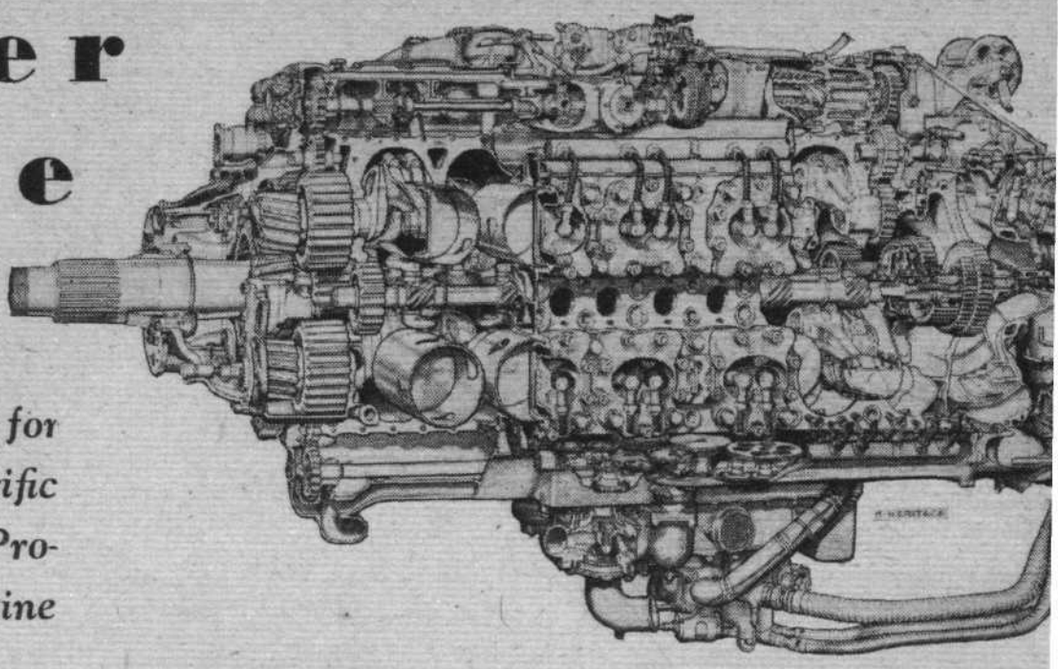
Napier Sabre VII



Over 3,000 b.h.p. for Take-off: Lowest Specific Weight of Any Production Piston Engine

REGULAR readers of *Flight* may remember that a detailed description of the Sabre engine was given in the March 23rd, 1944, issue, together with a good many illustrations, including a special cut-away drawing; but the subject of that description was the Mk. II, whereas the latest Sabre is the Mk. VII.

Series II engines were developed in three guises, the II, IIA and IIB, in which the boost pressures were progressively increased and the power outputs stepped-up from 2,090 to 2,220 and then to 2,420 b.h.p. Weight had also increased, but not proportionally, so that specific weight went down respectively from 1.12 to 1.06 until, with the IIB, it dropped below unity with the value of 0.98 lb./b.h.p.

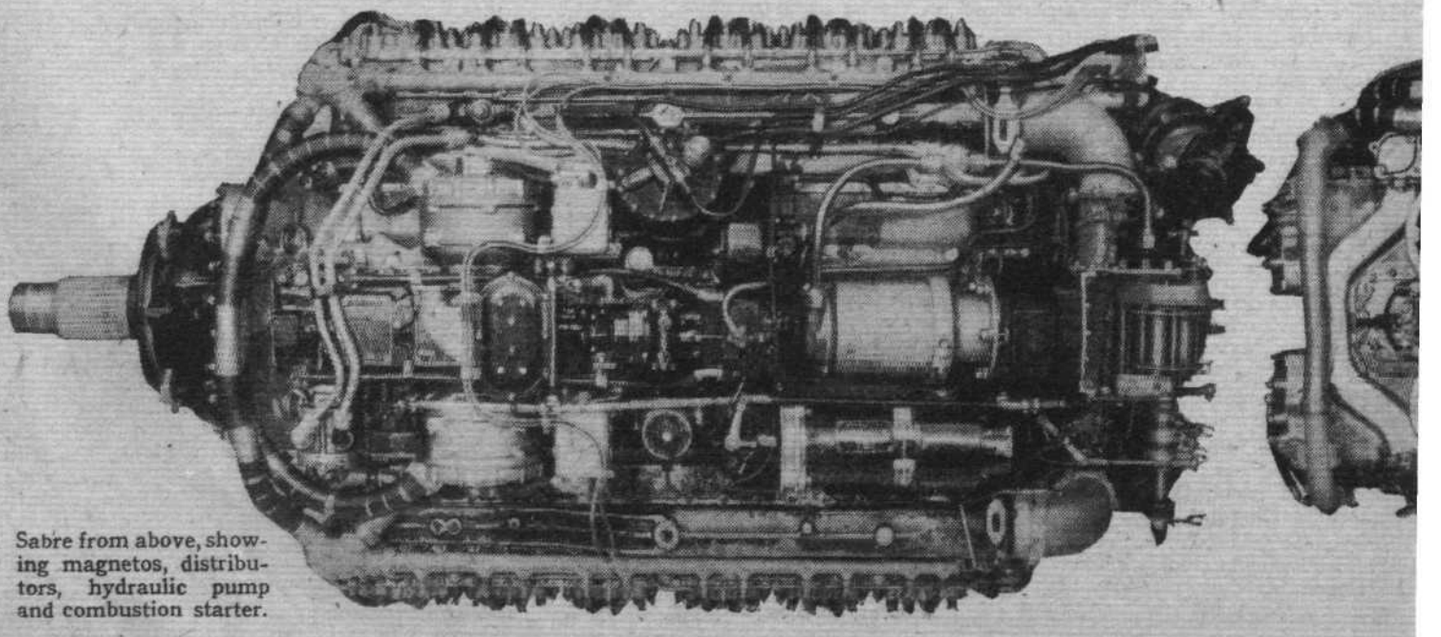
With increased output and increased rate of development the equipment for research and production testing naturally had to be extended, and in their choice of additional testing equipment those responsible displayed the established tendency of Napiers to explore and utilise the latest developments. By building a complete test establishment with fully regenerative dynamometers for engine and unit development the firm created an extremely valuable precedent. (It is interesting to point out that this idea was proposed many years ago by Mr. G. Geoffrey Smith, Managing Editor of *Flight*.) Thousands of gallons of high-octane fuel are no longer burned to produce only hot water, which is immediately cooled again; by using regenerative dynamometers the power output is used to produce electricity for the factory and outside supply, and an example of the output is that if a Sabre is running on a Sunday (when the factory is not working) the electricity generated by a single engine is sufficient to supply the entire demand from the whole Willesden area and still leave sufficient over for feeding into the national grid system.

Teething Troubles Cured

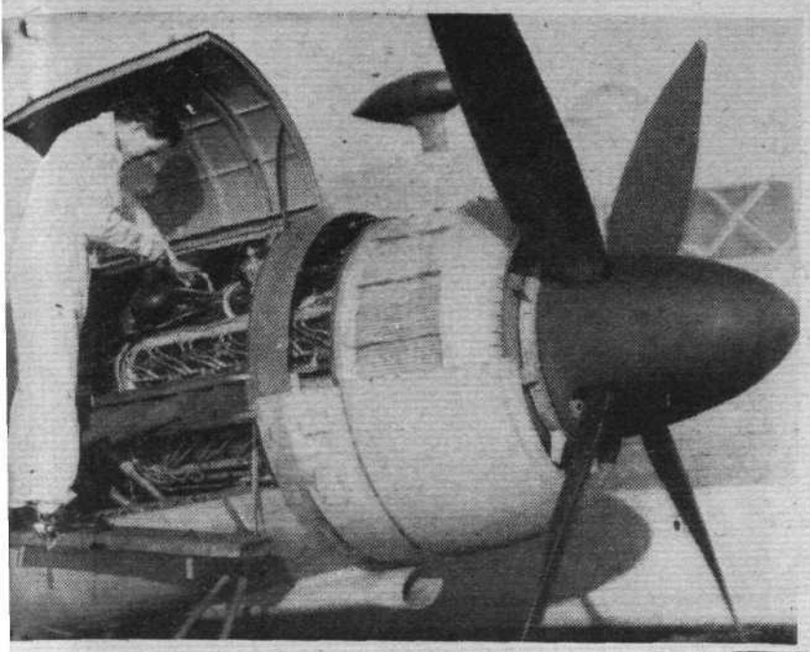
As with all engines developed at high pressure during the war, teething troubles were experienced with the Sabre. One such trouble was sleeve wear due to the ingress of sand and dust from new airfields and landing-strips. The resultant wear was in the nature of a groove, and piston-ring failure followed if this was allowed to become excessive. The consequent investigations were carried to great lengths in order to find a solution, which eventually lay in having the sleeves nitrided and lapped before assembly; but some 18 different materials and manufacturing processes were investigated before the final choice.

Trouble was also experienced with supercharger clutch linings, which was found to be due to the speed-up of pro-

Maximum Power 3,055 h.p. Dry Weight 2,540 lb. ←



Sabre from above, showing magnetos, distributors, hydraulic pump and combustion starter.



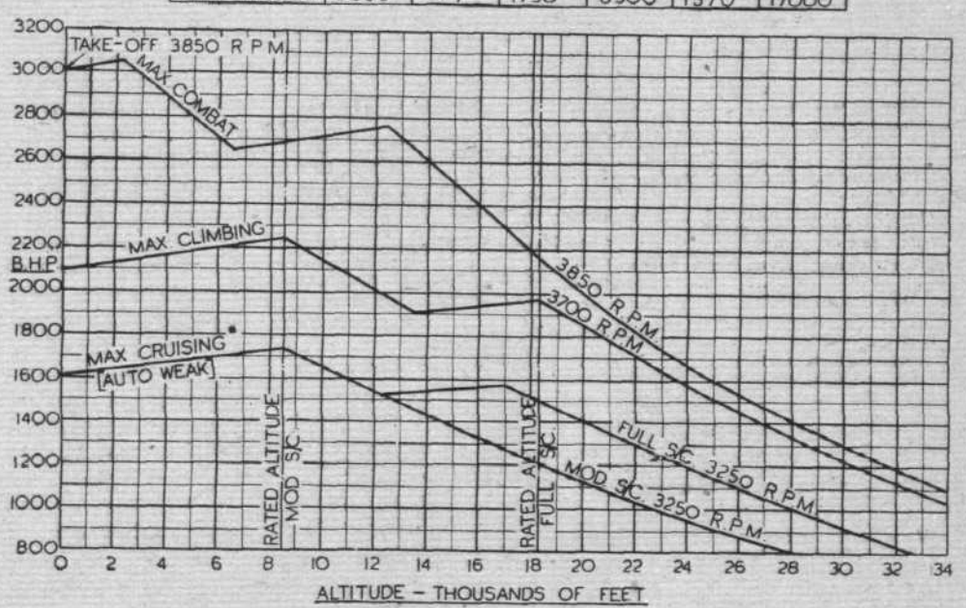
internal increases of strength to withstand higher boost pressures and r.p.m., and the use of Vandervell strip-type thin-wall bearings, this being the first occasion on which such bearings have been used in an aircraft engine with such high r.p.m. and heavy loadings. Disposition of the sparking plugs was also altered and ignition harness was re-designed to obtain more advantage from the high-altitude ignition equipment now fitted.

Supercharger Modifications

The double-entry supercharger impeller was replaced by a single-entry impeller of increased capacity, and the hydraulically operated two-speed clutch was re-designed to effect a saving of space and an increase in efficiency. Remodelling also included the addition of a boost pressure correction capsule to the boost-corrected ignition servo unit which, linked to the c.s.u. and thus responsive to engine speed, regulates the ignition timing for any engine operating condition. Perhaps the major modification of the VA over the previous marks was the replacement of the carburettor with Hobson-R.A.E. fuel injection and metering equipment, which embodies a fully automatic

(Above) Warwick installation of the Napier Sabre VI with annular radiator. (Right) Graph showing performance at altitude of the Sabre VII on 100 octane fuel. *Allows for drop in power due to weak mixture.

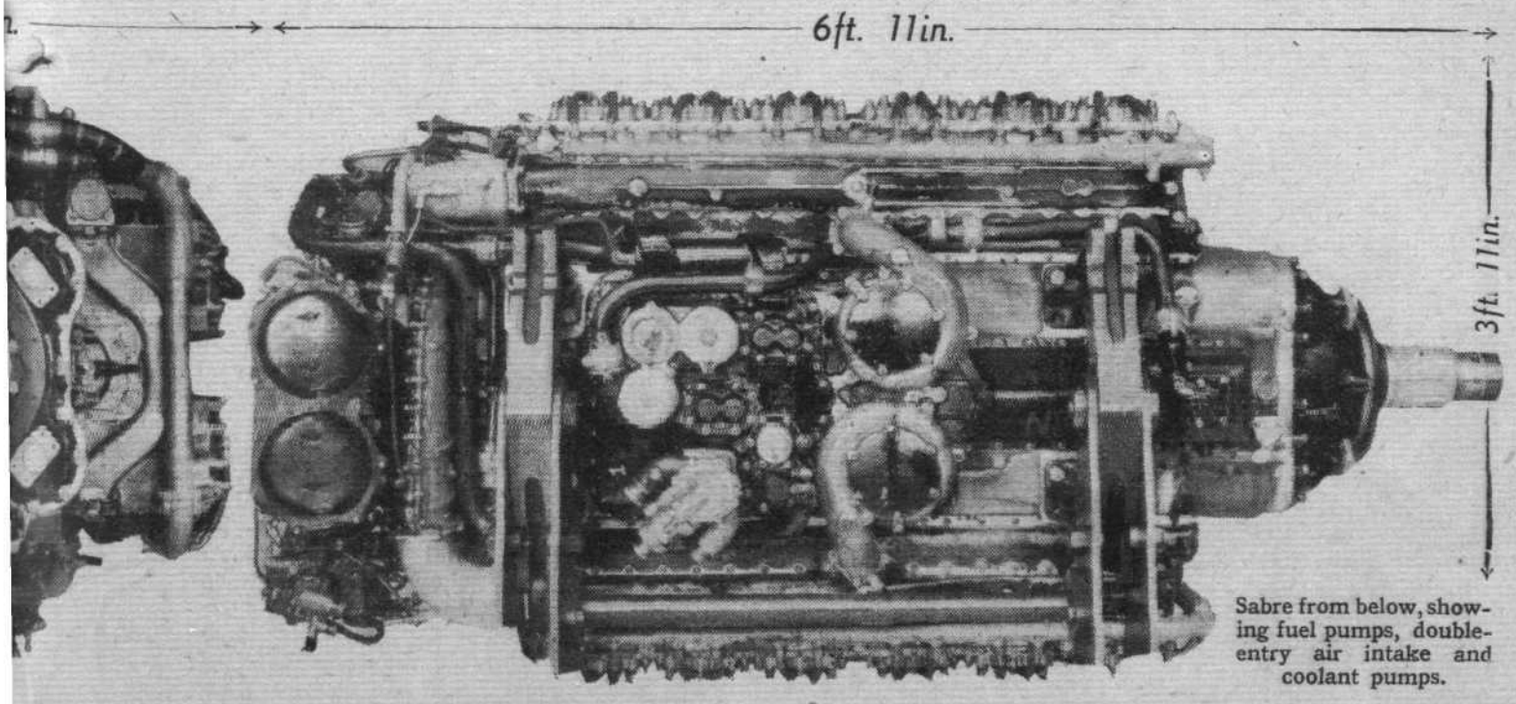
	MAX. R.P.M.	MAX. BOOST LB./SQ.IN.	MOD. SUPERCHARGER		FULL SUPERCHARGER	
			MAX. B.H.P.	ALTITUDE	MAX. B.H.P.	ALTITUDE
TAKE-OFF	3850	+17½	3000	S.L.	–	–
CLIMBING	3700	+10½	2235	8500	1960	18250
COMBAT	3850	+17½	3055	2250	2760	12450
MAX. CRUISING	3250	+7	1730	8500	1570	17000



duction and not to design. The practice of using the linings immediately after manufacture robbed them of an age-hardening process, but an artificial hardening was introduced which satisfactorily overcame the trouble.

The Sabre IIB was installed in the Hawker Tempest V, and this engine was closely followed by a Mk. III which was specially developed for the Blackburn Firebrand; however, only 25 Mk. III units were installed, owing to the very high priority attached to the production of the Mk. V. A preliminary flight development engine for the Mk. V was known as the Sabre IV.

Numerous modifications were incorporated into the design of the Mk. V and VA, among which were



Sabre from below, showing fuel pumps, double-entry air intake and coolant pumps.

NAPIER SABRE VII

boost control unit and charge temperature correction of the fuel/air ratio.

The Sabre VA passed its type test at the first attempt and is now being delivered installed in the Tempest VI. Developing 2,600 b.h.p. for a weight of 2,460 lb., its specific weight is 0.94 lb./h.p. Maximum r.p.m. has been increased to 3,850 and the maximum boost pressure to 15 lb., the unit output being equal to 71 b.h.p./litre.

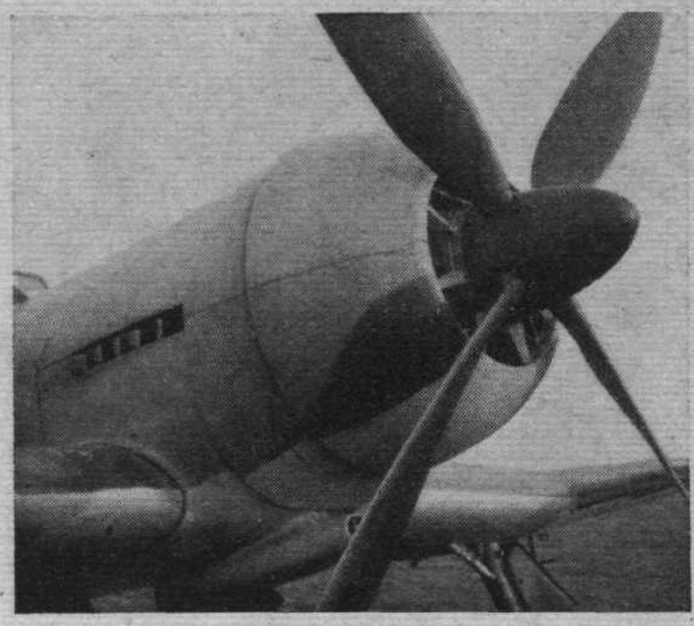
Following a development programme that paid special attention to installation problems, the Sabre VI emerged. This was basically a VA with modifications to suit an annular radiator and an engine-driven cooling fan. Very successful flights have been carried out with this installation and the performance is quite promising. However, this particular form of installation is dependent upon employment in an aircraft especially designed for it if the best use is to be made of the increased performance.

The latest stage in Sabre development has come with the Mk. VII in which the physical capacity of the blower impeller has been further increased in conjunction with water/methanol injection equipment. The purpose of water/methanol injection is to enable higher boost pressures to be used with consequent increase in power output; water has an extremely high anti-detonation value when introduced with the fuel and enhances the effective volumetric efficiency by virtue of charge cooling effect. Methanol, although a fuel, is embodied to prevent the water freezing at high altitudes, 60 per cent. methanol additive offering protection for heights up to 40,000 ft. In the Mk. VII the percentage of water/methanol to fuel is of the order of 35 per cent. in M.S. gear and 70 per cent. in F.S. gear, and it is, of course, necessary to arrange proportionate automatic stricture of the fuel passed by the fuel injector if over-rich mixtures are to be avoided.

An interesting point is that with the removal of a few gallons of fuel from an aircraft and its replacement with water/methanol—which is of greater weight—the range of the aircraft is quite considerably increased, this being due to the higher power output obtained.

Various components in the Sabre VII have been strengthened in order to cope with the increased loads, and the controls have been modified to suit the altered boost pressures and speeds and, further, to ensure that the water/methanol cannot be used except under appropriate conditions. In addition to the water/methanol unit, which is fitted on top of the supercharger bend at the rear of the engine, an ignition control over-ride valve is embodied to vary the effective pressure acting on the capsule in the ignition control unit when water/methanol is being used, and thus to alter the ignition timing accordingly. Two safety micro-switches are fitted to ensure that the water/methanol pump cannot function if engine conditions are not suitable, and a boost-restriction servo-valve is incorporated to prevent combat or take-off boost being used unless water/methanol is being supplied. In addition, the cylinder head form has been redesigned to allow two compression rings to be fitted between the head and the sleeve instead of the single ring used on previous engines.

It should be noted that at maximum combat conditions the



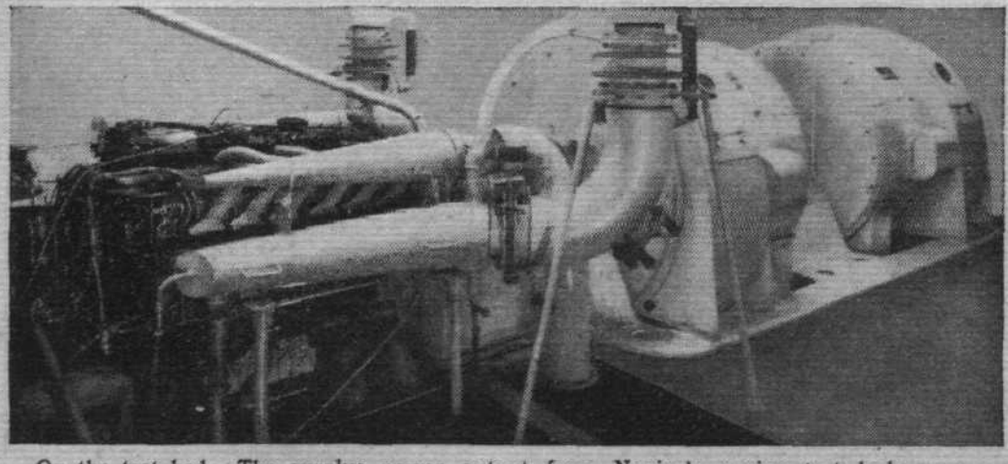
The Sabre with annular radiator installed in a Hawker Typhoon. The fan can be seen immediately behind the airscrew boss.

NAPIER SABRE VII
DATA

Bore	5in. (127 mm.).
Stroke	4¾in. (121 mm.).
Compression ratio	7.0 : 1
Total swept volume	2,238 cu. in. (36.7 litres).
Reduction gear ratio	0.2742 : 1
Reduction gear type	Spur gear through four layshafts.
A/S shaft rotation	Left-hand tractor.
Supercharger drive ratios :—	
M.S.	4.68 : 1
F.S.	5.83 : 1
Net dry weight	2,540 lb. (1,152 kilos).
Rated power :—	
M.S.	2,235 b.h.p. at 3,700 r.p.m. at 8,500ft.
F.S.	1,960 b.h.p. at 3,700 r.p.m. at 18,250ft.
Maximum power (combat) rating—5 minute limit :—	
M.S.	3,055 b.h.p. at 3,850 r.p.m. at 2,250ft.
F.S.	2,760 b.h.p. at 3,850 r.p.m. at 12,450ft.
Maximum take-off power :—	
M.S.	3,000 b.h.p. at 3,850 r.p.m. at sea level.
Continuous cruising (weak mixture) :—	
M.S.	1,610 b.h.p. at 3,250 r.p.m. and +7 lb./sq.in.
T.V. dive maximum	4,050 r.p.m. and +17½ lb./sq.in.

CONSUMPTIONS

Fuel :—	
Max. take-off conditions	235 gallons/hour.
Max. climbing conditions at altitude :—	
M.S.	214 gallons/hour.
F.S.	204 gallons/hour.
Max. combat conditions at altitude :—	
M.S.	239 gallons/hour.
F.S.	241 gallons/hour.
Max. continuous cruising conditions at altitude :—	
M.S.	117 gallons/hour.
F.S.	112 gallons/hour.
Water/Methanol :—	
Max. take-off conditions	65 gallons/hour.
Max. combat conditions at altitude :—	
M.S.	66 gallons/hour.
F.S.	102 gallons/hour.
Oil :—	
At maximum cruising conditions	47 pints/hour.
At maximum climbing conditions	67 pints/hour.
At maximum combat conditions	71 pints/hour.



On the test bed. The surplus power output from Napier's engine test beds goes to augment Willesden's electricity supply. The idea of utilising power developed on test beds—and normally going to waste—was advanced by *Flight* and *Aircraft Production* in 1942.

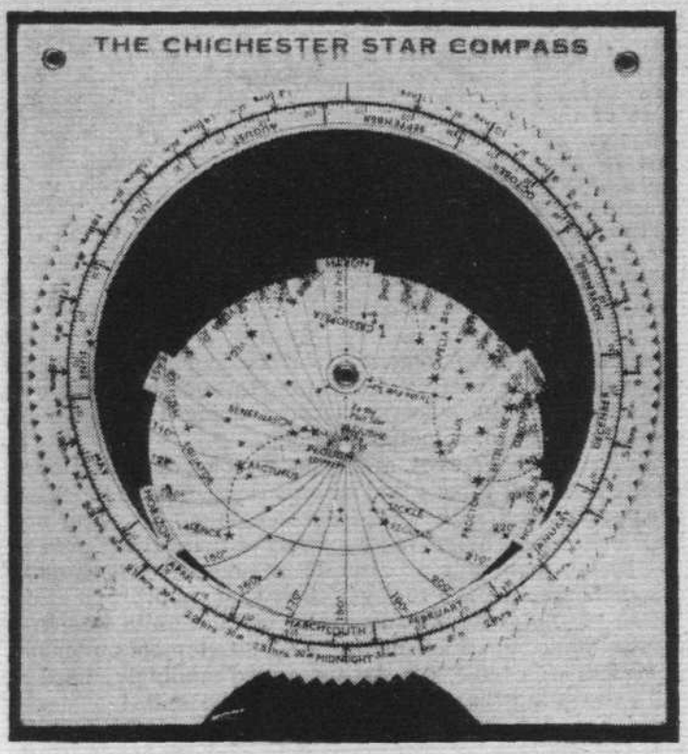
NAPIER SABRE VII

Sabre VII produces no less than 3,055 b.h.p., which is equivalent to the amazing unit output of 83 b.h.p./litre, a figure hitherto unapproached by any other aircraft piston engine in production, and one which represents an increase of 50 per cent. over the original power of the Sabre I—a remarkable achievement which has been attained within a period of five years.

This standard of development applies also to the specific weight, which has gone down to the very low value of 0.83 lb./b.h.p.

UTILITARIAN STAR-GAZING

IT is difficult to know whether one should treat Mr. Francis Chichester's latest navigational device* as a book review. It consists, in fact, of a handy little instrument in the pocket of an explanatory booklet. The "star compass" itself is made up of a rotating disc, carrying the various constellations to be seen in the sky at all times of the year between the latitude belt of 50 deg. and 55 deg. N, covered with a transparent graticule and the whole mounted on a necessary base. By turning the disc to bring the date-marks to coincide with the time-scale on the graticule, the dial provides a picture of the complete night sky at any particular moment. The stars to be seen amongst those used for air navigation are named on the chart in capital letters, while the main groups are named in italics.



Consisting of a rotatable disc carrying the date-marks and star positions, a transparent graticule with a time-scale and bearing lines, and a simple base-board, the Star Compass is quite a small affair. In the position shown, a "picture" is given of the sky hemisphere as at midnight on March 16. The disc's centre of rotation is, of course, the Pole Star, and the opaque section of the graticule covers that part of the star "map" which is not visible on any particular date in the Northern Hemisphere.

Although intended for serious use in setting a course, in checking a magnetic compass, in obtaining the Local Mean Time, or in finding one's longitude, it is felt that the instrument's primary value and interest lies in its educative value as a handy planisphere pure and simple. It can be used for this purpose in most areas of the Northern Hemisphere, and primary students of astro-nav. should, with its use, soon learn both to recognise the various stars of navigational importance and to know their relative positions. For an accurate navigational device it is rather too small, and it is felt that, except in ideal conditions, there might be some difficulty setting the disc correctly and in reading off the appropriate bearings with the required accuracy.

Mr. Chichester, who, at the time of his release from the R.A.F., was Senior Navigation Officer at the Empire Central Flying School, has, nevertheless, produced a most ingenious and useful instrument for the pupil, the casually interested amateur and the navigator travelling in a vehicle somewhat less fast and cramped than the average aircraft. The Star compass is an instrument complementary to the previously "published" Sun compass.

* *"The Chichester Star Compass." By Francis Chichester. George Allen and Unwin, Ltd. 5s. 6d.*

INTERIM R.A.A.F.

THE R.A.A.F. will maintain a strength of 40,000 men until the Government decides what size of force can be carried in peacetime. It will be known as the Interim R.A.A.F. The permanent air force will probably consist of 20,000 officers and men. The Interim Force will remain established for probably another 18 months. Further discharges will be made from the Interim Force when the size of the permanent force has been decided by the Government.

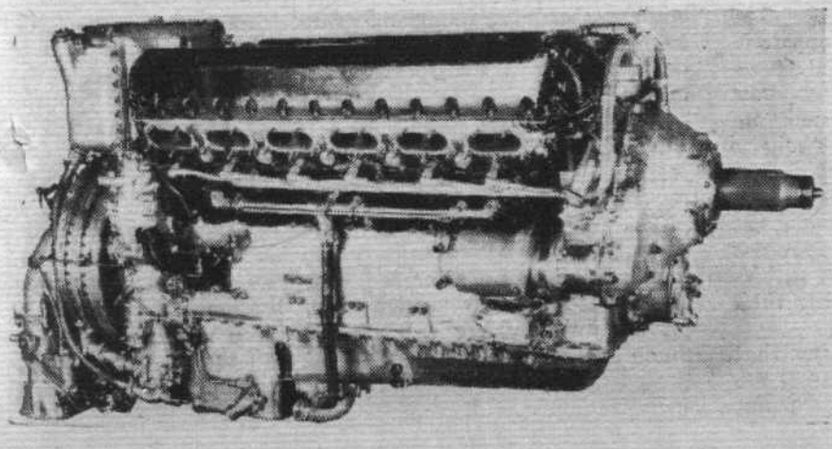
The R.A.A.F. is at present diverting most of its resources to the task of evacuating women and children and prisoners of war from Sumatra, where conditions have been the worst in south-east Asia. In five days it took 2,000 people to Singapore.

SPITEFUL WITH GRIFFON 69

IN the recent release of the Vickers-Supermarine Spiteful it was stated that the aircraft was powered with a Rolls-Royce two-stage two-speed Griffon 61. Strictly speaking, this is not wholly accurate, as the 61 was fitted only to the early prototypes of the aircraft, the normal production machines all having the Griffon 69.

As mentioned in *Flight*, September 20th, 1945, the maximum powers in the appropriate supercharger gears have been increased (in the Griffon 69) to 2,375 b.h.p. at 1,250ft. in M.S. gear, and 2,130 b.h.p. at 15,500ft. in F.S. gear, these being developed at a boost pressure of 25 lb./sq. in. Furthermore, the maximum output of the 69 exceeds that of the earlier two-stage Griffons by some 300 b.h.p. without any increase in weight, and connotes, in addition, that each cylinder contributes no less than 198 h.p., which is equivalent to a unit output of 64.75 h.p./litre and a power of 7 h.p./sq. in. of piston area; specific weight has gone down to 0.88 lb./h.p.

The new Griffon 69 is basically similar to the Mk65 fully described in *Flight* (as above), and differs from the earlier unit only in the arrangement of the ignition timing unit and the automatic boost control.



The 2,375 h.p. Rolls-Royce Griffon 69 as fitted to the Vickers-Armstrongs Supermarine Spiteful.