SECTION 8

POSSIBLE WANKEL ENGINE INSTALLATIONS IN HM2 AND CC-7 HOVERCRAFT

8 INTRODUCTION

One requirement for this report was to examine the installation of Wankel engines in existing craft, and the Hovermarine HM2 and the Cushioncraft CC-7 were selected for this exercise.

Both craft have power units within the range of current, although not immediately available, Wankel engines. They represent examples of the two main types of hovercraft:

(a) The water-borne sidewall craft, HM2.

(b) The peripherally skirted amphibious craft, CC-7.

Data sheets for these craft are given in Appendix VIII.

8.1 THE HOVERMARINE TRANSPORT LTD. HM2

8.1.1

This is a 60-seat passenger carrying craft for sheltered water operation. Its present power plants, Figures 8.1 and 8.2, are high speed diesel engines which, though heavy, are reasonable in first cost and running cost.

Various alternative arrangements for replacing the existing diesels by Wankel engines were considered; a practical example is that shown in Print No.4, using two Daimler-Benz M 950/4 engines for propulsion and two NSU KKM 612 units for lift. The propulsion engines are small enough to be installed within the sidewall, in place of the existing V-drive gearboxes, with direct drive to the propellers. The resulting saving in propulsion plant weight and space would permit seven extra seats to be installed and would make additional baggage space available. The two NSU KKM 612 lift engines could be installed on the existing engine bearers and the present fan drive would be retained. One fan volute would have to be reversed to allow for the opposite direction of rotation of one engine. With this arrangement 227 hp would be available for lift in place of the present 180 hp.

The Wankel engines proposed normally run on petrol and would need to be converted to use kerosene (see 6.1) to comply with Board of Trade requirements for passenger carrying craft. Consideration might be given, however, to carrying out initial trials with standard engines on an experimental craft, for example on the HM2 of the Department of Trade and Industry.

The proposed Wankel engine arrangements would result in a substantial reduction in first cost. There would be some increase in fuel costs, but this would be more than compensated by a potentially greater work capacity with more seats, reduced weight* and improved

* In fact, a saving of 9% on the normal gross weight of the craft.

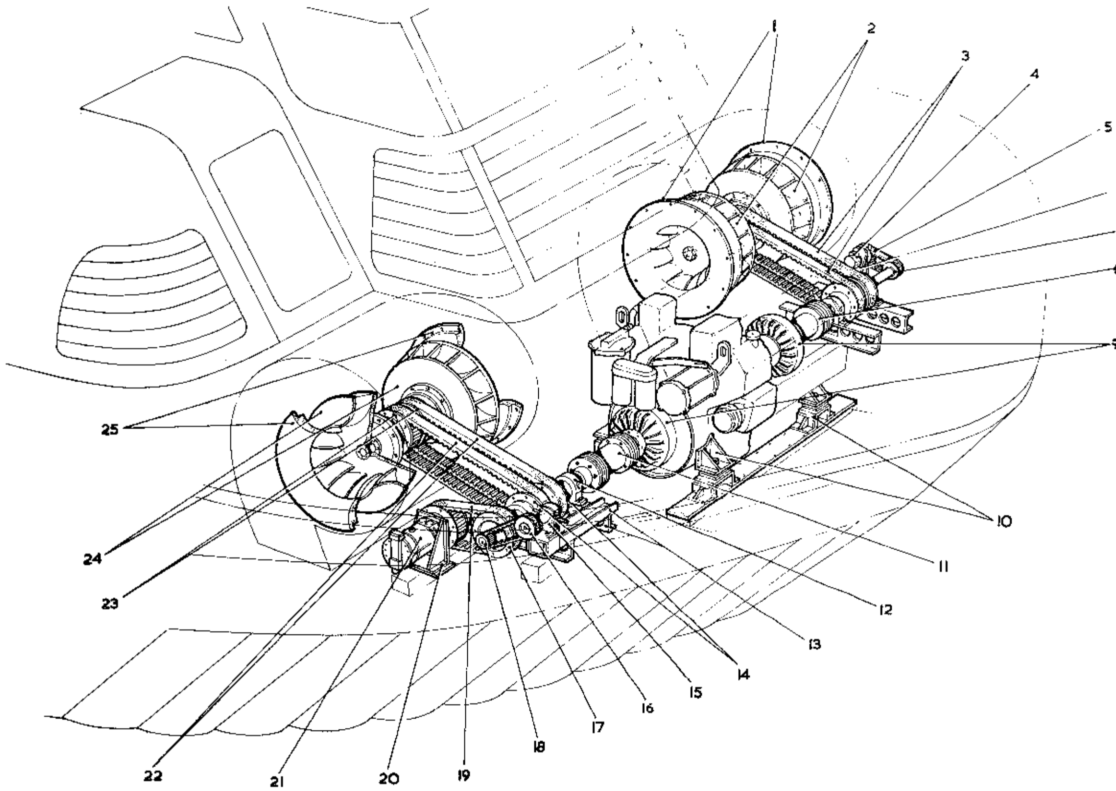

Fig.8.1 HM2 existing lift fan assembly

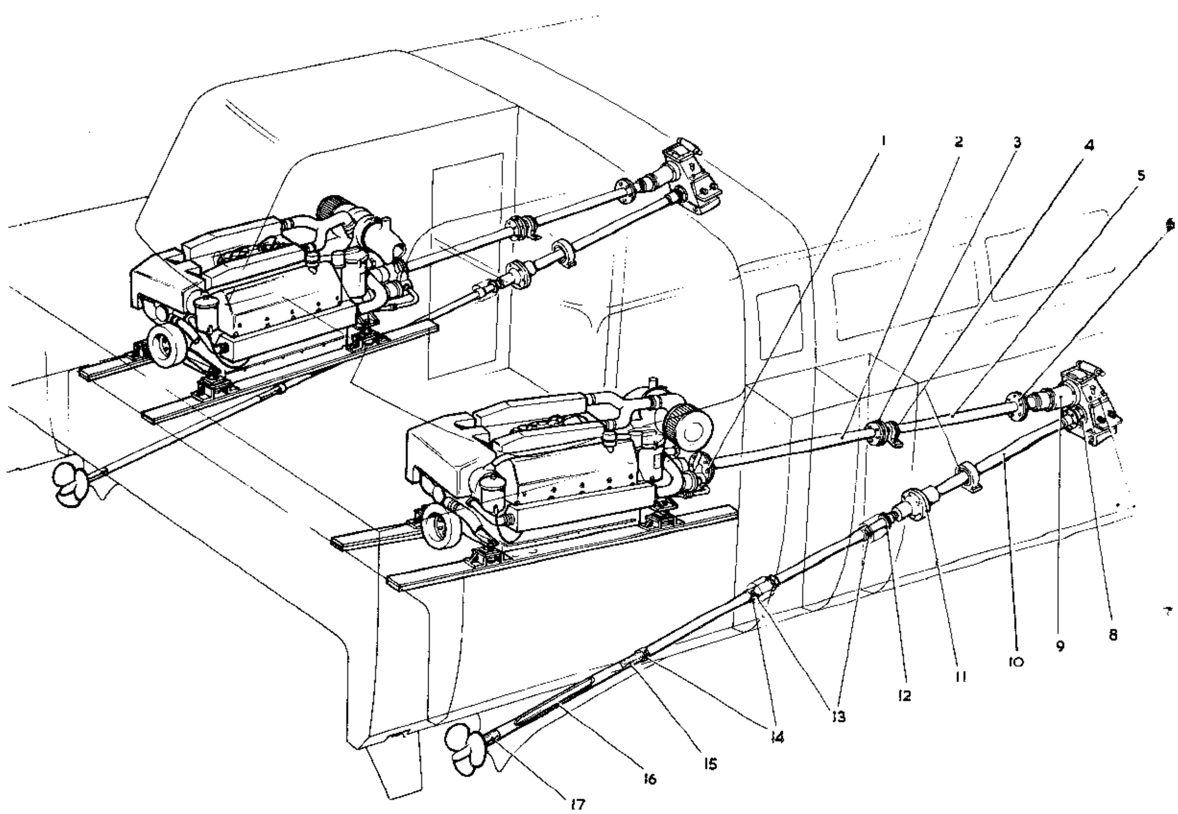

Fig.8.2 Existing propulsion assembly (Diagrams from HM2

performance. A detailed cost breakdown is given in Appendix VIII. Reduction of noise and vibration would give a more pleasant passenger ride. If current automotive experience can be carried over to operations in hovercraft, engine reliability should be improved. This, together with the elimination of the present V-drive, should result in a reduction in craft non-availability due to power plant troubles. Some of these factors may apply less in comparison with the new Mark III version of the HM2, which is to have a new V-drive and better soundproofing.

8.1.2 The Propulsion Installation

The two existing propulsion engines are each rated at 320 hp. To obtain this power with NSU KKM 612 engines it would be necessary to gang three together per propeller. The complexity and weight which would be involved obviates this as a practical solution, and the one which presents itself as the obvious answer is to use a Daimler-Benz M 950 at 350 hp, with a gearbox reducing engine to propeller speed, in place of each Cummins engine.

The new engines could quite easily replace the Cummins VT8-370M engines and use the existing rails, shafting and V-drive gearboxes. These gearboxes, however, are quite heavy units, (old type 250 lb), and since they are mounted on strong points capable of absorbing the full torque and weight, it is logical to consider mounting the engines themselves at these points. This is the arrangement which is now suggested, and shown in Print No.4.

This immediately allows the two existing engine compartments to be converted for payload purposes, for example seven seats can be accommodated in the port compartment, and the starboard compartment – which houses the aft lift fan/hydraulic motor assembly and is consequently rather noisy – can be available for baggage. According to Hovermarine, the present lack of baggage space is an embarrassment. The primary drive shafting is not required and in fact the total weight saving approximates to the weight of a bare M 950 engine, giving an overall basic weight reduction roughly equal to the weight of the propulsion diesels. Estimated weights are summarised in Table 8.1. Two seats a side will be lost opposite the engines but, with the present installation, these are also left out to clear the primary drive shaft in the aft quarters.

It is proposed that the engines be fitted with Borg Warner clutched hydraulic reversing gearboxes (type 72c is probably suitable), at 98 lb each*. Reduction ratios available at the moment include 2:1 and 3:1, giving propeller speeds of 3,500 rev./min. or 2,333 rev./min. compared with the present 2,800 rev./min. Therefore, new propellers might be required if a correct ratio gearbox were not available. Alternatively, it would be a relatively simple matter to fit waterjet propulsion. A raw water cooled heat exchanger is proposed, installed in the sidewall, and if the engine water pump is not capable of maintaining sufficient flow it may be necessary to provide a larger pump driven from the front end of the rotor shaft or from an auxiliary drive, for example that normally used for the power steering pump. Experimentally,

*Similar units are supplied to NSU for their Ro135 conversion to the KKM 612 engine.

the petrol version of the engine may be acceptable, but as mentioned elsewhere in the report a kerosene burning version ought to be sought. The panelling to the passenger cabin would b heavily soundproofed and firewall lined, e.g. stainless foil. It is suggested that the existing fu tanks be used for a first craft rather than increase their capacity to cater for the higher speci fuel consumption of the Wankel engine. Marinised electrics would be fitted. These have not been itemised at this stage. Generally, the engines could be protected as suggested in Table

8.1.3 The Lift Power Plant

The present lift assembly requires 180 hp, but Hovermarine say that additional powe would be an advantage, particularly for the aft skirt to improve the craft trim, and also for forward skirt.

The choice of a Wankel engine replacement for the existing Cummins V6-215M lies between a single Daimler-Benz M 950 engine and two NSU KKM 612 units. There are no Wankel engines available with an adequate power take off at both ends, as in the existing di engine, so if a single engine were used, either it would require extensive modification or a ne countershaft and engine bearers would be needed if the engine were to be installed transvers Alternatively, a single engine could be installed fore and aft, mounted on new bearers and driving a new angle drive gearbox.

On the other hand, two NSU KKM 612 engines providing a total of 227 hp could be mounted back to back on the existing engine bearers, driving through the existing countersh At one end this would involve a reversal of the direction of rotation compared with the exis arrangement, but this could be accommodated by providing new pulleys and belts and turni one fan volute assembly through 180°, while retaining the volute outlet into the craft botto skin. A cutting and rejoining modification should be quite easily effected on new craft as th material is glass reinforced plastic but might be more difficult on existing craft as the volute forms part of the hull structure. The plummer blocks for this fan shaft would have to be m aft some nine inches on sub plates. Alternatively, a gearbox to reverse the direction of rota could be fitted to one of the engines, doing away with the need to modify the fan volute; delivery of such a gearbox could be lengthy.

Hydraulic pumps to drive the aft lift fan would be driven from the front end of each engine, in place of the existing single pump driven from a countershaft. 10 to 20 additional hp would be available for this drive.

Each engine would require a new bell housing – which could be fabricated for an experimental installation – carrying a stub shaft linking the fan countershaft and the engine clutch. This would incorporate a rear mounting pad sitting on a cross beam on the existing main bearers. The standard automotive cross beam would be used at the forward end of the engine. To simplify the installation, certainly for the first unit, the motor car radiator with protected, only rudimentary waterproofing would probably be required, e.g. plating controls, enamelling carburettors and engine castings, fitting of marine alternators and starters, shrouding electrical joints. The existing automotive air cleaners could be retained. It is considered that this treatment would suffice on an experimental installation as the engines would presumably be under close and frequent surveillance.

The proposed arrangement, using two independent engines and lift fan drives, implies the ability to get home on reduced lift power in the event of failure of one engine.

TABLE 8.1

Estimated Weight Saving on HM2 resulting from the use of Wankel Engines

	CHANGES IN WEIGHTS						
	Propulsion (each unit)			Lift			
	Existing	Proposed	Difference	Existing	Proposed	Difference	
Engine, including primary gearbox*	2,775 lb	550 lb	- 2,225 lb	1,995 lb	700 lb per 2 engines	- 1,295 lb	
Transmission†	330 lb	N/A	- 330 lb	Same except for longer belts		+ 30 lb	
Hydrostatic drive	—	—	—	Extra pump, larger motor		+ 60 lb	
Total per propulsion unit			- 2,550 lb				
Total per craft			- 5,100 lb			- 1,205 lb	- 6,305 lb
Passengers carried: increase by 7 @ 180 lb						+ 1,260 lb	
Baggage carried: similar weight to balance craft						+ 1,260 lb	+ 2,520 lb
Net reduction (9% of normal gross weight)							3,785 lb

* Cooling and engine mountings considered to be comparable. † Assuming HM2 Mk.II gearbox.

8.2 THE CUSHIONCRAFT LTD. CC-7

In its standard configuration this is an eight/ten seater powered by a Pratt & Witney (UAC) ST-6B marine gas turbine rated at 390 hp. This is considered by Cushioncraft to be adequate but an increase in power would be desirable.

The choice for an experimental Wankel engine installation rests between the Daimler-Benz and the NSU units. (A large Curtiss-Wright engine would be suitable but is unlikely to be available.) Four NSU KKM 612 engines would be required which would involve a weight penalty of some 1200 lb over the present gas turbine installation.

A single Daimler-Benz four rotor M 950 engine arrangement would mean a weight increase of only about 50 to 100 lb over the ST-6 but with a power penalty of 40 hp. Thi might be acceptable for an experimental proving exercise and conceivably would meet the needs of some customers.

The logical choice, however, is a twin engine plant using the Daimler-Benz engine as described in 7.4 and shown in Print No.5. If we consider the installation of such a plant in existing CC-7 structure, probably the unit which would require most attention is the fan vo This has been evolved over a number of years and in its present form is able to absorb 550 (continuous). So also is the Salisbury gearbox, for a limited running time. Initially the po plant could therefore be limited to this output, providing experience in the installation and operation of a twin Wankel engine unit. Later the fan and gearbox could be developed or replaced by units capable of taking the 700 hp available from the power plant. Considerat could also be given to increasing the length of the craft and the cabin size, taking advantag the extra power available to increase the payload.

No important modifications to the engine are intended, only the induction system the main rotor block requiring particular attention (and possibly some test work) due to th relatively limited spaces. The standard craft mounting points could be used with suitable m brackets. The two panels flanking the engine would require trimming and a new recessed part fitted. By lowering the engine at an angle through a detachable roof panel, no cutting structural stringers should be necessary. Automotive radiators would be positioned in the wing compartments and cooled by air taken from the fan volute, with automotive electric as a standby for running the engines without the craft fans clutched in, e.g. whilst tuning. trial would be necessary to ensure that the automotive pump was sufficient to pump water the radiator, although this unit is believed by Daimler-Benz to be adequate for a remote ra

The exhaust for each engine, which would be independent initially, is a simple coll pipe system, with bellows between the joints, leading directly into a Servais stainless steel straight-through silencer, which could be a tandem unit if a high degree of silencing is requ

The speed of rotation does offer some problems in obtaining transmission shafts wh are an economical possibility. Hardy-Spicer consider their gear type coupling (GKN-Zurn) shafts should be suitable at small angles of alignment (up to 1½°). The gearbox dividing th drive into the two fans offers some difficulties at the full power which could be developed (700 hp) and whilst Salisbury express willingness to co-operate in an actual exercise, they that it would take time. Meanwhile, the present box could cope with limited running tim 550 hp max.

Marine type electrical equipment should be fitted. Specific alternatives have not been investigated since this depends on operational requirements. Assuming the engine is supplied as a complete unit, it is suggested that it be enamelled. Controls should be replaced by stainless or plated parts.

At the full output of 700 hp, the power plant proposed is 740 lb heavier than the existing gas turbine, but this would be more than offset by a 30% increase in available power and a 26% saving in specific fuel consumption. The saving in capital cost of the complete craft would be upwards of £15,000.