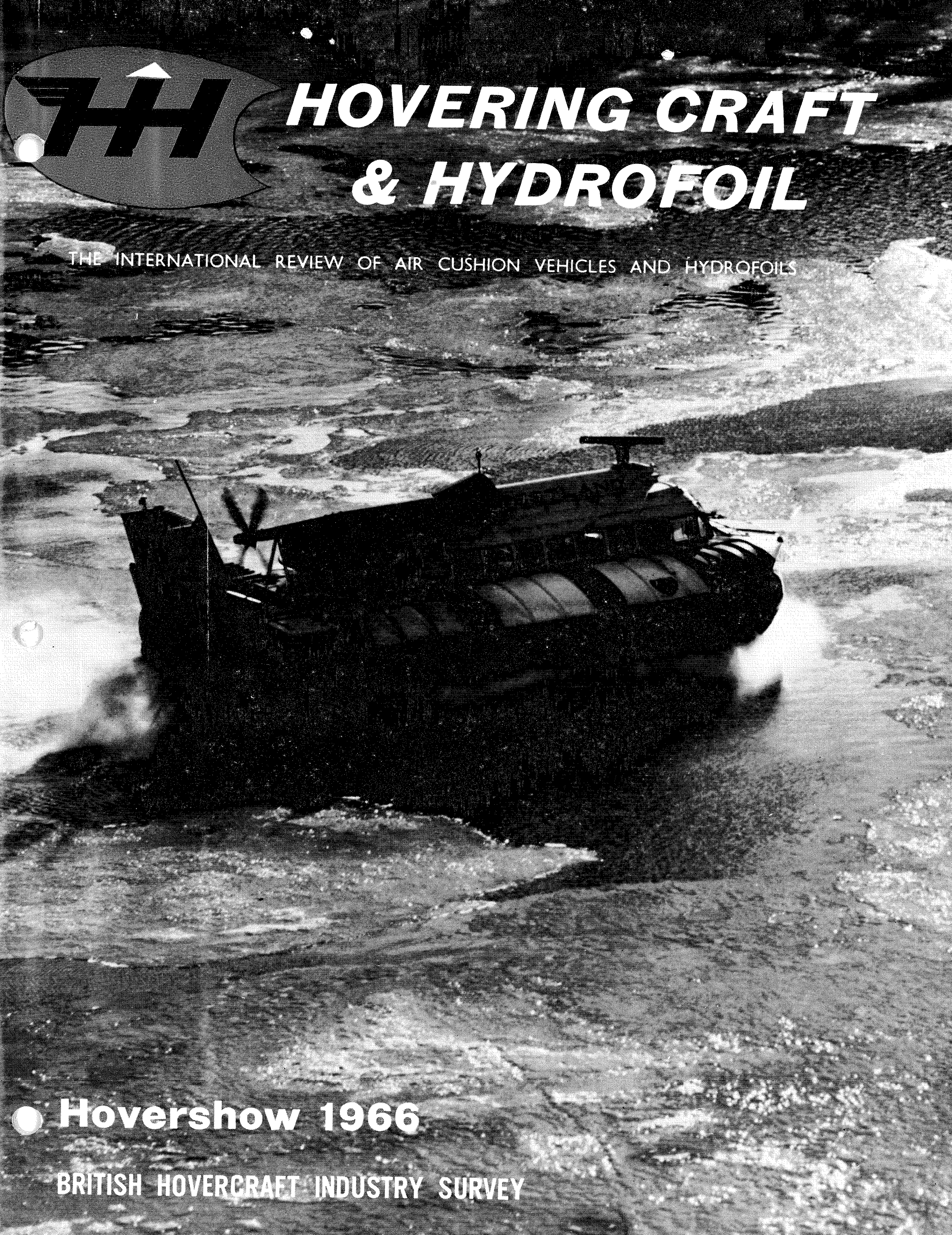
HOVERING CRAFT & HYDROFOIL

THE INTERNATIONAL REVIEW OF AIR CUSHION VEHICLES AND HYDROFOILS



Hovershow 1966

BRITISH HOVERCRAFT INDUSTRY SURVEY

HOVERING CRAFT & HYDROFOIL

FOUNDED OCTOBER 1961

First Hovering Craft & Hydrofoil Monthly in the World

MAY 1966 VOL 5, NO 8

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 and Canada $15. There are twelve issues annually.

COMMERCIAL ERA FOR HOVERCRAFT

"HOVERSHOW 66" marks the coming of age of a great British industry. We salute it in this issue with a survey of hovercraft from infancy to maturity. Almost everyone who has contributed to the industry's success is here given his due tribute, not to flatter, but to give perspective to the story of a British invention which will have a proud place in the annals of transport.

It is only proper that in doing so we should record the industry's achievements through the eyes of those firms and institutions which have played the biggest part in realising them. It is also a way of saying farewell to two well-known firms (Westland Aircraft Ltd and Vickers) as independent hovercraft producers. Their hovercraft interests are now merged in the British Hovercraft Corporation.

In advance it is impossible to judge the impact of the 1966 Show, the first of its kind. Our next issue will pass a judgment based on a comprehensive series of reports of every aspect of the Show. The manufacturers will by then have proof of the degree of their success in inquiries and orders, particularly from abroad. It is not too much to say that "Hovershow 66" will above all be viewed in relation to its export record.

For that reason it is worth drawing attention to the prospects of sales overseas as seen by the Export Services Branch of the Board of Trade. With its 200 commercial diplomatic posts all over the world, it is in a position both to explore sales possibilities and to bring manufacturers and prospective buyers together.

So far as hovercraft are concerned it is already plain that the opportunities are rich. It was in 1962 that the Export Services Branch first gave its overseas officers a full briefing on the industry's potential. Since then the active interest shown in the craft has been notable.

The vast majority of inquiries so far have been about passenger ferry services. In France, for example, interest has been shown in establishing a service across the River Gironde at Bordeaux. There are hopes of selling hovercraft to the Philippines and Macao. In Mexico the Department of Tourism is considering the purchase of both hovercraft and hydrofoils.

South Australia is thinking of hovercraft for the crossing to Kangaroo Island. Jamaica has a scheme for a service between Kingston and its airport across the harbour. Inquiries have been received from countries as varied as Malagasay and Ireland, the Sudan and Singapore, Finland and Kuwait.

An Austrian hotel-keeper is even planning to use a hovercraft for his ski-ing guests who normally have to use the cable railway or tramp through the snow!

All this augurs well for business at the Show. Its organisers, the British Hovercraft Association, have been greatly helped by the Board of Trade, the Ministry of Technology and the Central Office of Information. It is now up to the industry itself to reap the harvest of hovercraft orders.

IN THIS ISSUE

A message from Admiral of the Fleet, Earl Mountbatten of Burma KG OM DSO

WHEN I open Hovershow 66 on June 15th at Browndown, I shall look forward to welcoming all those who are present. I should like, however, to send a message to the many throughout the world who are unable to attend, but who are taking an interest in the Show.

(Photograph by Baron Studios Ltd)

When I was First Sea Lord, I was able to help Christopher Cockerell by giving the support of the Royal Navy to the development of the hovercraft. In the ten years which have elapsed since then, the speed of progress of this wholly British development has been wonderful and it must be a great satisfaction to all concerned with it.

The Hovershow is the shop-window for this new industry which has, I believe, as great a potential as any transport innovation of this century. It is this great direct potential, together with the many "derivatives — i.e. developments that have not yet been perfected, or even yet foreseen — that appeal to me personally. Technologists, particularly the young up-and-coming men, will accept the challenge to keep this country right ahead in the air cushion field.

It is of particular interest that the commercial vehicle and the military version are developing step by step together; this makes for an economical military vehicle which will increasingly come to the fore as the ubiquitous qualities of the hovercraft are experienced by the Services.

I send my best wishes to the British Hovercraft Association. May they go from success to success. And finally I add my congratulations to the journal *Hovering Craft & Hydrofoil* which was in 1961, and remains today, the only journal in the world wholly devoted to this new industry and its sister hydrofoil industry. May it prosper whilst telling the world of this great British achievement.

Mountbatten of Burma

A.F.

A message from The Rt Hon Frank Cousins, MP Minister of Technology

BRITAIN was the first country, more than ten years ago, to realise the enormous potential value of the application of the air cushion principle in transport vehicles. The inventions of Mr Christopher Cockerell, together with the strong support of the National Research Development Corporation, and the efforts of an industry willing to take risks in a new field, have given this country a world lead in hovercraft development and manufacture; a lead which we are maintaining.

This is why I am particularly pleased today to see that Britain has again taken the lead by initiating the world's first-ever exhibition built around the hovercraft.

As a result of the research and development on hovercraft carried out over the past ten years we can now see that there is an important commercial future for this new industry.

We have the goods for sale, the technical expertise to go with them, and we were first in the field. It is now vital that development, production and sales effort continue to expand to exploit all the applications of the hovercraft principle. I know that the British hovercraft industry will continue to show the same enterprise and initiative in the future as it has in the past. This Show is an example of this forward-looking attitude.

And I welcome the initiative of *Hovering Craft & Hydrofoil* in appreciating this point by devoting — at the time of the Hovershow — an entire issue to the British hovercraft industry.

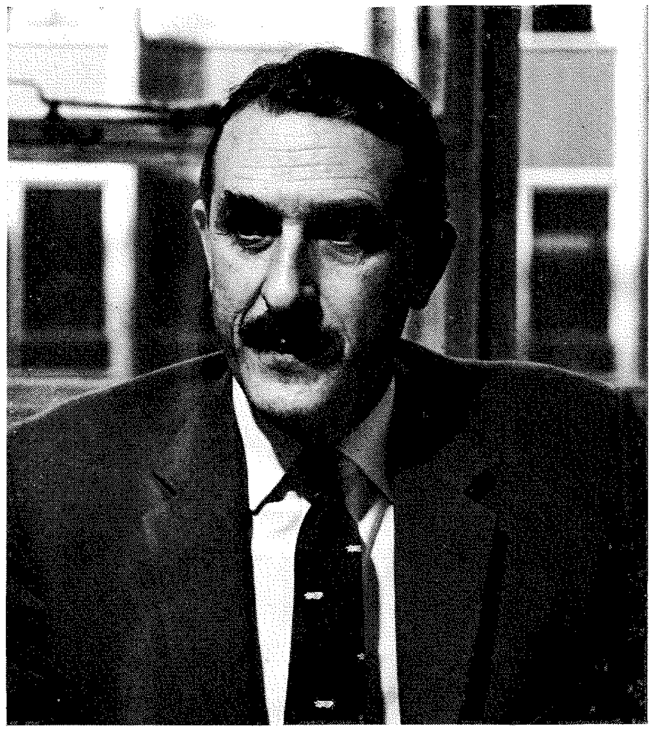
(*British Official Photograph*)

Frank Cousins

HOVERSHOW 66

Douglas Hammett

Hovershow Manager



Mr D. A. Hammett is a Chartered Engineer (Production) who, after his apprenticeship and a year or so as a methods engineer, served in the Army from 1939 to 1946 as a major in the Royal Fusiliers and a GSO2 in the Middle East. For the last eighteen months of the war he was seconded to the Foreign Service and appointed as a Commercial Secretary to the British Embassy in Beirut to help in the export drive. After the war he held a series of managerial appointments with the Mitchell Cotts Group in the Middle East, East Africa and South Africa. He returned to England and joined British Petroleum Co in 1956. He is now BP's Co-ordinator of Hovercraft activity and during the past four years has worked in close collaboration with the hovercraft industry in the promotion and development of the hovercraft and has been responsible for organising several British hovercraft events in this country and in Europe. At the beginning of this year, at the request of the British Hovercraft Association and with BP's agreement, he took on the job of organising Hovershow 66

(Photograph by John Hartley & Partners Ltd)

MEMBERS of the public, in both the general and specialised categories, are today bombarded with claims for "a first" and are becoming increasingly critical in their evaluation of achievements differing only marginally from a long list of others already presented — and applauded. Hovershow 66 is "a first" that is unlikely to be disputed by anyone.

The Hovershow is unique, first because the hovercraft itself is unique. There is nothing else quite like it, and the operational display will show, in a variety of ways, its impressive capabilities both as a commercial craft and in the military role. For example, one of the hovercraft's uses as a special-purpose craft will be seen in a staged fire-fighting and rescue event. With a little imagination the scene can be transformed in one's mind to a crashed aircraft lying out in the darkness and separated from help by an area of swamp or mud. Several events will lay stress on the overland and overwater obstacle-clearance capability and as a spectacle alone this will be worth watching, with so many members of the display team fresh from "real-life" operations in the Far East. Even with a technical audience the spectacular element is important in demonstrations and this will be brought out strongly in the demolition raid, assault demonstration and logistic support items in the military section. In any case, with the Westland SR.N3 and 120 Royal Marine Commandos playing a part, the spectacular aspect can be virtually assured. But not all the military events will be noisy, with simulated sounds of battle. A prisoner snatch will be carried out with the "silent" Britten-Norman CC-5. The programme will end with a formation display.

The live demonstration will be supplemented by a new 35 mm BP hovercraft colour film, *The Dawn of an Industry*, running for thirty minutes, which will be shown in various languages in the Show cinema.

The Exhibition Pavilion

The Hovershow Exhibition Pavilion will house not only the hovercraft manufacturers but also over forty of the more important firms and organisations supplying power-plant, components, equipment and services to the hovercraft industry. They are there not only to publicise their products but also to give advice to would-be operators — advice on setting up a hovercraft service, on the design of hovercraft terminals. Even on the insurance of hovercraft. There will be several Government exhibitors as well — the Ministries of Defence, Aviation and Technology, and Hovercraft Development Ltd.

Despite the very limited time they were given, all the exhibitors have gone to considerable trouble and expense to mount exhibits well up to their normal high standards.

The Emphasis is on the Visitors

The emphasis throughout the Hovershow has been on giving visitors, especially those from overseas, reliable and worthwhile information about the hovercraft. Important businessmen and senior officials travelling a great distance and giving up valuable time to come to the Show, at no small cost, are doing so, in the main, because they expect to obtain first-hand information about the hovercraft that cannot be obtained from other and closer sources. One of the ways in which this is being provided is by the presentation, organised by the Hovercraft Technical Steering Committee, to be given daily in the lecture hall, at which a panel of hovercraft specialists will be available to answer questions.

The Hovershow will be a special occasion for another and rather different reason from those already mentioned. It will be the first representative gathering of the "hovercraft pioneers" — the people and firms who had the foresight to recognise the potential of the hovercraft at an early stage and the courage to put money and effort into a project for which many people forecast failure. The hovercraft now has unquestionably arrived. It is no longer a matter of querying whether the hovercraft has a place in the transport spectrum but whether a particular hovercraft can do a particular job more efficiently and economically (or more profitably) than another form of transport. It is significant that the British hovercraft industry feels sufficiently sure of itself to mount a large-scale hovercraft display and exhibition and to attract potential buyers from all over the world to see something of what it has to offer.

A Co-operative Effort

When the Show is formally opened by Earl Mountbatten of Burma on June 15th it will be the culmination of a rather unusual but effective co-operative effort of the sponsors, the organisers and a team of enthusiastic and efficient collaborators from the Ministries of Defence, Aviation, Technology, Overseas Development and Commonwealth Relations, the Foreign Office and the Board of Trade, with what seemed to be the whole of the resources of the Central Office of Information devoted to this project.

Hovershow 66, although essentially practical and not at all pretentious, has an important message to put over to the world. There is no ambiguity about our aims. They are, quite simply, to attract — to inform — and to sell. To sell craft for preference but, if not, to sell the hovercraft idea — to potential buyers and potential users. And the most potent aid in selling hovercraft is seeing them in action.

★ ★ ★

SHOW EXHIBITORS

AEI Ltd
Air Age Publications Ltd
Alcan Industries Ltd
C. T. Bowring & Co (Insurance) Ltd
BP Co Ltd
Bristol Siddeley Engines Ltd
British Hovercraft Corporation
British Railways Board
Britten-Norman Ltd
BTR Industries Ltd
Cannon Electric (GB) Ltd
CIBA (ARL) Ltd
Crown Pump Manufacturing Co Ltd
Dagenite Batteries
Danforth Jackson & Co Ltd
Decca Navigator Co Ltd
Dowty Group
English Electric Co Ltd
FPT Industries
E. W. H. Gifford & Partners
Goodyear Tyre & Rubber Co Ltd
Hawker Siddeley Dynamics Ltd
P. J. Hibberd Ltd
High Duty Alloys Ltd
Hovercraft Development Ltd
Hoverlloyd
Hovermarine Ltd
Iliffe Marketing Co Ltd
Integral Ltd
Joseph Lucas Industries Ltd
Kalerghi Publications (*Hovering Craft & Hydrofoil*)
Ministry of Defence
Ministry of Technology
Pyrene Co Ltd
Rankin Kuhn & Co Ltd
Roles & Parker
Rolls-Royce Ltd
Rover Gas Turbines Ltd
Sperry Gyroscope Co Ltd
Stone Wallwork (Charlton) Ltd
Thermionic Products (Electronics) Ltd

Exhibition Consultants (all inquiries regarding exhibitions and stands), D. Ellwood Ltd, 81 Promenade, Cheltenham, Glos. (Tel: Cheltenham 24256.)

PR Consultants (all inquiries regarding Press and public relations), RCB (Consultants) Ltd, 169 Piccadilly, London, W1. (Tel: MAYfair 4919.)
Ask for Robin Britten or Kelvin Moyses.

Film and Television Co-ordinator, Mr R. Stafford, Hovershow 66, BP House, Ropemaker Street, London, EC2. (Tel: NATional 1200, ext 289.)

TICKETS

Limited-Admission Days: June 15th, 16th and 17th

Tickets for these three days *must be booked in advance*; no tickets will be sold at the gates.

Wednesday, June 15th
Opening by Lord Mountbatten. Admission £2, free parking.

Thursday, June 16th
Limited admission £1, free parking.

Friday, June 17th
Limited admission £1, free parking.

Public Days: June 18th and 19th

Individual tickets for the two public days are *not* bookable in advance. Admission at the gates: adults 7s 6d; children (under fourteen) 4s. Car park 2s 6d.

PROGRAMME

Apart from the special opening of the Show by the British Hovercraft Association's Patron, Lord Mountbatten, between 12.00 hrs and 13.00 hrs on June 15th, the programme for each day will be as follows:

Morning

Grounds open at 10.00 hrs each day; Exhibition Pavilion open at 10.30 hrs on June 15th, 16th and 17th and at 10.00 hrs on June 18th and 19th.

Out of doors a fully representative range of hovercraft will be on view for the entire morning. In addition, working scale models, including a radio-controlled model of the Westland SR.N4 (the 500-seat cross-Channel craft) and a large model of the revolutionary tracked hovercraft (the hovertrain) will be operating at frequent intervals throughout the morning.

"Hovercraft in Action"

There will be a presentation of hovercraft achievements, applications and administration, including a 30 min film, from 11.15 to 12.45 hrs on June 16th and 17th. Questions will be answered by a panel of experts.

Applications for invitations to attend these presentations should be made to the Hovershow Manager (address below), stating which date is required.

On the opening day, June 15th, the presentation will take place from 10.15 to 11.45 hrs.

Film Show

The new BP hovercraft film, *The Dawn of an Industry,* will be shown in a separate cinema at regular intervals and in different languages.

Afternoon

An Operational Display Programme will run from 14.30 hrs to 16.30 hrs. All current hovercraft, together with some of the historic prototypes, will be seen individually and in formation — on both land and sea — in conditions that will demonstrate the unique capabilities of these craft to the fullest extent.

A major event of the afternoon will be a series of military items in which 120 troops, with equipment, will take part. Among these operations will be a fire-fighting and rescue demonstration, a commando raid, a demolition raid, a coastal interception, a large-scale amphibious assault featuring ninety Marines, with vehicles and guns, and a "fly-past" in close formation.

Exhibition stands will be manned up to 17.00 hrs.

Hovershow Manager

Mr D. A. Hammett,
Hovershow 66,
BP House,
Ropemaker Street,
London, EC2.
(Tel: NATional 1200, ext 1508.)

BRITISH HOVERCRAFT INDUSTRY SURVEY

FOREWORD by R. A. Shaw OBE

Assistant Director/Aircraft Research
Ministry of Aviation

It is a rewarding experience to observe the development of a new idea from close in, much like watching a promising child grow up, and the time scales seem to be about the same. By these standards the child is in its tenth year; next year it faces the awesome 11+ in the launching and trials of the SR.N4.

One good measure of the real novelty of a new concept is the objections it raises and in this the hovercraft certainly ranks with the aeroplane. Both suffered the flat, disbelieving, uncommitted faces of committees and mercifully survived. Another measure of novelty, but also of real worth, is the capacity of the new concept to generate enthusiasm in its converts. This the hovercraft has certainly done, as anyone in the business knows, but the surprising thing is the number of converts that must have been made without their ever being personally involved at all. The idea itself, without sight or word of its success, grasps the imagination.

In some aspects, of course, hovercraft are not new; the seeds were there. Earlier inventors than Christopher Cockerell had had some of the ideas, but the circumstances were not favourable for growth. A fairy godmother in the way of State support, and a concentration of skills such as the team at Saunders-Roe provided, were needed to nurture the infant idea. It even needed the death of the P.177 rocket interceptor to make an unusually strong team suddenly available. The step from the cloth caps in a City basement and the tiny wooden model roaring around on a string, to the clinical blueprints, the strange new shapes in tank and wind tunnel, and the first glossy brochures, was only eighteen months.

Here, again, a crisis. The military departments were still suffering from shock at the White Paper of 1957 and the doubts that it threw on the value of manned military aircraft; the money for a manned prototype could not be provided. Fortunately, the Government coat had more than one pocket, and the National Research Development Corporation agreed to sponsor the prototype. It was an act of faith that paid off. Certainly the world must be full of "doubting Thomases" when the warm acceptance of SR.N1 at its début in 1959 is compared to the cool treatment the proposal to build it received in 1958.

Since SR.N1 the development of hovercraft in Britain has gone reasonably smoothly and well; slightly slower, perhaps, than it could have been, but well. Of course, there have been ups and downs. The building of SR.N2, as a second step, was a beautiful and magnificent gesture. The invention of the flexible skirt by C. H. Latimer-Needham — someone quite outside the hovercraft team — was a stroke of luck and quite transformed hovercraft prospects. Not surprisingly, like other basic inventions, it was not taken up immediately; but, fortunately, it did not have to wait long before Westland recognised its virtues. The interruption of sidewall hovercraft development by the voluntary liquidation of the Denny Company, who pioneered this type, was a great disappointment and I hope it will not be long before this work is restarted. Now that we have reached the stage of thoroughly practical hovercraft we should be at pains to exploit their potential to the full.

Throughout these ten years of working on hovercraft in the UK, the activity has been characterised by the most friendly co-operation, interservice, interdepartmental, and, with concessions for healthy rivalries, even among the teams themselves. I would hope that as the activity increases, as increase it must, this spirit of friendliness will continue.

Mr Ronald Andrew Shaw, OBE, MA, CEng, FRAeS, was born in Liverpool in 1910. He gained First Class Honours in Part I of the Maths Tripos in 1930, and First Class Honours in the Mechanical Sciences Tripos at Cambridge. In 1932 he was appointed Junior Staff Officer at the RAE, Farnborough, and from 1932 to 1938 he worked on wind tunnels and on in-flight fuel jettisoning. In 1938 he was appointed Senior Scientific Officer at the Marine Aircraft Experimental Establishment, Felixstowe, for work on flying boats. He continued there throughout the war and was also made responsible for full-scale and model work on anti-submarine weapons. His next promotion was to Principal Scientific Officer. He became attached to the Council for Scientific and Industrial Research, and from 1945 to 1947 took charge of the Aerodynamics Section of the Aeronautical Laboratory, Fishermen's Bend, Melbourne. From 1947 to 1950 he was attached to the Aerodynamics Division at the National Physical Laboratory, Teddington, for work on supersonics. In 1950 he was posted to the Joint Services Mission in Washington, DC, with responsibility for liaison in aerodynamics. In 1953 he was posted to Headquarters, London, as Assistant Director/Aircraft Research with responsibilty for research in aircraft and later for hovercraft

National Research Development Corporation

Denys Parsons

Manager
Information and PR Services
NRDC

CHRISTOPHER COCKERELL began his experiments on decreasing the resistance to ships' travel in 1953, by introducing air films under model boats. By the summer of 1955 he had conceived the hovercraft principle, calculated its performance, and confirmed the performance with simple test gear including a rig made from two coffee-tins separated by an air space.

From October 1955 until March 1958 Cockerell went the rounds of industrial firms and Government Departments. Most of his approaches were abortive, but the then Ministry of Supply offered a small research contract to an industrial firm which was rejected by that firm but a year later (1957) accepted by Saunders-Roe.

Cockerell was then referred to NRDC by Lord Caldecote of the English Electric Co and the first meeting took place with the Secretary of the Corporation, Mr R. A. E. Walker, on April 16th, 1958. The following quotation is from a letter dated April 22nd from Mr Walker to Sir Owen Wansbrough-Jones, then Chief Scientist of the Ministry of Supply, who was also at that time a member of the Corporation's Board:

"Our first acquaintance with this project was made at a meeting with the inventor, Mr C. S. Cockerell, on the afternoon of Wednesday last, the 16th April.

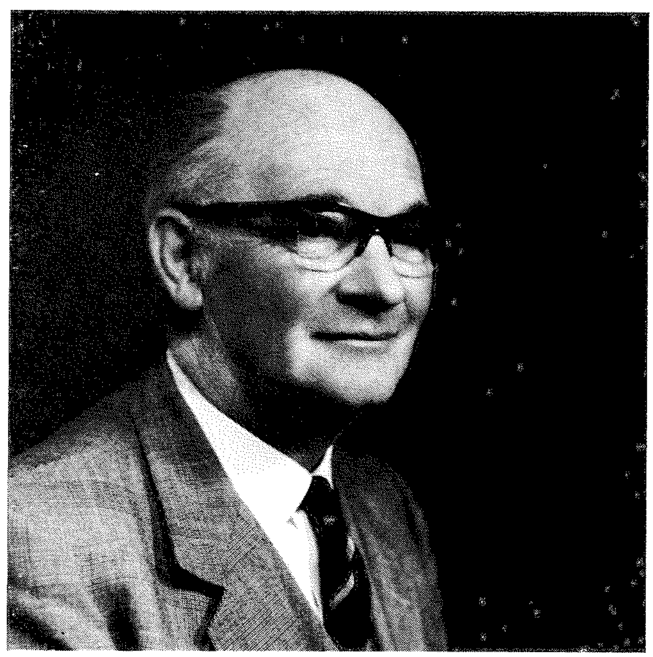
"He said that, while the Ministry of Supply had placed a preliminary study contract with Saunders-Roe, the latter's report would not be available for some weeks. His present difficulties were concerned with the finance of overseas patent applications. To secure Convention priority (desirable because of the activities of an intervening Swiss inventor) these applications had to be on file overseas by the 2nd May. He had been unable to make previous arrangements for these because the secrecy provisions of Section 18 of the Patents Act had been imposed. This imposition was, however, on the point of being withdrawn.

"Lord Halsbury decided on the spot to take crash action and finance foreign filings, and instructions were accordingly given to the inventor's Patent Agents within a few hours of our first seeing the inventor.

"We shall be reporting this to the Board tomorrow, and shall also seek their preliminary views as to the suitability of the project for the Corporation's sponsorship should we be asked to support further development—e.g. if the Saunders-Roe report is favourable but the Ministry of Supply decide not to take any further action.

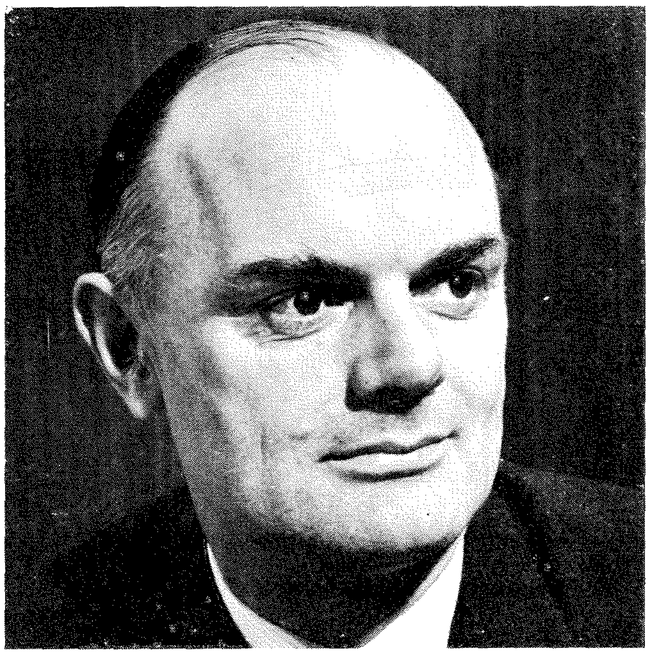
"The inventor has made a short film of his model in action, and (if the Board will agree) we shall get him to show it during the meeting."

The next day the NRDC Board under the chairmanship of Sir William Black confirmed the decision to support the hovercraft project and quickly realised that it was likely to become the largest project in terms of finance on which the Corporation had yet embarked, and for this reason they went on to set up a subsidiary company, Hovercraft Development Ltd, which was incorporated on January 8th, 1959, and made provision for shareholdings by Christopher Cockerell and some of his initial private backers and by the Corporation. The company was thereafter employed as the Corporation's instrument for promoting the development of hovercraft.



Lord Halsbury came to NRDC from Decca Record Co Ltd, where he was Research Manager. He was Managing Director of NRDC from 1949 to 1959 and took the first decision to support hovercraft. Lord Halsbury's present directorships include Joseph Lucas (Industries) Ltd, The Distillers Co Ltd and Head Wrightson & Co Ltd; he holds many public posts, being a member of the Science Research Council, Governor of the London School of Economics and Chairman of the Institute of Cancer Research. He is Chancellor-designate of Brunel University

Mr D. Hennessey was a Principal Patents Officer at the Ministry of Supply before he joined the Corporation's staff in 1950 at the age of thirty-eight as Patents Manager. He was made an Executive (Board) Member of the Corporation in 1956 and Deputy Managing Director in March 1959. Mr Hennessey has been concerned with the hovercraft project since NRDC became its sponsor, as Chairman of NRDC's subsidiary company, Hovercraft Development Ltd. He is also a non-executive Director of the British Hovercraft Corporation



Mr M. W. Innes is a member of the Institute of Chartered Accountants in England and Wales and of the Chartered Accountants Institute of Ontario, where he lived for eight years. In 1962 he became Manager of Finance, European Operations, in Crane Co of London. He joined NRDC in May 1965 as Controller of Commercial Services, and recently become a Director of Hovercraft Development Ltd

Mr J. C. Duckworth, who is forty-nine years old, has had a distinguished scientific career. After taking First Class Honours in Physics at Oxford in 1938, he played a leading part in radar research and development during the war. After the war he was engaged in fundamental nuclear physics research at Chalk River in Canada and at Harwell. In 1950 he joined Ferranti Ltd as Chief Engineer in charge of development and design of the guidance and control system of the guided weapon now known as "Bloodhound". In 1954 he joined the then British Electricity Authority with responsibility for the design, construction and operation of nuclear power stations. In 1958 he was appointed Chief Research and Development Officer of the Central Electricity Generating Board. In March 1959 Mr Duckworth was appointed by the Board of Trade to succeed Lord Halsbury as Managing Director of NRDC. Mr Duckworth is also a non-executive Director of the British Hovercraft Corporation

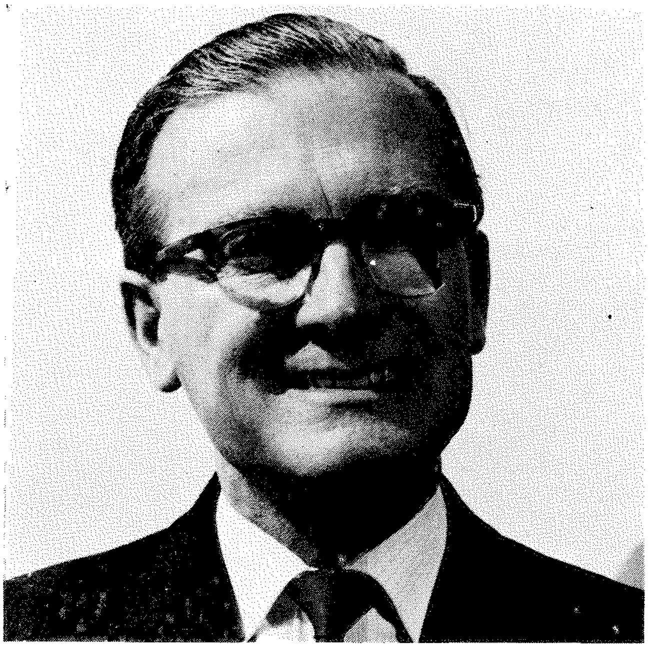
The new company's first act, on the instructions of NRDC, was to place a contract with Saunders-Roe Ltd for a manned experimental craft. This craft, the SR.N1, was completed well ahead of schedule and was demonstrated publicly on June 11th, 1959. On June 22nd it crossed the Solent and made a beach landing. On July 25th the SR.N1 made a successful crossing of the English Channel.

In the latter part of 1959 NRDC, through its subsidiary HDL, made arrangements for the expansion, with NRDC's financial assistance, of research and development of hovercraft in the United Kingdom with four major UK firms and set up with these firms a Hovercraft Policy Committee. They were William Denny Bros Ltd of Dumbarton; Vickers-Armstrongs (Engineers) Ltd of South Marston, Wilts; Westland Aircraft Ltd (Saunders-Roe Division), East Cowes; and Folland Aircraft Ltd.

By June 1961 four prototypes of the second generation of hovercraft had been launched: the Denny D-2, the Westland SR.N2, the Vickers VA-3 and the Cushioncraft CC-2. The latter, the "cushion-craft", was the product of Britten-Norman Ltd, whom NRDC had also licensed.

During 1962-63 arrangements were made for licensing the hovercraft inventions to United States and Japanese manufacturers by way of agreements made between (i) Westland, Hovercraft Development and Bell Aerospace Corporation; (ii) Vickers, Hovercraft Development and Republic Aerospace Corporation; (iii) Westland, Hovercraft Development and Mitsubishi; and (iv) Vickers, Hovercraft Development and Mitsui.

NRDC's main preoccupation during this period, however, was the need to develop in the United Kingdom and put into commercial service craft designed to meet specific operational



Mr R. A. E. Walker is a Fellow of the Institute of Chartered Patent Agents and practised in Chancery Lane from 1925 to 1940. From 1941 to 1949 he held various posts in the Board of Trade, and was responsible there for initiating the drafting of the Development of Inventions Bill, 1948, and, when this became an Act, setting up the National Research Development Corporation, of which he became the Secretary. Mr Walker is now Secretary and Controller of Professional Services and has attended every one of the 185 Board meetings of the Corporation

needs. The industrial collaborators were making intensive efforts to get commercial orders, but with little success, and in our 1962-63 Annual Report we announced: "We have formed the view that, in order to encourage a potential operator in the United Kingdom, it may prove necessary for the Corporation to make an investment in the commercial stage which the project is now entering, e.g. by financial participation in the development and construction of a craft designed for a specific operation, on terms which would permit the craft to be operated on a competitive basis."

We also made known through the Press our willingness to support hovercraft operators, yet it was not until 1965 that the first commercial service came into operation.

Then hovercraft began to get off the ground in the metaphorical as well as the literal sense, with the craft being supplied to operators both in the UK and overseas. It was announced by British Hovercraft Corporation on April 19th, 1966, that they had in hand twenty-seven orders for SR.N4, SR.N5 and SR.N6.

To date the Corporation has invested nearly £3,000,000 in hovercraft, and its support continues.

(Editor's Note: *At the time of going to press it was announced that Britain has won a long legal battle in the US on the basic hovercraft patent. The US Patent Office has come down unequivocally on the side of Christopher Cockerell, whose application was in conflict with a similar one in the name of an American, Melville Beardsley. This represents a triumph for the National Research Development Corporation and its patent advisers who acted on behalf of their subsidiary company, Hovercraft Development Ltd, to whom Cockerell assigned his patents. HDL will be entitled to receive royalties from American licensees of hovercraft over the next seventeen years.*)

Hovercraft Development Limited

A low-tide view of HDL's hangar and angled slipway at Hythe

HDL's TECHNICAL GROUP

J. E. Rapson BSc (Eng) Hons, AFRAeS
Chief Engineer
Hovercraft Development Limited

INTRODUCTION

THE National Research Development Corporation, which is funded on a loan basis by the Ministry of Technology, is responsible for the exploitation of British inventions. NRDC had Mr Cockerell's invention brought to its notice in 1958, and very shortly afterwards sponsored the building of the SR.N1 by Saunders-Roe Ltd.

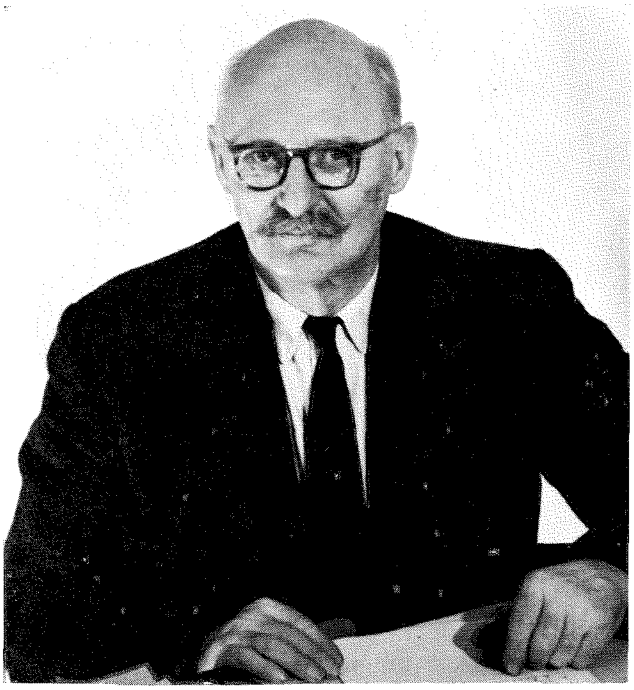
Even at this early stage it was realised that the hovercraft could have great potential, but would need careful nursing before it could make a useful contribution. Early in 1959, Hovercraft Development Ltd was set up as the subsidiary of NRDC to manage the patents. This was followed by the recruitment of a group of technical men under the direction of the inventor at Cowes. The initial work of this group was to investigate the many improvements which Mr Cockerell had already envisaged.

In those early days, a great deal could be achieved with little equipment. When the Group was moved to its present position at Hythe on Southampton Water later in 1960 and more space became available, larger and more ambitious experiments were started. Mr W. A. Pennington became Chief Engineer and Mr Cockerell acted as Technical Consultant to the company.

The facilities were extended over the following years and now include an open-air towing tank, an analogue computer, an air laboratory, a model shop and full-scale craft operating facilities comprising a hangar and slipway on to Southampton Water. Two test hovercraft, the HD-1 and the CC-4, are available for full-scale trials and a variety of large-scale models are used for both static and dynamic tests.

The work of the Group is aimed at investigating the most important of the very many aspects of hovercraft which affect the safety and efficiency of future variations.

It is often as important to establish that a new idea is impracticable as it is to confirm its validity. Hovercraft manufacturers may be reluctant to devote effort to ideas which may or may not succeed when there is so much pressure on them to improve the particular type of craft from which they are gaining their income. In general, the effort at Hythe is available to help the British Hovercraft Industry by looking further ahead than many manufacturers can justify doing.



The name of Christopher Cockerell, MA, is the best known in the hovercraft world and will remain so as the inventor of the hovercraft principle. Born in 1910, son of the late Sir Sydney Cockerell, the Curator of the Fitzwilliam Museum at Cambridge, and his wife, the former Florence Kate Kingsford, who was well known as an illuminator of manuscripts, his antecedents were humanist and artistic rather than technical. However, his interest in things mechanical became evident at an early age when he used a toy steam engine to drive his mother's sewing machine, and constructed a wireless set for his preparatory school in the early days of radio. When, later, he went to work for Marconi Wireless Telegraph Co, his father promised him £10 for every invention or improvement of his that the firm took up, but soon had to put a stop to the arrangement as it was proving much too expensive. He went to school at Gresham's School, Holt, and read engineering at Peterhouse, Cambridge. On leaving the university he was a pupil for two years at Bedford with W. H. Allen. After two further years spent at Cambridge, he joined the Marconi Wireless Telegraph Co at Chelmsford, where he stayed for fifteen years. In 1939 he headed the team which developed the radio direction-finder that went into every British bomber — known to the RAF as the Drunken Men, because it had two needles that swayed and crossed like two drunks helping each other home. Mr Cockerell, in later years at Marconi's, was Head of its Aircraft Radio Development Establishment until he and his wife bought a small boat-building and boat-hiring business on the Norfolk Broads, which they built up into a flourishing concern and named the Ripplecraft Co. From his boat business emerged the idea of introducing a film or cushion of air between hull and water, in order to reduce wave resistance and skin resistance, and he experimented first with a punt fitted with a fan to supply a film of air over the bottom contained by sidewalls, and later by full-scale tests with a 20 knot ex-Naval launch. These experiments led to the construction of the first hovercraft, a balsa wood model, and in 1957 he formed a company, Hovercraft Ltd, to exploit his invention. He demonstrated his model at the Ministry of Supply, and an historic scene occurred in a basement room in Whitehall where the small craft buzzed around some inches above the floor with interested Government experts scrambling out of its way. This led to a small contract being placed by the Ministry of Supply with Saunders-Roe for verification. The NRDC then set up Hovercraft Development Ltd, its largest subsidiary company, with Mr Cockerell as Technical Director (a post which he has now relinquished) and Consultant. Mr Cockerell enjoys fishing, a good round of golf, and gardening, where roses are his speciality. He has two daughters

ORGANISATION

The work of the Technical Group can be divided broadly under two main headings — Marine Hovercraft and Tracked Hovercraft. At the present time, the Division responsible for marine hovercraft is somewhat larger than that for tracked hovercraft and is more formally sub-divided. The sections of this Division cover the following subjects:

- Future Developments
- Project Design and Analysis
- Dynamics and Control
- Flexible Skirts
- Design
- Model Trials
- Full-scale Trials.

The development of the tracked hovercraft is still in its very early stages and the Division is therefore not split into so many sections. Most of the above functions, however, are carried out within the Division using common facilities where this is appropriate

Mr J. E. Rapson, BSc(Eng) Hons, AFRAeS, Chief Engineer, who is forty-one years of age, has worked on hovercraft since 1956. From Woodford House School, Birchington, he went to London University. His career started as an aerodynamicist with Handley Page, and he then moved to the Ministry of Supply and became a Senior Scientific Officer, where he stayed for ten years. In the later part of his career with the Ministry of Supply he was employed in the department dealing with research aircraft, including the Flying Bedstead, the SCI vertical-take-off aircraft, the Fairey Deltas, jet flap aircraft, etc. Part of the work of the department was to examine "mad" inventions. It was in 1956 that Mr Rapson came in contact with Mr Cockerell and became very interested in his work, and from there the association evolved. He joined NRDC in 1959 and transferred to HDL in 1961. An experienced dinghy sailor and not quite so experienced skier, his spare time is currently devoted to the building of a boat to get the whole family afloat

Mr R. D. Hunt, "Roly" to his colleagues, at thirty-six is the man in charge of the Marine Hovercraft Division, a position he has held for nine months, and has been with HDL for three years. He attended Taunton School and then went on to Bristol University, where he gained his BSc and flew Chipmunks in the University Air Squadron, and also worked as an exchange student in Holland and Sweden. From Bristol he went to Illinois University, USA, as a postgraduate for a year and took his MSc, and did some more piloting, this time in sailplanes. He also went to Cornell University, USA, for a year. "Roly" initially went to the States on an English-Speaking Union Fellowship chiefly to see the country, rather than for further technical education, and travelled over most of the United States and Canada, mostly driving truckloads of foreign students with the US Westminster Foundation. The most arduous leg of his round-the-world trip home was having to hitch-hike across Australia to change ships. He started his career with English Electric Aviation (later BAC) and was with them for just over seven years, being initially involved in the design and commissioning of EEA 4 ft square, Mach 0.4 to 4.5 blow-down wind tunnel. After becoming responsible for model and equipment design, two years' project work followed on V/STOL aircraft. As will be seen from his educational days, "Roly" enjoys foreign travel, and other interests are sailing (currently reduced to a "sailing plank" sailskiff), skin diving and squash

MARINE HOVERCRAFT DIVISION

Currently, much of the effort of this Division is centred on the design and construction of HD-2. This is the first of a series of small machines following the original research craft, HD-1. It will be used mainly to assess the effectiveness and practicability of a variety of control systems. The HD-2 may be regarded as a 30% scale model of a 90 ton passenger and car ferry, and as a three-times scale version of the series of tank models used by the Group for its model test work. The craft is 30 ft long and 15 ft beam, and, besides the driver and co-driver, can carry up to six observers. In its normal configuration it will weigh about 3 tons.

This craft and its successors are being used as the focus for much of the marine hovercraft effort, but a great deal of the work, which is of course available to the British hovercraft manufacturers, is applicable to a variety of large or small hovercraft projects.

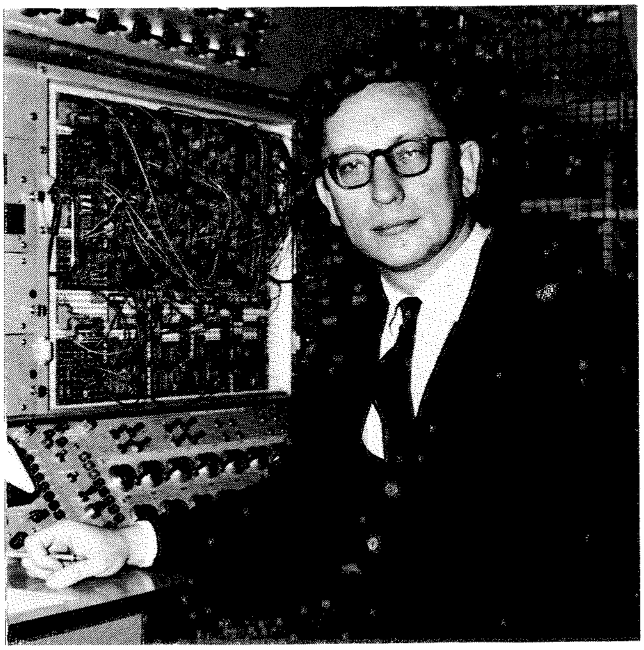
Future Developments Section

In the past, HDL was organised into sections covering particular aspects of hovercraft technology such as flexible skirts, performance of air curtains, fluid dynamics, etc. At that time there were no established or basic practices, and everybody was working on new ideas and so initiated and looked after their own "future developments". With time, knowledge has increased and trends have developed. The early trends depended to a large extent upon the quick successes of certain ideas, less immediately successful projects often being put aside purely due to the limited time and facilities available.

The situation now exists where individual sections can no longer cast their nets far and wide but have to concentrate their efforts on the problems of the moment, associated with the craft of today and tomorrow.

It is obvious that effort must be made available to look at the more distant problems that will surely arise, and if possible provide pointers to the solutions. There is also the need to look again at some of the ideas that have already been passed over, in light of the more recent developments.

Mr R. L. Trillo, CEng, AMIMechE, AFRAeS, another member of the Marine Hovercraft Division, being in charge of the Project Office, is thirty-nine years of age. He commenced his career with a four-year apprenticeship in mechanical engineering with Rotol Airscrews Ltd, now Dowty Rotol Ltd. Subsequently he was engaged on propeller development, ending up in 1953 as Senior Engineer in charge of marine propeller research and associated facilities. In 1954 he joined Canadair Ltd of Montreal, and whilst working on aircraft aerodynamics attended the first formal course in boundary layer control at the University of Wichita, Kansas. Bob was engaged by de Havilland in 1956 on aerodynamic development of the Sea Vixen and a commercial aircraft project and later, at Hatfield, became Senior Sales Executive for the Trident airliner, visiting many European airlines. Soon after joining HDL he was appointed in 1963 Assistant to the Technical Director, Mr Christopher Cockerell. During this time he published several papers on hovercraft economics and noise, and proposed a number of design innovations which are the subject of patent protection. He is a Member of the American Institute of Aeronautics and Astronautics and of the Canadian Aeronautics and Space Institute. While with Rotol Ltd, Mr Trillo played an active part in the formation and running of the Rotol Flying Club and was a private pilot from 1947 to 1953. He has a life-long interest in natural history, volcanoes becoming particularly interesting to him since visiting Vesuvius and Solfatara in 1963 with his wife and two eldest sons



Mr J. H. W. Wheatley, AFRAeS, also of the Marine Hovercraft Division, is in charge of Dynamics and Control. Mr Wheatley, who is thirty-nine, has been with HDL for five years, and whilst at Hull Technical College he gained his Higher National Diploma with aeronautical subjects. He joined Blackburn Aircraft Ltd in 1943 as a special apprentice and in 1949 went into the Project Department, and while there learnt to fly. In 1949 he joined the RAF (Education Branch) as a lecturer and in 1952 took employment with Auster Aircraft Ltd as an aerodynamics and senior flight test engineer. From Austers he went to Smiths Aircraft Instruments Ltd in 1958 as an autopilot and automatic landing research engineer. His main interests are reading, walking and golf

The current items being studied by the Future Developments Section include unorthodox means of propulsion and manoeuvre, cushion systems to give better ride characteristics, and general improvements that might lead to lower power requirements or better performance, including directional control. To these ends, a comparison is being made of all forms of propulsion, both conventional and unconventional, that may be applied to hovercraft in various operational environments. Also the use of cushion air for directional and ride control is being explored. Preliminary tests and model work have already commenced.

Project Design and Analysis Section

Over the past few years the potential of amphibious and sidewall hovercraft has been continually assessed from the technical and economic standpoints. One aspect of particular interest is route survey work which has been made on a worldwide basis to assess the potential of hovercraft in many countries without ignoring or underrating the competition from other existing or projected transport systems. The results of these studies have been passed to the manufacturers and, in some instances, to operators.

In the technical sense hovercraft have developed rapidly over the last few years. For instance, some years ago much effort was devoted to reducing cushion power requirements by such means as refined recirculation techniques. It is now felt that the development of the skirt/cushion system, as a whole, can produce a better result with many secondary benefits.

The potential of existing propulsion systems such as marine propellers, water jets and air propellers has also been closely examined. It has been shown that much scope exists for developing an air propeller specifically for amphibious hovercraft. The noise problem with existing air propellers has been analysed and an effective means of predicting noise levels has resulted. Furthermore, now that the significance of the various parameters is appreciated, future propellers may be logically improved, so that the noise problem will be substantially reduced or eliminated.

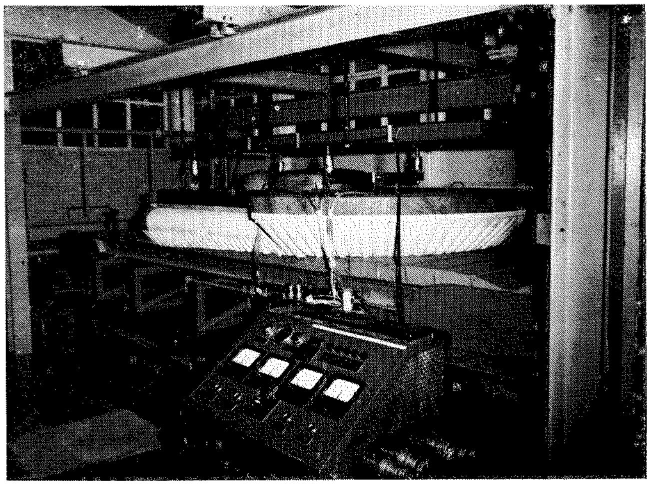
Recently contracts were placed by HDL with two propeller companies for the development of very quiet propellers and the study of unorthodox air propulsion systems. As an indication of the improvements which are possible with present techniques, the HD-2 should be the first noticeably quiet hovercraft propelled by air propellers, and there will still be a long way to go with further improvements.

A study of centrifugal-fan propulsion with particular reference to CC-4 and CC-5 has been undertaken in co-operation with Britten-Norman Ltd. Part of the HDL contribution has included a large number of rig tests to find the dependence of propulsive efficiency on volute geometry.

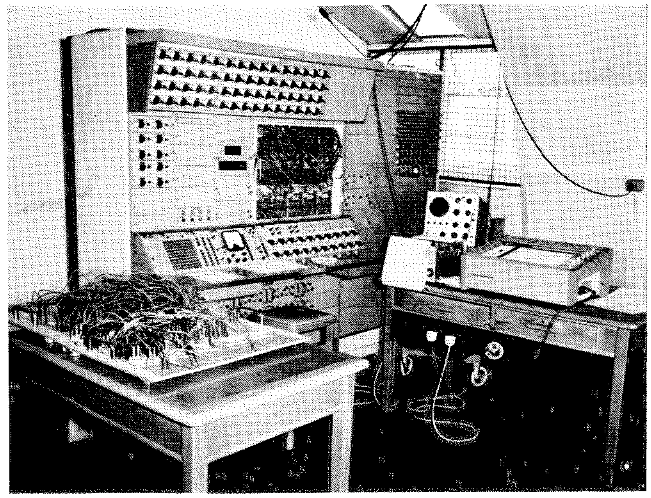
The Project Section has recently been involved with preliminary design of HDL's second research hovercraft, HD-2. There is a continuous "back up" programme arranged to probe various aspects of the craft's performance using model tests in the wind tunnel and towing tank. Numerous trial and recording techniques are being considered so that the performance and behaviour of HD-2 can be accurately measured, analysed and correlated with model data.

Currently, further test vehicles are being projected to tackle problems such as safety, ride control and manoeuvre. Considerable attention will be paid to refining body form and intake positioning to reduce, as far as practicable, the control and manoeuvring forces and moments required. This work will proceed in parallel with studies of full-scale passenger/car hoverferries to ensure that improvements applied to test vehicles are feasible on practical transport craft.

Twenty-eight-year-old Mr T. F. Melhuish, Trials Engineer/ Hovercraft Commander, is in charge of full-scale trials in the Marine Hovercraft Division. Mr Melhuish has been with HDL for a little over two and a half years. Hailing from Somerset, he attended Yeovil Technical College and later Southampton College of Technology, where he gained his HNC in Mechanical Engineering. He is also a Member of the Society of Environmental Engineers, and is at present studying endorsements for the AMIMechE. After serving five years' apprenticeship with Westland Aircraft, Yeovil, in 1958 he became an experimental engineer in the Development Group, working mainly on helicopter flight vibration and fatigue problems until 1963, when he joined HDL. His ambition is to learn to fly but, until his young family allows him to do so, finds the pilot's seat of the HD-1 hovercraft the next best thing. Terry took part in a hovercraft "first" when two boys were rescued from Southampton Water by the Denny D-1. On land, Terry enjoys a spot of quiet fishing



Experimental investigation of cushion dynamic behaviour is conducted with models over simulated wave surfaces on this wave belt test rig



An analogue computer PACE 231-R is used for theoretical investigation of craft suspension characteristics and control systems

Dynamics and Control Section

The efforts of this section are devoted to the study of the riding comfort of the craft passing over waves and the directional control of the craft.

The stability and dynamic behaviour of cushion systems is a difficult subject because of the lack of a close analogy with any other known dynamic system. An air cushion is an extremely good suspension system, but one which is not easily represented by the usual collection of masses, springs and dash-pots. However, a combination of experimental and theoretical approaches has improved understanding to the point where it is possible to make positive suggestions concerning the improvement of the ride of a craft over waves. The experimental methods have included suspending models over a moving belt with "waves" attached to it, and over an oscillating table. In both cases, the pressure changes within the cushion have been measured. A variety of different flexible "skirts" has been tried, and good agreement achieved with computer simulations.

To make the information on craft ride useful, it is also necessary to know what vibrations a human being can tolerate, and the size of waves likely to be encountered. Information on tolerance levels has been collected from a number of sources, and the section has collaborated with other organisations to develop a method for predicting wave conditions.

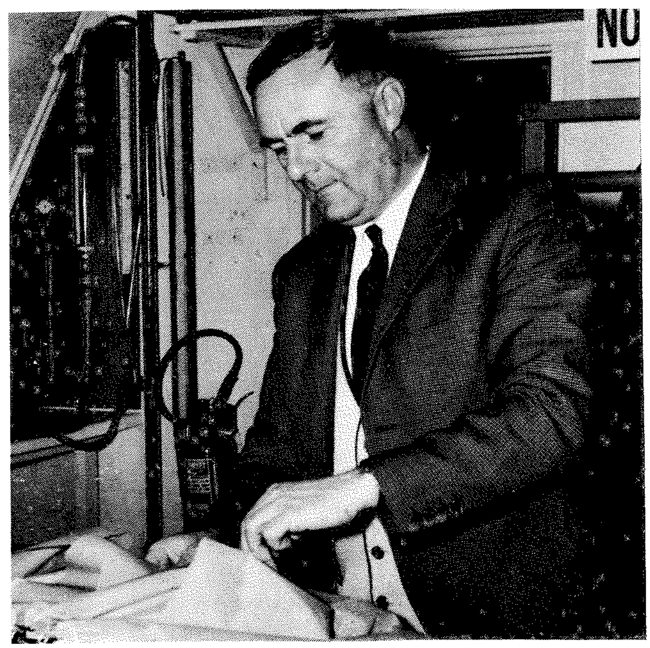
The most recent work has been concerned with the directional stability and handling of hovercraft. An analogue computer model with driver's control presentation is being used to assist in the design of control systems. This model will be refined as full-scale information becomes available, and used to give further design data.

In the future, it seems likely that hovercraft will become larger and faster. While larger craft may make ride problems less severe, they will presumably need further improvements in handling if operation is required in confined waters.

Flexible Skirts

It is now recognised that practically all applications of the hovercraft principle can benefit by the use of flexible skirts. In the early days, these tended to be flexible extensions of the annular jet. It was soon found that the inner wall was not always necessary and a great variety of skirt configurations was available to the hovercraft designer. Many of these had favourable features, but a process of logical development led the Technical Group to its present skirt design philosophy.

Since skirts are used to help reduce the air flow needed to seal the cushion boundaries, there is great merit in ensuring a close following of the local surface by the skirts. This indicates the use of materials having low inertia and arranged in a form which allows the minimum of leakage around bluff obstacles. The Flexible Section has therefore concentrated on skirts having these properties and has succeeded over the years in developing a system which meets these requirements and has additional benefits. For example, adequate craft stability in pitch and roll can normally be designed into a segmented skirt so that no internal compartmentation is necessary. The segments themselves are light in weight and simple in form. They are highly resistant to wear damage and the individual seg-



Mr L. A. Hopkins, AFRAeS, in charge of Flexible Structures, has been with HDL for four and a half years. Les Hopkins, who is forty-five years of age, was educated at Cheltenham Grammar School. He served an apprenticeship with the Gloster Aircraft Co and worked on the pioneer British jet aircraft, the Gloster/Whittle E28/39. He then became a stressman at Gloster, and worked for Airspeed, Folland and de Havilland. He used to play a lot of cricket and rugby and during the war played for the Cheltenham Rugby Football Club, but now prefers to be part of the "crowd". Another of his hobbies is woodwork, and he is also an ardent golfer ments can be changed easily. Most applications of the segmented skirt to a craft allow skirts to be repaired or replaced without lifting the craft from the ground. The cost of the skirt system is low, partly due to the lightweight materials used and partly due to the simplicity of construction.

Improvements are constantly being devised and these are put through a series of tests using both small- and large-scale two-dimensional air rigs, three-dimensional models which are tested statically and dynamically, and eventually full-scale testing on a research craft such as HD-1 or CC-4. Standard coated materials manufactured for other purposes have so far been used in all these tests. At present, greater improvements can be expected from changes in the skirt geometry than from improvements in skirt materials. The time will come, however, when the qualities of the materials used may prove to be limiting. The use of specially made materials may then be justified.

A small amount of effort is devoted to applying skirt sealing techniques to other uses; for example, the principle is being applied to the hoverbed for treating burned patients, and its use in the construction of air pads for moving heavy loads is under consideration.

Design Section

This section is responsible for the design of full-scale craft, models and testing facilities, and for supplying technical services.

Although HDL's first research hovercraft, the HD-1, was built by J. Samuel White at Cowes, the overall design was done at Hythe and the detail design carried out by White's under the supervision of the Technical Group's Design Section. The craft was designed to test surface-following side seals, but in order to establish a datum the craft was first fitted and tested with rigid sidewalls. Much of the Design Section's efforts over the past two years have been employed in modifying HD-1 to accept progressive skirt developments and to improve performance and handling of the craft. As a result of this work, HD-1 is now an easily managed craft in spite of its relatively low power-to-weight ratio.

The section has recently been expanded to enable it to handle the design work on HD-2, a much more ambitious and mechanically sophisticated machine than its predecessor. Close liaison is maintained between the Design and the Trials Sections, and members of the trials team have a hand in shaping the relevant parts of the craft. Great efforts are made to avoid developing special machinery or components for hovercraft and, where possible, tried and tested bought-out items are used. Development can thus be concentrated on the purely hovercraft problems.

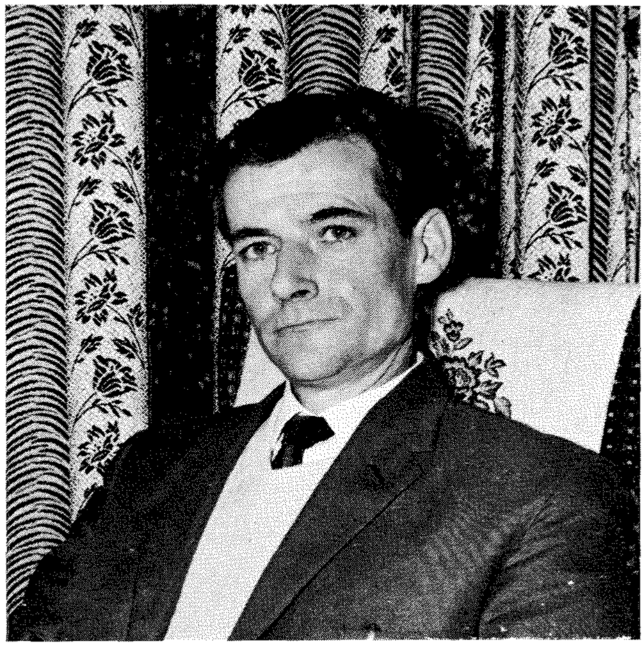
Due to the wide variety of work and small size of the Design Section, it is not practicable to split the group into separate functional divisions. Each member of the section therefore obtains experience in many fields and is constantly in touch with all aspects of hovercraft design and operation.

The section has been responsible for engineering the test tank facility at Hythe. This includes the wave maker, winch, retrieving and arresting facilities, as well as drag and measuring devices. The tank was originally 150 ft long and 20 in deep. It was recently completely rebuilt to a depth of 30 in and a length of 280 ft. This caused the tank to be out of commission for only eight weeks.

The models used on the tank are normally about 10 ft long and have self-contained interchangeable petrol or electric lift and propulsion packages. The same models may be used in the laboratory, in wind tunnels or in more sophisticated ship towing tanks.

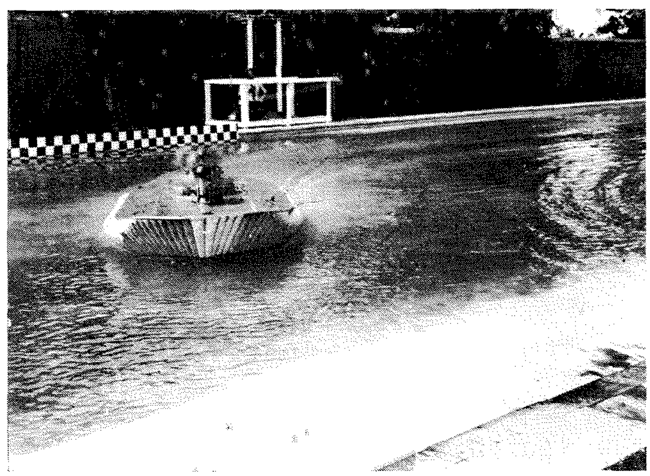
Model Trials

Not only is it possible to obtain performance and behaviour results more cheaply and more quickly using hovercraft models, but tests can be extended to extreme conditions without risk to the test crew of a full-scale craft. For all these reasons, the Technical Group has carried out extensive test programmes with hovercraft models and there appears to be an increasing need to do so in the future.

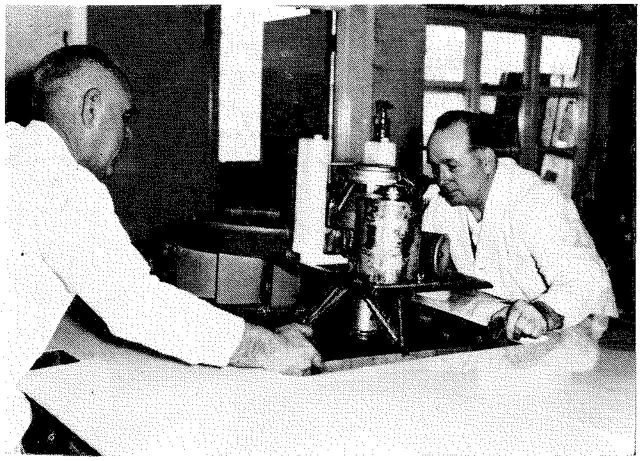


Mr K. H. Chiverton, at forty years of age, is in charge of the Modelshop at HDL. With the distinction of being the very first member of the staff, Mr Chiverton worked with Mr Cockerell on the Isle of Wight, where his "Workshop" was a 12 ft by 6 ft potting shed at a house called the White Cottage, the birthplace of HDL. Making one of the first rigs in the "potting shed" was quite an experience for Ken, because only half of it could be made at a time — half the rig was in the shed while the other half stuck out in the open. Later on Mr Cockerell bought an army hut which was eventually turned into the offices and workshop. Previous to joining HDL, Ken Chiverton worked at Saunders-Roe Research Establishment at Cowes, J. S. White Ltd (Aircraft Division), Cowes, and "Ranalagh" Yacht Yard Ltd, Fishbourne, as an engineering craftsman. His enthusiasm for golf led him to become Amateur Golf Champion of the Isle of Wight in 1953; his other interests are gardening and reading

In comparison with ships and aircraft, hovercraft are still in a very early stage of development, and with radically new ideas to be tried it is not surprising that much of the work is purely functional testing. Until the summer of 1965 HDL did not have any suitable facilities for this work, and models were taken to the ship tanks at the National Physical Laboratory. It was inevitable that shortcomings in the design of, say, a new type of flexible skirt would occasionally be found only when an expensive series of tests at NPL had commenced.



A skirt development model approaching the beach at speed during a round-the-pole test



A glass-fibre model for tank testing receives an interchangeable lift unit of HDL design

Towards the end of 1964, however, it was realised that for the cost of a few weeks' testing at NPL, a small tank could be built at Hythe in which a great deal of qualitative testing could be done. This materialised the following summer as a plastic-lined hole in the ground approximately 150 ft long, 30 ft wide and 21 in deep. A constant-force towing system was installed in a shed at one end of the tank, and an ex-farm tractor proved ideal for driving a paddle-type wave maker. With this simple equipment, and provision for stopping and returning the model, much useful work was done with model speeds of over 30 ft/sec. Also, by tethering to a centre post near the tank, self-propelled models could be operated round a circuit which included water, beaches and other obstacles.

This facility proved so useful that before long plans were in hand to extend it, and recently an enlarged tank lined with concrete was commissioned. Speeds up to 50 ft/sec are now possible, and the range of waves that can be generated has been increased. Models are accelerated automatically for a predetermined distance, and then during the constant-speed part of the run, essential parameters are recorded on an ultra-violet trace recorder. The equipment can also be used to measure model response data during round-the-pole operation, and slow-motion ciné film is extensively used for comparing different models.

The models are constructed from fibreglass, rigid foam plastic and wood, and are usually between 10 and 14 ft in overall length. They are all designed to accept a standard "lift package" which incorporates a 5 hp petrol engine driving a centrifugal fan. One or two propulsion units, also powered by petrol engines and using four-bladed airscrews, may be fitted for round-the-pole operation. Wherever possible, more power is installed than is thought to be required, as this gives greater flexibility to the test programme. It is hoped to replace the petrol engines with electric motors for round-the-pole running in the near future, and ultimately for straight towing as well.

In order that results from model tests, whether qualitative or quantitative, should be of maximum value, the model should be as near scale as possible. A total of three accurate models of HD-2 have been made. One of them is used as a wind tunnel model, one as a tank testing model and the third is to be tested as a free-running radio-controlled model. This will have all the normal controls operated remotely, including rotating pylons, and will enable problems of stability and control to be investigated.

All these facilities available at Hythe will not eliminate the need for testing at NPL, but this can now be reserved for accurate measurements with a well-tried model and skirt system. When the full-scale trials of HD-2 get really under way, it will enable much more to be learned of the relationship between model and full-scale results, and it is anticipated that, as time goes by, more and more quantitative results will be required from models, which may then be used confidently to give full-scale predictions.

Full-scale Trials

The Trials Section is primarily concerned with the planning and execution of full-scale tests with the firm's two vehicles, HD-1 and CC-4. In contrast with commercial practice, the accent has been to employ engineers to drive trials craft. This is important in such a small and closely knit group, it being of prime necessity that all members be as adaptable as possible.

Initial experience was gained with the original Denny D-1 sidewall craft and later expanded with the HD-1 and CC-4 programmes. HD-1 has proved a versatile machine which, in spite of its limitations of low thrust/weight ratio and low lift power, has provided invaluable amphibious experience over land, mud, shingle and saltings. Skirt segments of different materials and weights have been given extensive trials on the 9 ton craft. At one stage, HD-1 was operating for five months with a set of segments along one side made from proofed material weighing only 4 oz per square yard. When these eventually had to be replaced it was found that practically all the wear occurred when travelling over concrete, whereas over water the wear was negligible.

The policy HDL has adopted has been to lay down a broad programme of tests at Project Section level and delegate the operational planning and conception of test methods to the Trials Section. At one time or other the section members have been responsible for performance estimates, reduction of data, analysis of results and other facets of the work carried out at HDL.

Great value can be obtained from purely qualitative tests if the team has a thorough working knowledge of both the mechanical and theoretical factors involved. Neither of the two hovercraft drivers holds either Pilot's Licence or Master's Certificate, but it is considered that this has proved beneficial, since neither is biased by previous experience in the aircraft or marine fields.

In order to prepare for the HD-2 programme, one of the firm's engineer/drivers is undergoing a training course on the Westland SR.N6. This will provide familiarisation at the higher speeds to be achieved by HD-2 and provide a valuable datum for craft comparisons.

★

At intervals the results of the work of the sections of the Marine Division will be collected and channelled into the design of the latest experimental craft. At present this is the HD-2 but since no major changes can now be incorporated into this machine, some of the current development work will have to await the HD-3.

Although the prime function of the HD-2 will be to test combinations of various manoeuvre control systems, certain established features such as segmented skirts, lift air distribution, hull form, ride characteristics and quiet propellers are also embodied in its design. In this way control problems will be studied on an integrated design incorporating a set of consistent features. For instance, the hydrodynamic derivatives of the skirt depend considerably on the attitude of the craft, and in turn have a profound effect on the lateral control of the craft at speed.

Although a 90 ton craft has been cited as the full-scale version of the HD-2, the performance and behaviour of larger or smaller machines may be inferred from the trials results of this experimental craft.

TRACKED HOVERCRAFT DIVISION

In many respects the tracked hovercraft concept is in a similar position to that of the marine hovercraft in 1958 before the SR.N1 was built. A working model exists, but a man-carrying vehicle has not yet been designed. This Division of the Technical Group therefore has not only to carry out the technical development work, but also to sponsor the acceptance of the tracked hovercraft as a viable means of transport.

The tracked hovercraft is an overland public transport vehicle that is supported and guided by cushions of air on a prepared track. The principle can be applied to a range of vehicles carrying passengers, mail, cars and less bulky freight at speeds of up to 500 mph. Two distinct types of vehicle are the "sub-urban" vehicle, designed to provide a relatively high-speed

Mr D. S. Bliss, who is forty and in charge of the Tracked Hovercraft Division, joined Hovercraft Development Ltd a little over six and a half years ago. His first associations with the tracked hovercraft side of the house began when the first thoughts on this form of transport emerged soon after HDL started up on the Isle of Wight in 1960. From mid-1962, by which time the company had expanded to new premises at Hythe, Denis found the needs of marine hovercraft became his prime concern at HDL, and in 1965 was appointed Head of the Tracked Hovercraft Division. An Associate Fellow of the Royal Aeronautical Society, he gained a First Class Honours Diploma in Aeronautical Engineering at the Loughborough College. Mr Bliss was a senior aerodynamicist at de Havilland Aircraft Co at Hatfield from 1952-59 and was engaged on project studies of future aircraft, now flying as the Trident and HS-125. He served in the RAF as an airborne radar fitter from 1944-48. He has an active interest in photography and in 1952 he won a cup for the best print of the year at the College Photographic Society Annual Exhibition

Mr E. F. Needham, AFRAeS, is in charge of Engineering Design in the Tracked Hovercraft Division. Mr Needham, who is forty-eight years of age, joined HDL five years ago. He was educated at Gillingham County Grammar School and after matriculating went on to the Medway College of Technology and gained his HNC (Mechanical and Aero). On leaving the college, Ernie was employed by Short Bros, the flying-boat manufacturers, as a stressman on project, design and structural research. After leaving Short Bros he went to Airspeed Ltd as Chief Stressman on the Ambassador airliner. In 1952 Airspeed merged with de Havilland Aircraft Co, where he worked on subsequent military and naval aircraft built at the same works, as well as being responsible for all structural and fatigue testing on DH aircraft at Christchurch, he was also Chief Stressman. He was a member of the SBAC Fatigue Committee from 1960-61. His hobbies are mainly of the outdoor nature and he enjoys sailing, tennis, badminton, camping and golfing, and, when he can find time, cabinetmaking. A member of the Champion Junior Crew, South Coast Amateur Rowing Association, in 1949, he was a finalist in the National Championships of that year

commuter service, or a city centre to airport connection, and the "inter-city" vehicles, designed to compete with air transport on a time basis, and the railways on a cost basis. The type of vehicle required will depend on the nature of the route and the traffic it has to serve.

Although some work on the concept was started in 1960, the effort was small until the Tracked Hovercraft Division was set up at the end of 1963. It was charged with the development of the project in all its aspects.

Engineering Aspects

The achievement of stability was a problem of fundamental importance and demanded considerable effort from the Division. A static stability theory was developed covering the effects of displacements, cross coupling and cushion stiffness, and extended to cover dynamic stability. Test rigs were then designed and constructed, and experiments carried out to verify the theories. Preliminary designs have been made of lift pads, and a test rig constructed to analyse and demonstrate the system.

Considerable work has been done on the performance of tracked hovercraft. An evaluation of aerodynamic forces has been made (substantiated by wind tunnel tests) and a comprehensive theory for the calculation of power requirements established. Detailed design studies have been made on a range of vehicles (passenger and passenger/freight vehicles, ranging from 40 to 200 tons) and investigations into suitable power units — diesel, gas turbine, jet and electric — made. An assessment has been made of propulsion systems and from this the linear induction motor chosen as the most suitable system.

Considerable use has been made of analogue and digital computers for the design of the suspension system. A study was made of passenger comfort and an acceptable level determined. The analogue computer was used to simulate a vehicle travelling at 300 mph over track discontinuities and irregularities. Air cushion and seat springing effects were added. The suspension system was then deduced to keep the accelerations on the passenger below the maximum acceptable level.

The track, a simple concrete section that can be either elevated or at ground level, has been designed and costed in conjunction with E. W. H. Gifford & Partners. It has been designed to enable the necessary vehicle stability to be achieved, whilst its simple, elegant appearance does not detract from the beauty of the countryside.

Economic Aspects

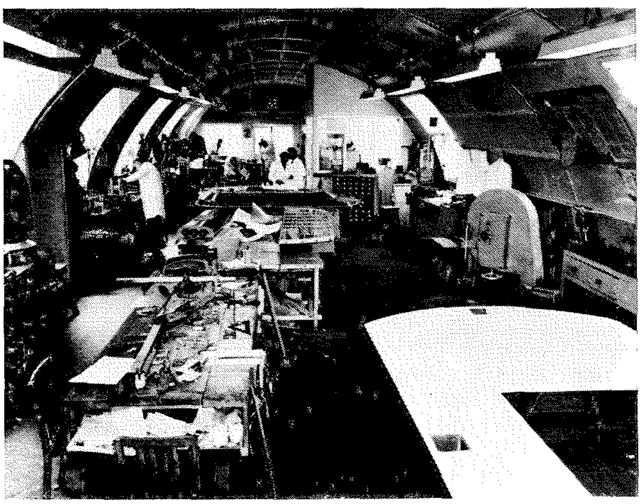
The success of the tracked hovercraft depends on the economics of its operation. A financial analysis of the various systems is therefore of prime importance. The calculation of the fare that must be charged to cover all costs and provide the necessary profit margin must be calculated for each prospective route. This involves not only the direct operating costs of the vehicle, but also the capital and associated costs of the track. The density of traffic plays a vital part in these studies.

Mr M. Charity, MA, aged thirty-four, is also a member of the Tracked Hovercraft Division, in charge of Theoretical and Experimental Studies, and has been with HDL for four and a half years. He is a Yorkshireman with an Irish background, since he was educated at Trinity College, Dublin University, where he won the Vice-Chancellor's Prize. Michael then worked for Shorts, at Belfast, on structural research. After this he went to Sperry Gyroscope as a mechanical engineer and worked on the control system of the Seaslug missile. Mr Charity is technically interested in the application of scientific method to more unusual subjects such as war games (a scientific process which Great Britain started and the Americans now put into practice!) and operational research — for instance, problems of transport networks and also the design of ingenious mechanisms and unusual structures. His interest is mainly photography, long range and close-up, but he is also interested in antiques and paintings and has just added his support to the National Trust

Mr J. A. Boutland, in charge of the Patent Department at Hythe but technically employed by NRDC, is thirty-eight years of age and has been a Patent Agent at Hythe for two years. He was educated at the Cowes Engineering School and served an apprenticeship in marine engineering at J. S. White & Co, Cowes, Isle of Wight. He left J. S. White to become an engineering officer in the Merchant Navy, serving in the Blue Funnel, Union Castle and Cunard Lines, including a spell of duty in RMS Queen Elizabeth. *This was followed by two years in the Patents Department of Westland Aircraft and Normalair Ltd of Yeovil as Technical Assistant (Patents) and five years as Patents Officer with the United Kingdom Atomic Energy Authority, Risley, Lancs. Away from hovercraft, Tony Boutland's interests are reading and cricket — mostly cricket*

Promotional Aspects

To assist in the promotion of the tracked hovercraft concept, a demonstration model has been built. The model is supported by cushions of air and runs over an elevated rectangular track. It is approximately 6 ft long and weighs over 30 lb. It is propelled by a linear induction motor which was designed and manufactured by Professor E. R. Laithwaite at Imperial College, London. The vehicle is guided by air cushion pads reacting against the side of the track, and both these and the support pads are mounted on representative suspension systems. The tracked hovercraft model will make its first public appearance at the Browndown Hovershow. This will be the first time that the concepts of the tracked hovercraft and the linear induction motor have been brought together and the model will give a foretaste of the merits of this futuristic form of transport.



The workshop, showing work in hand on a tracked hovercraft model and marine models for tank and tethered testing

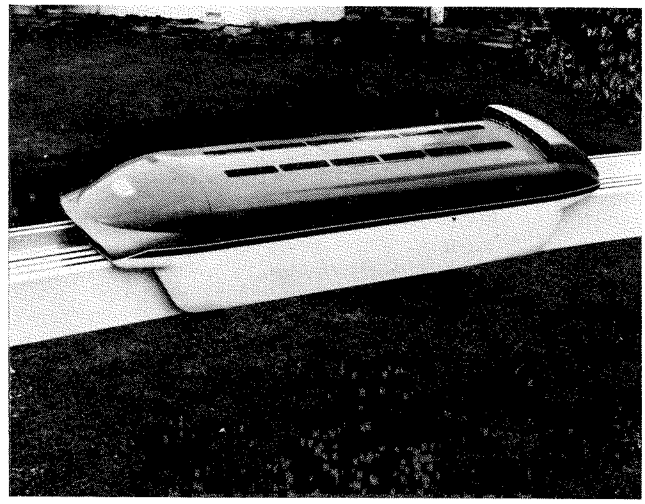
CONCLUSION

The hovercraft is still a new concept and is capable of immense further technical development. The existence of an independent Technical Group which is not tied to the day-to-day problems of a manufacturing organisation will ensure that effort is available to look far ahead. New ideas will continue to be evaluated and the more promising ones developed. At this stage of development, certain of these ideas may offer a gain of the order of 50% and will be used by the industry. Those giving smaller improvements can be shelved until development has slowed down to the point where even a 2% improvement is worth adopting. In this way, the Hythe Technical Group will help to ensure the continued development of hovercraft as a safe and economic means of transport over land and sea.

The HDL Tracked Hovercraft Project

D. S. Bliss AFRAeS

Head of Tracked Hovercraft Division
Hovercraft Development Ltd



Introduction : A Definition of Tracked Hovercraft

TRACKED HOVERCRAFT are hovercraft that are guided by an inherent directional stability between the vehicle and the track which supports it. They are thereby distinguished from hovercraft operating on a clearway or track, in which the forces providing directional control are monitored by an independent agency (or a third component in the system), for example, a driver. A transport system using tracked hovercraft may be regarded as an extension of present railway practice.

Tracked hovercraft can be designed either as single-vehicle hovercars or as a series of coupled units — hovertrains.

Basic Advantages

The basis for the commercial justification for a new transport system using tracked hovercraft is to be found in three intrinsic advantages of this vehicle over its conventional counterparts:

1. The use of air cushion support and suspension makes it possible to achieve comfortable ride conditions at speeds much faster than those at present in use on conventional railway systems without the need for extreme accuracy of track surface alignment.
2. The absence of contact between the vehicle and track and the fundamental simplicity of the vehicle minimise maintenance costs.
3. The relatively low bearing pressures inherent in air cushion support may, in certain circumstances, enable a relatively low grade and cheap track to be employed.

Application

In Great Britain, and other developed countries, the most likely application of tracked hovercraft is considered to be as a high-speed ground transport system operating directly between centres of population. Operating speeds of up to some 500 mph are thought to be technically feasible and could be used where they can be commercially justified and are geographically possible. For general use, however, speeds somewhat below this are likely to be adequate; for example, a 200-250 mph transport system could effect a transport revolution in Great Britain with far-reaching sociological consequences.

As a result of operating directly between centres of population at 200 mph, tracked hovercraft can offer shorter journey times than the present air services over distances up to about 500 miles — see Fig 1. Travel times between a centre of population and the airport are currently at a level which makes a nonsense of air travel over short distances — say up to 250 miles — where a direct rail route also exists. Although considerable improvements can be made towards reducing this lost time it is not likely that a time less than 30 min between leaving the centre and boarding the aircraft will be achieved. Also at least another 5 min will be lost taxi-ing out, taking off and setting course. This results in 35 min lost at each end of the air journey or 70 min total. It should also be noted that increasing the speed of the aircraft has only a secondary effect on reducing total travel time. It reduces the slope of the line of time against distance in Fig 1, and the lower line of the hatched area shown as current domestic air services already corresponds to 500 mph aircraft.

The effect of the considerable improvement over current conditions referred to above is also shown in Fig 1 as the "probable best air service". It is seen that compared with this standard a 200 mph tracked hovercraft has a shorter journey time to the Midlands and a 300 mph tracked hovercraft will reach Scotland in the same time as the air service. Tracked hovercraft can only be bettered by VTOL aircraft operating from centres of population. However, the advent of large, fast VTOL aircraft with an acceptable noise level for such a use does not seem likely for some time at least — if ever.

A track-supported and guided vehicle monitored by a

COMPARISON OF JOURNEY TIMES FOR VARIOUS TRANSPORT SYSTEMS

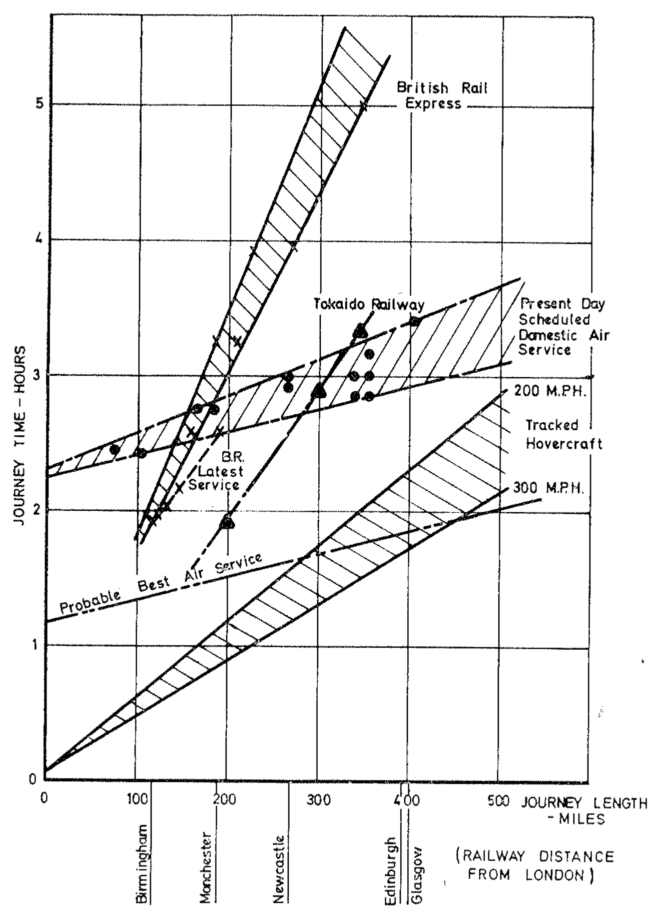


Figure 1

modern computer control system should represent the ultimate achievable in safety and also afford freedom from delay due to fog. Also the adverse effects of snow and ice are likely to be less on a vehicle which is designed to be free of the surface compared with one using wheels on either rails or runways. For these reasons, it is considered that tracked hovercraft enable a significant step to be made towards a frequent, fast, safe, reliable, all-weather transport system. Even so, it is not regarded as a complete replacement of any existing system, but rather as one which would supplement those already in use. It is likely to prove a direct competitor to many internal airline services and, when established, could become the preferred method of transport where traffic demands are high.

The Vehicle

As tracked hovercraft are high-speed vehicles, considerable attention must be paid a achieving a clean aerodynamic shape. Consequently, the overall appearance of the vehicle, as currently envisaged at HDL, resembles an aircraft fuselage part of which envelops the track, i.e. the vehicle is essentially a "beam rider". The vehicle is supported by air cushion lift pads on the horizontal surface of the track and guided by further air cushions acting on the sides of the track. The lift and guidance pads are, in effect, separate hovercraft. The thickness of the air cushion forms the first stage of the suspension and allows for the surface and alignment irregularities in the track. A second stage of suspension, between the lift pad and the vehicle body, accommodates track deflections and other irregularities up to a limit set by the stroke of the system. Recent work at HDL has shown that the first and second stages of suspension, as described above, can be combined into an integral unit of extreme fundamental simplicity. Such an air cushion suspension system can provide a high degree of passenger comfort at very high speeds over tracks constructed to tolerances used in present-day civil engineering.

A means of propulsion which does not involve contact with the track is a prerequisite for high-speed tracked hovercraft. Airscrews or ducted fans are one possible solution, but are noisy, create a considerable slipstream and are difficult to incorporate into a clean vehicle design. They are probably the lightest method of propulsion and may be used in some applications. However, for general use in densely populated areas a special form of electric traction — the linear induction motor — is considered to be especially suitable. This is essentially a normal induction motor in which the stator windings are attached to the vehicle and induce a thrust on a rail mounted on the track — see Fig 2. The linear induction motor involves no moving parts, is virtually silent in operation, and the majority of the heat generated is automatically dissipated into the track-mounted rail.

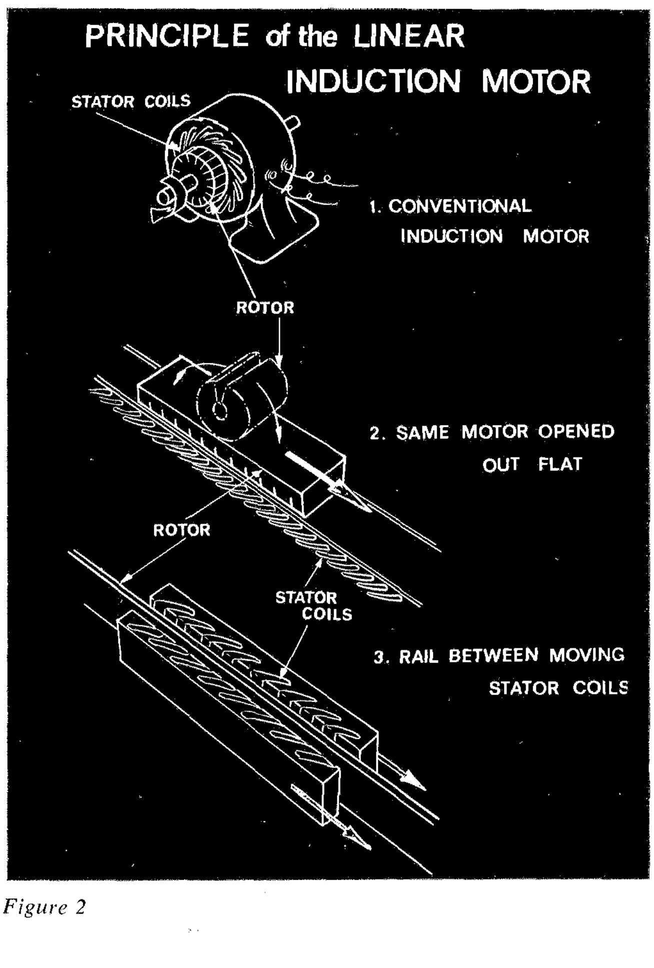


Figure 2

A demonstration model incorporating these salient tracked hovercraft features, viz air cushion support and suspension with linear induction motor propulsion, is shown on page 21. This model will be exhibited at Hovershow 66 running on a closed circuit track some 600 ft in length. On the model electric current is collected from the track through sliding contacts. On the full-size vehicle a similar arrangement may be employed if means of picking up the current at very high speed are developed, or alternatively the power may be generated on board the vehicle using a suitable prime mover and generator.

Tracked hovercraft may be designed to carry passengers or, if necessary, passengers and cars. Mail and light freight are also suitable payloads, but not bulk freights such as coal.

At any given stage of development it is considered that the highest speeds will be possible with single-unit vehicles. This is compatible with the general trend for the greater traffic demands to occur over the shorter routes and very high speed only being justified over long distances. The extra traffic capacity required on short routes could be provided by slower coupled-unit hovertrains, while on the longer routes high speed could be offered by single-unit hovercars. In all cases the size and type of vehicle and its operating speed should be optimised for the needs of the route.

Track

The track is currently envisaged as an elevated reinforced concrete structure to provide a maximum of safety and minimum of interference with existing road services, etc. In sparsely populated areas a ground-level track may be used but adequate precautions to prevent trespass would be necessary.

From all-round consideration a track cross-section that is basically rectangular is currently favoured. An inverted "T" section probably allows an easier solution to vehicle stability in cross winds but imposes difficulties in vehicle layout as well as not being a good beam cross-section.

As the track first costs have a major influence on the economics of operation, it is essential that the size and type of track is carefully evaluated with due consideration for likely future traffic needs.

HDL and Tracked Hovercraft

Work on the tracked hovercraft concept started at HDL in the summer of 1960 when the Technical Group was located on the Isle of Wight. It has continued on a low priority basis since that date, but is now being stepped up.

Basic feasibility and economic studies have been made and some basic experimental data obtained. The feasibility and costs of track construction have been investigated by E. W. H. Gifford & Partners acting as consulting civil engineers to HDL. Recently HDL retained the services of Professor E. R. Laithwaite of the Imperial College, London, to act as a consultant on the electric linear induction motor.

The next stage needed in the development of the project is considered to be the building and operating of a manned prototype vehicle. This, and the associated programme of research and development, would cover a period of four to five years. It would provide the data and experience required to design a safe high-speed vehicle of some 200-250 mph giving acceptable standards of passenger comfort when used on a track constructed to present-day civil engineering tolerances.

This research and development programme could logically lead to a pilot commercial service between centres of population — for example, London and the Midlands or London and one of the new development areas — using a 200 mph or faster tracked hovercraft. Such a service could be operating in ten to fifteen years' time and would represent a major advance in land transport.

The Siting of Hovercraft Car-Ferry Routes

by

Christopher Cockerell

In the next few years numbers of new hovercraft passenger/car ferry routes will be opened in this country and abroad, and it is therefore pertinent to investigate the extent to which their precise location affects the running costs of the service, and therefore the level of fares.

A characteristic of passenger/car ferries is the great variation in the load, not only as between summer and winter, but on the different days of the week, and in the different hours of the day. **Fig 1** shows the daily distribution of car movements on routes between the Isle of Wight and the mainland. Even here the extreme peak demand is suppressed and spread, due to the saturation of the service.

Now a "common carrier" has an obligation to carry all the traffic offered, and must provide a fleet capable of carrying the peak amount. The minimum possible fare therefore depends upon the amount of work the carrier can squeeze out of each craft at peak demand, so that the number of craft required is a minimum. A number of detailed analyses of the cost of running a hoverferry service shows that the break-even fare, using the same type of craft on different routes, is nearly proportional to the trip time at peak demand rate, and it is this which makes it possible to show the effects on fares of route laction.

Table I shows the make-up of the total trip time on four possible Solent routes, assuming a hovercraft with a cruising speed of 60 knots and a turn-round time capability at peak demand of 5 min. The fare ratios should strictly be shown as percentages, with the Gosport beach to Ryde (West) route as a datum; but it is thought permissible to use shillings, in order to bring out the effect more clearly. The 5s passenger fare on this route is thought to be realistic, based upon detailed costings and the Solent traffic pattern, for a craft of about 160 tons, but would be thought too low for a 10- or 20-tonner with the assumed traffic pattern. If the design of the craft and the hoverport are such that the minimum turn-round time is not 5 min but 10 min, then the passenger fares on all the routes must be increased by 2s 6d, and the car fares by 15s.

This underlines the importance of turn-round time on short routes. But the real thing which puts up costs is slowing down to 10 knots when crossing a harbour or getting out of a river. Without speed restriction and with minimum manoeuvre time, the Southampton–Cowes passenger fare would come down in the ratio 12/7 to 8/7, and the travelling time from 19 min to 11 min.

Table II compares three possible routes across the Straits of Dover. Here again the choice of a long route or one involving harbours affects the fare profoundly. The presence of other traffic and the restricted space in a harbour also increase the manoeuvring time and therefore the costs. The car passenger would prefer not to thread his way through the congested streets of a harbour town, and would not do so if he were offered a hoverport out of town. Again, if the minimum turn-round time is 10 min, then passenger fares must be increased by 2s 6d and car fares by 15s on each of the routes. A different traffic pattern and other factors will of course affect the actual fares, but this does not invalidate the relative merits of the various routes.

Table III looks at three routes farther down the Channel, from England to the Cherbourg peninsula. Convention would say that Southampton to Cherbourg Harbour is the proper route. However, cars are mobile, and therefore passenger/car hoverports can be put anywhere, and a much shorter route can be found by siting one end near Swanage and the other at the nearest suitable point on the Cherbourg peninsula. This route is 44 nautical miles shorter than the Southampton–Cherbourg Harbour route, and, surprisingly, 14 nautical miles shorter even than the route from Newhaven to Dieppe. A hovercraft service from the Swanage peninsula to the Cherbourg peninsula would help to reduce the congestion at the eastern end of the Channel. Experience to date seems to show that hoverferries have considerable passenger appeal, and therefore the traffic pattern for a hoverferry in competition with ship ferries is likely to be more favourable than the overall traffic pattern of the route, due to "creaming". This may mask for some years the unsuitability of a particular route for a hoverferry service.

The conclusion, however, seems plain. Hovercraft car ferries should be run, not from port to port, but from promontory to promontory.

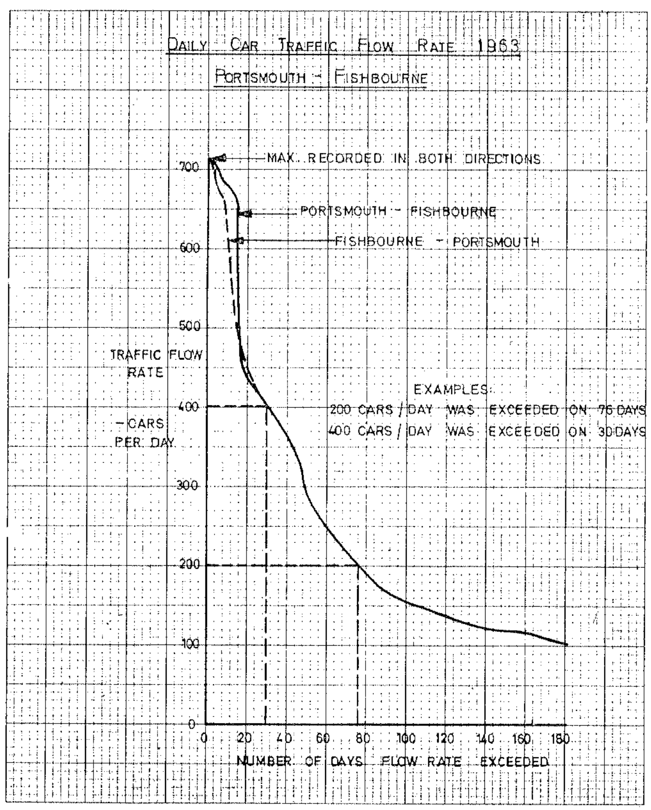


Figure 1

TABLE I — SOLENT ROUTES

	Gosport Beach to Ryde West Distance nm	Time min	*Portsmouth Harbour to Ryde West* Distance nm	Time min	*Portsmouth Harbour to Fishbourne* Distance nm	Time min	*Southampton (Itchen) to Cowes Harbour* Distance nm	Time min
Manoeuvre time, first end ...		0.5		1.0		1.0		1.0
Harbour/river at 10 knots ...	—	—	0.6	3.5	0.6	3.5	0.9	5.4
Acceleration distance	0.5	1.0	0.5	1.0	0.5	1.0	0.5	1.0
Cruise distance at 60 knots ...	2.1	2.1	3.2	3.2	4.2	4.2	7.7	7.7
De-acceleration distance	0.3	0.6	0.3	0.6	0.3	0.6	0.3	0.6
Harbour/river at 10 knots ...	—	—	—	—	0.2	1.2	0.4	2.5
Manoeuvre time, second end ...		0.5		0.5		1.0		1.0
Distance and journey time ...	2.9	4.7	4.6	9.8	5.8	12.5	9.8	19.2
Assumed turn-round time ...		5.0		5.0		5.0		5.0
Total trip time		9.7		14.8		17.5		24.2
Passenger fare ratios	5s 0d		7s 9d		9s 1d		12s 7d	
Car fare ratios	30s 0d		46s 6d		54s 6d		75s 0d	

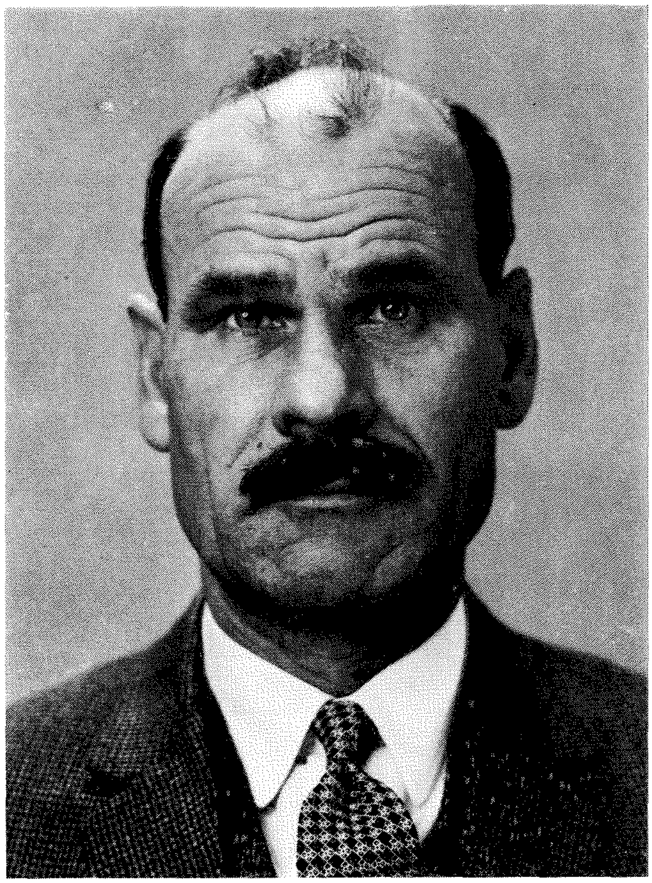
TABLE II — STRAITS OF DOVER ROUTES

	Ramsgate Harbour to Calais Harbour Distance nm	Time min	*Dover Harbour to Calais Harbour* Distance nm	Time min	*Best Channel Route* Distance nm	Time min
Manoeuvre time, first end		1.0		1.0		0.5
Harbour/river at 10 knots	0.2	1.3	0.7	4.1	—	—
Acceleration distance	0.5	1.0	0.5	1.0	0.5	1.0
Cruise distance at 60 knots	25.6	25.6	19.8	19.8	17.0	17.0
De-acceleration distance	0.3	0.6	0.3	0.6	0.3	0.6
Harbour/river at 10 knots	0.4	2.6	0.4	2.6	—	—
Manoeuvre time, second end ...		1.0		1.0		0.5
Distance and journey time	27.0	33.1	21.7	30.1	17.8	19.6
Assumed turn-round time		5.0		5.0		5.0
Total trip time		38.1		35.1		24.6
Passenger fare ratios	20s 0d		18s 3d		12s 9d	
Car fare ratios	120s 0d		109s 6d		76s 6d	

TABLE III — ENGLISH CHANNEL ROUTES

	Southampton (Itchen) to Cherbourg Harbour Distance nm	Time min	*Selsey Bill to Cherbourg Peninsula* Distance nm	Time min	*Swanage Peninsula to Cherbourg Peninsula* Distance nm	Time min
Manoeuvre time, first end		1.0		0.5		0.5
Harbour/river at 10 knots	0.9	5.4	—	—	—	—
Acceleration distance	0.5	1.0	0.5	1.0	0.5	1.0
Cruise distance at 60 knots	82.5	82.5	64.7	64.7	50.7	50.7
De-acceleration distance	0.3	0.6	0.3	0.6	0.3	0.6
Harbour/river at 10 knots	1.0	6.0	—	—	—	—
Manoeuvre time, second end ...		1.0		0.5		0.5
Distance and journey time	85.2	97.5	65.5	67.3	51.5	53.3
Assumed turn-round time		5.0		5.0		5.0
Total trip time		102.5		72.3		58.3
Passenger fare ratios	53s 0d		37s 6d		30s 6d	
Car fare ratios	318s 0d		225s 0d		183s 0d	

Westland Hovercraft Development



Mr Albert William Gregg was born in 1913 and educated at Roan School. In 1928 he was apprenticed to the RAF at Halton, became commissioned in the Technical Branch and served through most of the Second World War in the Department of the Air Member for Supply and Organisation at the Air Ministry. In 1946 he retired from the RAF. In 1947 he joined Normalair Ltd as Spares and Publication Officer. In 1959 he was appointed Public Relations Manager and Personal Assistant to the Managing Director of Westland Aircraft Ltd. In 1960 he was appointed Public Relations Manager to the Westland Group of Companies

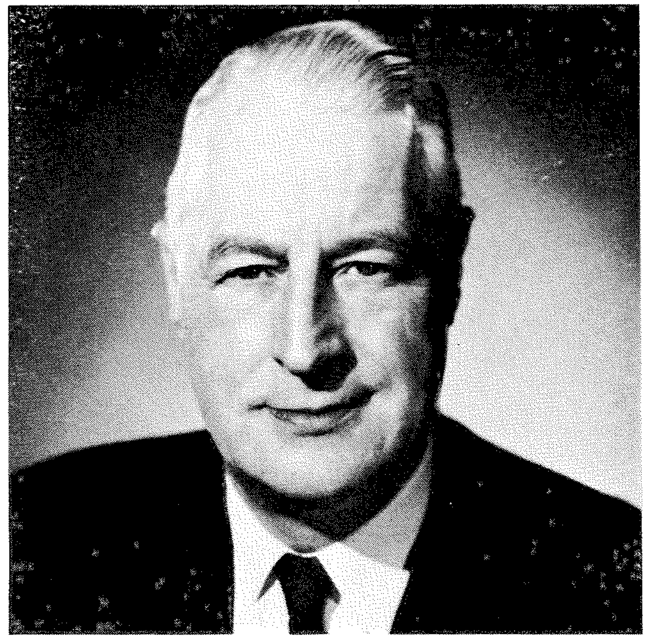
A. W. Gregg ARAeS, MIPR

FROM the outset, the Westland design philosophy has been squarely based on high speed coupled with amphibious capability. This combination has always seemed to offer by far the best prospects for successful commercial and military exploitation. Particular advantages are complete independence of the tide state and deep-water channels, and of costly dock and terminal facilities, which together give a new standard of operational flexibility.

This basic philosophy led naturally to the adoption of the flat-bottomed, annular-jet configuration. The experimental SR.N1 — Britain's very first hovercraft — quickly showed that the basic idea was sound. Within three months of being launched in May 1959, it made the first hovercraft crossing of the English Channel from Calais to Dover, to mark the fiftieth anniversary of the first cross-Channel flight.

Despite SR.N1's encouraging performance, Westland realised that, to be certain it was on the right lines, it would have to prove its design ideas in a craft more representative of the

Born in Carshalton, Surrey, Mr David Charles Collins, CEng, MIMechE, MIProdE, ARAeS, received his early engineering training at technical college. He first came into contact with the aircraft industry whilst completing his apprenticeship working on aero engines with T. H. England at Bristol. He subsequently worked for Gloster Aircraft for a short time before moving as Production Engineer to Blackburn Aircraft at Brough. In 1940 he joined the Fairey Aviation Co as Chief Planning Engineer, later becoming Deputy Manager and finally Manager of that company. In 1951 he accepted an invitation from Westland Aircraft Ltd to join the Board as Works Director, at the same time assuming similar responsibilities with respect to Normalair Ltd. Eight years later he became Deputy Managing Director of Westland and Managing Director of Normalair, and he still holds the latter post today. In 1965 he was appointed Managing Director of Westland, and in March of this year he also became Managing Director of the newly formed British Hovercraft Corporation Ltd. Mr Collins is a Council member of the SBAC and a Fellow of the Institute of Directors



Mr Edward Christian Wheeldon, CBE, CEng, MIProdE, FRAeS, is a Mancunian by birth and received his early engineering training at the Manchester College and Technology and with Metropolitan Vickers Ltd. He joined Westland Aircraft Ltd in 1938 as a planning engineer, later becoming Works Superintendent and then Works Manager. In 1944 he was appointed Works Director, a post he held until 1946, when he became Deputy Managing Director. Four years later, as Westland helicopter production really started to get under way, Mr Wheeldon became Managing Director, assuming additional responsibilities in 1960 as Deputy Chairman. In 1965, whilst retaining the latter position, he was appointed Chief Executive of the company, a post he holds today. Apart from helicopters, Mr Wheeldon has played a crucial role in establishing Westland as a world leader in the development and commercial exploitation of hovercraft. On the formation of the British Hovercraft Corporation this year, he was appointed Chairman of the new company, in which Westland has a 65% interest. In addition, he is Chairman of two wholly owned Westland subsidiaries, Normalair Ltd and Westland Engineers Ltd. Since 1950 he has served on the SBAC Council. He has also been a member of the Society's Management Committee since 1960. For the year 1964-65 he served as President of the SBAC, and is now Deputy President until his term of office ends on June 30th of this year. In addition, he is a long-standing member of the Institute of Production Engineers and is also a Fellow of the Institute of Directors

50-ton vehicle then thought to be the minimum size for efficient commercial operation. Already, the company was working on the assumption that this new form of transportation would probably have to get on its feet commercially, rather than through military programmes.

To avoid the obvious risks of jumping straight from a small research craft to a 50-ton vehicle, it was decided to build the smallest craft which could carry the major systems projected for the larger craft the company already had in mind. The result was the 27-ton SR.N2, which was launched on January 8th, 1962.

After intensive basic development trials, Westland decided to obtain certification to carry fare-paying passengers, so that operational experience could be built up as quickly as possible. In August 1962 an experimental passenger service was operated jointly with Southdown Motor Services Ltd between Southsea and Ryde, Isle of Wight. The invaluable operational experience gained was later significantly increased by the operation of passenger services across the Bristol Channel in 1963, and across the Solent in 1964.

Analysis of the 1962 cross-Solent service pointed to the need for a slightly larger machine for commercial operation, and the 37-ton, 150-passenger SR.N2 Mk 2 was developed. A military version of this craft — the SR.N3 — was ordered by the Ministry of Defence in March 1963, and delivered to the Inter-Service Hovercraft Trials Unit at Lee-on-Solent in June 1964 for thorough evaluation in possible Navy, Army and Air Force roles. It remains, incidentally, the largest hovercraft so far produced anywhere.

A Vital Breakthrough

At this stage the trend was towards a gradual increase in craft size, but while the SR.N2 programme was in full swing, research of the greatest future significance was going on with SR.N1. During the early SR.N1 trials, Westland designers had seen a possibility of achieving great improvements in over-wave and obstacle-clearance capability by the use of flexible skirts, without increases in either vehicle size or installed power. Sufficient progress had been made by the time SR.N2 was launched for it to be fitted with 2 ft skirts, which had much to do with the exceptional smoothness referred to time and again by passengers on the experimental services.

Mr Richard Stanton Jones was born in 1926 and educated at King's College, Cambridge, where he obtained an MA degree, and the College of Aeronautics, Cranfield, where he was awarded a Diploma with distinction. In 1949 he worked for de Havilland Aircraft for a short time before joining Saunders-Roe in 1950 as Senior Aerodynamicist. Subsequently he took charge of the High Speed Section of the Aerodynamics Department and in 1955 he was appointed Deputy Chief Aerodynamicist. He then spent a short period in the USA before returning to Saunders-Roe in 1956 as Chief Aerodynamicist. Two years later he was appointed Deputy Chief Designer, whilst retaining his previous title, and in 1959 he became Chief Designer. When Westland took over Saunders-Roe, Mr Stanton Jones continued to hold this position and in 1964 he assumed additional responsibilities as a Special Director. On the formation of the British Hovercraft Corporation he was appointed Technical Director of the new company

In the autumn of 1962 the real breakthrough was achieved with the successful testing of 4 ft skirts on SR.N1. A major effect of this — apart from the performance improvements already mentioned — was that small hovercraft were, for the first time, a commercial proposition. Their commercial attraction as a way of getting hovercraft services started without the need for large capital investment was obvious, and Westland immediately started work on the 7-ton, 18-passenger SR.N5. As the design reached its final stages, the company felt so confident of future prospects that, in August 1963, it decided to set up the world's first hovercraft production line without waiting for orders.

The first SR.N5 came off the line in April 1964, and by the end of June had received an Air Registration Board permit to carry fare-paying passengers. On the very day this permit was received, SR.N5 was put on to the cross-Solent service then being operated with the SR.N2. In the two remaining months of the service it carried some 10,000 passengers, with a maximum in one day of over 500, and achieved an outstanding reliability record. On many occasions it operated for eight or nine hours without the engine being stopped.

Before long, orders were coming in and during 1965 SR.N5s began operating commercially in the United States, Japan, Federal Germany, Brunei and Norway. Three SR.N5s are also in service with the British Inter-Service Hovercraft Trials Unit, and throughout 1965 two of these craft were engaged on intensive operational trials in the Far East, with results which the Minister of Defence has described as "most promising".

Mr Walter Oppenheimer, FCA, was born in 1914 and practised as a Chartered Accountant before joining Westland Aircraft Ltd as Financial Adviser in 1953. He was appointed Finance Director in the same year and in 1960 became Assistant Managing Director (Financial) of the company. He is now Assistant Managing Director (Financial) of the British Hovercraft Corporation

Mr Arthur N. Street first joined Saunders-Roe Ltd as an engineering apprentice at Eastleigh in 1938, receiving part-time education at the University of Southampton. By progressive promotion he achieved the position of Works Superintendent of the Eastleigh plant by 1952, and in 1959 he was appointed Works Manager. After the take-over of Saunders-Roe by Westland he continued in this capacity until the closure of Eastleigh in 1962, when he moved to Cowes as Production Manager. In 1963 Mr Street became Works Manager, the post he now holds with the British Hovercraft Corporation Ltd

Mr Eric Francis Gilberthorpe, MIMechE, MIProdE, MBIM, received his early engineering training at the Derby College of Technology and served his apprenticeship with Rolls-Royce Ltd. With the latter company he held a variety of managerial posts before joining Bristol Aircraft Ltd in 1953, where he became Production Manager, Production Engineering Manager and finally Experimental Manager. In 1959 he became Manager of that company's Helicopter Division and continued to hold this post after the take-over by Westland until 1962, when he moved to Cowes as General Manager of Westland's Saunders-Roe Division. In 1964 he was appointed a Special Director, whilst retaining his previous title, and with the formation of the British Hovercraft Corporation Ltd he assumed additional responsibilities as Works Director of the new company

Before joining Saunders-Roe Ltd in 1958, Lieut-Cdr Peter Melville Lamb had a distinguished career in the Fleet Air Arm. During the later years of the war he flew with 807 and 808 Squadrons in the Mediterranean and with 800 Squadron in the Far East. Afterwards he completed advanced courses at the School of Naval Air Warfare and Empire Air Navigation School to qualify as an instructor. In 1950 he flew as Senior Pilot with 800 Squadron in Korea and was awarded the DSC. He then completed No 10 Course at ETPS and became Senior Pilot of the Naval Test Squadron at Boscombe Down from 1952 to 1954, during which time he received the AFC. From 1955 to 1957 he commanded 810 Squadron and received a Bar to his DSC after the Suez operations. He subsequently took over command of 700 (Test and Trials) Squadron before joining Saunders-Roe as a test pilot. In 1955 he became Chief Test Pilot and continued to work in this capacity after the take-over by Westland. In recent years he has been concerned exclusively with hovercraft, and on the formation of the British Hovercraft Corporation assumed responsibilities for the testing of all BHC development and production craft as Chief Hovercraft Commander

In early 1965, Westland put into production the 38-seat SR.N6, which uses the same major systems as SR.N5 and utilises to the full the considerable experience gained with the smaller machine. SR.N6's greater carrying capacity, achieved with no significant loss of performance, has proved attractive to potential operators, particularly in the overwater ferry role in which they have so far shown by far the greatest interest.

Contracts for ten SR.N6s have so far been placed, and the type has already seen commercial service in Norway, Denmark, Brunei, Scotland and England. Well over 160,000 passengers have to date been carried on the regular SR.N6 service being operated by Hovertravel Ltd between Southsea and Gosport on the South Coast of England and Ryde in the Isle of Wight. At the end of April this year, two SR.N6 services opened across the English Channel, one operated by Hoverlloyd between Ramsgate and Calais and the other by Townsend Car Ferries Ltd between Dover and Calais.

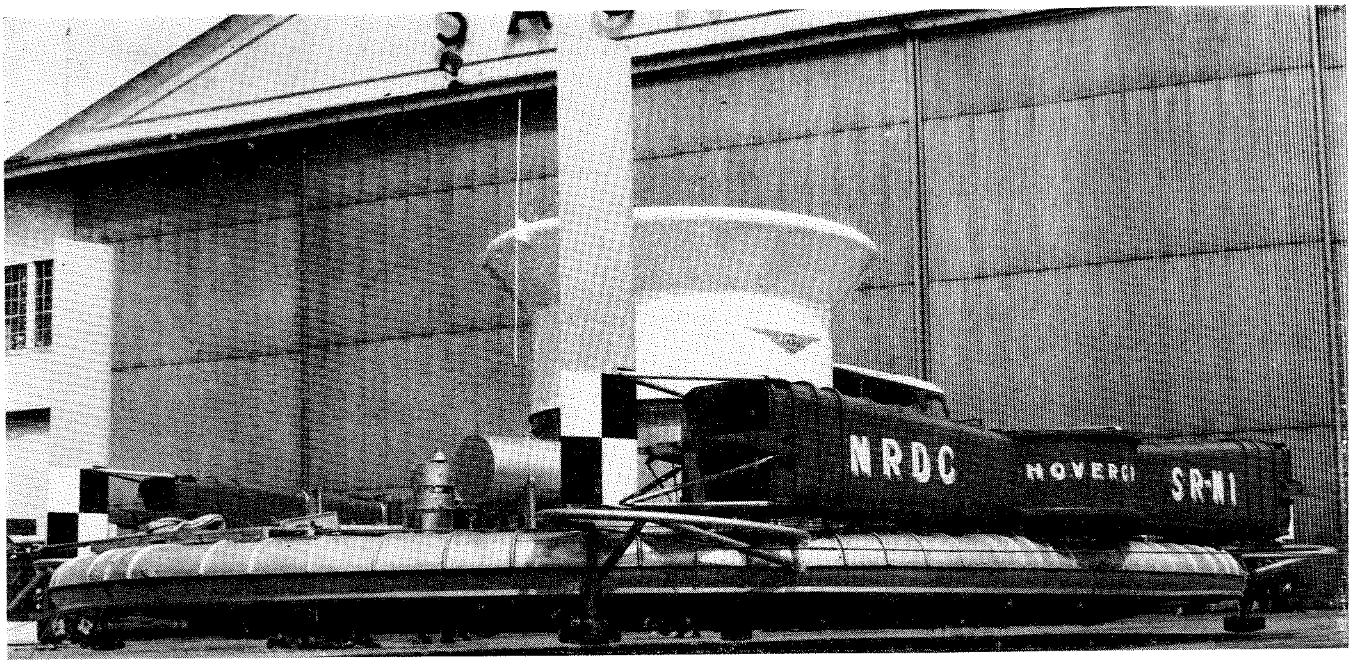
Total SR.N5/SR.N6 orders now cover twenty-four craft and the current production commitment is for a total of forty SR.N5 and SR.N6

Cross-Channel Ferries

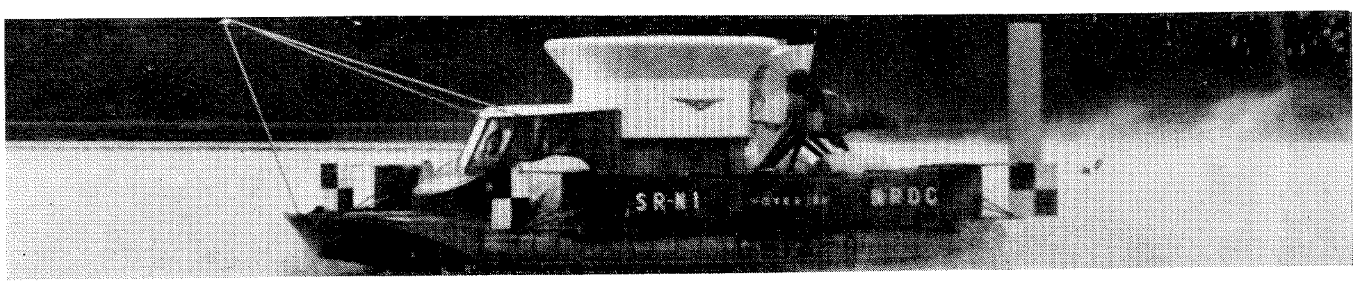
For all this, the need for a larger craft for year-round operation on such routes as the English Channel has been kept well in mind. In February 1964, Westland published detailed proposals for hovercraft ferry links across the English Channel, using the 160-ton SR.N4 passenger/vehicle hovercraft. An order for two SR.N4s was placed jointly by Swedish Lloyd Steamship Co and Swedish American Line in June 1965. These Swedish companies plan to open the first hovercraft passenger/vehicle ferry service across the English Channel, between Ramsgate and Calais, in 1968. It will be operated by Hoverlloyd. SR.N4 production is well under way, and the first craft is scheduled to begin its trials in 1967. Already, Westland is having serious discussions with several other possible SR.N4 operators in the UK and overseas, and British Rail have publicly announced their intention to operate an SR.N4 in the Solent area in 1968.

As was foreseen by the company, its hovercraft have, until now, made their way most rapidly in the commercial field. The very real military possibilities for this new vehicle have not, however, been neglected. As mentioned earlier, the 37-ton SR.N3 and the 7-ton SR.N5 are in service with the British Armed Forces. Westland has also been actively engaged in Government-sponsored project studies for a large hovercraft for military use. This can be viewed as an interim stage in the development of military hovercraft, as the technical feasibility of, say, a 90 knot frigate of around 1,000 tons gross weight is even now accepted. In the United States, the US Navy has three Westland-built SR.N5s under evaluation. Reports indicate that they may shortly be going to Vietnam for operational trials.

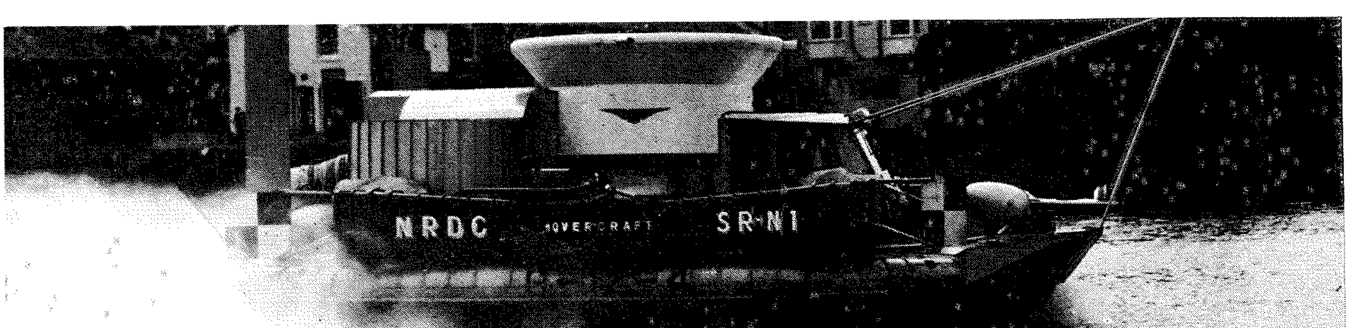
Westland hovercraft have now amassed more than 11,000 hours of operations — a figure unrivalled by any other manufacturer. This unique experience, which covers craft ranging in size from 4 tons to 37 tons, will provide an invaluable basis for the future development of both civil and military hovercraft by the recently formed British Hovercraft Corporation, in which Westland has the major holding.



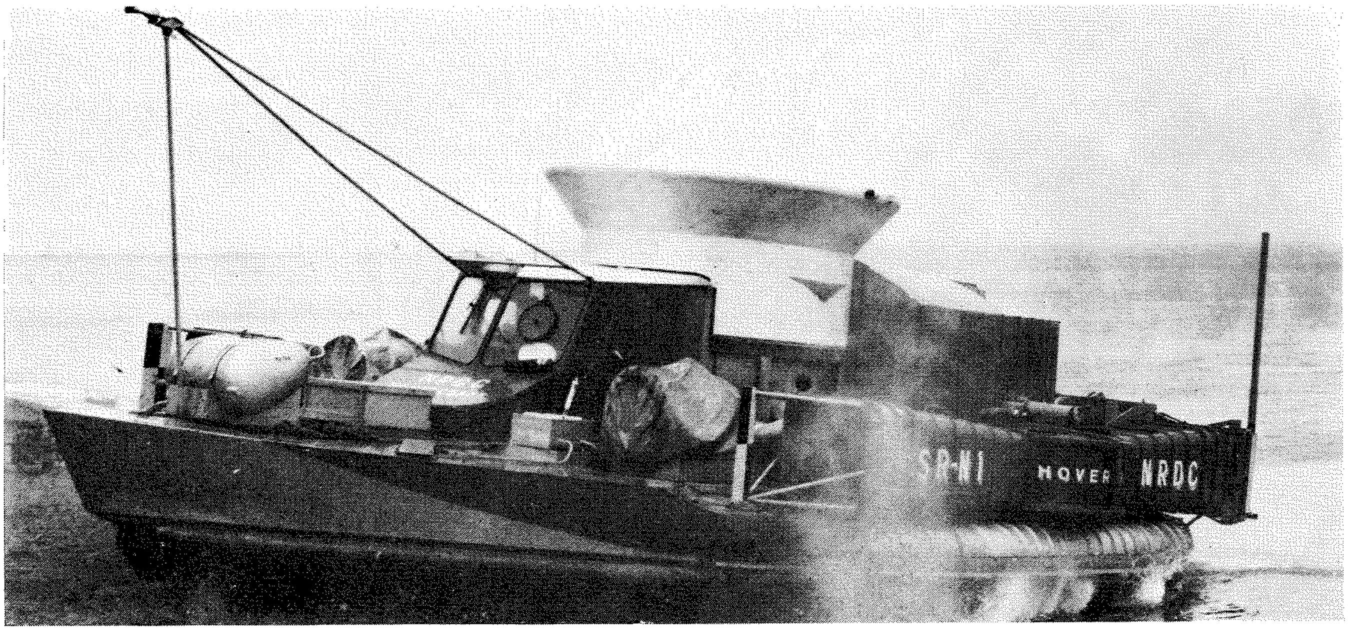
SR.N1 Mk 1 (May 1959 to April 1960)



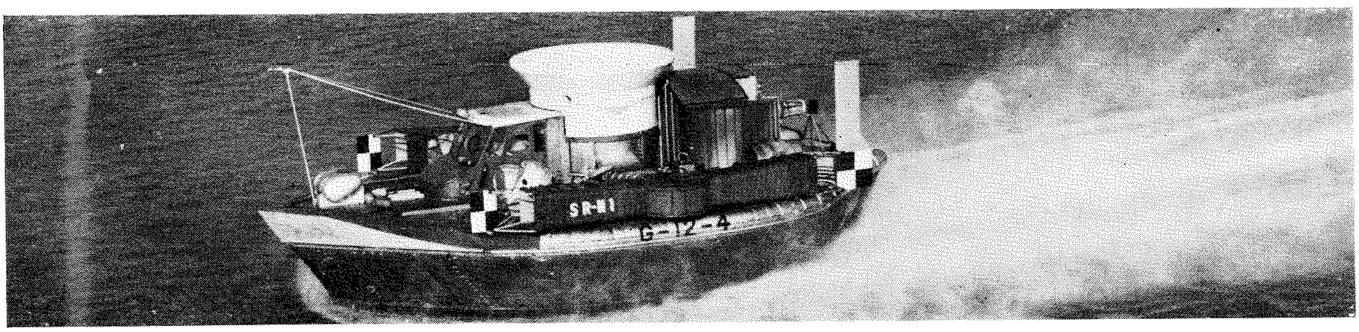
SR.N1 Mk 2 (April 1960 to June 1961)



SR.N1 Mk 3 (June 1961 to September 1961)



SR.N1 Mk 4 (October 1961 to 1962)

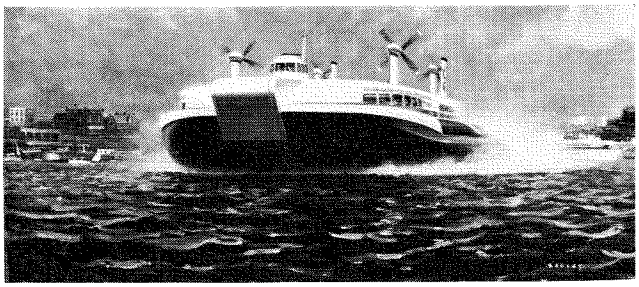


SR.N1 Mk 5. During the development of SR.N2, SR.N1 was fitted with 4 ft skirts (Mk 5). Hoverheight was increased and the development was of paramount importance in the whole development of hovercraft

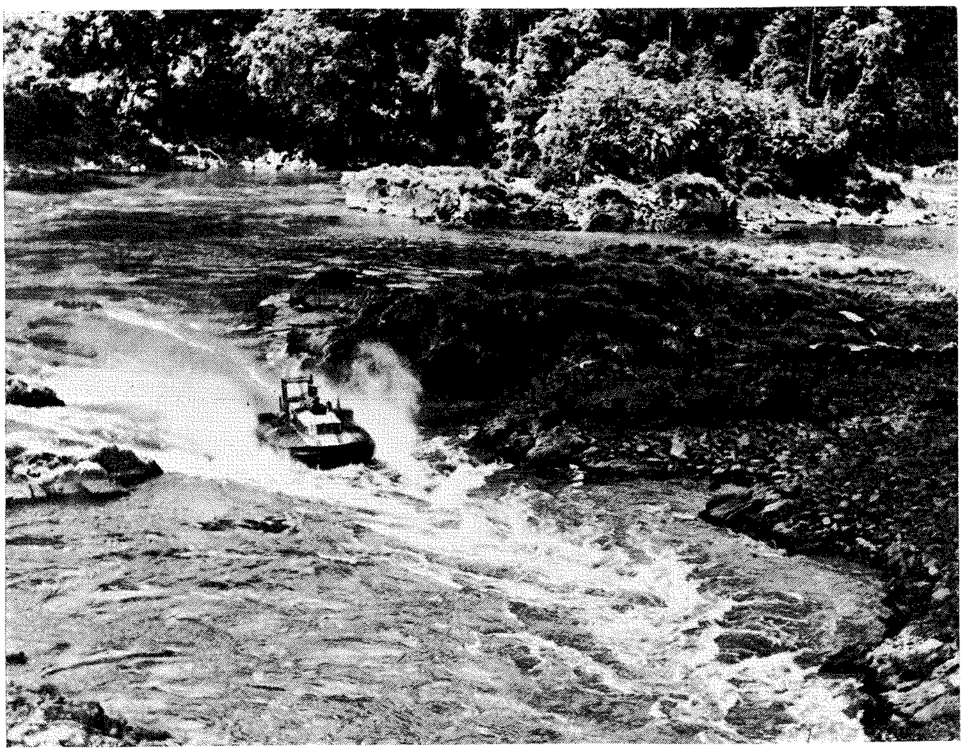
SR.N2 at the Penarth terminal during the experimental passenger service operated across the Bristol Channel to Weston-super-Mare during the summer of 1963. The picture clearly shows the very limited space needed for a hovercraft terminal

The 37-ton SR.N3 ashore at an Army training area in the British Inter-Service Hovercraft Trials Unit for military evaluation. The hovercraft's advantage over conventional landing craft is strikingly illustrated by this picture

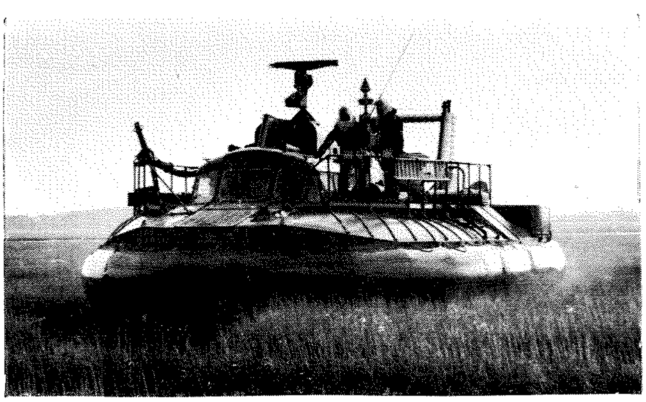
The SR.N3 at speed on the Solent. Since June 1964 it has been undergoing exhaustive evaluation in a number of possible overwater and amphibious roles



An artist's impression of the 160-ton SR.N4 ordered by Hover-lloyd for the first hovercraft passenger/car ferry service across the Channel, scheduled to start in 1968



In October 1965 the SR.N5 of the British Inter-Service Hovercraft Trials Unit took part in extensive Far East trials among the rapids of the twisting jungle rivers Rajang and Batang Balui in Malaysian Borneo. During the trials a journey of 112 miles was covered in 2½ hours. The picture shows the craft negotiating the narrow and dangerous rapids near Sibu



SR.N5 of the British Inter-Service Hovercraft Trials Unit operating over marshland in Southern England during recent trials in the rescue role

SR.N6

THE SR.N1 HOVERCRAFT GENERAL NOTES

The completion of the SR.N1 hovercraft G-12-4 on May 28th, 1959, marked the beginning of a new era in the field of transportation. Designed and developed by the Saunders-Roe Division of Westland Aircraft Ltd under contract to the National Research Development Corporation, the SR.N1 was the first hovercraft to be built anywhere in the world which was large enough for operational use as a research and development vehicle.

Since its completion there have been five marks, each representing a development stage of the same craft.

SR.N1 Mk 1 (May 1959 to April 1960)

Power-plant: Alvis Leonides air-cooled radial engine (used both for lift and propulsion). Propulsion was effected by bleeding air from the fan to truncated ducting on the port and starboard sides of the craft.

All-up weight: Originally 7,500 lb, increasing to 8,500 lb.

Maximum speed (ISA conditions): 25 knots.

Operational hoverheight: 8.7 in, reducing to 7.6 in (8,500 lb AUW).

SR.N1 Mk 2 (April 1960 to June 1961)

Power-plant: Alvis Leonides air-cooled radial engine (lift fan); Blackburn Marbore jet turbine (propulsion).

All-up weight: 11,150 lb, increasing to 12,350 lb.

Maximum speed (ISA conditions): 44 knots.

Operational hoverheight: 12.2 in (12,350 lb AUW), achieved with 15 in trunks (early form of flexible skirt).

SR.N1 Mk 3 (June 1961 to September 1961)

Power-plant: Alvis Leonides air-cooled radial engine (lift fan); Bristol Siddeley Viper jet turbine (propulsion).

All-up weight: 13,250 lb, increasing to 13,750 lb.

Maximum speed (ISA conditions): 64 knots.

Operational hoverheight: 11.4 in (with modified trunks).

SR.N1 Mk 4 (October 1961 to 1962)

Power-plant: Alvis Leonides air-cooled radial engine (lift fan); Bristol Siddeley Viper jet turbine (propulsion).

All-up weight: 14,250 lb.

Maximum speed (ISA conditions): 66 knots.

Operational hoverheight: 13 in (with bow and stern extension 17 in trunks).

SR.N1 Mk 5

During the development of SR.N2, SR.N1 Mk 4 was fitted with 4 ft skirts (Mk 5).

Although this had the effect of reducing maximum speed to 50+ knots owing to additional weight, hoverheight was considerably increased.

This development was of paramount importance and represented a major breakthrough in the development of hovercraft as a realistic form of transport.

SR.N1 Mk 5 achieved the following performances during trials fitted with 4 ft skirts:

1. A 3 ft 6 in rock groyne was negotiated without difficulty at 30 knots.
2. Negotiated 6 ft saplings and gorse at 15 knots.
3. Crossed saltings with gullies 4 ft deep and 20 ft wide at 35 knots.
4. Operated over short cross-seas 4-5 ft high at 20 knots.
5. Cleared steep banks topped by a 2 ft wall at 10 knots.

In over 400 hours of operation with skirts, the rubberised fabric showed negligible wear or deterioration.

WESTLAND SR.N2 Leading Particulars

Dimensions

Overall length	65 ft 3 in (19,9 m)
Overall beam	29 ft 6 in (9,0 m)
On landing pads:	
Overall height (over fin) ...	24 ft 9 in (7,54 m)
Height to top of cabin superstructure	12 ft 3 in (3,75 m)
Passenger cabin size (max dimensions)	22 ft × 15 ft 6 in (6,7 m × 4,72 m)
Freight doors:	
Height	5 ft 3 in (1,62m)
Width	7 ft 6 in (2,29 m)

Power-plant and Systems

Engines	Four Bristol Siddeley Nimbus free turbines, 815 shp max continuous power
Propellers	Two, four-bladed, 10 ft (3,05 m) dia variable pitch
Lifting fans	Two, 12 ft 6 in (3,81 m) dia centrifugal
Fuel	Standard kerosene
Fuel capacity	946 gall (4 300 litres) in four tanks
Transmission oil capacity (per system, 2 off)	10 gall (45,5 litres) (total) 6 gall (27,27 litres) (tank)
Engine oil capacity (per engine, 4 off)	13 pints (7,39 litres) (total) 11 pints (6,25 litres) (tank)

Weight Summary

The weights for each of the four basic layouts, namely, the first class, high density and commuter passenger versions and the freight versions, are very similar, and can be summarised as follows:

Basic weight	15.47 to 16.23 tons	(15,72 to 16,5 tonnes)
Passengers	5.0 to 5.78 tons	(5,08 to 5,87 tonnes)
Freight	8.0 to 10.0 tons*	(8,13 to 10,16 tonnes)
Fuel	3.5 tons	(3,56 tonnes)
All-up weight	24.5 to 27.0 tons	(24,9 to 27,43 tonnes)

* This range is obtained by reducing the fuel load proportionately

Typical Uses

Passenger ferry
Freight carrier
High-speed rescue craft
River and coastal police launch
Inland waterway weed and pest control craft
High-speed supply craft or tanker for ships and off-shore works
Geophysical survey and exploration craft where terrain permits
Mobile clinic or hospital

WESTLAND SR.N3 Leading Particulars

Dimensions

Overall length	77 ft 0 in
Overall beam	30 ft 6 in
Overall height — on ground handling wheels	32 ft 0 in
Freight door aperture:	
Cabin wall	10 ft 6 in × 6 ft 8 in
Cabin roof	10 ft 6 in × 7 ft 7 in

Power-plant System

Engines:	
Main	Four Bristol Siddeley Marine Gnome
Marine	Two Rover gas turbine — 2S/150/SR driving two retractable Schottel steering units

Propellers:

Main	Two Dowty Rotol variable pitch, 10 ft dia
Marine	Two Troost
Lifting fans	Two Westland centrifugal, 12 ft 6 in
Fuel	Kerosene
Fuel capacity	2,700 Imp gall, 270 Imp gall reserve

Performance (AUW 37 tons)

Max speed	70 knots
Endurance	9½ hours
Gradient at static conditions ...	1:10
Gardient with run	1:6
Wave clearance at 50 knots ...	5 ft

Obstacle Performance

Max height of step or wall ... 3 ft 6 in

Ditches up to 20 ft wide can be crossed at 40 knots

WESTLAND SR.N4 Leading Particulars

Dimensions

Overall length	128 ft 6 in (39,2 m)
Overall beam	75 ft 0 in (22,8 m)
Overall height on landing pads	36 ft 8 in (11,16 m)
Passenger/vehicle floor area ...	5,800 sq ft (539 sq m)
Vehicle deck headroom (on centre line)	11 ft 6 in (3,51 m)
Bow ramp aperture (height × width)	11 ft 6 in × 18 ft 0 in (3,51 m × 5,48 m)
Stern door aperture	31 ft 0 in × 11 ft 6 in (9,45 m × 3,51 m)
Skirt length — basic craft ...	About 6 ft 0 in (1,83 m)

Power-plant and Systems

Main engines	Four Bristol Siddeley Marine Proteus
Max continuous rating at ISAC	4 × 3,400 hp (4 × 3 447 cv)
Auxiliary power units	Two Rover IS/90 gas turbines
Propellers	Four four-blade, variable pitch, 19 ft dia (5,79 m)
Lift fans	Four Westland centrifugal 11 ft 6 in dia (3,5 m)
Fuel capacity	4,500 Imp gall (20 456 litres)

Weights

Disposable weight	66 tons (67 000 kg)
Normal gross weight	160 tons (162 500 kg)
Max gross weight	180 tons (183 000 kg)

Performance (at 160 tons normal gross weight) under ISA conditions

Max still air speed over calm water (max power)	77 knots (148 km/hr)
Max speed over calm water (max continuous power) ...	70 knots (133 km/hr)
Speed in 4-5 ft waves	55-65 knots (102-120 km/hr)
Speed in 8-10 ft waves	20-30 knots (37-56 km/hr)
Still air range	290 nm (540 km)

WESTLAND SR.N5 Leading Particulars

Dimensions

Overall length	38 ft 9 in (11,78 m)
Overall beam	23 ft 0 in (7,01 m)
Overall height on pads ...	12 ft 11 in (3,96 m)

Weights

Basic weight	4.06 tons (4 124 kg)
Normal gross weight	6.57 tons (6 686 kg)

Power-plant and Systems

Engine	One Bristol Siddeley Marine Gnome engine, 900 shp max cont power
Propeller	Dowty Rotol four-blade variable pitch, 9 ft dia (2,74 m)
Lift fan	Westland centrifugal 7 ft dia (2,13 m)
Fuel	Standard kerosene
Fuel capacity	265 Imp gall (1 205 litres)

Performance

Max speed over calm water (max power)	66 knots
Max speed over calm water (max cont power)	62 knots
Calm water practical range ...	205 nm
Endurance at max cont power	3.6 hours
Max gradient at static conditions	1:6

Typical Uses

Passenger ferry
Utility freight carrier
High-speed search and rescue craft
Weed and pest control
Survey and exploration craft
Logistic support military craft

WESTLAND SR.N6 Leading Particulars

Dimensions

Overall length	48 ft 5 in (14,76 m)
Overall beam	23 ft 0 in (7,01 m)
Overall height on landing pads	15 ft 0 in (4,57 m)
Cabin size (length × beam) ...	21 ft 9 in × 7 ft 8 in (6,62 m × 2,34 m)
Cabin floor area	166 sq ft (15,42 sq m)
Door aperture size (height × width)	5 ft 9 in × 3 ft 3 in (1,75 m × 0,99 m)
Skirt length	4 ft 0 in (1,22 m)

Power-plant and Systems

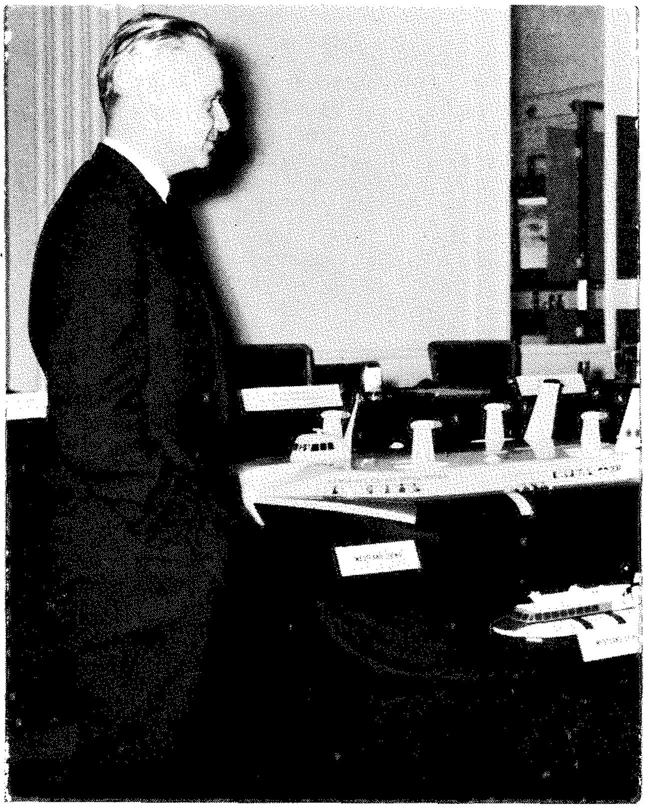
Engine	Bristol Siddeley Marine Gnome 1051
Max cont rating at ISA ...	900 hp
Propeller	Dowty Rotol, four-blade, variable pitch, 9 ft dia (2,74 m)
Lift fan	Westland centrifugal 7 ft dia (2,13 m)
Fuel capacity	265 Imp gall (1 205 litres)

Weights

Normal gross weight	9.12 tons (9 253 kg)
Max gross weight	10.3 tons (10 433 kg)

Performance (at 17,000 lb operating weight [7 711 kg] under ISA conditions)

Max speed over calm water (max power)	59 knots (109 km/hr)
Max speed over calm water (max cont power) ...	56 knots (105 km/hr)
Speed in 4-5 ft waves	36-49 knots (67-91 km/hr)
Still air range	200 nm (370 km)



Mr R. F. "Bill" Bailey was born in London in 1922 and educated at Rutlish School, Merton. From 1941 to 1947 he was a pilot in the RAF and served with Flying Training and Transport Commands in Canada, USA, Australia, Philippines, Singapore and UK. He attained the rank of Squadron Leader. From 1947 to 1951 he was engaged in Customer Relations for Shell Petroleum Co and from 1951 to 1953 he was an instructor at civil-operated RAF flying schools. From 1953 to 1959 he was Publicity Assistant at Normalair Ltd and thereafter Assistant Publicity Manager for Woods of Colchester. In April 1959 he became Assistant Group Public Relations Manager at Westland Aircraft Ltd and in May 1966 he was appointed Public Relations Manager of the British Hovercraft Corporation

SR.N2 in Canada

F. R. Bailey MIPR

"I WAS riding on air" ran the headline in a Canadian newspaper on a day early in May 1963 — and the writer meant it quite literally. The story described a ride taken the previous day by the paper's aviation reporter on the Westland SR.N2 hovercraft, on the opening day of a two-week demonstration programme in Montreal. He described the ride "like flying in an airplane, sailing in a luxury cruiser and driving in a car — all at the same time", and his impressions were to be echoed over and over by the 1,300 visitors who were later given their first experience of riding on air.

The demonstration achieved two "firsts" in one. As well as being the first overseas tour by what was then the world's most advanced hovercraft, it was also the first ever given by any hovercraft in Canada. SR.N2 was based throughout its stay at the Royal St Lawrence Yacht Club, Dorval, where the most generous facilities had been made available through the courtesy of the Commodore and members of the club. The compact harbour and slipway used could not better have highlighted the hovercraft's ability to operate safely in confined areas and to do without elaborate and costly docking facilities.

SR.N2 was shipped from the UK to Montreal aboard the Canadian Pacific cargo liner *Beaverfir*, and during its positioning trip from Montreal Harbour to the Yacht Club made history with the first high-speed crossing of the Lachine Rapids which have for more than 300 years been an impassable barrier to regular shipping on that stretch of the St Lawrence. The crossing was made without difficulty at a speed of well over 40 knots, and Westland test driver Harry Phillips afterwards commented: "Rapids? We just didn't know they were there."

The tour had been decided upon because of the exceptional interest in hovercraft even then being shown in Canada. This interest is easily understood, for there can be few, if any, countries as tailor-made as Canada for the world's newest transport vehicle. A long, severe winter season . . . vast tractless wastes of tundra and muskeg . . . scattered communities in remote undeveloped areas . . . large rivers and lakes, icebound for much of the year: all are conditions just made to measure for the hovercraft.

Hovercraft could revolutionise the pattern of Canadian transportation. In some industries, completely new systems could be introduced. Supplies for isolated coastal settlements could be delivered direct from ocean-going ships, eliminating a second trans-shipment at the shoreline. Oil, mineral and hydrographic surveys could be extended and speeded up by the more rapid and flexible deployment of men and equipment. Areas now difficult to reach over land could be opened up, in many cases enabling vast untapped mineral wealth to be exploited. With their unique amphibious capability, hovercraft would be invaluable as fast rescue vessels in coastal areas along rivers and on inland lakes.

Some 1,300 important civil and military guests converged on Montreal from literally all points of the globe. Federal and Provincial Government representatives came from every corner of Canada itself. The military Services of both the US and Canada sent large contingents, and top-ranking people from industry came from as far afield as South America and Japan.

The programme for each group of guests included a full-scale technical presentation of the latest Westland developments, in particular the then recent breakthrough with the successful testing of long flexible skirts. The vast improvement in both overwave and obstacle-clearance capability resulting from this breakthrough was of the greatest interest to many of the guests, who were only too familiar with the tremendous difficulties of transportation in difficult country.

In addition to this technical briefing, every guest took a trip in SR.N2 on the adjoining Lake St Louis. Not only was it possible to give them the exciting new experience of travelling up to 80 mph over water, but the handy availability of the odd island or two gave an excellent opportunity to demonstrate the hovercraft's unique amphibious capability. There were few visitors who were not openly impressed as SR.N2 headed for one of these islands at around 70 mph and, with never a bump or drop in speed, skimmed merrily straight across, completely disregarding scrub which in places was 2 ft or more high.

As to their overall reaction, there were clearly few, if any, who were not completely convinced that here was a new vehicle with outstanding capabilities and well-nigh limitless potential.

If there was one impression which stood out over others in the minds of the guests, it was the exceptional smoothness of the ride. Time and again people confessed to being most pleasantly surprised by the smooth comfort achieved at high speed, both over the sometimes quite choppy water of the lake and even more perhaps during the island crossings.

To round out the programme, SR.N2 made a series of crossings of the Lachine Rapids, in both directions and by several different routes, on its way back from Dorval to Montreal Harbour for return shipment to the UK. In the two weeks it was in Canada, the craft covered well over 500 miles.

The 27-ton, 70-passenger SR.N2 on the confined improvised slipway at the Royal St Lawrence Yacht Club, where it was based throughout its demonstration programme in Canada

The 27-ton, 70-passenger SR.N2 "shooting" the Lachine rapids at over 40 knots on its way from the port area of Montreal to the Royal St Lawrence Yacht Club

A REVIEW OF VICKERS HOVERCRAFT

D. R. Harris MBE

IN November 1959, Vickers-Armstrongs decided that their South Marston Works, at that time concerned with the last of the long line of Supermarine aircraft, should engage in the design and manufacture of hovercraft. Accordingly the company became associates of Hovercraft Development Ltd and acquired the technical data vested in the hovercraft patents.

The first Vickers research hovercraft, the VA-1, was built the following year, becoming operational in November 1960. For its initial trials overland, it was fitted with bare essentials only, and weighed 3,300 lb; but for protection on overwater trials a cabin and various fairings were added, increasing the weight to 3,500 lb. The VA-1, originally conceived as a test vehicle for a recirculation system, demonstrated at an early stage the technical difficulties likely to be encountered; and so it was converted to operate with a simple curtain instead of the recirculatory system. An extensive programme of tests was put in hand, investigating static stiffness characteristics, internal flows and control effectiveness. During its life, changes have been made affecting its appearance, its weight, its propulsion engine and even its ownership: it is now the property of the Ministry of Aviation. But although first-generation and thereby quite ancient in hovercraft terms, the useful life of this five-year-old veteran is not over yet.

The next step was the design and manufacture of second-generation craft. It was recognised at this stage of development that the next craft should be large enough to provide information relevant to the design of bigger craft for practical operations later on; but that, at the same time, it would be essential to have a craft of suitable size for transporting to distant trial areas in order to acquire experience in a variety of environments. To realise this double aim, it was decided to build two craft, the small VA-2 and the larger VA-3.

The VA-3 was completed first and began its trials in April 1962, starting on the airfield at South Marston, Wiltshire, and, a month later, transferring to the company's Itchen Works for trials on Southampton Water. But in less than three months it was to leave its base on the South Coast in order to be taken by ship for operational trials in the north-west. The trials were in the form of a service to carry twenty-four passengers across the estuary of the River Dee between Rhyl, Wales, and Wallasey, England. The service, operated by British United Airways with the active support of British Petroleum, began on July 20th, 1962, and was thus the world's first scheduled hovercraft service for fare-paying passengers. During the eight weeks which followed, the VA-3 travelled 3,500 miles and carried 3,765 passengers. Many of the passengers were holidaymakers from the neighbouring seaside resorts, but not unnaturally this first service drew visitors from all over the world. GPO mail was carried, with a special postmark to commemorate the event, and even some well-known vacuum cleaners. The primary objectives of the trial were to carry out an operational research programme to obtain practical experience of handling and maintenance in realistic conditions; to obtain experience of passenger handling and to assess their reactions; and to demonstrate to the public the safety-with-speed characteristics of hovercraft.

Mr D. R. Harris, MBE, Head of Sales, began as an auditor in 1942 but, having enlisted in 1944, he spent the next seventeen years in the Armed Forces. After a military career with a bias towards ground and air transport, he resigned his commission in 1961 and joined Vickers. Thereafter followed a year's training and experience in technical sales and then a posting to the Hovercraft Division

It would have been much easier, both for administration and for maintenance, to have operated a service in the vicinity of the works at Southampton; but the temptation to take the craft out of service back to the comprehensive maintenance organisation might have proved too strong. Instead, a bolder step was taken, the service being carried out some 200 miles away between two simple terminals located on open beaches. The terminals consisted of a caravan at each beach. The operational maintenance base, a workshop-caravan and a roped-off area of sand dunes, was at Rhyl, some two miles west of the terminal. Refuelling also took place at Rhyl from road tankers which were parked on the promenade. In these circumstances, divorced from the immediate support usually associated with the trials programme, the VA-3 was subjected to a severe test only three months after its first "hover".

The weather in Britain is often a source of disappointment, and the summer of 1962 proved no exception. The incidence of high winds and an accompanying build-up in wave height,

Mr A. E. Bingham, BSc(Tech), CEng, AMIMechE, AFRAeS, began as an apprentice in the Aircraft Division of English Electric in 1950. He transferred into mechanical engineering on flight development, being concerned with Canberra and Lightning prototypes. In 1956 he moved to Vickers-Armstrongs (Aircraft) Ltd as a design engineer, working on the Scimitar. His hovercraft career started in 1961 and in 1962 he was appointed as Chief Designer

Mr S. R. Hughes, AFRAeS, AFIAeS, Divisional Manager, began his aircraft career in 1932 as an apprentice with Saunders-Roe. In 1938 he joined the Supermarine Division of Vickers and later became Chief Aerodynamicist. During the Second World War he was associated with the development of the Spitfire and Seafire, followed by the jet aircraft Attacker and Swift. Appointed Chief Designer in 1959, he was associated with an aircraft programme which culminated in the Scimitar Naval strike aircraft. On the formation of the Hovercraft Division, he was appointed as Manager.

increasing to 4 or 5 ft, had a limiting effect on the operations from time to time. Naturally, passenger safety was of paramount importance; and in fact the Certificate of Construction and Performance issued by the Ministry of Aviation in conjunction with the Ministry of Transport stipulated the conditions under which the hovercraft could operate. Had more time been available for pre-scheduled trials, it is possible that experience would have shown that the VA-3 could have been operated without hazard in rougher weather.

Handling the craft in varying conditions of wind and water which would not ordinarily be experienced in the Solent was invaluable. There were constant changes in the coastal waters and, at low tides, in the exposed sand. In particular, the Dee has at least two areas of extremely deep water, so that although conditions may have been good at each terminal they were sometimes quite unsuitable at the mouth of the river, a factor not always apparent to the fare-paying public. Winds from the west or north of west were often an embarrassment: in fact almost all the cancellations imposed by the weather were because of westerly winds, blowing in from the open sea. On the other hand, quite strong southerly winds could be endured at low states of the tide. Winds from this direction only produced difficult sea conditions across the Dee estuary at high water.

In addition to the limitations imposed by the weather, the operating schedule was also affected by mechanical problems, almost all of which were connected with teething troubles with the engines. On the other hand, the structural integrity of the craft's frame and stability of the cushion were well proven. There is no doubt that the design philosophy and use of lightweight materials employed in VA-3 produced an extremely strong seaworthy craft capable of withstanding conditions much more severe than those assumed when the project was originally conceived. This was especially so when, after the conclusion of the trial, extremely high tides with waves up to 8 ft high were experienced. In these conditions, unusual for summer, the seaworthiness of the craft was thoroughly tested. It will be appreciated that, at this time, flexible skirts were not yet an integral part of the design of hovercraft.

Unfortunately, some passengers were inconvenienced by cancellations of service, most of which were attributed to either the weather or to mechanical faults in the engines. Despite this, passenger reaction was in the main enthusiastic, even among those whose schedule had been upset. Entering into the spirit of the operational trial, the comments of the passengers were quite forthright and their criticisms recorded on individual "passenger reaction forms" were usually constructive and certainly extremely helpful.

Immediately following the ending of the service, a combination of weather and engine troubles resulted in an incident involving the VA-3 in accidental damage. Unfortunate as this was, it did provide a most stringent test of strength for the structure of the craft. Both lift engines were out of action and it had been necessary to cancel the last two days' operations. VA-3 had had to be stationed on the open beach at Rhyl in readiness to move to Birkenhead Docks. Unfortunately, extremely high tides coincided with this, as a result of which VA-3 sustained a heavy pounding from the waves. It is a credit to the structural design that it withstood this punishment, but eventually on the night of Sunday, September 16th, with a Force 7 wind blowing, the moorings gave way, and before VA-3 was once again secured it had suffered some damage when striking the promenade wall. Consequently, it was necessary to return VA-3 to South Marston for repair.

In addition to the repairs, modifications were put in hand. These included the fitting of a 3 ft deep flexible skirt, the replacement of the two Turmo 603 free-turbine propulsion engines by two Artouste 2Cs, and the removal of the forward fins. The engines were changed so that the Turmos could be made available for lift power and the Artoustes, being fixed-shaft turbines, used for propulsion. The contribution which the forward fins made in providing side force was limited to a speed range in the higher end of the scale; and their effect was proportionately reduced when the addition of the flexible skirt increased the side area of the craft. It will be appreciated that part of the design philosophy was to incorporate various types of controls in order to test their effect; and among the systems,

Mr D. Tipping, MS(Aero), CEng, AMIMechE, AFRAeS, began his career in the aircraft industry in 1938 as an apprentice with Armstrong-Whitworth Aircraft. In 1944 he moved to Coventry Technical College for six years of lecturing in aerodynamics and allied subjects. This was followed by work of a more practical nature, including three years in Canada and five and a half in the USA; in this period he was concerned with the Brabazon, the Britannia and the Bristol Freighter, and a variety of executive aircraft, high-speed aircraft and missiles. He joined Vickers Hovercraft Division in 1962 as Chief Aerodynamicist, being responsible for all aspects of aerodynamics, hydrodynamics and craft dynamics

Mr G. V. Watts is Head of Structural Design. He joined Folland on design in 1939 and in 1943 moved to Gloster Aircraft, where he was employed on the structures including the Meteor. Two years later he was transferred to the Stress Office of Supermarine and remained with the company, eventually joining the Hovercraft Division on its formation

of which the forward fins were but one of several, the use of differential thrust from the variable-pitch propellers was proved to be the most effective.

In February 1964, after a test programme at its Southampton base, the VA-3 was shipped to New York to be operated by Republic Aerospace Corporation on extensive trials. The major part of the trials, which lasted until early the following year, was on behalf of the US Office of Naval Research. Initially based at Montauk, Long Island, NY, the VA-3 started with sea-keeping tests combined with a training programme for new drivers. Montauk was an ideal centre for a trials area. Situated on the Sound side of Long Island, it was near enough to the eastern tip for VA-3 to go into the more exposed waters of the Atlantic. Off Montauk Point there were tidal rips which created quite remarkable seas. Thus experience was obtained of operating in pure wind-generated waves in the Sound, in short steep waves in the rips, and in longer, higher waves and swells in the Atlantic. Not only that, there were beaches with excellent conditions for surfing later on in the programme, with extensive areas of sand dunes, marsh and reed within easy reach for testing and demonstration as the trials continued. The improvement in performance which resulted from the addition of flexible skirts was most marked. Whereas in 1962 3 ft waves were almost impossible, now the VA-3 was able to operate in waves measured up to 6 ft and, on occasions, estimated up to 8 ft high. Overland, the experience was equally exciting. It was now possible to drop down from 6 ft high sand cliffs without impacting the hard structure. Perhaps the outstanding contribution to the development of handling techniques made at Montauk was a phase concerned with operating on and off beaches through surf. The height of the surf at the point of breaking was estimated at between 8 and 10 ft. Riding in towards the beach on the surf was no particular problem. It was the return journey which might be described as adventurous, since at times the craft was pushed backwards by the force of the breaking waves.

Mr W. H. Bunting, AMIMechE, AFRAeS, started in 1934 as an apprentice in the gas industry but four years later moved to the aircraft industry, where he was employed on hydraulic design by Aircraft Components Ltd. In 1940 he moved again, this time to Supermarine as a draughtsman, being concerned with Spitfires and eventually the Attacker. He spent two years from 1946 with Airspeed, working on the Ambassador; and in 1948 returned to fighter aircraft activities with Vickers, including the Swift and the Scimitar. When, in 1959, the company began an active part in nuclear engineering, he was seconded to this work, but on the formation of the Hovercraft Division he set up the Project Office, eventually becoming its Head

Mr R. T. Old, Senior Hovercraft Captain, began his career in 1945 in the Merchant Navy, working his way up from midshipman to second officer. For his last nine months at sea he was the skipper of a sailing ship. But in 1955 he moved to a different environment, to become an aerodynamicist with the Gloster Aircraft Co. Three years later found him in Saunders-Roe, where he became Senior Flight Observer on prototype test flying in helicopters, including the first flight of a Scout. In 1961 he joined Vickers Hovercraft Division, to be concerned with the testing of the VA-1, VA-2 and VA-3. His 1,000 hours of hovercraft command have included a variety of environmental testing in Britain, Germany, Holland and Sweden

Left: Mr S. R. Hughes. Right: Mr L. R. Colquhoun, GM, DFC, DFM, forty-four-year-old ex-fighter pilot. In 1950 he won his George Medal when, during the testing of an Attacker aircraft, a wing folded during the flight. In spite of this he remained in the plane and landed it safely. Towards the end of the war he was seconded to Vickers as a Spitfire test pilot, and after the war he joined Vickers' staff as a test pilot. In 1961 he became Operations Manager responsible for hovercraft development and trials and was responsible for the testing of VA-1, VA-2 and VA-3 hovercraft

For the second part of the trials, the VA-3 was moved south to a new base at Norfolk, Virginia. Here the emphasis was on amphibious exercises and operations with a US Navy dock ship. Normally, the ship's dock would be flooded for such operations; but the hovercraft was able to enter the LSD *Fort Mandan* with its dock dry, while the ship proceeded at various speeds up to 15 knots. At higher speeds, the increased turbulence aft of the ship made it unwise to attempt the entry into what appeared to the driver to be a long dark box; having passed through the area of turbulence, the sudden decrease in drag would produce an alarming increase in speed. Having entered the dock, the propulsion engine layout of the VA-3 made it relatively simple to back out again.

At the conclusion of these trials, the VA-3 was returned to its base near Southampton in May 1965.

★

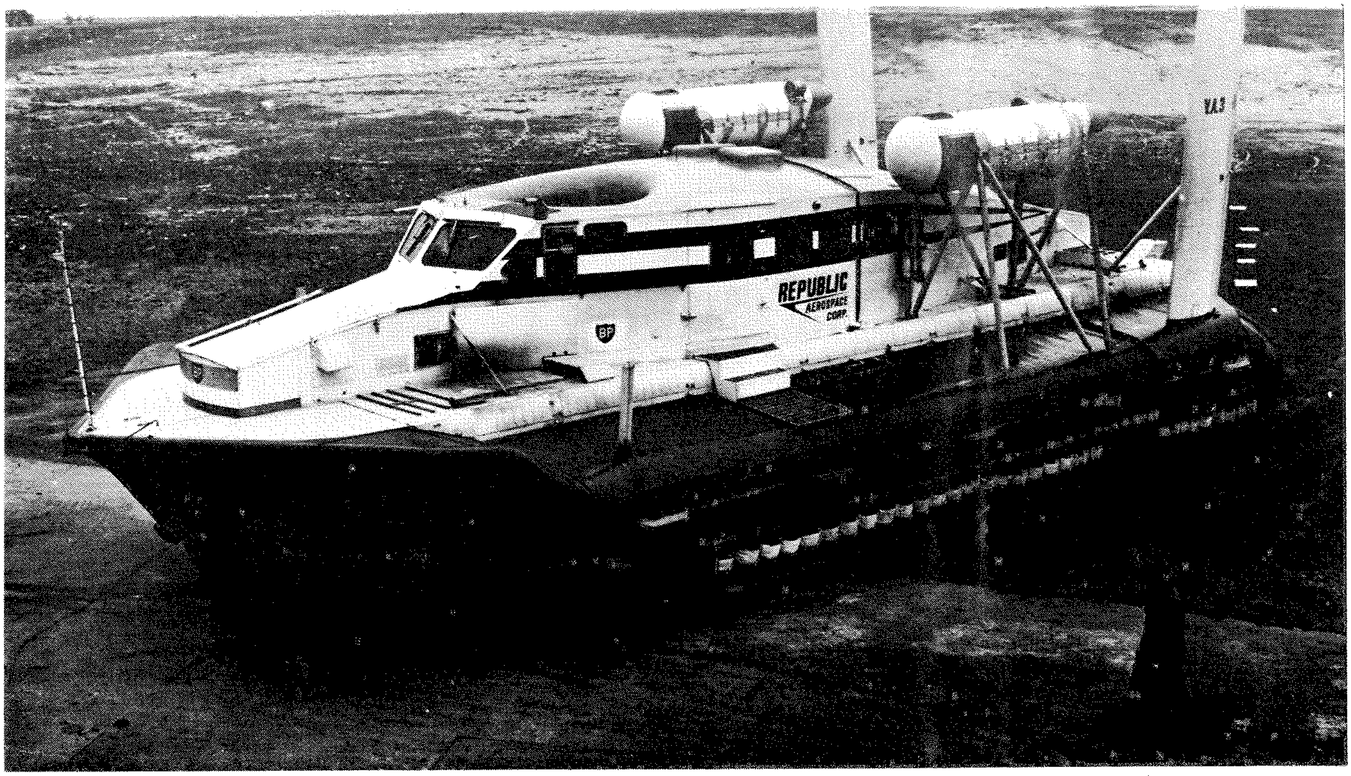
From their earliest days in hovercraft, Vickers had been giving considerable attention to the military applications of air cushion vehicles, including the possibility of modifying military vehicles to give increased mobility through the use of an air cushion system. After some detailed study which itself would make an interesting story, it was decided to modify a Land Rover quarter-ton truck. This would provide a practical research vehicle to investigate the effect of varying the weight bearing on the wheels, and at the same time be a convenient rig for testing the design of flexible skirts. It was perhaps appropriate that these two aspects of overland ACVs and flexible skirt design should be coupled in one vehicle, because these are particular areas where Vickers has made substantial and specialised progress.

So while the second-generation hovercraft were under design and manufacture, a prototype "hovertruck" was being built. It consisted of a Land Rover with an air cushion system comprising a convoluted flexible skirt and two centrifugal fans. Power for the cushion system was provided by a second Rover engine mounted in the back. Propulsion, stability and steering were all obtained in the usual way through the wheels, but the driver could vary the load on the wheels, the air cushion being used to support as much as 75% of the total weight. Four more hovertrucks were built, two of them being used for crop-spraying over agricultural land, and two by the US Army for research purposes. This same programme, or at least the overland aspects of it, led eventually to the design and manufacture of a system for a very much larger vehicle. Now under construction, the air cushion system will be fitted to a multi-wheeled heavy transporter and used when crossing certain bridges. Using the air cushion to spread the load when necessary, a transporter will be able to cross a bridge with a heavier load than normally permitted; for example, eventually with 300 tons instead of a 215 ton load.

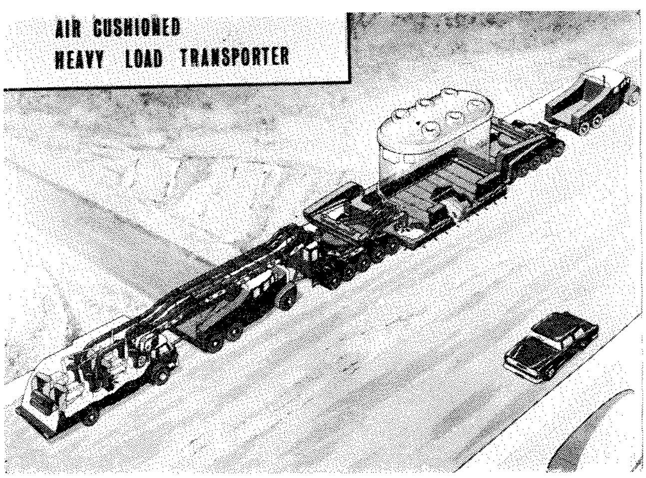
★

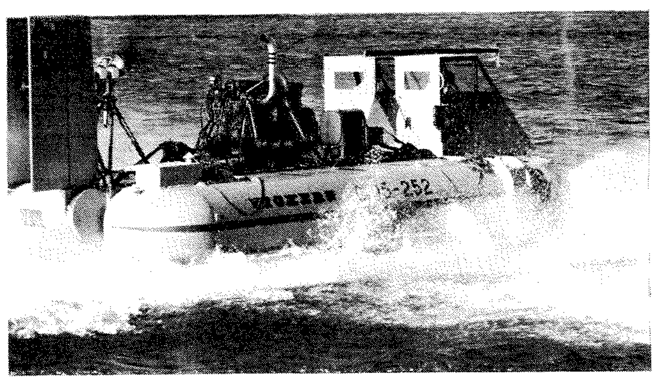
The manufacturing programme of the VA-2 had been re-phased so that the VA-3 could be made available for its first major trials in the summer of 1962. So the VA-2, intended to be the first of the Vickers second-generation hovercraft, had its initial testing in October 1962, shortly after the completion of the Rhyl–Wallasey trials programme. The testing went on through the winter, and included testing over frozen snow in January 1963, believed to be the first time a hovercraft had done this. A special feature of the craft is its retractable undercarriage, a pair of wheels amidships which can be selected for use at modest speeds over reasonably firm regular surfaces. They take about 10% of the craft weight and, by differential braking, they are used to give much finer directional control than would be possible otherwise. Their effectiveness was very quickly proven when the craft was driven between rows of parked cars giving only 6 in clearance on either side.

But if the planned date for the completion of the VA-2 had been delayed, time was not lost in embarking on the overseas tours for which it was intended. With the initial testing at South

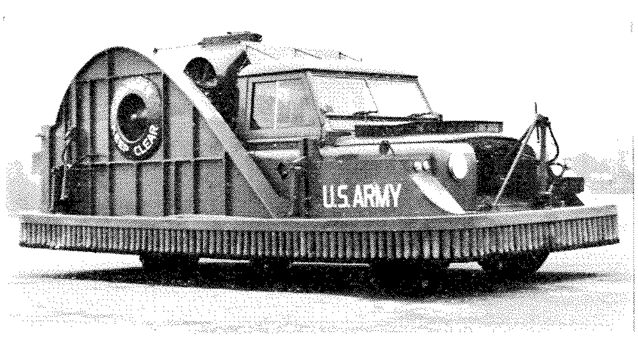


The modified VA-3 completing its trials on Southampton Water before it was shipped to America's Republic Aerospace Corporation





VA-1, the first Vickers research hovercraft



One of the Vickers hovertrucks which was used by the US Army for evaluation purposes

VA-2 during trials in Sweden in February 1964

Marston and Southampton completed by March 1963, the VA-2 began what was to become an extremely busy twelve months of environmental testing. In mid-March, it was loaded on to a truck, shipped across the English Channel and transported south to Ingolstadt, between Nuremberg and Munich. The craft designers had anticipated such an eventuality by arranging that the structure outboard of the cabin-line could be easily removed and reassembled by a small team of men. Thus the width could be reduced for transportation and, when necessary, the height by removing the fins and rudders. At Ingolstadt, the operating base was a small clearing in a wooded area on the bank of the River Danube, with access down a slipway on to the river. The purpose of the visit was to take part in a military demonstration to a large audience of NATO officers. The VA-2's contribution, which was under the auspices of the Inter-Service Hovercraft Trials Unit, was to demonstrate the high-speed overwater and amphibious capabilities of hovercraft. The combination of a fast-flowing river with shallow water provided interesting and worth-while experience, as did the rudimentary but adequate servicing facilities.

After two weeks in Germany, the craft was transported by road to Amsterdam where, at the invitation of British Petroleum, it was to operate in conjunction with the opening of a new petroleum installation. During the fortnight of its stay, demonstrations were given to a large number of visitors, mainly with commercial interests in the Netherlands and neighbouring countries; and it was in Amsterdam that the VA-2's first royal "driver" took the wheel. The craft has a dual control system so that induction of new commanders is simple. The maintenance base, rather more sophisticated than at Ingolstadt, was about half a mile from the slipway; so by using the wheels the craft could be driven with confidence through gates affording only 18 in clearance and along a road between parked cars.

On return to England, a 22 in flexible skirt of convoluted design was fitted in place of the original 8 in flexible nozzles, in readiness for more ambitious trials overseas. As a prelude to these, testing was carried out in conjunction with the IHTU at Thorney Island and Browndown Range, on the Hampshire coast. At Thorney Island the area included wet sand and saltings: light vegetation interspersed with ditches about 2 ft deep and 4 ft wide which were exposed as the tide went down. This kind of area, on the edge of an airfield, presents a problem to normal rescue services, and the VA-2 showed how hovercraft could reduce journey times by a factor of fifty in similar circumstances. By contrast, at that time Browndown was dry and dusty, and in fact was chosen for that very reason as a prelude to military trials overland later on. Although the period was short, the lessons learned were useful, especially in respect of propeller erosion problems.

But before the overland trials, another overseas visit was put into the programme, this time in Scandinavia. For two weeks at the end of September, the VA-2 was based at Malmö, Sweden, for demonstrations and trials on the Oresund. The operating base was in a corner of a shipyard, with a specially constructed slip having a 14° (1 in 7) slope into a basin with access to the Sound. Visitors representing commercial and Government interests from all the Scandinavian countries and Germany came in considerable numbers, and special days were reserved for military visitors. For some, the most striking demonstrations were the high-speed runs across to Amager Strandpark, near Copenhagen, during which the ability to operate in the shallows around Saltholm Island and thereby take the shortest route plus the transition on to the beach adjacent to the Copenhagen–Kastrup Airport road meant that the Oresund was crossed in about 15 to 20 min, compared with 35 to 40 min by hydrofoil or 90 min by normal ferry.

The two final trials of this hectic twelve months were devoted to something never before attempted, namely, operations over desert and over ice.

In the United Kingdom it is very difficult to find sufficient room to manoeuvre a high-speed hovercraft on land. Valuable as the tests over the "obstacle course" in the summer had been, much more room was necessary if a more ambitious trial was to be attempted. Accordingly, and with generous help from various sources, VA-2 was tested in a wide area of hard-surface desert. Although the temperature (in the order of 20°C) was consistently warmer than on any previous trials, it was not high enough to constitute a hot-weather test. Instead, the primary aims were to investigate control problems overland, and to study the environmental effects on the machinery and the flexible skirts.

Previously, trials areas had been approached by road and sea. This time the craft was "broken down", loaded into an aircraft and flown together with a joint Vickers-IHTU team to North Africa.

The main area for the trial was a level plain with a hard surface covered by a thin layer of dust, and with occasional slight depressions, interspersed with patches of scrub and small rocks. The scrub, wiry and resilient like a pot-scourer, was about 18 in high. There were miniature sand-dunes of similar height in places, but no real dunes in the normally accepted sense.

Leaving the maintenance base on a daily run to the area, VA-2 would use its undercarriage in following a road until the road petered out, when the wheels would be raised. As so often in the past, the wheels were essential for close-quarter manoeuvring. Beyond the road lay an area where vehicles had churned up the surface into a thick layer of fine dust and sand. Even a slowly moving field car would generate its own "smoke-screen", and VA-2, like every other vehicle, disappeared from view on all sides except immediately ahead. But unless there was a tail wind moving faster than the hovercraft, the driver's vision was never completely obscured.

Once clear of the dust-bowl, speed could be built up, and with increasing speed the dust was left behind in the form of a long low trail. The next section of the route began over fairly level ground strewn with rocks and then climbed a gradient of about 1 in 20, with some parts a little steeper. On the hill, the scrub was up to 24 in and had trapped the blown sand, giving the effect of fairly stiff thorn bushes. VA-2 rode these obstacles quite easily, although some drag could be felt. Speeds up the gradient would be up to 20 knots; on the plain beyond, faster speeds were possible, restricted only by the ability of the driver to identify obstacles and, when necessary, to take avoiding action. To new eyes, some areas of desert appeared quite flat at first. Depressions, man-made as well as natural, although not obvious from a distance, came up remarkably quickly when moving at 30 to 40 knots; and so when travelling across new ground it was essential to have an observer sitting alongside the driver, to navigate and to assist in identifying obstacles.

Approaching the trials area control point, all windows were closed, and all ground observers took care to avoid being down-wind, for it was during very slow manoeuvring, stopping and starting that the dust problem existed. The driver's forward vision was hardly ever blocked completely, except for a brief moment, but everything within a few feet of the craft would be covered in dust. In anticipation of this, extra air filters had been fitted and these effectively protected the engines.

In terms of a new environment and new experience, this was among the most valuable of trials, matched only by the next one three months later, near Norrköping, about 120 miles south of Stockholm.

Having been shipped via London and Stockholm, VA-2 arrived at the trials base in February 1964, where it was put into a workshop for assembly. From there to the Molastrom, VA-2 was driven through a 90° turn and then via a 20 ft wide road to a jetty and slipway. It was on this open slipway, usually used for the repair of cargo ships, that VA-2 was parked. Here all servicing was carried out in temperatures as low as −15°C, and at no time did the craft return to the heated workshop for repairs or attention. The only extra facilities required were lead lamps for night work, and an air-line for drills to perform small repairs. As for refuelling, the arrangement was a simple one, gasoline being transferred from fifty-gallon drums by a small electrically operated pump.

The test area, which was in the western end of the Bråviken, was approached from the base by three miles of river with a 90° bend about midway. The ice on the river presented a continuously changing face every day, dependent upon wind and

LEADING PARTICULARS OF VICKERS HOVERCRAFT

	VA-1	*VA-2*	*VA-3*
Length overall	26 ft 0 in	30 ft 4 in	55 ft 7 in
Width	13 ft 0 in	15 ft 0 in	27 ft 0 in
Gross weight	——	8,300 lb	30,150 lb
Skirt depth	——	22 in	36 in
Engines:			
Lift	1 x Gypsy Major, Mk 8	2 x Continental O.300 B	2 x Turmo 603
Continuous rating ...	1 x 130 shp	2 x 133 shp	2 x 450 shp
Propulsion	1 x Continental O.300 B	1 x Continental GIO-470 A	2 x Artouste 2C
Continuous rating ...	1 x 133 shp	1 x 310 shp	2 x 425 shp

passing ships. Some days it would be very flat ice all over the river; on other days it would be broken ice and water; and sometimes, with a strong wind, the ice would pile up off the entrance to the slip, presenting piles of block-ice up to 18 in high.

During the first few days of the trials, all types of ice that could be found were traversed: ice floes, ice blocks and broken floating ice. These were crossed progressively at speeds from just above the hump to 55 knots without difficulty. It was also possible to move slowly at 4 or 5 knots on the cushion over the ice blocks without contacting.

Having established the craft's behaviour and the nature of the problems that might arise, it was then possible to investigate these problems and to test the hovercraft's capability more fully. The problem of most interest was obviously that of icing-up. What would actually happen when the craft became covered with its own spray during icing conditions; would this ice build up to such quantities and weight that performance would be severely limited; would it further hamper the control problems of the hovercraft and make operation eventually impossible? These problems were investigated in calm water and windless conditions, with water temperatures at $-\frac{1}{2}$ to 1°C and air temperatures varying from 0 to −6°C. These were not severe conditions in themselves, but they were the conditions when severe icing occurred. At below −10°C the icing problem really no longer exists in inland water, since all water is frozen anyway and the air is sufficiently dry to obviate frosting and freezing. At sea there is a different icing problem: even though sea temperatures are less than zero and air temperatures sometimes down to −20°C, the sea does not freeze because of turbulence; but it does mean that spray created by water impact and cushion spray does freeze rather quickly on contact with the craft. To assess the icing-up of the craft, it was taken to clear water and hovered with little or no forward motion. Periodically the craft came ashore, the amount of ice was assessed, and the hoverheight measured. The icing was not so severe as expected.

Towards the end of the trial a "sortie" was planned to a small fishing village called Arkösund on the edge of the Bråviken and the Baltic Sea. Arkösund is approximately 33 miles from the base, along the Bråviken and through the archipelago. Navigating from a point east of Norrköping to Arkösund by chart compass and dead reckoning, the time taken for this 33-mile trip was 40 min, an average speed of 49.5 knots. The return over a short distance was at an average of 50 knots. The surface which the craft travelled over included concentrated ice blocks, pack ice, calm water, large floating ice floes, and flat ice with 5 in ridges of snow at craft-length intervals. During the return trip, the time measured between two points gave the average speed as 62 knots, confirming the Doppler speed meter to be correct. Later on, the maximum speed indicated by Doppler was 63 knots.

The next visit overseas was a remarkable one, but for the wrong reason. Two months after its successful winter trials, the VA-2 was taken to Düsseldorf for British Week, but, alas, stubbornly refused to perform; a component of the propulsion engine was at fault. Honour was restored on the craft's next visit to Germany, but in the meanwhile a long programme of testing at home was due. This programme, which lasted through the remainder of 1964 and most of 1965, included a detailed study of hump-crossing characteristics in deep and shallow water, and the effect on these characteristics of various modifications. These trials also included assessment of drag characteristics, and the effect on ditching and ploughing-in behaviour.

The most recent overseas trial to date of this much-travelled hovercraft was in February 1966, when for the third time it was taken to Germany, this time to Wesel for military trials on the Rhine. Shipped to Emmerich, just south of the Dutch–German border, the VA-2 was off-loaded on to a snow-covered quay. Next morning, after the fog had lifted sufficiently, the craft set off up the Rhine for Wesel. The river was higher than usual: in fact up by 12 ft in Emmerich; and the banks were flooded. Consequently, with the visibility affected by lifting fog, landmarks took on a different appearance. However, the 25-mile journey up a river crowded with barge traffic was completed in 40 min. A German river police boat made a vain attempt to pursue the craft; and the captain said later on, with good grace, that it was the first time he had ever been left behind. The trial, which included climbing a dyke with a 30° gradient, was judged to be a great success. Now, after some 11,500 miles of travelling to overseas trials areas, the VA-2 is once more back at base to continue the development programme which contributes to keeping Britain's lead in hovercraft.

* * *

THE LUCAS GROUP

The Lucas Group, of which eight companies are exhibiting at the Hovershow, has the capability of offering a very wide range of electrical systems, engine-starting devices, switchgear, navigation and other lamps, batteries, hydraulic pumps and engine fuel systems including diesel injection units. These can be taken from existing motor-car, heavy commercial vehicle, marine or aircraft equipment.

The companies involved are:

1. Rotax Ltd
2. Lucas Gas Turbine Equipment Ltd
3. Lucas Industrial Equipment Ltd
4. CAV Ltd
5. Joseph Lucas Electrical Ltd
6. Joseph Lucas (Batteries) Ltd
7. Butlers Ltd
8. Rists Wires & Cables Ltd.

The group recognises the potential of hovercraft as a future transport means. It is anxious to play its part on the equipment side and has already been substantially involved in all hovercraft so far produced.

Each of these companies has available extensive design and development facilities, and these are backed by the forward-looking Lucas Central Research Organisation.

The need to develop equipment to meet the special requirements of hovercraft is well appreciated and it is the policy of the organisation to see that this is done. Its technical teams are in constant and close touch with the hovercraft manufacturers and users for this purpose.

Forester Richard John Britten, AFRAeS, (left) is thirty-eight years old and was educated at RNC, Dartmouth, and de Havilland Technical School. He is a Director of Cushioncraft Ltd, Hovertravel Ltd, Britten-Norman Ltd and Crop Culture (Aerial) Ltd. Nigel Desmond Norman (right) is thirty-seven years old and was educated at Eton and de Havilland Technical School. He is a Director of Cushioncraft Ltd and Hovertravel Ltd, and founded Britten-Norman Ltd and Crop Culture (Aerial) Ltd

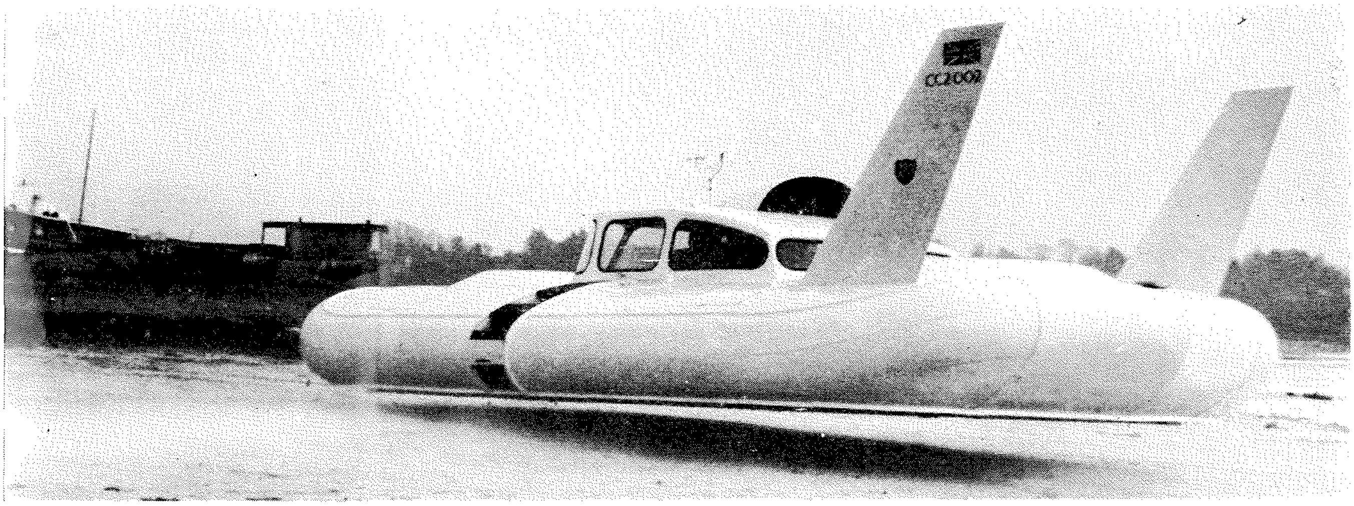
BRITTEN-NORMAN LTD

Hovercraft Development 1959-1966

by Christopher Bland

BRITTEN-NORMAN entered the air cushion vehicle world in 1960. This was partly due to the success which Westland were experiencing in proving the basic Cockerell principles and partly at the instigation of Elders & Fyffes, the banana shippers, with whom the company had considerable connections in West Africa. Britten-Norman were in fact using part of their fleet of crop-spraying aeroplanes to treat the banana plantations in this part of the world, this business being the company's mainstay. In subsequent years the profits from the crop-spraying operations were ploughed back into the hovercraft business and more recently for the development of the Islander light transport aeroplane.

Elders & Fyffes were worried by the large percentage of the crop which was being damaged between the plantation and the docks owing to the crude transport facilities and the state of the roads in this part of the world. An ACV seemed an ideal way of transporting crops to the docks, using bulldozed tracks which were probably smoother than the existing facilities. After the completion of CC-1 a lot of the problems associated with hovercraft were demonstrated, and the machine in fact stayed at Bembridge for research and development. At this time a great deal of work was done to improve the efficiency of the peripheral fan by the alteration of blade angles and reduction in the number of blades.



CC2-002

CC-1 became redundant when it was superseded by CC2-001 in 1961. It languished in the Bembridge hangar until 1962, when it was given to the Royal Military College of Science at Shrivenham for educational purposes. Its transport to Shrivenham was unique in that it left Bembridge suspended from a Belvedere helicopter, to be put down on a lighter positioned in St Helens Roads. From the lighter it went to the IHTU at Lee-on-Solent, where it resided for a year during which time temporary skirts were fitted.

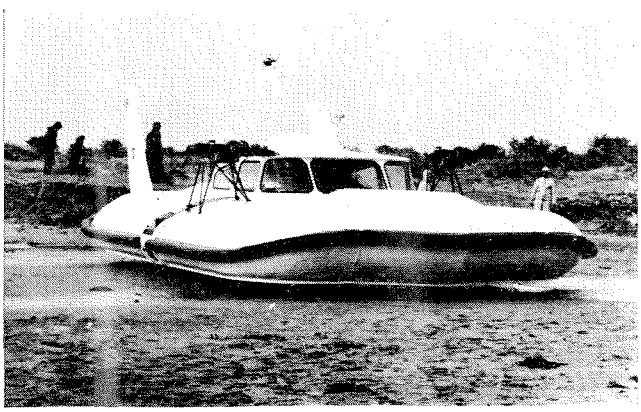
CC2-001 had much improved lines and has always been considered one of the best-looking hovercraft ever produced. Propulsion was by deflected air jets under the hull, supplemented if necessary by aerodynamically altering the trim of the craft, forcing the air cushion out to the rear. Yaw was achieved by one or other set of the propulsion vanes being moved through 60° to produce a turning moment in the desired direction. Maximum speed was 30 knots. CC2-001 had a daylight clearance of approximately 11 in, air being produced by two 6 ft, 30-bladed centrifugal fans. The machine was exhibited at the International Boat Show in 1962, after which, having been purchased by the Ministry of Aviation, it went to the Royal Aircraft Establishment at Bedford.

The Ministry purchased CC2-001 at the instigation of Mr R. A. Shaw, who was then a supporter of the hovercraft and who has done valuable work in this field ever since. It remains at Bedford to this day. Comprehensive modifications were carried out during 1964, including the fitting of 7 ft fans constructed of fibreglass to RAE design and the addition of 100 hp propulsion engines driving 6 ft propellers to supplement the existing system. By this time the weight was creeping up and whilst the new fans were probably 60% more efficient than the original 6 ft fans, the clearance was very similar.

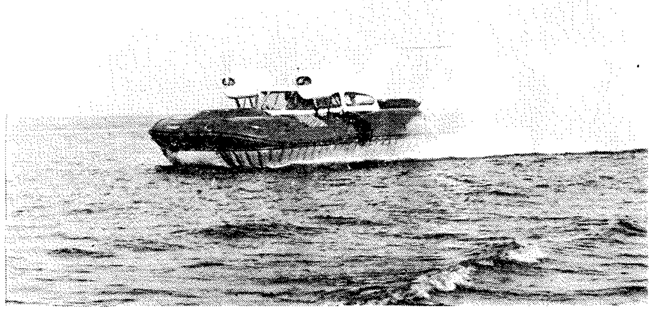
During 1962 plans were made to produce a batch of CC-2 machines for sale on the commercial market. These plans were made in conjunction with J. Samuel White, the shipbuilders, and were in fact delayed and finally abandoned in favour of producing a further prototype at Bembridge.

Britten-Norman hovercraft have relied on the Rolls-Royce V.8 motor-car engine for their lift and in later machines for propulsion as well. CC2-002 was no exception. It appeared in March 1963 with a more powerful 240 hp Rolls-Royce V.8 engine and 7 ft diameter fans of HEBA 100 design as supplied by Airscrew Weyroc. This machine was purchased by the Ministry of Defence for the Fighting Vehicles Research and Development Establishment at Chertsey in Surrey, and was eventually delivered in April 1963. Before delivery a certain number of trials were carried out at both Bembridge Airport and Bembridge Harbour, mainly to evaluate the exact performance. Two 40 hp Ardem converted Volkswagen engines were mounted on each sidebody (see picture) to assist propulsion and general manoeuvrability. These enabled the machine to achieve a speed of approximately 33 knots and considerably improved its yawing capabilities. Little is known about the activities of this machine at FVRDE before 1966, when it was shipped to the Research and Development Establishment, Cardington, for the attachment of some experimental skirts which Cardington had been developing. The results of these tests are not yet known.

The last in the range of CC-2 machines, CC2-003, was produced between February and July 1963 and served the company as a development platform for segmented flexible skirts. This programme was carried out in collaboration with Hovercraft Development Ltd, who were responsible for the design of the



CC2-002 (in its present form)



CC2-003

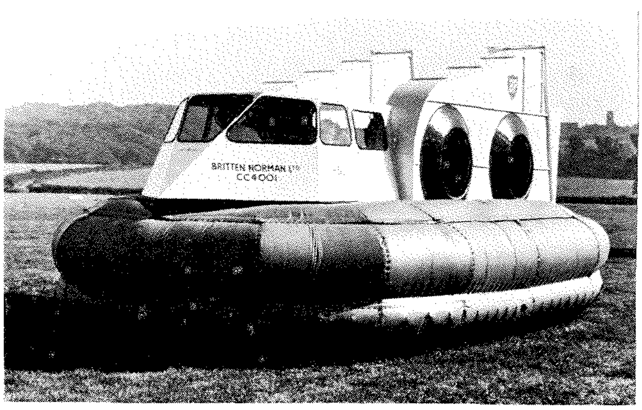
Mr P. H. Winter was educated at Solihull School and served his apprenticeship at Bristol Aeroplane Co Ltd. He took an Honours Degree in Aero Engineering at Bristol University, and after two further years' research and study at Massachusetts Institute of Technology gained his Master's Degree. Until 1959 he was Senior Aerodynamicist at Saunders-Roe, working on SR.53 and SR.177 rocket fighters. In 1959 he started Vero Electronics Ltd to manufacture a new type of printed circuit board. In 1962 he joined Britten-Norman Ltd as Chief Engineer responsible for the development of CC-2 and the design of CC-4 and the BN-2 Islander aircraft. Since 1965 he has been Technical Director of Britten-Norman Hovercraft Division engaged on the design of CC-5 and new projects

Mr Christopher Bland did National Service in the Royal Engineers from 1955 to 1957. He then joined Rolls-Royce as a commercial apprentice for three years, after which he represented them for the sale of industrial engines for a further two and a half years. At the same time, he was studying for a Certificate in Commerce. In 1961 he joined Crompton Parkinson, the electrical manufacturing company, and in 1962 joined Britten-Norman Ltd to look after the commercial side

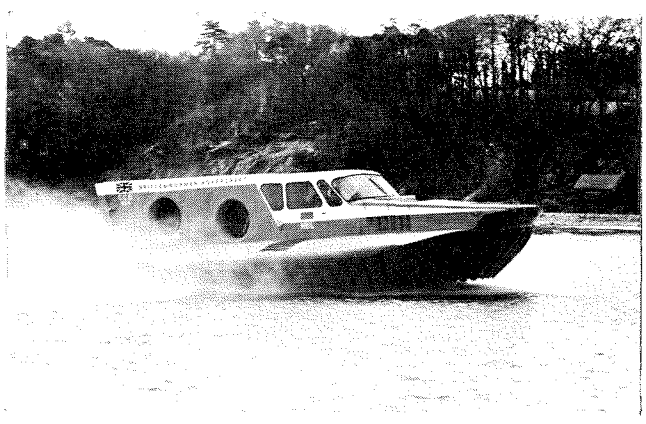
18 in skirts fitted. Whilst these were quite up to expectations on land, the machine tended to stay below "hump" speed in the water in spite of full power from the two Continental C.90 propulsion engines which had been fitted by this time. These produced some 800 lb of thrust, which should have been ample for going through the "hump". It was eventually discovered that, owing to the high thrust of the engines, the skirts were being forced deeper into the water as more power was applied. A simple remedy in the form of an inflatable bag on the front skirt was formulated and this solved the problem. In this configuration speeds of 45 knots were achieved. CC2-003 has recently been purchased by the Ministry of Aviation for work in connection with dust filtration systems for turbine-engined hovercraft.

By the middle of 1964 the company felt that aircraft propellers were generally unsatisfactory for small hovercraft owing to their close proximity to the ground, resulting in tremendous erosion problems under certain circumstances, and their obvious dangers. Noise was another factor which was all-important in view of the fact that many small hovercraft of the future would be operating in densely populated areas.

As a result of this thinking an integrated lift and propulsion system was devised whereby centrifugal fans were used for both lift and propulsion, in the latter case forming a large low-pressure jet from the rear of the vehicle. This resulted in a quiet and simple craft with adequate control as both rudders and trimming elevators could be situated in the jet outlet. Differential use of the jets could be made for yawing in confined spaces. This system was proved on the CC-4, which appeared at the end of 1964, using four 42 in fans driven by a single Rolls-Royce V.8 engine. In the case of CC-4 the lift and propulsion systems were integrated so that all the fans provided air for both lift and propulsion. This system was later modified in CC-5, where the fans were separated for the two



CC4-001



CC5-001

Both Mr Britten and Mr Norman are Directors of Hovertravel Ltd, which has opened its third cross-Solent ferry route (between Southsea and Sandown). The service will operate twice daily with a Westland SR.N6

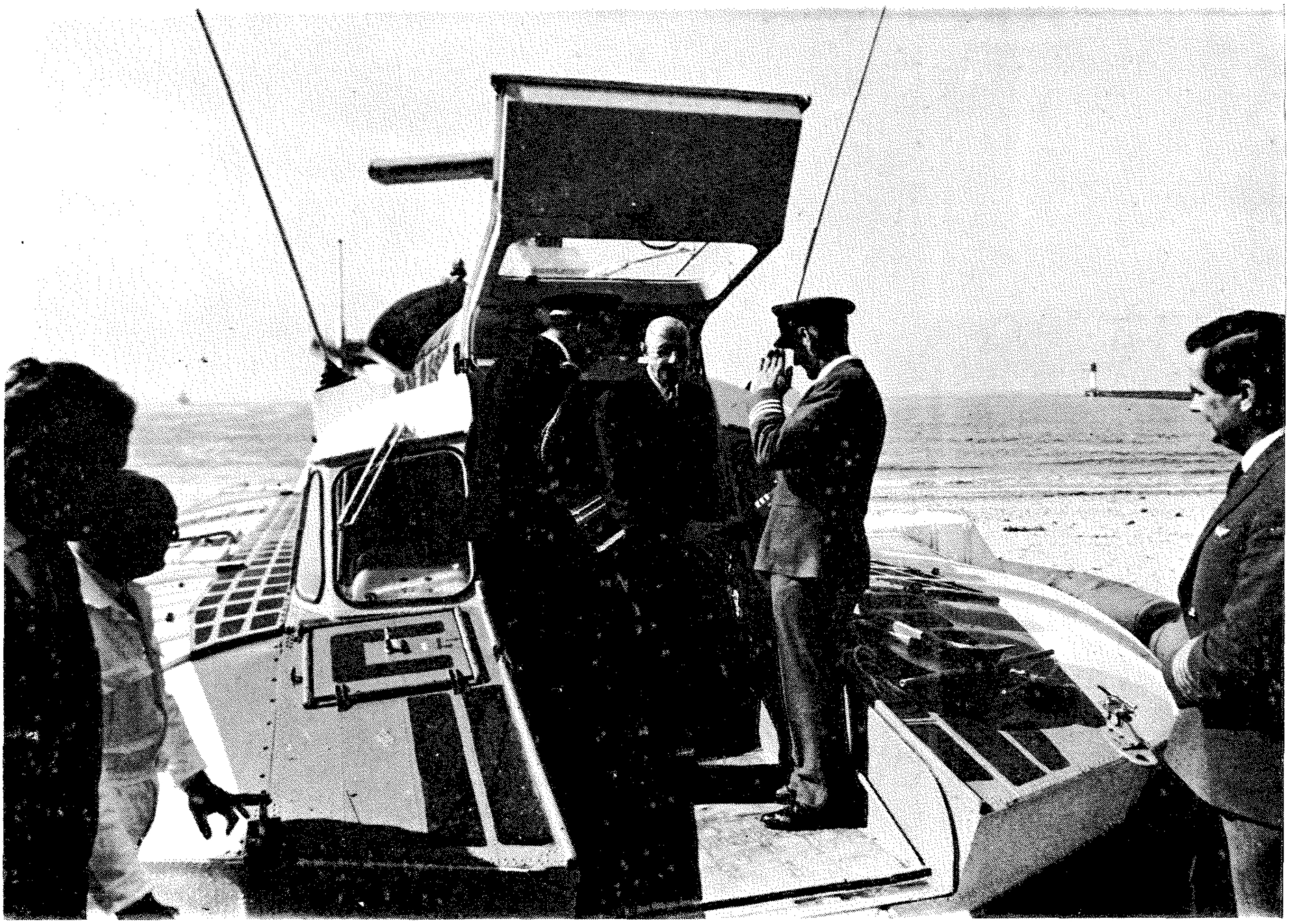
purposes, the lift fans being made to absorb approximately half the horse-power of the propulsion fans by a system of notched belts and variable-sized pulleys. CC-4 was and looked a purely development machine and left a lot to be desired from the aesthetic point of view. It had a maximum speed of approximately 32 knots. It is currently in the hands of HDL at Hythe, where development is continuing.

CC-5 was designed as a result of the lessons learnt with CC-4 and an attempt has been made to incorporate some of the good looks of CC-2. CC-5 was designed and built in under seven months and appeared at the beginning of this year. Unlike CC-4, where the engine was at the back with the fans, CC-5 was laid out similarly to the conventional motor car with the engine at the front and a long propeller shaft going back to an automotive differential unit. This resulted in a central payload and the redundancy of any type of ballasting. All trimming on CC-5 is carried out by four flaps in the jet outlet which more than compensate for fore and aft loading in the cabin. Work is currently in progress to improve the performance of CC-5, which has a maximum speed of 40 knots. It is felt that the efficiency of the propulsion system could be considerably improved by variations of fan diameters and volute shapes, as well as variations in the jet sizes.

CC-5 is the first full-size plenum chamber craft to be produced and it is fitted with a 2 ft convoluted skirt designed by HDL. The company has already announced its intention to build an altogether larger range of hovercraft in the 18/20-ton bracket for carrying mixed cargoes of vehicles and passengers. Development work on CC-5 could be directly applied to these projected vehicles, which will be equipped with centrifugal fan propulsion resulting in many advantages for operation in built-up areas.

CC-2, CC-4 and CC-5 will appear at Hovershow 66, together with studies of the company's future projects.

Type	*Power Unit*	*Length*	*Width*	*Method of propulsion*	*Skirt*	*Weight*	*Payload*
CC-1	Coventry Climax 170 bhp	18 ft 10 in dia	Round	Twin propeller	No skirt	1,900 lb	
CC2-001	Rolls-Royce 220 bhp	28 ft 0 in	17 ft 1 in	Plenum air	No skirt	3,200 lb	Experi-mental
CC2-002	Rolls-Royce 240 bhp 2 Ardem 40 bhp	30 ft 0 in	17 ft 1 in	Propeller	No skirt being fitted	4,000 lb	Experi-mental
CC2-003	Rolls-Royce 240 bhp 2 Continental C95s	30 ft 0 in	17 ft 1 in	Propeller	18 in HDL convoluted	4,400 lb	Experi-mental
CC4-001	Rolls-Royce L.V.8 240 bhp	23 ft 9 in	15 ft 0 in	BN centrifugal fan	36 in bag type convoluted	2,800 lb	800 lb
CC5-001	Rolls-Royce 240 bhp	30 ft 4 in	15 ft 2 in	BN centrifugal fan	24 in segmented	3,200 lb	1,100 lb



President Charles de Gaulle shakes hands with Commander Bill Williamson, (right) at Calais on April 25th after a short sea trip on board the British-built hovercraft Sure, *which is being used in a regular service between Calais and Ramsgate. Seen on the far right is Mr L. R. Colquhoun, Chief of Operations for Hoverlloyd*

HOVERLLOYD

John Bray

WHEN hovercraft *Swift* departed from the brand-new Ramsgate Hoverport at 7.30 on a bright spring morning on the last day of April, cross-Channel history was made. It was the first crossing of that stretch of water by a hovercraft carrying fare-paying passengers, and a new era in passenger transportation had begun.

The background to this startling event extends over nearly two years. Swedish Lloyd and Swedish American Line jointly agreed that to complete their links with Europe, a service connecting England with France was required. They already had efficient and modern connections between England and Sweden across the North Sea, and so a consultant was dispatched to England to investigate how they could best close the circle and establish a link with France.

Mr Arne Glucksman was the chosen consultant. He spent months investigating likely ports, talking to travel experts, and in the course of his investigations came to Westland. He became convinced that the most efficient method for future transportation across short stretches of water was the hovercraft and, as a result of his findings, the two world-famous Swedish shipping companies formed a company to develop and run a hovercraft service between England and France.

The company's name was eventually selected as Hoverlloyd Ltd and the ports chosen were Ramsgate and Calais. Ramsgate was eventually chosen because after Dover it was the nearest port to France — which meant using Calais. But Ramsgate had advantages over Dover. It was a port with little traffic that could interfere with hovercraft schedules. It was ripe for development. It had good road connections, and the town itself was willing to co-operate wholeheartedly.

So Swedish Lloyd and Swedish American Line became the first to place orders for the giant SR.N4 hovercraft. This had been on their drawing board for many years, but Westland were unable to develop it themselves. It needed an initial order for them to go to the vast cost of laying down a production line. The Swedes ordered two and Westland immediately made arrangements to build four.

But these craft could not be available until 1968 and in the meantime it was essential to train personnel, to prove the route, to gain experience of running a cross-Channel hovercraft service. They decided, therefore, to use the spring, summer and autumn months of 1966 and 1967 to achieve this, and this meant using SR.N6 hovercraft.

Two SR.N6 hovercraft were ordered for the Ramsgate service, which was scheduled to start in May 1966. The Swedish operators were prepared to invest their money just to gain this valuable experience, even if it meant making a loss.

The harbour of Ramsgate became the centre of extreme activity early in January 1966 when men and machines moved in to create a hoverport — the first international hoverport in the country.

Westland co-operated in helping to prove the run in the initial stages and during February the sound of a hovercraft entering and leaving Ramsgate became familiar to local ears. Many runs were made across the Channel each week and this involved careful plotting of the Goodwin Sands because, for the first time in history, a passenger service route was going directly across these "killers" of the Channel.

Hoverlloyd christened the first craft at Ramsgate on May 7th, and the second craft at Calais on May 30th. Immediately, and because of the names selected, the service was given an advertising tag — the *Swift* and *Sure* way to France.

The Chief of Operations for Hoverlloyd is Mr Leslie Colquhoun, who has been closely associated with hovercraft development since 1961. He selected seven men to serve as commanders of the hovercraft and several of them already had experience of hovercraft service with the operation in the Clyde. The names of the commanders — all in their early thirties — are: Bill Williamson, Tom Wilson, George Kennedy, Roy Mortlock, David Wise, Ted Ruckert and Bill Forsyth.

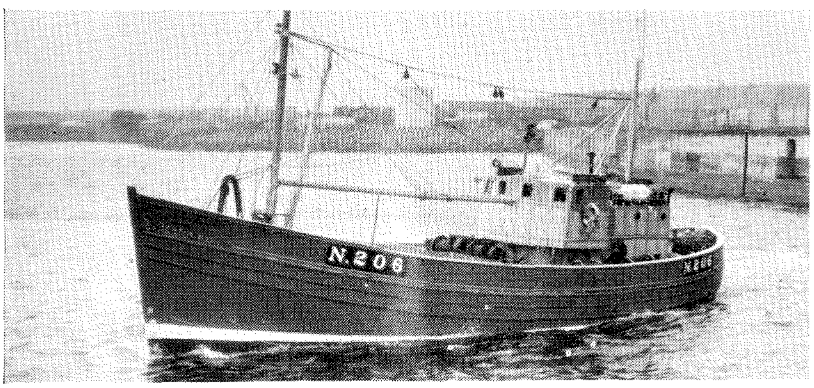
All the commanders received extensive training both on operation of hovercraft and their handling, and on the route between Ramsgate and Calais. Hoverlloyd was the first company to be given a passenger service certification for cross-Channel hovercraft operation, and this was achieved after extensive tests supervised by Air Registration Board, Ministry of Aviation and Board of Trade officials.

In the first twelve days of the service, Hoverlloyd have carried a total of 520 passengers on cross-Channel trips — this in spite of weather which stopped the craft from flying on a number of days in the first week. The pleasure trips along the Kent coast — at 12s 6d a time for a ten-minute trip — have proved a winner. On the first weekend crowds queued all afternoon and evening, and by the second weekend 2,350 trippers had been on the modern and hovercraft equivalent of "Round the Lighthouse".

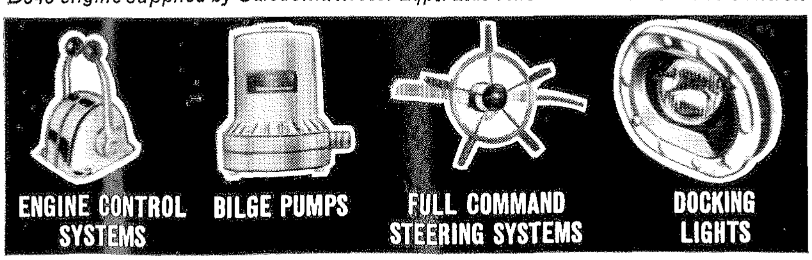
For the record, the fare for the cross-Channel crossing is 45s single and the schedule in the early days of May allowed for four crossings daily — when the weather permitted. Later, and using both craft to their capacity, up to ten crossings of the Channel will be made daily.

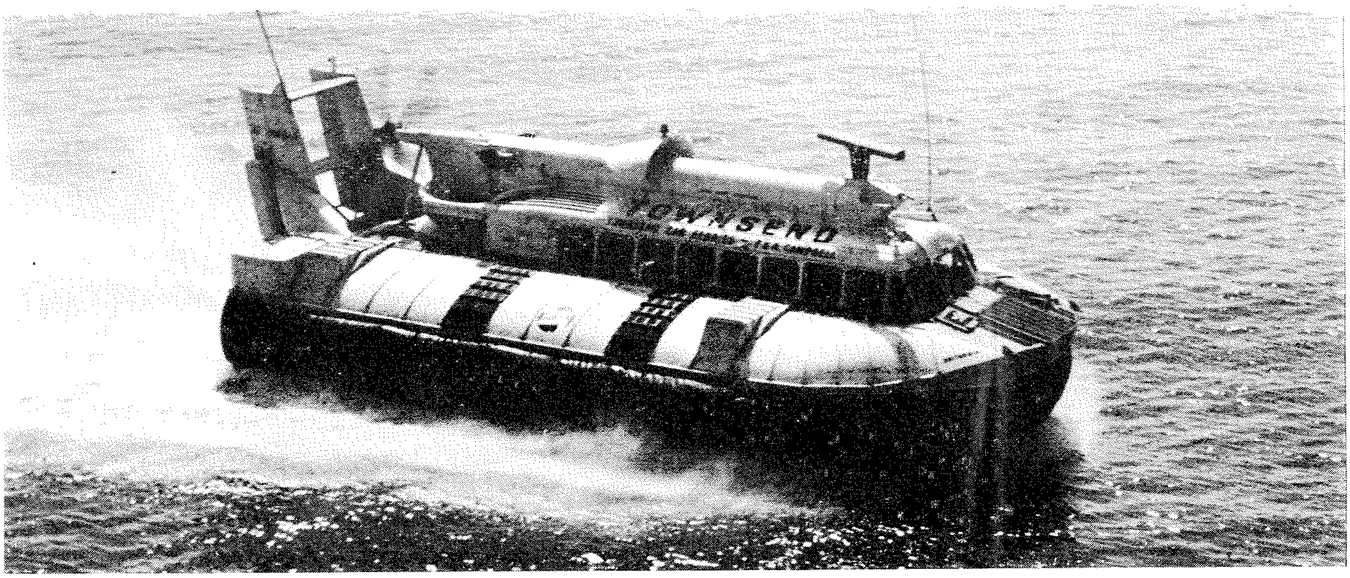
Hoverlloyd are looking to the future. 1968 and the introduction of SR.N4 hovercraft will be a turning-point for cross-Channel passenger transportation. Then the company will be able to operate all the year round, carrying up to 250 passengers and 30 to 35 cars a time.

They are convinced that it will be big, exciting and successful.



75 ft. trawler 'Castle Bay' built by J. G. Forbes of Sandhaven powered by a Caterpillar D343 engine supplied by Caledonia Motor Eqpt. Ltd. This uses a MORSE MK Control.





Townsend Car Ferries Ltd—P. and A. Campbell Ltd

by S. C. Smith-Cox CBE

Mr R. B. Wickenden, Chairman of George Nott Industries Ltd and Townsend Car Ferries Ltd, is a Chartered Accountant

Mr S. C. Smith-Cox, CBE, Managing Director of P. & A. Campbell, is a Chartered Accountant. He is a Director of several West Country companies

FROM the earliest days of our island history, men have crossed or sought to cross the English Channel in both directions. Ships of all sorts and sizes and aircraft joined in the endless procession. It is only now in 1966 that the newest form of transport of them all, the hovercraft, embarks on its voyages across the Channel.

Some six years ago, in the Solent, the SR.N1 — a small craft with little but an engine and a space for the pilot — first demonstrated its potentialities. With it, at that time, was Mr Christopher Cockerell, the inventor; it was one of those original demonstrations that the writer of this article attended. Progress from that point was speedy and in the summer of 1963 an experimental cross-channel service by hovercraft, this time across the Bristol Channel, was operated by P. & A. Campbell Ltd in conjunction with Westland Aircraft Ltd. That year, in six weeks some 6,000 passengers were carried; there were numbers of breakdowns and disappointments, and while on many occasions sea states rendered the operation impossible, some 50% of the scheduled crossings took place. A great wealth of detail and information was obtained. The craft used that year was the experimental SR.N2, carrying some fifty-five passengers.

In 1964 a company, *Hovertransport Ltd*, was formed for the purpose of operating, and investigating the possibility of operating, various hovercraft services. It was a combination of Britten-Norman Ltd, P. & A. Campbell Ltd, George Nott Industries Ltd and the National Hovercraft Development Corporation. In the summer of 1964 an inaugural service across the Solent, once again using the SR.N2, was commenced; it was augmented in the latter part of the year by an SR.N5. In all, the service was scheduled to run on fifty days, and of these fifty days the SR.N2 operated on all or part of thirty-three of them; while the SR.N5, which was frequently used as a relief or stand-by machine, operated on all or part of thirty-six days. During this period the service was suspended for weather reasons on only two and a half days, and for mechanical reasons on two complete days and six separate half-days. A total of 29,909 passengers was carried, together with one chimpanzee making its way to an island zoo.

This service was encouraging, particularly when on five days during the period over 1,000 passengers were carried; on Thursday, August 27th, the number reached 1,431. On this day the SR.N2 made twenty-three crossings and the SR.N5 twenty-six.

The arrival of the SR.N5 permitted more regular services; the craft was in continuous operation for as much as nine hours a day without the engine being stopped during this experimental period.

Both the experiments in the Bristol Channel and across the Solent were conducted from ordinary beaches with little or no preparation, except the construction of temporary terminal buildings such as booking offices and waiting-rooms. A fund of goodwill from local people was obtained with the Solent service, and so what may be called the first experimental period was completed as operations ceased at the end of the summer in 1964.

1965 saw the introduction of a regular service by Britten-Norman Ltd between Portsmouth and Ryde, and Ryde and Gosport; these services have proved most successful and are used regularly.

Now for the English Channel. It is 1966, and in preparation for the summer P. & A. Campbell Ltd in conjunction with Townsend Car Ferries Ltd, both members of George Nott Industries Group, have planned the operation of the first cross-Channel hovercraft service between England and France. This service will operate between Dover and Calais. The inaugural service was planned for April 30th, and as from May 15th three crossings in each direction every day of the week except Saturday have been scheduled.

For the cross-Channel service a Westland SR.N6 (a further development of the SR.N5) carrying thirty-five passengers was ordered; it has been named *Britannia*. The name, it is hoped, will indicate it is a British company that came first in operating this service; at the same time it will carry on the name of one of the most famous passenger steamers owned by P. & A. Campbell Ltd.

In addition to the services across the Channel which operate in each direction three times in the morning, the craft is scheduled to travel from Dover to Margate or from Dover to Hastings on various advertised days. The craft leaves Dover at 12.30, returning in the evening from Hastings or Margate, as the case may be. So that the maximum interest may be encouraged in hovercraft, arrangements have been made with the authorities at Hastings and Margate for short journeys to sea to be made throughout the afternoon, while the craft is at one of those resorts. In addition, a number of visits to Folkestone will be made during the course of the summer season.

Foremost in encouraging the operation of the cross-Channel service has been Mr R. B. Wickendon, a Chartered Accountant, who is Chairman of George Nott Industries Ltd and Townsend Car Ferries Ltd. From the start he has shown great interest in the development of this new form of transport. Mr Peter Southcombe is another who has shown tremendous enthusiasm for the project. He recently joined the George Nott Group of Companies, having previously for some time been concerned with the passenger steamship services both in the Bristol Channel and between Dover and Calais; he was responsible in 1964 together with a representative of Britten-Norman for the day-to-day management of the Solent service.

In the opinion of the operating companies, it is essential to encourage the public to appreciate the reliability of hovercraft and not to be dissuaded by the occasional day upon which weather conditions make the service impossible to maintain. For this reason the service operates alongside an established sea route and thus passengers intending to cross the Channel by hovercraft can, without any great delay and certainly with no difficulty, be conveyed by shipping services belonging to the same company, should the necessity arise. The great part of the traffic it is expected will consist of no-passport day trip passengers, travelling one way by hovercraft and the other by ship. A hovercraft terminal has been set up at Calais and arrangements also made for the reception and maintenance of the craft at Dover. Terminals have been established on the beaches at Margate and Hastings, where it has not been necessary to do other than erect a limited number of barriers, offices and the like.

Maintenance of a hovercraft is no easy matter — but nor, for that matter, is the maintenance of any form of transport. It is upon maintenance, however, that all depends. For this reason, the most methodical arrangements have been made to maintain the *Britannia* in a perfect state of repair, the overall work being carried out under the supervision of a superintendent engineer. The crew of the hovercraft will consist of the master, and an engineer concerned largely with radio and navigation. Two relief crews have been engaged so that adequate changes in personnel can be made throughout the day.

The companies operating this service experimentally this year, are used to regularity and are anxious that regularity should be the keynote of the hovercraft service as well. For this reason timetables have been produced, and no doubt as the season progresses the experience gained will be invaluable for future operations.

Throughout the period of preparation for what is now the first cross-Channel hovercraft service, there have been times of frustration and times of humour; over the years the experiments have not been without incident!

A well-remembered day is one in the Bristol Channel service when the 30 knot wind made landing on the beach an adventurous proceeding. From one stop to another, hovering, then moving ahead a few feet at a time, went the SR.N2, until finally it arrived at its appointed place. There was an occasion, when the writer was aboard the craft, travelling at 50 knots across the channel, when it hit a fairly high wave in somewhat awkward fashion. One will not forget this experience of travelling ahead at 50 knots, then, five seconds later, the craft having turned completely round, travelling slow astern! However, it was safe, and the craft finally came to its destination. A result, however, was that the writer, together with others concerned, stood talking to the disembarking passengers whilst standing in front of a fairly large hole in the aluminium skirt, hoping that they would not see it! It did not constitute a danger but was perhaps hardly reassuring.

There was the occasion on Weston beach when rain, which seems to hamper any British summer enterprise, reached such a pitch that even the sand began almost to be "quicksand" and the craft, resting on this sand, began slightly to sink into it during the night. Large piles from Weston pier had to be obtained and the craft rested on them. On a subsequent occasion a man working on maintenance beneath the craft had to crawl out quickly as the piles began to sink into the extremely wet sand.

This article has covered little of the cross-Channel operations in 1966. Operations will be of greater interest in future years; from this year's experiment lessons will be learnt the better to plan the future. Sufficient to say that the experiment in hovercraft so far has been a great adventure; it is with hope and great confidence that those engaged in it look ahead.

When this time comes, no doubt the companies now operating with this new form of transport will be in the van, and, given suitable encouragement, the Hovercraft Industry will continue to demonstrate throughout the world the ingenuity of British brain-power and industry.

★ ★ ★

"BRITANNIA" HOVERCRAFT

Services May 15th - June 30th 1966

Excursions from Dover

Daily (Saturdays excepted)

No-Passport Day Trips to CALAIS outward by hovercraft and return by ship.

Leave Dover 7.45, 9.20 and 10.45 am by hovercraft for Calais. The passage occupies approximately 35 minutes.

(Note: Passengers should report to the Townsend Car Ferry Centre, 1 Camden Crescent, one hour prior to the scheduled time of departure.)

Leave Calais 6.15 pm by ship for Dover.

The passage occupies approximately 90 minutes.

Fares (Adult or Child over three) : **67s 6d** return.

(Note: Passengers may make a one-way voyage to Calais or vice versa by hovercraft, single fare 60s.)

The hovercraft leaves Calais at 8.30, 10.5 and 11.30 am for Dover.

Every Sunday, Wednesday and Friday

Afternoon Trip to MARGATE.

Hovercraft

Leaves Dover 12.30 pm. Due Margate about 1.15 pm.
Leaves Margate 7.30 pm. Due back at Dover about 8.10 pm.

Coach

Passengers may if they wish travel one way by special East Kent Road Coach leaving Dover at 1.0 pm, due Margate 2.0 pm, or leave Margate 6.30 pm, due Dover 7.30 pm.

Fares (Adult or Child over three) :

One way by coach, one way by hovercraft, **45s.**

Both ways by hovercraft, **70s.**

Every Monday, Tuesday and Thursday

Afternoon Trip to HASTINGS.

Hovercraft

Leaves Dover 12.30 pm. Due Hastings about 1.45 pm.
Leaves Hastings 7.25 pm. Due back at Dover about 8.45 pm.

Coach

Passengers may if they wish travel one way by special East Kent Road Coach leaving Dover at 1.0 pm, due Hastings 2.45 pm, or leave Hastings 6.30 pm, due Dover 8.15 pm.

Fares (Adult or Child over three) :

One way by coach, one way by hovercraft, **50s.**

Both ways by hovercraft, **70s.**

From Hastings

every MONDAY, TUESDAY and THURSDAY

From Margate

every SUNDAY, WEDNESDAY and FRIDAY

Special Trips by HOVERCRAFT
from the beach
Fare : **12s 6d** (Adult or Child over three)
every 15 minutes
From Hastings 2.0 pm until 7.0 pm
From Margate 1.30 pm until 7.0 pm

On certain days the hovercraft will operate trips from the beach at Folkestone. For full particulars apply to Townsend Car Ferry Centre, 1 Camden Crescent, Dover. Tel: 2721.

Hovertravel Ltd will run a special service between Southsea and Hovertravel's Gosport terminal, next to the Hovershow site, specifically for the benefit of visitors to the Show. The service will be in operation from 9.0 to 11.0 am; the return service will operate from 4.30 to 7.0 pm

(Photograph by John Hartley & Partners Ltd)

HOVERTRAVEL/HOVERWORK

R. B. Stratton, C Eng, AFRAeS, AMSLAET

THERE has never been any substitute for practical experience as a basis for making sound judgments, and only infrequently does an opportunity occur to initiate a new technology. Until experience has been gained, a vivid imagination is an essential guide!

The staff of Hovertravel Ltd have been associated with the earliest experiments with public transport hovercraft operations in the Solent, in which the Westland SR.N2 and SR.N5 craft were initially employed. Temporary bases were set up at Eastney (Portsmouth) and Appley (Ryde), and the first passengers were embarked in 1964.

The next major development was the reorientation of the Solent service to Clarence Pier (Southsea), Ryde Esplanade and Stokes Bay (Gosport), and the introduction of a 30-seat SR.N6 on July 24th, 1965. By May 1st, 1966, this service had amassed almost 2,000 hours of operating experience by day and night, and had moved 171,000 passengers, with one craft. A second SR.N6 was scheduled to commence operations on the same route on May 16th, thereby offering 100 trips each day and 3,800 seats. With an established block speed averaging 7 min for the 4 nm route, this represents a breakthrough in communications with the Isle of Wight of an order that could never have been achieved by any other method — tunnel, bridge or aeroplane!

No other organisation can match the experience of Hovertravel Ltd, and it was a logical progression for a wholly owned subsidiary, Hoverwork Ltd, to be formed to market the unique "knowhow" of the parent firm.

The selection, design and development of terminals can be shown to be a critical factor in establishing safe and reliable hovercraft services, and the development of radio, radar and lighting equipment to extend the operation into hours of darkness, and to maintain operations in near-zero visibility, is equally critical, both in terms of performance and cost effectiveness.

The selection and training of craft operating personnel, both pilots and engineers, likewise benefit from accumulated experience and achievement, and the success of any enterprise lies fairly in the hands of people selected to run it. The setting up of any efficient organisation to handle the passenger and freight traffic likewise plays a significant part in promoting revenue and in maintaining scheduled services. Your image is your best friend!

However, it is in the field of the probability of success of hovercraft on any potential, proposed or intended route, in the UK or anywhere abroad, that "knowhow" alone can provide reliable guidance, and Hoverwork Ltd have access to meteorological and route performance data, and technical and administrative cost statistics, derived from their Solent explorations, on which alone sound judgment can be based.

Route analysis pro-forma have been compiled by contributions from the whole team of Hovertravel Ltd, and route surveys can be made and a comprehensive consultancy service offered.

Finally, of course, there is no substitute for the experience of "going to sea" in hovercraft, and as an alternative to taking the plunge into the deep end (financially) Hoverwork will undertake to set up a charter exploration with craft, personnel and essential "knowhow", to prove the viability of a potential route after a route survey has been carefully compiled and analysed. The productivity of hovercraft in passenger, freight and "workhorse" activities throughout the world will remain largely unrecognised, until more hovercraft operators take the plunge!

B P's Role in the Hovercraft Picture

A. Cadman Clinton FRAeS FBIS, MSEE

BP's hovercraft exhibition stand has appeared at major exhibitions all over the world. The models are true to scale and operate on the authentic hovercraft principle; the rail on which they run is merely to guide them and give them current

THE BP Group are extensive users of transport in their exploration, production, refining, distributing and marketing operations. As a matter of course new forms of transport are examined and assessed by BP as soon as they come on the scene, with the object of determining whether they can be utilised in BP's own activities.

It was for this reason that BP first became interested in hovercraft. But since that time, five years ago, BP's interest has appreciably broadened. They have demonstrated their belief in this new transport concept by collaborating with the industry in every possible way — in research, in development and in promoting the hovercraft all over the world.

BP were closely involved in the organisation of the first commercial hovercraft service, the Rhyl–Wallasey service in 1962. They were in fact partners in this venture with Vickers and British United Airways. Since that time they have played what everyone admits has been a prominent part in the planning and presentation of over thirty hovercraft events, in conjunction with Westland, Vickers, Britten-Norman, Denny and Hovercraft Development Ltd. Apart from an appreciable number of demonstrations in Britain, BP have also had considerable experience of hovercraft operations in Africa, Australia, Germany, Holland, Denmark, Sweden, New Zealand and the Middle East.

Recently BP men were alongside Westland, Bristol Siddeley and Ministry of Defence specialists in gruelling desert trials set up under the direction of the Ministry of Aviation. And as this article goes to press BP are collaborating with the same organisations in a six-week SR.N5 programme of ice-trials in the Canadian Arctic.

As a result of this type of co-operation and close involvement with Ministries, manufacturers and operators, BP have forged a strong link with the hovercraft world and have accumulated a wealth of first-hand operational experience.

BP point with pride to the fact that they were invited by the British Hovercraft Association to collaborate in the presentation of Hovershow 66 — and in fact a BP man, Mr Douglas Hammett, is organising this event on behalf of the industry.

The Nature of BP's Function

Broadly speaking, BP's co-operation falls under two heads, technical and commercial. On the technical side it is probably only natural that BP's technological resources would be of service to the industry; as an indication of the magnitude of these resources, the BP Research Centre at Sunbury employs over 800 qualified personnel, more than half of whom hold degrees. On the commercial side it is very much in BP's interest, as large-scale users of transport, to remain closely acquainted with developments, and, in addition, to acquire invaluable experience of a form of transport they believe will assume an importance in the world that present success barely hints at. For this latter reason much of BP's collaboration has been directed towards promoting the hovercraft "ideal" and, wherever possible, actually promoting the sale of hovercraft.

Types of Tec'nical Liaison

Probably the most fundamental, and perhaps also the most important, of BP's functions on the technical side is the recommendation of specific products and grades for a given set of applications. It is nowadays universally conceded that lubrication, for example, is a science, and it is no reflection on the designer's ability that he consults specialists to advise him on this aspect of his work. And very often BP's consultative role goes considerably beyond merely advising on the correct products for an existing lubrication system; it is not at all uncommon for BP to be consulted about the actual design of the lubrication system itself. Problems connected with lubrication can often be eradicated by redesigning the lubrication system, but to do this *ex post facto* is, in almost every case, impracticable or prohibitively expensive; to do it during the design stage, on the other hand, often involves no more than the stroke of a pen or a few strokes of a designer's pencil.

Reverting to the selection of the correct products for a given application: the broad classification of fuels and lubricants that prevail in the petroleum industry are aviation, marine and automotive products. Because of the antecedents of the Hovercraft

Industry it was inevitable that thinking would in the main be along aviation lines. Of course, the fact that aviation power-plants have been widely employed has influenced this trend, but it goes considerably deeper than this. Air-frame constructional techniques are still the order of the day in the Hovercraft Industry, and it is frankly impossible at this stage to say that this mode of construction is wrong; it may even prove possible, in the future, completely to justify the retention of aeronautical principles in the design and construction of hovercraft. But that is not to say that all the restrictions and regulations proper to the aviation business should necessarily be imported without any alteration into the fledgling hovercraft business. It may well have struck many readers that an ARB or AID Release Note is an unnecessary refinement when the craft being fuelled will not operate more than 18 in off the surface.

The upshot of this is that BP have collaborated, and are continuing to collaborate, with hovercraft and power-plant manufacturers with the object of enabling operators, both commercial and military, to use standard products in preference to aviation ones. Operators are well aware that the testing and checking implicit in the supply of aviation products has to be paid for, and the manufacturers are sympathetic in this respect. Thus, where relaxation is permissible, standard products are being recommended in place of the aero products that could otherwise seem the only possible ones. A typical aviation lubricant — a synthetic rather than a mineral-oil lubricant — might very easily be *ten times more expensive* than a perfectly serviceable standard lubricant. This is the order of economy that this type of thinking can introduce.

The type of technical liaison so far mentioned might seem somewhat desk-bound. This impression does not by any means do justice to the very active support that BP have given to field-trials. The VA-2 trials in the icy waters of Northern Sweden are a good example of technical support that is the very antithesis of desk-bound. And the ice-trials in Canada referred to earlier are another example. A BP man, Derek Illing, is out in Canada with the SR.N5 at this moment. BP people, among them Douglas Hammett, Hovershow Manager, were out in North Africa with the VA-2 and more recently in Aden on sand-trials with the SR.N5. Though the problem in sand is largely one of filtration rather than lubrication, BP's experience in this field is extensive. BP have already had much experience in filtration with railway diesel locomotives in Australia and, though the large mass air-flows with gas turbines add a new dimension to the problem, a great deal of BP's Australian and general filtration work will be of use in the hovercraft context.

In Arctic and sub-Arctic environments a truly effective de-icing fluid is imperative. BP's policy has been to try to select products for hovercraft from the very wide range of products already available, so as to avoid the expense to operators of "special" products, but in the case of ice-formation the already available aviation products were not suitable for continuous sub-zero operation, often in clouds of spray. Aviation de-icing fluids are formulated to give short hold-over periods — of up to two hours — but they are not capable of preventing ice-formation during twelve or twenty-four hours of parking in freezing conditions. For this reason new formulations, based on earlier work with the VA-2 in Northern Sweden, are being tested at the moment in Canada.

Other examples of technical liaison abound. Trouble was experienced with the gearing in the Schottel units on the Denny D-2; BP were able to overcome this problem by recommending a formulation of gear-oil with an effective load-carrying additive. In another instance knit-wear air-filters needed a very "tacky" oil if they were to work effectively, but the oil was so tenacious that it was almost impossible to get it off when the filters were taken down for cleaning; BP recommended a completely different type of product, which worked completely satisfactorily but was removed with ease. The CC2-003 needed two completely different fuels and lubricants for its automotive lift-engine and its two propulsion engines; BP recommended a rationalisation that worked to everyone's satisfaction, one fuel and one lubricant performing both functions, with resultant simplification of ordering, storage and dispensing.

Work continues on many aspects of hovercraft fuelling and lubrication. Much of it is confidential but all of it tends towards greater efficiency of hovercraft operation at the lowest cost consistent with safety and long service. Sometimes the work is of a startlingly different nature from what one would expect — soil-stabilisation, for example, with the object of producing hovercraft bases at low cost — but the bulk of it is what BP have been accustomed to doing for every aspect of industry. It is merely that here the new element is the hovercraft itself.

Types of Commercial Liaison

"From July 20th, 1962, for a period of eight weeks, the world's first commercial hovercraft service was operated by British United Airways and Vickers-Armstrongs (Engineers) Ltd. It carried a total of 3,760 fare-paying passengers across the Dee Estuary, between North Wales and England. By hovercraft a twenty-five-minute connection could be provided, compared to the land journey of two hours by rail or ninety minutes by car." We have already seen that BP were partners in this service, and since that time BP's active participation in hovercraft events has been truly impressive.

A mere catalogue of events in which BP have actively engaged is sufficient to indicate BP's wholehearted involvement in the crucially important work of promoting the hovercraft ideal. BP worked closely with Denny in their epic D-2 voyage from Dumbarton to London — still the longest journey a hovercraft has undertaken under its own power. (And BP made a film of it, too — *800 Mile Voyage* — but more of films later.) BP were at Düsseldorf with the VA-2, in North Africa and in North Sweden, again with the VA-2 (here again the sales-promotion aspect, as distinct from the technical, was the film footage obtained, which adds additional impact to the new BP hovercraft film *The Dawn of an Industry*), at the inauguration of the Clyde service, at Cuxhaven, at Kalundborg, at the British Week in Holland, at the SEATO demonstration (at BP's own Isle of Grain refinery) and at Hovertravel Ltd's inauguration on the Solent.

It is almost impossible to characterise the exact role BP have played in the commercial promotion of hovercraft. The British Hovercraft stand, built and manned by BP, has been to innumerable important exhibitions and events: Sydney, Munich, the Boat Show, a great number of institution events — the list would occupy the whole of the space allotted for this entire article. The working models themselves, the central feature of the stand, must alone have been responsible for kindling an enthusiasm for hovercraft in the hearts of thousands of schoolboys — of all ages.

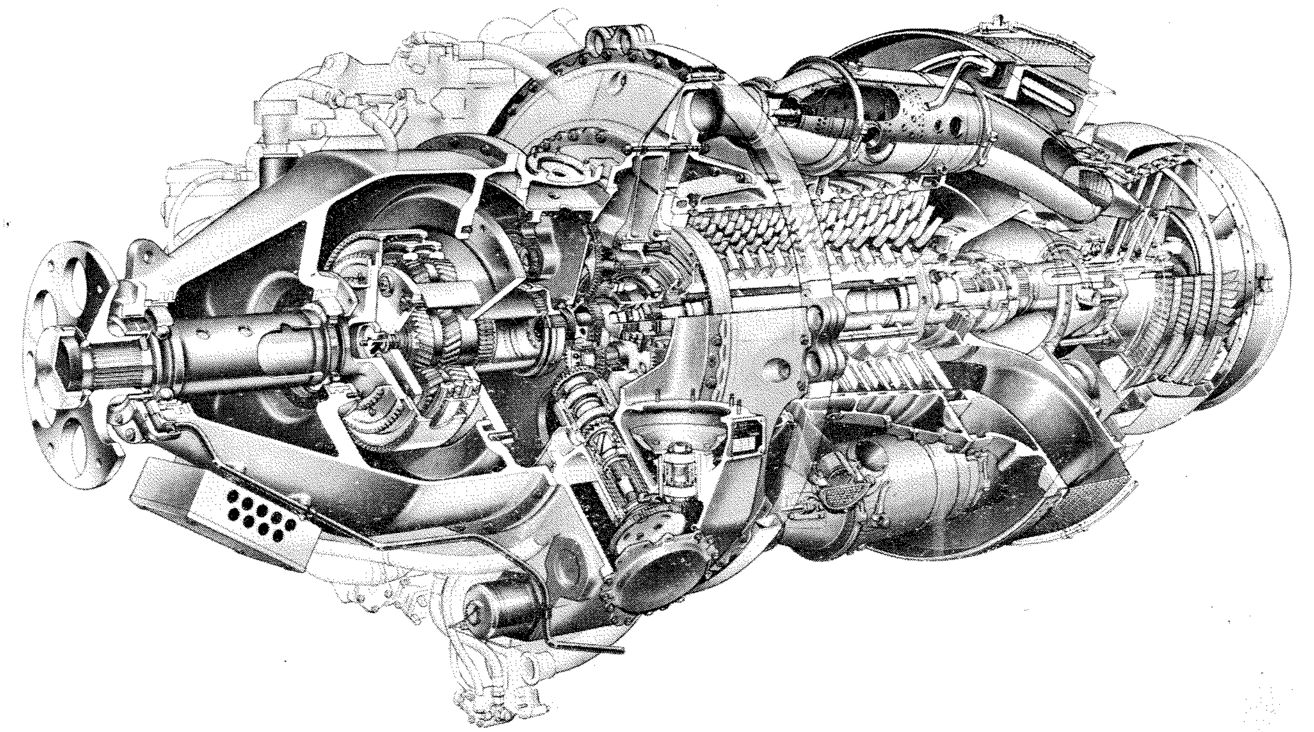
BP's publications have usefully supplemented other published material; of particular importance, judging from the quantities given in response to responsible requests, has been *The Story of Hovercraft*. BP's hovercraft films, of course, are a by-word, and not only in the world of hovercraft. The latest in the long line, *The Dawn of an Industry*, will be premièred in London shortly before Hovershow 66, and may well be said to be the high-water mark of BP's hovercraft film activities; in colour, it runs for half an hour and covers the incredibly rapid growth of the hovercraft concept, from coffee-tins to blasé acceptance of the hovercraft by commuters across the Solent, and all in eight short years.

BP's Belief in Hovercraft

It has been said, on all sides of the industry, that hovercraft will really come into their own when they have grown really large. We are already on the threshold of this stage in their development, with the SR.N4 in production and on order for Hoverlloyd Ltd. The future is promising indeed.

BP believe that hovercraft have always had the potential for success. It is easy nowadays to see this potential, but it is a matter of plain historic record that BP had this profound conviction even when many wiseacres shook their heads and wrote off the hovercraft as an ingenious toy. Perhaps an even more corrosive form of scepticism was the one that followed, whereby the hovercraft was disparagingly discounted as a mere gimmick. Through the tribulations of the infant industry BP's faith remained unshaken.

It remains unshaken still. BP believe the hovercraft is here to stay.



BS Marine Proteus engine

Bristol Siddeley Marine Gas Turbines for Hovercraft

by Selwyn Sharp MIPR

By the time Cockerell was hard at work on hovercraft, Bristol Siddeley were also hard at work on the job of adapting or converting to marine use an existing and well-proven lightweight gas turbine engine originally designed for aircraft.

This was the Proteus, which then had a background of more than 2,000,000 flying hours.

Because of this early work Bristol Siddeley were the first British engine company to supply gas turbines for hovercraft, and today all British gas turbine-powered hovercraft use their engines.

This type of engine is particularly suitable because of its low weight and small size. Specific engine weights are in the order of 0.7 lb per hp and specific volumes are less than 0.1 cu ft per hp. Engines below 10,000 hp have specific consumptions in the region of 0.6 to 0.8 lb/hp/hr.

Comparable performance for high-speed craft is impossible with any other type of prime mover.

Their ability to give full power within a minute or two of a cold start, their high torque at low rotational speeds, their simplicity of construction, all add to the attractions of lower installation costs.

The first hovercraft to be launched in May 1959 was the Westland SR.N1 and originally it was powered by a piston engine. It now has a Bristol Siddeley Viper as well. It is an experimental craft being used to develop the flexible skirt principle and the Viper has not been fully marinised. The Gnome (1,050 hp), the Proteus (4,250 hp) and the Olympus (22,300 hp) have been marinised.

The next Westland hovercraft, the SR.N2, was launched in January 1962 and has four Bristol Siddeley Nimbus engines coupled in pairs, each pair driving a fan and airscrew combination.

With the four engines ordered were two spares, and between them these six engines have done over 2,500 hours at sea.

In April of the same year Vickers-Armstrongs launched the VA-3 with four Bristol Siddeley 360 hp Turmo engines for both lift and propulsion. Two spares were supplied and the total running time before the craft went to the USA, where American engines were installed, was 700 hours.

The Ministry of Defence bought a Westland SR.N3 hovercraft early in 1964 and this is fitted with the fully marinised Bristol Siddeley Gnome gas turbine of 1,050 hp. The SR.N3 has, in all, four engines for lift and propulsion. The Gnome has now accumulated more than 11,000 hours at sea and is in production for small hovercraft up to about 40 tons weight.

The Proteus of 4,250 hp is on order for the next and bigger generation of hovercraft. These craft will be in the 150 ton class, carrying up to 700-800 commuter passengers on short routes, or 500 seated, or a combination of 250 people and 30 or more cars. Their 10 ft skirts will enable them to operate in 10 ft seas Speeds in calm weather of the order of 70 knots over distances of about 300 miles are envisaged.

British Railways have said they will operate a hovercraft of this size on the Isle of Wight crossing, and Swedish Lloyd have said they will use two on a cross-Channel service. Both are expected to go into service in 1968.

When he was Minister of Aviation, Mr Julian Amery talked about a projected hovership and for such large deep-sea craft the Marine Olympus of 22,300 hp is suitable machinery. The Olympus is a pure jet engine and Bristol Siddeley have designed a power turbine to convert the gas energy from the jet into shaft horse-power.

A number of comprehensive studies have been made by hovercraft designers into ships of this type up to 3,000 tons.

Bristol Siddeley marine gas turbines offer a selection of powers in combinations of one to four engines from 1,000 to 100,000 hp.

The Defence Services Contribution to the Development of Hovercraft

Lieutenant Colonel J. F. Kenyon, MC RA, Central Staff, Ministry of Defence

THE Defence Services of the United Kingdom have been actively concerned with the development of hovercraft since the late fifties, when an Inter-Service Hovercraft Working Party (IHWP) was set up under the auspices of the Admiralty. Jointly manned by all three Services and including representation from the Ministry of Aviation, this Party has since its creation been actively concerned with the development of hovercraft in military roles.

Limited at first to studies but little practical experience, it soon became clear to the Working Party not only that hovercraft were of potential military use but that full evaluation of craft would have to take place under the auspices of the Ministry of Defence. Commercial users were, and still are, only concerned with operating their craft under ideal conditions; the Services on the other hand would have to operate under adverse climatic and operating conditions, with terrain and water of a nature which may prove equally unhelpful. 1961 therefore saw the creation of the Inter-Service Hovercraft Trials Unit (IHTU) at Lee-on-Solent. This Unit, like the Working Party which controls it, is jointly manned by the three Services; its task is to evaluate hovercraft for military roles, as directed by IHWP.

At the beginning of its life, IHTU naturally had to devote most of its attention to acquiring expertise, operating procedures, and to trials of a technical nature. However, as the problems thus met were overcome, the Unit found itself ready to pay more attention to trying out its craft in a series of differing roles and environments. Until this year, all trials were limited within IHTU to one SR.N3 and one SR.N5. The SR.N3, still the largest hovercraft in operation today, is really a blown-up version of the SR.N2, and cannot be called a truly military hovercraft any more than the SR.N5. Thus, all military trials carried out by IHTU have been limited by the inherent disadvantages of using craft not designed for military purposes.

SR.N3 has been used primarily for Naval trials, and in 1965 proved itself well suited in the anti-submarine role; equipped with standard detection devices, its ability to move with speed on to a detected target and its comparative immunity to hostile counter-measures showed that here indeed lies a probable role for hovercraft in the immediate future. In May of this year, the same craft was used in an Army support role, taking part in a NATO exercise in the Bremerhaven area. Working with a SR.N5, IHTU was given the task of moving troops and their vehicles across the mouth of the River Weser — six miles as a hovercraft moves, but some twenty miles for the landing craft which were deployed in the same role and which had to avoid mudbanks, islets, etc. The SR.N3 and SR.N5 carried out their task with such speed and efficiency that the landing craft looked — and were in fact — hopelessly out-dated.

IHTU'S SR.N5 has competed with a host of tasks, and mention here will be made only of the more important ones. Recent trials carried out by the RAF have shown the versatility of this craft in the crash-rescue-firefighting role. Its amphibious characteristics coupled with speed make it an ideal craft for all airfields based near coastlines, marsh, or in the inundated paddy deltas of South East Asia. Furthermore, the craft has proved itself to be able to carry an overload of some fifty men and still remain within safe operating limits. Here is a role highly suitable not only for the Services but also for civilian-operated airfields; Kowloon (Hong Kong) and Gibraltar are but two airfields which immediately come to mind — there are countless others. At the end of 1965, SR.N5 was sent to Aden to carry out sand-desert trials; due to sand ingestion, both engines lasted only six hours each! Some have pointed to these trials as a failure; MOD and MOA take the opposite view. The problems, accented by the wet and salty sand of that area, have been highlighted and are now in the process of being overcome; once overcome, the Army will doubtless be looking further into the role of the hovercraft as a logistic support vehicle in desert areas. Currently, a SR.N5 which belonged to the unit sent to the Far East (see below) is operating in Canada on the frozen Mackenzie River, and although details of this trial have not yet been received, sufficient news has arrived to tell us that no real difficulties have been met and that the craft is performing remarkably well. The ice breaking-up season, due now, may prove more hazardous. Deployment of United Kingdom forces in conditions such as these is unlikely, but doubtless the United States, Canada, Sweden and Norway will be following the trial with considerable interest and an eye towards adopting the hovercraft for troop and store-carrying in the frozen North.

The most lengthy trials, and the only ones carried out under operational conditions, were those completed by the Hovercraft Unit (Far East). This Unit was raised and trained by IHTU in 1964; it consisted of two SR.N5s bought by the Army but jointly manned. It spent the whole of 1965 in the Far East, returned to this country at the end of that period and was absorbed within IHTU at the end of April of this year, thus bringing that Unit up to a total strength of four hovercraft. During the Far East Unit's sojourn in the Far East, it was in the main deployed in support of the Army in logistic and troop-lifting roles, where it showed itself not only complementary to air transport but also proved itself able to operate in weather conditions when aircraft were grounded. The SR.N5s were of the standard commercial pattern and were therefore by no means ideally suited for the tasks with which they had to compete. However, they received minor modifications which included the fitting of light armour around the engine, a machine-gun mounting, and radar and communication facilities. In the Army role the craft performed superbly, carrying troops and stores over fast rapids where normal craft have to be unloaded, in swamp and delta mouths, over marsh and on log-strewn rivers. Eleven-day journeys by conventional craft were cut to eleven hours. In the Naval role the Unit showed that hovercraft are well suited for fast patrol work, in support of coastal radar or radar-carrying ships, for the interception of infiltrating craft — more particularly where a multitude of islands and shallow waters make operations by other craft at times not only difficult but impossible. As a fitting end of the Unit's stay in the Far East, it carried out a series of amphibious trials and demonstrations in Thailand with great success. Operating in a trial area where the latest American amphibious and cross-country vehicles were proved, the SR.N5s moved over a course at an average speed of 35 mph where American vehicles could do no better than to average 3 to 4 mph.

It may be fairly said that the British Armed Services have maintained in their own sphere the lead which they inherited from Mr Cockerell and from British designers who have followed him. No country other than the United States has any experience of hovercraft in a military role, and the Hovershow to be held in June will show to the Defence Attachés and other overseas military visitors the progress we have made. Anti-submarine and fast patrol work for the Navy; logistic support, troop movement and ship-to-shore work for the Army — possibly also in river and coastal patrol work by a more silent craft such as Britten-Norman's CC-5; crash-rescue-firefighting for the RAF. These are all roles which can be foreseen now. But in order to maintain our lead, and bearing in mind the increasing interest being taken by the United States Armed Forces — not least the recent deployment of two SR.N5s to Vietnam — the Ministry of Defence will be doubtless looking ahead to as yet untried roles; whatever progress is made will, we hope, be carried out without losing the momentum which has recently been achieved. For not only do we look to the introduction of hovercraft into the Services as a form of transport and as a weapon-system, either complementary to or replacing existing means; of equal importance we see in their progress the pioneering of hovercraft operations under conditions which would cause commercial operators to think twice before undertaking them, thus opening to wider fields the scope for manufacture, sales and operating.

The views here expressed are those of the author and not necessarily of the Ministry of Defence.

Hovershow 66 Stand 40

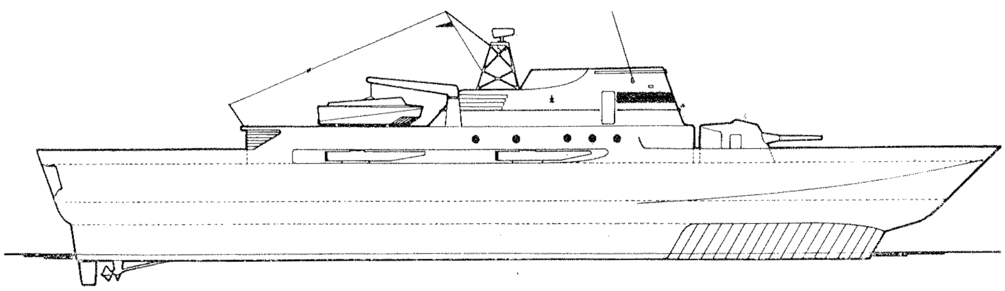
Consult

HOVERMARINE LTD

for

FUTURE CIVIL & MILITARY APPLICATIONS

HM 300 Series

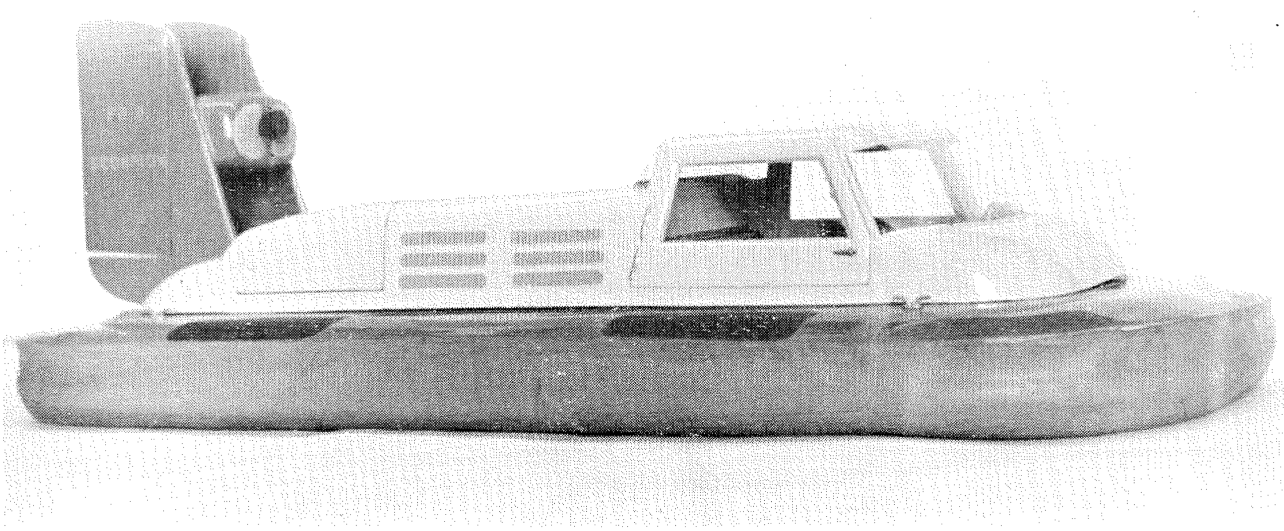


All up Wt. 300 Ton   Speed 55 Kt   Power 15,000 BHP

Hovershow 66 Stand 12

THE MANX HOVERCAT

4-5 Seater



Manx Hovercat Ltd. Ramsey, Isle of Man