HOVERING CRAFT & HYDROFOIL

THE INTERNATIONAL REVIEW OF AIR CUSHION VEHICLES AND HYDROFOILS

Volume 6 Number 9
JUNE 1967

KALERGHI PUBLICATIONS

HOVERING CRAFT & HYDROFOIL

FOUNDED OCTOBER 1961

First Hovering Craft & Hydrofoil Monthly in the World

JUNE 1967 VOL 6, NO 9

Editor:
JUANITA KALERGHI

HOVERING CRAFT AND HYDROFOIL is produced by Kalerghi Publications, 50-52 Blandford Street, London, W1. Telephone WELbeck 8678. Printed in Great Britain by Villiers Publications, London, NW5. Annual subscription: Five Guineas UK and equivalent overseas. USA $15 There are twelve issues annually.

ADVERTISING REPRESENTATIVE
L. Temple Rosswick Ltd, 3 Queens Court, Queensway, London, W2. Telephone BAYswater 5812

ADMIRALTY WAVE TABLES?

THE advent of hovercraft and hydrofoils and other fast-moving craft has made the height and character of waves — those "undulating inequalities", as Dr Johnson calls them, which wind makes upon the sea — of particular interest to many seagoers. It is thought that there is now a need to bring into one book all the information on waves that is now partially available in several places, as well as the data hidden in records from the past.

In World War II, landings on enemy coasts from assault craft created a need for detailed studies to be carried out concerning wave heights and lengths likely to be encountered on the day, and these facts were of equal interest to the supply build-up organisation. In some cases the information was limited to certain areas and certain times of the year, but in others investigation covered the entire year. Over the years the sea state at the end of each watch has been noted in ships' log books. Light vessels, weather ships and offshore oil rigs have maintained regular and accurate surveys.

World interest in the harvest to be gathered from the seas and oceans is increasing rapidly. This harvest is not confined to fish and fuel but includes geological and chemical products as well. Its value has already reached some £5,000 million a year. Developments in the branches of science involved in these on, in and under the sea matters are only just starting, with the population explosion triggering interest in this hitherto largely neglected area.

Apart from obtaining information for military — in its widest sense — requirements, oceanographic ships of many countries are busy collecting data on a wide range of subjects, and the race amongst the world's leading maritime nations for the acquisition of sea knowledge is running parallel to the space race. Wave information has its place in the list of sought-after details.

Technical journals are publishing articles on advanced fishing and diving equipment, data-recording instruments and a host of other aids. Businessmen are quick to note the commercial opportunities that are opening up, and they need *facts*.

The general public in its pursuit of leisure is taking to the sea in ever-increasing numbers, and the lifeboat service finds itself called upon far more frequently than before. There are also those who go in for ocean and round-the-world sailing. Wave tables will be needed on many a charthouse and cabin bookshelf.

It is suggested that a standard work entitled Admiralty Wave Tables should be compiled to take its place alongside the Admiralty Tide Tables. The tables must, of course, be historical, based on averages obtained from existing records. Tides are relatively tidy and predictable. Not so the waves. The height and period of the waves may be deduced from measurements of wind speed and direction; however, in many cases wind speed and direction vary continuously.

Wave recordings have been made by Ocean Weather Ship *Weather Explorer* and then by her replacement, *Weather Reporter*, on Stations A, I, J and K in the North Atlantic since 1952. The instrument used is the Shipborne Wave Recorder. The ship is on station for about two-thirds of the year and her time is fairly well distributed over the four stations. The National Institute of Oceanography has now sufficient records available from each month at Station "Juliett" to allow a year's analysis to be made. The results of the analysis are divided into the four seasons, and give separately the characteristics of wave height, period and spectral-width parameter; the joint occurrence of height and period is also given.

Wave recordings have also been made in Smith's Knoll Lightship from March 6th, 1959, using a shipborne

(Continued on page 35)

IN THIS ISSUE

COVER PICTURE: *Residents of Kingsville, Ontario, turned out in force to welcome the Bell Aerosystems air cushion vehicle after it travelled about 250 miles across frozen Lake Erie from Buffalo, NY. Bell demonstrated the craft to Pelee Island residents and officials of the Canadian and Ontario Governments to show how the amphibious vehicle could provide year-round transportation to and from the Canadian or US mainlands. (See story, page 14)*

The Hovercraft Pioneers

by
Bryan Cooper

The first three articles in this series described the pioneer hovercommanders, the men responsible for testing the first hovercraft prototypes and developing new techniques for piloting this new form of transport. But what of the pioneer designers, the men who took Christopher Cockerell's basic concept and made it a reality? Foremost among them is Richard Stanton Jones, MA, DCAe, CEng, AFRAeS, at one time Chief Designer of Saunders-Roe, who was appointed Technical Director of the British Hovercraft Corporation on its formation in 1966 and became Deputy Managing Director later in the same year.

In his spacious office overlooking the waters of Cowes harbour, Richard Stanton Jones looks back on a career that spans the whole history of hovercraft development over the past ten years. The various craft on which he and his design team have been engaged, starting with the experimental 4-ton SR.N1 and now leading to the 160-ton SR.N4, have between them chalked up more than 23,000 operating hours, no mean achievement in so short a period.

"All our earliest studies back in 1959 showed that, to make economic sense, the real need was for a craft of over 100 tons," says Stanton Jones, a quiet, soft-spoken man of forty-one who combines a deep-rooted faith in hovercraft with an assured manner that one cannot ever imagine becoming ruffled. "But we could not go straight to this from an experimental craft of 4 tons. We had to feel our way and learn as we went along."

This meant a long programme of research and development, much of it breaking new ground although based on Stanton Jones' own experience as an aerodynamicist. Further craft were built and tested, modified, and tested again. And now all this work has resulted in the 30-car, 250-passenger SR.N4, which has passed the prototype stage and is being manufactured, with orders already coming in from all over the world. It marks the beginning of a new era in super-hovercraft, fulfilling the dreams of the early pioneers. Much of the credit must go to Stanton Jones — and not least for his work on the development of hovercraft skirts.

"Our first practical work on skirts, after model tests, began in 1960 on the SR.N2," he recalls. "Those first skirts lasted for only ten minutes or so. Then, with better designs and materials, we went to one hour, one week, and then longer until now we can be assured that the life of a skirt is about 1,000 hours. It was not until the beginning of 1966 that we could say the skirt idea had been really proved."

Stanton Jones came into the hovercraft industry, like so many others, through his work as an aircraft designer. As a boy, born in 1926, he was always fascinated in aircraft and aircraft design. After obtaining an MA degree at King's College, Cambridge, he went to study at the College of Aeronautics at Cranfield and obtained a diploma, with distinction. His first job, in 1949, was with de Havilland Aircraft, but less than a year later he joined Saunders-Roe as a senior aerodynamicist. He was subsequently put in charge of the High Speed Section, and in 1955 became Deputy Chief Aerodynamicist.

Later that same year he emigrated to the United States to work as an aerodynamicist on the F.104 Starfighter — becoming in fact part of the early "brain-drain". But in 1956 he was back in Britain, now as Chief Aerodynamicist of Saunders-Roe. By this time, Christopher Cockerell was trying to arouse interest and find backing for his hovercraft idea. Stanton Jones had done a lot of work in the United States on blow-down flaps for ground effect, and the similar principles involved in the two ideas appealed to him. At one time there was even a suggestion that Lockheed might undertake a small development contract for the Ministry of Aviation. Then Cockerell found his way to the NRDC, and they asked Saunders-Roe to investigate the idea and see if there was anything in it.

This couldn't have come at a more opportune time. By now, Stanton Jones had become Deputy Chief Designer for Saunders-Roe — but with little for his team to design after the blind had been pulled down on fighter aircraft production in Britain. A design team was therefore available to go into the new project and, after making preliminary studies, a proposition was put forward for the building of an experimental craft. Had it not been for the cancellation of aircraft contracts at this time, it is debatable how far forward hovercraft development would have been taken.

Richard Stanton Jones

"Quite early on, there was no doubt in my mind that hovercraft could work," says Stanton Jones. "But there was a great deal we didn't know about such things as wave effects and structures. Even so, most of the basic sums we did in 1956 have not been proved far wrong today."

In 1958, NRDC gave the go-ahead and the SR.N1 was built. Mistakes were made, of course, but at the same time valuable experience was being gained. While the experimental craft was being tested in 1959, Stanton Jones was further promoted to Chief Designer, and he continued to hold this position after the take-over of the company by Westland. By the end of the year, he had completed drawings for a new, bigger craft, the 27-ton SR.N2. This was a crucial time for the hovercraft design team, for it was not known whether the new Westland Board would decide to continue with the project. A few days before Christmas Day, 1959, the plans were put before the Board. Their decision was favourable, and early the following year work started on the SR.N2 — known as the "Christmas Craft" because of the timing of this decision.

Shortly afterwards, an initial project design for the SR.N4 was undertaken. But Stanton Jones realised that this was making too big a jump. There was still much to learn about the behaviour of hovercraft. The SR.N1 had shown that the aerodynamics, based on existing knowledge of aircraft design, were about right. But the load factor was still a problem. Here, the company was able to draw on the previous experience of Saunders-Roe designers on flying-boats, and this proved to be invaluable. At the same time the company's design team, which now totalled about 600, were naturally working on other projects, and where these involved marine craft and space vehicles, as well as aircraft, the cross-fertilisation of ideas that was made possible led to a rapid development in hovercraft and structural techniques were devised which would otherwise have taken much longer.

The SR.N2 was completed at the end of 1961 and began the first passenger-carrying experimental operations in the Solent. Then came the 37-ton SR.N3, a stretched version of the SR.N2 which the military authorities took over as an experimental vehicle. The next craft also, the SR.N5, was used by the military in a number of countries, including Vietnam.

By 1965, hovercraft were being widely used as operational vehicles, and Westland had built or had contracts to build fourteen SRN5s and twenty-one of the later 9-ton, 38-passenger SR.N6s, four of them for military use. This led to the compilation of a great deal of operating experience in different countries and climates. Hovercraft were no longer experimental. They were practical vehicles, being increasingly used for passenger-carrying ferry services. Stanton Jones, who the year before had been made a Special Director, felt the time had come to begin work once again on the SR.N4 and his design team, now almost equally divided between hovercraft and spacework, went back to the drawing boards and the manufacture of a prototype began.

With the formation of the British Hovercraft Corporation in 1966, Stanton Jones was appointed first Technical Director and then Deputy Managing Director. While the building of the existing craft went ahead, an initial project design for the 40-ton BH.7 began and the application of the hovercraft principle was extended to other industrial fields.

"The work of our design team is now split into various individual projects," explains Stanton Jones. "The biggest effort is being made on a high-speed marine craft, for use on calm water and a skirted version for rougher seas."

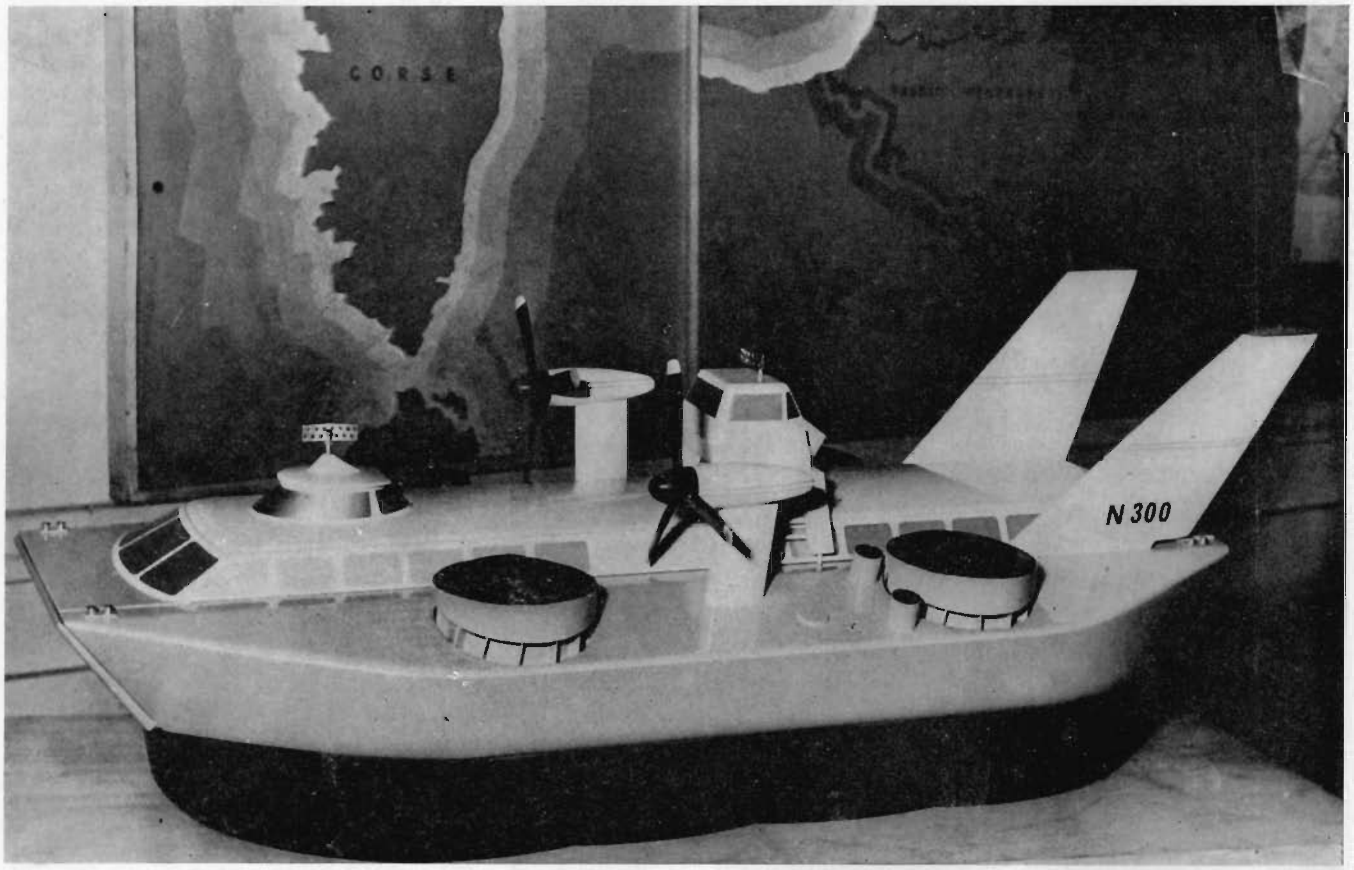
Here, Stanton Jones sees a big gap in the speed spectrum of existing marine craft between 60-70 knots, which hovercraft are best equipped to fill. At lower speeds, between 40-50 knots, hydrofoils provide strong competition, but they can run into difficulties when they try to *increase* this.

"Then there is the use of slow-moving hovercraft pallets on the road, for spreading the weight of heavy loads up to several thousand tons — like the job we did for the Central Electricity Generating Board in helping to drive a large generating unit over a bridge which could not normally take its weight. Other industrial uses include developing this principle as an alternative to conveyor belts. And, of course, there is all the work we are doing on the hovertrain idea."

For the future, Stanton Jones looks forward to the development of a really fast marine hovercraft, possibly a multi-thousand-tonner. But to be fast, it would have to be kept out of the water, and designers will have to avoid the temptation of a hovercraft-cum-hydrofoil idea, with some part of the craft kept in the water to provide additional directional control. But this is apart from much useful work that can be done in the field of actual sidewall craft, for different purposes.

The proving of his early faith in hovercraft has done nothing to lessen Stanton Jones' enthusiasm.

"It is all a question of development now," he says. "Hovercraft provide a glorious hunting-ground for the designer."



If everything runs according to plan, a French hovercraft will be making experimental trips between St Tropez on the French Riviera and St Remo in Italy. This is the model of the craft submitted to the French Ministry of Planning. (See below for details)

People and Projects

At a meeting held on May 22nd at the Hotel Matignon, Paris, the Interministerial Committee presided over by M Georges Pompidou discussed the amount of financial support, in the shape of a credit, to be assigned to the Société d'études et de développement des aéroglisseurs marins (SEDAM) for the further development and commercial exploitation of the **"Naviplane"** hovercraft.

The Committee heard various proposals by M Raymond Marcellin, delegate Minister responsible for matters relating to the allocation and use of territory for purposes of scientific research and development. M Marcellin reported that SEDAM would have the support of the Ministries of Transport and of War and the Delegation for Scientific Research.

The type of hovercraft under discussion is known as the N-300, now in construction by Bréguet et Nord Aviation, which is due for completion in October of this year and for entry into commercial exploitation in the Mediterranean in July 1968. Its preliminary trials are to be carried out on the River Adour, and later on the Berre lagoon.

Measuring 24 m (78 ft 9 in) in length, and weighing 27 tons, it will have a speed of 100 km/hr (about 62 knots) and will be capable of maintaining this speed with reasonable comfort in waves of up to 1.5 m (about 5 ft) high. It will be capable of carrying either 100 passengers, or eight cars and their occupants, or 11-13 tons of freight. Power will be provided by two "Turbomeca" turbo-jet units, developing 1,500 hp, which will drive both the fans feeding the eight flexible skirts which sustain the vessel and the two reversible aircraft propellers which drive it along.

The service most favoured, among several which have come under consideration, for the initial exploitation of the N-300 is that along the Côte d'Azur (the coast of the French Riviera), where it would reduce congestion of the existing coastal services between Nice and Saint-Tropez, or alternatively might run regular services to Corsica and Italy.

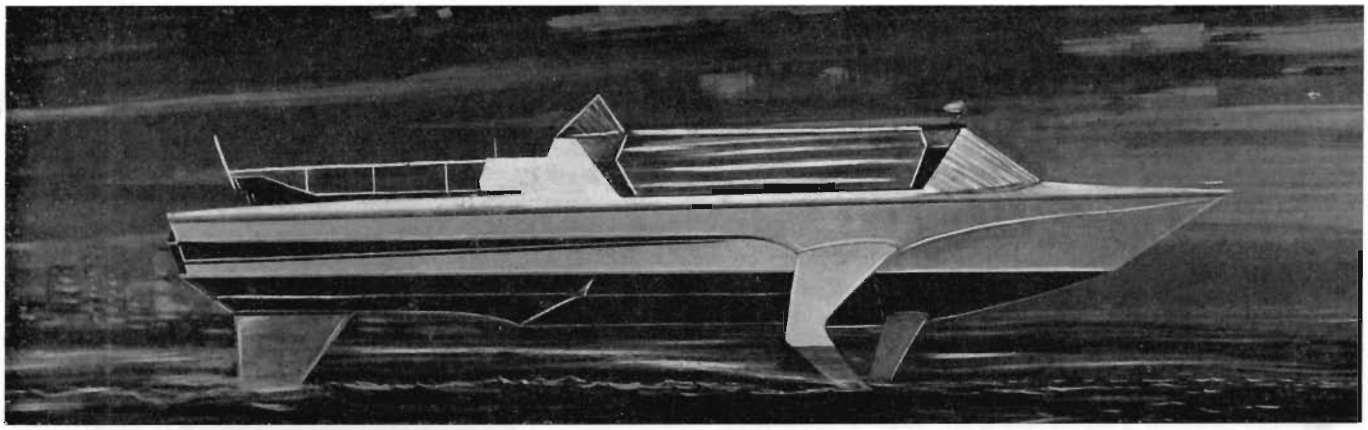
* * *

The **Bertin Terraplane** will be demonstrated in North America later this month. It employs an air cushion effect generated by compressed air fed to ten flexible circular skirts, and a driver-controlled hydraulic system which allows weight transference to the wheels to be varied from 5 to 20% of the total weight.

This amphibious "hovertruck" can carry a 2½-ton payload over rough or swampy ground at a speed of 30 mph. It is equipped with two 50 bhp Renault engines for traction and a 140 bhp Chevrolet V8 engine to drive the centrifugal fans.

Special paddle vanes can be fitted to the wheels to allow the truck to travel over water at a speed of approximately 4 mph.

★ ★ ★



"Nevka", the 12 to 14 passenger Soviet hydrofoil run-about. (See below)

Details have recently been published of a Soviet hydrofoil run-about, carrying twelve to fourteen passengers, of which two prototypes were to be tested out in service last spring. Principal particulars of this type, known as the **"Nevka"**, are as follows:

Max length	10.9 m (35 ft 9 in)
Max breadth of deck ...	2.7 m (8 ft 10¼ in)
Overall breadth (including foils)	4.0 m (13 ft 1½ in)
Displacement:	
Light	4.1 tons
Loaded	5.4 tons
Draught:	
Waterborne	1.6 m (5 ft 3 in)
Foilborne	0.8 m (2 ft 7½ in)
Speed, at full displacement, in calm water ...	54-58 km/hr (33.5-36 knots)
Cruising range, on foils	220 km (137 miles)
Power of main engine (Diesel 3D20) ...	250 hp

The boat, which has a fibreglass hull, can be supplied in three variations: open; open, but with a stiff canopy; and closed (with a translucent roof). Though designed primarily for passenger transport or taxi work, or as a simple sports boat, it may be supplied also as a cruiser, with sleeping accommodation, a galley and toilet facilities. The engine is controlled by the helmsman, in the steering position, which may be either forward of the saloon, or on deck in the middle of the boat.

The advantages claimed for the *Nevka*, as compared with other similar craft, are:

(1) Greater seaworthiness when foilborne and greater speed (at least 55 km/hr [34 knots]), in waves due to wind Force 2. This is achieved by the original design of the hull, and by the use of deeply submerged foils, combined with angular transmission of power.

(2) The use of fibreglass for the hull provides greater durability and resistance to corrosion.

(3) The fitting of a fast-running diesel engine of 250 hp, with angular transmission of power, gives greater reliability and greater economy in running in sea conditions.

(4) The adequate passeger-carrying capacity (twelve to fourteen).

Modern lines in the design, original colour schemes and the comfort of the passenger saloon, which has excellent all-round view, are further advantages.

In order to keep down the building costs and selling price, and to ensure reliability, maximum use is made of standard materials and fittings made in the USSR.

Preliminary estimates show that the *Nevka* is in every way suitable for the economical transport of passengers at high speed in coastal waters.

★ ★ ★

The **National Research Development Corporation** has announced a proposal to form a new subsidiary company, Tracked Hovercraft Ltd, to promote the world-wide use of this new form of transport.

Implementation of the Corporation's proposal is subject to the consent of the Minister of Technology. The Ministry is considering the NRDC proposal with other interested Departments and in the context of other proposals for high-speed transport.

The object of the new company would be to accelerate technical development and economic evaluation programmes already begun by another NRDC subsidiary, Hovercraft Development Ltd, at Hythe. This research has been confined to static rigs and working models, and NRDC feels that further progress can best be made by constructing a full-scale vehicle and length of track. NRDC would invest £2,000,000 in this phase of this work.

The new company would work closely with the National Physical Laboratory's Hovercraft Unit, which has taken over the research facilities at Hythe, and with other Government Departments. It would also seek the co-operation of industry both during the development of the tracked hovercraft system and its subsequent exploitation at home and abroad.

Interest in high-speed air cushion vehicles running on fixed tracks has been shown in the United States, Europe, Japan and elsewhere. In most industrialised countries conventional means of transport are overloaded. Hence the interest in a new system which could give short city-centre to city-centre journey times, a frequent service, safety and a low level of noise and vibration.

The quietness of the vehicle would not only allow it to operate on long-distance journeys from the centres of towns and cities but may also encourage its use over new local routes.

The initial programme of the company would include the construction of a length of full-scale track and the development and demonstration of a vehicle supported on air cushions and propelled by a linear induction motor. The air cushions will be contained by peripheral jets of the type designed by the inventor of hovercraft, Mr C. S. Cockerell. Professor Eric Laithwaite, who holds the Chair of Heavy Electrical Engineering at Imperial College, will act as consultant to the company on the design of the linear motor, which was his invention.

The combination of air cushion suspension and linear motor gives silent propulsion, by reaction against a continuous aluminium rail fixed to the track. It also means vibration-free running since neither the motor nor the vehicle itself comes into contact with the track during operation. Further, the use of air cushions so distributes the load of the vehicle on the track that extremely low pressures, in the region of 2 lb per sq in, are generated. The first cost of the track and of the vehicle and, in particular, the maintenance costs should therefore be low.

The first test vehicle should be capable of speeds of up to 300 mph. A study will be made of the effects of speed on the lift and guidance air cushions and on the linear motor and current collection systems. Information will also be sought on vehicle stability under gusty conditions, on power consumption and the effect of track irregularities. This work should result not only in designs for practical systems but also in better economic data than we have now for the evaluation of possible routes.

Economic evaluation would be a vital part of the company's activities from the start. Valid conclusions can only be reached by considering complete systems in their own particular environments. The basic data on track costs per mile, power consumption and so on are, of course, essential but they are insufficient. Routes must be optimised, taking full advantage of the benefits of high vehicle speeds; the relationship must be established between the location of stations and the growth of traffic over a considerable period of years and the whole compared with alternative methods, whether conventional or otherwise. Studies would be made along these lines of potential routes, both in Britain and overseas.

The headquarters of the new company, Tracked Hovercraft Ltd, would be at NRDC's offices, Kingsgate House, Victoria Street, London, SW1. The location of the test track is under study: much help has been given by British Rail over this question.

The Chairman of the company would be Mr D. Hennessey, Deputy Managing Director of the NRDC, Chairman of HDL and a Director of British Hovercraft Corporation.

Mr T. G. Fellows, Deputy Chief Executive of NRDC's Department of Planning and Policy Co-ordination, would be seconded to the company as Managing Director. Mr D. S. Bliss, who was head of the Tracked Hovercraft Division of Hovercraft Development Ltd, would be Chief Engineer.

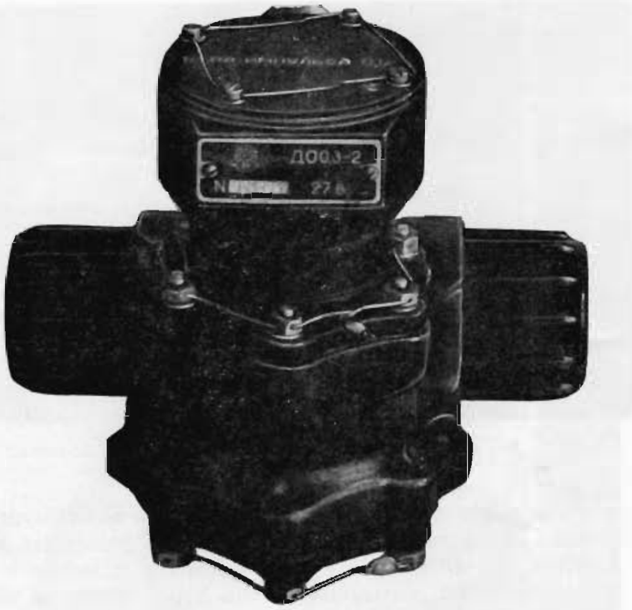
★ ★ ★

British Hovercraft Corporation has chartered a 38-passenger SR.N6 to Aeronave SPA of Naples.

It will be used on passenger services between Naples–Capri and Naples–Ischia. The route length in both cases is just under 20 nm. These will be the first regular commercial hovercraft services in the Mediterranean area.

Aeronave's SR.N6 has already been in Italy for some weeks and has been in use for crew training and route proving. The Italian company announced plans to inaugurate its services on June 10th.

This new contract brings the number of SR.N6s in operation or on order to sixteen. In almost 20,000 hours of operation, SR.N6s have seen service in Norway, Denmark, Sweden, Brunei, Southern England and Scotland. During the summer of 1966, a seasonal service was operated by Hoverlloyd between Ramsgate and Calais, and is again running this summer, from April through to September. More than 600,000 passengers have so far been carried by SR.N6s in commercial operations.



DO 0.3-2, a Soviet instrument for measuring fuel consumption in hydrofoils. (See below)

BHC now has a total operational experience of just on 30,000 hours with eight different types of hovercraft, ranging in size from the 4-ton SR.N1 up to the 37-ton SR.N3, which is the largest hovercraft so far operated anywhere in the world.

★ ★ ★

Details have been published recently in the **Soviet Union** of an interesting instrument, DO 0.3-2, which has been designed and made there for the measurement of fuel consumption in hydrofoil vessels on trial, in the first place, but suitable also for general usage. This instrument, which is now in series production, is of a common rotating type. The fuel consumption is measured by the transmission of impulses of electrical current according to the number of revolutions of a cup, or container, in the instrument, which is set in motion by the flow of fuel to the engine, each turn of the cup corresponding to a determined amount ($30\ cm^3$) of fuel. The movement of the cup is transmitted through a magnetic coupling and a reducer to a system of contacts, the reducer being geared so that each impulse represents a consumption of $100\ cm^3$. The exact value of the impulse, as measured in the course of testing and graduation, is indicated on a certificate supplied with the instrument.

The instrument weighs only 1,500 grammes, and has a range of from 30 to 300 litres/hr (sufficient for the measurement of consumption of any engine of up to 1,200 hp). It works with a pressure in the fuel pipe of up to $1.5\ kg/cm^2$ (as determined in the main pipe after the fuel has passed through a fine filter). The hydraulic resistance in normal working and with a fuel consumption of 200 litres/hr does not exceed $0.05\ kg/cm^2$. The instrument works normally with a frequency of vibration of 20 hectocycles and an amplitude of 1.3 mm (it may be mounted at an angle of 60° to the vertical and the two mutually perpendicular surfaces).

The instrument is designed for the transmission of impulses from the ship's electrical circuit or from a battery of $27 \pm 10\%$ volts dc. The impulses may be recorded by means of an automatic recorder or an electro-magnetic coil oscillograph.

★ ★ ★

A public inquiry is to be reopened into an application by **Hoverlloyd Ltd** for planning permission to build a hovercraft terminal on the foreshore of Pegwell Bay, near Ramsgate, Kent.

The Ministry of Housing and Local Government said the Minister had decided this because British Rail Hovercraft had said it intended to operate a similar hovercraft service from inside Dover harbour.

This information was not available when his inspector held the public inquiry last January, and the Minister considered that the relative advantages of using Dover harbour as compared with Pegwell Bay should be more fully explored.

The Ministry said Hoverlloyd had proposed to operate a cross-Channel service from Pegwell Bay to Calais from May 1st, 1968, using the SR.N4 hovercraft, which would carry up to 250 passengers and 34 cars.

"The Minister called in the planning application for his own decision in view of the wider implications and its effect on the regional transport systems," the Ministry said.

In his report after the public inquiry the inspector recommended that in light of the information available to him the application should be granted.

He said the problem as a whole required a number of basic decisions to be made. These included the integration of hovercraft travel into a national transport plan, and questions of overall design and location of hovercraft terminals for future cross-Channel hovercraft traffic between England, France and Belgium.

The letter giving the Minister's decision said he had not reached conclusions on the other factors raised by the Hoverlloyd application. Although the proceedings on the application were not the occasion for a fundamental approach to the question of hoverports in South-east England, he wanted to be fully satisfied about the possibility of using Dover harbour before taking further steps.

"First, he wishes to avoid unnecessary development of a stretch of unspoilt coastline if other satisfactory arrangements can be made for the operation of hovercraft.

"Second, as he stated in his call-in letter of October 18th, 1966, he wishes to be more fully informed of the effect on the regional transport systems," the Ministry said.

★ ★ ★

Leslie R. Colquhoun, DFC, GM, DFM, Hoverlloyd's Managing Director, commenting on the Minister of Housing's decision to reopen the Pegwell Bay hoverport inquiry, says:

"This may well be the surrender of Britain's lead in a vital new industry. We at Hoverlloyd, and all associated with the British hovercraft industry, now have some hard facts to face, and some serious questions to ask ourselves. This is a 'do or die' for Pegwell Bay or for Dover. Neither can go ahead for six months. Can this country really afford the time?

"My view, backed by my Board, is that to get the SR.N4 service off to a good start, to ensure it is successful as a commercial operation, and above all to see that it is a safe operation, we must keep clear of the tidal race at the entrance to Dover harbour, we must have a decent open run-in, and we must have a properly planned hoverport.

"This was our platform at the inquiry in January; this is what it was all about.

"Hoverlloyd have never made idle statements. Our opinions have been formed by more than a year's running across the Channel with SR.N6 hovercraft — experience that has cost money to get.

"Is the Minister's decision a political one to protect the interests of British Rail Hovercraft, and to give them an opportunity to catch up on the experience we at Hoverlloyd have?

"It seems to be an odd way for the Minister to deal with a matter of such national importance.

"It seems a cavalier way to deal with investors from Sweden who, at a critical time when everyone else sat on the fence, placed the vital order with Britain that signalled the go-ahead for the building of the SR.N4s — a £3,000,000 export order.

"Hoverlloyd have faith in hovercraft; our order is for two SR.N4s — not to play with, but to run a scheduled, regular, all-weather service to France.

"The eyes of the world will be watching the performance of this valuable British invention.

"We at Hoverlloyd are utterly astounded at the Minister's decision to reopen the public inquiry into our application for planning permission to build the necessary hovercraft terminal on the foreshore of Pegwell Bay in Kent.

"I will even say that we are alarmed! Coming so soon as it does after the Minister's decision to go completely against the recommendations of his inspector at Stansted in the inquiry there concerning building of a third airport for Greater London, it is completely inexplicable why in my company's application almost the reverse should have happened. At Stansted the inspector advised that unless the national interest was at stake consent should be refused. In our case the inspector's conclusion was that it was in the national interest that consent should be granted!

"In his report (which runs to eighty-six pages), the Minister's inspector recommended that planning permission applied for be granted subject only to two conditions, one of which might be regarded as the standard condition as to detail, and the other again a matter of detail concerning the site of the hoverport in relation to the cliffs at the rear. This recommendation is, in my view, and remains, just about as unqualified as it can be.

"The Minister stated that he had reopened the inquiry because British Rail Hovercraft had said they intended to operate a similar hovercraft service from inside Dover harbour.

"At the inquiry which lasted some ten days in January, the unsuitability of Dover harbour was continually emphasised, not only by my own company from its experience of cross-Channel operations (of which British Rail Hovercraft have none), but also by our consulting engineers and even more strongly by the manufacturers of the craft themselves, the British Hovercraft Corporation, the prime consideration being the safety of the craft and its occupants, bearing in mind that to be commercially viable the craft must operate in all weathers. Indeed, the inspector in his conclusions states the following:

"(a) That my company has considerable justification in saying that a further investigation and inquiry would waste time and achieve nothing. There was no other evidence or source of evidence. My company had it all, and it was put forward at the inquiry, where it was not seriously challenged. The evidence incontrovertibly pointed to Pegwell Bay as the ideal site and just as firmly ruled out Dover.

"(b) British Rail Hovercraft (whose decision to operate from Dover was announced some time in March) did not offer any evidence at the inquiry and did not, therefore, submit themselves to cross-examination. A statement was made that they had not made up their minds.

"In his report the inspector concludes that British Rail were known to be investigating hoverport sites, but they made 'no useful contribution to the inquiry'. Indeed, quite apart from their own operational experience (across the Solent) their only source of information was the same as that open to my company, at least as far as the SR.N4 was concerned, namely the manufacturers.

"I must also point out that immediately following the British Rail Hovercraft Co's decision to operate their SR.N4 across the Channel instead of in the Solent as had been their first intention, one of my directors made contact with their Chairman in order to explore possible co-operation between our two companies. This was in February 1966. On our initiative these discussions continued throughout that year, although with little response from them.

"Furthermore, following the inquiry in January, we again approached British Rail, and went so far as to suggest that a joint company be formed by ourselves, themselves and Hambros Bank. British Rail introduced Townsend Ferries and French Rail into these discussions. A joint committee was set up as a result to evaluate, a second time, the Lydd–Le Touquet and Pegwell Bay–Calais routes. Dover was excluded from this further investigation because all agreed that there were operational problems concerned with the harbour entrances that were unanswerable other than by cancelling the service. The findings of this committee were overwhelmingly in favour of the Pegwell Bay–Calais route.

"What is the purpose of an inquiry which dealt so exhaustively with the points on which it has now been reopened?

"How can we accept that British Rail Hovercraft, who were able to make a decision (for what reason nobody knows) in March to operate from Dover, were unable to give their reasons to support this decision at the inquiry in January which had been convened by the Minister to determine just these factors?

"The whole outcome is totally unsatisfactory, and like Stansted seriously impugns the whole concept and purpose of a public inquiry of this nature.

"Everything we at Hoverlloyd have ever said or maintained about Dover still stands.

"We have no intention of taking upon ourselves the responsibility of exposing the SR.N4 to the serious risk of a major accident and possible loss of lives by operating from such a highly unsuitable base.

"We cannot go against all our own experience, the advice of the experts who designed the SR.N4, and, let's face it, against the opinions expressed by the chaps down the line at British Rail, who will be responsible for their operation."

★ ★ ★

The first two patients have been successfully treated on the Hoverbed, a new design of "bed" for the treatment of very serious burns, in which the patient floats on a cushion of warm air. The results have been so encouraging that the **National Research Development Corporation** has decided to sponsor the construction of a two-bed clinical trial unit by **Allen & Hanburys (Surgical Engineering) Ltd.**

This was announced in a joint article in *The Lancet* written by doctors of the Institute of Orthopaedics (London University), Mount Vernon Hospital, and an engineer of Hovercraft Development Ltd who constructed the equipment.

One patient had petrol burns over one-third of his body, front and back. The other patient was burning waste paper in a gale force wind when his oily clothes caught fire and he received burns on his right side. The first patient was on the Hoverbed for six hours and the second for 15½ hours.

In both cases, the doctors report, the weeping areas of the burns dried very rapidly — that is the reason for using a Hoverbed — and it proved easy to nurse the patients.

The Hoverbed consists of a rigid framework inside which is hung a fabric bag made from a light nylon coated with a synthetic rubber, normally used for anoraks and light mackintoshes. The top of the bag consists of two rows of pockets based on the segmented skirts of hovercraft. Warm sterile air at low pressure (¼ to ⅓ lb per sq in) pumped into the bag inflates the pockets, which meet along the centre.

When the patient is placed on the bed the pockets form a seal along the side of his body, and fall away beneath it. The body is left solely supported on air, though normally the head is supported on a pillow. The seal automatically conforms to any size of patient and follows any movement of the patient.

The air supply unit is housed in a four-wheeled trailer outside the ward.

After the treatment is concluded the fabric of the Hoverbed can be removed, suitably wrapped, and sterilised.

The development of the Hoverbed is a remarkable example of collaboration between doctors and engineers and official organisations. The National Engineering Laboratory of the Ministry of Technology constructed the first (rigid top) bed, and Hovercraft Development Ltd the later flexible models. The work has been assisted by grants from the Ministry of Defence (Army), the Medical Research Council, the Leverhulme Trust Fund and Courtaulds Ltd. All three arms of the Ministry of Defence have provided technical assistance, equipment and personnel. In addition, upwards of fifty industrial firms have supplied materials, components or facilities free of charge.

★ ★ ★

Cantiere Navale **Leopoldo Rodriquez** of Messina are building a 91 ft PT 20 hydrofoil craft for Sheikh Ahmed Bin Ali Althani. It will be propelled by two 1,350 bhp Mercedes-Benz diesel engines.

★ ★ ★

The first sale of air cushion vehicles for commercial applications in the United States has been made by Textron's Bell Aerosystems Company of Buffalo, NY, to **Skimmers Inc** of Anchorage, Alaska.

Bell Aerosystems has announced that Skimmers Inc has taken delivery of two 7½-ton Bell SK-5 ACVs. The craft were transported aboard ship from Seattle to Seward and then skimmed for more than 300 miles across the Gulf of Alaska, around the Kenai Peninsula and up Cook Inlet to Anchorage.

Skimmers Inc, an Anchorage-based firm, is the first US company organised exclusively to operate a commercial charter service utilising air cushion vehicles.

Officials of Skimmers Inc have announced that the two Bell SK-5s will be used for logistical support of off-shore oil-drilling operations on Cook Inlet. Route testing of an experimental passenger service between Anchorage and various points along Cook Inlet is also planned.

Skimmers Inc was formed in March 1966 by four businessmen active in the field of transportation in Alaska. They are Hugh B. Mitchell of Seattle, Washington, President; Paul A. Pollack of Seattle, Secretary/Treasurer; Julian C. Rice of Fairbanks, Alaska, Vice-President and General Counsel; and Lawrence H. Landry of Anchorage, Alaska, Vice-President (Operations). In addition to Skimmers Inc, their business affiliations include Alaska Van & Storage Company, Alaska Terminals and Alaska Household Goods & Movers.

The SK-5 models, which Skimmers Inc will operate in Alaska, are capable of carrying up to eighteen passengers or up to 5 tons of cargo. The craft are 39 ft long, have a beam of 22.9 ft and are 16 ft high.

A high-resolution radar aboard the SK-5 permits all-weather operation of the craft.

Powered by a 1,000 hp marine gas turbine engine, the SK-5 can achieve speeds up to 60 knots (70 mph). The same engine supplies the power to operate the 7 ft lift fan, which creates the air cushion, and the four-blade, 9 ft variable pitch propeller, which provides propulsion.

The integrated lift-propulsion system gives maximum power flexibility. Over smooth surfaces, additional power can be fed to the propulsion propeller at the expense of hoverheight with a corresponding increase in speed. Conversely, over rough surfaces, speed can be reduced and hoverheight increased, to maintain passenger comfort.

The 7-ton SK-5 appears to ride only a few inches above the surface, but the hard bottom of the craft actually travels on an air cushion more than 4 ft thick. This is made possible by flexible, air-actuated rubber skirts which also give the SK-5 greater obstacle clearance and ditch-crossing capability over land and improved riding qualities over water.

Control of the SK-5 is achieved by rudders mounted on the twin-fin, tailplane unit, which operates in the slipstream of the propellers and by bleeding air from the cushion.

A large buoyancy chamber, subdivided into watertight compartments and extending almost the entire length and width of the craft, assures flotation in any sea condition.

★ ★ ★

Now that literally hundreds of hydrofoil vessels of Soviet design, though not always of Soviet construction, are in service on all the main inland waterways of the USSR and beyond the frontiers of that country, the **Soviet shipbuilding authorities** have found it necessary to make provision for the fact that the repair and refitting of such vessels present certain special problems.

The Gorodets technical-constructional bureau, near Leningrad, which specialises in the designing of ferro-concrete craft, was entrusted with this matter, and has now completed the design of a floating repair base made in sections, which can be assembled as needed to meet specified requirements. In an interview concerning this novel vessel, published in *Vodniy Transport* of May 9th, the chief constructor responsible, V. Mironov, said that it would be fitted with a crane capable of lifting out the main engine, and of raising the stern or bow part of the hydrofoil vessel clear of the water, for the examination, and replacement if necessary, of the foils or the propeller. It will carry spare parts of all kinds, and will have workshops for repair work and so on.

The prototype is to be completed this year at the shipyard at Kostroma, at the junction of the river with the River Volga, after which it will go into series production, the floating repair bases being stationed at points where hydrofoil traffic is densest.

(*Continued on page 35*)

LETTER TO THE EDITOR

Hong Kong Hilton

May 16th, 1967.

Dear Editor,

While in Naples I had an experience which I think bears repeating because similar conditions may exist in other parts of the world. In Florence I made reservations on the Rodriquez PT 50 hydrofoil (round trip to Capri) through a tourist agency. When I checked with the agency in Naples to confirm our trip they told me that the hydrofoil trip was somewhat unpredictable and that we should take the conventional steamer to Capri. When I protested they told me that the hydrofoil was operated only in good weather and that since the weather was somewhat threatening it was unlikely that it would be operating the next day, and with this I converted our tickets to the steamer.

As we left the pier bound for Capri, I saw a PT 50 coming into Naples and I asked our guide about it and he told me that "Yes, the hydrofoil is running to Capri, but that we should not ride on it because it was very rough and we would be seasick." En route to Capri, we passed several other hydrofoils, one of them being the small PT 20, and in each instance our guide insisted that they were rough-riding and most of the passengers would be seasick. I told our guide that regardless of this fact we were going to return to Naples via hydrofoil even though we had an additional 4,800 lire to pay. I introduced myself to the captain and spent the entire trip back to Naples on the bridge of the PT 50, and the ride was obviously very smooth.

The captain implied that there was a tie-in between various travel agents and the steamship companies operating to Capri and that this accounted for the misrepresentation that took place. Mrs Sedgwick and our daughter Joan rode in the cabin and experienced no difficulty whatsoever. I am telling you this story because, as I indicated some time ago, I believe the chief obstacle to a successful hydrofoil operation is psychological rather than technical, and that the preoccupation of engineers on supercavitating foils, etc, is unwarranted and that more effort should be expended in the direction of gaining public acceptance by dispelling some of the myths that surround hydrofoil operation.

The captain of the PT 50 told me that at present there are three distinct forms of transportation between Naples and Capri: conventional steamer, hydrofoil and helicopters. Soon a hovercraft operation will be added, and the hydrofoil operators have expressed some concern. When I heard this it occurred to me that here is a "made to order" laboratory for comparing these four forms of transportation. At any rate, it would make an excellent article for *Hovering Craft & Hydrofoil*.

Yours sincerely,
E. V. Sedgwick

PS—Our hydrofoil trip from Capri to Naples was on April 7th, 1967, and the captain told me they had not missed a scheduled trip for nearly a year. Further, that the maximum number of days when flights were cancelled *in any year of their operation* was ten days.

A Hover Transporter

R. A. Cole

In many branches of engineering the natural growth of projects and the size of the associated equipment required are two features that have collectively led to a big transportation problem. The need for bigger and consequently heavier units comes from growing complexity, refinement of design and higher operating efficiency. In turn these requirements dictate that such equipment is manufactured in specialised industrial complexes and then moved as an entity to the customer's plant. Thus in so very many instances the days when an item could be built up from smaller sub-assemblies on the site are over. What is more, the tight costing necessary for the building of new high capital plants is being increasingly based on the availability of ready manufactured units that can be dropped into place when required.

Naturally, the task of transporting such pieces increases with their size and weight, and the problems manifest themselves when the item has to be transferred from one type of transport to another. Although it would at first appear that such transference of loads is an exporter's problem, this is not always the case. The slow speeds at which heavy loads travel on land plus the limited number of routes available to them make water transport very attractive. Unfortunately, the number of cranes that can lift 200 tons without arguing are very few and far between in this country and non-existent in others. One is therefore left with the problem of how to embark and disembark such heavy loads.

A Solution

Although not directly confronted with all the exporters' problems, the Central Electricity Generating Board (CEGB) manage to come against practically all of them when planning and building their new power stations. The carriage and safe delivery of transformers weighing around 200 tons and even up to 250 tons to what are essentially out-of-the-way sites is perhaps their greatest concern. They have pioneered a quite unique solution which is partly based on the use of a hover transporter.

In most cases roads to serve the power station site have to be specially constructed or existing ones have to be improved. The weight of the loads to be delivered has a strong influence on the final cost and character of these ways. Where local roads can be improved then so much the better, but even so a great deal of money can be spent if bridges have to be reinforced or new ones built.

The prospect of increasing the ground area over which the load is carried — that is, an effective reduction of the surface bearing stress — is attractive and technically appealing for obvious reasons. It would allow the use of many more existing roads and reduce the status and therefore cost of any new ones that have to be constructed. What is more, it represents a relatively quick and economically attractive solution to the many other problems involved.

That this end can and has been attained is proven by the hover transporter developed and built for the CEGB. It is intended for use along with a pair of special shallow-draught ships that have a roll-on/roll-off facility for the loaded transporters. Each vessel can accommodate a maximum of four loaded trailers, three within the hold and a fourth as deck cargo. However, as the nautical part of the facility does not directly concern us we will no more than mention these aspects for completeness.

The Transporter

The hover transporter itself consists of a well-known and proven type of low-loading platform carried on two forty-eight-wheeled bogies. A heavy tractor unit tows the whole assembly at a speed dictated by the law to be no faster than 5 mph (8 km/hr), although the installed power will allow faster progress to be made. Of course, such a limitation means that the vehicle cannot travel on the new motorways.

In this case the low-loading platform has been modified by the addition of a fairly simple skirt which is lowered for use by a number of hydraulic rams. Horizontal folds in the skirt give it a bellows-like appearance and action, the formation being retained by a simple system of cross wires which traverse the length and breadth of the platform.

For maximum economy of power and consequently highest efficiency the smallest possible air gap is essential. In this case the gap is quoted at 0.02 in (0.5 mm). It should be borne in mind that this dimension would apply only on a dead smooth and flat surface, a condition never exhibited by a road surface. Irregularities ensure that the gap will vary from nil in some places to greater than 0.02 in in others. To obviate wear of the actual skirt material, the lower edge is shod with light steel plates.

Pressures

At the time of the first big-lift and a press showing at the Associated Electrical Industries works at Withenshaw, Manchester, the transporter had not been evaluated across its full designed operating range. The cushion pressure to be employed during the first job was of the order of 1½ lb/sq in (0.1 kg/sq cm), and this provides a support of approximately 43 tons. But the maximum pressure envisaged is 5.4 lb/sq in (3.8 kg/sq cm), and this will provide a lift or axle off-loading of no less than 155 tons. Working back from these figures, we can deduce that the effective cushion area is of the order of 5,500 sq ft (511 sq m).

For the time being it is intended that the air cushion shall be employed only for short periods that will allow the transporter to cross weak bridges. However, one got the impression that this was purely a precautionary measure that will probably be relaxed when experience has been gained. Ultimately it will probably be used for longer periods so that the transporter can use low-grade roads. Its use over level ground will presumably reduce the drawbar pull needed to move the load, but this appears to be an aspect which has not yet been investigated.

Support Power

The air for the cushion is supplied by a battery of four Rolls-Royce B81 SV type petrol engines which are carried in a very well sound-insulated truck. These units have a reputation for reliability and are able to maintain their output for long periods. Each engine drives a centrifugal type compressor via a composite gearbox and fluid coupling unit manufactured by Associated Electrical Industries Ltd. They are rated individually at 235 hp at 4,500 rpm.

In fact the transporter requires the output from only three units and the fourth is provided as a safety margin. All four are run simultaneously and the output from one is continually spilled. If one of the units were to fail or lose power then an automatic valve arrangement would take charge and modulate the amount being spilt and so ensure a full supply to the cushion.

Four trunks carry the air from the compressor vehicle to the platform and these traverse a service vehicle that follows the main train. The idea is that the compressor truck will make its own way to the site where it is required and not be tied to the slow progress of the transporter itself. This arrangement will give the maximum economy of manpower.

The Future

Although the first vehicle of its type, there is already little doubt about its success and future potential. So far as the CEGB are concerned they will more than save the development and constructional costs of the entire transporter system within a very short period. What is more, they have enough work on hand to keep it fully employed over the next five years. Furthermore, it is the Board's intention that the whole system shall be available to assist British industry in general by being available to make deliveries anywhere in Europe. Indeed, they will even stretch this limit to include the near Middle East.

Overall, then, it would appear likely that other vehicles employing this principle will appear in due course, and the possibility of export orders for them cannot be overlooked.

People and Projects

(Continued from page 35)

The Ministry of Defence has announced that the Navy is to form its first operational hovercraft unit, using a modified SR.N6. Its primary role will be as a fast amphibious communications craft capable of acting in support of Royal Marine units. It will not be armed.

The Army already has a hovercraft squadron and will eventually have one SR.N5 and three SR.N6s by the end of the summer.

★ ★ ★

Large numbers of local residents in the Cleveland area turned out to view this craft lying alongside the city pier. Shortly after this photo was taken the craft departed for Pelee Island, Ontario, through a fog which grounded Bell's photographic helicopter travelling with it, as well as all aircraft using nearby Burke Lake Front Airport

Hovercraft Offer Canadian Great Lakes All-Weather Transport Operation

G. Ray Gibson

For thousands of years, before the white man came to North America, the St Lawrence was an Indian highway, known as "River Without End". Jacques Cartier was the first explorer known to have visited the St Lawrence; his ships reportedly were forced to stop at Montreal because of the Lachine Rapids. From Cartier's visit in 1534, well into the 1700s, the rapids remained obstacles to all save a few daredevils who would "shoot the rapids". Several attempts to build small canals, 12-18 in in depth, to allow passage of canoes, were frustrated by either Indian raids or the difficulty of cutting through the rocks.

The British are credited with building the first locks around the rapids. Their canoes passed the Cascade, Cedar and Coteau Rapids, about twenty-five miles upriver from Montreal. Five stone locks, with 2½ ft of water, allowed passage of the flat-bottomed bateaux which could carry several families. The boats still had to be carried around Niagara Falls; but by 1798 there was also a small canal on the British side of the Sault Ste Marie.

The first major canal constructed on the lakes was the Erie, completed in 1825. It made important cities out of such then insignificant villages as Buffalo and Cleveland, with goods moving easily from New York City as far west as Detroit.

After the Erie was opened, a young Canadian, William Hamilton Merritt, organised a company to build a competing canal. The canal would bypass Niagara Falls, and eventually be a part of a series of canals reaching to the open seas. He received a charter from the Upper Canada Legislature, which led to the start of construction in 1824.

Completed in 1829, Merritt's canal with forty wooden locks permitted vessels to overcome the obstacle of Niagara Falls for the first time. Each of the locks was 110 ft long, making it possible to tow sailing vessels and barges through channels 8 ft deep.

Today's Trade Route

The present St Lawrence Seaway, in opening the Mid-continent's inland lakes to ocean traffic, has added an important new route to the world's established trading patterns. The exposure of inland cities to the major seaports of the world has contributed to increased efficiency

At a time when no sensible mariner would be seen out of port, the Bell Aerosystems SK-5 air cushion vehicle skims over jagged ice as it proceeds across Lake Erie. In making this trip, the SK-5 became the first surface vehicle to travel the length of Lake Erie — a 500-mile round trip journey — under winter conditions before the opening of the navigation season. The craft also successfully demonstrated the feasibility of an ACV to provide year-round transportation between Pelee Island and the Canadian and US mainlands

Two different ice conditions encountered by the SK-5 are visible here as the craft skims over Lake Erie. The craft was heavily instrumented to record its performance, and crossed ice obstacles up to 5 ft high achieving speeds exceeding 50 mph

Boulders locked in ice were only some of the obstacles encountered by the SK-5. During its 500-mile round trip the craft gathered engineering data on the overall performance, handling qualities and operation of an ACV over a maximum range of Lake Erie winter conditions, such as rough, broken and smooth ice, calm and rough water, freezing temperatures, snow and fog and convenience, eliminating almost entirely the necessity and expense of trans-shipment of general cargo.

Prior to the completion of the Seaway, export and import commodities flowing between the continental interior and the nations of the world had to be transported by a combined ship–overland route involving both handling and rehandling procedures en route to various destinations. Now, vessels plying this route can move a ton of bulk cargo from Chicago to Liverpool for less cost than the overland freight charges to East Coast trans-shipment ports. Machines, tools, automobiles and a host of general cargoes are now shipped directly between the Mid-continent and its trading partners in Europe and elsewhere — requiring, in most cases, only one loading from departure point to destination — offering important savings in shipping costs.

Each year more ships are plying their way to Africa, South America, Australia and Asia. Surprisingly, there is often a saving in distance to even these far-off areas of the world. Here, again, significant cost savings make such traffic attractive to both shipper and receiver.

However, winter weather and ice conditions do not permit year-round operation and from December to mid-April each year the St Lawrence Seaway closes down. During this period no ships use the canal system and few local craft venture on to the lakes. While the deeper lakes remain relatively free from heavy ice, the shallower ones, including the river area, become frozen over with thick ice. During the break-up period this ice, aided by wind and lake currents, forms into jagged masses 10-20 ft deep and several miles across, with a capability of damaging the strongest lake vessels.

ACV Ice Operational Studies

Early in April this year, the Bell Aerosystems Company investigated these ice conditions with a view to hovercraft operation across Lake Erie. This being the most shallow of the Great Lakes, it offers the most serious ice conditions. The craft, a Bell Aerosystems SK-5 air cushion vehicle, travelled from Buffalo, New York, throughout Lake Erie, visiting such places as Cleveland, Ohio, Pelee Island and Kingsville, Ontario (areas noted for serious icing conditions). During the 500-mile round trip many serious ice and weather problems were encountered and overcome. On one occasion, during the Cleveland to Pelee Island leg of the journey, wind and fog conditions proved so serious that the Bell Aerosystems photographic helicopter had to be grounded. Likewise, all other aircraft at the nearby Burke Lake Front Airport stayed grounded while the SK-5 alone braved the weather.

All concerned with the trials were impressed with the handling capabilities of the ACV during this test period. Conditions encountered, the worst of the winter season, proved no match for the craft. Final test results have shown that these machines can, and no doubt will, serve Canadian and United States Coastguard Great Lake patrol operations, in particular such bad weather winter operations, calling for air-sea rescue and inter-island mercy trips, when helicopters, etc, must remain grounded.

It is the opinion of this writer that future transport hover vehicles may well take over a major portion of the St Lawrence Seaway operation during the winter period, with ships unloading direct to these craft in the salt-water tidal area of this great river.

Hydrofoils, by Christopher Hook and A.C. Kermode

(Sir Isaac Pitman & Sons Ltd 32s 6d)

Reviewed by Baron Hanns von Schertel

The authors' statement in the preface of the book, "This little book is one that ought to have been written years ago", is well-founded, and it is certainly true "that the public do not know enough about hydrofoil craft". It is surprising to notice that, though twenty-five years have passed since the first serviceable hydrocraft flew on the Baltic Sea, and several hundreds of passenger hydrofoils have come into regular service in the last ten years, the public is still so little informed about this modern and fascinating means of transport.

There are perhaps only two countries where hydrofoil boats have aroused wide interest in the population — Russia and Japan: Russia because hundreds of craft are in operation on the 300,000 miles of navigable inland waterways, partly competing with rail transport thanks to higher speed and lower fares; in Japan because hydrofoils were introduced by a large newspaper campaign and followed up by a population very open-minded to any technical novelty.

It is strange that people are better acquainted with the hovercraft, which made its first successful flight two decades later than the hydrofoil boat, and that almost everybody seems to know its basic principle. The hovercraft, of course, benefited by a much better launching campaign.

In the light of these facts the book of Messrs Hook and Kermode must be welcomed warmly, all the more that it is intelligible to the layman, too, and will thus make up for the scarce publicity that hydrofoil development has known up to now.

This very instructive book deals with all that is worth knowing about hydrofoils, from the hydrodynamics of foils to the stability and control of the boat and its performance in waves. Among other things, we become acquainted with the different types of craft, different control and propulsion systems used at present. The historical development is related at the end of the book, which also includes an excellent and complete description of the Hydrofin system; there the reader will find all that may interest him, such as the different stages of development, incidence control, propulsion methods and foil retraction. The last items are specially instructive because they apply more or less to any system. However, the reader who wants to be fully informed might be somewhat disappointed to find only little about other types. A more detailed description of them would not only make the book more complete, it would also increase its value. It is much to be hoped that the book will meet with such a success that a new — revised — edition becomes necessary.

For the sake of easy understanding some physical data depending on one or more other values are given as absolute. The optimum angle of incidence (for best lift/drag ratio), for instance, is indicated with 3-4°, though this applies to a certain profile only. In general, the optimum angle depends on the camber of section's mean line, position of maximum ordinate and the aspect ratio. The book fixes the lower speed limit for a hydrofoil at 30 knots whereas, correctly, the speed/length ratio (Froude number) has to be considered, which does affect the above figure. A Froude number not under 1,0 ($F = v/\sqrt{gL}$) is recommended to make the boat sufficiently superior to conventional craft, and to avoid poor sea-behaviour in a following sea. It is thought that an interested reader with a normal school education should understand these relations. The applied simplifications, which distort true conditions, are therefore felt to be unnecessary.

Still another part of the book seems open to objection. In the very interesting section "Hydrofoil Craft in Waves — a Summary" the authors claim that waves can be "platformed" just with the predicting Hydrofin feeler arm. This is, of course, possible in the case of short waves, which are filtered out by the provided spring-suspended heel, and perhaps in the case of certain wave lengths when the boat is travelling in or against the direction of the sea, but it is certainly not possible in the case of long waves. For platforming a sensor is required, which refers to the horizon, or at least a rate-gyro and/or accelerometer to damp pitch and roll motions. The Hydrofin system cannot dispense with such sensors, either, if platforming tendency under all wave conditions is desired.

The book gives a very good and rather complete summary of the history of hydrofoil boats, but one important event does not find adequate consideration — the period of the breakthrough of the hydrofoil idea, the time when the hydrofoil development passed from the purely experimental boat to really usable craft. Ricaldoni, Crocco, Forlanini and Graham Bell could not solve all problems in connection with the flight in water and abandoned their efforts after a few years. This fact was admitted by General Crocco when the reviewer visited him some eleven years ago. In the above-mentioned period boats of the surface-piercing type with a size up to 80 tons and top speeds of 51 knots were built (even a 60 knot craft was constructed but was destroyed in an air raid before launching) and run for many years under very severe sea conditions in the Baltic until they had proved their superiority. It was another milestone in the history of hydrofoils when Christopher Hook practically for the first time proved that an incidence-controlled boat can fly stable and with excellent seakeeping qualities.

Full approval must be given to the authors' opinion that further development of hydrofoils should be directed towards simplification of the system, inasmuch as the good seaworthiness of the controlled fully submerged foils should be combined with the rigidity, reliability and ease of maintenance of the surface-piercing configuration. The USA tend to apply space technique to hydrofoil vessels: this results not only in such a rise of costs that a passenger service becomes economically impossible, it also decreases the reliability of the boat and multiplies maintenance to such an extent that the Navy craft is bound to be found in the harbour most of the time.

The book is wished the best success, and it is hoped that it will find wide circulation so that it may contribute to the popularity of the hydrofoil boat.

A powerful new force in gas turbines:

Rolls-Royce Industrial and Marine Gas Turbine Division

The industrial and marine gas turbine activities of Rolls-Royce and Bristol Siddeley, two leading companies in the gas turbine world, have been amalgamated to form the Rolls-Royce Industrial and Marine Gas Turbine Division.

A new division drawing on vast resources of know-how in the applications of gas turbine engines to electricity generation, marine power, gas and oil pumping.

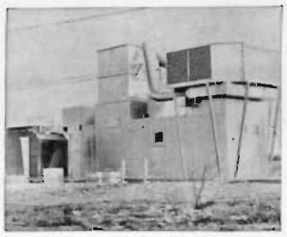
A new division that presents the world's largest and most advanced range of industrial and marine gas turbine engines.

A new division with the massive facilities to meet the ever increasing demand for power.

Rolls-Royce industrial and marine gas turbines provide power for everything from nuclear station standby to hydrofoils and hovercraft. Here are some of the applications of our range of engines:

1 Industrial Avon

An Avon powered Cooper-Bessemer pumping installation in Canada. The Avon is a single spool 18,000 ghp gas generator. 145 industrial Avon engines have already been sold, for electricity generation and pumping duties throughout the world. To date they have totalled more than 200,000 hours in industrial operation.



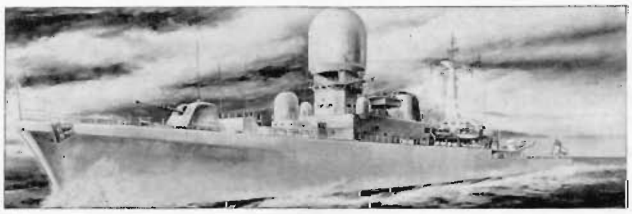
A 14MW single Avon powered pre-packaged A.E.I. generating set in service with the Newfoundland and Labrador Power Commission, St John's, Newfoundland. Avon gas generators power electricity generation sets up to 56MW capacity and sets with power outputs of over 100MW are on offer.

2 Industrial Olympus

An Olympus powered 140MW generating station at Rye House, in England. The Industrial Olympus is a twin spool gas generator available in a range of power outputs from 17.5MW to 70MW. Nearly 1,000MW of Olympus powered generating capacity has been either ordered or installed.

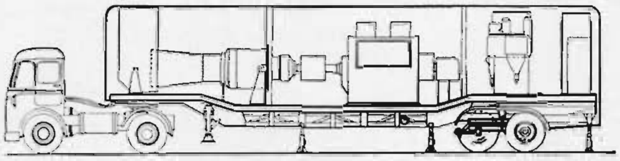
3. Marine Olympus

The Marine Olympus will power the Royal Navy's revolutionary Type 82 destroyer. It is a 24,000 shp twin spool gas generator with a single stage free power turbine. Five navies have ordered this engine.



4 Marine Tyne

The Tyne 4,500 shp turboshaft engine powers the Grumman "Dolphin" passenger hydrofoil. It has also been chosen to power a new hydrofoil gunboat for the U.S. Navy—the PGH1.



5 Industrial Proteus

This is the 'packaged' Proteus—2.7MW of power station on a trailer. The Proteus is a free turbine turboshaft engine delivering 4,000 shp for electricity generation and for pumping. Proteus engines have been installed or ordered for use in more than a dozen countries.

6 Marine Proteus

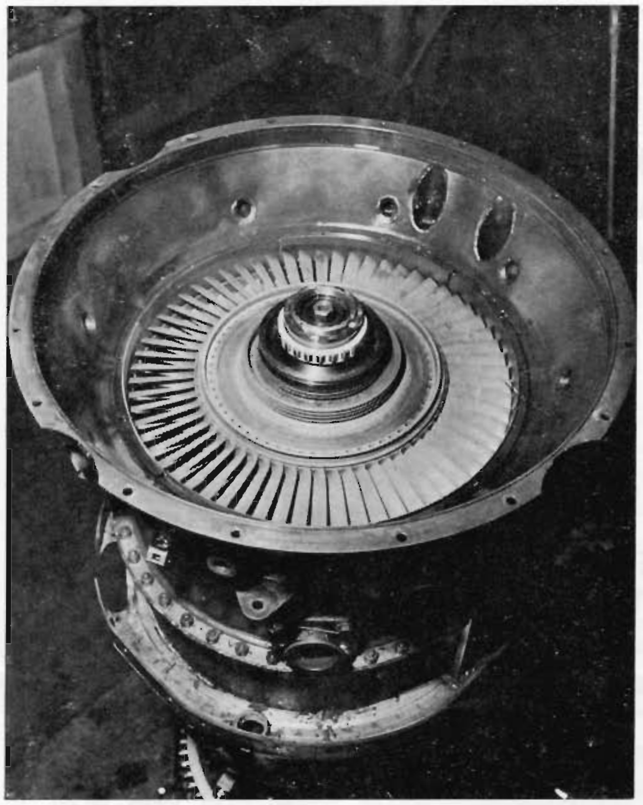
The Swedish Navy's fastest patrol boats are powered by Marine Proteus engines. The 4,250 shp Marine Proteus turboshaft engine has been chosen by 10 navies for a variety of vessels including hydrofoils and hovercraft.

7 Marine Gnome

The SRN6 hovercraft is Marine Gnome powered. The Gnome is a free turbine turboshaft delivering 1,050 shp. It powers more hovercraft than any other engine in the world. Craft using the Marine Gnome include the BHC SRN3, SRN5 and SRN6.

ROLLS
RR
ROYCE

ROLLS-ROYCE
Industrial & Marine Gas Turbine Division
P.O. BOX 72, COVENTRY, ENGLAND.

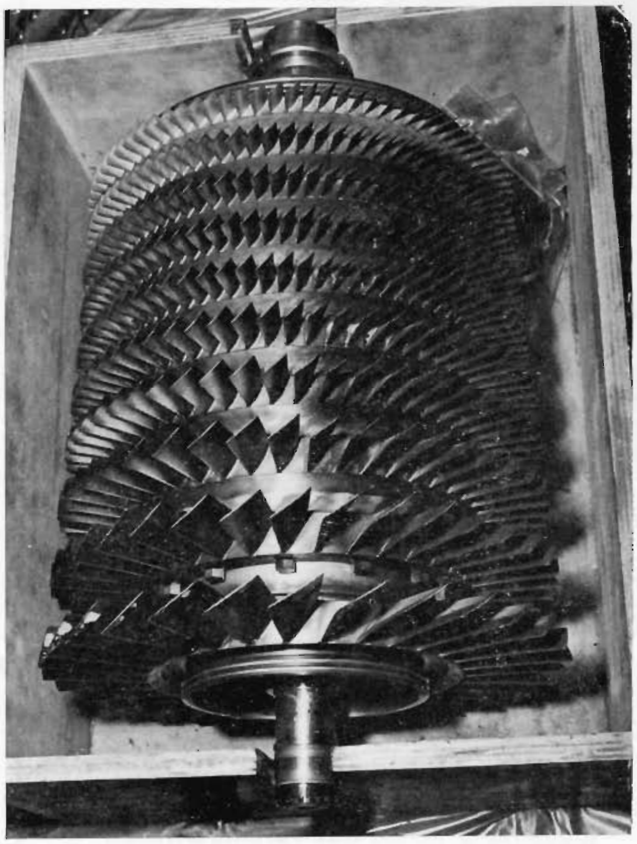


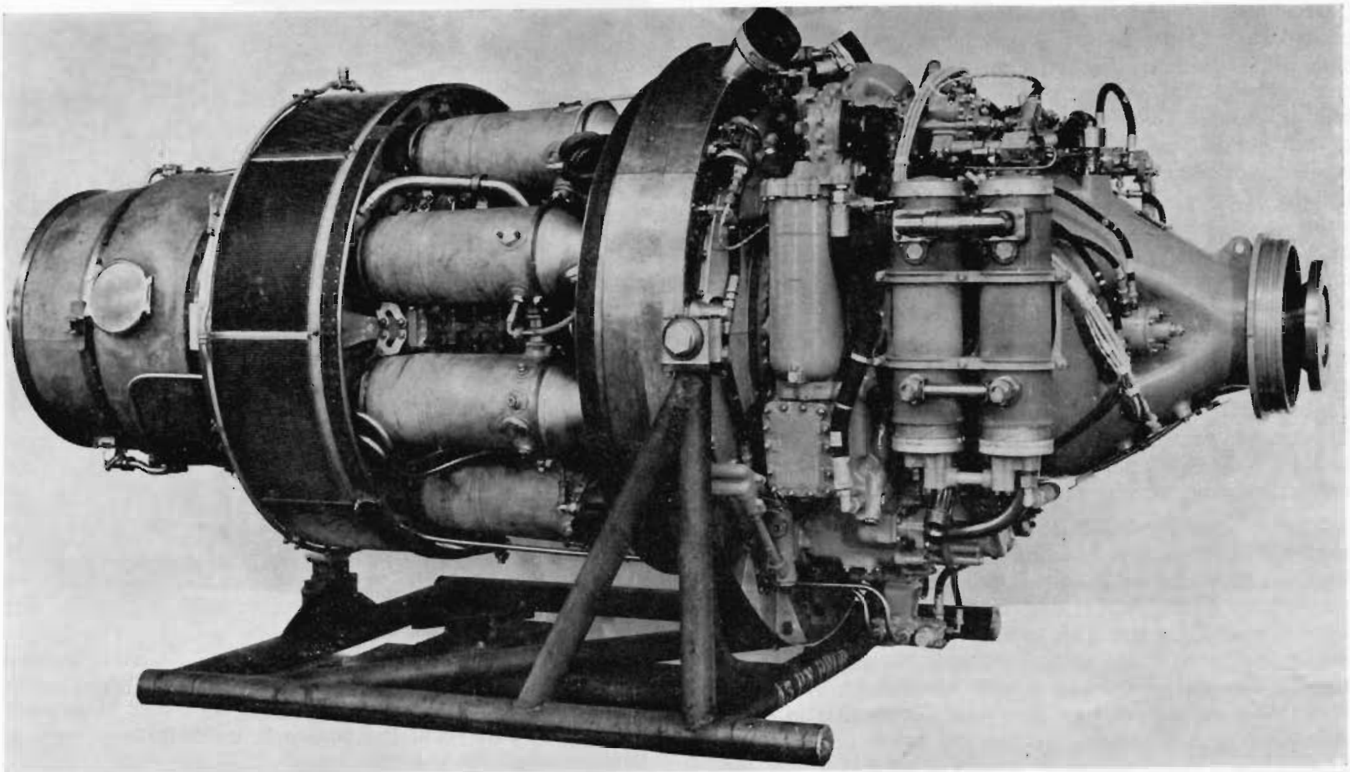
The Marine Gnome engine in Hovertravel's SR.N6 was the first to complete 1,000 hours between overhauls. The photographs show (above) the power turbine and (below) the compressor rotor

TURBINES IN HOVERCRAFT

by

TERENCE FORD AFRAeS





Four Marine Proteus engines will power the SR.N4, and single and twin Proteus installations have been specified for the BH.7 and BH.8 respectively. The Marine Proteus has had more than 25,000 hours' sea experience

ESSENTIAL to the development of hovercraft during the past eight years has been the research conducted into the means of propulsion and the evolution of engines derived from aero applications. Bristol Siddeley Engines Ltd has been in the forefront of this work and the company's power plants have equipped all British gas turbine hovercraft. Beginning with well-tried types, the firm has improved and developed the engines so that they will fulfil the present and immediate future needs for marine power plants intended for use in the larger craft soon to be put into service.

About fourteen years ago, when the ACV concept was in the early stages of development, Bristol Siddeley was considering the use of aero gas turbines for marine and other applications. The first engine on which work was concentrated towards a seagoing application was the Proteus, which was eventually developed for fast patrol boats. This marine background was to prove invaluable a few years later when it was found that, using the basic aero-engine and making changes in the fuel system, component materials and reduction gearing, a satisfactory power plant could be developed to operate in the new medium.

The acceptability of adaptations similar to that outlined paved the way for hovercraft gas turbines, since the use envisaged is largely the same as in other marine applications. Aero gas turbines must, however, embody modifications designed to take account of the changes in environment and load which have effects on the operation of the engine. The main advantages in the use of these power plants in the marine field are their low weight and volume, which make them particularly suitable for high-speed craft. Rapid starting and acceleration is possible at a greater rate than with other forms of engines, together with simplicity of construction and ease of maintenance. Greater reliability is also a great advantage, and about the only drawback compared with other kinds of power plants is the necessarily high fuel consumption. This, however, is partly overcome by the use of diesel fuel, which practice is already standard in most of the aero-derived marine engines as it is much cheaper than kerosene.

Adaptation of existing engines to burn the diesel fuel is more or less straightforward, involving alterations in burner nozzle and combustion chamber design to ensure good combustion and to avoid smoke. One factor has to be borne in mind regarding diesel fuel: turbine blade corrosion is greatly aggravated by sodium sulphate attack and consequently any measures taken to protect turbine blading from corrosion of any kind must allow for the use of a sulphur-bearing fuel.

Environmental Considerations

One problem that arises when hovercraft use adapted aero-gas turbines is common to all marine installations, ie that of combating the effect of sea water and salt-laden air. There are two main effects: deposition of salt on compressor blading reduces the efficiency of the compressor and the mass flow of the air with a consequent loss of performance, and the turbine blading can suffer corrosion from salt attack. The sodium sulphate attack referred to in the previous paragraph greatly aggravates this condition.

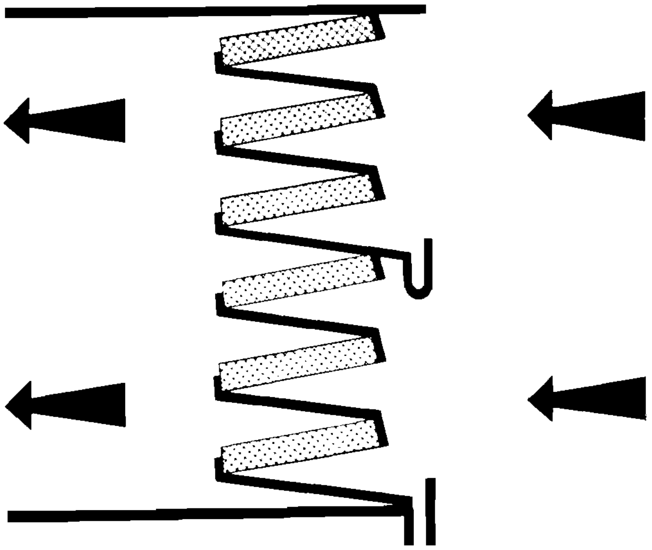
Cleaning of the blades is essential to minimise these effects, and in the case of the compressor in the past this has been done by water washing, but more recently the use of solid cleaning agents has become standard practice.

Carbo-blast (ground walnut shells and fruit stones) has proved easy to use in the Royal Navy and is extremely effective. Turbine blade corrosion has proved a more difficult problem and has been until recently complicated by lack of data sufficiently reliable to determine the amount of salt present in the air in a marine environment, the efficiency of filter systems and the mechanism of attack on turbine blading. It had been shown by tests that catastrophic corrosion can be produced in a short time with high salt concentrations and sulphur-bearing fuels, but more recently it has been ascertained that the amount of salt present in a hovercraft on the inside of a filter had been overestimated and that laboratory testing with salt concentrations was not necessarily a reliable guide to seagoing conditions as the incidence of attack with these concentrations was not linear. The now well-known Knit-Mesh filters are the outcome of this work, using banks of knitted polypropylene pads which have shown a distinct advantage over other systems.

One of the hovercraft's great advantages over other means of transport is its ability to operate directly on to beaches, thus eliminating costly port installations. It is this very ability which gives rise to the tendency, when hovering over dry sand, for the craft to envelop itself in a miniature sandstorm, and under such conditions the erosion of the turbine compressor blading is both rapid and severe. Tests undertaken on one current type have shown that in severe conditions a Gnome engine can be made unserviceable after a very short period of hovering over sand. In connection with this effect, it should be mentioned that high forward speeds reduce this deterioration, since sand thrown up from the skirt is left behind and does not reach the air intakes in such large quantities. In craft which operate almost entirely on a sea route, the effect of sand erosion is obviously much less, but even on such short sea routes as the Solent the problem can be a very real one. To quote the Gnome engine again, the stainless steel blades used for the compressor seem to be as effective a material as known at present, but nevertheless filters are certainly a necessity when desert operations are contemplated.

The Noise Problem

This is a complex subject because hovercraft noise originates from several sources. With the gas turbine, the high frequency noise from the air intake ducts is such that it can be attenuated by designing the air intake ducts of such a size that the air velocities are kept at a relatively low level and also by siting longitudinal sound-absorbent splitters in the ducting. The hovercraft, with its broad beam and large surface area, lends itself to the use of a plenum chamber air intake with low intake velocity among other advantages. The second source of noise is mechanical in nature, radiated from the engine casings, and this can be dealt with by sound-absorbent cowlings. Exhaust noise is the other type, which is in a lower frequency band and can prove difficult. It should be realised that noise from a turboprop exhaust in a hovercraft is not of the same order as that from a turbojet, since most of the energy has been expended in the power turbine stages of the engine. A low rumble is the noise which is produced and this is not normally very objectionable, but there are, however, occasions when special measures are necessary, for example when operating in confined waters in built-up areas. Extended exhaust diffusers with sound-insulating linings may become necessary, as is often the case with gas turbines used on land for power generation, although in the case of these installations much greater noise reduction is called for than would be required for hovercraft application.



Diagrammatic cross-section of the Knit-Mesh filter system

It is considered that the measures taken or being taken in the near future will be adequate to cope with hovercraft noise, and that from the engine is unlikely to present a problem since the chief source of ACV noise will probably remain the propeller. Work being undertaken in this sphere should result in developments in noise reduction.

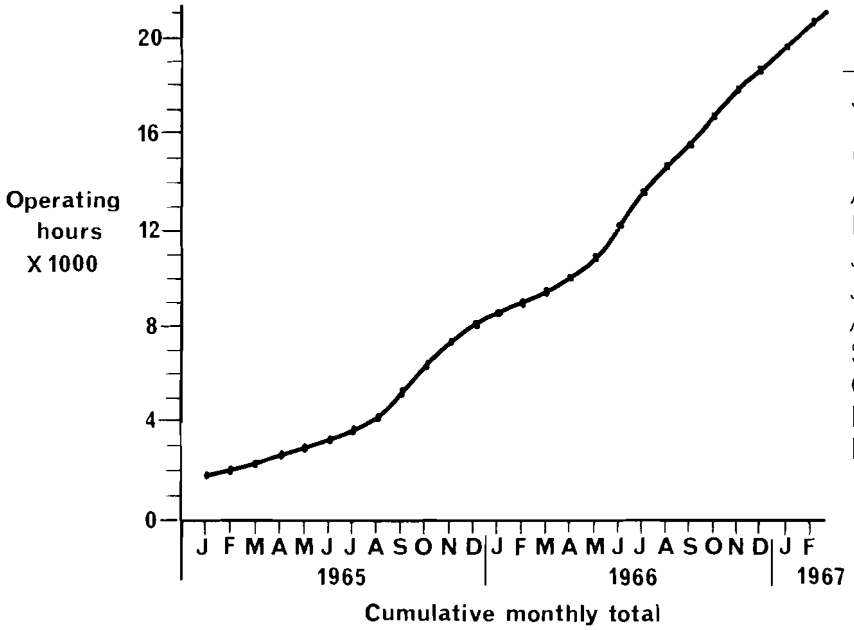
Progressive Developments

At the beginning of the development of gas turbine engines for ACVs, it was realised that certain factors required consideration as regards the operation of these power plants: longer periods at full marine rating will be necessary and the percentage of operating time above the cruise rating may be in the region of 5% ; the engine will be required to operate at sea-level conditions for its entire life ; an overhaul life of 1,000 to 2,000 hours being required, the choice of marine rating is usually a question of running an engine at as high a temperature as possible consistent with achieving this figure.

The factors to be taken into consideration regarding overhaul life can be put under three broad headings, namely: high turbine entry temperature causing creep limitations on hot components and possibly limiting flame tube life ; mechanical failures caused by high pressure loadings (for example, on thrust bearings), and blade fatigue ; and corrosion resulting from salt water and the presence of sulphur in the fuel (referred to previously).

Bristol Siddeley has allowed a temperature margin on its ACV gas turbines to cater for the increase in intake temperature and the effects of salt deposition on compressor blading. Marine engines are now run with a turbine entry temperature of about 100° C below the equivalent aero engine take-off value. This gives adequate flame tube life and ensures that the life of the turbine components will not be limited by creep.

Another consideration dictated by sea-level conditions is that of mechanical failure produced by pressure loading in the high ambient conditions. Bristol Siddeley has found that bench testing and consequent developments have been most valuable in combating this problem and has reduced the loading associated with the lower operating temperatures of marine engines, which is expected to ensure that adequate life is achieved.



	1965	1966	1967
January	**1780**	**8560**	**20228**
February	**1840**	**8950**	
March	**1940**	**9460**	
April	**2220**	**10190**	
May	**2440**	**10870**	
June	**2670**	**11830**	
July	**3186**	**13850**	
August	**4044**	**14450**	
September	**5460**	**16700**	
October	**6340**	**18130**	
November	**7180**	**19130**	
December	**7950**	**19700**	

Marine Gnome operating hours. (Cumulative figures for beginning of months stated)

With the adaptation to marine use, certain additional modifications have been found necessary with the propeller-turbine: it is often found necessary to alter the reduction gear ratio to provide a drive at the appropriate speed; the fuel system may be simplified by the elimination of such aircraft components as the combined control unit and the air/fuel ratio control unit; there may be a need for inching or barring motors which rotate the compressor and turbines to ensure that no brinnelling of the ball and roller bearings will occur, when the engine is not being used but is subjected to vibration from other operating machinery.

Air intake arrangements for hovercraft have received particular attention since it was realised that the system used for conventional marine applications, ie fast patrol craft, involving inlet trunking with noise-reducing water-separating splitters leading into a plenum chamber around the engine compressor inlets, was basically satisfactory for ACVs but could be improved. This has occurred recently and the craft applications now include the construction of frames holding a thick screen of finely woven strands of nylon-type fibre (knit-mesh). These are located in the walls of the hovercraft engine room, and engine air is drawn through this mesh and the separated water is drained overboard.

The exhaust system has been developed for hovercraft with the idea that, as funnels are not desirable because of drag and the space required, transom exhausts are required where a small additional advantage is obtained from the jet thrust, at the same time ensuring that water does not enter the exhaust and flood the engines and also that exhaust gases are not recirculated into the engine via the air intakes. The importance of lightweight components is similar in the hovercraft to that of the aircraft application, and in this connection it is obviously essential that the weight of gearing and transmission is of the order of one-fifth to one-tenth that of conventional marine equipment.

On the various types of gas turbine engines supplied to hovercraft manufacturers, a great deal of operating experience has been built up, and although in the early days of ACVs the engines were chosen after the craft had been designed, it is now considered essential that new craft are designed around the engine since there are few types of fully-marinised engines available. It may be appropriate here to give some details of the Bristol Siddeley equipped hovercraft that have been in operation since 1959.

The first power plant in the SR.N1 was originally a piston engine, but this was later supplemented by a Viper. This craft has undertaken a great deal of development work and more recently evolved the flexible skirt principle pioneered by Westland. In 1962, the VA-3 was launched with four Turmo engines of 360 hp supplying the power for both lift and propulsion. Together with two engines supplied as spares, these power plants have totalled well over 700 hours' running for experimental purposes.

In January of the same year, the Westland SR.N2 was launched with the power for lift and propulsion being supplied by four Nimbus gas turbines of 815 hp maximum rating. These engines are coupled in pairs and situated at the aft end of the vehicle, each pair driving a fan and airscrew combination. Again two engines were supplied as spares, and the aggregate total of running hours of the six engines is 2,345. In 1964, a Westland SR.N2 hovercraft was supplied to the Ministry of Defence for evaluation in a number of military roles. This was powered by four Gnome engines of 1,050 hp each. The SR.N5 craft has a Gnome engine, coupled to a single fan and a reverse-pitch propeller.

The development of the marine Proteus from the well-known aero engine has been mentioned already, and it is estimated that during the six-year period up to 1964, 20,000 hours have been recorded under seagoing conditions. Service experience of this engine has been increasing at the rate of 7,000 hours per year and a further large increase is envisaged when the SR.N4 craft begins its trials this autumn and goes into service in the spring of 1968.

Operational Reliability

Among the marine Gnome engines in service, the first to accumulate 1,000 hours between overhauls was fitted in one of Hovertravel's SR.N6 craft. This service has been established since August 1965, operating between Ryde and Gosport and Southsea. It was found to be an ideal route on which to introduce the SR.N6, with the craft crossing the Solent at 60 knots in calm water or about 50 knots in 4-5 ft waves, and resulting in a journey time of six minutes.

When the Gnome went into service in hovercraft, Bristol Siddeley chose a conservative 500 hours TBO, but this figure was quickly exceeded by a number of operators and Hovertravel's engine reached the 1,000 hours TBO. When the engine was removed and inspected, it was found to be in excellent condition, with the power factor the same as when new. The manufacturers of the Gnome have made it clear that the mesh-type filters in the intake system contributed in no small way to the achievement of this record of reliability. When hovering, the craft tends to envelop itself in dense spray, so that the efficiency of the filters must be very good indeed. Tests undertaken by the National Gas Turbine Establishment have shown that with the mesh-type filters, the samples of spray taken immediately downstream of the filters with the craft hovering showed a salt content of only 0.04 parts per million. The results of these tests have been borne out by service experience with the Gnome, when no serious corrosion troubles have arisen despite the small size of the compressor blades.

This high-utilisation service by Hovertravel carried over 250,000 passengers during the summer of 1966, and by October of the same year a total of more than 15,000 trips had been accomplished.

When British Rail Hovercraft entered the field of high-density services, the integration of hovercraft services with existing train timetables played an important part in demonstrating the benefits of hovercraft travel. In the period July 6th to October 15th, 1966, 40,000 passengers were carried and a steady commuter service showed signs of building up. The daily average utilisation of the SR.N6 on this route is thirteen hours, with the marine Gnome shutting down for one brief period only during the day.

Cross-Channel operations were undertaken by the Hoverlloyd company in May last year between Ramsgate and Calais and, despite the limitations imposed by the heavy seas during the summer, more than 10,000 passengers made the thirty-one-mile crossing, as well as 40,000 passengers being carried for their first experience of a short hovercraft trip along the coast.

In the military field, the Interservice Hovercraft Trials Unit (IHTU) at Lee-on-Solent has evaluated many types of hovercraft, but in 1964 was equipped with an SR.N3 and three SR.N5s and has concentrated most of its later work on these craft. Operation of hovercraft has been undertaken in extremes of temperature in many parts of the world and over many kinds of terrain, designed to prove the reliability and efficiency of the craft's construction and power plant under any conditions envisaged.

In the Far East, SR.N5s have performed many trials, including operations and demonstrations in Eastern Malaysia, Singapore and Thailand and involving the logistic support of ground forces, night operations, amphibious demonstrations over rapids and a general military carrier over the terrain of Tawau, Sabah, which has a number of rivers flowing into Cowie Bay after meandering through mangrove swamps and dense jungle. The technique evolved for operations over rapids has proved very successful and involved maintaining maximum cushion height and immersing the skirts as little as possible. This means that high turbine speed and low propeller-blade pitch angles must be maintained and emphasises the significance of having a reliable engine. In Thailand, the SR.N5s were able to show their ability to operate over rice paddy and its associated bund walls up to 3 ft 4 in high, through elephant grass 9 ft tall, through dense scrub vegetation 7-10 ft high and over a causeway road 5 ft 2 in above the surrounding marsh land. The only effect of the varying types of vegetation and obstacles was to reduce speed somewhat.

Arctic trials have also been extensive, being conducted by a joint British/Canadian team. The trials began with some preliminary performance work involving thrust measurement and over-ice handling techniques, and then the craft was tested over deep, soft snow. Appreciable quantities of this type of snow were thrown up by the SR.N5 in static hover, but the engine plenum chamber intakes proved to be quite capable of dealing with it. The Knit-Mesh filters showed no signs of icing up, although they were not treated with de-icing fluid.

These trials carried out in the Far East and Canada showed the abilities of craft designed for commercial purposes being used in a military environment and, limited though this series was, it did show how the hovercraft had proved of a sufficient reliability and flexibility to be able to undertake military tasks. Two results followed directly from these trials: the Royal Corps of Transport will have four SR.N6s modified for military use (this is in addition to the hovercraft unit's three SR.N6s and an SR.N5), and two BH.7 hovercraft were ordered. These latter craft will have a normal gross weight of 40 tons.

These trials and demonstrations, together with others all over the world, have underlined the progress maintained in gas turbines for hovercraft, and the evolution of power plants for the new medium. Marine Gnome operating hours now considerably exceed 20,000, of which 40% has been achieved by three scheduled commercial operators, Hovertravel, Hoverlloyd and British Rail Hovercraft. TBO for the Marine Gnome is now 1,250 hours and it is confidently expected that this figure will be increased to 2,000 hours by the end of this year.

The progress thus far in the design of power plants for these craft has been made possible by the co-ordinated Government and industrial research programmes and the availability of lightweight gas turbines originally designed for aircraft purposes, together with Bristol Siddeley's already considerable experience with these engines in conventional surface vessels. From the days of the SR.N1 craft, the power plants have been developments of existing types and even with the SR.N4 160-ton hovercraft, due to go into service next spring, the Marine Proteus engines are versions of the original aero engine. It may be thought appropriate, therefore, to wonder whether hovercraft engines will continue to be developed variants of existing types used in other environments or will in the near future be considered as a different type of power plant, designed from the beginning with the special environmental and operating problems posed by ACVs in mind. Certainly, with the coming of much larger hovercraft and hoverships, a great deal of consideration will have to be given to the large power requirements of these craft and the special measures essential to the most efficient and economic means of propulsion.

NOTE: On April 10th, 1967, a new division was formed incorporating the old industrial division of Bristol Siddeley Engines and industrial gas turbine interests of the Rolls-Royce Company at Derby. The new division is now known as the Rolls-Royce Marine and Industrial Gas Turbine Division.

Supramar's PT 150-DC

The largest hydrofoil vessel in the world is being built by Westermoen Hydrofoil A/S Mandal, under contract to Göteborg-Frederikshavn-Linjen, Eriksbergs Mekaniska Verkstad, Rederi AB Bifrost and Nya Ångfartygs AB Heimdal. It will be delivered in June 1968.

1.01 GENERAL INFORMATION

The Supramar Hydrofoil Boat PT-150 Dc for 250 passengers and a crew of eight men, or alternatively approximately 150 passengers and eight medium-sized cars, has been designed for seagoing service and can operate under conditions given under paragraph 1.03. The passenger compartments are arranged for medium-distance operation, eg as a passenger/car ferry. For long-distance operation, the passenger compartments can be made more spacious, with a corresponding reduction in the number of passengers carried. The subdivision of the boat represents a two-compartment ship as required by the London convention for operation on international routes.

1.02 MAIN DIMENSIONS

Length overall	37.46 m	(123.00 ft)
Length over deck	37.20 m	(122.00 ft)
Beam over deck	7.40 m	(24.25 ft)
Foil span	16.00 m	(52.40 ft)
Draught:		
Floating	5.50 m	(18.05 ft)
Foilborne	2.70 m	(8.85 ft)
Displacement:		
Fully loaded	150 tonnes	(147.80 tons)
Unloaded	120 tonnes	(118.20 tons)

Payload Capacity (23 tonnes)

As passenger ferry	250 passengers
As passenger/car ferry ...	150 passengers plus 8 cars
Speed (continuous for 4 hr at 3.400 hp)	300 nm

1.03 SEAWORTHINESS

The seaworthiness of the boat depends mainly on the height of waves encountered in the operation area. Tank tests, under very unfavourable conditions (regular waves), revealed that a boat of 150 t displacement can travel foilborne at speeds of 38-40 knots through waves of up to 2.5 m in height. This wave height represents wind scale 8-9 (Beaufort) in the Baltic Sea. In a higher sea, and in a following sea which is higher than a wave height of 2.0 m, it is advisable to travel half-immersed and at reduced speed. However, with a stabilised boat (see part 4.03) higher waves than those mentioned above can be ridden.

1.04 HULL AND SUPERSTRUCTURE

1.04.1 Shape of Hull

Designed for the two basic modes of hydrofoil craft operation (displacement condition and foilborne), the shape of the hull has a characteristically fairly high dead rise, and hard chine sections, for performance as a planing hull in waves, and for structural impacts in a seaway during flight. Dead rise amidships amounts to about 20° at the transom. The hull has a straight ascending sheer of main and lower deck, designed without round of beam on both decks

1.04.2 Design of Hull and Superstructure

The hull is of a riveted light metal alloy design and is a combination of longitudinals and the transverse framed method.

The frame spacing for the bottom longitudinals is 300 mm. The longitudinals between the transom and frame 102 are stiffened by web frames at 900 mm intervals. The distance of the longitudinals in the main and lower deck is 350 mm. The forepeak is tranverse framed, frame spacing 300 mm.

The main deck is continuous from stern to bow, but on the lower deck the engine room is situated between frames 44 and 71. The lower deck is watertight, and the engine bearers extend aft to frame 32 and forward to frame 102.

A detachable hatch is fitted on deck, above the engines, to enable these to be removed for major overhauls.

The superstructure has two expansion joints, and is not included in the load-bearing structure. It is also designed in a combination of longitudinal and transverse framed method. Spacing is 350 mm for longitudinals and 600 mm for transverse frames.

The extruded sections used for the frames and stiffeners have been especially developed by Supramar Ltd to correspond with the particular loads to which this type of craft is subjected. Material: sea-water resistant type B-51, with certificates from DNV, in accordance with instructions of Supramar Ltd.

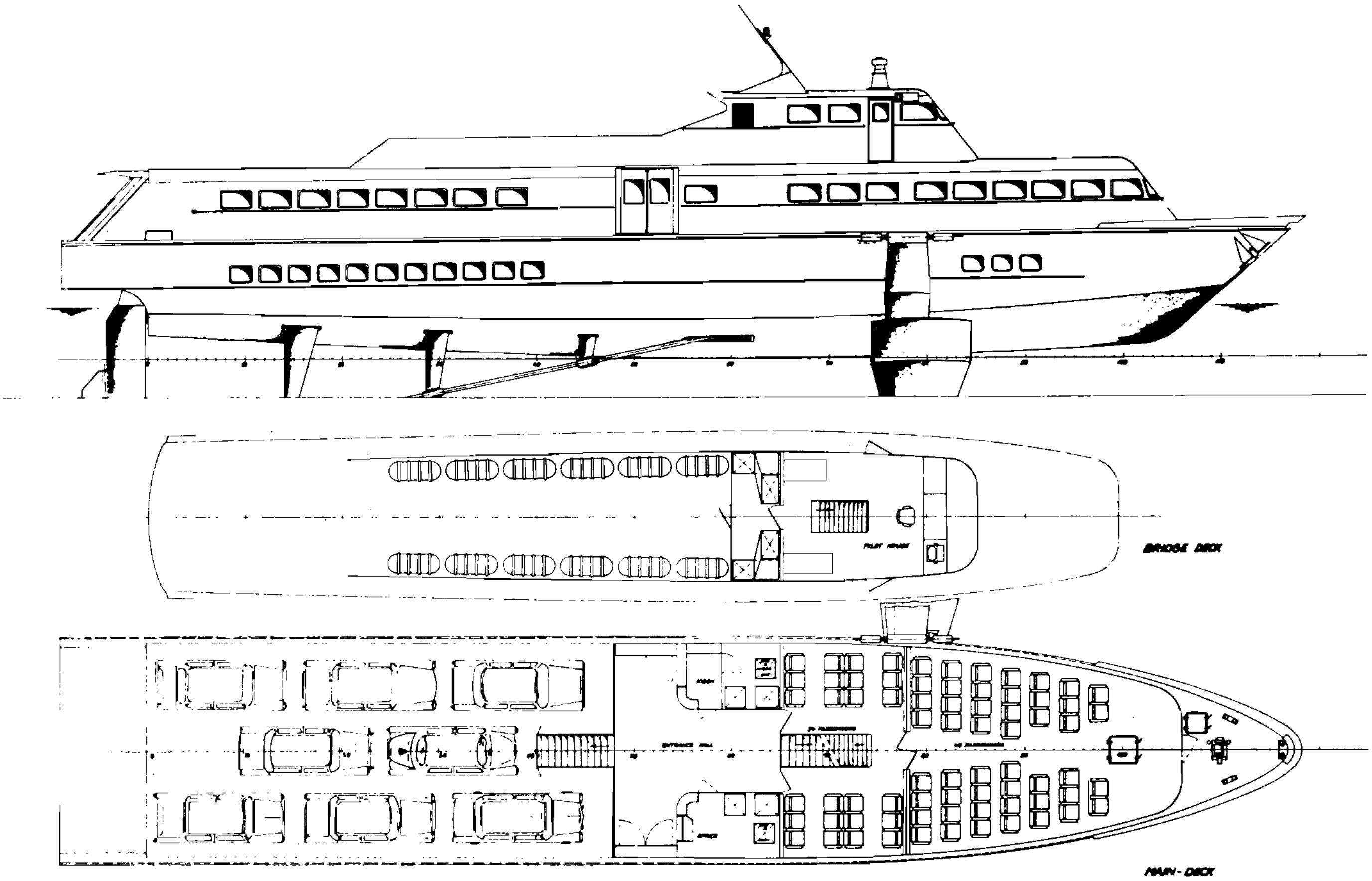
Approximate thickness of plates:

Shell (bottom side) ...	4-8 mm	(0.158-0.300 in)
Main deck	2.5-3 mm	(0.098-0.0118 in)
Tank deck	2.5 mm	(0.098 in)
Superstructure	2-2.5 mm	(0.078-0.098 in)

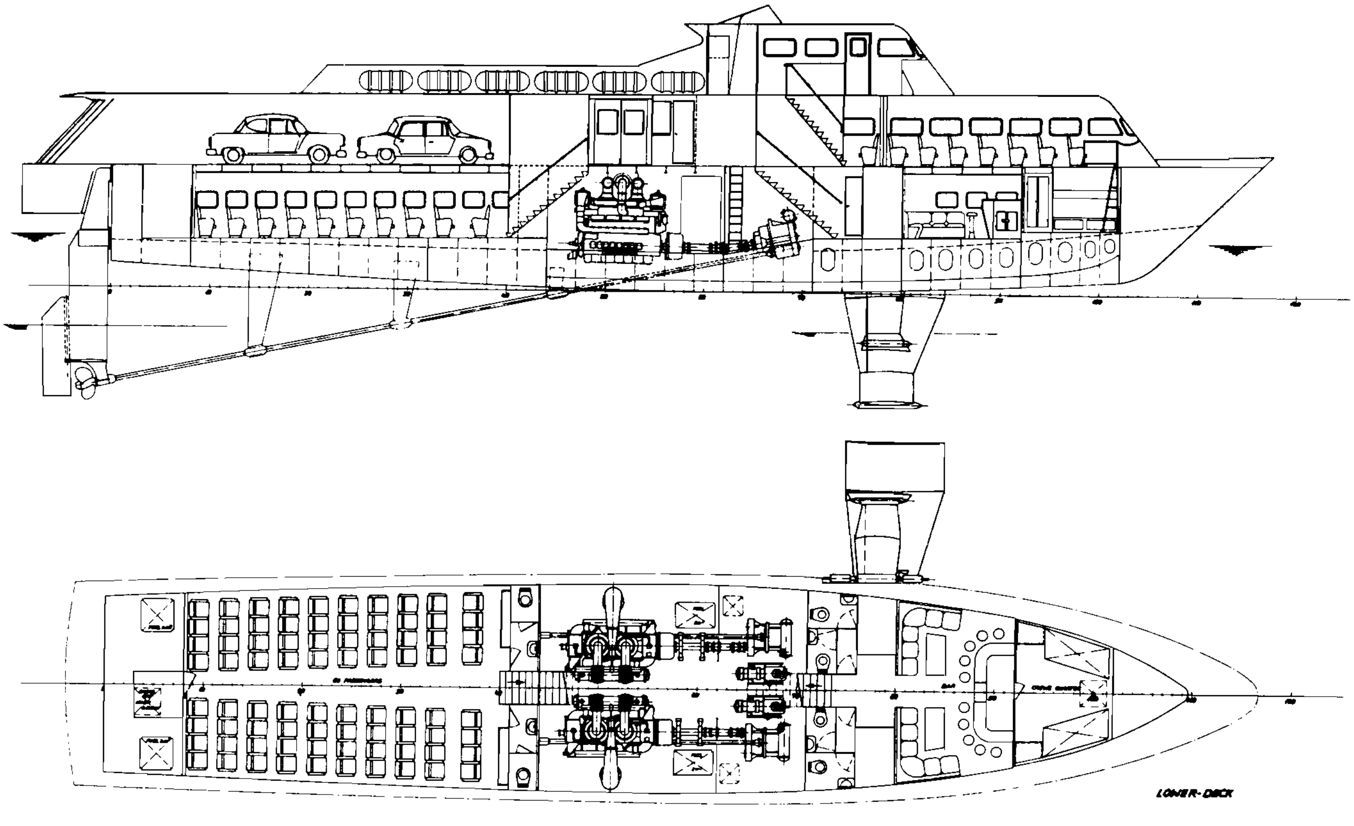
All aluminium plates in the strengthening members are of quality B-54S ¼H with DNV certificate (description in accordance with Nordisk Aluminium-industri's standard).

The stern is made of welded aluminium plates (alternatively 3.0 mm steel), and the keel is made of aluminium plates. All steel parts are hot galvanised, and are insulated by a synthetic product (corro plastic or equivalent) when in direct contact with light metal alloy.

The steel parts are fastened to the aluminium hull with



GENERAL ARRANGEMENT PLAN — PT-150 DC



either cadmium-plated steel rivets, cadmium-plated steel bolts or stainless steel bolts.

Steel is used only for highly stressed parts such as fittings for bow and aft foil, shaft bossings, foundation plates for shaft struts, hoisting arrangements, etc. Material: Mst-52.3 or equivalent, sand-blasted and zinc-sprayed before mounting. Rivets: steel and aluminium rivets in accordance with Supramar specification, and with DNV certificate. All nails are cold riveted.

1.04.3 Subdivision

The general layout of the craft can be seen in the accompanying drawings. The craft is subdivided by the following five major watertight bulkheads:

Aft peak
Aft engine room bulkhead
Forward engine room bulkhead
Bulkhead
Collision bulkhead.

Four fuel tanks with an approximate volume of 2 cu m each are installed in the aft peak to starboard and port. In addition to this, the aft peak can be used as a store. The main deck is provided with two detachable hatches as per the drawings of Supramar Ltd, to permit the removal of the fuel tanks. An auxiliary engine with generator, connected to an emergency bilge and fire pump, is mounted in the aft peak (see 2.15).

There are two toilets and a kiosk/bar at the forward part of the lower aft passenger compartment. A central companion ladder leads to the main deck foyer. The bottom tank beneath the lower deck is subdivided by two watertight bulkheads into three compartments, which are accessible by watertight manholes in the lower deck.

The engine room is subdivided by a wing bulkhead into a main engine room and a generator room. Two fuel tanks of approximately 1 cu m volume each are installed aft of the wing bulkhead. The engine room is accessible on the port side from the foyer by a watertight hatch. In addition, an emergency exit has been provided to starboard at the same location. In the engine room there is a small working bench with 4 in vice, a sink with cold water (see Sanitary) and a locker for accessories, complete with a padlock.

A companion ladder leads from the foyer to the lower forward compartment, with two toilets with wash basins, in the forward section. The saloon has seating facilities for up to twenty-four passengers. From the saloon, an emergency exit leads to the main deck. The bottom compartment underneath the forward lower deck is subdivided by two watertight bulkheads into three separate compartments. The forepeak serves for storage of the boatswain's gear and ropes, and the chain locker is also installed there. The forepeak is accessible by a watertight hatch from the forward main deck. A store is provided.

On the main deck abaft the foyer, there is a car deck for the accommodation of eight medium-sized cars, eg Opel Record 1700. At the after end of this compartment is a hinged gate, constructed of light metal, which when lowered is used for roll-on/roll-off for the cars at the stern. When open there is an entrance width of 2 × 2.6 m, and a height of 2 m. The gate is hydraulically operated, and can be used as an emergency exit for the passengers.

The forward part of the upper deck forms the upper passenger compartment.

Passengers board the vessel through double doors at port and starboard, which lead to the single, large, centralised foyer, from which doors and companion ladders lead to the respective passenger compartments on the lower deck. The kiosk to starboard can be used as a shop for duty-free goods. The space to port is for luggage.

A companion ladder leads from aft of the forward passenger compartments to the pilot house, which is situated above the main deck and slightly forward of midships. The pilot house has three watertight doors, one on the port side and one to starboard, which allow access to the open deck, thus allowing better visibility when operating in harbours at low speed. The third door leads to the aft superstructure deck, where the inflatable life rafts are stored. (Pilot house: sec 1.05.4.)

1.05 ACCOMMODATION

1.05.1 Passenger/Car Capacity

The boat has been designed for the following passenger capacity:

Main deck: forward passenger compartment, approximately 50 passengers.

Car deck: approximately 8 cars or approximately 100 seats.

Lower deck: aft passenger compartment, approximately 76 passengers; forward passenger compartment, approximately 24 passengers.

Total: approximately 150 passengers and 8 cars, or 250 passengers.

1.05.2 Furnishing

The floors of the passenger compartments are covered with wool carpets (chosen for their self-extinguishing properties in the case of fire).

The passenger seats are lightweight (10 kg, approximately 22 lb) aircraft type, of Westermoen Hydrofoil design. Each chair is usually furnished with a countersunk ashtray, a number plate, and an elastic netting bag is attached to the back of the seat. In all saloons are a series of side windows of Perspex, which ensures maximum visibility for the passengers.

The ceilings are covered with fire-resistant plastic material, similar to that used in aircraft construction.

The sides and bulkheads are covered with plastic materials or luxury plywood, depending on the choice of customers.

A hat-rack, with coat-hooks for passengers, is fitted in the saloon, pilot house and toilets.

The windows are fitted with expensive curtains on sliding rails. The ship owner and the yard co-operate regarding the choice of materials and the colour of the furnishings, and lightweight materials are used.

All passenger compartments are provided with emergency exits. The position of these emergency exits can be seen on the General Arrangement Plans.

1.05.3 Crew Quarters

The storeroom can be modified to serve as crew quarters, if specially requested. However, there are usually sofas in the wheelhouse and saloons, with a sleeping capacity for eight persons, and also an electric plate, 100W, and lockers for the personal belongings of the crew (see 1.07.5).

1.05.4 Toilets

The toilets (six) are equipped with water closets and sinks, are shown on the plans. The walls are either covered with plastic materials or painted, depending on the wishes of the shipping company. The water closets, constructed of glass-reinforced plastic, are flushed with sea water by a pressure-tank system. In the toilets are also stainless steel sinks, with running hot and cold fresh water (see Sanitary System, 2.11). Ventilation, heating and lighting: see 2.15.

1.05.5 Pilot House

This is equipped with windows which ensure 360° visibility. The pilot's seat is situated centrally, and all the controls and relative instruments are centralised on a dashboard. To the right is the seat for the engineer, and a dashboard with the controls for the operation of the engine and inverters. In the cabin is a chart table, and lockers for charts, publications and navigation instruments.

The rudders are hydraulically operated, and connected to the same pressure piping system for the foil-flaps operation. The oil is circulated in the system by means of two pumps attached to the main engines. An electrically operated pump is provided for emergency use. The positions of the rudders and flaps are indicated on special instruments on the dashboard.

Instruments arranged on the instrument board:

Thermometers and manometers for the temperature and pressure of engine oil, before and after filtering.

Thermometers and manometers for the oil temperature for inverters.

Manometers for the oil pressure for the hydraulic plant, and flaps control.

Thermometers for the main engine cooling water.

Themometers for the exhaust temperatures of the main engines.

Switches for the window wipers.

Red lights and alarms for:
- Water level — engine room.
- Cooling system — main engines.
- Oil pressure — main engines.
- Charging of batteries.

Push buttons for:
- Starting and stopping of main engines.
- Starting of emergency hydraulic pump.
- Siren.

Instruments for the control of auxiliary engines.

Instruments relative to the control and operation of the air-stabilisation unit installed.

Voltmeter for rudder and foil indicators.

Ammeter for measuring total consumption of 220 volt ac.

Flap angle indicators.

Stern foil angle indicator.

Rudder angle indicator.

Radio

A Simrad 60W radio-telephone with signal generator is installed. Twelve international frequencies can be chosen, according to the areas in which the vessel will operate.

VHF

A VHF can be installed in the pilot house, if requested by the owner.

Recommendation: Stono VHF, Type COM-19-50.

This is a 50W VHF complete with sixteen channels, control boxes, two aerials, and rectifiers for 220 volt 50 c/s.

Loudspeakers, Intercommunication, etc

There are thirty-two loudspeakers on board, distributed as follows: eight in the lower aft saloon, nine in the lower forward saloon, eight in the upper aft saloon, six in the upper forward saloon, four on the bridge and two on the upper deck aft.

The loudspeakers are controlled from the bridge, and are installed for the broadcasting of music, briefing, messages, etc.

A tape recorder is connected to the system, and there is a possibility of additional radio facilities.

The intercom system is centralised on the bridge, and provides the following communication:

Bridge — kiosk/bar in lower aft saloon, and vice versa.
Bridge — foyer, and vice versa.
Bridge — car deck, and vice versa.
Bridge — engine room, and vice versa.
Bridge — poop, and vice versa.
Forward lower saloon — kiosk/bar in aft saloon, and vice versa.

1.06 DECK EQUIPMENT

The deck equipment consists of the following, which is approved by DNV and Den norske Skipskontroll, or equivalent institution:

Anchor gear.

Bollards, clamps and cleats as per the yard's standard.

Ropes, fenders and boat hooks.

Two hydraulically operated windlasses on the aft deck extensions.

Spotlight (see 2.15).

1.06.1 Anchor and Ancillary Equipment

Three Danforth anchors are provided: two of 100 kp, with 55 m of 19 mm dia chain, and 100 m nylon rope with 32 mm dia each; and one of 65 kp in spare, placed ashore.

An hydraulically operated windlass is mounted on the fore deck.

1.06.2 Mooring Hawsers

Four × 40 m, 22 mm dia nylon, according to the requirement of the class; towing line 100 m, 28 mm dia nylon. A sufficient number of fenders and heaving lines are provided, type and dimensions as required by the individual shipping company.

1.06.3 Deck Fittings

The boat is provided with the following deck fittings: on the forward upper deck, central, the bow chock for mooring and towing. Sufficient number of bollards, on the fore and aft deck, as standard, sand-blasted, zinc-sprayed and painted. The bollards are of welded steel construction. They are screwed to the deck by stainless steel bolts. Hard wood liners are placed between the deck and the bollards. Carlings are arranged below deck in the region of the bollards.

1.06.4 Life-saving Equipment

The boat is equipped with the following life-saving devices:

Eleven inflatable life rafts, each for twenty-five persons, and one for ten persons, manufactured by RFD Company or equivalent. These life rafts are stored on the aft superstructure deck. Lifebelts are stored underneath the seats, sufficient for the maximum number of passengers. Eight lifebuoys are provided on the side walls of the superstructure, near the main entrance and on the aft deck, six of which have a self-lighting emergency light and two have a 6 ft line.

All life-saving equipment is of proven manufacture, and in accordance with the international regulations and rules of Den norske Skipscontroll. One medicine locker, with contents in accordance with the requirements of the authorities, is situated in the neighbourhood of the wheelhouse.

1.06.6 Windows

All windows are of the fixed type. On the lower and upper deck there are frames of light metal as standard, fastened with stainless screws. The glass is 8 mm Security or Plexiglass; all curved windows of Plexiglass.

The wheelhouse is furnished with wide windows, the three front windows being of safety glass, with electric de-icing. Marine wipers, type Straight-Line, and fresh-water spray jet are fitted to the front windows. The side and aft windows are all of Perspex, with rubber mouldings.

1.06.7 Locking System

All doors, etc, can be locked in accordance with a locking system approved by the owner.

1.07 EQUIPMENT AND FURNISHINGS

The four saloons are furnished according to contemporary Scandinavian design, with aircraft type lightweight armchairs, Norwegian all-wool wall-to-wall carpets, polished woodwork, and with colours suited to complete a picture of sober elegance.

The saloons are insulated from the acoustic as well as from the thermic aspect.

1.07.1 Main Deck — After Saloon

The passenger saloon aft is equipped for the accommodation of 100 passengers, to the same standard as the other saloons, with easily removable chairs, carpets and décor so that the saloon can be quickly converted to a car deck for eight medium-sized cars.

1.07.2 Main Deck — Foyer

This is the main entrance for passengers — embarking, either from starboard or from the port side, through wide double doors.

There is a kiosk or duty-free shop to starboard, and space for baggage or for hanging clothes to port.

Both sides have air channels, engine room entrance/exit, cables and tubes. There is a bar on the port side, and a coffee pantry, or similar, to starboard.

1.07.3 Main Deck — Forward Saloon

The forward passenger saloon is equipped for fifty passengers. At the forward end of the saloon is the emergency exit door, and there are also lockers for the spare lifebelts, lights, etc.

1.07.4 Lower Deck — After Saloon

This saloon is equipped for seventy-six passengers. At the after end is the emergency exit, with a staircase leading directly outside on to the main deck between the two car gates. At the forward end starboard is a toilet with two WCs, and a stainless steel sink, a mirror, a paper towel holder, etc, and on the port side is the kiosk/bar, which can be fitted out to customer's specifications.

The main entrance to the saloon is central, a staircase leading down to the saloon from the foyer on the main deck.

1.07.5 Lower Deck — Forward Saloon

At the forward end of the foyer, on the main deck, is a staircase leading to the forward lower saloon, which can be fitted out as a first class saloon for twenty-four passengers.

Forward of this saloon are two toilets for ladies and two toilets for men.

1.08 HOIST ARRANGEMENT

The boat will be delivered with fittings, wires and struts, so that it can be lifted by one or two cranes, and thus equipped the boat weighs approximately 130 tons.

2.01 MAIN ENGINES

The boat is powered by two twenty-cylinder supercharged diesel engines with air intercooler, make Maybach type MD 1081, with the following output characteristics in relation to the intervals of overhauling:

	Continuous output (hp)	*Speed* (rpm)	*Time between overhauls* (hr)
(a)	3,000	1,740	4,000
(b)	3,200	1,740	3,000
(c)	3,400	1,740	2,000

The fuel consumption at 3,400 hp is about 169 gr/hp/hr (0.382 lb/hp/hr).

The lub oil consumption at 3,400 hp is about 5 kp/hr (8.8 lb/hr).

These figures are valid at an air entry temperature of 20° C (78° F), a cooling water entry temperature of 20° C (78° F), a barometric pressure of 736 TORR (29 in) and a relative humidity of 60%. The figures are based on a type of gas oil corresponding to DIN 51601 with a lower calorific value of about 10,000 kcal/kg (87,500 BThU/lb).

The mean pressure at 3,400 hp is 16.55 kp/sq cm (194 psi). The engine is air started. The installation of the main engines is controlled by Maybach, and mounted according to Maybach's instructions and drawings.

One level tank for each engine is installed. The tank has over- and under-pressure valve and control gauge for the height of the liquid (see 2.08).

2.01.1 Turbo-charger

Two turbo-chargers are installed on each main engine. Each charging unit consists of a single-stage axial gas turbine, driving a single-stage radial turbine and a charging air intercooler. Both engines are equipped with dry air filters recommended by Maybach.

2.01.2 Elastic Mounting

Both engines are elastically mounted.

2.01.3 Torque Converter

A torque converter is mounted on each engine (see 2.03).

2.01.4 Hoisting Equipment

The engines will be equipped by Maybach with bolts to facilitate the lifting and lowering of the engines.

2.01.5 Engine Control

Each engine will be fitted with a handwheel by Maybach for local mechanical control. An instrument panel will be constructed by the yard, and will be situated in the engine room for the instruments provided by Maybach for the local control of the starboard and port engine. Each panel contains the following instruments:

Two main engine lub oil manometers.
One main engine oil thermometer.
One main engine piston cooling oil manometer.
One main engine fresh water cooling manometer.
One main engine fresh water thermometer.
One main engine sea water cooling manometer.
One main engine charging air manometer.
One main engine revolution indicator.
Twenty main engine cylinder exhaust thermometers.
One main engine stop button.
One main engine gear oil manometer.
One main engine gear oil thermometer.
One main engine signal lamp astern.
One main engine signal free coupled.

2.01.6 Turning Gear

The turning system is delivered by Maybach.

2.02 REVERSE GEAR

Instruments: see 2.02.1.

The reverse and reduction gear is manufactured by Zahnradfabrik Friedrichshafen AG, Germany. It is hydraulically operated.

The torque can be fully transmitted in forward direction, and astern about 50%. The gear consists of three shafts with two spur gear trains. The direction of rotation of the output shaft is either the same as that of the input shaft, or counter to it, depending on the power being transmitted via the intermediate gear train or the direct gear train. The corresponding power connection operates a hydraulically operated double clutch on the input shaft.

The gear is engaged by means of an engine room remote control, which is coupled to the engine feed control lever.

A gear type pump on the input shaft supplies oil when the engine is running.

A gear type pump, on the intermediate shaft, pumps oil through when the engine is stationary and the propeller is turning. This pump operates in both directions, forward and astern.

The gear is mounted separately, and connected with the engine by an axis with a universal link of Maybach manufacture.

The sea water cooled lubricating oil heat exchanger is mounted on the gearbox with all necessary pipes, and is thermostat controlled.

Two streamlined filters, with a magnetic plug and an overcharge valve set at six atmosphere overpressure (60.8 psi), are connected.

2.03 TORQUE CONVERTOR

The torque convertor is manufactured by the firm of Maybach, Friedrichshafen, Germany, and is rated for an output of 3,400 hp. The torque ratio is 1 : 2 (—).

The components of the drive consist of: one pump on the input shaft, one stator on the housing and one turbine on the output shaft.

The torque convertor is connected to the engine.

2.04 FUEL SYSTEM

The fuel is contained in four tanks of 2,000 litres (440 Imp gallons) each, which are installed in the aft-peak, and two tanks of 1,000 litres (220 gallons) each are installed aft of bulkhead 62 in the engine room. Refuelling is effected by means of a filter filler situated on deck, and each tank can be used independently of the other.

The tanks have flame-protected vent pipes, leading to the upper deck. Fuel is fed through a pipe below the passenger compartment into a settling tank in the engine room. A quantity of 100 litres (22 gallons) in the settling tank can be used as a fuel reserve when the main tanks are empty. The fuel pump driven by the main engine draws the fuel from this tank, and delivers it via a double filter to the injection pumps. Between the delivery pump and the settling tank is a solenoid-operated stop-valve, by means of which the fuel supply to the main engine can be stopped from the control position on the bridge.

In addition, a streamlined filter and a stop-cock are installed in front of the delivery pump. Leaking fuel from injection pump nozzles returns to the settling tank.

All pipe connections to the engines are flexible, and consist of fireproof rubber hoses, with a special fire-protection covering, in accordance with the rules of DNV. Level gauges are fitted to all fuel oil tanks.

2.05 ENGINE LUBRICATION SYSTEM

All the working parts of the engines are lubricated by a pressure-fed system, and the oil is drawn from the sump by a gear type pump and forced through a filter into the various oil pipes. A small primary pumping unit, which is manufactured by Maybach and which comprises an ac motor and a gear type pump, is installed to facilitate starting. The hand-pump, provided for the removal of waste oil, can also be used for primary pumping purposes in the event of an emergency.

Reserve oil is contained in a 200 litre (44 gallon) tank, which can be filled from deck. It is installed in the engine room, and fitted with a hand-pump by means of which the oil can be pumped into the engine sump via a filter.

Control instruments for one engine: see 1.05.5.

2.06 REVERSE GEAR LUBRICATION SYSTEM

All components for the lubrication of the gear are integral, and a gear type pump — supplying in both directions of rotation — draws the oil from the gear's oil sump and it is then forced through the oil cooler and the filters to the various lubricating points. A thermostat is installed between the oil cooler, which controls the oil circulation if the oil temperature becomes too low. A suction tube, connected to the oil sump and provided with a hand-pump, serves to remove oil from the sump to a shore connection on deck.

Instruments in the engine room, and on the bridge, measure the oil pressure entering the filter and the oil temperature entering the cooler (see 1.05.5).

2.07 SEA WATER COOLING SYSTEM

Sea water for cooling the engines is conveyed by ram-pressure from a specially formed nozzle situated below the waterline of the rudder, via flexible hoses through the transom and inboard. The sea water is led via a main stop-valve, and mud filter, through a pipe to the sea water pump which is connected to the main engines.

A control valve is installed between the pump suction pipe and the pressure pipe, to ensure that the system is cooled by ram-pressure in the event of failure of the water pump. The water is fed from the supercharger intercooler to the fresh water heat exchanger, and then to the gear oil coolers, from where the combined total quantity is fed to three different positions:

(a) to a pressure-tank system used for sanitary purposes, which has an overflow to outboard (see 2.11);
(b) to the water injection nozzle in the exhaust system;
(c) to the cooling jacket of the stuffing box, and to the lub. water connections of the rubber bearings of the shaft. This pipe is provided with control gauge (see Gauge).

Control instrument: one manometer for pressure reading of pre-cooling in the water pump, which is located in the engine room.

2.08 FRESH WATER COOLING SYSTEM

Each engine has an independent fresh water cooling system with an incorporated pre-heating system. Preheaters: 220 volt Pyrox element. 6-9-15 kW each. The purpose of the pre-heating system is to heat the coolant up to a minimum of 45° C prior to starting the main engine.

A stop-valve is fitted to prevent circulation in the preheater circuit when the engine is running. A pre-heater switch is situated in the engine room.

The transfer pump forces the fresh water, drawn from the engine, back to the pump via the oil cooler. A thermostat regulates the flow, either via the sea water cooled heat exchanger, or directly to the engine connection. An expansion tank, containing 40 litres (9 gallons), is mounted on deck (see 2.01), with fitting tubes and an overflow valve, which opens at 0.15 kg/sq cm above and below the atmospheric pressure.

Control instruments:

One pressure gauge for pre-cooling reading of the oil cooler.

One thermometer for the cooling water prior to discharge, and another remote reading thermometer for the same purpose, on the bridge.

2.09 BILGE PIPE SYSTEM

Compartments I, II, IV, V, VI, VII, VIII and IX are connected to the bilge pump which is attached to the main engine. Each suction point can be shut off by a control valve. The capacity of the bilge pump is 300 litres/min (66 gallons/min) at 20 m (60 ft) pressure head. The fore peak is pumped by hand-pump, which is kept in the engine room. A diesel-driven emergency bilge and fire pump is installed in the aft peak (driven by an auxiliary engine), in accordance with the requirements of Den norske Skipskontroll.

The bilge pump can also be used for fire-fighting, in which case the water is drawn via a sea valve to a fire valve which is situated above the upper deck. Bilge water cannot be utilised for the fire-fighting system.

The lower passenger compartments each have two special drain holes, and there are also six depth-sounding pipes for compartments II, III, IV, VI, VII and VIII below. The water level alarm is mounted in the engine room, with an alarm on the bridge. The main suction point valves can be operated from deck if required by Den norske Skipskontroll.

2.10 FIRE-FIGHTING INSTALLATION

In the event of fire, four CO_2 (carbon dioxide) containers, operated from the bridge, can be discharged into the engine room, and also into the aft peak, which contains the fuel tanks. All the relevant valves are in the control position on the bridge. Four portable fire extinguishers are installed in the engine room. Ten hand fire extinguishers are also distributed throughout the boat.

A water intake, which is situated below the waterline of the hull astern, is connected to the emergency bilge pump, and has a fire hose and nozzle which can also be utilised for washing purposes. Fire hydrants are 1½ in, with NOR-connections; and a rubberised hose, 15 m long, with NOR-type light connection, is stored in a locker in the after end of the superstructure. The hose is fitted with a 1½ in all-purpose nozzle, and the fire nozzles and extinguishers are of approved manufacture. A sprinkler installation will be provided on the car deck (if necessary) in accordance with the regulations of the marine authorities, and a Dito Salwico Gas Detector Indicator, or similar.

2.11 SANITARY INSTALLATION

The salt water for flushing the WCs is supplied from the engine cooling water system. An electrically driven pressure-actuated pump of approximately ½ hp, with sufficient capacity to maintain pressure at all outlets, will be installed (type Rotomatic).

The WCs are of glass reinforced plastic, and are manufactured by Messrs Werkspoor. The outlets are above the waterline and have non-return systems, and the actual flushing pipes have 3 in dia spring-loaded valves.

2.12 FRESH WATER SYSTEM

A water tank of approximately 500 litres supplies water for the stainless steel wash basins in the toilets and in the cafeteria, and an electrically driven pressure-actuated pump of approximately ½ hp, with sufficient capacity to maintain the pressure at all outlets (type 1 in Rotomatic), will be installed.

One ¾ in hand-operated pump is installed in the cafeteria to provide pumping capacity if the main pump fails to operate.

Cold fresh water is supplied to all wash basins, and a 50 litre hot water tank is installed for the bar and cafeteria wash basins. This tank is thermostatically controlled, and has a heating element (adjustable) of approximately 5 kW.

A wash basin of stainless steel, for cold water, is located in the engine room, and drainage is to the bottom of the boat. The remaining basins have outlets above the waterline, and are fitted with non-return valves, as shown on the Supramar Ltd drawings.

An exhaust piping system of stainless steel is connected to the asbestos-insulated manifold on the engine. It consists of two parts, one elbow pipe, and one elastically suspended section, with an exit socket, which is rigidly connected to the vessel. A water injection nozzle leads to the second exhaust section. This section is fastened to the elbow pipe by means of a stainless steel compensator. The pipe is asbestos-insulated as far as the injection nozzle. The exhaust outlet is below the flotation waterline. If the boat is not foilborne, the exhaust gases escape through a second and smaller opening, which is located just above the flotation waterline. Two thermometers, of Maybach manufacture, which transmit exhaust temperature readings to the bridge, are fitted between each main engine exhaust and the turbo-chargers.

2.13 HYDRAULIC INSTALLATION

A hydraulic pump is attached to each engine, and oil is drawn from an elevated tank of 30 litres (8 gallons) to a four-way valve in the control position on the bridge, from where it flows to another four-way valve, built into the steering apparatus, and then returns to the tank. The rudder and the foil-flaps are both manoeuvred by rods situated centrally on the dashboard.

The hand-operated four-way valves, which control the adjustment of the stern and bow foil-flaps and rudder, direct the oil to either one side of the cylinders or the other, according to the position of the controller.

The rudder angle on each side of centre line is 30°.

2.14 HEATING SYSTEM

The boat is heated and ventilated by a special system designed by Svenska Fläcktfabriken.

The boat is subdivided as follows (air is drawn in by fans and re-charged by the same method):

1. Lower passenger compartments and kiosk/bar.
2. Upper passenger compartment forward and foyer.
3. Bridge.
4. Engine room.
5. Toilets and lavatories.
6. Car deck.

The heating system is rated for:

Cruising speed ... ... 65 km/hr (37 knots)
Outside temperature ... −10° C (14° F)
Room temperature ... ... +18° C (64° F)

To compensate for the heat loss, air intake channels are provided with an exchanger, connected to the cooling system of the engine. The exchangers are made by Bacho. The ventilation on the car deck is as required by Den norske Skipskontroll.

2.15 ELECTRICAL PLANT

The complete electrical system is supplied by two diesel engines, coupled direct to an alternating current generator of approximately 24 kVA, 220 volt ac, 50 cycles, $\cos \phi = 0.8$, or corresponding.

Agreement will be made with the owner about the *E*-balance, and will show the electric consumption as a whole. The capacity of the diesel engines and the generators will be stipulated on that basis. Each generator will have sufficient capacity to supply the normal load (100% spare "reserve"). The electric layout will be arranged so either one or the other, or both, generators may be loaded.

The electrical plant and the type of cables, etc, will be approved by DNV, and by the authorities if necessary.

All fans will have two-speed motors, where practicable. Small fans for WCs, etc, will have one-speed motors.

There is a shore connection on board for the use of all 220 volt equipment, and also for charging the 24 volt batteries. The shore connection will be fitted with cable and plug suitable for the quay to which it will be connected.

The engine pre-heating plant has a capacity of 6-9-15 kW, with one pre-heater per engine. The pre-heater is regulated by a thermostat, attached to the shore connection and to the generators on board. An automatically regulated rectifier for charging the 24 volt emergency battery will be mounted on board. The lighting on board includes 220 volt fluorescent tubes, and the type will be selected according to the approved proposal made by the yard, as will be the bulbs for outside lighting in the WCs, and stores, and for the emergency lighting.

Connected to the loudspeaker system are radio, tape recorder and a microphone for information, etc. All instruments will be operated from the wheelhouse (see 1.05.4).

All navigation instruments and lights are equipped for 220 volts, 50 cycles ac.

All instruments on the bridge will have 24 volt internal lighting, with dimmer arranged for dimming groups of instruments.

Rudder and foil indicator, 24 volts dc, is in accordance with the standard of the yard. It is mounted on the control panel on the bridge, in front of the captain.

A 10 amp socket is provided in the wheelhouse, and there is one in all saloons — after peak — and engine room. Total will be according to approved suggestion from the yard.

Electrical material corresponding to Norwegian standard is generally used.

One chart-table, with dimmer, will be mounted in the wheelhouse.

One searchlight, 220 volts XZ 250, on a low pedestal, will be fitted of Jungner manufacture, or equivalent.

Electric lights certificated by Den norske Skipskontroll will be mounted. Make: E. Ohlson, Helsingborg, or equivalent. Lantern control, with control lamps, and acoustic alarm will be installed.

Voltmeter, ammeter (alternatively kilowatt meter) and frequency meter for each of the diesel generators will be mounted on the bridge.

An alarm for the height of the water in the engine room will be installed (for the remaining alarms, see 2.02.1).

An emergency stop switch controlling all ventilation will be mounted on the bridge.

All electric motors on board are rated for 220 volts ac where approved by DNV.

Pantry — Inventory

Hot water is connected to two taps. One coffee percolator about 2 kW, a heating cupboard about 1 kW, one electric cooker about 1 kW, a refrigerator about 200 litres. All the hand basins in the WC are supplied with cold water.

Pressure Tanks

One salt water and one fresh water pressure tanks will be fitted, and an electric 220 volt ac pump.

Two 24 volt dc flood lights for the rafts. Flood lights type Francis 40 W are mounted on deck, and are connected to the emergency batteries.

An electrically driven air compressor for a 220 volt ac engine of a suitable size will be installed in the engine room.

Navigation Room

Built to separate drawings, and equipped with the following equipment and fittings:

Decca Navigator.
Radar.
Compass, Plath reflector compass.
Three windows, with electrical heating system and three wipers.

The radar display unit is fully transistorised. Fluorescent lamps are provided for lighting. The switchboard is installed in the engine room. A secondary board, and a board for the navigation lights, are mounted on the bridge. All cables are plastic coated according to the requirements of DNV.

2.16 AUXILIARY ENGINE

Two diesel generators are installed with a capacity of about 20 kW each.

One auxiliary engine in the engine room, and one in the after peak. The latter with emergency bilge, and with a fire pump attached. Capacity of the pump will be in accordance with the requirements of Den norske Skipskontroll, or equivalent institution.

An auxiliary engine and generator are mounted in the aft peak, with an emergency bilge and fire pump attached. The capacity of the pump will be according to the requirements of Den norske Skipskontroll.

Each auxiliary engine is water cooled, and has a V-belt driven cooling water pump, which supplies adequate fresh water, as recommended by the manufacturers. Each engine has an electro-operated sea water pump for the cooling of the water to the cooler, and is supplied from the sea water.

The total capacity of the generators will be twice the capacity usually needed for the running of the boat.

The engines are manufactured by Daimler-Benz (four-cylinder, four-stroke), water cooled, type OM 636, and fitted with the following:

1. Fly-wheel.
2. Bosch fuel pump.
3. Centrifugal force regulator.
4. Fuel feeding pump, and pre-pumping of fuel.
5. Revolution adjuster.
6. Exhaust manifold.
7. Filter for fuel oil and air.
8. Forced lubrication v.h.a. gear pump.
9. Electric starting engine, 24 volt, two-poled.
10. Incandescent ignition — resistance and control lamp.
11. Rim of gear wheel mounted on the fly-wheel.
12. Fresh water cooler, with sea water cooling.
13. Sea water resistant sea water pump.
14. Cooling water thermostat.
15. Exhaust pipe, with expansion pipe.
16. Sound baffle.
17. Instrument board elastically mounted on the engine,

with revolution numerator, oil pressure manometer, long-distance thermometer, starting switch and glowing control.

18. Tools.
19. Spare parts according to DNV requirement.
20. DNV certificate.
21. Elastic coupling, mounted on the fly-wheel.
22. Elastic suspension blocks. Generator engine coupled together for direct running.

2.16.1 Air Compressor

The main engines are air started; the working pressure, maximum 40 kg/sq cm. An electric air compressor, air cooled, of a reputable make, eg type Hatlapa LHD 15-IN, approximate capacity 10 cu m/hr atmospheric air, will be installed. The compressor will be equipped with automatic condenser-water drainage. The compressor motor will be equipped with starter, and pressure switch.

A hand-driven emergency compressor of type Zöllner L-64, or corresponding, will be installed in the engine room.

Two air flasks of approximately 125 litres capacity each will be provided. A pressure gauge and drain valves on each flask, size of compressor — capacity of flasks and pipe arrangement with valves, non-return valves, etc, will be installed as indicated by Supramar's drawings and according to directions given by Maybach and the requirements of the class.

2.16.2 Control Air System

This provides 6 atmosphere control air from the main engines. The system will be supplied from the starting air system, via two 40/6 atmosphere reducing valves.

All pipes are connected with an EMB or Ermeto armature.

2.17 NOISE AND VIBRATION

Special attention has been given to absorbing noise, and to providing adequate thermal insulation.

The choice and the application of the various materials in the engine room, in the passenger saloons and in areas where noise is prevalent, has been made to reduce noise to a level which will not inconvenience the passengers. Thermic lagging as shown on drawings, 25 mm Divinycell RTA-45 plates, glued, or equivalent.

2.18 FIRE LAGGING (as shown on the plans)

The fire lagging in the engine room consists of sprayed asbestos to a thickness of 32 mm (A-60) on each side of the bulkheads below the deck, and on the ship's side to waterline level. The lagging below deck is covered by 0.5 mm plates of galvanised steel. The sprayed asbestos is also covered by asbestos cement, and painted.

The after peak is similarly insulated in the event of the auxiliary engines being mounted there, and if required by the authorities.

2.19 PROPELLERS

One three-bladed propeller will be mounted clockwise and one counter-clockwise in accordance with Supramar construction. The yard chooses the supplier. The vessel will have two spare propellers. The propellers are cast in copper aluminium nickel alloy, as per the recommendation of the maker. The propellers are delivered statically and dynamically balanced, quality classed I in the international tolerance list ISO TC 8.

The propellers will be delivered with DNV certificate, and marked by the yard reference No 1 to 4, which will be used later as reference numbers in the maintenance journal.

2.20 PROPELLER SHAFTS AND COUPLINGS

The couplings are made of stainless steel, and hydraulically mounted (SKF system).

The propeller shafts are of stainless steel, to Supramar's specifications. The shafts are supported by means of rubber bearings (Continental type) and water lubricated.

Drawings and torsional vibration calculations are approved by DNV. The coupling bolts are of stainless steel.

2.21 PIPING SYSTEMS

All pipes are made of first-class materials, nickel copper alloy, and welded joints on pipes may be silver-soldered. All pipe systems will have sufficient flexibility to prevent thermal expansion and shock vibrations.

Supports to be installed where necessary.

Synthetic rubber connection joints will be used, as shown on plans, and where approved by DNV.

Plastic pipes to be used where approved by DNV.

Pipe Marking

All systems to be colour-coded according to the Flocode system of identification.

Valve Marking

Identification plates will be fitted to all automatically operated valves. Manually operated valves will be marked on the valve rod; a label plate, describing the functional service of the valve, will be fitted.

The text on all plates will be according to the specification of the owner.

3.01 FOIL UNITS

The entire craft is lifted above the water surface by the lifting forces which as a function of speed are generated on the foils. The foil units are adjusted in such a way that the distance between baseline (keel without step) and water level at maximum speed amounts to 1,200 mm. An additional adjustment can be obtained on the front foil by flaps, and on the rear foil by adjusting the angle of attack. Both adjustments are hydraulically operated and can be handled from the bridge when under way.

The boat is fitted with two foils in tandem arrangement, the front foil being arranged at frame 85 and the rear foil at the transom. The front foil carries approximately 62% of the weight of the craft.

The foils themselves and the rudders are made of anticorrosive rolled steel (designation 4582 — German Standard). Thereby it is possible to leave these parts unpainted. Since the roughness of the surface of these parts has a considerable influence on the performance of the boat, it travels faster without a coat of paint, which also reduces the maintenance costs. All other parts such as struts, fins, etc, are constructed of a low alloy manganese steel (German Standard Mst 52-3). The foil material can be easily welded and no heat treatment is required after welding.

Front and rear foils are designed in hollow steel construction. By extensive use of welding, the number of connecting parts (such as screws, bolts, etc) has been reduced to a minimum.

The weight of the front foil is about 18,000 kp and that of the rear foil about 8,000 kp.

3.02 FRONT FOIL UNIT

The front foil is designed in accordance with the system of a surface-piercing non-split foil. It provides the necessary lateral stability. In foilborne conditions the boat is inherently stable.

The foil unit includes the foil itself with flaps attached, the so-called fins, the struts and the suspension. Port and starboard side of the foil are detachably connected at the lower foil point. The suspension on the hull is effected by means of steel fittings which are riveted to the hull.

The foil can be detached from the hull by loosening a few connecting elements. This can also be performed in floating condition. The entire foil structure can be put ashore, without any assistance of divers, by crane.

3.03 REAR FOIL UNIT

Contrary to the front foil, the rear foil is fully submerged and contributes only little to the lateral stability of the foilborne craft. It includes the foil itself with the attached two rudder heads and rudder flaps. The rudder heads are bolted to the transom and can easily be detached. To the rear foil the struts for the aft-most propeller bearings are attached. The propellers are located below the rear foil.

3.04 AIR-STABILISATION

The stability of the vessel in foilborne condition is maintained jointly by:

1. The surface-piercing front foil of reduced auto-stability and a fully submerged rear foil;
2. The air-stabilisation, which is divided into:
   - (a) the arrangement for varying lift of the foils by air admittance to the low-pressure area of the foil section;
   - (b) the air valves which control the admitted air quantity. This results in a distribution of lifting forces which is guided by sensors and responds to the motion of the craft.

The static and dynamic stability of the vessel is maintained by the two elements in accordance with the following principles:

Submergence Depth Stability

This is ensured by the auto-stability of the surface-piercing front foil. Compared with the conventional front foils of the Schertel-Sachsenberg system, the foil has a reduced submergence characteristic (dl/dh = change of lift with submergence), in other words it reacts smoother to head seas.

The dynamic submergence stability of the front foil is increased by the artificial stabilisation (air-stabilisation) which results in a damping or reduction of its vertical motions, in waves.

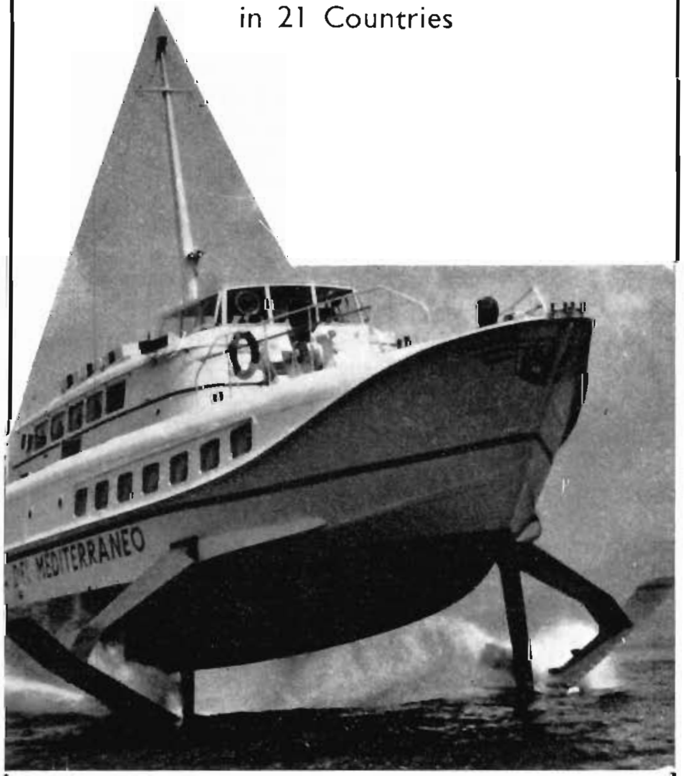
Roll Stability

This is ensured partly by the auto-stability of the front foil, partly by the artificial stabilisation.

Pitch Stability

This is maintained statically by the auto-stability of the combination front foil/rear foil. The artificial stabilisation reduces the pitching angles. The fully submerged rear foil has a natural submergence stability in tandem arrangement with the front foil, because deviations from its submergence depth are connected with restoring changes of angles of attack which occur when pivoting the vessel about the front foil.

Because in this system the artificial stabilisation provides only a part of the total stability of the vessel, the system is designated "part stabilisation" in order to differentiate from the "full stabilisation" of fully submerged electronically controlled foils which produces the total stability alone.



(*Continued from page 3*)

wave recorder, and the results have been compared with those obtained previously in the Irish Sea from the Morecambe Bay Lightship.

Since January 1962 waves have been recorded by a shipborne wave recorder in the Sevenstones Light Vessel, which is stationed about twenty miles south-west of Land's End in about 200 ft of water.

The wave measurements taken by several light vessels and by Ocean Weather Ships have been used by Professor J. Darbyshire in the development of his wave-forecasting technique, and the method has been expressed graphically by Mollie Darbyshire and L. Draper of the National Institute of Oceanography in their study "Forecasting Wind-generated Sea Waves".

In May 1963 the National Physical Laboratory Hovercraft Sea State Committee was formed to help in improving the specialised knowledge of sea conditions required for hovercraft operation. Its membership covers the Ship Division, NPL; Hovercraft Development Ltd; National Institute of Oceanography; Meteorological Office; Westland Aircraft Ltd; Vickers Ltd; and Britten Norman Ltd.

Emphasis of the work has been placed on the devising of methods for forecasting wave statistics in coastal areas from wind data available from Met. stations. The procedure developed by Mr Draper of NIO in conjunction with Professor Darbyshire (who acted as a consultant to the Committee) has been applied in the Morecambe Bay and Dover Strait areas, and the results were found to compare well with corresponding measurements from recorders in lightships in these areas. A year's hindcast for the Dover Strait area has been carried out by Mr Barratt of HDL in consultation with Mr Draper. Interest in this project has been shown by other organisations, including Channel Tunnel Site Investigations.

The task of collation and production of wave tables from the vast amount of existing data will be expensive in time and money. However, in the years ahead the demand from those who will want to know what conditions are likely to be experienced in a given area in a given period will be such that maritime nations will consider it worth while co-operating on the task. Averages over several years or surveys in many parts of the world might justify programming a computer to do the work. The tables will require updating at intervals, as the years yield more and more accurate information, but the prize will be — it is suggested — of best-seller status.

(*Continued from page 11*)

Textron's **Bell Aerosystems Company** has announced that it is building an Air Cushion Vehicle Technology Laboratory at its main plant adjacent to Niagara Falls International Airport.

The one-storey laboratory will replace an existing Air Cushion Vehicle (ACV) test centre located in an enclosed part of the plant's production area.

The new facility north of the main plant is part of Bell's increased ACV activity in recent months. The firm is at present involved in a multi-million-dollar programme to tool up for quantity production of three ACV models.

The first phase of construction, costing $300,000, started in May and should be completed by late September. The project will be expanded to include additional facilities and equipment in the future. General contractor for the project is Wright & Kremers Inc of Niagara Falls, NY.

The technology laboratory, measuring 240 ft by 117 ft, will contain two model test basins — a 100 ft square pool and a 50 ft dia doughnut-shaped pool for manoeuvring and towing ACV models.

The square manoeuvring tank will be fitted with a wave-making machine so Bell engineers can test ACV models under rough-water and surf conditions.

"It will also give us an opportunity to make water-to-land transition tests," said E. Vernon Griffith, ACV Laboratory Test Director.

Mr Griffith explained that at one end the pool will have a ramped area. Models tethered or radio-controlled at this end of the tank will be able to skim up the incline and back into the water.

Models tested in the 50 ft dia tank will be carried by a large "whirling arm" towing device, allowing engineers to test craft at various speeds, altitude and water depths. Both tanks are 4 ft deep. Tests in them will be carried out in about 3 ft of water.

The models will be observed visually and through closed-circuit television cameras which will focus on various parts of each model. The TV system will be equipped with a video tape recorder so researchers can review test results and keep taped records of the tests.

In the whirling arm tank, Bell will install a removable ground board above the water level, for simulated overland tests.

The test models, which weigh 40-50 lb and measure 4-10 ft long, are exact scale replicas of full-sized ACVs. They are equipped with instruments to show their reaction to test conditions.

Mr Griffith said the facility will be used mainly for doing research with ACV models, testing experimental ACV designs and modifications for present ACVs.

Besides scale model tests, the laboratory will perform tests on ACV components, especially the flexible skirt which contains the thick cushion of air on which ACVs ride. These experiments involve performance and structural tests of various skirt materials, including sections of full-size material.

The ACV is an amphibious craft that can travel at high speeds over land, sea, mud, ice or snow on a cushion of air. Bell made its first commercial sale of ACVs last month to Skimmers Inc of Anchorage, Alaska, delivering two Bell SK-5 craft.

The US Navy purchased three SK-5s, which it designated Patrol Air Cushion Vehicles, last year and put them into combat against Viet Cong guerrillas in South Vietnam. The PACVs were returned to the United States for refitting and crew training last January.

The company is tooling up to manufacture the 7½-ton SK-5, the 10-ton SK-6 and the 25-ton SK-9. The first of an initial mixed production quantity of sixty-five ACVs will roll off the line late this year.

Since 1958, Bell has developed several experimental craft based on the air cushion principle. Following design and development of three small experimental ACVs, Bell built the 30-ton SKMR-1 Hydroskimmer for the US Navy, the largest ACV built in the United States.

In 1963 Bell joined forces with the leading ACV designers and manufacturers in Europe — British Hovercraft Corporation and Hovercraft Development Ltd — in an international programme aimed at promoting and developing the full potential of this new form of transportation.

★ ★ ★

Two large hovercraft are to be ordered within the next few weeks from the **British Hovercraft Corporation.** They are the 40-ton BH.7, powered by Rolls-Royce Proteus gas turbine engines. One will be evaluated by the Royal Navy as a fast patrol craft and the other by the Army for logistic support roles.

(*Continued on page 13*)