under a light wooden platform by means of manually operated surfaces which flapped about a horizontal axis.

In the 19th Century, Thornycroft, the English Engineer proposed the lubrication of ship hulls by an air film.

In the 20th Century, James Porter took out several patents for different forms of vehicle suspension and propulsion almost to the point of inventing the annular jet.

Kaario of Finland invented craft that gained both propulsion and support from a single air source acting in ground effect.

De Lima of Peru, as late as 1955 filed provisional applications for the basic idea leading to a peripheral jet system, but did not complete the Patent.

About 1950, Sir Christopher Cockerell had begun to think about ways of reducing the resistance of ships and in 1955 he obtained the first basic patent covering the principles of the simple air curtain.

M. Bertin, in France also discovered the significance of ground effect during tests on jet engines in the middle fifties and extended his ideas of ACV design to land and marine vehicles.

Many other names might be mentioned in connection with the early history of ACV and further information can be found on this subject in Reference 2.

3. Basic Concepts

The fundamental ideas behind the use of the air cushion principle were aimed at improving craft speed and capability by:-

(a) Reducing surface contact drag.

(b) Improving vehicle suspension at high speed over rough surfaces.

(c) Reducing surface bearing pressure.

(d) Achieving an amphibious capability.

The reduction in contact drag is obviously desirable in improving performance and efficiency of surface dependent vehicles, but account must be taken of the equivalent drag or power penalty due to supplying pressurised air to the cushion. A conflict arises here with the requirements of improved suspension for high speed craft operating over rough surfaces. In this case the provision of a thin film of lubricating air has to be replaced by a thicker cushion capable of absorbing surface irregularities. This implies a considerable increase in cushion power to provide the necessary air.

The various ways in which this problem was tackled will be discussed later.

Two important advantages of the air cushion followed naturally from the original interests. First it was possible to support the vehicle over most of the planform area using a low surface bearing pressure. This allowed craft to be operated over a variety of 'tender' surfaces. Secondly, if containment of the cushion could be achieved by the air itself or by a non-solid boundary, it would be possible to operate craft over both land and water, and perhaps more importantly to keep the craft out of solid contact with the water in marine applications.

The amphibious capability is perhaps the most important and certainly the unique characteristic of the ACV as a high speed craft. There are, however, areas in the transport spectrum, especially in sheltered water conditions and with the larger sizes of craft, where the non-amphibious craft can be a favoured configuration.

4. Evolution of the ACV Principle

(a) The Peripheral Air Jet.

The present interest in ACV dates primarily from the early work and patents of Sir Christopher Cockerell. He found that a peripheral air jet angled towards the cushion space would generate and contain a pressurised cushion. The power required was much less than a pure plenum cushion of the same clearance height. For practical clearance heights it was found that the cushion was unstable in pitch or roll without stability jets within the cushion. These jets effectively divided the cushion into compartments which produced stabilising differential pressures as the craft rotated relative to the surface.

Whilst the pure peripheral jet gave low contact drag and good suspension characteristics, the cushion power requirement was embarrassing especially at high forward speed when the momentum drag of the ingested air became a very significant part of the overall drag.

Various schemes were tried to reduce power requirements including recirculation of the jet air but the gain of power was generally small and was offset, to some extent, by the inconvenience and weight penalty of the necessary ducting within the hard structure.

Flexible extensions were added to the jet openings to gain clearance height with a much reduced height of jet and consequently volume flow, but these devices did not survive