SECTION 7

POWER GROUPS OF COUPLED ENGINES

7.1 INTRODUCTION

The Wankel engines likely to be available in the reasonably near future are, except for the very small machines, automotive units up to 350 bhp. In order to extend the power range upwards to suit the larger hovercraft, the possibility of coupling two or more engines together has been investigated. Several configurations are possible, coupling two engines to a common output shaft, gearing more than two engines together, and a pancake arrangement consisting of several engines grouped round a common output shaft. Pancake arrangements, however, have been discarded because investigation showed that they would be unacceptably bulky. The choice among the other arrangements may well depend on the shape of the available space.

Provided fairly simple precautions are taken, coupling or gearing several engines to a common output shaft is feasible and practical. In order of their importance, these precautions are:

(a) Care must be taken that cyclic torque fluctuations are reduced, e.g. by providing adequate flywheel masses.

(b) Every input into the common gearbox should incorporate torsional flexibility to protect the gearing from undesirable shock loads. Suitable flexible couplings for this purpose, resembling the spring centres of clutches, are available.

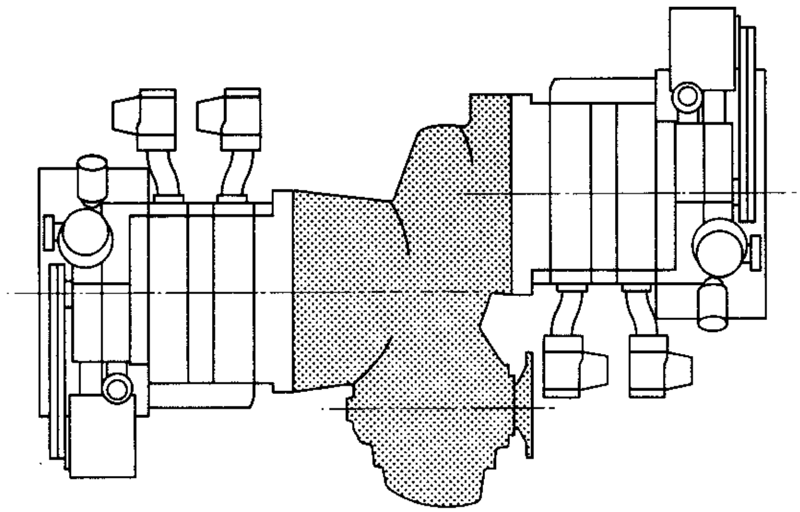
(c) Care must be taken when adjusting the fuel and ignition system so that each engine contributes to the power output as nearly equally as possible.

Experience has shown that the problem of gearing together two or more engines is minimised if the cyclic torque fluctuations of the individual engines are low. Ignoring the smoothing effects of the flywheel, twin and multi-rotor Wankel engines are good in this respect. For example, the cyclic torque fluctuations of a four cylinder four stroke piston engine amount as a rule to 100% – from nil to maximum torque. In contrast, the fluctuations of a twin rotor Wankel engine amount to around 88% and with a three rotor unit to only about 29% of maximum torque.

7.2 TWO ENGINES COUPLED BY GEAR AND CHAIN DRIVES

Figures 7.1 and print No.1* show two NSU KKM 612 twin rotor Wankel engines driving through a gearbox sandwiched between them. As the two engine ends face each other, they rotate in opposite directions, which ought to have beneficial effects on dynamic balance and vibration levels. The drive from one engine meshes directly with the output shaft gear. The other engine drives via a chain, to avoid the necessity of including an idler gear to reverse the direction of rotation.

* Prints will be found enclosed separately at the end of this report.



Length = 51"
Width = 36"
Height = 21"
Weight = 675 lb

Fig.7.1 Two NSU KKM 612 engines coupled by gear and chain drives

It may appear unorthodox to combine chain and gear drives in one transmission, but chain drives have made advances in recent years. For example, Messrs Renold Chain Ltd. estimate a chain life of 10,000 hours for this particular application provided adequate lubrica-tion is ensured. An example of outstandingly successful modern chain drives is to be found the Jensen Formula Ferguson four-wheel drive car.

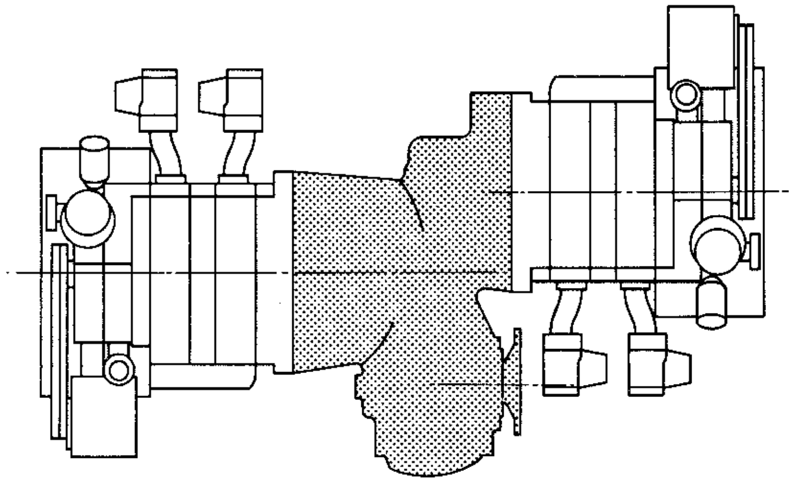
Incorporation of a single plate automotive clutch in the drive from one engine and of two sliding muff couplings on the output shaft facilitates isolation of each engine, besides halving the number of starter motors, which are relatively heavy.

It should be emphasised that the smoothest running arrangement of twin or multi-eng units is obtained when the engines are positively coupled together, thus ensuring regular firin intervals. Unfortunately, this arrangement requires a far more powerful and heavier starter motor and accompanying internal modifications, (e.g. stronger gearing, etc.).

7.3 TWO OR MORE ENGINES GEARED TOGETHER

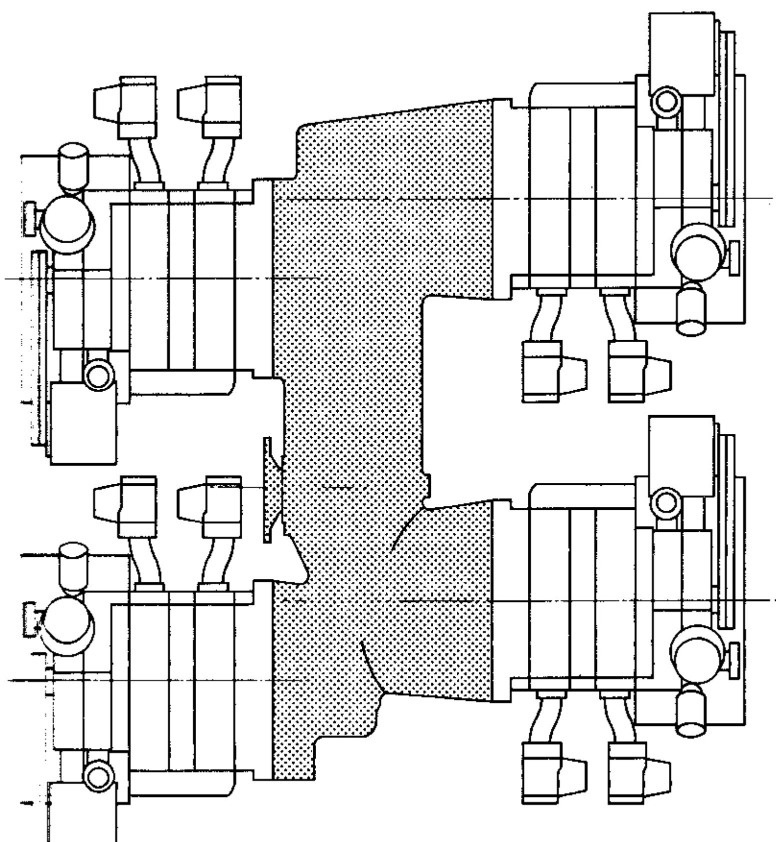
Figures 7.2 and 7.3 and print No.2 show a more orthodox approach to transmission design than 7.1, relying exclusively upon gearing for coupling two or four engines together. The gearbox elevation is the same in both cases.

Considering this arrangement as a gearbox for coupling two engines, it may be costlie and noisier than the gear and chain drive described in 7.2. The same basic design, however, offers the advantage of allowing four engines to be geared to the same output shaft, for exa to provide 450 bhp from four NSU KKM 612 units if an overall width of 67 inches is accep It is possible to reduce this width by dispensing with the alternators on every engine, (thus saving 3 inches per engine), and rearranging one or two other accessories. This implies certai engine modifications which NSU is not prepared to undertake.



Length = 51″
Width = 33″
Height = 21″
Weight = 685 lb

Fig.7.2 Two NSU KKM engines geared together



Length = 51″
Width = 67″
Height = 21″
Weight = 1300 lb

Fig.7.3 Four NSU KKM 612 engines geared together

A further 4 inches saving on width may be achieved by replacing the carburetto fuel injection systems or downdraught carburettors and bends. As the Plessey ultrasoni atomisation system may not be available in the near future, it seems advisable to investi alternatives; for instance, the systems of Lucas-CAV-Simms, Associated Engineering Ltd Group Research and Development Establishment at Cawston, Rugby).

Whilst a two to one reduction is shown in all the schemes, other ratios apart fr to one are equally feasible, though it is important to realise that the centre distances c reduced a great deal.

7.4 ALTERNATIVE ARRANGEMENT OF TWO ENGINES GEARED TOGETH

Figure 7.4 and print No.3 show two Daimler-Benz four rotor M 950/4 engines side by side and geared to a common output shaft. This is the arrangement suggested CC-7 in 8.2. The overall size could be reduced by repositioning the various ancillaries

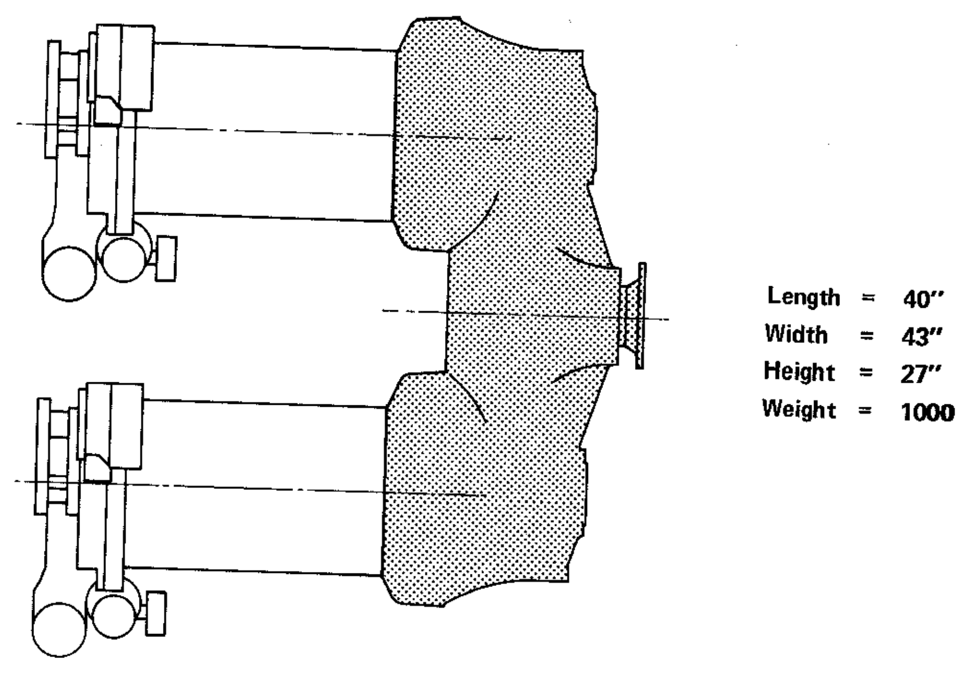


Fig.7.4 Two Daimler-Benz M 950/4 engines coupled side by side

If this side by side disposition were adopted for the NSU KKM 612 units th width would be about 63 inches depending on the location of the ancillary equipme could be reduced to about 55 inches by using a different carburettor and induction

To put this question of overall size into perspective, Table 7.1 compares the weight of the two coupled Daimler-Benz Wankel engines with the Continental GTSK light aircraft engine produced by Rolls-Royce.

TABLE 7.1

Engine	R-R Continental	D.B. 2 x M950/4
bhp/rev./min.	375/3,400	700/3,540
Fuel Oct. Requirement	100/130	80-95
Dry Weight	580 lb	1,000 (estimated)
Specific Weight	1.55 lb/bhp	1.43 lb/bhp
Width	34 in.	43 in.
Height	26.8 in.	27 in.
Length	43.1 in.	39.5 in.
Specific Volume	105 cu.in./bhp	55 cu.in./bhp
Swept Volume	8,521 cc	4,800 cc per engine shaft rev.

Note: The swept volume of a D.B. M950/4 as defined by displacement per revolution of the eccentric shaft is 2,400 cc. For comparison with piston engines this may be taken as the equivalent of 9,600 cc per twin engine unit.

In considering this comparison, it should be borne in mind that the Wankel engine concerned is an automobile unit, and that if it were ever developed into an aircraft engine the comparison would be much more in its favour. Such development would include the replacement of various cast iron components, such as the rotor, by light alloy, and the reduction of frontal area by repositioning the ancillaries. The comparison does not take account of the need for a cooling system for the Wankel engines.

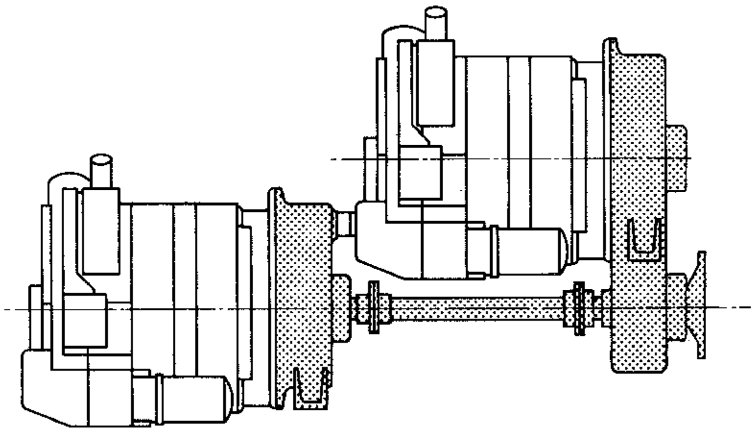
7.5 TWO ENGINES COUPLED IN LINE

It is impracticable to couple two NSU KKM 612 engines in line because the existing Woodruff key at the front end of the rear engine, (normally designed strong enough only to drive the auxiliaries), cannot take the torque of the front engine. Furthermore, the detail design of the output end of the second engine, which would have to carry the power of both engines, must also be suspect. The same considerations would preclude coupling two Daimler-Benz M 950 engines in line.

The alternative of increasing engine power by adding rotors appears to be available in the Daimler-Benz design on account of the inclusion of split gears and bearings. The power output of a six rotor Wankel engine assembled on a new shaft from components of type M 950 engines would amount to at least 525 bhp at 7,000 rev./min. Since the NSU KKM 612 does not incorporate split gears and bearings, similar development is not practicable.

7.6 TWO ENGINES COUPLED INDIRECTLY IN LINE

The problem of in line coupling can be overcome by the use of an auxiliary shaft running under the second engine, as illustrated in Figure 7.5. An advantage of this arrang is that the carburettors and exhaust connections are all on one side, which simplifies the co and the necessary connections to the air cleaners, exhaust system, cooling system, etc. On negative side is the increase in weight and cost of the gearing arrangements. Finally, as bo engines rotate in the same direction, the vibration levels would be expected to be higher th for the arrangement described in 7.2.

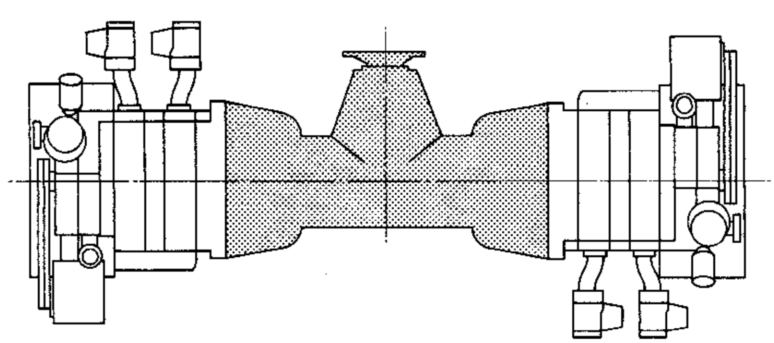


Length = 54"
Width = 27"
Height = 32"
Weight = 728 lb

Fig.7.5 Two NSU KKM 612 engines coupled indirectly in line

7.7 TWO ENGINES COUPLED TO A BEVEL RIGHT ANGLE DRIVE

An alternative layout which might be useful when the space available for the engi very restricted fore and aft is shown in Figure 7.6. In this case two engines are coupled each side of a gearbox containing bevel drives to the output shaft. In this way, the lengt the unit, using NSU KKM 612 engines, is reduced to 31.5 inches for a width of 64 inches. If single plate clutches were included between each engine and the gearbox, the width wo be increased to 67 inches.



Length = 32"
Width = 67" app
Height = 21"
Weight = 700 lb

Fig.7.6 Two NSU KKM 612 engines coupled to bevel right angle drive