'A.S.R.1'

BY

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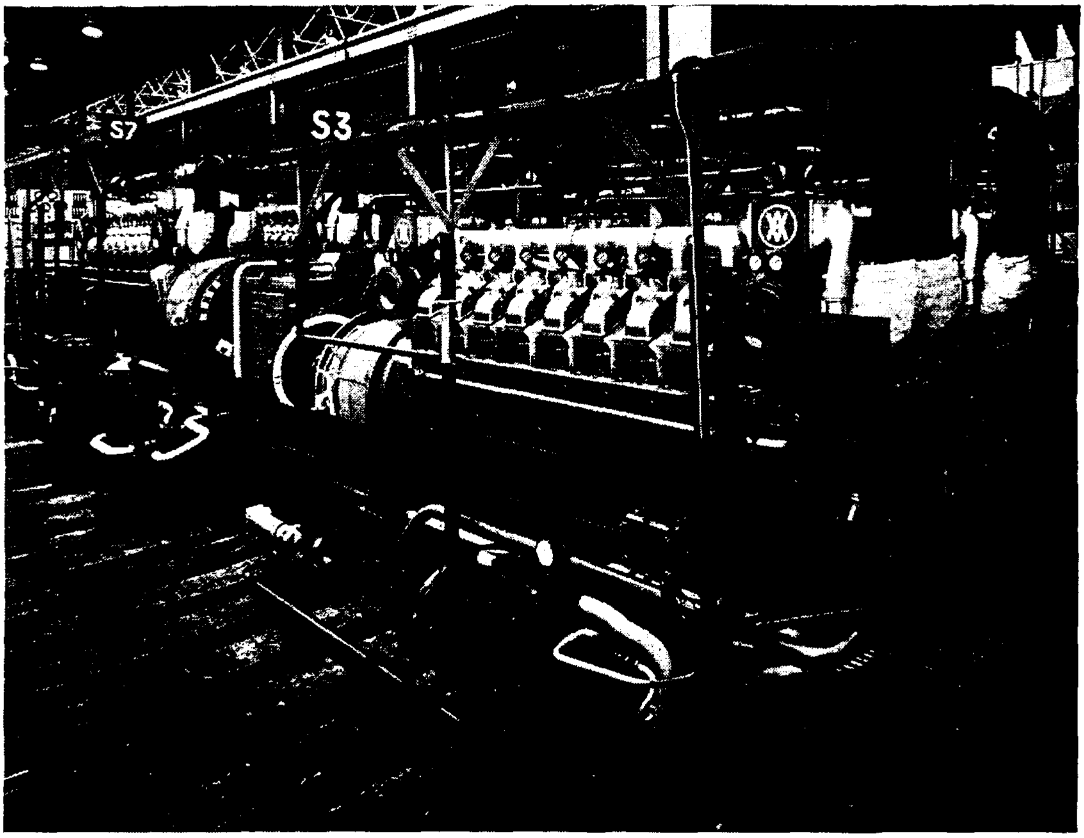
Early History of the Engine

Before World War II, except in submarines, internal combustion engines were used in comparatively small numbers in the Service. The type of engine used for any particular application, was mainly determined by its suitability for the service in view, and the final choice was often decided by cost. The question of standardization of types was not considered of paramount importance, and adaptation of ordinary commercial designs for marine use was the standard practice. The design and construction of submarine engines was very specialized and, from World War I, the Admiralty produced and made designs of their own as well as using designs from a restricted number of firms.

During World War II, the requirement for Diesel engines increased enormously and a large number of these were of comparatively high power. To meet the demand, an undesirably large number of different types of engines of British, American and European origin had to be used and approximately 300 types were in service by 1944. This caused a serious problem in the supply of



A FOUR ENGINE UNIT FOR A FRIGATE

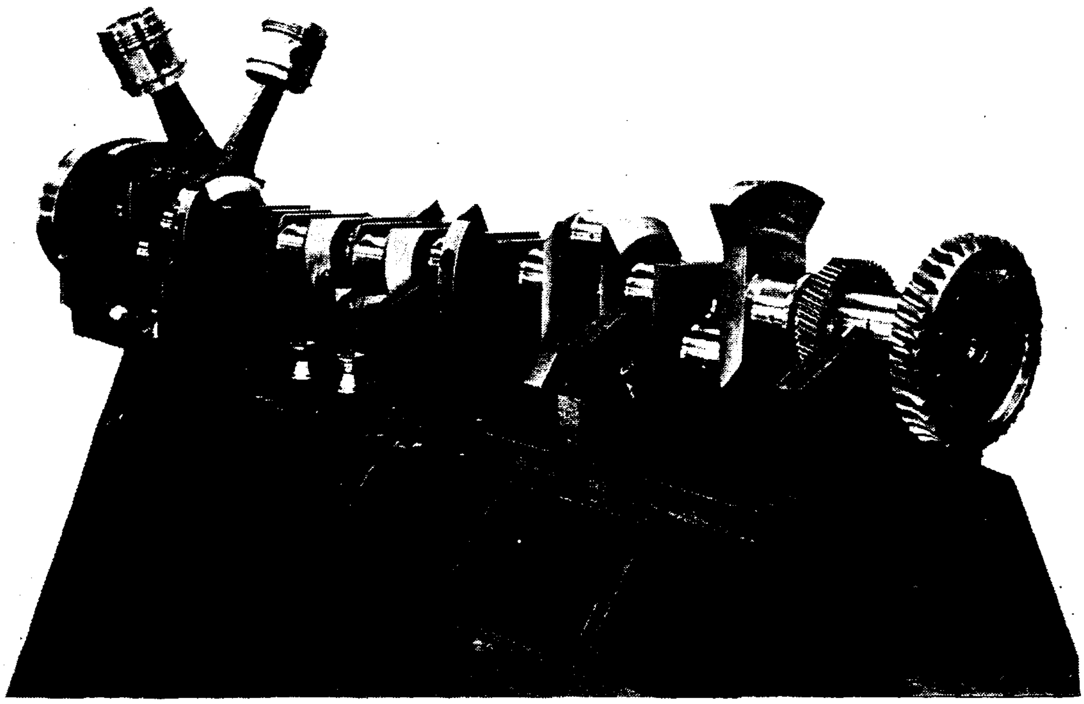
spare gear and, as a result of war experience, an inter-services committee was formed to investigate the question of a standard range of Diesel engines for use in the Services. The Committee finally recommended that all future requirements for these engines, except for very light weight and other special types, could be met by four standard ranges each comprising a variety of arrangements of cylinders of standard sizes and details. It was also agreed that the Admiralty would be responsible for the design of the two ranges of larger bore sizes (Range I and Range II) while the Ministry of Supply would concentrate on the smaller engines (Ranges III and IV).

Particulars recommended for Range I were :—

Horse Power :	180 to 2,000
No. of Cylinders :	3 to 16
Maximum Power :	125 h.p. per cylinder
Bore :	8 in to $10\frac{1}{2}$ in
Stroke :	10 in to 12 in

Design of the Admiralty Engine

The Admiralty already had a design available which could be used as a basis for the Range I engine. This design had been produced in 1937 by the Admiralty Engineering Laboratory, West Drayton, for a high speed submarine engine and a prototype 16-cylinder ' V ' engine built by Chatham Dockyard was extensively tested at the laboratory. This prototype, called Muscovic, was not supercharged and was rated at 1,300 b.h.p. at 920 r.p.m., had a bore and stroke of $9\frac{3}{4}$ in and $10\frac{1}{2}$ in respectively, Ricardo Comet 4-valve cylinder heads, cast iron frame and two-piece crankshaft with centre camshaft and multi-block fuel pump drive.



CRANKSHAFT, CONNECTING RODS AND PISTONS

At the beginning of the war, Muscovic development was stopped, but as a result of the Range I decision, development was recommenced and the engine converted to turbo supercharging. Meetings among representatives of the Engineer-in-Chief's Department, the Admiralty Engineering Laboratory and Chatham Dockyard were held and a number of departures from the Muscovic design were agreed. Some of these were the result of war experience with other engines ; others were necessary to make the design suitable for a variety of arrangements of cylinders. The final outline design specification for the A.S.R.1 engine was :—

Bore :	$9\frac{3}{4}$ in
Stroke :	$10\frac{1}{2}$ in
No. of Cylinders :	6 and 8 ' in line ' 8, 10, 12 and 16 in ' V ' form
' V ' angle :	45°
Cylinder Pitch :	17 in
Power/Weight Ratio :	17 lb/h.p. for 16-cylinder engine at 2,000 b.h.p.

Max. Rating—Initial

Turbo Supercharged

125 h.p. per cylinder at 1,000 r.p.m. i.e. 126·2 lb /sq in B.M.E.P. at 1,750 ft/min mean piston speed.

Sea-water temperature : 85° F.

Ambient air temperature : 110°F.

Relative humidity : 60 per cent.

Unsupercharged

90 b.h.p. per cylinder continuous rating under tropical conditions as above.

Design Information

Max. r.p.m. : 1,150 or 2,010 ft/min mean piston speed.

Max. cylinder pressure : 1,500 lb/sq in.

Max. rating expected from 16-cylinder pilot engine, exhaust turbo charged : 2,750 h.p. at 1,000 r.p.m. (174 lb/sq in B.M.E.P.).

Satisfactory operation under conditions of 30° maximum angle of heel and 10° trim.

All engines to be capable of running at least 5,000 hours at the maximum continuous rating between major overhauls.

Overall Dimensions and Weights

The overall dimensions and weights of the supercharged engines should be within :—

Engine	*Length* *ft in*	*Width* *ft in*	*Height* *ft in*	*Dry Weight* *lb*
16 Cylinder ' V ' ..	17—5	5—8	9—4	38,000
12 ,, ' V ' ..	14—6	5—8	9—4	31,000
8 ,, ' V ' ..	11—7	5—8	9—4	23,000
6 ,, in line ..	14—6	5—0	9—4	20,000

The weights quoted include the engine fitted with the oil and water pumps, superchargers, air coolers and inlet and exhaust manifolds.

Framing and Bedplate

Welded steel or cast iron construction (former generally for Admiralty service).

Crankshafts

One-piece forged steel, for larger engines and high ratings.

One-piece cast iron, for smaller engines with low ratings.

Pins 6¼ in diam. Journals 7 in diam.

Full torque take-off from either end.

Cylinder Heads

4-valve direct injection, high duty cast iron.

Connecting Rods—' V ' Engines

Fork and blade type.

Camshafts—' V ' Engines

Twin camshafts carrying exhaust, inlet and individual fuel pump cams driven from the normal driving end of the crankshaft by single helical spur gear trains.

Fuel Pumps

Individual flange-mounted drive incorporating timing adjustment while running.

Pistons

One piece uncooled aluminium alloy. To be capable of removal through the crankcase doors.

Superchargers

Exhaust turbo blowers for normal applications, mechanically driven positive displacement blowers for high exhaust back-pressure applications. (Camshaft drive designed to allow for this).

Cylinder Liners

Perlitic cast iron with or without chrome hardened bores.

Cooling Water System

Fresh water preferred.

Starting System

Compressed air—rotary disc distribution with relay operated valves in cylinder heads or air-start motor.

Auxiliaries

Pressure supply and scavenge lub. oil pumps

Fresh and sea-water circulating pumps

Fuel supply pump.

In addition, the Admiralty stressed that particular attention was to be paid to complete interchangeability of all replaceable parts, including identical crankshafts and bed-plates for ' in line ' and 'V ' versions of equivalent crank throws, to accessibility and ease of maintenance. Also, all drawings had to be dimensioned in accordance with the proposed revision of B.S. 308, Drawing Office Practice, so that dispersed production of engines and components could be carried out, with assembly by semi-skilled labour, but at the same time retaining the complete interchangeability requirement. Special consideration had to be given to ensure that the design was sufficiently robust to withstand the effect of underwater shock.

Early in 1947, Chatham Dockyard started the design work on a prototype 16-cylinder engine, to be built at Chatham, incorporating the majority of the above requirements, and arranged it for easy conversion from unsupercharged to mechanically or turbo supercharged. At the same time, arrangements were made with the British Internal Combustion Engine Manufacturers' Association for a number of their member firms to criticize, mainly from the production point of view, drawings showing details of all the major components of the engine.

In May, 1947, a requirement arose for 6, 12 and 16-cylinder engines for survey vessels and frigates and discussions were held with B.I.C.E.M.A. concerning the manufacture by some of their members of part, or all, of the engines required. Simultaneously the opportunity was taken to discuss the possible commercial application of the engine, the Admiralty offering to make the design and drawings, when completed, available to any manufacturer who wished to undertake the manufacture of the engine for the commercial market, no one firm being granted exclusive rights. A number of firms showed interest and visited the Admiralty Engineering Laboratory in June, 1947, for an inspection of Muscovic, which had been stripped for examination, and also to comment on the design of the A.S.R.1.

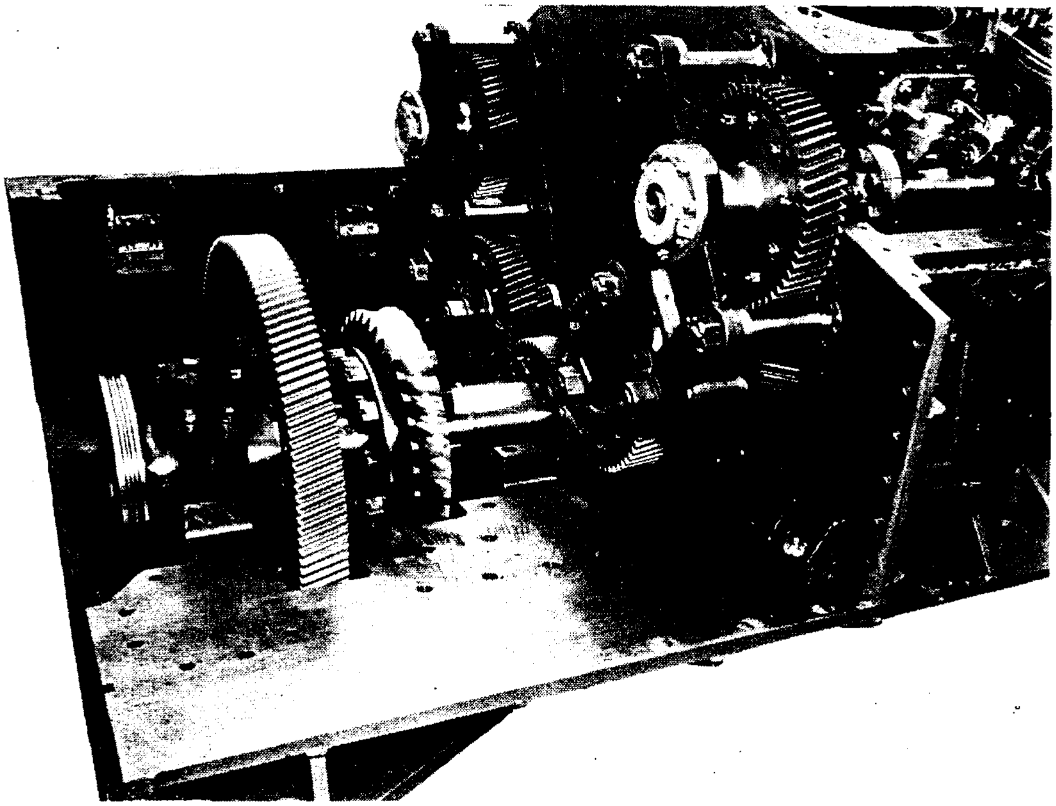
After troubles, which resulted in a delay of about a year, the prototype engine was completed in 1949 and started unsupercharged running at Chatham. After 400 hours, the engine was converted to turbo supercharge by fitting variable camshafts, pistons, manifolds and Napier turbo blowers. Well over 1,200 hours running was completed in this way, correct valve overlap was established and large-end development was carried out. As a result of these trials it was decided to adopt copper-lead loose-shell bearings and these have since proved very satisfactory. This bearing development showed that initial running in on white-metal bearings was advantageous because the dirt, left in the engine during erection, did little harm to crankshaft journals. The polish of the journals by the whitemetal which resulted, gave a most satisfactory surface for the copper-lead bearings, particularly on the relatively soft crankshafts (180–220 Brinell) used in the prototype and the production engines ordered in 1948–49. Failure of other engine components occurred on the prototype and, wherever necessary, design changes were made to overcome similar failures in the production engines.

The orders for these engines were placed with Messrs. Vickers-Armstrongs, Messrs. Peter Brotherhood (6 LTS and 16 VTS engines) and Chatham Dockyard (6 LTS and 12 VUS engines).

Consideration of Commercial Designs

During 1948, discussions continued with B.I.C.E.M.A. on the commercial application of the Admiralty engine, but in May, B.I.C.E.M.A. informed the Admiralty that their member firms, interested in an engine of the A.S.R.1 size, had decided that it was unsuitable for commercial exploitation. Instead they were proceeding to build new designs incorporating the cylinder dimensions of A.S.R.1 and generally similar combustion arrangements. The Admiralty were asked whether it would not be possible to use these engines in lieu of the A.S.R.1 for its immediate requirements. The Admiralty replied that it was not possible to abandon further work on the A.S.R.1 design and accept commercial designs, which were still in the drawing board stage. Discussions with B.I.C.E.M.A. then ceased until late 1949 when, after further consideration, it was decided that three commercial designs should be put forward in competition with the Admiralty design, and that the Admiralty would, if possible, select one which would fill the Range I requirement. The selected design would then be made under licence, in time of emergency, by all the firms concerned. The three commercial engines comprised two 12-cylinder and one 16-cylinder model and were completed in 1950.

The selection of the engine was made by type test conducted at the maker's works (Chatham Dockyard for the Admiralty design) and this was run in two parts. Part I consisted of a series of trials to check the general performance and included a 72-hour run at a rating equivalent to 125 b.h.p. per cylinder under tropical conditions, with full allowance for any specific engine driven auxiliaries. At the completion of the 72-hour run, a 'V' line of running parts (piston, connecting rods and large-end bearings) haphazardly chosen by an Admiralty representative from production parts, was fitted and a further 24-hour trial was run at the test rating to prove interchangeability requirements. In addition to the results of the Part I type test, each design was judged using the original minimum Statement of Requirements for Range I engines as a basis. From the results, the Admiralty intended to make a first choice which would then undergo an endurance run as specified in Part II of the Admiralty Test Specification. Certain relaxations of the minimum Statement of Requirements were permitted, provided the engine makers concerned satisfied the Admiralty that such modifications could be made to bring these engines strictly within the limits of the



TWO-CAMSHAFT DRIVE GEAR TRAINS WITH TURNING-GEAR WORM WHEEL AND SINGLE HELICAL GEAR FOR SUPERCHARGER DRIVE IN A 16 VMS GENERATOR SET FOR PORPOISE CLASS SUBMARINE

Admiralty requirements. Type testing started in September, 1950, and was completed in January, 1951. The performance of all four engines was so close that it was decided that all of them should undergo an endurance run of at least 1,000 hours. The final judging took place in February, 1951, and the basis of the marking was as follows :—

		Maximum Marks
1(*a*)	Length	40
1(*b*)	Breadth	50
1(*c*)	Height	30
1(*d*)	Installation Weight	100
2(*a*)	Fuel Consumption	40
2(*b*)	Lubricating Oil	5
2(*c*)	Smoke	20
3	Performance in Hand	60
4	Development Potential	60
5(*a*)	Accessibility, Tuning	50
5(*b*)	Accessibility, Top Overhaul	50
5(*c*)	Accessibility, Running Repairs	50
5(*d*)	Accessibility, Damper	10
6(*a*)	Reliability, Combustion Moving Parts	40
6(*b*)	Reliability, Mechanical	40
7	Suitability for Naval Use	50

Marking for 1(*a*) to (*d*), 5(*a*) to (*d*) and 7 was based mainly on inspection of drawings and general examination of the engine type tested.

Marking for 2(*a*) to (*c*), 3, 4 and 6(*a*) and (*b*) was based mainly on the results of the type test trials.

Results of the competition showed that the Admiralty engine was the most suitable to meet Naval requirements and B.I.C.E.M.A. were informed accordingly.

Present Position of the Admiralty Engine

Meanwhile, design of the Admiralty engine has proceeded and drawings prepared for a range of models, which included 6 and 8 in line and 12 and 16 ' V ' cylinder models, both unsupercharged and turbo supercharged, and a 16 ' V ' mechanically supercharged model. Provision was made for flange mounted generators on some models.

To meet the requirements of the Naval programme, the engine, which has been adopted for propelling machinery or generators of survey vessels, frigates, aircraft carriers, tugs and submarines, is now being built by Chatham Dockyard, Messrs. Vickers-Armstrongs Ltd., Peter Brotherhood Ltd., Cammell Laird & Co., Polar Engines and Crossley.

Continual development running has been carried out at the Admiralty Engineering Laboratory, West Drayton, where the following engines are available :—

(*a*) The 16-cylinder ' prototype ' engine.

(*b*) One 6 LTS engine coupled to a dynamic brake.

(*c*) A number of single and 'V ' two-cylinder unit engines.

Of these :—

(*a*) is available for unsupercharged and turbo or mechanical supercharged running generally, and is very suitable for bearing and other running gear endurance testing.

(*b*) is mainly used for higher supercharge development.

(*c*) is primarily concerned with governor development, particularly on governors for A.C. application for ship use, where close speed control is very necessary.

(*d*) are used for general combustion, piston and bearing research ; it is usual to test prototypes of all new components in these before quantity production is put in hand.

The design target for the A.S.R.1 engine is a rating of 180 lb/sq in B.M.E.P. at 1,000 with a top overhaul period of 2,500 hours and a major overhaul period of 5,000–10,000 hours depending on the rating. At present one of the major troubles being investigated at the laboratory is the corrosion on the backs of cylinder liners, and trials are being carried out with various corrosion resisting metals and other coatings in an attempt to solve the problem. A new design of cylinder head is also under trial. Generally, however, development running at the A.E.L. and nine months in H.M.S. *Vidal* (a survey vessel fitted with A.S.R.1 propulsion and generator engines) have revealed a surprisingly small number of defects in design.

The leading dimensions and present and future ratings of the various models in production at the present time are shown in Tables I and II. In addition to the models shown in these tables, mechanically supercharged engines are also being manufactured, these being fitted with Rootes or centrifugal type superchargers—and have a maximum rating of 126 lb/sq in B.M.E.P. under surface running-conditions and 103 lb per sq in B.M.E.P. under full ' snort ' conditions.

TABLE I—PROPULSION ENGINES

Engine and Model	*Admiralty Ratings (B.H.P.) for Propulsion*				*Wet Weight (Lb)*	*Super-charger*	*Overall Dimensions L × B × H*
	Present		*Future*				
	Continuous	*2 hr. Overload*	*Continuous*	*2 hr. Overload*			
A.S.R.1 16 V.T.S.	2200 @ 1000 @ 139 BMEP	2420 @ 1000 @ 153 BMEP	2500 @ 1000 @ 160 BMEP	2750 @ 1000 @ 176 BMEP	40,500	Napier Turbo	16′ 10″ × 5′ 4″ × 8′ 8½″
A.S.R.1 16 V.U.S.	1420 @ 1000 @ 90 BMEP	—	—	—	34,000	—	15′ 8″ × 5′ 4″ × 8′ 0″
A.S.R.1 12 V.T.S.	1650 @ 1000 @ 139 BMEP	1815 @ 1000 @ 153 BMEP	1900 @ 1000 @ 160 BMEP	2090 @ 1000 @ 176 BMEP	30,000	Napier Turbo	14′ 0″ × 5′ 4″ × 8′ 6″
A.S.R.1 12 V.U.S.	1050 @ 1000 @ 90 BMEP	—	—	—	28,000	—	12′ 10″ × 5′ 4″ × 8′ 0″
A.S.R.1 8 V.T.S.	1100 @ 1000 @ 139 BMEP	1210 @ 1000 @ 153 BMEP	1250 @ 1000 @ 160 BMEP	1375 @ 1000 @ 176 BMEP	22,500	Napier Turbo	12′ 9 ″ × 5′ 4″ × 8′ 6″
A.S.R.1 8 L.T.S.	1100 @ 1000 @ 139 BMEP	1210 @ 1000 @ 153 BMEP	1250 @ 1000 @ 160 BMEP	1375 @ 1000 @ 176 BMEP	24,500	Napier Turbo	16′ 6″ × 4′ 3″ × 8′ 7″
A.S.R.1 8 L.U.S.	710 @ 1000 @ 90 BMEP	—	—	—	23,500	—	15′ 8″ × 4′ 3″ × 8′ 0″
A.S.R.1 6 L.T.S.	825 @ 1000 @ 139 BMEP	910 @ 1000 @ 153 BMEP	950 @ 1000 @ 160 BMEP	1045 @ 1000 @ 176 BMEP	22,000	Napier	14′ 0″ × 4′ 3″ × 8′ 16″
A.S.R.1 6 L.U.S.	525 @ 1000 @ 90 BMEP	—	—	—	20,000	—	12′ 10″ × 4′ 3″ × 8′ 0″

Note.—' V ' represents a' V ' Engine.
L represents an in-line engine.
T.S. represents a turbo supercharged engine.
U.S. represents an unsupercharged engine.
M.S. represents a supercharged engine with mechanically driven supercharger.

Engine and Model	*Admiralty Ratings (B.H.P.) for Generators*				*Wet Weight (Lb)*	*Super-charger*	*Overall Dimensions*
	Present		*Future*				
	Continuous	*2 hr. Overload*	*Continuous*	*2 hr. Overload*			
A.S.R.1 8 V.T.S.	892 @ 900 125 BMEP (612 kW)	982 @ 900 138 BMEP (674 kW)	962 @900 135 BMEP (662 kW)	1059 @ 900 149 BMEP (729 kW)	24,000	Napier Turbo	12′ 9″ × 5′ 4″ × 8′ 6″
A.S.R.1 8 L.T.S.	739 @ 720 128 BMEP (500 kW)	813 @ 720 140 BMEP (550 kW)	962 @ 900 135 BMEP (662 kW)	1059 @ 900 149 BMEP (729 kW)	24,500	Napier Turbo	16′ 6″ × 4′ 3″ × 8′ 7″
A.S.R.1 8 L.U.S.	570 @ 900 80 BMEP (392 kW)	627 @ 900 88 BMEP (432 kW)	—	—	23,500	—	15′ 8″ × 4′ 3″ × 8′ 0″
A.S.R.1 6 L.T.S.	525 @ 720 123 BMEP (360 kW)	577 @ 720 135 BMEP (396 kW)	720 @ 900 135 BMEP (495 kW)	792 @ 900 149 BMEP (545 kW)	22,000	Napier Turbo	14′ 0″ × 4′ 3″ × 8′ 6″
A.S.R.1 6 L.U.S.	427 @ 900 80 BMEP (293 kW)	470 @ 900 88 BMEP (322 kW)	—	—	20,000	—	12′ 10″ × 4′ 3″ × 8′ 0″
A.S.R.1 16 V.T.S.	1895 @ 900 125 BMEP (1225 kW)	1964 @ 900 138 BMEP (1348 kW)	1925 @ 900 135 BMEP (1325 kW)	2118 @ 900 149 BMEP (1458 kW)	40,500	Napier Turbo	16′ 10″ × 5′ 4″ × 8′ 8″
A.S.R.1 16 V.U.S.	1140 @ 900 80 BMEP (784 kW)	1254 @ 900 88 BMEP (863 kW)	—	—	34,000	—	15′ 8″ × 5′ 4″ × 8′ 0″
A.S.R.1 12 V.T.S.	1340 @ 900 125 BMEP (920 kW)	1474 @ 900 138 BMEP (1012 kW)	1440 @ 900 135 BMEP (990 kW)	1584 @ 900 149 BMEP (1090 kW)	30,000	Napier Turbo	14′ 0″ × 5′ 4″ × 8′ 6″
A.S.R.1 12 V.U.S.	855 @ 900 80 BMEP (587 kW)	940 @ 900 88 BMEP (645 kW)	—	—	28,000	—	12′ 10″ × 5′ 4″ × 8′ 0″