Engines

ALVIS LTD. is the second largest British aero-engine producer, with an output of one Leonides, or Leonides Major, per day — in addition to which repair and overhaul of RAF Provost engines and those from RAF, RN and civil helicopters is currently running at double that figure, about 60 a month. A high reputation for reliability is being built up by the Leonides, with engines in the Scottish Aviation Twin Pioneer now on a thousand-hour overhaul life.

A surprise was the new 600/625 bhp Leonides 530, which completed its civil type test run and was stripped to the satisfaction of the ARB during the Display. The stroke has been increased from 4.41 in. to 4.8 in., with the result that the diameter also has gone up by 1.5 in. Design practice follows that of the earlier Leonides and it will also be available in vertical helicopter form.

Data: Net dry weight 860 lb.; dia. 43 in., length 54.4 in.; bore and stroke 4.8 in.; capacity 783 cu. in.; compression ratio 7.5:1; fuel 100/130 grade; max. continuous rating 565 ghp (min.) at 3000 rpm, + 6.5 psi boost, 4500 ft.; max. take-off 600 bhp (min.) at 3200 rpm, + 8 psi boost, sea level; max. weak mixture 355 bhp at 2600 rpm, zero boost, 11,250 ft.

Blackburn and General Aircraft also brought one out of the hat, the A.129, a development of the basic Turboméca Palas to a higher pressure ratio and output through the addition of two initial axial stages to the centrifugal compressor. The new compressor is driven by a two-stage turbine, which lengthens the afterbody, and the casing of the axial section of the compressor is extended forward to an annular intake with a circular rear flange for the mounting of accessories. This is the basic "boiler" from which a "Meccano" series of about double the output of the Palas can be built up.

The free-turbine version, first run August 29 has a bifurcated exhaust assembly akin to that of the Turmo—this could be a competitor in the UK twin-1000 hp helicopter engine race. Data are meagre: length 60 in., dia. over accessory mounting plate, 19.75 in.; weight 390 lb., initial rating 840 shp, sfc 0.78 lb/shp/hr.; developed rating 950 shp, sfc 0.66 lb./shp/hr.

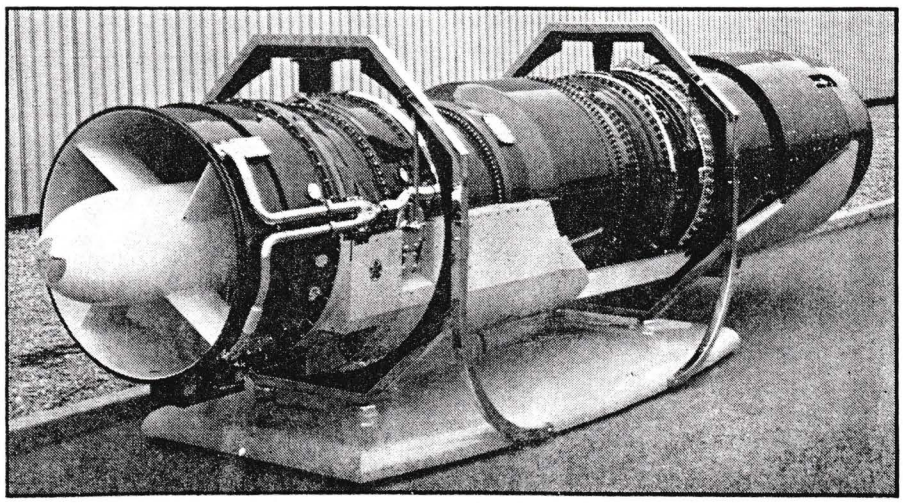
Bristol-Siddeley Engines was in evidence by placards above the adjacent sides of the paternal Bristol and Hawker Siddeley stands, since the company is not yet an SBAC member. It is, in fact, an ambiguous situation, both joint and individual literature being offered on each stand; broadly, however, it appears as a pooling of interests and facilities so that large resources are available to back development and sales of two engine ranges which have little overlap.

Armstrong Siddeley Motors exhibited six beige and chrome plated engines; the Sapphire ASSa. 7R, and Viper XI turbojets, the Double Mamba ASMD.8, P.181 and P.182 shaft turbines, and the minute PR.23 rocket.

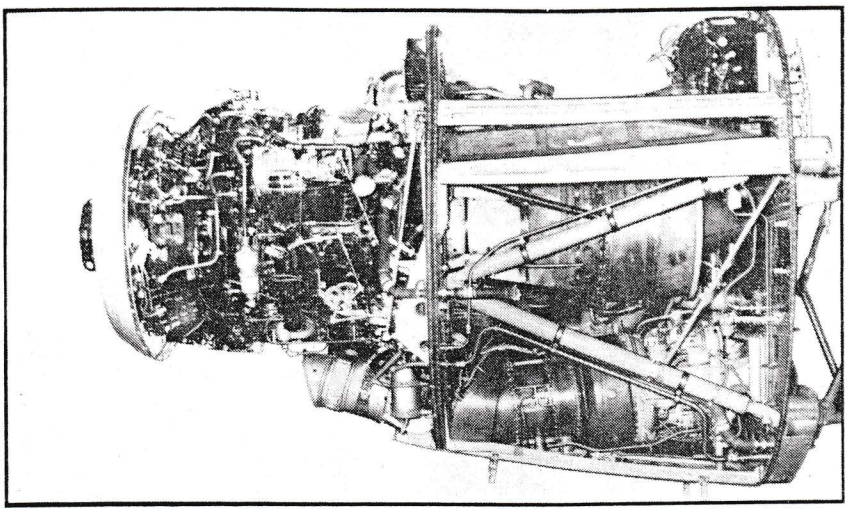
Most interesting were the P.181/P.182 twins, largely re-designed since 1957, of which the former is now running. Although they do not look very much alike, they are basically identical, apart from the power take-off and the control system. Common to both is a three-stage compressor (two axial stages plus a centrifugal) giving a pressure ratio of 5.91 and air mass flow of 12.5 lb./sec. at 20,000 rpm. Air is diffused into an annular reverse-flow combustion chamber containing the familiar ASM vaporising "walking-stick" fuel injectors. A two-stage turbine, of small diameter since it lies inside the inner wall of the combustion chamber, drives the compressor, power being extracted by a free turbine. Accessories are driven by an integral gearbox at the bottom of the axial compressor casing.

The P.181, an all-angle mounting engine for helicopters, has a bifurcated exhaust pipe and the power take-off shaft is short and projects aft. The P.182 turboprop has a straight exhaust, forward-pointing co-axial shaft, sleek annular intake and close-grouped accessories. Data (P.182 in parentheses): length 60:82 in. (60.23 in.); dia. 27.45 (27.45); installed weight 550 lb. (600 lb.); reduction gear ratio 4.95:1 (13.82:1): output shaft rpm 2950 (1,448); power 1020 shp (1175 ehp); sfc 0.71 lb/shp/hr (0.65 lb./ehp/hr).

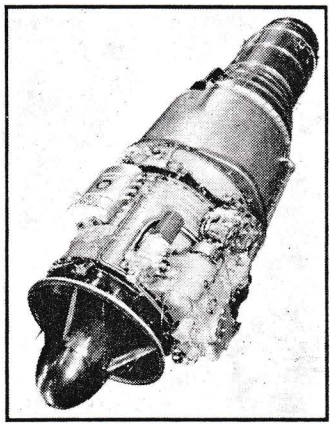
The tiny PR.23 rocket unit, looking something like a blunderbus and weighing only 30-32 lb. for a thrust of 500 lb., showed just what can be done in the way of miniaturizing a variable-thrust rocket. It is offered as a "trimmer" for ballistic missiles, as a control surface augmenter for very high altitude airplanes, as a provider of nose-up/nose-down moments for



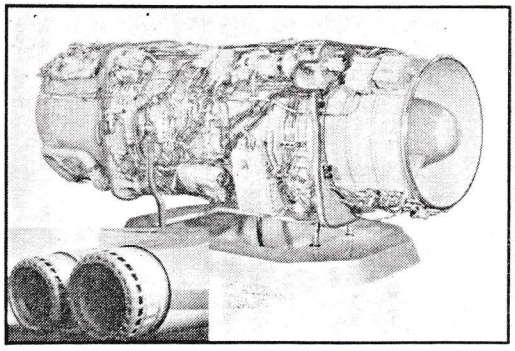
For the second year, Orenda Engines Limited displayed a show model of its big supersonic turbojet, the Iroquois, which was the largest unit in the Show.



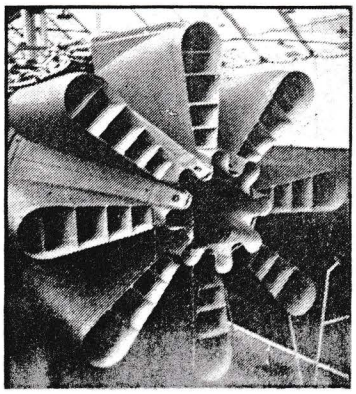
Above, Napier Eland N.E1.6 CL-66, with Blackburn-Turboméca Palouste air starter unit (at bottom, ahead of firewall).



Bristol Orpheus has rating of 4850 lb. th.; weight 825 lb. Thrust/weight ratio of 5.9:1 is highest for any production engine in the world.



Sapphire ASSa.7 with reheat giving 12,300 lb. th. Inset shows variable area nozzle for engine as installed in Javelin FAW-8.



Latest Rolls-Royce noise suppressor, on Conway R.Co.10, can be readily adapted to thrust changes by fitting new central nozzle unit of appropriate area.

heavily loaded aircraft at take-off, as an emergency motor, or even as a prime-mover motor.

Bristol Aero Engines showed the Olympus 200 series with Solar Aircraft designed variable-area afterburner, the Orpheus and a Proteus 765.

The Proteus 765 has higher cruising power and lower fuel consumption than the 755 fitted to the first long-range Britannias. Data: dry weight 2900 lb.; length 100.6 in.; diameter 40.1 in.; air mass flow 44.3 lb./sec.; pressure ratio 7.2:1; take-off power 3960 shp + 1260 lb. = 4445 ehp, sfc 0.60 lb./ehp/hr; typical cruise (ISA, 25,000 ft., 325 kts. TAS), 2197 shp + 380 lb. = 2672 ehp, sfc 0.486.

Bristol also showed some diagrams and literature suggesting the virtues of the ramjet for long-range missiles, stand-off bombs and supersonic airliners. In addition to suggesting that material research will enable M 7.0 or M 8.0 engines to be designed in the future, a more modest suggestion was for a M 3.0 80,000 ft., 400,000 lb. airliner to fly from London to Montreal in two hours. . .

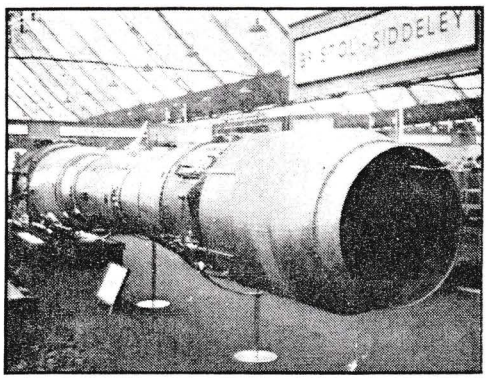
The de Havilland Engine Company lined up its products, from the reciprocating Gipsy Major 215, through the shaft-turbine Gnome (GE-licensed T-58), fixed and variable thrust Spectre rockets, Gyron Junior, transonic DGJ.1 and supersonic DGJ.10, with the latter's afterburner uncoupled, to the almost 30,000 lb. thrust (reheated) Gyron DGy 2 for the Hawker P.1121 interceptor.

The Gyron is a low pressure ratio lightweight turbojet scaled down on the "square-cube law" from the Gyron. The DGJ.1 version appears to be a straightforward turbojet, made in conventional materials, with a horizontally-split compressor casing housing a six or seven stage compressor and variable inlet guide vanes. It has a characteristic British integral oil tank in the cast light alloy intake annulus, with hot-air bleed from the compressor for anti-icing the whole assembly, including the starter nose bullet and the VIG vanes. Accessories are compactly grouped under the belly of the compressor, where they are driven by a gear train, itself driven by a shaft in the vertical nose-bullet strut.

The fully annular combustion chamber has been kept well within the intake diameter and is fitted with

13 Duplex fuel injectors supplied through rigid primary and secondary fuel piping. Around the combustion chamber is an air-bleed annulus for tapping high-pressure air to the super-circulation system in the airframe—specifically the flaps and ailerons of the Blackburn NA.39. There appear to be two turbine stages to drive the large air-mass flow compressor. It is palpably a transonic powerplant in which some sacrifice in specific fuel consumption has been made in order to have a small, light, and simple engine.

Following through the DGJ.10 one finds modifications for high supersonic speeds—this version was intended for the sadly cancelled Saro SR.177 Mach 2.5 dual-power fighter. The first change is the removal of the oil reservoir from the intake annulus, where supersonic ram compression would heat the oil, to a tank on the port side behind the main group of the accessories—there is a fuel-cooled oil cooler among them. The new intake annulus is fabricated from sheet metal and carries air ducts for compressor-bleed anti-icing—at cruising and low speeds. The compressor casting is split four ways, another indication of the heat of speed, since it means a change to heat-resistant material (probably titanium alloy) at the delivery end. There appears to be seven stages and in addition to VIG vanes there is a single row of variable-incidence stator blades, which are actuated by individual hinged links from the VIG vanes.

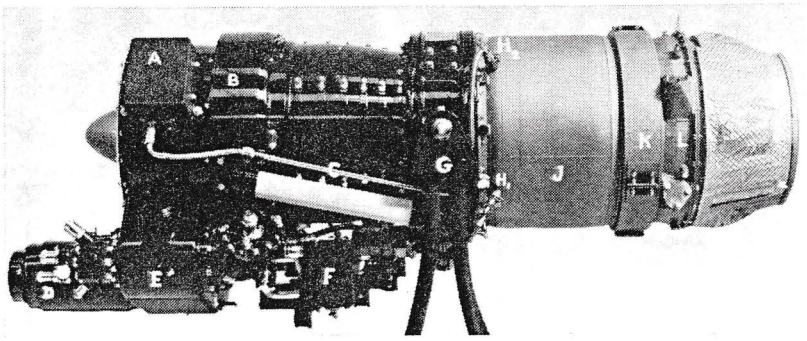


A new name and an outlet: Bristol-Siddeley showed the Olympus 200 with Solar variable-area afterburner nozzle.

The DGJ.10 has a similar air-delivery duct to that of the DGJ 1, save that it appears to be fabricated from heat-resistant alloy instead of being a light metal casting. The annular combustion chamber has no air-bleed shroud for BLC—the delta wing SR.177 was to have had leading-edge flaps, but not flap blowing. A muff round the zone of the inner tail cone support struts indicates that very hot gas is tapped for some purpose. Possibly because of its two-bearing shaft, the DGJ.10 has three pairs of mounting points, on the air intake casing, the air-delivery casing and the first-stage turbine shroud. Security had required the detachment of the vast supersonic afterburner and, with its length wrapped in heat-insulating blankets and its orifice blanked, little could be seen save that it seemed considerably larger than the Gyron Junior! The variable convergent-divergent nozzle is of multi-leaf type, but appears to be much simpler than that for the Gyron shown at last year's Paris Salon.

D. Napier and Son celebrates this year not only the company's 150 Anniversary but also its first postwar production products—the Eland turboprop, the Gazelle free-turbine, and the Double Scorpion rocket. This time the Eland was flying not in a testbed aeroplane, but as the powerplant of the twin-engined Fairey Rotodyne and Westland Westminster prototypes. In its N.E1.6 form, the Eland is now in production for the Canadair CL-66 and for the re-engining program for the CV-340 and CV-440 airliners that are meeting Viscount competition. An interesting feature of the CL-66 Eland installation is the inclusion of a Blackburn-Turboméca Palouste LP air starter with a Rotax turbine for Arctic operation. The original piston engine nacelle line leaves ample space for the slender turboprop and the tiny air compressor. At present the Palouste is installed only for starting, but it is likely to be modified with a clutch drive to the airframe accessory gearbox, so that it can be used for emergency and ground servicing.

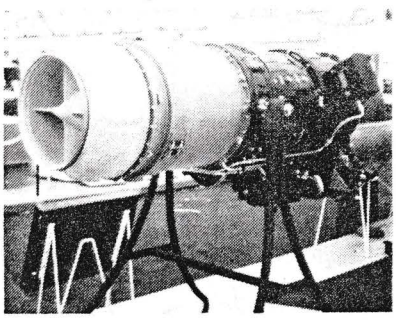
The free-turbine Gazelle is now being delivered in some quantity for the Royal Navy's single-engined Westland Wessex and the RAF's twin-engined Bristol 192. The Double

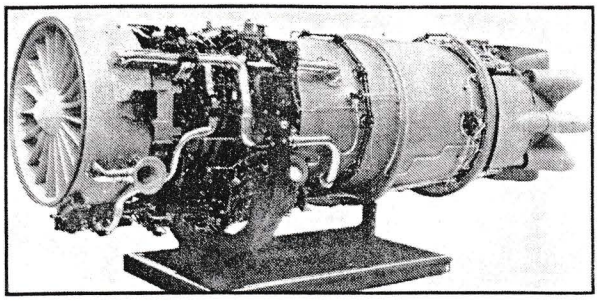


A newcomer was the Rolls-Royce RB-145, which, in this view, is almost dwarfed by its "etceteras". Indicated by the annotations are: A—HE igniter box; B—"Zero" compressor stages; C—anti-icing hot air bleed; D—generator; E—wheelcase and oil tank; F—fuel accessories; G—air delivery casing with trunnions and integral fuel gallery; H_1 and H_2—HE igniters; J—annular combustion chambers; K—air-bleed annulus (?); L—air impingement starting annulus (?).

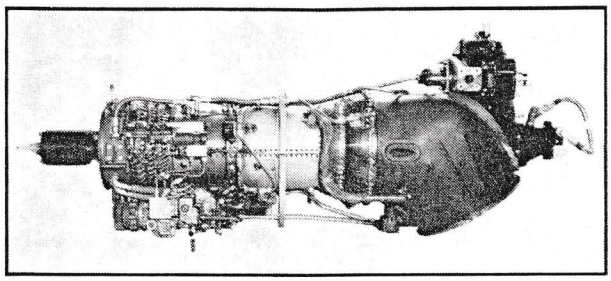
The three-quarter rear view of the RB-145 at lower right makes an interesting comparison with the top photo, which shows the other side of the engine.

The RB-145 has a similar main body to that of the RB-108 VTOL engine, from which it was developed. However, the six-stage compressor casing has been extended forward and probably incorporates one or two "zero stages" to increase the pressure ratio. A thrust of 2750 lb. has been given.

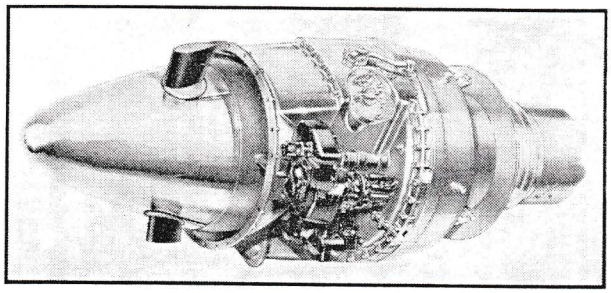




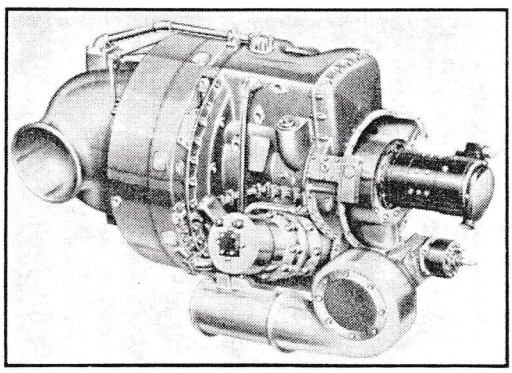
R-R Conway R.Co.10 Mk. 505 powerplant for Boeing 707/420 has integral thrust reverser and reheat.



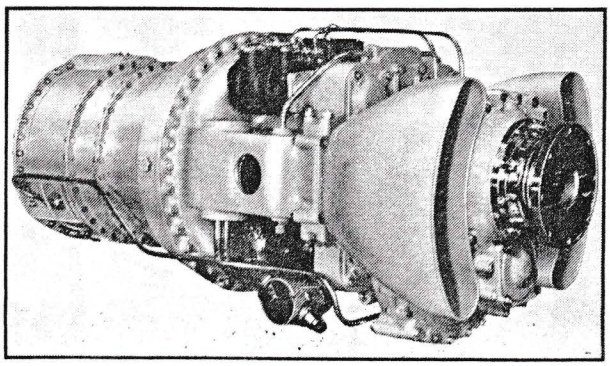
The D.Ge.1 Gnome is the de Havilland-built version of the 1000 hp General Electric T-58 turboshaft.



Armstrong Siddeley P.182 turboprop develops 1100 shp plus 200 lb. th. Weight, 600 lb., and length, 60 in.



Armstrong Siddeley P.181, similar to P.182, but intended for helicopters, etc.



One of the Blackburn line of small turbines, the Artouste 600 fixed shaft drive unit of 475 bhp.

Scorpion rocket was shown in part of its twin-finned ventral pack for the English Electric Lightning.

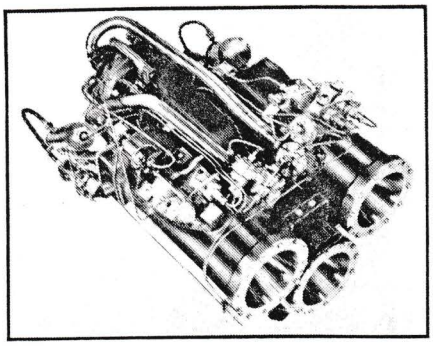
Orenda Engines again exhibited the mighty Iroquois (show model), still the largest unit in the Show. This year the afterburner nozzle was unmasked —which was a dubious blessing since the mechanism revealed has been superseded! It proved to be a many-leafed design, very slightly convergent-divergent when open, and each of the leaves has a hardened arcuate cam running on a grooved roller. One understands that, like so many afterburners, the new design has fewer leaves and a simpler mechanism.

The Rolls-Royce stand was the tops for interest with the Conway 505 powerplant, civil Avon RA.29 (with a case of 1000-hour components), Avon RA.24R with afterburner, Tyne powerplant, sectioned Dart R.Da.7 and, out of the hat, the RB.145 lightweight turbojet.

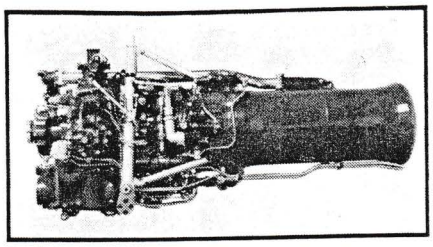
Two versions of the civil Avon are offered, the Mk. 525 for shorthaul use and the Mk.524, lightened by titanium compressor blading for range flying where every pound counts, at the cost of another £2600 sterling. Initially, the civil Avon enters airline service in the Caravelle and Comet with a 1000-hour overhaul life at a thrust rating of 10,500 lb., later, when Rolls-Royce considers that airline experience warrants it, 11,700 lb. and 13,300 lb. versions will be available to cater for rising airliner weights.

The compactness of the Conway R.Co. 10 (Mk. 505 pod powerplant for the Boeing 707-420 and closely akin to that for TCA's Douglas DC-8) with its integral thrust reverser and afterburner was quite remarkable and should dispel forever criticisms about the bulk of by-pass turbojets. The fabricated air intake annulus has fixed inlet guide vanes with a small nose bullet—as a two-spool engine the starter drives the HP shaft—and has two HP compressor delivery hot-air bleed pipes for anti-icing plus two spill outlets.

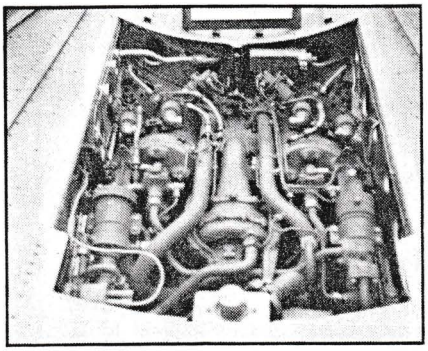
Compactly grouped round the LP compressor casing (black area) are the accessories, with a wheelcase drive for oil and fuel pumps under the belly and integral with a surprisingly small (24 pints) oil tank. The fuel system incorporates a fuel heater, fed from the hot-air bleed, as well as a fuel-



Napier Triple Scorpion rocket motor can be stopped and started at will at any altitude. Self-igniting combination of oxidant and fuel is used.



DH Spectre 5-rocket engine has a thrust output fully variable from idling to max. rated power. Suitable for use in high performance interceptors or missiles.



Rocket "pack" is an appropriate term for the way the Napier Double Scorpion is pannier-mounted for the English Electric P.1B Lightning.

cooled oil cooler. Rigid piping is used for the fuel gallery to the Duplex burners which is mounted on the relatively cool (under 200°C) by-pass duct. Under the combustion zone can be seen a small common-drain tank. Starting is by way of a Sunstrand drive to the HP rotor from an air turbine. The system for large airplanes is to install a turbocompressor APU in one nacelle and start the other engines by air bleed from the first one.

For pod mounting, the Conway has three-point suspension — two fittings on top of the LP compressor casing and one above the turbine housing. The thrust - reverser/noise-suppressor assembly is a remarkably compact unit. A cowling mounting ring is bolted to the jet pipe and carries, above and below, the jack assembly for actuating the internal deflecting doors and the external fairing panels. When the latter are swung open they reveal an area of perhaps two-and-a-half square feet on each side containing a grid of deflecting louvers. These are made of Nimonic alloy with longitudinal strips bolted to the front edge of the opening and gudgeoned to fittings at the rear end—naturally this part is subject to severe thermal shock and its simplicity belies its tricky design problems.

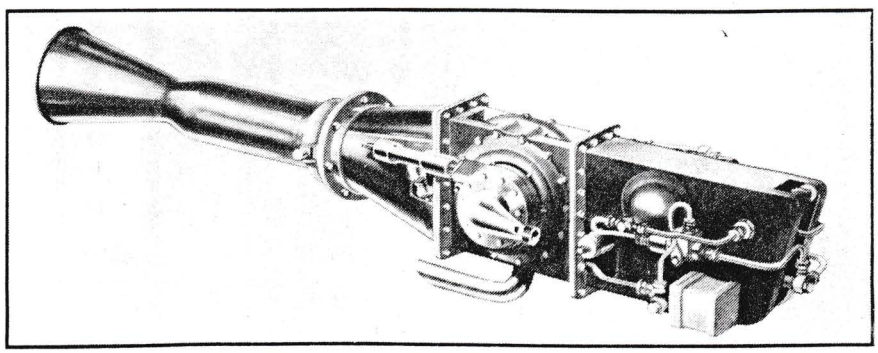
The crenellated suppressor differs from that on straight turbojets because the cool by-pass airflow makes it unnecessary to induce cold air into the louvered "splitters". Negligible drag in cruising flight, as well as minimum thrust loss are claimed for the unit. Both the thrust reverser and the suppressor have been designed to last the overhaul life of the engine itself.

Most figures for the Conway are still reserved for the military and privileged airline officials; but the initial thrust will be 16,500 lb.; then, after airline experience, the fuel system will be re-calibrated, without charge to the customer, to raise the thrust to 17,500 lb. (R.Co.12 rating); after which a change of turbine materials at overhaul (cooled blading is already in use on the R.Co.10) will raise it to a guaranteed minimum of 18,500 lb.

Continuing the by-pass story was an artist's impression of the RB 141, of 12,000 lb. initial take-off rating, which is being developed for British European Airways' three-jet DH.121.

The RB.145 is a conventional development from the elemental VTOL RB.108 and so small is it that its accessories appear disproportionately large. The RB.145 has a similar main body, but the six-stage compressor casing has been extended forward and probably incorporates one or two "zero stages" to increase the pressure ratio and thereby improve the sfc. Under the air intake is a wheelcase and integral oil tank on which are mounted fuel and oil pumps and, projecting forward, an alternator. The high-energy ignition box on the port side looks large in comparison with the 15 in. diameter compressor; under the belly of the casing are fuel control and distributor units; and on the port side a compressor air bleed delivery pipe for intake anti-icing.

Like the RB.108, the fuel gallery is internal and the combustion chamber is probably fully annular. An annulus just ahead of the turbine appears to be a pressure air-bleed—in the RB. 108, delivery air is tapped for the balance/control jet system. Bosses on the turbine shroud suggest that air-impingement starting, again as in the RB.108, may be used. That is, air is blown on to the turbine itself to rotate the engine. The only figure given for this engine is its thrust of 2750 lb.



Armstrong Siddeley's PR.23 500 lb. th. rocket engine is intended for such applications as augmenting the control surfaces of aircraft at great altitudes.