HOVERING CRAFT & HYDROFOIL

THE INTERNATIONAL REVIEW OF AIR CUSHION VEHICLES AND HYDROFOILS

"Hovercraft first costs are high compared with ferry boats and series production aircraft in terms of work capacity, payload and cruising speed. This state of affairs may be expected to change with technical development and the establishment of a design from which a number of substantially similar craft may be built; however, at the moment the first cost makes a considerable contribution to hourly operating costs by way of interest on capital, depreciation and insurance."

A. E. Bingham
Vickers-Armstrongs (Engineers) Ltd

1964

"We have now built over 40 hydrofoils which have been sold to eleven different countries. Our first hydrofoil, the 72-seat PT20 Freccia del Sole, which started operating in 1956 on the Messina-Reggio Calabina-Messina line, has now travelled more than 430,000 nautical miles and carried over 1,[illegible],000 passengers."

Leopoldo Rodriquez
Messina, Italy

1961

"Whether the civil market will have need of large ocean-going hydrofoils is difficult to predict. Much depends on the rate of growth of the tourist traffic to still unexploited areas, and of future competition from ground effect machines and VTOL airplanes. There seems to be a future for the hydrofoil in certain specific fields of application. The development and building costs are high, however, compared to conventional craft. For this reason it is essential to avoid technical pitfalls and to concentrate resources on such lines of development which can be expected to be profitable in the future."

Curt Borgenstam
Captain (E)
Royal Swedish Navy

1963

"Dozens of working GEMS (ground effect machines) have been built in everything from backyard garages to big business experimental laboratories. But why aren't they in production? Simply because they aren't engineered with a dollar sign on the slide rule. Once a realistic approach is taken toward GEM design, a most important hurdle has been crossed."

Carl Weiland

1961

"The introduction of hydrofoils on the Norwegian coast became an immediate success."

Erling Aanensen
Det Stavangerske Dampskibsselskab, Norway

1962

"Mr R. A. Shaw, Deputy Director of Aircraft Research, has stated publicly that in his opinion the hovercraft industry will eventually be as big as the aircraft industry or the shipping industry.

"If the hovercraft concept is to be fully exploited, then I estimate that we ought to be spending an average of ten million pounds a year on development for the next twenty years."

Christopher Cockerell

1961

"The year ending December 31st, 1966 was our first full year of operations and therefore we have no previous yardstick by which to judge results. The consolidated results of your company, which include those of the wholly-owned subsidiary, Hoverwork Ltd, show a profit of £3,892 resulting from a turnover of £176,000. We believe that these are the first profits to be earned by a hovercraft operating company and their size indicate in some measure the endless struggle to operate these craft as economic units at their present level of development."

D. R. Robertson
Hovertravel Ltd

1967

"We have to replace our old ferries eventually and the hydrofoil could be the answer. When we buy something more we are obviously going to give greater consideration to something we know. We still have the hovercraft in the background, but these craft are not nearly as advanced as the hydrofoil."

J. C. Needham
Port Jackson and Manly Steamship Co

1965

"Mr Desmond Norman, of Britten Norman, Isle of Wight, has stated that lack of finance is holding up the introduction of a regular hovercraft and passenger ferry service across the solent to the Isle of Wight.

"Mr Norman stressed that the British do not seem willing to put money into things of this nature and that two leading merchant banks in the City who had been approached had felt that normal risk money would not be available."

Hovering Craft and Hydrofoil
People and Projects

1964

"No other form of transport has been so rapidly developed from the laboratory experiment to operational feasibility as the ACV.

"It is estimated that the total world expenditure will have reached nine to ten million pounds by the end of 1963, of which about half will have been spent in Great Britain."

L. Boddington
Westland Aircraft Ltd

1963

"Ten hovercraft of the SR.N4 type could carry annually across the Channel the passengers, cars and light freight visualised for a Channel Tunnel in 1970."

Sir Eric Mensforth
Westland Aircraft Ltd

1963

"Air cushion vehicles offer some of the most interesting possibilities for both civilian and military use. They include land and amphibious sports machines, flying-pallet riding toys, amphibious commuter vehicles, and sub-sonic transit trains capable of all-weather safe speeds of 200 mph and above."

Kenneth G. Wood
Air-Go Inc

1967

"It is a year since *Seaspeed* (British Rail Hovercraft Ltd) operations were launched on the Solent, and during that time the two SR.N6s operated for more than 4,000 hours and carried well over 100,000 passengers and 5,000 freight consignments."

Hovering Craft and Hydrofoil
People and Projects

July 1967

"The National Research Development Corporation are encouraging the establishment of commercial hovercraft services in Britain by offering to assist potential operators in the purchase of the craft they select. Officials of the NRDC and its subsidiary, Hovercraft Development Ltd, have discussed their proposals with a number of manufacturers and potential operators.

"The Corporation are prepared to help operators by making up the difference between the price the manufacturers would have to charge and the maximum the operator felt he could afford to pay, and will regard their contribution as an investment in the operation."

Hovering Craft and Hydrofoil
People and Projects

1963

"Considerable more capital outlay will be necessary by far-sighted governments, industries or private individuals to arrive at optimum vehicles for mass production and world-wide sales.

"The total investment made to date in air cushion vehicles is insignificant compared with the potential value of the concept to mankind."

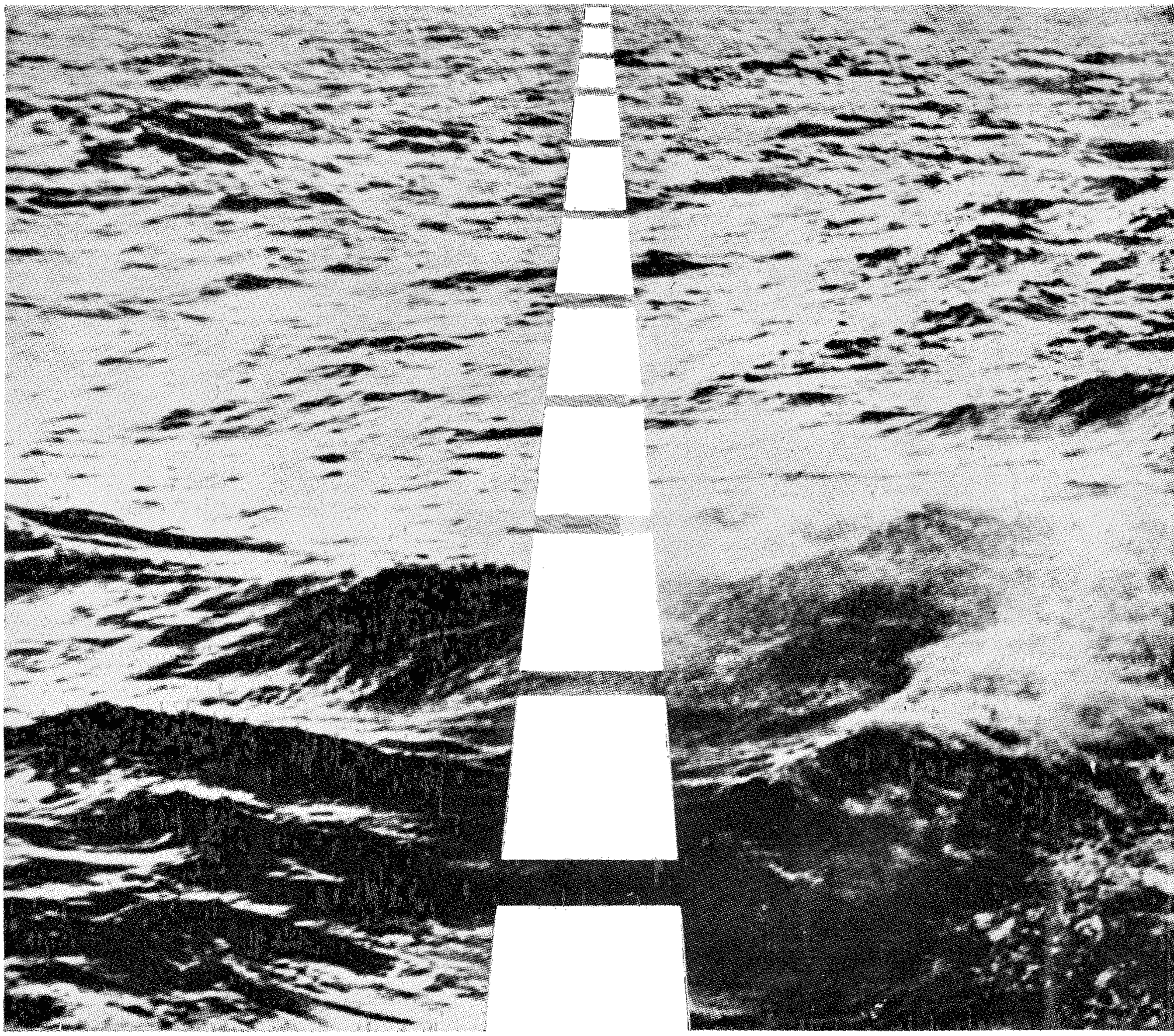
Dr William Bertelsen
Bertelsen Manufacturing Co Inc

1964

MAY 1968

Volume 7 Number 8

CROSS CHANNEL MOTORWAY



Come summer, the new SR.N4 hovercraft will have established virtually a motorway across the English Channel. These 165-ton craft, the world's fastest sea transport, will skim between Calais/Ramsgate for Hoverlloyd and Boulogne/Dover for British Rail in record time at motorway speeds. Carrying 254 passengers and 30 cars, the SR.N4 will be capable of operating in almost any weather in the same way as conventional ferries. The SR.N4 is the world's largest hovercraft and is in quantity production at Cowes, Isle of Wight. Hoverlloyd and British Rail are the first ferry operators to exploit the vast potential of open-water hovercraft. The 'bus ride' to Europe is but the first step.

BRITISH HOVERCRAFT – WORLD LEADERS IN THE HOVER TRANSPORT REVOLUTION

BHC **british hovercraft corporation**

EAST COWES · ISLE OF WIGHT · ENGLAND

BRITISH HOVERCRAFT CORPORATION LIMITED IS A SUBSIDIARY OF WESTLAND AIRCRAFT LIMITED

HOVERING CRAFT & HYDROFOIL

FOUNDED OCTOBER 1961

First Hovering Craft & Hydrofoil Monthly in the World

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JUANITA KALERGHI

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Productivity . . . To Produce Abundantly

THE Central London Productivity Association deserve warm thanks for their initiative in sponsoring the conference on business aspects of hovercraft and hydrofoils in London on May 15th. The conference will bring leaders of the hovercraft and hydrofoil industries to meet those whose interest is in investment in new developments. To these formal thanks is added the appreciation of this journal which is able to give in advance the papers that are to be presented.

In the past there have been symposia and conferences to give information on the technical problems being experienced and the techniques employed to overcome these problems. Often listeners gave voice to their doubts of the viability of the projects—some remained frankly sceptical of the outcome. Some with the courage to enter the operating field gained merit and experience, but lost money. Some who overstated their case in speaking of their product should have red faces remembering their words of yesteryear!

Now, in the spring of 1968, is the time to take a cool hard look at the business aspects of hovercraft and hydrofoils. This journal believes that both systems—and the hovertrain—are here to stay. If this belief is correct, then there are questions to be asked and answered frankly and accurately.

Can the production engineer rapidly and markedly reduce capital costs? Will the "runs" in the yards be adequate to make full use of modern techniques? Are the insurance rates too high? Has a promotion ladder for employees been planned? Do the industries offer security for men who work on the production lines so that the best men are attracted? Can the operator get a good return for the capital employed?

This conference will give investors and potential operators the opportunity to meet designers, builders and existing operators, face to face, and personal commercial sense will come into play in making individual assessments. They will want to feel sure that there will be some profit short-term—enough to whet their appetite to wait for the long-term success commensurate with the risks they take at the start.

Men who back sea ventures have always been ready to take a chance; were this not so they would remain commercial landlubbers content to invest in bricks and mortar! The call of the sea penetrates even into the most unlikely veins. All, however, need to be informed of the risks as well as the potential—to be given reliable forecasts of the likely progress of these new tools of the sea trade, based on facts and figures produced by past experience.

This is why the conference is being held—"Business Aspects of Hovercraft and Hydrofoils"—in the cinema theatre of Britannic House kindly lent by the British Petroleum Company, to whom both the hovercraft and hydrofoil industries owe a great debt of gratitude for its early support.

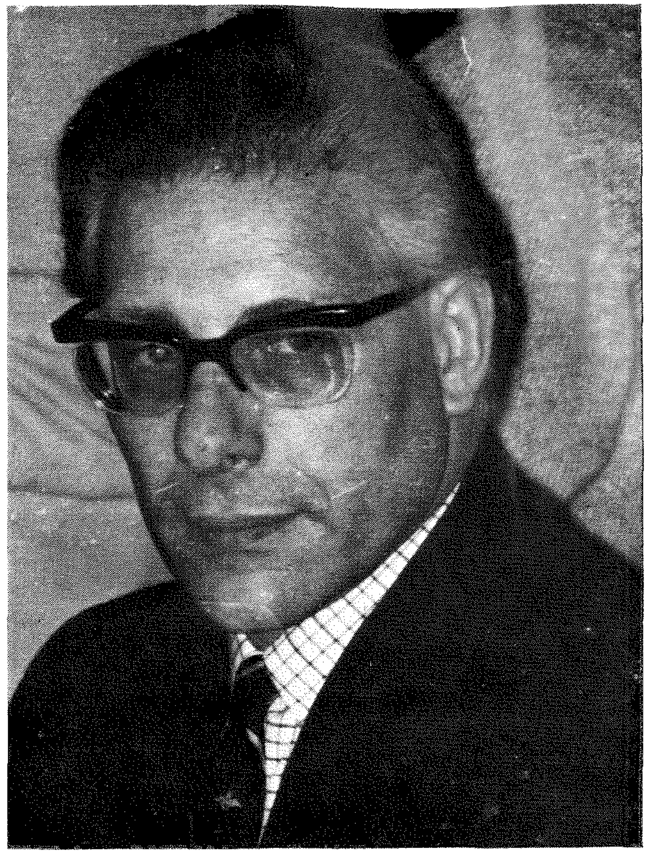
This journal welcomes the opportunity to take up another aspect with readers overseas who have not the opportunity to attend the conference, ask pertinent questions of the speakers, and buttonhole those in the audience with specialised knowledge. Will they please contribute papers for publication in the journal, telling of what they are doing, and what problems they are facing?

Some may feel that this open diplomacy will not pay, for profit is their motive. Is this really so in these technically sophisticated times? In international fast travel, barriers are being broken down, and by co-operation and mutual understanding the pace of development is speeded and profits to individuals enhanced. The speakers at the conference will surely give the lie to any "cards close to the chest" legend.

THE EDITOR

Britain's First Conference On Hovercraft and Hydrofoils

G. WANSBROUGH WHITE ARAeS, AIM
Director
Business Operations Research Ltd



Mr G. Wansbrough-White entered civil aviation in 1936 served on East African routes and in the Royal Air Force from 1939 to 1946. He became director of a shipping and transport company in East Africa until 1952, then emigrated to the UK to join the Bristol Aeroplane Co. He spent six years in the Britannia Design Organisation and then two years in the newly formed O and M Department. In 1960 he joined Metal Industries Ltd Group Management Services Unit, and in 1964 he joined Business Operation Research Ltd to form the [Systems] Company as Managing Director. He is currently Director of Business Planning of the BOR Group. Still very interested in aviation and transport in general, he is a Member of Council of the Royal Aeronautical Society and retains a pilot's licence. He is a member of the British Computer Society, the British Institute of Management, the Operational Research Society, and helped to found the Management Studies Group of the Royal Aeronautical Society. An itinerant aviation historian and writer, he once owned the oldest floating vessel in Britain and still prefers to live on a boat.

THE Editor has invited me to write an Introduction to this Special Edition of *Hovering Craft & Hydrofoil*, presumably in my capacity as Chairman of the Management Sciences Committee of the Central London Productivity Association — the sponsors of the Conference.

However, having risen on my cushion, I feel that I should do more than just make a small platitudinous journey to say what splendid things hovercraft and hydrofoils are, *Hovering Craft & Hydrofoil* is, and the Conference will be. I intend to make a slightly longer trip. . . .

The Central London Productivity Association is interested in productivity, which is another way of saying improved profitability, which implies a viable *business* running at an optimum level of efficiency. So the interest, and the purpose, is to view hovercraft and hydrofoils as the sales products of a healthy business able to create and serve a new transport market. And as pioneers of hovercraft, to meet world competition — for I must not forget that we are part of the British Productivity Council.

After a depressing Budget and in a disillusioned era this may well sound as so much pious claptrap, but however it sounds the hard fact remains that this is a young, promising industry that is going to meet, if it has not already met, daunting problems which could well cripple some enterprises. Which, I hope, is not to be pessimistic, but practical.

The end of any commercial enterprise is to be profitable, and the means is the product or the service, and to achieve and maintain this the enterprise must be viable by way of a planned efficiency to meet a justified objective. Whilst the hovercraft and hydrofoil industry has its own problems, and perhaps the particular British one of being pioneers, the fundamental rules of business are no less applicable. And here my set course (now that I'm well on my cushion) is influenced by the very fact that I serve a "Management Sciences" Committee.

Experience in business, shipping, transport, aviation and in management consultancy leads to one inevitable and simple conclusion: that a successful business is supported by a tripod, the legs being the product — the market — the administration, and held together by a proper understanding of money (finance). One leg, even two legs are not enough, and so often projects and businesses fail through neglect of the other/s. The post-war history of Britain is littered with the wrecks, many in the technological field.

A good design only becomes a good product through good administration, and even then is a meaningless objective without an available market. To satisfy, perhaps even to create, that market means the specified product meeting a price and a delivery date. All of which has been said many times before, and hardly bears repeating except for two uncomfortable facts that

(a) the right product at the right price at the right time is a problem which still defeats many companies in Britain, and

(b) the problem is often insoluble without the analysis and application of modern techniques of management decision and control.

With the growing complexity and cost of modern business and technology there is a parallel need for relevant decision and management sciences. Properly applied to the relevant problem, the product — the market — the administration can be measured and improved. The risks are greater, but the means to measure risk are better.

The littered wrecks (public and private) show how easy it is to become technique rather than problem orientated, product rather than market orientated — in short, to forget that one is in business!

This Conference, then, is concerned with commerce and economics, with the business aspects of hovercraft and hydrofoils. I hope I have arrived at destination at ETA, not too obscured in verbal spray, but before I let down my cushion, say, that the CLPA is greatly encouraged by the help given and the interest taken in this Conference. Discussions are well in hand to establish the Conference as an annual event in the hovercraft and hydrofoil world.

The CLPA is grateful to the Conference Chairman, Mr R. A. Shaw, to BP and to *Hovering Craft & Hydrofoil* for their co-operation, and this will be a rare occasion when a magazine is pre-published to become the Conference Papers.

Which would appear to be the right product at (presumably) the right price, but certainly at the right time!

A MESSAGE FROM

R. STANTON-JONES, MA, DCA, CEng, AFRAeS

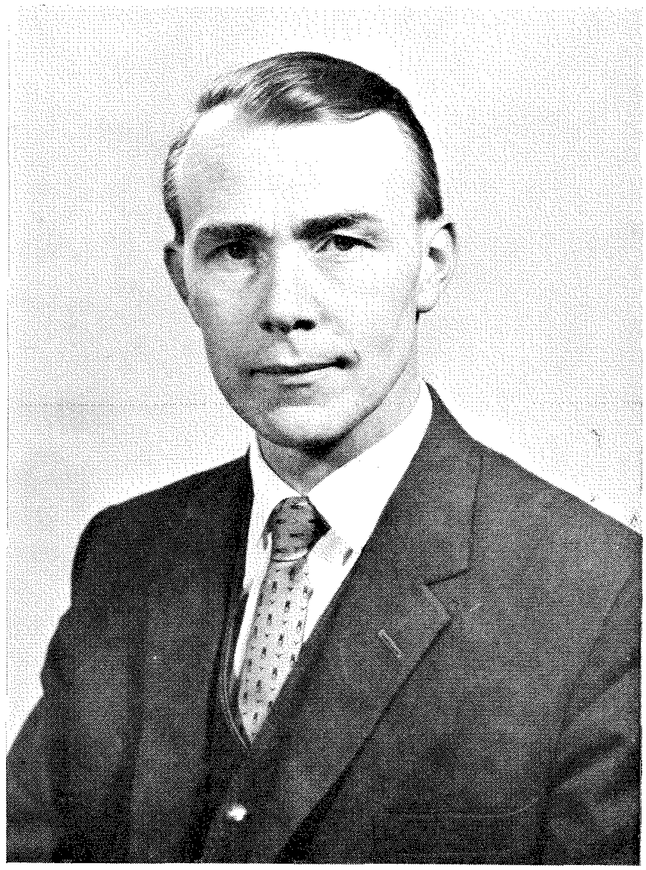
Managing Director British Hovercraft Corporation Ltd

TEN years ago the SR.N1, now destined for the Montagu Motor Museum, Beaulieu, heralded the birth of the hovercraft industry in the United Kingdom. Its appearance was greeted with tremendous enthusiasm by the British public and Press but as the years of development passed by without the announcement of massive export sales, there has been a growing disenchantment with the efforts of the industry. This body of opinion does, however, tend to forget that in ten short years the basic idea moved from the laboratory into full-scale production: from a craft weighing a mere 4 tons to a craft of 160 tons. The first really practical craft went into production only in 1964, and since that time sales have steadily doubled each year.

There is now little doubt that the hovercraft system of wholly or partially supporting a craft on a cushion of air has considerable commercial potential and in the near future craft will be able to compete directly, in terms of operating economics and first cost, with all existing and well-established forms of over-water transport, although initially operations will be limited to areas of high-density traffic which can stand slightly higher fares and areas where no other form of transport can function effectively.

For a relatively small industry, very substantial sums have already been invested in research and development to prove the basic principle and bring the hovercraft to a practical and commercially attractive reality. Since the first production craft came into service, continuous development has brought four- to five-fold improvements in technology relating to reliability, performance and control. As more craft come into service and the confidence of potential operators grows, there will be a corresponding increase in demand which will lead directly to substantial reductions in basic first costs.

There are now several new types of craft coming into service and there will doubtless be a certain hiatus in commercial development until these new types have been fully evaluated. Nevertheless, it is significant to note that the total output of this embryonic industry over the next two years will be equal to the total sum spent on hovercraft during the preceding decade.



Mr R. Stanton-Jones was born in 1926 and was educated at King Edward VII School, Stourbridge, King's College, Cambridge, and the College of Aeronautics, Cranfield.

In 1949 he joined De Havilland Aircraft Co as a junior aerodynamicist. In 1950 he became a senior aerodynamicist with Saunders-Roe Ltd and in 1955 was appointed Deputy Chief Aerodynamicist. After a period with Lockheed Aircraft Co in California, USA, he returned to Saunders-Roe Ltd as Chief Aerodynamicist in 1956, and in 1958 he was also appointed Deputy Chief Designer.

In 1959 he became Chief Designer of Saunders-Roe Ltd (which became the Saunders-Roe Division of Westland Aircraft Ltd in 1960), and in 1964 he was appointed Special Director of Westland Aircraft Ltd.

On March 1st, 1966, he was appointed Technical Director of British Hovercraft Corporation Ltd on the formation of that company, and later in the year became Deputy Managing Director. In 1968 he was appointed Managing Director of BHC Ltd.

Business Aspects of Hovercraft & Hydrofoils

R. A. SHAW O.B.E., MA., C Eng., FRAeS

Chairman
Hoverprojects Ltd
The Bowring Group

Mr Ronald Andrew Shaw 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 responsibility for research in aircraft and later for hovercraft. His headquarters were Ministry of Supply, then Ministry of Aviation, then Ministry of Technology. At the end of March 1968 he resigned from the Ministry of Technology and joined the firm of C. T. Bowring & Co Ltd as a consultant in aeronautical, hovercraft and related matters. He is Chairman and Managing Director of Hoverprojects, a subsidiary of the Bowring Group.

THE business world, it would appear, can be divided into three parts — into those who are buying, those who are selling, and the entrepreneurs, the matchmakers, who bring the first two together and help them make a satisfactory bargain. I exclude those officials and tax gatherers whose job it is to raise the obstacles and dig the ditches in the steeplechase of trade.

The field of hovercraft and hydrofoils is fast transport and in this impatient world of today they are potentially good buys, if the price is right, because everyone wants to save time. These craft fall naturally into different classes according to their route and function. Marine hovercraft and hydrofoils are direct competitors on straightforward over-water routes. Their relative advantages and disadvantages, compared with one another and with the conventional ships which they may replace, will be weighed carefully by the buyers and the entrepreneurs. Amphibious hovercraft are in a class by themselves, particularly if their rough-going over-land capacities are used extensively, and their main rival then is the helicopter. Swimming vehicles can be compared, but generally adversely, unless the water part of the journey is very short. For fast craft of great size, say 1,000 tons up, though none has yet appeared, the only likely contender is the hovercraft.

At this stage buying one of these craft is not like buying a pair of shoes — there is not an infinite variety of styles and sizes to choose from. It is more like Hobson's choice even if you do not have to take the one nearest the door; it is still a very small stable. If your needs are important enough to demand a new design and fund a prototype, it is perhaps some consolation that, at least with hovercraft, the development costs, in contrast to aircraft, are only of the same order as the unit cost in batch production.

For most customers, however, the immediate question will be whether or not existing craft will meet their needs. A careful assessment of the craft themselves, based, where practicable, on proved performance, and of the intended route conditions and task, is essential before attempting to make a choice or commit any considerable finance. A customer new to the field — and most customers are likely to be that — might do well to consider employing a specialist team to do the assessment for him. Their report would present the practical factors in both route and craft on which the customer could make his choice. More than this, it could set standards of performance which the customer could require the manufacturer to demonstrate. It could also make responsible forecasts of the economics of the operation which the customer could use to help generate additional finance if that should be necessary.

Once decided on buying the craft, the customer still has the problem of bringing it into operation. Satisfying all the Government Departments involved can be pioneering work if the craft happens to be the first of its kind imported into the country. Assuming that there are no protection laws forbidding its importation, it still has to negotiate the verbal meshes of the Customs handbook. After that it has to satisfy a host of maritime, safety and fire regulations aimed at a very different type of craft. Patience and diplomacy of the highest order are required at this stage. Finally, the operation itself has to be set on. It can be done from scratch with a local team, carefully recruited and with the key personnel given specialist training. A safer and more reliable alternative is to start with an experienced team whose job it is to launch the operation. If they are made responsible they will anticipate many of the snags which would take a new team by surprise, and those snags which surprise them they will know how to cope with.

The business aspects from the seller's point of view are rather different from, but in many respects complementary to, those of the buyer's. Marketing a new, durable (we hope) item in the field of public transport, aimed generally at operating speeds several times greater than the public is accustomed to, is bound to raise problems. Problems are raised quite properly by those who intend to ride in the craft, but they are often raised still more by those who have absolutely no intention of doing so.

The seller's problem is primarily that of discovering where the prospective customers are and then establishing an educative process to win them, and their business and official environment, over to the new concept. There is room for advertisement and publicity but, most important of all, there is need for practical demonstrations. Along with these the presence of convinced and informed representatives who can explain, argue, persuade and ultimately convert all concerned to accept the concept is essential to put the project under way. In this area of explanation and conversion there is a job which can be helped considerably at official level. Something in this direction is already being done and our own embassies and trade delegations have shown admirable initiative. Even in the field of legislation the decision here to establish hovercraft as a distinct class of vehicle is of tremendous importance in launching the concept on the world.

The Editor of *Hovering Craft & Hydrofoil* wishes to thank all those mentioned below who have contributed substantially towards preparations for the Conference on "Business Aspects of Hovercraft and Hydrofoils":

Mr J. Boldero, Central London Productivity Association
Mr G. Wansborough-White, Central London Productivity Association
Mr R. A. Shaw, Hoverprojects Ltd
Mr H. J. Dive, The London Boroughs Management Services Unit
Miss V. Hodge, The London Boroughs Management Services Unit
Mr G. Reid, The British Petroleum Company
Mr W. Wells, The British Petroleum Company
Mr M. Northorpe, The British Petroleum Company
Mr R. Dobson, The British Petroleum Company
Mr G. Weight, The British Petroleum Company
Mr L. A. Putnam, The British Petroleum Company
Mr B. J. Ball, The British Petroleum Company

IN THIS ISSUE

The Problems and Experiences of a Hydrofoil Operator

PETER DOREY
Managing Director
Condor Ltd
Guernsey

Peter Dorey was born in October 1927. Before deciding to enter the family business he worked with a number of companies in the City of London for some years, and also in Scandinavia. He became Chairman and Managing Director of Onesimus Dorey & Son Ltd, Guernsey, in 1963, following the death of his father, Mr Cecil Dorey, in that year. He founded Condor Ltd, Guernsey, in 1964, of which he is Chairman and Managing Director.

Introduction

I SHOULD like to make it clear that this paper is presented in a form which, it is hoped, makes for easy readability and interest and is therefore generally non-technical. It should be noted also that the substance of this paper deals with my own company's problems and experiences, which may not necessarily be paralleled elsewhere.

It may be of interest in the first instance to give some background information to our hydrofoil operation which is maintained between the Channel Islands and St Malo.

My family have been in shipping since around the 1850s when cargo-carrying sailing vessels were owned and operated in a small way on a world-wide basis. Later in the last century our trade tended to be confined to northern Europe and in particular a passenger and cargo liner service was operated between the South Coast of England, the Channel Islands and France. Early in the current century the passenger interests were discontinued, but various cargo interests have been maintained to the present day. It was not until 1964 when Condor Ltd was formed as a subsidiary company to the parent company that we re-entered the passenger transportation field.

Mr Alexander Silverleaf observed in 1965 that "the potential commercial [hydrofoil] operator has still to be guided largely by intuition and enthusiasm for what is still a novel form of transport". That statement was probably true of our own operation when we started our services. It is now very evident that hydrofoil transportation is rapidly moving out of its formative period.

General Observations

In considering the problems and experiences of a hydrofoil operator, it is perhaps necessary to examine the reasons why anyone should consider hydrofoils in addition to or instead of conventional transportation. Short-haul and relatively short-haul traffic has been in operation over a long period but the point in time has now been reached where, it will probably be accepted, apart from marginal improvements which may be made in the fields of propulsion and hull design, broadly speaking it is virtually impossible if not wholly uneconomic to obtain any better performance or cost reductions from conventional hulls.

Accepting this as a correct appraisal, it is therefore pertinent to examine what the possibilities are with alternative vehicles.

I feel that a large body of people do not yet understand or are unwilling to acknowledge what potential a hydrofoil has. Since the hydrofoil is essentially a marine vehicle, a close examination of it and its potential is therefore necessary. The first obvious point is the much higher speed, generally economically obtained, compared to that of conventional ferries. Whether we like it or not, speed is becoming more and more important, not only to operators in terms of time-utilisation, but particularly to passengers who in general simply want or need to travel as fast as possible with maximum comfort and minimum effort. The essence of hydrofoil operation is frequency of service and speed of turnround, which in consequence means minimum waiting time for passengers combined with rapid transportation between terminal points. Operationally, it is much more convenient to handle passengers in relatively small numbers more frequently than large numbers less frequently.

The substantial reduction in the size requirement of hydrofoils over existing conventional ferries is obvious. Broadly speaking, it is currently true that a hydrofoil one-third the passenger complement of a conventional ship has the same work capacity, but the work capacity will of course increase with higher speeds. From a manning point of view, reduction in size means a drastic reduction in the number of personnel required for operations. This is a most important point and will become increasingly more important as the years go by with current manning trends as they are known to us all.

It may be recalled that in 1964 there was enormous, and still is quite considerable, publicity relative to hovercraft. It was widely felt that when we started our operations we had made a grave error in electing to purchase a hydrofoil. A hovercraft, it was thought, was a natural development from a hydrofoil which therefore made the latter obsolescent. I am of the opinion that hovercraft (the term being used in its broadest sense) and hydrofoils each have their place; in the future, any given area will have to be intelligently appraised to determine which vehicle is best suited for the required purpose. In effect, industry will be selling "transport" rather than a particular type of craft. We considered the hovercraft which were becoming available in 1964 and concluded that they would be quite unsuitable for what we required, one of the more important requirements being that of reliable control, which is simply not possible with peripheral hovercraft. In this connection it is worth emphasising that hydrofoils have excellent stopping capability, particularly when compared to conventional vessels. Whereas a conventional ferry might required up to say half a mile to stop, a hydrofoil can literally stop in about three ship's lengths from cruising speed, merely by cutting power. The deceleration is very acceptable and indeed is hardly noticeable. Complete control is retained. Hydrofoils also offer far greater flexibility than conventional vessels, with considerable savings in many areas.

Evaluating the hydrofoils available in 1964, it was really inevitable that if we were to have any craft at all it would be a Supramar PT.50, which may be termed a first-generation craft. These craft are basically standard designs, ie about 32 knots cruising speed, having two Maybach-Mercedes diesel engines of 1,350 bhp each. Our version was designed for a passenger complement of 140 persons. Extensive tests on *Condor 1* were in fact carried out by the Board of Trade at the yard of L. Rodriquez, Messina, prior to our taking delivery of the ship and we have maintained a very close liaison with the Board of Trade ever since.

It was of course one thing to believe that a PT.50 offered an interesting future in our intended operating area; it was quite another thing to execute the operation effectively. The fact is that our operating area of the Channel Islands and adjacent coasts of France is not an easy one. It may be common knowledge that in Guernsey we have a tidal range of up to about 30 ft, Jersey up to about 36 ft, and St Malo up to about 45 ft. These tidal ranges produce many tide rips, overfalls and confused seas, and there are numerous reefs. The area is exposed to the Atlantic to the west, mists and fogs are not uncommon, and the weather and sea conditions can change rapidly more or less at any time. Wind itself is a minor problem for a hydrofoil: it is sea conditions which are highly material.

Accepting the physical hazards, competitive considerations had to be taken into account. British Rail discontinued their conventional sea connection between St Malo and the Channel Islands in 1963 but another operator took their place. British Rail have, however, maintained services between Guernsey and Jersey, whilst BEA and/or BUA operate services on all our routes except to Sark, which does not allow motor vehicles of any description. It may be seen, therefore, that the physical hazards, combined with competition from other forms of transport, present a picture which is no small problem.

With these known conditions in mind we decided literally to jump off the deep end and try to make the best of it, partly because we wished to enter a new field which appeared to offer a number of attractions and partly also because our conventional cargo trade was in decline. We had few illusions about the problems we were about to face, but it must be said that our problems proved in fact to be considerably greater than we had anticipated. It will be readily understood, in the light of all these factors, why, although we needed publicity for revenue purposes, we were not too keen for it in view of our operational inexperience and all the many other unknown factors. From the publicity point of view, therefore, we tended to lean on the side of caution.

I propose to divide my paper into roughly two main sections; the first will deal with physical operations and maintenance, etc, and the second will deal with statistical and financial considerations.

Physical Operations and Maintenance

It is perhaps obvious that when initially considering an operation of this nature, close attention must be given to the physical limitations and facilities relative to berthing points at each terminal.

Most of our terminals do have tidal limitations, but one way or another we manage to overcome these. We were helped by the enthusiasm of local and French harbour authorities and in a very short space of time we ourselves had built pontoons for Guernsey and Jersey whilst the French provided berthing facilities at St Malo, Granville and Cherbourg on our behalf.

Reflecting on our first schedules in 1964, it is clear that we tried to serve too many places irregularly rather than fewer places regularly. Regular and frequent services appear to generate their own traffic. We had few guide-lines on which to work and by trading to many different places we were able to judge the interest shown and to gauge the various operational problems. Our Board of Trade International Certificate — Britain's first — permits us to operate between St Malo, Granville, Cherbourg, Jersey, Alderney and Sark in any rotation in wave heights of up to 10 ft or Force 6 Beaufort Scale. We also hold the first and only Board of Trade Hydrofoil Certificate for cross-Channel operations which was granted in September 1964. Altogether we undertook three voyages in each direction between Torquay and Guernsey at that time.

An appraisal of any area makes it necessary to define exactly what type of traffic may be anticipated. In the main we are concerned with holiday traffic, although our analyses show that our single and period return sales are rising annually. This undoubtedly is evidence of the utilisation of the hydrofoil as a specific means of transportation. In fact, from the very beginning of the venture we were anxious to avoid any question of a "gimmick", although this thought was certainly in the minds of many people. The operation was indeed openly regarded as a seven-day wonder but it is now, without question, an accepted part of the local transportation system during the more amenable parts of the year. Here it may be mentioned that we did have hopes of utilising *Condor 1* during the winter-time in some other area, but as it happened we needed the time available during the winter, every winter, for one reason or another.

Generally speaking we operate a very "tight" schedule and at peak periods easily transport say 400 people or so to various destinations during any morning, retaining the obligation to redeliver them or other persons in the evening. There have been occasions, fortunately infrequent, and will no doubt be occasions in the future when the weather has suddenly deteriorated or some mechanical fault has developed where such an obligation is impossible to implement. In spite of this fact, either by transferring passengers to available conventional vessels or by chartering aircraft, we have always met our obligations in full, although it must be appreciated that some passengers have suffered delays. Whilst delays are frustrating, they are nevertheless fairly well accepted in, for instance, air travel; but if for one reason or another we are delayed by minutes it is not unusual to have comments. Being a one-ship company, this problem is of course more pronounced.

In general, however, we have maintained extremely punctual schedules, even in relatively bad conditions.

Passenger reaction to hydrofoil transportation is interesting. It has been variously described as fascinating, exhilarating, terrible and wonderful. Unfortunately, because of one or two rather rough trips early in 1964 we suffered from extensive adverse word-of-mouth publicity. It took us more than two years to kill this. Broadly speaking, in spite of sea conditions which sometimes give exceptional craft movement, passengers are now highly appreciative of hydrofoil travel. They are able to walk around the craft and go out on deck provided the weather is suitable, and they know that the old days of lumbering ferries at 15 or 20 knots do not apply to them. They are able to get more out of their day.

Hydrofoils generally, and our PT.50 in particular, do have relatively good sea-keeping capability, within limits. We have always been able to proceed on the hull in very adverse conditions, in case of need at say 10–12 knots, but we prefer to cancel schedules if wave heights exceed approximately 7–8 ft. Much depends on the direction of the wind, which directly affects sea conditions; for instance, westerly winds present more difficulties than easterly winds. Much depends also on the nature of the seas themselves: we have virtually no difficulty with a beam sea, whilst a head sea is better than a stern sea. In general it cannot be over-emphasised that the ability of a hydrofoil to give precision control is extremely important.

As regards navigational aids, we use a Decca 202 Radar, which we find very good on this craft, Decca Navigator Mark 12 and a Decca Flight Log, which is of course similar to those used in aircraft. The Flight Log is particularly useful for a quick check on position when visibility is poor. It must be appreciated that actual plotting on a chart whilst foilborne is extremely difficult.

The question of life-saving appliance equipment is proving a difficult one for us. The UK version of the IMCO Solas lifejacket is far too bulky to stow under our seats. We presently have dispensation to continue with the "Victory" type lifejackets this year, but what is to be done next year is still an open question. It is highly undesirable to stow lifejackets in lockers in what is necessarily a confined area, yet if we have to use the new lifejackets, locker stowage would be necessary and our passenger numbers would have to be reduced accordingly. On the other hand, the IMCO lifejackets of other countries do stow perfectly well under our seats.

As an operator, I find it very difficult to understand why an internationally agreed specification should produce such a variety of lifejackets all of which may be legally used in international trade by the country of origin. It is to be hoped that a practical solution will be found to this problem.

The question of LSA equipment is further complicated when it is considered that peripheral hovercraft are allowed to operate on international routes with small aircraft-type inflatable lifejackets, merely because they have a "permit to 'fly' ". When peripheral or any other hovercraft travel over water, it appears to me to be entirely logical that they should comply with maritime legislation. Surely the governing factor must be literally "the safety of life at sea". Technical "legal" elasticity does not alter this view. Hydrofoils are very safe and seaworthy craft, even in adverse conditions, but the seaworthiness of peripheral hovercraft, particularly if there are engine failures, has still to be proved. Another anomaly *vis-à-vis* hovercraft and hydrofoils relates to fire protection which, so far as hovercraft are concerned, is still an unresolved question.

Mention should be made of the personnel in an operation of this kind. It will be appreciated that operations in these waters are different from relatively calm water operations, such as the Messina Straits or the Oresund between Denmark and Sweden. A far greater "feel" for small craft is necessary, and indeed small craft psychology is immensely important. Having secured the right crew, the question of crew fatigue is important, for however diligent and loyal a man may be, as a high standard of alertness is desirable it is necessary to pay regard to constitutional capabilities. We have developed a rota system which works extremely well in this respect to the satisfaction of both the crew and ourselves and entails flexibility of personnel. Also, with no sleeping accommodation aboard, the opportunity exists for many crew members to stay overnight with their families and live a more "normal" life. In our case we are somewhat overmanned since, having one craft only, relief masters and chief engineers are required in greater proportion than would be the case with two or three hydrofoils. There is always someone aboard during our "in commission" period. Once the crew members have left, a watchman/cleaner takes over and in this respect, as indeed in so many other respects, the whole operation is more akin to that of aircraft operations rather than of marine operations.

Turning now to mechanical and maintenance questions, I may say that our problems have been considerable. During 1964 we consumed no fewer than eight pairs of propellers, many failures being due to simple fractures. We were not unnaturally perturbed to ascertain by analysis that the metallic composition of the propellers was below normal standards. We therefore insisted on, and now obtain, propellers of a higher standard. Nevertheless, the question of cavitation has always been and probably will always be with us so long as we use water propellers. On average we find that the propellers need repairing after some 250 hours' duration. We are, however, constantly experimenting with different designs and our latest feeling is that we can increase the life of our propellers considerably at only marginal extra cost per unit. It is always a problem to decide what attitude to adopt. Expensive propellers can be obtained with a much longer life factor but the possibility of damage is still present. An operator has to decide whether to spend more money on propellers which will require less frequent changing but which may be damaged during the first hour of operation, or alternatively cheaper propellers which have to be changed more frequently and which may still also be damaged very shortly after fitting. I may say, however, that damage to propellers has been minimal and on average we have touched objects only about twice per year. To touch an object with the propellers does not necessarily mean that a schedule cannot be completed, depending always of course upon the degree of damage. It does mean that in order to obtain the most efficient results a change has to be made as rapidly as possible after the contact. We have always made a practice of inspecting our propellers regularly under water, and because of our fortunate geographical position we are able to change the propellers during a low water merely by berthing *Condor* in a suitable berth and allowing the tide to fall. We fitted special skegs to enable her to take the ground safely, standing on her foils. As a matter of interest, we have changed propellers under water with skin divers both in daylight and at night, and we hope that we may improve upon our methods, which can be very useful at times.

We have really had very little trouble with the foils themselves, which are extremely strong, and they have not suffered from cavitation erosion. Contact with débris is akin to a knife cutting cheese: the faster the knife is allowed to fall, the more efficiently is the cheese cut. With hydrofoils, the foils or struts tend to be like cutting edges, so the greater the speed and size of craft the larger is the débris that can be destroyed. We always try to avoid débris, however, since there is always the danger of its being carried down our inclined shafts to the propellers. Obviously, "Z" drive propellers or water jets will greatly minimise damage of this description.

Corrosion is of course a very material point. We carried out extensive trials with different paints from many manufacturers, all of whom were confident of the success of their own products. It is fair to say, however, that in general not one single paint was satisfactory on the underwater sections until we finally got to the root of our problem by fitting anodes at certain specific points on the hull, not the struts. During 1967, our first year with anodes, virtually no corrosion took place at all and the paint consequently continued to adhere. It is of course difficult to keep paint on the foils themselves, and whilst our foils are constructed of specially hardened Asera 52 steel it is evident that progress will demand that foils will be made of polished steel, despite the extra expense; thus foil painting will no longer be relevant. It is noteworthy that marine growth will take place on the foils themselves, which in consequence have to be carefully maintained by scrubbing and painting from time to time so as to ensure as smooth a surface as possible. There is marked deterioration in performance, even as much as 3–4 knots, if foils are not well maintained. This in turn results in increased engine temperatures. Fixed or non-retractable foils, such as we have, call for regular maintenance both under water and when the craft is dried out. Retractable foils, which one may not unreasonably anticipate in the future, are of course advantageous in this respect. We have had unfavourable experience of corrosion and cavitation of pipework, etc. Had better materials been used initially, much maintenance cost could have been eliminated or minimised.

I feel that sufficient consideration has not up to now been given in respect of the ease with which craft can be maintained. Ease of maintenance in many cases can also mean a drastic reduction in the cost of maintenance and is absolutely paramount with hydrofoil operations. Delay in completing maintenance can of course mean loss of schedules and revenue, and also dissatisfaction by intending travellers. Strict routine inspection and maintenance is essential, and much of our work is carried out at night so as to avoid cancellation of schedules. As those connected with the aircraft industry may be termed aircraft-minded, so may those connected with hydrofoils be referred to as hydrofoil-orientated. Once sea-going and shore personnel think along the right lines, regarding everything as "normal", much of the difficulties disappear and operations are paradoxically easier.

In the light of these remarks it will be understood how vital it is to have adequate repair and maintenance facilities at hand, which are really a prerequisite of any hydrofoil operation.

Structurally, we found our hydrofoil deficient in a number of ways and since we started operations we have progressively modified her. One very big problem that developed was in 1965 in connection with the foil boxes, which are a point on the hull to which the foils are bolted. During "heavy conditions" fractures developed so that the foil boxes started "panting". Constant temporary repairs were necessary throughout the remaining part of the season. At the end of the season those units were completely redesigned and strengthened, following which we have had no further trouble. We have, however, had continual trouble with gussets, frames and rivets, and in 1967 we found that our vessel had taken a permanent "set" at the time of the engine fractures. We greatly increased the strength of all replacement gussets, etc, realigned the shafts, and the craft is now operating perfectly normally.

The main engines have on the whole worked satisfactorily apart from a rather high consumption of spares. Fractures of cylinder heads and corrosion and cavitation of cylinder liners have, however, been considerable. In 1967, at the peak of our season — in mid-August — we had our greatest setback when on a routine examination at Guernsey we found that the port main engine entablature and some cylinder blocks were fractured in a number of places. It was evident at that time that little could be done to continue our services and they were therefore discontinued until our 1968 season, which commenced on March 21st.

Whilst the starboard engine appeared to be satisfactory, we nevertheless sent both engines to the builders — Maybach, Mercedes-Benz at Friedrichshafen — where it was later discovered that the starboard engine also had sustained a cracked entablature. These fractures were put down to heavy weather conditions, and stringent examinations of the engines were made by the engine builders and the BoT. The engines have been modified. The amount of work and expense in dealing with that situation has of course been enormous relative to the size of the project and there is no doubt that in many ways it severely strained our inclination to continue operations. I may also say at this point that at the end of the 1965 season we seriously reappraised our activities, since we appeared to have nothing but excessive difficulties and expenses, with nothing to show for it. Indeed, it is fair to say that if a buyer had offered a fair price at that time, we may well have taken it. To that extent our faith has not been unshakeable. We constantly have to remind ourselves that in many ways we are asking a Dakota to do the work of a Boeing 707.

Generally it is my opinion that a much closer liaison must be maintained in the future between designer, builder and operator. This will entail a mutual co-operation which is not always easy unless those concerned give freely of themselves. In a commercial operation, as distinct from naval or military considerations, at the end of the day it is the operator and the operator alone who is of prime importance, since without a satisfied operator neither the designer nor the builder would continue in business. I believe that this co-operative attitude of mind is now beginning to be realised.

Statistical and Financial Considerations

Our operation is entirely privately financed, my own company holding the controlling interest. The total outlay with ancillary equipment was approximately £200,000. We have not as yet received a return on our investment, nor indeed have we been able to set aside enough for depreciation purposes based on an eight-year amortisation. We have therefore to accept and are financially well able to accept the situation that either the unearned depreciation is set against the experience, knowledge and knowhow gained, or the decision to depreciate over an eight-year period was too optimistic in the overall circumstances. In this respect there is a precedent in that the first commercial Supramar hydrofoil is still operating well after twelve years' service. The possibility of technological obsolescence has of course to be considered but I believe that the surface-piercing hydrofoil will continue alongside developing types of craft for very many years to come — again a similarity with the aircraft industry.

Although we have owned and operated only one type of hydrofoil, there is no doubt that actual participation in the hydrofoil world enables us to evaluate other types of hydrofoils and, indeed, hovercraft, particularly as we always make a point of keeping very well informed about existing and proposed types. It should be remembered that our services were not started in parallel with existing services but were entirely new. It is obvious therefore that two or three seasons were necessary thoroughly to establish the project, and it will readily be seen how unfortunate it was that 1967 could not be completed naturally, since the trend was so very favourable and we believe would have been our breakthrough year.

Disregarding the usual "glossy" sales literature which most manufacturers seem bound to present in appallingly glowing terms, we of course made our own estimates of costings. These estimates were exceeded by a considerable margin, despite contingency allowances, and undoubtedly the most serious additional costs have been those of repairs, maintenance and redesign, etc. In retrospect it seems unbelievable that since we commenced operations on May 1st, 1964, we had spent over £75,000 on these items by the time the vessel re-entered service on March 21st, 1968. A considerable amount of the work should not have been necessary.

It may be regarded as exceptional for a private company to detail the figures which follow, but we feel that we have little to lose by so doing and indeed much to gain, especially if constructive criticism is forthcoming. The figures are undoubtedly interesting, however, because they show trends in an area which is already well served by existing vehicles, both aircraft and ships. I am presenting four appendices and will comment on them individually:

Appendix 1 shows a general information chart, the columns being lettered A to F inclusive.

A. It will be noted that the total number of passengers carried up to August 13th, 1967, was 199,636.

B. With the base year of 1964, the progressive increases over the previous years should be noted and in particular the increasing penetration up to and including 1967.

C. Passenger mileage totalled 6,353,449 to August 13th, 1967.

D. The overall load factors are self-explanatory.

Whilst these figures are reasonably good, they must of course be related to the actual hours of operation as shown in E.1.

E.1. It is generally estimated that vehicles of this description should operate for 1,500–2,000 hours per annum. So far we have been unable to achieve anything approaching these figures although we are extending our period of operation year by year. To compensate for the shorter period of operation, the fare structures are of course considerably higher than might be expected in other areas. Although they

		1964	1965	1966	* 1967
PASSENGERS CARRIED	A	31,082	53,948	61,399	53,207
PERCENTAGE INCREASE OVER PREVIOUS YEAR	B		78%	21%	26%
PASSENGER MILEAGE	C	1,036,649	1,583,506	1,987,370	1,745,924
OVERALL LOAD FACTOR COMBINED ROUTES	D	37·19%	45·30%	59·34%	57·15%
SCHEDULE HOURS (ACCOMPLISHED)	E_1	739	849	907	870·5
ENGINE HOURS	E_2	896	1012	1040	965
SCHEDULED OPERATIONAL DAYS	F_1	153	170	190	146
NON-OPERATIONAL DAYS (WEATHER AND MACHINERY)	F_2	34 1/2	36 1/12	40	19 2/3

* TO 13th AUGUST 1967

Appendix 1

are competitive with existing services, falling somewhere between those of air services and conventional sea services, they are, if anything, nearer to the air fares. However, if we cannot operate because of weather or mechanical reasons, then our loss is likely to be very much greater than it would have been in a lower-revenue-producing area.

E.2. These figures are given only for comparative purposes.

F.1. The figures given in this column are related to the actual days which were scheduled between our commencement and finishing dates. In the case of 1967, the figure is only taken to August 13th but in fact, had we been able to complete satisfactorily, the scheduled days would have amounted to 212.

F.2. A cancelled day is divided up into the number of legs during that day. For instance, if there are six legs in a day, cancellation of one leg would be one-sixth of a day,

FARES PER PASSENGER/MILE

			1964	1965	1966	1967	1968
GUERNSEY/JERSEY	28 MILES	D	9·5	8·5	8·5	8·5	10·7
		C	11·1	9·3	9·3	9·3	(12·5)
JERSEY/ST. MALO	38 "	D	11·3	10·0	10·0	10·25	11·1
		C	13·2	11·7	11·7	12·0	(12·9)
ST. MALO/JERSEY	38 "	D	11·3	11·3	11·3	11·3	13·8
		C	13·2	13·2	13·2	13·2	(16·1)
JERSEY/SARK	22 "	D		9·25	9·5	10·9	13·6
		C		10·8	11·1	12·7	(15·9)
GUERNSEY/ST. MALO	58 " (DIRECT)	D	7·0	6·5	6·5	6·6	7·2
		C	8·1	7·6	7·6	7·7	(8·4)

D = PENCE STERLING
C = CENTS U.S. £1 = $(2·80)

Appendix 2

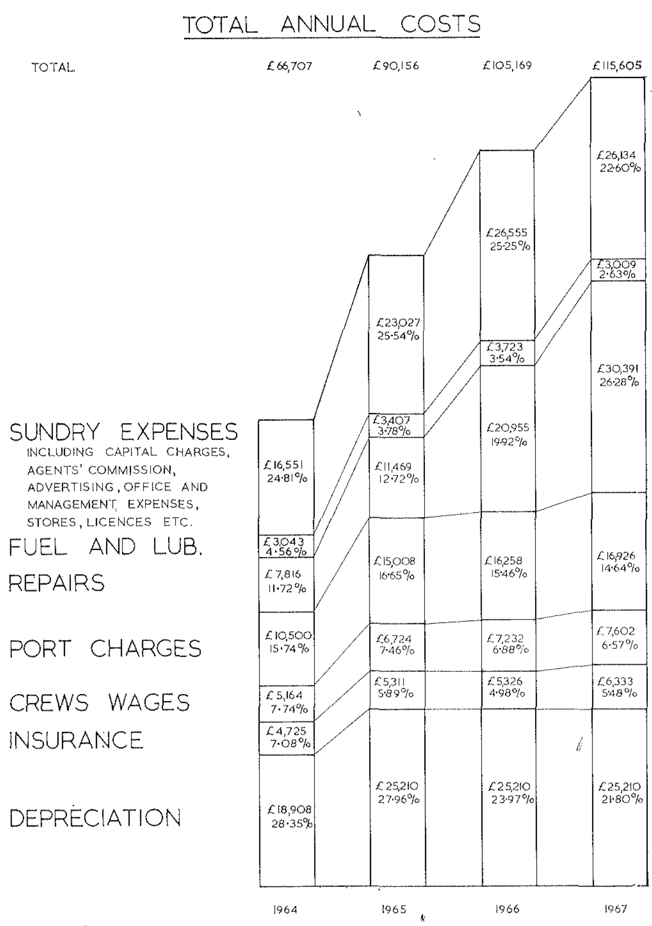
etc. These figures should under no circumstances be taken to mean that the vessel was idle for the number of days stated in this column. Very often we were able to operate on some routes but not on others, depending on weather conditions.

Appendix 2 showing fares per passenger mile is self-explanatory. The bracketed figures under 1968 are only inserted to show the proportionate increases based on the pre-devaluation dollar rate of exchange of $2.80. Naturally, pennies and cents presently have the same value.

Appendix 3 shows total annual costs, 1964-67 inclusive. The fuel and lubricants economy will be noted. The most serious charge relates to those of repairs, etc, and the very steep rise in that area will be noted. The amounts are of course grossed up and whilst there have been some insurance recoveries and further recoveries are anticipated, claims nevertheless tend to inflate insurance premiums. Ours this year has increased very substantially indeed.

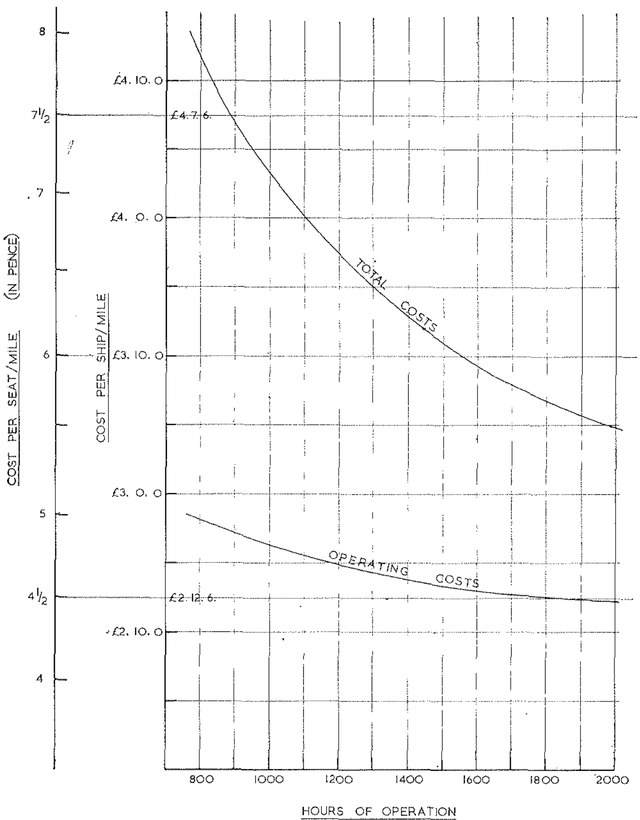
The item "Crew's Wages" might appear on the low side, but it must be remembered that in the "off-season" a number of our personnel are absorbed into our other activities or else may be on a seasonal basis, ie employment during the operating period only.

Appendix 4 shows the estimate for 1968 of costs per mile. This is of course broken down to costs per seat-mile and costs per ship-mile, and is self-explanatory.



Appendix 3

ESTIMATE FOR 1968 OF COSTS PER MILE



Appendix 4

The Last Word . . .

I am bound to agree with many others that somehow in the world today provision of transport services very often appears to be widely regarded as an obligation on the part of the operator, whether nationalised or not. Sufficient thought is not given to the fact that an operator must make a satisfactory return, as with any business. The return on the shipping industry generally is appallingly low, yet capital assets are immensely expensive and risks no less so, particularly in view of the rapidly changing technological scene. Unless one is in a highly favoured position, losses and mistakes cannot merely be written off as not infrequently happens in some areas. However, since subsidies in one form or another appear at present to be a fact of life with which we have to live, it is all the more important that the most economic and attractive vehicles are utilised in their given roles and that general enlightenment will prevail in that field. We have had and will no doubt continue to have our problems, though we hope less severe than hitherto, yet our attitude is that if the fast water transportation era has any future at all, it must stand on its own feet. This, we feel, our operation is beginning to do, and that what we have achieved has been very worth while and encouraging for the future.

We are convinced that economic developed hydrofoils will begin to appear in the fairly near future and their ability to deal with really severe weather conditions (ie normal North European year-round weather) will make them extremely attractive to operators in that area. It should be remembered that only within the last few years has it been technologically possible to get to grips with hydrofoil development in its fullest sense and I feel that developments from now on will be akin to those of the aircraft industry in the 1930s and 1940s.

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BLOHM AND VOSS AG, 2 Hamburg, Postfach 720.

THE BOEING COMPANY, Advanced Marine Systems Organisation, Seattle 24, Washington, USA.

CONVAIR DIVISION OF GENERAL DYNAMICS, San Diego, California, USA.

DE HAVILLAND AIRCRAFT OF CANADA LTD, Downsview, Ontario, Canada.

FMC CORPORATION, Ordnance Engineering Division, 1125, Coleman Avenue, Box 367, San Jose, California, USA.

GDANSK SHIP RESEARCH INSTITUTE, Technical University, Gdansk, Poland.

GRUMMAN AIRCRAFT ENGINEERING CORPORATION, Bethpage, Lonf Island, USA.

[GARRETT CORPORATION] (world-wide distributor and sales agent for the Grumman "Dolphin"), 9851-9951 Sepulveda Boulevard, Los Angeles, California 9009, USA.

LUDWIG HONOLD MANUFACTURING CO, Chester Pike and Folcroft Avenue, Folcroft, Pennsylvania, USA.

HITACHI SHIPBUILDING & ENGINEERING CO, Kanagawa Shipyard, 1-Mizve Cho, Kawasaki City, Kanawaga Prefecture, Japan.

HUNGARIAN SHIP & CRANE CO, Vac, Hungary.

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INTERNATIONAL HYDROFOILS & AIR CUSHION VEHICLES, 241 East 44th Street, New York 10017, USA.

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KRASNOYE SORMOVO SHIPYARD, Gorki, USSR.

MARYLAND SHIPBUILDING & DRYDOCK CO, PO Box 537, Baltimore 3, Maryland, USA.

MITSUBISHI HEAVY INDUSTRIES LTD, Shimonoseki Shipyard and Engine Works.

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SEAFLIGHT SpA, Via della Munizione 3, Messina, Italy.

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SOUTHERN HYDROFOILS LTD, 24 Cumberland Place, Southampton, England.

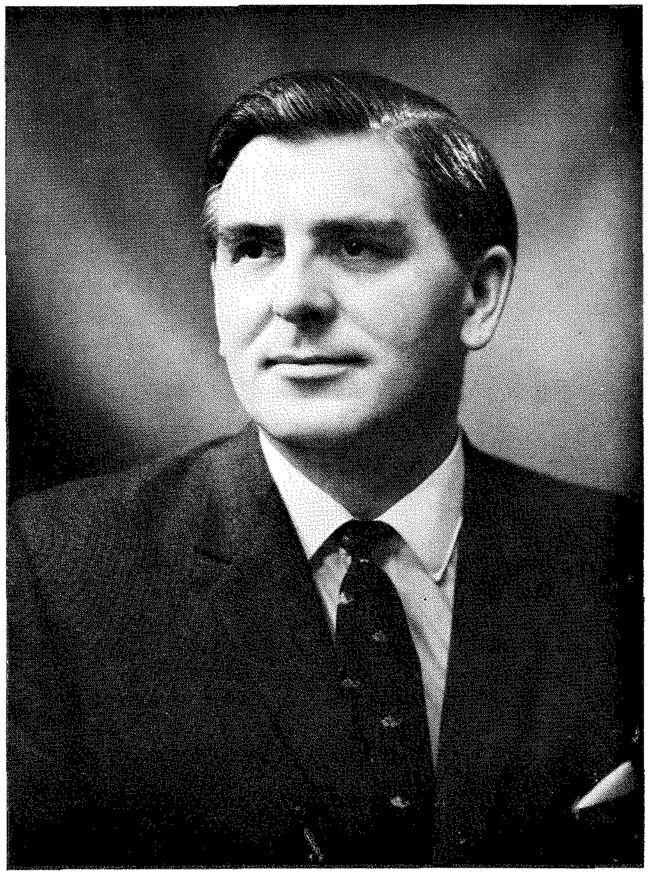
WALTER SPYDER MARINE LTD, 157 Richard Clark Drive, Downsview, Ontario, Canada.

SUPRAMAR AG, Denkmalstrasse 2, Lucerne, Switzerland.

WESTERMOEN HYDROFOIL A/S, Mandal, Norway.

Commercial Hovercraft Operation

C. A. BRINDLE A.I.Mar.E
General Manager
British Rail Hovercraft Ltd



Mr C. A. Brindle, who is forty-one, was in the Royal Navy from 1943 to 1947 and served an apprenticeship in mechanical engineering. After technical experience with an engineering company in the automotive and aircraft component industry he entered the marketing field in 1949 and subsequently worked with a European organisation as consultant to British, European and American companies in the engineering fields.

He joined British Railways in May 1962 as Sales Manager in the Divisional Manager's Office in Birmingham. During his service with Western Region of British Railways, Mr Brindle was closely concerned with the inauguration of the joint rail-air links between the Midlands, the West Country and London Airport.

In 1965, Mr Brindle was appointed to set up the railways' hovercraft interests, and he is now the General Manager of British Rail Hovercraft Ltd — operating the "Seaspeed" hovercraft services. His field of responsibility embraces the technical evaluation of hovercraft, route investigation, and planning and commercial and trials operations.

He is a hovercraft pilot, an Associate of the Institute of Marine Engineers and a member of the Institute of Marketing.

Most successful transport operators have been brought up in the empirical school where there has existed a basis of long-standing practice. The operation of hovercraft, however, is, in itself, a new science and, while many of the basic principles of transport operations in general will apply, the hovercraft operator has, in these early days, to set his own standards of professionalism.

Successful transport operational practice improves with every development in the breed of vehicle or craft it uses. Thus, the basis of good ship operational practice has been evolved over a considerable period of time and can be reflected through the development of ships in sail from the *Carrack* to the *Yankee Clipper* and for the power vessel from *Sirius* and *Great Western* through steam turbine to diesel and to nuclear power.

The nineteenth-century railway companies were probably the first organisations to attempt to harness transport operational practice into a working science whereby the operation of a transport unit should be safe, economical, efficient and properly geared to the market. In making any comparison with hovercraft, this comparison will be with surface transport, but it is nevertheless interesting to note that a number of airlines drew their original operating personnel — and expertise — from the railroad industry.

For the hovercraft industry, there is a close relationship with the birth of aviation in that there is no prime fund of experience upon which to draw.

The operation of any hovercraft service must commence with a study of the application of hovercraft to a specific route and, in this context, a series of factors need to be considered, some of which are more obvious than others:

(a) The market — its size, its structure and its trends.
(b) The natural geographical situation.
(c) The craft available.
(d) The evaluation of competition, both existing and potential.
(e) Specific regulation to be applied.
(f) Terminal availability.
(g) Terminal access.
(h) Onward surface transport connection.

Obviously, no service operation would be considered without a potential market, and the intelligent assessment of a market must be a fundamental part of the initial work.

There is no need to elaborate upon the results of market research, upon the study of existing traffic flows, for when all the available commercial information has been assimilated and all the statistics produced, the final decision to proceed with the detailed operational planning of a service will depend upon judgment. Marketing in transport is fundamentally no different from marketing in any other industry, in that any major decision will be made primarily upon judgment, all other factors considered albeit to a lesser degree.

Accepting that the commercial decision has been reached, ie that there is a market for a rapid-transit marine ferry, then an assessment must be made of the available craft — amphibious hovercraft or immersed sidewall hovercraft — and the configuration of the craft itself in terms of passengers, accompanied vehicles and freight.

The principal decision will be one in relation to the type of craft, and the advantages or otherwise of each may be summarised as follows:

Amphibious Hovercraft

Advantages

(a) Potentially very high block speeds.
(b) Simple low-cost terminals.
(c) Ability to operate over shoal and drying ground.
(d) Rapid discharge and loading.

Disadvantages

(a) Relatively high operating cost (so far).
(b) Low times between overhaul on specific components, ie engines and propellers.
(c) Maintenance of aircraft-type structures.
(d) Relatively high-cost staff (sea-going).

Immersed Sidewall Hovercraft

Advantages

(a) Low operating cost.
(b) High times between overhauls on rotating components.
(c) Low cost maintenance of simple structures.
(d) Block speeds high in relation to conventional ferries.

Disadvantages

(a) Requirements for berthing facilities through tidal range.
(b) Requirement for slipping and cranage facilities.
(c) Longer route distances in tidal waters with resultant lower point-to-point timings.

To illustrate the advantages of each type of craft, consider two routes in the United Kingdom: Portsmouth (Hampshire) to Ryde (Isle of Wight), a cross-Solent route, on the one hand, and Grimsby (Lincolnshire) to Hull (Yorkshire), across the Humber Estuary, on the other.

In the case of Portsmouth to Ryde, the route distance is some 4 miles for an immersed sidewall craft as against 3½ miles for an amphibious craft at the low tide state, and it will be seen that an amphibious craft capable of operating with a block speed of 50 knots will complete a passage, including berthing, in 6–7 minutes, while an immersed sidewall craft operating on a block speed of 30–35 knots will require some 10 minutes to complete the passage. At the present state of the hovercraft art, there is no doubt that the cost per seat-mile for operation of immersed sidewall craft is considerably less than that for amphibious craft. Thus, in the specific case of the Portsmouth–Ryde route, it is shown that between the two craft there is a net difference of only about 3–4 minutes — so short a time is of little consequence — but at the advantage of a considerable reduction in the operating cost per seat-mile. Thus, this is a route which clearly favours the immersed sidewall craft in the purely passenger role.

In the case of Grimsby–Hull, there is a need to traverse up and across the Humber Estuary with its wide expanse of mud and sand at low water, and as a result produces by no means such a clear situation. In considering the application of a timetable, account must be taken of the low tide state, and the application of point-to-point timings must always take account of the maximum distance which will need to be traversed. In the specific case of Grimsby–Hull, at the low water state an immersed sidewall craft, even with its very modest draught, requires to navigate over a route distance of some 16½ miles and with a block speed in the 30–35 knot range. This will result in an elapsed time on passage of about 35–38 minutes. This factor, coupled with the allowance for berthing in fast-flowing tides, means in practice using an interval timetable, a service pattern of a single journey each hour.

In the case of amphibious craft, the route distance between Grimsby and Hull is about 12½ nautical miles at any tide state. This, coupled with a block speed in the 50 knot range, results in an effective passage time of about 20 minutes. Simple loading and discharge facilities means a total single journey within 30 minutes. It will therefore be clear that by taking craft of similar capacity, a single craft in the one case will produce a service pattern which requires two craft in the other. This is, of course, accepting a situation where there is a market requirement for an hourly service.

No potential operator is going to ignore the competitive situation. Is there an existing transport service over the proposed route? If not, why not? There may be an existing conventional ship service already operating and providing an adequate link, but if that service has an existing high traffic pattern, then probably a rapid-transit service is going to be a highly marketable product.

On routes between the mainland and the Isle of Wight there are three traditional conventional routes — from Lymington to Yarmouth, which carries about 20% of the total traffic with a ship passage time of 30 minutes; from Southampton to Cowes, which again carries about 20% of the total traffic with a passage time of 1 hour; and from Portsmouth to Ryde/Fishbourne, which carries about 60% of the total traffic with a passage time of 30 minutes. The first hovercraft services on the Solent paralleled the Portsmouth–Ryde and Southampton–Cowes services but it was clear that there was a market for a service between Portsmouth and Cowes, Prior to the introduction of a hovercraft service, to the ship passage time of 30 minutes had to be added, for the passenger to Cowes and West Wight, a further 20–40 minutes by car or bus. For a ship to undertake the passage direct from Portsmouth–Cowes would require a passage time of some 60 minutes, showing no advantage in total time, whereas a hovercraft can, and does, accomplish the passage between Portsmouth and Cowes in an average time of 16½ minutes.

Cognisance must be taken of the degree of profitability of any existing service. Many conventional ship services have been established over a very long period of years during which berthing facilities, for instance, may have been written off with a result that faced with serious competition there would be room for a cutback in what might be an existing high fare structure.

The cost structure of hovercraft operation differs in some marked degree from that of any other means of surface

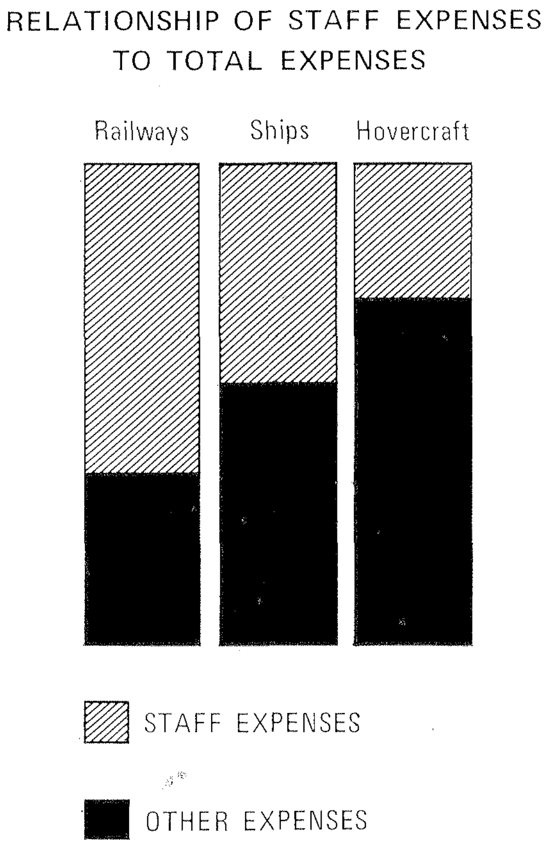


Figure 1

transport. Any transport operational cost structure will be made up of two prime factors: the direct or variable cost, and the fixed or non-variable cost. The direct operating cost being that part of the total cost structure which is directly related to the utilisation of the vehicle or craft, and the indirect cost being that part of the total which remains fixed, ie amortisation, interest, overheads, staff and so on. Furthermore, by virtue of their construction and performance, the hovercraft operating business is one which is predominantly low in labour intensity. Fig 1 has been drawn to indicate the relationship between railways, ships and hovercraft in this context, and it will be seen that the greater part of the total cost of operating a railway is made up of staff costs. In the case of ship operation, under the existing manning scales the proportion of the total cost spent in labour is still of high proportion, whereas in the case of hovercraft this cost is considerably less: therefore, low labour intensity.

A not dissimilar situation exists in relation to the total cost structure of hovercraft when compared with other forms of surface transport. Fig 2 indicates the relationship of variable to non-variable costs in the case of railways, ships and hovercraft. To operate a railroad, there must be extensive provision of track and signalling systems before even the provision of the train and there is a high labour intensity required to maintain that track and signalling system. Thus the greater part of the cost of running a railway has to be spent before anything moves. In the case of shipping, similar principles apply. Expensive facilities are required to service the ship. She must be constantly maintained whether or not she be on passage. Thus, the non-variable costs are extensive. The case for hovercraft is a different one. A hovercraft of the size of the SR.N4, which in itself has a work capacity of a ship very considerably bigger, requires a flight crew of three people — again this low labour intensity — and by virtue of the type of structure, be it coated alloys or glass reinforced plastics, it is one which does not depreciate or require maintenance when unused. For instance, the existing SR.N6 hovercraft can be stored at almost no cost, its engine and systems completely inhibited, its structure not deteriorating and its working life being prolonged in direct relationship to its unused time. A hovercraft service can, therefore, be allied more closely to a traffic pattern, and particularly a seasonal traffic pattern, than other forms of transport because such a great part of its total cost is directly related to its time on service.

One of the problems which face the hovercraft operator to date has been the lack of legislation in existence; thus an operator has had to take the most careful cognisance of safety to prevent even the most minor mishap. In terms of operational practice, however, local authorities have attempted to make temporary rules, not all of which have been to the advantage of the operator. For instance, as yet there is no legislation on the measurement of hovercraft in terms of net tonnage and different authorities have applied different formulae to calculate harbour dues and the like.

It is likely that legislation will be forthcoming in the very near future, and a number of advisory committees have been working to provide the necessary information for use in the drafting of legislation.

The selection and training of staff in a business as new as hovercraft must be done with considerable care and it is particularly important in the manning and maintenance of craft. The most careful training has had to be planned and carried out, for there has been no fund of experience upon which to draw.

No transport operation is worth a fig without the highest standards of safety, and safety is made up of three basic factors:

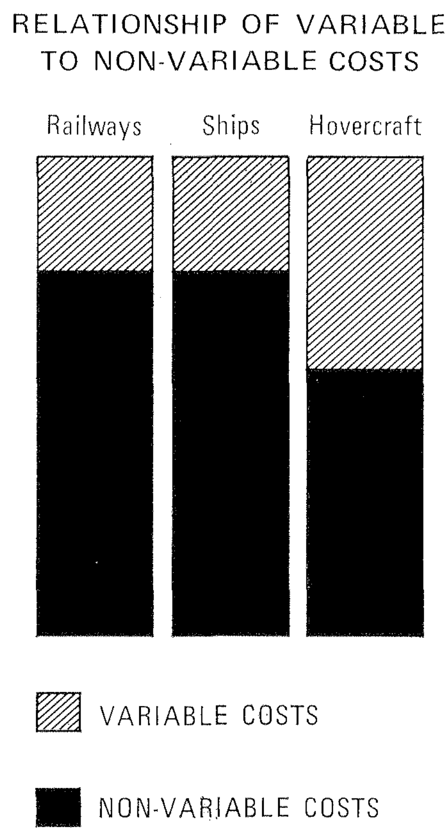


Figure 2

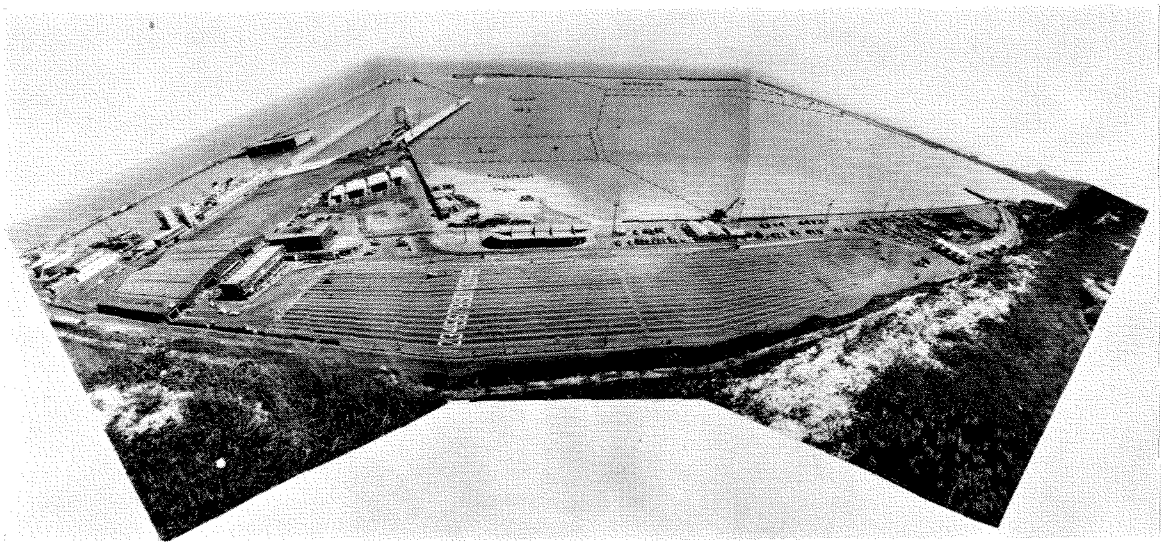


Figure 3a. The hoverport at Dover Harbour under construction

1. Regulation;
2. Application; and
3. Discipline.

Without the right selection and training, the safety effectiveness is in peril and the safety of operation must at all times be paramount.

The combination of the two basic types of hovercraft allows for the use of almost any type of waterside facility. In the case of immersed sidewall craft, provided there is a sufficient depth of water, it can be berthed in any conventional water berth, though because of its low freeboard as compared with conventional vessels special arrangements may be required for discharge and loading of passengers either by floating pontoon or by a series of tidal landings. So far as the amphibious craft is concerned, it holds very specific advantage by virtue of the most simple facility required. Fig 3 shows a typical purpose-built terminal which was constructed at very low cost and yet is sufficient in size to deal with four of the current SR.N6 type craft at one time.

The figure indicates the very marked simplicity and small area used. A very simple slipway of short length and moderate gradient (1 in 10), a level apron, provision of a refuelling facility, a prefabricated terminal building fitted with the essential services, and a car park. A slipway need extend no more than a minimum distance between the high and low water marks, at low water the craft traversing any natural surface.

The selection of site for a terminal must, of necessity, be a compromise between the choice of situations that may be available, from those most desirable from a craft handling point of view, ie direction of slipway relative to prevailing winds, etc, and the location in terms of the connections on shore.

A hovercraft passage is most likely to be only a proportion of the total journey made, therefore the connections with the centre of a conurbation to be served must not be under-rated. Similarly, while it is obvious that a car park is a very necessary element in the overall requirement, equally the shore-based public services of road and rail must be served as efficiently as is possible.

Regrettably, it is insufficiently realised in transport operation in general that the passenger's journey commences not upon boarding but upon arrival at the port or terminal, and indeed the passenger's first impression will be not of the craft but of the terminal. It must be clean, it must be seen to be efficient, it must provide the necessary facilities and it should be designed to focus the traveller's attention upon the mode to be used.

Transport in its various forms has suffered a series of growing pains, with a long history repeating itself.

It is often imagined that transport is the easiest profession in the world to enter. It is often overlooked that it is probably the most competitive of businesses. In the days of the railway mania, a multitude of small companies were formed, most of them under-capitalised and ill-managed; most of them failed. In the early 1920s there was a flood of investment in small road transport businesses, many based upon one man's gratuity. The 1920s and 1930s saw a multitude of one-bus or one-truck operations. Many failed through lack of professional knowledge and operating knowhow. A similar history applies to the early days of aviation.

Enthusiasm which breeds investment in the early days of a transport development must be coupled with the most assiduous attention to the detail of operating practice.

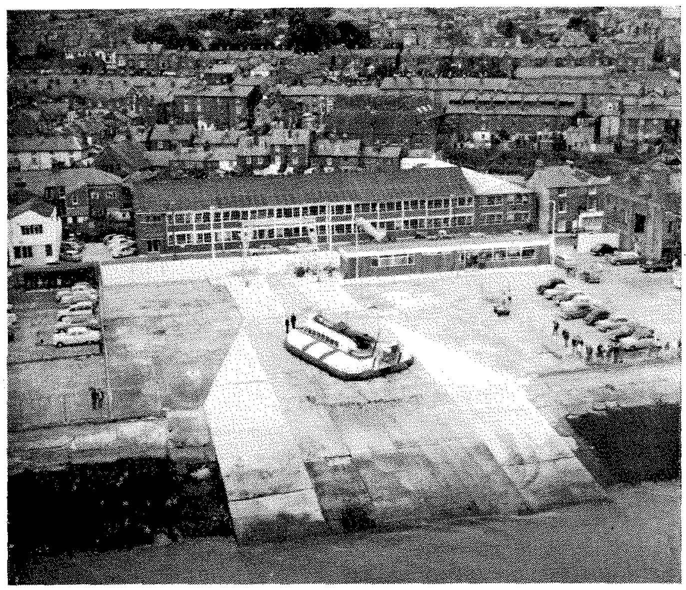


Figure 3b. An aerial view of the slipways and terminal at Cowes, Isle of Wight

FUTURE OF THE COMMERCIAL HYDROFOIL

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While at school at Stuttgart and Wiesbaden, Baron von Schertel became interested in gliders and was able through experimentation and reading to gain knowledge of aerodynamics which in turn led his thoughts to the causes and associations of physical phenomena — particularly as regards the dynamic lift of a "water wing" or foil.

Experiment followed experiment, so gradually knowledge came to him the hard way! After a world cruise in 1933 he built boat No 7 in 1934. This boat had the advantage of the foils being tested in Hamburger Schiffbau Versuchhanstalt. Some successful prototypes led him to an order from Koln-Düsseldorf Steamship Co for a tourist passenger boat which was built in the shipyard of Gebrüder Sachsenberg AG.

In 1937 in co-operation with Herr Gotthard Sachsenberg the Schertel-Sachsenberg Schnellboats-Konsortium was started.

During the early war years von Schertel with a team of experts developed hydrofoils up to 17 tons and 47.5 knots — a speed record that was held for twenty-one years. By 1943 a craft of 80 tons had been completed but was not used operationally.

A period of theoretical and design work followed; in 1950 Herr Sachsenberg and von Schertel agreed with Swiss interests to construct what became a successful 30-passenger hydrofoil. In 1952 the company Supramar was formed to design and develop hydrofoil craft. The way forward was still hard and progress in interesting shipping companies was slow, until the first licensee, Signor Carlo Rodriguez of the Cantieri Navali Leopoldo Rodriguez, appeared. In 1956 the first PT.20 started operations across the Straits of Messina. The struggle was not yet won and only five boats were commissioned up to 1958. Since then the successes of Supramar craft are well known to all readers.

THE future commercial hydrofoil craft which is being considered in this paper is the craft of tomorrow, that is to say, the craft expected to come into service within the next decade, which is anticipated from the trend of development of today. Progressing technology brings about changes in the conception of the currently plying ferries and such important additions to the old systems that we can safely speak of a coming second generation. It is not intended to venture long-term prognoses as to what could be designed and constructed in two or three decades. Such forecasts would be too vague to be of interest and may even be wrong, because in our technical age breakthrough discoveries may give an unexpected direction to hydrofoil development.

Consequently, if we try to visualise the commercial passenger vessel of tomorrow we have to base our considerations on the technical stage of the present hydrofoils and then investigate the development tendencies on the one hand and the type of hydrofoil needed in the near future to meet the requirements of fast seaborne communications on the other hand. For the second-generation hydrofoil, not only the presumable technical configuration is being examined here, but also the reliability and safety which must be offered to the passengers.

It is known that the hydrofoil as a new means of passenger transportation has been developed in Europe. It is in Russia where geographic conditions are most ideal that it has found its largest application. Russia is covered with a net of rivers and canals offering far better transport conditions than the mostly poorly maintained roads in the countryside. It can be assumed that the Russian Government has put some 300 hydrofoils (Fig 1) into public passenger service on inland waterways. Their foil system is stabilised by making use of the surface effect which acts on a foil that is running under the water surface at a smaller distance than half the chord length. The Russian boats have flat or slightly dihedral, large chord foils which approach the surface at cruising speed to one-fifth of their chord length, in average, for adequate stabilisation effect. These craft give excellent performance in inland waterways for which they are in fact built, but the foil system applied does not allow rough water

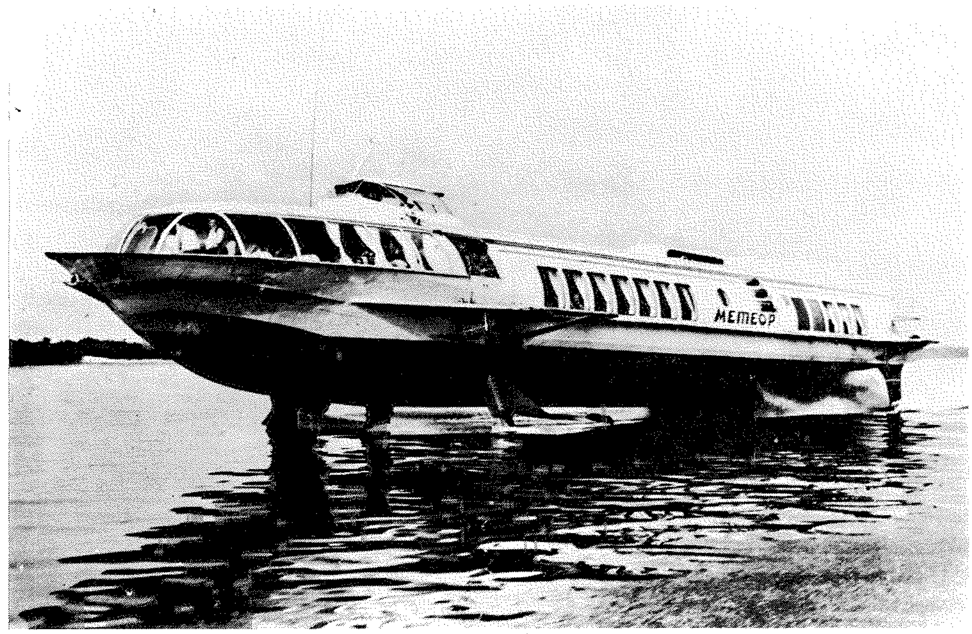


Figure 1

service. It is obvious that such foils emerge already in small waves and give a bumpy ride so that they cannot be used for off-shore service. It is believed that it is not possible for the system to be developed further for seaways. Therefore, the Russian system is unlikely to have its "second generation".

The only commercial hydrofoils which are commonly used for coastal service throughout the world are the Supramar passenger ferries which are provided with surface-piercing foils, characterised by their structural simplicity and inherent stability. The first regular hydrofoil service in the world was inaugurated by Supramar on the Lago Maggiore in North Italy in 1953, the same lake on which Forlanini made his trials fifty years before. The first foil-borne passenger-carrying craft, which was licensed by classification societies for coastal service, was a Supramar-designed 30-ton craft (Fig 2). After her successful and profitable operation, a new prototype of 63 tons (Fig 3) was constructed in 1958 to be used on off-coast routes. These two types were constantly improved in line with the results of the endurance tests of everyday service. They can be regarded as the only hydrofoils in the western hemisphere which have overcome development troubles since many years.

More than 100 of these commercial craft are today in scheduled ferry service with a total seating capacity of over 8,000 passengers. Some of them attain the yearly service time of jet passenger planes. They cover an accumulated daily distance of about 22,000 nautical miles, which means a circle around the world a day. The total number of passengers carried up to the present is estimated at roughly 35 million persons and the total distance covered more than 25 million nautical miles.

The reason why the Supramar vessels have become accepted as a means of coastal and off-shore passenger transportation and the explanation for their economic success is seen in the company's design principle to apply structural simplicity and avoid components which have not yet proven their reliability and durability. This policy has often gained Supramar designs the criticism of obsolescence, because the importance of safety was not fully appreciated. However, the past twelve years have proven that Supramar made the correct approach and it is supposed that the commercial foilborne vessel of tomorrow must be conceived on the same lines in order to arrive at the same degree of safety and to operate economically. Experience has shown

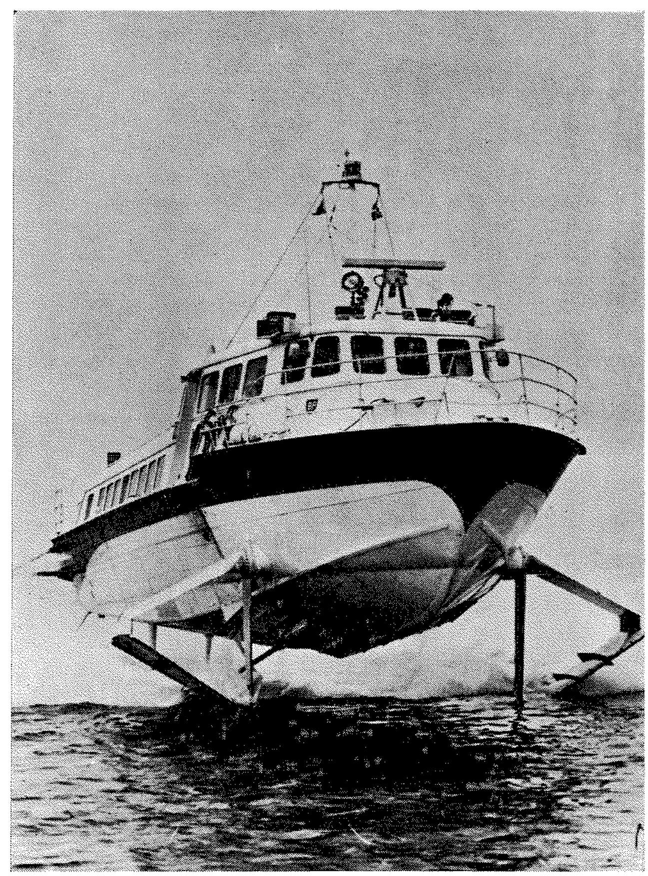


Figure 2

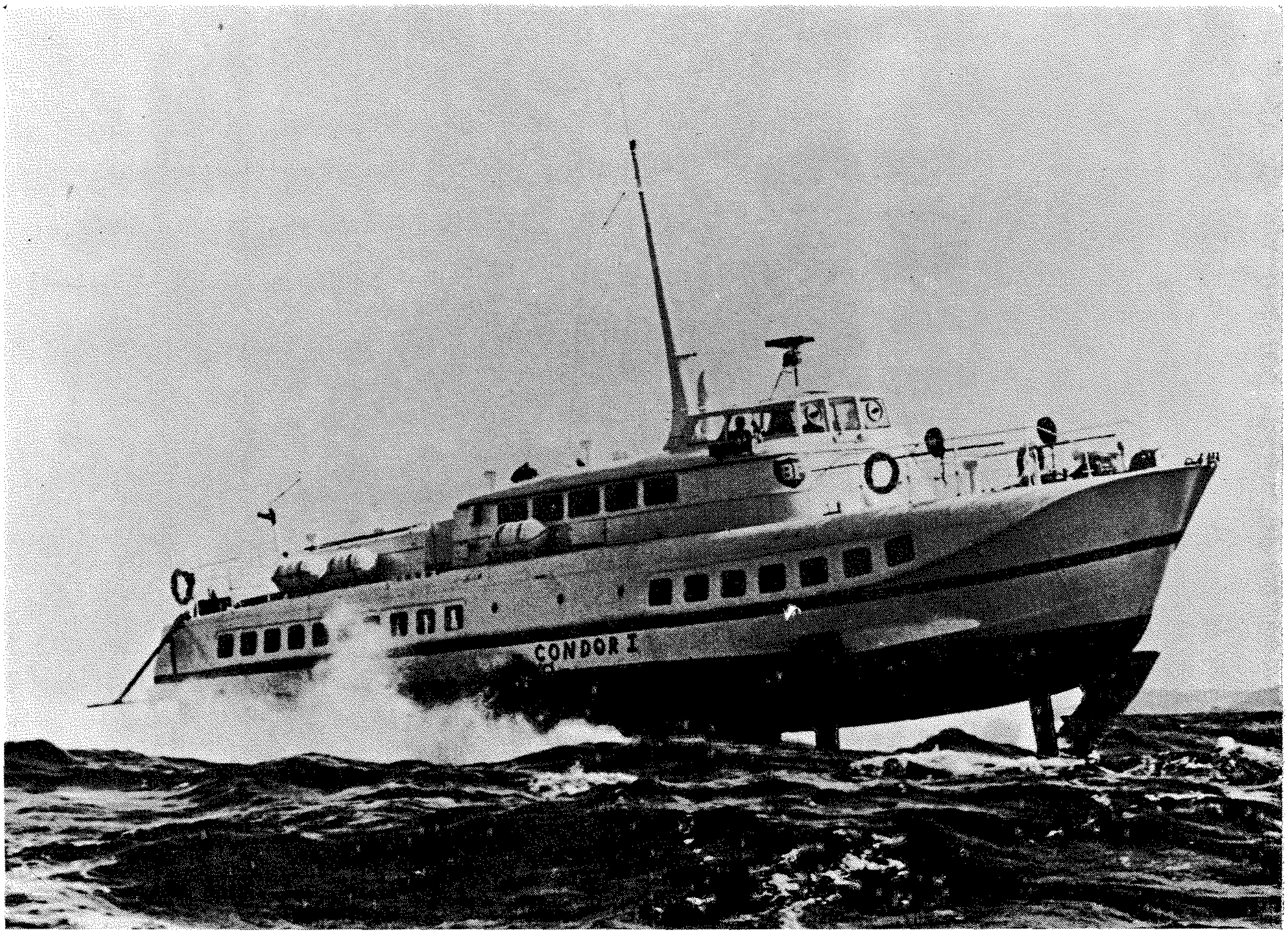


Figure 3

that sensitive high cost systems, requiring specialists for maintenance, are not interesting for a private operator regardless of how impressive sea performance is because he will fail to get an adequate return on his investment. In this respect it must be recognised that the airliner, flying between airports which dispose of facilities and a team of specialists, operates under conditions which allow to apply sophisticated and vulnerable devices which are unacceptable in rough ship service under salt water influence.

Twelve years of regular passenger service have shown that the performance properties of Supramar hydrofoils ensure safer operation than most of the known means of transportation. Indeed, in about 900 million passenger miles no life has been lost and only in very few cases have passengers sustained slight injuries when foils hit rocks or a large buoy in one event. According to statistics, 6.7 fatal accidents happen in air traffic and 40 in motor car traffic of the same passenger-mile range.

People often believe that the foils are a danger when colliding with rocks or floating débris. Experiences have, however, proven that drifting objects are either broken or tossed aside and the foils swing backwards or shear off in case of grounding or hitting heavy obstacles. The hull comes down onto the water in an essentially horizontal position. In such events conventional boats would have suffered extensive hull damage and probably lost their buoyancy. On the other hand, besides the improved sea performance in flying condition, foils of the Supramar configuration are a very effective means to increase seaworthiness in exceedingly high waves which force the craft to half foilborne or hullborne operation. In this condition foils provide a very great stability, a low centre of gravity due to their weight below the hull and a motion damping action. The smaller 30-ton type could once continue travel in 13–16 ft waves at reduced speed. The commercial Supramar hydrofoils are consequently not in danger if they come by accident in rougher seas than foreseen. The good performance at reduced speed of the craft of today provides an outstanding safety factor which must find full appreciation in the design of the foil configuration of future hydrofoil craft.

High-speed transportation requires more rigorous attention to safety precautions than conventional waterborne traffic. In addition to stability and seaworthiness, good manoeuvrability in higher speed ranges is also of importance. The off-shore commercial hydrofoil of today meets all passenger protecting safety regulations set up by the classification societies and the SOLAS convention. It is noteworthy that for the new 150-ton Supramar ferry an additional weight of 13.5 tons, that is nearly 10% of the total displacement, is put up with for the sake of passengers' safety. This weight increase is relatively higher than provided for any other vehicle and corresponds to a loss of more than 140 passengers. Much of the auxiliary weight results from the fire insulation and fire-fighting plant. It must be realised that safety regulations are being tightened with time. An example of this trend is the new international

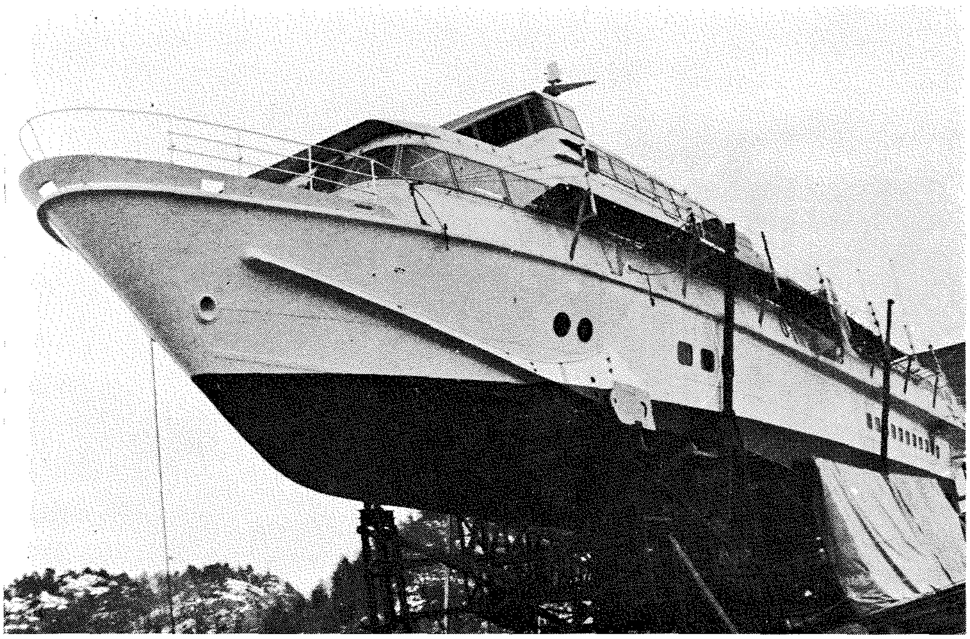


Figure 4

convention for motor cars. Weight sacrifices of about 10% of the displacement for safety equipment will, no doubt, be inevitable for future vehicles and decrease their economy perceptibly. This makes the problem of profitability more difficult and the necessity of avoiding costly components and appliances more imperative. It is known that air cushion vehicles have so far been subject to the control of the aviation authorities with the result that precautions for passenger safety are not yet complete though these vehicles are water craft which can unexpectedly be exposed to adverse sea conditions and in case of operational mishaps or collisions have to face the same dangerous situation as any other ship. Consequently, the second generation of hovercraft, too, will be obliged in the future to meet the safety regulations in total, to keep their advantages and competitiveness though this means a reduction of profitability.

Regarding now the performance and economical aspect, we can state that the hydrofoil craft of today satisfies the requirements of short-distance ferry service in protected areas. Only in very few cases an increase of the current cruising speed of 35 knots has been asked for. Well-organised lines operating in normal seaway conditions and providing adequate maintenance could keep their scheduled service up to 98%. Initial costs and operation expenses of the hydrofoils are sufficiently low for a shipowner to run a non-subsidised line with profit, even in less prosperous areas or in countries with high labour costs and low transportation fees, like in the United States. It must be realised that there will always be a demand for foilborne transportation on inland waters and near the sea coast. For these areas the hydrofoil of tomorrow will basically have the same conception as today. There is neither a technical nor nautical nor economical reason for departing from the reliable, low cost and easily maintainable surface-piercing foil configuration and adding complex systems. The same is true for the Russian system as long as it is used in calm waters.

It is believed that the near future development of this moderate wave hydrofoil type will be restricted to improvements of system, comfort and speed. Hydrofoils must follow in speed other means of transportation in a certain ratio in order to remain competitive with vehicles of road, rail and air. Today passenger hydrofoils can compete successfully with train and car communications along the coast, because of their unhindered straight course travel, and with aeroplanes because of their place-to-place, rather than airport-to-airport performance. As to higher speeds we must be aware that, beside the hovercraft, the hydrofoil is the only vessel which can operate at high speeds on inland waters because her slight wash does neither disturb ship traffic nor damage the banks.

Now in order to answer the question as to what will be the technical conception of the commercial hydrofoil of the second generation, we shall first regard the future operation area and the specific conditions she will be subjected to.

Investigations into large-scale transportation with Supramar designed craft enabled to anticipate the problems of future lines and to analyse what type would be suitable for the various prevailing conditions. When hydrofoil passenger service was inaugurated, the first boats were used in shuttle service along the coast of not more than 10 miles. Later, and after commissioning the PT.50, open sea routes of up to 120 miles were serviced. The commercial hydrofoil fleet of today is plying over an average distance of about 50 miles. Regular services have been established in already the greatest part of densely populated areas which ensure profitable operation. But there is still a definite lack of rapid open sea, long-distance communication.

Therefore, a growing interest arose for craft capable of operating in high sea states while maintaining acceptable passenger comfort levels. When speaking of comfort we think of the limitation of vertical and lateral accelerations to about 0.15 g for low wave-encountering frequencies which is commonly regarded to be tolerable for passengers in long duration travels.

In this case rolling angles are to stay under 5° and pitching angles under 3° to avoid unpleasant sensations. This requirement has determined the trend of development of the last years which is now leading toward the passenger-carrying hydrofoil of tomorrow. A characteristic of her sea performance will be her capability to cope smoothly as defined with wave heights in the order of one-tenth of the boat length.

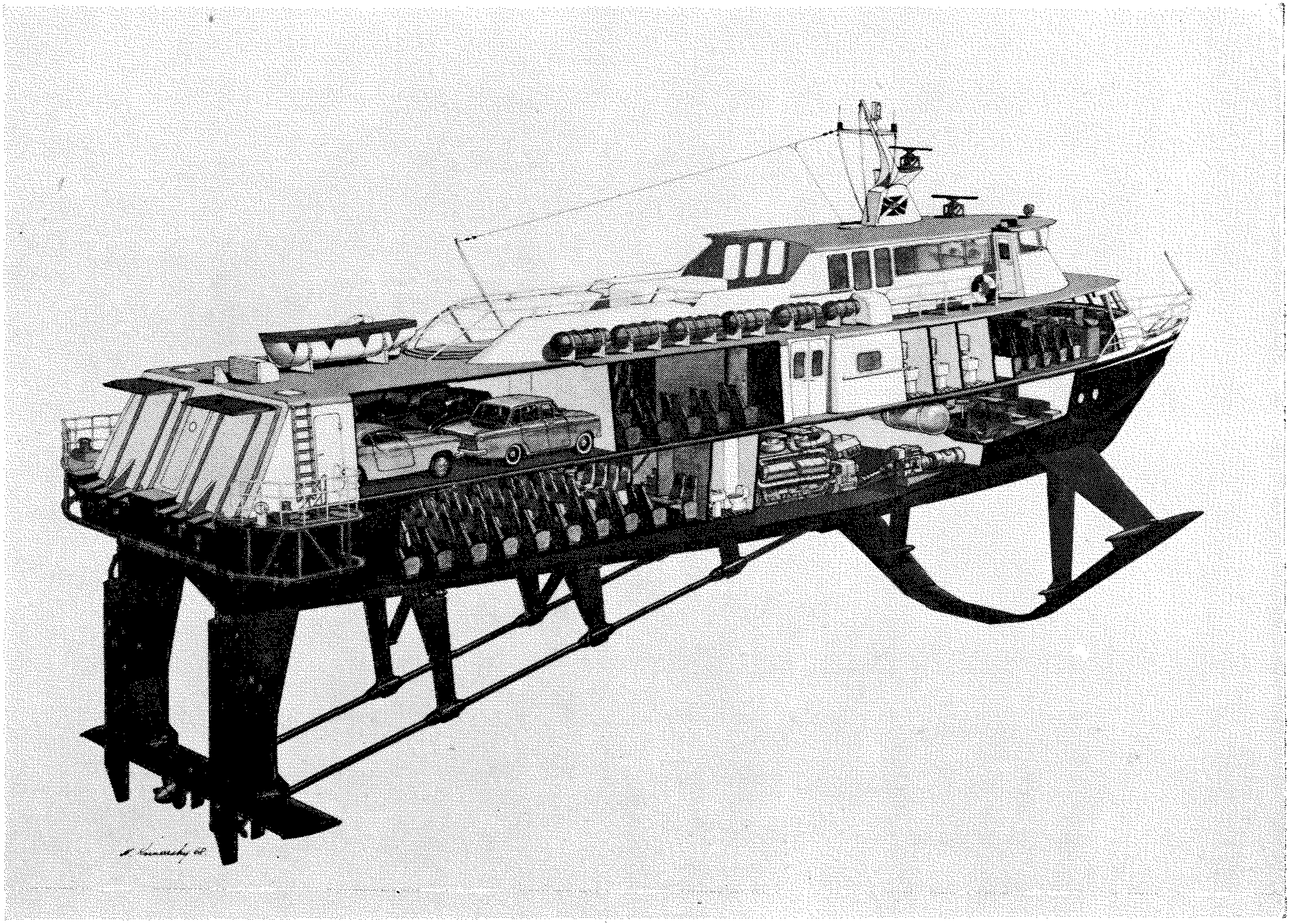


Figure 5

We know that the autostable, rigid foil systems cannot ensure adequate comfort in open sea operation in spite of their high seakeeping qualities. Due to the inherent stability they respond to wave contours with abruptly induced rolling and pitching oscillations, which are only tolerable for passengers in shorter runs or in wave heights of less than one-twenty-fifth of the boat length. From this we can take that the long-distance open-sea craft with surface-piercing foils would have to be built in rather large sizes to attain an agreeable ride. This would mean that many of the present economical and operational advantages of the hydrofoil would get lost.

Consequently, the hydrofoil of high sea state capability of the second generation must apply a foil system which, so to speak, adapts itself to the seaway, a foil with changeable lift and controlled by a stabilisation. Ship stabilisation systems, as are currently known, reduce the roll angles in waves by producing restoring moments. In the case of hydrofoil boats, the stabilisation for rolling and pitching is effected automatically by causing the lift of the foil to vary in a seaway so that motion opposing moments are generated. The motion sensors which give the signals for the lift changes respond to deviations from the horizontal position of the craft rather than to the agitated water surface, which results in the desired smooth sea performance with a strong reduction of the accelerations felt by the passenger. Simultaneously the strain of structure and propulsion plant of the craft is decreased substantially, which makes for better reliability, less maintenance expenditure and higher life endurance. Today few lines are still served with comparatively small craft of the rigid foil type where heavy sea conditions are prevailing which call for the new stabilised hydrofoils. An outstanding example is the *Condor 1* in the Channel Islands area which is most of the time overstressed so that periodical costly overhauls are unavoidable.

There are two developments under way for the craft of tomorrow with stabilised foil systems:

1. The "partly stabilised" hydrofoil whose stability is jointly maintained by the natural stability of the dihedral foil and the artificial stabilisation. Her operation areas are off-shore routes where higher sea states have to be coped with than currently met on the short-distance communications of the rigid surface-piercing foil type.
2. The "fully stabilised" craft with fully submerged foils which have no autostability. Their operation areas are the open sea with heavy sea states.

We shall first investigate the "partly stabilised" Supramar boat which has already been introduced and which represents an intermediate low cost solution between the rigid surface-piercing and the controlled fully submerged foil system. Her sea performance comes very close to that of the controlled submerged system but the simplicity and reliability of the conventional hydrofoils are kept. On this vessel the later described "air-stabilisation" was applied. The additional costs for this system and its maintenance are comparatively low so that they do not impair the economy of the craft. Profitability, which presents a difficult and still unsolved problem in the case of the submerged foil type, is ensured here. It is believed that the partly stabilised type

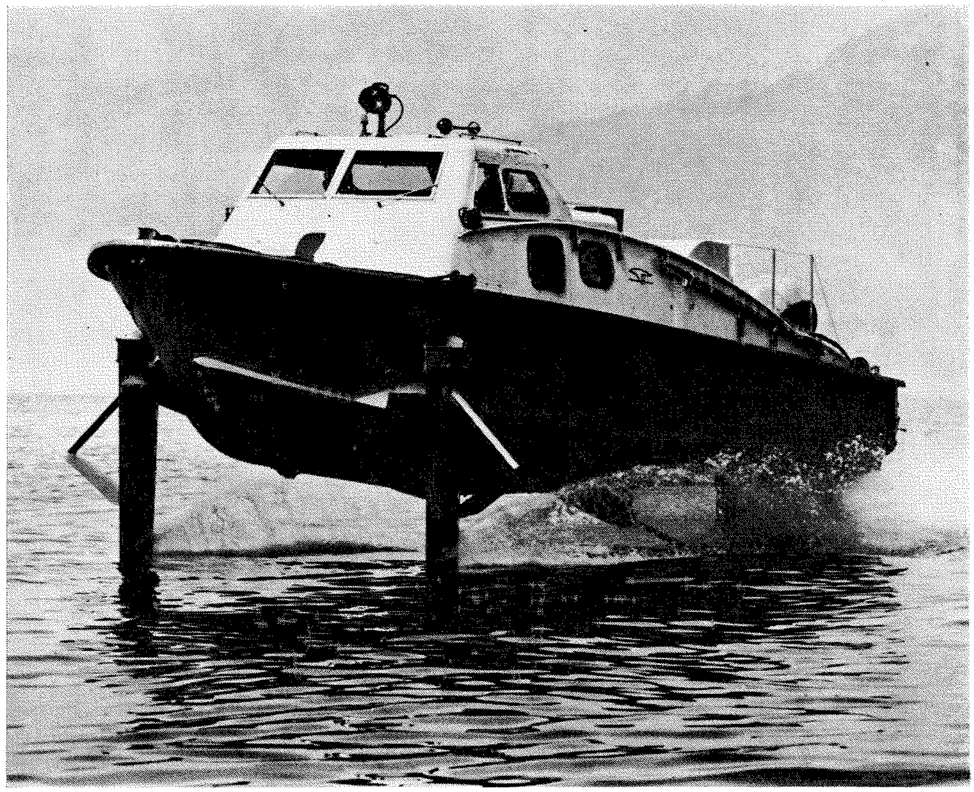


Figure 6

will remain an attractive alternative solution to the submerged foil type also in the future, thanks to its structural sturdiness, ease of handling and higher economy.

Publications on the 50-ton partly stabilised Westermoen prototype *Flipper* have already been made so that only some details will be given of the new 150-ton vessel Supramar PT.150 of the same yard, which will begin trials in May 1968 (Fig 4).

This is the first car ferry and the largest commercial sea-going hydrofoil in the world, intended to commence regular service in the Kattegat, with seating for 240 passengers or 8 cars and 160 passengers, at a cruising speed of 39 knots. The front foil (Fig 5) of the surface-piercing configuration maintains submergence depth inherently stable so that an artificial control can be dispensed with. The straight rear foil is fully submerged and each half is controlled by an independent stabilisation unit, capable of maintaining stability on its own. The natural stability of the craft is reduced as compared with the conventional hydrofoils in order to decrease the water impact on the front foil and increase the effectiveness of the artificial roll stabilisation. The boat is able to continue travel "foilborne" at somewhat reduced speed in the very improbable event of a failure of both stabilisation units. The middle part of the front foil is stabilised as well for damping pitch motions.

The applied air-feed system of the foils is based on new physical principles. To achieve lift variations air is admitted, or better sucked in from the free atmosphere via ducts and air-exit apertures on the foil surface into its low-pressure regions. As a result, lift is reduced and varies with the admitted air quantity which in turn is controlled by a valve. The air-fed stabilisation which does not need motor-driven power input, is characterised by its simplicity and reliability.

Now we shall examine the "fully stabilised" foilborne craft with fully submerged foils for open sea operation. Her development has been pioneered successfully by the US Navy and also private companies have demonstrated passenger craft of this new conception with excellent sea performance. However, the necessity for large hull clearance for heavy seaway operation leads to expensive propulsion systems which pose engineering problems. The only feasible method of transmitting power from the engine to the propeller appears to be for this type of craft the double right angle bevel gear. But this results in high costs and complexity, and perhaps does not obtain the operation time between overhauls of at least 4,000 hours required for commercial boats. Up to the present only one endurance test of 10,000 hours was made with a double bevel gear on a Japanese boat of low engine output. The water jet seems to offer a better approach for solving machinery problems but the available efficiency in the speed ranges from 35 to 50 knots is not more than 80% of that of a propeller-driven hydrofoil. The open sea hydrofoil is additionally sophisticated by the automatic lift control. Lift variations are generated on the boats of today by geometric changes of the foil sections either by varying the angle of attack or deflecting the pivotable flap on their trailing edge. To move the foils or flaps, hydraulic actuators are needed which have to be rather voluminous to overcome the hinge moments and the inertia of the foil portions in the required very small fraction of a second in a seaway. Sensors control the hydraulic actuators via an electric computer.

The described technical intricacy going together with extravagant maintenance is the reason why this type of craft could not yet be operated economically by a private shipowner. For military application complexity is acceptable as long as reliability is ensured and operation does not require specialists on board. Consequently, very serious problems are still to be solved to convert the fully stabilised high sea state craft of today into a profitable craft of tomorrow.

The new air bleeding lift control brings the second generation conception closer to meeting the requirements of economy and safety, because it can dispense with the movable parts, and electronic and hydraulic circuits. In order to study what performance could be attained with this new system, a 4.9-ton experimental boat (Fig 6) with fully submerged air-controlled foils was built by virtue of a US Navy contract. The boat reached a speed of 54 knots with very good stability and showed excellent seakeeping qualities and smooth behaviour during test runs in the Mediterranean. Vertical accelerations in wave heights of one-tenth of the boat length were measured with 0.08–0.09 g, that is they stayed well within the limit of comfort. No doubt, also simplifications for the propulsion will come about if not new and better systems will be developed in the next years.

To appraise the engines which will be used on the future vessel we must note that all currently plying commercial craft are powered by diesel engines. With the experiences accrued in rail traction and seaborne service safety of operation could be so much improved that motors and gears are now capable of achieving at least 10,000 hours between major overhauls. Marine gas turbines, on the other hand, have offered only a fraction of this life until now so that for seasonal service of 3–4,000 hours money has to be raised for a spare turbine in addition to the high initial costs of the main turbine. This explains why Supramar has provided also the new car ferry with diesel engines. However, if on the other hand the advantages of the gas turbine which consists in light weight and higher safety of operation, find appreciation and the steady progress in gas turbine development is considered, then we can visualise that the time will come when turbine-driven hydrofoils can compete in profit with diesel propulsion: if we further take into account that the higher speeds in future ask for more powerful propulsion units than available with diesel engines, then we can safely predict that the second-generation high-speed commercial hydrofoil for open sea operation will be propelled by gas turbines.

When speaking of the future of hydrofoils, immediately the question of their presumable size arises with regard to the hydrodynamic and structural limitations. All too often the economical aspects which are of greatest importance for passenger transportation are disregarded. From the commercial point of view the smaller vessel which — assuredly — is able to cope comfortably with the expected sea state in the operation area, should be given preference. The advantages of such a small boat consist in low investment, small risk, and in the well-known fact that a shuttle service with many small units results in a higher passenger frequency than a service with large units sailing at long intervals. Besides, the shuttle schedule is less affected by the stoppage or failure of a single boat out of several in service. It is a definite advantage of hydrofoils over hovercraft that they can obtain the same seakeeping qualities as hovercraft with much smaller sizes. This further increases the well-known economical superiority of the foilborne vessels.

Hydrofoil lines will never go in for Atlantic crossings or passages on similar long routes over oceans because of the competition of aeroplanes which on such distances monopolise all advantages of speed and comfort. These commercial considerations also restrict the wave heights likely to be handled as well as the displacements of hydrofoils in perhaps a more decisive way than technical conditions. Consequently, the hydrofoil of the next generations will scarcely exceed the 1,000-ton limit.

DIRECTORY OF HYDROFOIL OPERATORS AND ROUTES

ADRIATICA SpA di Navigazione Venezia. Tremoli–Isoledi Tremiti.

ALIMAR SA, Argentine. Buenos Aires–Colonia.

ALISCAFI SpA. Naples–Capri. Naples–Ischia. Messina–Reggio. Messina–Taormina–Eolian Islands. Trapani–Egadi Islands.

ALISCAFI DEL SUD. Livorno–Elba–Corsica.

AMERICAN HYDROFOIL LINES INC. New York–Boston.

BIWAKO KISEN CO LTD. Biwa Lake.

CALDERONE ENTERPRISES, New York.

COMPAGNIA DI NAVIGAZIONE. Lake Maggiore. Lake Como.

COMPAGNIE GENERALE DE NAVIGATION, Geneva. Lake Léman.

CONDOR LTD, Guernsey, Channel Islands. Guernsey–Jersey–St Malo.

COMPANIA SHELL. Lake Maracaibo.

DANISH RAILROAD. Copenhagen–Malmo.

FAR EAST HYDROFOIL CO. Hong-Kong–Macao.

FIERA INTERNATIONALE GENOVA. Costa Ligure.

HARDANGER SUNNHORDLANDSKE DAMPSKIBS-SELSKAB. Bergen–Tittelsness.

A/S HAANES REDERI. Scandinavian waters (charters).

HANKYU MAIKAI KISEN CO LTD. Kobe–Naruto.

HONG-KONG MACAO HYDROFOIL CORPORATION. Hong-Kong–Macao.

HUNGARIAN NAVIGATION CO. Budapest–Vienna.

HYDROFOIL CRUISES LTD. Lake Wakatipu.

HYDROFOILRUTENE OSLO. Oslofjord.

INDONESIAN GOVERNMENT. Patrol.

INNOSHIMA SUICHU YOKUSEN CO LTD. Onomichi–Innoshima.

IWASAKI KISEN CO LTD. Matsuyama–Hiroshima.

SOC JUGOSLAVA JADROLINIJA DI RIJEKA. Fiume–Rab Island.

KANSAI KISEN CO LTD. Osaka–Takamatsu.

KERRIDGE ODEON CORPORATION, Auckland.

KYUSHU SHOSEN CO LTD. Misumi–Shimabara.

MALTA ALISCAFI LTD, Malta.

MARITIMA ANTARES, Madrid. Las Palmas–Santa Cruz de Tenerife.

MINISTRY OF COMMERCE, Cairo. Assuan–Abu Simbel.

MINISTRY OF TRANSPORT, Milan. Lake Garda.

A/S MASL. Helsingborg–Copenhagen.

NAVECA SA. Maracaibo–Cábimas.

NAVITE SA. Cannes–Nizza–Monte Carlo–San Remo.

NEITETSU KAIJO KANKO CO LTD. Nagoya–Gamagori. Toyohashi–Toba.

NISHISSKURAJIMAMURA KOTSUBU. Kagoshima–Hakamakoshi.

NIHON KOSOKUSEN CO LTD. Enoshima–Atami.

NORTHWEST HYDROFOIL LINES. Seattle–Washington–Victoria, BC.

ORESUND AB. Copenhagen–Malmo.

PAIJANTEEN KANTOSIIPI OY. Lahti–Jyvsäkylä, across Lake Päijäne.

PHILIPPINE NAVY. Coastal.

PORT JACKSON & MANLY STEAMSHIP, Sydney. Sydney–Manly.

SETONAIKAI KISEN CO LTD. Miyajima–Hiroshima; Onomichi–Imabari.

(*Continued on page* 45)

CHANNEL OPERATIONS

L. R. COLQUHOUN GM, DFC, DFM
Managing Director
Hoverlloyd Ltd

Mr L. R. Colquhoun joined the Royal Air Force in 1940 and served on Spitfires for a short period in Fighter Command, and then with Photographic Reconnaissance Units in Malta, North Africa and Italy. In 1945 he was seconded to Vickers Armstrong as a test pilot. He was demobilised from the Air Force in 1946 and remained at Vickers as a civilian test pilot until 1962.

In 1960, in addition to being Chief Test Pilot at Vickers, South Marston Works, he was appointed Operations Manager for their Hovercraft Division, and as such was responsible for the development of all Vickers hovercraft projects and for practical hovercraft demonstrations in various parts of the world. This continued until January 1966, when he joined Hoverlloyd as Chief of Operations, and in January 1967 became Managing Director of the company.

THE English Channel provides perhaps the dividing line between the British people and the continental peoples. For centuries we have tended to regard it as a bastion against invasion — not always a successful one, but nevertheless a deterrent. However, modern forms of transport, particularly the aeroplane, have completely changed the Channel's strategic significance; no longer can it be regarded as a last line of defence, but rather it must be considered an obstacle to be successfully bridged if we as a country are to trade freely with the rest of Europe and provide facilities for the traveller seeking the sun of southern Europe for his holiday.

Since the second war it can be claimed that a revolution has taken place in the habits of the British holidaymaker. No longer does the average family book up year after year for the annual trip to the guesthouse at Brighton, Worthing, Ramsgate. Instead, the glossy travel brochures are eagerly scanned around Christmas time, and throughout January the family discusses to which exotic sun spot the annual pilgrimage should embark. One has only to examine the statistics to realise the extent of this revolution, and it has only just begun. In the years to come as travel becomes cheaper and easier the trend will increase. Unfortunately, it is at the moment one-way traffic, the sun-starved Briton seeking an escape from the unpredictable climate of his native land. However, there is a realisation, particularly amongst the British hotelkeepers and the tourist trade, that something must be done to attract the European to our shores and this must be encouraged by all possible means. Unfortunately, this country cannot offer settled weather but it has a wealth of tradition and, let's face it, Marks & Spencer. It is not suggested that a fully balanced traffic can be achieved but the fact that active steps are now being taken to do so must improve the situation that has existed over the past few years.

However, every visitor to Britain or Britisher visiting the Continent means a Channel crossing. There is a vast choice of methods of doing this, from swimming, water-skiing, yacht, rowing boat, old bed, Channel ferries, aeroplane — in fact, almost every conceivable method has been tried. Discounting the unconventional methods, there are only two ways to ensure a safe crossing, either by air or by a Channel ferry. This conference is of course not interested in air travel.

The conventional Channel ferry ships have been running for many years, the best-known departure point from the UK being Dover. Other departure points are Folkestone, Newhaven, Southampton and Harwich. Naturally, all these ports have enjoyed the post-war boom in travel but none more so than Dover. Its rate of increase in traffic has over the past ten years run at almost double that of all the others. Partly this is because it is traditionally the Channel port but perhaps more so because it gives the shortest Channel crossings, and for people who are unused to, and therefore worried about, a sea crossing this is an obvious advantage.

Entirely because of the enterprise of Swedish Lloyd and Swedish American Line the hovercraft now emerges to make its mark on this Channel scene. It is interesting to recall that this interest by the Swedish companies largely came about because their efforts to follow their Norwegian rivals, Thorensen, into the lucrative Channel traffic were blocked by non-availability of a port. Their thoughts therefore turned to less conventional ideas and as a consequence in June 1965 an order was placed for two SR.N4 hovercraft, to be delivered one in 1968 and the other in 1969. This was the very first order for these large 250-seat 30-car hovercraft designed especially for Channel crossings.

The route chosen was Ramsgate to Calais, a distance of 27 miles. At that time Ramsgate was the only port contacted that was responsive to the idea of hovercraft travel and it was sufficiently close to Calais to offer a short crossing time.

In order to gain experience in hovercraft travel the Swedish companies formed an English associate, Hoverlloyd Ltd, who were to be responsible for the operation of the service. Furthermore, in order to gain experience of hovercraft travel in Channel conditions it was decided to run an SR.N6 service during the summer of 1966/67. This obviously was not a commercial proposition and was never intended to be, but the experience gained has proved invaluable to the company and has also been beneficial to the development of the hovercraft itself. For example, it was quickly learned in 1966 that the skirt materials currently in use were totally inadequate for long over-water operations.

As a matter of history Hoverlloyd made some 1,500 hovercraft crossings during the two seasons and 21,000 people enjoyed their first experience of a hovercraft Channel crossing. Weather factors naturally played an important part in the operations — during 1966 only 55–60% of the planned operations proved possible; however, the summer of 1967 showed some improvement and 60–65% of the schedules were carried out. This was a little closer to the 70% target that had been set, based on available weather statistics and the results of trials and operating experience with the SR.N6 in other areas.

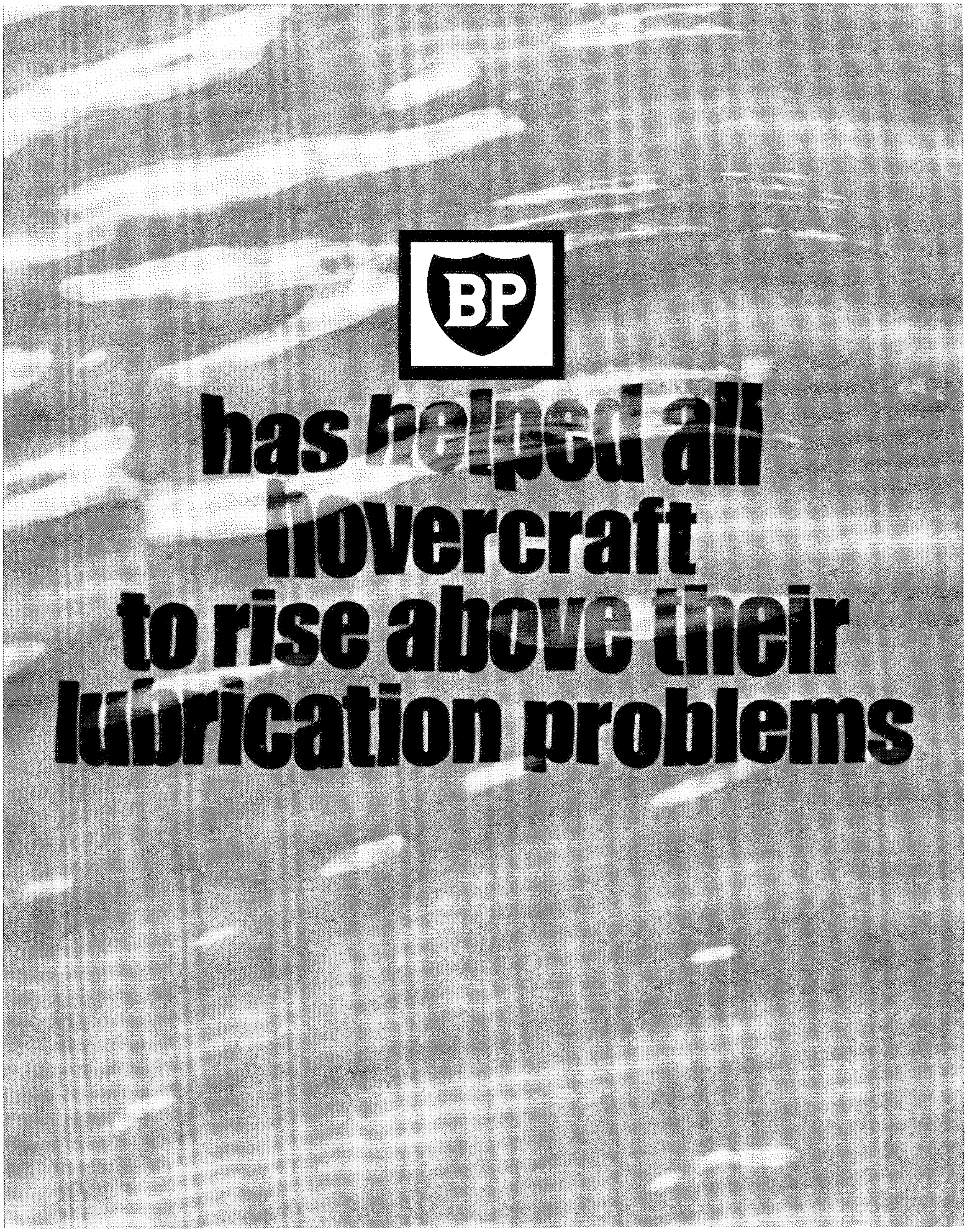
These and our own cross-Channel trials showed that the SR.N6 was quite capable of operating in wind conditions of up to Force 7; such winds can produce waves of 8 ft trough to crest height in the Channel. However, it was quickly realised that a new limitation had to be set that was directly related to passenger comfort. Taking this into account, winds in excess of Force 4 caused cancellations since such winds produced waves that caused discomfort among the passengers. Furthermore, it was also realised that journey time was a relevant factor. The estimated time for an SR.N6 crossing was 45 minutes. So long as winds of up to Force 4 were on the beam or astern, this crossing time could be maintained. However, in head-wind and head-sea conditions the journey time increased. As proof of this it can be said that whilst the shortest crossing time recorded was 33 minutes there were others, particularly during the trials period, that were in excess of $1\frac{1}{2}$ hours. These, I might add, were all in the more severe conditions of winds of Force 5 and upwards. As operators we set a maximum journey time of 1 hour, and if it was obvious that this would be exceeded then operations were cancelled. This particularly occurred with winds from the north-west.

By rigidly adhering to these basic limitations the SR.N6 Channel service ran for two years without incident, a record that can be regarded by the company with pride. The view was quite rightly taken that any incident would have made headline news and been detrimental to ourselves and the industry. Perhaps there was an element of luck, but there can be no doubt that every effort was made to ensure that the craft were in good shape mechanically and as I have said company limitations were not exceeded.

When the contracts for the SR.N4 hovercraft were signed in 1965 the intention was to run the craft from within Ramsgate Harbour. The initial operations with the SR.N6 in February 1966 clearly showed that no real thinking had been done on this problem, certainly nobody with operating experience was asked his opinion at the time the contract was signed. Operations with the N6 showed that in anything but reasonable weather conditions entering through the harbour entrance was a risky performance. This was due to some extent to the poor downwind control characteristics of the craft and to the entrance width. This can be measured at 210 ft, and when one considers that the SR.N6 is only some 28 ft wide one would be justified in thinking that there was ample room. However, in order to get the maximum shelter from the wind and sea conditions within the harbour the entrance piers are staggered; this meant that if the maximum entrance width was to be used the craft was faced with a sharp turn just inside the entrance. This proved a difficult manoeuvre, especially when strong south-westerly winds were blowing. Since south-westerly winds are the most prevalent, it meant that in strong winds operations had to be cancelled and in moderate conditions there was an element of risk. Thus operations with the SR.N4 (at least four times as wide dimensionally as the N6) were clearly out of the question.

This experience led us to believe, and in this we are supported by everybody associated with hovercraft operations, that a hoverport designed for amphibious craft such as the N6 and N4 should have open approaches allowing the craft to line up with the slipway some way off and thus due allowances can be made for drift, etc, at an early stage. In this way a controlled approach can be carried out without sudden changes of direction or engine power. Thus noise and risk to passengers and craft are considerably reduced. If such a base can have reasonable shelter from the wind, particularly the prevailing wind, and also easy access to trunk roads and railheads, then an ideal base exists. Such a base is the one that we have chosen and fought for at Pegwell Bay.

In France similar characteristics have been sought. Obviously, at Calais it has not proved possible to achieve the degree of perfection as at Pegwell Bay, but at least


BP
has helped all
hovercraft
to rise above their
lubrication problems

protection is afforded from the prevailing south-westerly winds and seas. Thus we feel that operations will not be hindered by conditions at base; the only limitation will be set by the ability of the craft to negotiate mid-Channel sea states, and this is as it should be.

The advantages of good sheltered bases have been clearly established by British Rail in the Solent. Their hoverports within Cowes Harbour and up the River Itchen offer protection from all but the most violent conditions and therefore their service has been able to operate almost regardless of the weather. On the other hand, Hovertravel operating from an open beach at Southsea have had to cancel operations due to the difficulties of making safe approaches when strong to gale force south-westerly winds are blowing on to the beach.

Some emphasis has been put on this point since, like aircraft coming in to land or taking off, hovercraft could be in the greatest danger during approaches. The extent of the danger depends, of course, on the weather conditions. If safety factors are to be observed — and after all these must be of prime consideration — then hoverports must be sited and designed so that all possible hazards are eliminated and the task of the commander made as easy as possible. This has been the basis of this company's philosophy.

We were also conscious that although conditions at Ramsgate Harbour might preclude operations, en route and Calais terminal conditions could be quite safe. We have had the unenviable experience of trying to explain this to irate would-be travellers. This of course is bringing to light the most important rule for the operator: the service he operates must be reliable and regular. Some delays on any transport system are unavoidable but they should be kept to a minimum and everything possible should be planned to this end.

We feel that hovercraft must maintain this standard. So far operators with the SR.N6 have in general succeeded, but the costs have been high. The SR.N4 represents the essential breakthrough for the hovercraft industry, therefore every effort must be made to ensure that operations get off to a good start and a high degree of reliability is achieved. The N4 after all is pitting itself against a very competitive market. The modern Channel ferry is a comfortable and efficient form of transport. Against this the hovercraft can offer speed and a more comfortable passage, but the passenger will be required to stay in his seat. He will be unable to roam about as on the ship, nor will he be able to go to the bar and relieve the tedium of the journey with a drink, although experience may show that this latter privilege might be possible.

A good marketing operation will therefore be necessary if the maximum number of seats are to be sold, and this alone will require an excellent reliability record. Nothing could undermine the marketing operation more quickly than a series of service cancellations for whatever reason.

This of course places a heavy responsibiilty on the manufacturer. The operator having taken the plunge must then rely on the hardware living up to the claims of the glossy brochures and salesmen's blurb. If the craft cannot achieve the performance speeds, or the ride in waves is unacceptable to passengers, then the operator is in trouble. Similarly, if the maintenance backing is disproportionately large to maintain the service, then he is also in trouble. This is particularly so since most ferry routes are seasonal. The Channel and the Solent are classic examples, but an analysis of most routes will show this tendency, whether it is a daily, monthly or weekly variation. Thus at the peaks the craft must work hard, for it is during these periods that the fat must be stored up to sustain the off-peak activity. If breakdowns occur, then not only are the passengers — and in the Channel operation case these are almost certain to be holidaymakers — let down but the revenue earned so necessary to offset the winter traffic will be lost.

It is interesting to reflect that on a route such as the Channel, or for that matter the Solent or even any commuter service, the operator is faced with an imbalance of traffic. It has already been said that the French are not exactly queueing up to come to England, therefore the traffic is mostly made up of British travellers going to the Continent. Thus at the beginning of the season it is all one way and at the end of the season the reverse flow occurs. During mid-season, of course, there is more of a two-way traffic since people are coming and going. A breakdown of any passenger statistics will clearly show this trend. This being the case, it can be argued that the highest overall load factor that can be achieved is 50%. This has to be qualified to some extent but it does show that to achieve higher load factors efforts must be made, and this obviously costs money.

Any operation therefore must be able to achieve a break, even with at least a 50% overall load factor. If this cannot be done then the operation is doomed to failure, and even at a 50% level it is certainly not going to be a particularly happy operation; something better than this must be achieved.

There are two sides to a balance sheet, one mostly made up of costs and the other income. It can be argued that the situation can be improved if income, ie in our case the fares, are increased. However, this is not always the case. Over the past few years transport fares generally have risen but despite this balance sheets have not improved. This can, of course, be explained by the fact that an increase in fares is inevitably followed by an increase in costs, but is not the fact that the higher the fare the less inclined the traveller is to use that mode of transport also a reason? In other words, the load factor drops, thus offsetting the expected increase from the increased fare. I am probably oversimplifying the problem but psychology is involved here, and although the easy answer is to put up the fares it does not necessarily follow that it will provide the answer.

Naturally, with any new form of transport one can charge almost what one likes. The snob value of being able to say that you went by hovercraft can sustain a high load factor even at a high fare. However, we are not now in the fairground business. SR.N4 operations are very much a commercial enterprise and if it cannot be demonstrated that such a service is commercially viable then the future of the industry is not good. Fares, therefore, must be competitive. If the hovercraft operator charges a higher fare than the ship, then he must prove that he is giving the passenger value for money.

The fare must also be related to costs. Little purpose will be achieved if a fare is charged that even with a 100% load factor provides no return on the capital employed. It might be interesting therefore to consider what affects costs.

First and foremost is the capital cost of the hovercraft itself. With the SR.N4 this is a very substantial item and presents very difficult problems in the amortisation of such a sum. One sincerely hopes that such a craft has a life of at least ten years, but in this swiftly developing industry can one afford to give it such a long life? It might be that in order to keep abreast of competition a new type of craft will be needed at the end of five years. Under these circumstances one can only hope that the original craft will have a second-hand value such as is experienced in the air transport world. Viking and even Dakota aircraft are still giving sterling service to some operator or other. However, the air transport field is well established; hovercraft are just starting the learning curve. Capital cost and amortisation therefore are very significant.

However, as with any other high-cost piece of equipment, maximum utilisation will help to offset these factors. But it is no good running the craft to and fro and thus achieving a high utilisation if it is not earning money. Passengers must be carried, and here quite firm limits are set by the people wishing to travel. Again one is back to the marketing operation.

Insurance represents another large item of cost and of course is directly influenced as far as hull insurance is concerned by the capital cost. So far, hull insurance rates are relatively high, although underwriters may well argue that rates should be even higher. One can only hope that as hovercraft develop and accident-free records are achieved the basic rates will fall. Unfortunately, as far as passenger liability is concerned, premiums look like increasing. At the moment there is every likelihood that the Board of Trade will insist on a limit of liability being stipulated, which is a good thing so long as too high a limit per head is not applied. Internal air flights are now faced with a limit of liability of £21,000 per passenger; it is hoped that hovercraft will not be faced with such a high figure, but there can be little doubt that the present £6,000 limit used so far will increase.

Crew and ground personnel costs must also be charged against the operating costs, as must be the cost of fuel, oil, spares, engine, propeller and other accessory overhauls.

Then come the indirect charges, rent, rates, marketing, advertising, PR, booking procedures, telephones, administrative staff costs, port dues, passenger dues, etc, all forming a very significant figure.

No attempt has been made to enumerate these items specifically: they will vary from company to company and from one type of craft to another. However, even listing them under headings as I have done, it can be seen that substantial sums of money are involved.

It has been frequently said that hovercraft slot neatly into the gap in the transport spectrum between aircraft and ships. In the early days of hovercraft this gap appeared significant; however, there can be no doubt that over the past five years ships have become more efficient and faster, and aircraft seat-mile costs have reduced. The jumbo jets should get this figure even lower. The gap therefore has become smaller. This more than ever forces the hovercraft industry to contain its costs. To my mind the N4 and the N6 represent the ultimate in hovercraft cost for their respective sizes. As an operator one would like to see costs of such vehicles reduced, but having been involved on the manufacturing side when I was at Vickers I realise the difficulties. Design and development has to be paid for somehow. If one could see production lines of 100 or more hovercraft, then such development costs could be proportioned out and the effect on first cost would not be significant. However, with the small numbers of hovercraft presently involved these costs represent a much larger percentage of the capital cost, to the detriment of pioneer operators such as Hoverlloyd.

Sidewall craft appear, at the moment, to have achieved lower first costs, but it is hard to see how such craft can fulfil the performance requirements demanded by the operator. This is not meant to imply the requirement for very high forward speeds but rather to the ability to maintain speed in slightly worse than average sea states. In order to maintain a reliable service, a necessity for which I have stressed at great length, such a characteristic is a prime requirement.

How, then, do we see the future of hovercraft? We still maintain our great faith epitomised originally by the placing of our order for the SR.N4s in 1965 and of course by BHC in going ahead with the manufacture of the craft. After all, it is a tremendous step forward to jump from 37 tons, the AUW of the N3, to the 160 tons of the N4.

We appreciate that the picture has changed since 1965. Costs have risen and factors not considered at that time have been introduced, not least of these being cost of hoverports and the effects of harbour dues and toll taxes on the economics of the operation. Dues and passenger taxes represent a significant item on the costs, for example a tax of four francs is payable on every passenger embarked or disembarked at Calais. Devaluation has of course increased the cost of this item.

Furthermore, now that the machine is actually in being it is possible to put a more concise figure to the actual operating costs. These inevitably have also risen. Every effort must of course be made to reverse this trend. This is not impossible: our experience with the SR.N6 showed that maintenance costs were reduced during the second year. This was particularly apparent in skirt costs. With a brand-new type of craft it is expected that costs will be higher the first year; this is the inevitable consequence of not giving enough development time to the machine before it is cleared for operations. For some inexplicable reason hovercraft are expected to go into service almost straight from the drawing board. This is certainly not the case with aircraft and not even with a motor car. In the case of an aircraft, at least two years' development testing takes place, and as far as the motor car is concerned some twelve months' testing is carried out.

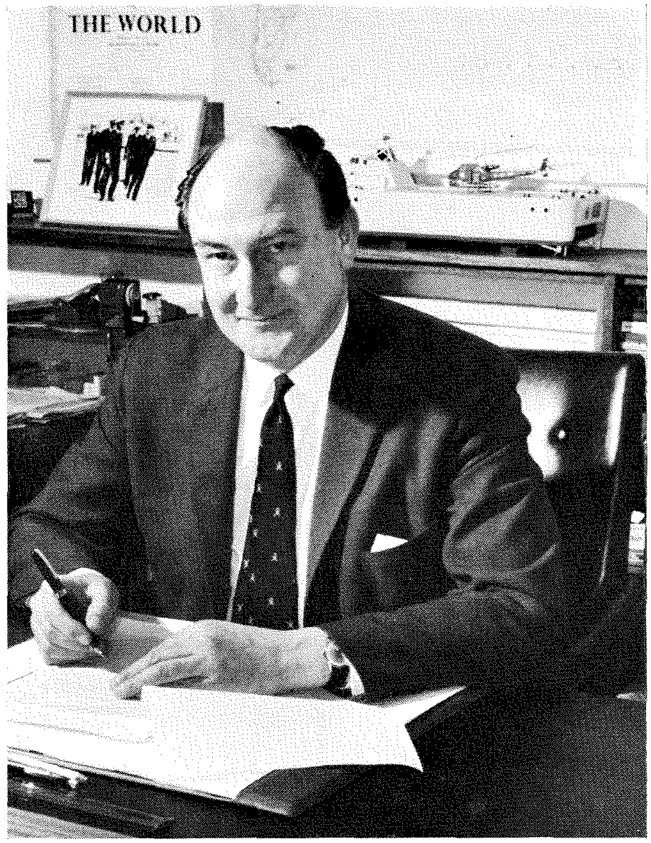
One is not saying that danger is involved with the policy so far adopted in the hovercraft industry, although carried too far an accident could happen; it was fortunate that the overturn accidents on the N5 took place during pre-operation trials. However, in terms of cost the responsibility falls heavily on the operator. Manufacturers may well claim that the operator gets their full support in the early stages both in material and manpower, but the loss of revenue caused when the craft is taken out of service is not covered and falls directly on the operator. Furthermore, if unserviceability is a frequent occurrence, then the reputation of the operator also suffers. This of course reflects back on everybody. Hovercraft could now become big business but they must face up to the facts of life, and to my mind this is fundamental.

Naturally, even with an adequate development period, troubles will occur and operators do not expect to be cushioned from these. They, too, have a part to play, and however well he tries the manufacturer can never quite achieve the utilisation or the exact environment of the operator. In this respect the operator must liaise fully with the manufacturer and in this way problems can be overcome.

This paper has not quite kept within the province of Channel operations, but these fundamental facts apply to any route. In voicing them neither I nor my company are showing a lack of faith in the future of hovercraft. Quite the contrary — it is because we have this faith that we feel these problems must be fully understood. We are, after all, in business to make a profit, or if that is too vile a word these days, to make a return on the capital invested. We are in a very competitive market and only by being competitive ourselves will we be able to stay in business. Hovercraft is the "with it" word of today, but unless it can demonstrate its commercial viability it will quickly go out of fashion. I don't think this will happen, but we must not be complacent about the present or the future.

ECONOMIC FACTORS ASSOCIATED WITH THE PRODUCTION OF SIDEWALL HOVERCRAFT

NORMAN PIPER
Managing Director
Hovermarine Ltd



Tynesider, telecommunications engineer with the GPO, then Fleet Air Arm pilot, Mr Norman Piper became in 1941 an RNVR ordinary seaman after a "low-flying" exploit. A submarine service volunteer, he saw service in the Arctic and Mediterranean. After 1945 he transferred from the RNVR to the Royal Navy, serving in both small and big ships. He again saw active service in Korea; in 1951 he was given command of an experimental minesweeper. Meeting members of the Clearance Diving Division, he joined them and became officer in charge of the Mediterranean under-water bomb and mine disposal base.

After leaving the Service he had good experience with Turner & Newall on the marine applications of thermal and acoustic insulation. In 1956 he joined Saunders-Roe (later called SARO [Anglesey]) and as Sales Manager travelled the world.

In 1961 he prepared a detailed report on sidewall hovercraft for the Far East but there the matter lay!

Temporarily with Hawker Siddeley Group in their head office, he then moved to the Marine Division of Hawker Siddeley, gaining experience in their advanced plans, which however did not mature. Further widening of his experience came with a senior appointment to Allen & Hanburys. However, all the time the sidewall concept called and Hovershow '66 found him and his friends on a stand. He took over as Hovermarine Managing Director in 1966 and in February 1967 a licence to build and sell sidewall hovercraft was obtained.

BEFORE discussing the subject of sidewall hovercraft and their economics it is perhaps of value to define what a sidewall hovercraft is. In simple terms it is a marine vehicle mainly supported by a cushion of air trapped between the base of the craft and the surface of the water over which it is operating by means of flexible skirts at the front and rear of the craft, and rigid side walls or keels along the sides of the craft. It could be likened to an air-lubricated catamaran, and in fact in large sizes of craft there is a very real similarity. Having briefly described what a sidewall hovercraft is, it is pertinent to ask what properties it possesses which would lead a company such as ours into producing it as a sound commercial proposition.

Displacement craft are restricted to relatively low speeds by the very nature of the resistance characteristic of these vessels which shows that exorbitant power and costs would be involved in attempting to propel such craft faster. Very dense payloads can, however, be carried by these vessels. For sixty years hydrofoil craft have been under development and have enabled commercial operators to achieve much higher speeds in operations than would otherwise be possible with displacement craft. There are, however, certain engineering limitations as well as appreciable operating costs associated with hydrofoil craft compared to hovercraft; it is difficult to increase their speed economically (at the moment 35 knots is a typical speed for this type of craft) because of the cavitation and resistance characteristics; perhaps of more importance is the limitation imposed on the percentage of gross weight which may be attributed to payload as size increases. As size increases the foil weight increases disproportionately and the net effect is reduction in payload percentage. Ten years ago the first moves were being made to assess the benefits to be gained by the adoption of a hovercraft principle as demonstrated by Mr Cockerell. This initial assessment work led to two main lines of hovercraft development:

1. Peripheral air curtain craft, and
2. Sidewall craft.

The history of the development of sidewall craft by the Denny Co is well known, and the subsequent unfortunate contraction in the scale of their activities due to the liquidation of the parent company. The advent of the fully amphibious peripheral air curtain craft was superficially of much greater impact and the development of this type, because of its dramatic amphibious capabilities, proceeded steadily. From the very early days of Hovercraft Development Ltd and Denny Hovercraft Ltd work on sidewall hovercraft, it was clear that for moderate speeds of up to say 40 or 50 knots the sidewall hovercraft concept offered vastly superior economics to those of the amphibious variety.

The development of sidewall hovercraft is now once again under way at an ever-expanding rate of activity with the Hovermarine Co. Apart from possessing a potential for greater profitability than amphibious craft, sidewall hovercraft also offer numerous other advantages. Some of these may be listed as follows:

1. Control

Since the sidewall hovercraft possesses keels immersed in the water and the propulsion units may be positioned far apart beneath the side walls, the degree of directional control possessed by these craft is extremely good.

2. External Noise

Sidewall hovercraft, not being amphibious, may be propelled by conventional marine screws or some form of water-jet propulsion. This means that the greatest source of current amphibious hovercraft noise, that of the air propellers, is removed.

Since the external noise of sidewall hovercraft is negligible, any limitations imposed by local authorities on the number of operations to and from a particular site are avoided. This can also mean that the scale of operation, ie the number of craft in use, is unlikely to be limited. These problems of noise are very similar to those around any major airport, and the economic penalty of noise may be extremely heavy as many airlines are well aware.

3. Power Requirements

Because the major part of the periphery of the cushion is sealed by a rigid wall running immersed in the water, the loss of cushion air from the sidewall hovercraft is very much less than that of a peripheral type. Consequently the power requirements for lift are very much less, and this enables the designer to use much cheaper but heavier high-speed diesel engines. This in turn means that, certainly in the smaller sizes of craft, we may offer designs which can be readily accepted by existing operators of diesel-engined craft.

4. Skirt Maintenance Costs

The sidewall hovercraft does not encounter the wear and abrasion problems associated with amphibious operation over beaches or concrete slips and aprons. Further, as previously mentioned, the skirted periphery is very much less, one-quarter to one-fifth of that of an amphibious craft. Skirt maintenance costs have to date in hovercraft operations proved to be high, and although sidewall hovercraft skirts will still suffer from the effects of flexing, leading to fatigue, and water immersion, leading to possible reduction in strength, there is little doubt that the incremental costs associated with skirts will be very much less than on peripheral craft.

5. Speed

Without going into the technical reasons for sidewall hovercraft at the present time making more sense below say 40–50 knots, and peripheral craft making more sense above these speeds, there is one aspect of speed in marine ferry duties which should be brought out. A hovercraft, like a ship or an aeroplane, must not only be designed to perform a certain function, ie to carry a certain payload at a certain speed over a certain distance, but must also be able to operate effectively in the particular environment. Of fundamental importance with hovercraft is the capability to give a good ride in terms of passenger comfort over the sea states likely to be encountered on the routes for which it is designed, eg an English Channel crossing will determine the approximate wave heights and lengths over which a craft must be able to operate satisfactorily. This requirement leads immediately to considerations of craft size (length and beam) that must be provided.

At the present time, passenger and passenger/car hovercraft ferries are unlikely to be designed as multi-deck craft since considerations of centre-of-gravity height in relation to stability would dictate otherwise. This situation will ease for craft of about 500 tons gross weight and upwards which may begin to appear in about five to seven years' time. In the meantime and for all small craft of less than say 250 tons, the length and beam demanded by sea state and induced wave drag considerations will determine the order of the payload for which capacity will be provided. For instance, a craft designed to operate for the majority of occasions in 6 ft high seas or less would have a length of around 100 ft, and a length/beam ratio to give an economically sensible resistance characteristic would lead to a payload of about 250–300 passengers. If now the predicted traffic volume is examined over the routes for which the craft is intended and practical operating schedules are set up (assuming that two or more craft are required for a satisfactory service), then some guidance will be found as to the order of service speed which the craft must have. In our many studies at Hovermarine we have found that the majority of commercially sensible speeds fall in the 30–50 knot bracket. As traffic continues to grow, however, justification for higher speeds will come and with it, we believe, the ability of the industry to design profitable craft in the 50–100 knot range. There is no major engineering problem in this speed range but the costs at the moment may be prohibitive for commercial ferry application.

The Market

An obvious first market for sidewall hovercraft is the ferry business. The existing ferries of the world have displacement vessels running between 10 and 24 knots and several hundred hydrofoil craft running at around 30–35 knots. The displacement vessels have been in the above speed range for a very long time; there has been very little upward movement. Ferry traffic is growing at a high rate — in the order of 14% for both passengers and passenger cars. A recent simple check showed that each year between forty and fifty new ferry ships above 1,000 tons each are being ordered. The larger ships such as the cross-Channel vessels of 4,000–5,000 gross tonnage represent considerable work capacity (payload × speed) and it will be some time before they are replaced by hovercraft. On short crossings, however, where sea states do not call for very large hovercraft, existing and projected sidewall hovercraft make good sense. The same pontoon or jetty arrangements may often be used and also operations from simple inexpensive concrete slipways may often be possible. The shallow draught of sidewall hovercraft also means that many new ferry routes may now be considered, apart from the fact that such routes may also be established as a direct result of the very much higher speed which is now available.

In addition to ferry uses of sidewall hovercraft there are, we believe, a large number of other applications. We have already sold craft for hydrographic survey where the high speed, shallow draught and low costs are especially attractive when coupled with the current high-speed data recording techniques. Such craft we believe will do the job much more effectively at a much reduced cost over present survey ships with their relatively slow speed, traditional equipment and large crews. Fire-fighting is another possible operation in which Hovermarine is involved and we have also been asked to look into such subjects as oil slick removal and various fishing applications.

Craft to Meet Market Requirements at the Right Costs

Since its inception Hovermarine Ltd has endeavoured to consider the requirements of the potential customer. The 60-seat capacity of the first Hovermarine production craft, the HM.2, was very much determined by discussions with possible buyers, although it would have been much easier for a new company in Britain to have started with a smaller craft. An examination of current ferry costs and fares gives a very clear indication of the levels which a competitive craft must reach. Some increase in fares for higher speed or novelty may be possible, but there is a limit as to how far an operator can count on this and from the manufacturer's point of view it is best not to depend upon these advantages. Of vital importance, then, is the need to come up with a design for which the cost will bear some acceptable relationship to the revenue-earning capacity or work capacity of the craft. This relationship may be judged by looking at the trends of existing forms of over-water passenger transport. It is found that successful ferries and passenger aircraft are very similar in this respect and when the capital cost of these craft is divided by their work capacity the majority of them are found to fall in the range of £200–£400/ton knot. HM.2 at £350/ton knot is comfortably inside this band and at this figure is 70% of the cost of an equivalent amphibious hovercraft craft. A further interesting point to note is that as hydrofoil craft size increases their specific cost will increase, while the opposite is true for hovercraft. This difference arises from the nature of hydrofoil support as opposed to air cushion support.

Since operating costs are highly sensitive to first cost it is found that the above situation of the relative positions of various types of craft holds true also for operating costs even though the make-up of the operating costs may vary to a marked degree.

Because small sidewall hovercraft are less sensitive to weight than the peripheral-skirted type it is possible to use high-speed diesel engines. For a craft of the size of HM.2 the diesel engine cost is approximately half that of an equivalent gas turbine installation, but — also equally important — the maintenance costs are only a small fraction of the gas turbines. Offsetting these very clear advantages are the effects on craft layout resulting from the large volume occupied by diesel engines and their noticeable effect on cg position. Further, as craft size increases the diesel engine weights and volumes become excessive. For instance, a craft of only twice the width and length of HM.2 would require about five times the power. In addition, for power levels around 3,000–4,000 shp the choice of available high-speed diesel engines is small. It appears therefore that although at the moment high-speed diesels are the best solution for a craft of HM.2 size, as larger craft are developed the gas turbine will begin to take its place, and this process will be accelerated as marine experience is gained in greater quantity and more appropriate lower-cost engines become available.

The cost of propellers for the sidewall HM.2 is approximately one-seventh of that of equivalent air propellers to provide the same thrust, and the maintenance costs will be negligible unless severe damage from débris is frequent. The design and material of the HM.2 propellers is such that no cavitation erosion has yet occurred in over 100 hours' running. It is interesting to record here that the ARB Certificate granted to Hovermarine makes it the first company specifically certificated to design hovercraft, and in addition Hovermarine is certificated to design marine screws.

The major cost of a craft such as HM.2 is its structure. The choice of structural material is dependent, of course, on a large number of factors. Some of these factors are discussed in the next section, in particular those having a direct bearing on costs.

Production Aspects

The decision to build HM.2 and subsequent sidewall designs was not taken lightly. The overriding factor was one of economics.

The British and American Navies have had something like fifteen years' experience with small craft manufacture in reinforced plastics, and we felt it wise to draw from their experience. One of the outstanding cost savings which have resulted from their use of this material has been that of maintenance costs, which have been reduced by up to 70%. On the design side another saving which can be easily overlooked is that resulting from the need for far fewer detail drawings than are required with, say, aluminium alloy structure. This situation is only true, of course, for the basic structure of the craft, for there is not very much savings with the use of glass reinforced plastics as far as installation drawings are concerned.

The production process requires the provision of an accurately formed plug on which a mould may be built. When completed it is removed and the structure to be built is then laid up within this mould; hence the initial tooling required (plug plus mould) for the first craft can be exactly that required for all subsequent craft. From this procedure it follows that for large numbers off the tooling costs become very small indeed. The plug is in a sense the vital component in this production method and permits one or more moulds, and in this way new production centres may be set up by the provision of the necessary moulds from the original plug. This can be especially important when larger craft

are considered and the physical problems of exporting large completed craft involve very high costs or perhaps, in some cases, is simply not practical. The plug represents about two-thirds of the total tooling cost for a single production line. The sidewall hovercraft shape introduces some particular disadvantages as far as the use of glass reinforced plastics is concerned; for instance, many of the surfaces are large, flat areas and in single thickness the glass reinforced plastics skin has a rather low stiffness. This characteristic means that a considerable amount of internal framing structure is required, calling for additional material and relatively expensive labour effort.

The glass reinforced plastics structure is made up of two main components, glass fibre cloth in a variety of forms (woven roving or chop strand matting, for instance), and resin. Two types of resin are commonly in use, polyester resin and epoxy resin. The former is less than 20% of the cost of epoxy resin and in the HM.2 craft it is used throughout the structure. Other advantages of polyester are that it is non-toxic and is easier to apply during the laying up of the structure. The labour force required for glass reinforced plastics fabrication needs a lower standard of skill than is required for aluminium alloy structures. On the other hand, the operators must not only be trained but also must maintain a degree of uniformity in their work, and this uniformity must also exist regardless of which operator is performing a particular job. This situation arises because it is simply not practical to detail on production drawings every structural conjunction, fillet and local irregularity. The manufacture of craft such as HM.2 does therefore depend to some extent on the introduction of techniques involving craftsmanship, coupled with effective and of course more costly supervision. At the present time wage levels are slightly lower for the main labour contingent where rather less skill is required, but this is offset to some extent by a resulting higher turnover of labour forces.

The handling and storing of plugs and moulds present a few difficulties; the mould shell when completed is fairly flexible and before being removed from the plug it has to be stiffened up so that it may be lifted and set up in its correct position without risk of distortion. In the case of a very large craft the plug may be a very expensive item as it occupies valuable floor space and of course serves no useful purpose, once the initial moulds have been obtained from it, until it is used again. In certain cases and provided suitable protection is afforded the plug may be stored outside.

Concluding Remarks

Hovermarine set out in business with the intention of providing hovercraft with the characteristics and operating economics with which an operator could confidently expect to make a profit. This result clearly depends not only upon a close matching of craft capabilities to market requirements, but also the determination of optimum solutions in the design and manufacturing processes. In our case we were fortunate enough to have some prior knowledge and experience in hovercraft design, high-speed craft production as well as glass reinforced plastics techniques, and therefore some appreciation of the economic factors involved. It is comforting, therefore, that whilst the first production costing of the HM.2 made so long ago has varied to some degree, it has not increased sufficiently to price the craft out of the market or to deprive the operator from retaining a worth-while profit margin.

Industrial and Domestic Applications of the Air Cushion Principle

Mr Leslie H. Hayward was born in Bristol in 1918, and his interest in aeronautics started in 1931 when he won the Royal Empire Society (Bristol Branch) Essay Competition "A journey by air to Australia". In 1934 he was apprenticed to the Engine Division of the Bristol Aeroplane Co Ltd, where he remained until 1939. From 1939 until 1945 he was engaged on engine development and technical publications on the staff of D. Napier & Son Ltd. From 1945 to 1950 he was Assistant to the Patent Engineer of the Bristol Aeroplane Co Ltd and from 1950 to 1953 he worked as Patents and Commercial Engineer of Fairey Aviation Ltd. In 1951 he obtained the International Cierva Memorial Award. Since 1954 he has been Group Patents Manager, Westland Aircraft Co Ltd. His publications include "The History of the Helicopter", "Jet Propulsion of Helicopters" and "The History of Air Cushion Vehicles". In 1962 he became the fifth British recipient of the Bronze Medal of the Swedish Society of Aeronautics.

LESLIE HAYWARD

Group Patents Manager
Westland Aircraft Ltd

THE inventor has long thought of the desirability of using air for supporting transport devices, from Swedenborg, the Swedish scientist and philosopher, in 1716, to the present-day patentee. The first man, probably, successfully to demonstrate the use of low-pressure air to support a vehicle was A. U. Alcock, of Perth, Western Australia, in 1912, with a simple model comprising a platform of wood 4 ft × 4 ft × 2 in, on which was mounted an electric motor driving a compressor and propeller. Air from the compressor was delivered to the underside of the platform by way of a single orifice and provided a thin supporting cushion resulting in an arrangement which, today, is generally referred to as a "levapad", although at that time referred to by Alcock as "floating traction". Unfortunately, no interest was shown, even though the demonstration was reported in the Australian *Sunday Times*, and the idea remained dormant until 1939, when Alcock again demonstrated, on that occasion at the Cricklewood Ice Rink. Considering that both demonstrations were made before world wars, it seems incredible that no one seized upon the idea and initiated its development.

It was not until Christopher Cockerell eventually managed to make his experiments known in the middle fifties that development was undertaken which resulted in the SR.N1 hovercraft (now at the Montagu Motor Museum, Beaulieu), and world-wide interest was aroused in a new form of transport. It is not the passenger transport aspect of air cushion applications on which I wish to dwell, but upon industrial uses of the new art.

Where the air cushion principle probably illustrates its greatest propensities is in its adaptation to use with large transport vehicles which convey heavy loads, such as transformers weighing in the order of 250 tons. Whilst running on well-bedded roads the vehicles comprise tractors, a multi-wheeled trailer and a special air compressor vehicle, travelling normally on road wheels. Obviously, a very heavy point loading is transmitted to the road surface, being in the case of a trailer having forty wheels and a load of 250 tons, in excess of 6 tons. Such loading can often be too great for many bridges and weak road structures to bear without suffering damage, and it is under such contingencies that air cushion support proves its effectiveness and value. The transporter illustrated can modify the pressure effect upon the road surface by reducing the forty point loadings from, say, 6 tons each to 2 tons each, with the remaining weight being evenly distributed over an area in the order of 450 sq ft at a pressure of approximately 5.4 psi, ie an off-loading of the wheels of 155 tons.

The cushion is contained beneath the trailer by means of a flexible skirt that is attached or extended from a retracted position when required. Abrasion of the edges of the skirt is reduced by means of light steel plates attached to the hem. Compressed air is provided from the special vehicle carrying four internal combustion engines each delivering 235 hp at 4,500 rpm, and driving centrifugal compressors. Delivery to the cushion region is by way of four conduits, and during operation output from one of the four units is deliberately allowed to waste so that in the event of failure of any one of the three other units the wasting air is automatically and immediately directed to the cushion. Non-return valves prevent leakage back through the failed unit.

It will be apparent that on bridges which have a span length which is greater than the length of the load-carrying trailer the advantages of air cushion support reduce, as there is no relief in sheer stress and only a small amount in bending moments, so that a cushion which supports about 40% of the weight of the transporter and its load is sufficient. Nevertheless, with a 32 ft long trailer on a 50 ft span this would allow a load to be increased, for example, from 150 tons to 215 tons without subjecting the bridge to any higher stresses. Applications of a somewhat similar nature where heavy loads are being moved across soft ground use an air cushion supported trailer towed by a tractor, or, alternatively, the trailer is moved by its own powered winch. Such transport devices as these need none of the sophistication of self-propelled vehicles designed to integrate with other transports using public and commercial routes.

There are many regions where the agriculturist is confronted with large areas of soft ground or land which does not readily drain; and which, after long periods of rain, is difficult to work. In such regions the industrial use of air cushion support can again prove its value by permitting movement of equipment where normally it would be impossible to do so. The agricultural engineer is often called out to repair or retrieve equipment in the field where he could use a four-wheel-drive utility which is skirted to provide a plenum chamber beneath its chassis. An air compressor mounted on the vehicle pressurises the chamber, and when driving from a firm surface to a soft one an air cushion is generated to relieve the road wheels of some of the load, preventing the vehicle from becoming bogged-down and still provide the necessary traction. Should ancillary equipment be required to be carried, a skirted trailer can be towed behind the utility or a tractor, and be supplied with compressed air from the utility, the road wheels being relieved of some of the applied load.

As part of a retrieval kit, the agricultural engineer may carry a device to put under a bogged vehicle. In its simplest form, such a device resembles a car inner-tube with a skirt hanging from it. The tube has a series of small holes around its inner periphery and an inlet port adapted for connection by hose to a compressor. The device would be placed in a collapsed condition beneath a flat surface of the bogged vehicle and inflated from the compressor; this would initially raise the vehicle and provide a plenum chamber under the flat surface. Air flowing from the small holes into the chamber lifts the vehicle to a height equal to the extent of the skirt. Several of these devices may need to be placed under an object to be retrieved, and a number of devices can be connected together in an impervious box or flexible bag.

Another agricultural vehicle incorporating the air cushion principle is the crop sprayer. This can be in the form of an assisted support wheeled vehicle, or it can be fully air cushion supported. Special purpose vehicles require power take-off means for driving the lift fans but as the power required to drive the vehicle decreases as the weight is taken by the air cushion, and the lift can be proportional to fan speed, a compatible condition exists between the two power requirements. This form of crop sprayer tracks its wheels between the rows of plants, whereas a wholly air supported vehicle can move across plants without damage to them. A lightweight hovercraft of approximately 1,500 lb weight, capable of distributing 200 lb of liquid as a fine spray from 14 ft booms, can effectively treat small plants of say 4–6 in high without suffering damage from the air cushion. Spraying from a low height using a hovercraft has many advantages over spraying by aircraft, inasmuch as the dispersion effects of the spray due to wind are greatly reduced. Wind speeds greater than 15 mph usually curtail aerial operations, but would have little effect upon spraying close to the ground, also the problems of visibility are much less critical to the operator of a hovercraft sprayer, while the ability to manoeuvre angles of fields is greater. It would appear that the only advantage an aircraft offers is in the ability to spray steep slopes. Hovercraft weighing approximately 20,000 lb have successfully operated over paddy-fields without damaging the young rice plants.

For stiff-stalked crops which are grown in very wet ground conditions, or water-covered ground, reaping devices can be attached to a hovercraft greatly facilitating harvesting.

Another outdoor industry that could probably benefit from the use of air cushion supported devices is in timber or lumbering. In British Columbia I can imagine that an amphibious tractor vehicle capable of towing logs through the water and across the ground to the sawmill in a single action would be of considerable value at the collection basins where the logs are gathered after floating down the rivers.

In the kindred industry of forestry wholly or partially air supported vehicles and trailers would be of service on marshy ground conditions during reforestation, when thousands of young trees are moved onto sites.

This brings me to the movement of goods generally, and so to the transport industry. With the advent of "containerisation", air cushion support can really be used most effectively, and if the various branches of industry co-operate to the full in the introduction of standardised equipment great facility of movement will be achieved. One of the primary features to be standardised is the bed-height of road and rail vehicles, and of handling wharfs, whereby goods can be transhipped without lifting or lowering tackle being necessary. Containers can be equipped with a number of air cushion pad membranes attached to their underside, and at the present time such pads are available "off the shelf" both in Great Britain and the USA for fitting to customers' own structures. Each pad forms a flexible bladder on the underside of a rigid plate, the edge and centre part of the membrane being secured to the plate and forming a flexible pocket or cavity. Compressed air supplied to the annular interior of each bladder passes out through a series of holes into the cavity to provide a local air cushion. Pad membranes, produced in different shapes and sizes to suit various platform configurations and loading requirements, can be arranged in many patterns beneath the platform to provide the greatest stability to suit the load. In an example of the facility provided by such pad membranes to the movement of loads, an 8 ft × 8 ft × 20 ft container weighing 5,500 lb loaded can be supported by four elements requiring only two electrical horse-power (1,492 watts) to provide the compressed air, whilst being manoeuvred manually by one man over a smooth floor. As an alternative to securing pad membranes to containers they can be fitted to hand-trolleys to provide an air cushion supported device. Besides the obvious advantage of reduced manual effort being required in their movement they provide a vibration-free ride for the goods being transported, which can be a valuable asset, particularly where fragile articles or articles having very fine finishes are moved between departments for various stages of manufacture and assembly. I suggest that transporters of this type have application and would be appreciated in very many industries, ranging through, for example, leather dressers, packaging industries, bullion dealers and confectionery manufacturers. Where a trolley has to move to and fro around large works it would need to be free-moving and would carry its own air compressor, and might even include fork-lift apparatus. Self-propulsion could be provided by a single powered road wheel, and to provide extra containment of the cushion air, allowing for greater unevenness of factory yards over that of shop floors, skirting can be fitted to hang from the trolley base.

The use of the air cushion principle in factories can be of great practical use to the maintenance teams, or millwrights, who are often posed with problems of installing or moving heavy equipment or machine tools under restricted conditions, many times including the need to pass between other equipment, which leaves minimal clearances and insufficient space for men to work alongside, as required by the conventional use of rollers. After equipment has been installed, it may still use an air cushion as a feature of its working life, and two machines which are particularly suited for this purpose are drilling and milling machines. The movement of jigs and work-pieces about the bedplate of the machine is made easier by mounting them on an air-cushioned support member which can be magnetically held in place during working.

Stevedoring can be considerably relieved of much of the physical effort by use of air cushion trolleys, which obtain compressed air from air-lines fitted in a ship's hold and supplied from compressors in the engine room. Freight at the dockside can be transferred to the ship's hold by means of air-supported conveyor-belt systems set up between dockside and freight openings in the ship's side.

Conveyor-belt systems, although varying in detail design, all conform to the single principle that the belt upon which the goods are loaded is supported by compressed air, obviating or greatly reducing the number of rollers required. In the simplest example, the belt passes over a bed having orifices in its surface through which compressed air is discharged. This arrangement is somewhat wasteful of air and is improved by using a single central longitudinal row of unvalved vortex orifices and a row of slow-leaking orifices flanking each side of the central row. The outer rows leak sufficient air to "unstick" the belt and allow the vortex flow to become effective to support a load. In another design the belt is arranged to pass over membrane pads similar in design to those used in the trolley application, only in this instance they are inverted.

In fixed bed conveyors using no belts, air is supplied through ports in the bed surface to support flat-bottomed loads, and this form is of particular use where a conveyor is laid down for a reasonable period of time. One means for conserving air is to insert a ball-valve in each discharge orifice such that a portion of the ball breaks the surface of the bed, it being depressed by the leading edge of the advancing load and held depressed until the load has passed.

Where the layout is likely to be frequently moved, it is preferable to install a simple solid surface and use a load-pallet or patform which discharges compressed air from its base. The pallet may be provided with a single resilient sheet quilted to form pockets on its underside into which compressed air discharges to facilitate "lift-off" from a condition of rest, before being wholly supported.

I find it difficult to quote industries which would not benefit from using some application of the air cushion principle.

A transport problem, which could by no other means be so effectively overcome, is the resiting of large industrial structures such as storage tanks. A 300,000-gallon tank of 50 ft diameter, a height of 30 ft and over 50 tons weight has been moved 350 yards across a storage site, by attaching a flexible skirt around the base of the structure and allowing an annular cushion of air to initially "unstick" the tank and then further develop beneath it.

Pressurised air at 60 lb/sq ft was fed into the skirt by small mobile compressors which were secured to the tank by a cable, and the whole assembly was winched over two railway tracks, a road and two stretches of rough ground, one of which was of slightly increasing gradient. A natural feature which would have caused difficulty, using conventional rollers and jacks, was that the water table was just below the surface of the ground.

Difficulties often arise in lifting heavy objects with a crane because the ground on which it operates is soft and cannot bear the high point loadings at the wheels or pads. If the bearing area is increased by providing an air cushion under the full area of the crane-bed the weight distribution can be spread and the point loading reduced to an acceptable figure.

Applications of some of the equipment which has been described may soon be seen on large building sites, but even the small builder can avail himself of the air cushion. Loads of, say, about 5 cwt can be moved about the site on an air-supported wheel-less barrow which permits easy movement of bags of cement, bricks, house fittings, etc, without the usual troublesome practice of having to lay boards when the site is like a quagmire.

Progressing from barrows, it is a reasonable step to mention stretchers, which have been developed for military medical purposes and have undoubted value for moving wounded over boggy or rough ground. Such devices could be of value in the transportation of people injured in other walks of life.

Aircrew brought in on air cushion stretchers may have sustained severe burns and it is another air-supported principle that can prove so very beneficial in their treatment in hospital. The first experimental "hoverbed" was installed in the Royal National Orthopaedic Hospital at Stanmore. On such beds, the patient is wholly supported by a film of air which applies a relatively uniform support pressure rather than local areas of support. Using levitation, burns can dry within approximately $1\frac{1}{2}$ hours, whereas under treatment the wounds take 24–36 hours to dry. Air is supplied to a compartment beneath the bed, brought to body temperature and sterilised before issuing at approximately $\frac{1}{4}$ psi to support the patient. A very interesting and informative article on this subject appeared in *The Lancet* of June 10th, 1967.

Air cushion support is beginning to move into the service industries, where, in a launderette, washing machines have been so equipped, the object being to accommodate the vibrations which arise during sequences of spin-drying.

Such an application brings us to uses of the principle in the home, where, in most instances, there already exists a power source capable of lifting about 3 cwt — the household vacuum-cleaner. To move the heavier pieces of equipment, eg cookers, storage heaters, loaded wardrobes, they could be adapted to receive an inverted, shallow tray slid into slots at their base, so that the tray is very close to the floor. A hose connection on the tray being connected to the vacuum-cleaner via its hose.

Maybe in the not too distant future, as the vast field of application of air cushion support comes to be appreciated, we shall find that homes are equipped with a compressor in the garage and piping built into the structure of the house with valved outlets spaced at convenient positions along all the skirting boards. By that time, perhaps, the furniture and domestic appliance designers may be persuaded to include a suitable cavity or plenum chamber under their wares, and so provide the requirements of an integrated system. An additional service that the pressure circuit in the house would allow is the use of a paint sprayer, and at the time of installation it may be worth while to adapt the equipment to provide suction and enable vacuum-cleaning to be done, and further, the compressor could provide the air-flow for a warm-air heating circuit.

Pressure outlets could be supplied in the garage and even at points about the garden so that wander air-lines could be kept to a reasonable length for air cushion equipment such as barrows, mowers, and perhaps a go-cart for the youngsters. A hover-pallet or trolley would be of advantage in districts where the householder has the dubious privilege of setting his dustbin at the kerbside each week for the local cleansing department to empty.

That department, in the larger cities, could probably use hover-pallets to advantage in their nightly collections from the large office blocks, restaurants and other commercial establishments where very large waste bins have to be handled.

Air cushion pallets would be most useful in saving space required for manoeuvring cars in high density car park facilities; however, even this adaptation may be unnecessary in the not too distant future when, perhaps, after attending a symposium such as this the vehicle that takes you home may be an automatically guided hovercar.

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CLARK EQUIPMENT CO, INDUSTRIAL TRUCK DIVISION, Battle Creek, Michigan, USA.

GARRETT CORPORATION, 9851-9951 Sepulveda Boulevard, Los Angeles, California 90009, USA.

GENERAL MOTORS CORPORATION, INLAND MANUFACTURING DIVISION, General Motors Building, 3044 West Grand Boulevard, Detroit, Michigan, USA.

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HOVERLIFT LTD, Shore Road, Hythe, Southampton.

NATIONAL RESEARCH DEVELOPMENT CORPORATION, TRACKED HOVERCRAFT LTD, Kingsgate House, Victoria Street, London, SW1.

NATIONAL PHYSICAL LABORATORIES HOVERCRAFT UNIT (in conjunction with NRDC), St John's Street, Hythe, Southampton.

SPENCER (MELKSHAM) LTD (a member of the Elliott-Automation Group), Melksham, Wiltshire.

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US ARMY TRANSPORTATION RESEARCH, Fort Eustis, Virginia, USA.

The Economic Aspects of Hovering for Pleasure

G. HARDING A.M.I.Mech.E., A.M.I.M.I. M.I.R.T.E.

Geoffrey Harding is at present General Manager, Wallasey Corporation Passenger Transport Department.

During the last war he served with the midget submarines, and having continued to serve in the Naval Reserve he is now a Lieutenant-Commander, RNR.

After demobilisation in 1946 he obtained training at the College of Automobile Engineering and at Wandsworth Technical College, following which he was employed as Technical Assistant in the Road Haulage Executive. His first post in connection with municipal transport was as Assistant Test Engineer with Birmingham City Transport and has since then been employed by four different municipal undertakings in engineering capacities and latterly as General Manager.

He has been building hovercraft as a hobby during the last seven years and has constructed some thirty-three craft of various sizes. His latest man-carrying craft, "Wotsit 1" and "Wotsit 2", are propelled by contact with the ground and are designed primarily for beach rescue purposes. "Wotsit 1" is now a part-time member of the Wallasey Fire Brigade Rescue Service.

I CAN almost hear your saying that the title is a contradiction in terms for a start. It is often true that to assess the cost of something we do for pleasure is to cause that something to be no pleasure at all, at least for the moment However, perhaps I can persuade you that these terms, which appear to be strange bed fellows, should have a place together after all.

As I see it there are three aspects of this subject about which I may comment.

There are first the question of building and/or driving one's own light hovercraft for the fun of it; secondly the question of building light hovercraft designed to be sold to others to operate for pleasure and the profit of oneself; and lastly the question of building or buying hovercraft to be hired to others for your profit and their pleasure.

I am using the term light hovercraft in the same way as the Board of Trade uses it at present. This is to denote a craft which either weighs under 2,000 lb or has an installed engine power not exceeding 80 bhp or is designed to carry not more than two people.

Building hovercraft for your own pleasure can be almost as cheap or as expensive as you wish. It is to most enthusiasts what motor-cycling was to many lads for a number of decades: a cheap thrill. I do not mean that disparagingly at all. It was both thrilling and cheap, and so can be building and driving your own hovercraft. In addition to that, building a craft of your own design is to follow a course strewn with a continuously absorbing succession of engineering problems, most of which are quite new in character to you.

It is possible to buy from Hover-Air Ltd, of Peterborough, for about £600 a kit of parts from which you can assemble a craft of a type of which many have been built. It will operate quite well and whilst it will not tax the ingenuity of the builder at all or the ability of the handyman much, it will provide all the thrills that are available from driving something akin to an aeroplane which has lost nearly all of one of the dimensions in which it normally lives.

For about £2 10s you can buy a set of plans and instructions from the Hover Club of Great Britain Ltd in Ryde which will tell you all you need to know in order to build a craft like the *Players No 6* craft. In my view building this will tax your ingenuity very little, your ability (even if you are an engineer) a great deal and your pocket a lot. As, other than the prototype, none of these craft has yet been built I can only guess that building one would cost you around £600 or £700, because most people would need a number of parts made for them and few parts for the craft could be bought second-hand.

For five shillings you can buy from the *Daily Express* a booklet on how to build a craft designed to be built by schools and technical colleges. This craft will probably cost somewhere between £50 and some hundreds of pounds to build depending on how much second-hand material is used in its construction. At the time of writing this paper none but the prototype has been made. This type of craft is easily built with simple tools and the only ingenuity required relates to obtaining parts for it cheaply or free!

At the bottom of the scale, if you write to the Hover Club of Great Britain Ltd and ask "How do I build a hovercraft?", for the price of a stamp you will probably receive a foolscap sheet of paper with some notes I have written telling you how to make the simplest of hovering platforms similar to one I and two others constructed at a demonstration in March in 36 minutes. Whilst this craft had no propulsion mechanism, it easily lifts four grown men some 9 in off the ground, and such a craft has been built for a total of £5. Building a craft like this requires no skill, but all the ingenuity you and your friends and relatives can muster and more.

There is practically no specific legislation governing the operation of craft like these but certain legislation affects their operation.

For example, in the case of say a county borough having a by-law which precludes the operation of mechanically propelled vehicles on a beach within its boundary, whilst one could argue in the case of some craft that

(a) they are not *on* the beach and

(b) if they are, they are not mechanically propelled,

common sense dictates that one should avoid such a beach.

Again, it is common sense to take out appropriate insurance cover and indeed if one is to enter into Club competitions this is a prerequisite.

In this connection, too, craft are required to be inspected by competent inspectors before competing in organised events and the Hover Club has a set of recommendations relating to craft and environmental integrity.

As I have said, a craft can cost what you want it to cost, or more accurately usually about twice what you want it to cost, and incidentally at twice the weight you want, too.

One literally big problem is that craft tend to be large, for as they work at such a low air pressure per square foot they need a lot of square feet of base area and therefore a fairly large space in which they can be built.

Driving hovercraft is undoubtedly fun, perhaps if for no other reason than because they are almost frictionless and at low speed driving one can be not unlike sliding on a continuous banana skin.

Nearly all of these craft readily slide down gradients, dislike going up gradients, and have a great tendency to be gone with the wind if it is blowing appreciably.

They are mostly noisy and they are cheap to run. Third party insurance for one costs between £20 and £50 a year.

Coming now to the second category in my sequence, the question of building craft for sale is one which has attracted the attention of many people, most of whom have upon close acquaintance quickly become disenchanted with the project. When considering this category one must bear in mind that at present most people who are keen to hover for the sake of hovering for fun are equally keen to ensure that it costs them next to nothing. One often has cause to feel that if you offered an enthusiast a new Hillman Imp or even a Rover gas turbine engine for a penny he would be inclined to haggle. But others who want to hover may well be those whose work can be better done by using a hovercraft and one of the comparatively rare breed who as yet are enlightened enough to realise it.

There are also those who want to drive purely for fun or to enable them to pursue another sport more comfortably, and there will soon be those who want to buy the craft from you which has the best chance of any of enabling them to win the now £100, soon £1,000 and later the several thousand pounds of prize money in national and international races. The draw of really fast hovercraft operating on *terra* fairly *firma* and also on water at the car Grand Prix speeds of not so long ago has not yet been fully realised. When it is, it is bound to be the case that such activities draw crowds and money from them and, at that time, this purely amateur sport will become, if not a profession, at least a professional sport. This in turn will mean that the craft used will be fitted with hotted-up Wankel units and small gas turbines, and not as they often are today with an engine taken from an autocycle found in the village pond.

In time it will unfortunately be a case of the success of the wealthiest, and a great deal of money will no doubt be spent upon pure racing craft.

Perhaps this is looking into the crystal ball rather too deeply and for the present the picture is one of virginal amateurish amateurism and it is desirably clean and fresh as a result.

In the light hovercraft field, apart from one or two types of toy-like craft which cost about £125 and will carry a small child, two makes of craft are currently available to the public. Hover-Air Ltd of Peterborough are producing a craft called the Hover Hawk, and a company called Barwren Ltd of Whitstable are producing a craft called the Crested Wren. The former craft has been developed from the Hover Bat and Hover Twins produced by this company more than a year ago which are still available in the kit form I have previously mentioned, and such kits form the basis of very many of the craft driven for fun today. The price of a Hover Hawk is now from £1,450. The Crested Wren has come on the market during the last six months and is similar to the original Crested Wren which almost swept the board at the rallies held during 1967. Unlike the Hover Hawk, this craft has one engine instead of two for propulsion and sells for about £1,250.

These craft are soundly built light hovercraft which will exceed 30 mph on land and water under good and even not so good conditions and will operate in weather conditions worse than one might might. Hover-Air also produce a craft referred to as Type HA, designed for many purposes including crop spraying. This is fitted with two lift engines to increase its ability to lift weight above that of the Hover Hawk. Such craft as these can be supplied with many different items of equipment, such as radio and echo sounders and so on, which can substantially inflate their prices.

For their size these craft seem expensive when compared with the price and performance of a car. I am told that the basic standard craft contain some £500–£600 worth of bought-in equipment, and it seems that the small two-stroke engines with which they are equipped are very expensive in terms of cost per horse-power as compared with, say, a car engine. Of course, the quantities in which these craft are produced are at present minute, and it will probably be a long time before they are anything other than very small. I say "probably" because I cannot quite decide what I think will happen when the fast-boat fraternity quite literally find themselves being left very far behind. Certainly in Mediterranean waters they are very "one-up-manship" conscious, which reminds me that it is bad enough swimming where their boats speed without being pursued up the beach by an amphibian.

Apart from production craft, Hover-Air, for example, have agreed to produce a one off craft for a special purpose and it is likely that such arrangements will occur again in the future.

For my own pleasure I build craft in which I can compete in rallies and races and which are designed as they are so that they can fulfil the following requirements:

1. Being capable of being driven, after only a few minutes' tuition, by anyone who can drive a car or motor-cycle.
2. Being capable of operating in adverse weather conditions and be practically unaffected by cross and head winds.
3. Being capable of being accurately steered and positioned, say, alongside a person trapped in mud or quicksand, even in adverse conditions, without danger to that person.
4. Possessing accelerating and braking performance of a fairly high order.
5. Being capable of speeds on land of the order of 25–50 mph and on water of the order of 10 knots (greater speed on water is desirable, although not essential).
6. Being capable of climbing gradients of up to 1 in 6 from a standing start and being capable of stopping and moving off again on such a gradient.
7. Being capable of operating on any surface found in many estuaries and particularly in the Mersey, where an obstacle-clearance ability for boulders and rock outcrop of about 10 in is required.
8. Being capable of being driven transversely across the face of a slope of the order of 1 in 15 to 1 in 20.

9. Providing an accurate measure of speed and distance covered at least on land.
10. Being cheap to produce and operate, and requiring the smallest amount of power possible to achieve the foregoing.

One of these craft, known as *Wotsit 1*, is now a part-time member of the Wallasey Fire Service rescue facilities and whilst I wish no one any harm I can't help hoping that the day will come when someone needs rescuing in a situation with which only a *Wotsit* can cope.

There are numerous applications for special light craft capable of meeting particular requirements. It is often the case that such a craft can be easily and cheaply built from second-hand parts for a strictly limited life, and I have little doubt that a few people will make some money from producing designs for others on an *ad hoc* basis.

Personally, I do not think there is even a very small fortune to be made out of making and selling light hovercraft yet, and, in fact, it must be difficult to make a living at it.

The position is almost the same in connection with the manufacture and/or supply of parts to the sport. Whilst the market for such bits is many times larger than the market for the whole craft, as it has been estimated that about 1,000 light craft are currently being built in the United Kingdom alone, unfortunately, however, very many of the people who want the bits at present haven't the money to pay for them.

I always tend to associate with light hovercraft one can drive light hovercraft one cannot drive. Perhaps the best examples of this are the Flymo lawn-mower and the Hoover Constellation vacuum-cleaner. Perhaps such devices are slightly outside my terms of reference but each fulfils a useful purpose, and if you have, say, a steep grassy bank in your garden a Flymo is a tool which is a pleasure to use. How it comes to be priced as it is beats me, unless it is the case that its manufacturers are really aircraft industry men in disguise. I'm not very happy about the Constellation vacuum-cleaner either, but for a different reason. A vacuum-cleaner is basically a thing designed to suck. A hovercraft is basically a thing designed to blow. If you use a thing designed to blow as a thing designed to suck, it won't suck as well as a thing designed to suck and not used to blow in addition, if you see what I mean.

What I am really saying is that although gimmickry may pay off as gimmickry, it may be the case that it will only do so at the expense of efficiency.

Having said that, in my opinion there are numbers of opportunities to use the principle of lifting things with lots of low-pressure air for the purpose of giving others some pleasure and yourself some profit.

Amongst the things I have in mind are household items like electric cookers, refrigerators and pianos, as well as filing cabinets in offices, all of which could, at least on some floors, be moved in the house very easily if provided with a base designed for hovering and for attachment to the blowing end of a vacuum-cleaner or something of the sort when they are required to be moved.

The pleasure obtainable from shifting such things must inevitably be small, for it only occurs from the discomfort which would have been experienced had the job not been made suddenly easy. Although this is so, it seems to me that this form of hovering is something capable of being achieved profitably if it is incorporated during the early design stage of an item. An alternative which would not involve great cost would be a hovering tray or pallet upon which various pieces of furniture or equipment stand permanently.

Yet another form of hovering device not designed to be driven is one that can be used as an adjunct to an existing pleasure.

An example of such a device is a boat-launcher designed to enable small craft to be launched on beaches where wheeled trailers can only be used with difficulty or cannot be used at all. This launcher is hand-propelled in one way or another and can be equipped to act as a wheeled boat trailer, but it is thought that such launchers would normally be club-owned, like the concrete ramp it would replace at some sites, rather than individually owned.

A useful hovering device such as this has several advantages over a light hovercraft from the potential manufacturer's point of view. It is a particularly simple machine, the lift unit for which could be provided for as little as, say, £50 including a built-in gravity-feed fuel tank and probably with hand as opposed to electric starting. The hull of such a craft would lend itself to being moulded in one material or another, and although a proper costing exercise has not been carried out the simplicity and small number of parts required to complete a launcher of this type enable one to be confident that its selling price would be only a fraction of that of a light hovercraft.

In addition, the market into which such launchers are to be sold is not normally as penny-pinching as that of the hovercraft enthusiast. On the other hand, whilst hovering and boating enthusiasts do not seem to mind if their respective craft gives them a wetting from time to time, the boating fraternity would probably object if their launcher made them wet even before they got afloat. The result of this is that hovering pressures would have to be low to avoid this and problems with dust so far as possible.

The final aspect of this subject about which I have said I will talk is concerned with the hiring of craft to others. In this case the owner of the craft may either purchase them or build them.

Not so long ago trips round the bay in a speedboat called *Miss Brighton* or something of the sort were part of every holiday scene, but I do not think that it is likely to be revived for very long by replacing the speedboat by a hovercraft. My remarks so far have been confined to light craft and by definition the maximum load allowable is two persons including the driver. Giving rides on this basis and living on the return is probably the best possible way of slimming. Except to use temporary excess capacity for work from time to time, it is difficult to imagine a £100,000-plus hovercraft being used for trips round the bay and the only intermediate-sized amphibious craft likely to become available is what was called the Manx Hovercat, the design of which is now in the hands of Hovermarine Ltd of Southampton.

When the designer of this 4–5-seater craft last spoke to me on the subject he said he thought this VW-powered craft could be constructed to sell at between £5,000 and £6,000, but I feel that this could be a substantial under-estimate. One cannot envisage permanently using such a craft for the purpose of giving joy-rides, but one can envisage seeing such craft and smaller craft being used for the purpose of giving primary hovercraft driving tuition and as charter vehicles. A charter for a shooting trip or by the police to search a marsh or by a harbour board to carry out a survey or by a company to advertise its products or something of this sort seems to me to offer serious economic possibilities. Something of a parallel to this occurred soon after the war in connection with under-water work.

Self-contained diving apparatus had been developed very substantially during the war and the technique of swimming under water for long periods was evolved from scratch. As a result divers using these new techniques with the latest equipment could work more quickly and cheaply than those using traditional equipment, and they literally cashed in as a result.

In a similar way it should be remembered that some jobs previously possible only by using an expensive helicopter can now be accomplished by a cheap hovercraft enabling the customer and the vendor to obtain satisfaction.

I am pursued by people like fairground proprietors from time to time who sometimes seem anxious to replace the "Tunnel of Love" with a "Hover to Hell" or something of the sort, but as I see it unless the customer can clearly see and feel that he is hovering for his money he is likely to prefer the joys of the "Tunnel of Love" — which might be a "good thing" after all, as the capital cost of these is probably low.

In the past it has not been considered a practical proposition to hire fast motor-boats or small fast self-drive cars to the general public at fairgrounds and the like, and it seems to me to be even less practical to let the general public off on their own in a fast, almost frictionless, lightly constructed craft.

To sum up my thoughts on the matter with which I have attempted to deal, as I see the position it is this.

Whilst there is a lot of pleasure to be obtained from hovering, the commercial prospect resulting from involvement with light hovercraft is not yet bright.

I feel that this position will change as interest increases in competitive events for hovercraft, and such interest is currently expanding very steadily. There also remains unresolved the question of power-boat men and their desire to keep up with the Jones's.

Between now and the time when manufacturing and selling light hovercraft becomes really attractive I believe there is some money to be made and experience to be gained from the hovering equipment like a boat-launcher.

I shall watch with the greatest interest the fortunes of those already concerned professionally with light hovercraft. I shall do this whilst doing my best to put them out of business by proving in competition events that my string, firewood and polythene machines have a performance superior to their craft. If I don't succeed it will be a case of "back to the drawing board" — I feel sure I can use it as a structural member somewhere in the next craft.

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Secretary: Major Peter Rubie, PO Box 6131, Station J, Ottawa 13, Ontario, Canada.

National Association for Air Cushion Vehicle Enthusiasts
Secretary: Mr Jan Eglen, 2912 Andros Costa Mesa, California 92627, USA.

Trinidad and Tobago Hover Club
Secretary: Nigel Seale, Seale Building, 1 Richardson Street, Point Fortin, Trinidad, West Indies.

Club Francais des Aeroglisseurs
Secretary: Monsieur Jean Beaudequin, 85 Rue de la Republique Suresnes (Seine), Paris.

(*Continued from page* 26)

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WATER POLICE (GERMAN). Patrol service on the Rhine.

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AEROGLIDE SYSTEMS INC, 120 Broadway, New York 10005, USA.

AEROJET GENERAL CORPORATION (subsidiary of the General Tyre & Rubber Co), 1100 West Hollyvale Street, Azusa, California 91702, USA.

AEROMAR CORPORATION, 567 Fairway Road, Ridgewood, New Jersey, USA.

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BRITISH HOVERCRAFT CORPORATION, Yeovil, Somerset, England.

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HITACHI SHIPBUILDING & ENGINEERING CO, 47 Edabori 1-chome, Nishi-ku, Osaka, Japan.

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KAWASAKI KOKUKI KOGYO KABUSIHKI KAISHA (Kawasaki Aircraft Co Ltd), 38 Akashi-Machi, Ikutaku, Kobe, Japan.

KRASNOYE SORMOVO, Gorki, USSR.

MITSUBISHI HEAVY INDUSTRIES LTD, Kobe Shipyard and Engine Works, Japan.

MITSUI SHIPBUILDING AND ENGINEERING CO, 6-4 Tsukiji 5 Chome, Chuo-Ku, Tokyo, Japan.

NATIONAL PHYSICAL LABORATORIES HOVERCRAFT UNIT, St John's Street, Hythe, Southampton.

RESEARCH AFFILIATES INC, 12401 River Road, Potomac, Maryland 20854, USA.

SOCIETE D'ETUDES ET DE DEVELOPPEMENT DES AEROGLISSEURS MARINS (SEDAM), 22 Avenue d'Eytau, Paris XVIe, France.

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VOSPER THORNYCROFT, Paulsgrove, Portsmouth, Hants.

VEHICLE RESEARCH CORPORATION, 161 East California Boulevard, Pasadena, California, USA.

DIRECTORY OF HOVERCRAFT OPERATORS

AERONAVE SpA, Naples, Italy. Naples–Capri. Naples–Ischia June 1967.

BIRD'SEYE HOVER SERVICES PTY LTD, Hindmarsh Square, Adelaide, South Australia. Plans to operate services between Wallaroo–Port Pirie and Cowell–Whyalla.

BRITISH RAIL HOVERCRAFT LTD (Seaspeed Ltd), Marine Court, The Parade, Cowes, Isle of Wight, England. Services commenced in July 1966. Cowes–Southampton. Cowes–Portsmouth. Will operate Dover–Boulogne.

COMPAGNIE MAROCAINE D'EXPANSION TOURISTIQUE ET INDUSTRIELLE, Tangier, Morocco. Plans to operate services between Tangier and Gibraltar.

GOVERNMENT OF BRUNEI. One craft is in service for general communications duties.

HOVERLLOYD LTD, Marlow House, Lloyds Avenue, London, EC3; also The Hoverport, Ramsgate, Kent. Parent companies: Rederi-AB Svenska-Lloyd and AB Svenska Amerika Linien. Formed in December 1965 as Cross-Channel Hover Services Ltd to operate services between Ramsgate–Calais as well as pleasure cruises from Ramsgate Harbour. Will operate cross-Channel service from Pegwell Bay to French coast.

HOVERTRAVEL LTD, Easton House, 12 Lind Street, Ryde, Isle of Wight; also Quay Road, Ryde, Isle of Wight. Formed in April 1965 to operate services between the Isle of Wight and the mainland. Commenced operations in July 1965. Operations suspended during winter months.

HOVERWORK LTD. Subsidiary of Hovertravel Ltd specialising in crew training and charters.

HOVERWORK CANADA LTD, PO Box 7129, Ottawa 7, Ontario, Canada. Subsidiary of Hoverwork Ltd. Formed in 1966 to operate services for Expo '67. Commenced services in April 1967.

KYUSHU SHOSEN KAISHA, Japan. Commenced services in September 1967 on the Kumamoto–Hondo and Kumamoto–Shimabara routes.

LINJÈBUS INTERNATIONAL, Halsingborg. Pilot service between Halsingborg and Copenhagen. Halsingborg–Elsinore. Commenced June 1967.

MINISTRY OF DEFENCE. The Interservice Hovercraft Trials Unit has evaluated hovercraft in various military roles.

ROYAL CORPS OF TRANSPORT, 200 SQUADRON. World's first military hovercraft unit. Began operations in 1967, high-speed amphibious logistic support.

ROYAL NAVY. Took delivery of a civilian type hovercraft in 1967. Operational unit formed later in the same year. Fast amphibious communications.

ROYAL DUTCH/SHELL GROUP OF COMPANIES, Shell Centre, London, SE1. Currently using a hovercraft in Brunei in support of off-shore oil rigs.

RED FUNNEL STEAMERS LTD, 12 Bugle Street, Southampton. Intend to operate across the Solent between Southampton--West Cowes.

SCANDINAVIAN HOVERCRAFT PROMOTIONS LTD, Oslo, Norway. Formed in March 1964 to introduce hovercraft to Norway. Suspended operations in 1966.

SKIMMERS INC, Anchorage, Alaska. Formed in March 1966 to promote commercial charter services.

THAILAND CUSTOMS DEPARTMENT. Has operated a Japanese hovercraft since August 1967.

TOWNSEND CAR FERRIES, Nuffield House, 41 Piccadilly, London, W1. Associated with P. & A. Campbell Ltd. Commenced services between Dover–Calais in April 1966. Service cancelled for 1967. Now operates pleasure trips between Kent and Sussex seaside resorts.

UNITED STATES NAVY. Evaluating hovercraft. Three were put into combat service against guerrillas in South Vietnam in 1966.

WESTLAND CHARTERS LTD, Yeovil, Somerset. Lease BHC hovercraft to operators.

WORLD WIDE HELICOPTERS LTD, Alma House, Alma Road, Reigate, Surrey. Operates hovercraft on behalf of the Brunei Government.

THE CENTRAL LONDON PRODUCTIVITY ASSOCIATION

exists to further in Central London the aims of the British Productivity Council which has a national responsibility.

These aims are, briefly, to improve efficiency in business and industry so that the economic position of our country may be bettered, thus providing an enhanced standard of living for all. It believes that the welfare of all in Great Britain, and indeed the whole world, depends on producing more of the goods and services required by the people with less and less effort. It believes that this higher productivity is largely the responsibility of all levels of management and trade union leaders, and directs its efforts to improving management techniques and their application with the sympathy and co-operation of the trade unions.

Members are drawn from management on all levels and members and officers of various trade unions who seek to further these aims by sponsoring or arranging lectures, conferences, demonstrations, visits, etc, showing how productivity can be improved in various industries and trades.

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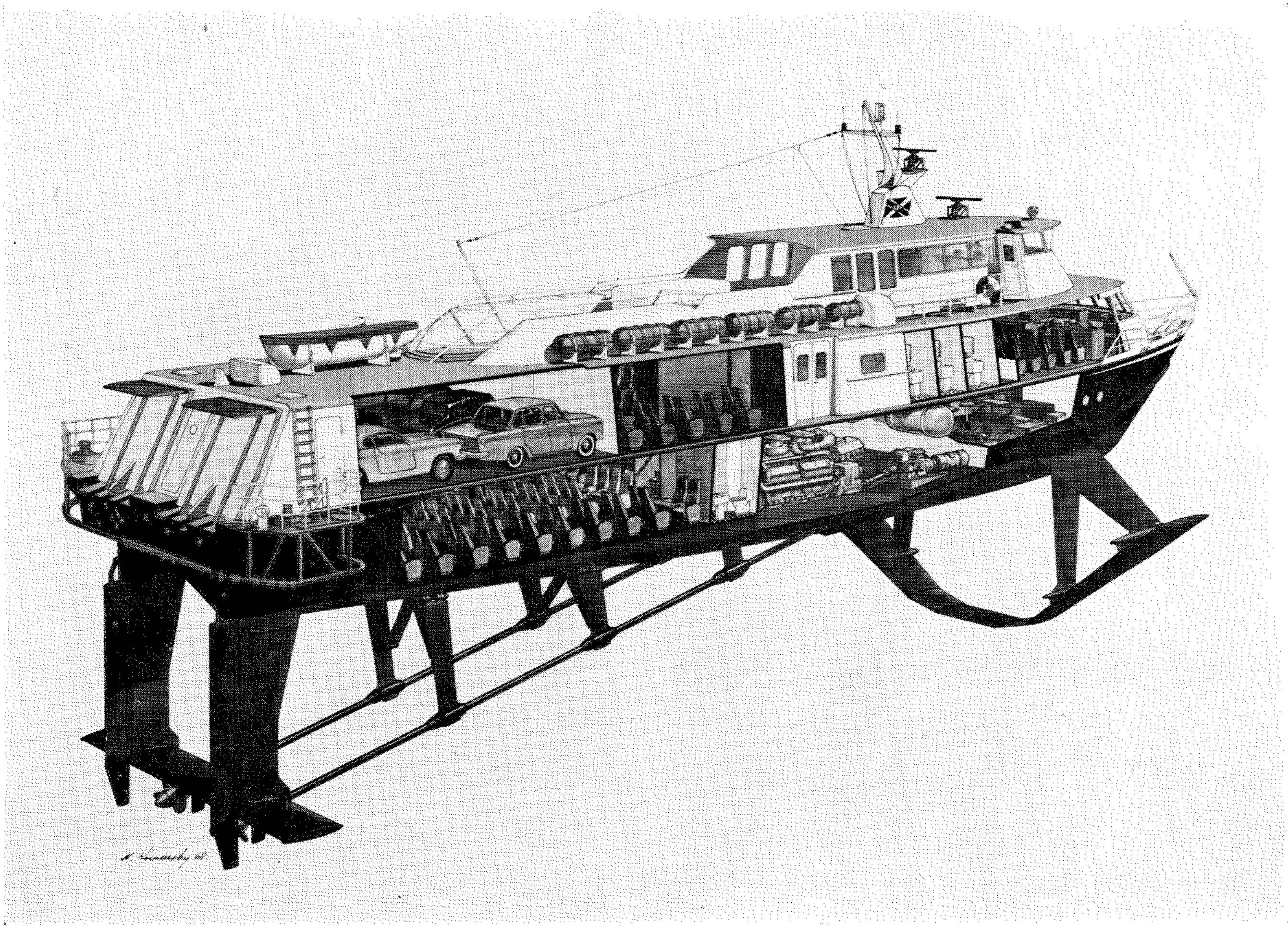

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