in relation to the flow of water. In this way it always produced the same amount of lift, whether the speed varies, or the foils' submerged surface varies in a wave crest or cavity.

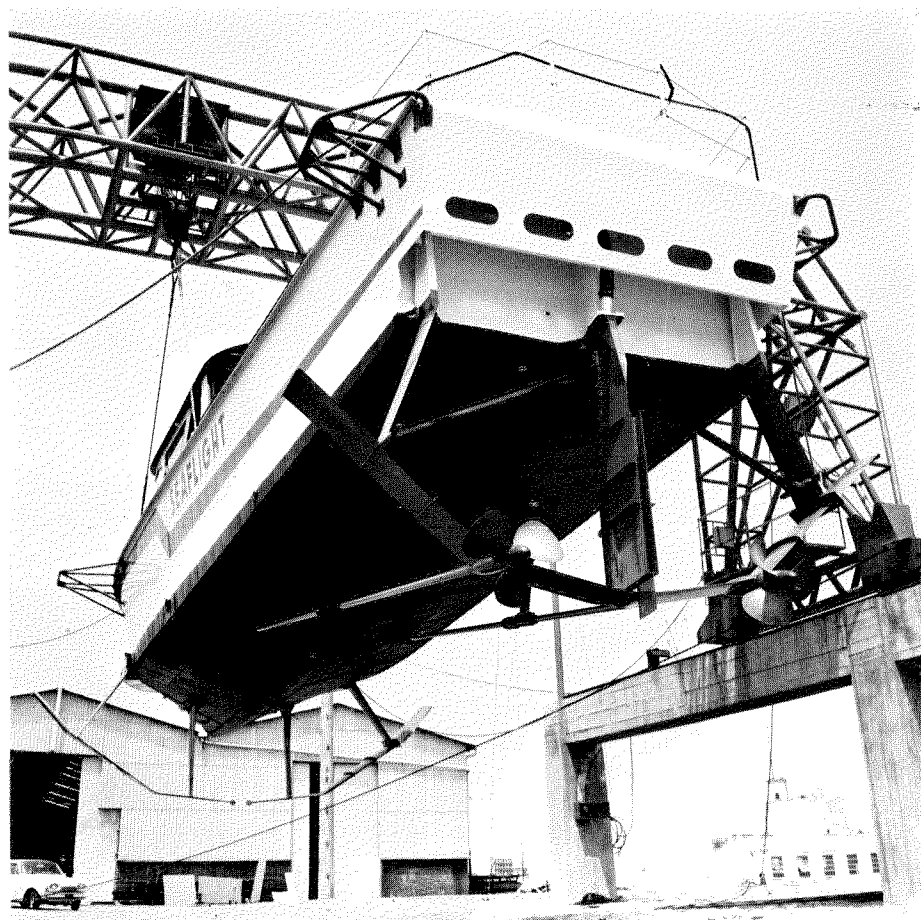
Seaflight is backed by a group of Messina industrialists. Construction of the Seaflight yard on the beach at Torre Faro began in November 1962, and the prototype Seaflight was launched in January 1964. The yard has capacity for the production of fifteen hydrofoils a year.

SEAFLIGHT P.46

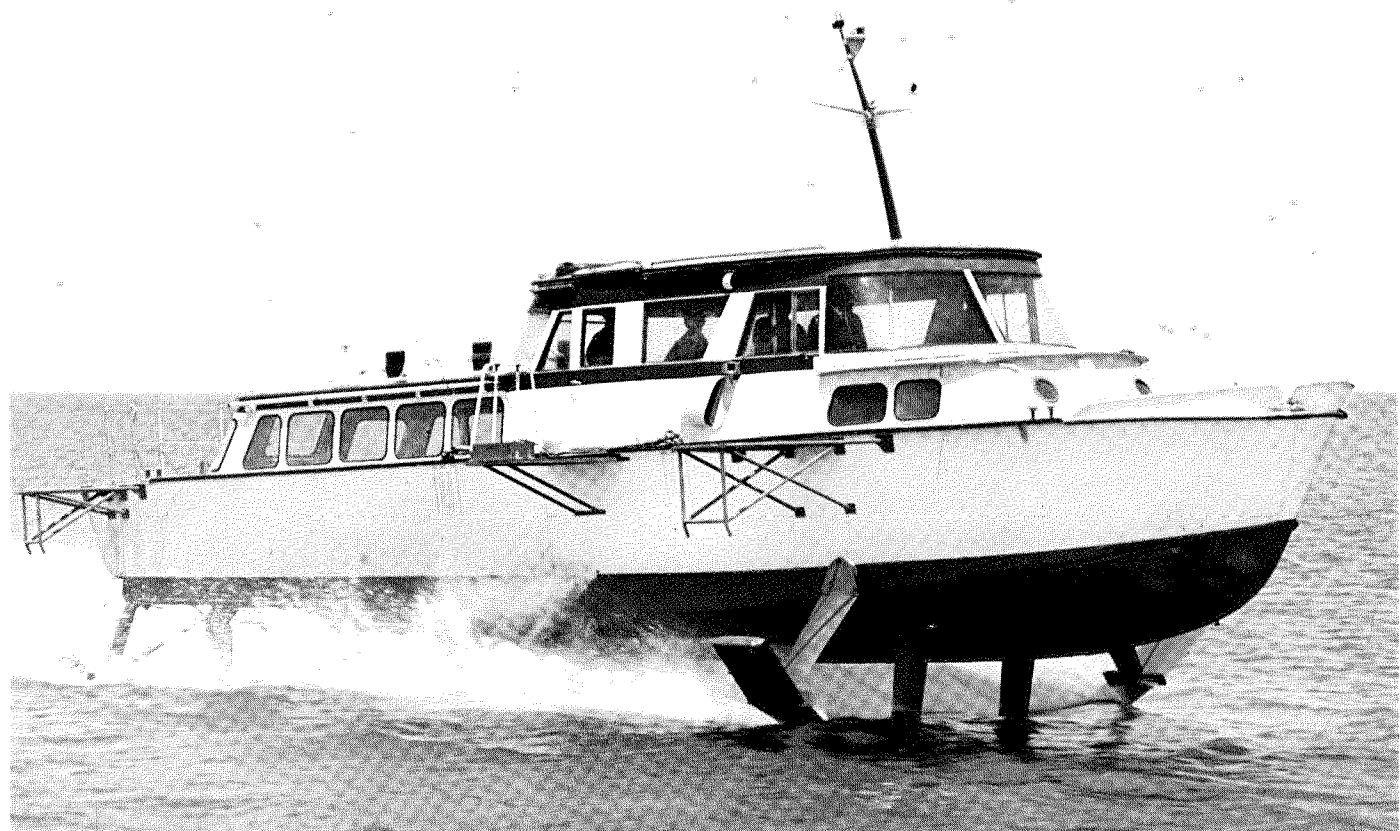
Designed for off-shore and inter-island passenger ferry services, the Seaflight P.46 seats 32 in its roomy passenger saloon and cruises at 32-35 knots (60-65 km/h).

FOILS: The craft incorporates a foil system in which the foil automatically assumes the best angle of incidence in relation to the wave condition.

A lever attached to the hydrofoil bearing assembly is connected by springs to the hull, so that a reaction force rotates the lever and bearing assembly, together with the foil, in a direction opposite to that in which it would tend to be rotated by lift forces exerted on the foil. The spring reaction force may be manually adjusted.



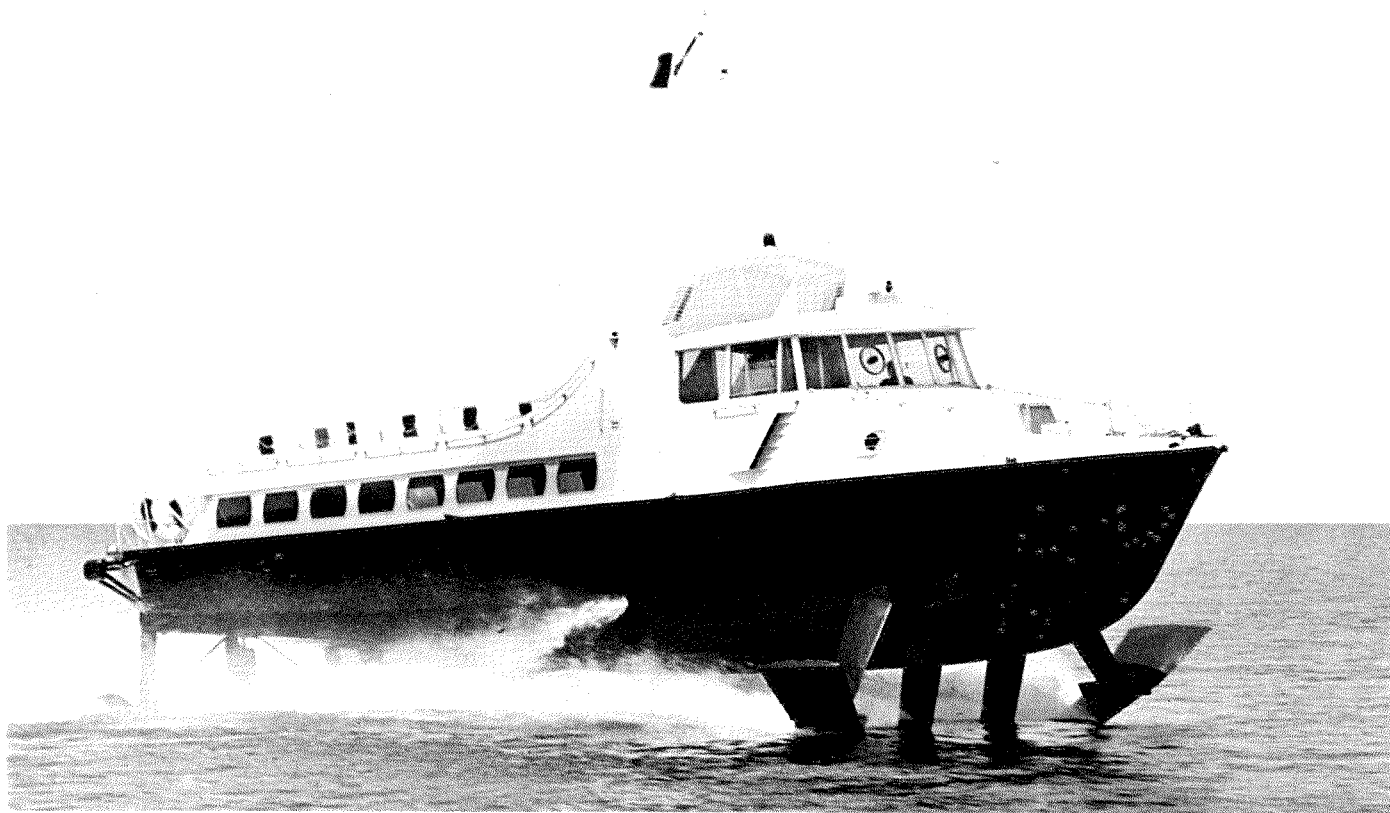
Seaflight P46 showing the rear foil assembly and the split bow foil which combines a horizontal submerged centre section with inclined surface piercing areas



Seaflight P46 (two Cummins VT8N-370-M) is available as a 30-32 seat passenger ferry, luxury yacht or fast coastal patrol boat. A mechanically operated system of incidence control is fitted to the bow foil

HYDROFOIL MANUFACTURERS

SEAFLIGHT: Italy



The Seaflight H57 (two 650 hp Fiat-OM) seats 60 passengers and has a maximum speed of 39 knots (72 km/h)

The bow foil is of the split-type and combines a horizontal, submerged centre section, with inclined, surface-piercing areas. The configuration is stated by the company to offer a good compromise between the fully submerged foil, with its horizontal lift surfaces, and the surface piercing foil with its oblique surfaces. The Seaflight's horizontal foil surfaces produce about two-thirds of the lift required.

POWER PLANT: Power is provided by two Cummins VT8N-370-M marinised, turbo-charged V8 engines, each developing 370 hp.
HULL: The hull is riveted, light alloy construction and the foils are of specially strengthened corrosion-resistant steel.

DIMENSIONS:

Length overall	45 ft 11 in (14.00 m)
Breadth over foils	16 ft 5 in (5.00 m)
Draught afloat	5 ft 9 in (1.75 m)
Foilborne draught	2 ft 6 in (0.75 m)

WEIGHTS:

Displacement	12.50 tons
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PERFORMANCE:

Max speed	40 knots (74 km/h)
Range	270 nautical miles (500 km)

SEAFLIGHT H.57

This is a larger and more powerful development of the C.46 seating 60 passengers. Hull construction is in riveted light alloy and its foils are in specially strengthened corrosion resisting steel. Power is supplied by two 650 hp Fiat Carraro diesels

DIMENSIONS:

Length overall	57 ft 1 in (17.50 m)
Breadth over foils	26 ft 3 in (8.00 m)
Draught afloat	8 ft 1 in (2.47 m)
Draught foilborne	3 ft 8 in (1.12 m)

WEIGHTS:

Max displacement	26.00 tons
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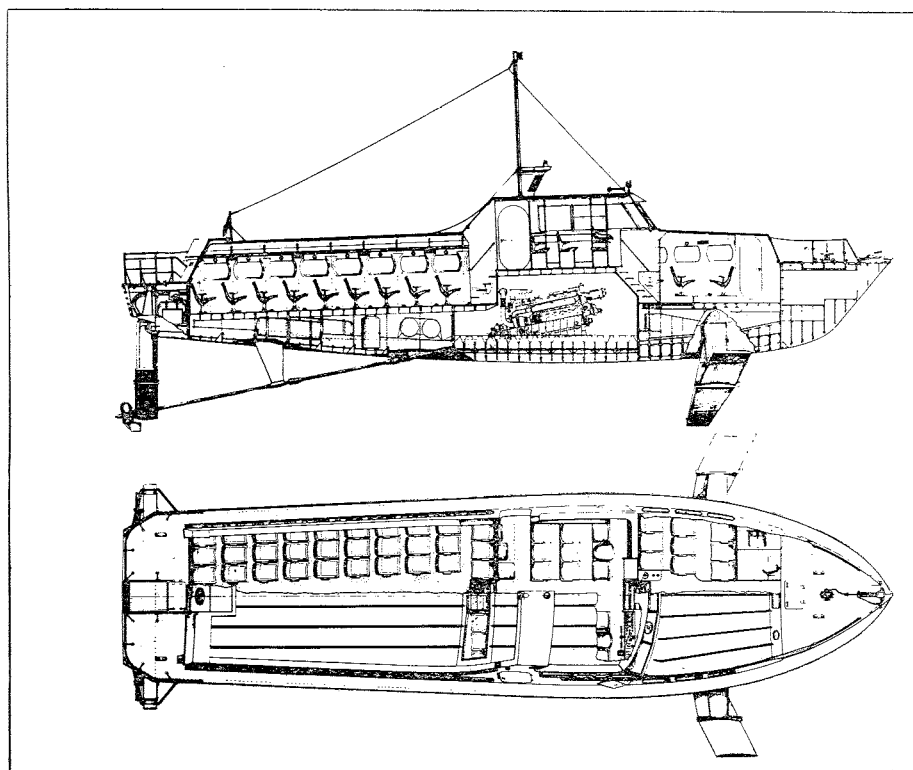
PERFORMANCE:

Cruising speed	32-35 knots (60-65 km/h)
Max speed	39 knots (72 km/h)
Range	270 nautical miles (500 km)

SEAFLIGHT L.90

The prototype of the L.90, latest passenger

ferry hydrofoil in the Seaflight series, is under construction at the company's yard at Torre Faro, Messina. Powered by two 1,350 hp CRM 18/DS diesels, it will accommodate 100-120 passengers, and have a cruising speed of 35 knots.



Seaflight L90 side and plan view

HYDROFOIL MANUFACTURERSItaly / Japan: **SEAFLIGHT / HITACHI**

FOILS: The foil system is of the fixed surface piercing type. The split bow foil combines a horizontal submerged centre section with inclined surface piercing areas and incorporates the Seaflight mechanically operated system of incidence control. The geometry of the foils is such that it is possible to beach the vessel on a falling tide on a nearly flat sandy bottom, the hull remaining stable.

HULL: The V-bottom hull is mainly in marine corrosion resistant aluminium alloys. Steel is used for highly stressed parts.

ACCOMMODATION: In the standard ver-

sion, passengers are accommodated in three compartments; a forward saloon seating 18; an observation or belvedere deck in the wheelhouse superstructure seating 22, and a main aft saloon seating 60. The forward compartment contains two toilet/washbasin units. Access is through either of two doors, port or starboard in the forward cabin, or two doors either port or starboard in the wheelhouse superstructure.

POWER PLANT: Power is provided by two CRM type 18/DS diesels with a maximum output of 1,350 hp at 2,075 rpm, and normal

output of 950 hp at 1,950 rpm. Each engine drives a three-blade fixed propeller through an inclined shaft.

DIMENSIONS:

Length overall	69 ft 3 in (21.10 m)
Width across foils	28 ft 9 in (8.80 m)
Draft afloat	9 ft 3 in (2.81 m)
Draft foiborne	4 ft 0 in (1.21 m)

WEIGHTS:

Maximum take-off displacement	37 tons
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PERFORMANCE:

Cruising speed	35 knots (64 km)
Cruising range	270 nautical miles (499 km)

HITACHI SHIPBUILDING & ENGINEERING CO**HEAD OFFICE:**

47 Edabon 1-chome, Nishi-ku, Osaka, Japan

HYDROFOIL SHIPYARD:

Kanagawa Shipyard, 1 Mizve-cho, Kawasaki-City, Kanagawa Prefecture

DIRECTORS:

Yosomatsu Matsubara, Chairman of the Board of Directors

Takao Nagata, President

Hideo Fukuda, Managing Director and General Manager of Shipbuilding Division

JAPAN

Yoshio Kinoshita, Director and Manager of Product Development Department

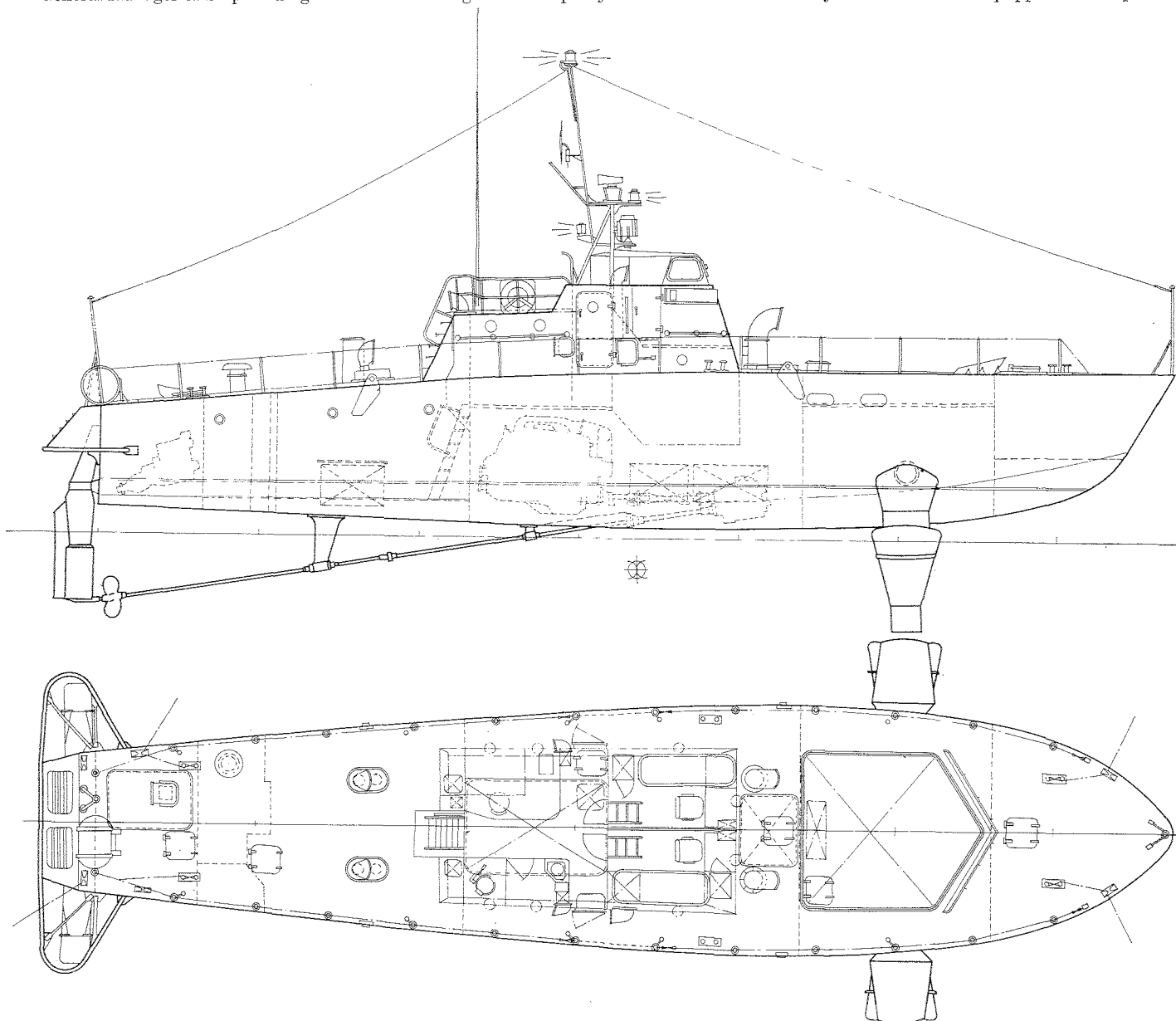
Isao Yoshimura, Director and Manager of General Affairs Department (including advertising sect):

Hitachi, the Supramar licensee in Japan, has been building PT 3, PT 20 and PT 50 hydrofoils since 1961. The majority of these have been built for fast passenger ferry services across the Japanese Inland Sea, cutting across deep bays which road vehicles

might take two-to-three hours to drive round, and out to offshore islands. Other PT 20s and 50s have been exported to Hong Kong and Australia for ferry services.

Specifications of the PT 3, PT 20 and PT 50 will be found under Supramar (Switzerland). The Hitachi-built craft are identical apart from minor items.

In 1962 Hitachi, in conjunction with Eidai Sangyo Co Ltd, introduced two small hydrofoil runabouts equipped with Supramar



General arrangement of the PT 32 fast patrol hydrofoil developed for the Philippine Navy for contraband patrol and coastguard duties. Two craft of this type were delivered by Hitachi in November 1965. Armament comprises a twin .50 calibre machine gun mounted above the forward deck well and a single .50 calibre machine gun on the aft deck. Cruising range is 360 miles and the cruising speed is 32 knots

HYDROFOIL MANUFACTURERS

HITACHI: Japan

foils. The foils can be retracted and folded close to the sides of the hull by means of a lever operated from the cockpit.

A special military hydrofoil, based on the Schertel-Sachsenburg foil system, and designated PT 32, has been designed and built by Hitachi for the Philippine Navy.

PT 32

This craft was specially designed as a fast patrol boat. Two have been delivered to the Philippine Navy for contraband patrol and general Coast Guard duties in coastal waters. The PT 32 is powered by a 1,350 hp Mercedes-Benz-Ikegai diesel, which gives a maximum speed of 35 knots. The hull is of light alloy, riveted construction and accommodation is provided for three officers and twelve NCOs and ratings. The armament comprises a twin .50 cal machine gun mounted above the forward deck well, and a single .50 cal machine gun on the aft deck.

DIMENSIONS:

Length overall	69 ft 0 in (21.0 m)
Length over deck	56 ft 9 in (20.0 m)
Beam over deck	15 ft 9 in (4.8 m)
Width over foils	25 ft 7 in (7.8 m)
Depth from top of keel to deck at side, amidships	9 ft 10 in (3.0 m)
Draft, hullborne, from base of foils	9 ft 2 in (2.8 m)
Draft, foilborne from base of foils	4 ft 3 in (1.3 m)

WEIGHT:

Fully loaded displacement approx 32 tons

PERFORMANCE:

Cruising speed	approx 32 knots
Maximum speed	35 knots
Cruising speed	360 miles
Speed with auxiliary engine	approx 4 knots

Main engine Licence built:

Mercedes-Benz-Ikegai MB 820 Db supercharged diesel engine

MB 820 Db supercharged diesel engine

Maximum output 1,350 hp × 1,500 rpm

Continuous full output

1,100 hp × 1,400 rpm

Fuel consumption

0.364 lb/hp/h (165 g/hp/h)

Auxiliary propelling power:

Diesel engine 60 hp

Complement:

Officers 3 persons

Enlisted personnel 12 persons

Total 15 persons

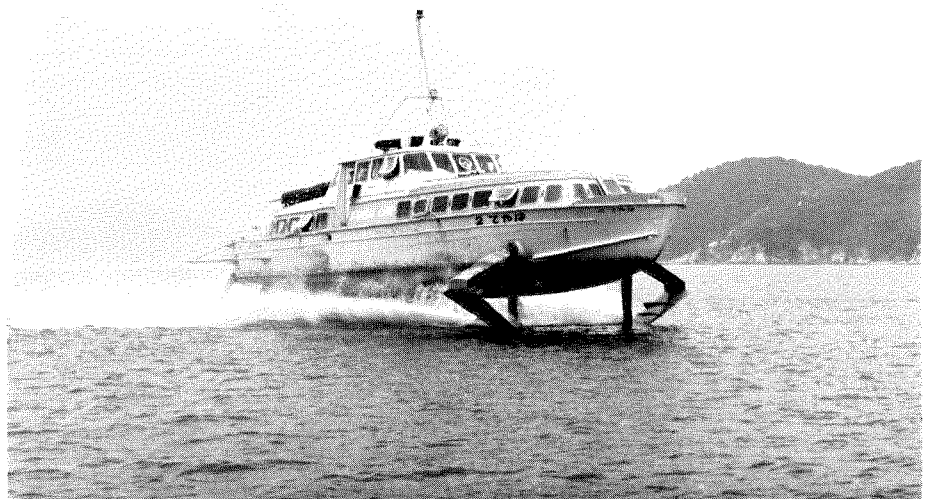
AT-FOIL

In addition to their range of Supramar-designed commercial passenger craft, Hitachi also manufactures retractable foils for the YODO-14 and -16 hydrofoil runabouts, substantial numbers of which have been sold throughout Japan and South East Asia.

CONSTRUCTION: Built by Eidai Sangyo Co Ltd, of 33 Hirabayashi Minamino-cho, Sumiyoshi-ku, Osaka-City, and constructed in marine ply, the craft are powered by standard 40-70 hp marine outboards.

FOIL DESIGN: The front foil is of the surface-piercing split type, and the rear foil is a fully submerged type. Both front and rear foil systems fold upwards for retraction.

ACCOMMODATION: YODO-14 is a 14 ft craft seating 3-4 passengers, and uses AT-40 foils; YODO-16, a 16 ft craft, seats 5-6 and is fitted with AT-75 foils.



Hayate 2, one of the two Hitachi PT 20s operated by Kansai Kisen Co. between Osaka and Takamatsu



Wakashio, a Hitachi PT 50 (two 1,350 hp MB 820 Db diesels) which has been operated between Enosima and Atami by Nihon Kosokusen since 1963.



YODO-16, a 5-6 seat, 34 knot sports hydrofoil built by Eidai Sangyo Co. and fitted with Hitachi-Supramar retractable AT-foils

HYDROFOIL MANUFACTURERS

Japan: HITACHI/IHI

YODO-14**DIMENSIONS:**

Length	13 ft 6 in (4.1 m)
Beam	5 ft 1 in (1.55 m)
Width across foils:	
Foil extended	9 ft 5 in (2.87 m)
Foil retracted	7 ft 4 in (2.24 m)
Draught foilborne	1 ft 8 in (0.50 m)
Draught afloat:	
Foil extended	2 ft 10 in (0.85 m)
Foil retracted	9 in (0.23 m)
Complement	4 persons

WEIGHT:

Weight displacement 905 lb (410 kg)

PERFORMANCE:

Max speed:	
2 passengers	32 knots (60 km/h)
fully loaded	30 knots

Max permissible wave height in foilborne condition (1 ft 0.30 m approx)

Take-off performance:

It takes about 30 sec with engine at 1,000 rpm to reach max speed

Landing:

About 10 sec with engine at 4,500 rpm to stop the boat. Distance about 60 m

Turning radius 329 ft (100 m approx)

Complement 4 persons

Outboard engine 40 hp × 1

YODO-16**DIMENSIONS:**

Length	15 ft 2 in (4.7 m)
Beam	6 ft (1.85 m)
Width across foils:	
Foil extended	11 ft (3.23 m)

Foil retracted 8 ft 5 in (2.62 m)

Draught foilborne 1 ft 8 in (0.50 m)

Draught afloat:

Foil extended 3 ft (0.90 m)

Foil retracted 11 in (0.26 m)

Complement 5 persons

Outboard engine 75 hp × 1

WEIGHT:

Light displacement 1,234 lb (560 kg)

PERFORMANCE:**Max speed:**

2 passengers 37 knots

full load 34 knots

Max permissible wave height in foilborne condition 1 ft 6 in (0.40 m approx)

Take-off performance as for YODO-14

Landing as for YODO-14

Landing radius 329 ft (100 m approx)

Ishikawajima-Harima**ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIES****HEAD OFFICE:**

3, 2-Chome, Fukagawa-Toyosu, Koto-Ku, Tokyo, Japan

TELEGRAMS:

IHTOYOSU TOKYO

OFFICERS:

Renzo Taguchi, Director

I. Itoh, Manager, Development Department, Research Institute

The Technical Development Department of Ishikawajima-Harima has been conducting a hydrofoil research and development programme since 1960. This has led to the construction of a series of small hydrofoil sportscraft and the IHF-3 waterbus. Two larger craft, the 23-ton IHF-8 and the 70-ton IHF-25 are in the planning stage.

IHF-3

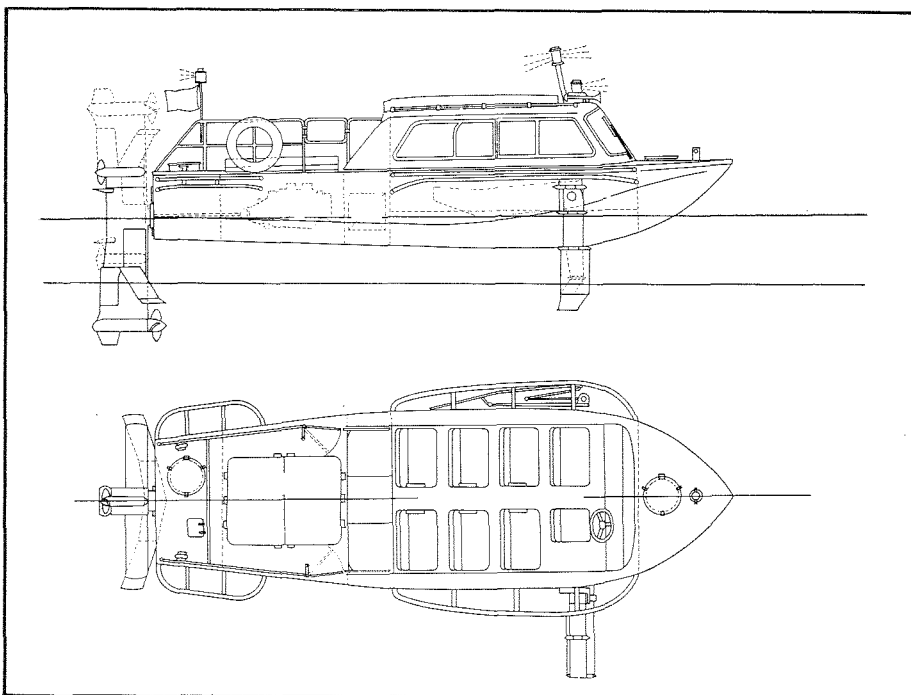
A 15-seat multi-purpose transport, the IHF-3 was the first production craft to use IHI's retractable and folding foil system, which permits the craft to operate in displacement mode and go alongside piers and other vessels without damaging the foils. Applications include sightseeing, high-speed water-taxi, fire, harbour police and lifeguard patrol and pilot boat.

HULL: The hull is constructed in anti-corrosive aluminium alloy. The cabin seats a maximum of 13 passengers and a crew of 2.
FOILS: Front and rear foils are of the split, surface-piercing type, the front foil being fully foldable. When retracted the forward foil assembly is up above the water line. The power for this operation is supplied by a hydraulic pump driven by the main engine. Folding and unfolding is controlled by a lever sited by the helmsman's seat and can take place when under way at low speed.

POWER PLANT: Power from a 280 hp Chrysler (or similar engine) is transmitted to the propeller through a vertical shaft with bevel gears. The power strut also serves as the support for the aft hydrofoil, and is extended upwards in order to support a small auxiliary propeller which is driven through the same vertical shaft. The whole integral assembly, including the aft hydrofoil and the two propellers at the opposite ends of the power strut, is rotated hydraulically through 180° about a horizontal axis in an athwartship



The IHF-3's foil system is retracted hydraulically. The forward foil assembly is folded and swings aft above the waterline. The complete aft foil assembly is rotated through 180° bringing the hullborne propeller into position.



IHF-3, 15-seat passenger ferry and general purpose hydrofoil

plane. It is so arranged that in the inverted position the auxiliary propeller is set at the correct position to propel the craft at minimum draught.

HYDROFOIL MANUFACTURERS

IHI / MITSUBISHI

DIMENSIONS:

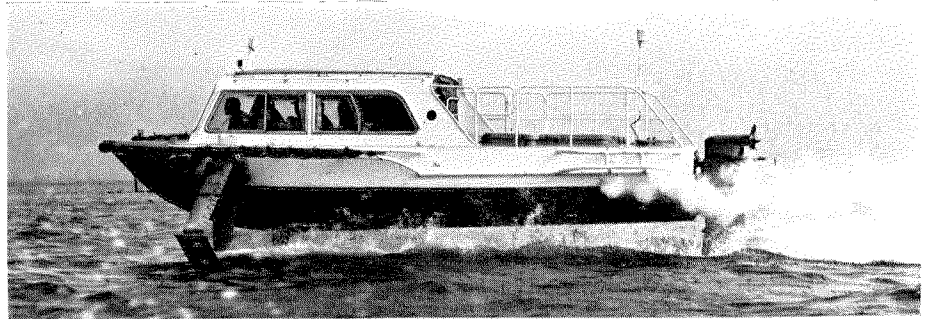
Length overall, hull	26 ft 3 in (8.00 m)
Length waterline, hull	23 ft 7½ in (7.20 m)
Hull beam	8 ft 2½ in (2.50 m)
Length overall, foils retracted	29 ft 9 in (9.06 m)
Length overall, foils extended	29 ft 9 in (9.06 m)
Max beam, foils retracted	12 ft 5 in (3.78 m)
Max beam, foils extended	16 ft 9 in (5.09 m)
Draught, foils retracted	1 ft 2 in (0.66 m)
Draught, foils extended	6 ft 1½ in (1.86 m)
Freeboard	1 ft 0 in (0.61 m)

WEIGHTS:

Gross tonnage	4½ tons
Light displacement	3¼ tons
Max take-off displacement	4 tons
Useful load (fuel, water, passengers, baggage and crew)	1½ tons

PERFORMANCE:

Max speed, foilborne	36 knots (66 km/h)
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The IHF-3, a 13 seat multi-purpose hydrofoil for services in lakes, bays and estuaries. Cruising speed is 35 knots

Cruising speed foilborne, (30 knots 55 km/h)	Turning radius at cruising speed
Cruising speed, hullborne	1,640 ft (500 m)
Max permissible wave height in foilborne mode	Fuel consumption at cruising speed
	0.53 lb shp/hr
	Cruising range approx 156 miles (250 km)

	Turning radius at cruising speed
	1,640 ft (500 m)
	Fuel consumption at cruising speed
	0.53 lb shp/hr
	Cruising range approx 156 miles (250 km)

Mitsubishi

MITSUBISHI HEAVY INDUSTRIES LTD

HEAD OFFICE:

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TELEPHONE:

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CABLES:

Dock Shimonoseki

DIRECTORS:

F. Kono

K. Kita

SENIOR EXECUTIVES:

S. Katsumata, General Manager

T. Kaneko, Sales Manager

Y. Kaneko, Chief Designer

Mitsubishi entered the hydrofoil field in 1960 and built the prototype of the 38-ton MH30, the first large Japanese-designed hydrofoil, in 1962. Five MH30s have so far been delivered for passenger services. The company has also built the MH03, a 20-passenger water-bus and has prepared designs for the 168-seat MH60. In 1964 Mitsubishi built the MH3 fully submerged foil test craft and in 1966 the company completed a waterjet propelled test craft which has reached a speed of 42 knots (77 km/h).

MH30

Designed for rough water operation around the Japanese Islands, the Mitsubishi MH30 seats eighty passengers and has a crew of four. Power is supplied by a Mitsubishi 12 WZ or Maybach MD655/18 high speed diesel. The cruising speed is 33 knots (61 km/h).

FOILS: The foil configuration is a combined surface-piercing and submerged system and is non-retractable. The split-Vee bow foil supports 65% of the load and the single, fully-submerged rear foil, which carries the propeller pod, supports the remaining 35%. The bow foil is in welded mild steel plate, and the rear foil is constructed in solid high tensile steel. Twin rudders, which act individually for port or starboard turns, are fitted to the trailing edges of the aft foil struts.

HULL: The hull is an all welded, aluminium structure of the high speed type with hard chine sections for performance as a planing hull in waves.

ACCOMMODATION: Accommodation is on two levels. Passengers board the craft through single doors located amidships, port and starboard, leading to a 19-seat central saloon. Companion ladders lead down to the fore and aft saloons, with seats for 37 and 24 passengers respectively. Each cabin is fully air conditioned. Separate entrances, port and starboard, are provided for the pilot and crew. There is a toilet in the aft saloon. Two emergency exits are provided and a full range of safety equipment is carried, including life rafts.

POWER PLANT: Power is supplied by a Mitsubishi 12WK-AK high-speed diesel developing 1,500 hp at 1,600 rpm maximum; and 1,350 hp at 1,500 rpm normal. The output is transmitted through a mechanical right-angle drive transmission to a 0.76 m diameter, aluminium bronze, subcavitating propeller.

SYSTEMS:

AIR CONDITIONING: Daikin air conditioning unit.

ELECTRICAL: APU-driven 15 KVA 225 volt ac generator.

AUXILIARY POWER UNITS: Mitsubishi 22 Ps and 11.5 Ps diesels.

COMMUNICATIONS AND NAVIGATION: Marine radio-telephone and radar standard.

DIMENSIONS, EXTERNAL:

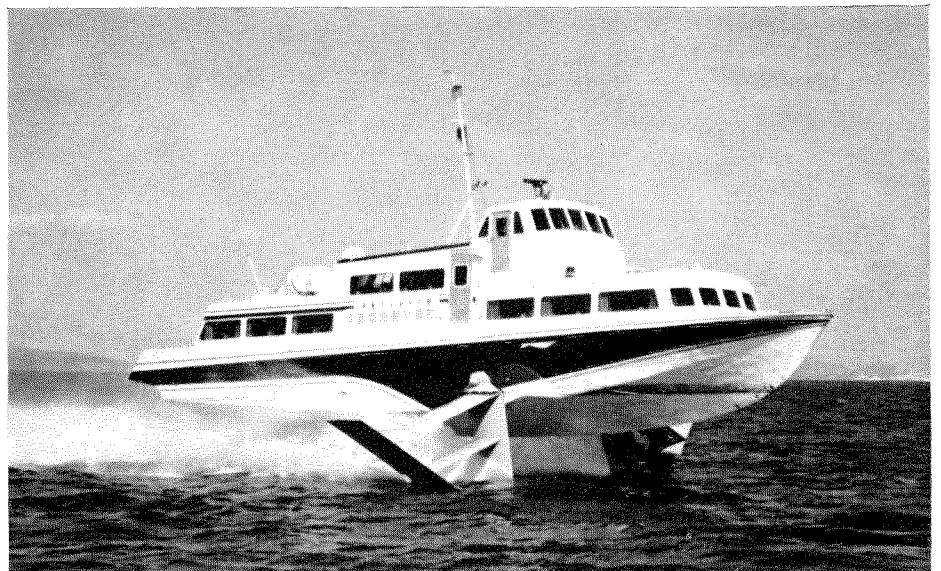
Length overall, hull	69 ft 0 in (21.0 m)
Length waterline, hull	64 ft 4 in (19.6 m)
Hull beam	15 ft 9 in (4.8 m)
Beam across foils	41 ft 6 in (12.66 m)
Draft afloat	10 ft 9 in (3.26 m)
Draft foilborne	4 ft 8 in (1.4 m)
Freeboard	5 ft 0 in (1.45 m)
Height overall	38 ft 5 in (11.7 m)

WEIGHTS:

Max take-off displacement	37.2 tons
Light displacement	27.13 tons
Net tonnage	30 tons
Max payload	7.2 tons

PERFORMANCE:

Max speed foilborne	38.2 knots (70.8 km/h)
Max speed hullborne	14 knots (25.7 km/h)
Cruising speed	33 knots (61.6 km/h)



Powered by a Mitsubishi 12WZ-AK high-speed diesel developing 1,500 hp, the Mitsubishi MH30 seats 80 passengers and cruises at 33 knots. Five are in service with Japanese operators.

Max permissible wave height in foilborne mode	6 ft 6 in (2 m)
Designed range at cruising speed	200 n. miles (37 km)
Turning radius at cruising speed	820 ft (250 m) app
Number of seconds to take-off (theor app)	40 sec
Number of seconds to stop craft	40 sec
Cost of standard craft:	

Approx 100,000,000 Yen

WATERJET RESEARCH CRAFT

Research into waterjet propulsion systems led to the construction of a four-seat test craft powered by a GE T58 gas turbine. The craft was completed in January 1966, and has since been used to evaluate waterjet systems and provide performance information.

FOILS: The foil configuration is a combined surface piercing and submerged system and is non-retractable. The Vee bow foil supports 18% of the load, the split-Vee foils slightly aft of amidships support 40%, and the fully-submerged, 8 ft span rear foil supports the remaining 42%. Total foil area is 22 sq ft (2.075 m²) and the foil loading is 3.3 ton/m². Bow and rear foils are in solid mild steel and the midship foils are in welded mild steel plate. An adjustable flap is fitted to the trailing edge of the rear foil to assist take-off and adjust the flying height. Side and reverse thrust from the main waterjet nozzle provides directional control.

HULL AND ACCOMMODATION: The V-bottom hull is of metal construction. Welded aluminium alloy is employed throughout for frames and plating. The cabin accommodates a crew of two and two technicians.



Mitsubishi's waterjet research craft. The waterjet is generated by a double-section centrifugal pump powered through a reduction gearbox by a General Electric T58

POWER PLANT: The waterjet is provided by a double-suction centrifugal pump powered through a reduction gearbox by a General Electric LM100 (formerly T58) gas-turbine, rated at 1,250 hp. Propulsion water enters a ram scoop at the base of the rear foil strut and is ducted upwards to the pump.

SYSTEMS:

ELECTRICAL: One 24 volt, 150 Ah battery.

HYDRAULICS: 1,000 psi pressure hydraulic system to operate waterjet steering system; 2,000 psi system to operate tail foil flap.

DIMENSIONS, EXTERNAL:

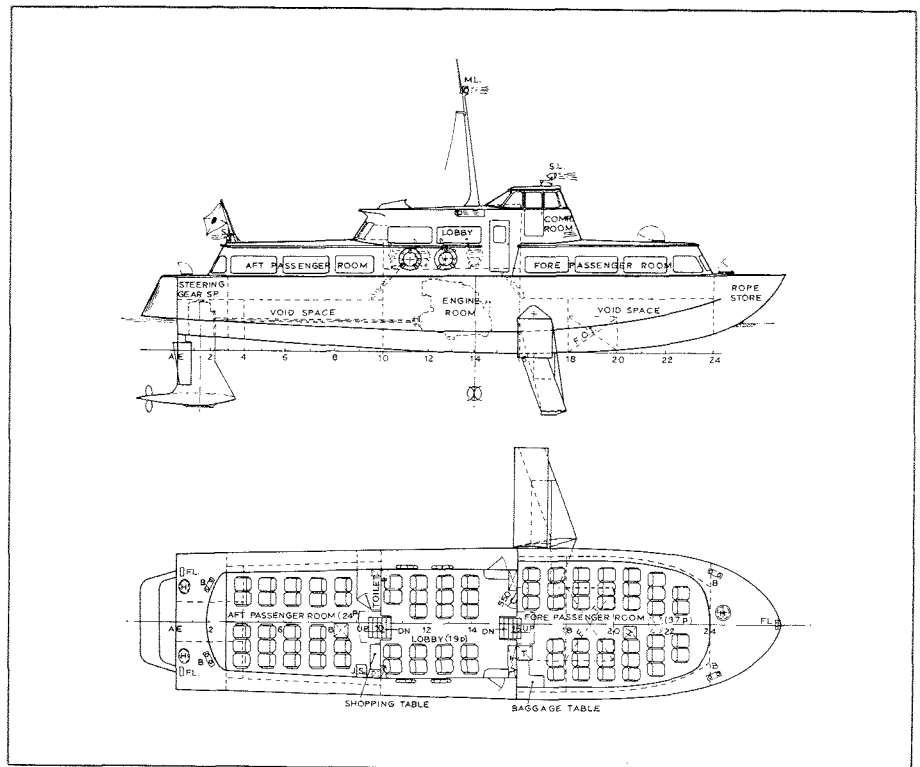
Length overall, hull	37 ft 5 in (11.4 m)
Hull beam	11 ft 4 in (3.4 m)
Beam across foils	21 ft 11 in (6.7 m)
Draft foilborne	2 ft 2 in (0.65 m)
Height overall	11 ft 9 in (3.6 m)

WEIGHTS:

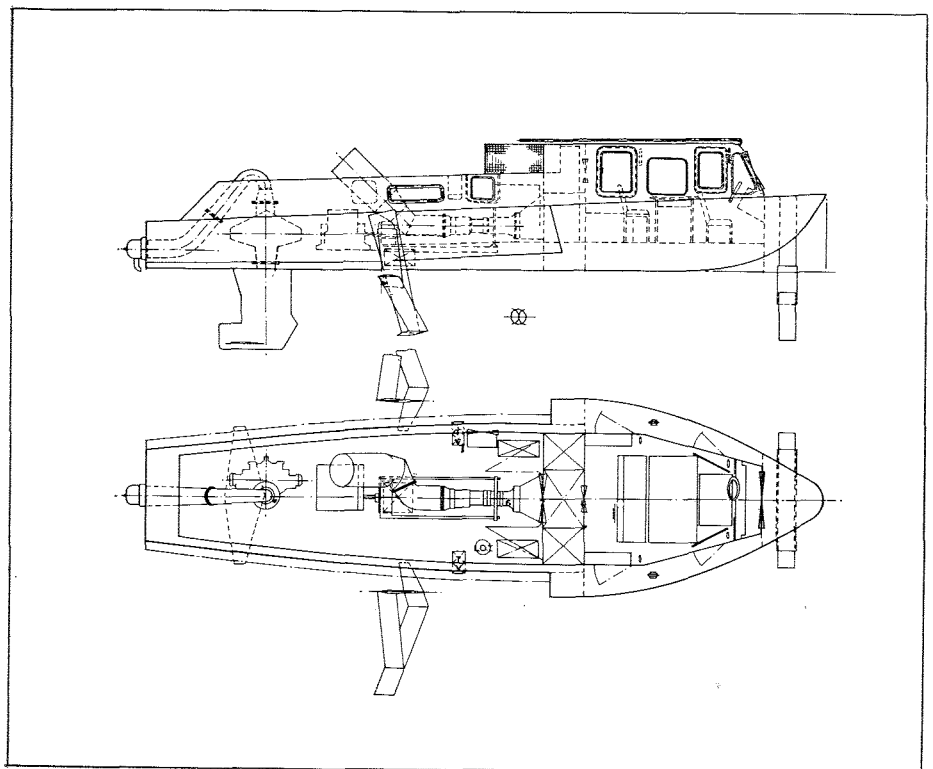
Normal take-off displacement	7.6 tons
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PERFORMANCE:

Max speed foilborne	42 knots (77 km/h)
Cruising speed foilborne	38 knots (71 km/h)



Mitsubishi MH30



Mitsubishi waterjet test craft

Max permissible wave height in foilborne mode	3 ft 4 in (1 m)
Turning radius at cruising speed	329 ft (100 m)

M3 SUBMERGED FOIL TEST CRAFT

This craft is basically a Mitsubishi M3 adapted as a test craft for the company's submerged foil research programme, and fitted with a Mitsubishi autopilot system.

FOILS: The foil system is fully submerged and non-retractable. It comprises two forward foils located forward of the centre of gravity and supporting 64% of the load and

a single auxiliary foil, supporting the remaining 36%, located aft as a tail assembly. Foils and struts are in welded mild steel plate. Total foil area is 1.226 m² and the loading is 3.5 T/m². The autopilot system input is received from a sonic ranging probe in the bow which senses the height above the water of the bow in relation to a fixed reference, from rate gyro, which measures pitch, and from rate gyro, from accelerometers, and from a vertical gyro which senses the angular position of the craft in pitch and roll. This information is processed by the autopilot computer and fed to the foil control surfaces.

HYDROFOIL MANUFACTURERS

MITSUBISHI / WESTERMOEN: Japan / Norway

HULL AND ACCOMMODATION: The craft has a Vee-bottom high speed hull of metal construction. Welded aluminium alloy is used throughout for frames and plating. The cabin accommodates the crew of two plus the bulk of the autopilot system and data gathering equipment. Entry is via either of two hinged hatches, port and starboard, each measuring 50 cm x 50 cm.

POWER PLANT: Propulsion is provided by a GM automotive engine rated at 280 hp at 4,000 rpm. Power is transmitted through a mechanical right-angle drive transmission to a 0.3 m diameter aluminium bronze-subcavitating propeller at the aft end of a strut and pod assembly.

DIMENSIONS, EXTERNAL:

Length overall, hull	26 ft 1 in (8.0 m)
Length overall, foils extended	32 ft 0 in (9.7 m)
Hull beam	7 ft 3 in (2.2 m)
Beam across foils	14 ft 9 in (4.5 m)
Draft foilborne	2 ft 4 in (0.72 m)
Height overall	10 ft 6 in (3.2 m)

WEIGHTS:

Light displacement	4.3 tons
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The Mitsubishi M3 submerged foil test craft

PERFORMANCE:

Max speed, foilborne	38 knots (70 km/h)
Cruising speed, foilborne	33 knots (61 km/h)
Max permissible wave height in foilborne mode	1 ft 6 in-2 ft 6 in (0.5-0.8 m)
Turning radius at cruising speed	328 ft (100 m)

Number of seconds and distance to take-off (theoretical, approx)	20 sec
Number of seconds to stop craft (theoretical approx)	20 sec

NORWAY**Westermoen****WESTERMOEN HYDROFOIL A/S****HEAD OFFICE:**

Hollendergt, 1 Mandal, Norway:
Postboks 143

CABLES:

Hydrofoil

TELEPHONE:

2981

TELEX:

6514 Hydrofoil ML

MANAGING DIRECTOR:

Toralf Westermoen

Westermoen Hydrofoils A/S was founded in 1961 by Toralf Westermoen and Kr Haanes with the object of building hydrofoils and fast naval patrol vessels. The company, a Supramar licensee, completed the first PT 150, a 150 ton mixed car/passenger ferry, for Gothenburg-Friedrikshaven Line in June 1968. The craft is now operating on the route Gothenburg, Aalenburg, Friedrikshaven.

The PT 150 was the fifteenth craft to be built at the Westermoen shipyard, which employs a staff of 150. The company has previously built four PT 20 and three PT 50 hydrofoils.

Specifications for the PT 20, PT 50 and PT 150 will be found under Supramar (Switzerland).



H/S Expressan, built by Westermoen Hydrofoil A/S and operated by Gothenburg-Fredrikshavn Line

At the end of 1966 a PT 50 (ex Westfoil) was returned to the yard to be fitted with a Schertel-Supramar fully submerged, air-stabilised rear foil in place of the normal surface-piercing unit. Renamed Flipper, it was the first craft to be fitted with an air

stabilised foil and it was demonstrated to marine authorities in February 1967. Flipper is now on charter in Scandinavian waters.

A description of the Flipper hydrofoil appeared in the 1967-8 edition of Jane's Surface Skimmer Systems.

POLAND

Gdansk

GDANSK SHIP RESEARCH INSTITUTE

ADDRESS:

Technical University, Gdansk

TELEPHONE:

41-47-12

DIRECTORS:

L. Kobylinski

M. Krezelewski

Research on problems connected with hydrofoil design and construction have been conducted by the Department of Theoretical Naval Architecture at Gdansk Technical University since 1956.

Experience with various dynamic test models led to the construction of the K-3 four-seat runabout which, powered by an FSC Lublin converted auto-engine, has a top speed of 27 knots (50 km/h).

In 1961 the Department was invited by the Central Board of Inland Navigation and United Inland Shipping and River Shipyards Gdansk, to design a hydrofoil passenger ferry for service in the Firth of Szczecin. Designated ZRYW-1 the craft seats 76 passengers and cruises at 35 knots. It was completed in 1965. A second craft, the W-2, intended for passenger services in the Baltic, is under development.

During 1966 the Ship Research Institute designed two hydrofoil sports craft, the WS-4 Amor and the WS-6 Eros. The prototypes were completed in 1967 and both types will be put into series production during 1969.

ZRYW-1

The ZRYW-1 was completed in May 1965, and sea trials were initiated the following month. On scheduled passenger services between Szczecin and Swinoujscie, a distance of 36 nautical miles (67 km), the average operating speed has been in excess of 39 knots (73 km/h). The journey has been covered successfully in Sea States 2-4, with wave heights up to 5 ft 0 in (1.5 m).

FOILS: The foil configuration is a combined

surface piercing and submerging type. The foils are welded assemblies fabricated from 0.2 to 0.28 in (5.7 mm) thick stainless steel. The configuration is subcavitating and is designed to be inherently stable in any expected combination of heave, pitch, roll and yaw.

HULL: This is a light alloy structure of almost fully welded construction, riveting being applied mainly to the joints of the longitudinal and transverse framings with the outer plating of the vessel's roof, and also the joining of steel elements, such as the foil foundations and stern tube, with light alloy members.

POWER PLANT: Provided by a single Russian-built M-50F4 diesel, rated at 1,000 hp continuous and 1,200 hp maximum, driving a fixed-pitch, three-blade propeller.

The engine room, sited amidships, houses the main engine together with reversible gear, auxiliary set, tanks, and pumps serving the engine room system.

ACCOMMODATION: Forty passengers are

carried in the forward passenger saloon, and thirty-six passengers in the aft saloon.

Comfortable, upholstered seats are fitted and the floors are covered with vinyl.

The wheelhouse, crew cabin and toilet are situated forward. Passenger entrance doors are provided on both sides of the craft and lead to a small vestibule forward of the crew's cabin. The two passenger compartments are provided with heat and acoustic insulation, and are electrically heated when stationary (shore supplied) and when in motion.

DIMENSIONS:

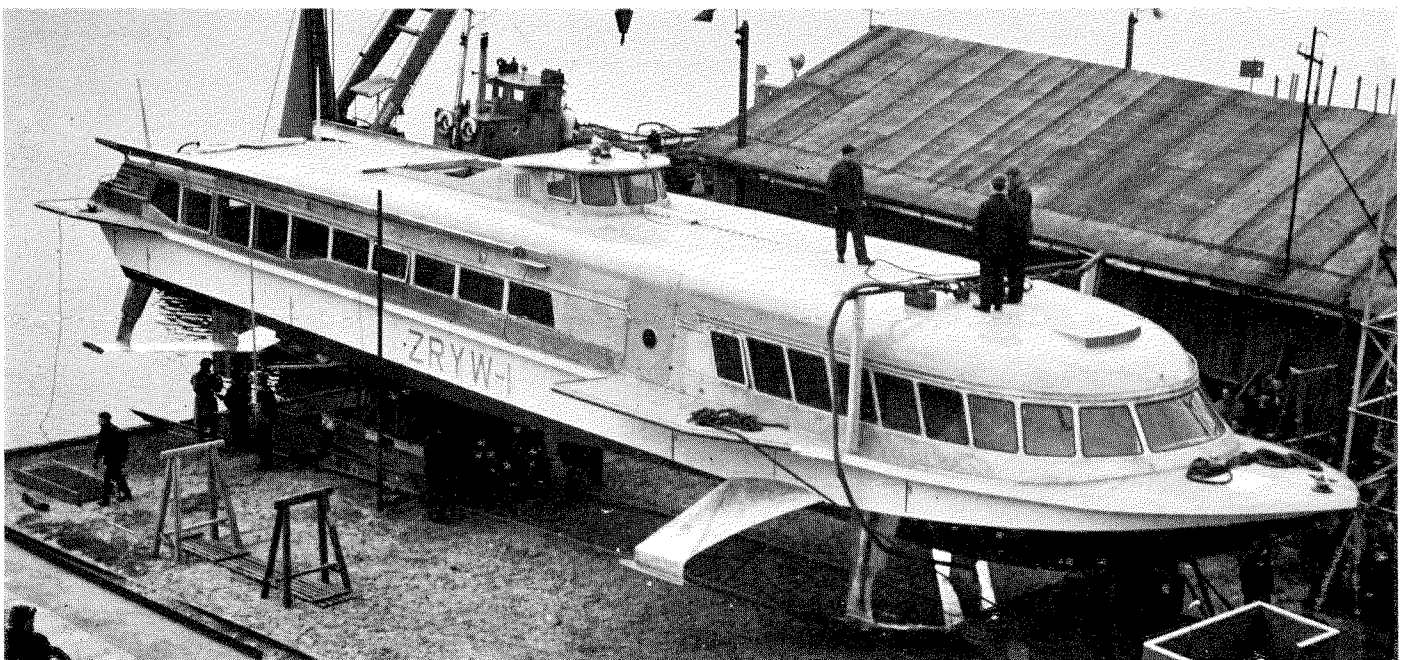
Length overall, hull	90 ft 7 in (27.60 m)
Length waterline, hull	75 ft 6 in (23.00 m)
Hull beam	14 ft 6 in (4.40 m)
Width across foils	24 ft 10 in (7.56 m)
Draft afloat	8 ft 1 in (2.45 m)
Freeboard	4 ft 3 in (1.30 m)

WEIGHTS:

Light displacement	22.7 tons
Max take-off displacement	30.7 tons
Useful load (fuel, water, passengers, baggage and crew)	8.0 tons



The ZRYW-1 (one Soviet-built M-50F 4 diesel) averages more than 39 knots on scheduled services between Szczecin and Swinoujscie, a distance of 36 nautical miles (67 km)



The 76-seat ZRYW-1, first Polish designed passenger hydrofoil to go into service

HYDROFOIL MANUFACTURERS

GDANSK SHIP RESEARCH INSTITUTE: Poland

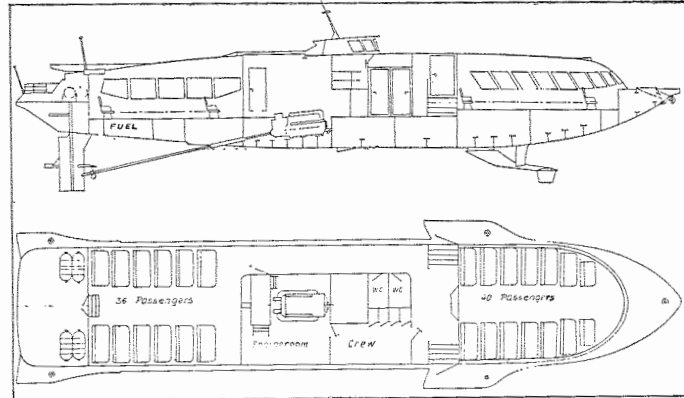
PERFORMANCE

Cruising speed:
 foilborne 35 knots (65 km/h)
 hullborne 16 knots (30 km/h)
 Sea State max capability State 3
 Design foilborne range 250 miles (460 km)
 Fuel consumption at cruising speed
 176 lb/hr (80 kg/h)
 Fuel consumption hullborne
 330 lb/hr (150 kg/h)

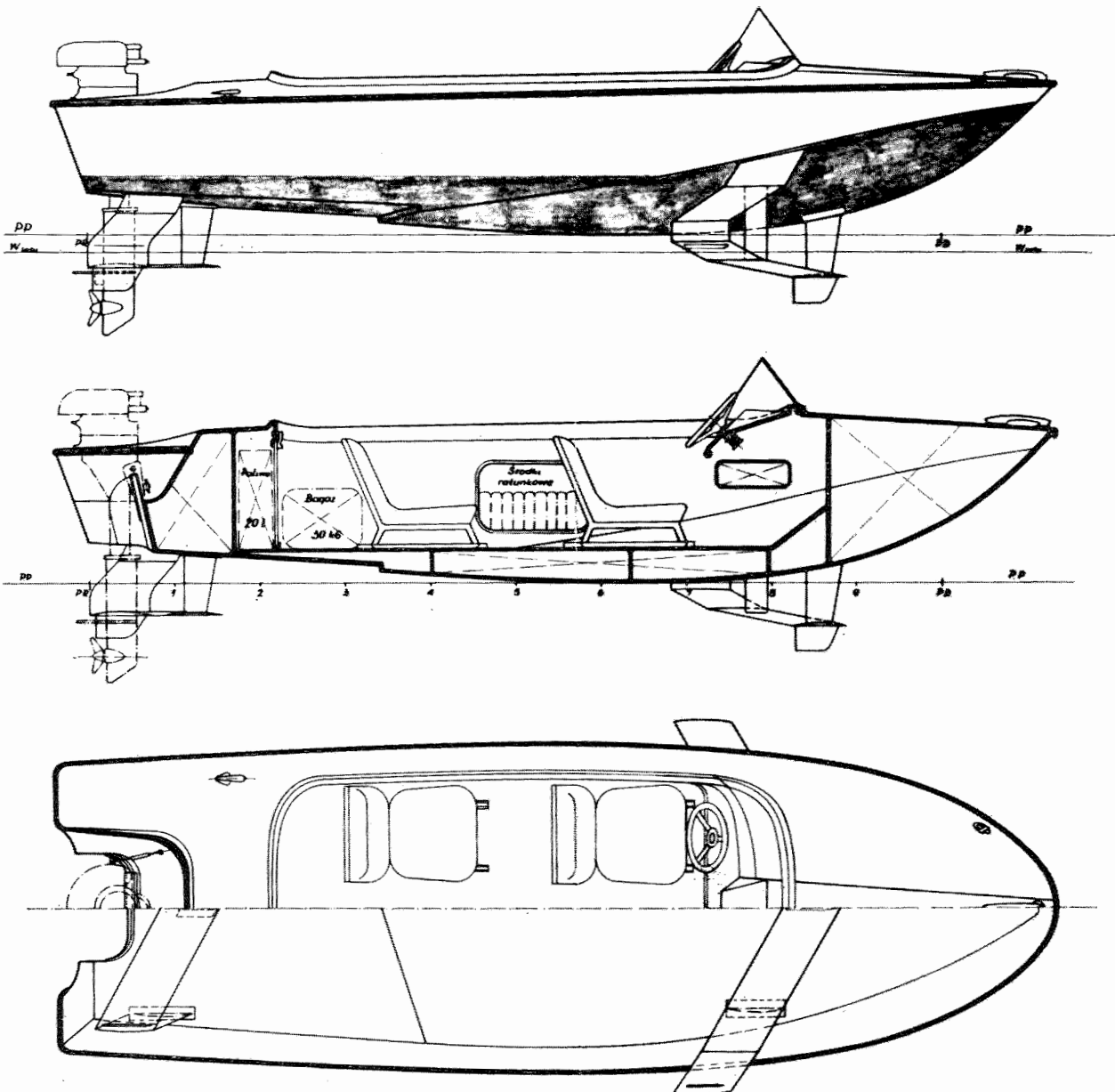
WS-4 AMOR

A four-seat sports hydrofoil designed by E. Brzoska, the WS-4, is of moulded fibreglass construction and powered by an outboard engine. It will be put into series production in 1969.

FOILS: The foil system is of combined surface piercing and submerging type and non-retractable. It comprises a shallow draft surface-piercing bow foil and a fully submerged rear foil. Both are made of solid aluminium alloy. The foil arrangement is tandem in the sense that when foilborne the load is balanced between bow and rear foils.



The ZRYW-1 76-seat passenger hydrofoil designed by Gdansk Technical University, Ship Research Institute, High Speed Division



The Gdansk Ship Research Institute WS 4 Amor

HYDROFOIL MANUFACTURERS

Poland: GDANSK SHIP RESEARCH INSTITUTE

ACCOMMODATION: Comfortable upholstered seats are provided for a helmsman and three passengers. The hull is of moulded fibreglass construction and incorporates a step to facilitate take-off.

POWER PLANT: The standard model is equipped with a Mercury 350 outboard, with single lever throttle and gearshift control. The engine propeller unit turns for steering. Fuel is contained in a 6 gallon tank.

DIMENSIONS, EXTERNAL:

Length overall, hull	15 ft 4 in (4.67 m)
Length waterline, hull	13 ft 2 in (4.0 m)
Hull beam	5 ft 0 in (1.5 m)
Width across foils	5 ft 11 in (1.8 m)
Draft afloat	1 ft 8 in (.05 m)
Draft foilborne	9 in (0.23 m)
Height overall	3 ft 4 in (1.0 m)

DIMENSIONS, INTERNAL:

Length	7 ft 3 in (2.2 m)
Max width	4 ft 0 in (1.2 m)
Floor area	27 sq ft (2.5 m ²)

WEIGHTS:

Light displacement	1,521 lb (686 kg)
Max payload	881 lb (400 kg)

PERFORMANCE (with normal payload):

Max speed foilborne	34 mph (55 km/h)
Max speed hullborne	19 mph (30 km/h)
Cruising speed foilborne	80 mph (50 km/h)
Max permissible wave height in foilborne mode	6 in (0.15 m)
Designed range at cruising speed	31 miles (50 km)

Number of seconds to take-off (theoretical, approx) 15 sec

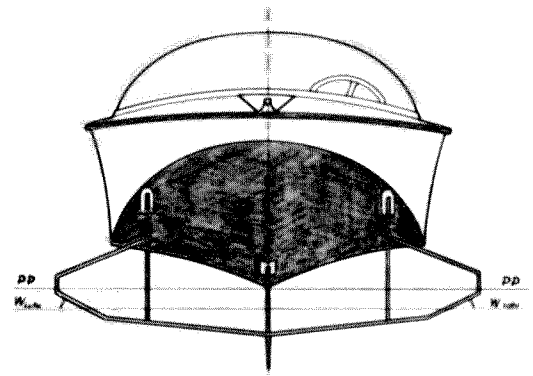
Number of seconds to stop craft (theoretical, approx) 10 sec

WS-6 EROS

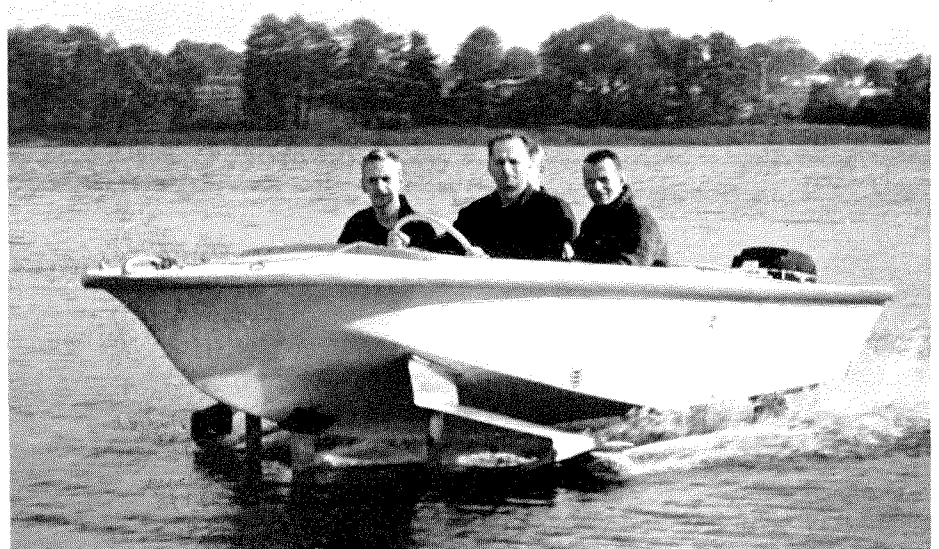
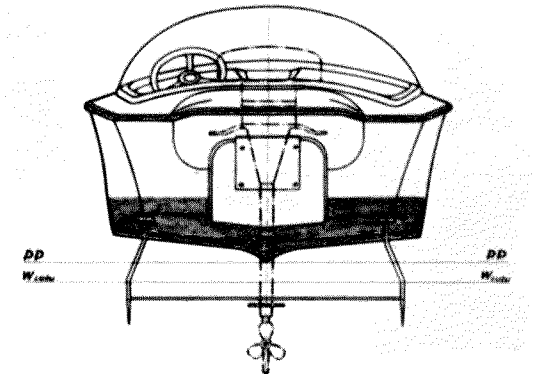
A six seater hydrofoil runabout, the WS-6 Eros was designed by W. Krenicki, and like the smaller WS-4 will be put into series production in 1969.

HULL: The prototype is built of marine plywood, but the hull of the production models will be in moulded fibreglass.

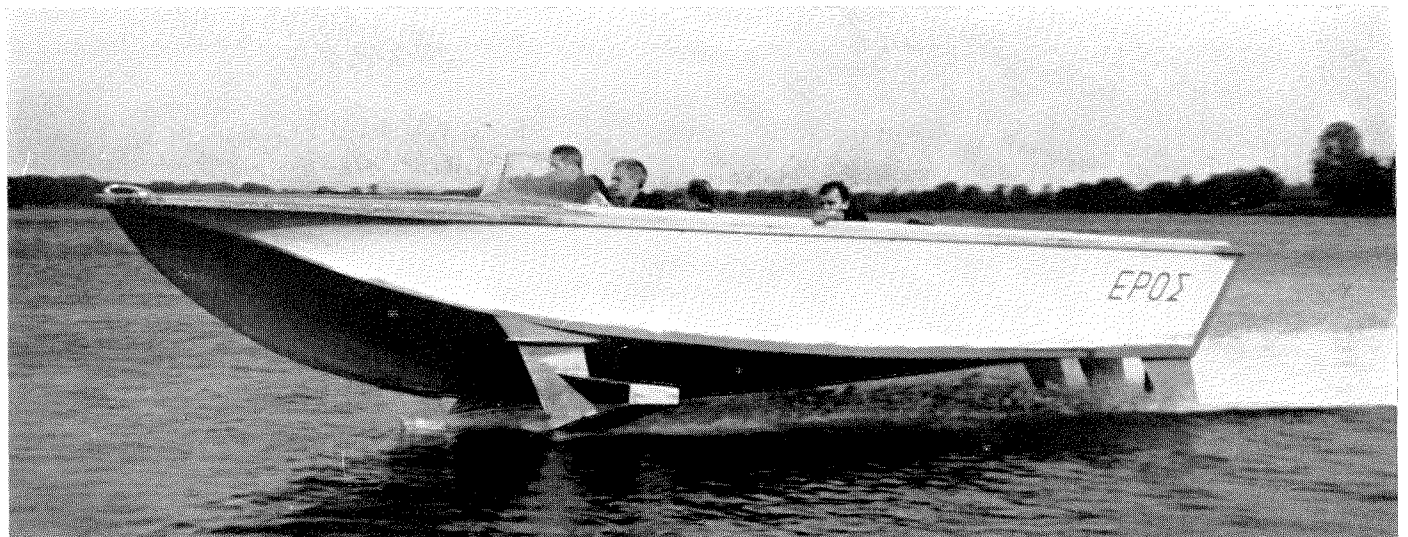
FOILS: The foil system is similar to that of the WS-4. It is a combined surface piercing and submerged configuration with a shallow draft surface piercing bow foil central "keel" and a fully submerged rear foil. Foils are of solid aluminium alloy. About 52% of the load is carried by the bow foil and 48% by the rear foil. Total foil area is 11.5 sq ft (1.07 m²).



WS-4 Amor



The WS-4 Amor, a four-seat runabout designed by Gdansk Ship Research Institute and powered by a Mercury 350 outboard motor



A six-seat fibreglass-hulled sports hydrofoil, the WS-6 Eros is powered by a Volvo Penta Aquamatic 110/200 and has a top speed of 30 knots

HYDROFOIL MANUFACTURERS

GDANSK SHIP RESEARCH INSTITUTE: Poland

ACCOMMODATION: Upholstered seats are provided for a helmsman and five passengers.

POWER PLANT: The production model will have a Volvo Penta Aquamatic 110/200. Power is transmitted through a right-angle drive transmission to a 3-blade propeller at the base of a strut-and-pod assembly which rotates for steering. Total fuel capacity is 100 litres.

DIMENSIONS, EXTERNAL:

Length overall, hull	23 ft 9 in (7.25 m)
Length waterline, hull	20 ft 2 in (6.15 m)
Hull beam	7 ft 4 in (2.24 m)
Beam overall, foils extended	8 ft 6 in (2.6 m)
Draft afloat	3 ft (0.9 m)
Draft foilborne	1 ft 2 in (0.36 m)
Freeboard	2 ft 2 in (0.65 m)
Height overall	5 ft 1 in (1.55 m)

DIMENSIONS, INTERNAL:

Cockpit length	10 ft 2 in (3.1 m)
Max width	6 ft 7 in (2 m)
Floor area	67.2 sq ft (6.2 m ²)

WEIGHTS:

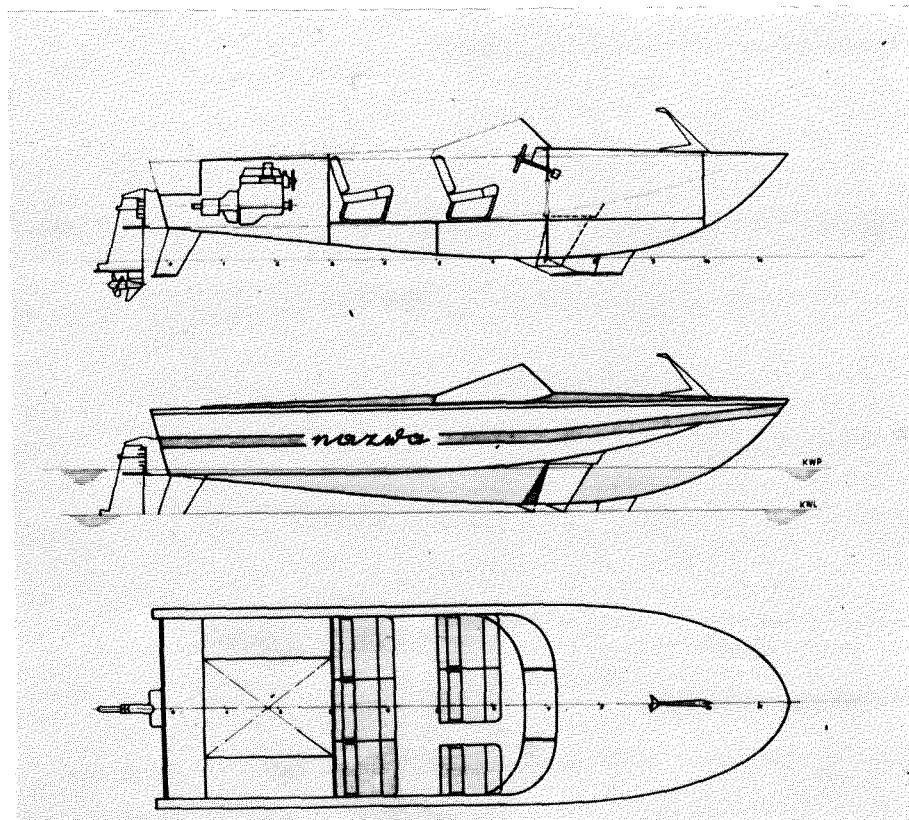
Light displacement	1.05 tons
Normal take-off displacement	1.6 tons
Max take-off displacement	1.75 tons
Normal payload	0.55 tons
Max payload	0.7 tons

PERFORMANCE:

Max speed foilborne	35 mph (56 km/h)
Cruising speed foilborne	31 mph (50 km/h)
Max permissible wave height in foilborne mode	10 in (250 mm)
Number of seconds and distance to take-off	10 sec, 394 ft (120 m)
Number of seconds and distance to stop craft	8 sec 329 ft (100 m)
Turning radius at cruising speed	820 ft (250 m)

REKIN**W-2**

The W-2 is a projected hydrofoil ferry designed primarily for operation in the Baltic. Similar to the ZRYW-1, which was



Eros, a six-seat hydrofoil runabout designed by W. Krenicki of the Gdansk Ship Research Institute. The craft has a shallow draft surface piercing bow foil and a submerged rear foil. It will go into production in 1969

designed specifically for the relatively sheltered waters of the Szczecin Bay, the W-2 is slightly larger and more sturdily built. It will have a completely redesigned bow, V-foils of revised and deeper configuration and the more powerful Paxman Ventura 12YJXM marine-diesel, rated at 1,020 hp at 1,350 rpm.

Design of the W-2 and tests of the $\frac{1}{3}$ scale dynamic model illustrated in Jane's Surface Skimmer Systems 1967-8 edition are now complete.

DIMENSIONS:

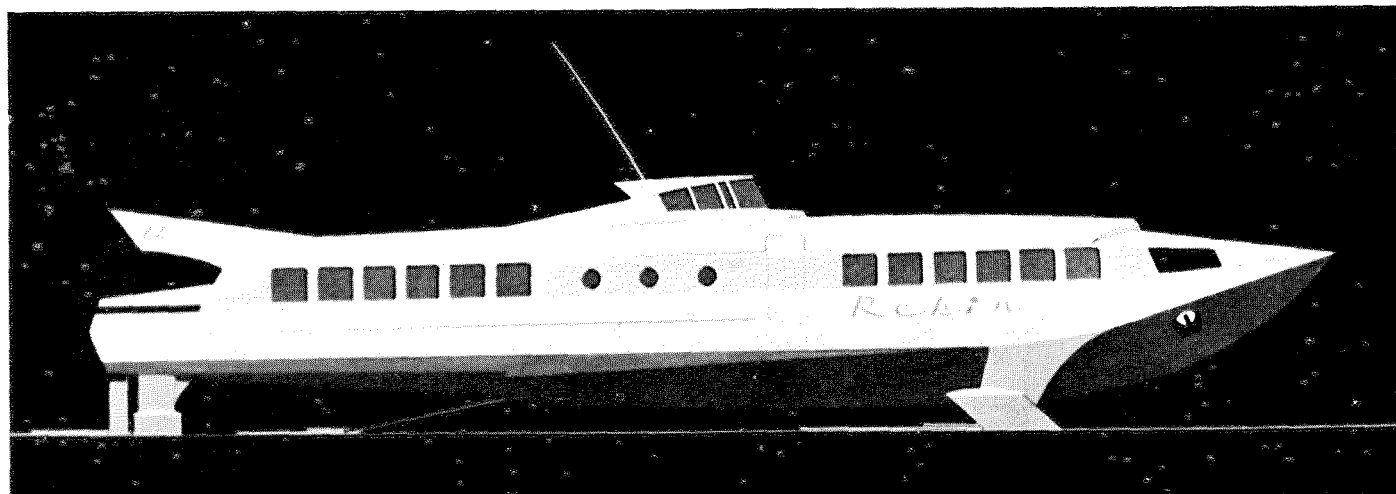
Length overall	93 ft 6 in (28.50 m)
Beam	15 ft 5 in (4.70 m)
Width across foils	24 ft 7 in (7.50 m)
Draught afloat	9 ft 1 in (2.75 m)
Draught foilborne	5 ft 5 in (1.65 m)

WEIGHTS:

Displacement, loaded	35 tons
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PERFORMANCE:

Maximum speed	47 mph (75 km/h)
Cruising speed	40 mph (65 km/h)



Impression of the W-2 Rekin, a passenger hydrofoil designed at Gdansk for services between ports on the Baltic

SWITZERLAND

Supramar SUPRAMAR AG

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Supramar was founded in Switzerland in 1952 to develop on a commercial basis the hydrofoil system introduced by the Schertel-Sachsenberg Hydrofoil Syndicate and its licensee, the Gebrüder Sachsenberg Shipyard.

The co-operation between the companies started in 1937 and led to the development of the VS6, a 17 ton hydrofoil, which in 1941 attained 47.5 knots, and the VS8 an 80-ton supply hydrofoil completed in 1943 which attained 40 knots. The inherently stable, rigid V-foil system used on these and subsequent Supramar vessels, stems from experimental work undertaken by Baron Hanns von Schertel between 1927-1937.

In May 1953, a Supramar PT 10, 32-passenger hydrofoil began the world's first regular passenger hydrofoil service on Lake Maggiore, between Switzerland and Italy. In August 1956, the first Rodriguez-built Supramar PT 20 opened a service across the Straits of Medina and became the first hydrofoil to be licenced by a marine classification authority for carrying passengers at sea.

Basically a research and design company, Supramar employs a staff of 40, mainly highly qualified scientists and engineers specialising in hydrodynamics, marine engineering, foil design and propulsion. The company does not build hydrofoils but licences shipyards to produce its hydrofoil designs. Current licensees are Cantiere Navale Leopoldo Rodriguez, Messina, Italy; Hitachi Shipbuilding & Engineering Co Ltd, Osaka; Westermoen Hydrofoil A/S, Mandal, Norway; and the General Dynamics Corp, Quincy Division, Quincy, Mass, USA. Hydrofoils being built by these companies are referred to elsewhere in this section under the respective company headings.

The latest Supramar design to be completed is the PT 150 DC, a 150-ton passenger/car ferry, the first of which was built by Westermoen Hydrofoil A/S and delivered on June 28, 1968 to Gothenburg-Frederikshavn-Line. The craft cruises at 35 knots in waves up to

8 ft (2.5 m) in height and will carry 150 passengers and eight cars, or 250 passengers. A second PT 150 is to be built by Leopoldo Rodriguez at Messina.

The PT 150 has a partly air stabilised foil system, stability being maintained jointly by the inherent stability of the vee-shaped surface-piercing bow foil and the air-fed, fully-submerged rear foil.

The company is now developing a fully submerged foil system with air stabilisation. First craft to use this system is a 4.9 ton experimental boat built under a US Navy contract. During tests in the Mediterranean it has demonstrated promising stability and seakeeping qualities and has reached a speed of 54 knots.

PT 4

A 4.4 ton hydrofoil with applications ranging from sightseeing and sport-fishing to fast passenger ferry, the PT 4 is designed for use on comparatively sheltered waters—lakes, rivers and bays. Powered by a 300 hp Chrysler M413D, it has a payload of 1.3 tons tons and cruises at 32 knots.

The PT 4 was given Board of Trade approval on completion of sea tests off the Cornish coast in March 1966. Since the craft is powered by a gasoline engine, passenger capacity is restricted to 12 persons in accordance with international safety regulations.

FOILS: The foil configuration is a combined surface-piercing and submerged system. The surface piercing bow foil supports 68% of the load and the fully submerged rear foil supports the remaining 32%. Total foil area is 1.16 m².

The bow foil is made in solid, machined FB 70 steel, and the rear foil which is partly of hollow construction, is in FB 70 and MST 52.3 steel.

Bow and rear foils, together with their supporting struts and a horizontal guide form a uniform framework which facilitates the exchange of the foil structure.

The rudder, of combined hollow and solid steel construction, forms part of the aft foil frame.

Angle of incidence of the bow foil can be adjusted in flight by a hydraulic actuator to counteract the effect of large variations in passenger loads.

HULL: Constructed in seawater-resistant light metal alloy, the V-bottom hull is longitudinally framed, with web frames spaced 2.95 ft (900 mm) apart. Joints are partly welded, partly riveted. Steel is used for higher-stressed parts such as foil hull connections and the shaft bracket.

POWER PLANT: Power is supplied by 300 hp Chrysler M413D gasoline engine coupled to a reverse and reduction gear with a 2 : 1 reduction ratio.

Engine output is transmitted through an inclined shaft to a three-bladed bronze propeller located ahead of the rear foil.

SYSTEMS:

ELECTRICAL: 12V, 135 Ah batteries for electrical services.

HYDRAULICS: 120 kp/cm² pressure hydraulic system for operating rudder and bow foil angle of incidence.

COMMUNICATIONS:

RADIO: Small ship-shore radio-telephone.

DIMENSIONS, EXTERNAL:

Length overall, hull	37 ft 6 in (11.45 m)
Length over deck	36 ft 3 in (11.05 m)
Beam max	10 ft 6 in (3.20 m)
Width over foils	14 ft 2 in (4.32 m)
Draft afloat	4 ft 8 in (1.45 m)
Draft foilborne	1 ft 8 in (0.57 m)

DIMENSIONS, INTERNAL:

Cabin (Pilot stand incl):	
Length	15 ft 6 in (4.8 m)
Max. width	8 ft (2.4 m)
Max. height	6 ft 6 in (2.0 m)
Floor area	87 sq ft (8.0 m ²)
Volume	813 cu ft (23.0 m ³)

WEIGHTS:

Max take-off displacement	4.4 tons
Payload	1.275 tons
Light displacement	3.125 tons

PERFORMANCE:

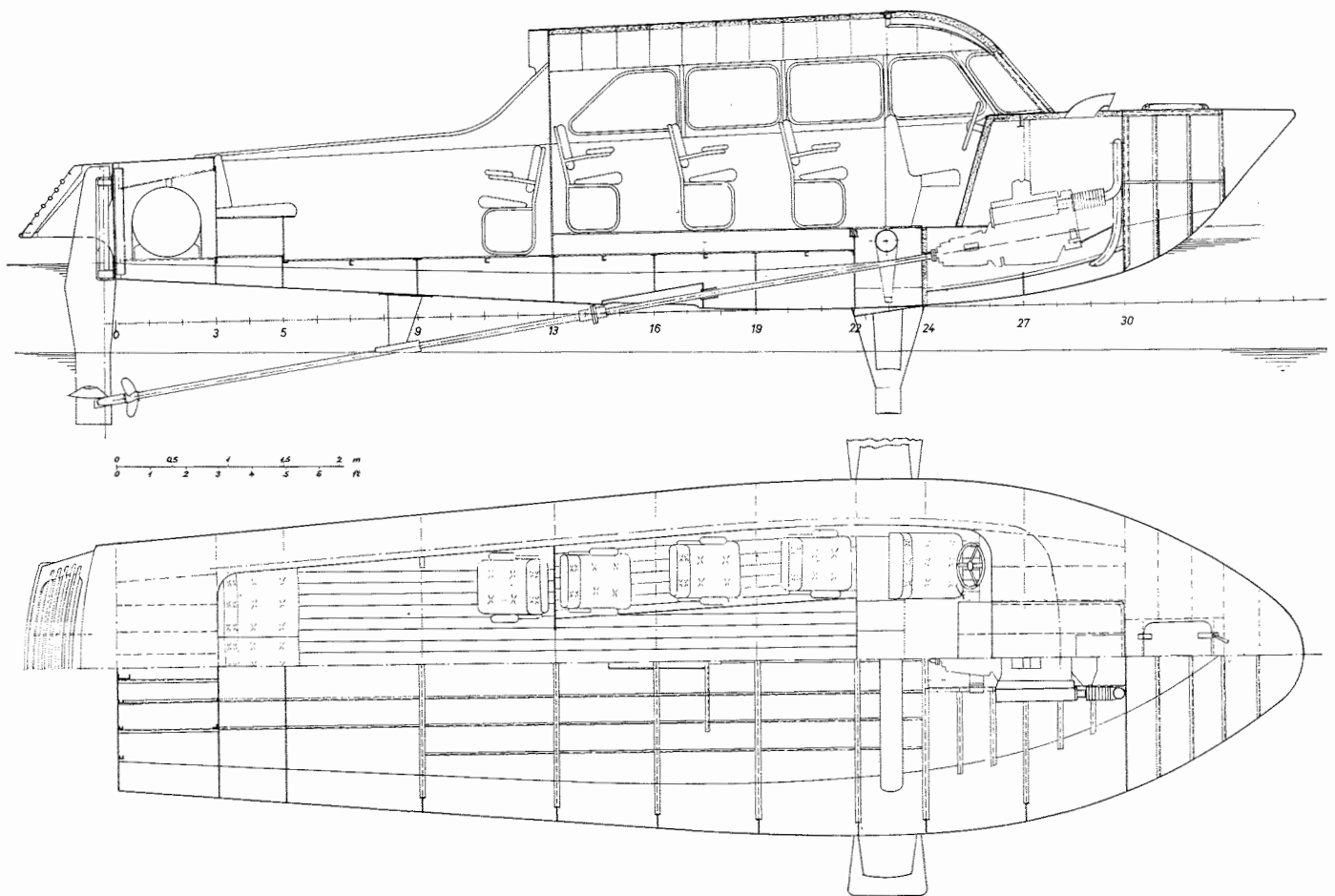
Max speed foilborne	39 knots
Cruising speed foilborne	32 knots (60 km/h)
Range	155 nautical miles (290 km)
Cost of standard craft:	approx \$US 40,000



The PT 4 (one Chrysler M413D) is designed for services on lakes and rivers. As a sightseeing craft it will seat 12 passengers.

HYDROFOIL MANUFACTURERS

SUPRAMAR: Switzerland



Inboard Profile and deck view of the Supramar PT 4

PT 10

A 13-ton boat for 32-36 passengers, the PT 10 has been designed for commuter and sightseeing services on inland waters and protected bays.

Powered by a single 540 hp Daimler-Benz MB 837 diesel engine, it is of riveted light metal alloy construction and has a cruising speed of 35 knots.

FOILS: Bow foil and rear foil are of standard Schertel-Sachsenberg surface piercing type, with the bow foil supporting 52% of the load and the rear foil supporting the remaining 48%. Both are made from solid high tensile steel, and their struts and fins are of hollow steel design. The two foils together with

their supporting elements form rigid frame units which are easily attached or detached as necessary.

The angle of incidence of the bow foil may be adjusted during flight by means of a hydraulic actuator acting on the foil strut supporting tube.

RUDDER: Hydraulically operated, the rudder is of hollow, welded steel design, and forms part of the aft foil frame.

HULL: The V-bottom hull is of riveted light alloy construction. Transverse framing is employed with 1 ft (300 mm) frame spacing. Foil fittings, shaft brackets and the shaft exit are in high tensile steel.

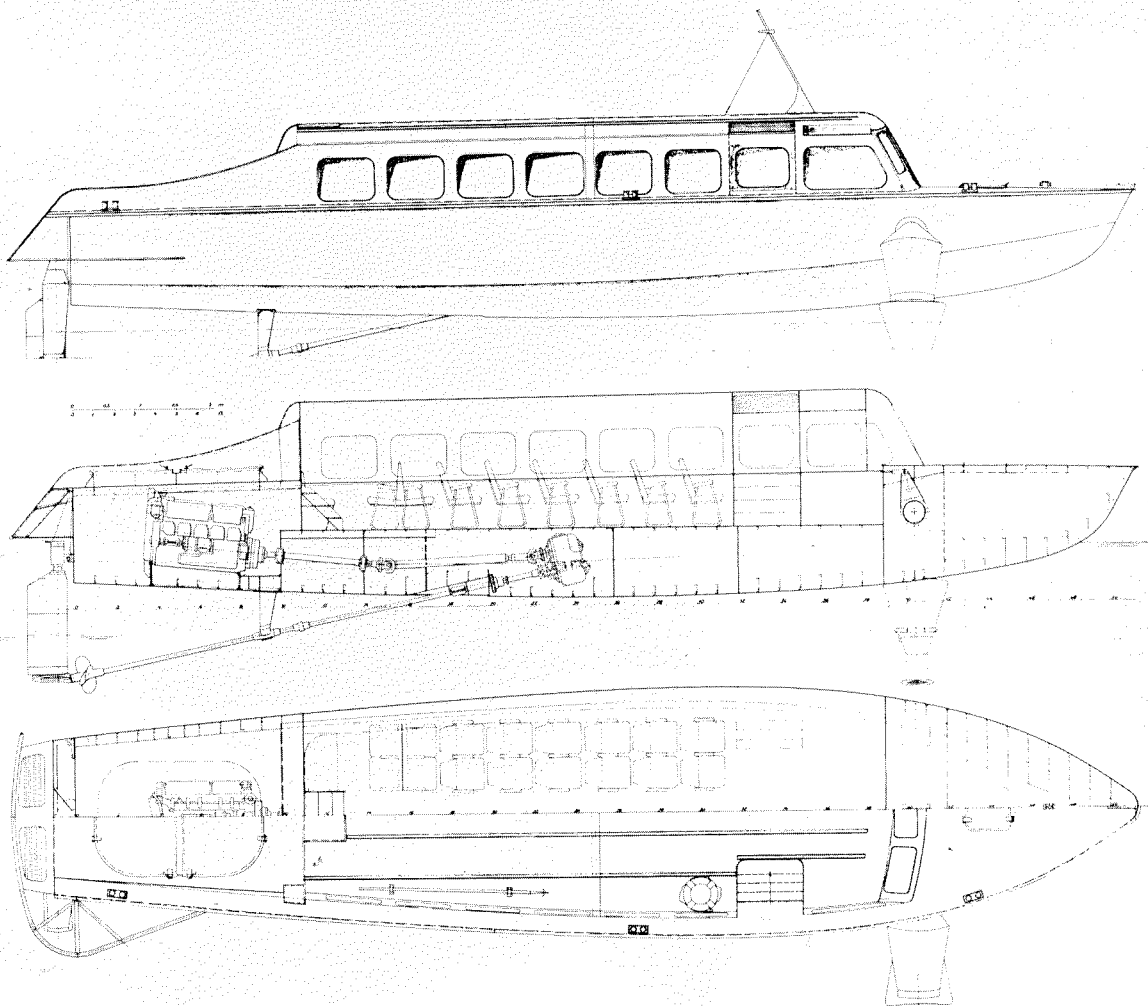
ACCOMMODATION: A single cabin seats

32 passengers and a crew of 2. Access is through either of two sliding hatches, located forward, port and starboard aft of the steering stand. An emergency window exit is provided at the aft end of the compartment. Lifebelts are provided for each passenger and the two crew members.

POWER PLANT: Power is supplied by a single Daimler-Benz MB 837 Ea 8-cylinder supercharged diesel, rated at 540 hp at 1,800 rpm. Engine output is transferred to the propeller through a V-drive and a stainless steel propeller shaft. A special reverse and reduction gear, type BW 200 ES 28, made by Zahnradfabrik Friedrichshafen, is placed between the engine and the drive shaft.



The Supramar PT10 (one 1,100 hp MB 820 Db diesel), a 32 passenger hydrofoil for sightseeing or commuter services on inland waters and protected bays



Side and deck views of the Supramar PT 10, 32 passenger hydrofoil

SYSTEMS:

ELECTRICAL: 24 volt generator driven by the main engine; batteries with capacity of 500 Ah.

HYDRAULICS: 120 kp/cm² pressure hydraulic system for steering and bow foil incidence control.

COMMUNICATIONS AND NAVIGATION: Ship-shore radio telephone is fitted; radar is optional.

DIMENSIONS, EXTERNAL:

Length overall, hull	53-60 ft (16-34 m)
Length over deck	51-50 ft (15-70 m)
Max beam	11-81 ft (3-60 m)
Width over foils	18-50 ft (5-64 m)
Draft afloat	6-73 ft (2-05 m)
Draft foilborne	2-79 ft (0-85 m)

DIMENSIONS, INTERNAL:

Cabin (inc pilot stand):	
Length	27 ft 7 in (8-4 m)
Width	8 ft 7 in (2-6 m)
Height	6 ft 3 in (1-9 m)
Floor area	234 sq ft (21-8 m ²)
Volume	1,449 cu ft (41-0 m ³)

WEIGHTS:

Light displacement	9-5 tons
Normal take-off displacement	13-3 tons
Normal payload	3-8 tons

PERFORMANCE:

Max speed foilborne	36 knots
Cruising speed foilborne	35 knots
Range at cruising speed	145 nautical miles
Turning radius app.	400 m
Take-off time	30 sec

Fuel consumption at cruising speed 90 kp/h
Cost of standard craft: app \$US 160,000.

PT 20

The PT 20, a 27-ton boat for 72 passengers, is considered by Supramar to be the smallest size hydrofoil suitable for passenger-carrying coastal services. The first of this very successful series was built by the Rodriguez shipyard at Messina in 1955 and since then nearly 70 PT 20s of various types have been built in Sicily, Japan, Holland and Norway. The design has been approved by almost every classification society. Fast patrol boat variants, the PT 32 and the PAT 20, are described under the entries for Hitachi (Japan) and Leopoldo Rodriguez (Italy) respectively.

FOILS: Foils are of standard Schertel-Sachsenberg, surface-piercing type, with 58% of the load supported by the bow foil and the remaining 42% by the rear foil. Submerged foil area in foilborne condition is 5-50 m². Together with the struts and a horizontal guide, each foil forms a uniform framework which facilitates the exchange of the foil elements. The medium steel foils are of partly hollow, welded construction. The angle of incidence of the fore hydrofoil can be adjusted within narrow limits from the steering stand by means of a hydraulic ram operating on a foil support across the hull. To counteract the effects of large variations in passenger load and to ensure optimum

behaviour in sea waves the angle of attack can be adjusted during operation. If required, the rear foil can be stabilized by the Schertel-Supramar air feed system. A fully submerged foil then replaces the standard surface piercing type.

HULL: The hull has a V-bottom with an externally added step riveted into place. Frames, bulkheads, foundations, superstructure and all internal construction is in corrosion-proof light alloy. Platings are of AlMg 5 and the frames, bars and other members are made in AlMgSi. Watertight compartments are provided below the passenger decks and in other parts of the hull. Several of these are filled with foam-type plastic which makes these boats practically unsinkable.

POWER PLANT: Power is supplied by a supercharged, 12-cylinder Daimler-Benz MB 820Db with an exhaust turbo-compressor. Maximum continuous output is 1,100 hp at 1,400 rpm. A BW 800/HS 20 reversible gear, developed by Zahnradfabrik Friedrichshafen AG, is placed between the engine and the drive shaft.

ACCOMMODATION: The boat is controlled entirely from the bridge which is located above the engine room. Forty-six passengers are accommodated in the forward cabin, twenty in the rear compartment and six aft of the pilot's stand in the elevated wheelhouse. There is an emergency exit in each passenger compartment, and the craft is

HYDROFOIL MANUFACTURERS

SUPRAMAR: Switzerland

equipped with an inflatable life raft and life belts for each person. A crew of four is carried.

SYSTEMS:

ELECTRICAL: 24 volt generator driven by the main engine; batteries with a capacity of approx 250 Ah.

HYDRAULICS: 120 kp/cm² pressure hydraulic system for rudder and bow foil incidence control.

COMMUNICATIONS AND NAVIGATION: VHF ship-shore radio is supplied as standard equipment. Radar is optional.

DIMENSIONS, EXTERNAL:

Length overall, hull	68.07 ft (20.75 m)
Length over deck	67.50 ft (19.95 m)
Hull beam, max	16.37 ft (4.99 m)
Width across foils	26.39 ft (8.07 m)
Draft hullborne	10.10 ft (3.08 m)
Draft foilborne	4.59 ft (1.40 m)

DIMENSIONS, INTERNAL:

Aft cabin (inc toilet)	145 sq ft (13.5 m ²)
Volume	954 cu ft (27.0 m ³)
Forward cabin	280 sq ft (26.0 m ²)
Volume	1,766 cu ft (50.0 m ³)
Main deck level (inc wheelhouse)	129 sq ft (12.0 m ²)
Volume	847 cu ft (24.0 m ³)

WEIGHTS:

Gross tonnage	approx 56 tons
Max take-off displacement	32 tons
Light displacement	25 tons
Deadweight (incl. fuel, oil, water, passengers, baggage and crew)	7 tons
Payload	5.4 tons

PERFORMANCE (with normal payload):

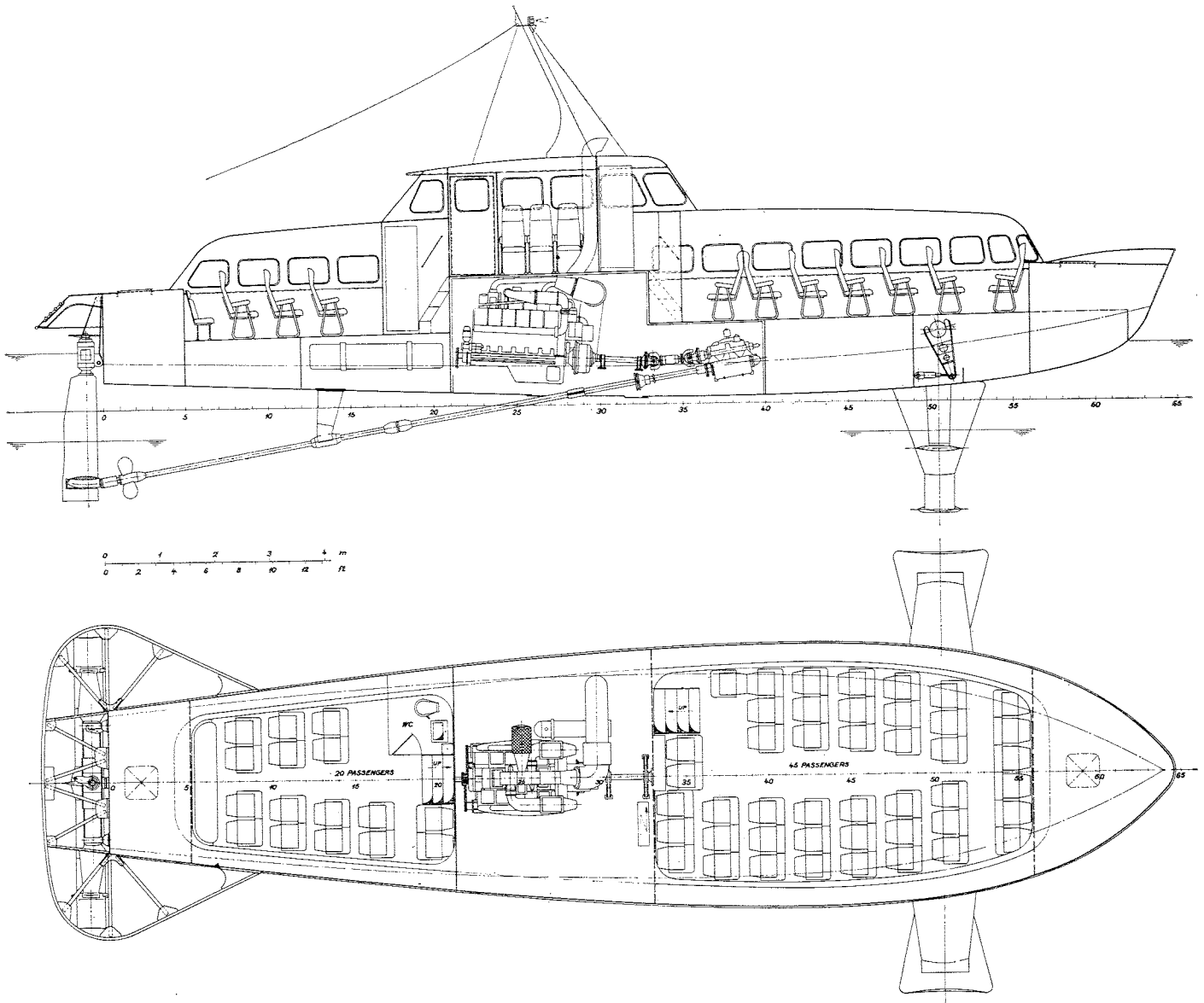
Cruising speed, foilborne	34 knots (63 km/h)
Max permissible wave height in foilborne mode	4.25 ft (1.29 m)

Designed range at cruising speed

	216 nautical miles (400 km)
Turning radius	427 ft approx (130 m)
Take off distance	493 ft approx (150 m)
Take-off time	25 sec
Stopping distance	230 ft (70 m)

Fuel consumption at cruising speed 150 kp/h
SEA TEST: Prototype tests were undertaken in the Mediterranean in every kind of sea condition, and further tests have taken place off Japan. Acceleration measurements have shown maximum values below 0.5g when accelerometer had been fitted above the bow foil. Maximum lateral acceleration was 0.32g. Measurements were made in wave heights of approx 1.2 to 1.5 m. These are the maximum measurements obtained and subsequent tests have seldom equalled these figures.

Cost of standard craft: \$US 330,000.



Inboard profile and deck view of the Supramar PT 20



The PT 20, a 72-seat hydrofoil for coastal services, has been in continuous production since 1955. Nearly 70 are in service in 21 countries

PT 20B

In this model of the PT 20, the engine room and bridge are arranged in the foreship. This improves the pilot's vision in waters likely to have an influx of driftwood and provides a large main passenger cabin with seats for 65 for commuter services.

The first four craft in this series, built for the servicing of offshore drilling platforms on Lake Maracaibo, Venezuela, were designated PT 27.

FOILS: The foil design is similar to that of the PT 20. About 66% of the total weight is borne by the bow foil and 34% by the rear foil. Submerged foil area in foilborne condition is 6.2 m². The forward foil can be tilted within narrow limits by means of a hydraulic ram acting on the foil strut supporting tube. The angle of attack can therefore be adjusted during operation to assist take-off and to counteract the effect of large variations in passenger loads.

The rear foil can be stabilized by the Schertel-Supramar air feed system with a fully-submerged foil replacing standard surface piercing type.

HULL. This is of riveted light metal alloy design and framed on a combination of longitudinal and transverse formers. Watertight compartments are provided below the passenger decks and in other parts of the hull, and some are filled with foam-type plastic.

POWER PLANT: Power is supplied by a 12 cyl Mercedes-Benz Mb 820 Db with a max continuous output of 1,100 hp at 1,400 rpm. Average service time between major overhauls is approx 10,000 hours. Engine output is transferred to a 3-bladed 700 mm diameter bronze subcavitating propeller through a BW 800/H 20 reversible gear made by Zahnradfabrik. The propeller shaft is

of 3.5 in (90 mm) diameter stainless steel and supported at three points by seawater lubricated rubber bearings.

SYSTEMS:

ELECTRICAL: MWM AKD412E single-phase, 220 volt, 7.1 kVa, 50 c/s generator.
HYDRAULICS: 120 kp/cm² pressure hydraulic system for operating rudder and bow foil angle of incidence control.

ACCOMMODATION: The PT 20B has a crew of 4 and seats 71 passengers. The main passenger compartment seats 65, and the small cabin behind the pilot's stand seats a further 6. Access to the main compartment

is through either of two doors, located port and starboard, to the rear of the wheelhouse. An emergency exit is provided at the rear of the main passenger compartment.

A full range of safety equipment is carried, including inflatable rafts and lifebelts for each passenger and crew member.

COMMUNICATIONS AND NAVIGATION: A vhf ship-shore radio is supplied as standard equipment. Radar is an optional extra.

DIMENSIONS, EXTERNAL:

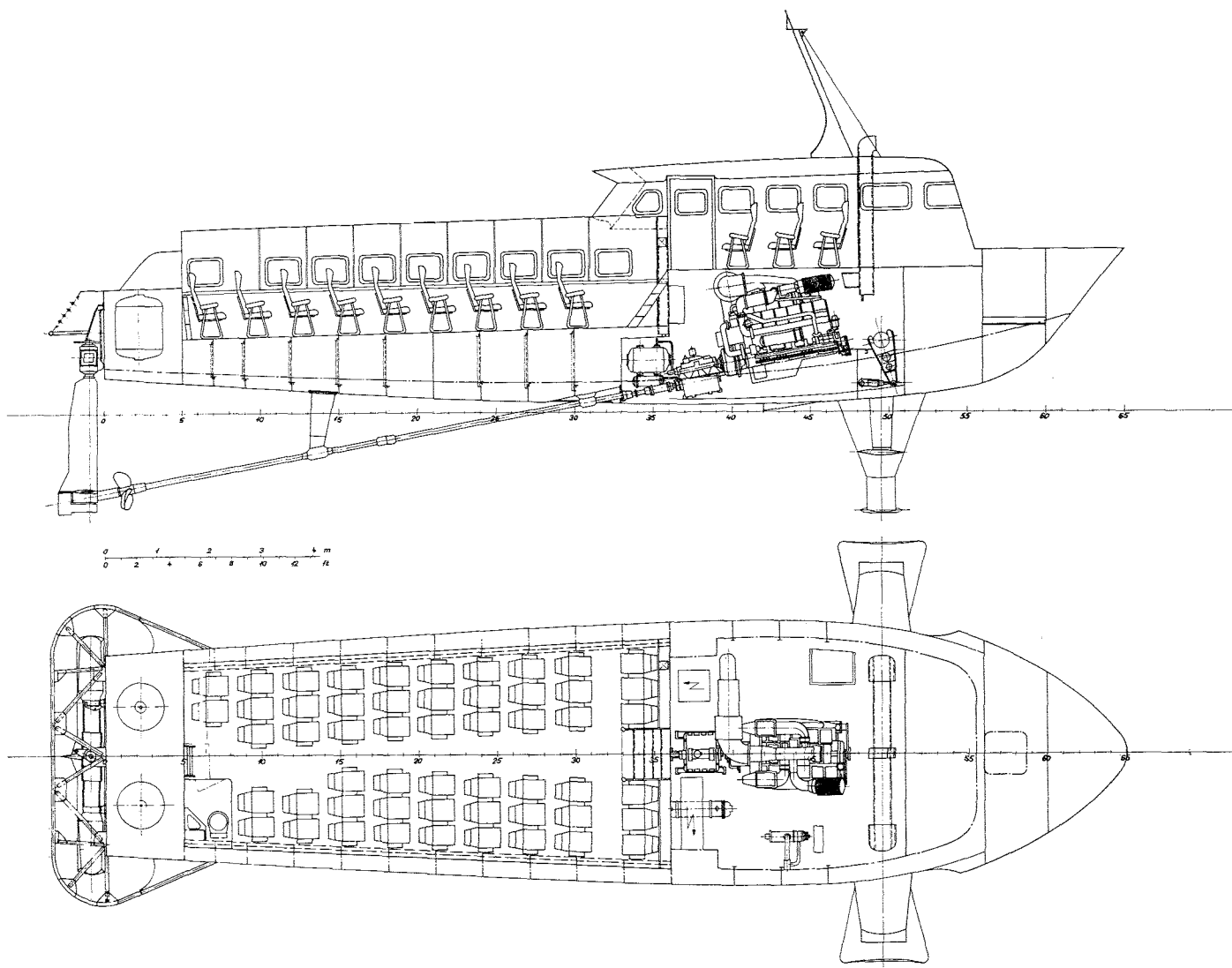
Length overall, hull	67.50 ft (20.58 m)
Length waterline, hull	67.10 ft (20.45 m)
Hull beam, max	17.05 ft (5.20 m)



Bridge of the PT 20B is located in the foreship to provide improved vision. Sixteen passengers are accommodated in the forward cabin above the engine room and fifty-four in the main cabin. Powered by an MB 820Db diesel rated at 1,100 hp continuous, the craft cruises at 34 knots (63 km/h)

HYDROFOIL MANUFACTURERS

SUPRAMAR: Switzerland



Side and deck views of the PT 20B

Width over foils	26.40 ft (8.05 m)
Draft hullborne	10.04 ft (3.06 m)
Draft foilborne	4.56 ft (1.39 m)

DIMENSIONS, INTERNAL:

Main passenger compartment (inc toilet):	
Length	30 ft 7 in (9.3 m)
Width	12 ft 6 in (3.8 m)
Height	6 ft 7 in (2.0 m)
Floor area	379 sq ft (35.3 m ²)
Volume	2,489.5 cu ft (70.6 m ³)

Main deck compartment (inc wheelhouse)	
Length	17 ft 9 in (5.4 m)
Width	13 ft 6 in (4.1 m)
Height	6 ft 7 in (2.0 m)
Floor area	237 sq ft (22.1 m ²)
Volume	1,553 cu ft (44.0 m ³)

WEIGHT:

Max take-off displacement	32.5 tons
Light displacement	25.4 tons
Deadweight (inc fuel, oil, water, passengers, luggage, crew)	7.1 tons
Payload	5.44 tons

PERFORMANCE (with normal payload):

Cruising speed	34 knots (63 km/h)
Max permissible wave height in foilborne mode	4.25 ft (1.29 m)
Turning radius	426 ft (app 130 m)
Take-off distance	492 ft (app 150 m)
Take-off time	app 30 sec
Stopping distance	231 ft (app 70 m)
Stopping time	app 10 sec
Fuel consumption at cruising speed	150 kp/h
Cost of standard craft, app:	\$US 330,000

PT 50

The successful and profitable operation of the PT 20 led to the development of the PT 50, a 63-ton hydrofoil passenger ferry designed for offshore and inter-island services. The prototype was completed by Rodriguez early in 1958, and more than thirty are now operating regular passenger services in areas ranging from the Baltic and Mediterranean to the Japanese Inland Sea.

The craft has been approved by almost every Classification Society including Registro Italiano Navale, Germanischer Lloyd, Det Norske Veritas, American Bureau of Shipping and the Japanese Ministry of Transport. The requirements of the SOLAS 1960 convention for international traffic can be met by the type if required.

FOILS: Both rear and forward foils are rigidly attached to the hull but the lift of the forward foil can be modified by hydraulically-operated flaps, which are fitted to assist take-off and turning, and for making slight course corrections and adjustments of the flying height. The foils are of hollow construction using MSt 52-3 steel and GS 22 Cr Mo 4 castings.

The bow foil comprises the following elements:

Two fins, forming connecting links between the foil and the supporting structure which is riveted to the hull.

The hydrofoil which (according to its foil

section characteristics) generates the lift and, with the stern foil, provides transverse stability in foilborne conditions.

Two struts, which transmit the main lift loads to the supporting structure.

The stern foil, also a rigid frame structure, is formed by the following:

A supporting structure (stern box) connecting the two sides of the frame at the transom. Two struts, forming the connection between the foil and the supporting structure.

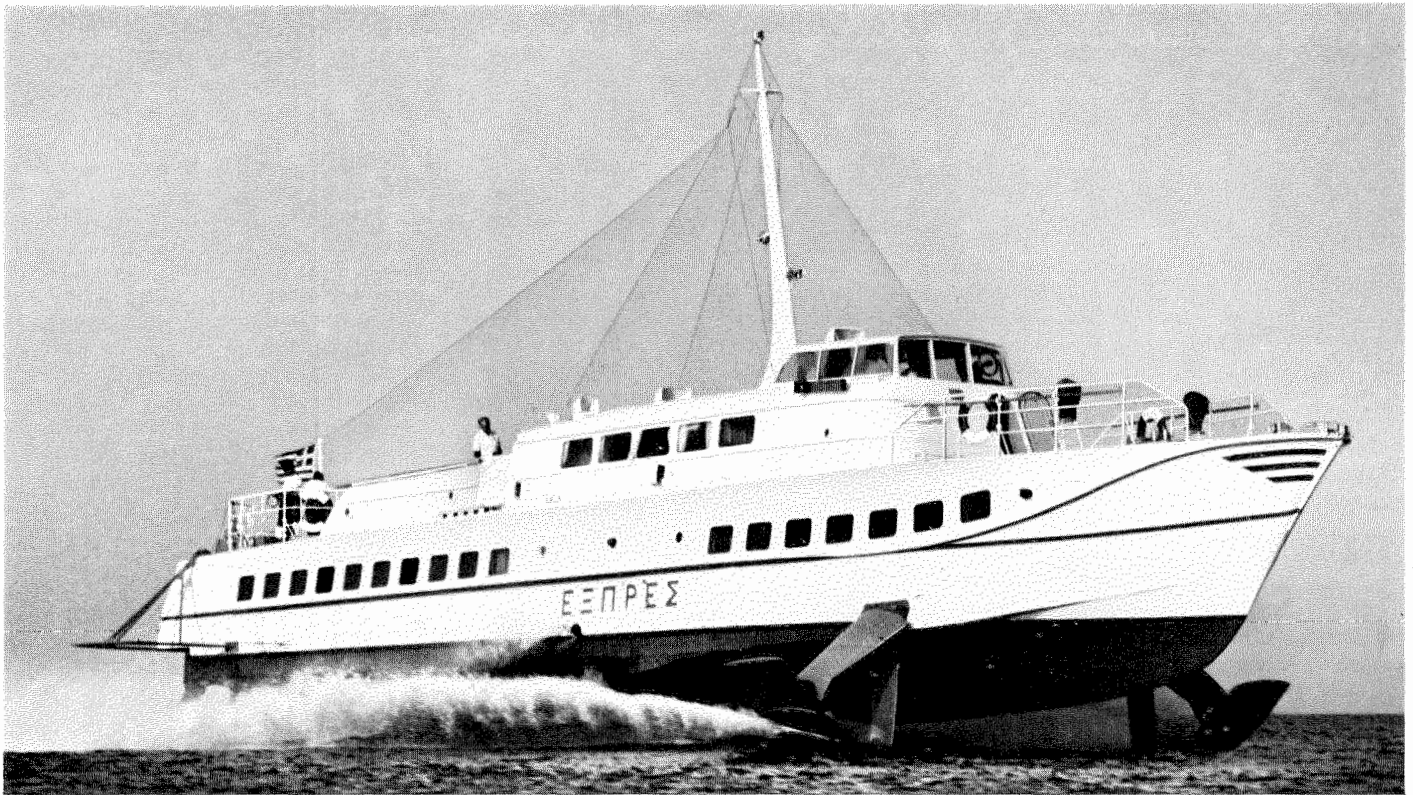
The surface-piercing V-foil.

The rudders, which also transmit the main part of the lift into the supporting structure.

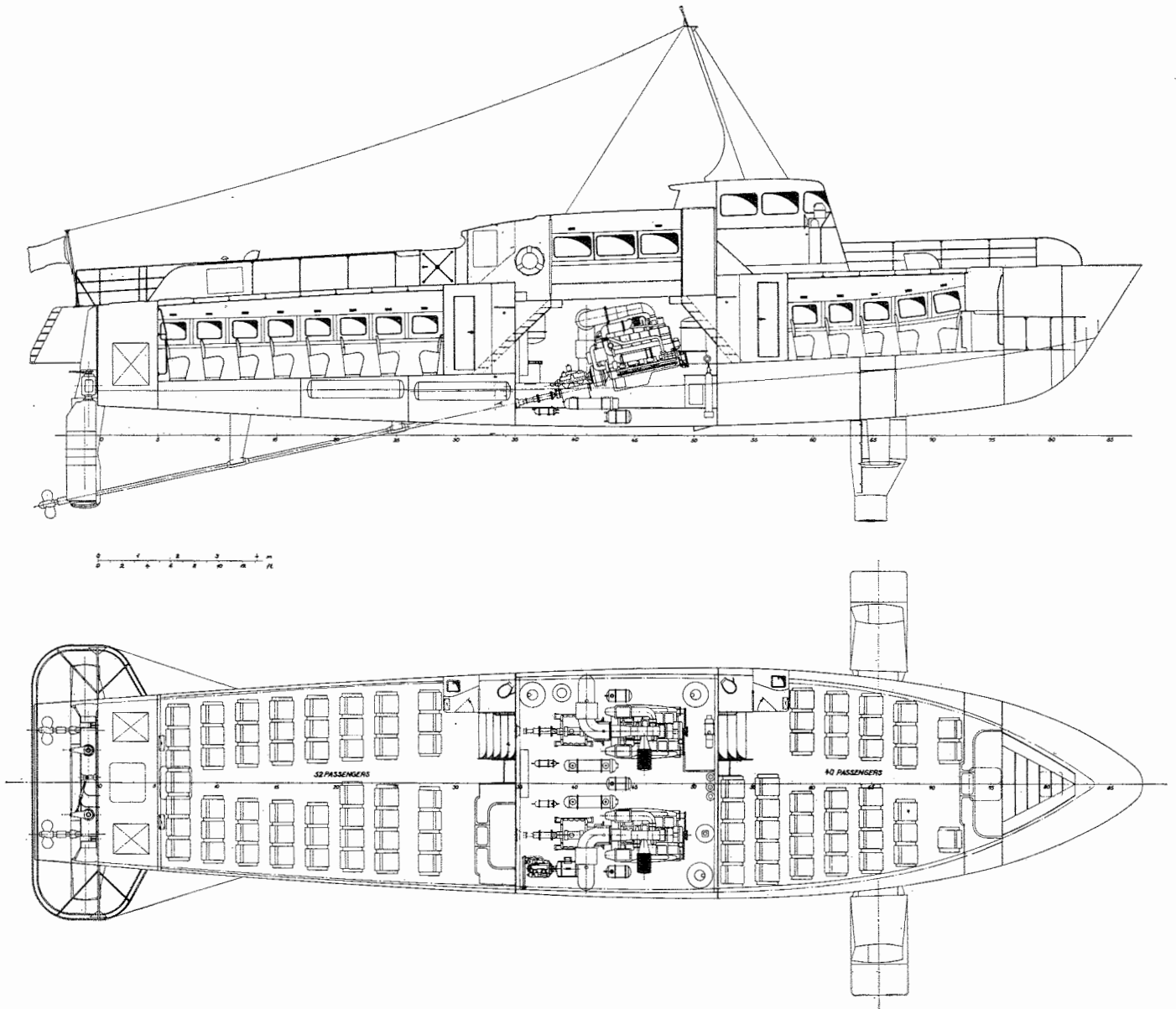
The rear foil can be stabilised by the Schertel-Supramar air feed system, with a fully-submerged foil replacing the standard surface piercing type.

HULL: Of hard chine construction, the hull is of riveted light metal alloy design and framed on longitudinal and transverse formers. Steel is used only for highly stressed parts such as the foil fittings, and the shaft brackets and exits.

ACCOMMODATION: On long distance operations 105 passengers are carried in three saloons, two of which have bars. On shorter operations and ferry services the bars are omitted and seating can be provided for up to 140 passengers. The crew varies from 6-8 members, depending mainly on local regulations.



A Rodriguez-built Supramar PT 50, a 63-ton hydrofoil with a cruising speed of 34 knots, and seating up to 140 passengers



Inboard profile and deck view of the Supramar PT 50

HYDROFOIL MANUFACTURERS
SUPRAMAR: Switzerland

Passenger seats are of lightweight aircraft type and the centre aisle between the seat rows has a clear width of 30 in (0.76 m). Floors and ceilings are covered with lightweight plastic material and the walls, including web frames, are clad in luxury plywood. Toilets are provided in the rear and forward passenger spaces. Each passenger compartment has an emergency exit. Inflatable life rafts and lifebelts are provided for 110% of the passenger and crew capacity. **POWER PLANT:** The craft is powered by two Maybach-Mercedes-Banz MB 820 Db diesels each with a continuous output of 1,100 hp at 1,400 rpm. Engine output is transmitted to two 3-bladed 700 mm diameter bronze propellers through two inclined stainless steel propeller shafts, each supported at four points by seawater lubricated rubber bearings. Average operation period between overhauls is 10,000 hours. Electric or pneumatic starting can be provided. Reverse and reduction gear with built-in thrust is manufactured by Zahnradfabrik Friedrichshafen, Germany. The reverse clutches are solenoid-operated from the bridge.

Eight cylindrical fuel tanks with a total capacity of 3,650 litres are located in the aft peak and below the tank deck. Oil capacity is 320 litres.

SYSTEMS

ELECTRICAL: One diesel generator set, Daimler-Benz-Still, type DM 636-DAK 166-2,

capacity 24 KVA, 50 cps, 3-phase. Engine-driven 24 V dc generator with 210 AH batteries for emergency lighting and navigation equipment.

HYDRAULICS: 120 kp/cm² pressure hydraulic system for operating twin rudders and front foil flaps.

COMMUNICATIONS AND NAVIGATION: Standard equipment includes UHF and VHF radio telephone. Radar and Decca Navigator is optional.

DIMENSIONS, EXTERNAL:

Length overall, hull	91.55 ft (27.90 m)
Length overall, deck	89.50 ft (27.23 m)
Hull beam, max	20.01 ft (6.11 m)
Width across foils	34.93 ft (10.68 m)
Draft afloat	11.48 ft (3.50 m)
Draft foilborne	4.66 ft (1.42 m)

DIMENSIONS, INTERNAL:

Aft passenger Compartment (incl. bar and toilet):	
Length	9.0 m
Width	4.9 m
Height	2.0 m
Floor area	44.1 m ²
Volume	88.0 m ³
Forward passenger compartment (incl bar and toilet):	
Length	7.1 m
Width	5.4 m
Height	2.0 m
Floor area	38.3 m ²
Volume	76.6 m ³

Main deck passenger compartment (incl wheelhouse):

Length	8.0 m
Width	3.6 m
Height	2.0 m
Floor area	28.8 m ²
Volume	57.6 m ³

WEIGHTS:

Max take-off displacement	63.3 tons
Light displacement	49.3 tons
Deadweight (incl fuel, oil, water, passengers, baggage and crew)	14.0 tons
Payload	9.5 tons

PERFORMANCE (with normal payload):

Cruising speed	34 knots (63 km/h)
Range	300 nm (555 km)
Turning radius	1,542 ft (470 m)
Take-off distance	819 ft (250 m)
Take-off time	35 sec
Stopping distance	264 ft (80 m)
Time to stop craft	10 sec
Fuel consumption at cruising speed	300 kp/h

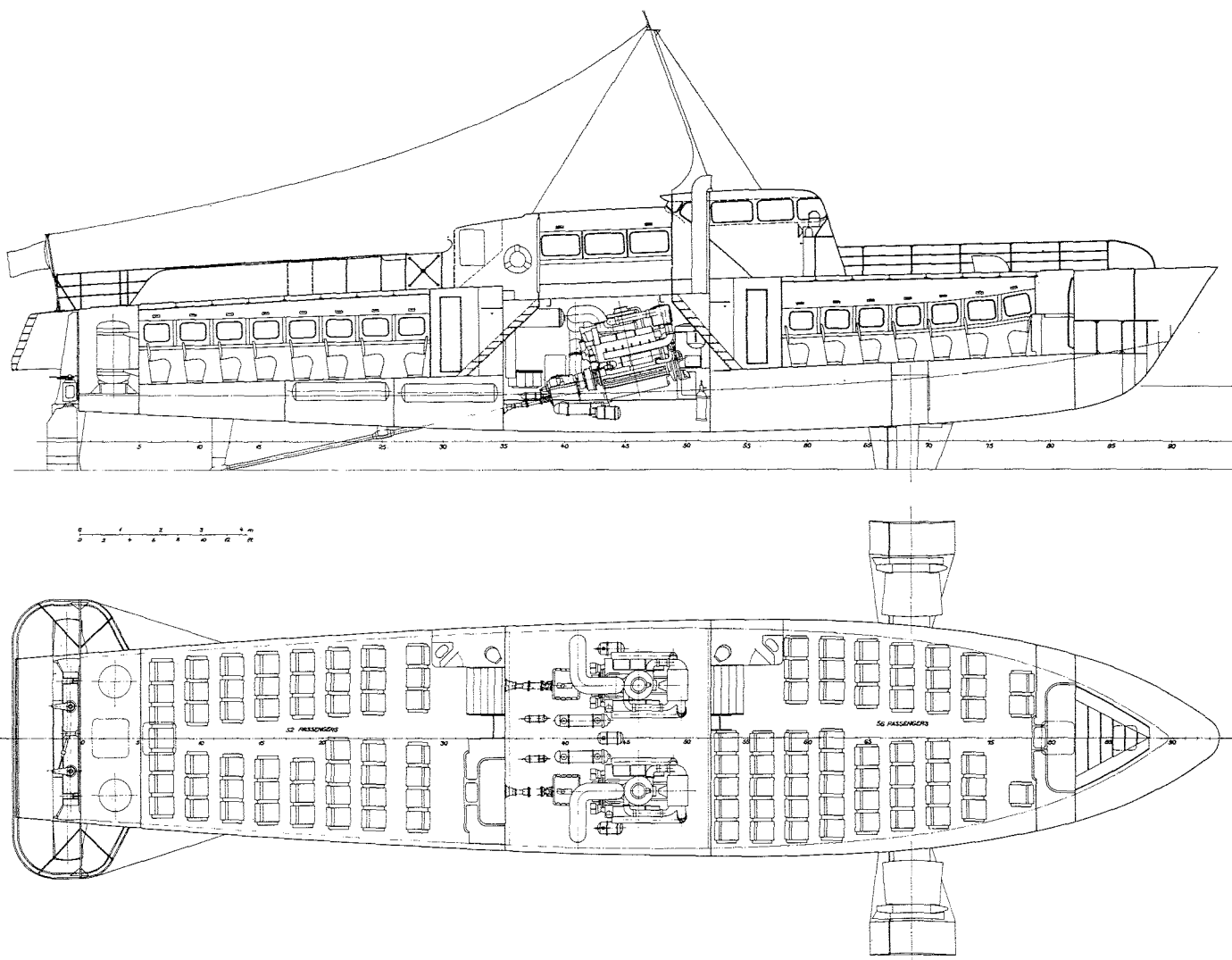
SEA TESTS: Location of the most recent test was off the south coast of Norway.

CONDITIONS:

Beaufort	6-7
Speed of Boat	30 knots
Wave height	3 ft 4 in-5 ft (1.1-1.5 m)
Wave-length	65 ft 8 in-166 ft (20-50 m)

ACCELERATIONS:

Max vertical 0.5g bow foil; 0.37g stern foil
 Max transverse
 0.23g rear section; 0.32g forward section



Inboard profile and deck view of the PT 70, a new Supramar hydrofoil passenger ferry designed to seat up to 155 passengers

HYDROFOIL MANUFACTURERS

Switzerland: SUPRAMAR

The test, of 40 minutes duration, was undertaken in all wave directions and the above values were the absolute maximum obtained.

Cost of craft (standard): approx \$US 650,000

PT 70

This recent addition to the Supramar design range is basically an enlarged and more powerful PT 50, seating up to 155 passengers. It is almost identical to the PT 50 in most respects but the hull length is increased by 6 ft (1.8 m) and there is a choice of three different twin-diesel power plants. The type has not been constructed so far.

FOILS: As for PT 50.

HULL: A combination of transverse and longitudinal framing has been adopted for the V-shaped hull. The bottom of the craft has transverse frames while the decks and sides are framed longitudinally. Thickness of the corrosion proof light metal alloy sheets is between .08 in (2 mm) and .20 in (5 mm). For several of the constructional members high tensile steel is used.

ACCOMMODATION: Normally seating is provided for 120 passengers. If the bars are omitted a further 35 seats can be installed.

POWER PLANT: Three different twin-engine arrangements are available:

Two 1,450 hp Maybach-Mercedes Benz MB 835s; two 1,450 hp MB 655/18s, or two 1,500 hp Paxman Ventura 12YJCM. Fuel consumption of each of these engines is approx 170 gHPH or 0.38 lbHPh. Engine output is transferred to two 3-bladed bronze propellers through two inclined stainless steel shafts. Reduction and reverse gears



The first Supramar PT 150, a 150-ton 37-knot passenger/car ferry built by Westermoen Hydrofoil A/S, Mandal, Norway, for Gothenburg-Fredrikshavn-Line. The craft was delivered in June 1968 and is now operating between Sweden and Denmark, calling at Gothenburg, Aalborg and Fredrikshavn

are Zahnradfabrik Type BW 800/H20s with built-in thrust bearings.

SYSTEMS: As for PT 50.

DIMENSIONS, EXTERNAL:

Length overall, hull	96.75 ft (29.50 m)
Length overall, deck	95.00 ft (28.93 m)
Hull beam, max	19.80 ft (6.03 m)
Width over foils	34.95 ft (10.66 m)
Draft afloat	12.36 ft (3.77 m)
Draft foilborne	5.28 ft (1.66 m)

WEIGHT:

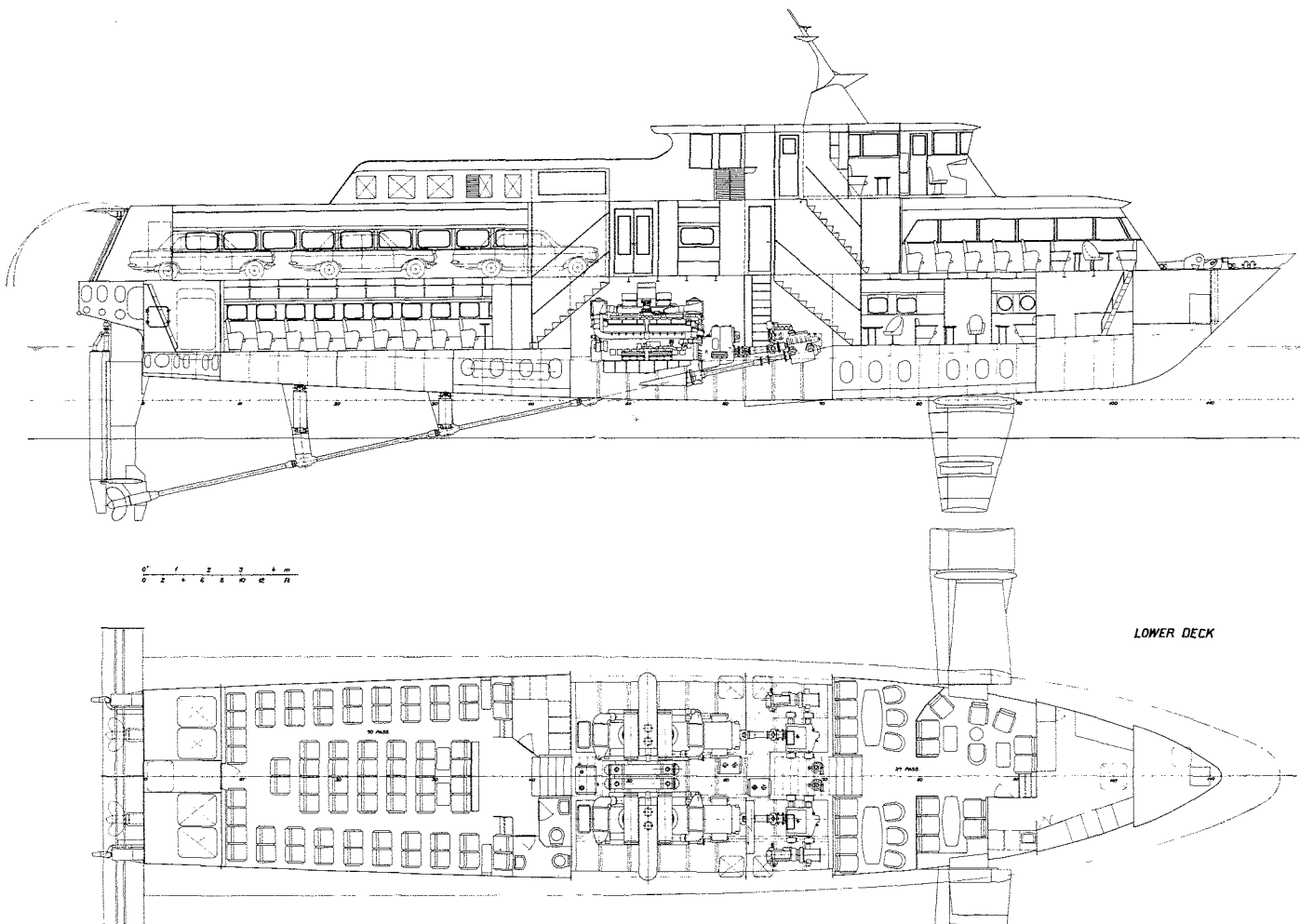
Displacement, fully loaded 70 tons

PERFORMANCE:

Cruising speed	35 knots (67 km/h)
Range	260 nm (480 km)

PT 150

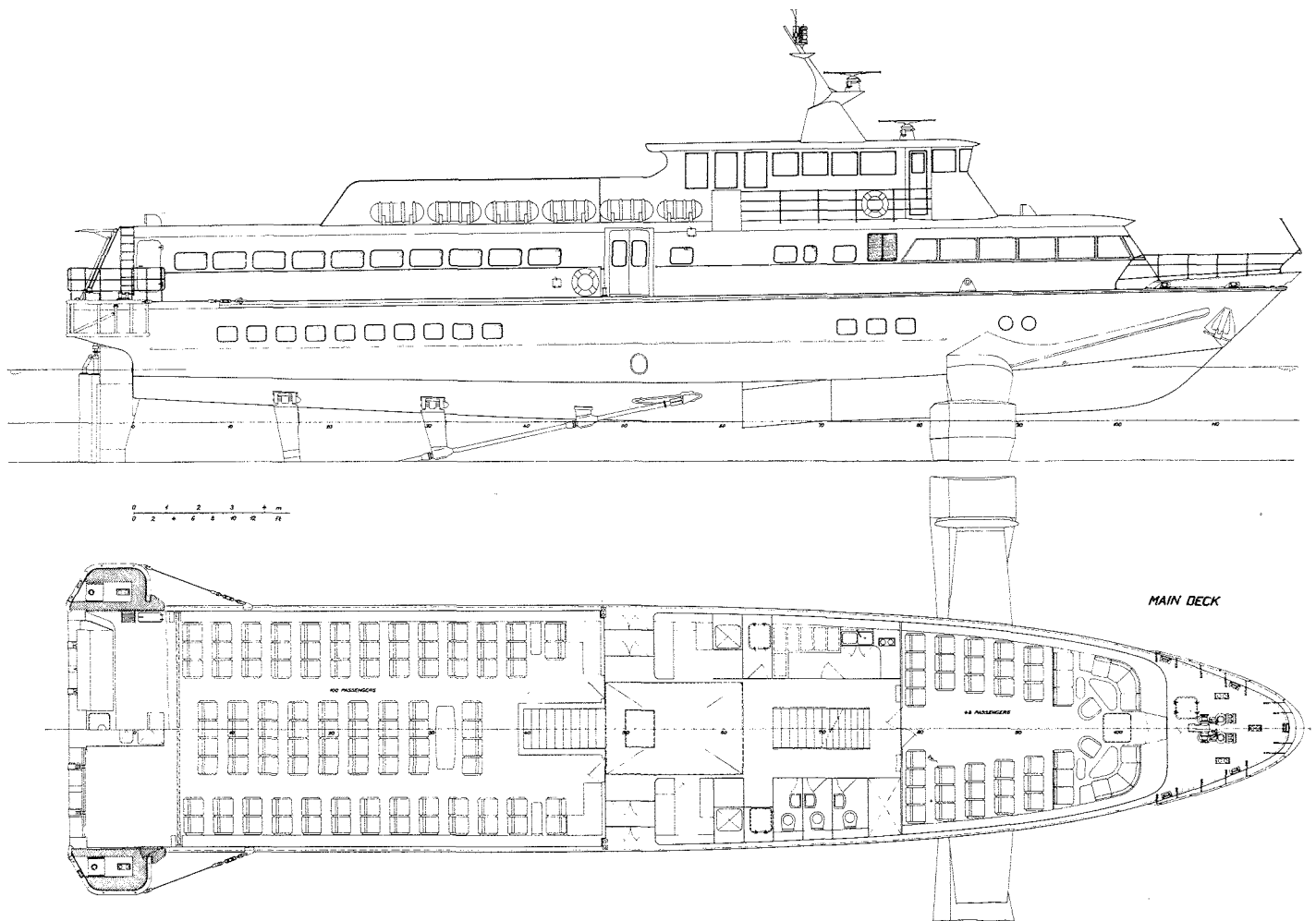
In August 1966, Gothenburg-Fredrikshavn-Line placed an order with Westermoen Hydrofoil A/S, Mandal, Norway, for a 150 ton



The Supramar PT 150 prototype, built by Westermoen Hydrofoil A/S, Mandal, Norway. Inboard profile and lower deck view

HYDROFOIL MANUFACTURERS

SUPRAMAR: Switzerland



Profile and main deck view of the Supramar PT 150

Supramar PT 150 to operate a fast passenger/car ferry service between Sweden and Denmark, calling at Gothenburg, Aalborg and Fredrikshavn. Originally the PT 150 was intended purely as a 250 seat passenger ferry, but at the request of the operating company, the basic design was modified to allow an alternative payload of 150 passengers and 8 cars to be carried.

Close co-operation between Gothenburg-Fredrikshavn-Line, Westermoen and Supramar led to the completion of the first craft within twenty-two months of the order being placed. The prototype PT 150, the world's largest seagoing commercial hydrofoil to date, was delivered to her owners on June 17th 1968.

Building was superintended by Norske Veritas, and the craft was granted the class designation 1A2-Hydrofoil-K.

The second PT 150 is being built at Messina by Leopoldo Rodriquez, Supramar's Italian licensee.

FOILS: The foil configuration is a combined surface piercing and submerged system. The bow foil, which provides the necessary lateral stability, is of the Schertel-Sachsenburg surface-piercing V design and carries 65% of the load. The rear foil, which bears about 35% is of the submerged, Schertel-Supramar air-stabilized type. In foilborne condition the boat is inherently stable.

Hydraulically-actuated flaps are fitted at the trailing edges of the bow foils to balance out larger longitudinal load shiftings, assist take off and adjust the flying height.

The rear foil is fully submerged and makes only a small contribution to lateral stability. It includes the lift-generating sections, rudders and the rear suspension structure which serves as a connecting element with the hull. Struts for the aftermost propeller bearings are also attached to the rear foil, the propellers being sited beneath the foil. The complete assembly is a framed structure which can easily be detached from the transom. The angle of attack of the rear foil can be controlled hydraulically both during take-off and in foilborne operation.

Air stabilisation is fitted to the rear foil for improved passenger comfort under heavy sea conditions. Separate port and starboard systems are installed to stabilise rolling and pitching.

The system feeds air from the free atmosphere through air exits to the foil upper surface (the low pressure region) decreasing the lift. The amount of lift is varied by the quantity of air admitted, this being controlled by a valve actuated by signals from a damped pendulum and a rate gyro. The stabilising moment is produced by decreasing the available air volume for the more submerged side and increasing that of the less submerged one.

The bowfoil centre section is also provided with submergence depth stabilization, the quantity of air admitted being varied with the degree of submergence. The submergence depth control is only used in a following sea.

Foils and rudders are made of anti-corrosive

rolled-steel. Front and rear foil are of hollow construction and by the extensive use of welding, the number of connecting parts requiring screws, bolts or similar means of attachment is reduced to a minimum.

HULL: This is of riveted light alloy construction and framed on longitudinal and transverse formers. It has fairly high dead-rise and hard chine sections for performance as a planing hull and for structural impacts in a seaway while foilborne. A step is provided to facilitate take-off. While the main or structure deck is continuous from bow to stern, the lower deck is interrupted by the engine room, sited amidships. The superstructure, which is also framed on longitudinal and transverse formers, is not included in the load bearing structure.

ACCOMMODATION: The forward part of the upper deck forms the forward upper passenger saloon, and seats 48. The aft saloon, which seats 100, is designed for rapid conversion to carry eight cars or the corresponding amount of palletised freight. Hydraulically-operated loading ramps at the rear of the superstructure are lowered for cars to roll on or off over the stern.

Passengers board the craft through double doors to the single centralized foyer, from which doors and companion ladders lead to the respective passenger saloons on the upper and lower decks. The kiosk on the port side can be used as a duty-free shop. An office on the starboard side serves as a ticket and information office and also as a crew's day room.

The lower aft passenger saloon seats 70. A companion ladder at the centreline leads to the main deck foyer. The lower forward saloon has a bar and seats 27.

Provision is made for all passengers to be served in their seats with cold meals and drinks as in an airliner.

Passenger seats are of lightweight aircraft type. Floors and ceilings are covered with lightweight plastic material and the walls are clad in luxury plywood. Each passenger saloon has fitted carpets. Each room has an independent ventilation unit. Six toilets are provided.

The bridge, which is on a separate level above the main deck, slightly forward of midships, is reached by a companion ladder at the aft of the forward passenger compartment. The bridge itself has seating for another 5 passengers, but these are reserved for VIP guests of the shipping company. All passenger saloons have emergency exits.

The craft carries 12 inflatable RFD life-rafts (for 110% of the classified number of passengers and crew) which are stowed along both sides of the superstructure deck, aft of the wheelhouse extension. Lifebelts are arranged beneath the seats.

POWER PLANT: Power is supplied by two 20-cylinder Maybach MD 1081 supercharged and intercooled diesels each rated at 3,400 hp continuous at 1,740 rpm. To improve torque characteristics during take-off two engine mounted Maybach torque converters are provided.

Reverse and reduction gears are of the lightweight Zahnradfabrik BW 1500HS18 hydraulically-operated type, and incorporate the propeller thrust bearings. They have three shafts and two gear trains, one of which has an idler. The output shafts rotate either in the same direction as the input shaft or the opposite direction, depending upon the gear through which power is directed. Selection is by pneumo-hydraulic double-plate clutches on the input shafts. A mechanical lock-up is provided so that the gear can transmit full torque in the event of clutch slip while in service. This takes the form of a dog clutch which is effective in one direction, and can only be engaged in the "stop" condition. The gearboxes each have integral oil pumps for lubrication and clutch operation.

The inclined propeller shafts are made of high tensile stainless steel. The propellers are 3-bladed and of approx. 41 in diameter.

SYSTEMS:

ELECTRICAL: The total electrical system is supplied by two diesel generators with an output of 44 KVA each. An emergency diesel generator of 32 KVA output is installed on the upper deck.

In the event of an electrical failure the emergency generator is switched on automatically by a STILL starter to operate the emergency lighting system as well as the services and communications system.



A modified ST 3 is being employed by Supramar as a research craft for the Schertel-Supramar fully-submerged, air-stabilised foil system. Powered by a 1,000 hp GE LM100 gas-turbine, the craft has reached speeds in excess of 54 knots during tests in the Mediterranean

HYDRAULICS: Steering, variation of the front foil flap angle and the angle of attack of the rear foil are all operated hydraulically. Each system has its own circuit which is monitored by a pressure controlled pilot lamp.

CONTROL: Starting, manoeuvring and operation of the craft is controlled from the bridge, but in cases of emergency the main engines may be controlled from the engine room.

The two main engines are each controlled by an operating lever designed for single-handed control. Propeller reversal is also by means of these levers, the reverse gear being actuated by pneumatic remote control between bridge and main engines.

To start the boat both operating levers must be put in the "full ahead" position simultaneously. The engine mounted torque converter gear is actuated automatically. Foilborne speed can be regulated by five adjusting of the operating levers. No other control devices are necessary for the main engines.

Levers for variation of the front foil flap angle and the angle of attack of the rear foil are actuated only before and after starting. During foilborne operation these can be used for trim compensation. All instrumentation and monitoring equipment is installed on the bridge.

COMMUNICATION AND NAVIGATION: Standard navigation equipment of the PT 150 DC includes two Raytheon 2502-3 cm radar units with IP-33 display panels, one of which is north-stabilized; an Arma Brown gyro

compass type Mk 1 Mod 5; a Plath T 12 magnetic compass and a Decca Navigator Mk. 12 with track plotter.

Communications equipment includes a Fisher F811 coast telephony station, a VHF telephony transceiver type ME-23C, produced by SRA Stockholm, and an intercom system to the engine room and office.

DIMENSIONS, EXTERNAL:

Length overall, hull	123.2 ft (37.55 m)
Length overall, deck	121.8 ft (37.10 m)
Hull beam, max	24.6 ft (7.50 m)
Deck beam, max	24.3 ft (7.40 m)
Width across foils	52.45 ft (16.0 m)
Draft afloat	17.7 ft (5.38 m)
Draft foilborne	8.3 ft (2.53 m)

WEIGHTS:

Displacement, fully loaded	150 tons
Payload	23 tons
As passenger ferry	250 passengers
As passenger/car ferry	150 passengers + 8 medium size cars

PERFORMANCE:

Cruising speed at 6,880 hp	39 kt (72 km/h)
Cruising range	300 nautical miles (555 km)
Max permissible wave height in foilborne mode at full power	7 ft 6 in (2.28 m)
Approximate cost	\$US 1,500,000

ST 3 FOIL RESEARCH CRAFT

A modified Supramar ST 3 (formerly PT 4) is being employed to evaluate fully-submerged foils of the Schertel-Supramar air-stabilised type and provide data to assist the development of this system for larger craft.

The craft is powered by a 1,000 hp LM100 gas turbine and during tests in the Mediterranean has exceeded 54 knots (88 km/h).

HYDROFOIL MANUFACTURERS AIRAVIA / ANGLIAN

UNITED KINGDOM

Airavia AIRAVIA LTD

HEAD OFFICE:

20 North Road, Shanklin, Isle of Wight

TELEPHONE:

Shanklin 3643

DIRECTORS:

H. H. Snowball, Managing Director

A. Oztemel (USA)

E. Perper (USA)

G. V. Whale, Secretary

Formed in January 1968, Airavia is the sales representative for Sudoimport hydrofoils and air cushion vehicles in the United Kingdom, British Commonwealth countries, Scandinavia and Western Europe. The company will also lease Kometa passenger hydrofoils on wet or dry charters in these areas. Airavia has imported four Volga sports craft and has ordered a Kometa for delivery in early 1969 for service on a route in the United Kingdom, subject to a passenger licence being granted by the Board of Trade.



The Kometa off Tower Bridge

Anglian ANGLIAN DEVELOPMENT

HEAD OFFICE AND WORKS:

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TELEPHONE:

Southend 524281

DIRECTORS:

W. H. Holmes, Chairman and Managing Director

G. R. Browne

C. I. Browne

SENIOR EXECUTIVE:

P. A. Nott MA (Cantab)

Development of the Hi-foil started in 1964 and the craft is the company's only product to date. It is the first sports hydrofoil designed in the UK to go into production, and has been sold to private owners in many parts of the world.

Hi-foil 2

FOILS: The foil system is of canard configuration with a fully submerged main foil located at the stern, and bearing 67% of the weight, and a small inverted 'V' emerging foil located at the bow.

The bow foil is mounted at the base of a handle-bar equipped steering head, an arrangement similar to that of a motor cycle. The operator turns the handlebars and leans inwards to match the radius of turn required. The foil system is designed to maintain stability in a turn and prevent 'digging-in' or 'skidding'. If the craft meets a large wave, the increased drag pivots the front foil against a spring and shock absorber to a lower angle of incidence, thus producing less lift and helping to dampen both porpoising and shocks.

HULL: A flat-bottomed planing design, the hull comprises two fibreglass mouldings bonded together to form a single large buoyancy chamber.

The cockpit well is located amidships and fitted with a motor cycle pillion style seat for two. The seat is fitted with a safety ignition cut-out switch and unless the operator is sitting on the seat the motor will not operate.



Hi-Foil 2, a two-seat, fibreglass-hulled sports hydrofoil. Steering is similar to that of a motorcycle. Top speed is 25-35 mph according to the outboard motor installed

Beneath the seat is a portable 5 gallon fuel tank. A 3-position gear lever—forward, neutral, reverse—is mounted at the side of the cockpit, and a twist-grip controls engine output. The central boss in the steering head will house a speedometer or compass if required.

The forward deck section, with the steering head and front foil, hinge upwards for transport and easy launching, as do the motor and rear foil, which are mounted on a pivoted steel frame.

POWER PLANT: The craft can be fitted with any standard long-shaft outboard from 15-25 hp. A subcavitating propeller of about 9 in (229 mm) diameter is normally used.

DIMENSIONS:

Length overall, hull 8 ft 10 in (2.69 m)

Length waterline, hull	7 ft 10 in (2.38 m)
Length overall, foils retracted	9 ft 10 in (2.99 m)
Length overall, foils extended	8 ft 10 in (2.69 m)
Hull beam	3 ft 5 in (1.04 m)
Beam across foils	3 ft 5 in (1.04 m)
Draft afloat, foils extended	2 ft 9 in (0.8 m)
Draft afloat, foils retracted	9 in (230 mm)
Draft foilborne	1 ft 4 in (0.4 m)
Freeboard	6 in (153 mm)
Height overall, foils extended	4 ft 2 in (1.27 m)

WEIGHTS:

Craft and motor without fuel	300 lb (136 kg)
Max take-off weight with fuel driver and passenger	650 lb (294 kg) app

HYDROFOIL MANUFACTURERS

United Kingdom: ANGLIAN

PERFORMANCE:

Max speed foilborne 30 mph (48.2 km/h)
 Cruising speed foilborne
 20 mph (32.2 km/h)
 Max permissible wave height in foilborne
 mode 12 in (306 mm)

Turning radius at cruising speed:

Number of seconds and distance to take-off
 5 secs, 60 ft (18.28 m)

Number of seconds and distance to stop
 craft 3 secs, 60 ft (18.28 m)

Fuel consumption at max speed

2½ gal. p/h (9.2 lit p/h)

Fuel consumption at cruising speed

1½ gal/ p/h (6.7 lit. p/h)

COST:

Standard craft, f.o.b., less engine, £150

HYDROFOIL MANUFACTURERS

HYDROFIN: United Kingdom

Hydrofin**NEW HYDROFIN LTD****HEAD OFFICE:**Burfield Flat, Bosham Lane, Bosham,
Sussex**MANAGING DIRECTOR:**

Christopher Hook

Christopher Hook's early Hydrofins demonstrated for the first time the stability and excellent seakeeping qualities of incidence-controlled, submerged foil craft, and marked a turning point in hydrofoil design.

Nearly seventy Hydrofins of various types have been built since 1949 in Norway, the USA, Poland and Israel. The company's latest design is the 22 ft Channel Skipper, a four-seat fibreglass-hulled runabout, the prototype of which is scheduled for completion in 1969.

CHANNEL SKIPPER

Developed from the earlier K2 Hydrofin, the K2D Channel Skipper is a four-seat sports hydrofoil fitted with mechanical wave sensors to control the incidence angle of the fully submerged main foils. Torsionetic universal joints are fitted to the propeller drive shaft to permit retraction.

FOILS: The fully submerged foil system is of "aeroplane" configuration with 65% of the weight carried on the two main foils and the remainder on the aft foil. All three foils

have swept back leading and trailing edges. A high-riding crash preventer plane is mounted ahead of and beneath the bow. The plane is also used as a platform for mounting a lightweight pitch sensor which is hinged to the rear. The sensor rides on the waves and continuously transmits their shape through a servo system and connecting linkage to vary the incidence angle of the main foils as necessary to maintain them at the required depth. A filter system ensures that the craft ignores small waves and that the hull is flown over the crests of waves exceeding the height of the keel over the water.

Two additional sensors, trailing from port and starboard beams immediately aft of the main struts, provide roll control. The pilot has overriding control through a control column, operated in the same manner as that of an aircraft.

All three foils and the crash plane arm are retractable. The crash plane arm retracts into a hull slot; the two main foils swing forward above the displacement waterline and the rear foil strut assembly retracts upwards into the hull at the same time raising the propeller and drive shaft.

POWER PLANT: Motive power is provided by a single 80 hp Ford diesel engine, driving a 3-bladed propeller through a Vee-drive and a system of Torsionetic joints produced by the Eaton Spring Division of Eton, Yale and

Towne Inc. The joints are fitted between the engine and the gearbox, and the gearbox and the drive shaft to permit retraction.

DIMENSIONS:

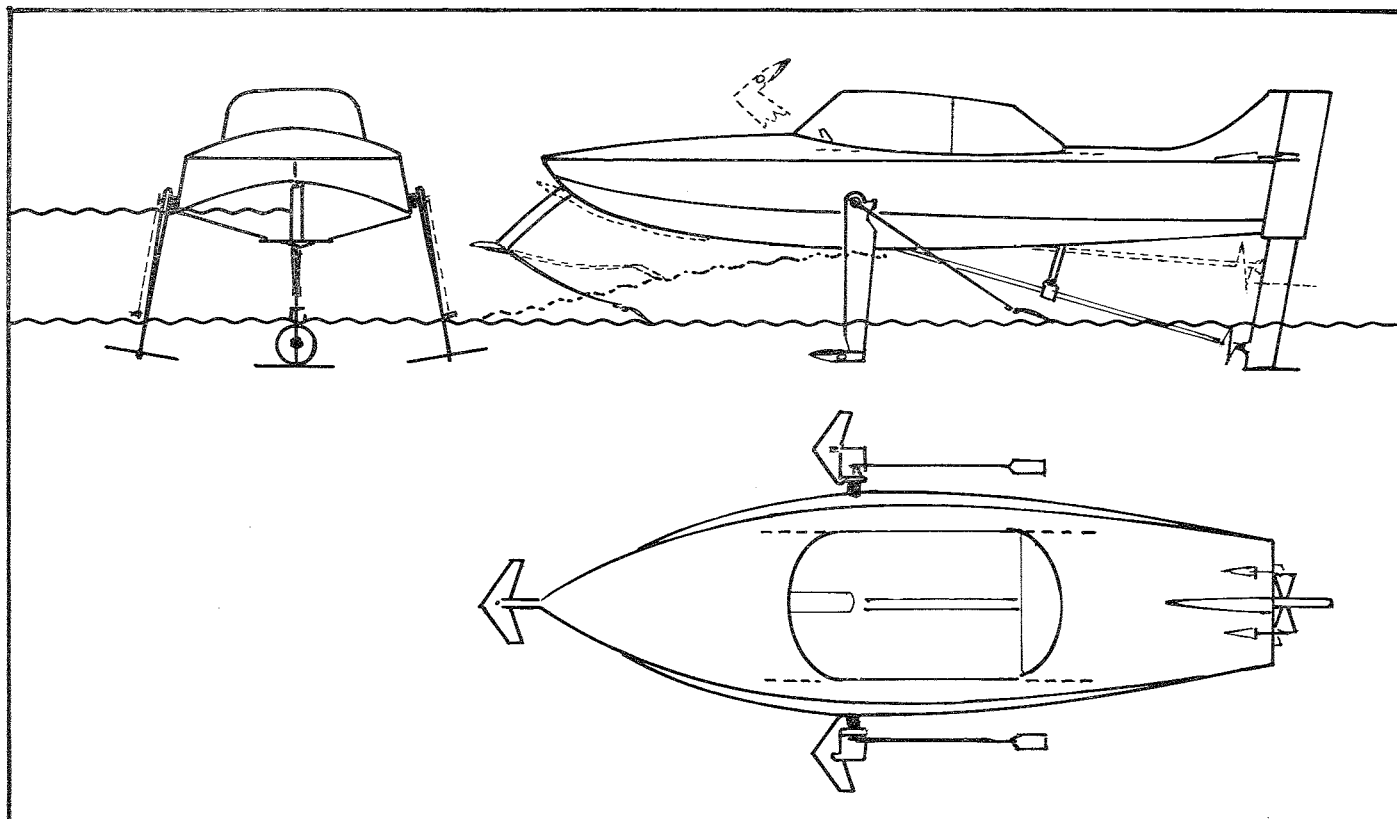
Length overall	22 ft 0 in (6.71 m)
Length waterline, hull	18 ft 0 in (5.48 m)
Hull beam	6 ft 7 in (2.00 m)
Length overall, foils extended	19 ft 7 in (5.96 m)
Max beam, foils retracted	10 ft 9 in (3.27 m)
Max beam, foils extended	13 ft 5 in (4.09 m)
Draft afloat, foils retracted	1 ft 7 in (0.48 m)
Draft afloat, foils extended	5 ft 3 in (1.60 m)
Freeboard	2 ft 6 in (0.76 m)

WEIGHTS:

Gross tonnage	1.8 tons
Net tonnage	1.2 tons
Light displacement	1.2 tons
Useful load (fuel, water, passengers, baggage and crew)	1,300 lb (598 kg)

PERFORMANCE:

Cruising speed, foilborne	32 knots (51 km/h)
Cruising speed, hullborne	8-12 knots (14-21 km/h)
Sea state capability	Unlimited in seas corresponding to Barnaby's "average rough sea" providing they conform as regards proportions
Turning radius at cruising speed	150 ft (45.7 m) fully banked on turns.



Southern SOUTHERN HYDROFOILS LIMITED

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CABLES:

Hydrofoils Southampton

DIRECTORS:

W. J. Sloss, Managing Director
Commander M. Thornton, DSO, DSC
M. J. N. Bonner
C. F. Bridle
J. M. Thomson
C. M. Stacey CEng, AMRINA, Technical
Director

Southern Hydrofoils was founded in April 1963 to design, manufacture and market hydrofoils with fully-submerged systems.

A small test craft was used during 1964-5 to develop a mechanical feeler arm system, which was later improved by the addition of an electro-hydraulic response modification unit. The system is being employed in the prototype Sea Ranger 1, now under construction at Dartmouth, Devon.

Design studies for larger hydrofoils are in hand.

SEA RANGER 1

Sea Ranger is an 8½ ton passenger hydrofoil powered by two 283 hp General Motors Detroit 8V53 diesels. Wave sensing arms control the incidence angle of the submerged bow foils to maintain them at the required depth and provide the necessary hydrodynamic forces for stability.

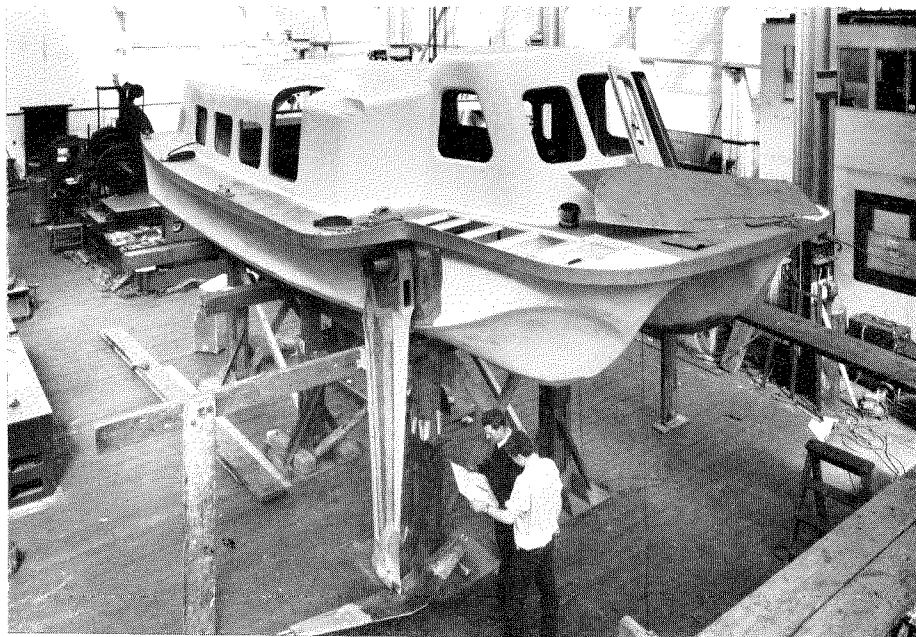
The standard craft will seat up to 25 passengers, but alternative versions, with modified superstructure and internal arrangements will be offered for a variety of applications ranging from fast naval, police and customs patrol to ambulance duties.

FOILS: The foil system is fully submerged and of conventional "aeroplane" configuration. The two bow foils are located slightly forward of amidships and the single rear foil is attached to the propeller pod.

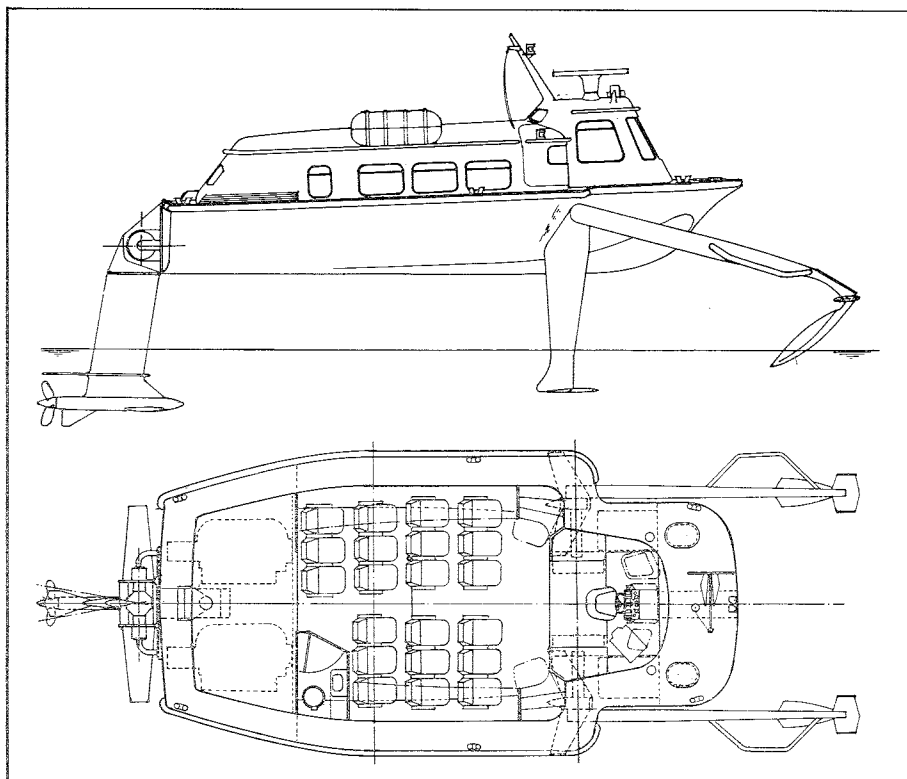
The angle of incidence of the two bow foils is varied by two wave-sensing arms extending well ahead of the main foil struts and pivoting on the strut axes. Take-off, banking and response modification is controlled hydraulically. A secondary function of the wave sensors is the provision of temporary support for the bow should there be a loss of lift on either or both of the bow foils. Bow and rear foils and the two sensor arms are raised hydraulically above the waterline to permit manoeuvring in shallow water.

HULL: Designed for production in glass-reinforced plastic, the wide "W" section, twin-keel hull has high deadrise bows flattening to a planing surface aft. The main foils are sited within the hull beam to simplify berthing.

POWER PLANT: Propulsion is supplied by two 283 bhp General Motors Detroit Type 8V53 marine diesels. Power is transferred through a hydrostatic transmission system to a 2 ft 6 in (0.76 m) diameter fixed pitch



Prototype Sea Ranger



Sea Ranger inboard profile and deck

propeller. A retractable Volvo Penta out-drive unit housed in a well in the engine compartment and driven hydrostatically from either of the main engines, provides auxiliary propulsion.

Total fuel (diesel) capacity is 140 gallons (568 litres).

DIMENSIONS:

Length overall, hull	30 ft 0 in (9.140 m)
Beam overall, hull	15 ft 6 in (4.720 m)
Draft foils extended,	8 ft 5 in (2.56 m)
Draft, hullborne	1 ft 8½ in (0.52 m)

WEIGHTS:

Disposable load	5,600 lb (2,540 kg)
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Displacement 8½ tons

PERFORMANCE (designed):

Speed, foils retracted	8 knots (14.7 km)
Max speed, fully loaded	40 knots (75 km/h)
Cruising speed	35/40 knots (65/75 km)
Fuel consumption at continuous rated speed	20 Imp galls per hour (91 litres per hour)
Fuel consumption at displacement cruise speed	5 Imp galls per hour (22.7 litres per hour)
Designed endurance and range at cruising speed	7 hours/240 n. miles at 35 knots (64 km)

THE UNITED STATES OF AMERICA

Atlantic

ATLANTIC HYDROFOILS INC

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516 (Area Code) 751-0711

DIRECTORS:

John K. Roper, President

The Atlantic Hydrofoils' mechanically-controlled submerged foil system was the first to be approved for use on hydrofoil passenger ferries. The first order for craft employing this system, was placed by Sea World, Inc of San Diego. The success of the first 28-passenger, 30-knot craft ordered by the company resulted in orders for an additional three.

The Flying Cloud, described below, is a development of the Sea World craft and utilises a similar foil system. Two versions of the Flying Cloud were built, the first with two 600 hp Cummins Vimmer T diesels, production of which was abandoned, and the second with a Solar Saturn gas turbine.

FLYING CLOUD 2

The Flying Cloud 2 was the first gas-turbine powered hydrofoil built for commercial passenger services in the United States. Powered by a 1,100 hp Solar Saturn gas-turbine, it accommodates 70 passengers and a crew of 3.

FOILS: The foil system is of fully submerged aeroplane configuration with two split foils forward and an identical single foil aft. All three foils have trailing edge flaps, those of the forward foils being controlled by an automatic mechanical control device. Hinged vertical control flaps on the trailing edges of the forward struts automatically deflect the foil flaps to maintain the craft at a stable inflight attitude in all sea states. The aft foil can be adjusted in flight to compensate for changes in the longitudinal position of the centre of gravity. The aft foil-strut unit is steerable and acts as a rudder. All three foils retract clear of the water when not in use.

HULL: Laminated wood framing with plywood fibreglass-plating. Deck and superstructure are of plywood and fibreglass construction.

POWER PLANT: Power is provided by a Solar Saturn gas turbine with a normal

service output of 1,100 hp, driving a 30 in (762 mm) diameter, 26 in (661 mm) pitch Columbian Style B propeller through a V drive. The turbine is mounted below deck amidships, with air intake apertures on the port side of the cabin superstructure. The exhaust stack discharges directly aft of the pilothouse.

ACCOMMODATION: Seats are provided in a comfortably appointed cabin for 70 passengers and a crew of three. Access to the cabin is through either of two doors located amidship, port and starboard. An emergency window exit is provided in the aft passenger compartment. A full range safety equipment is carried in accordance with US Coast Guard requirements.

DIMENSIONS:

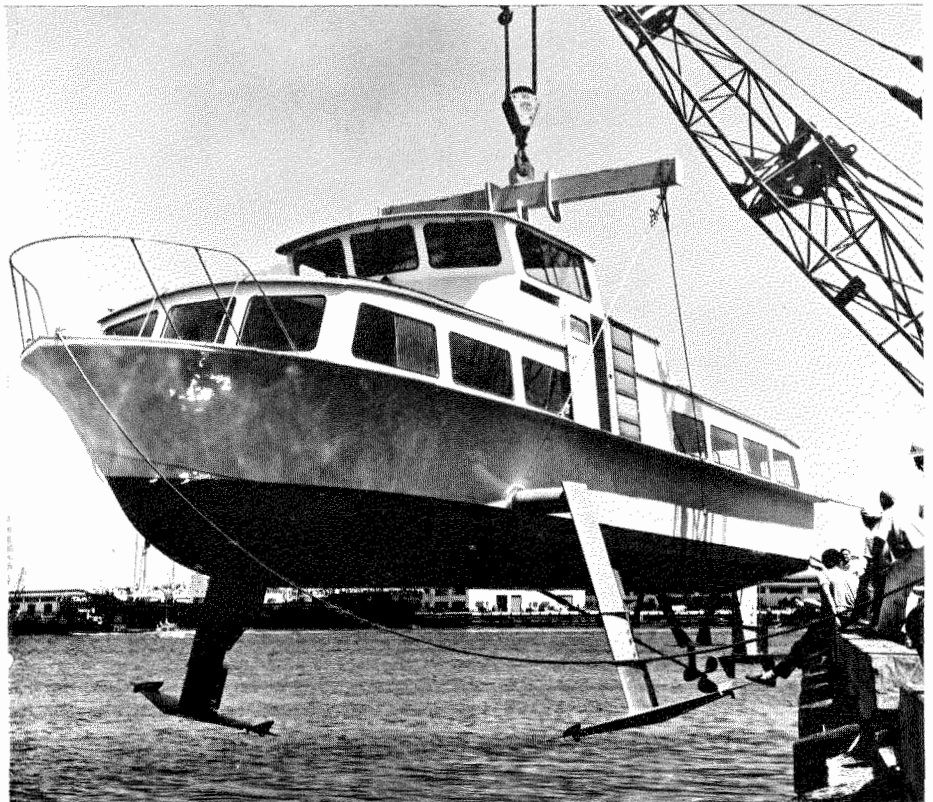
Length overall, hull	61 ft 6 in (18.7 m)
Hull beam	12 ft 0 in (3.6 m)
Width across foils	28 ft 0 in (8.5 m)
Draft afloat	7 ft 9 in (2.3 m)
Forward foil area	30.6 sq ft (2.82 m ²)
Aft foil area	15.3 sq ft (1.43 m ²)

WEIGHTS:

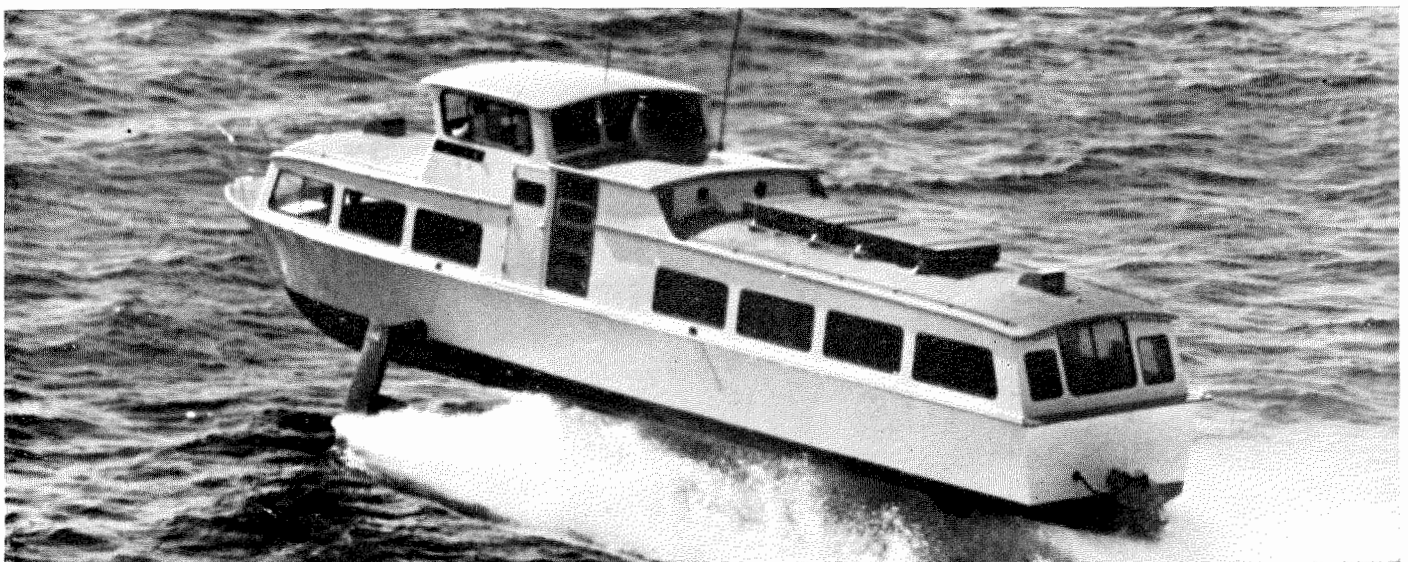
Gross weight	46,000 lb (20,861 kg)
Max payload	11,500 lb (5,221 kg)
Fuel capacity	500 gallons (2,272 litres)

PERFORMANCE:

Max speed	35 knots (64 km/h)
Cruising speed	32 knots (57 km/h)
Cruising speed hullborne	10 knots (14 km/h)
Take-off speed	18 knots (32 km/h)
Designed range at cruising speed	200 nautical miles (322 km)



The Flying Cloud showing the mechanically operated submerged foil system. Hinged vertical control flaps on the trailing edges of the forward struts automatically deflect the foil flaps to maintain the craft at a stable inflight attitude in all sea states



Flying Cloud, designed by Atlantic Hydrofoils Inc., and built by Teledyne Inc., of Gardena, California, is powered by a 1,100 hp Solar Saturn gas turbine and has a service speed of 32 knots

HYDROFOIL MANUFACTURERSUnited States of America: **BOEING****Boeing****THE BOEING COMPANY****Advanced Marine Systems Organisation****HEAD OFFICE:**

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EXECUTIVE:

Airo M. Gonnella, Manager, Advanced Marine Systems

The Boeing Advanced Marine Systems Organisation was formed in 1959 to conduct research, development, design, manufacture and the testing of high performance marine vehicle systems. Boeing also has a 60 per cent interest in Alinavi SpA, the Italian hydrofoil company, with headquarters in Rome. Boeing's entry into the hydrofoil field was announced in June 1960, when the company was awarded a \$2 million contract for the construction of the US Navy's 120 ton PCH-1 High Point, a canard design which was the outgrowth of experiments on a similar arrangement in the test craft Sea Legs.

Boeing has also built a jet-driven hydroplane, the HTS, for testing foil models at full-scale velocity; the Fresh-1, a manned craft for testing superventilating or supercavitating foils at speeds between 60-100 knots and a water-jet test vehicle, Little Squirt. The company has also completed a water-jet propelled gunboat, the PGH-2 Tucumcari, for the US Navy's Ship Systems Command.

The Tucumcari is now based at San Diego and is serving with the US Navy Pacific Fleet Amphibious Command.

PCH-1 HIGH POINT

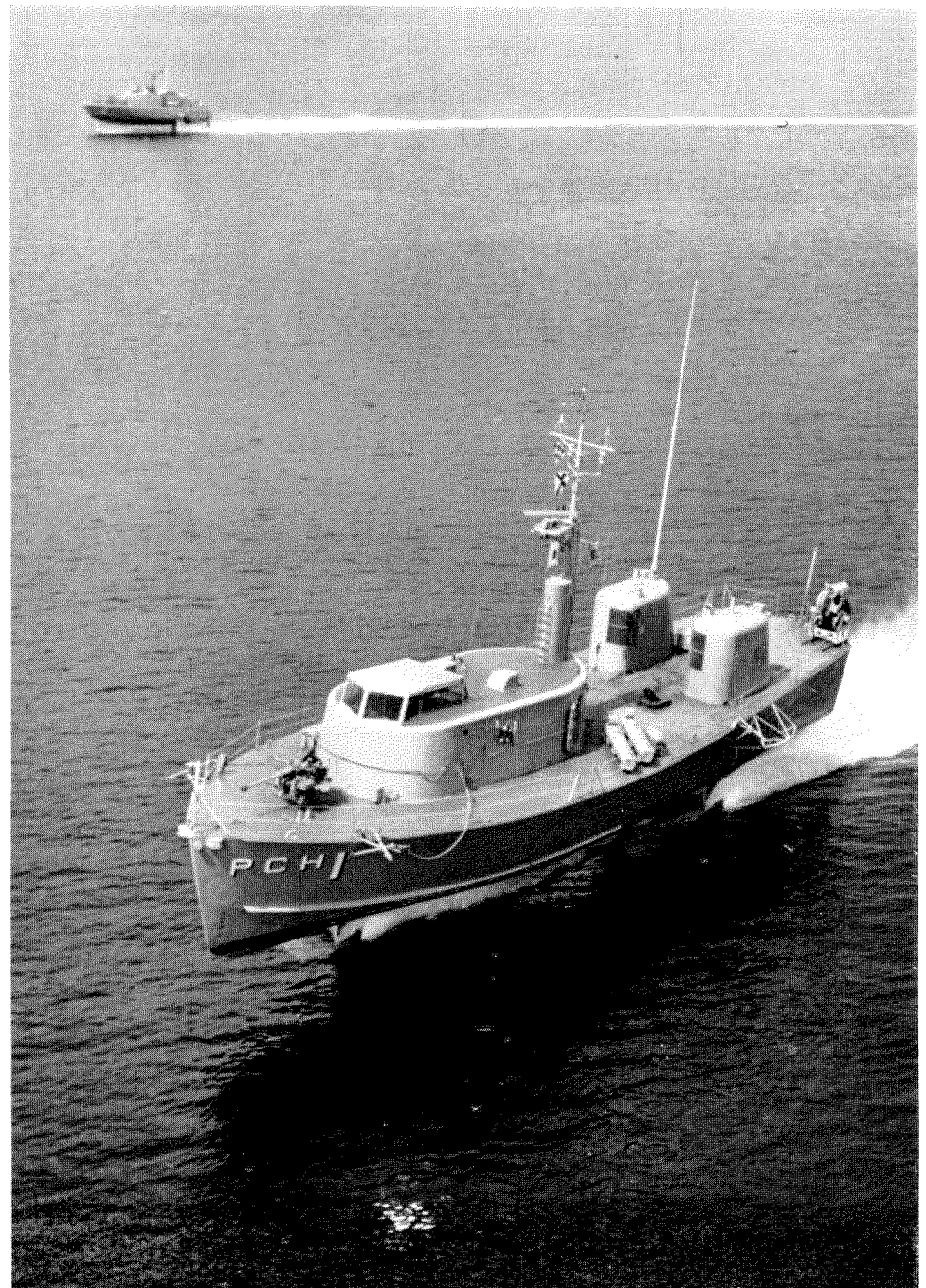
General design of the PCH-1 High Point was specified by the US Navy's Bureau of Ships, with responsibility for detail design and construction assigned to Boeing. The ship was accepted by the US Navy in August 1963 and based at the Puget Sound Naval Shipyard at Bremerton, Washington. Since then it has been undergoing a wide range of tests to evaluate the performance of an inshore hydrofoil ASW system.

FOILS: The submerged canard foil system, with 70 per cent of the foil area located aft, and trailing-edge flaps on all foils for lift control, is a scaled-up version of that employed on Sea Legs. The foil struts retract vertically into the hull. Foils and struts are of built-up construction in HY-80 weldable steel.

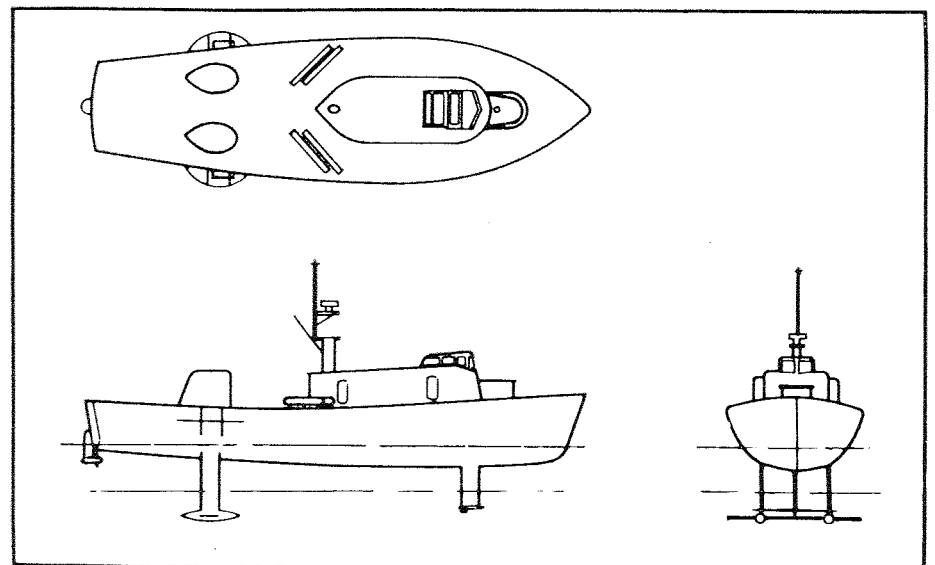
HULL: The hull is of all-welded, corrosion resistant 5456 aluminium. Integral plate stiffener extrusions are extensively used for decks and portions of the sides not having excessive curvature.

POWER PLANT: Foilborne propulsion is provided by two Proteus Model 1273 gas turbines, each rated at 3,900 shp. The turbines are located aft and take air through the two towers housing the retracted foil struts. The exhaust is discharged directly aft through the transom. Each gas-turbine is coupled to a pair of contra-rotating, sub-cavitating propellers, 29 in (737 mm) in diameter, through two right-angle gearboxes; one at the top of each aft strut and the others in each of the underwater nacelles.

Hullborne propulsion is supplied by a single Curtiss-Wright Model 1D-700 rated at 600 hp for continuous operation. The engine is



Boeing's PCH-1 is being employed by the US Navy to evaluate the performance of an inshore hydrofoil ASW system. In the above photograph the craft is seen equipped with high speed sonar handling gear at the stern and lightweight homing torpedoes. In the background is the Tucumcari waterjet propelled hydrofoil gunboat



Boeing's PCH-1 High Point, a 120 ton experimental hydrofoil employed by the U.S. Navy since 1963 to evaluate the performance of an inshore hydrofoil ASW system

HYDROFOIL MANUFACTURERS

BOEING: United States of America

coupled to a 43 in (1,092 mm) diameter propeller through a retractable outdrive unit, which is steerable through 360 degrees and rotates about the axis of the horizontal shaft for retraction.

CONTROLS: The autopilot system, devised by Hamilton Standard, is designed to maintain the craft at a stable in-flight attitude in all sea states. It receives craft motion input from a sonic height sensor in the bow, and from roll and pitch gyros and vertical accelerometers. The information is processed by an electronic computer and fed continuously to hydraulic actuators of the foil control surfaces. The control surfaces develop the required hydrodynamic forces for stability manoeuvring and counteracting forces imposed by wave action.

The attitude control is entirely automatic except for steering. The take-off procedure on the PCH-1 is simply to set the desired flying height, then advance the throttles. At a gross weight of 117 tons take-off occurs at 27 knots with 3,880 total horsepower delivered to the transmission system, the speed stabilizing at 36.6 knots at that power setting. Minimum foilborne speed is 24 knots. At a cruising speed of 40 knots 4,400 hp is required, with propellers turning at 1,270 rpm.

DIMENSIONS, EXTERNAL:

Length overall, hull	115.7 ft (35.3 m)
Length, waterline, hull	110.0 ft (33.5 m)
Length overall:	
foils retracted	117.0 ft (35.7 m)
foils extended	117.0 ft
Max beam:	
foils retracted	31.5 ft (9.6 m)
foils extended	31.5 ft
Hull beam	32.0 ft (9.75 m)
Draught afloat, foils retracted	6.5 ft (2.0 m)
Freeboard	12.0 ft (3.7 m)

WEIGHTS:

Light displacement	93.0 tons
Max take-off displacement	120.0 tons
Useful load (fuel, water, equipment, armament, crew)	27.0 tons

PERFORMANCE:

Cruising speed:	
foilborne	in excess of 40 knots
hullborne	12 knots

ACCOMMODATION:

Crew	13
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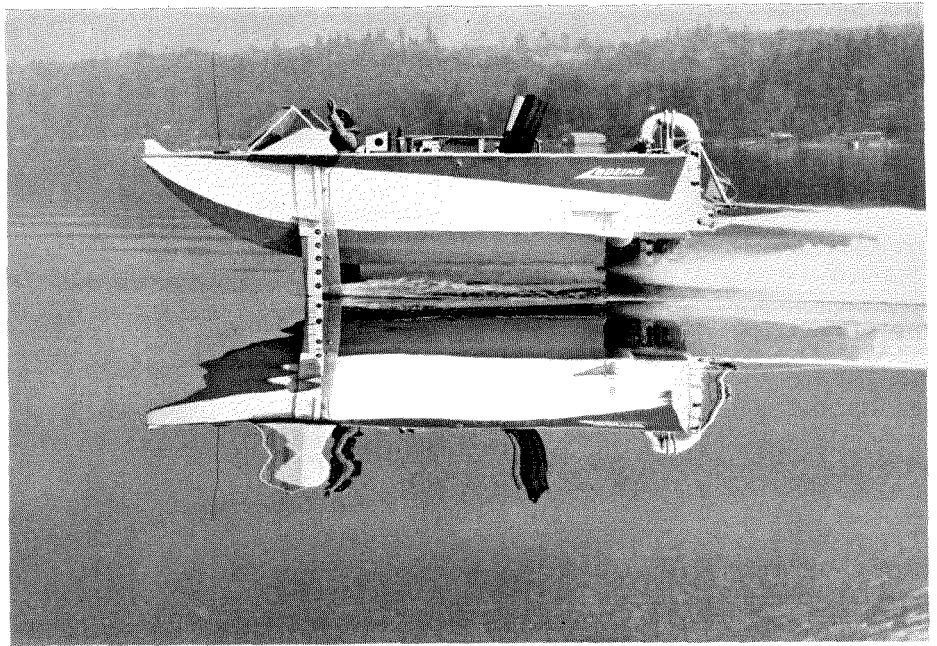
LITTLE SQUIRT

Little Squirt was designed and built by Boeing in 1962 as a company sponsored water-jet research vehicle.

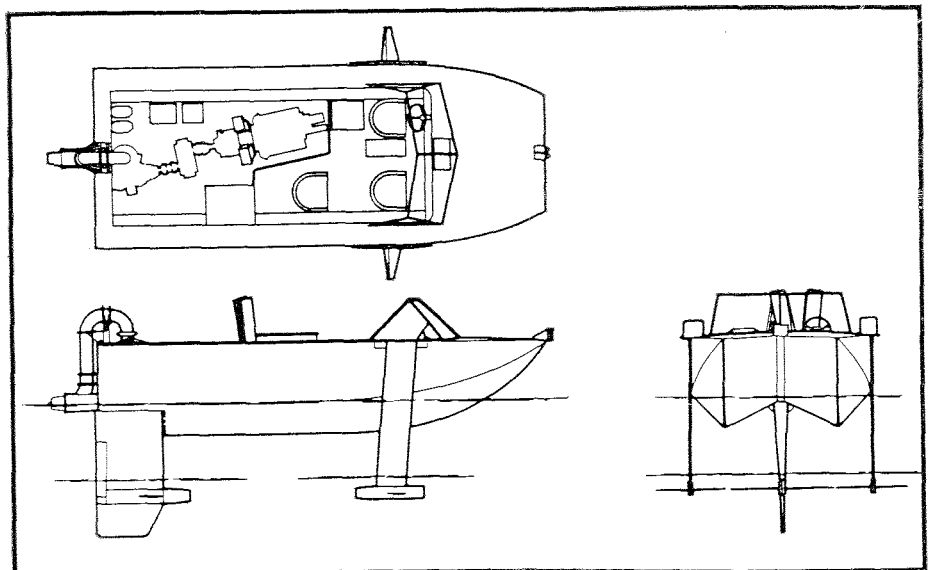
FOILS: The three fully submerged, fixed foils have subcavitating sections with trailing edge flaps. Control of lift is obtained through variable incidence by rotating each foil. The flaps are for lift augmentation during take-off and are retracted for cruising. The foil arrangement, two forward and one aft, is tandem in the sense that the total forward foil area is equal to the aft foil area.

The foil incidence can be adjusted during operation, compounding the action of the moveable control surfaces. A Boeing automatic control system is installed that utilises craft motion and height inputs to maintain foilborne flight.

HULL: Built in plywood, the hull is of stepped "W" form. This configuration was chosen as it would provide greater roll safety for the craft.



Little Squirt is employed by Boeing for waterjet research. Propulsion water enters a scoop at the base of the aft strut and is ducted upwards to a double-suction centrifugal pump powered by a Boeing 502 gas turbine



Little Squirt, Boeing's waterjet research craft

POWERPLANT: The waterjet is provided by a double-suction centrifugal pump powered through a reduction gearbox by a Boeing 502 gas-turbine rated at 450 hp. The propulsion water enters a ram scoop at the base of the aft strut and is ducted upward through the pump. At 2,360 rpm the pump absorbs 425 hp and produces a flow of 3,600 US gallons (13.63 m³) per minute at a pressure head of 400 ft (121.9 m). The craft had completed more than 140 hours of foilborne operation by mid-June 1968.

DIMENSIONS, EXTERNAL:

Length overall, hull	22 ft (6.71 m)
Length waterline, hull	17.1 ft (5.20 m)
Length over foils	22 ft (6.71 m)
Hull beam	8 ft (2.49 m)
Width across foils	11.25 ft (3.43 m)
Draft afloat	5.5 ft (1.68 m)
Draft foilborne	8 in to 2.5 ft (0.2 m to 0.7 m)
Freeboard	3.0 ft (0.91 m)

WEIGHTS:

Light displacement	2.28 tons
Max. take-off displacement	2.65 tons
Useful load	0.37 tons

PERFORMANCE:

Cruising speed, foilborne	48 knots
Max permissible wave height in foilborne mode	2.5 ft (0.762 m) waves

ACCOMMODATION:

Crew	1
Passengers	2

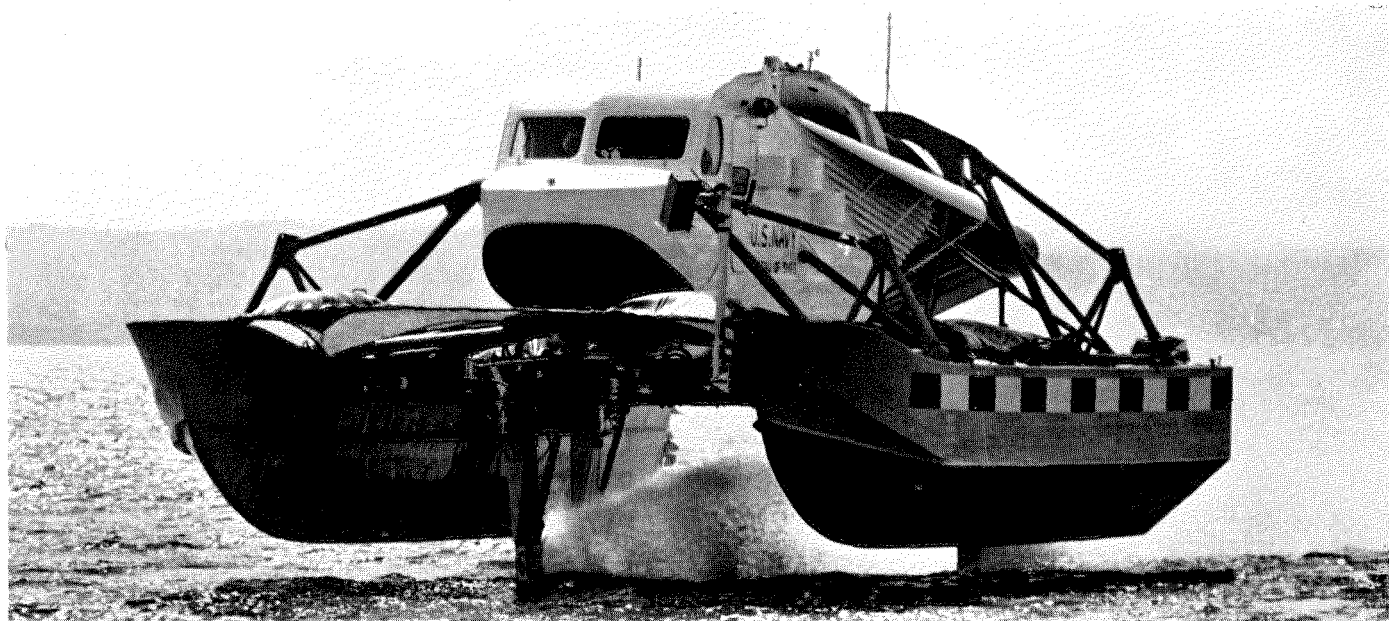
FRESH-1

The FRESH-1 (Foil Research Super-cavitating Hydrofoil) was built as part of the US Navy's accelerated research and development programme aimed at gathering data for the design of large, high-speed, ocean-going hydrofoils.

FOILS: The twin-hull catamaran arrangement provides a large, clear space between the hulls, within which different foil systems can be mounted. The foils and struts are attached to lateral beams between the hulls and may be positioned at several different longitudinal attachments point, providing a great deal of freedom in the choice of the foil locations. The foils have been arranged in a conventional configuration, with two foils forward and one aft, and also in a canard

HYDROFOIL MANUFACTURERS

United States of America: BOEING



The world's fastest hydrofoil is the 80-100 knot FRESH-1 (Foil Research Supercavitating Hydrofoil) twin-hulled test craft. Foils under test are attached to lateral beams which may be positioned at several different points between the hulls providing a choice of foil locations

configuration, with one foil forward and two foils aft.

The first system tested comprised three fully submerged and fully flapped foils of cambered-parabolic blunt base section. The foils, of machined 17-4 PH steel forgings, each had an area of 7.46 sq ft. The foil loading was 1,600 lb sq ft.

POWER PLANT: The choice of powerplant a JT3D-3 fan-jet developing 18,000 lb (8,200 kg) st—means the propulsion system does not disturb the water flow around the test foils.

Hullborne propulsion is supplied by two 75 hp outboard engines.

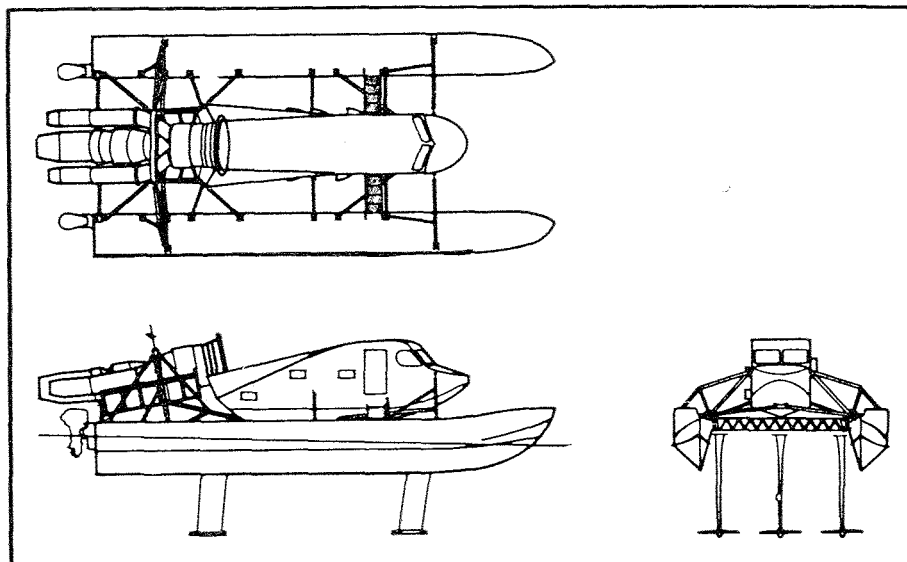
AUXILIARY POWER: Electrical and hydraulic power are furnished by a turbine-driven auxiliary power unit and by the main engine respectively. Auxiliary power systems have been designed to accommodate a wide range of future hydrofoil systems.

HULL: The catamaran hulls are in aluminium with steel truss members. The hull and cabin have been constructed to withstand a variety of loadings due to different attitudes of crash as a result of system failures during tests.

TEST EQUIPMENT: A most important tool in the test programmes is the analogue computer. An analogue simulation of the characteristics of each foil configuration is developed and maintained.

As the test data becomes available, the simulation is modified to ensure that it will duplicate the characteristics of the boat as accurately as possible. Before each test is run, it is simulated. It is possible in this way to analyse the system behaviour and thus determine the safety of the test. The accuracy of the simulation is most important if accidents or errors are to be avoided, particularly when a test is conducted near the limits of the boat's capability.

In the design of FRESH-1, the problem of data acquisition was given as much attention as the design of the craft itself. Because the purpose of the craft is testing untried foil systems, it was necessary to provide a data system capable of recording instantaneous and continuous dynamic data.



Foils under test on the FRESH-1 are attached to lateral beams between the hulls. They can be arranged in aeroplane configuration with two foils forward and one aft, and also in canard configuration. Foilborne cruising speed is 80-100 knots

The data system utilizes a magnetic-tape recording system with instrumentation capable of providing 84 continuous channels, 82 commuted channels sampled 20 times per second, and 176 pressure channels sampled once per second.

SYSTEMS:

ELECTRICAL: Turbine-driven 120/208 volt, 3-phase 400 cycle generator with 30 KVA continuous rating.

HYDRAULICS: Dual system for foil flaps; pressure, 3,000 psi.

DIMENSIONS, EXTERNAL:

Length overall, hull	47.0 ft (14.33 m)
Length waterline, hull	45.0 ft (13.72 m)
Length over foils	57.3 ft (17.44 m)
Hull beam	22.5 ft (6.86 m)
Draft afloat	10.5 ft (3.20 m)
Freeboard	2.5 ft (0.76 m)

WEIGHTS:

Light displacement	12.4 tons
Max. take-off displacement	16.5 tons
Useful load	4.1 tons

PERFORMANCE:

Cruising speed, foilborne	80-100 knots (148-180 km/h)
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Cruising speed, hullborne

4.5 knots (8.4 km/h)

ACCOMMODATION:

Crew 3

PGH-2 TUCUMCARI

A 58-ton waterjet-propelled hydrofoil gunboat, the PGH-2 was ordered from Boeing by the US Navy's Ship Systems Command in 1966, under a \$4 million, fixed price PGH (Patrol Gunboat Hydrofoil) programme. Launched in July 1967, the craft first became foilborne in mid-October and was handed to the US Navy for testing and evaluation in February 1968.

The craft is now operating with the US Navy Pacific Fleet Amphibious Command and is based at San Diego.

FOILS: Like High Point, Tucumcari has a fully submerged canard arrangement with retractable foils. Unlike High Point however, the aft foils are divided for sideways retraction, instead of retracting vertically, and the single forward strut retracts forward into a slot in the bow. Doors preserve the hull lines when the strut is either fully extended or retracted.

HYDROFOIL MANUFACTURERS

BOEING: United States of America



Boeing PGH-2 Tucumcari hullborne with foils retracted clear of the water. The craft is now based at San Diego and is operating with the U.S. Navy's Pacific Fleet Amphibious Command

Foils and their struts are fabricated in 17-4PH steel and have thin sections to avoid cavitation within the speed design range. Control flaps on the three foils are of marine aluminium alloy.

Both aft foils have anhedral to reduce their tendency to ventilate in banked turns.

CONTROLS: A Boeing automatic control system stabilizes the craft in foilborne operation. This system consists of dual sonic height sensors; an inertial sensor package with vertical gyro, yaw rate gyro and vertical accelerometer; command signal equipment, control system computer and the hydraulically actuated control surfaces. The helmsman is responsible for controlling craft heading from the bridge through a wheel which controls the steerable bow foil. Height command is the only other manual input and this control is used primarily during take-off and landing.

HULL: The hull shape is designed to minimize the structural loadings due to wave impact. It has a 25 degree deadrise, rounded chines, a flaring bow and straight runs aft. Construction is entirely of welded aluminium and careful design has resulted in a relatively low hull weight of 10 tons. The deckhouse includes both welded and mechanically fastened aluminium structures. Four watertight bulkheads are incorporated.

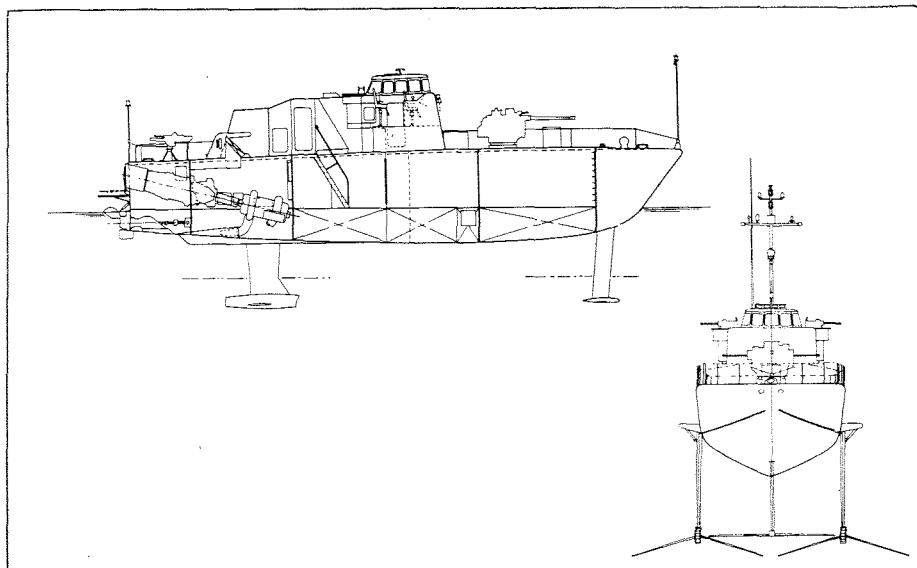
POWER PLANT (foilborne): The waterjet propulsion system consists of a 3,200 hp Rolls Royce Proteus gas turbine driving a lightweight Byron Jackson two-element double suction centrifugal pump through a direct coupling.

Water is drawn into the system through two ports in the two aft foil/strut intersection pods then ducted up through the hollow struts to the pump's intakes, each strut supplying one pump element. From the pump it is discharged through two nozzles beneath the transom. The system ejects about 27,000 US gallons (102 m³) of water a minute, providing 24,000 lb (10,000 kg) thrust.

POWER PLANT (hullborne): A Buehler centrifugal pump, powered by a General Motors 160 hp diesel propels the vessel when



Main armament of the PGH-2 comprises a 40 mm gun forward of the bridge and an 81 mm mortar aft. Manually operated twin .50 machine guns on ring mountings are sited aft of the wheelhouse on each side of the bridge superstructure. Foilborne cruising speed is in excess of 40 knots



Boeing PGH-2 Tucumcari

hullborne. Steering and reversing are accomplished by vectoring the water jet exit flow, eliminating the need for reverse gearing.

The propulsion machinery space is divided into two watertight compartments. The hullborne diesel is located in one compartment and the Proteus in the other, permitting the craft to operate with either engine compartment flooded. Both foilborne and hullborne waterjet pumps are designed to operate under water in an emergency.

ARMAMENT: Main armament comprises a 40 mm gun forward of the bridge and an 81 mm mortar aft. Hand operated twin .50 machine guns are sited each side of the bridge.

DIMENSIONS, EXTERNAL:

Length overall, hull 70 ft 1 in (21.64 m)
Length waterline, hull 66 ft 0 in (20.12 m)

Length overall:	
foils retracted	80 ft 0 in (24.38 m)
foils extended	74 ft 6 in (22.71 m)
Hull beam	19 ft 6 in (5.94 m)
Max. beam:	
foils retracted	25 ft 0 in (7.62 m)
foils extended	35 ft 4 in (10.77 m)
Draft afloat (foils retracted)	4 ft 6 in (1.37 m)
Freeboard	7 ft 0 in (2.13 m)

WEIGHTS:

Light displacement	40.8 tons
Max take-off displacement	57.4 tons
Useful load (fuel, water, equipment, armament and crew)	18.7 tons

PERFORMANCE:

Cruising speed, foilborne
in excess of 40 knots

ACCOMMODATION:

Crew

FMC**FMC CORPORATION**

Ordnance Engineering Division

HEAD OFFICE:

1125 Coleman Avenue, Box 367, San Jose,
California

The Ordnance Engineering Division of FMC Corporation has engaged in concept, research, design, development and production of defence material for over 25 years, starting early in World War II with the design and production of over 11,000 amphibious assault vehicles. Current activities include the development of amphibious vehicles, railroad cars, hydrofoil craft, landing craft, airborne multipurpose vehicles, and operations analyses studies.

During World War II, FMC designed, developed and produced seven versions of LVTs, under contract to the Bureau of Ships.

Current amphibious vehicle programmes being conducted for the Bureau of Ships are: Landing Craft Assault (LCA), Landing Vehicle Hydrofoil (LVHX2), Assault Amphibian Personnel Carrier (LVTPX12), and Landing Vehicle Tracked Family of Vehicles (LVTP5A1).

The LVHX2 is the final product of a programme which began in 1961 and included design, development, scale-model hull and foil testing, and fabrication of two full-scale vehicles. This vehicle is 38 ft long, capable of 35 knot foilborne speed, and 40 mph land speed while transporting a 5-ton cargo.

The division also designed and developed the L312G hydrofoil test craft for the purpose of optimising hydrofoil system configurations and draft control systems. This 30 ft craft carries 12 passengers at speeds up to 45 knots. The latest hydrofoil passenger craft built by the company is the 48 passenger L548D.

LVHX-2

Designed and built for the US Navy Bureau of Ships, the LVHX2 is an amphibious, aluminium-hulled, 38 ft hydrofoil landing craft with a cargo capacity of 10,000 lb. Its mission is the high-speed transfer of cargo and equipment from ship to shore during amphibious assault operations. It operates foilborne to the surf zone, negotiates off-shore waters and the surf in the displacement mode, then quickly moves inland on four large, sand-type tyres.

The maximum foilborne water speed is 35 knots. Maximum displacement speed is 12 knots, and maximum land speed on hard surfaces is 40 mph.

FOILS: The foil system consists of split forward surface-piercing foils and a rear foil which remains fully submerged. The foil struts retract vertically into the hull and the hinged sections of the forward foil fold upward into recesses in the hull sides.

The foils may be retracted or extended while in motion. A simple autopilot system is used to provide a smoother ride in State 3 seas and to counteract adverse effects of a following sea. The LVHX2 can be operated, however, in the foilborne mode without the autopilot.

POWER PLANT: The LVHX2 is powered by an 1,100 hp Solar T1000-S27 two-shaft gas turbine engine. The integrated drive system permits use of marine and land power simultaneously when needed. This system also increases vehicle reliability and decreases



Land power for the LVHX2 is transmitted from the 1,100 hp Solar T 1,000-S27 gas turbine to the wheels through an Allison TX 365-2 six speed transmission and non-slip differentials



The LVHX2, an amphibious hydrofoil landing craft built by FMC for the US marines. The craft operates at 35 knots to the surf zone, negotiates shallow areas as a displacement craft, then moves quickly inland on four sand-type tyres

HYDROFOIL MANUFACTURERS

FMC: United States of America

weight. Power for marine operation is transferred through a marine reverse gear to the vertically-retracting rear strut assembly of the aft foil. This arrangement provides full power transmission to the propeller when the strut is being extended or retracted. For land operation, the gas turbine engine is de-rated to the necessary power level. Land power is transmitted to the wheels through an Allison TX365-2 six-speed transmission and non-slip differentials. The craft is capable of negotiating 60% slopes in forward or reverse and can operate on 30% side slopes. **CONTROLS:** Three power-assisted steering modes are provided; conventional two-wheel steering, conventional four-wheel steering, and oblique four-wheel steering. The four wheels are individually suspended by a simple air-spring and hydraulic shock absorber system which provides a smooth ride over rough terrain. The wheels are retractable for water operation to facilitate loading and unloading in the land mode. Individual wheel retraction capability permits the vehicle to "kneel", "squat", or tilt, simplifying cargo loading and unloading on irregular terrain.

Air pressure in the 8-00 x 25 sand-type tyres can be varied by a central inflation system controlled by the driver.

Two LVHX2 prototypes have successfully completed Navy acceptance trials and are currently under test by the US Marine Corps. **DIMENSIONS:**

Length overall	37 ft 0 in (11.28 m)
Vehicle width	10 ft 6 in (3.20 m)
Width over main foil	21 ft 6 in (6.55 m)
Freeboard, combat weight	3 ft 9 in (1.14 m)

WEIGHTS*:

Combat	17.4 tons
Net	12.9 tons
Payload	4.5 tons

PERFORMANCE:

Fuel capacity	430 US gal (1,625 litres)
Speed foiborne	35 knots (65 km/h)
Speed, afloat	12 knots (22 km/h)
Speed, beaching	8 knots (15 km/h)
Speed, land	40 mph (64 km/h)
Gradeability, forward slope	60%
Gradeability, side slope	30%
Turning radius, foiborne	300 ft (91.4 m)
Turning radius, afloat	75 ft (22.9 m)
Turning radius, land	35 ft (10.7 m)
Endurance on water at 35 knots	5 hrs
Endurance on land at 25 mph	10 hrs

***Weight**

Combat: Weight of vehicle fully equipped and serviced for combat, including crew and payload for 10,000 lb.

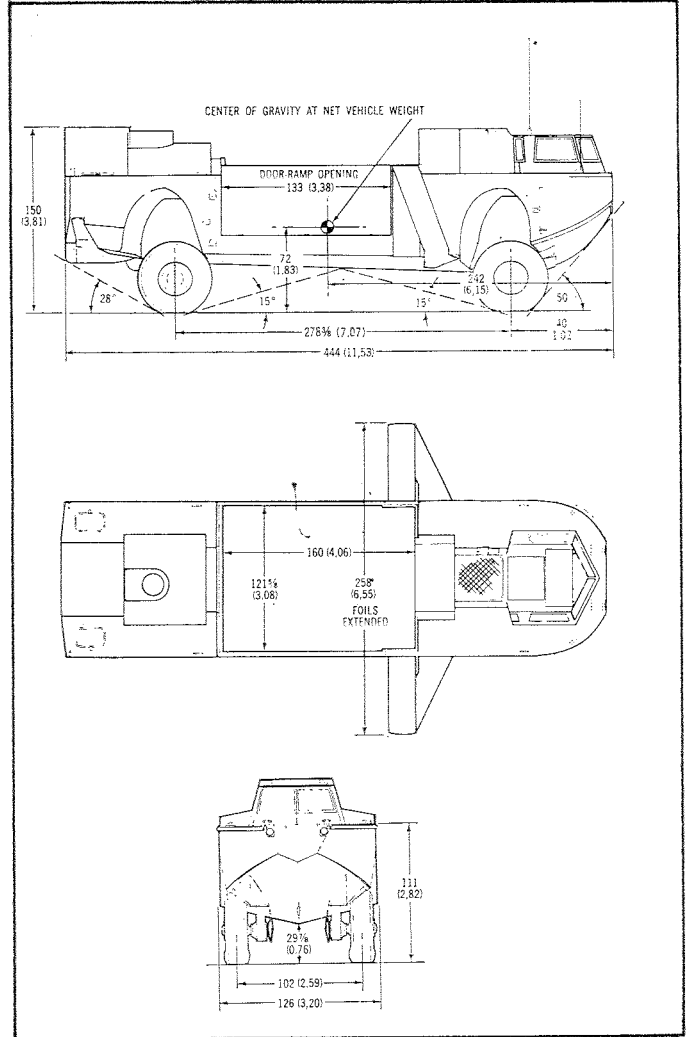
Net: Weight of vehicle fully equipped and serviced for combat, including crew, but without payload.

L548D

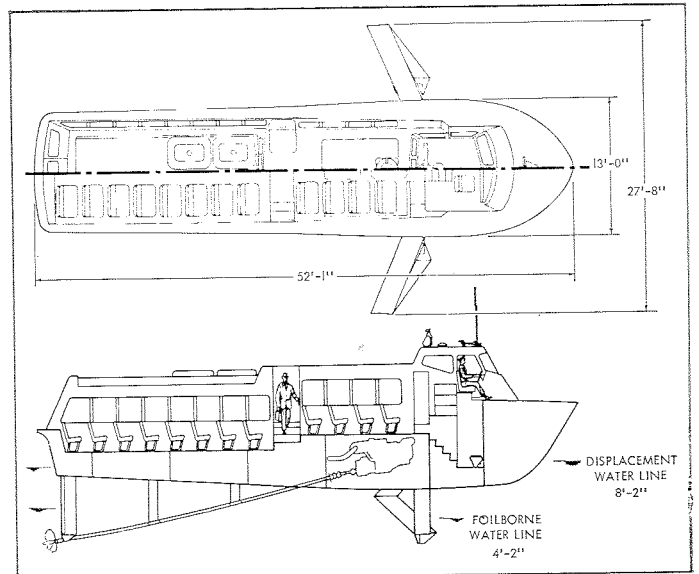
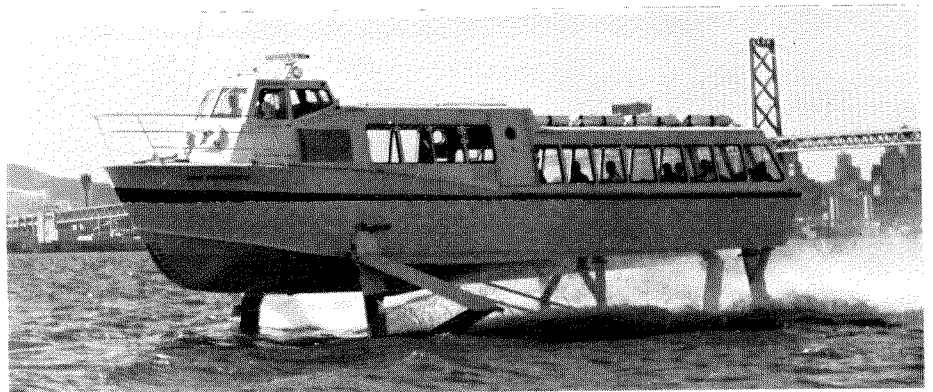
Designed for fast, comfortable services across bays, lakes and sounds, the L548D hydrofoil passenger ferry has an operating cost of about 3½ cents per seat mile at 100% load factor. The prototype has logged over 3,500 miles during engineering tests in San Francisco Bay.

The maximum operating displacement is 14.29 long tons which includes 4.33 long tons of useful load. Design speeds are 45 mph maximum, 41 mph cruising and 10-11 mph during hullborne operation.

Right: LVHX2 landing vehicle hydrofoil. Two are undergoing tests with the US Marine Corps



Below: FMC Corporation's L548D 48-seat hydrofoil passenger ferry. Twin Cummins VT8-390 M diesels, each rated at 390 hp at 3,000 rpm and driving counter-rotating propellers give the craft a cruising speed of 41 mph (66 km/h)



The L548D 48-seat passenger hydrofoil for bays, lakes and sounds

HYDROFOIL MANUFACTURERS

United States of America: FMC



Seating 12 passengers and capable of speeds in excess of 45 mph (72 km/h), the FMC L312G is a 30 ft (9.14 m) test and demonstration craft. It was used to obtain data for the design of the 48-passenger L548D

FOILS: A combined surface piercing and submerging foil configuration is employed, with two forward surface piercing foils supporting 70% of the load and two fully submerged aft foils supporting the remainder. The foils, which are fixed, are built in aluminium. The foil configuration is designed to be inherently stable in any expected combination of heave, pitch, roll and yaw.

To prevent settling in a following sea and also to smooth out the ride generally, a Hamilton Standard stability augmentation system automatically controls trailing edge flaps on the forward foils to provide additional stability in heave and roll. Rudder flaps are fitted to the trailing edges of the aft foil struts for steering control.

HULL: The craft is of welded aluminium construction and carries 48 passengers in an attractive, soundproofed cabin with a temperature controlled ventilation system.

POWER PLANT: Power is provided by twin Cummins VT8-390M watercooled diesels, each with a normal service output of 390 hp at 3,000 rpm. Each engine drives its own propeller shaft and the twin screws are contra-rotating. Controls are all sited in an elevated wheelhouse with a 360°-view at the fore end of the passenger compartment.

The engine transmission units are mounted in a compartment below the forward passenger deck. Removal seat deck sections and a removable roof hatch facilitate speedy replacement of either unit.

ACCOMMODATION: Passengers are accommodated in a split-level cabin with 32 in the main, aft compartment, and 16 in the forward

compartment. Access to both is through either of two gull-wing doors located amidships, port and starboard. Separate doors, port and starboard, are provided for the pilot and crew. An emergency window exit is provided in the aft passenger compartment.

A full range of safety equipment is carried, including four portable fire extinguishers, life jackets for each passenger and crew member, plus five additional children's life jackets. Inflatable rafts, catering for 50% of the passenger and crew capacity (minimum) are also carried.

SYSTEMS AND CONTROLS: Standard electrical equipment of the L548D includes a Raytheon Model DE-718A depth sounder, a Raytheon Model 1065C radio-telephone and Decca 202 radar.

DIMENSIONS:

Length overall, hull	52 ft 1 in (15.88 m)
Length waterline, hull	47 ft (14.32 m)
Hull beam	13 ft (3.96 m)
Width across foils	27 ft 8 in (8.43 m)
Draught afloat	8 ft 2 in (2.49 m)
Draught foilborne	4 ft 2 in (1.27 m)
Freeboard	5 ft 8 in forward (1.73 m) 3 ft 6 in aft (1.07 m)

WEIGHTS:

Gross tonnage	36
Net tonnage	24
Light displacement	9.96 long tons
Max take-off displacement	14.29 long tons
Useful load	4.33 long tons

PERFORMANCE:

Cruising speed, foilborne	41 mph (66 km/hr) 45 mph max (72 km/hr)
Cruising speed, hullborne	10-12 mph

Sea State capability	2
Design foilborne range	270 statute miles (334 km)
Turning radius at cruising speed	550 ft (167.6 m)
Fuel consumption at cruising speed	32 gal/hr (22.7 litres/hr)
Fuel consumption, hullborne	5 gal/hr (13.6 litres/hr)

L312G

After completing the basic design of the LVHX2, the FMC Ordnance Division conducted a company-sponsored research programme into hydrofoil systems. Following this investigation, it was decided to build a 30 ft test and demonstration hydrofoil to verify the results of the study and to provide a test vehicle for further research.

The L312G, an all-aluminium craft with surface-piercing main foils, was launched in September 1964.

Powered by a Daytona Marine rated at 380 hp at 3,800 rpm, it has a maximum speed of 50 mph. Seats for 12 passengers are provided in the enclosed cabin, or alternatively, 2,880 lb of equipment or cargo can be carried.

DIMENSIONS:

Length overall	30 ft (9.14 m)
Hull beam	9 ft (2.74 m)
Width across foils	17 ft 6 in (5.33 m)
Draught afloat	5 ft 3 in (1.6 m)
Draught foilborne	2 ft (0.6 m)
Displacement:	
Nett	5,900 lb (2,676 kg)
Gross	9,500 lb (4,309 kg)
Range at gross weight	120 mile (193 km)

HYDROFOIL MANUFACTURERS**GENERAL DYNAMICS:** United States of America**General Dynamics
QUINCY DIVISION****HEAD OFFICE:**

97 East Howard Street, Quincy, Massachusetts 02169

TELEPHONE:

617 471-4200

General Dynamics has entered into a licence agreement with Supramar Ltd of

Lucerne, Switzerland, under which General Dynamics will manufacture and sell hydrofoil boats in the United States and other Western Hemisphere nations based on Supramar's patents and engineering drawings.

Responsibility for hydrofoil programmes has been assigned to the Convair Division in San Diego, California, which is exploring adaptation of Supramar hydrofoil concepts for

a number of military missions, including fast patrol boats, antisubmarine warfare and air-sea rescue missions.

General Dynamics also will direct its efforts to expand the use of hydrofoils as fast, stable passenger ferries on lakes, rivers and coastal waters, for Coast Guard and customs work, and for use in connection with off-shore drilling operations.

HYDROFOIL MANUFACTURERS

United States of America: GRUMMAN

Grumman**GRUMMAN AIRCRAFT ENGINEERING CORPORATION****HEAD OFFICE:**

Bethpage, Long Island, USA

CABLES:

Grumair

DIRECTOR:

E. C. Towl

WORLDWIDE DISTRIBUTOR AND SALES AGENT FOR THE DOLPHIN:

The Garrett Corporation, 9851-9951, Sepulveda Boulevard, Los Angeles, California, 9009.

DIRECTORS:

H. H. Wetzell, President

W. J. Pattison, Vice-President, Sales and Service

J. W. Calvert, Director of Hydrofoil Sales

Grumman entered the hydrofoil field in 1956 when it acquired Dynamic Developments Inc. The initial product of this venture was the experimental XCH-4, built for the Office of Naval Research in 1955. Powered by two aircraft engines with air propellers, this eight-ton vessel established a world's speed record for hydrofoil craft, exceeding 78 knots (145 km/h). In 1958, the 60-knot XCH-6 Sea Wings, the first boat to employ supercavitating foils and a supercavitating propeller, was also built for the

Office of Naval Research. In the same year a hydrofoil kit designed by William Carl was made available for do-it-yourself installation on 14 to 16 ft (4.3 to 4.9 m) outboard runabouts.

In 1960, Grumman was awarded a contract by the Maritime Administration for the design and construction of the HS Denison, an 80-ton open ocean research vessel which was launched in June 1962. This craft (described in the 1967/8 edition) has been operated at speeds above 60 knots (111 km/h) demonstrating good foilborne manoeuvrability and seakeeping ability in rough water.

Grumman also designed the 320-ton, 212 ft (64.6 m) AG(EH) for the US Navy. The foils for this craft were the forerunners of those used on the Dolphin and the more recent PGH-1 Flagstaff.

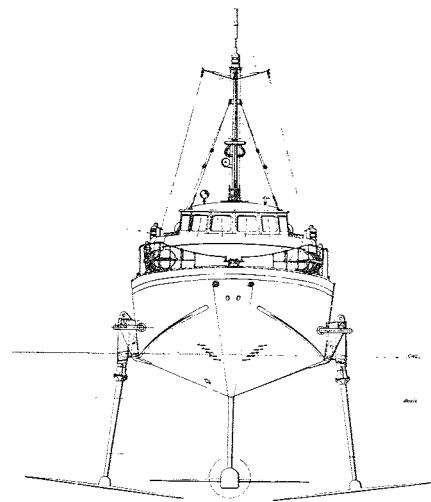
The Flagstaff is currently being evaluated by the US Navy. Dolphin class hydrofoils are being built for Grumman by Blohm & Voss, Hamburg, and the second craft was due to be completed during the autumn of 1968. Blohm & Voss will also build the 325 ton Grumman Neptune, a description of which appears in the entry for Blohm & Voss, Germany.

DOLPHIN

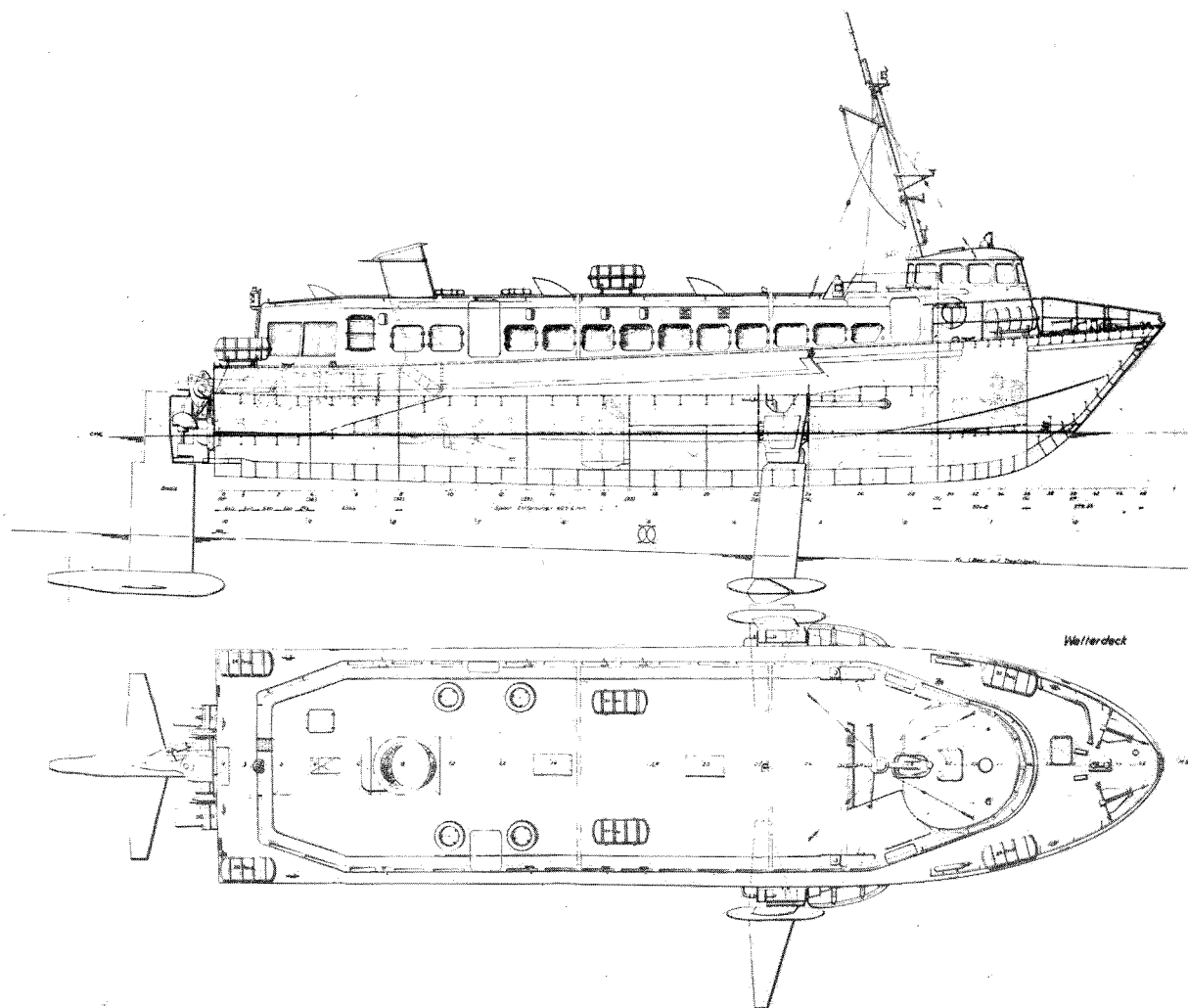
A 64-ton hydrofoil ferry, the Dolphin is designed to carry a maximum of 116 passen-

gers over routes of up to 300 nautical miles. Foilborne cruising speed of the vessel is 50 knots (93 km/h) and it can maintain schedules in 8-10 ft (2.4-3 m) waves.

It incorporates several design features resulting from operating experience with the Denison, but unlike the Denison it has fully submerged main foils. Foilborne power is supplied by a single Rolls-Royce Type 621 gas-turbine driving a KaMeWa propeller.



Blohm & Voss Hydrofoil 'Dolphin' end view



Dolphin—side and deck views

HYDROFOIL MANUFACTURERS

GRUMMAN: United States of America

The Dolphin is being built under contract by Blohm & Voss of Hamburg and marketed by the Garrett Corporation. The prototype was operated by Maritima Antares in the Canaries and has recently been purchased by an operator in the United States. The second Dolphin was due for trials in the autumn of 1968, and has also been sold to an American operator.

FOILS: The fully submerged foil system is of conventional aeroplane configuration with 70% of the weight supported by the two bow foils and 30% by the single tail foil, A Garrett electronic autopilot system controls the incidence angle of the three foils. The stern foil strut rotates for steering and all three foil struts are retracted hydraulically. The foils are of forged aluminium.

The Dolphin autopilot is fully automatic and can be programmed for specific water conditions. It consists of a bow-mounted height sensor, accelerometers, gyros, a solid state electronic computer and an electro-hydraulic foil control system. The sensor sends data on the height of water approaching the hull. The computer translates data from the height sensor, gyros and accelerometers into the optimum foil angle, and sends a continuous positioning signal to the control system.

HULL: The hull is of aluminium alloy construction. Transverse framing is utilised throughout and all frames and bulkheads are welded assemblies.

ACCOMMODATION: The elevated wheelhouse at the forward end of the passenger compartment provides side-by-side seating for the captain and an engineer. A single wheel is provided at the captain's station. All instrumentation is located so that it can easily be monitored. The crew normally comprises a captain, an engineer and one deck hand.

In addition to 116 and 60-80 passengers, first-class seating arrangements, low density luxury seating, workboat and cargo configurations are available. Crew and passengers' accommodation is air conditioned.

Four operators can order sight-seeing versions of the Dolphin with full vision windows extending the length of the superstructure on both sides. Alternatively, the entire passenger superstructure can be omitted and, for excursion trips on sheltered water, a top provided to roll up or down as desired. With an open well deck, the Dolphin can also be used as a workboat for servicing offshore oil rigs, and carrying high priority cargo.

Access to the passenger compartment is through an aft door on the starboard side. There are three emergency exits. A full range of safety equipment is carried, including approved life rafts, sufficient for the crew and 116 passengers. Life jackets for adults and children are also provided. The safety arrangements have been approved by Seeberufsgenossenschaft, Germany.

POWER PLANT: Foilborne propulsion is provided by a single Rolls-Royce Tyne 621 marine gas turbine, rated at 3,600 bhp at 14,500 rpm. Power is transferred through a mechanical right-angle drive transmission to a KaMeWa supercavitating, controllable-pitch stainless steel propeller of 3 ft 9 in (1-140 mm) diameter at the end of a strut

and pod assembly. Hullborne power is supplied by two 216 hp GM6 V-53 N diesels driving two waterjets, each fitted with a moveable nozzle and reversing bucket. An acoustic bulkhead and two rest rooms separate the power plant, which is mounted aft from the main passenger cabin.

COMMUNICATIONS AND NAVIGATION: Standard equipment includes an RCA Cruisephone 110 CRM P 12-A-100 radio telephone and Raytheon MP 1900 radar.

SYSTEMS:

AIR CONDITIONING: Anton Kaeser, type Granturbo HLHK IE 325.

ELECTRICAL: Diesel generator GM 3-53 N model 5034-8100/GE 40kW/225/450 V, 60 cps for auxiliary power, lighting, master warning, monitoring system and autopilot.

HYDRAULICS: 210 atu for strut retraction, foil incidence control and auxiliary power.

APU: Batteries for autopilot system.

DIMENSIONS, EXTERNAL:

Length overall, hull	74 ft 3 in (22-63 m)
Length waterline, hull	66 ft 8 in (20-32 m)
Length overall, foils retracted	86 ft 4 in (26-31 m)
Length overall, foils extended	89 ft 11 in (27-40 m)
Hull beam	18 ft 8 in (5-68 m)
Beam overall, foils retracted	32 ft 2 in (9-80 m)
Beam overall, foils extended	36 ft 10 in (11-24 m)
Draft afloat, foils retracted	4 ft 2 in (1-28 m)
Draft afloat, foils extended	12 ft 10 in (3-91 m)

Draft foilborne

3 ft 11½ in-8 ft 6 in (1-20 up to 2-60 m)	
Freeboard	5 ft 9 in (1-75 m)
Height overall	45 ft 7 in (13-90 m)

DIMENSIONS, INTERNAL:

Superstructure includes the wheelhouse, passenger cabin, toilets and upper part of the plenum chamber. The wheelhouse, passenger cabin and toilets are separated by partitions; the plenum chamber by a bulkhead.

Length	42 ft 8 in (13-00 m)
Max width	15 ft 3 in (4-65 m)
Max height	6 ft 5 in (1-95 m)
Floor area	613 sq ft (57-00 m ²)
Volume	(110-00 m ³)

BAGGAGE: Racks for hand luggage in passenger cabin, baggage hold in forepeak.

WEIGHTS:

Gross tonnage	83 tons
Net tonnage	52 tons
Light displacement	50 tons
Normal take-off displacement	67 tons
Max take-off displacement	69 tons
Normal deadweight	17 tons
Max deadweight	19 tons
Normal payload	10 tons
Max payload	12 tons

PERFORMANCE (with normal payload):

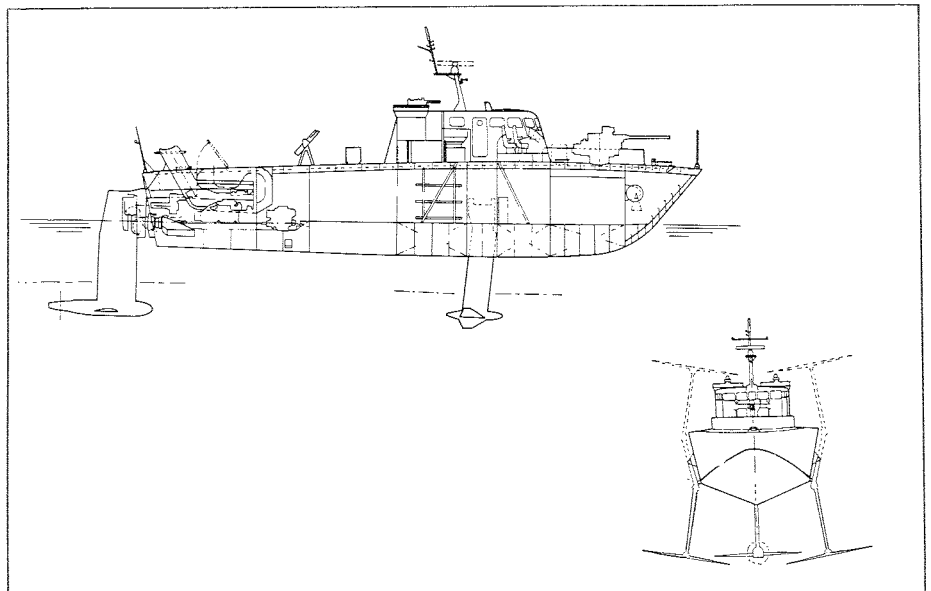
Max speed, foilborne	50 knots (93 km/h):
Max speed, hullborne	10½ knots (19 km/h)
Max permissible wave height in foilborne mode	11 ft 6 in (3-5 m)
Cruising speed, foilborne	48 knots (90 km/h)
Cruising speed, hullborne	10 knots (14 km/h)
Designed endurance and range at cruising speed	approx 300 n.m.
Turning radius at cruising speed	656 ft (200 m)
Number of sec and distance to take-off	25 sec 590 ft (180 m)
Number of sec. and distance to stop craft	6-2 sec 230 ft (70 m)
Fuel consumption at max speed	257 gallons per hour
Fuel consumption at cruising speed	250 gallons per hour

SEA TEST: Tests have been undertaken in sea states 4, 5 and 6. In state 3 seas the maximum vertical acceleration has been 0-095 g. Beyond sea state 3 accelerations have been from 0-1 to 0-29 g. Accelerometers were located amidships.

PG(H)-1 FLAGSTAFF

The 65-ton PG(H)-1 Flagstaff hydrofoil gunboat was developed from the civil Dolphin. It was due to be delivered to the US Navy for trials in September 1968.

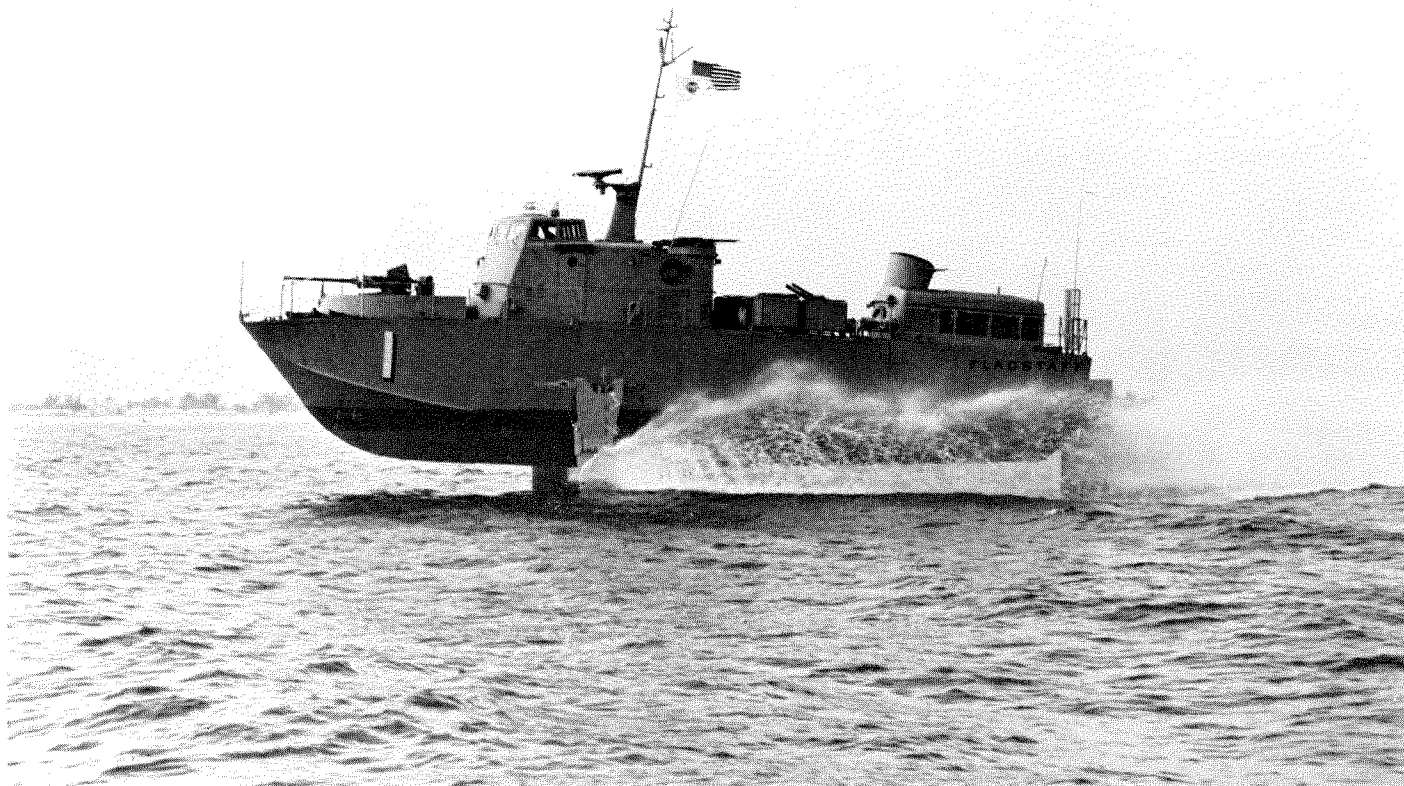
FOILS: The fully submerged foil system is of aeroplane configuration, with approximately 70% of the weight supported by two bow foils and 30% by the single tail foil. The three foils are incidence-controlled and operated by an electronic autopilot. The stern foil strut rotates for steering and all three foil struts retract hydraulically, completely clear of the water.



Grumman PGH-1 Flagstaff

HYDROFOIL MANUFACTURERS

United States of America: GRUMMAN



The Grumman PGH-1 undergoing tests at the Naval Ship Research and Development Center's Hydrofoil Special Trials Unit, Bremerton, Washington

HULL: The hull is of aluminium alloy construction. All frames and bulkheads are welded assemblies and transverse framing is used throughout.

ARMAMENT: The main armament comprises a 40 mm gun mounted forward of the bridge and an 81 mm mortar aft. Manually-operated twin .50 machine guns on ring mountings are sited each side of the bridge.

PROPULSION: The main engine is a 3,600 hp Rolls-Royce Marine Tyne 621 gas-turbine driving supercavitating KaMeWa controllable pitch propeller through a mechanical right-angle drive transmission. Hullborne power is supplied by two 320 hp General Motors disselers driving two waterjets.

DIMENSIONS:

Length overall	73 ft 0 in (22.2 m)
Length waterline, hull	66 ft 8 in (20.3 m)
Hull beam	21 ft 5 in (6.5 m)
Length overall, foils retracted	86 ft 4 in (26.3 m)
Length overall, foils extended	89 ft 0 in (27.1 m)
Max beam, foils retracted	34 ft 0 in (10.3 m)
Max beam, foils extended	37 ft 2 in (11.3 m)
Draft afloat, foils retracted	4 ft 3 in (1.3 m)
Freeboard, minimum	6 ft 6 in (1.9 m)

WEIGHTS:

Max take-off displacement 65 tons app

PERFORMANCE:

Cruise speed, foilborne

In excess of 40 knots (76 km/h)

Crew

13

AG(EH)-1 PLAINVIEW

The 320 ton AG (EH)—the designation

means auxiliary general experimental hydrofoil—was built by the Lockheed Shipbuilding & Construction Company, Seattle, Washington. It is being used by the US Navy's Hydrofoil Special Trials Unit, Bremerton, Washington to investigate the performance of a large seagoing hydrofoil under operational conditions. The guidance design and preparations of contract specifications were undertaken by Grumman under the direction of the Bureau of Ships.

Initially the craft will operate at subcavitating speeds below 60 knots, but the design provides for subsequent doubling of power and adaptation to high speed supercavitating foils. The hull is therefore built to withstand wave impacts at 90 knots.

FOILS: The foil system is fully submerged and automatically controlled by a Hamilton Standard autopilot system similar to that used in High Point. The foil arrangement is of the conventional "aeroplane" type with 90% of the weight carried on the two main foils and the remainder on the aft foil. The stern foil strut rotates for steering and all three foils struts retract completely clear of the water. The three foils, which have considerable sweep and taper, are geometrically similar with an aspect ratio of 3. The swept back leading edges help to delay cavitation and facilitate the shedding of seaweed and other neutrally buoyant debris. They also reduce impact loads associated with water entry after foil broaching. The main foils have some dihedral while the tail foil is flat. All three foils are incidence controlled.

HULL: The hull is almost completely fabricated of 5456 aluminium alloy. All

deck, side and bottom plating is made from integrally stiffened, aluminium extruded planks. The hull is predominantly welded construction with the exception of the pilot house and certain longitudinal hull seams that act as crack stoppers.

The hull shape is designed to minimize the structural loadings due to wave impact and the bow shape has been developed for this specific purpose. Bottom deadrise is carried all the way to the transom with the objective.

POWER PLANT: Foilborne propulsion is supplied by two General Electric LM 1500 gas turbines (marine version of the J-97) of 14,000 bhp continuous rating, connected by shafting and gearing to two supercavitating propellers at the end of the propulsion pods on the main foils. The air inlet for the main turbines is introduced at the top of the deckhouse. Because of the need to prevent ingestion of water or saltspray into the gas turbines, there are lowered deflectors over the inlet opening, followed by a bank of sheet metal spray separators.

There is a dam for solid water separation and four right angle turns before the air reaches the engine bellmouths.

The hullborne powerplants are two Curtiss-Wright Model 12v-142 diesels rated at 900 hp maximum and 700 hp continuous. Each diesel drives aft through a shaft to a right angle gear drive resembling a large outboard motor, mounted on the side of the hull. Each of these right angle drives is retractable about a horizontal axis and steerable about a vertical axis through 360 deg. rotation. A subcavitating propeller is mounted at the end of each right angle drive.

HYDROFOIL MANUFACTURERS

GRUMMAN: United States of America

Auxiliary power is supplied by two Cummins VT8-430 diesels rated at 260 hp continuous and each is capable of providing all the ships' hydraulic and electric power. Normally one is operating while the other serves as a standby. In addition to the diesels a small gas turbine auxiliary power unit is carried, which drives a 200 hp hydraulic motor capable of starting both main engines simultaneously.

SYSTEMS:

AIR CONDITIONING: The pilothouse, CIC compartment, living, messing and berthing spaces are air-conditioned during the cooling season by a 13 ton capacity freon type compressor system. Sanitary and washroom areas, galley, displacement engine room, main engine room, windlass room and the engineers control booth are all mechanically ventilated.

DIMENSIONS:

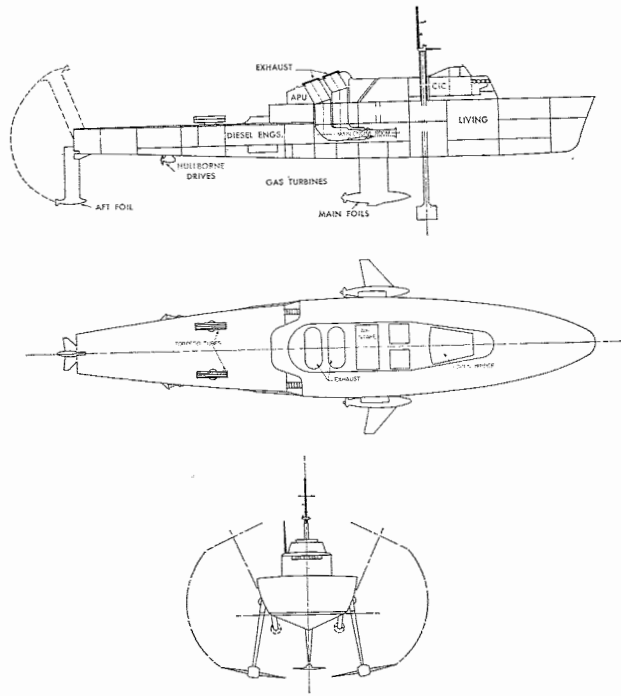
Length overall	212 ft 0 in (64.6 m)
Max beam	40 ft 0 in (12.2 m)
Draught afloat, foils retracted	6 ft 0 in (1.8 m)
Draught afloat, foils extended	25 ft 0 in (7.6 m)

WEIGHTS:

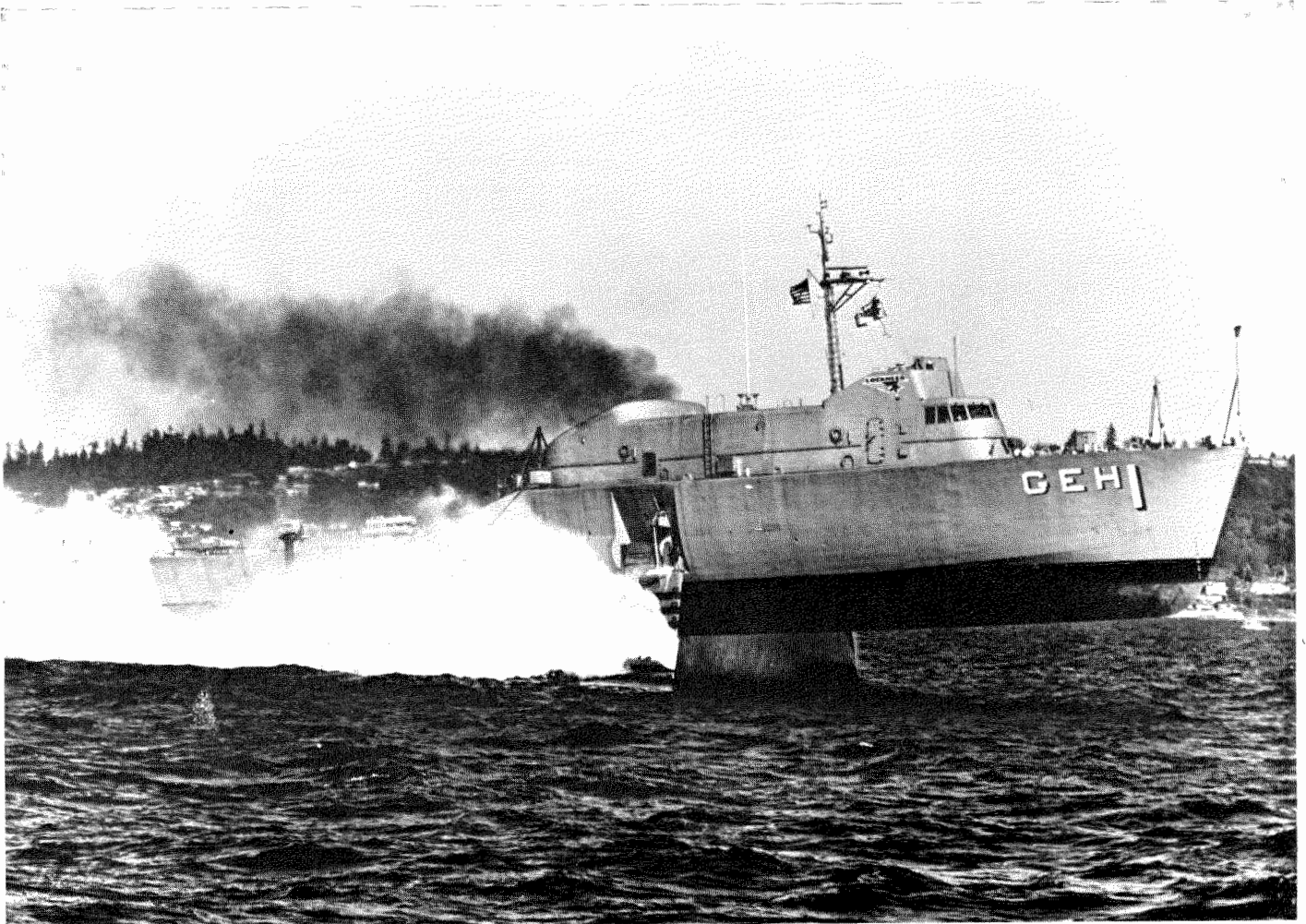
Displacement	320 tons
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PERFORMANCE:

Max speed foilborne	50 knots plus (8.29 km/h) plus
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The US NAVY'S AG (EH) experimental hydrofoil designed by Grumman and built by the Lockheed Shipbuilding & Construction Company



The P-1 undergoing tests at the Naval Ship Research and Development Center's Hydrofoil Special Trials Unit, Bremerton, Washington

HYDROFOIL MANUFACTURERS

United States of America: HONOLD/INTERNATIONAL HYDROLINES

Honold**LUDWIG HONOLD MANUFACTURING COMPANY****HEAD OFFICE:**

Chester Pike and Folcroft Avenue, Folcroft,
Pennsylvania

The introduction of Albatross marked the entry of the United States into the commercial hydrofoil field. The first commercial hydrofoil service in the New York area was inaugurated with the departure of an Albatross with 16 passengers aboard from Port Washington, Long Island, bound for the foot of Wall Street in Manhattan, on July 15, 1963.

The craft was designed by Helmut Koch for Ira Dowd's American Hydrofoils, Inc, and the prototype was built in Wilmington, California. Production craft for the New York World's Fair service operated by American Hydrofoils Inc were built by Ludwig Honold.

American Hydrofoils reported that during the World's Fair they carried just over 100,000 passengers for a total of 1,600,000 passenger-miles (2,575,000 passenger-km), without a single reported passenger injury.

Albatross operators currently include United States Hydrofoils, Miami, New York Hydrofoils Inc and Crillion Tours Ltd, La Paz, Bolivia.

In addition to the production-type Albatross, Ludwig Honold has developed a sports fishing model, equipped with fishing chairs in a large cockpit and a flying bridge atop the cabin.

ALBATROSS

The Albatross was the first hydrofoil in the United States to be certificated by the Coast Guard for passenger services in lakes, bays and sounds.

Accommodation is provided for 22 passengers in twin, aircraft-type seats arranged two abreast along a centre aisle. On short routes only one crew member is normally carried to navigate the craft but two are carried at night.

Power is supplied by a General Motors 6V-53 diesel, developing 197 shp at 2,800 rpm, and driving a single screw through a 1.5 : 1 reduction gear. The inclined drive shaft is supported in the middle by a vee strut.

The hull, of the deep vee stepped type, is of all-welded aluminium construction. All side-panels throughout the cabin area and all spaces beneath the passenger deck not utilis-

ed for machinery and control equipment are filled with an approved foam for structural reinforcement and buoyancy.

The fixed-surface piercing foils are of welded aluminium construction and are fastened, with their supporting struts, to the hull attachment plates with stainless steel bolts. These are designed to shear off to prevent hull failure in case of grounding or collision with a submerged object.

The rudder post is utilised for the rear foil centre support, the propeller shaft bearing, and to accommodate the engine cooling water scoop and injection piping.

The navigation, fire protection and life-saving equipment is as specified by the US Coast Guard for small passenger craft. The steering system is hydraulically operated and a manual tiller is provided for emergencies.

DIMENSIONS:

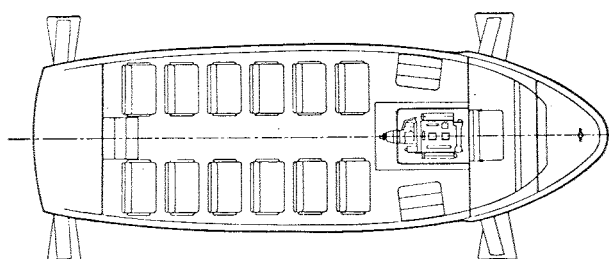
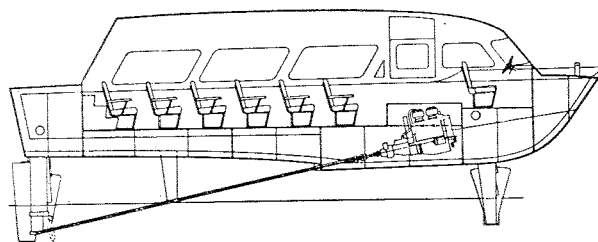
Length	34 ft 1 in (10.39 m)
Beam	11 ft 4 in (3.45 m)
Width across foils	15 ft 2 in (4.62 m)
Draught afloat	6 ft 6 in (1.98 m)
Draught foilborne	2 ft 6 in (0.76 m)

WEIGHTS:

Displacement	6 tons
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PERFORMANCE:

Cruising speed foilborne	28 knots
Max speed	35 knots



The 22-seat ALBATROSS—first hydrofoil to be approved by the US Coast Guard for commercial passenger service

HONO-FOIL SPORTFISHERMAN

Sportfisherman is built to provide rapid passage to and from fishing grounds. It is basically similar in construction to the Albatross, but equipped with a large cockpit with fishing chairs aft of the cabin superstructure, and a flying bridge for improved vision.

It is reported that interest in the Boston area in a fast means of getting lobsters to market may result in a cargo version based on this design.

The cabin is 15 ft 6 in (4.72 m) long and has 6 ft 3 in (1.90 m) headroom. Sleeping accommodation is provided for four. Standard equipment includes foam rubber cushions on berths and dinette seats, enclosed head with manually operated toilet, stainless steel wash basin, vanity mirror and medicine chest, and a complete galley with sink, two-burner alcohol stove, ice-box glass and dish rack, utensil drawer and food locker.

Basic equipment of the flybridge includes two pilot folding seats with safety belts, power steering, throttle and clutch, and a complete dashboard with all switches and gauges.

Weight of the craft is 11,000 lb (5,000 kg). Dimensions and performance as for the Albatross.

International Hydrolines
INTERNATIONAL HYDROLINES INC**HEAD OFFICE:**

245 Park Avenue, New York 10017

TELEPHONE:

2-0700

DIRECTORS AND OFFICERS:

Gerald O. Rennarts, President and Director

J. Roland Leduc, Vice President in charge of Operations

Charles E. Laidlaw, Treasurer and Director

Howard F. Cerny, Secretary

Ira E. Dowd, Vice President and Chairman

Robert Arum, Director

Charles Plohn, Director

This company succeeds International Hydrofoils and Air Cushion Vehicles. Although organised initially for the purpose of operating hydrofoils, air cushion vehicles and surface effect ships, it will also market these craft and has been selected by Satra Corporation as their representative for Sudoinport hydrofoils in the Western Hemisphere.

HYDROFOIL MANUFACTURERS

LOCKHEED: United States of America

Lockheed**LOCKHEED SHIPBUILDING & CONSTRUCTION COMPANY****HEAD OFFICE:**

Seattle, Washington, USA

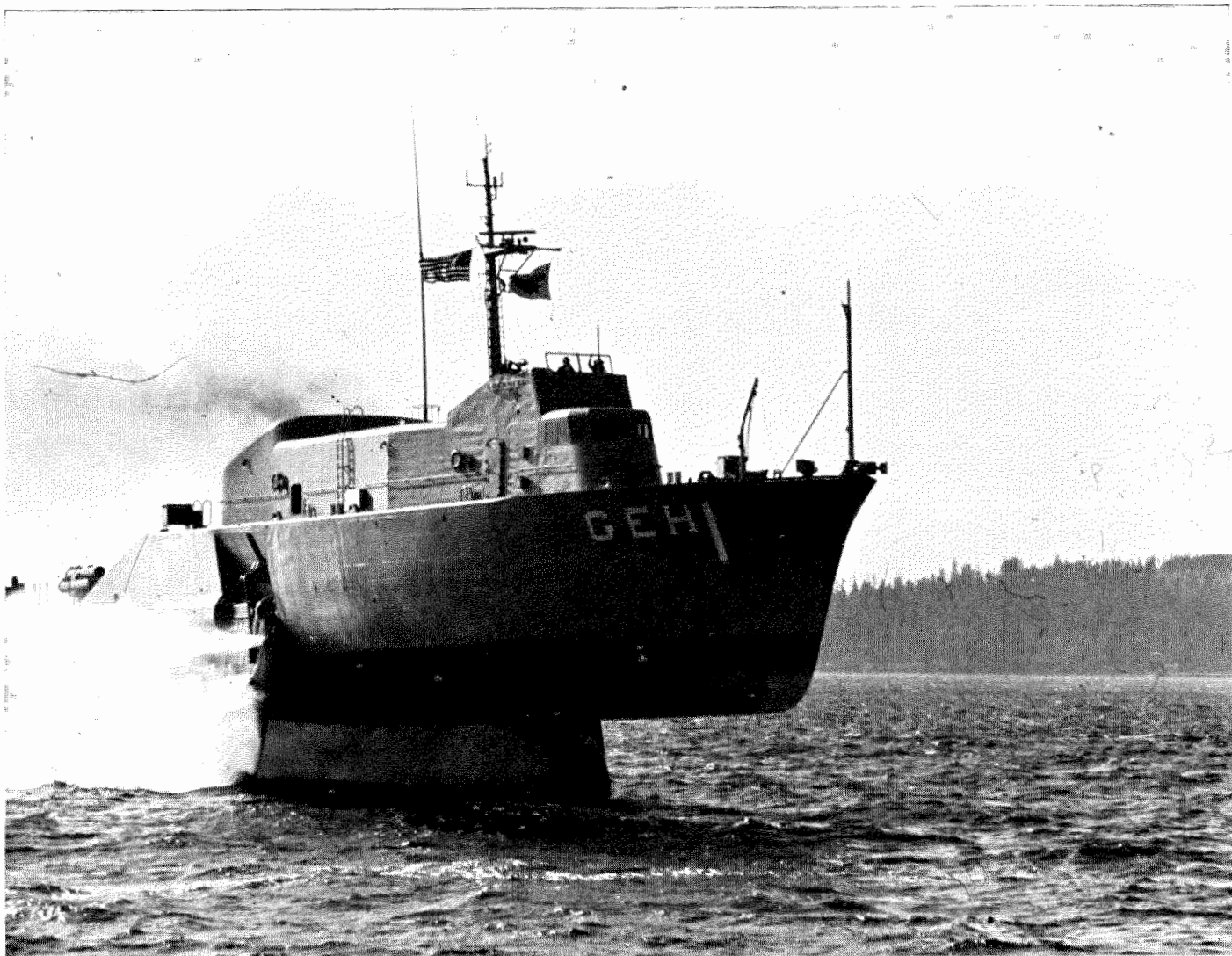
In June 1963 Lockheed Shipbuilding & Construction Company was awarded the contract for the detailed design and construction of the 320 ton AGEH-1 Plainview, the world's biggest hydrofoil to date. The hull was launched in June 1965 and the US Navy took delivery of the craft in late 1967. The craft successfully completed her maiden flight in Puget Sound on March 21st, 1968.

The AGEH-1 has been assigned to the US Navy's Hydrofoil Special Trials Unit and will undergo extensive evaluation for several years. The potential of the craft as an ocean going vessel for the US Navy will be fully explored. To facilitate analysis of data obtained from the extensive instrumentation installed aboard the craft, provision has been made for continuous and simultaneous recording of more than two hundred data channels on a single magnetic tape.

The power plant at present consists of two General Electric LM 1500 gas turbines, each driving one propeller through a right-angle bevel gear transmission. The design will permit the addition of two more engines at a later date to enable the craft to achieve much higher speeds using a ventilated or supercavitating foil system.



Wheelhouse of the AGEH-1 Plainview



The Plainview is being tested by the Hydrofoil Special Trials Unit, Bremerton, Washington

HYDROFOIL MANUFACTURERS

United States of America: MARYLAND

Maryland

MARYLAND SHIPBUILDING AND DRYDOCK COMPANY

HEAD OFFICE AND YARD:

PO Box 537, Baltimore 3, Maryland

The HS Victoria, a 75-seat hydrofoil passenger ferry designed by Gibbs & Cox and built by Maryland Shipbuilding & Drydock Company for Northwest Hydrofoil Lines Inc., is now operating between Seattle and Victoria BC. The craft operates a daily service, with two round trips per day on Fridays, Saturdays and Sundays. Journey time is just under 2½ hours, reducing by two hours the time taken by conventional ferries. The vessel has a fully submerged foil system of canard configuration and is powered by two LM100 gas-turbines driving non-reversing water propellers. The foil system is controlled automatically by a General Electric Foil-Borne autopilot system.

FOILS: A fully submerged canard configuration is employed, with an incidence controlled bow foil and two main foils with trailing edge flaps. Approximately 20% of the weight is supported by the bow foil and each of the rear foils supports 40%. All foils have straight taper in plan form. Fore and aft struts are located approximately ¼ and ¾ of the length of the craft from the bow. The foil struts are tapered from top to bottom. Strut length was chosen to permit the craft to perform well in the design sea state without producing excessive strut deflection in turns. Struts and foils are constructed of HY80 steel and are non-retractable, but provision is made for retractable foils on subsequent vessels of this type.

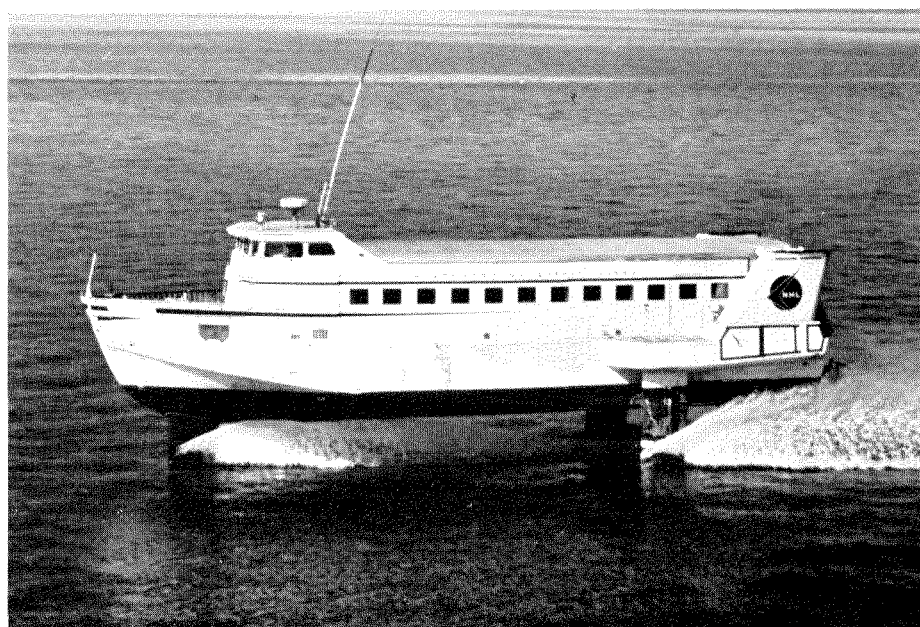
AUTOPILOT. A Foil-Borne Control System, designed and manufactured by the General Electric Defence Electronic Division is provided to automatically maintain the stability of the Victoria when foilborne and provides height, heel, trim and heading control and power steering. It consists of the following components: (1) control computer; (2) three hydraulic actuators; (3) three rate gyros; (4) vertical gyro; (5) height sensor; (6) two accelerometers; (7) control panel; (8) directional compass system.

The system makes the maximum use of solid state electronics and of modular construction. Individual modules have a Mean Time Between Failure of 10,000 hours and mechanical components will provide 2,000 hours of operation between overhauls. It is designed to operate efficiently in a State 4 sea, which includes waves to a maximum height of 4-8 ft (1.21-2.43 m).

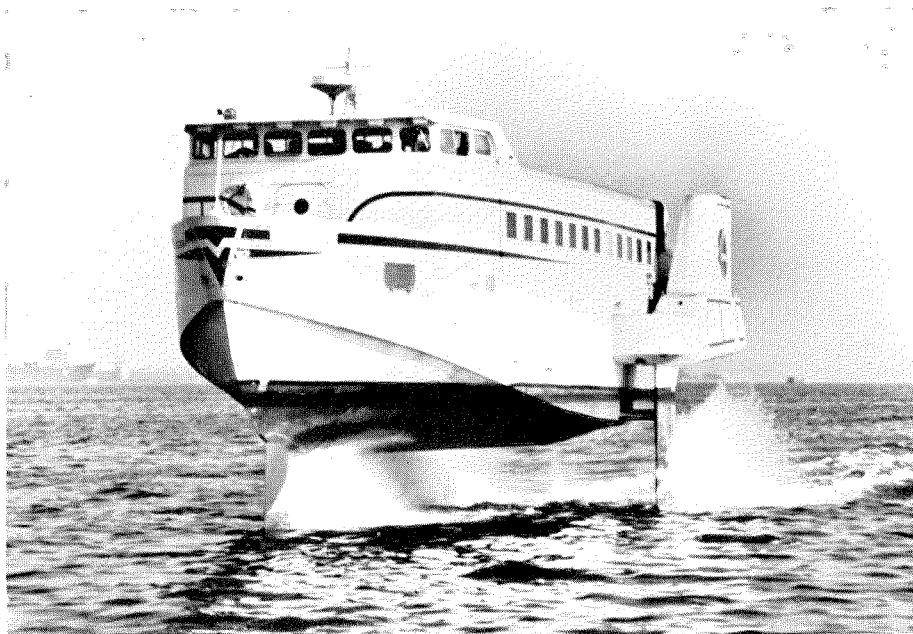
HEIGHT CONTROL: The height control loop maintains an altitude at the stern of +6 in (153 mm) of a set value in calm water, including effects of height and pitch control loops in cascade. Vertical accelerations of +0.15g are maintained in the designed sea state.

PITCH: Pitch altitude is maintained within ± one degree from the vertical in the designed sea state. A signal from the pitch loop is summed at the port and starboard servo amplifiers with a signal from the roll loop. The resultant signal, applied to a servo valve, causes the actuator ram at the top of each strut to activate the flap on each rear foil.

ROLL CONTROL: Roll attitude is maintain-



HS Victoria carries 75 passengers at 37-40 knots. Powered by two 1,000 hp GE LM100 gas turbines it is now operating between Seattle and Victoria BC



HS Victoria at speed in Puget Sound

ed within ± one degree from the vertical while foilborne in the design sea state. Roll is controlled by the differential motion of the port and starboard flaps by means of the servo-actuators. A roll trim control permits the manual introduction of a small bank angle during turns.

DIRECTION CONTROL: Control: The directional control loop maintains the craft to within ± one degree of a set course while the craft is foilborne. For course correction and normal power steering, steering wheel torque acts on a torque transducer to control the electrohydraulic servo system.

HULL: The hull, designed for two-compartment subdivision (ie any two adjacent compartments below the main deck may be flooded and the vessel will remain afloat) has a hard chine, high deadrise forward, planing form selected for easy entrance, good planing surface aft, and good re-entry characteristics for take-offs and landings. Approximately 65% of the main hull is formed by extruded panels combining shell

plating and toe stiffeners. It is built in 5000 series aluminium.

ACCOMMODATION: The wheelhouse, located forward, provides an unobstructed 360° view and is equipped with duplicate steering controls for the captain and first officer.

The passenger cabin is arranged in airliner style with three and four seats abreast on either side of a longitudinal aisle. The cabin is acoustically and thermally insulated. It is sheathed in aluminium, and the forward and after cabin bulkheads are covered with a Firm-a-Flex walnut wood veneer. The passenger cabin deck is covered with acrylan carpeting, and the reclining seats are vinyl covered and equipped with foot rests and seat belts. The cabin is complete with water dispensers and overhead racks. Two lavatories in the passenger cabin are located one fore and one aft. All construction materials, including curtains, are fireproof in accordance with US Coastguard rules and regulations.

HYDROFOIL MANUFACTURERS

MARYLAND: United States of America

Passenger and crew spaces are fully heated and ventilated by a hot air system. Air conditioning is optional.

The displacement drive compartment, auxiliary machinery space, fuel oil tanks, electronic compartment and baggage freight compartment are all located below the main deck.

A Carbon-Baron-Freon (CBRF₂) fixed flooding fire fighting system is installed to protect compartments below the main deck and the gas-turbine sponsons. A sea water fire main runs the length of the Victoria with two fire stations located so as to reach any point in the vessel with a 25 ft (7.62 m) hose.

Four 25-man self-inflating life rafts of the latest type are provided, as required by the US Coast Guard.

POWER PLANT: Power is supplied by two General Electric LM100 marine gas turbines, each rated at 1,000 shp. The LM100 is equipped to burn Diesel ID fuel. Other fuels can also be used.

The compression section of the engine is a 10-stage axial-flow unit which delivers more than 12 lb of air per second at a pressure ratio of 8 to 1. Inlet guide vanes and the first three stages of stator vanes are variable to allow rapid starting, acceleration and deceleration. Starting power is supplied by 28-volt batteries, and the turbine can attain full speed in less than one minute.

The gas-turbines are located in watertight sponsons outside the main hull and drive non-reversing propellers through a single train right angle reduction gear system consisting of a reduction gear, upper and lower spiral bevel gear pairs and vertical shafting.

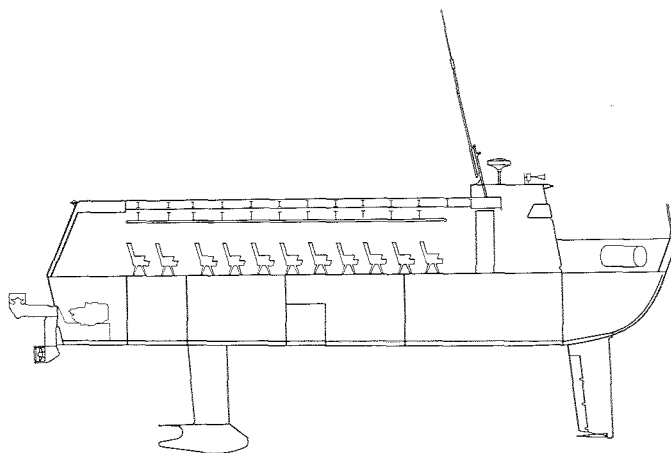
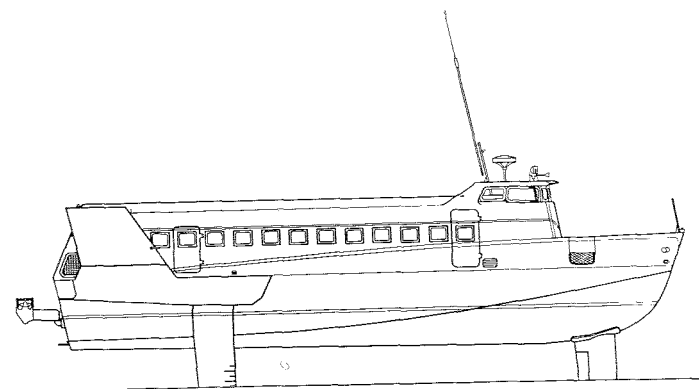
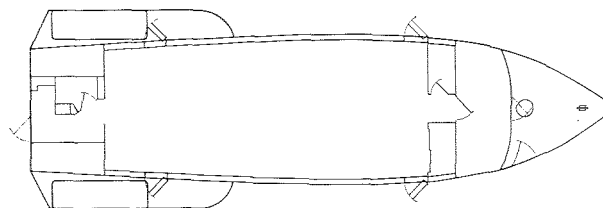
A 100 hp Harnischfeger lightweight diesel with a Hydro-Drive retractable right angle drive unit is mounted in the stern for hullborne propulsion.

The starting and stopping operations of the main turbines and auxiliary diesel engine are remotely controlled from the wheelhouse. The remainder of the auxiliaries are remotely controlled from the control area of the main cabin.

COMMUNICATIONS AND NAVIGATION: Equipment includes a radio-telephone, a radio direction finder, radar, echo depth sounder, electric horn and three compasses.

SYSTEMS:

ELECTRICAL: The vessel is provided with an electric plant having a nominal 24 volts D.C. The power sources are: (a) two 500-amp, 30-volt, aircraft-type generators, one driven off each main turbine; (b) one 170-amp-hour (at the one-hour rate) 24-volt nickel cadmium battery; (c) one 35-amp-hour 24-volt nickel cadmium battery; (d) one 200-amp, 30 volt aircraft type standby generator, arranged for belt drive by the diesel engine.



General arrangement drawing of HS VICTORIA

Quick-connecting, aircraft-type receptacles are provided on the weather deck of the craft for the connection of shore power while in dock. A separate shore power connection is provided for the lube oil heater.

HYDRAULICS: Hydraulic power for the foil control system is provided by three 5 hp constant pressure hydraulic oil pumps driven, one each, by the two GE gas turbines and the displacement diesel.

BILGE: A bilge main serves all compartments in the ship. The fire pump, driven by the displacement diesel engine, is self-priming and also serves the bilge main. Its capacity is 50 gallons per minute. This pump operates in the displacement condition. The salt-water cooling pump, which serves the lubricating oil cooler and hydraulic oil cooler, is self-priming and also serves the bilge system. It has a capacity of 60 gpm and operates when the craft is foilborne.

All bilge suction valves are mechanically operated from the deck.

DIMENSIONS:

Length overall, hull	64 ft 9 in (19.7 m)
Hull beam	16 ft 0 in (4.87 m)
Beam overall, across foils	30 ft 6 in (9.29 m)
Draft afloat	14 ft 1 in (4.29 m)
Draft foilborne (full load, maximum)	7 ft 6 in (2.28 m)
Draft foilborne, minimum	4 ft 0 in (1.22 m)

WEIGHTS:

Maximum take-off displacement	40 tons
Gross tonnage	87 tons
Payload	10 tons

PERFORMANCE:

Cruising speed, foilborne	37 knots (69 km/h)
Max speed, foilborne	40 knots (74 km/h)
Range at 37 knots, full load	180 nautical miles (290 km)

HYDROFOIL MANUFACTURERS

United States of America: NIGG/SATRA

Nigg DONALD J. NIGG

ADDRESS:

7924 Fontana, Prairie Village, Kansas,
USA 66208

TELEPHONE:

913-642-2002

The development of a practical sailing hydrofoil has been the objective of a few imaginative designers for the past two decades. Fewer than a dozen full-scale experimental craft have lifted from the water surface under sail power alone, and each has had its own unique problems.

A true development class of sailing hydrofoil has been slow to emerge, but Donald Nigg's Flying Fish, which was successfully tested during the summer of 1968, may mark the beginning of such a class.

Theoretical speeds of twice the wind velocity are the main attraction of these craft. The speed potential falls between that of the modern catamaran and the ice-yacht.

Development of the Flying Fish began in 1963 at Lake Quivira, an inland lake in Kansas. Donald Nigg believed that if the pitchpole moment and vertical stability problems could be solved, the front-steering three-point suspension system typical of the modern ice-yacht offered several advantages. Previous craft had often used three-point suspension, but all appear to have used rear steering. To develop this new approach, Exocoetus, an experimental platform was built. It was evolved through three distinct versions during 1964-67 and established the basic feasibility.

Interest in the experiments resulted in numerous requests for plans, but although the craft was ideal as a development platform, it was not a design suitable for home construction. In response to these requests the Flying Fish was produced.

To keep the costs to a minimum, the craft is designed to carry a sail area of 100-150 sq ft. It was anticipated that most of those interested in building a sailing hydrofoil would be small boat sailors, owning a boat carrying a mainsail of this size. The design thus allows the builder to share the sail and rigging with an existing dinghy.

The monohull and buoyant crossbeam of the Flying Fish represents a simpler and more rugged structure than that of the Exocoetus. The crossbeam provides stability when in dock and in a displacement condition at low speeds. At 2-3 knots the horizontal safety foils at the top of the Vee of the rear foils



Exocoetus on landing approach to dock

provide interim foil stabilization up to the take-off speed of 5 knots and prevent dragging an end of the crossbeam in the water. At foilborne speeds the safety foils preclude the possibility of an end of the crossbeam being driven into the water by sudden heeling.

FLYING FISH

First of a development class of sailing hydrofoils, the Flying Fish has been specially developed for home builders. Built mainly in wood and with a length overall of 16 ft 6 in (5.02 m), it has a maximum foilborne speed of more than 30 knots.

The estimated cost of constructing a craft of this type, less sail and rigging (the 125 sq ft mainsail and rigging from a Y-Flyer were used for the prototype illustrated), is \$US 175.00.

FOILS: The foil configuration is surface piercing and non-retractable with 16% of the weight supported by the vee bow foil and the remaining 84% by the outriggered main foils. The latter are also of the vee type, with cantilevered extensions at the apex. Total foil area is 15.3 sq ft (1.42 m²) and the foil loading is 300 lb sq ft max at 30 knots. The front foil and its supporting strut are built in aluminium and oak, and the main foil is in oak only.

STEERING: A basic feature of the design is the use of front rather than rear steering. Directional control is provided by the movement of the hinged bow foil.

HULL: This is an all-wooden structure built in fir plywood, $\frac{1}{4}$ in thick and sealed. Torque load is carried by the skin, and bending loads are carried by the skin and the internal beam structure.

RIG: A catamaran rig of 100-150 sq ft (92-13.9 m²) area is recommended.

DIMENSIONS:

Length overall, hull (plus boom overhang at rear, dependent on sail plan)

16 ft 6 in (5.02 m)

Length waterline, hull

16 ft 0 in (4.87 m)

Beam

20 ft 0 in (6.09 m)

Draft afloat (fixed foils)

3 ft 6 in (1.06 m)

Draft foilborne

12-30 ins over operating speed range

Height, approx

24 ft 0 in (7.3 m)

PERFORMANCE:

Max speed foilborne

5 knots

Over 30 knots, design cruise range

optimized for 20-30 knots

Max speed hullborne

10 knots

Min wind for take-off

10 knots

Number of seconds and distance to take-off

(theor. app)

3 secs with 50 ft (15.2 m) run in favourable

wind

Number of seconds and distance to stop

craft (theor. app)

Can land from 20 knots in 150 ft (45.6 m)

in about 6 seconds



The Flying Fish in a broad reach in a moderate wind. Boat speed estimated at about 18 knots

SEA TEST: The craft has been tested in 10-25 knot winds on a relatively sheltered inland lake, with a max chop of about 18 inches. Ten hours testing has been accrued on the final design at the time of going to press. Speeds up to approx 30 knots have been attained. Enquiries regarding plans should be made direct to Donald J. Nigg at the address given above.

Satra

SATRA CORPORATION

HEAD OFFICE:

7 Park Avenue, New York, NY 10016

Satra is a New York trading corporation holding the Sudoimport licence to import

Soviet hydrofoils. The corporation has imported the Volga hydrofoil, which has been restyled and marketed in the USA as the Forte, and also the Raketa. A 100-passenger Kometa is also being imported by Satra and

was expected to arrive in the USA in the autumn of 1968. International Hydrolines has been selected by Satra as the representative for Sudoimport hydrofoils in the Western Hemisphere.

HYDROFOIL MANUFACTURERS

WYNNE-GILL: United States of America

Wynne-Gill**WYNNE-GILL ASSOCIATES, INC****HEAD OFFICE:**

261 S.W.6th Street, Miami, Florida 33130

TELEPHONE:

(305) 373-3130

MARITIME FLIGHT 1

This 21 ft four-seat sports hydrofoil has been designed by international offshore

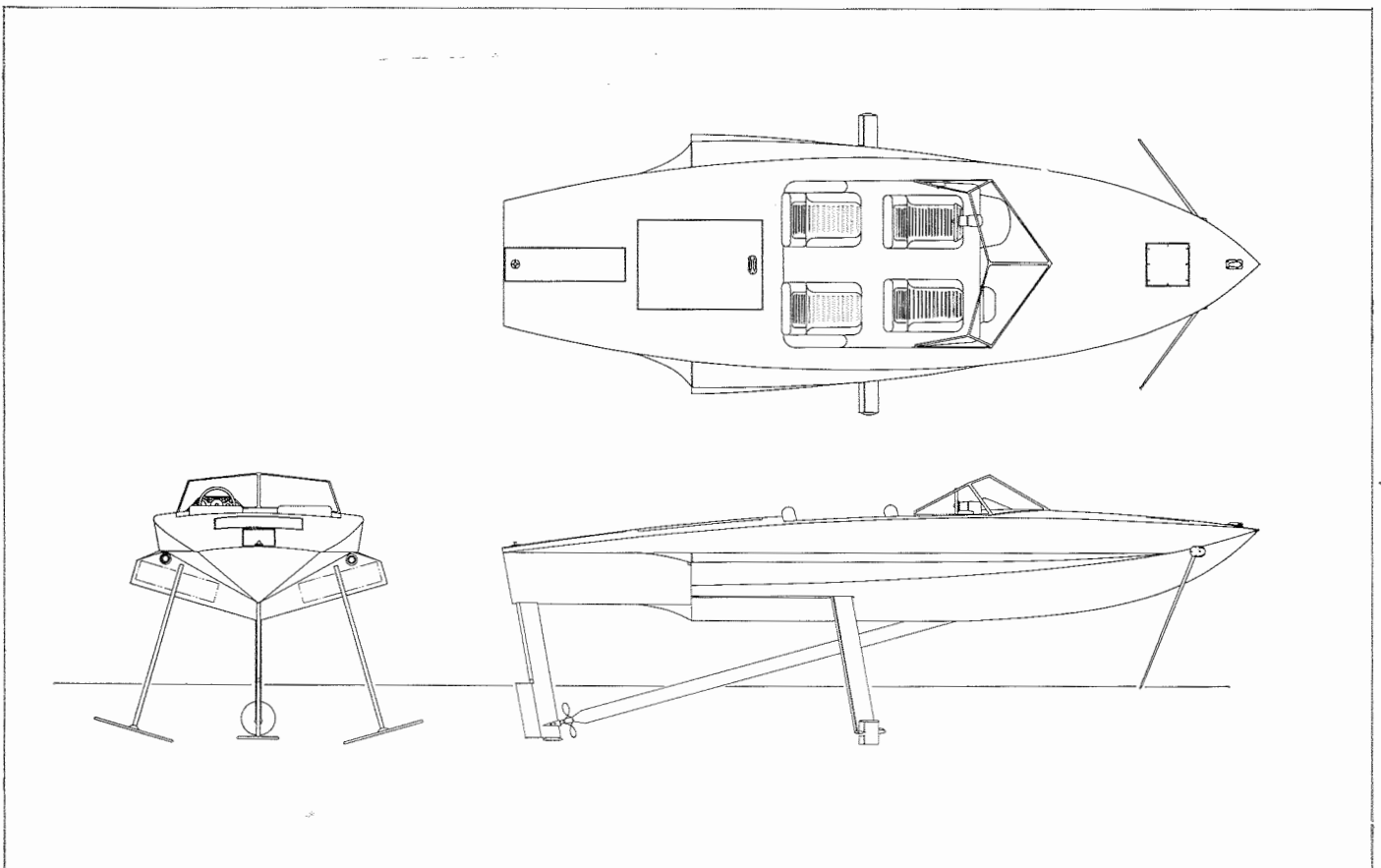
powerboat champion Jim Wynne and his partner, John Gill, for the Maritime Corporation, Alliance, Ohio. The craft has a fully-submerged foil system, with mechanical wave sensors operating trailing edge flaps to maintain the foils at the required depth, and provide stability in all four axes—heave, pitch, roll and yaw. For the first time in hydrofoil design use has been made of Torsionetic Universal joints on the propeller

drive shaft to permit retraction. Though designed for construction in corrosion resistant aluminium alloy, the prototype is of marine ply.

FOILS: The fully submerged foil system is of conventional "aeroplane" configuration with about 80% of the load supported by the two rectangular bow foils and the remainder by the rear foil. All three foils retract



The Wynne-Gill Maritime Flight I 4-seat sports hydrofoil prototype. The craft has a fully submerged foil system with mechanical wave sensors operating trailing edge flaps to maintain the foils at the required depth.



Wynne-Gill Maritime Flight I, out-board profile.

HYDROFOIL MANUFACTURERS

United States of America: WYNNE-GILL

hydraulically. The two main units retract rearwards into hull slots and the rear assembly retracts upwards through the hull, at the same time raising the propeller and drive shaft.

Lightweight mechanical feeler arms trailing from the bow ride on the waves and continuously transmit their shape through a connecting linkage to adjust the angle of the trailing edge flaps on the main foils.

The driver has overriding control. By pushing the wheel forward, the craft rides lower; and by pulling it back it rides higher. When turned to the left or right, the hull will bank to the particular side. The rudder, at

the trailing edge of the stern foil strut, is operated by foot pedals.

POWER PLANT: Motive power is provided by a single 200 hp Holman and Moody inboard engine driving a single 3-bladed propeller through a vee-drive and a system of Torsionetic joints, produced by the Eaton Spring Division of Eaton, Yale and Towne Inc. The Torsionetic joints are fitted between the engine and the gearbox and between the gearbox and the propeller shaft, enabling the shaft to be retracted.

HULL: Deep transverse frames on multiple longitudinal stringers with slotted sponsons and keel for foil retraction.

SYSTEMS:**ELECTRICAL:** 12 volt**HYDRAULIC:** 1,000 psi retraction cylinders**DIMENSIONS:**

Length overall	21 ft 3 in (6.47 m)
Hull beam	7 ft 3 in (2.20 m)
Width across foils	9 ft 3 in (2.81 m)
Draft foils, lowered	4 ft 7 in (1.39 m)
Draft, foils retracted	2 ft 2 in (0.66 m)

WEIGHTS:

Light	2,250 lb (1,021 kg)
Max gross	3,200 lb (1,452 kg)

PERFORMANCE:

Max speed	45 mph (72 km/h)
Cruising speed	38 mph (61 km/h)
Take-off speed	20 mph (32 km/h)

THE UNION OF SOVIET SOCIALIST REPUBLICS

Sormovo

KRASNOYE SORMOVO SHIPYARD

HEAD OFFICE AND WORKS:

Gorki

OFFICERS:

M. Yuriev, Shipyard Director

Dr Rostilav Yergenievich Alexeyev, Head of the Central Design Bureau for Hydrofoil Vessels

OVERSEAS REPRESENTATIVES:

United Kingdom, Western Europe and British Commonwealth, Airavia Ltd, 20 North Road, Shanklin, Isle of Wight

TELEPHONE:

Shanklin 3643

USA and Western Hemisphere:

International Hydrolines, Inc, 245 Park Avenue, NY 10017, USA

TELEPHONE:

Murray Hill 2-0700

Krasnoye Sormovo is one of the oldest established shipyards in the Soviet Union. In addition to building displacement craft of many kinds for the Soviet River Fleet, including cargo-carrying catamarans, the yard constructs the world's widest range of passenger hydrofoils, the majority of which are equipped with the Alexeyev shallow draft submerged foil system. Dr Alexeyev started work at the end of 1945 on the design of his foil system which had to be suitable for operation on smooth, but open and shallow, rivers and canals. He succeeded in making use of the immersion depth effect for stabilising the foil immersion in calm waters by the use of small lift coefficients.

The system comprises two main horizontal lifting surfaces, one forward and one aft, with little or no dihedral, each carrying approximately half the weight of the vessel. A submerged foil loses lift gradually as it approaches the surface from a submergence of about one chord. This effect prevents the submerged foils from rising completely to the surface. Means therefore had to be provided to assist take-off and prevent the vessel from sinking back to the displacement condition. The answer lay in the provision of planing sub-foils, port and starboard, so located in the vicinity of the forward struts that when

they are touching the water surface the main foils are submerged approximately one chord.

The foils have good riding characteristics on inland waters and in small waters.

The system was first tested on a small launch powered by a 77 bhp converted car engine. Three more small craft were built to prove the idea, then work began on the Yard's first multi-seat passenger craft, the Raketa, the first of which was launched in June 1957.

The yard is also responsible for the development of seagoing craft with V-type surface piercing foils, similar in configuration to those of the Schertel-Sachsenburg system. Craft employing this system are generally described as being of the Strela-type, Strela being the first operational Soviet design to use V foils. Seating 90 passengers, the vessel is powered by two M-50 diesels and, visually speaking, is a cross between the PT 20 and the PT 50, though smaller than the latter. A military derivative is currently employed by the Soviet navy for coastal patrol in the Baltic and the Black Sea.

Several of the V-foil range have been designed in Leningrad, including the Nevka and Delphin. The latest Soviet hydrofoil to be announced is the gas-turbine powered, 90-seat passenger ferry Typhoon, the prototype which was due to be completed in 1968.

BUREVESTNIK

First Soviet gas-turbine hydrofoil to be designed for series production, the Burevestnik has two 2,000 hp marinized aircraft gas-turbines driving two three-stage water-jets. The prototype was launched in April 1964 and two models are now being built; one for medium range, non-stop inter-city services, seats 130 passengers, the other for suburban services, seats 150 passengers.

There is a four-man crew, comprising captain, engineer, motorman and a seaman. After extensive trials the Burevestnik began operating on the Gorky-Kuibyshev route, about 700 km (435 miles), on April 26, 1968.

FOILS: There are two main foils and an auxiliary stabilizer foil sited behind the bow foil, all built in titanium alloy. Each is

square-tipped and slightly wedge-shape in planform. The foils are secured to the hull by columns and brackets. The columns are welded to the upper surface of the foils, then bolted to the brackets, an arrangement allowing the angle of incidence to be changed when the craft is in dock.

HULL: The hull, which is divided into eleven watertight compartments, is framed on longitudinal and transversal formers with the aluminium alloy skins welded into place.

ACCOMMODATION: Saloons and cabins are air-conditioned and are decorated with pastel-shade panels and soundproofed with glass-fibre insulation. The engine room is at the stern and separated from the saloon by a sound-proof double partition.

POWER PLANT: The two 2,000 hp Ivchenko gas turbines, adapted from those of the IL-18 airliner, operate on either kerosene or light diesel fuel and have a consumption of about 300 gallons per hour. Sufficient fuel can be carried to operate non-stop over a range of 270 nautical miles (500 km). The shaft of each of the two three-stage water jets is connected with the shaft of one of the turbines by means of a flexible coupling, via a reduction gear.

CONTROLS: Four rudders are fitted adjacent to the waterjet streams to provide directional control. Reversing is achieved by using a hydro-reversal system in which two deflectors reverse the waterflow. The waterjets themselves are on fixed mountings and cannot be rotated.

Operation of the waterjets, turbines, rudders and deflectors is all effected from the bridge by electro-hydraulic control.

DIMENSIONS:

Length	142 ft 0 in (43.3 m)
Hull beam	22 ft 0 in (6.7 m)
Draught afloat	5 ft 10 in (1.8 m)
Draught foilborne	1 ft 4 in (0.4 m)

WEIGHT:

Displacement, loaded	62 tons
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PERFORMANCE:

Maximum speed	60 knots (110 km/h)
Cruising speed	52/53 knots (95-97 km/h)
Crew	4
Passengers, maximum	150



The gas-turbine powered Burevestnik, latest in the family of Soviet hydrofoils inspired by the Meteor. The craft cruises at 60 knots and opened a service between Gorky and Kuibyshev in April 1968

HYDROFOIL MANUFACTURERS

The Union of Soviet Socialist Republics: SORMOVO

BYELORUS

This craft was developed from the Raketa via the Chaika for fast passenger services on winding rivers less than 3 ft (1 m) deep and too shallow for vessels of the standard type.

In 1965 it was put into series production at the river shipyard at Gomel, in Byelorussia. **FOILS:** The shallow draught submerged foil system consists of one bow foil and one rear foil and a midship subfoil. Main foils are in welded stainless steel and the subfoil is of aluminium alloy plate.

HULL: Hull and superstructure are built in aluminium magnesium alloy. The hull is of all-welded construction and the superstructure is both riveted and welded.

ACCOMMODATION: The craft seats 30 passengers in aircraft-type seats.

POWER PLANT: Power is supplied by a 735 hp M-50 diesel. The wheelhouse is fitted with an electro-hydraulic remote control system for the engine, reverse gear and fuel supply.

PERFORMANCE:

Maximum speed 42 knots (78 km/h)
Cruising speed 35 knots (60 km/h)

CHAIKA

An experimental 30-passenger craft, Chaika is used as a test-bed for the development of diesel-operated waterjet systems. It was designed initially as a 30 passenger waterbus for shallow rivers but was found to be unsuitable for negotiating sharp river bends at high speed.

HULL: Hull and superstructure are built in aluminium magnesium alloy.

POWER PLANT: An M-50 diesel, developing 1,200 hp drives a two-stage waterjet.

CONTROLS: Rudders adjacent to the water stream govern the flow of the ejected water for directional control.

DIMENSIONS:

Length overall 86 ft 3 in (26.3 m)
Hull beam 12 ft 6 in (3.8 m)
Draught afloat 3 ft 10 in (1.2 m)
Draught foilborne 1 ft 0 in (0.3 m)

WEIGHT:

Displacement loaded 14.3 tons

PERFORMANCE:

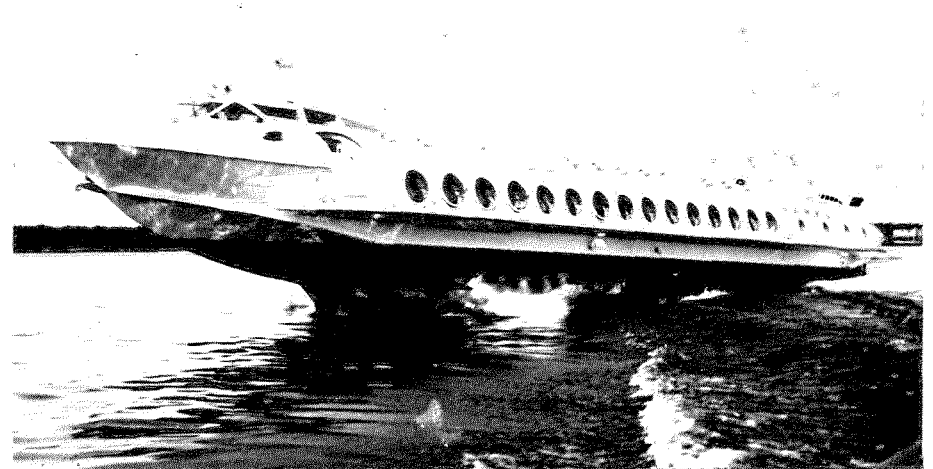
Cruising speed, foilborne 46.5 knots (86 km/h)

DELPHIN

Only limited details of this craft have been received. Powered by a marinised aircraft gas turbine, the Delphin is described as a "later member of the Strela family of hydrofoils". A waterjet propulsion system



Byelorus, a 30-45 seat hydrofoil developed for fast ferry service on shallow waters, seen on the Irtysch river. Powered by a 735 hp M-50 diesel the craft cruises at 60 km/h



Chaika, an experimental 30 seat waterbus designed for shallow rivers. The craft is used as a test bed for the development of diesel-driven waterjet systems

is employed and the top speed is quoted as being in excess of 70 knots (130 km/h).

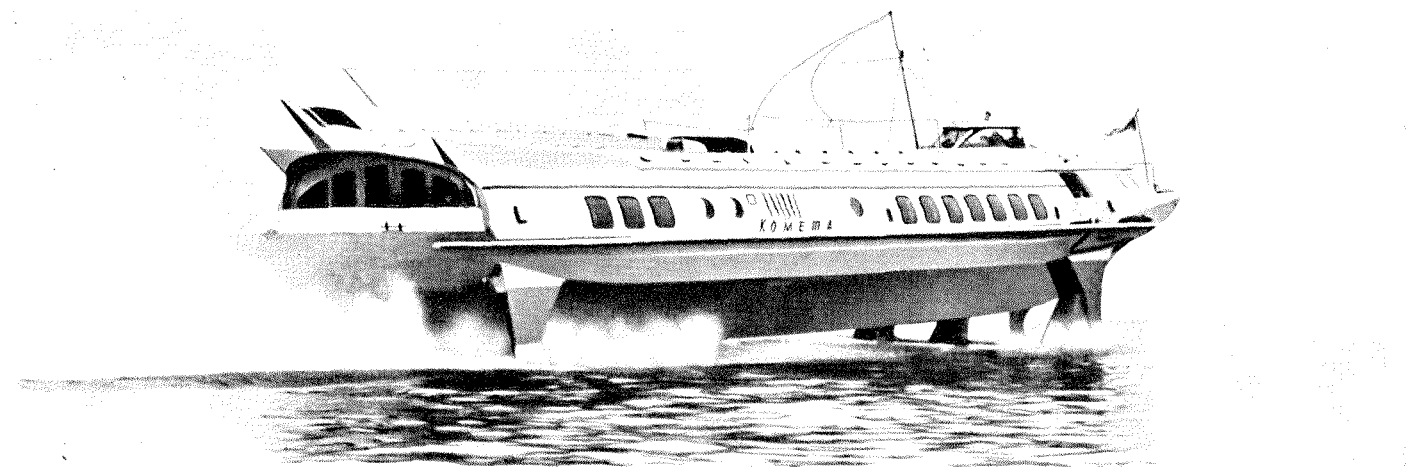
KOMETA

Seagoing version of the earlier Meteor, the Kometa prototype made its maiden voyage on the Black Sea in the summer of 1961. Seating 100 passengers in three heated and ventilated cabins it is designed for daytime operation on coastal services and has a cruising range of 311 miles (500 km).

Kometas are built at the Krasnoye Sormovo Shipyard, Gorki, but in addition a number

have been assembled at Poti, one of the Black Sea Georgian Yards from prefabricated sections sent from Gorki. The craft has been exported to Yugoslavia, where five are in service, and another was due to be delivered to International Hydrolines for services between Trinidad and Tobago and Grenada towards the end of 1968.

The vessel has proved to be exceptionally robust and has a good all-round performance. On one charter a Kometa covered 3,300 miles (5,310 km) by sea and river in 127 hours.



Kometa

HYDROFOIL MANUFACTURERS**SORMOVO:** The Union of Soviet Socialist Republics

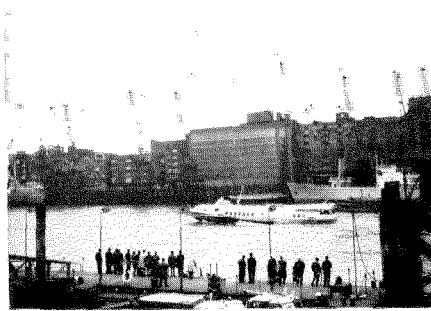
The Kometa operates as a hydrofoil in waves up to 4 ft 1 in (1.25 m) high and can travel hullborne in waves up to 8 ft 3 in-10 ft 0 in (2.5-3.0 m) high.

FOILS: Bow and rear foils are in welded stainless steel and the midship subfoil and stabiliser fin are in welded aluminium-magnesium alloy. The bow foil, struts and the outer struts of the rear foil can be unbolted from the hull for maintenance or replacement. Struts of the midship sub-foil and keel struts of the stabiliser fin and aft foil are non-detachable.

HULL: Similar in shape to that of the earlier Meteor, the hull has a wedge-shaped bow, raked stem and a spoon-shaped stern. Hull and superstructure are built in aluminium magnesium alloy; the hull is of all-welded construction and the superstructure is both riveted and welded. Below the freeboard deck the hull is divided by watertight bulkheads into thirteen compartments, which include the engine room, and the compartments for fuel, the fire-fighting system, tiller gear and the fuel transfer pump.

ACCOMMODATION: The standard version of the Kometa seats 100 passengers. It carries a four-man operating crew, comprising captain, engineer, motorman and a seaman, and also a barman. Embarkation platforms sited immediately below the wheelhouse provide access to the craft. Passengers are accommodated in three compartments, a forward saloon seating 24, and central and aft saloons seating 48 and 28 respectively. The central saloon has three exits, two forward, leading to the embarkation platforms, and one aft, leading to the promenade deck. This is located between the side spaces above the engine room and is partially covered with a removable metallic awning.

To the starboard side is a crew's off-duty cabin, hydraulic system pump room, bar



A Kometa on the Thames in August 1968 during a sales tour which took the craft from the Black Sea to the Baltic, Copenhagen, Antwerp, Rotterdam and London

store and bar, and to the port are two toilets, boiler room, battery room and a second crew cabin.

The aft saloon has two exits, one forward leading to the promenade deck, the other aft, leading to the weather deck, which is used for embarking and disembarking when the vessel is moored by the stern.

Floors of the passenger saloons, crew's cabins, bar and wheelhouse are covered in coloured linoleum and the deckhead in the passenger saloons, as well as bulkheads and the sides above the lower edge of the windows, are finished in light coloured pavinol. Panels of the saloons beneath the windows are covered with plastic.

Passenger saloons are fitted with upholstered chairs, racks for small hand luggage and pegs for clothing. The middle and aft saloons have niches for hand luggage and the former is fitted with cradles for babies. The bar is fully equipped with glass washers, an ice safe, an automatic Freon compressor, electric stove, etc. The wheelhouse is equipped with seats for pilot and engineer, a folding stool, chart table, sun shield and a locker for signal flags.

SAFETY EQUIPMENT: A full range of life-saving equipment is carried including four inflatable life rafts, each for 25 persons, 115 life jackets, and 6 circular lifebelts, two with life lines and two with luminous buoys. Life rafts are located two on the forward sponsons and two on the aft sponsons. When thrown into the water the life rafts inflate automatically. Life jackets are stowed under the seats in all saloons, and the circular life belts are stowed on the embarkation and promenade platforms.

FIRE FIGHTING EQUIPMENT. An independent fluid firefighting system is provided for the engine room and fuel bay. An automatic light and sound system signals a fire outbreak. The fire fighting system is put into operation manually from the control deck above the engine room door. Boat spaces are equipped with hand-operated foam and CO₂ fire extinguishers, felt cloths and fire axes.

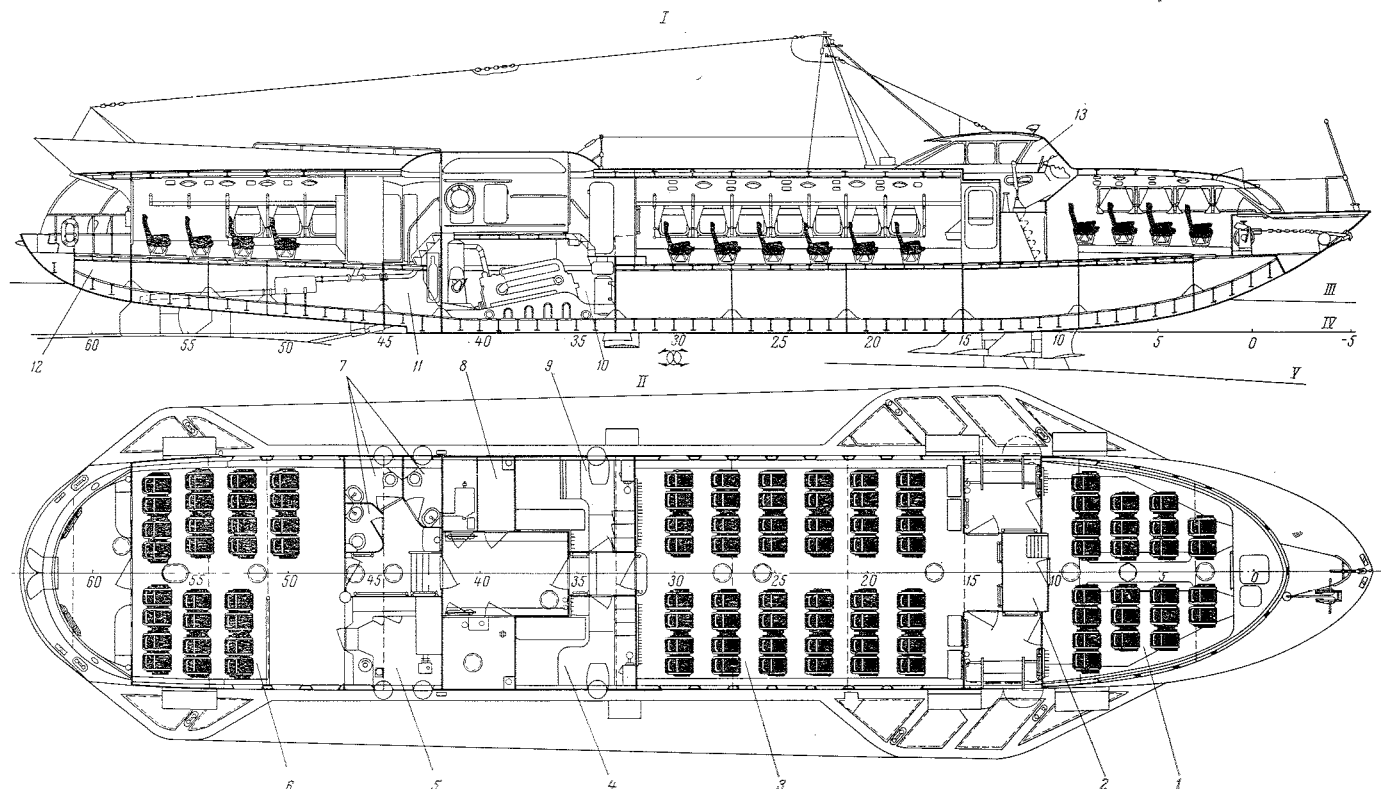
POWER PLANT: Power is supplied by two M-400 watercooled, supercharged 12-cylinder V-type diesels, each with a normal service output of 900 hp at 1,650 rpm and a maximum output of 1,100 hp at 1,800 rpm. Each engine drives via a reverse gear its own inclined shaft and the twin propellers are contra-rotating. The shafts are of steel and are parallel to the craft.

The propellers are of five-bladed design and made of brass. Two sizes are available: 2 ft 2 in (0.65 m) diameter with 2 ft 8 in (0.80 m) pitch, and 2 ft 3 in (0.69 m) diameter with 2 ft 6 in (0.76 m) pitch.

Main engine controls and gauges are installed in both the wheelhouse and the engine room. A diesel-generator-compressor-pump unit is provided for charging starter air bottles; supplying electric power when at rest; warming the main engines in cold weather and pumping warm air beneath the deck to dry the bilges.



The Kometa entering Dover harbour during its visit to the United Kingdom in August 1968



Kometa—inboard profile and main deck plan.

I inboard profile; II main deck; III waterline (afloat); IV keel; V foilborne waterline. 1 forward passenger cabin, seating 24; 2 accessories room; 3 main passenger cabin seating 48; 4 cloakroom; 5 bar; 6 aft passenger cabin seating 28; 7 WC/washbasin units; 8 storeroom; 9 duty cabin; 10 engine room; 11 firefighting equipment; 12 fuel tanks; 13 wheelhouse

Diesel oil tanks with a total capacity of 6,612 lb (3,000 kg) for the main engines and the auxiliary unit are located in the after-peak. Two lubricating oil service tanks and one storage tank located at the fore bulkhead of the engine room have a total capacity of 551 lb (250 kg). Diesel and lubricating oil capacity is sufficient to ensure a range of 230 miles (370 km).

CONTROLS: The wheelhouse is equipped with an electro-hydraulic remote control system for the engine reverse gear and fuel supply, fuel monitoring equipment, including electric speed counters, pressure gauges, lubricating and fuel oil gauges. The boat is equipped with a single, solid aluminium magnesium alloy balanced rudder, which is controlled through an electro-hydraulic steering system or a hand operated hydraulic drive. In an emergency, the rudder may be operated by a hand tiller.

SYSTEMS:

ELECTRICAL: Power supply is 24 volts dc. A 1kW dc generator is attached to each of the two engines and these supply power while the craft is operating. A 5.6 kW generator is included in the auxiliary unit and supplies power when the craft is at rest. It can also be used when under way for supplying the heating plant or when the 1.0 kW generators are inoperative. Four 12 volt acid storage batteries, each of 180 amp/hr capacity and connected in series to provide 24 volts, supply power during short stops.

HYDRAULICS: The hydraulic system for controlling the main engines and reverse gear consists of control cylinders located in the wheelhouse, power cylinders located on the engines, a filler tank, pipe lines and fittings. **COMMUNICATIONS:** A radio transmitter/receiver with r/t and w/t facilities is installed in the wheelhouse for ship-shore and inter-ship communications on SW and MW bands.

A portable emergency radio and automatic distress signal transmitter are also installed in the wheelhouse. A broadcast system is fitted in the passenger saloons and a two-way crew communications system is installed in the wheelhouse, engine room, anchor gear compartment and mooring stations.

NAVIGATION: The following navigation aids are standard: a gyro compass, magnetic compass (reserve) and log.

DIMENSIONS:

Length	115 ft 6 in (35.2 m)
Beam	31 ft 6 in (9.6 m)
Overall height above water level when foilborne with mast raised	28 ft 7 in (8.7 m)
Draught, foilborne	4 ft 7 in (1.4 m)
Draught, hullborne	10 ft 6 in (3.2 m)

WEIGHTS:

Light displacement (max)	42 tons
Full-load displacement (max)	56 tons

PERFORMANCE:

Cruising speed (full load) Not less than 32 knots in calm water and in wind conditions up to Force 3

Sea State capability Craft is normally able to operate foilborne in waves up to 4 ft 1 in (1.25 m) high and can travel hullborne in waves up to 8 ft 4 in - 10 ft 0 in (2.5-3 m) high

Turning diameter 558-656 ft (170-200 m) when operating hullborne with the rudder shifted 35°; 1,640-1,804 ft (500-550 m) when foilborne with the rudder shifted 10-12°

METEOR

Dr Alexeyev's Meteor made its maiden voyage from Gorki to Moscow in the summer of 1960, bringing high performance and unprecedented comfort to the river boat scene, and setting the pattern for a family of later designs.

FOILS: The foil arrangement consists of one bow and one stern set, with the stanchions of the bow system carrying two additional planing subfoils. The foils are attached to the stanchions, which are of a split type, by flanges and bolts. The foil incidence can be altered when necessary by the insertion of wedges between the flanges and the foils when the craft is in dock.

HULL: With the exception of the small exposed areas fore and aft, the Meteor's hull and superstructure are built as an integral unit. The hull is framed on longitudinal and transverse formers and both hull and superstructures are of riveted construction with welded steel members.

POWER PLANT: The Meteor is powered by two 12-cylinder M-50 watercooled, supercharged V-type engines, each with a normal service output of 900 hp and a maximum output of 1,200 hp. Each engine drives its own propeller shaft and the twin-screws are contra-rotating. Controls are all sited in a small wheelhouse set above and at the rear of the fore saloon. Aircraft styling is used in the wheelhouse and the throttles are of dual-lever aircraft type.

ACCOMMODATION: Up to 150 passengers are seated in a short haul version built for suburban services, while alternative models for inter-city services, seat 116-130. Meteors are fitted with full air-conditioning, a bar and an aft promenade deck.

DIMENSIONS:

Length overall	112 ft 10 in (34.4 m)
Hull beam	19 ft 8 in (6.0 m)
Draught afloat	7 ft 6 in (2.3 m)
Draught foilborne	3 ft 11 in (1.2 m)

WEIGHTS:

Displacement loaded	52 tons
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PERFORMANCE:

Max speed, foilborne	35 knots (65 km/h)
Maximum endurance	9 hours

HYDROFOIL MANUFACTURERS

SORMOVO: The Union of Soviet Socialist Republics

MIR

First Soviet passenger craft to use a surface piercing foil system was the MIR (Peace), built in the autumn of 1961. Described as the first Soviet seagoing hydrofoil it is in many respects similar to the Supramar PT 50. The hull is of welded aluminium construction and the foils are in high tensile stainless steel. It can undertake voyages in up to State 4 seas and has a maximum speed of 47 knots (87 km/h). Power is supplied by twin M-50 diesels driving twin screws. The engines are electro-hydraulically controlled from the wheelhouse, which has an auto-pilot system for emergencies.

MOLNIA

This popular six-seat hydrofoil sports runabout was derived from Alexeyev's original test craft. Many hundreds are available for hire on Russian lakes and rivers and in slightly modified form the type is now being exported to countries including the United

Kingdom and the USA. The craft is navigable in protected off-shore water up to 2 miles from the land and has particular appeal for water-taxi and joy-ride operators.

FOILS: The hydrofoil assembly comprises two forward foils, one aft foil and planing sub-foils.

POWER PLANT: Powered by a 77 bhp CAZ652 Volga car engine, it has a top speed of about 32 knots (60 km/h) and a range of about 100 nautical miles (180 km).

HULL: Built in sheet and extruded light alloy, the hull is divided into three compartments by metal bulkheads. The forepeak is used for stores, the midship compartment is the open cockpit, and the compartment houses the engine, and gearbox. The cockpit is fitted with a steering wheel, throttle, reverse gear lever and an instrument panel adapted from that of the Volga car. Individual life jackets are carried for each passenger and are incorporated into the seat cushions.

DIMENSIONS:

Length overall	27 ft 11 in (8.50 m)
Hull beam	6 ft 5 in (1.95 m)
Draught afloat	2 ft 10 in (0.85 m)
Draught foilborne	1 ft 10 in (0.55 m)

WEIGHTS:

Displacement:	
loaded	1.8 tons
empty	1.25 tons

PERFORMANCE:

Max speed at 1.8 tons displacement	32 knots (60 km/h)
Fuel capacity	17 gall (80 litres)
Range	97 nautical miles (180 km)

NEVKA

This small fibreglass-hulled passenger ferry is being built by a Leningrad yard and will be used initially at Black Sea and Baltic holiday resorts.

FOILS: Bow and rear foils are both of fixed V surface piercing type and made of steel. The foils are detachable for maintenance or replacement.



MOLNIA, a popular six-seat runabout, is said to be navigable in protected off-shore waters up to two miles from land, and ideal for water-taxi services and joy-ride operators. Top speed is 32 knots



The Nevka is available as a 12-14 seat open cockpit water-taxi, cabin cruiser or sightseeing craft with a transparent roof. A 250 hp diesel provides a speed of 60 km/h

HYDROFOIL MANUFACTURERS

The Union of Soviet Socialist Republics: SORMOVO

HULL/ACCOMMODATION: The hull is in moulded glass fibre reinforced plastic, it can be supplied with an open 12-14 seat cockpit equipped with a wide windshield; as a cabin cruiser with a solid top or as a sightseeing craft with a transparent cabin roof.

As a cabin cruiser, the craft is equipped with bunks, a galley and toilet. The driving stand can be located either at the fore end of the cabin or in a raised position amidships.

POWER PLANT: Power is supplied by a 250 hp diesel driving a three-bladed propeller through a vee drive.

DIMENSIONS:

Length overall, hull	35 ft 11 in (10.9 m)
Beam	8 ft 11 in (2.7 m)
Width across foils	13 ft 2 in (4.0 m)
Draft foilborne	2 ft 9 in (0.8 m)
Draft afloat	5 ft 3 in (1.6 m)

WEIGHTS:

Max take-off displacement	5.5 tons
Displacement, unloaded	4.1 tons

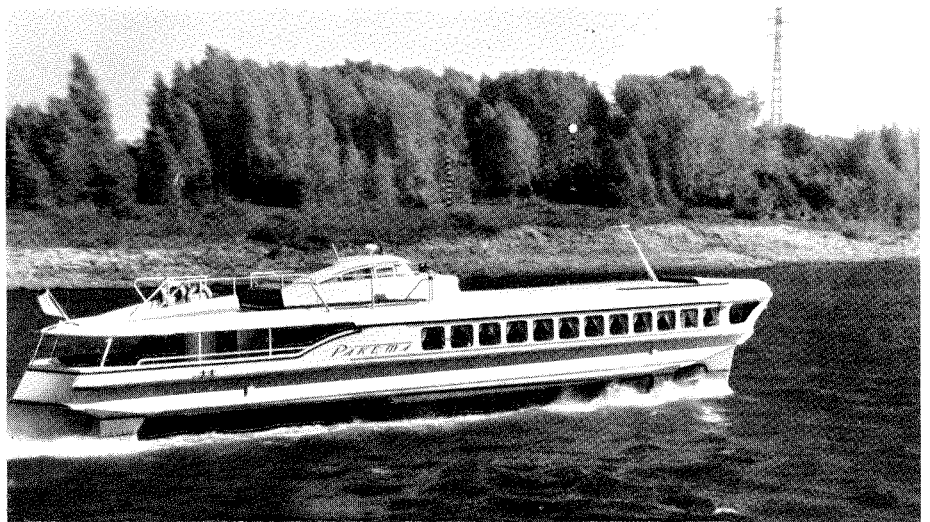
PERFORMANCE:

Max speed, calm water	37 mph (60 km/h)
Cruising range	137 miles (220 km)

RAKETA

The prototype Raketa was launched in 1957 and was the first multi-seat passenger hydrofoil to employ the Alexeyev shallow draught submerged foil system. Several hundred are now in service on all the major rivers of the USSR.

Since 1960, an increasing number of export orders have been placed for the craft. The first, for two Raketa 340s, came from Hungary and these began operation during the summer of 1962, one serving the route Budapest-Mohacs, 118 miles (190 km) to the south, and the other between Budapest and Estergom. The following year the service was extended to Vienna. Other countries operating Raketas include Bulgaria and Finland. Trinidad-Tobago Hydrolines, a division of the American owned International



Raketas are in service on all the major rivers of the U.S.S.R. and on the Danube. The first to be exported to North America is to operate a service in Trinidad between Port of Spain and San Fernando

Hydrolines Inc is planning to operate a Raketa between Port-of-Spain and San Fernando.

The Raketa is powered by a 1,200 hp M-50 diesel and cruises at 33.5 knots.

The craft is designed for services in daylight hours in protected waters under moderate climate conditions. It meets the requirements of Soviet River Register Class 'O'.

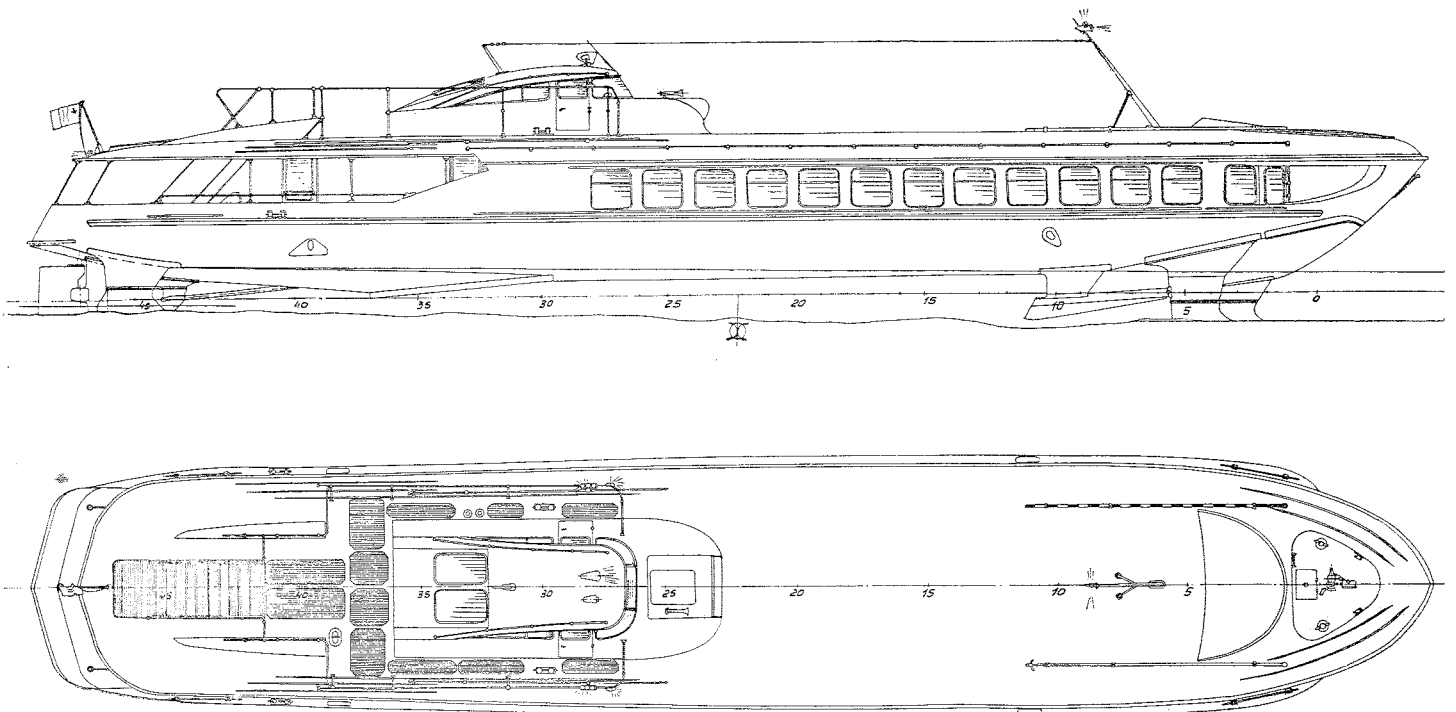
In October 1968 it was announced that the design of a new shallow draught variant had been completed. By changing the position of the propellers and regucind the hull weight, the draft will be reduced to 3 ft 11½ in (120 cm) or almost halved. The modernised version is expected to have a speed of 43.5 mph (70 km/h). Seating arrangements vary from 50-64 passengers according to the route length and conditions. The crew consists of a captain, engineer, motorman, and barman.

FOILS: The foil system consists of one bow foil and one rear foil and two subfoils. The main foils are in welded stainless steel and the subfoils are of aluminium alloy plate.

HULL: The hull is framed on longitudinal and transverse formers and all the main elements—plating, deck, framing, partitions, bulkheads, platforms and wheelhouse—are of riveted aluminium alloy.

Beneath the freeboard deck the hull is divided by watertight bulkheads into six compartments.

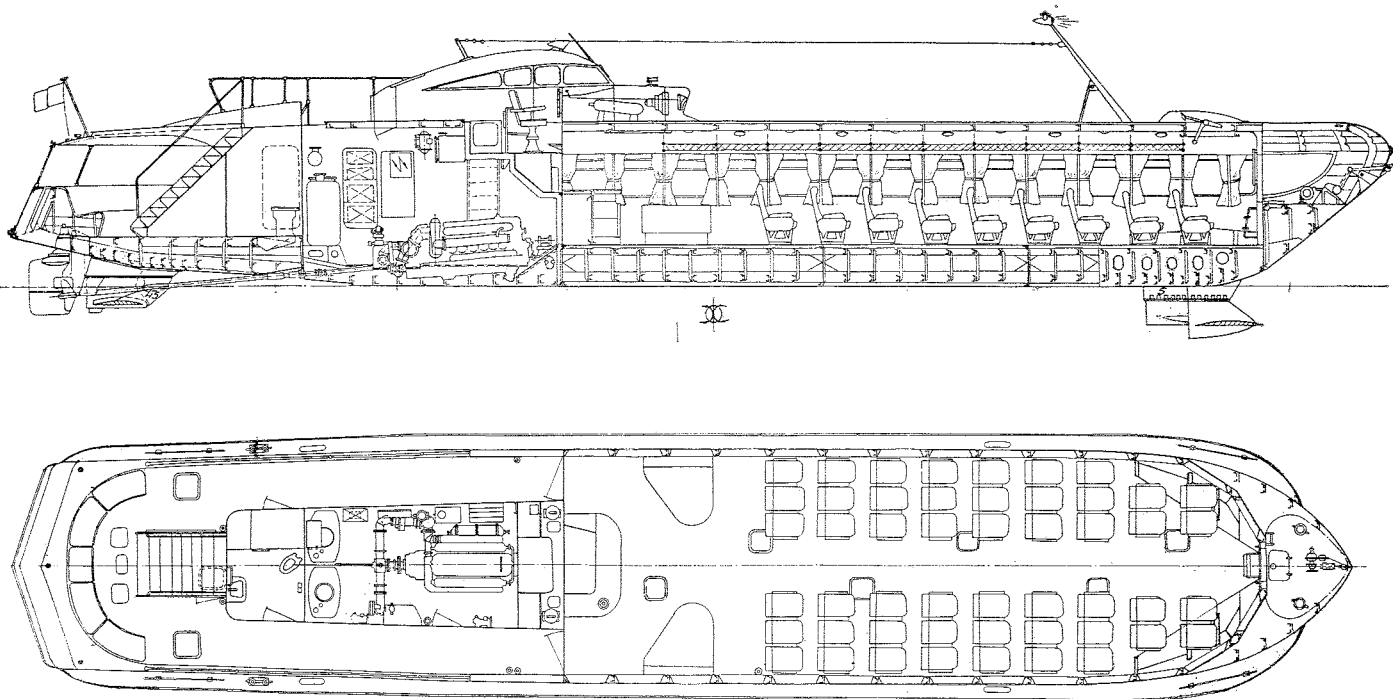
ACCOMMODATION: The passenger saloon of the standard model seats 50 in aircraft-type seats. At the aft end of the saloon is a bar. The saloon has one exit on each side leading to the promenade decks and one forward, leading to the forecabin. Aft of the saloon is the engine room, toilet, a promenade deck with a sofa, and the embarkation companionway leading to the awning deck. Beneath the companionway is a store room.



Raketa—General view

HYDROFOIL MANUFACTURERS

SORMOVO: The Union of Soviet Socialist Republics



Inboard profiles and deck views of the Raketa

The craft carries a full range of life-saving and fire-fighting equipment. There are 54 life jackets stowed in the passenger saloon, and 4 circular lifebelts located on the embarkation and promenade decks. Firefighting equipment includes four foam and four CO₂ fire extinguishers, two fire axes, two fire buckets and two felt cloths.

POWER PLANT: Power is supplied by a single M-50 watercooled, supercharged 12-cylinder V-type diesel, with a normal service output of 850 hp at 1,600 rpm, and a maximum output of 1,100 hp at 1,800 rpm. Specific fuel consumption is approximately 193 g/hp/h and the engine service life is 1,000 hours. The engine drives via a reverse gear and stainless steel intermediate and propeller shafts, a six-bladed brass propeller. The fuel system comprises two fuel tanks with a total capacity of 2,204 lb (1,000 kg) a fuel priming unit, and a hand-fuel-booster pump and filter. Lubricating oil system consists of a 120 litre service tank, and an 80 litre oil storage tank. A compressed air system, comprising a propeller shaft-driven air compressor and two 40 litre compressed air bottles, is provided for main engine starting, operating the foghorn and scavenging the water intake.

CONTROLS: The wheelhouse is equipped with an electro-hydraulic remote control system for the engine, reverse gear and fuel supply. The boat is equipped with twin balanced rudders in solid aluminium alloy. The rudders are controlled by a hand-operated hydraulic drive and in emergency by a hand tiller.

SYSTEMS:

ELECTRICAL: Power supply is 24 volts dc. A 1 kW dc generator attached to the main engine supplies power while the craft is operating. Four 12 volt acid storage batteries, each of 180 amp/hr capacity and connected in series to give 24 volts, supply power during short stops.

HYDRAULICS: The hydraulic system for controlling the main engine, reverse gear and fuel supply, consists of control cylinders located in the wheelhouse, power cylinders located on the engine, a filler tank, pipelines and fittings.

HEATING AND VENTILATION: Passenger saloon and wheelhouse are provided with a natural ventilation system, using ram inflow when the boat is in motion. When at rest the saloon and wheelhouse are ventilated through open windows and by electric fans. In cold weather the cabin is heated by water from the main engine cooling system. A conventional motor radiator serves as the heat exchanging unit. Engine room, passenger saloon and wheelhouse are heated by electric heaters using a shore power supply when the craft is at rest.

COMMUNICATIONS: A radio-telephone with a range of about 19 miles (30 km) is installed for ship-to-shore and ship-to-ship communication. The craft also has a public address system and intercommunication speakers linking the engine room, wheelhouse and forecabin.

DIMENSIONS:

Length overall	88 ft 5 in (26.96 m)
Beam, amidship	14 ft 6 in (4.4 m)
Breadth, moulded	16 ft 5 in (5.0 m)
Draught, hullborne	5 ft 11 in (1.8 m)
Draught, foilborne	3 ft 8 in (1.1 m)
Freeboard	2 ft 8 in (0.8 m)
Height overall (without mast)	14 ft 7 in (4.46 m)

WEIGHTS:

Light displacement	17.93 tons
Loaded displacement	25.33 tons

PERFORMANCE:

Cruising speed 32-32½ knots (58-60 km/h)
Sea State capability Will normally operate foilborne in waves up to 1 ft 8 in (0.5 m) high and will operate in hullborne condition in waves up to 4 ft 1½ in (1.25 m) high

Diameter of turn hullborne

328 ft (100 m) with rudders shifted 35°

Diameter of turn foilborne

820 ft (250 m) with rudders shifted 7°

Time and distance required to become hullborne 1 min 25 sec (800-1,000 m)

Time and distance required to stop craft

1 min 20 sec; (150-200 m)

SPUTNIK

The 100-ton Sputnik was the first of the Soviet Union's large hydrofoils. On its maiden voyage in November 1961, the prototype carried 300 passengers between Gorki and Moscow in 14 hours. Although a heavy autumn storm was encountered en route the craft was able to continue under way at a cruising speed of 40 knots through several large reservoirs with waves running as high as 8 ft.

FOILS: The foil system comprises a bow and rear foil with the outer struts of the bow assembly carrying two additional planing subfoils.

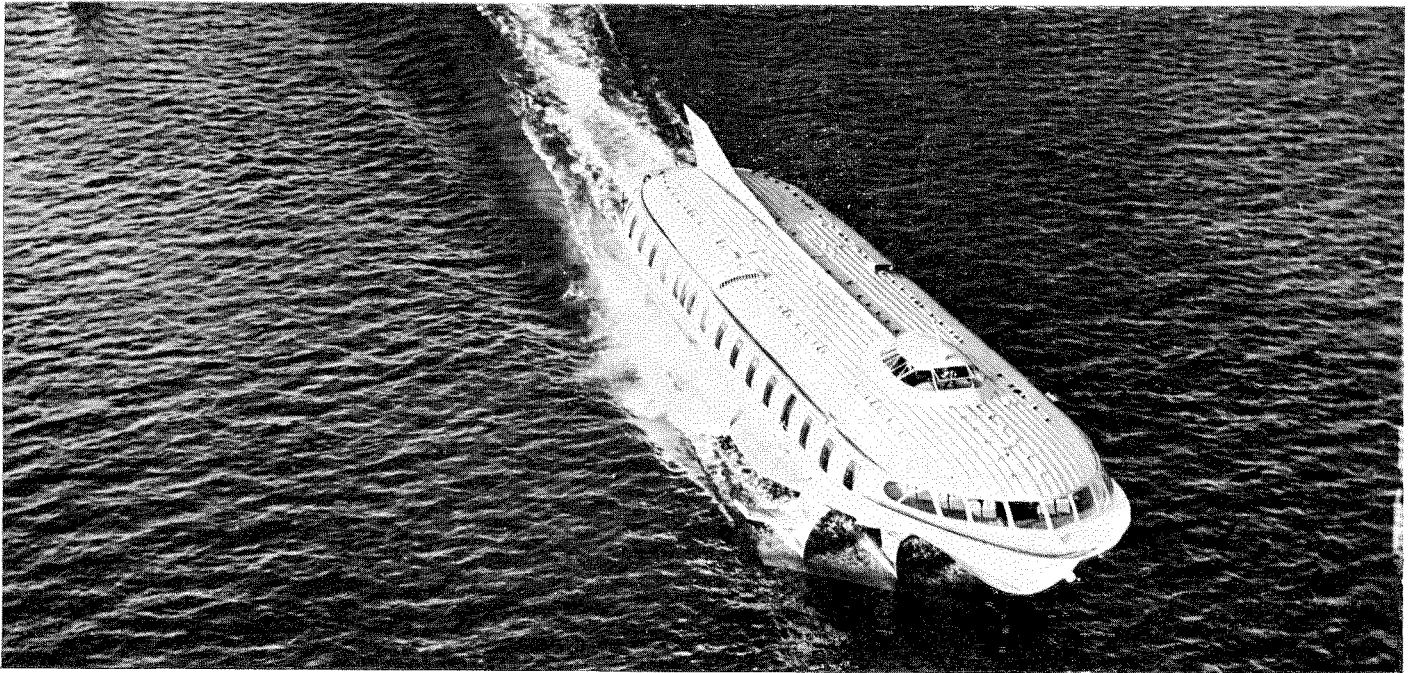
HULL: The hull is welded in AlMg-61 aluminium-magnesium alloy. Adoption of an all-welded unit construction facilitated prefabrication of sections at the Sormovo shipyard and elsewhere, the parts being sent to other yards in the USSR for assembly. One yard used for assembling Sputniks is at Batumi, on the Caspian Sea.

POWER PLANT: Power is supplied by four 850 hp M-50 watercooled, supercharged V-type diesels, each driving its own propeller shaft and controlled electro-hydraulically from the forward wheelhouse.

ACCOMMODATION: Passengers are accommodated in three saloons, a well-glazed fore compartment seating 68, and central and aft compartments each seating 96. On short, high frequency services, the seating is increased to 108 in the latter compartments by the substitution of padded benches instead of adjustable aircraft-type seats. Two separate

HYDROFOIL MANUFACTURERS

The Union of Soviet Socialist Republics: SORMOVO



Hydrofoils of the Soviet river fleet are playing an increasingly important part in the passenger transport scene on the Volga. In 1965 forty-one Raketas, Meteors and Sputniks carried over two million passengers on a route network on the river totalling 7,786 km. Above is a 110-ton Sputnik, passing down the Volga at Gorki

off-duty cabins are provided for the 5-man crew. The cabins are attractively finished in pastel shades and fully insulated against heat and sound. Full fire fighting and other emergency provisions are made and in addition to lifebelts for all passengers and members of the crew, two inflatable rubber boats are carried.

DIMENSIONS:

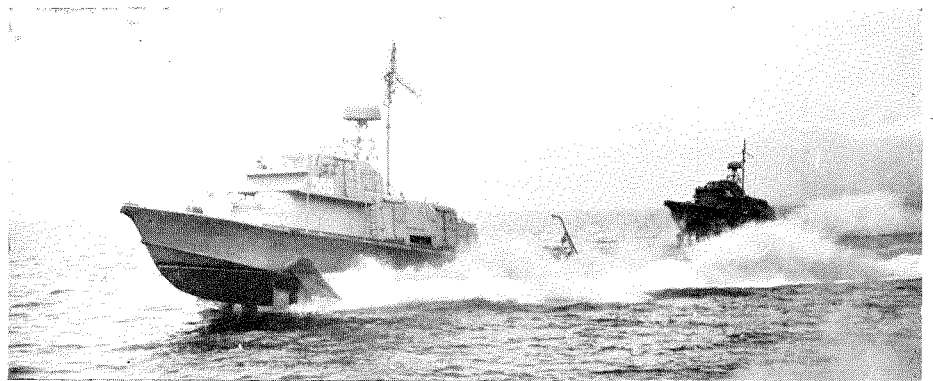
Length overall	157 ft 2 in (47.9 m)
Beam overall	29 ft 6 in (9.0 m)
Draught afloat	4 ft 3 in (1.3 m)
Draught foilborne	2 ft 10 in (0.9 m)

WEIGHTS:

Displacement full load	110 tons
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PERFORMANCE:

Cruising speed	41 knots (75 km/h)
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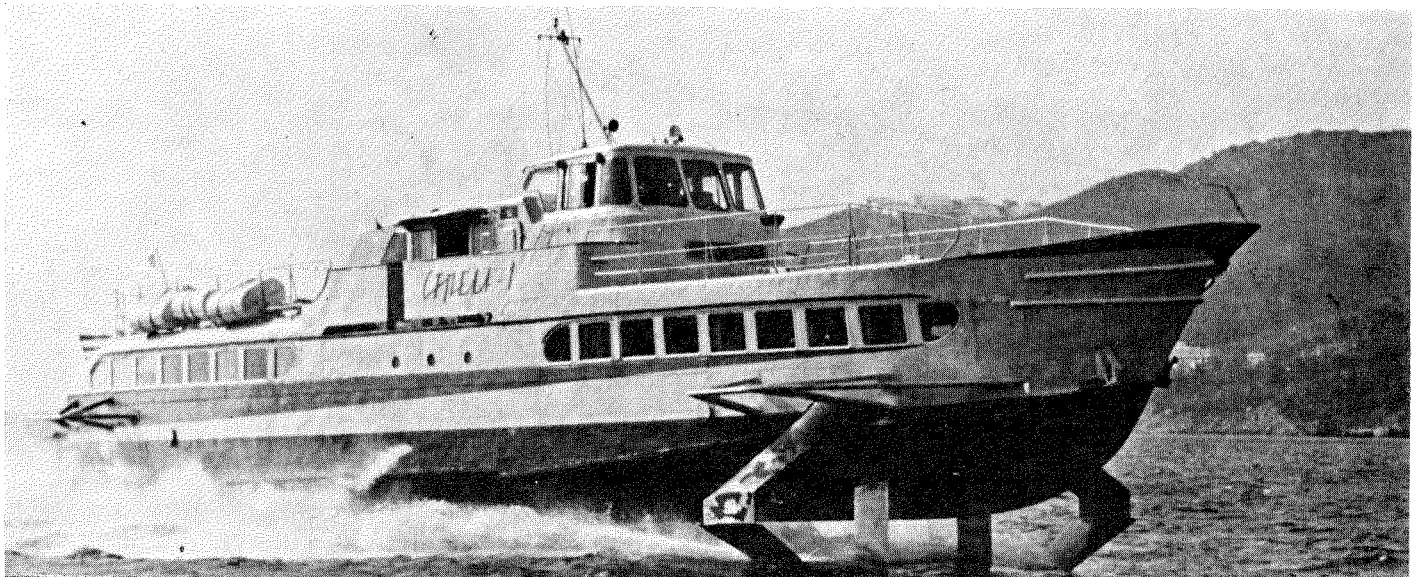
Two fast patrol hydrofoils of the Soviet Navy photographed at sea in February 1968. This class of vessel has been developed from the Strela commercial hydrofoil

STRELA

Developed from the MIR and intended for services across the Black Sea, the prototype Strela (Arrow) completed its acceptance trials towards the end of 1961. The craft, which

is built by a Leningrad shipyard, was first put into regular passenger service between Odessa and Batumi, and later between Yalta and Sebastopol. More recently a Strela 3 has been operating a service between Leningrad and Tallinn. It covers the distance in

four hours, ninety minutes faster than the express train service connecting the two ports. Two 1,200 hp 12-cylinder V-type M-50s driving twin screws give the Strela a cruising speed of 40 knots (75 km/h). The craft can operate in State 4 seas.



STRELA (Arrow) a ninety-two passenger hydrofoil with a surface piercing foil system, operates between Yalta and Sevastopol on the Black Sea, and between Leningrad and Tallinn. Two 1,200 hp 12-cylinder supercharged V-type M-50 diesels driving twin screws give it a cruising speed of 40 knots

HYDROFOIL MANUFACTURERS

SORMOVO: The Union of Soviet Socialist Republics

TYPHOON

This new gas-turbine powered, seagoing hydrofoil is under construction at a Leningrad shipyard and was due to be completed during 1968. The foil system (it has not been stated whether this is fully or partly submerged) is controlled by an electronic autopilot. Craft motion input is fed into and processed by a small computer.

The craft seats 90 passengers and is designed to maintain a speed of 38 knots in severe storms.

Power is supplied by two 1,700 hp gas turbines. No further information was available at the time of going to press.

VIKHR

Seagoing version of the Spuntik, Vikhr is the biggest passenger hydrofoil operating today. Described as a 'coastal liner' which can operate as far as 50 miles from the shore, the craft has been designed for regular, year-round coastal services on the Black Sea. **FOILS:** Compared with the Sputnik, innovations include more sharply swept-back foils, a form of auto-stabilisation, and sets of subfoils amidships in addition to those fore and aft, to increase seaworthiness and stability.

POWER PLANT: Power is provided by four 1,200 hp M-50s each driving its own propeller. **CONTROLS:** Engines and rudders are controlled from the wheelhouse electro-hydraulically.

ACCOMMODATION: As with the Sputnik, there are three passenger saloons. The fore saloon seats 70, the central saloon seats 96 and the aft 94. At the rear of the central cabin is a large buffet and bar, beneath which is the engine room. From the bar, double doors lead to the off-duty quarters for the seven-man crew.

In high seas passengers board from the stern, across the promenade deck. In normal conditions embarkation takes place amidships through a wide passageway across the vessel between the fore and middle saloons. Seats are arranged in three rows of four abreast across each cabin with two aisles each one metre wide between, to ease access to the seats.

DIMENSIONS:

Length	156 ft 0 in (47.5 m)
Beam	37 ft 9 in (11.5 m)

WEIGHTS:

Displacement, full load	110 tons
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PERFORMANCE:

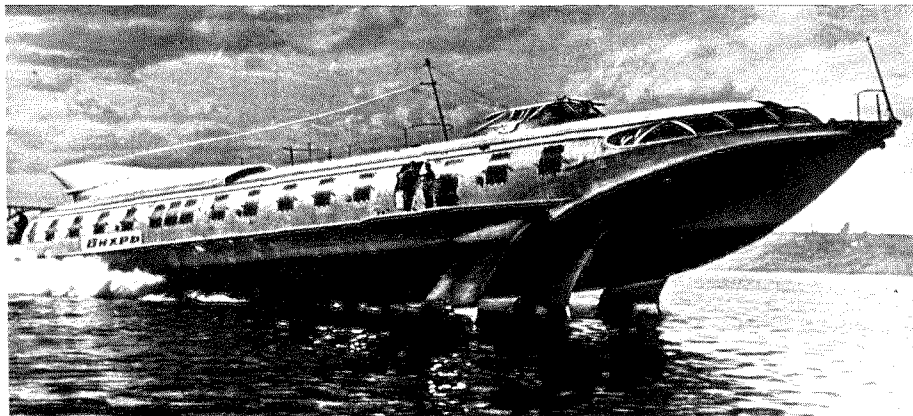
Max speed	43 knots (78 km/h)
Cruising speed	40 knots (73 km/h)

VOLGA

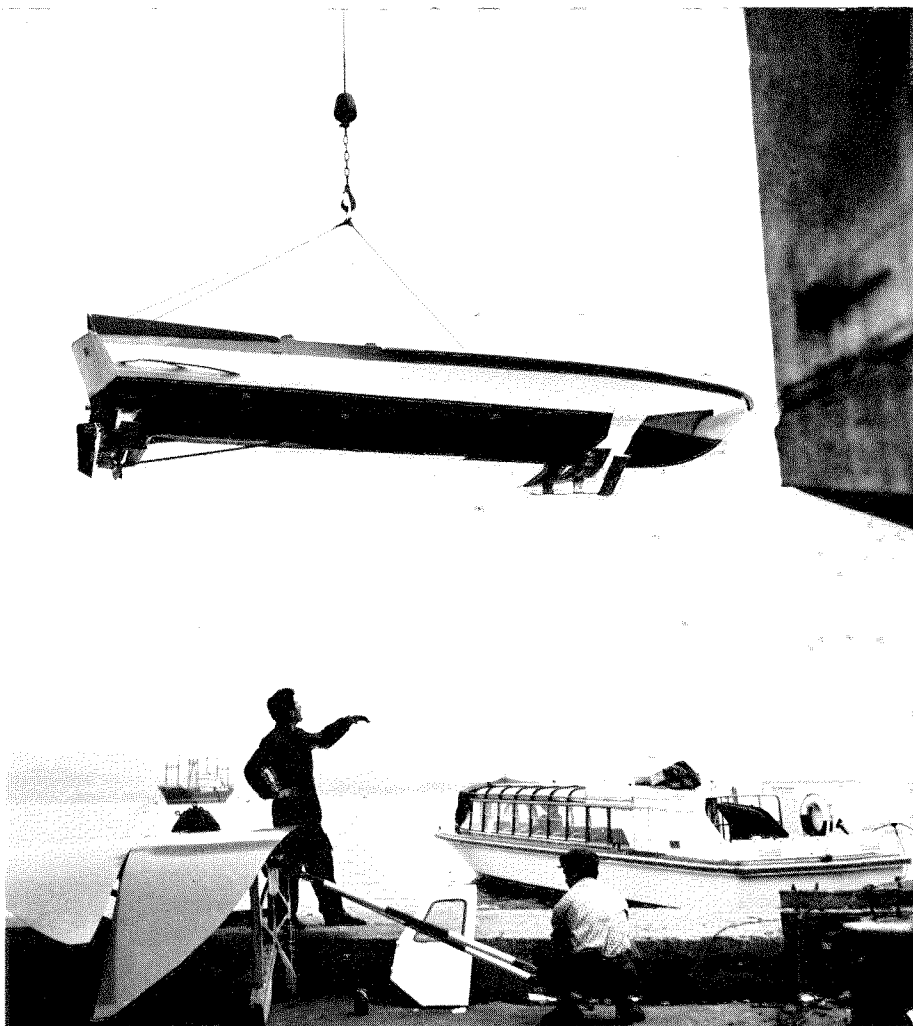
Export version of the Molnia sports hydrofoil, the Volga incorporates various design refinements including a completely redesigned bow foil. The craft has been exported to countries including the United Kingdom and the United States. The USA model, which has been re-engined and re-styled, is known as the Forte.

FOILS: The foil system consists of a bow foil with stabilizing subfoil and a rear foil assembly. The foils are of stainless steel.

HULL: Built in sheet and extruded light alloy, the hull is divided into three compartments by metal bulkheads. The forepeak is used for stores, the midship compartment is the open cockpit and the aft compartment houses the engine and gearbox.



Seagoing variant of the 300 passenger Sputnik, the Vikhr has been designed for regular, year-round services on the Black Sea. Innovations include an amidships subfoil for improved stability and an electronic autopilot system



Underside of the Volga showing the bow and rear foil assemblies.

ACCOMMODATION: Seats are provided for six—a driver and five passengers. The controls, instruments, magnetic compass and radio receiver are grouped on a panel ahead of the driver's seat. A full range of safety equipment is provided, including life jackets for six, life line, fire extinguisher and distress flares. A folding awning can be supplied.

POWER PLANT: Power is supplied by a 77 hp M652-Y 6-cylinder automotive engine, which drives a 3 bladed, stainless steel propeller through a V drive. The shafting comprises an intermediate shaft, propeller shaft, stern gland with rubber bearings, propeller shaft coupling boxes with reduction gear and propeller shaft bracket.

SYSTEMS:

ELECTRICAL: 12 volt dc. Starting, instrument and navigation lights and siren, are provided by an engine-mounted generator and an acid storage battery.

DIMENSIONS:

Length overall	27 ft 11 in (8.5 m)
Beam	6 ft 11 in (2.1 m)
Draught afloat	2 ft 9½ in (0.85 m)
Draught foilborne approx	1 ft 8 in (0.5 m)

WEIGHTS:

Total displacement	3,090 lb (1,886 kg)
Fuel	141 lb (64 kg)

PERFORMANCE:

Cruising speed	32 knots (60 km/h)
Range	112 miles (180 km)

HYDROFOIL OPERATORS

HYDROFOIL OPERATORS

AMERICA, NORTH

USA

Operator: New York Hydrofoils Inc
Type(s): Albatross, 2 (Honold)
Route: East 90th Street-Wall Street. Com-
muter service

Operator: US Hydrofoils
Address: DuPont Plaza Marina, Florida
Type(s): Albatross, 3 (Honold)
Route: Biscayne Bay, Miami

Operator: Northwest Hydrofoil Lines Inc
Address: 1412 Vance Building, 3rd and
Union, Seattle, Washington 98101
Type(s): Victoria (Maryland)

Route: Daily service between Seattle and
Victoria (BC); two round trips on Fridays,
Saturdays, Sundays.

Operator: International Hydrolines, Inc
Address: 245 Park Avenue, New York, NY
10017

Telephone: MUrray Hill 2-0700

Type(s): Raketa, Kometa (Krasnoye Sor-
movo)

Routes: The company's initial area of
operation is the Caribbean. Its first craft,
a Raketa, will operate in Trinidad between
Port-of-Spain and San Fernando. In late
1968 the company was due to take delivery
of a Kometa to operate from Trinidad to
Tobago and Granada.

Operator: US Navy Pacific Fleet Amphibious
Command

Type(s): Boeing PGH-2 Tucumcari
Base: San Diego

Operator: US Naval Ship Research and
Development Center

Type(s): High Point, PCH-1; Plainview
AGEH-1; Flagstaff, PGH-1

Purpose: US Navy hydrofoil development
programme

AMERICA SOUTH

ARGENTINE

Operator: Alimar SA
Type(s): PT 50, 3 (Rodriquez)
Route: Buenos Aires-Colonia-Montevideo

BOLIVIA

Operator: Crillon Tours Ltd
Address: PO Box 4785 Av Camacho 1223 Ed,
Krsul, La Paz
Type(s): Albatross, 2 (Honold), modified by
Helmut Kock
Route: Lake Titicaca

VENEZUELA

Operator: Compania Shell
Type(s): PT 20, 4 (Werf Gusto)
Route: Offshore oil drilling operations on
Lake Maracaibo
Operator: Naveca SA
Type(s): PT 20, 4 (Rodriquez)
Route: Maracaibo-Cabinas

EUROPE

CHANNEL ISLANDS

Operator: Condor Hydrofoil Services, Guern-
sey
Type(s): PT 50, 1 (Rodriquez)
Route: Guernsey-Jersey-St Malo

DENMARK

Operator: Danish Railroad
Type(s): PT 50, 1 (Westermoen)
Route: Copenhagen-Malmö

FINLAND

Operator: Pajanteen Kantosiipi Oy
Type(s): Raketa, 1 (Krasnoye Sormovo)
Route: Lahti-Jyväskylä, across Lake Päijäne

FRANCE

Operator: Navite SA
Type(s): PT 20, 2 (Rodriquez)
Route: Cannes-Nizza-Monte Carlo-San Remo

GERMANY

Operator: Water Police
Type(s): PT 4, 3 (German Shipyard)
Route: Patrol service on the Rhine
Operator: Hamburg Transport Dept
Type(s): Seafight P46, 2
Routes: In Hamburg harbour

GREECE

Operator: John Latsis
Type: PT 50
Route: Athens-Passalimni-Hydra

HUNGARY

Operator: Hungarian Navigation Company
Type(s): Raketa, 2 (Krasnoye Sormovo)
Route: Budapest-Vienna

ITALY

Operator: ENIT
Type(s): P 46, 2
Route: Cruise routes
Operator: SNAV, Messina
Type(s): PT 50, 3; PT 20, 1 (Rodriquez)
Route: Naples-Capri-Ischia
Operator: Aliscafi SpA
Type(s): PT 20, 5; PT 50, 1 (Rodriquez)
Route: Messino-Reggio-Isole Liparre
Operator: SAS Trapani
Type(s): PT 50, 1; PT 20, 3 (Rodriquez)
Route: Trapani-Egadi Islands
Operator: Tourist Ferryboat Co.
Type(s): P 46, 2; H 57, 1
Routes: Messina-Reggio Calabria
Operator: Adriatica SpA di Navigazione
Venezia
Type(s): PT 50, 1 (Rodriquez)
Route: Tremoli-Isoledi Tremiti
Operator: Ministry of Transport, Milan
Type(s): PT 20, 3 (Rodriquez)
Route: Lake Garda
Operator: Compagnia di Navigazione
Type(s): PT 20, 1 (Rodriquez)
Route: Lake Maggiore
Operator: Compagnia di Navigazione
Type(s): PT 20, 1 (Rodriquez)
Route: Lake Como
Operator: Lauro Navigation Co
Type(s): H 57, 2
Routes: Naples-Capri; Naples-Ischia
Operator: Fiera Internazionale Genova
Type(s): PT 20, 1 (Rodriquez)
Route: Liguria Riviera-Genoa
Operator: SAS and SNAV
Type(s): PT 50, 1 (Rodriquez)
Route: Palermo-Eolian Islands
Operator: Societa Sirena, Palermo

Type(s): PT 50, 1; PT 20, 1

Route: Palermo-Ustica
Operator: Societa Tosco Sarda di Nav Porto
Ferraio
Type(s): PT 20, 2
Route: Piombino-R. Marina-P. Azzutto

MALTA

Operator: Malta Aliscafi Ltd
Type(s): PT 20, 1 (Rodriquez)
Route: Malta-Cozo

NORWAY

Operator: Stavangerske Dampskibsselskab
Type(s): PT 50, 2; PT 20, 1 (Rodriquez)
Route: Stavanger-Haugesund-Bergen
Operator: Hardanger Sunnhordelandske
Dampskibsselskab
Type(s): PT 20, 1 (Rodriquez)
Route: Bergen-Tittelsness
Operator: Hydrofoilrutene Oslo
Type(s): PT 20, 2 (Westermoen)
Route: Oslofjord

POLAND

Operator: Central Board of Inland Naviga-
tion
Type(s): ZRYW-1
Route: Szczecin-Swinoujscie

SOVIET UNION

The Soviet Ministry of the River Fleet
operates approximately 700 hydrofoil
passenger ferries employing the Alexeyev
foil system on routes which cover practically
all the major rivers, lakes, canals and
reservoirs from Central Russia to Siberia
and the Far East. In addition Strela-type
hydrofoils operate services in the Gulf of
Finland between Leningrad and Tallinn and,
supported by Kometas and Vikhrs, provide
year-round services between ports on
the Black Sea. Strelas are likely to be
joined in 1969 by the new gas turbine
powered Typhoon, built in Leningrad. The
Typhoon seats 90 passengers, has an auto-
stabilised foil system, and is designed for
operation in Sea State 5.

There are now 54 hydrofoil services on the
Volga alone, operated by vessels of the
Meteor, Raketa and Spuntik series. These
older, diesel powered designs were joined on
the Volga on April 26 1968 by the prototype
Burevestnik, which is now operating between
Gorky and Kuibyshev, a distance of 435
miles (700 km).

The Burevestnik is powered by gas-turbine
driven waterjet units and has a service speed
of 95-97 km/h. It seats up to 150 passengers
on shorter range routes and 130 on non-stop
intercity services.

SWEDEN

Operator: AB Sundfart Malmö
Type(s): PT 50, 1; PT 20, 2 (Westermoen)
Route: Copenhagen-Malmö
Operator: Svenska Rederiaktiebolaget
Oeresund
Type(s): PT 50, 2 (Rodriquez)
Route: Copenhagen-Malmö
Operator: Gothenburg-Fredrikshavn Line
Type(s): PT 150 (Westermoen)
Route: Gothenburg-Aalborg-Fredrikshavn

HYDROFOIL OPERATORS

SWEDEN/DENMARK

Operator: Oerosund AB
 Type(s): PT 50, 2 (1 Rodriquez, 1 Westermoen)
 Route: Copenhagen-Malmo

SWITZERLAND

Operator: Societé de Nav. sur le Lac Léman
 Type(s): PT 20, 1 (Rodriquez)
 Route: Lake Léman

UNITED KINGDOM

Operator: Red Funnel Steamers Ltd
 Type(s): Seafight H57
 Route: Southampton-Cowes

YUGOSLAVIA

Operator: Split Airport/Globtour
 Type(s): Kometa, 6 (Sormovo)
 Route: Pula-Dubrovnik

EGYPT

Operator: Ministry of Commerce, Cairo
 Type(s): PT 20, 3 (Rodriquez)
 Route: Abu Simbel-Asswan
 Operator: Suez Canal Administration
 Type(s): PT 4, 1 (Werf Gusto)
 Route: Suez Canal

ASIA, AUSTRALIA & NEW ZEALAND

AUSTRALIA

Operator: Port Jackson & Manly Steamship, Sydney
 Type(s) PT 20, 2; (Hitachi and Rodriquez)
 Route: Sydney bay and coastal services

HONG KONG

Operator: Shun Tak Co
 Type(s): PT 20, 1 (Rodriquez)
 Route: Hong Kong-Macao
 Operator: Hong Kong Macao Hydrofoil Co
 Type(s): PT 20, 4; PT 50, 4 (Rodriquez)
 Route: Hong Kong-Macao
 Operator: Far East Hydrofoil Co
 Type(s): PT 50, 3 (Hitachi)
 Route: Hong Kong-Macao

INDONESIA

Operator: Indonesian Government
 Type(s): PT 20, 1 (Rodriquez)
 Route: Patrol

JAPAN

Operator: Biwako Kisen Co Ltd
 Type(s): PT 3A, 1 (Hitachi)
 Route: Biwa Lake
 Operator: Kyushu Shosen Co Ltd
 Type(s): PT 3A, 1 (Hitachi)
 Route: Misumi-Shimabara
 Operator: Nishisskutajimamura Kotsubu
 Type(s): PT 3A, 1 (Hitachi)
 Route: Kagoshima-Hakamakoshi
 Operator: Innoshima Suichu Yokusen Co Ltd
 Type(s): PT 3A, 1; PT 3B, 1; PT 5, 2 (Hitachi)
 Route: Onomichi-Innoshima
 Operator: Neitetsu Kaijo Kanko Co Ltd
 Type(s): PT 20, 2 (Hitachi)
 Route: Nagoya-Gamagori; Toyohsahi-Toba
 Operator: Kansai Kisen Co Ltd
 Type(s): PT 20, 2; PT 50, 1 (Hitachi)
 Route: Osaka-Takamatsu
 Operator: Setonaikai Kisen Co Ltd

Type(s): PT 20, 3 (Hitachi); MH 30, (Mitsubishi)
 Route: Matsuyama-Hiroshima; Onomichi-Imabari
 Operator: Hankyu Maikai Kisen Co Ltd
 Type(s): PT 20, 2 (Hitachi)
 Route: Kobe-Naruto
 Operator: Iwasaki Kisen Co Ltd
 Type(s): PT 20, 1 (Hitachi)
 Route: Matsuyama-Hiroshima
 Operator: Neitetsu Kaijo Kanko Co Ltd
 Type(s): PT 50, 1 (Hitachi)
 Route: Nagoya-Gamagori
 Operator: Nihon Kosokusen Co Ltd
 Type(s): PT 50, 1 (Hitachi)
 Route: Enoshima-Atami
 Operator: Shimakatsuurakankokisen
 Type(s): MH 30, 3
 Route: Gamagori-Toba-Nagoya

NEW ZEALAND

Operator: Kerridge Odeon Corporation
 Type(s) PT 20, 1 (Rodriquez)
 Route: Auckland-Waiheke Island

PHILIPPINES

Operator: Tourist Hotel and Travel Corporation
 Type(s): PT 20, 2 (Rodriquez)
 Route: Manila-Corregidor
 Operator: Philippine Navy
 Type(s): PAT 20, 2 (Rodriquez); PT 32 2 (Hitachi)
 Coastal Patrol
 Operator: Sundaharya Corp, Djakarta
 Type(s): PT 20
 Route: Indonesian Coast

**REPORT ON
HYDROFOIL DEVELOPMENT**

REPORT ON HYDROFOIL DEVELOPMENT

Four vessels—the Tucumcari, Plainview, Victoria and PT 150—demonstrated in 1968 how far and how fast hydrofoil technology has advanced since the PT 20 prototype opened the first-ever scheduled hydrofoil sea service twelve years ago.

The superb performance of the Tucumcari waterjet-propelled hydrofoil gunboat prompted four European navies to send observers to study the craft at Seattle. A key point in their interest is that the Tucumcari is suitable for patrolling long coastlines at well over 40 knots and can operate without difficulty in heavy seas.

It is being argued increasingly that naval patrol vessels of the future must be small and fast. Twenty-five to thirty rocket-equipped hydrofoil warships, for example, would provide twenty-five points of naval fire, and because of their size and speed would be far less vulnerable to air or guided missile attack than a conventional cruiser.

The Italian Navy has shown particular interest in the Tucumcari, and is reported to be considering an order for thirty, which would be built in Italy. Airo M. Gonnella, head of Boeing's Advanced Marine Systems Organisation, which designed and built the craft, estimates there is a market for 200-300 military hydrofoils in Europe initially.

The Tucumcari is now in its home port of San Diego, operating with the US Navy Pacific Fleet Amphibious Command, where it is due to be joined by the Grumman Flagstaff. Both craft will be evaluated by the US Navy which, according to a press report, is considering an initial purchase of about 30 of one of the two gunboat designs.

Boeing dismisses the debris "problem" as a highly localised one, confined to only a few areas such as Puget Sound, where the Tucumcari was tested extensively. The craft struck debris several hundred times and splintered every log it hit, including one 25 ft long, 18 in diameter timber weighing 1½ tons. The hull structure is designed to crumple under severe impact, absorbing the force before the strut is damaged or sheared off.

Debris in other areas, the Mediterranean for example, might be up to the size of a railway tie, but no larger, and craft like the Tucumcari can withstand strikes of objects that size without damage. Debris will not present any serious problems in naval operations, and as vessels get larger, the problem of sustaining foil damage in this way, will disappear altogether.

Just how large hydrofoils will become eventually seems to be anyone's guess. At one time it was considered that because of the size of the foils required, and the performance of the powerplants available, hydrofoils would be limited in size to about 1,000 tons displacement. Today this figure appears to be on the conservative side. Relatively small high-lift foils, new marine gas-turbines with twice the output, and new, less complex propulsion systems are being developed which could lead to the construction of hydrofoils several times the size of craft envisaged ten to twelve years ago.

Not long ago the design of a hydrofoil capable of operating in the Atlantic was thought to be out of the question. Now most hydrofoil designers concede that this is feasible.

Certainly projects for much larger craft are beginning to take shape. Boeing states that the company could build boats of up to 1,000 tons, employing the same basic technology as that of the Tucumcari, and having similar performance.

Meanwhile, the world's biggest hydrofoil to date is the 320 ton USS Plainview, which successfully completed her maiden flight at Puget Sound on March 21, 1968. The craft will provide the first opportunity to evaluate the potential of submerged foil craft for full ocean-going naval service. The guidance design was completed by Grumman and the contract for detailed design and construction was awarded to Lockheed Shipbuilding & Construction Company. In addition to its large size, its design is substantially different to that of the PCH-1, the US Navy's experimental hydrofoil patrol boat. Foil lift variation is effected on the Plainview by changing the incidence angle of both the main foils and the tail foil. Ultra-sonic height sensors are mounted both at the bow and the stern.

Initially the powerplant comprises two General Electric LM1500 gas turbines, each driving one propeller through a right-angle bevel gear transmission. Provision has been made however for adding two more engines to permit much higher speeds to be attained. A ventilated or supercavitating system would be fitted to the craft in this form. The AGEH-1 has been assigned to the US Navy's Hydrofoil Special Trials Unit at Bremerton, Washington, and will undergo extensive evaluation for a period of several years. Grumman has now completed the design of a commercial derivative—the 325 ton Neptune. The standard version, designed for mixed traffic, will accommodate 302 passengers on the upper deck and 37 cars on the vehicle deck beneath. The craft will be capable of operating in sea state 6 and will have a cruising speed of 50 knots. Blohm & Voss AG of Hamburg, which built the first two Grumman Dolphins, will also build the Neptune and handle its sale in Europe.

After various delays, the HS Victoria, built by Maryland Shipbuilding & Drydock Co. for William I. Niedermair, President, Northwest Hydrofoil Lines, got away to a flying start on its scheduled service between the heart of Seattle and Victoria B.C. in the summer of 1968. By the end of August the craft was operating with clockwork regularity and carrying capacity payloads. To cope with the traffic, the service has been increased to two round trips per day on Fridays, Saturdays and Sundays. Journey time is just under 2½ hours, reducing by two hours the time taken by conventional ferries.

Victoria, one of the world's most sophisticated passenger hydrofoils, was designed by Gibbs & Cox. The vessel carries a crew of four and 75 passengers and will operate in

8-10 ft waves at 37-40 knots. It has a fully submerged foil system of canard configuration and is powered by two LM1500 gas turbines driving non-reversing water propellers. The incidence controlled bow foil and the trailing edge flaps of the main foils are controlled automatically by a Foil-Borne Control System designed and manufactured by General Electric Defense Electronic Division.

In complete contrast to the electronics employed to stabilise Tucumcari, Plainview and Victoria is the Schertel-Supramar stabilisation system employed on the world's biggest commercial hydrofoil to date—the 150 ton Supramar PT 150 built by Westermoen for the Gothenburg-Fredrikshavn Line. Latest in the long line of Supramar designs, the craft is the first to be built for fast ferry services in unprotected waters away from the coast. Originally the PT 150 was intended as a 250 seat passenger ferry, but at the request of the operating company, the basic design was modified to allow an alternative payload of 150 passengers and 8 cars to be carried.

The craft has a surface-piercing bow foil and a fully submerged rear foil. Stability is maintained jointly by the inherent stability of the bow foil and the air stabilisation system fitted to the rear foil. Separate port and starboard systems are installed to stabilise rolling and pitching. The system feeds air from the free atmosphere through air exits to the foil upper surface (the low pressure region) decreasing the lift. The amount of lift is varied by the quantity of air admitted, this being controlled by a valve actuated by a damped pendulum and a rate gyro. The craft is stabilised by decreasing the available air volume for the more submerged side and increasing that of the less submerged one. The bow foil centre section is also to be provided with submergence depth stabilisation, the quantity of air admitted being varied with the degree of submergence.

During the first two months of service, the craft carried more than 25,000 passengers on the Gothenburg-Fredrikshavn route. The journey time, compared with that taken by conventional ferry boats, was reduced from four hours to one hour and forty minutes. The costs per seat/mile ranged between 2¼d and 3d. A second PT 150 is under construction by Rodriquez.

Supramar refers to the craft as being 'partly stabilised'. In 1968 the first of a new generation of "fully stabilised" Supramar craft was being evaluated in the Mediterranean. The craft, an ST 3 (formerly PT 4) test bed, with a fully submerged foil system, is powered by a GE LM100 gas turbine, and has been operated at speeds up to 56 knots.

Two Soviet-built hydrofoils that made news in 1968 were the Kometa, the seagoing version of the earlier Meteor, and the new fast patrol derivative of the 90-passenger Strela hydrofoil ferry. The Kometa visited London and the Isle of Wight at the end of a sales tour which took the craft from Poti, on the Black Sea, to the Baltic. Copenhagen,

Antwerp and Rotterdam en route. The craft proved to be exceptionally robust and to have a good all-round performance. It has a cruising speed of 32 knots and is normally able to operate foilborne in waves up to 4 ft (1.25 m) high. It can travel hullborne in 8-10 ft (2.5-3 m) waves. Export orders for the Kometa continue to grow. Six have been supplied to Yugoslavia, which has recently increased this order, and one is being shipped to International Hydrolines of New York for a service between Trinidad and Tobago.

Interest has been shown in the craft by potential operators in the United Kingdom, and one is on order through Airavia Ltd, the Sudimport representatives, for delivery in early 1969 for a service in the UK, subject to a passenger licence being granted by the Board of Trade.

Photos of the new Soviet coastal patrol hydrofoil reveal few details of the craft or its armament, apart from the use of a Scherffel-Sachsenburg type surface-piercing bow foil, and what appears to be a remotely-operated bow turret mounting twin machine guns. It is possible that the design has been developed from the Strela via the new 90-passenger Typhoon, and like the latter has a gas turbine powerplant and a form of autostabilisation. Craft of this class are likely to be operated in the Baltic, Black Sea and the Caspian Sea.

A number of new craft with mechanically-operated incidence control systems are currently being developed. The latest are the Wynne-Gill Maritime Flight 1, a 21 ft four-seat sports hydrofoil designed by international offshore powerboat champion Jim Wynne, and his partner, John Gill, for the Maritime Corporation, Alliance, Ohio, and the New Hydrofin Ltd's Channel Skipper,

Maritime Flight 1 has a fully-submerged foil system with mechanical wave sensors operating trailing edge flaps to maintain the foils at the required depth. For the first time in hydrofoil design, use is made of

Torsionetic universal joints on the propeller drive shaft to permit retraction. Top speed is about 40 knots. Christopher Hook's Channel Skipper is developed from his earlier K2 Hydrofin, and is also a four-seater. A high-riding crash preventer plane is mounted ahead as a platform for mounting a lightweight pitch sensor which is hinged to the rear. The sensor rides on the waves and continuously transmits their shape through a servo system and connecting linkage to vary the incidence angle of the main foils. A filter system ensures that the craft ignores small waves and that the hull is flown over the crests of waves exceeding the height of the keel over water. The prototype is expected to be completed in 1969.

A growing range of sports hydrofoils is becoming available. The best known are the Molnia and Volga, of which several thousand have been built (the Forte, on sale in the USA, is a derivative); the Hungarian-built Nikex (production of which has now ceased) and the very successful Water Spyder series, constructed by Water Spyder Marine Ltd, Downsview, Ontario. In 1969, two new Polish designs will be added to the range—the six-seat WS-6 Eros and the four-seat WS-4 Amor. The craft, which are designed by Gdansk Ship Research Institute, have glass fibre hulls and will go into series production.

If hydrofoil enthusiasts prefer sail to power, they can build a new class of sailing hydrofoil—the Flying Fish—designed by Donald J. Nigg. The estimated cost of constructing this craft, which is capable of more than 30 knots, is \$US 175-00, less sail and rigging. The design allows the builder to share the sail and rigging with an existing dinghy.

Another new craft due to be completed in 1969, will be the prototype Seafight L.90, a 100-120 seat passenger ferry which has been designed by this Italian company for export. The craft has been developed from the successful 60-seat Seafight H.57, one of which has been ordered by Red Funnel

Steamers Ltd for services between Southampton and Cowes, Isle of Wight.

Like its forebears, the L.90 incorporates a foil system in which the foil automatically assumes the best angle of incidence in relation to the wave condition. The split bow foil combines a horizontal submerged centre section with inclined surface piercing areas, and the geometry of the bow and rear foils is such that it is possible to beach the vessel on a falling tide on a nearly flat sandy bottom, the hull remaining stable.

Seafight vessels are now in service in Hamburg and are operating an increasing number of scheduled passenger services around the Italian coastline. Several have been employed for holiday cruises and have operated to the coast of North Africa. Variants of the C.46, H.57 and L.90 include fast luxury yachts and fast coastal patrol craft.

In 1968 hydrofoils were operating in increasing numbers and spreading to more and more countries. Progress in the past has been painfully slow, but the tremendous growth in the use of commercial hydrofoils during the past few years, combined with the increasing interest of the world's navies, suggests that the opposite will be true in the future.

Even in the United Kingdom, which unlike most other European countries, still has no scheduled hydrofoil ferry services, there is an awakening to its possibilities. Desmond Plummer, leader of the Greater London Council, foresees a future for them on the Thames. He says: "We are finding out it is going to be practicable for hydrofoils to be employed on inter-city services. These craft have also, I am sure, a great future on passenger ferry services within London. I look forward to the day when the worker in Central London can be carried speedily from his home at Thamesmead, our new town near Erith, free from the weary journey on overcrowded trains. The visitor to London may, before long, be able to enjoy high speed travel to the Continent by water, as well as by air".

**SAFETY, RELIABILITY AND
MAINTAINABILITY OF
SUPRAMAR COMMERCIAL
HYDROFOIL BOATS**

by BARON HANNS VON SCHERTEL

SAFETY, RELIABILITY AND MAINTAINABILITY OF SUPRAMAR COMMERCIAL HYDROFOIL BOATS

by

BARON HANNS VON SCHERTEL
SUPRAMAR LTD., LUCERNE

INTRODUCTION

Hydrofoil boats are a comparatively new means of transportation. With their arrival a new era in short distance water communications began. For the first time in the history of transportation a waterborne vehicle was capable of competing successfully with fast land vehicles wherever such competition was geographically possible. Hydrofoil boats can also compete in profit and even in journey time with short distance airliners because they operate from place-to-place, rather than from airport-to-airport.

However, a rapid passenger service is only justified if the timetable can be strictly adhered to. Frequent long delays would destroy the advantage over slower communications and many passengers would, no doubt, turn to the shipping lines which guarantee punctual arrival. This illustrates the importance of safety and reliability of operation for rapid means of transportation.

It is obvious that in the case of a long distance service in unprotected waters profitable operation can only be expected if the vessel has sufficient riding comfort. But the system employed for obtaining smooth performance in rough seas should be of simple design and reliable. Experience has shown that sensitive high cost foil systems, requiring specialist engineers for maintenance, are of little appeal to a commercial operator, however impressive the sea performance may be, because he will fail to get an adequate return on his investment.

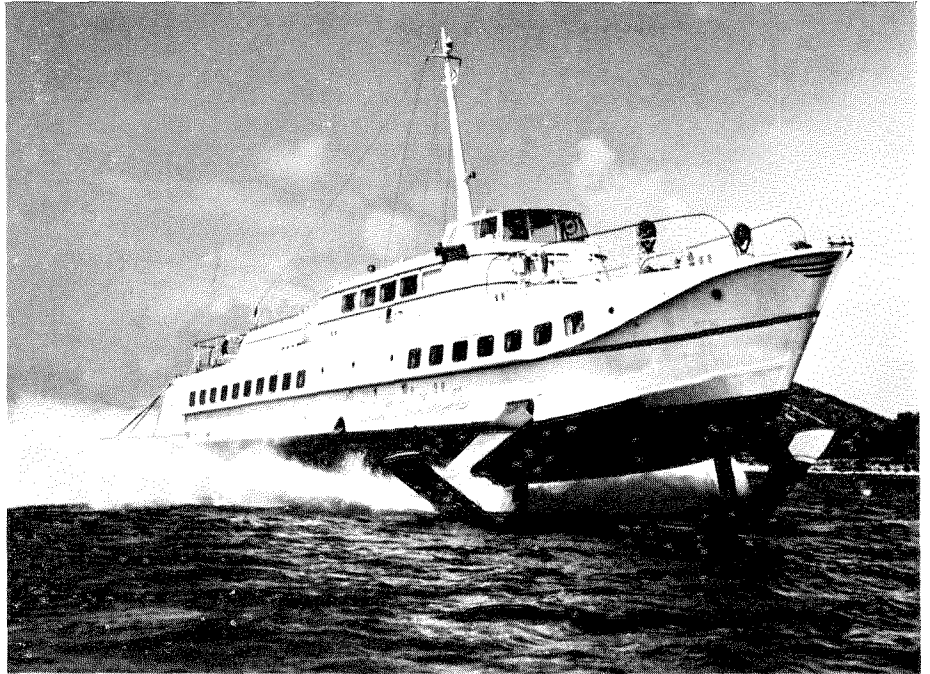


Figure 2. The 63 ton PT 50, seating 130 passengers

COMMERCIAL HYDROFOILS IN THE PAST DECADE

Before we investigate how the requirements for safety, reliability and maintainability are met by the hydrofoils operating in passenger service at present, let us briefly review the developments of commercial hydrofoils in the past decade.

The first regular public hydrofoil service in the world was inaugurated in 1953 by Supramar Ltd., on Lake Maggiore in northern Italy. With experience gained from this service and with the hydrodynamic and technical knowledge in hydrofoil construction gathered since prewar times, the company was in the position to plan larger and more economical passenger vessels. The recognition that complicated devices reduce reliability and require increased maintenance, which affects profits, led to the decision to use only simple components with proved reliability and durability. This policy has contributed towards having hydrofoil craft accepted as a commercial means of passenger transportation.

If we disregard the Russian government operated craft, no other type of hydrofoil could be used profitably up to the present on public passenger lines.

The first foilborne passenger-carrying craft to be approved by classification societies for coastal service, was a Supramar designed 30 ton craft, the PT 20, built in the Rodriguez Shipyards (Fig. 1).

After successful and profitable operations with this boat, a 63 ton vessel, the PT 50 (Fig. 2) was constructed in 1958, to be used on off-shore routes. The machinery of this 91 ft boat consists of two of the same diesel units as used in the smaller type, and seating is provided for 130 passengers.



Figure 1. The PT 20, first passenger carrying hydrofoil to be approved by classification societies for coastal services

In June 1968, a third type was added to our fleet, the PT 150, the world's largest seagoing passenger hydrofoil and first to carry cars over long distances. The prototype, the "Expressan" is now plying between Sweden and Denmark and can accommodate 250 passengers or 8 cars and 150 passengers (Fig. 3). This ship is provided with the most comprehensive safety equipment ever used for a hydrofoil, as we shall see later.

During operation these vessels are being constantly improved in line with the results of day-to-day endurance tests, thus overcoming development troubles successfully.

More than one hundred craft of Supramar design have been built. They have a total seating capacity of over 8,000 passengers and are operating throughout the world. They cover an accumulated daily distance of about 22,000 nautical miles, which is the equivalent to a daily circle around the world. The total number of passengers carried to date is estimated to be 35 million persons, and the total distance travelled by all passenger craft more than 25 million nautical miles.



Figure 3. The prototype PT 150 Expressan passenger/car ferry, now operating between Sweden and Denmark

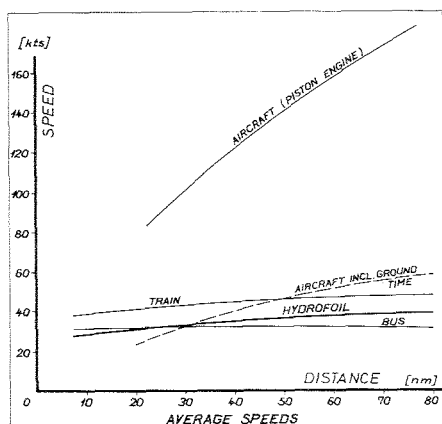


Figure 4. Average Speeds

To illustrate why hydrofoils can compete successfully with transportation by train, car, bus and aeroplane, a comparison of speed and fares has been made. Figure 4 shows that the mean speeds of land vehicles come very close to that of the hydrofoil which generally has in straight course a shorter route; and that also the total air trip speed of a short-haul domestic liner is not greatly superior if ground travelling time to and from the airport is added which, today, runs up to about 70% of the total elapsed time. Figure 5 shows that only the bus fares are lower than those of the hydrofoil.

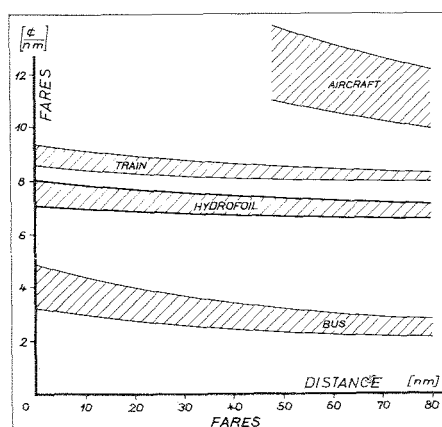


Figure 5. Fares Chart

The very extensive experience obtained through the operation of Supramar craft has enabled the company to analyse and discuss in detail the safety reliability and maintainability of these craft.

SAFETY OF THE PASSENGER-CARRYING HYDROFOIL

Our first consideration is the operational safety of the passenger-carrying hydrofoil. Fourteen years of regular passenger service have shown that the performance is safer than most means of transportation. Indeed in about one billion passenger miles no life has been lost, and only in very few cases have passengers sustained slight injuries when foils hit rocks or in one instance a large buoy. According to statistics as represented in Figure 6, 1 fatal accident happens in trains, 2 in buses, 6 in airlines and 27 in motor cars in the same passenger-mile range.

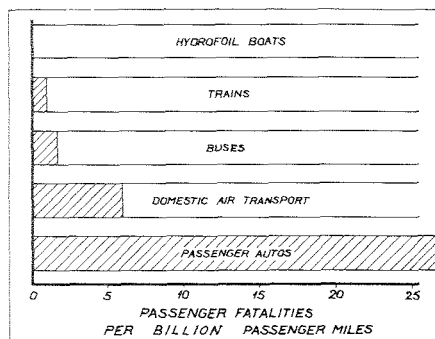


Figure 6. Passenger Fatalities

The exceptionally good, fatality free performance of the hydrofoil boat must be attributed to the following performance characteristics:

The Supramar boats are provided with surface-piercing front foils which are distinguished by their simplicity of construction and inherent stability. These foils have a higher static and dynamic transverse stability in flying condition than conventional ships. In addition, they provide a strong damping effect in waves. In hullborne

condition at low speeds the stability is again greater, due to the foil weight below the hull, as compared with ordinary ships. The low centre of gravity in floating condition combined with the motion damping action of the foils provides an important safety factor. Indeed, not one hydrofoil craft of this type has ever capsized.

By the 1950s the prototype of the smaller PT 20 had already proved the sea-keeping qualities of the 68 foot vessel. Forced down by a severe storm off the coast of Greece, it was possible for her to continue in sea waves in the order of 13 ft and a speed of 15 knots. At a later date, a PT 20 came into the tail of a hurricane in the Caribbean with very long waves of up to 16 ft in height and was able to remain foiborne. These examples show that a commercial hydrofoil is not endangered if she meets by accident a sea state which has not been foreseen.

The distance required for a complete stop from full speed is in the order of 500 ft. The inherently good stopping ability in addition to the rapid response to rudder deflections ensures adequate manoeuvrability at high speed. The turning radius of the boat is approx. 300 ft when speed is reduced to below 30 knots.

It is often believed that floating debris offers a considerable danger. Experience has, however, shown that even quite large pieces of driftwood are either broken or tossed aside by the foils. It appears that the kinetic energy of the heavy steel foils is sufficient for an uneventful outcome for such collisions. Scale model tests in the Berlin towing tank confirmed that the decelerations of 1 g for 1/10 sec are too short to be dangerous and that after the collision the hull always comes down onto the water in an essentially horizontal position.

We shall now see to what extent safety precautions are applied on hydrofoil craft.

Commercial hydrofoils meet all passenger protection safety regulations set up by the shipping authorities. If a boat is serving on international routes also, the requirements of SOLAS convention are observed. The hull is divided into several compart-

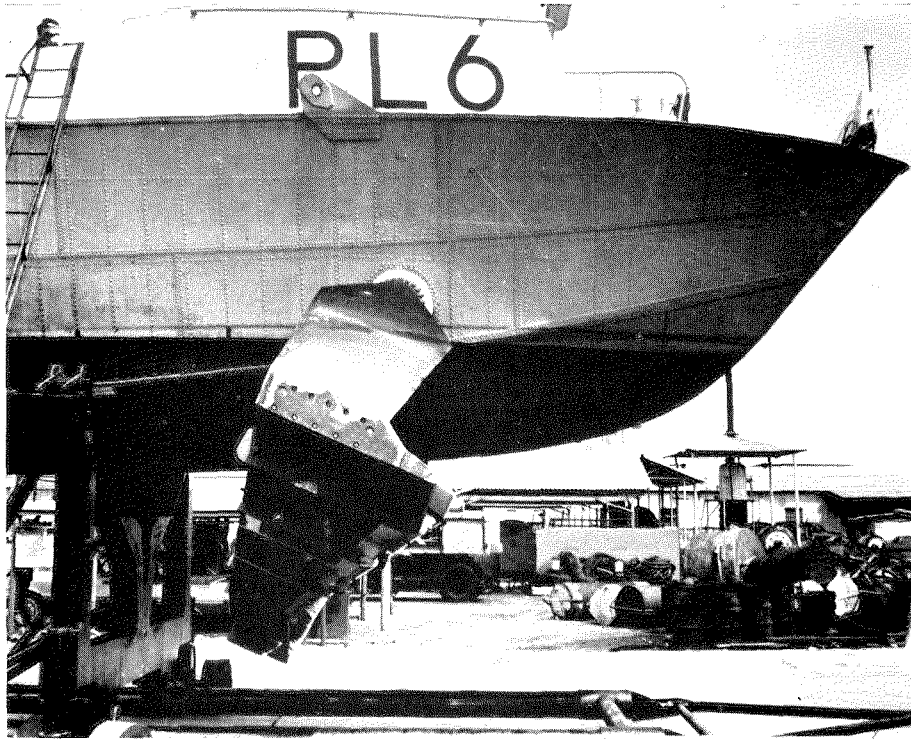


Figure 7. Bow foil of PT 20 swings backward if the craft is grounded or hits a heavy obstacle

ments so that buoyancy is ensured even when two neighbouring compartments are flooded. The life saving equipment on board is made up by life jackets, belts and rafts. In the new PT 150 car ferry (Fig. 10) for instance, fire protection includes an A 60 insulation in both engine room and car deck, fire-fighting plant with two fire pumps, 2 powder extinguishers in every room and an automatic sprinkler installation with its separate pump. An automatic starting emergency power station with a power output of 75% of the normal electric supply is provided on deck to ensure operation in all eventualities. Navigational aids are duplicated with all wiring arrangements. A total additional weight of 13.5 tons is added in the interests of passenger's safety. This weight increase corresponds to a carrying capacity loss of more than 140 passengers.

RELIABILITY AND SAFETY OF FOILS, HULL STRUCTURE AND PROPULSION SYSTEM

We shall now consider reliability and safety of the foil system, hull structure and propulsion plant.

The first stage of development revealed that the foil system is not so vulnerable as was initially suspected. This has been demonstrated several times involuntarily. Due to a wrong gear shifting of an unskilled pilot a PT 20 prototype crashed into an iron jetty with the outer section of the front foil. The jetty was quite badly bent whereas the boat suffered only buckling of the hull plating in the vicinity of the foil attachment, and service was continued for a month before she underwent routine repairs. Another hydrofoil cut up the sidewall of a cement carrying wooden barque of about 150 tons displacement in a collision. The sinking barque was beached, but the hydrofoil continued service after inspection.

In cases of grounding or hitting heavy obstacles, the bow foil adjusting lever of the PT20, which is attached to the foil supporting

tube, first bends and absorbs part of the shock energy before breaking. The foil system then swings backwards on the bearings of the supporting tubes (Fig. 7). On the PT 50, the bolts which fasten the front foil system to the hull shear off and the foil separates. In both cases the hull suffered no damage. In only one incident, in bad weather conditions, when a captain went off course in dangerous waters, were both foils so heavily damaged that repairs were exceedingly difficult. The picture shows the bow foil after the accident (Fig. 8). The rear foil detached entirely from the transom but the hull remained watertight. No passenger came to grief. The latter is an example of the good protection the foils give to the hull. It shows that the passengers' safety has not been in any way impaired through their use. A conventional boat would have suffered extensive hull damage and would probably have sunk.

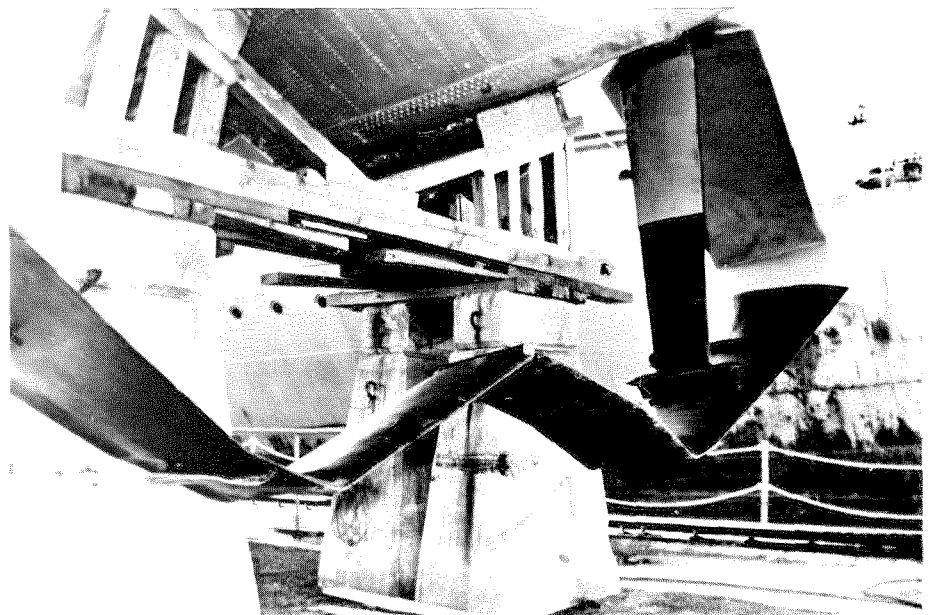


Figure 8. Bow foil of the PT 50 after grounding in dangerous waters

The specific load factors of foils were determined over long operating periods and by aid of load measurements. In fact, foil failures have never been experienced when the periodical inspection included welding of the small cracks which may occur occasionally. In this respect it must be noted that the surface piercing foil system provides an additional safety factor which is not considered in stress analysis. For the front foil represents a multiple indeterminate system in which stress displacements take place from temporarily overloaded foil portions to less stressed parts.

With regard to the hull, it is very often believed that it requires thicker plating than conventional ships, because of the bending moments to which the hull is exposed when being sustained by two foils separated by considerable distance. This is not true. The thickness of the plating is determined by the local stress imposed by wave impact on the bottom which exceeds the bending stress. However, the plating at the bottom must not be as thick as that required for surface craft due to the described dampening effect of the foils.

A safety factor of 1.5 against calculated wave impact stress is introduced in the hull design. With this safety assumption only once was damage experienced in a strong gale. The boat involved was the PT 50 Condor I, which is plying between the Channel Islands under definitely too heavy sea conditions. The skin and several frames of the bow part section were pushed in. Thanks to the deformability of the aluminium alloy used, the hull remained watertight as in other cases when the hull parts were involved in collisions. In all cases when commercial hydrofoils have suffered hull damage, they have safely reached harbour.

When considering reliable operation the propulsion plant is of prime concern. Supramar hydrofoil ferries are powered by Maybach Mercedes-Benz diesel engines which underwent severe endurance testing in Trans European Express trains. With the experience obtained in rail traction and marine service, safety of operation could be so much improved that motors and gears are now capable of achieving at least 10,000

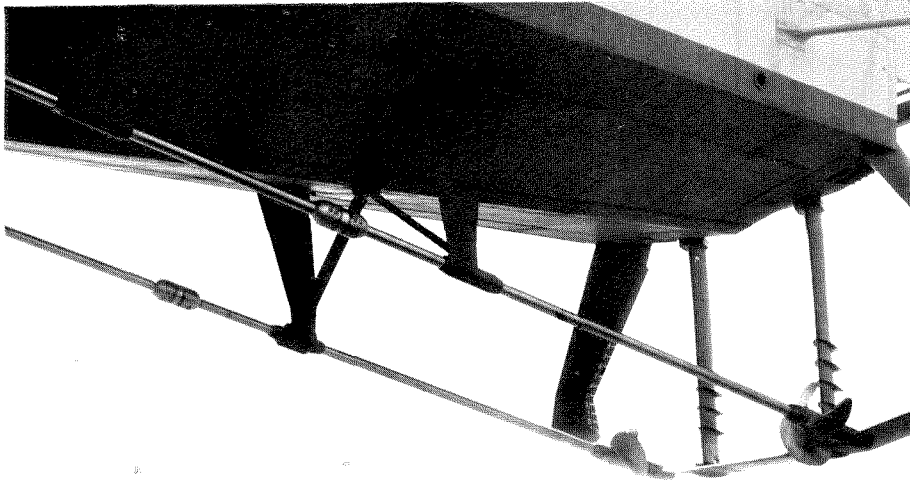


Figure 9. Inclined shaft transmission on a Supramar hydrofoil

hours between overhauls. Marine gas turbines, on the other hand, have offered only a fraction of this life until now so that for a seasonal service of 3-4,000 hours, money has had to be spent for a spare turbine in addition to the high initial costs of the original installation. This explains why the PT 150 is also provided with diesel engines.

But with the steady progress in gas turbine development we can envisage that the time is near when turbine driven hydrofoils can compete profitably with diesel propulsion. There are three main systems to transmit power to the thrust generating device.

The inclined shaft as transmission between motor and propeller (Figure 9) is not an ideal solution, particularly because it sets limits to the hull clearance with regard to sea behaviour. But again, after evaluating the causes of fractures on a dozen shafts, this transmission has proved to offer greatest safety at lowest costs. The double bevel gear transmission is technically difficult and has not been sufficiently tested for endurance. A satisfactory water jet propulsion has only been achieved recently by the Boeing Company, though its efficiency is about 20% lower than that of propellers. Both these solutions reduce, however, the economy of a hydrofoil service due to the initial costs which are higher than that of inclined shaft propulsion. The high speed propellers had in the first years a rather short life—they were either destroyed by cavitation erosion or damaged by floating debris. By placing the propellers behind the rear foil and applying careful design methods the life of the propellers could be increased up to 4,000 hours.

REGULARITY OF PASSENGER SERVICE

The regularity of passenger hydrofoil services, as a measure of their reliability, can only be assessed from the information made available by operators. The percentage of time of scheduled service in well organized lines, which operate under normal seaway conditions, is 96-98%. Only 1-2% of the failures are caused by mechanical mishaps and the rest by bad weather.

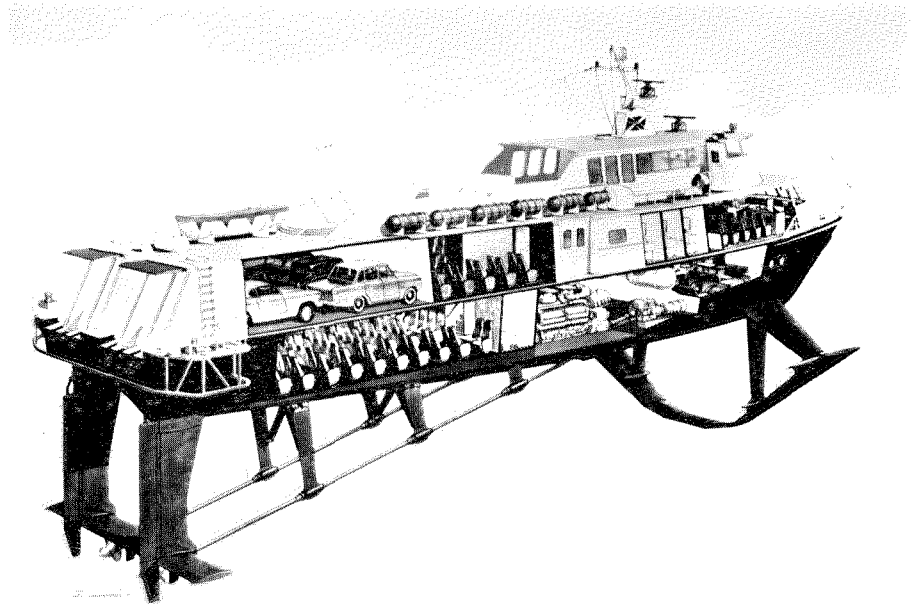


Figure 10. Stability of the PT 150 is maintained jointly by the surface piercing bow foil and the air stabilised rear foil

RELIABILITY OF AIR-STABILIZED CRAFT

Supramar has designed two air-stabilized craft which have both been built at the Westermoen Shipyard in Norway. These craft are provided with a dihedral surface piercing bow foil and a fully submerged rear foil. Stability is maintained jointly by the inherent stability of the front foil and air stabilization which causes a change of lift on the rear foil, in a restoring sense, when the boat is leaving her normal position in a seaway, thus reducing roll and pitch angles. Lift variation is produced by the Schertel-Supramar-System by the admittance of air drawn from the free atmosphere into the suction areas of the foil, the quantity of air being automatically controlled. A craft with this system, which is rather simple in its conception, can be designated as "partly stabilized".

In 1966 an air-stabilized PT 50 underwent successful trials and proved to have superior

riding comfort in comparison with the conventional PT 50 in a seaway.

Regarding the reliability of the air feed lift control system, experience shows that the air outlets at the foil for the air supply are never blocked by soiling due to the prevailing suction and can therefore be regarded as fail-safe. The structural simplicity of the part-air-stabilized craft and the stabilization unit, which does not need a power supply, ensures a high degree of operational safety. One such unit is provided for each foil half, and each is capable of maintaining stability on its own. In this way the reliability of the system is further increased. In fact, the new stabilization of the "Expressan" (Figure 10) worked faultlessly from the first trial run until the vessel was put out of service at the end of the 1968 season. In the improbable event of a simultaneous failure of both stabilization units, the boat can still continue the trip at decreased flying height, with however, somewhat reduced seakeeping capability. This is an important advantage over craft with fully submerged foils which

in the event of a failure can only proceed in a displacement condition.

MAINTENANCE AND MAINTAINABILITY

The Supramar foil system requires only modest maintenance and this is more or less limited to cleaning, smooth-finishing, and corrosion protection measures. This is a routine job and has to be done at intervals of a fortnight to 3 months, depending on sea conditions and the marine growth development in the operating area. Because of the sturdiness and simplicity of the structure, maintenance can be further reduced by devoting special attention to the selection of materials with reciprocal low potential differences to avoid electrolytic corrosion. The use of non-corrosive steel for the foils is another means of reducing maintenance.

During maintenance the ship is either drawn onto a slip, raised by a crane, or she is tended by divers. Maintainability is simplified considerably when the foils are retract-

able. Foil retraction is acceptable as an additional technical mechanism in the case of fully submerged foils, whereas for surface piercing foils the additional costs resulting from retractability are in most cases not compensated by the advantage of easier cleaning. Therefore, Supramar applies retractable foil systems only where necessary, such as operation in shallow waters.

The danger of corrosion of light metal hulls cannot be excluded. However, if care is taken to avoid strong electrolytic potentials between plates, rivets, interior components and steel foils, then the useful life of the bottom aluminium plates alloyed with less than 5% magnesium has reached up to 8 years before replacing. This presupposes that bottom painting is done every 3 to 4 months.

Between major overhauls, engine and gear are subject to routine maintenance on board. At the request of the surveying authorities the engine is opened up every year for random inspection of one piston rod bearing.

To maintain these vessels, including repairs, cleaning and painting, some 1,800 man-hours are required on an average each year. If we

assume that each craft has an annual utilisation of 2,500 hours, then maintenance hours are in the ratio of 70 to 100 operating hours which is reasonably low as compared, for instance, with the competing helicopter, where we have to allow 400-600 maintenance hours for every 100 operating hours. The maintenance costs of a hydrofoil amount to 12-15% of the total operating costs against 18-19% for an airplane.

RELIABILITY AND SAFETY OF FUTURE HYDROFOIL BOATS

Finally, let us try to visualise the reliability and safety which can be expected of future hydrofoils. The seagoing hydrofoil of the second generation must inevitably be of more sophisticated design to meet modern requirements for better riding comfort in a seaway, and increased complexity poses new problems for operational safety. However, when speaking of the future, only craft for open sea service are generally considered and it is not realized that the demand for foilborne transportation in inland waters and protected sea areas will continue to expand. Here the hydrofoil of tomorrow will be basically the same as today and only its speed, safety and

reliability will increase in the course of improved technology.

It is believed that in future there will be two seagoing types, the partly and the fully stabilized craft. The first type which we have already described will be for off-shore service and is an intermediate low cost solution, since it is a cross between vessels with rigid surface piercing and fully submerged controlled foil systems. Sea performance of the first comes close to that of the latter but its structural sturdiness, simplicity and ease of handling provide a higher reliability and economy. However, the future hydrofoil for severe sea conditions will, no doubt, have fully submerged controlled foils, although many technical difficulties are involved which are liable to impair profitability and safety of operation. Problems arise from the required large hull clearance leading to intricate propulsion systems and from the foil lift control which must be completely fail-safe and easy to maintain. The air-feed system for controlling fully submerged foils, could bring second generation hydrofoil designs closer to the requirements of economy and reliability.