NEW GAS TURBINES FOR THE ROYAL NAVY

Acknowledgement is made to Messrs Metropolitan-Vickers, Ltd., and Messrs Rolls-Royce, Ltd., for permission to reproduce the illustrations in this article.

On the 14th July, 1947, the first ship in the world to be propelled by a gas turbine, motor gunboat M.G.B. *2009* of the Royal Navy, put to sea. Since that day the gas turbine engineering art has progressed far in terms of power and efficiency. The greatest progress has undoubtedly been made in the field of aero-engineering. The Royal Navy, however, has not been lagging behind and two new types of gas turbine have been developed for application to propulsion of coastal craft.

One is a 4,800 h.p. boost engine developed by Messrs Metropolitan-Vickers, and is known as the G.2, and the other is a 6,000 h.p. main propulsion engine known as R.M.60 developed by Messrs Rolls-Royce Ltd.

THE METROPOLITAN-VICKERS G.2

Following the successful operation of the Gatric engine at sea a contract was placed with Messrs Metropolitan-Vickers for the design of four larger engines working on the same cycle as Gatric and known as the G.2. These engines have now completed shore trials, have been installed and sea trials are now in progress.

The G.2 gas generator comprising compressor, combustion chamber, compressor turbine and auxiliaries is an adaptation of the Beryl jet engine with certain modifications. A power turbine has been added to change it from a jet engine to a marine propulsion set. This is mechanically independent from the gas generator and drives the propeller through reduction gearing.

These engines were originally designed to develop 4,800 h.p., but pending operational experience at sea, the maximum power has been declared at 4,500 h.p., with a maximum continuous rating of 4,000 h.p.

As in M.G.B. *2009* (later re-numbered *P.5559*) the gas turbines are used only at high speeds and are designed for a total life of 1,000 hours, of which 300 may be run at maximum power. Diesel engines provide power for cruising and manoeuvring.

As the following figures show, the 4,500 h.p. gas turbines have a much better power/weight ratio than the 2,500 h.p. Gatric set.

		Gatric	*G.2*
Rating	s.h.p.	2,500	4,500
Gas Turbine Unit (excluding Gears) ...	lb	4,350	6,949
Gears	lb	2,600	2,772
Total	lb	6,950	9,721
Power/Weight ratio, Gas Turbine only	lb/s.h.p.	1.74	1.54
Power/Weight ratio, complete unit	lb/s.h.p.	2.78	2.16

The specific fuel consumption at full design power is .78 lb/s.h.p./hr. and at the rated maximum power is .8 lb./s.h.p./hr.

The compressor is an eleven stage machine giving a pressure ratio of 4.03 : 1 for a mass flow of 62.6 lb/sec. at a maximum speed of 7,830 r.p.m. The rotor is an aluminium alloy forging into which the blades, made from R.R.57 aluminium alloy pressings, are inserted axially.

The combustion chamber is of the annular type pioneered by Metropolitan-Vickers and as used in all their jet engines. The inner chamber is manufactured in Immaculate 5 austenitic steel and cooling air on the outside of this keeps its temperature down to 700° C. Twenty burners with upstream injection are provided for introducing the fuel.

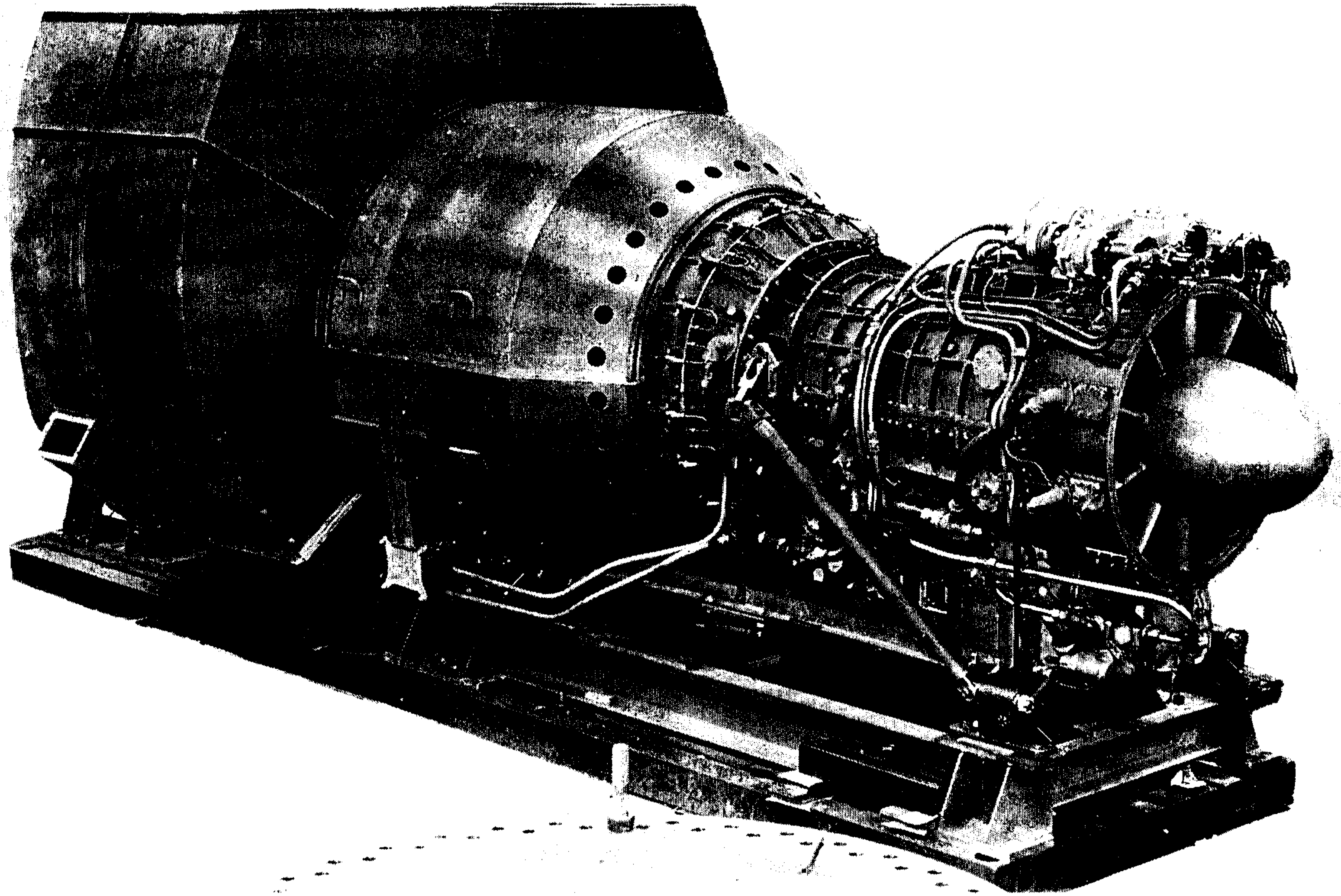
The h.p. or compressor turbine is a single-stage design directly coupled to the compressor. The disc, made from moly vanadium steel, is overhung from the after gas generator bearing. The stator blades into which the gas flows at 800° C. are built into a diaphragm supported from the combustion chamber outlet branch. Stator blades are in Nimonic 80 nickel chrome alloy and rotor blades, which are inserted into fir-tree slots in the rotor, are in Nimonic 80A.

The three-stage power turbine, mechanically independent from the H.P. turbine and running at 5,200 r.p.m. provides the propulsive power. The rotor is forged in three parts and these are welded to form the complete rotor. The material is F.C.B.(T) austenitic steel. The blading is handed to provide opposite rotation for the port and starboard engines. The moving blades, which are made in F.C.B.(T) are inserted axially into fir-tree slots in the rotor. The fixed blades are of moly vanadium steel.

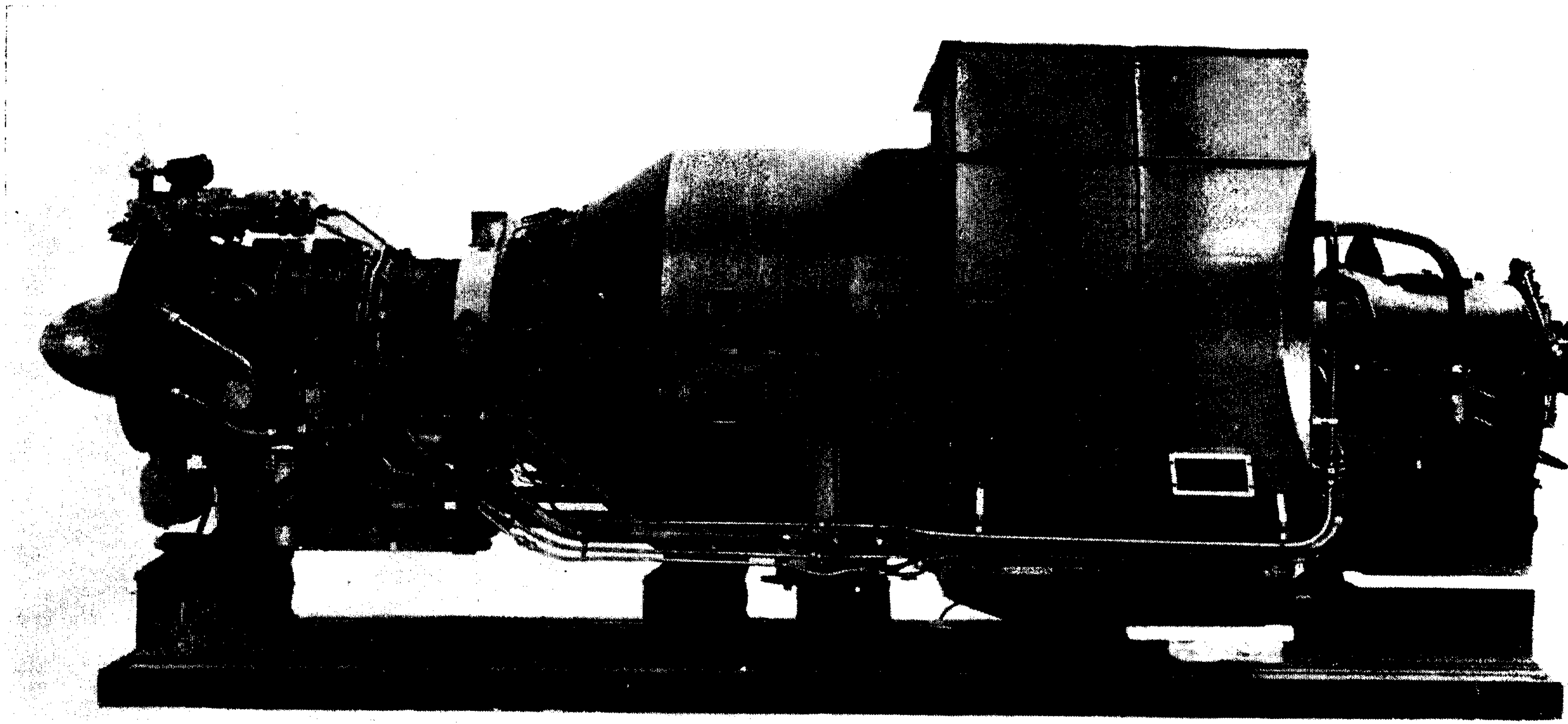
The main gearbox is of the side pinion helical type with a reduction ratio of 4.73 : 1 which brings the propeller speed to 1,100 r.p.m.

The engine auxiliaries, which include the lubricating oil pump, fuel oil pump, air starting motor, turning motor and the fuel boost pump, are grouped at the top and bottom of the forward end of the compressor casing. The drive for these is taken from the compressor shaft. The pressure and scavenge lubricating oil pumps for the gearbox are driven from the gearing.

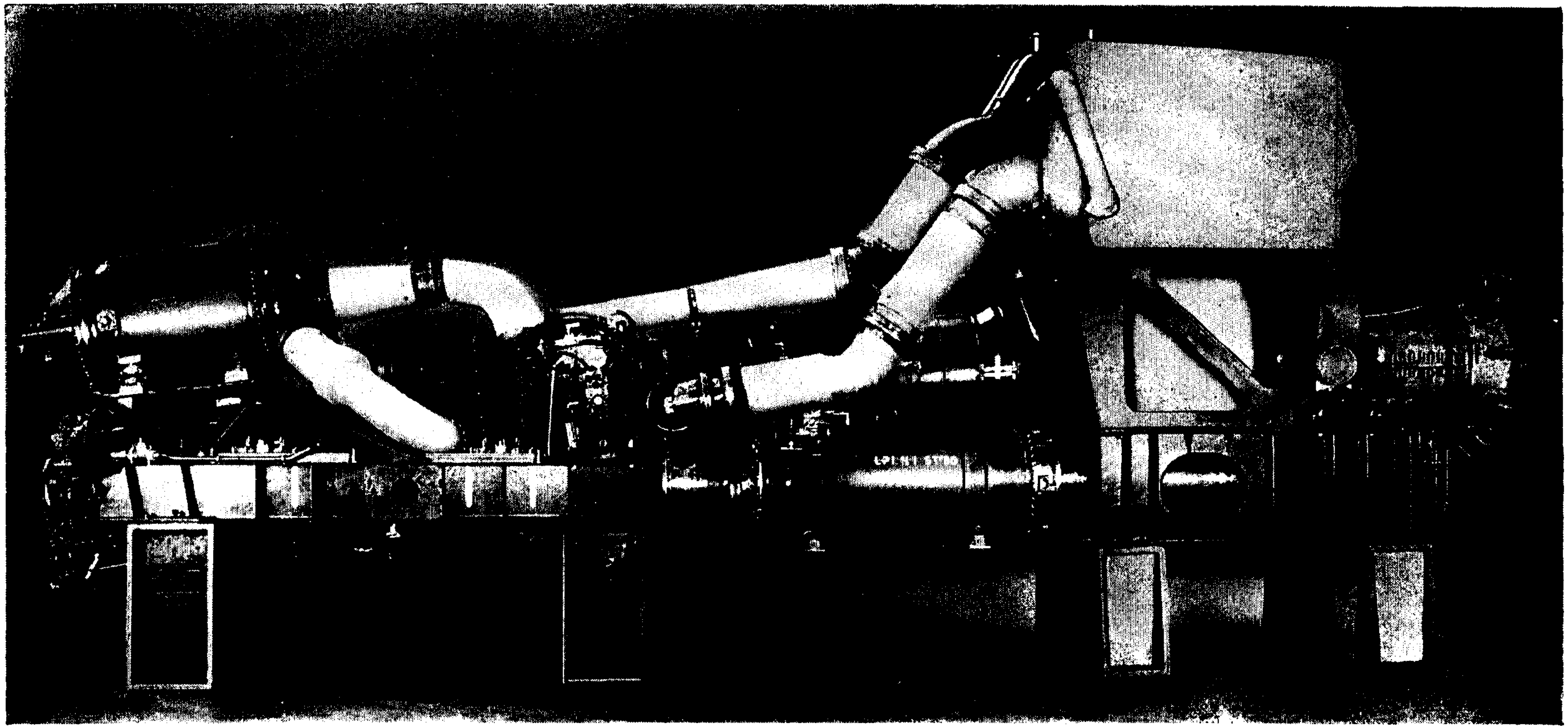
The engine is provided with ball and roller bearings throughout, lubrication



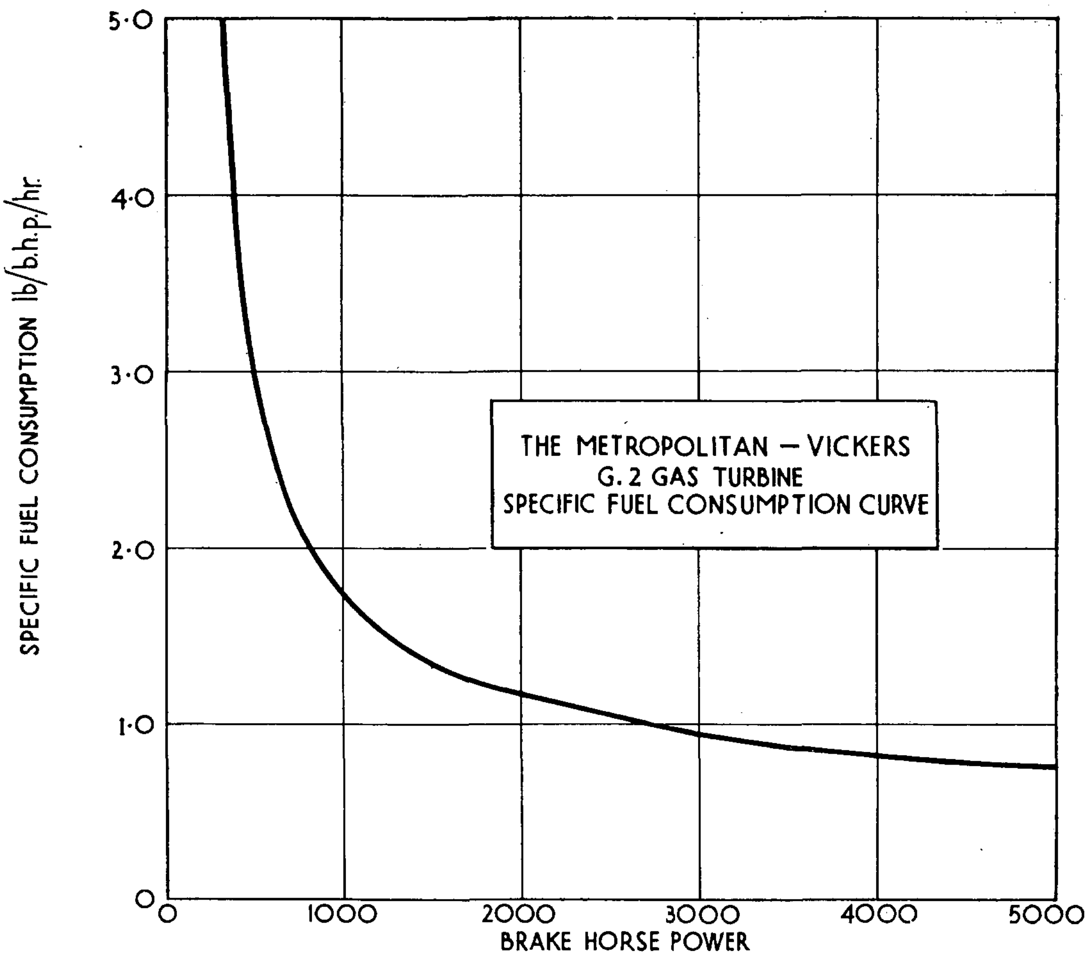
The Metropolitan-Vickers G.2



THE METROPOLITAN-VICKERS G.2



THE ROLLS-ROYCE R.M.60



of these being by oil mist on a total loss system. The gearbox, however, has a circulating oil system. The engine lubricating oil pump, which has eight feeds, meters the oil to the two gas generator bearings, the two power turbine bearings with four feeds to the auxiliary gearbox. To cater for lubrication of the power turbine bearings under trailing conditions a separate small pump is provided on the main gearbox. During starting a motor driven auxiliary oil pump provides oil for lubrication of the gearbox. In the event of failure of pressure in the gearbox lubricating oil system, a trip is provided which stops the engine should the pressure fall below 3 lb/sq. in.

The engine is kept cool by means of lagging on the hot parts and an air casing which surrounds the combustion chamber, turbines and exhaust volute. Air from the Engine Room is drawn through this casing by means of the ejector effect of the engine exhaust, thus keeping the casing cool.

For convenience the same oil, OMD–110, is used for both the gas turbines and diesel engines.

The engine is started by means of an air operated swash plate motor, the air supply being taken from a bottle. Several starts can be made before re-charging of this air bottle is necessary. The starting motor is similar to the air motors used in torpedoes, and is manufactured by the Torpedo Experimental Establishment, Greenock. The normal working pressure is 450 lb/sq. in. and approximately 75 cu. ft. of free air at an average pressure of 350 lb/sq. in. will start the engine in 30 seconds.

Provision is made for periodically injecting distilled water into the compressor intake to clean the compressor blading.

The performance shown in the graph has been obtained from a series of bench tests carried out at the works of Metropolitan-Vickers.

THE ROLLS-ROYCE R.M.60

Shore trials are nearing completion with this new type of marine gas turbine. The two prototype engines are to be installed in H.M.S. *Grey Goose* for sea trials.

During the last ten years a large part of the capacity of the British aircraft industry has been expended on the intensive development of gas turbines for aircraft propulsion. The advantages of applying the experience gained on aircraft gas turbines to marine propulsion have been fully appreciated by the Admiralty for some time and Rolls-Royce were asked to explore the possibilities.

After considerable investigation by Rolls-Royce under the direction of the Engineer-in-Chief of the Fleet a contract was placed by the Admiralty with Rolls-Royce in 1946 for the development of a Naval gas turbine.

Detail design work was started in December 1947, and by 26th June 1951 a complete engine was on test. During these first tests 90% of the design power was achieved and 220 hours of test running were completed before the engine was stripped for examination.

The vessel chosen for the installation of these two power units is the *Grey Goose*, a gunboat of 205 tons standard displacement and originally powered by two 4,000 h.p. steam turbines. The installation of these engines will start in 1953.

The Admiralty has kept the United States Navy informed of developments and this collaboration has resulted in an order being placed with Rolls-Royce for two prototype engines for the U.S. Navy Department.

Some Details of the R.M.60

In order to comply with naval requirements for economical low power cruising, a high compression ratio and a heat exchanger are necessary. Overall performance is further improved by intercooling after each stage of compression.

The operating cycle consists of a low pressure axial flow compressor, delivering air through a sea-water cooled intercooler to a two-stage centrifugal compressor. Intercooling is again employed between each stage of the centrifugal compressor. Air at maximum cycle pressure is then passed through a heat exchanger where it is heated by the exhaust gases before being delivered to two combustion chambers. Fuel is injected and burned in each combustion chamber and the resulting high temperature gas is expanded through three mechanically independent turbines. The high pressure turbine drives the high pressure compressors. The power turbine drives the propeller through a two-stage reduction gear and the low pressure turbine drives the low pressure compressor. This cycle has the advantage of enabling economy to be maintained down to low powers.

The engine will drive a three-bladed variable and reversible pitch Rotol propeller, which provides a very convenient means of reversing and allows a variation of engine speed with ship speed in order to obtain the best results at a given power. The propellers are arranged to reverse through feather.

The Company's aero-engine practice has been adopted for the general principles of many components. This policy has resulted in a light and compact power unit giving considerable increase in total power and a reduction of 50%

in total machinery weight as compared with the lightest steam machinery yet produced for Naval purposes. In addition a saving in machinery space has been made possible.

The R.M.60 is designed as a medium life engine for development purposes only and it is anticipated that the experience gained during its operation will materially assist in future development of marine gas turbines with long life between overhauls.

It is hoped that further details of this most interesting development will be published in a future issue of the *Journal.*