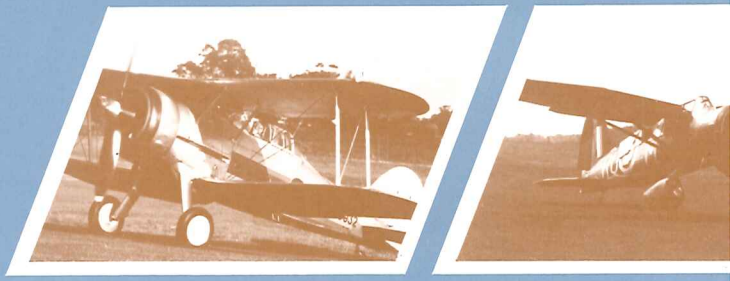
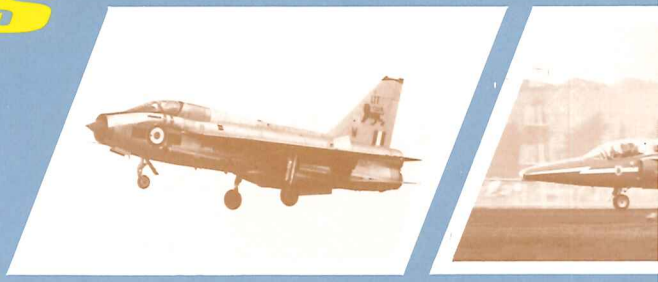
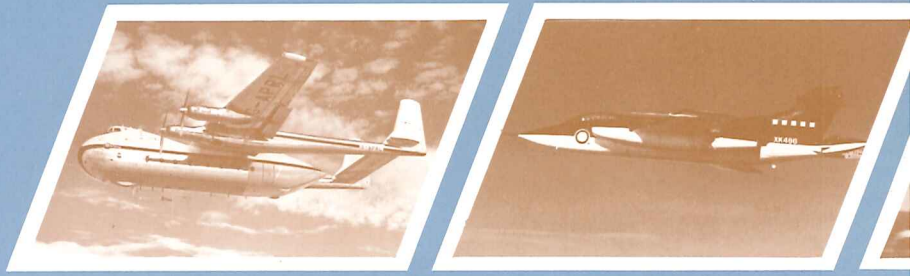
Dowty Rotol landing gear

Kawasaki KD 5/92 with Dowty Rotol internally sprung wheels

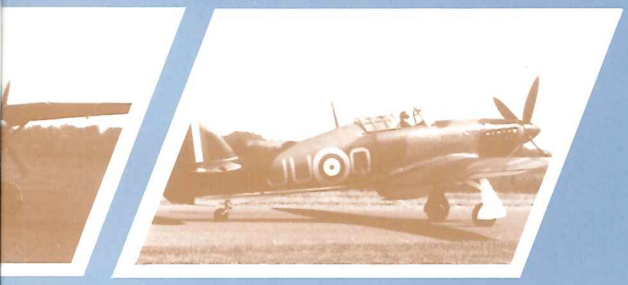


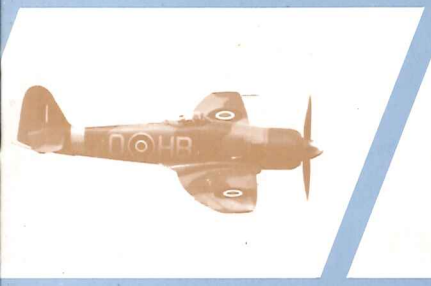


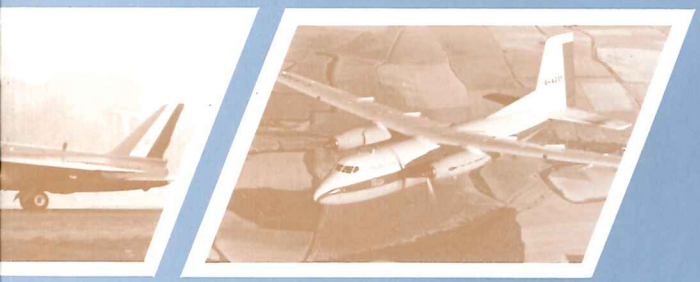


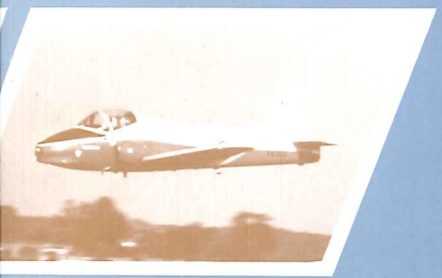
Dowty landing gear has been fitted to over 200 different types of world aircraft

Front cover:
Panavia Tornado fitted with Dowty landing gear









Fifty years ago the Japanese Kawasaki KD 5/92 was fitted with the first Dowty landing gear which incorporated the ingenious internally sprung wheel. Since then, over 135 000 landing gears have been produced.

Today Dowty leads world aviation in the design, development and production of landing gear for civil and military aircraft and offers a total service from design concept and programmed engineering, to full certification clearance and world-wide product support.

Airbus A310 and below, the main landing gear by Messier–Hispano–Bugatti in collaboration with Dowty Rotol

Dowty landing gear on AV- 8B

Landing gear expertise

In 1931 Dowty produced the world's first internally-sprung landing gear wheel. The shock absorber and brakes were housed in the wheel thereby enabling the realisation of an aero-dynamically clean fixed-type landing gear. The first order was for the Japanese KD 5/92 aircraft, the second for the British Gloster Gladiator.

Many other original landing gear ideas followed including the liquid spring shock absorber, a principle applied to a number of the world's high performance aircraft. Because of its compactness when landing gear space is at a premium, it contributed towards ease of maintenance and gave long service efficiency. Dowty also pioneered the introduction of nitrogen into shock absorber hydraulics achieving savings up to 25% in volume and 40% in weight and an improved performance over a wider temperature range.

The equally ingenious kneeling-type landing gear developed by Dowty for freighter aircraft provided the means of varying the height of freight floors to facilitate loading. This was accomplished by a levered suspension geometry incorporating a two-stage system of shock absorption.

Another Dowty innovation was controlled articulation for bogie-type landing gear.

In the VTOL/STOL landing gear fields, Dowty acquired unrivalled experience on the Kestral, P.1127, Harrier and Dornier Do.31 projects. This technology is being applied to the McDonnell Douglas AV-8B and other advanced VTOL/STOL aircraft for the 80s. The developments include quadricycle configurations with the nose and main units in line under the fuselage and outrigger wheels acting as stabilisers below the wing tips.

Similarly Dowty has acquired unique experience on landing gear for deck landing aircraft and has produced specialised units which are particularly robust for a whole series of carrier based machines such as the Buccaneer, Sea Hawk, Sea Fury, Seamew, Sea Prince and the Sea Harrier in service with the Royal Navy. Landing gear for these applications incorporate design features to cope with arrested landings, catapult and ramp take-offs, also deck rolling.


MARINES
MCDONNELL
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Landing gear design, test and development

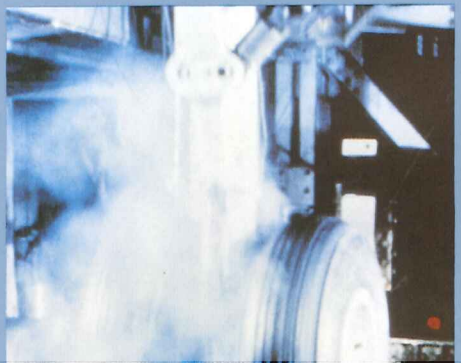
Using models during design

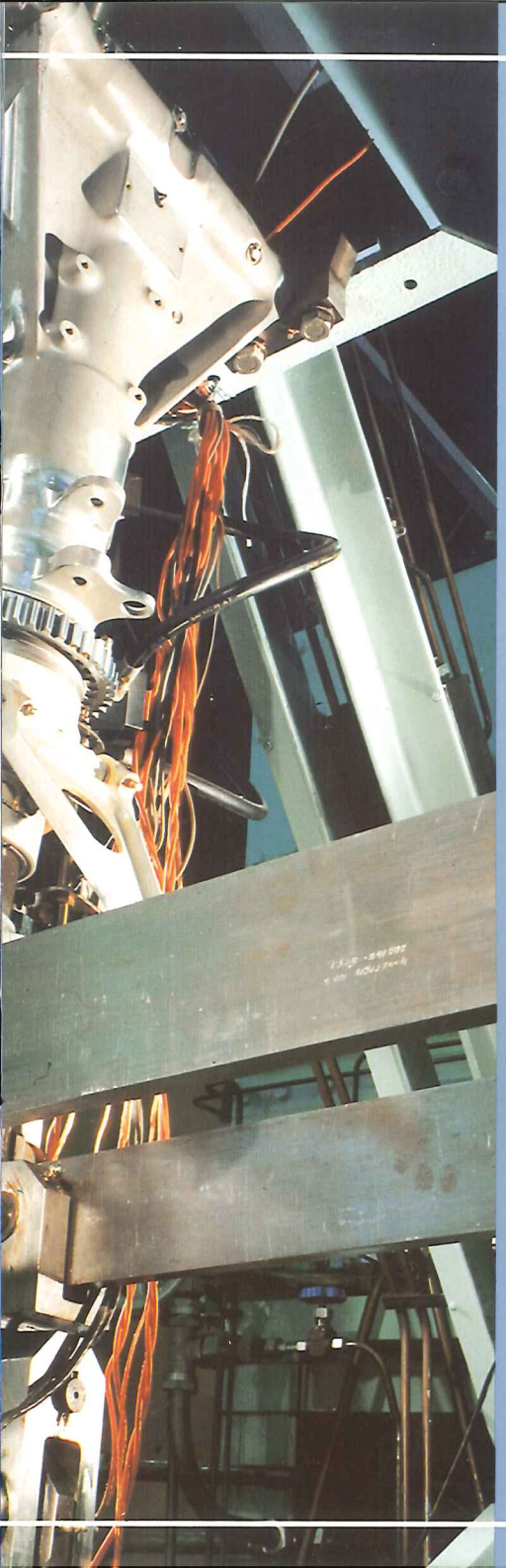
The design of landing gear for modern high performance aircraft involves a large number of disciplines and specialist techniques. The process must produce a landing gear of minimum weight. Special emphasis must also be placed on the design of bearings and mechanisms to achieve the high degrees of durability required in all landing gear applications. Dowty's vast wealth of experience, with over 50 years of design and production, ensures that all its landing gears are built to these same rigorous standards.

The unique complex of Dowty Rotol facilities includes a staff of over 250 specialist engineers using the most modern techniques, hundreds of test rigs and investigation laboratories for metallurgy, chemical problems, stress analysis and radiography.

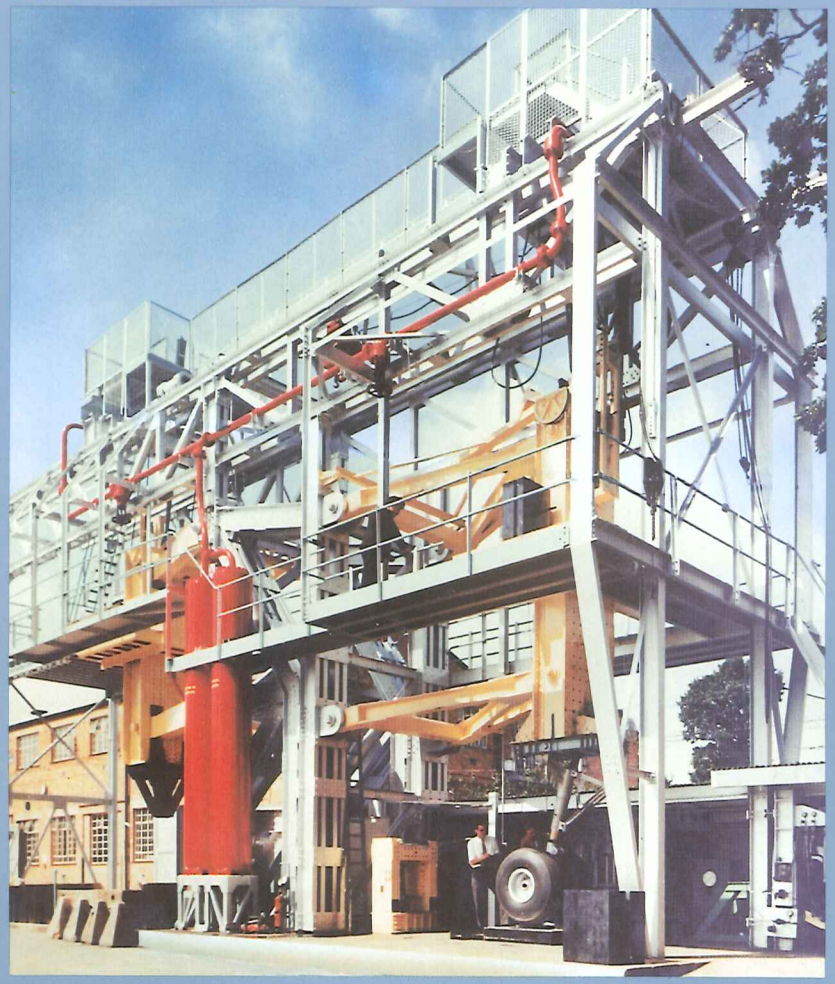
Test requirements cover every aspect of landing gear development and fall into seven main groups, drop rotation of the wheels before drop testing commences.

The principal structural landing gear components are tested statically to determine ultimate strength. During loading, brittle lacquer, the use of photo-elastic film with polarised

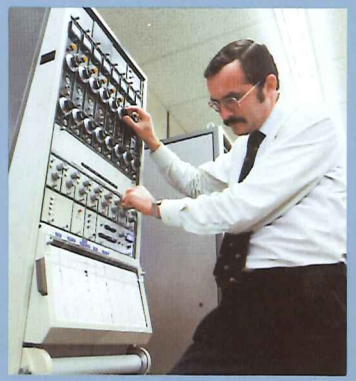




Drop test rig for landing gear up to 400 000 lb auw



Air Gabon Fokker F.28 with Dowty landing gear



Landing gear fatigue test control console

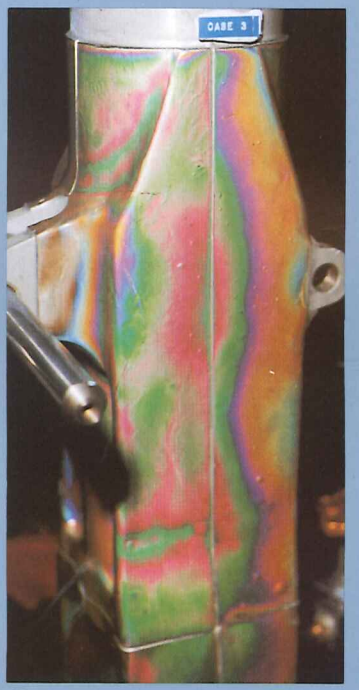
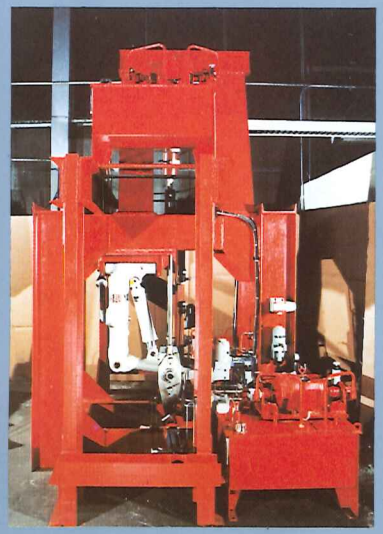
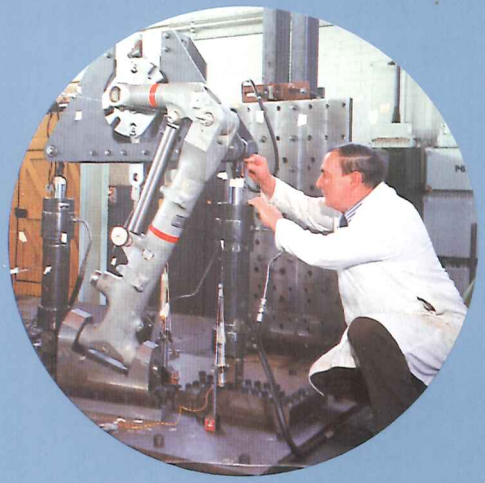


Photo-elastic testing



Fatigue testing Canadair Challenger 600 landing gear



Strength testing Casa Aviojet landing gear

light and strain gauge techniques, are used to verify stress levels and pin-point stress concentrations. The test facility is equipped with loading machines capable of accommodating landing gear structures for small single engined aircraft through to large body civil airliners and military aircraft.

As it is necessary that no major components should be replaced during the life expectations of the aircraft, complete landing gears are mounted in test rigs which operate at many loadings a minute. This covers the complete cycle of loadings to which the landing gear will be subjected in service including ground manoeuvring, engine run-up, taxi-ing, take-off, retraction, lowering, landing and braking. In fact, the complete cycle from take-off to safe touch down.

Dowty landing gear on Casa Aviojet

Complete fatigue testing may involve continuous running of the test rig for up to three years, during which time 250 000 landing cycles will have been achieved and providing the operator with quipment fully certificated for up to 60 000 landings. This important design and testing process, in addition to providing long finite life, enables Dowty also to achieve long periods between overhauls. Some civil aircraft fitted with Dowty landing gear are currently achieving 20 000 hours between overhal and that means a lot more operating time and lower operating costs.

Other rigs include portions of the aircraft structure so that all attachment points are completely tested.

The company's range of functioning test rigs ensures the satisfactory operation of all mechanical, hydraulic and electrical equipment associated with the landing gear.

Special rigs with rotating drum assemblies are used in-house to test freedom of shimming and to check steering system performance, resolution, efficiency and durability.

Environmental testing for landing gear follows British and American standards regarding temperature, pressure, humidity, vibration and shock; salt spray, sand, dust and explosive atmosphere; acceleration, explosive decompression and electro-magnetic interference. Separate environmental tests are carried out on paints and seals, to ensure durability and storage life.

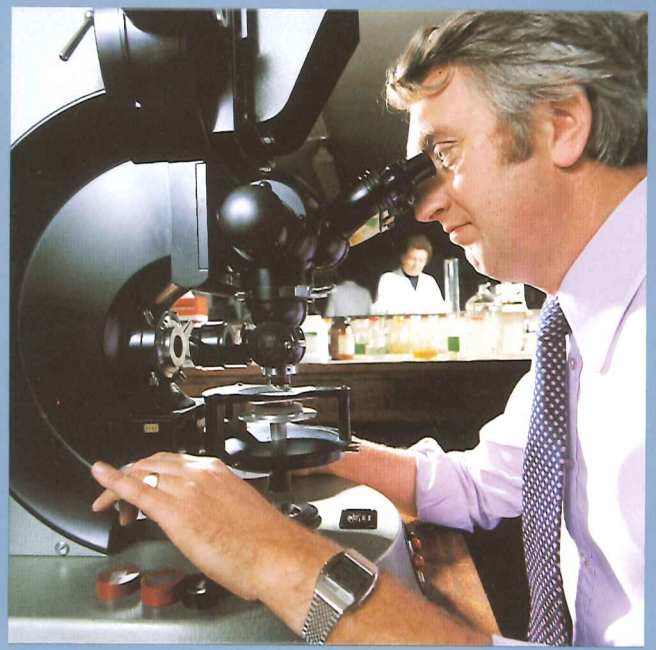
The design and qualification of landing gear is a continuous process of evolution and today includes the utilisation of advanced materials and technology, able to cope with the increasingly arduous parameters required for modern civil and military aircraft.

A major Dowty development is that of springing and damping characteristics to optimise performance for operation of tomorrow's aircraft from semi-prepared and unprepared runways.

B.Ae 146 is to be fitted with Dowty landing gear

Atomic absorption spectrophotometer

Analysis of chrome plating solution for landing gear



Tensile testing plastics

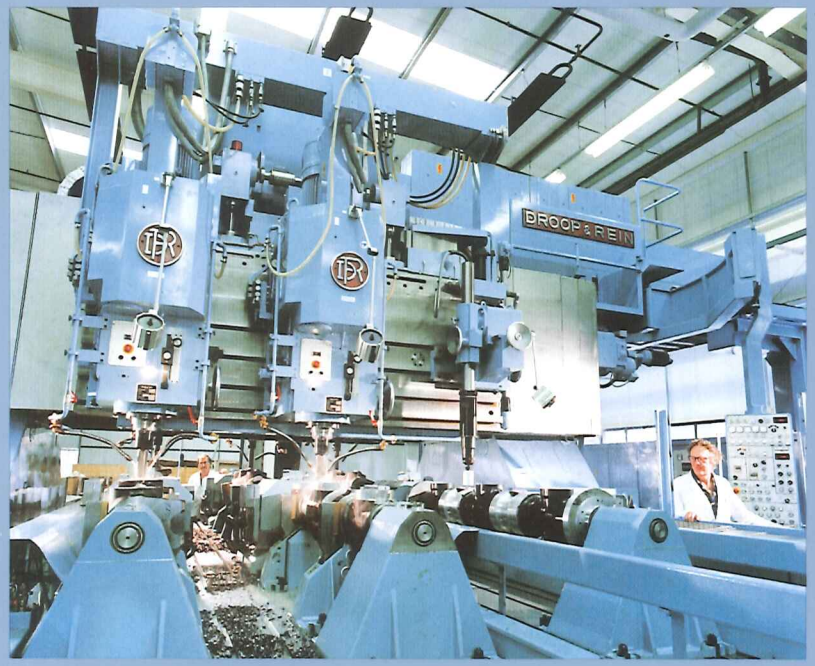
Metallographic examination of landing gear sample

Landing gear production

Company manufacturing capacity covers 70 600m^2 (760 000 ft^2) floor space, of which 7432 m^2 (80 000 ft^2) is taken up with landing gear production. Machines range from deep hole borers with capacities up to 760 mm (30 in) diameter swing and 3650 mm (144 in) between centres – through numerically controlled lathes, profile mills, external and internal grinders – to vertical honers with a maximum stroke of 1825 mm (72 in).

Machining centres are used for both light alloy and steel landing gear fittings. Manufacturing processes include roughing out operations on the forgings, heat treatment in the company's own facility and further precision machining to finished drawing dimensions.

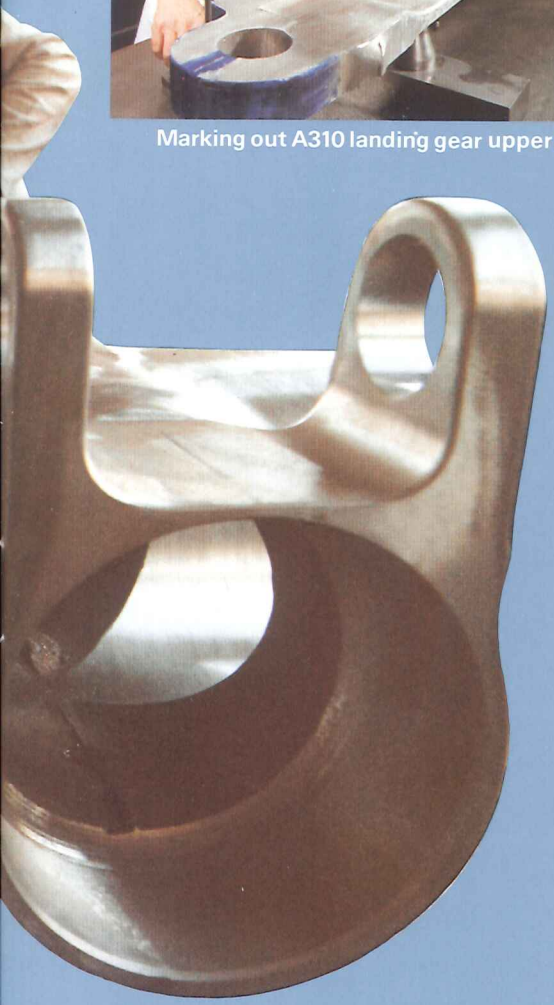
Landing Gear high strength components follow a more complicated programme. This includes deep hole boring, stress relieving, heat treatment, pre and post-chrome machining. Sliding members with integral axles, such as the Fokker F.28 and Panavia Tornado use gap bed grinding machines and chuck-and-steady grinders with a maximum swing of 3650 mm (144 in) and 910 mm (36 in) diameter respectively.

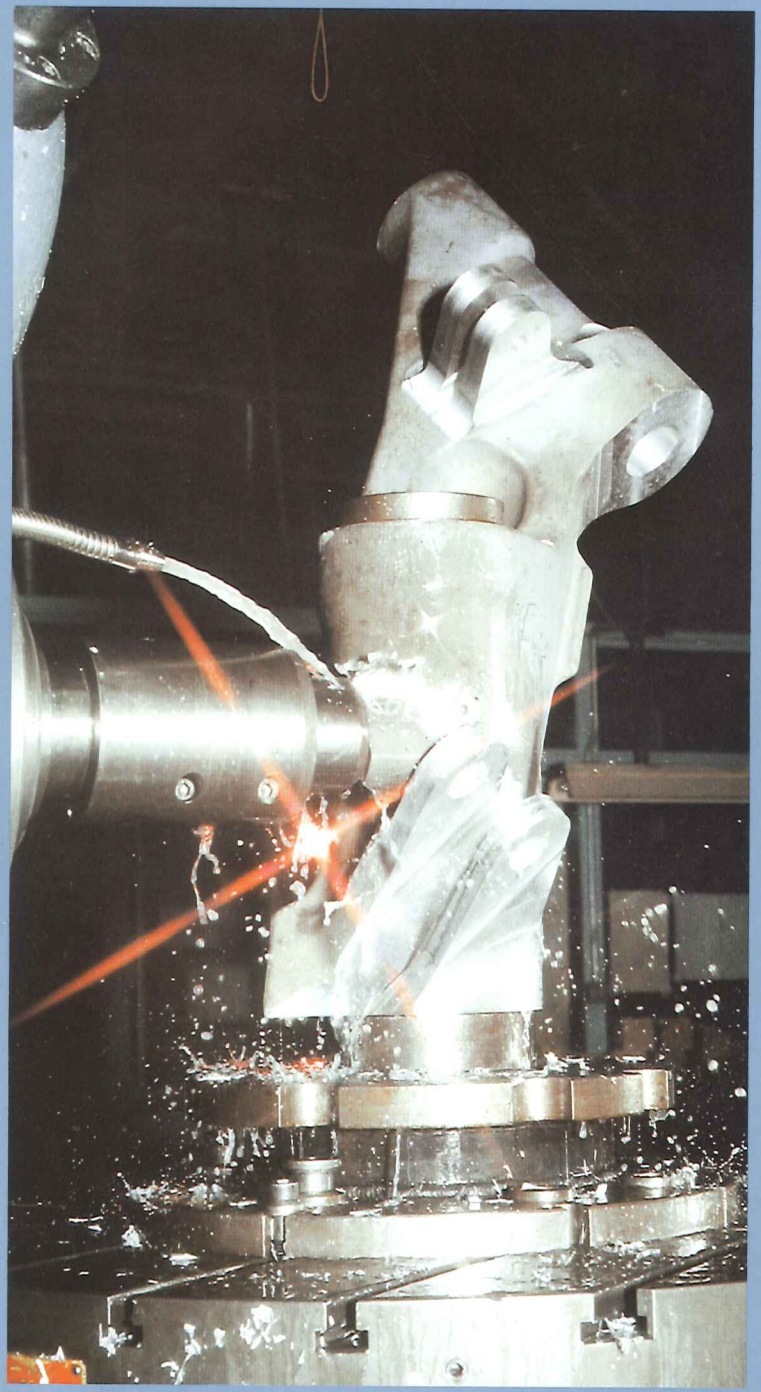


Numerically controlled six spindle profile mill

A310 main landing gear bogie units

Marking out A310 landing gear upper stay

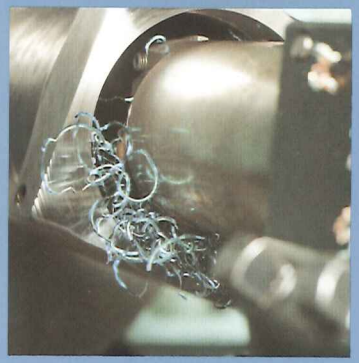




Machining Tornado main leg

Jaguar take off from grass

HS 748 fitted with Dowty landing gear

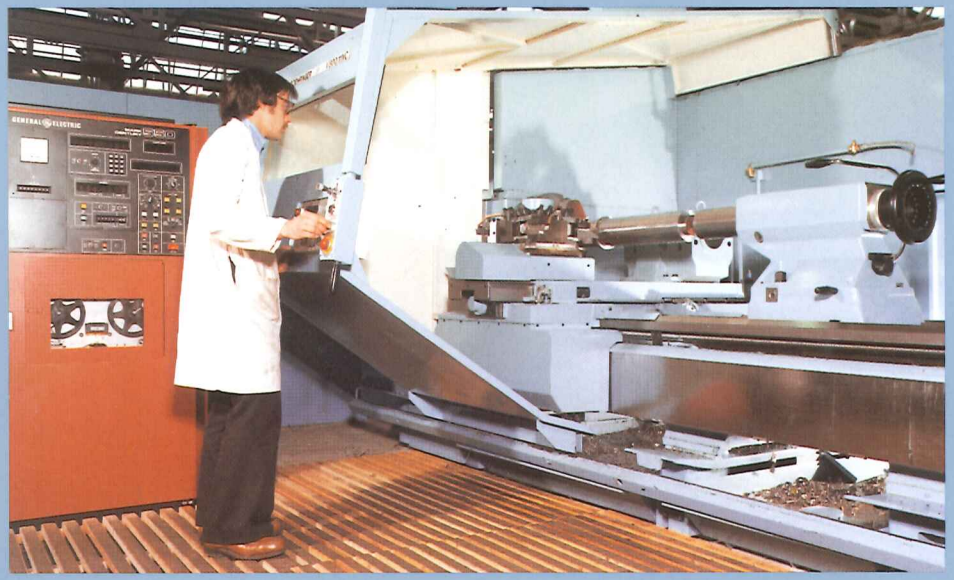


Boring a landing gear main cylinder

Harrier nose steering valve assembly

Rough airfield usage of Dowty landing gear on Fokker F.27

3D inspection of Fokker F.28 main leg



Tornado nose landing gear assembly

Numerically controlled lathe

The company has developed special processes and purchased purpose-built machinery to cope with the metal removal parameters required for machining ultra high tensile steels. A programme of training is also given to ensure optimum manufacturing efficiency. Other in-house facilities cover the heat treatment of steels and aluminium alloys.

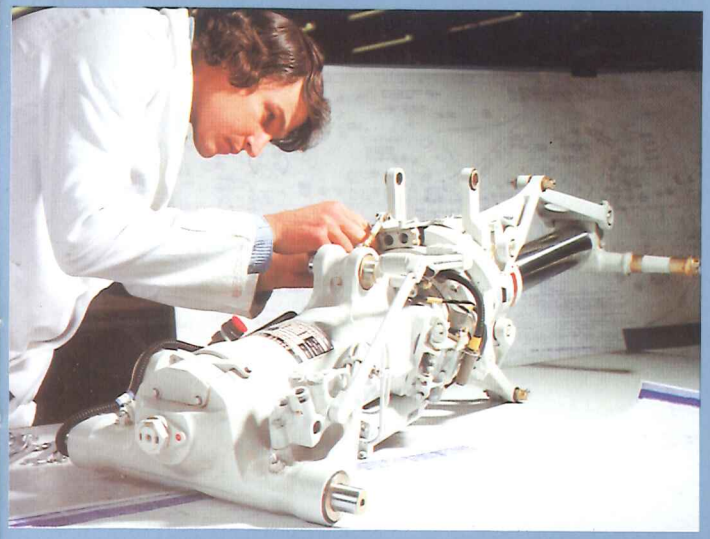
There is also a machine area of 3250 m^2 (35 000 ft^2) to handle the largest tensile steel landing gear components for wide body aircraft.

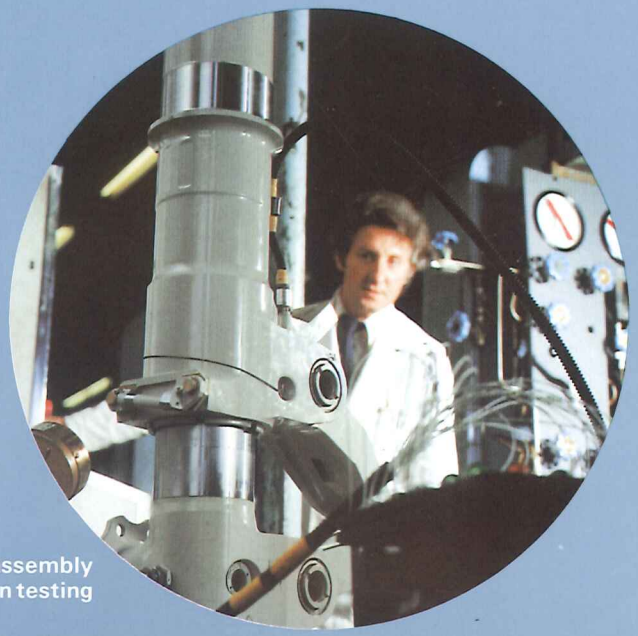
This recently completed facility is equipped with machines incorporating the latest advances in metal cutting technology – including a large six spindle profile mill, computerised lathes and machining centres.

Assembly is a step-by-step procedure governed by a progress card which can entail 200 separate operations. Each operation is checked by an inspector. The same procedure applies to associated hydraulic units.

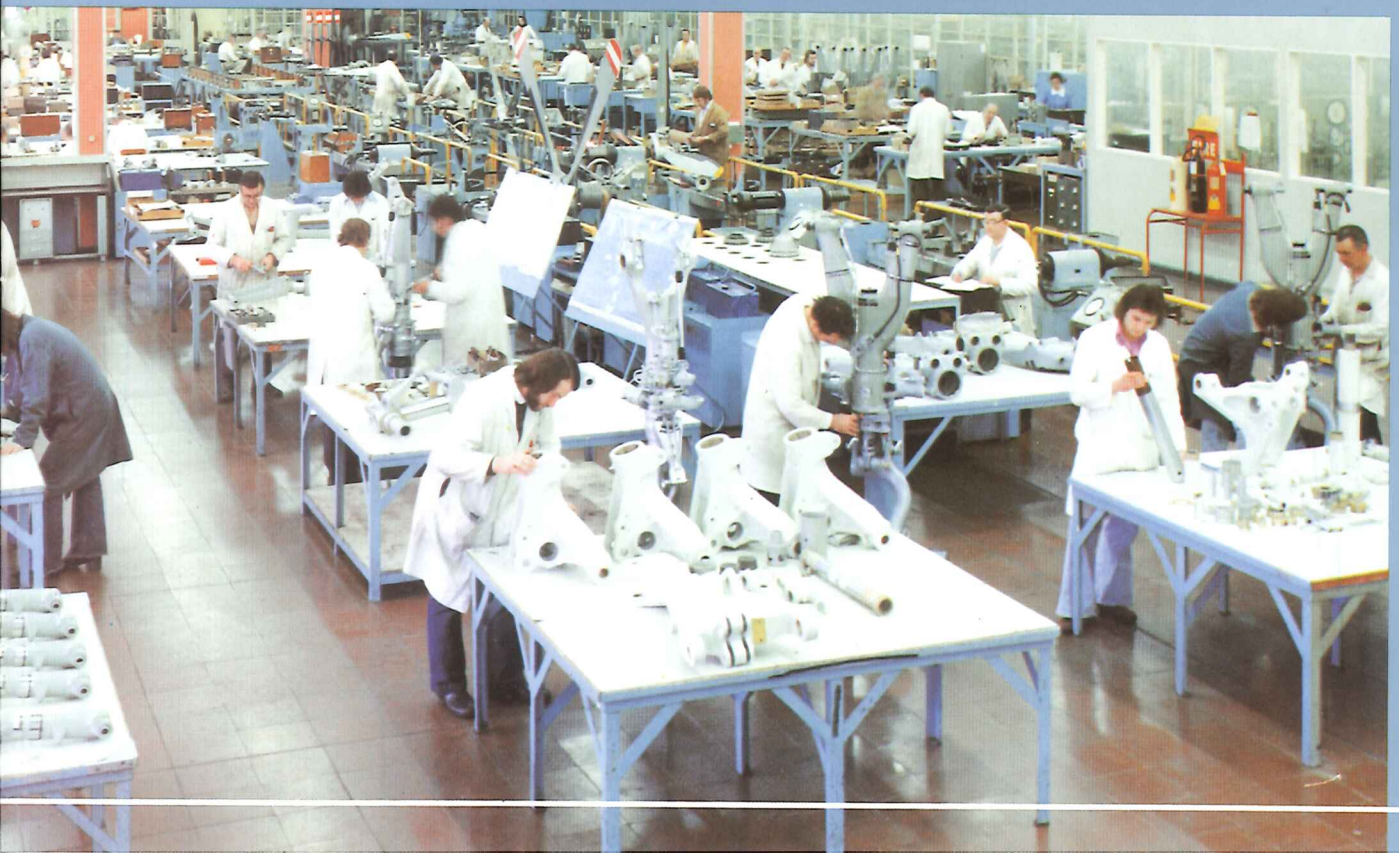
After assembly and inspection, the landing gear legs and shock absorber units are filled with hydraulic fluid then tested in compression presses to simulate aircraft loads, final levelling being adjusted by nitrogen charging. Landing gear steering mechanism is also tested for full functioning. Sub-units for landing gear, like jacks and valves, are also tested for function, pressure responses and operating times.

The units then move on to painting, labelling and locking and final inspection prior to packing and despatch.

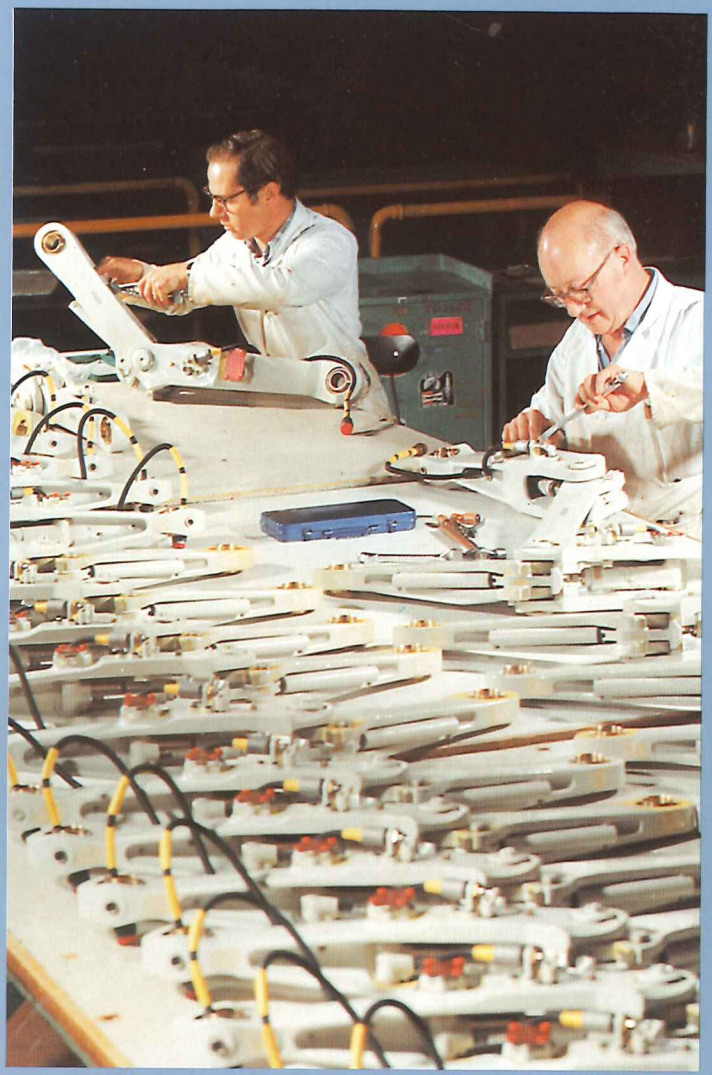




Tornado shock absorber post assembly
hydraulic compression testing



One of the assembly shops



Assembling landing gear lock struts

Dowty landing gear on Canadair Challenger 600

Landing gear product support

Field servicing of Fokker F.27 main landing gear

Dowty Rotol Product Support provides a 24-hour, 7 day a week, worldwide service. This includes field service, spares control, customer training, technical publications and the co-ordination of customers' overhaul and repair requirements.

FIELD SERVICE SUPPORT

Dowty Rotol maintains a team of Product Support and Service Engineers at both Dowty Rotol Limited, Staverton, UK and Dowty Rotol Incorporated at Virginia, USA, who are fully trained in servicing, repair and trouble shooting of all Dowty landing gear products. Service Engineers are resident at major aircraft manufacturing companies who use Dowty landing gears.

Product Support Engineers and Service Engineers make regular visits to customers worldwide to advise on repair and overhaul methods, servicing and trouble shooting problems. They also assist with customer training in the field and advise on the incorporation of modifications.

SPARES SUPPORT

The main spares store at Dowty Rotol, Staverton, UK, occupies an area of 3700 m^2 (40 000ft^2) and houses over £2.5 million of detail spares, unit assemblies and tools. Stocks of catalogue spares for initial provisioning, routine spares and AOG requirements are available from the above store.

There are also repair/spare facilities

Dowty product support for operational Harrier

Part of Dowty main computer complex

at Dowty Rotol Inc., Virginia, USA, and Dowty Equipment of Canada Limited, Toronto, Canada. Dowty also have repair agents in Germany, South Africa and the Far East.

Spares control is maintained by a Burroughs computer stock control system feeding into a central computer. All customers are encouraged to provide usage data to assist Spares Control in advance ordering to meet spare parts catalogue load times.

CUSTOMER TRAINING

Dowty Rotol provides overhaul repair and servicing courses at the Staverton factory in lecture rooms and training workshops equipped with the latest visual and practical aids. Training at the customer's factory or operator's facility can also be provided with visiting instructors. A training manual is normally provided for each student and where possible, uses the same diagrams as the component maintenance manual. Detailed training programmes are usually agreed with the customer well in advance.

TECHNICAL PUBLICATIONS

Dowty Rotol provides maintenance, overhaul and repair manuals in accordance with ATA 100 specification and spares catalogues and initial provisioning data to ATA 200 specification for civil customers and to the appropriate military specification for military customers. Service Bulletins and revision service are also provided in accordance with the appropriate civil or military specification.

DOWTY

Aircraft fitted with Dowty Rotol landing gear

Airbus A310 · Airspeed Ambassador · Airspeed Ferry · Armstrong Whitworth Argosy · Armstrong Whitworth Meteor · Armstrong Whitworth AW52 · Auster 9 · Aviation Traders Accountant · Avro Ashton · Avro Athena · Avro Lancaster · Avro Lancastrian · Avro Lincoln · Avro Manchester · Avro Shackleton · Avro Tudor · Avro Vulcan · Avro York · Avro 698 · Avro 707 · Avro 707A · Avro 707B · Avro 707C · Avro Canada Arrow · Avro Canada CF-100 · Avro Canada C.102 · BAC 221 · B.Ae Harrier · B.Ae Sea Harrier · B.Ae 146 · Blackburn Botha · Blackburn Buccaneer · Boulton Paul P.111 · Bristol Belvedere · Bristol Blenheim · Bristol Bombay · Bristol Brabazon · Bristol Britannia · Bristol Bulldog · Bristol Freighter · Bristol Sycamore · Bristol Wayfarer · Bristol 142 · Bristol T.188 · Canadair CL.600 Challenger · Canadair CF.104 · Canadair CL.41 · Casa 101 · Casa C202 · Casa C203 · Cierva C.24 Autogiro · Comper Mouse · De Havilland Sea Vixen · De Havilland TK4 · Dornier Do.31 · Douglas DC10 · English Electric Canberra · English Electric Lightning · Fairchild Hiller FH.227 · Fokker Promoter · Fokker F.27 · Fokker F.28 · Fokker S.12 · Fokker S.13 · Fokker S.14 · Folland Gnat · Folland Midge · General Aircraft ST4 · Gloster Gauntlet · Gloster Gladiator · Gloster Javelin · Gloster Meteor · Gloster E.28/39 · Gloster E.1/44 · Gloster GA5 · Gloster F.5/34 · Gloster F.9/37 · Gloster SS19, SS19A, SS19B · Grumman XF-5FI · Handley Page Halifax V · Handley Page Hampden · Handley Page Harrow · Handley Page Hastings · Handley Page Herald · Handley Page Hereford · Handley Page Victor · Handley Page 115 · Hawker Audax · Hawker Demon · Hawker Fury · Hawker Hart · Hawker Hector · Hawker Henley · Hawker Hind · Hawker Hotspur · Hawker Hunter · Hawker Hurricane · Hawker Tempest · Hawker Tornado · Hawker Typhoon · Hawker Sea Fury · Hawker Sea Hawk · Hawker P.1040 · Hawker P.1052 · Hawker P.1067 · Hawker P.1081 · Hawker P.1083 · Hawker P.1127 · Hawker Siddeley Kestrel · Hawker Siddeley Andover · Hawker Siddeley 650 · Hawker Siddeley 748 · Heston Hagg Racer · Heston Phoenix · Hindustan HF.24 · Kaman Seasprite · Kawasaki KD 5/92 · Lockheed Starfighter · Martin Baker MB1 · McDonnell Douglas AV-8A · McDonnell Douglas AV-8B · Miles Hawk · Miles Magister · Miles M.100 · Norair CF.5 · Norsk Flyindustri 5 A Finmark · Panavia Tornado · Percival Gull · Percival Jet Provost · Percival Pembroke · Percival Prentice · Percival Provost · Percival Sea Prince · Percival H126 · PZL 7 · Saro Cloud · Sepecat Jaguar · Scottish Aviation Twin Pioneer · Shorts Belfast · Shorts Seamew · Shorts Skyvan · Shorts 360 · Shorts Stirling · Shorts SA4 · Shorts SB5 · Spartan Cruiser · Swiss APU P.16 · Swiss Federal N.20 · Valmet Vihuri · Supermarine Scimitar · VFW 614 · Westland Lysander · Westland Welkin · Westland Westminster · Westland Whirlwind · Westland Wyvern · Westland F.13/44 · Westland N.11/44

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