UNIVERSIDAD TECNOLÓGICA NACIONAL
FACULTAD REGIONAL HAEDO

CONOCIMIENTOS AERONÁUTICOS Y ESPACIALES II

TRABAJO DE INVESTIGACION N°1

Armstrong Siddeley Double Mamba

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Fecha de entrega: 24/06/2024

Índice

Objetivos 3
Consignas 3
Entregables a evaluar 3
Recursos y bibliografía 3
Anexo A 4

Objetivos

Se espera que los alumnos investiguen sobre un sistema real siendo capaces de comprender su funcionamiento y de relacionar los temas teóricos vistos a lo largo de la materia con el caso práctico, justificando sus respuestas y agregando sus conclusiones.

Consignas

Deberán leer el artículo que se encuentra adjunto a este documento (Anexo A) del grupo moto propulsor Armstrong Siddeley Double Mamba que equipa la aeronave Fairey Gannet, debiendo confeccionar un informe de lo entendido relacionándolo con los temas vistos en la materia. En el informe deberán darse respuestas a las siguientes preguntas:

- Clasificar el tipo de motor empleado en esta configuración y explicar brevemente su funcionamiento
- ¿Cómo se transmite el movimiento desde el grupo motor al grupo propulsor?
- ¿Qué beneficios se obtienen de esta configuración de motor?
- ¿Qué beneficios se obtienen con esta configuración de hélices?
- ¿Qué desventajas presentaba esta configuración de planta motriz?

Incluir las conclusiones a las que llegaron luego de la realización de este trabajo.

Entregables a evaluar

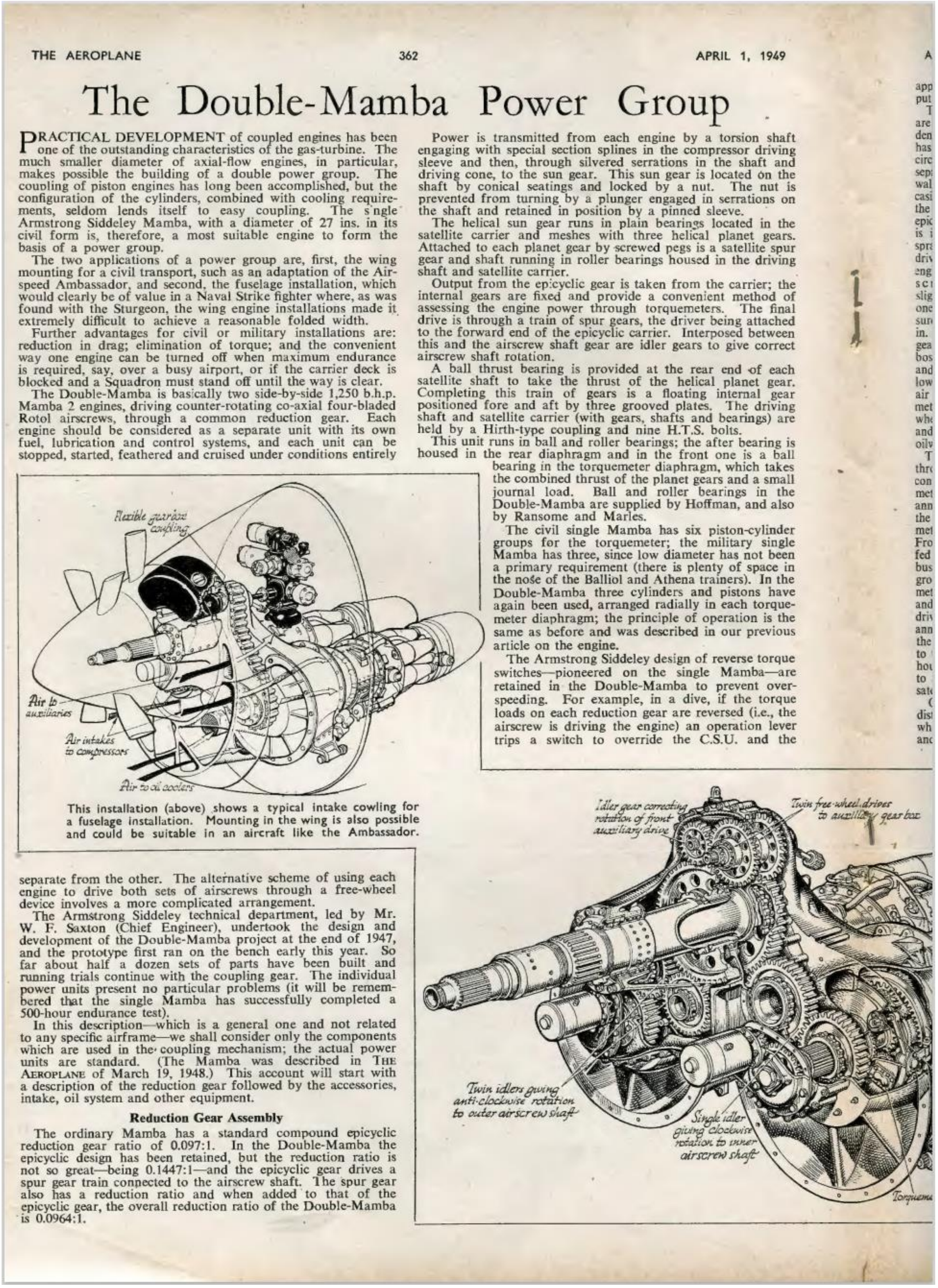
1. Trabajo con carátula, índice, nombres de los integrantes del grupo, legajos y sus correos
2. La comprensión de los temas y como relaciona los contenidos de la materia con el tema del presente trabajo.
3. Los análisis, conclusiones y observaciones asociadas al presente trabajo.

Nota: Adjuntar el link de cualquier otra documentación utilizada además de la que se brindó en este documento. Verificar la fiabilidad y veracidad de los datos obtenidos.

Recursos y bibliografía

- Apuntes de la cátedra
- Articulo brindado en este informe (Anexo A)

Anexo A



The Double-Mamba Power Group

PRACTICAL DEVELOPMENT of coupled engines has been one of the outstanding characteristics of the gas-turbine. The much smaller diameter of axial-flow engines, in particular, makes possible the building of a double power group. The coupling of piston engines has long been accomplished, but the configuration of the cylinders, combined with cooling requirements, seldom lends itself to easy coupling. The single Armstrong Siddeley Mamba, with a diameter of 27 ins. in its civil form is, therefore, a most suitable engine to form the basis of a power group.

The two applications of a power group are, first, the wing mounting for a civil transport, such as an adaptation of the Airspeed Ambassador, and second, the fuselage installation, which would clearly be of value in a Naval Strike fighter where, as was found with the Sturgeon, the wing engine installations made it extremely difficult to achieve a reasonable folded width.

Further advantages for civil or military installations are: reduction in drag; elimination of torque; and the convenient way one engine can be turned off when maximum endurance is required, say, over a busy airport, or if the carrier deck is blocked and a Squadron must stand off until the way is clear.

The Double-Mamba is basically two side-by-side 1,250 b.h.p. Mamba 2 engines, driving counter-rotating co-axial four-bladed Rotol airscrews, through a common reduction gear. Each engine should be considered as a separate unit with its own fuel, lubrication and control systems, and each unit can be stopped, started, feathered and cruised under conditions entirely separate from the other. The alternative scheme of using each engine to drive both sets of airscrews through a free-wheel device involves a more complicated arrangement.

This installation (above) shows a typical intake cowling for a fuselage installation. Mounting in the wing is also possible and could be suitable in an aircraft like the Ambassador.

The Armstrong Siddeley technical department, led by Mr. W. F. Saxton (Chief Engineer), undertook the design and development of the Double-Mamba project at the end of 1947, and the prototype first ran on the bench early this year. So far about half a dozen sets of parts have been built and running trials continue with the coupling gear. The individual power units present no particular problems (it will be remembered that the single Mamba has successfully completed a 500-hour endurance test).

In this description—which is a general one and not related to any specific airframe—we shall consider only the components which are used in the coupling mechanism; the actual power units are standard. (The Mamba was described in THE AEROPLANE of March 19, 1948.) This account will start with a description of the reduction gear followed by the accessories, intake, oil system and other equipment.

Reduction Gear Assembly

The ordinary Mamba has a standard compound epicyclic reduction gear ratio of 0.097:1. In the Double-Mamba the epicyclic design has been retained, but the reduction ratio is not so great—being 0.1447:1—and the epicyclic gear drives a spur gear train connected to the airscrew shaft. The spur gear also has a reduction ratio and when added to that of the epicyclic gear, the overall reduction ratio of the Double-Mamba is 0.0964:1.

Power is transmitted from each engine by a torsion shaft engaging with special section splines in the compressor driving sleeve and then, through silvered serrations in the shaft and driving cone, to the sun gear. This sun gear is located on the shaft by conical seatings and locked by a nut. The nut is prevented from turning by a plunger engaged in serrations on the shaft and retained in position by a pinned sleeve.

The helical sun gear runs in plain bearings located in the satellite carrier and meshes with three helical planet gears. Attached to each planet gear by screwed pegs is a satellite spur gear and shaft running in roller bearings housed in the driving shaft and satellite carrier.

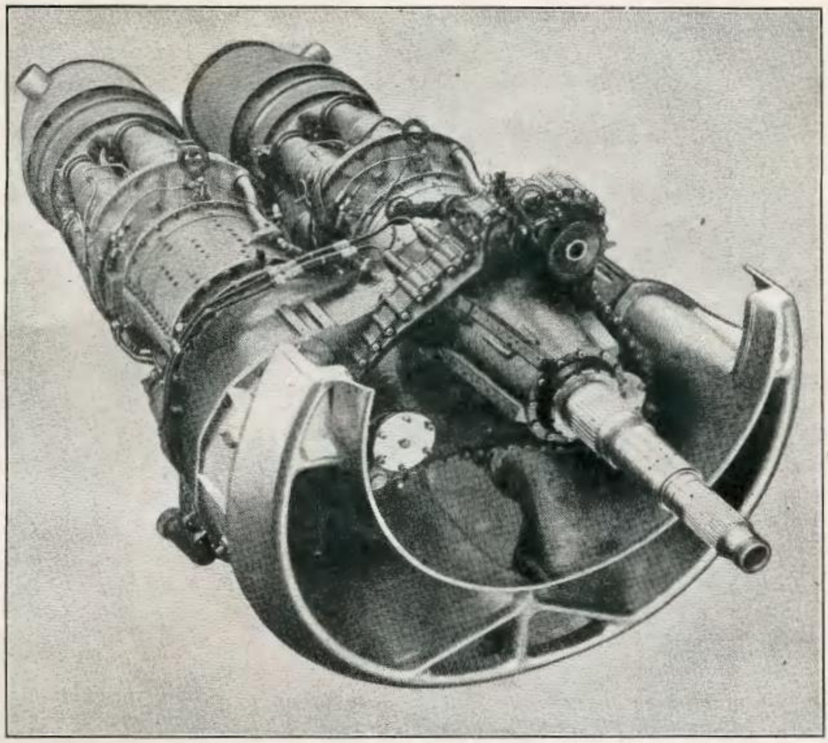
Output from the epicyclic gear is taken from the carrier; the internal gears are fixed and provide a convenient method of assessing the engine power through torquemeters. The final drive is through a train of spur gears, the driver being attached to the forward end of the epicyclic carrier. Interposed between this and the airscrew shaft gear are idler gears to give correct airscrew shaft rotation.

A ball thrust bearing is provided at the rear end of each satellite shaft to take the thrust of the helical planet gear. Completing this train of gears is a floating internal gear positioned fore and aft by three grooved plates. The driving shaft and satellite carrier (with gears, shafts and bearings) are held by a Hirth-type coupling and nine H.T.S. bolts.

This unit runs in ball and roller bearings; the after bearing is housed in the rear diaphragm and in the front one is a ball bearing in the torquemeter diaphragm, which takes the combined thrust of the planet gears and a small journal load. Ball and roller bearings in the Double-Mamba are supplied by Hoffman, and also by Ransome and Marles.

The civil single Mamba has six piston-cylinder groups for the torquemeter; the military single Mamba has three, since low diameter has not been a primary requirement (there is plenty of space in the nose of the Balliol and Athena trainers). In the Double-Mamba three cylinders and pistons have again been used, arranged radially in each torquemeter diaphragm; the principle of operation is the same as before and was described in our previous article on the engine.

The Armstrong Siddeley design of reverse torque switches—pioneered on the single Mamba—are retained in the Double-Mamba to prevent overspeeding. For example, in a dive, if the torque loads on each reduction gear are reversed (i.e., the airscrew is driving the engine) an operation lever trips a switch to override the C.S.U. and the



appropriate airscrew is put into coarse pitch.

The lubrication systems are arranged independently and each gearbox has its own oil pump; circulating oil is kept separated by dividing walls in the gearbox casing. Lubrication of the port and starboard epicyclic reduction trains is identical, whereas the spraying of the starboard driving gears (from the engine shaft to the airscrew shaft) differs slightly from the port one. Oil from the pressure pumps at 70 lb./sq. in. enters the reduction gear casing through a boss on the bottom facing and passes through a hollow aerofoil web in the air duct to the torquemeter diaphragm flange, where it branches fore and aft through drilled oilways.

The oil passes aft through a hollow dowel connected with the torquemeter diaphragm, to an annulus formed between the oil seals in the torquemeter bearing housing. From this annulus oil is fed to bellcrank lever bushes and through three grooves in the torquemeter pump driving gear, and three holes in the driving shaft, to a second annulus formed between the end of the driving shaft and its extension. Oil then passes to the three forward satellite bearings; to the front plain bush housed in the driving shaft (which supports the sun gear); and to three hollow dowels connecting the driving shaft, with the satellite carrier.

Oil is also passed to a third annulus formed in the distance piece between the carrier and its rear bearing, from where it is fed through drilled holes to the rear satellite bearing, and to the rear plain bearing supporting the sun gear. A series of jet holes are drilled in the oil ways in the carrier and spray oil onto the sun satellite planet and internal gears. The spray impinges on the gear teeth midway, and at the point of intersection of the teeth. Oil leakage from the main bushes and oil seals also lubricates the carrier rear bearing and front bearing.

The system for the port driving train consists of a forward passage in the reduction gear casing to the entry boss and oil passes along a gallery in the diaphragm to the final-drive gear, and to the port idler gear. The bearing housing bosses for the gears have oil troughs cast in them, which collect oil draining off the casting walls and feed it to the rollers and tracks of the bearings through drilled holes.

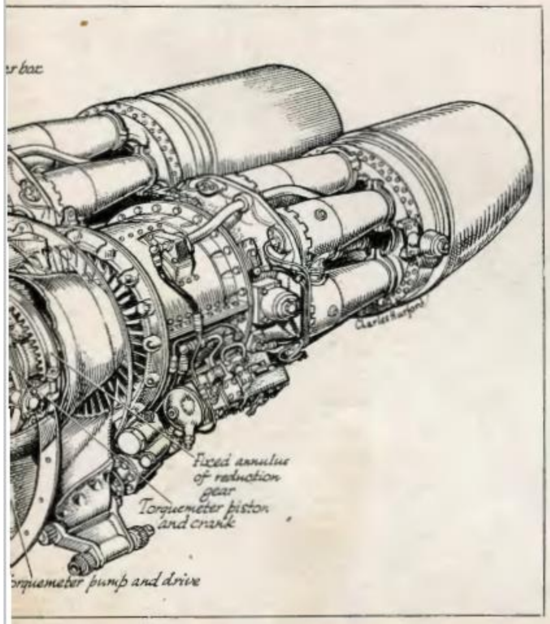
On the starboard driving train, the forward passage feeds oil from the entry boss through the main diaphragm to the front cover and to a three-way distributor, which in turn feeds the oil to steel oil jets mounted between the gears. One of these sprays oil onto the starboard final drive gear and the first idler gear and the other jet sprays the second idler gear and the rear airscrew shaft.

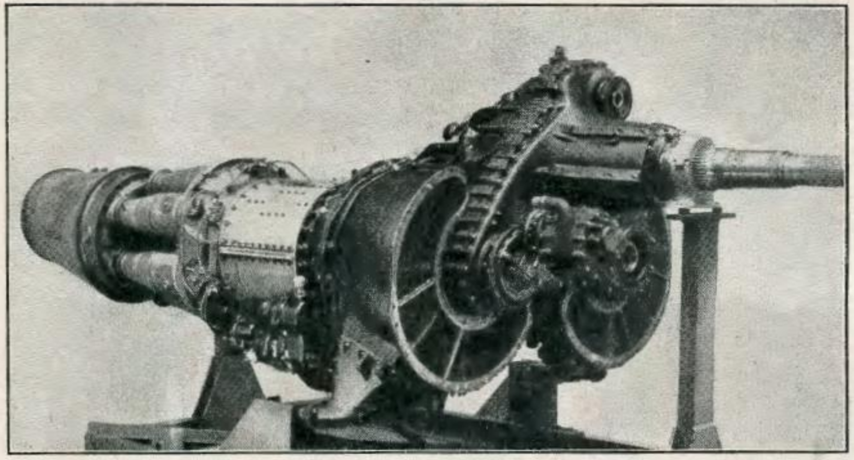
Oil splash from the airscrew shaft gears is carried upwards to each accessory driving gear—the bores of which are lipped to provide a reservoir for lubricating the gear roller bearings and free-wheel rollers when one gear is idling. The main journal bearing housing for the accessory drive shaft is also lipped. After lubricating and circulating, oil mist drains to the bottom of the casings (which are interconnected by cored drain holes) to the sump in the reduction gear casing from where it is scavenged by the port and starboard scavenge pump.

Oil for airscrew pitch changing is delivered to the forward airscrew through inner and outer tubes, up the centre of the hollow shaft and is piped from the port C.S.U. pump to enter the tubes through a transfer cover mounted on the rear of the reduction gear casing. The outer tube carries "fine pitch oil" and the inner "coarse pitch oil." C.S.U. oil for the rear airscrew is piped from the starboard C.S.U. pump to two unions screwed into the reduction gear casing and oil passes through two adjacent bosses in the casing through hollow dowels in the main diaphragm, where it is transferred to the appropriate C.S.U. tubes.

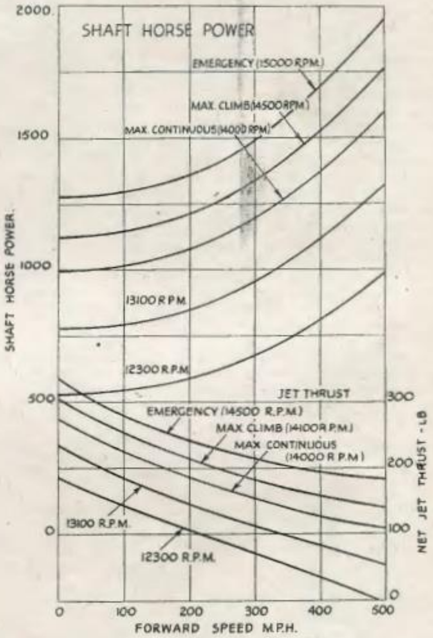
Lubricating oil for the compressor front bearing is scavenged through the normal engine system. Oil passed to the turbine bearing is not scavenged.

The oil circulation rate for each engine is 500 gallons/hour and in the design of the oil tank there is a need to reduce frothing which may result. If one tank is visualized for service for the oil systems, it is necessary to have a central wall in the tank to keep the two systems separate. The consumption at





(Left) The Mambas in the 2,500 h.p. power group are entirely separate and the airscrew of each can be started, cruised or feathered independently of the other. There is a common intake cowling and reduction gear. (Below) Estimated performance at 30,000 ft. of the Armstrong Siddeley Double-Mamba power group at I.C.A.N. standard atmospheric conditions. This graph shows output in terms of forward speed.



maximum cruising r.p.m. is no more than 0.25 gal./hr./engine. Included in the lubrication system is 8½ lb. of oil for the front C.S.U. and 5 lb. for the rear.

Airscrews, Intake and Accessories

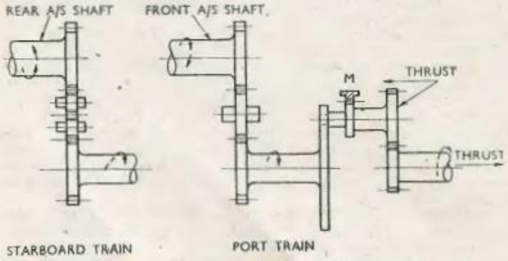
Air is delivered to each engine through two kidney-shaped intakes, located behind and below the reduction gear case. Each intake, made of a High Duty Alloy casting, forms an annulus which prepares the air for entry into the 10-stage axial-flow compressors (design of which constitutes one of the differences in performance between the Mamba 1 and 2). Each engine has its own controls grouped on top of the main air intake body casting on a common counter shaft, providing a convenient aircraft pick up position. Controls for the pick up are the throttle lever and isolator valve lever on each engine (making four levers in all).

The isolator control on each engine is a fuel shut-off cock interconnected to a manual feathering selector lever on the C.S.U. The actual feathering operation is completed by a push-button for each engine in the pilot's compartment which operates the feathering pump. Fuel is fed from the main aircraft fuel tanks to a fuel control unit on each engine, filtered and delivered to a fuel pump, and then returned to the high-pressure side of the fuel control unit.

From the control unit, fuel is fed to a distributor and, during normal engine running, delivered to the six burners situated in the centre diffuser section. On starting, however, fuel is fed from the distributor to the solenoid valve and then to the four Kigass primer jets and two igniter primer jets in the centre diffuser casing, until the governor switch opens above 4,000 r.p.m., thus breaking the ignition circuit and allowing normal engine running.

The throttle of each engine, in conjunction with the cam box, automatically relates engine r.p.m. with the fuel flow. The cam box, situated on the lower half of the centre diffuser section casting, houses two cams; one operates the fuel flow mechanically, and the other selects engine r.p.m. through an hydraulic servo motor, in conjunction with each C.S.U.

Immediately aft of the air intake, and engine-mounting casting, is the accessories casing. The engine accessories are grouped axially on the lower-half of this casing, and driven by a radial bevel shaft, which passes through an aerofoil in the main air-intake casting from the compressor rotor of each power-unit.



The arrangement of port and starboard spur gear trains which carry the rotational movement to the common airscrew assembly. For details of fixed annulus at M, see p. 334, issue March 19, 1948.

Engine accessories grouped on the casing are as follows: two Rotol feathering pumps (8.5 lb. each); two Rotol C.S.U.s (19 lb. each); Smiths r.p.m. indicators (6 lb.); two B.T.H. turbo-starter motors (17 lb. each); two alternative 8 h.p. B.T.H. or Rotax electric motors (25 lb. each); two breeches and six cartridges (42 lb.); and four ignition coils (10 lb.). Other auxiliary equipment on each engine includes the Lucas control unit and fuel filter, and Lucas fuel pump.

Blade diameters of the airscrews will be specified by airframe manufacturers. Feathering and braking counter-rotating co-axial airscrews and spinners, with 11-ft. diameter blades, weigh 582 lb.—the front airscrew and spinner (left-hand tractor) weighs 278 lb. and the rear one (right-hand tractor) with spinner 304 lb. (the increased weight of the rear assembly is mainly due to the fact that the pitch-changing cylinder cannot be in the normal place, but must be mounted on the side of the shaft). The Dural blades have a N.A.C.A. 16 series aerofoil section.

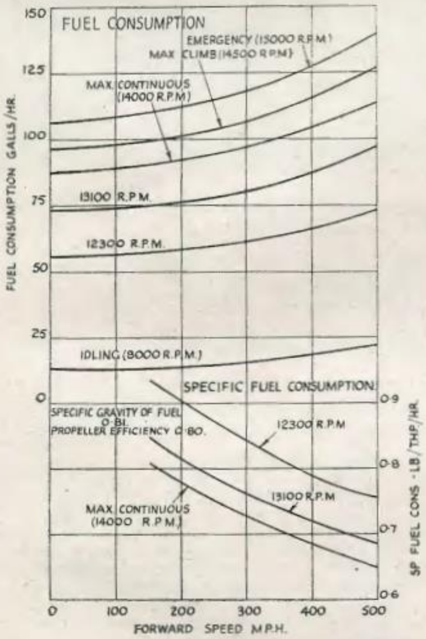
There is a mechanical stop at the minimum flight pitch angle, which is around 10 degrees and a "solid" stop at zero pitch. The controller units weigh 17 lb. each; the feathering pump and motors amount to 10 lb. each.

The polar moment of inertia is 1,190 lb./ft. The gyrocouple, due to the double engine without airscrews and at maximum r.p.m. and an aircraft turning speed of 1 radian/sec., is 1,860 lb./ft. The approximate horizontal centre of gravity position of the Double-Mamba is 42.5 in. aft of the rear airscrew centre line, and the vertical centre of gravity 2.34 in. above the centre of the engine.

The engine has three mounting points; the upper one is positioned at the top of the main air-intake casting, and faces aft in a downwards direction on the vertical centre line of the engine; a hemispherical ball joint is provided, to which an adjustable aircraft link can be fitted. The other two mounting points are arranged on the lower half of the casting, a fixed link on the starboard side and an adjustable one on the port side. Both have hemispherical ball joints.

A drive is provided for a suitable Rotol accessories gearbox and taken out rearwards from the top of the main engine gearbox; the rotational speed is 0.182 times engine speed with a capacity of up to 100 h.p. at maximum cruise r.p.m. Direction of shaft rotation is anti-clockwise viewed from the front.

It is desirable to isolate the combustion chamber compartment from the compressor and accessories compartment. This can be achieved by fitting a fireproof bulkhead at the convenient point forward of the forward joint of the chambers.



	Two Single-Mambas	One Double-Mamba
	lb.	lb.
Engine (net dry)	1,500	2,000
Bulkhead	50	
Cowls	78	
Electric starter	50	34
Starter cables	8	10
Tacho.	6	6
Controls	20	12
Pipes	34	18
Oil coolers and fixing	69	14
Oil tank and mounting	64	35
	1,879	2,129

This table shows a comparison of installation weights.

Alternatively, the chambers on each engine can be completely shrouded by a circular shield, which should be cooled.

To the rear of the engine there should be another firewall to isolate the combustion chambers from the aeroplane structure. Suitable fire extinguisher rings will be fitted to each; one ring draped round the engine accessories and two further rings round the joints of the combustion chambers.

The exhaust cone on each engine is secured to the turbine stator case and finishes in a flange designed for the fitting of a quickly detachable clamp for easy removal of the engine from the jet pipe. Disposal of the 13.5-in. jet pipes presents a problem to the aircraft manufacturer, but, if possible, their length should be kept down to a minimum. Use of free bends is not objected to, but if change of shape, say, from round to elliptical, is required, the equivalent area of the round pipe has to be maintained.

An account of the development of the Mamba was given to the R.Ae.S. by Mr. W. H. Lindsey on November 25, 1948 (reported in THE AEROPLANE of December 10, 1948).

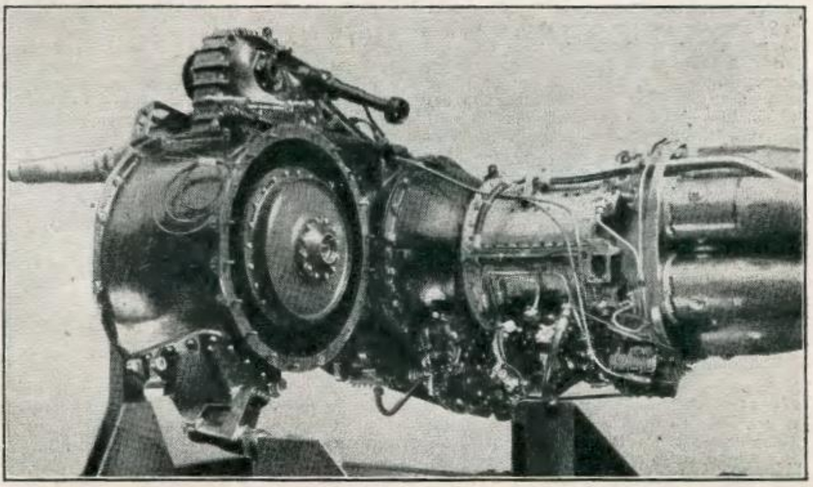
Other suppliers of parts for the Double-Mamba include Avimo, Ltd. (couplings and sleeves); George Angus (oil seals); Brico (seal rings); Hepworth and Grandage (seal rings); Firth-Vickers (stainless steel); Firth-Derihon (stampings); David Brown, Penistone (castings); Henry Wiggin (Nimonic alloys); Plessey and Co. (electrical fittings); Tecalemit (micro-pump); Smiths Clayton Forge, Ltd. (stampings and forgings); Dependable Springs and Pressings (springs); Fozel Castings, Ltd. (aluminium castings); George Salter (springs); Lodge Plugs (ignitors); J. Holding and Co. (forgings); Electro-Hydraulics (solenoid valves); W. Jessop (turbine discs); Chas. Weston (oil seals); Dunlop Aviation Dept. (flexible hoses); Teleflex Products (control linkage); Wellworthy (seal rings).

Technical Data

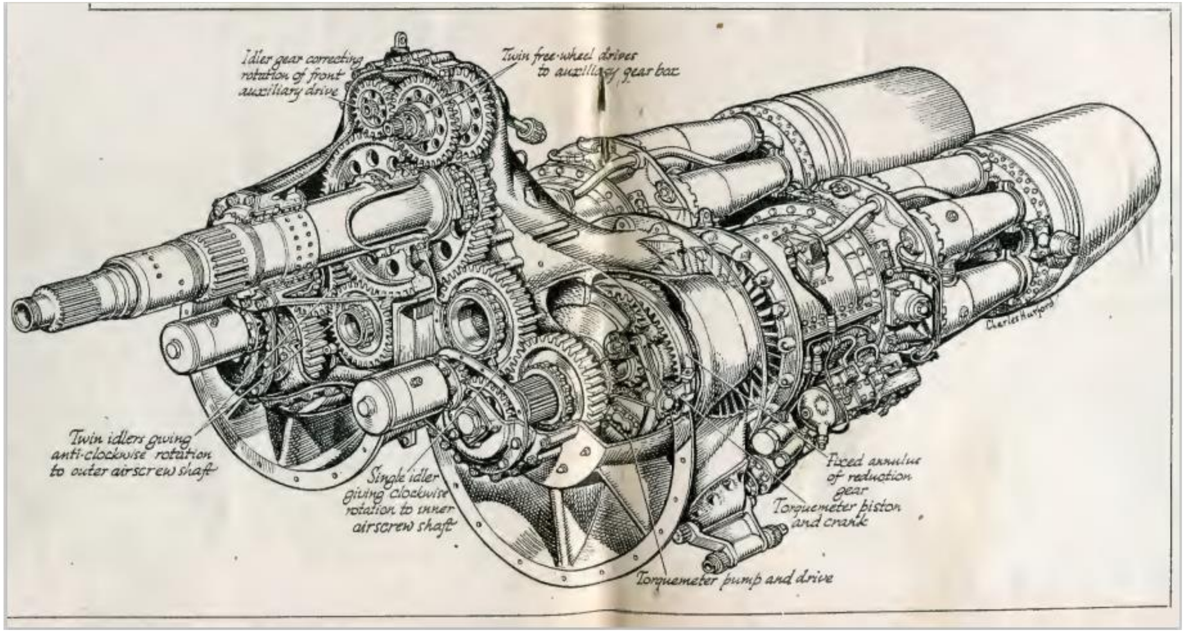
DIMENSIONS.—Overall length, 79.83 ins. (2.0 m.); minimum length of exhaust cone, 18.9 ins. (0.55 m.); inside diameter of jet pipe, 13.5 ins. (0.39 m.); overall width, 52.8 ins. (1.2 m.); overall height, 42.35 ins. (1.05 m.).

WEIGHTS.—Net dry weight, 2,000 lb. (900 kg.); final drives and reduction gear, 800 lb. (360 kg.); engine units, 575 lb. each (260 kg.); combustion chamber heat shield, 38 lb. (17 kg.); Graviner rings, 12 lb. (5.4 kg.).

PERFORMANCE.—Max. take-off, sea level, 2,540 s.h.p., jet thrust 770 lb., fuel consumption 250 gallons/hour; max. emergency at sea level and 300 m.p.h., 3,040 s.h.p., 380 lb. thrust, 281 gallons/hour; max. climb at 200 m.p.h. 2,360 s.h.p., 428 lb. thrust, 239 gallons/hour; max. cruising at 400 m.p.h. 2,670 s.h.p., 150 lb. thrust, 240 gallons/hour.



(Above) Showing output against fuel consumption, this estimated curve of the Double-Mamba is corrected to I.C.A.N. standards at 30,000 feet. (Right) Each Mamba 2 turbine can be plugged into the power group easily. The basic engines of the Double-Mamba are standard units similar to the one which recently completed a 500-hour endurance test.


Idler gear correcting rotation of front auxiliary drive
Twin free-wheel drives to auxiliary gear box
Twin idlers giving anti-clockwise rotation to outer airscrew shaft
Single idler giving clockwise rotation to inner airscrew shaft
Fixed annulus of reduction gear
Torquemeter piston and crank
Torquemeter pump and drive
Charles Hurford