ROLLS ROYCE

CUSTOMER TRAINING CENTRE

course notes

D. J. WHITEHEAD.

6 6 67

VISITORS' INFORMATION

We welcome you to the Rolls-Royce Customer Training Centre and trust that you will enjoy a profitable and pleasant course and that you will obtain the type of information which will assist you in your work in connection with the Rolls-Royce products.

Our aim is to present the essential information in an interesting form and preplanned sequence, using a variety of visual aids designed to make the subjects as easy as possible to learn. All members of the staff have been trained to use the same technique which we call "Teaching by Analysis".

A staff briefing session is held prior to each course to plan the best possible programme in the light of the variety of training requirements. Our intention is to remove as many obstacles to easy learning as possible, although to meet all training requirements on the dates demanded can produce a number of complications.

I shall be happy to discuss with you any points you care to raise during your visit. (My office is at the head of the main staircase).

Before your departure at the end of the course, you are invited to record your comments and suggestions on the form provided, to help us to ensure that the detailed organisation of our courses remains in step with the customer's requirements.

E MANGHAM
Manager - Customer Training Centre

THE CUSTOMER TRAINING CENTRE STAFF

MANAGER - E MANGHAM

- SECRETARY - Miss B Flatt

DEPUTY MANAGER - A J M Peace

INSTRUCTORS

G W Maltby	Senior Instructor	- i/c Tyne Engine Course & Lift Jets
C A Dring	Senior Instructor	- i/c Spey Engine Courses
E Robinson	Instructor	- Spey Engines
L Anderson	Instructor	- Spey Engines
R Fortin	Instructor	- Spey Engines
J H Wakefield	Senior Instructor	- i/c RR Continental Engine Courses Also assisting on Spey Courses
J Tucker	Senior Instructor	- i/c Spey (Phantom) Engine Courses
A N Dixon	Instructor	- Spey (Phantom) Engine
D N Welch	Senior Instructor	- i/c Dart Engine Courses
P Beasley	Instructor	- Dart Engines
G Wilkins	Instructor	- Dart Engines
R Whitehurst	Senior Instructor	- i/c Gazelle Engine Courses. Also assisting on Dart courses
G L Meeson	Senior Instructor	- i/c Avon Engine Courses
C E Fallows	Instructor	- Avon Engines
L A Stiff	Senior Instructor	- i/c Conway Engine Courses. Also assisting on Phantom Spey courses
O W Ayre	Senior Instructor	- i/c 'C' Range Diesel Engine and Railcar Traction courses
J C Forrest	Senior Instructor	- i/c 'D' and 'K' Range Diesel Engine Courses
T J Armson	Senior Instructor	- i/c Adour Engine Courses
J G Baldwin	Instructor	- Adour Engine (and i/c Projection Theatre and Films)

TRAINING AIDS AND EQUIPMENT

A Gatenby - i/c All equipment and training aids

J T Foster - Model maker

Cyril

Cliff Roger.

Alan Deacon.

COURSE HOURS

Morning Session:	9.00 a.m. to 12.15 p.m.
Afternoon Session:	2.00 p.m. to 4.50 p.m. (3.30 FRIDAY).

A 15 minute break for coffee and tea is made at 10.15 a.m. and 3.15 p.m.

Luncheon for visitors is provided free of charge by the Company in the dining room after 12.15 p.m. Please be seated by 12.30 p.m. Please inform the Canteen Manageress if you will not be taking lunch on any occasion.

Should you have any special diet problems please notify the Catering Manageress in good time.

Immediately after lunch and before the afternoon session begins an optional film show is put on in the projection theatre, and consists of films of general interest but with an engineering flavour.

On course termination day you can expect to be free to travel by 4 p.m.

PUBLICATIONS

You will accumulate a full set of course notes and diagrams as the programme proceeds, so that IT IS UNNECESSARY TO TAKE COPIOUS NOTES DURING LECTURES.

The notes are written, by the instructors, and every endeavour is made to ensure that these notes are up-to-date at the time of issue, but no amendment action can be taken owing to the large number of copies involved.

Your own organisation will be in receipt of the Company's official manuals and all amendments for these. Your notes should be checked and amended from these periodically, but they should not be regarded as an official publication.

Course notes can only be supplied for the course being followed. There is a charge for any extra sets of notes supplied.

EXAMINATION

A multi-choice answer style examination is held on the last day of the course. The minimum pass mark is 65% and qualifies you for a Certificate stating satisfactory completion of the training. No Certificate is issued if less than 65% is obtained. If 95% or over is obtained the certificate will carry a "MERIT MARK" seal.

Examination results are forwarded to the Officials of the customer organisation concerned.

LOCAL TRANSPORT

Our buses will transport to and from their accommodation those visitors who have been previously notified to this effect and this includes those whose accommodation is the more distant.

We would ask that you are ready when the transport arrives as the bus cannot wait or return. The transport time may vary slightly from day to day but will be from 8.30 a.m. onwards.

Transport departs at 5 p.m. each day (3.40 p.m. FRIDAY). Please be sure you are aboard as no transport is available after this time.

CAR PARKING

If the visitors section of the car park is full, you can use the car park adjacent to the main road drive entrance.

Cars may be left overnight in the park but it should be borne in mind that the gates are locked from 5.15 p.m. to 8 a.m. We can accept no responsibility for the car and contents.

MAIL

You may have your mail sent to you at this address:

The Customer Training Centre
Rolls-Royce Limited,
Derby.

Your mail will be found on the mailboard in the Visitors' Common Room.

The cable address is: ROYCAR DERBY.

Post cards of the Customer Training Centre can be supplied by your instructor (without charge).

Please quote a forwarding address on your "booking-in" card if you expect mail to follow after your departure.

ACCOMMODATION

Accommodation will have been arranged on your behalf, if requested, and every endeavour will have been made to meet the advised requirements. Any accommodation problems should be referred to the Deputy Managers' Office.

COSTS

The payment of all accommodation and subsistence charges is the responsibility of the visitor.

The Rolls-Royce Company normally bears the cost of the training course as a part of a comprehensive Sales and Service Organisation to assist their civil customers.

The training facilities may be made available to others on payment of a fee.

CAMERAS

It is necessary to obtain permission before cameras are used on the premises.

Cameras are not allowed in the factories.

VISITS TO THE FACTORY

When applicable, a conducted tour of one of the main factories is arranged to see engines during production, but some of our engine types are produced in our Scottish factories and therefore it is not possible to see these in the Derby factories.

Overhaul engineers will, in pre-arranged cases only, spend some week after the course in the overhaul departments to follow a training programme arranged by the Overhaul Engineering Department. This type of training cannot be arranged at short notice.

Any queries on Overhaul Training programmes should be referred to the Deputy Manager.

PERSONAL CONTACTS

A list of visitors attending courses is circulated to all relevant departments of the Company, including the Sales Dept., Service Dept., and Development Depts., so that officials of these departments may contact you for any special discussions.

MEDICAL FACILITIES

When medical attention is required visitors should consult one of the local General Practitioners.

The exception is:-

R.N. Personnel - Dr J Gemmell 306, Uttoxeter Rd Derby.

'First Aid' treatment can be given by some members of the staff.

TELEPHONE

The Customer Training Centre telephone No. is Derby 21355 and Derby 23953.

Visitors wishing to make business calls should use the extension in the Visitors' Common Room on the first floor.

The telephone switchboard is not able to deal with outgoing calls between 12.20 p.m. and 1.30 p.m.

RAIL TRAVEL

The nearest railway station is Derby; approx 3 hours' travel from London St. Pancras.

For rail travel times consult the railway timetable in the visitors' Common Room.

ROLLS-ROYCE WELFARE AMENITIES SOCIETY

Details of the activities of the Society can be obtained from the Deputy Manager who can make arrangements for visitors to participate in chosen activities.

THE ROYAL AERONAUTICAL SOCIETY - DERBY BRANCH

Notices of meetings are posted on the notice board and visitors are invited to attend.

The meetings are held in the Rolls-Royce Welfare Hall, Nightingale Road.

MAPS OF DERBY

Small maps of Derby and district are available from the secretary.

FIRE WARNING

High pitched sirens give warning of fire. Fire warning switches are placed at all exists.

FIRE WARNING TEST

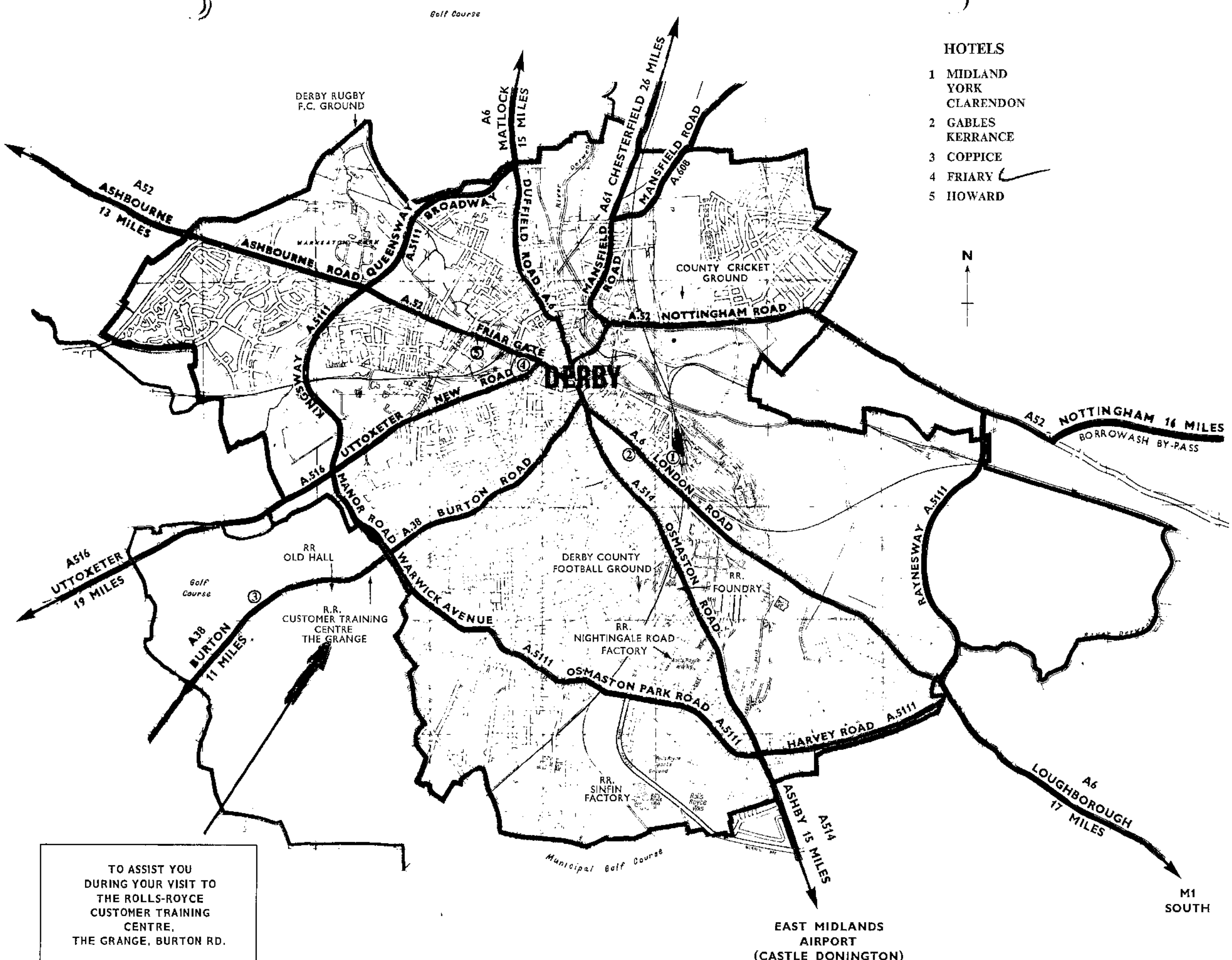
At 11 a.m. on the first Friday of each month a short test is carried out on the fire warning system.

To:- THE MANAGER - ROLLS-ROYCE CUSTOMER TRAINING CENTRE

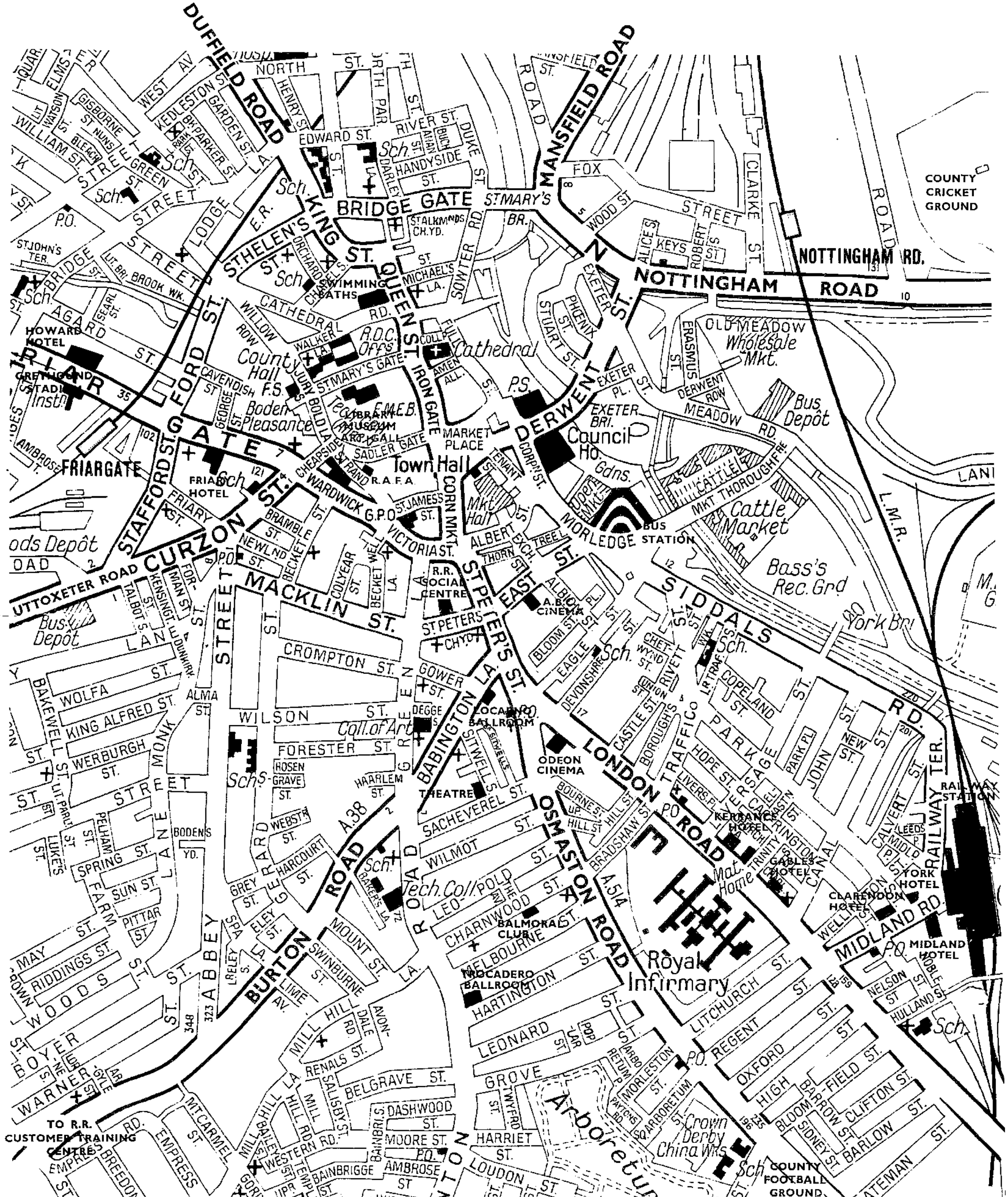
VISITORS' COMMENTS AND SUGGESTIONS

Course attended.........................Signed...............

The completed form should be placed in the box provided in the Visitors' Common Room.



TO ASSIST YOU
DURING YOUR VISIT TO
THE ROLLS-ROYCE
CUSTOMER TRAINING
CENTRE,
THE GRANGE, BURTON RD.


DUFFIELD ROAD
MANSFIELD ROAD
NOTTINGHAM RD.
NOTTINGHAM ROAD
COUNTY CRICKET GROUND
BRIDGE GATE
ST. MARY'S BR.
KING ST.
QUEEN ST.
IRON GATE
CORN MKT.
ST. HELEN'S ST.
SWIMMING BATHS
Cathedral
County Hall
LIBRARY MUSEUM ART GALL.
E.M.E.B.
MARKET PLACE
Town Hall
R.A.F.A.
DERWENT ST.
Council Ho.
OLD MEADOW
Wholesale Mkt.
MEADOW RD.
Bus Depôt
HOWARD HOTEL
GREYHOUND STADIUM
FRIARGATE
FRIAR GATE
FRIARY HOTEL
STAFFORD ST.
CURZON ST.
WARDWICK
G.P.O.
VICTORIA ST.
MORLEDGE
BUS STATION
Cattle Market
Bass's Rec. Grd
SIDDALS RD.
York Bri.
L.M.R.
Goods Depôt
UTTOXETER ROAD
MACKLIN ST.
R.R. SOCIAL CENTRE
A.B.C. CINEMA
ST. PETER'S ST.
EAST ST.
Bus Depot
CROMPTON ST.
WILSON ST.
FORESTER ST.
Coll. of Art
LOCARNO BALLROOM
ODEON CINEMA
THEATRE
LONDON ROAD
TRAFFIC ST.
KERRANCE HOTEL
GABLES HOTEL
CLARENDON HOTEL
YORK HOTEL
RAILWAY STATION
RAILWAY TER.
MIDLAND RD.
MIDLAND HOTEL
BABINGTON LA.
GREEN LA.
ABBEY ST.
BURTON ROAD
OSMASTON ROAD
Tech. Coll.
BALMORAL CLUB
TROCADERO BALLROOM
Royal Infirmary
Arboretum
Crown Derby China Wks.
COUNTY FOOTBALL GROUND
TO R.R. CUSTOMER TRAINING CENTRE

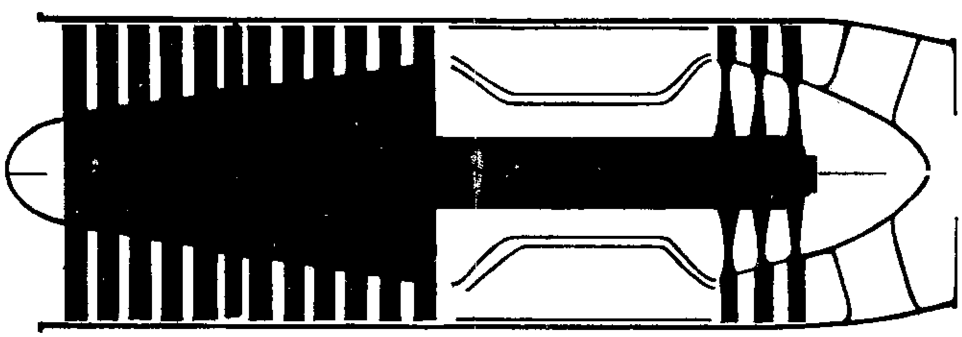
GENERAL PRINCIPLES OF GAS TURBINE ENGINES

THE SIMPLE TURBO JET.

The operating principle of the turbo jet is an application of Newton's third law of motion which states, 'that for every action there is an equal and opposite reaction'.

In this case, the reaction (thrust) results from the continuous acceleration of air rearwards.

In the basic gas turbine cycle, air is first compressed, heated by the addition of burning of fuel, then expanded through a turbine and propelling nozzle. The turbine extracts sufficient energy to drive the compressor, whilst the propelling nozzle increases the velocity of the gas stream to produce thrust.



JET ENGINE

The overall efficiency of the jet engine is dependant upon the thermal efficiency of the cycle and the propulsive efficiency.

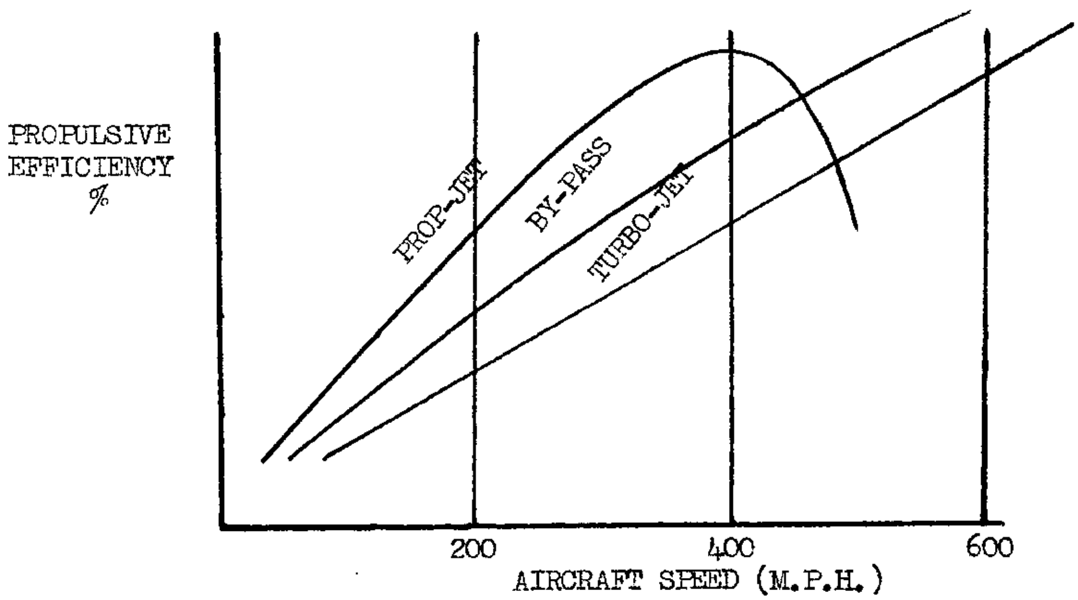
Thermal efficiency increases with increased operating temperatures, but unfortunately, in the turbo-jet, this results in an increase in jet velocity.

Propulsive efficiency is affected only by the jet velocity and aircraft speed, when the difference between these two factors is low the propulsive efficiency will be high.

/continued.

The characteristic high exit velocity of the simple turbo jet makes it particularly suitable for high speed aircraft (fig.2).

What is ideally required is an engine which operates at high temperatures, yet will impart a low acceleration to the largest possible airflow in order to minimize the jet velocity.



THE TURBO-PROP-ENGINE.

A gas turbine driven propeller is a means of obtaining high propulsive and thermal efficiencies at relatively low aircraft speeds.

The thrust is produced by a propeller accelerating a large mass of air to a relatively low velocity.

Increased flame temperatures can be used because more energy is absorbed from the gas stream by the turbines in order to drive the propeller. This results in a comparatively low exit velocity and thus a high overall efficiency reflected in a reduction in specific fuel consumption.

Fig.2 shows the optimum aircraft speed for highest propulsion efficiency beyond which, falling propeller efficiency reduces propulsive efficiency and sets a limit to the systems useful range of operation.

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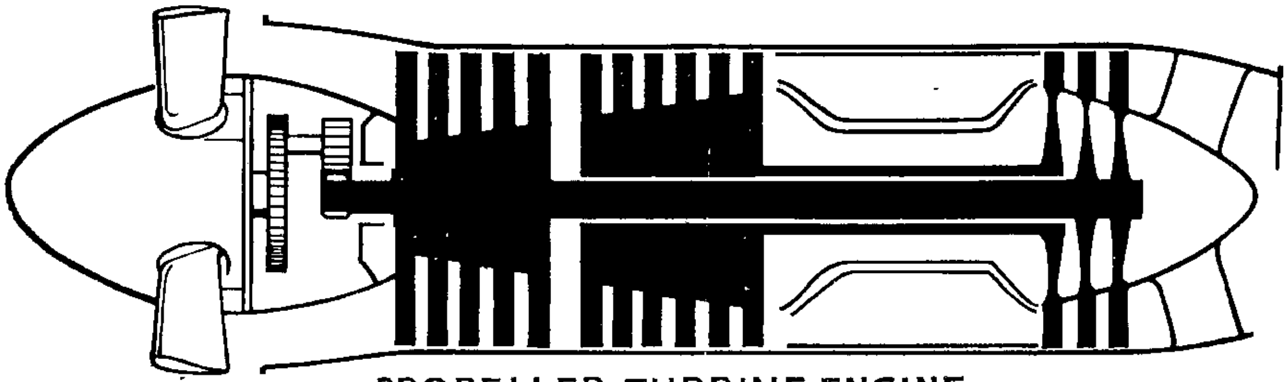


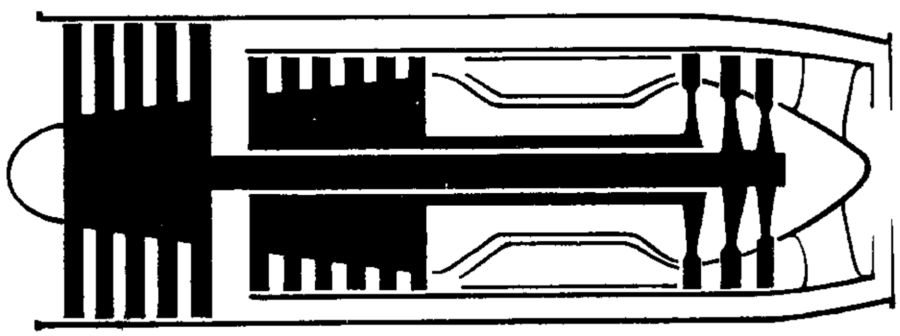
PROPELLER TURBINE ENGINE

THE BY-PASS JET ENGINE.

This engine combines the best features of turbo-jet and prop-jet engines. The addition of the by-pass to the jet engine improves its propulsive efficiency by reducing the jet speed, whilst the omission of a propeller allows the engine to operate at high forward speeds.

The by-pass principle employs a large L.P. compressor which delivers only a portion of the air to the H.P. compressor, the remainder being ducted around the engine rejoining the gas stream after the turbines to obtain a slower cooler jet stream.

Because of the by-pass flow most of the energy is extracted from the combustion gasses by the H.P. and L.P. turbines. This allows the engine to be run at high temperatures with a resulting improvement in thermal efficiency, which with the higher propulsive efficiency, improves the specific fuel consumption.



BY-PASS ENGINE

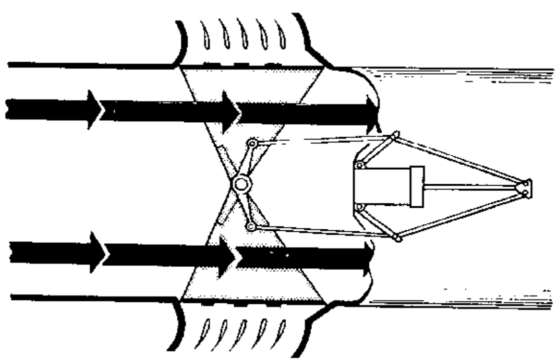
THE PRINCIPLE OF A THRUST REVERSER.

To reduce the landing run of turbo-jet powered aircraft the engine thrust is reversed by deflecting the gas stream in a forward direction to oppose the aircraft motion.

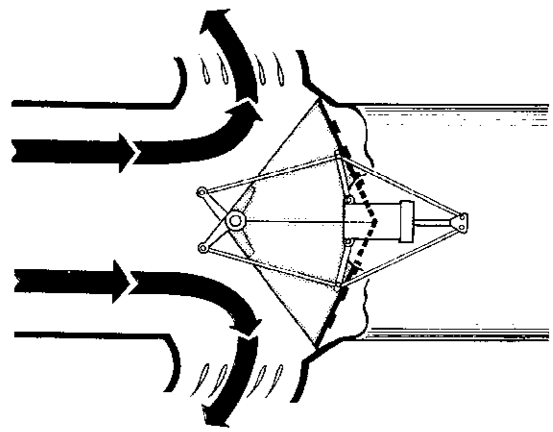
/continued.

The gas stream is directed forwards by deflector vanes which are uncovered when the 'eyelids' in the jet pipe close off the normal gas exit.

The braking effect can be controlled by operating the throttle in the normal manner, as engine power is increased the reverse thrust builds up to approximately half the amount available for forward propulsion.



NORMAL OPERATION



REVERSE THRUST SELECTED

THE PRINCIPLE OF A TWO POSITION NOZZLE.

In order to obtain a limited increase in engine thrust for take-off, without affecting the engines performance in the cruise range, a two position nozzle can be fitted to the jet pipe.

By reducing the final nozzle area for take-off, pressures and temperatures through the engine are increased, the net result is an increase in final jet velocity and engine thrust.

THE PRINCIPLE OF RE-HEAT.

Re-heat is a means of considerably increasing the thrust of a jet engine when extra power is required for take-off, climb and combat. This is accomplished without great increases in weight and no increase in frontal area.

/continued.

The maximum thrust of a turbo-jet is limited largely by the temperature to which the gas can be raised without overheating the turbine, this results in only a portion of the air being used for combustion the remainder controlling the gas temperature.

The re-heat equipment overcomes this limitation and takes advantage of the unburnt air by burning fuel in the jet pipe to re-heat the gas stream after it has passed through the turbines.

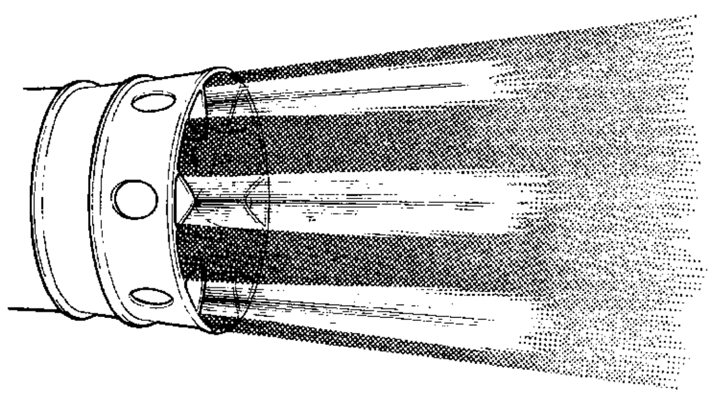
This causes the gas to expand further and so increase the gas velocity out of the jet pipe to obtain more thrust.

A variable propulsive nozzle is essential with re-heat as the increased expansion of the gas would cause a severe rise in jet pipe pressure were the nozzle area not increased.

SILENCING NOZZLES.

These units are designed to reduce the noise of a turbo-jet engine. The noise is the result of turbulence produced when the jet exhaust mixes with the atmosphere, the faster the exhaust stream the more noise it will produce.

A reduction in noise will be achieved if the speed of the gas stream is reduced as quickly as possible. This can be accomplished by a corrugated jet nozzle, which alters the shape of the exhaust stream as it leaves the engine. This permits air to be entrained with the gasses and encourages a more rapid mixing and slowing down of the gas stream.



SILENCING NOZZLE

ROLLS-ROYCE AERO ENGINE SCHOOL

DERBY · ENGLAND

SPEY

Course Notes

Prepared and written by the Staff of the .....

AERO ENGINE SCHOOL.DERBY

Issued to	Date

CUSTOMER TRAINING CENTRE
COURSE NOTE
No. TSp. 399
Printed in Great Britain

ENGINE ANTI-ICING

Selected by pilot — controlled by a press. reg: valve

Cockpit indication

L. Engine anti-ice	R. Engine anti-ice

PYROMETRIC SYSTEM

Limits maximum engine operating temperatures i.e.
H.P. compressor delivery temperatures
Turbine gas temperatures

Cockpit indications

T.G.T. — Amplifier warning light

PROPULSION UNIT

An axial flow by-pass turbo-jet and a reheat jet pipe
Separate fuel control systems for engine and reheat

Cockpit indications

Engine: H.P. r.p.m. — Fuel flow — T.G.T.

Reheat: Nozzle position

ENGINE AIR BLEED SYSTEM

Supplies air bleed for aircraft services and boundary layer control

Cockpit indication

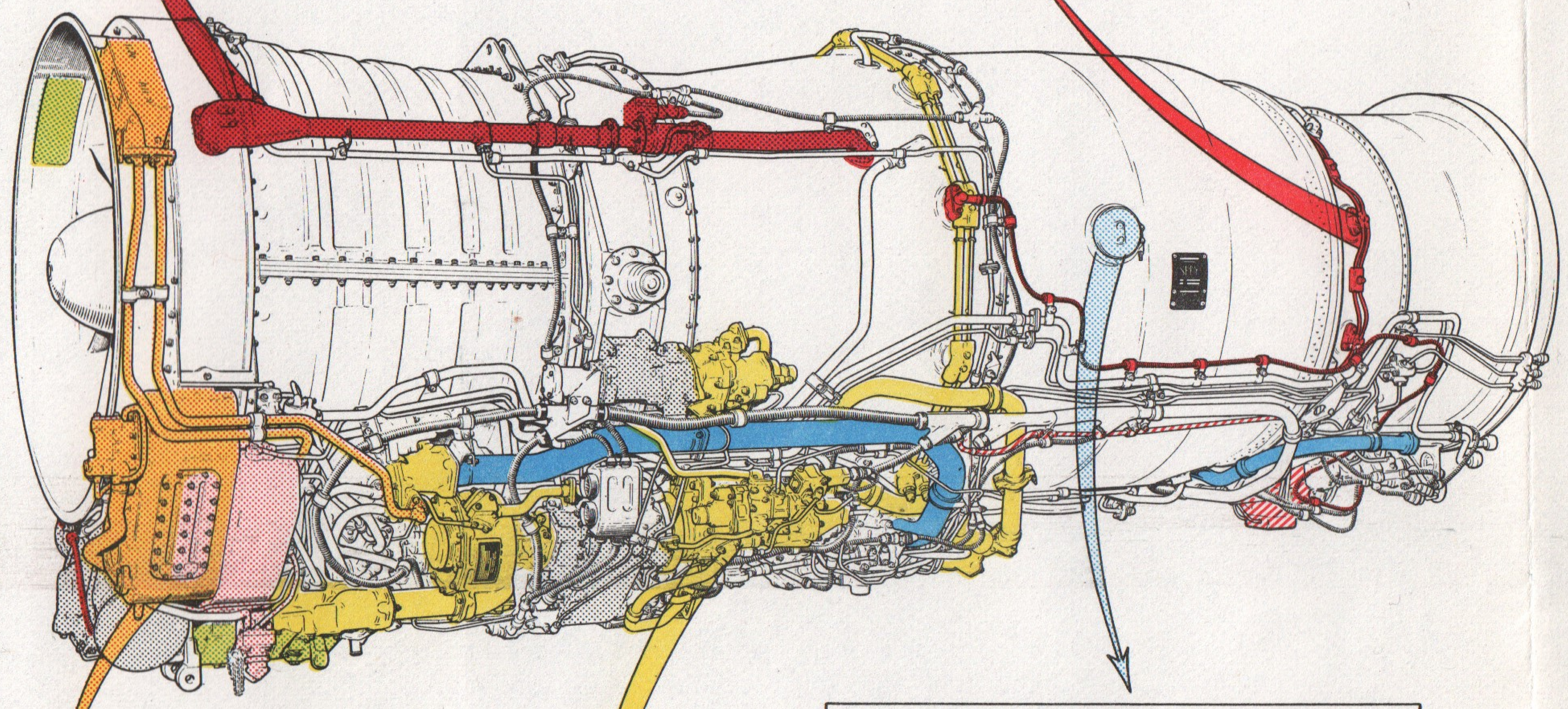
L. Engine bleed	R. Engine bleed

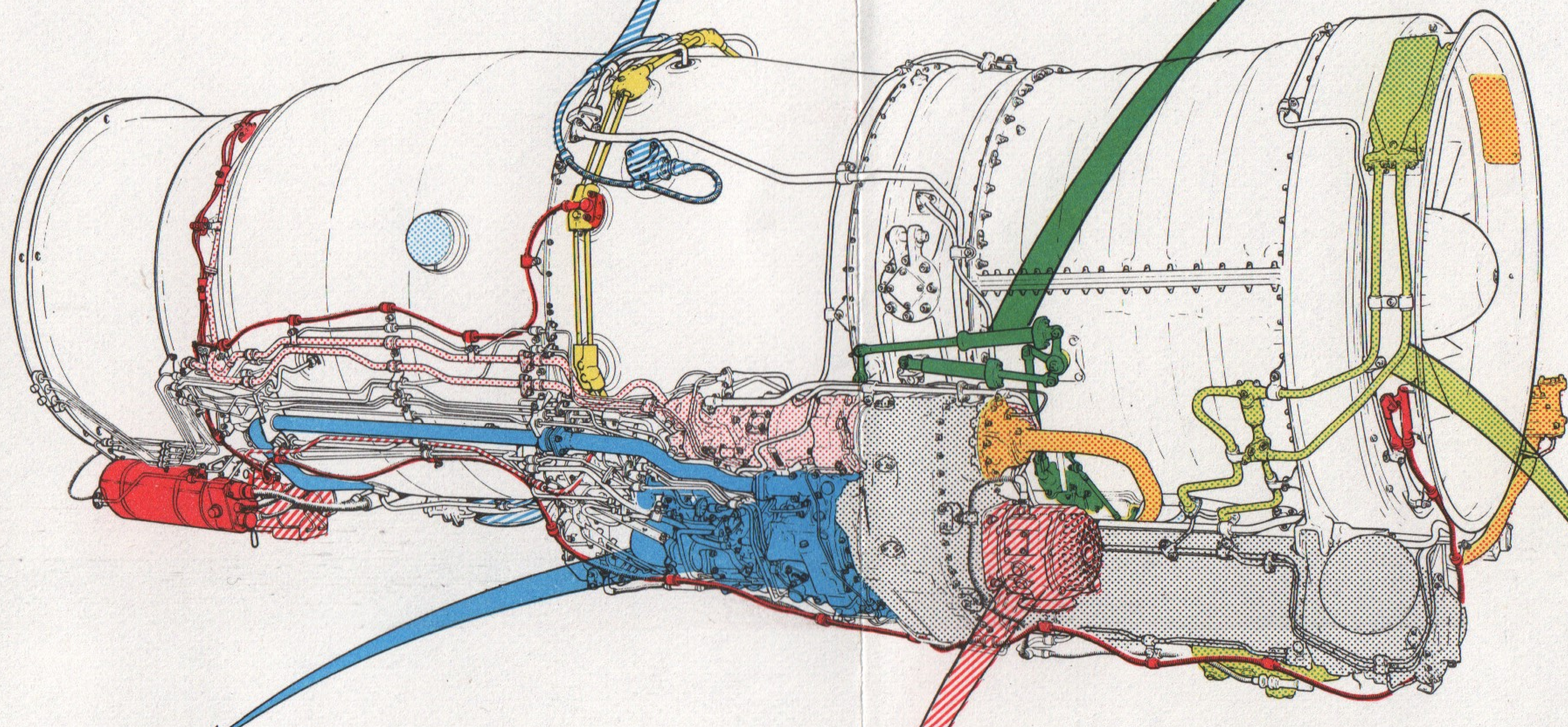
COMPRESSOR AIRFLOW CONTROL SYSTEM

To maintain H.P. compressor stability

Cockpit indication

Amplifier warning light





AIR SEALING AND COOLING SYSTEM

Pressurises bearing housings to prevent oil loss and cools hot engine units

Cockpit indication

Cooling air temperature warning light

REHEAT FUEL CONTROL SYSTEM

Controls reheat fuel flow for selected throttle positions and varying airflows

CONSTANT SPEED DRIVE GENERATOR SYSTEM

To maintain constant generator speed with variations in engine speed

Cockpit indication

Generator warning light

ENGINE LUBRICATION SYSTEM

Oil distribution by single pump to main shaft bearings and gearboxes

Cockpit indications

L. Engine low oil pressure	R. Engine low oil pressure

ENGINE STARTING

L. P. air start Mk. 201 engines Gas turbines start Mk. 202 engines H.E. igniters in combustion liners nos. 4 and 8

Cockpit indication

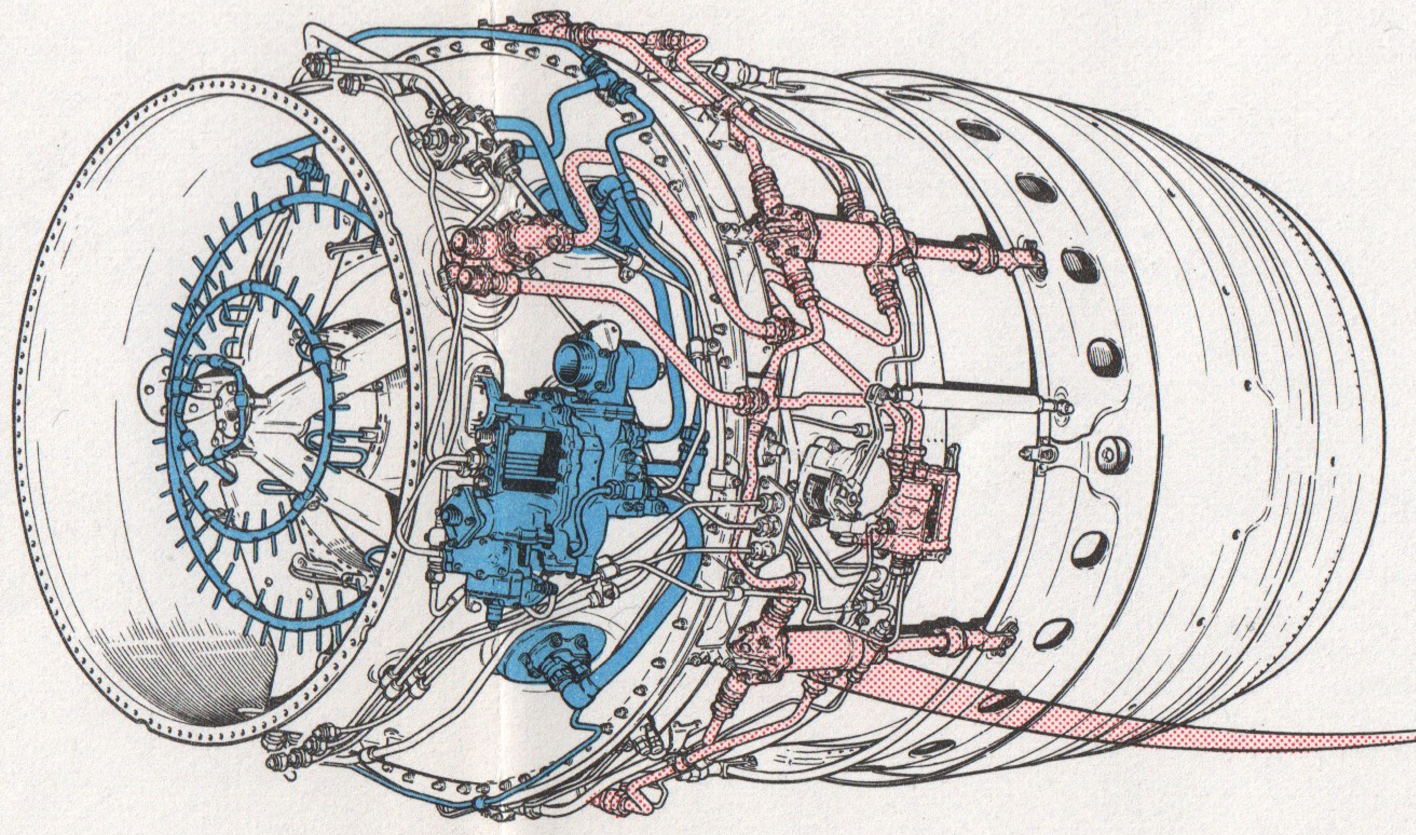
L.P. Shaft rotation — H.P. r.p.m. — T.G.T.

ENGINE FUEL CONTROL SYSTEM

Controls engine fuel flow for accelerations and varying airflows

Cockpit indication

Fuel flow — Amplifier warning light



REHEAT NOZZLE OIL SYSTEM

Operates nozzle mechanism to vary nozzle area

Cockpit indication

Nozzle position indicator

INTRODUCTION TO SPEY Mk. 201/202 PROPULSION UNIT — SYSTEMS, CONTROL AND INDICATIONS

CUSTOMER TRAINING CENTRE
COURSE NOTE
No. TSp 301
Printed in Great Britain

SPEY MK 201/202

PROPULSION UNIT

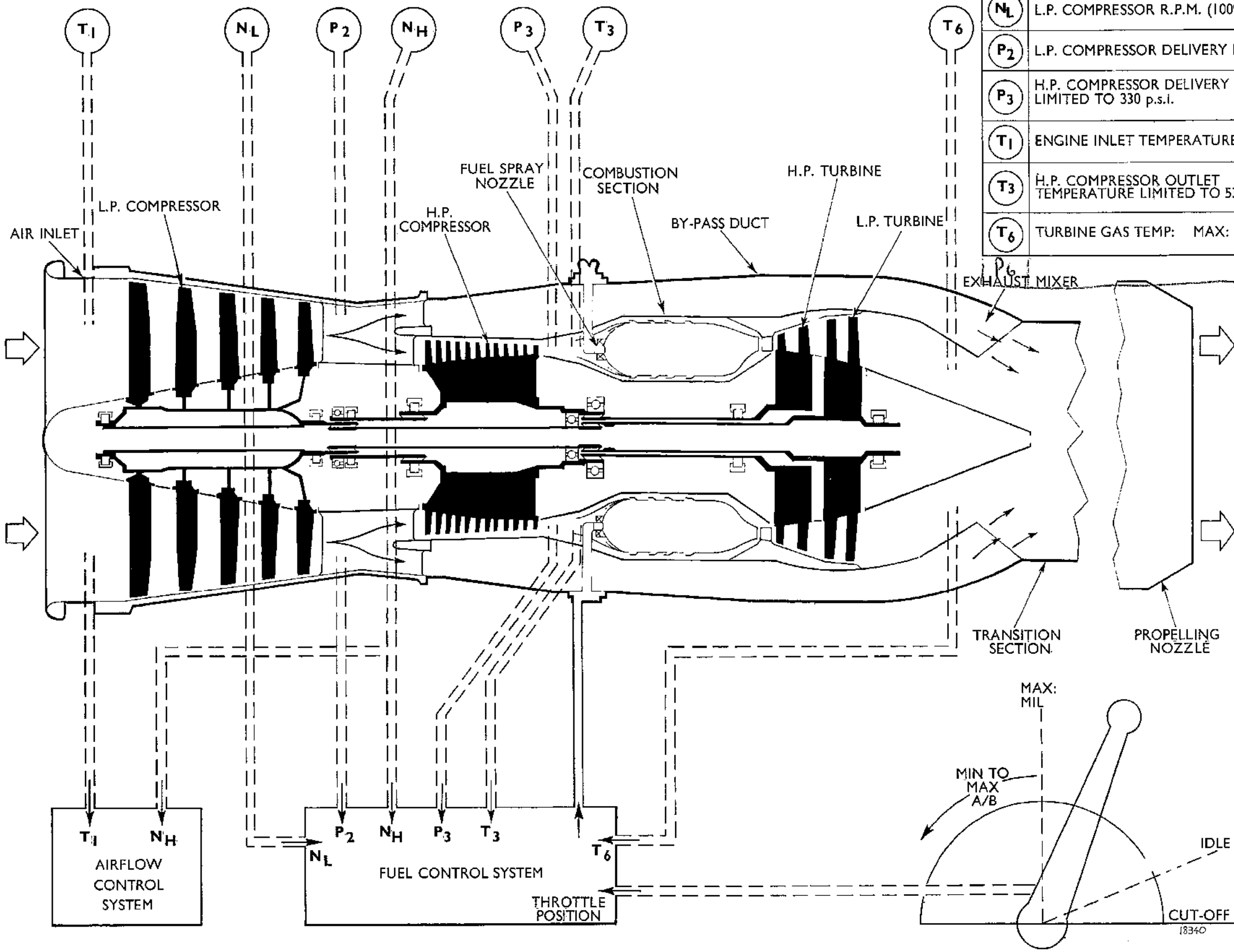
OPERATION AND CONTROL

SEQUENCE HEADING CHART

Printed in Great Britain

24 7 67

N_H	H.P. COMPRESSOR R.P.M. (100% = 12640)
N_L	L.P. COMPRESSOR R.P.M. (100% = 9115)
P_2	L.P. COMPRESSOR DELIVERY PRESS:
P_3	H.P. COMPRESSOR DELIVERY PRESS: LIMITED TO 330 p.s.i.
T_1	ENGINE INLET TEMPERATURE
T_3	H.P. COMPRESSOR OUTLET TEMPERATURE LIMITED TO 533°C
T_6	TURBINE GAS TEMP: MAX: °C



SPEY Mk. 201/202 ENGINE OPERATION AND CONTROL

1.9.67

CUSTOMER TRAINING CENTRE
COURSE NOTE
No. TSp.397
Printed in Great Britain

SPEY MK 201

1. ENGINE DATA.

Type of Engine	-	Bypass Turbo Jet.
Total Mass Airflow	-	205 lbs/sec.
Bypass Ratio	-	0.62 : 1.
Compressors	-	L.P. 5 stages. H.P. 12 stages with Variable Inlet Guide Vanes and a Bleed Valve.
Compression Ratio	-	20: 1.
Combustion Equipment	-	10 interconnected straight flow liners within an annular air casing.
Turbines	-	H.P. 2 stages L.P. 2 stages
Fuel System	-	Multi-plunger fuel pump controlled by a mechanical, combined acceleration and speed control regulator unit.
Starting System	-	L.P. air operated turbine starter.
Engine Weight (Dry).	-	3290 lbs (approx).
Dimensions	-	Intake Diameter 32.45 ins. Length 123.475 ins.

1.3.65.

SPEY Mk 201/202

PROPULSION UNIT

OPERATION AND CONTROL

1. INTRODUCTION

The propulsion unit consists of the engine which is an axial flow bypass turbo-jet and a reheat jet pipe.

The engine is required to produce sufficient thrust to propel the aircraft at high speed, and produce it economically to give the aircraft a good operating range.

To enable the aircraft to achieve rapid climb and supersonic speeds, additional thrust is produced by reheating the engine gas stream in the jet pipe.

Control of engine and reheat thrust is required so that varying degrees of power can be selected and to prevent operating limits being exceeded.

This is achieved by using separate fuel control systems for engine and reheat and by the use of top limiting devices.

Separate indicators to show correct or incorrect functioning of engine or reheat are provided in the cockpit.

2. ENGINE OPERATION

The thrust is produced by accelerating the air drawn into the engine inlet.

The low pressure compressor handles the total airflow, a proportion of which is then passed through the high pressure compressor, combustion chambers and turbine assemblies.

A duct, around the H.P. section of the engine, accepts the remaining air which is known as the bypass air.

Bypass air is fed into the gas stream at the rear of the turbines, cooling the stream and so reducing its velocity.

The total stream is then expanded to atmosphere through the propelling nozzle.

/continued

This arrangement permits the use of a high turbine entry temperature so ensuring high thermal efficiency and, since less energy is wasted to atmosphere, giving greater propulsive efficiency, the required thrust is produced economically.

3. ENGINE CONTROL

Manual control of engine power is provided by the throttle lever which selects a fuel flow thus producing a given H.P. shaft r.p.m. for the prevailing airflow conditions.

Changes in airflow, signalled to the fuel control system, automatically modify the fuel flow to maintain the selected H.P. r.p.m.

To prevent Engine Operating limits being exceeded when the throttle is fully open, topping controls reduce fuel flow by over-riding the throttle signal as follows:-

1. Turbine Gas Temperature (T6) control

Excessive turbine entry temperature (T4) would shorten the life of the turbine assemblies.

It is therefore necessary to limit the max. T4 at which the engine operates.

Since there is a known relationship between (T4) and Turbine Gas Temperature (T6) and because T6 is of a lower value and gives a more stable signal, it is used to control fuel flow so that T6 (and hence T4) does not exceed the limiting value.

A T6 signal, in excess of the limiting value, fed from thermocouples in the exhaust mixer unit to an amplifier and from there to mechanism in the fuel flow regulator causes the necessary reduction in fuel flow.

This will of course result in a reduction of H.P. r.p.m.

2. H.P. Compressor Delivery Temperature (T3) limiter

In high speed flight at low altitude, H.P. compressor delivery temperature (T3) increases.

To prevent any adverse effects on materials in the diffuser casing area there is a limiting maximum T3.

/continued

Thermocouples sensing T3 feed a signal via the amplifier to the same mechanism as that used for T6 control.

Excessive T3 signal will therefore cause a reduction in fuel flow and so reduce H.P. r.p.m.

3. H.P. Compressor Delivery Pressure (P3) limiter

To prevent unnecessary stressing of compressor and diffuser casings the maximum H.P. compressor delivery pressure (P3) is limited.

A signal of P3 is supplied to mechanism in the fuel flow regulator.

If this signal exceeds a preset spring force the mechanism is operated to cause a reduction in fuel flow.

This again will result in a reduction of H.P. r.p.m.

4. Low pressure shaft Overspeed Governor

This is a mechanical governor (Flyweights against a preset spring) driven from the low pressure shaft.

If the L.P. shaft speed increases till flyweight force overcomes spring force, fuel flow is reduced to prevent L.P. shaft overspeed.

2

ROLLS RR ROYCE

CUSTOMER TRAINING CENTRE
COURSE NOTE
No. TSp.302
Printed in Great Britain

SPEY MK 201

AFTERBURNER OPERATION AND CONTROL

SEQUENCE HEADING CHART

1. INTRODUCTION.

2. OPERATION.

3. AFTERBURNER CONTROL.

4. OPERATING LIMITATIONS.

5. CONSOLIDATION PERIOD.

Printed in Great Britain

1.3.65.

SPEY MK 201/202

REHEAT

OPERATION AND CONTROL

4. OPERATION.

To enable the aircraft to attain supersonic speeds, an increase in thrust is required, above that produced by the engine.

To obtain additional thrust, fuel is burnt in the jet pipe to reheat the gas stream and increase its velocity.

The reheat system comprises:-

1. A jet pipe incorporating a burner assembly and variable area exit nozzle.
2. A unit to control fuel supply to the burner assembly.
3. An ignition system.
4. A hydraulic system to provide nozzle movement.
5. A unit sensitive to engine pressure ratio changes, which co-ordinates fuel supply and nozzle area.

When the throttle lever is moved beyond the maximum r.p.m. position and through the reheat range, a mechanical signal of lever movement is relayed to the reheat fuel control unit.

The unit determines the total fuel delivery of a pump and controls the distribution of fuel flow to the burner assembly.

On selection of reheat, fuel supply to the burners is ignited resulting in an increase in jet pipe pressure (P6).

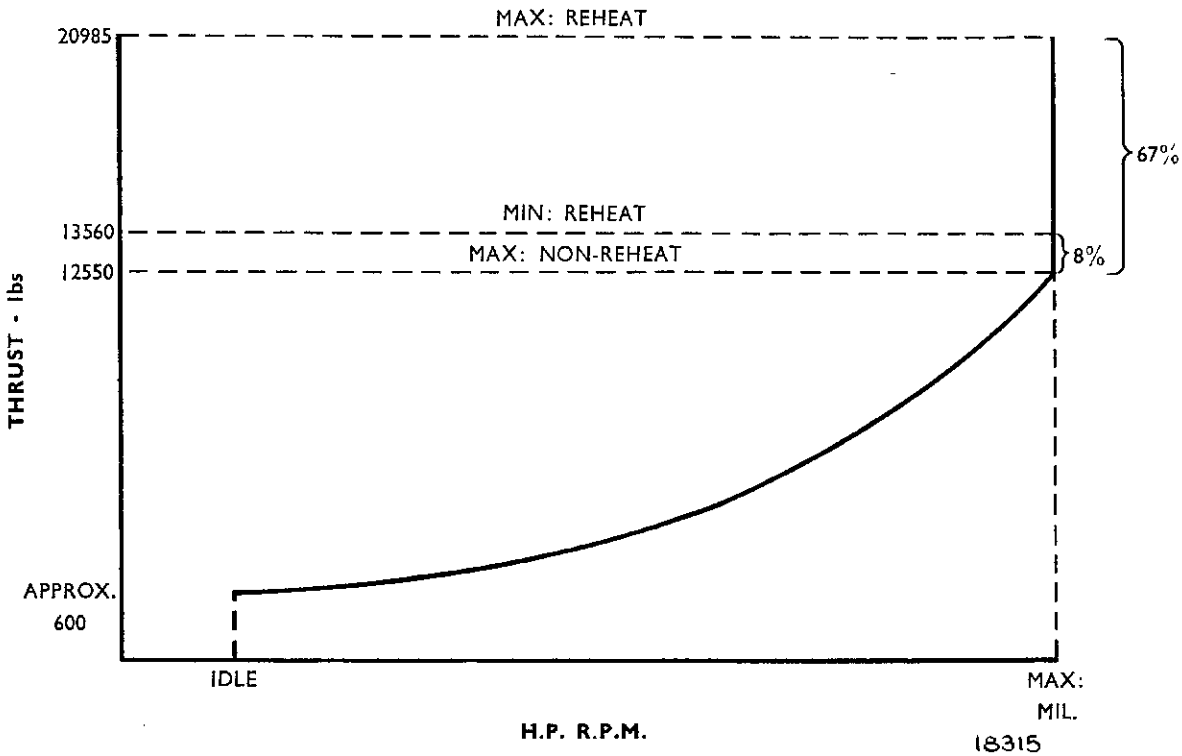
This alters the pressure ratio across the turbines (P3/P6) and if this was permitted to continue it would adversely affect engine operation.

It is prevented by increasing the exit area of the jet pipe nozzle until the correct P3/P6 ratio has been restored.

With further throttle opening to increase the degree of reheat, nozzle area is progressively increased to maintain a satisfactory P3/P6 ratio.

/continued.

The increase in thrust obtained is shown in Fig.1.



Nozzle movement is achieved as follows:-

An actuating skirt, which surrounds the jet pipe, carries a number of rollers which bear on camtracks attached to master flaps forming part of the variable nozzle.

The forward edge of the skirt is attached to six hydraulic rams and these are pressurised by an oil pump.

Pump output is controlled by connecting it to a pressure ratio ram unit which is sensitive to variations in P3 : P6.

The sequence of events with selection of an increase in reheat is as follows:-

a. Fuel control unit schedules an increase in pump output i.e. Total Flow increases.

b. Jet pipe pressure (P6) increases, altering the pressure ratio P3 : P6.

c. Pressure ratio ram unit alters pump output causing an unbalance between hydraulic ram load and gas load on nozzle flaps.

d. Gas load opens nozzle i.e. exit area is increased.

e. As nozzle opens the actuating skirt moves rearwards.

/continued.

f. The increase in nozzle area restores the P3 : P6 ratio and the pressure ratio ram unit alters pump output till balance is restored between nozzle rams and gas loading on nozzle flaps.

The correct nozzle area is thus selected to maintain a satisfactory P3 : P6 ratio.

5. REHEAT CONTROL.

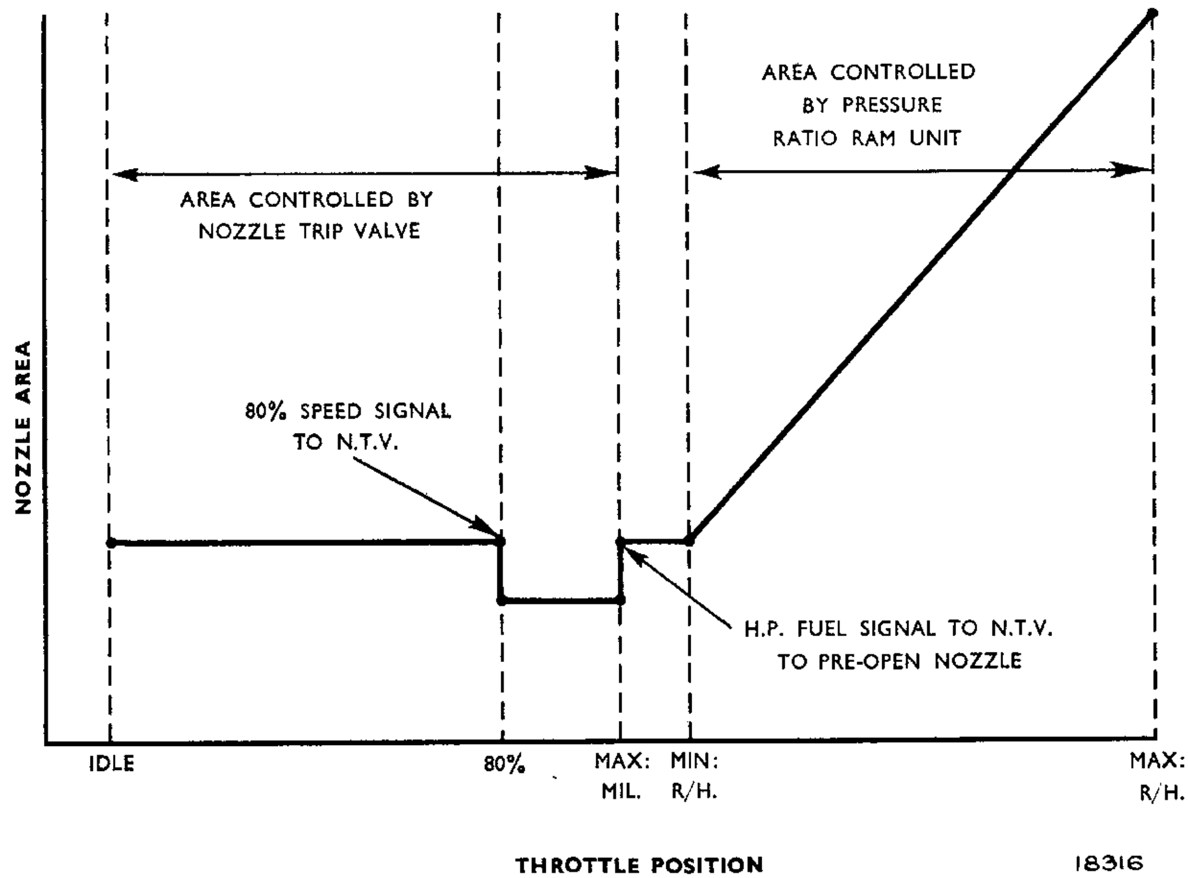
The degree of reheat obtained is determined by throttle lever position.

A signal of lever position is fed to the Reheat Fuel Control Unit (R.F.C.U.) which controls the output of the reheat fuel pump.

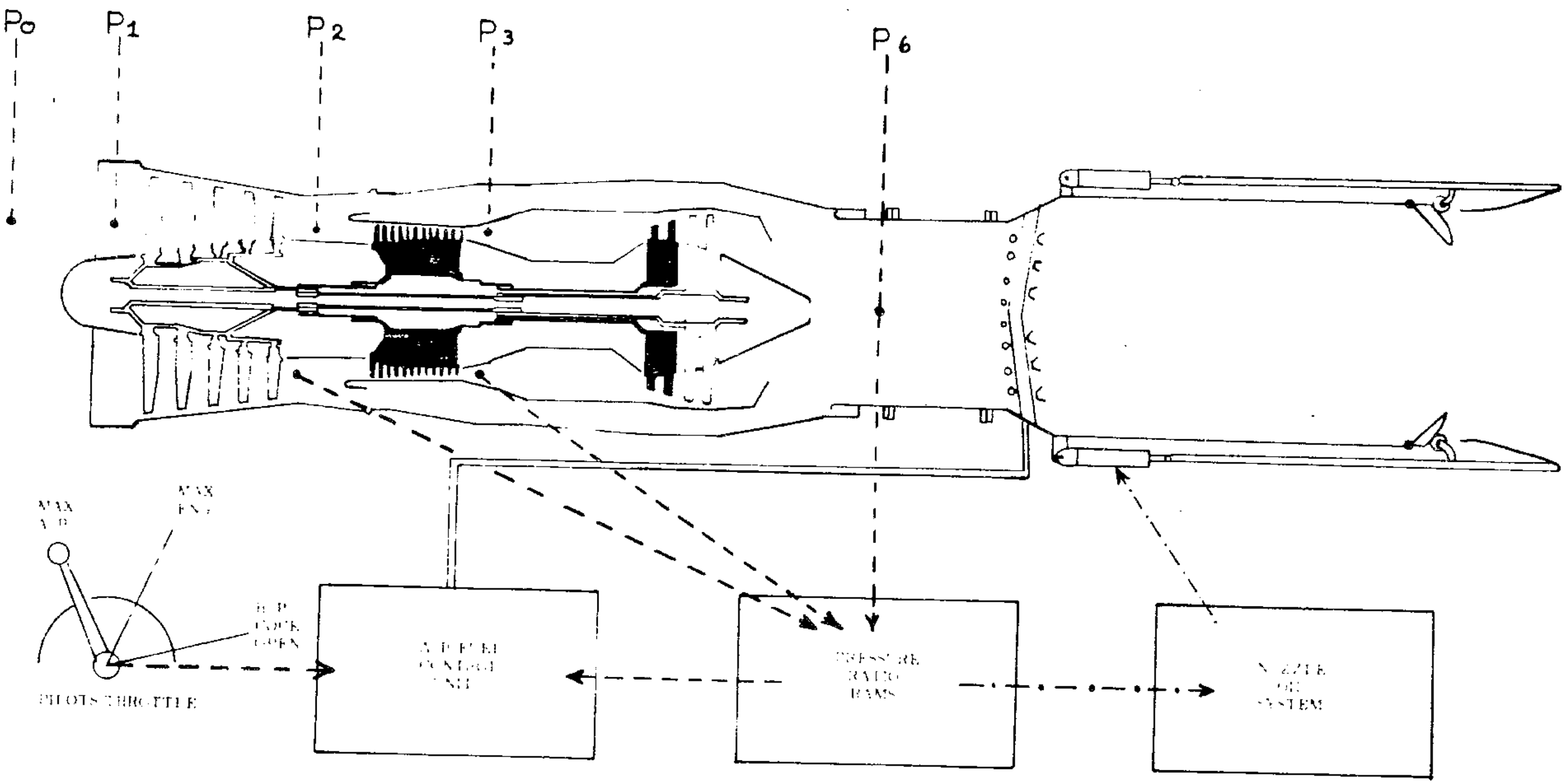
Variations in airflow due to change of altitude or forward speed are signalled to the R.F.C.U. causing fuel flow to be modified.

As previously explained, the area of the nozzle is controlled automatically to maintain a satisfactory P3 : P6 ratio.

The following graph Fig.2 shows the relationship between throttle position and nozzle area over the range: Idle (NON R H) through selection of MIN R/H TO MAX R/H.



SPEY MK201 AFTERBURNER OPERATION AND CONTROL



SPEY MK 201

ENGINE AND AFTERBURNER CONSTRUCTION

SEQUENCE HEADING CHART

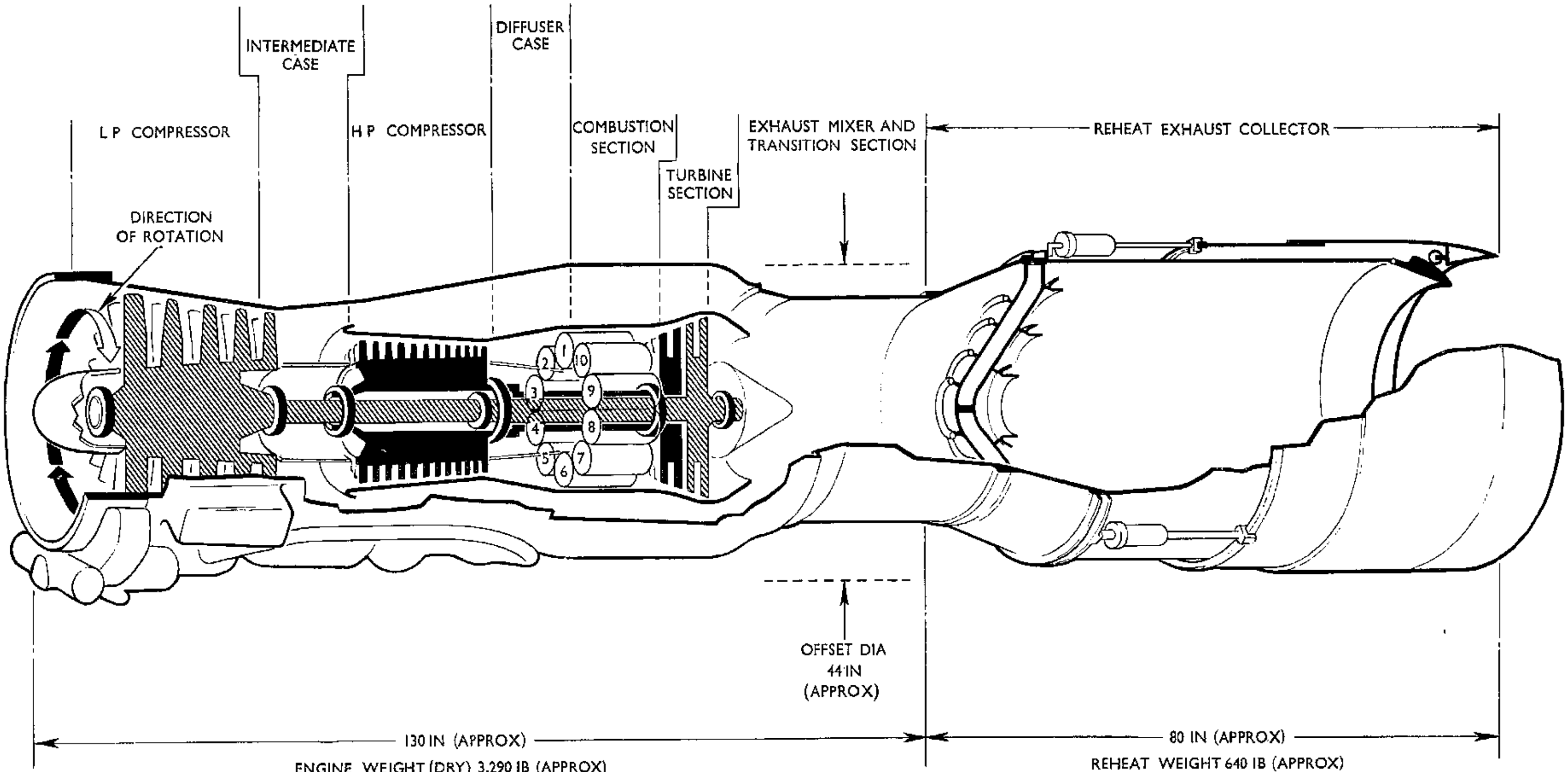
ENGINE CONSTRUCTION.

1. ENGINE DATA.
2. AIR INLET CASE.
3. L.P. COMPRESSOR SECTION.
4. COMPRESSOR INTERMEDIATE CASE.
5. H.P. COMPRESSOR SECTION.
6. DIFFUSER CASE.
7. COMBUSTION SECTION.
8. TURBINE SECTION.
9. AUXILIARY DRIVES.
10. CONSOLIDATION PERIOD.

AFTERBURNER CONSTRUCTION.

1. AFTERBURNER DATA.
2. JET PIPE.
3. BURNER ASSEMBLY.
4. NOZZLE ASSEMBLY.
5. CONSOLIDATION PERIOD.

1.3.65.



RT. 5047.

SPEY Mk. 201 ENGINE – BASIC PROPULSION UNIT

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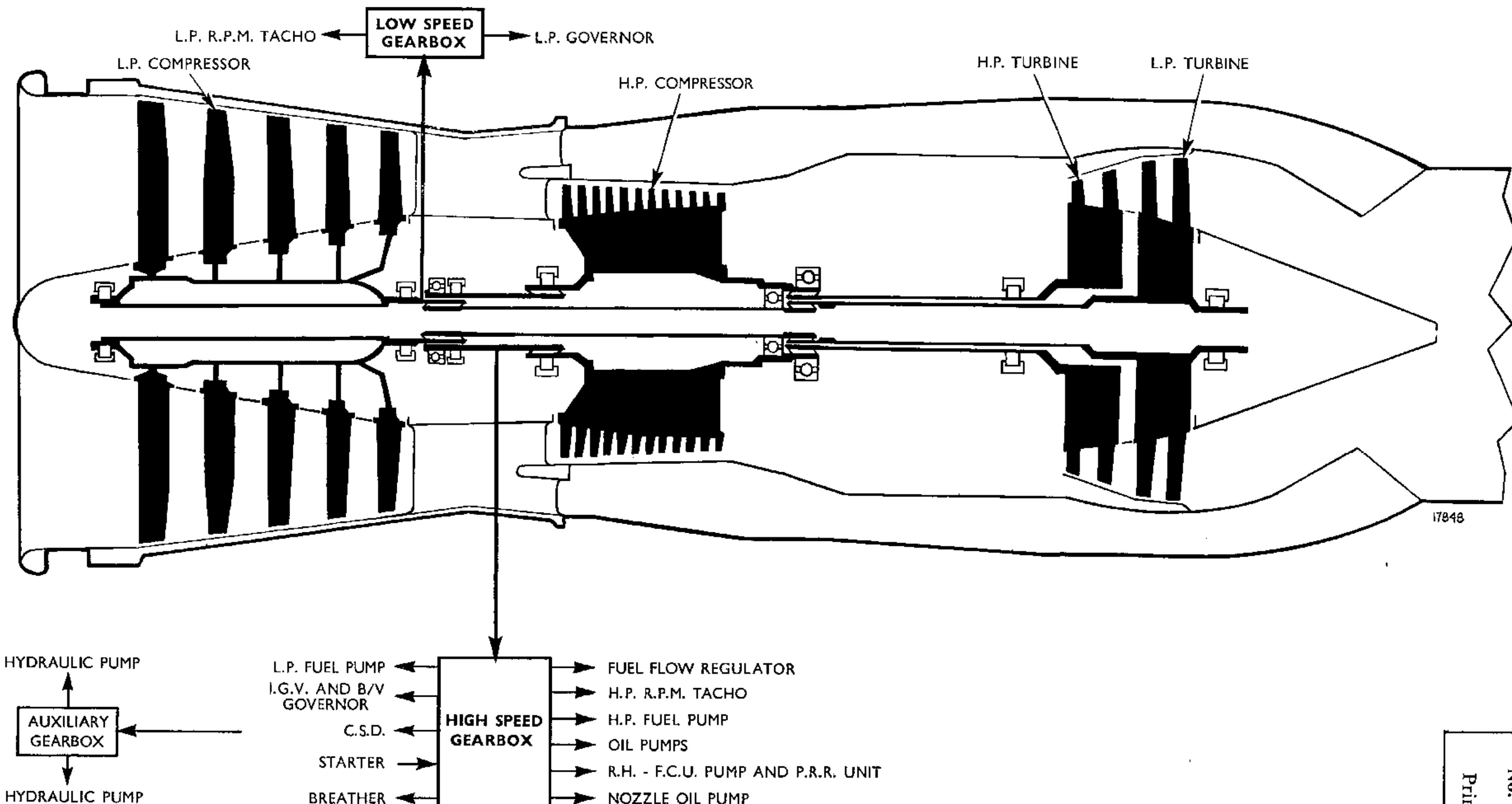

MAIN ROTATING ASSEMBLIES AND GEARBOX DRIVES

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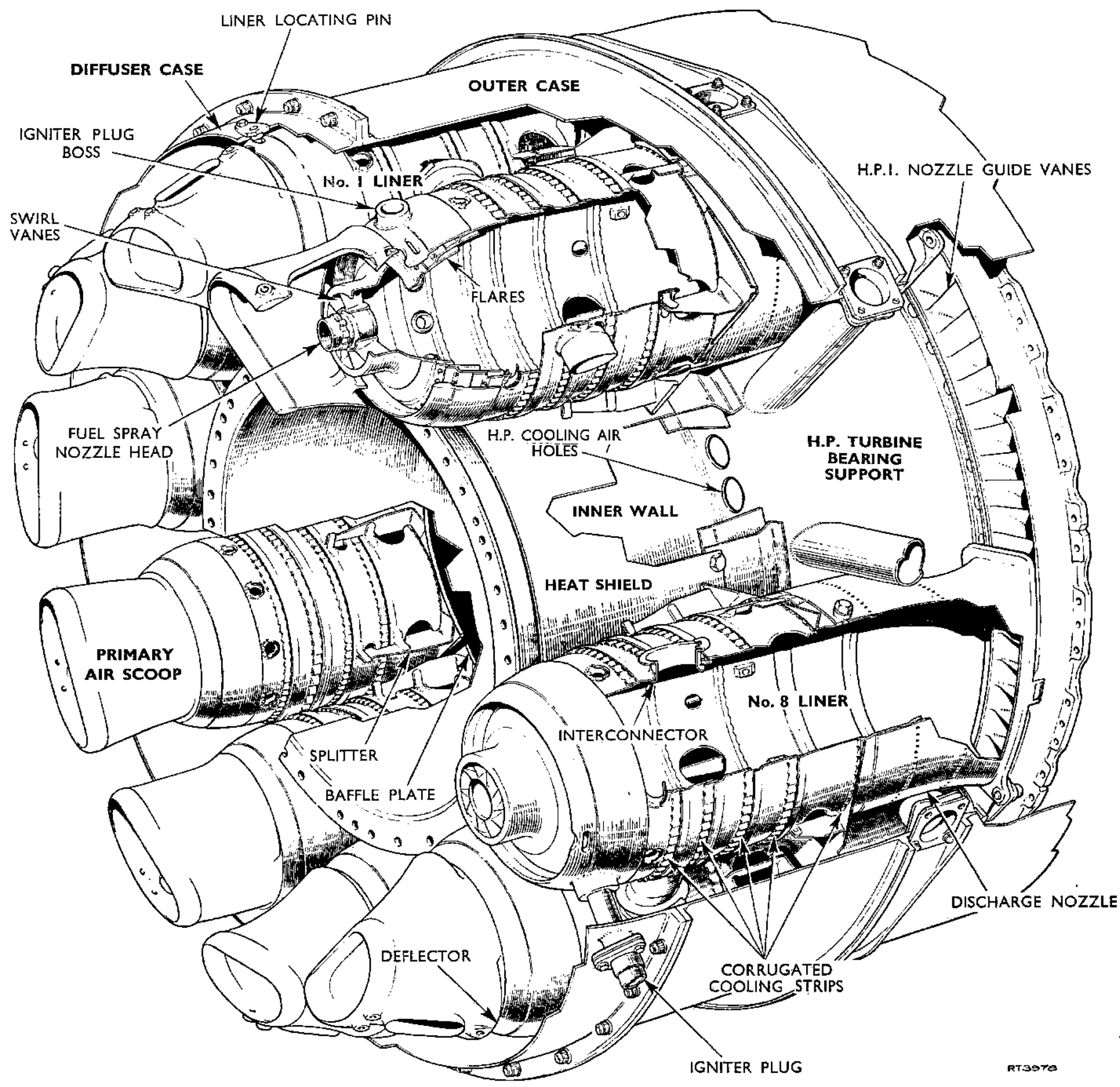
x 1st + 5th stage clapper blade

SPEY Mk. 201 COMPRESSOR SECTION

1.2.66



SPEY Mk. 201 COMBUSTION SECTION

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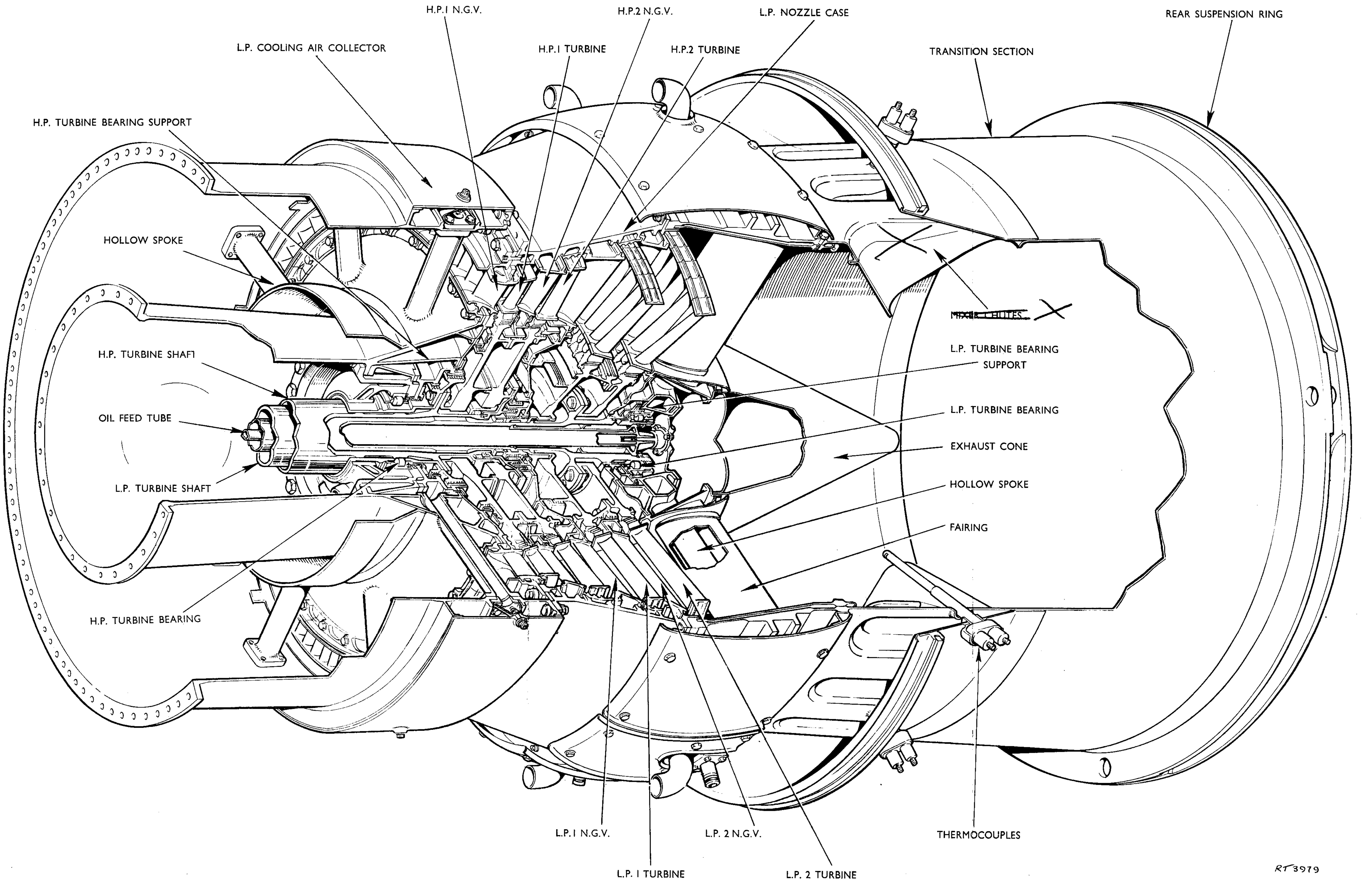
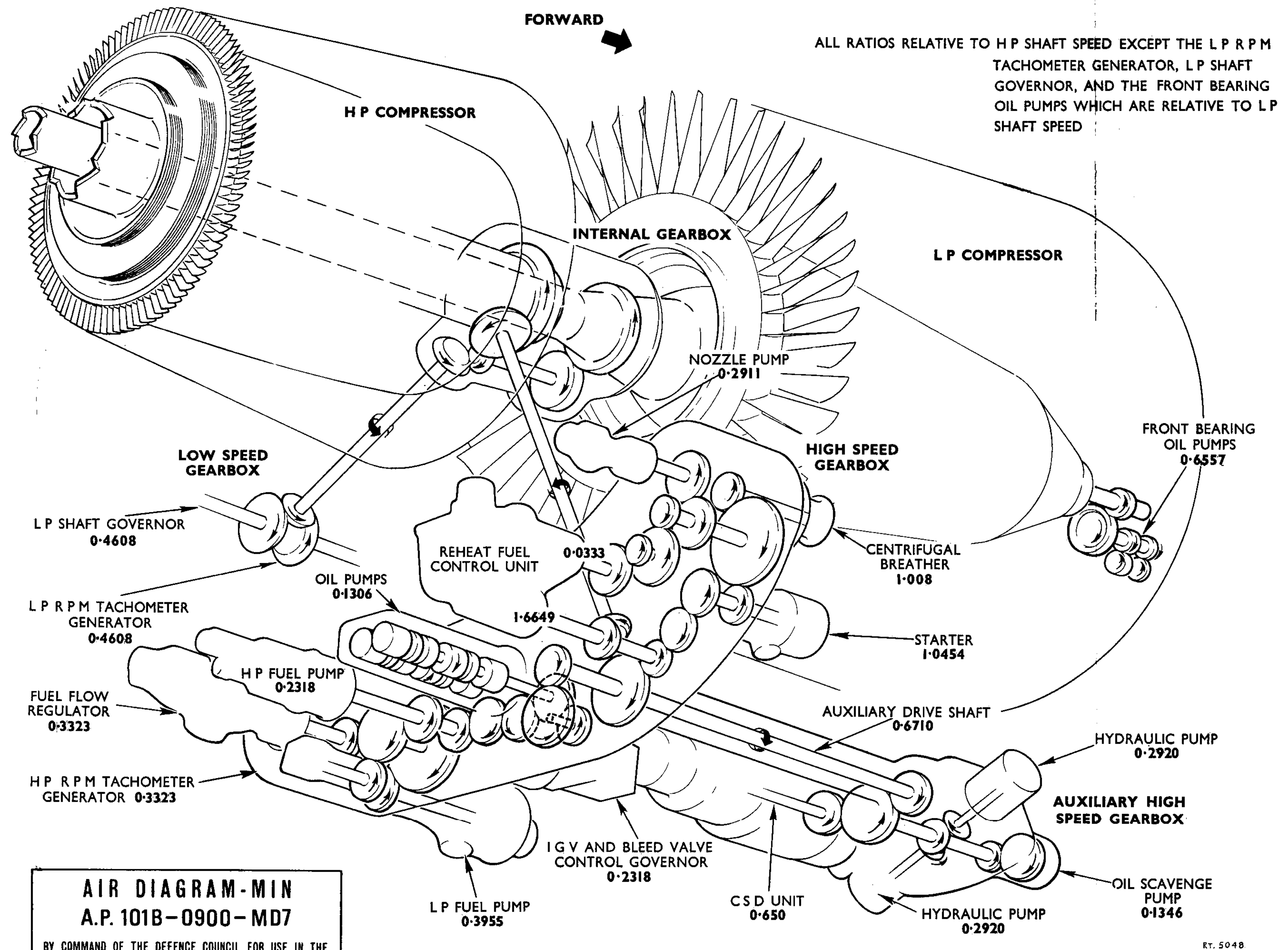


SPEY Mk. 201 TURBINE SECTION



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SPEY Mk. 201 ENGINE — GEARBOX DRIVES

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NOTE - ENGINE SHOWN IS NOT TO A SPECIFIC MODIFICATION STANDARD FOR PRECISE DETAILS REFER TO SYSTEM AND UNIT DESCRIPTIONS

AIR INLET AND FRONT BEARING SUPPORT CASE

1 AIR INLET HUB
2 FRONT BEARING
3 INLET GUIDE VANE
4 HOT AIR ANTI-ICING MANIFOLD
5 HOT AIR ANTI-ICING TUBES

LOW PRESSURE COMPRESSOR CASE

6 STAGE ONE ROTOR BLADE
7 AIR SEAL
8 STAGE ONE STATOR VANE
9 L P COMPRESSOR SHAFT
10 FRONT BEARING OIL RETURN TUBE
11 L P COMPRESSOR ROTOR WHEEL
12 OUTLET GUIDE VANE

COMPRESSOR INTERMEDIATE CASE

13 L P COMPRESSOR REAR BEARING
14 LOW SPEED GEARBOX DRIVING GEAR
15 INTERNAL GEARBOX
16 INTERNAL GEARBOX H S GEARBOX DRIVE BEARING
17 HIGH SPEED GEARBOX DRIVING GEAR
18 BY-PASS DUCT FAIRING
19 VARIABLE INLET GUIDE VANE
20 VARIABLE INLET GUIDE VANE ACTUATING RING
21 H P COMPRESSOR FRONT BEARING
22 LOW SPEED GEARBOX DRIVE SHAFT

HIGH PRESSURE COMPRESSOR CASE

23 H P COMPRESSOR SHAFT
24 H P COMPRESSOR ROTOR WHEEL
25 STAGE ONE ROTOR BLADE
26 STAGE ONE STATOR VANE
27 BLEED VALVE
28 COOLING AIR TUBE
29 STAGE SEVEN AIR MANIFOLD (B L C AIR)
30 L P COMPRESSOR INTERMEDIATE SHAFT
31 OIL FEED TUBE

DIFFUSER CASE

32 H P COMPRESSOR OUTLET GUIDE VANE
33 ANTI-ICING AIR MANIFOLD
34 STAGE 12 AIR MANIFOLD
35 L P COMPRESSOR/TURBINE THRUST BEARING
36 H P COMPRESSOR/TURBINE THRUST BEARING
37 B L C AIR DUCTING

COMBUSTION CASE

38 COMBUSTION LINER AIR SCOOP
39 COMBUSTION LINER INTERCONNECTOR
40 HEAT SHIELD
41 FUEL SPRAY NOZZLE
42 COMBUSTION LINER
43 DISCHARGE NOZZLE

TURBINE CASE

44 H P TURBINE SHAFT
45 H P TURBINE BEARING
46 L P TURBINE SHAFT
47 H P I TURBINE DISC
48 H P I NOZZLE GUIDE VANE
49 L P COOLING AIR COLLECTOR
50 H P I TURBINE BLADE
51 H P 2 NOZZLE GUIDE VANE
52 H P 2 TURBINE BLADE
53 H P 2 TURBINE DISC
54 TURBINE INTERSTAGE SEALS
55 L P I TURBINE DISC
56 L P I NOZZLE GUIDE VANE
57 L P I TURBINE BLADE
58 L P 2 NOZZLE GUIDE VANE
59 L P 2 TURBINE BLADE
60 L P 2 TURBINE DISC
61 L P TURBINE BEARING
62 L P TURBINE BEARING SUPPORT STRUT

EXHAUST MIXER AND TRANSITION SECTION

63 EXHAUST INNER FAIRING
64 T G T THERMOCOUPLE
65 EXHAUST MIXER CHUTE

SPEY Mk. 201 ENGINE — INTERNAL ARRANGEMENT

1.3.67

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1. AUXILIARY GEARBOX
2. C S D OIL PRESSURE FILLER
3. ENGINE OIL TANK PRESSURE FILLER
4. REHEAT OIL TANK PRESSURE FILLER
5. ENGINE H P OIL FILTER
6. C S D UNIT
7. A C GENERATOR
8. AIR STARTER
9. INLET GUIDE VANE AND BLEED VALVE CONTROL GOVERNOR
10. H P TACHOMETER GENERATOR
11. H P FUEL PUMP
12. OIL PUMPS
13. CAMBOX
14. H P FUEL SHUT-OFF VALVE
15. ELECTRICAL HARNESS REAR DISCONNECT
16. HIGH ENERGY IGNITION UNIT
17. T_1 T_3 T_6 AMPLIFIER

RT5053.

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1. T_1 T_3 T_6 AMPLIFIER
2. REHEAT FUEL INJECTOR PROBE
3. T_3 THERMOCOUPLE
4. FUEL SPRAY NOZZLE
5. BOUNDARY LAYER CONTROL VALVE POSITION SWITCH
6. PRESSURE RATIO RAMS
7. NOZZLE OIL PUMP
8. REHEAT FUEL CONTROL UNIT
9. HIGH SPEED GEARBOX
10. AIR STARTER
11. C S D AIR COOLED OIL COOLER
12. T_1 SONIC THERMOCOUPLE
13. HYDRAULIC PUMP MOUNTING
14. AUXILIARY GEARBOX

SPEY Mk. 201 ENGINE – RIGHT HAND VIEW

1.3.67

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1. ENGINE AIR COOLED OIL COOLER
2. ENGINE OIL TANK
3. HYDRAULIC PUMP MOUNTING
4. REHEAT SYSTEM OIL TANK
5. VELOCITY CLEANED FUEL FILTER
6. FUEL COOLED OIL COOLER
7. L P FUEL PUMP
8. L P TACHOMETER GENERATOR
9. ANTI-ICING HOT AIR VALVE
10. LOW SPEED GEARBOX
11. ELECTRICAL HARNESS FORWARD DISCONNECT
12. FUEL FLOW REGULATOR
13. L P GOVERNOR
14. REHEAT CATALYST FUEL FLOW CONTROL UNIT

RT5052

SPEY Mk. 201 ENGINE — LEFT HAND VIEW

SPEY MK 201/202

PROPULSION UNIT

MECHANICAL ARRANGEMENT

1. ENGINE MAIN ASSEMBLIES.

Having considered a general outline of the engine and its systems we can now study briefly the mechanical arrangement of the engine.

This section describes some detail of engine construction and the materials used.

The diagrams included in the section name and position the main assemblies which are now described.

(a) COMPRESSOR SECTION.

Air Inlet Extension.

A short steel extension ring secured to the front face of the air inlet case carries two air cooled oil coolers and an intake thermocouple and ejector system.

Air Inlet Case.

Consists of an annular outer case, inlet guide vanes and support for the L.P. compressor front bearing.

A small housing, secured forward of the bearing support, contains metering and scavenge oil pumps.

The housing is enclosed by a light alloy nose fairing.

L.P. Compressor Case.

The case is formed by two light alloy semi-circular sections which house four stages of light alloy stator vanes.

The vanes are grouped in packs with a shroud ring secured to the inner end of the packs to keep them rigid.

An extension to the shroud ring forms the static member of an interstage seal.

/continued.

L.P. Compressor Rotor.

A 3 piece shaft (Mk 201 engs)
2 piece shaft (Mk 202 engs)
carries five stages of blades.

Stage 1 and 5 blades are titanium and are 'clapper blades'.

Stages 2, 3 and 4 are light alloy blades.

Drives are taken from the shaft for:-

Front bearing oil pumps (front end)
Low speed gearbox (rear end)

Compressor Intermediate Case.

Consists of an inner and outer case connected by eight hollow radial struts.

The case is of steel and contains the internal gearbox.

It also provides location for the H.P. compressor variable inlet guide vane actuating disc and for the I.G.V's.

External mounting faces carry the Low Speed and High Speed gearboxes and the front inboard and outboard suspension points.

A concentric fairing in the duct between inner and outer cases, divides the total air flow from the L.P. compressor into two flows:- i.e.

Bypass flow.
H.P. compressor flow.

H.P. Compressor Case.

This is a
Nickel alloy case (Mk 201)
Steel case (Mk 202)
in two halves which house steel stator vanes.

Two external circumferential flanges locate a 7th stage air bleed manifold.

A bleed valve (H .P. compressor airflow system) is located around the forward end of the manifold.

Air for aircraft services and for boundary layer control (B.L.C.) is tapped from the manifold.

/continued.

H.P. Compressor Rotor.

A two piece shaft carries the 12 stages of rotor blades.

Stages 1 to 8 (inclusive) are titanium, Stage 1 being clapper blades.

The remaining four stages are:-

Nickel alloy (Mk 201 engs)
Steel (Mk 202 engs)

A stub shaft, splined to the front end of the H.P. shaft, carries a bevel gear which transmits the drive to the high speed gearbox.

Diffuser Case.

Consists of an inner and outer case connected by 10 hollow struts.

Three of the struts carry oil feed or return pipes.

All struts permit air to pass from a manifold around the inside of the inner case to a manifold which surrounds the outer case.

Air is tapped from the outer manifold for:-

1. Engine anti-icing.
2. Aircraft Air Services and Boundary layer control.

The outer case provides location for the fuel spray nozzles.

Fitted between the struts at the rear of the diffuser case are ten primary air scoops.

(b) COMBUSTION SECTION.

Incorporates ten combustion liners located in an annular chamber.

The chamber is formed between:-

1. An outer combustion case.
2. A heat shield which surrounds the inner wall of the H .P. turbine bearing support.

A manifold at the rear of the outer case collects all low pressure sealing and cooling air and discharges it overboard through one of two outlets, to permit engine handing.

Igniter plugs are fitted to No's 4 and 8 combustion liners.

 /continued.

(c) TURBINE SECTION.

This consists of:-

1. A nozzle case which contains N.G.V's.
2. A high pressure turbine bearing support.
3. H.P. and L.P. turbine assemblies.
4. A low pressure turbine bearing support.

H.P. and L.P. turbines and their nozzle guide vanes are housed in the nozzle case.

Both turbine assemblies are supported by roller bearings in their respective supports.

$H.P._1$, $H.P._2$, N.G.Vs and $H.P._1$ turbine blades are air cooled.

The L.P. turbine bearing support consists of a central hub secured to an outer case by 6 hollow struts.

Each strut conveys air from the bypass duct to cool and seal the L.P. turbine bearing.

Streamlined fairings surround each strut and two of the fairings carry oil feed and return tubes.

(d) EXHAUST MIXER AND TRANSITION SECTION.

This is a steel case incorporating ten chutes at its front end.

It is secured to the L.P. turbine bearing support.

An outer conical section of the mixer provides location for the following:-

1. 8 T_6 thermocouples.
2. A P_6 probe.
3. A piston type sealing ring.

A double flange at the rear of the transition section provides location for a pair of suspension link rods and the rear flange provides the mounting face for the reheat pipe.

(e) BYPASS DUCT.

A two piece case which encloses the rear half of the engine forming a duct for bypass air.

The rear end is supported on the piston type seal on the exhaust mixer.

/continued.

This permits differential expansion and prevents leakage of bypass air.

Sole plates on the duct, fitted with sliding seals, provide passages for:-

1. Oil feed and return tubes.
2. Fuel spray nozzles.
3. Igniter plugs.
4. Air supply ducts.
5. Pressure tappings.

4

SPEY MK 201

AFTERBURNER DATA

JET PIPE UNITS.

Diffuser Section	Incorporates the burner assembly supported on 5 radial struts.
Burning Section	Cylindrical steel section incorporating a fuel shield and a single and double skin heat shield.
Nozzle	Fully variable area nozzle comprising; (a) 20 master flaps with cam type tracks (b) 20 sealing flaps.

BURNER ASSEMBLY.

3 vapour gutters and 4 main burners concentric with the jet pipe diffuser.

NOZZLE ACTUATING MECHANISM.

Skirt	Cylindrical Titanium skirt incorporating a fixed diameter ejector nozzle.
Nozzle rams	6 hydraulic rams, equi-spaced around forward end of jet pipe.

AFTERBURNER.

Diameter	37"
Weight	approx. 640 lbs.

JET PIPE MOUNTED ACCESSORIES.

Nozzle rams

Staging valve

Nozzle trip valve

Nozzle position transmitter

SPEY MK 201/202

MECHANICAL ARRANGEMENT

2. REHEAT JET PIPE (MAIN ASSEMBLIES).

(a) Diffuser Section.

A short steel divergent section attached to the rear flange of the transition section.

Five hollow tangential struts, located in the diffuser, provide support for the burner assembly.

The burner assembly consists of:-

3 vapour gutters and 1 main outer manifold - secured downstream of the struts

3 main manifolds - secured upstream of the struts

Fuel tubes to the gutters and main manifolds are located in the struts.

(b) Burning Section.

Consists of a main outer skin and a concentric inner heatshield.

To give improved cooling for the hotter region at the rear of the burning section the heatshield rear section is of double skin construction.

The shield is supported to the main skin by a number of steel tubes which pass through 'V' shaped brackets.

The brackets are alternately secured to main skin and heatshield.

(c) Variable Nozzle.

This consists of twenty master flaps and twenty sealing flaps which are separately pivotted on a flanged steel ring.

The ring is secured to the rear of the burning section.

/continued.

(d) Nozzle Actuating Sleeve.

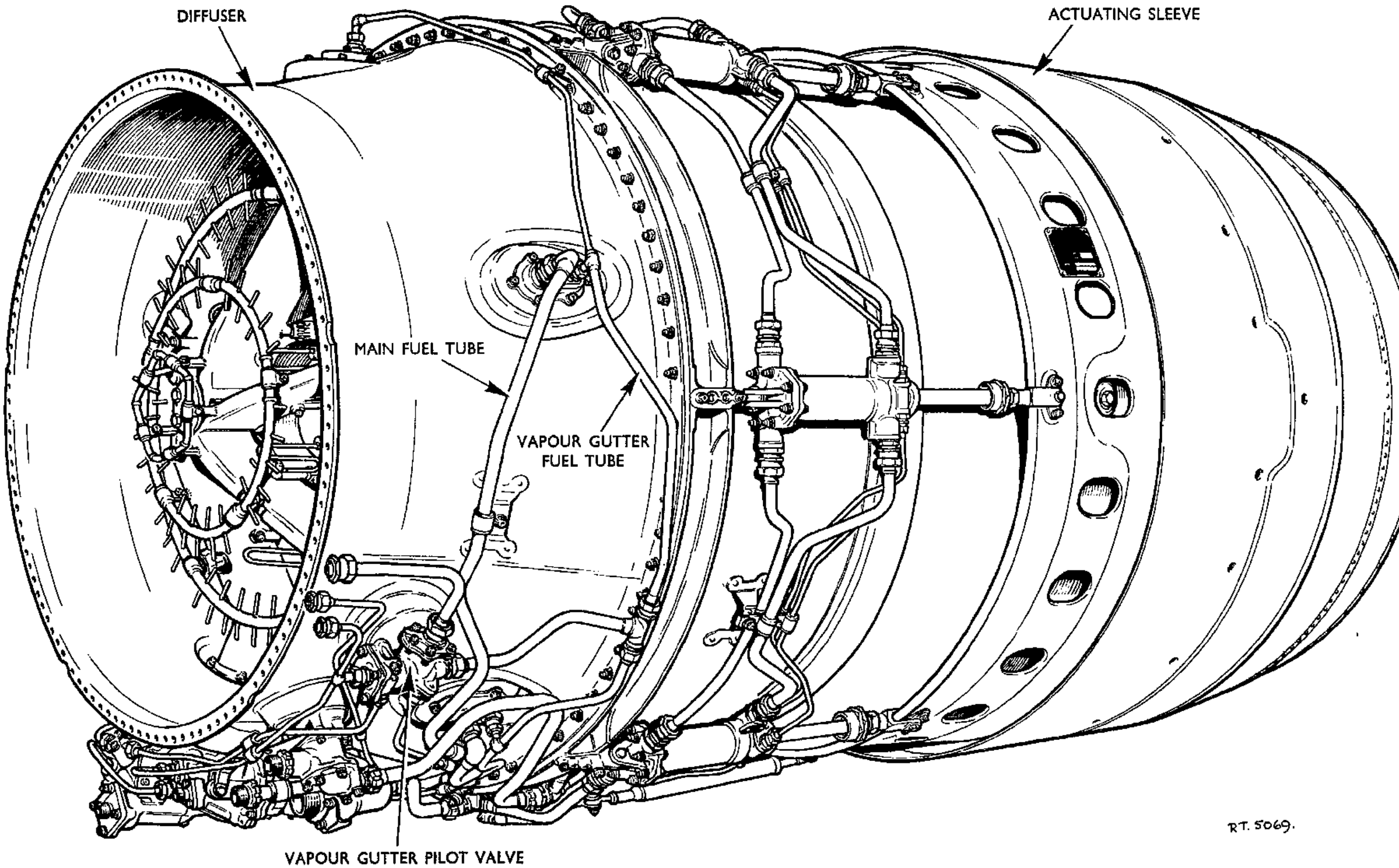
The sleeve surrounds the burning section and the variable nozzle.

It is supported on guide rollers and connected to 6 nozzle operating rams.

The forward edge of the sleeve:-

1. Carries a tappet which operates a nozzle trip valve lever.
2. Transmits nozzle movement by means of a control rod to a potentiometer which then provides an electrical signal to a cockpit nozzle position indicator.
3. Incorporates a wear resistant sleeve which is the bearing surface for aircraft seals.

The rear end of the sleeve supports an ejector nozzle and carries twenty nozzle operating rollers.



REHEAT JET PIPE - LEFT HAND SIDE VIEW

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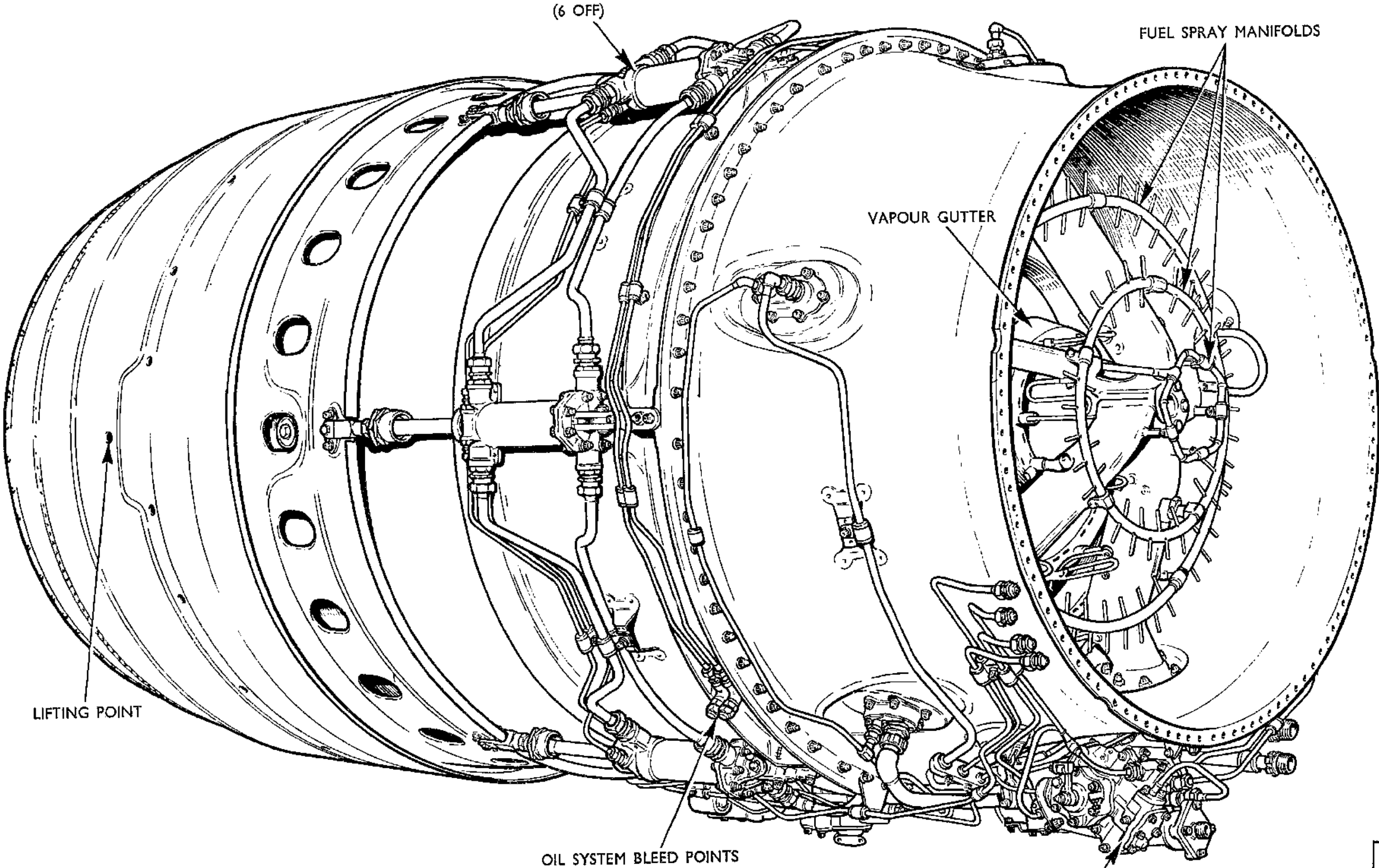

REHEAT JET PIPE - RIGHT HAND SIDE VIEW

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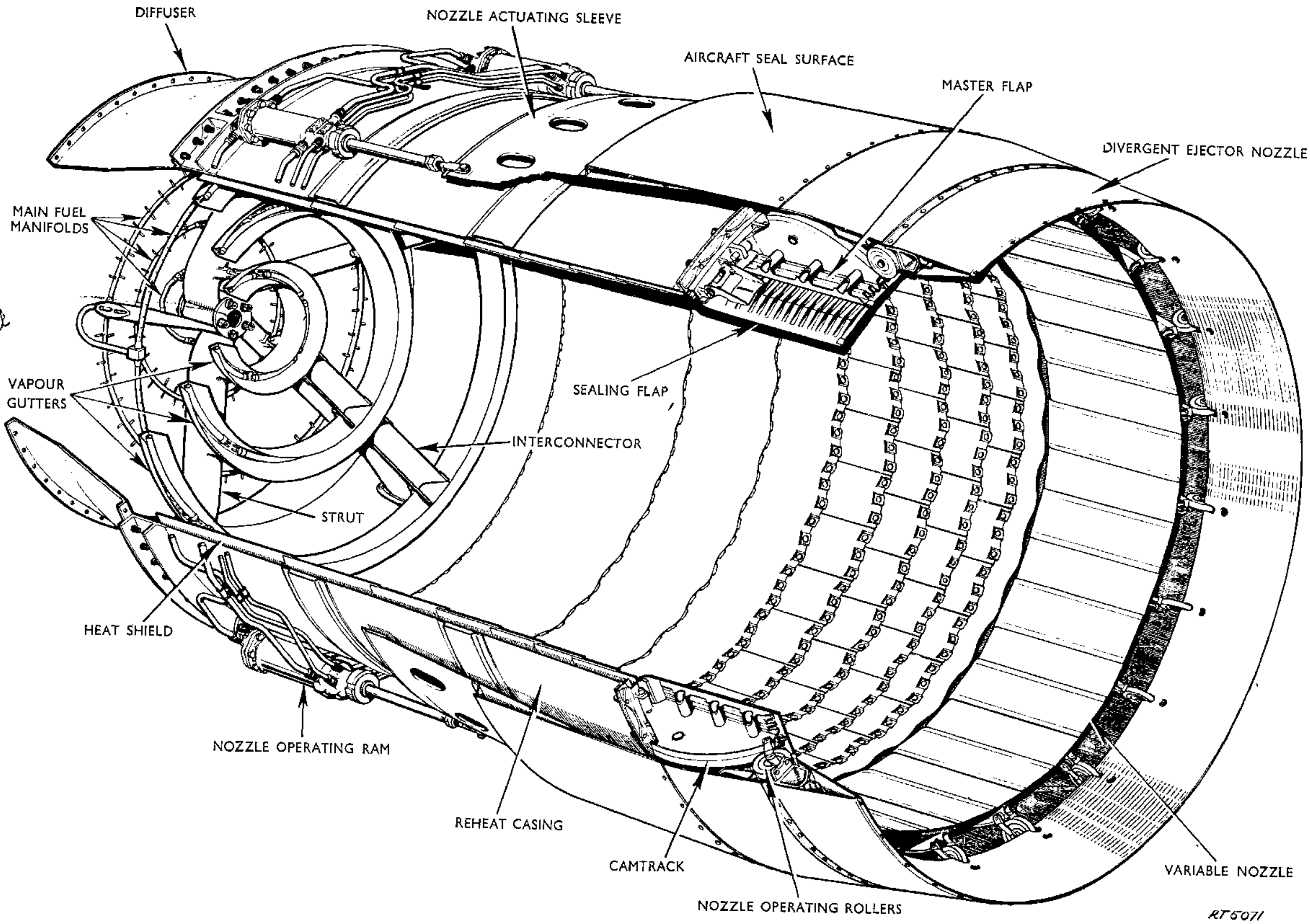

X Burner mounted catalyst missing

SPEY Mk. 201 ENGINE — REHEAT JET PIPE

ROLLS ROYCE

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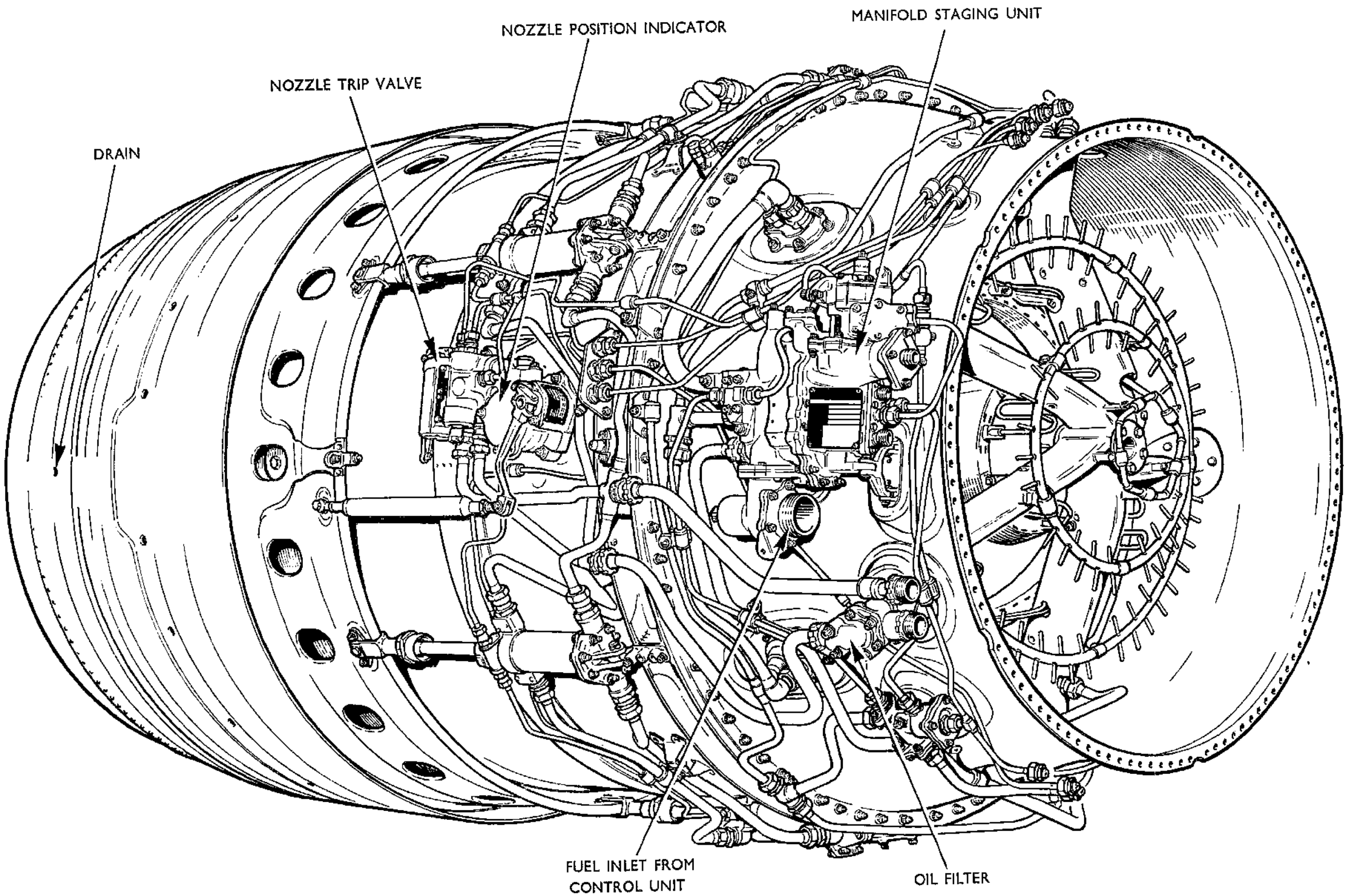

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REHEAT JET PIPE - UNDERSIDE VIEW

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5

SPEY MK 201/202

ENGINE FUEL SYSTEM

SEQUENCE HEADING CHART

1. BASIC FLOW DIAGRAM.

2. LOW PRESSURE SYSTEM.

3. HIGH PRESSURE SYSTEM.

   BASIC CONTROLLING PRINCIPLES WHICH ENSURE :-

   (a) FUEL ATOMIZING.

   (b) CONTROL OF FLOW TO MATCH ENGINE REQUIREMENT.

   (c) CONTROL OF FLOW WITH THROTTLE LEVER MOVEMENT.

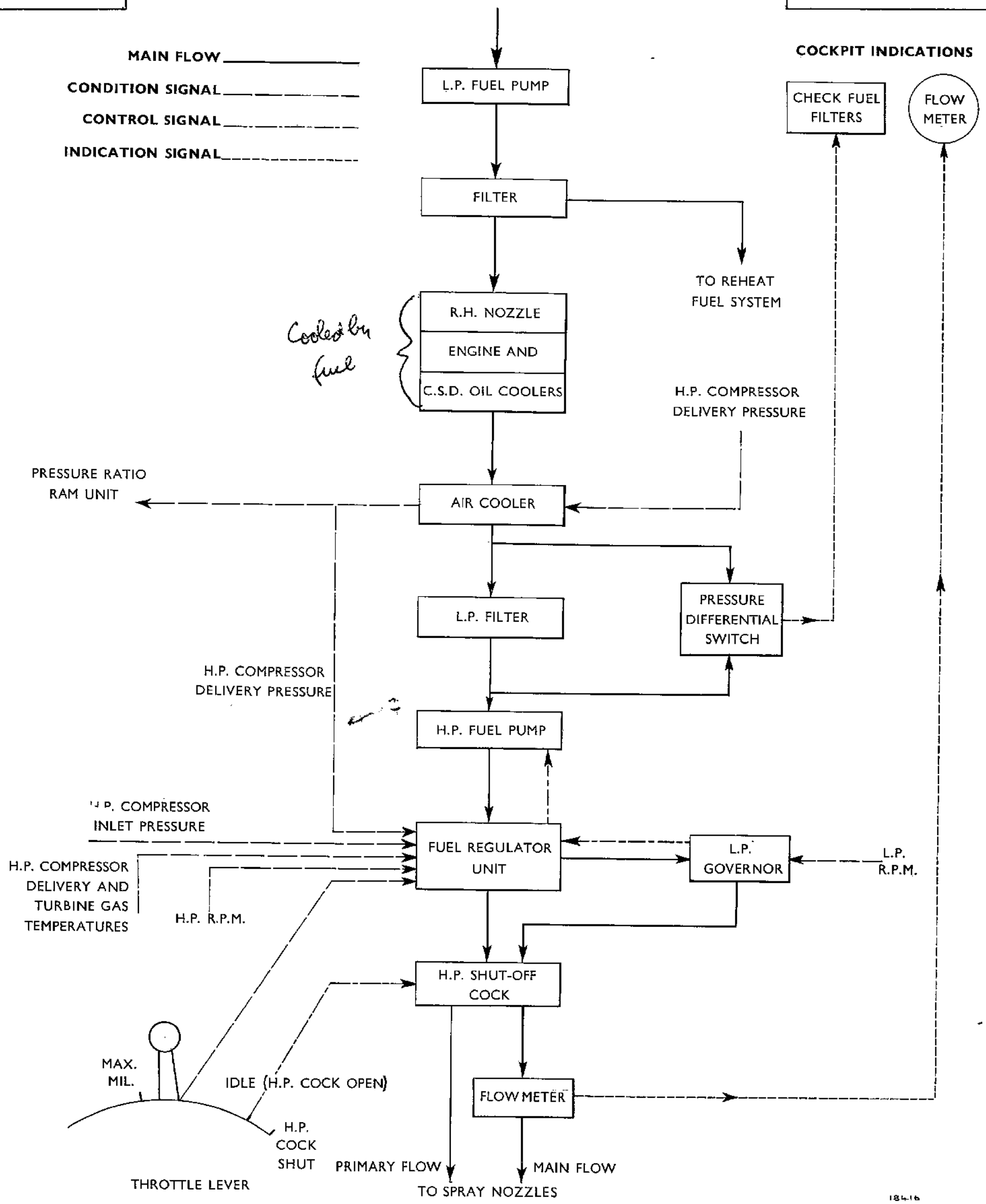
   (d) CORRECTION OF FUEL FLOW FOR VARYING AIRFLOWS.

   (e) PREVENTION OF EXCESSIVE:-

      1. P3.
      2. L.P. SHAFT r.p.m.
      3. T6.
      4. T3.

   (f) STOPPING THE ENGINE.

4. MAINTENANCE.



SPEY Mk. 201/202 FUEL SYSTEM BASIC PRESENTATION

1.9.67

SPEY MK 201/202

2. LOW PRESSURE FUEL SYSTEM.

INTRODUCTION.

Fuel from the A/C tanks is supplied to the engine driven H.P. pump through the following units.

Engine driven L.P. pump (backing pump)
Velocity cleaned filter
Afterburner nozzle oil cooler
Engine oil cooler
Constant speed drive oil cooler
Low pressure filter

LOW PRESSURE PUMP.

The pump provides a fuel supply to the main H.P. pump at an adequate pressure to prevent cavitation.

This ensures greater reliability and better performance at altitude.

It is a centrifugal type pump and is mounted on the front face of the main gearbox.

Low pressure fuel to the afterburner system is also supplied by this pump.

VELOCITY CLEANED FILTER.

This filter ensures a clean fuel supply to the afterburner system.

FUEL COOLED OIL COOLERS.

L.P. fuel flows through 3 oil coolers. These are:-

1. Afterburner nozzle oil cooler
2. Engine oil cooler
3. Constant speed unit oil cooler

The passage of fuel through these coolers maintains a satisfactory oil temperature in the 3 oil systems and the transfer of heat to the fuel helps to prevent formation of ice particles in the fuel.

/continued.

L.P. FILTER.

This is housed in a casing located on the underside of the by-pass duct.

A spring loaded pressure plate which secures the filter element, is located in a cover attached to the base of the casing.

The filter case can be drained by opening a valve in the cover.

Sensing pressure drop across the filter element, which could be increased by the collection of ice particles or dirt on the element, is a switch, which is connected to a "Fuel Filters" blocked indicator in the cockpit.

SPEY MK 201/202

ENGINE FUEL SYSTEM

3. BASIC CONTROLLING PRINCIPLES.

(a) Fuel Atomizing.

A spray nozzle delivers fuel to each combustion chamber.

Each nozzle has a primary and a main jet, the flow to each jet being proportioned by the fuel flow regulator.

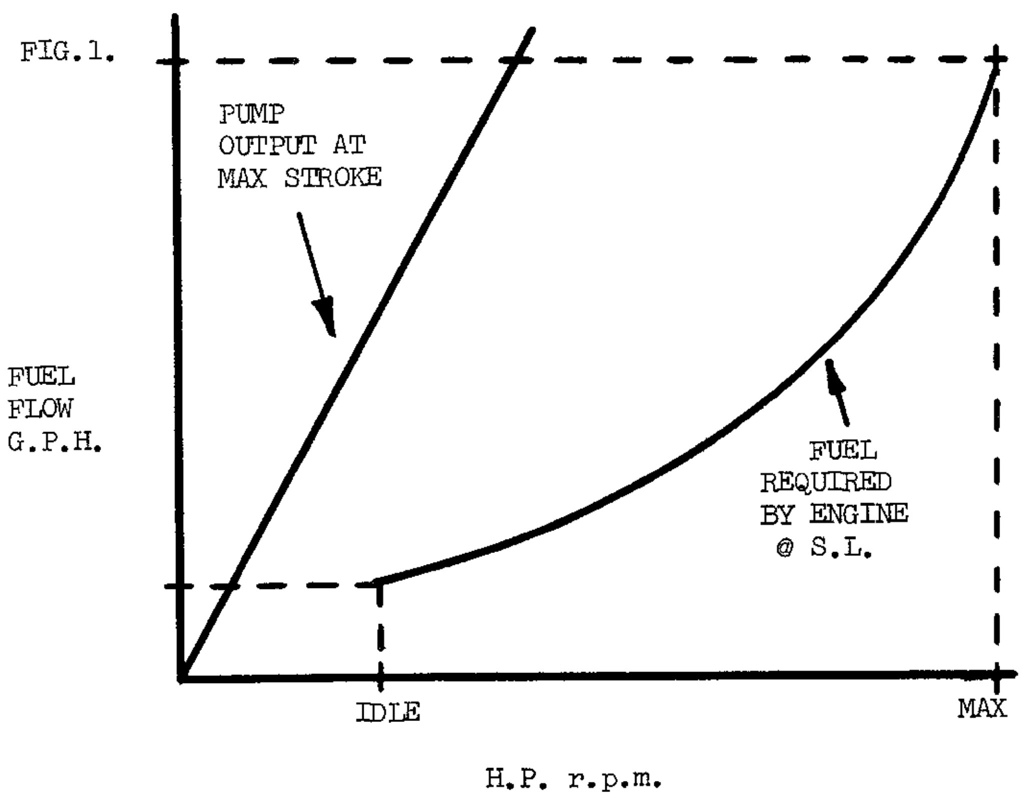
(b) Control of Fuel Flow to Engine Requirement.

Fuel is delivered to the spray nozzles by an engine driven variable camplate type pump.

The output of the pump, at maximum camplate angle and driven at a fixed ratio to H.P. shaft r.p.m. is shown on the graph (Fig.1).

The graph also shows the amount of fuel required by the engine at S.L. to give the selected H.P. shaft r.p.m.

FIG.1.



/continued

To match pump output to engine requirement, camplate angle is controlled by a servo piston.

The piston senses pump output pressure on one side and a reduced pressure on the opposite side.

The reduced pressure results from passing pump output through restrictors in the fuel flow regulator e.g. valves A and B.

The difference in pressure across the piston is balanced by a spring.

(c) Control of Flow with Throttle Lever Movement.

This is done:-

(1) By controlling the area of a hole through which pump output flows. The hole is known as the Variable Metering Orifice (V.M.O.)

(2) By controlling the pressure drop across the V.M.O. with a valve known as the Pressure Drop Valve.

Considering Item (1) i.e. Control of V.M.O. area:-

When the throttle lever is moved to select a higher or lower r.p.m., the initial increase or decrease in V.M.O. area occurs as follows:-

Throttle movement is relayed to the speed selector lever and this alters the loading of a spring acting on the Speed Control Governor Valve (A).

The travel of the valve and therefore the initial increase or decrease in V.M.O. area is limited by stops:-

Acceleration stop - opening throttle.

Deceleration stop - closing throttle.

If V.M.O. area is increased, pump stroke (output) increases. The reverse occurs if V.M.O. area is reduced.

Item 2. The mount of fuel delivered by the pump is determined by the action of the Pressure Drop Valve (B).

Valve (B) senses pressure difference across the V.M.O. and balances it against a H.P. r.p.m. signal (flyweights).

Let us now see how fuel flow is controlled to give a satisfactory acceleration, i.e. without surge or high turbine gas temperature.

If the throttle is opened rapidly, initial overfuelling is limited by the action of valves (A) and (B).

To maintain the correct amount of overfuelling throughout the acceleration a signal of the increase in airflow through the H.P. compressor is used to move valve (C).

/continued.

This controls the rate at which V.M.O. area is further increased.

The valve is moved by connecting it to a capsule assembly.

A section of the capsule senses P_2 (H.P. compressor inlet pressure) the remainder of the capsule being evacuated.

The chamber containing the capsule assembly senses a reduced value of P_3 (H.P. compressor delivery pressure).

Therefore, throughout the acceleration, as P_3/P_2 increases, the capsule is progressively collapsed, controlling the rate at which V.M.O. area increases.

Since the pressure drop across the V.M.O. is limited by the action of Valve (B), overfuelling is matched to the increase in airflow through the H.P. compressor.

As the selected H.P. r.p.m. is reached, flyweights, which receive a H.P. r.p.m. signal, move valve (A) to reduce the V.M.O. area, causing pump stroke (output) to be reduced.

When the forces on valve (A), i.e. flyweight force and spring force, are balanced, V.M.O. area is correct.

Pressure drop across the V.M.O. is controlled by valve (B) therefore the fuel flow is correct.

We can now consider how underfuelling is controlled during deceleration. Closing the throttle reduces spring load on valve (A) causing flyweight force to close down the V.M.O.

The initial reduction in area is limited by a stop (deceleration stop).

Pump servo piston moves to reduce pump output and as r.p.m. and therefore P_3 fall, the capsule assembly progressively reduces V.M.O. area.

Since valve (B) controls the pressure drop across the V.M.O., underfuelling is controlled to give a satisfactory deceleration.

Balance between flyweight force and the reduced spring force is finally achieved and H.P. r.p.m. is governed at the lower value.

(d) Correction of Fuel Flow for Varying Airflow.

Changes in altitude or forward speed alter airflow through the engine, necessitating a change in fuel flow so that the selected H.P. r.p.m. is maintained.

Any change in airflow causes the capsule assembly to alter V.M.O. area, thereby correcting the fuel flow.

/continued.

(e) Prevention of Excessive:-

(1) P_3 (H.P. compressor delivery pressure).

(2) L.P. shaft speed.

(3) T_6 (Turbine Gas Temperature).

(4) T_3 (H.P. compressor delivery temperature).

(1) P3

At low altitude with high forward speed, maximum P_3 may be obtained.

To prevent the limit (330 p.s.i.) being exceeded, a bellows assembly, sensing P_3, opens a valve against a preset spring force, to reduce capsule chamber pressure.

V.M.O. area and therefore fuel flow is reduced.

(2) L.P. Shaft Speed.

To prevent excessive L.P. shaft r.p.m., valve (D) is repositioned when flyweight force exceeds the preset spring force.

The restriction caused by the valve increases upstream pressure causing pump stroke (output) to be reduced.

(3) T6 (Turbine Gas Temperature).

If maximum T_6 is reached a signal from the 8 exhaust mixer unit thermocouples fed to the $T_1/T_3/T_6$ amplifier causes an electric actuator to reposition fulcrum point (**X**).

Spring force on valve (A) is reduced and flyweight force reduces V.M.O. area.

Pump stroke (output) reduces to prevent excessive T_6.

(4) T_3 (H.P. Compressor Delivery Temperature).

To prevent maximum T_3 being exceeded, a signal from two thermocouples to the $T_1/T_3/T_6$ amplifier operates the same mechanism as for T_6 control.

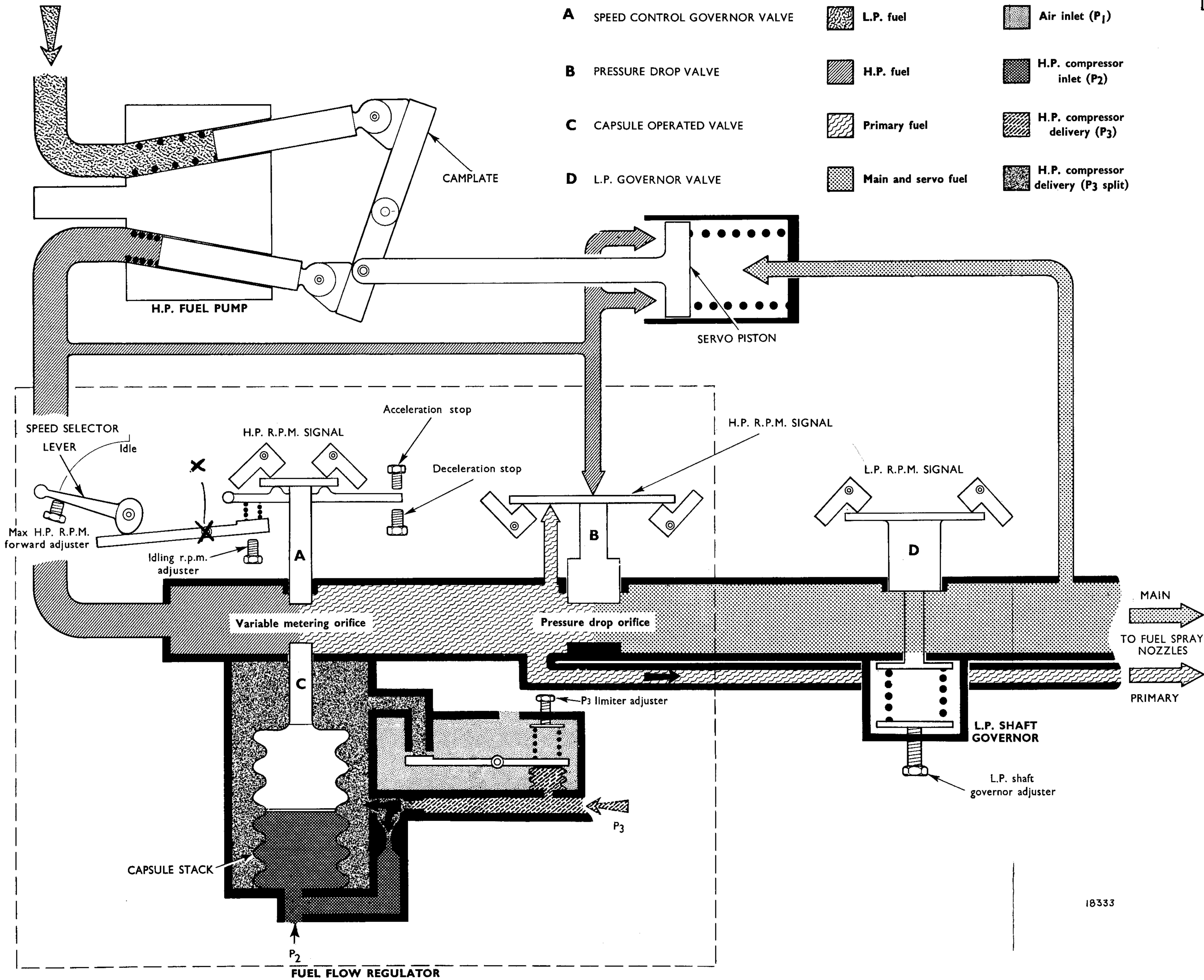
The thermocouples are fitted forward of Nos 3 and 9 spray nozzles.

(f) Stopping the Engine.

A plunger type H.P. shut-off valve in a housing mounted on the left hand side of the controls cambox, operates as follows:-

In the 'OPEN' position, fuel is allowed to flow to the main and primary spray nozzles.

When 'CLOSED' the valve shuts off fuel to the nozzles and during engine rundown, pump delivery is recirculated to pump inlet. Fuel remaining in main and primary manifolds is routed through the shut-off valve housing to an airframe mounted drains collector tank.



SIMPLIFIED FUEL SYSTEM - PHANTOM SPEY

CUSTOMER TRAINING CENTRE

COURSE NOTE

No. TSp. 350

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BY COMMAND OF THE DEFENCE COUNCIL FOR USE IN THE NAVAL SERVICE/ROYAL AIR FORCE

SHEET 1 of 1

ISSUE 1 Prepared by the Ministry of Aviation

SPEY Mk. 201 ENGINE FUEL SYSTEM

1.4.67

6

SPEY MK 201/202

COMPRESSOR AIRFLOW CONTROL SYSTEM

INTRODUCTION.

The H.P. compressor is designed to give a high compression ratio and maximum efficiency in the high r.p.m. range where the engine normally operates.

However, stability is necessary over the lower r.p.m. range to permit selection of a low power condition for taxying or descent.

It is also necessary to be able to accelerate the engine smoothly to the higher r.p.m.

At low r.p.m. the airflow into the H.P. compressor would approach the first stage blades at an unsuitable angle.

This would cause two things to occur:-

1. Stalling of the first stages.
2. Choking of the rear stages.

The result would be high blade stresses and finally compressor surge.

1. REQUIREMENTS OF THE SYSTEM.

To prevent stalling of the first stages by correcting the approach angle of the airflow onto the first stage rotor blades.

This is done by a set of variable angle inlet guide vanes at the entry to the H.P. compressor.

To prevent choking of the rear stages a bleed valve permits H.P. compressor 7th stage air to be bled into the by-pass duct from an annulus around the compressor casing.

Since changes in inlet temperature affect the air mass flow through the compressor, the r.p.m., at which the guide vanes and bleed valve operate, must be corrected for temperature change.

2. OPERATION.

Variation of I.G.V. Angle.

Movement of the I.G.V's is over a 40° range i.e. from ± 40° (I.G.V's closed) to - 0° (I.G.V's open) and this movement is required over a given range of r.p.m.

/continued.

The motive force required to rotate the I.G.V's over this angular range is supplied by a hydraulic ram.

Ram movement is achieved by feeding H.P. or L.P. fuel to either side of the ram piston.

Fuel pressures to the piston are controlled by positioning a spool valve housed in a governor unit.

Connected to the spool valve is one leg of an 'L' shaped beam, while the other leg pivots about a variable fulcrum point.

Two forces, acting on the 'L' beam, tend to move the spool valve axially in opposite directions.

The two forces are:-

(a) The force from a set of governor flyweights, which are rotated at a proportion of H.P. shaft speed.

(b) A spring force.

The line of action of these forces on the 'L' beam is shown in the following diagram:-

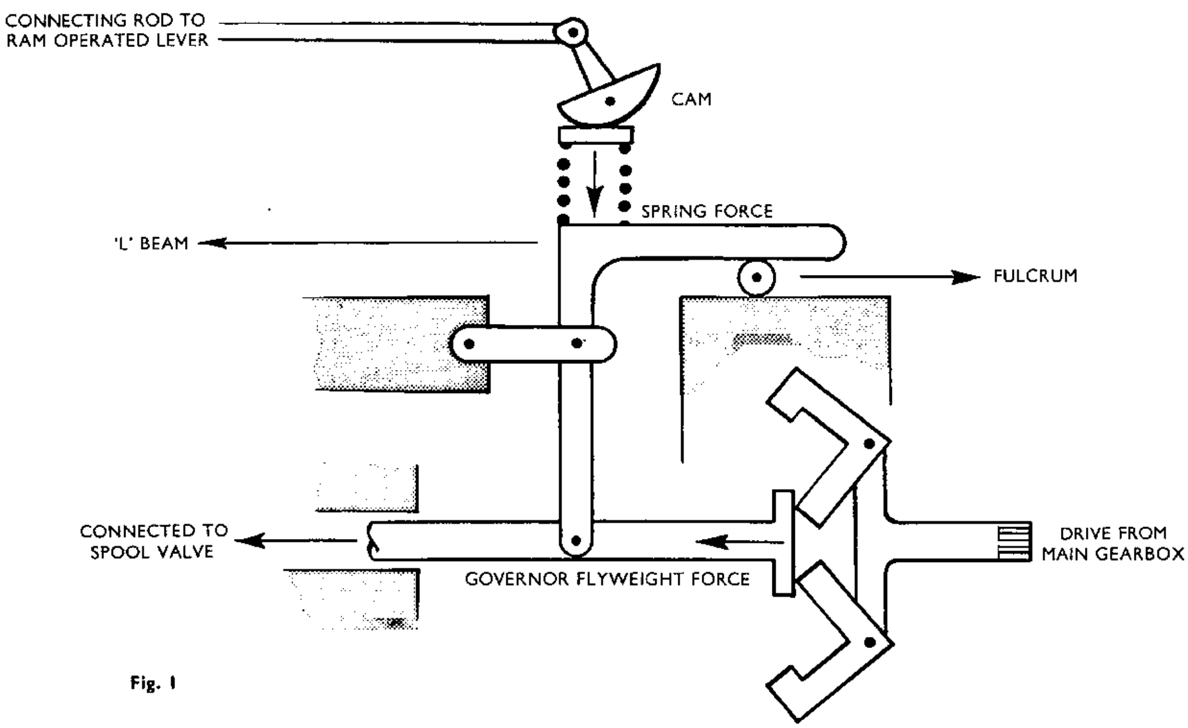


Fig. 1

/continued.

The spring force is influenced by a cam, rotated by linkage attached to the ram operating lever.

Assuming a fixed fulcrum point for the 'L' beam, the system is now described at the following engine conditions:

(a) Engine static.
(b) During start and acceleration to idle r.p.m.
(c) During acceleration.
(d) Steady running at an intermediate r.p.m.
(e) During deceleration.

(a) Engine Static.

I.G.V's at +40° position, ram fully extended, with L.P. fuel on both sides of the ram piston.

Spool valve positioned by spring force acting on 'L' beam, there being no governor force.

(b) During Start and Acceleration to Idle R.P.M.

During the start H.P. fuel is directed from the centre recess around the spool valve, to the head of the ram piston.

The underside of the piston head remains open to L.P. return.

H.P. fuel thus holds the I.G.V's and bleed valve at the correct position.

As the engine accelerates to Idle r.p.m., governor flyweight force increases moving the spool valve towards a central position.

(c) Acceleration from Idle R.P.M.

As engine r.p.m. is increased from Idle and governor weight force continues to increase, the spool valve finally reaches the central position.

At this point the fuel passages to and from the ram piston are blanked.

Any further increase in r.p.m. causes the spool valve to be moved, now venting the head of the piston to L.P.

Simultaneously H.P. fuel is fed to the underside of the piston head, and subsequent ram movement causes the I.G.V's to move from the +40° position towards the 0° position.

(d) Steady Running at an Intermediate R.P.M.

Assuming that the selected r.p.m. is such that the I.G.V. angle is between +40° and 0° positions the following events will occur.

/continued.

As r.p.m. increases towards the selected value, movement of the ram, via connecting linkage causes the cam in the governor unit to be rotated. This progressively increases the spring loading in opposition to the increased governor flyweight force.

The spool valve is thus moved back to a central position, blanking off the fuel passages to both sides of the ram.

The ram is now hydraulically locked, maintaining some intermediate I.G.V. angle between $+40^{\circ}$ and 0°.

During Deceleration.

The sequence of events is the reverse of those occurring during an acceleration.

Operation of Bleed Valve.

The bleed valve is designed to allow a progressive air bleed from the 7th stage of the compressor as engine r.p.m. is reduced into the lower range.

Operation of the bleed valve is effected by the I.G.V. operating ram.

On reducing engine r.p.m. the valve is opened progressively, permitting air to bleed into the by pass duct.

During an increase in r.p.m. the bleed valve is required to fully close before completion of the guide vane movement.

The additional travel of the ram, required to complete the guide vane movement is achieved by connecting the bleed valve linkage to the operating ram by a spring strut.

Correction for Air Temperature (T_1) Variation.

The inlet guide vanes and bleed valve are required to operate at an r.p.m. corrected for inlet temperature variation, i.e. compression ratio.

To do this, the fulcrum point for the 'L' beam is varied as inlet temperature changes.

A roller, which acts as the fulcrum point, is repositioned by an electric actuator.

Variation in T_1 signal to an amplifier produces the e.m.f. to operate the actuator.

A feed back motor produces a signal proportional to fulcrum movement.

This signal is compared with the T_1 signal to the amplifier, and any variation between the two is corrected by operation of the actuator.

Hence, relative to the line of action of the spring, the fulcrum point is a true function of T_1.

/continued.

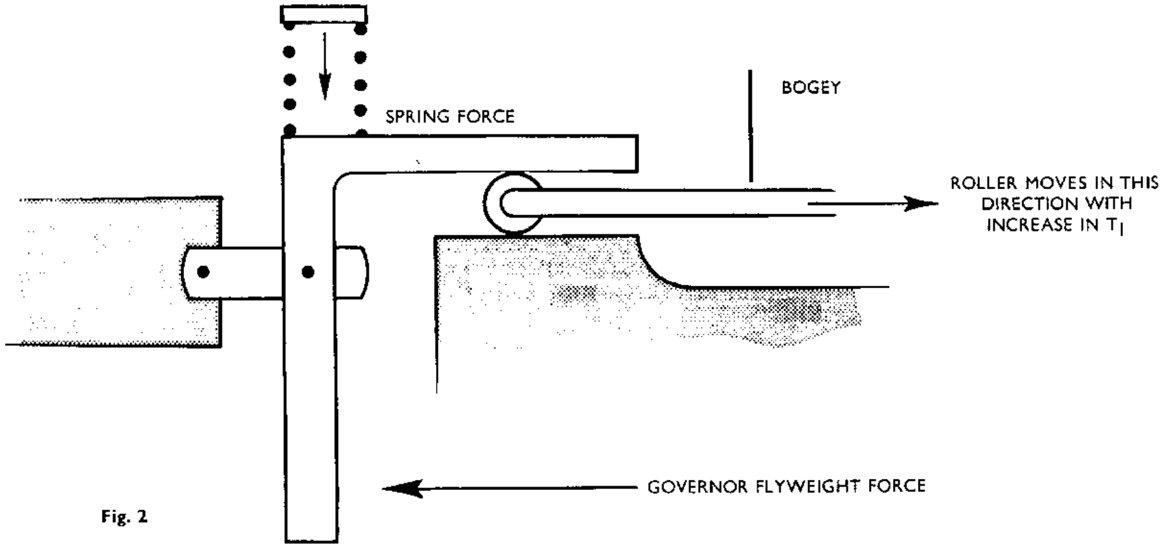


Fig. 2

With increase in temperature, the roller is moved in direction shown in fig.2.

Since the line of action of the spring force is now a greater distance from the fulcrum it follows that the spring force is increased.

The increased spring force now requires an increase in governor force i.e. a higher r.p.m. to move the spool valve.

The I.G.V's and Bleed valve will thus commence to move at a higher r.p.m. i.e. an r.p.m. corrected for the increase in T_1.

A decrease in inlet temperature produces the reverse effect.

/continued.

DESCRIPTION OF OPERATING MECHANISM.

Inlet Guide Vane Assembly.

The inner end of each vane is connected by a short lever to the rim of an actuating disc.

The disc is located at the rear of the internal gearbox.

Partial rotation of the disc moves all vanes simultaneously.

The disc is rotated by a relay lever which connects with the inner end of a shaft.

This shaft passes through a hollow support strut in the intermediate case, to the outside of the engine.

A lever, secured to the outer end of the shaft, is connected by linkage to a ram operated lever.

Bleed Valve Assembly.

A manifold formed around the compressor case, receives air from the 7th stage of the compressor through slots in the stator vane roots and outlet ports in the case.

A flanged steel ring, which forms the bleed valve, encircles the manifold and seals it whilst operating in the high r.p.m. range.

On reducing the r.p.m. the ring is moved progressively to open the manifold to the by-pass duct and allow the required air bleed from the compressor.

The ring is connected to four equi-spaced support levers. These are rotated about pivots attached to the compressor case, by a quill shaft splined into the hub of one lever, thus moving the ring across the manifold.

The quill shaft passes through to the outside of the by-pass duct and is externally connected to the inlet guide vane ram operating lever.

As the r.p.m. is increased, the bleed valve is required to fully close before completion of the guide vane movement.

To allow the additional travel necessary to complete the guide vane movement, the bleed valve control rod to the quill shaft, is connected by a spring strut. This allows movement of the control rod to continue after the bleed valve is closed.

I.G.V. and B/V Ram.

The ram consists of a double sided piston the extension of which is also connected to the ram lever.

/continued.

Tubes, connected to ports in the housing for the piston and piston extension, permit the following:-

H.P. or L.P. to either side of the piston.
L.P. fuel return from around piston extension.
Fuel drainage from piston extension seal.

INLET GUIDE VANE AND BLEED VALVE CONTROL GOVERNOR.

This unit is mounted on the front of the main gearbox.

It houses a spool valve, around which three recesses are machined.

A recess on each side of a centre one is connected to L.P.

The centre recess accepts H.P. fuel from the engine driven pump.

This pressure is applied to either side of the ram piston through 2 tubes.

These tubes also connect each side of the piston to L.P. dependant upon spool valve position.

Spool valve movement is produced by spring or governor flyweight force acting on an 'L' beam.

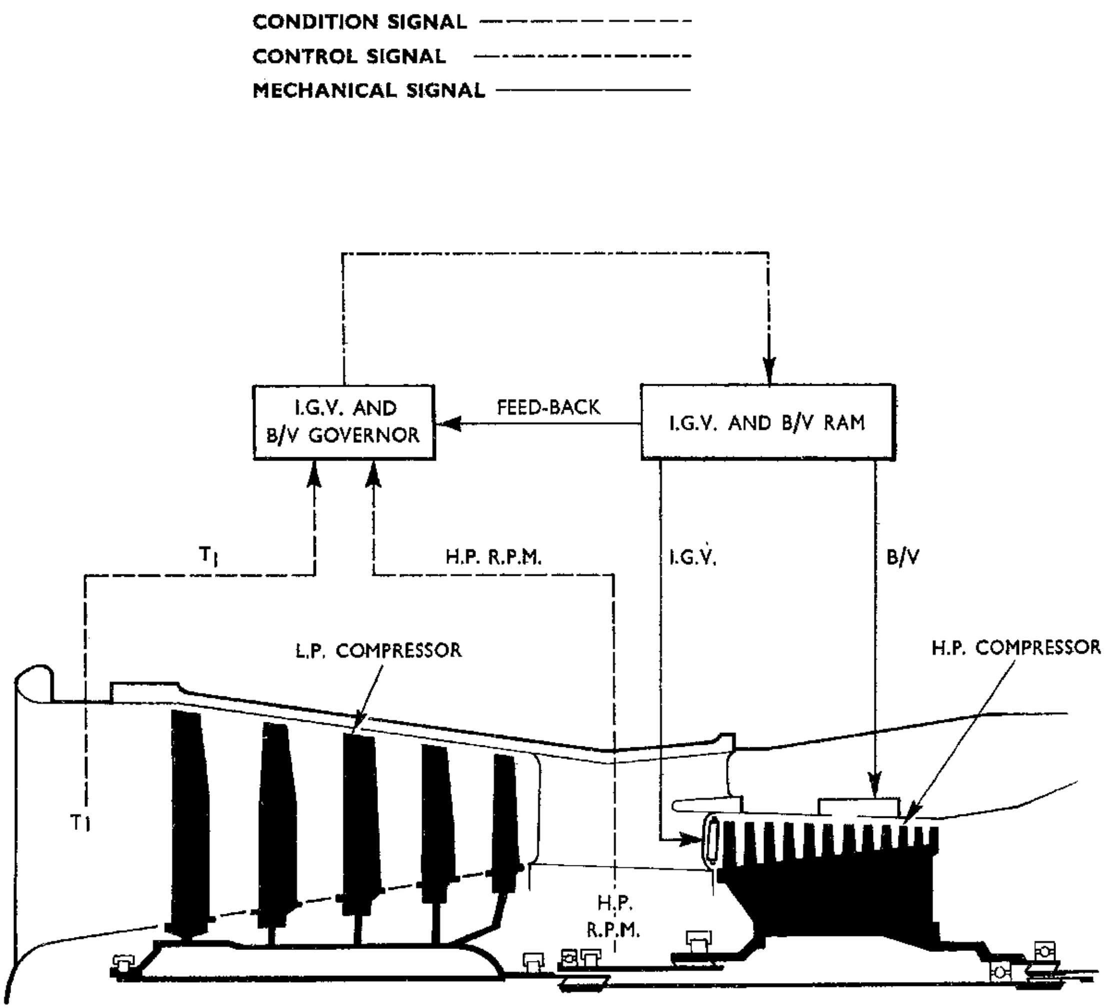
The spring is re-rated by the rotation of a cam connected by linkage to the ram lever.

An opposing governor force is achieved by driving governor weights from the main high speed gearbox.

With changes in T_1 a roller type fulcrum point, attached to a bogey, is repositioned.

The bogey is connected by a lever to a wheel driven through gearing by an electric actuator.

A feed back motor driven by the wheel produces a signal which is compared with the T_1 signal in the amplifier.



REQUIREMENTS:

1. To maintain compressor stability when operating in the lower R.P.M. range

2. HOW IS THIS DONE?

By varying the angle of guide vanes at entry to the H.P. compressor and by bleeding air from the centre of the compressor through a valve

3. HOW IS IT OPERATED?

By a fuel operated ram

4. WHAT DETERMINES RAM POSITION?

Fuel pressure from a governor which senses:-

H.P. R.P.M.
T_1
FEED-BACK FROM A RAM

18246

BASIC PRESENTATION - AIRFLOW CONTROL SYSTEM

1.7.67

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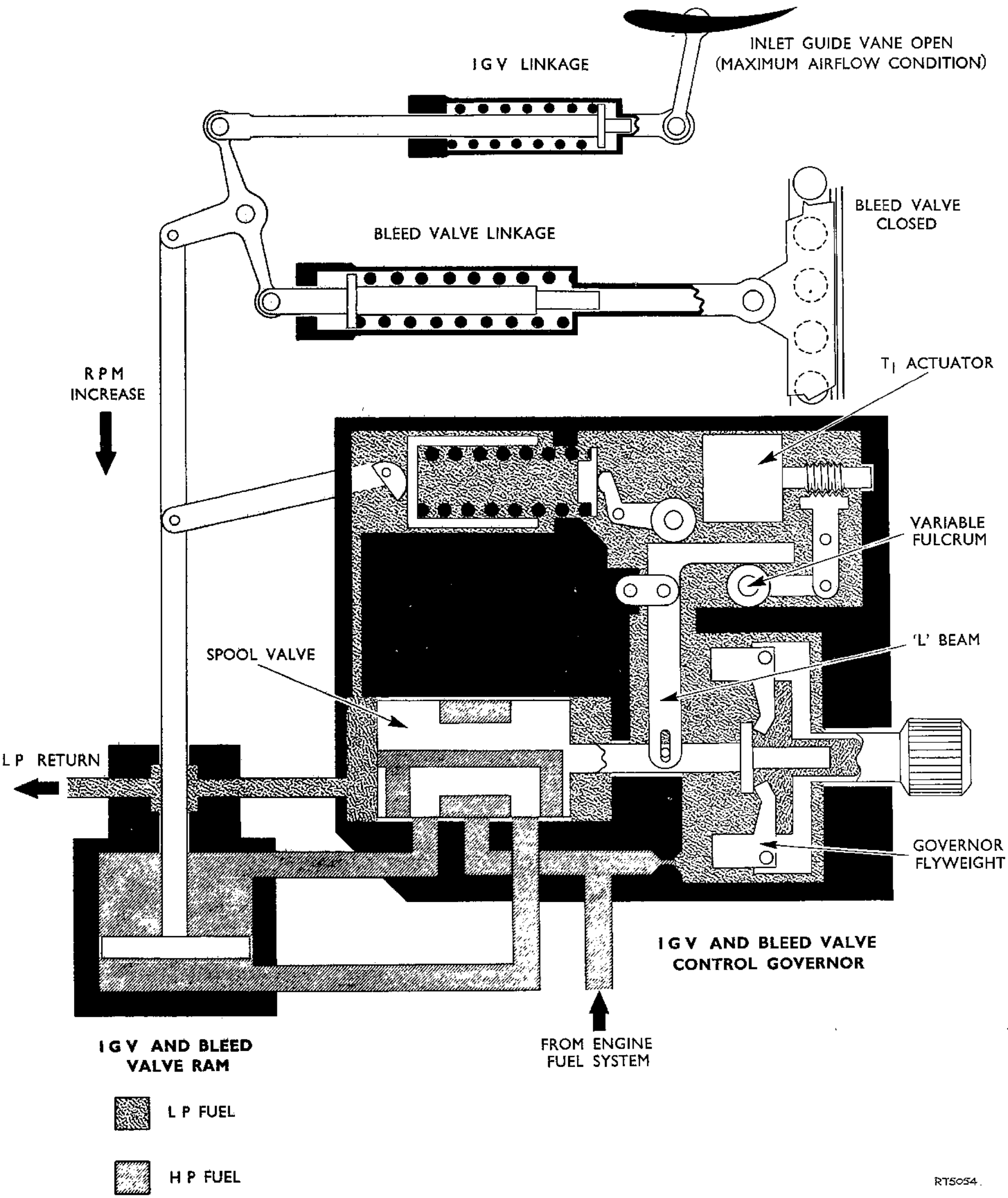


SPEY Mk. 201 ENGINE — AIRFLOW CONTROL SYSTEM

7

SPEY MK 201/202

REHEAT SYSTEM

INTRODUCTION.

To permit rapid take off and high speed flight, an increase in thrust (above that produced by the engine) is required.

Additional thrust is obtained by burning fuel in the jet pipe to increase gas stream velocity.

To prevent this process increasing jet pipe pressure, which would adversely affect engine performance, a variable area propulsion nozzle is used.

Co-ordination of fuel flow and nozzle area is controlled automatically.

1. REQUIREMENTS.

The system must:-

a. Distribute fuel flow in the jet pipe.

b. Control fuel flow according to pilots lever movement.

c. Modify flow for changes in airflow.

d. Ignite fuel from the burners on initial selection.

e. Control nozzle area.

f. Purge the burner assembly of fuel flow when the system is cancelled.

To fulfill these requirements the system uses the following units:-

a. A burner assembly secured to support struts in the diffuser section of the jet pipe.

The assembly consists of:-

3 vapour gutters.
3 main manifolds.

b,c. A fuel control unit (R.F.C.U.) which incorporates:-

Pilots selection and shut off valve.
A low pressure fuel shut-off valve.
A vapour core pump.
An inlet throttle and servo piston.

In addition the system uses:-

A spill valve and manifold shut off valves. These are housed separately from the R.F.C.U.

/continued.

d. A catalyst igniter mounted at the centre of the burner assembly and a catalyst fuel timing valve located on the intersection between engine and jet pipe.

e. An oil system consisting of:-

An oil tank.
Variable camplate type pump.
Operating rams.
A trip valve assembly.

To select the correct nozzle area the system uses a Pressure Ratio ram unit.

f. A purging air valve.

2. OPERATION (Principles of Control).

a. Fuel Distribution.

When reheat is selected fuel is delivered to all vapour gutters and main fill manifolds.

The full control unit proportions the total flow, a fixed percentage being fed to the vapour gutters.

Remaining fuel passes through manifold shut off valves to the main fill manifolds.

The shut off valves open immediately on selection of reheat.

The vapour gutters produce a region of relatively low velocity gas in which good fuel/air mixing and stable burning can take place.

The arrangement of main fill manifolds ensures even distribution of fuel burning in the jet pipe. (See diagram TSp 425).

b. Control of Fuel Flow according to Pilots Lever Movement.

Total fuel flow control to the manifolds is determined by the fuel control unit. (Diagram TSp 428).

Assuming a fixed air mass flow condition, this unit varies the delivery of a vapour core pump, according to pilots throttle position.

Delivery is determined by throttling the inlet to the pump.

A sleeve, which can be moved across the pump inlet, is positioned by a piston.

One side of the piston is connected to engine H.P. fuel.

The other side feels restricted engine H.P. fuel which is finally vented to L.P. through a pressure drop regulator.

/continued.

The regulator valve senses:-

1. The pressure drop across a Total Flow Metering Valve (T.F.M.V.)
2. Force from a set of governor weights rotated at a proportion of H.P. shaft speed.

Pressure drop across the T.F.M.V. is therefore proportional to H.P. r.p.m.

The T.F.M.V. controls the area of a passage through which total fuel flow can pass to the burners as follows:-

One end of a beam is connected to the T.F.M.V.

The other end is connected to a valve called the Vapour Gutter Flow Metering Valve (V.G.F.M.V.)

At a fixed flight condition, i.e. no variation in air mass flow, the V.G.F.M.V. position is fixed.

A pin, fitted through a slot in the beam, is connected by a linkage to the pilots control lever.

Movement of the lever will therefore, via the pin and slot cause the beam to pivot about the end attached to the V.G.F.M.V.

If the throttle is opened, total flow metering area is increased.

P.D. across the T.F.M.V. is reduced momentarily and movement of the pressure regulator valve increases spill to L.P. from the restricted H.P. side of the servo piston.

The sleeve is moved, and inlet area to the vapour core pump is increased.

Pump output increases and P.D. across the T.F.M.V. is restored.

The division of total flow between the vapour gutters and main manifolds is controlled by a Vapour Gutter Pressure Drop Regulator (V.G.P.D.R.)

One end of the valve senses fuel pressure downstream of the T.F.M.V.

T.F.M.V. downstream pressure is fed through 2 restrictors back to Vapour Gutter pressure.

A tapping of the pressure between the 2 restrictors is sensed on the other end of the V.G.F. pressure drop regulator and is assisted by spring pressure.

As pump output increases, the V.G.F. pressure drop valve opens permitting an increase in flow to the manifolds.

Any variation in P.D. across the V.G.F. metering valve and hence across the regulator valve will reposition the regulator valve.

/continued.

P.D. across the metering valve is thus constant and a constant flow is maintained to the vapour gutters, regardless of the degree of R/HT Selected.

To prevent 'rich' extinction which might otherwise occur if the throttle is opened rapidly from Min R/HT to Max R/HT the V.G. pressure drop regulating valve spills excess fuel to low pressure.

Conversely, if the throttle is closed rapidly from Max R/HT to Min R/HT, the sudden drop in manifold pressure could cause weak extinction.

This is prevented by movement of the V.G.F. regulator valve which restricts the main manifold line thus maintaining a satisfactory pressure to the vapour gutters.

c. Modification of Flow with Changes in Airflow.

This is achieved by altering the position of the V.G. flow metering valve as follows:-

One end of the valve senses P6 plus spring pressure.

This is balanced by feeding a split P3 pressure to the opposite end.

The split P3 pressure is generated by passing P3 back to P6 through two restrictors.

The area of one of these is fixed, while the area of the other varies with changes in mass flow.

The signal of change in mass flow is provided by the P3/P2 ratio ram in the pressure ratio unit.

Any variation in split P3 causes movement of the V.G.F. metering valve.

Since throttle position is fixed, the T.F.M. valve is repositioned and as previously described the total flow is modified.

Division of fuel between the vapour gutters and main manifolds is controlled by the V.G.F. pressure drop regulator.

d. Ignition.

This is achieved by spraying fuel on to a catalyst element located in the centre of the burner assembly.

Chemical action between the catalyst and fuel results in ignition of the fuel spray.

/continued.

The resultant flame ignites fuel from the burner assembly. Diagram TSp 427 shows a sectional view of the burner mounted catalyst element and the fuel supply to it.

A catalyst fuel control valve, mounted on the intersection between engine and jet pipe, controls the time period for which fuel is fed to the catalyst.

On cancellation of reheat the control valve is rapidly reset in readiness for the next selection.

e. Control of Nozzle Area.

This is now considered at the following conditions:-

1. Engine at max r.p.m. prior to selection of reheat.
2. Selection of reheat.
3. Increase of reheat from MIN to MAX.
4. Cancelling reheat.

Condition 1.

At max r.p.m. (non-reheat) the nozzle is closed.

Nozzle actuating sleeve is held fully forward by the hydraulic rams.

This closed area is maintained by spilling H.P. oil to pump inlet through the nozzle trip valve thus balancing ram force against gas load on the nozzle flaps.

In the non-reheat condition the P3:P6 ratio ram is inoperative and biases the nozzle pump camplate towards maximum positive angle

Condition 2.

When min reheat is selected the nozzle area is immediately increased by resetting the nozzle trip valve with a signal of engine H.P. fuel. The area selected is known as the pre-open area.

A separate engine H.P. fuel signal unlocks the pressure ratio ram unit which corrects pre-open area as necessary to restore the correct P3:P6 ratio.

Condition 3.

Selecting an increase in reheat puts more fuel to the burner assembly and upsets the P3:P6 ratio.

To restore the correct P3:P6 ratio nozzle area is increased as follows:-

Oil pressure on rear of the rams is reduced by altering pump camplate angle.

This is done by movement of a servo piston in the pressure ratio ram unit.

 /continued.

Servo piston movement is caused by spilling engine H.P. fuel from one side of the piston to L.P.

A sleeve, integral with the servo piston, surrounds an extension to an air piston.

The air piston senses variations in P3:P6 ratio and movement of the air piston causes the necessary bleed of engine H.P. fuel to L.P. through passages in the air piston extension.

When nozzle area increases P3:P6 is restored and the air piston and extension returns to its original position.

Servo piston follows air piston movement reducing camplate angle restoring balance between ram load and gas load, thus maintaining nozzle at the larger area.

Condition 4.

On cancelling R/HT i.e. throttle lever returned to max engine r.p.m. position, fuel flow to the manifolds and vapour gutters ceases.

The pump camplate angle is altered to increase oil pressure to the head of the ram pistons.

Forward movement of the actuating skirt causes nozzle area to be decreased.

Finally, as nozzle approaches the correct "Nozzle Closed" area, contact is made between a tappet secured to the forward end of the skirt and a lever which operates the nozzle trip valve.

The trip valve is positioned to spill H.P. oil from the head of the piston to intermediate pressure.

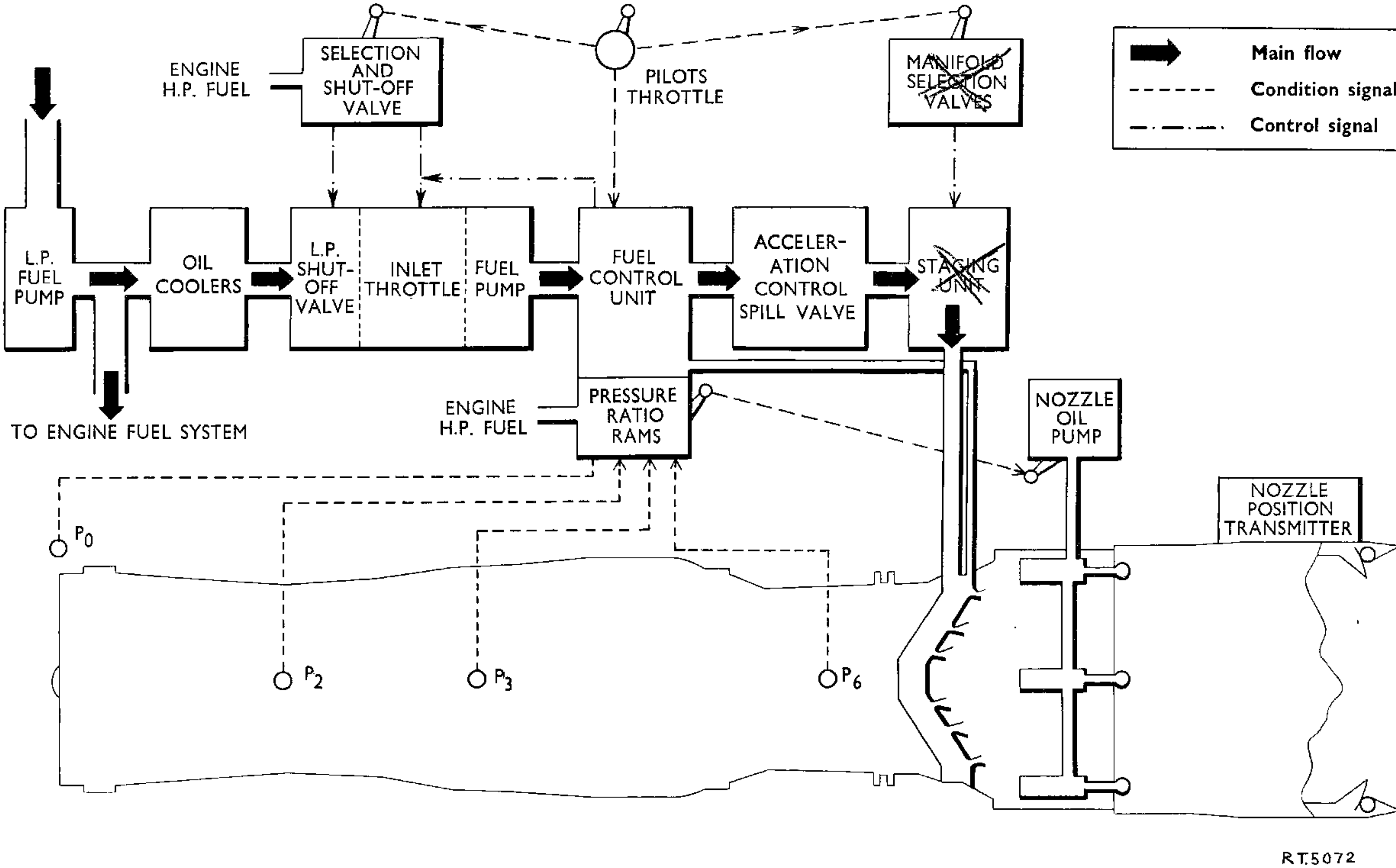
This restores balanced forces across the ram pistons to hold the nozzle at the correct closed area.

g. Purging the Fuel Manifolds.

On cancellation of R/HT engine H.P. fuel supply to the air purge valve is cut off.

The valve opens, permitting a flow of H.P. compressor delivery air (P3) to purge the burner assembly of any residual fuel.

This air supply is continuous while reheat is not in operation.



SPEY Mk. 201 ENGINE — BASIC REHEAT SYSTEM

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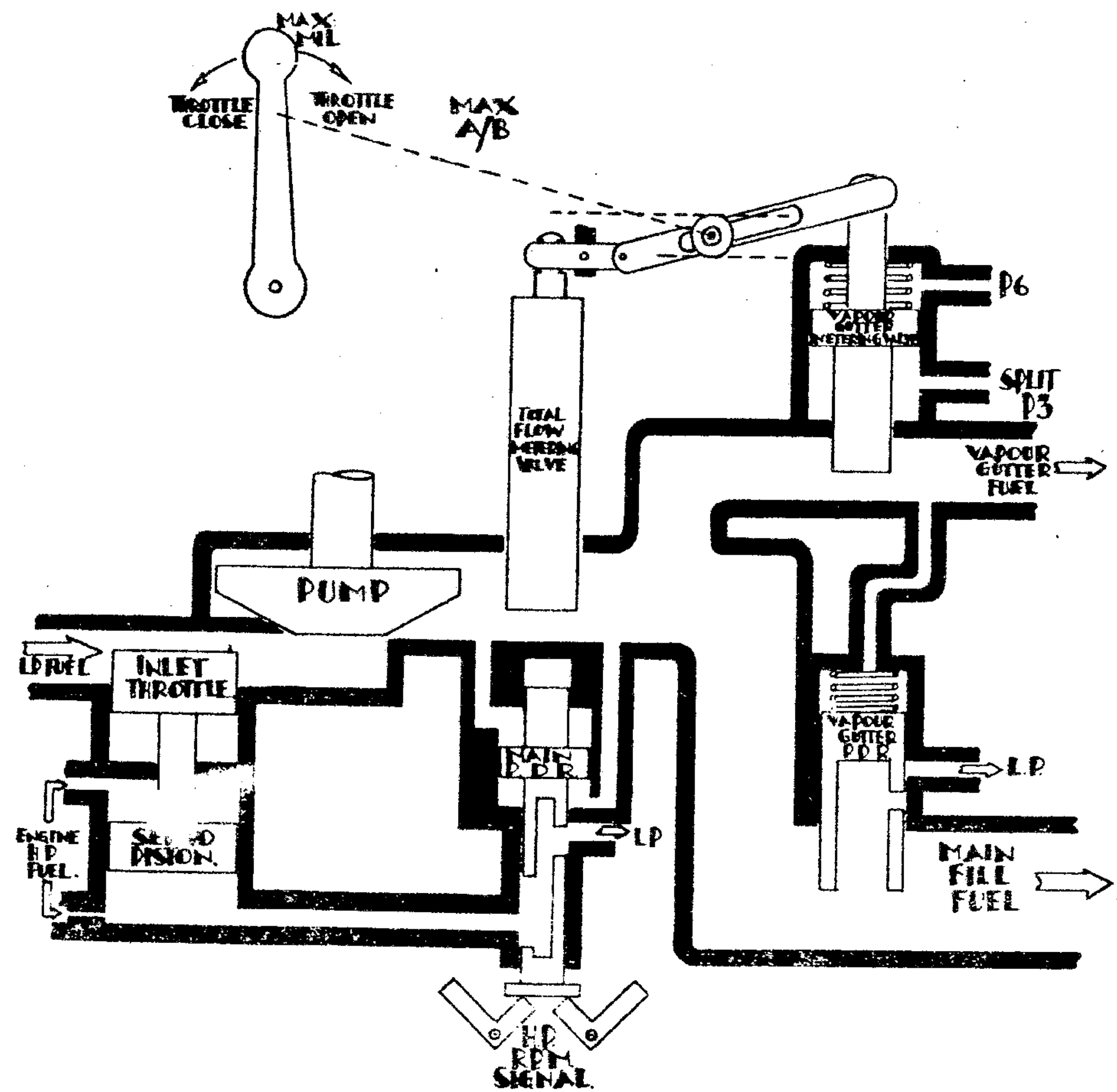
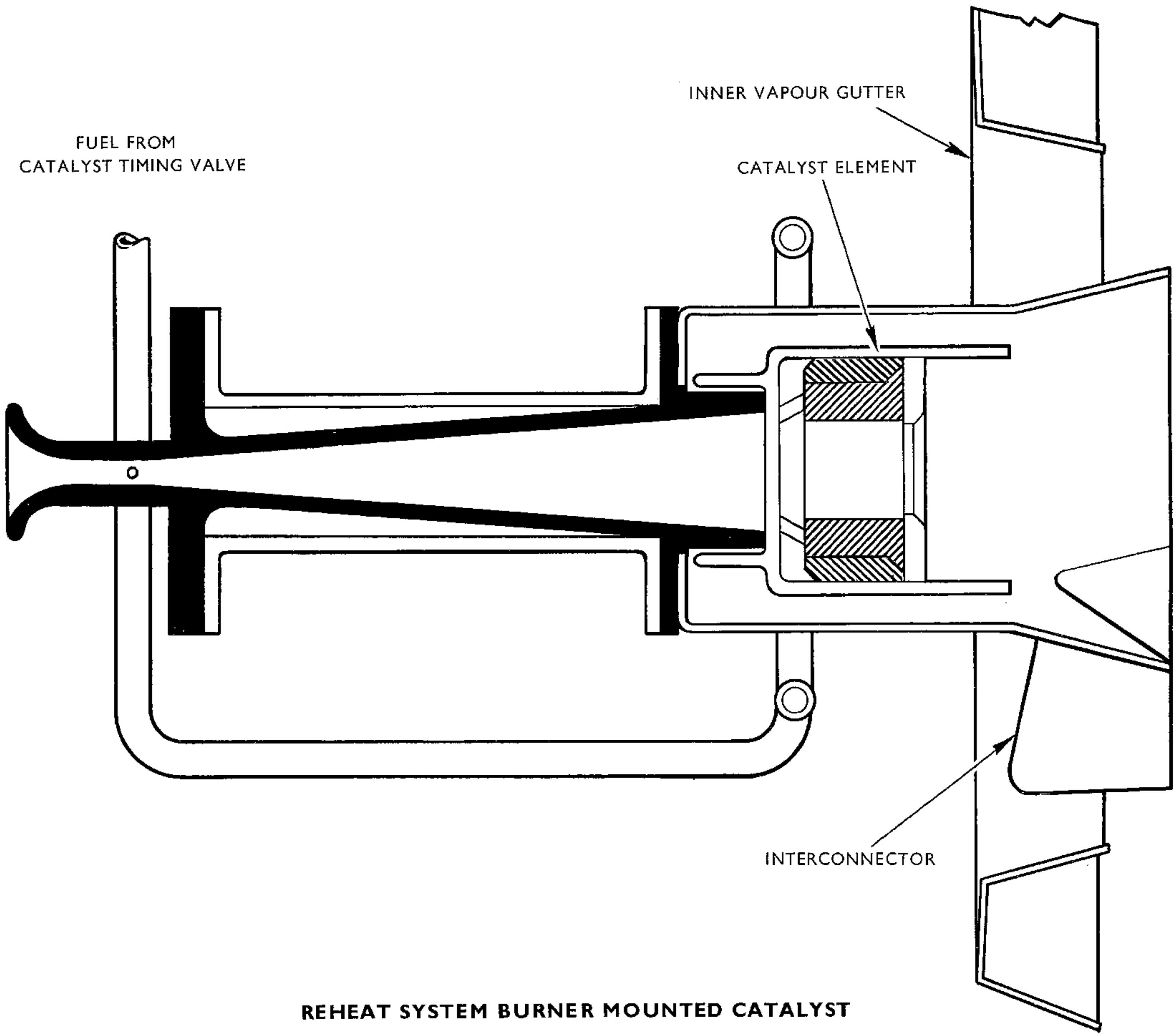

MAX MIL
THROTTLE CLOSE
THROTTLE OPEN
MAX A/B
TOTAL FLOW METERING VALVE
P6
SPLIT P3
VAPOUR GUTTER FUEL
PUMP
LP FUEL
INLET THROTTLE
ENGINE HP FUEL.
MAIN P.D.R.
LP
VAPOUR GUTTER P.D.R.
L.P.
MAIN FILL FUEL
H.P. RPM SIGNAL.



REHEAT SYSTEM BURNER MOUNTED CATALYST

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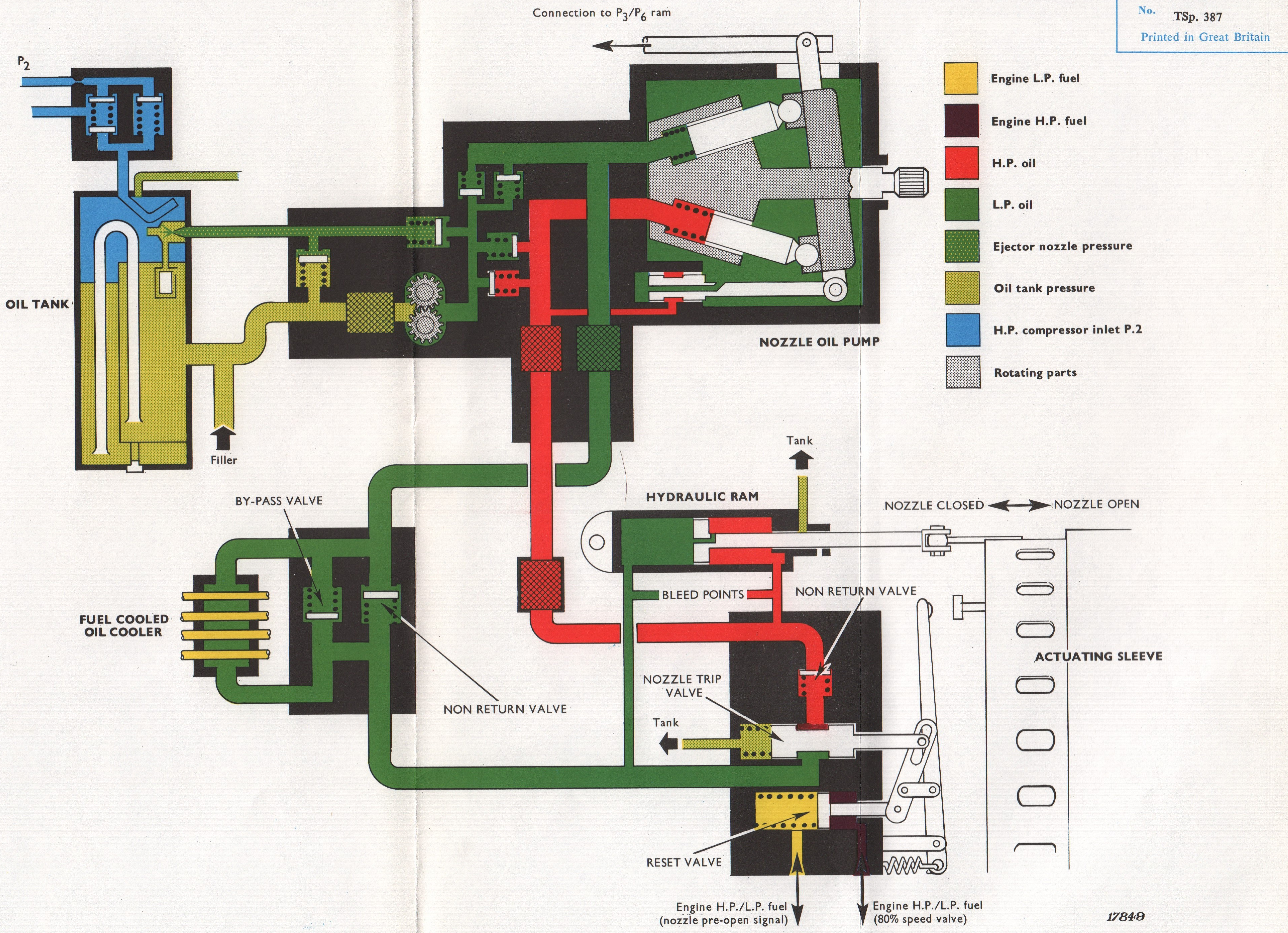

REHEAT NOZZLE OIL SYSTEM

1.6.67

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COURSE NOTE
No. TSp. 351
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* NOT ON EARLY ENGINES

REHEAT FUEL AND NOZZLE CONTROL SYSTEMS

1.4.67

8

SPEY MK 201/2

PYROMETRIC SYSTEMS

INTRODUCTION.

To provide signals for indication and control, temperature measurements are taken in three areas of the engine.

The three areas are:-

a. Engine Air Inlet (T_1)

b. H.P. Compressor Diffuser (T_3)

c. Exhaust Unit (T_6)

1. REQUIREMENTS.

a. T_1 signal.

To correct the operating r.p.m. of the H.P. compressor inlet guide vanes and bleed valve for changes in air inlet temperature.

b. T_3 signal.

To prevent maximum H.P. compressor delivery temperature being exceeded.

c. T_6 signal.

1. To provide cockpit indication of turbine gas temperature.
2. To provide engine top temperature control.

These requirements are fulfilled by the following units:-

a. T_1 system.

A triple element, sonic type thermocouple, mounted in a cannister secured to the air inlet extension.

An ejector in the cannister supplied with H.P. compressor air (P_3) which draws inlet air across the thermocouple elements at sonic velocity.

/continued.

The elements are connected in parallel and feed a T_1 signal to a $T_1/T_3/T_6$ amplifier mounted on the underside of the engine transition case.

Mechanism in the I.G.V. and B/V governor is actuated by variation in the T_1 signal from the amplifier.

b. T_3 system.

Identical triple element thermocouple probes are mounted through the soleplates of Nos 3 and 9 spray nozzle arms.

Elements are connected in parallel and supply a T_3 signal to the $T_1/T_3/T_6$ amplifier.

The T_3 signal from the amplifier drives a motor and mechanism in the fuel flow regulator.

a. T_6 system.

Eight single element thermocouples wired in parallel measure the mean temperature of the exhaust gases (Turbine Gas Temperature).

The signal of T_6 is supplied to the top temperature control channel of the $T_1/T_3/T_6$ amplifier and from the amplifier to the same motor and mechanism in the fuel flow regulator which is operated by T_3.

2. OPERATION.

a. T_1 system.

To correct the operating r.p.m. of the inlet guide vanes and bleed valve the T_1 output signal from the amplifier is compared with a feed-back signal from a motor in the I.G.V. and B/V governor. Any error between the two signals causes the governor mechanism to be repositioned (as described in the Airflow Control Section) until no error exists.

b. T_3 system.

To prevent max. T_3 being exceeded the signal received by the amplifier is compared with a reference voltage in the amplifier.

The reference voltage is equal to the output of the T_3 couples at the limiting H.P. compressor delivery temperature.

If the output of the couples exceeds the reference voltage, current is fed from the amplifier to drive the motor in the fuel flow regulator. This results in a reduction in fuel flow as described in Section 5 Fuel System.

/continued.

Reduction of fuel occurs until no error exists between the T_3 signal and the reference voltage.

c. T_6 system.

1. Indication.

An indicator in the cockpit receives a signal from the exhaust unit thermocouples and registers T_6 (Turbine Gas Temperature) in ^{o}C.

2. Control.

The maximum operating temperature of the engine is controlled by feeding a signal from the eight exhaust unit thermocouples to the T_6 channel in the amplifier.

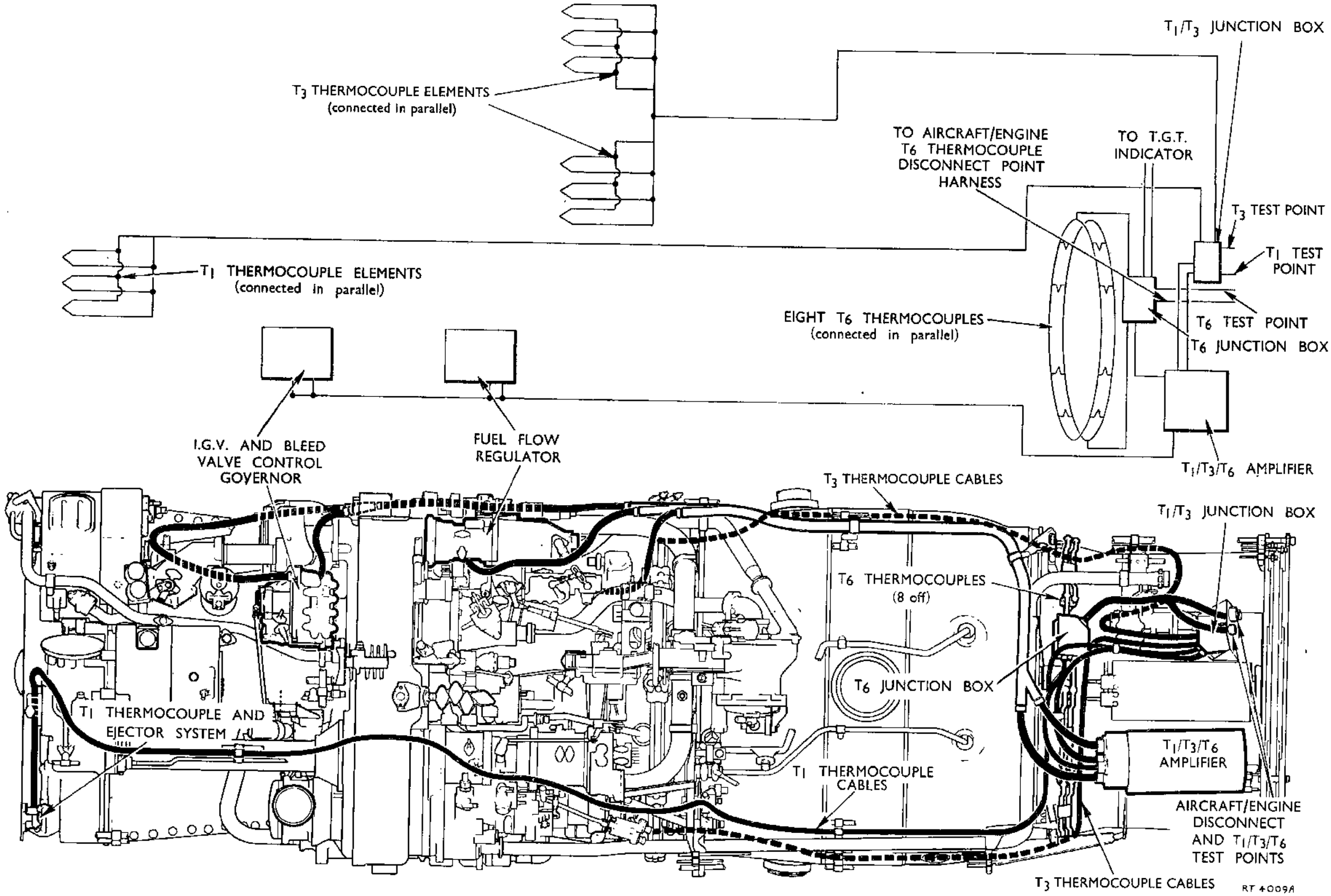
As with the T_3 control system, this signal is compared in the amplifier with a reference voltage.

A T_6 signal greater than the reference voltage drives the fuel flow regulator trim mechanism towards the max trim position.

Fuel flow is then reduced to prevent T_6 becoming excessive.

When B.L.C. is selected a different T_6 datum or reference voltage is required. This is because the relationship between T_4 (turbine entry temperature) and T_6 (turbine gas temperature) changes when 7th or 12th stage air is bled from the H.P. compressor for B.L.C.

The system is redatumed for 7th stage B.L.C. by a signal from the 7th stage pressure switch and when the 12th stage B.L.C. solenoid valve is energised, the datum changes from 7th to 12th stage.



PYROMETERY SYSTEM

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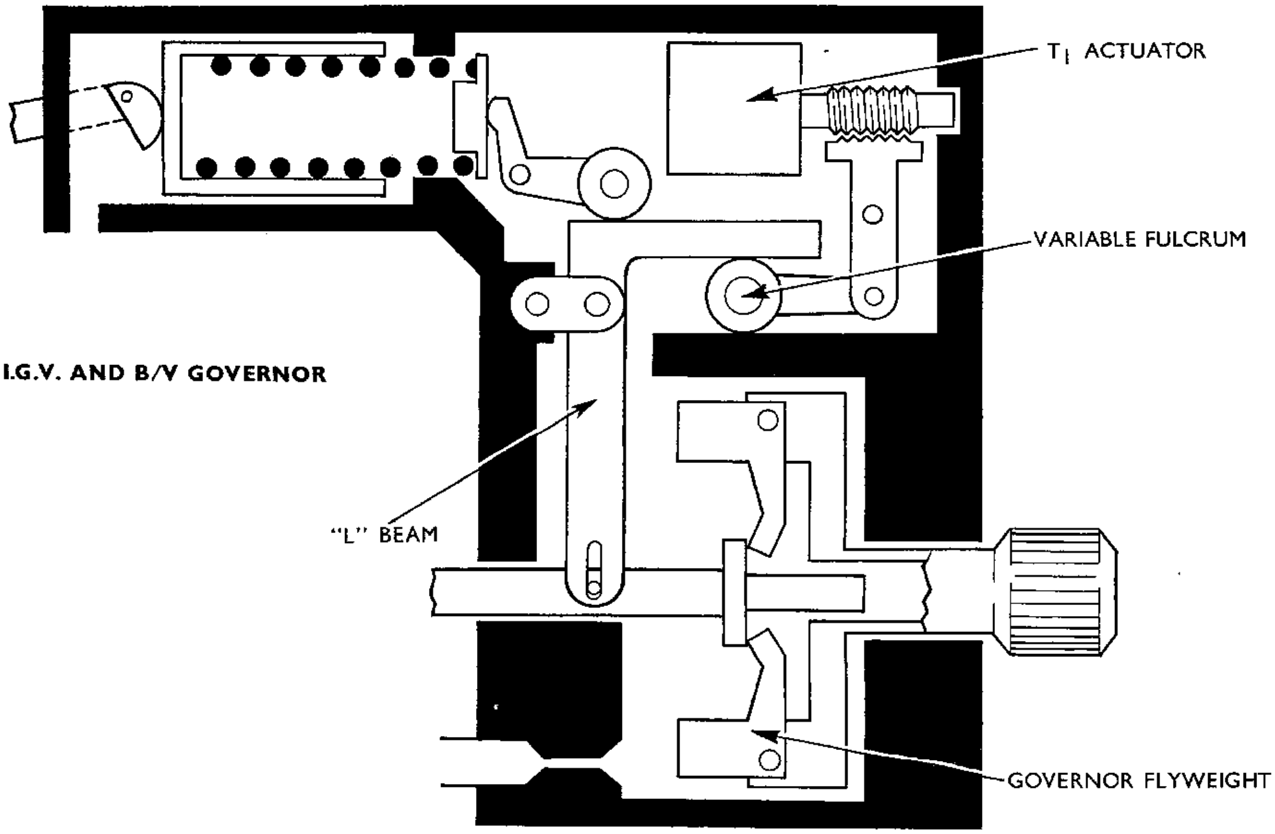

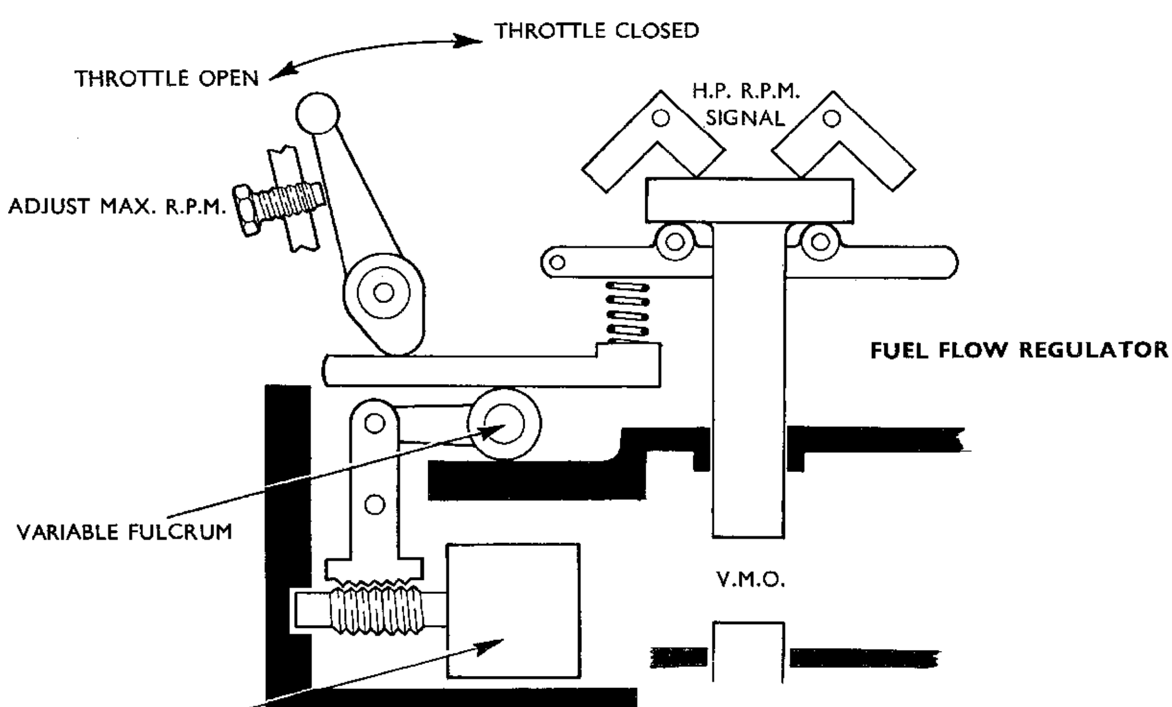

TEMPERATURE CONTROL OF I.G.V. AND B/V GOVERNOR AND FUEL FLOW REGULATOR MECHANISM

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SPEY MK 201/202

PYROMETRIC SYSTEMS

SEQUENCE HEADING CHART

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1. REQUIREMENTS.

2. OPERATION

   INTAKE TEMPERATURE (T_1) SYSTEM

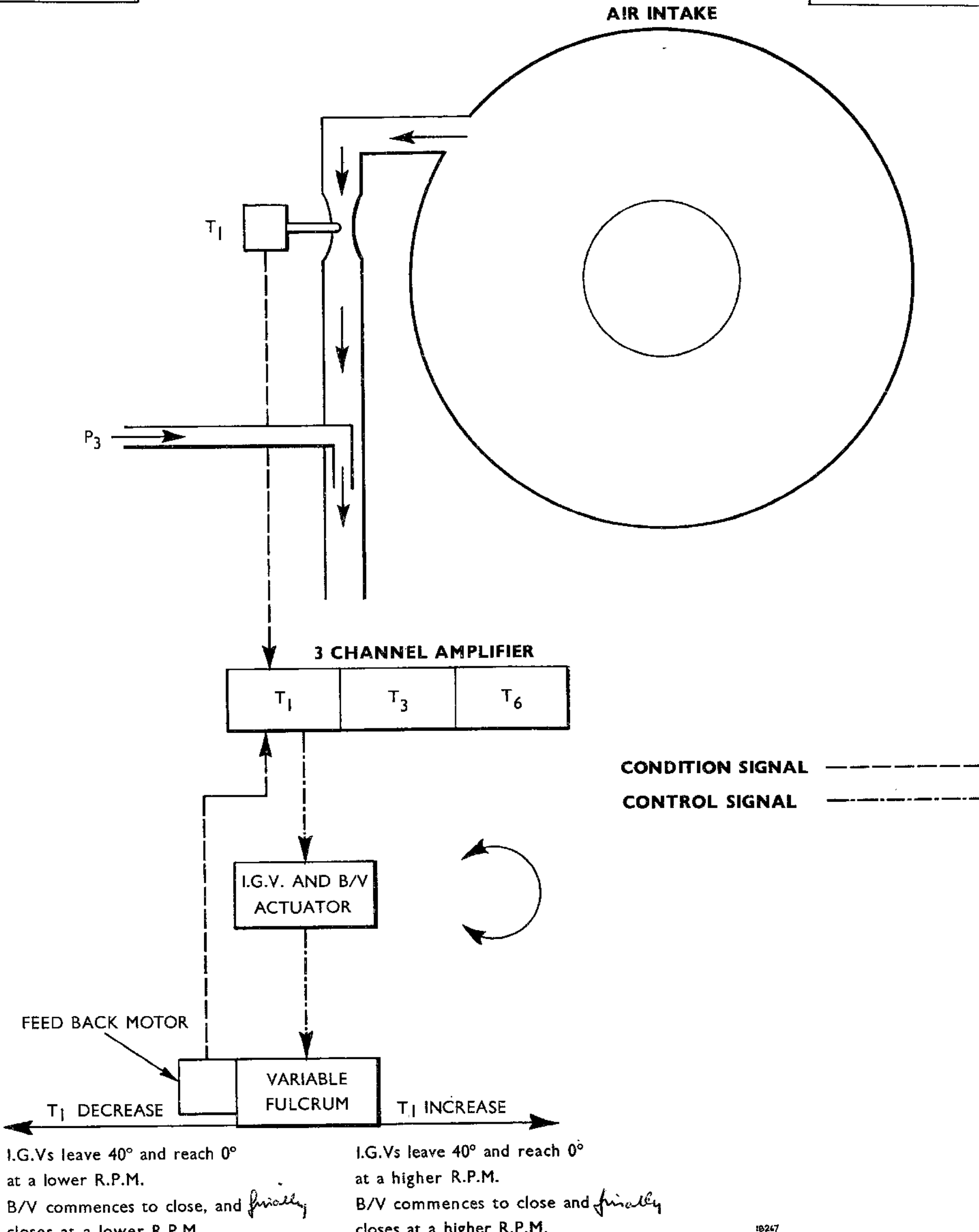
   H.P. COMPRESSOR TEMPERATURE (T_3) SYSTEM

   TURBINE GAS TEMPERATURE (T_6) SYSTEM

3. OPERATING LIMITS.

4. MAINTENANCE.

4 4 67



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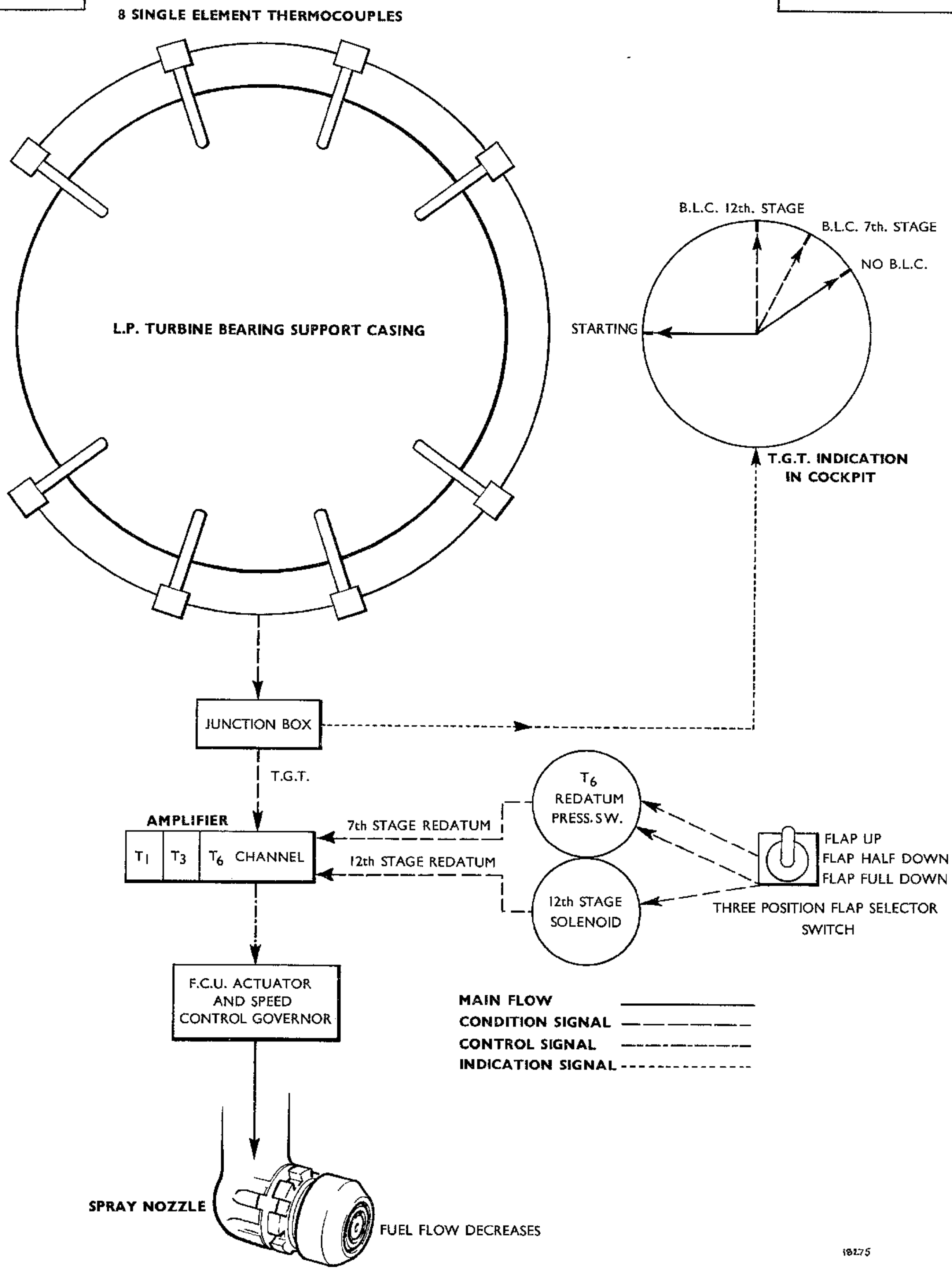
BASIC PRESENTATION OF T1 CONTROL OF I.G.V. AND B/V GOVERNOR



BASIC PRESENTATION T_6 CONTROL

9

SPEY MK 201/202

ICE PREVENTION SYSTEM

SEQUENCE HEADING CHART

SPEY MK 201/202

ICE PREVENTION SYSTEM

1. REQUIREMENTS.

To prevent ice forming on the engine intake surfaces in the following ambient conditions:-

Low air temperature.
High moisture content.

This is done by circulating heated air through the intake components.

2. SELECTION AND INDICATION.

Selection of the system is by a switch to the left of the throttle levers.

Indication that the system is selected is provided by separate indicators marked:-

Left Engine Anti-Ice or
Right Engine Anti-Ice

These are situated on a warning panel to the right of the main engine instruments.

3. OPERATION.

(a) Air Distribution.

The heated air is circulated through:-

Inlet guide vanes.
Nose fairing.

Airflow is shown in the diagram TSp.366.

(b) Air Supply.

The supply of hot air is taken from a manifold surrounding the diffuser casing.

Offtake to the manifold is from a number of equally spaced points around the casing.

This prevents excessive temperature scatter around the combustion section and at turbine entry.

/continued.

(c) Pressure Regulation.

A valve, positioned in an external duct, controls system operating pressure and acts as an ON/OFF valve.

Operation of the valve is as follows:-

Valve outlet port area is determined by the position of a sleeve.

With the system not selected, the sleeve is held closed by air pressure acting on the outside of the sleeve run.

The control chamber and the closing chamber are both open to atmospheric pressure.

On selection of the system the control chamber is pressurized, moving the regulating sleeve thus opening the outlet ports.

The air supply to move the sleeve is controlled by a transfer valve and piston, which is spring loaded to the closed position.

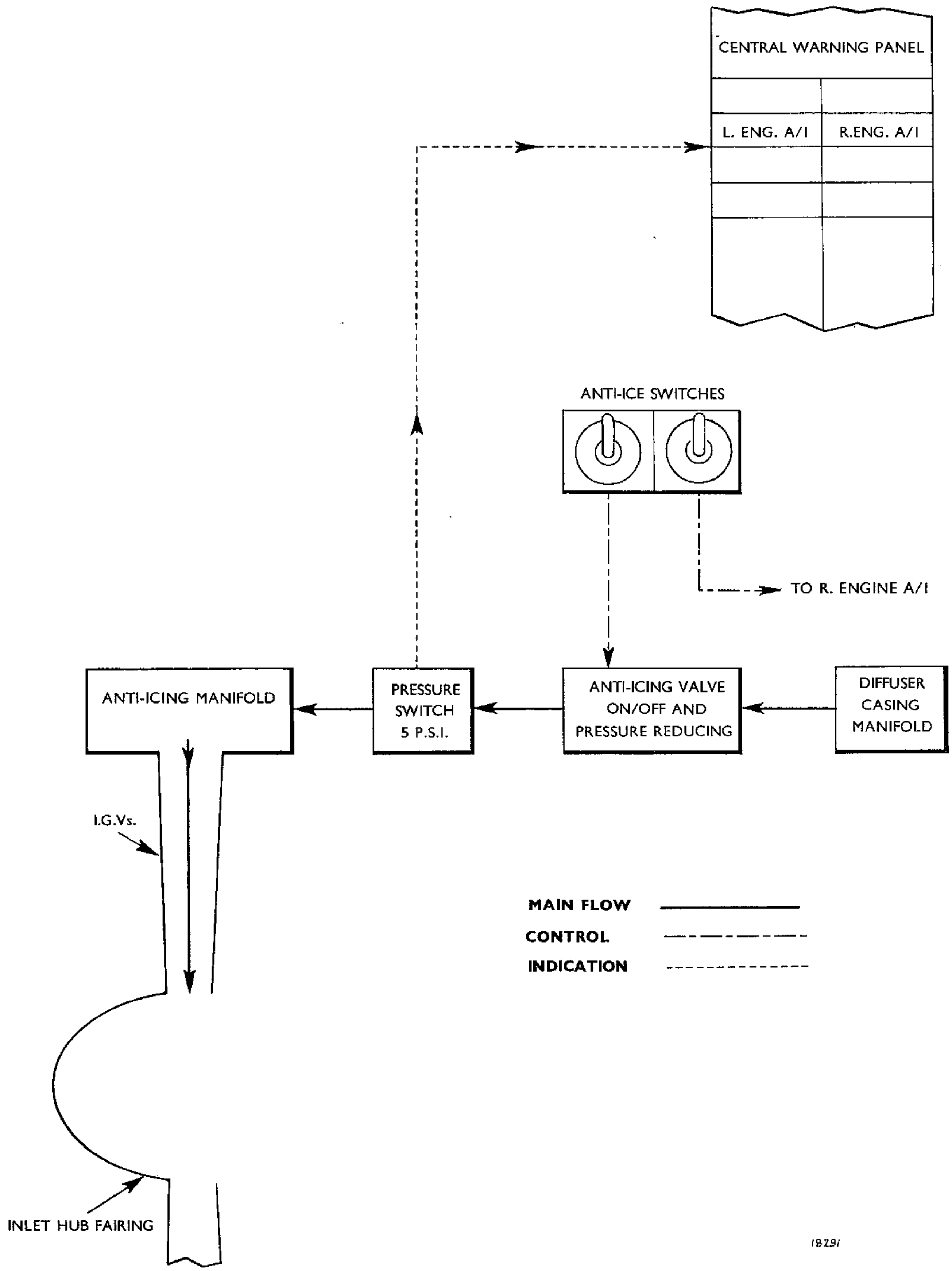
A solenoid, energized when the system is selected, repositions the transfer valve to allow an air feed into the control chamber.

Chamber pressure is regulated by a valve which vents a proportion of the air to atmosphere.

With the regulating sleeve open, the increase in downstream pressure is felt in the closing chamber.

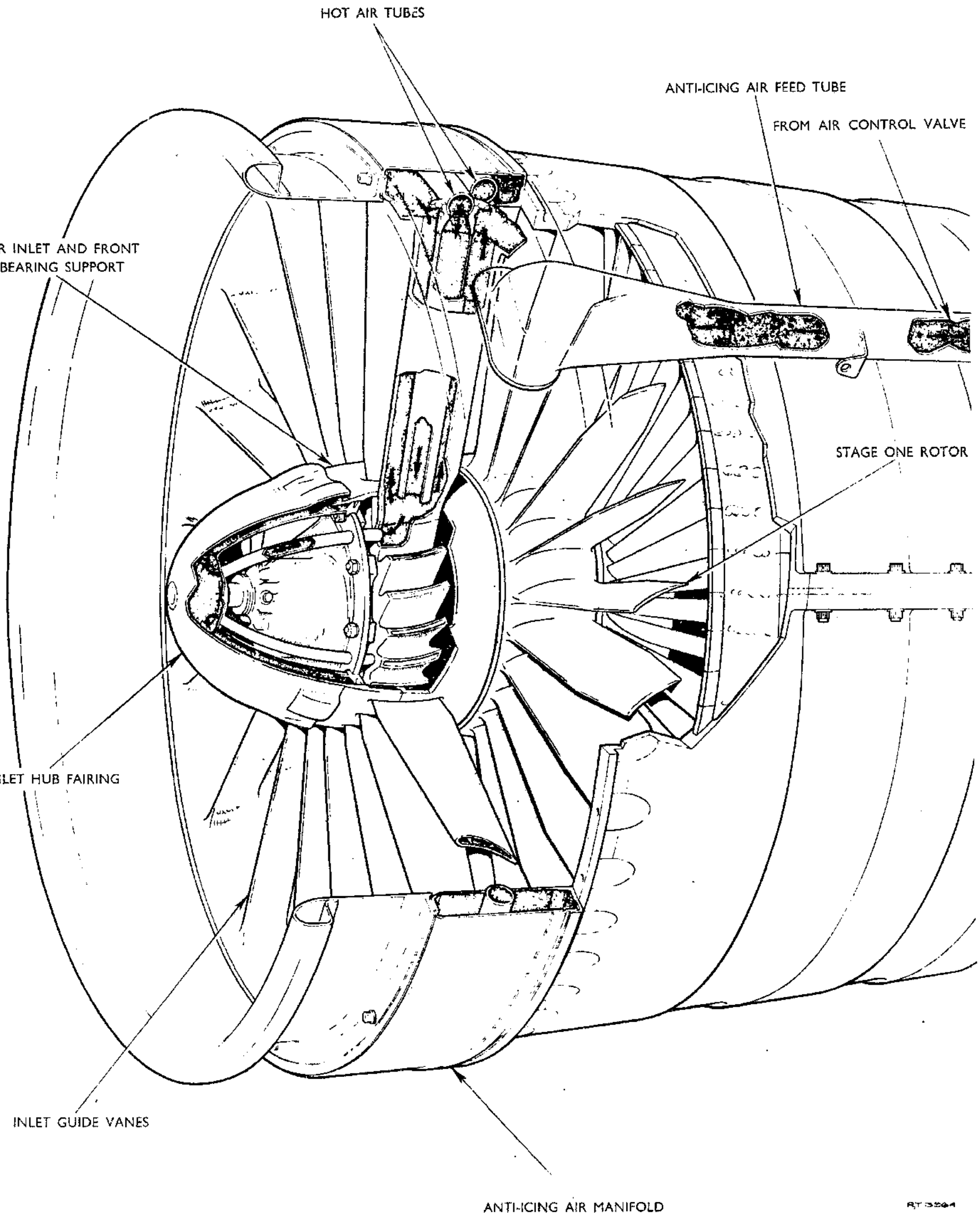
Increasing downstream pressure causes the regulating sleeve to reduce outlet port area till opposing forces on the sleeve are equal.

Downstream pressure is stabilized at a value determined by the pressure regulating valve.

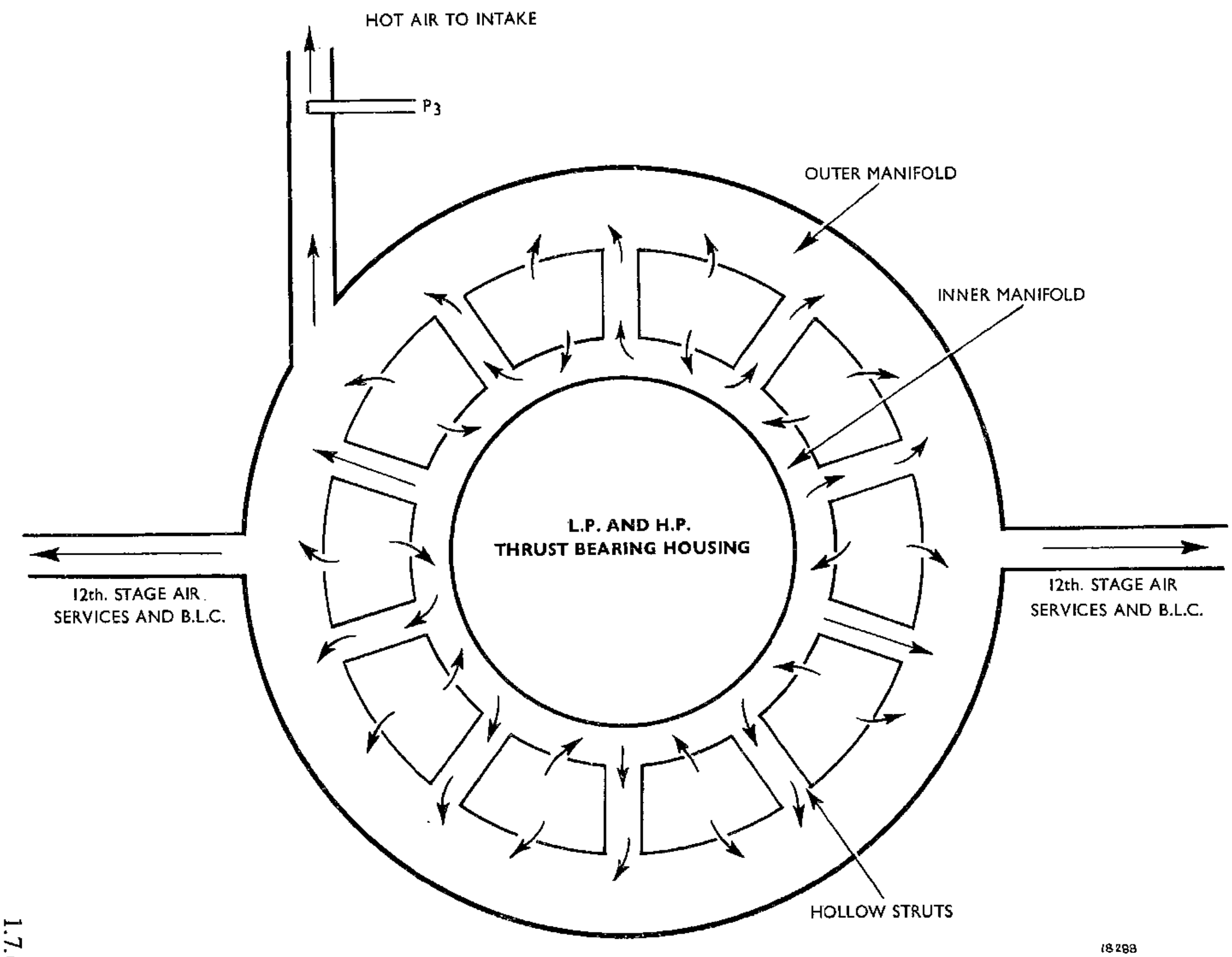


BASIC PRESENTATION - ICE PREVENTION SYSTEM

1.8.67



SPEY Mk. 201 ENGINE ANTI-ICING



DIFFUSER CASING AND AIR OFF-TAKES

1.7.67

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COURSE NOTE
No. TSp. 392
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10

SPEY MK 201/202

BOUNDARY LAYER CONTROL SYSTEM

SEQUENCE HEADING CHART

1. REQUIREMENTS.

2. OPERATION.

3. CONTROL CIRCUIT.

4. MAINTENANCE.

10 4 67

SPEY MK 201/202

AIR BLEED SYSTEM

FOR BOUNDARY LAYER CONTROL

INTRODUCTION.

Increased 'lift' is required to enable the aircraft to take-off, either from the short deck of an aircraft or from runways of restricted length.

In addition, the approach and landing speed of the aircraft, which is designed primarily for supersonic flight, must be as low as possible without danger of stall.

Flaps, which are positioned for take-off or landing provide additional lift, but a further increase can be achieved by restricting the 'break away' of boundary layer air from the upper surfaces of mainplanes and flaps.

This is done by 'blowing' air from the H.P. compressor over these surfaces during take-off and landing.

1. REQUIREMENTS OF THE SYSTEM.

Air for B.L.C. and other aircraft services is taken from the 7th or 12th stages of the H.P. compressor and the system is required to:-

1. Provide air from the correct stage of the compressor.
2. Prevent re-circulation of air from 12th to 7th stage.
3. Provide warning indication of incorrect operation of 12th stage air bleed.
4. When flap blowing is operating provide reset signals to:-

   (a) The engine fuel control unit.
   (b) The afterburner nozzle area control system, when A/B is in operation.

To satisfy these requirements the air bleed system consists of the following units.

/continued.

1. A pressure operated switch and solenoid, with an associated aircraft electrical circuit.
   Ram operated butterfly valves in the 12th stage air outlets.
2. Non-return valves between 7th and 12th stage air offtakes.
3. Limit switches to give cockpit indication of incorrect butterfly valve position.
4. A valve which senses B.L.C. air bleed.

2. OPERATION.

Air from the 7th stage passes into a manifold surrounding the H.P. compressor casing and then through two diametrically opposite outlets into ducting located in the by pass duct.

Two outlets from a manifold around the diffuser casing join this ducting.

Butterfly valves in these outlets permit 12th stage air to pass into the common ducting which terminates at a single outlet at the bottom of the by pass duct.

Since 12th stage air bleed, with the throttle full open, would result in excessive power loss, it is necessary to ensure that the butterfly valves cannot open during take-off.

This is done by breaking the circuit to a solenoid which controls the opening of the valves.

7th stage air is therefore used for B.L.C. during take-off, but once the aircraft is airborne and flaps and undercarriage are retracted the circuit is re-made.

7th or 12th stage air is now automatically selected by a switch sensitive to 7th stage pressure as follows.

7th STAGE PRESSURE	PRESSURE SWITCH POSITION	AIR BLEED STAGE
1. ABOVE 85 P.S.I.	OPEN	7th
2. BELOW 75 P.S.I.	CLOSED	12th

NOTE:- Between 75 p.s.i. and 85 p.s.i. either 7th or 12th stage is acceptable so this band is used for switch setting tolerances.

During approach and landing with engine throttled back, i.e. 7th stage pressure low, when the flaps are selected down, a direct feed to the solenoid ensures that the 12th stage butterfly valves are selected to open.

/continued.

When the butterfly valves open, the non-return valves between 7th and 12th stage air outlets close, thus preventing re-circulation of 12th stage air.

If either of the butterfly valves fail to open this is indicated by the bleed warning light 'ON' in the cockpit.

Limit switches, operated by an extension to the butterfly valve shaft, complete the circuit to the warning light.

When bleeding air for B.L.C. it is necessary:-

(a) To reset the engine fuel control unit to ensure a satisfactory acceleration.

This is done by feeding a P_3 signal from a B.L.C. sensing unit valve in the fuel control unit.

The sensing unit contains a valve which is attached to a diaphragm.

A split pressure, derived by feeding B.L.C. duct pressure from between 7th and 12th stage outlets through a fixed restrictor and then to P_6 is sensed on one side of the diaphragm.

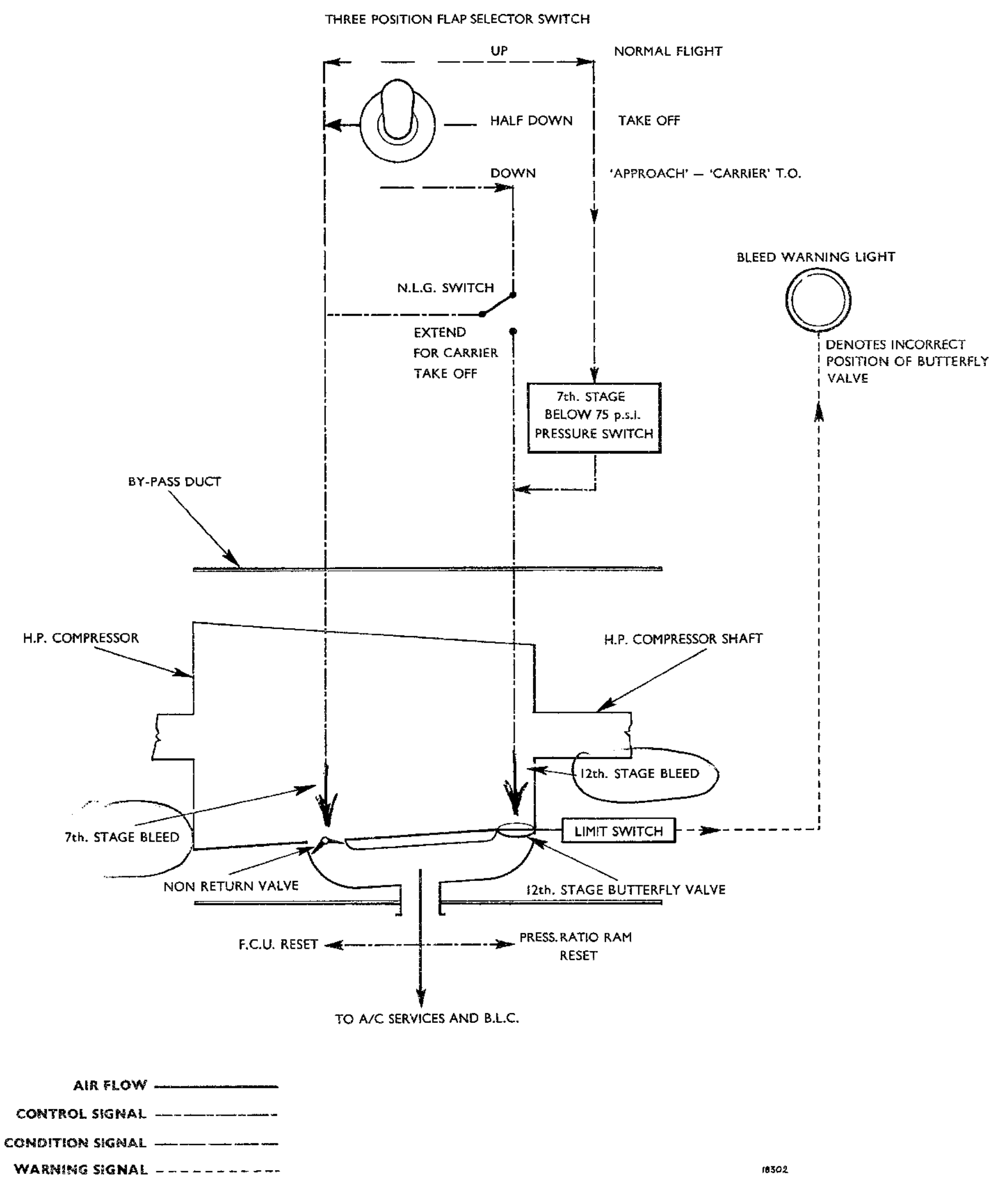
The other side senses throat pressure in venturi downstream of the 12th stage outlet.

With B.L.C. in operation the resultant increase in pressure difference across the diaphragm opens the sensing unit valve.

This permits a supply of H.P. compressor delivery air (P_3) to operate the fuel control unit reset valve.

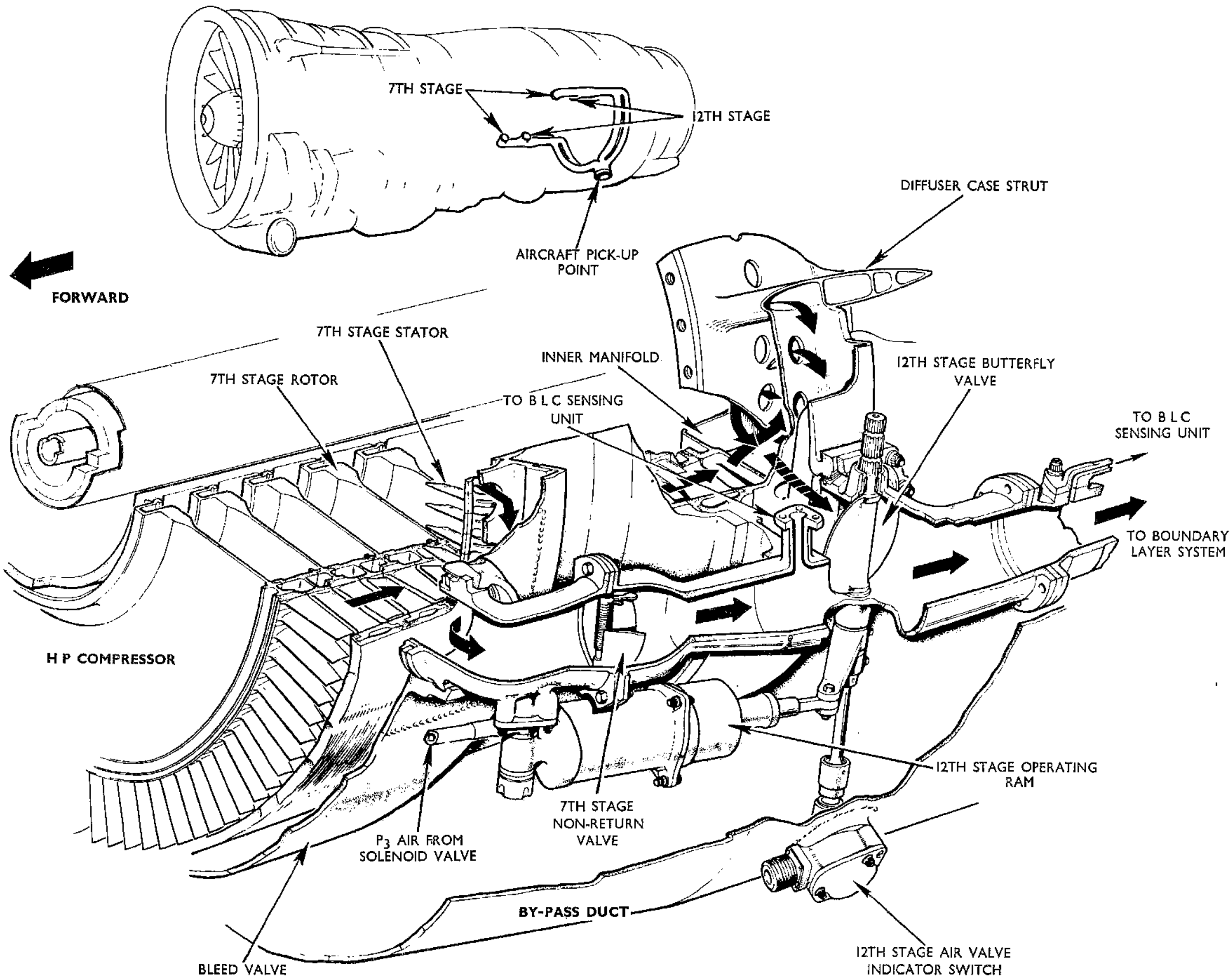
(b) To modify the split P_3 signal to the P_3/P_6 ratio ram which controls nozzle area in order to prevent any possibility of L.P. compressor instability.

This is done by supplying P_3 via the open sensing unit valve to operate a B.L.C. changeover valve which causes the split P_3 signal to the P_3/P_6 ram to be controlled by a differently profiled needle.



BASIC PRESENTATION AIR BLEED SYSTEM 'PHANTOM SPEY'

1.8.67



AIR OFF-TAKES FOR A/C SERVICES

RT 4043A

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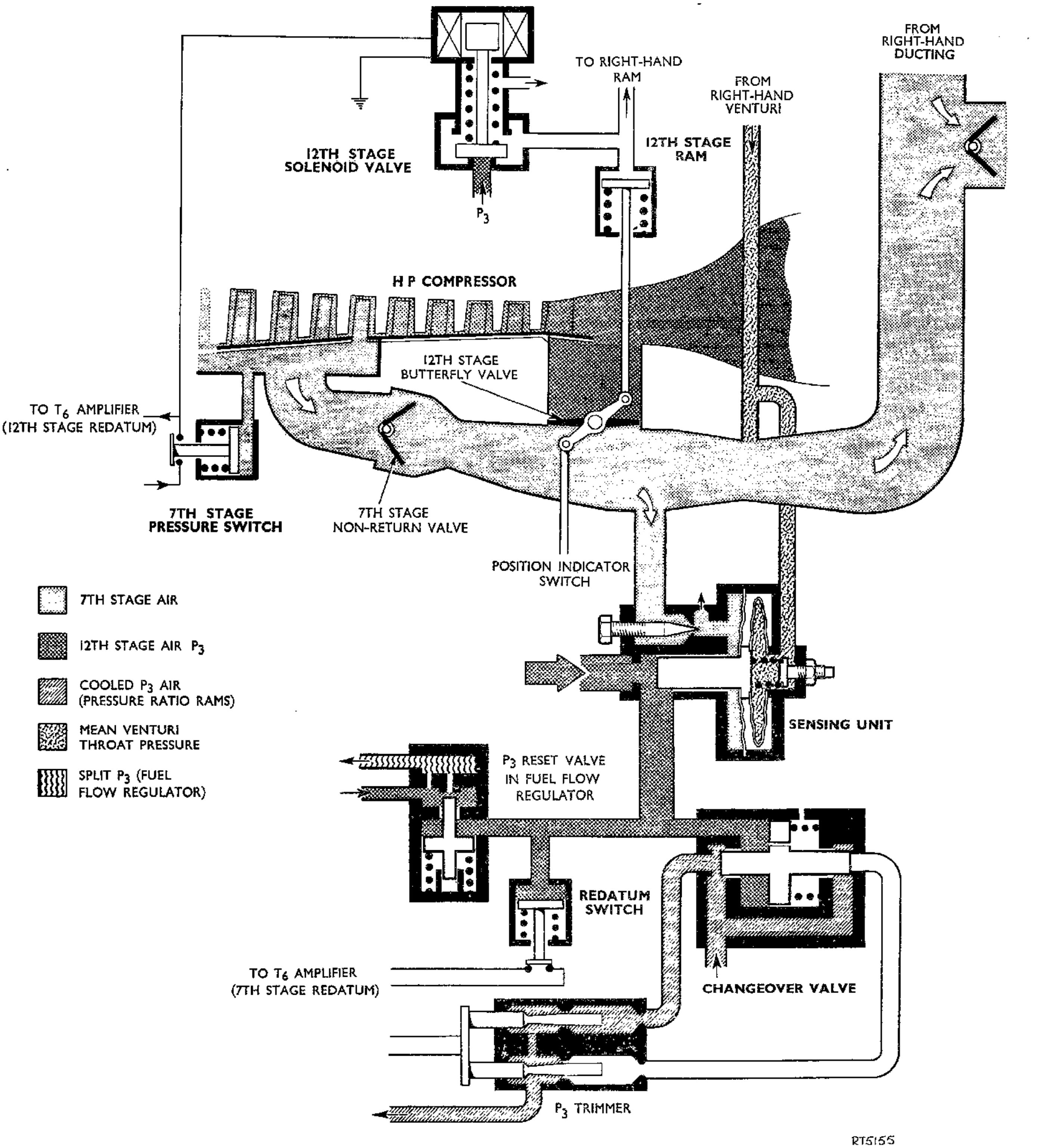


B.L.C. RESET SYSTEM

1.4.67

SPEY MK 201/202

AIR BLEED SYSTEM

ELECTRICAL CIRCUIT

OPERATION.

The operation is described at the following conditions:-

	CONDITION	A/C FLAP POSITION	BLEED STAGE
1.	CATAPULT TAKE-OFF	FULL DOWN	7th
2.	AIRFIELD TAKE-OFF	HALF DOWN	7th
3.	NORMAL LANDING	FULL DOWN	12th
4.	SINGLE ENGINE LANDING	HALF DOWN	7th
	DURING FLIGHT	FLAPS UP	7th OR 12th

(1) Prior to a catapult take-off with flaps at 'FULL DOWN' position during which 7th stage air is used for B.L.C., manual operation of the nose landing gear (N.L.G.) extension switch causes the Bleed Stage Override Relay to move to the 'LATCH' position.

This breaks the circuit to the 12th stage solenoid thus preventing 12th stage air being selected for B.L.C. during take-off.

When the N.L.G. is correctly positioned for catapult take-off the N.L.G. Bleed Interlock Warning Relay is energized to the 'NOT SHRUNK AND NOT COMPRESSED' position.

Thus, if the Bleed Stage Override Relay has not moved to 'LATCH' the Bleed Stage Warning light will be 'ON'.

With the Bleed Stage Override Relay at 'LATCH' if either of the 12th stage butterfly valves are 'NOT CLOSED' the warning light will be 'ON'.

After catapult take-off, when the landing gear and flaps are raised the Bleed Stage Override Relay is energized to the 'Reset' position.

The control of 7th or 12th stage air bleed is then automatic during flight, being controlled by the 7th stage pressure switch.

(2) When take-off is from an airfield the N.L.G. extension system is not required.

/continued.

The Bleed Stage Override Relay remains at the 'RESET' position and the circuit to the 12th stage solenoid is broken due to the selection of $\frac{1}{2}$ Flap down position.

Therefore 12th stage air should not be bleeding but if either of the 12th stage valves is 'NOT CLOSED' the warning light will be 'ON'.

After airfield take-off, when flaps are raised, 7th or 12th stage air is automatically selected by operation of the 7th stage pressure switch.

(3) During approach, for normal landing, with the flaps at the 'FULL DOWN' position, current is fed direct to energize the 12th stage solenoid.

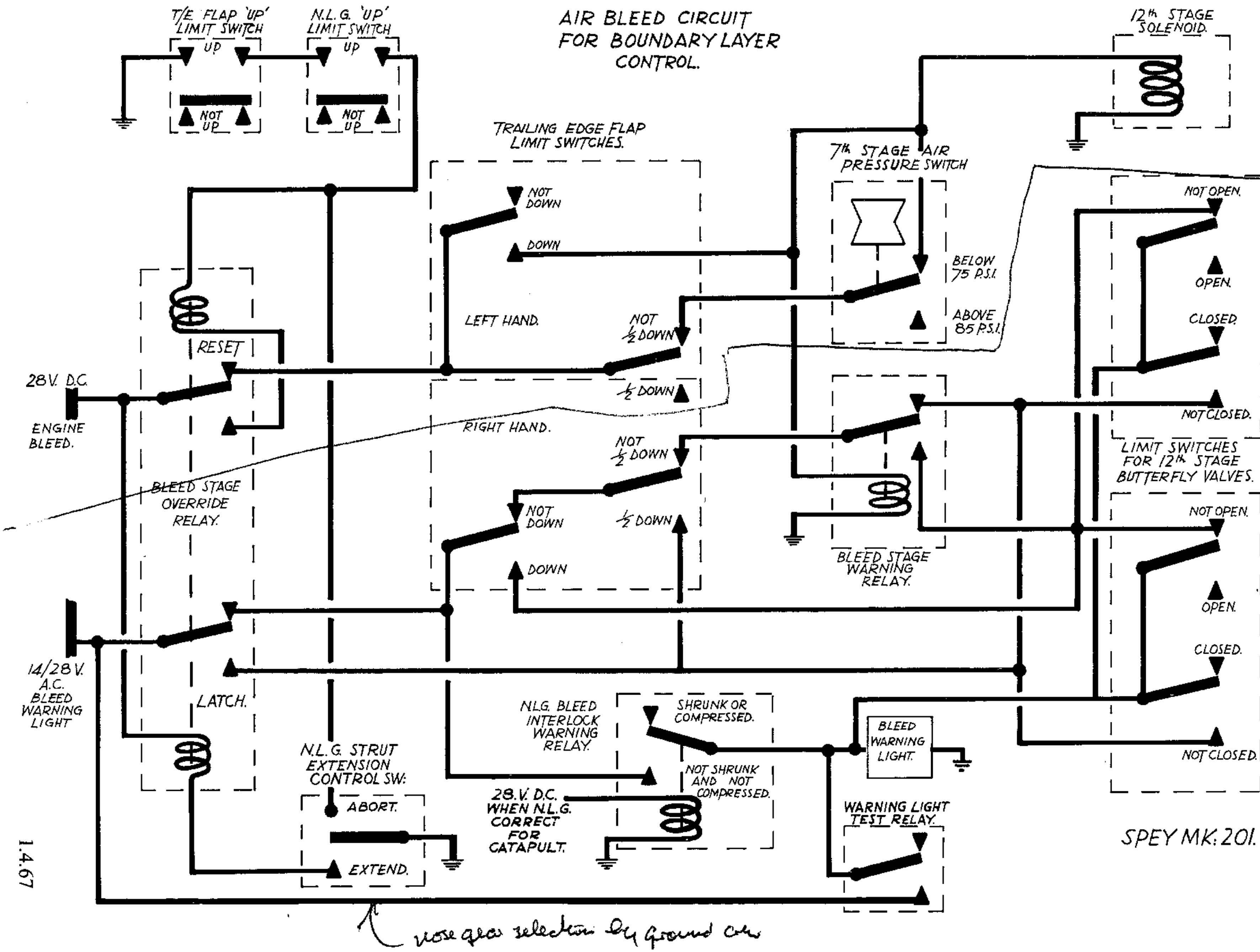
If either of the 12th stage valves are "NOT OPEN' the bleed stage warning light will be on.

For a 'wave-off', 12th stage air will continue to be supplied for boundary layer control until the flaps are housed.

The system will then revert to automatic control by the operation of the 7th stage pressure switch.

(4) For single engine landing, with flaps at 'HALF DOWN' the circuit to the 12th stage solenoid is broken therefore the 12th stage valves should be closed.

If either of the valves is 'NOT CLOSED' the warning light will be 'ON'.



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COURSE NOTE
No. TSp. 384
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CUSTOMER TRAINING CENTRE
COURSE NOTE
No. TSp 310
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SPEY MK 201/202

ENGINE STARTING

SEQUENCE HEADING CHART

1. REQUIREMENTS.

2. OPERATION.

   1. (a) LOW PRESSURE AIR STARTER.
      (b) GAS TURBINE STARTER.

   2. IGNITION SYSTEM.

3. STARTING AND MOTORING PROCEDURE.

   a. PRE-START CHECKS.
   b. STARTING DRILL.
   c. FAILURE TO START.
   d. STOPPING THE ENGINE.
   e. MOTORING DRILL.

4. START CONTROL CIRCUITS.

5. MAINTENANCE.

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SPEY MK 201/202

ENGINE STARTING

1. REQUIREMENTS.

To start an engine it is necessary to:-

1. Rotate the engine to produce air and fuel flow to the combustion liners.

2. Provide ignition.

3. Provide for selection of ignition only for relighting an engine in flight.

The requirements are fulfilled by:-

1. (a) A low pressure air turbine starter (Mk 201 Engines)
   (b) A gas turbine starter (Mk 202 Engines)

2. Two high energy ignition units and igniter plugs.

To operate the above units start selection switches are provided in the cockpit.

3. To permit selection of ignition only, separate ignition buttons are provided on each throttle lever.

2. OPERATION.

1. (a) Low Pressure Air Turbine Starter.

When L.P. air is supplied to the starter, guide vanes direct it onto the turbine.

Through a reduction gear and sprag clutch, this rotates a drive coupling which engages with the high speed gearbox.

The starter incorporates a centrifugally operated cut-out switch, driven from the reduction gear, which causes air supply to the starter to be cut off when the engine reaches a self sustaining speed.

The rollers of the sprag clutch are freed, thus disengaging the drive coupling from the reduction gear.

/continued.

The coupling continues to rotate with the high speed gearbox, whilst the starter comes to rest.

To prevent the engine driving the starter if the sprag clutch jams or the drive coupling support bearings seize, a latch and coupling jaw disengages the drive coupling from the starter.

1. (b) Gas Turbine Starter.

When a start is selected, current is supplied simultaneously to:-

a. A gas generator cranking motor.

b. A solenoid operated fuel valve.

c. The starter ignition coil.

The cranking motor drives the gas generator which consists of

1. A centrifugal compressor and single stage axial flow turbine mounted on opposite ends of a shaft.

2. A reverse flow annular combustion chamber.

3. Eight burners supplied with fuel from a flow control unit.

When the solenoid valve is energised fuel is initially supplied to two of the eight burners.

This mixes with air from the compressor and is ignited by two plugs adjacent to the two operating burners.

As combustion takes place, an increase in gas generator speed occurs and progressively the remaining six burners are supplied with fuel.

Gas produced by the generator is fed to a free-power turbine, which through a starter reduction gearbox and sprag clutch drives the engine high speed gearbox.

After a predetermined time the cranking motor and ignition circuit are de-energised.

When the engine reaches a self sustaining speed, a cut-out switch, driven from the starter reduction gearbox, de-energises the fuel solenoid.

Free power turbine speed reduces and the sprag clutch disengages the starter from the high speed gearbox.

/continued.

2. Ignition System.

The units in the system are:-

Two high energy ignition units.

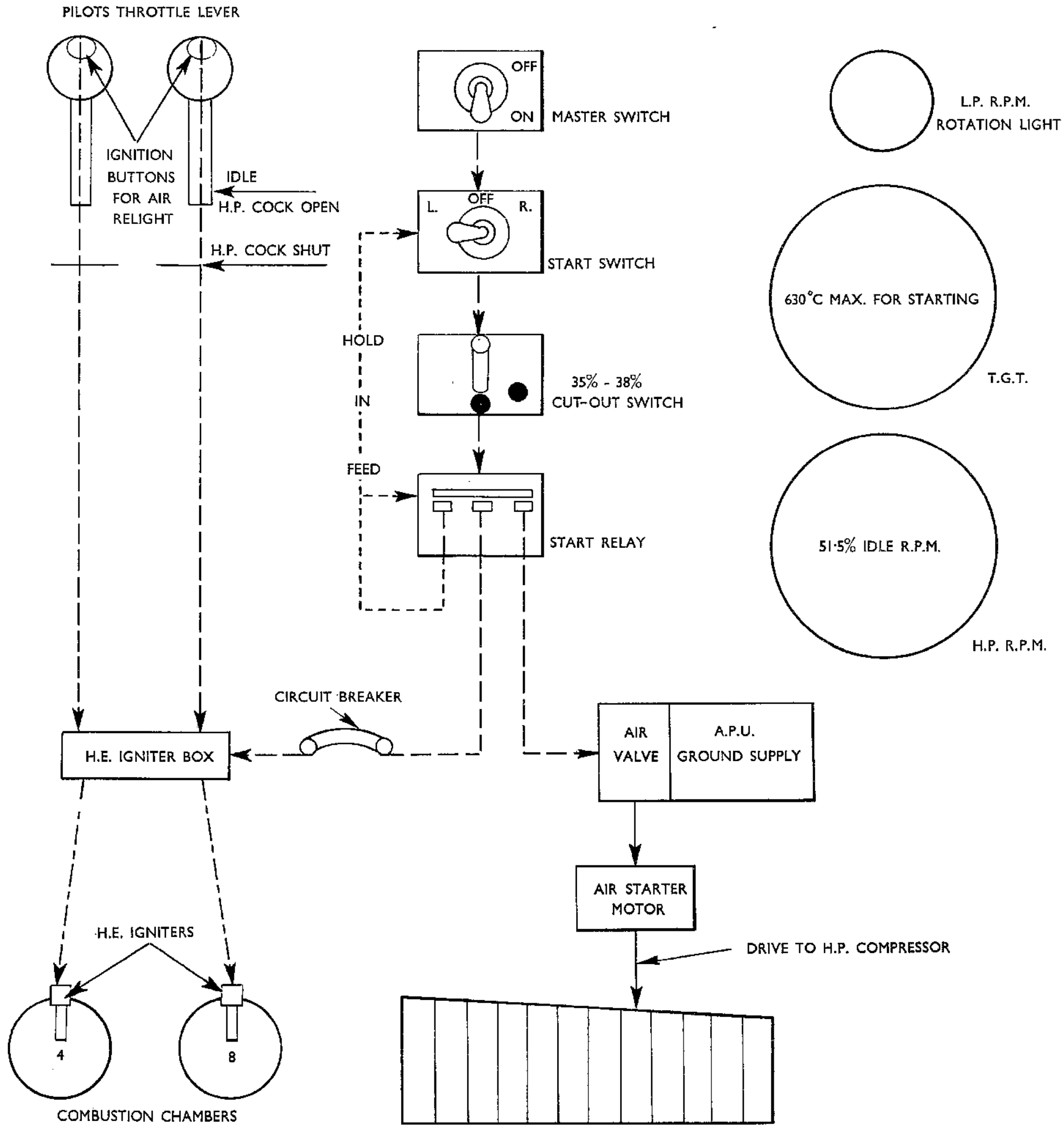
Two igniter plugs.

The igniter units transform the low voltage supply from batteries to a high voltage, and provide an intermittent high amperage supply to the igniters.

The igniters are fitted in Nos. 4 and 8 combustion liners.

The igniter units are mounted in a common case and a cooling coil in the case receives a flow of low pressure fuel to cool the units.

The case is mounted on the underside of the engine transition section.



CONTROL SIGNAL — — — — — — —
HOLD IN SIGNAL - - - - - - - - - - - - - -
AIR SUPPLY SIGNAL ————————
H.E. IGNITER SIGNAL ENERGISED — - — - — - — -

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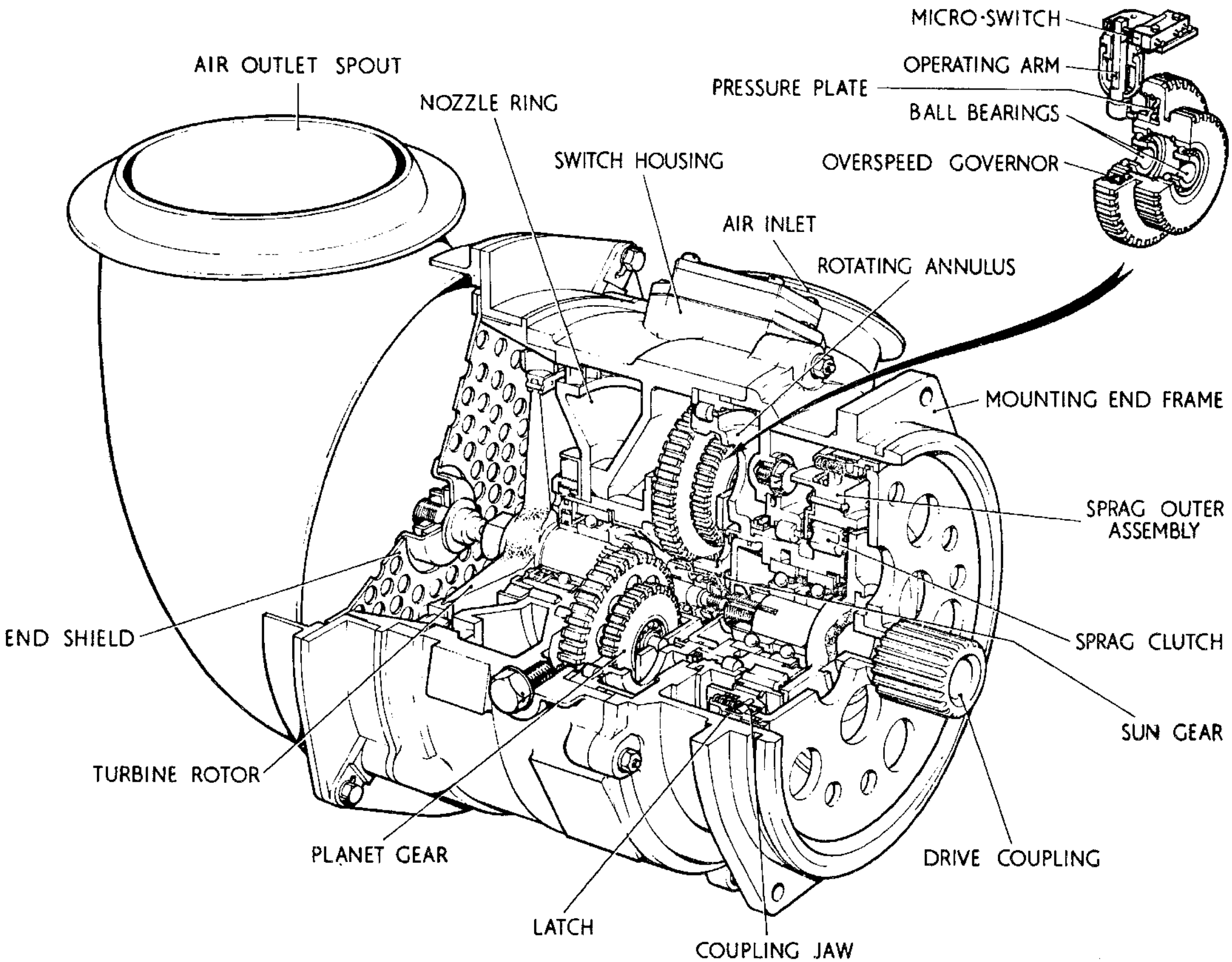
BASIC PRESENTATION AIR STARTING SYSTEM PHANTOM SPEY 1.8.67



TA. 1176 SPEY - STARTER MOTOR

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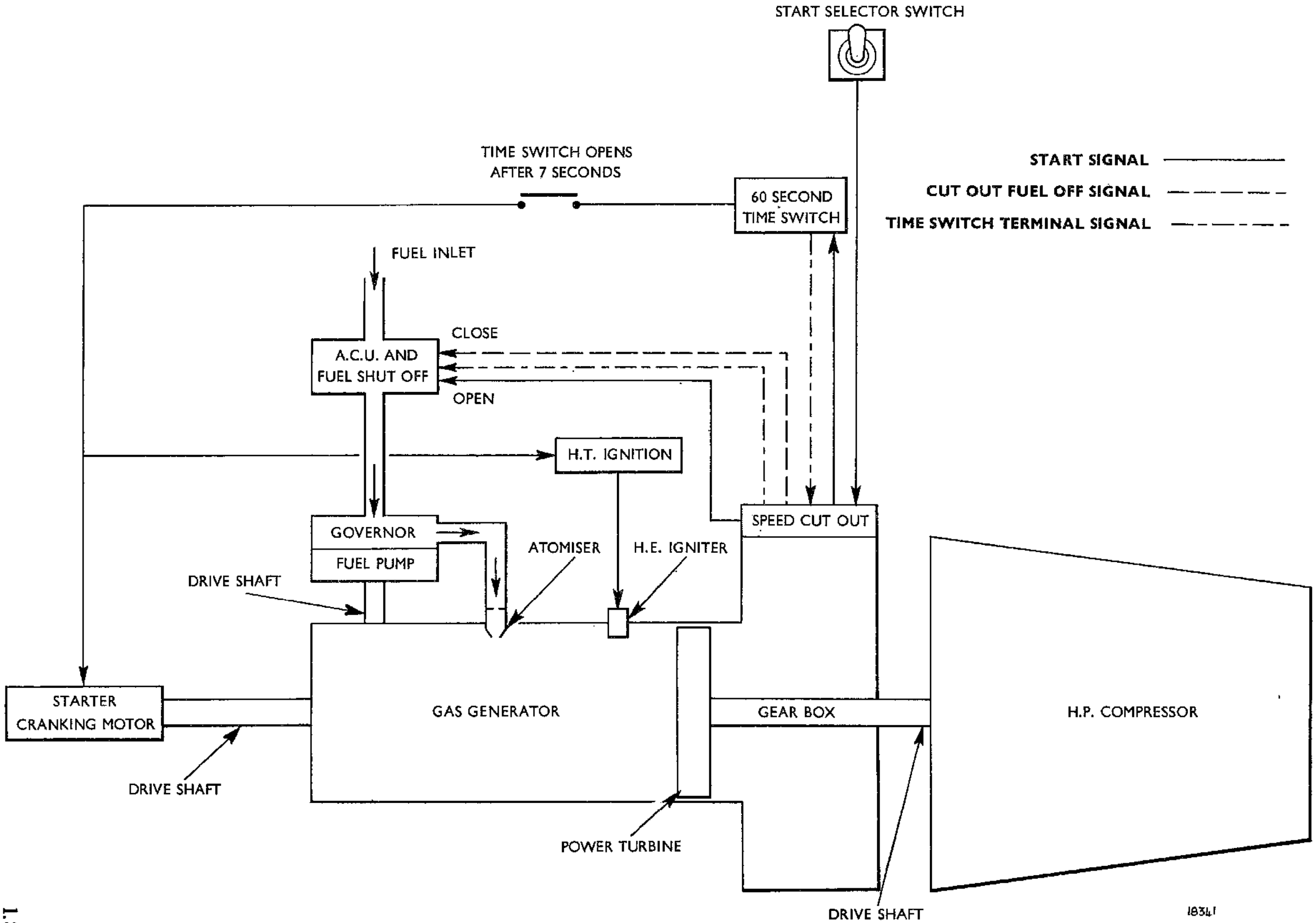
1.6.62



GAS TURBINE STARTING BASIC PRESENTATION

1.8.67

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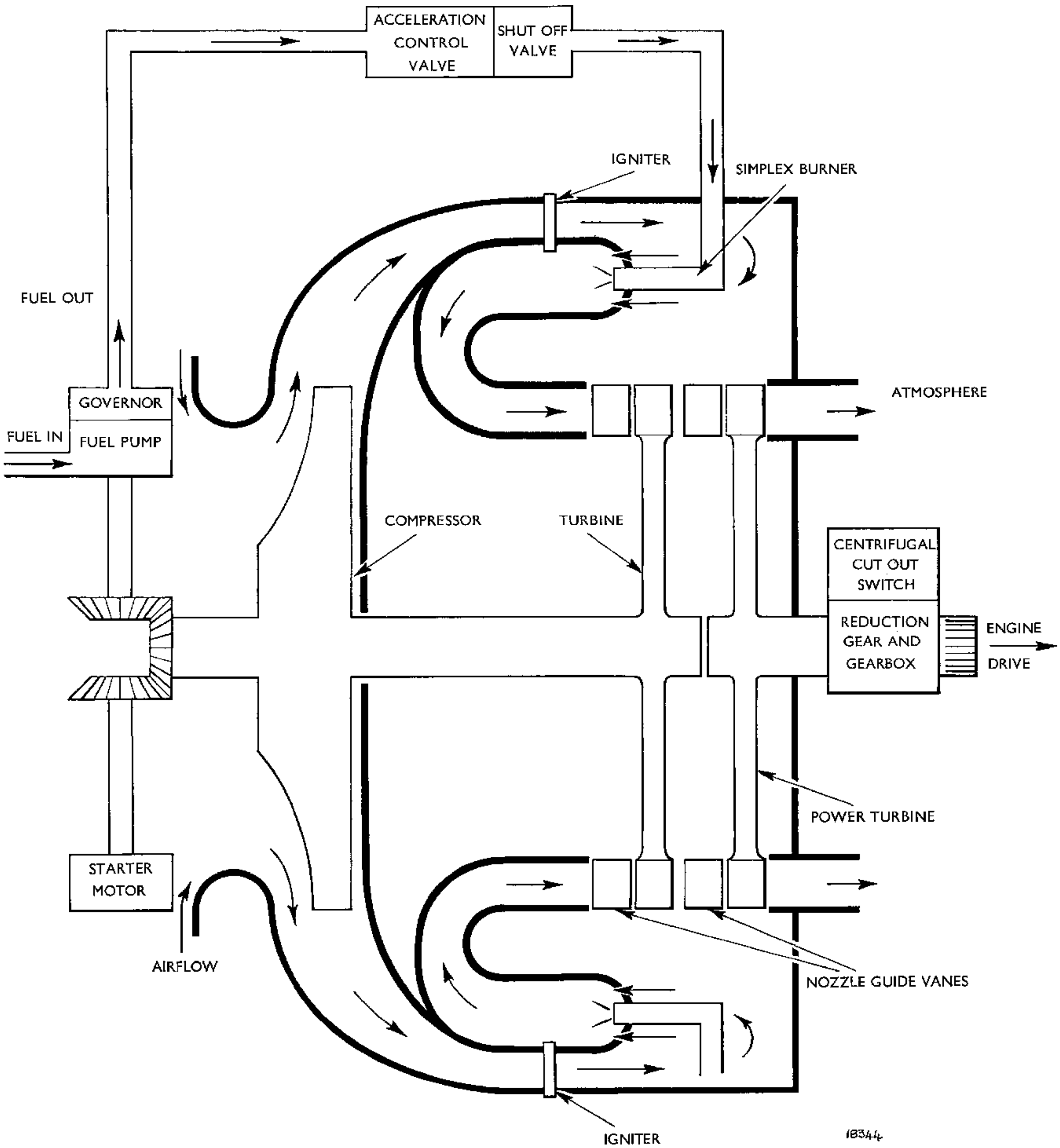

GAS TURBINE STARTER PHANTOM SPEY Mk. 202 1.9.67

SPEY MK 201/202

ENGINE STARTING.

3. STARTING AND MOTORING PROCEDURE (LOW PRESSURE AIR STARTER).

Before starting an engine the following items must be checked and cautions observed, though not necessarily in the sequence given.

For the complete and correct sequence refer to the relevant Air Publication.

a. Checks.

a. Engine oil levels	-	Correct
b. Ground air and Electrical Supply	-	Connected
c. Warning lights	-	TO TEST - Return to NORMAL
d. Fire warning light	-	TEST
e. Throttle lever	-	OFF
f. Fuel boost pressure	-	
g. Engine anti-icing switch	-	OFF
h. Aircraft air bleed services	-	OFF
i. Engine Master Switches	-	ON
j. Flaps selects up, flaps at ½ or up	-	UP

CAUTION:-

WITH FLAPS full DOWN, THE B.L.C. AIR DUCTS ARE OPEN AND THE RESULTANT AIR BLEED FROM THE ENGINE DURING STARTING MAY RESULT IN A HOT START.

b. Starting Drill.

1. Start switches - Select appropriate engine.
2. Immediately L.P. shaft rotation green light comes on:-
   Throttle lever - Idle. (or when HP RPM are 13-15%)

NOTE:-

Light up should occur within 5 secs after moving the throttle to IDLE.

/continued.

CAUTION:-

During starting, if maximum T.G.T. is rapidly approached and appears likely to be exceeded, move the throttle lever to the 'OFF' position.

Abnormal T.G.T.

If the T.G.T. during the start exceeds 630°C but does not exceed 800°C, record in engine log book.

Before attempting another start, examine turbine for signs of damage.

If the T.G.T. during starting exceeds 800°C - reject the engine.

~~After 6 hot starts, i.e. above 630°C - reject the engine.~~

NOTE:-

If A.C. power is not available, the fire warning system will not operate.

Checks after Starting.

When idle r.p.m. and T.G.T. have stabilised, check following:-

1.	Generator	- ON (light out)
2.	Oil pressure warning light	- OUT
3.	Engine bleed light	- OUT
4.	Nozzle position indicator	- Below $\frac{1}{4}$ open
5.	Engine anti-ice indicator	- Check operation of anti-ice.

Disconnect external air and electrical supply.

c. Failure to Start.

NOTE:-

If the engine fails to either:-

1. Light up within 10 secs of moving the throttle lever to idle

or

2. Attain idling r.p.m. within 1 min.

Move the throttle lever to 'OFF' then select engine starter switch off and allow engine to drain for 2 mins. Resume starting drill if all is satisfactory.

d. Stopping the Engine.

NOTE:-

Before stopping the engine, ensure FLAPS are UP and if the engine has been run above 80% H.P. r.p.m., select idle and run for a minimum of 30 secs, then:-

Throttle lever - OFF

If it is necessary to make an emergency stop, the throttle lever may be moved to OFF from any position. The engine must then be checked for freedom of rotation.

e. Motoring Drill.

1. Throttle - OFF
2. Circuit breaker to ignition units - TRIP
3. Engine Master Switches - ON
4. Starter Switch - To appropriate engine
5. L.P. shaft rotation light - ON

CAUTION:-

If L.P. shaft rotation light is not on within 10 seconds,

Starter Switch - OFF

On completion of motoring cycle

6. Engine Master Switches - OFF
7. Circuit breakers - REMAKE

STARTER MOTOR LIMITATIONS.

To prevent the starter motor overheating, continual use of the starter is limited to 3 operations, each of one minute maximum duration.

After 3 operations the motor must be allowed to cool to ambient temperature (+ 20°C) before further use.

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COURSE NOTE
No. TSp 311
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SPEY MK 201/202

ENGINE OIL SYSTEM

SEQUENCE HEADING CHART

1. REQUIREMENTS.

2. OPERATION.

3. OPERATING LIMITS.

4. MAINTENANCE.

11.4.67.

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ENGINE OIL SYSTEM

1. REQUIREMENTS.

To ensure adequate lubrication of engine bearings and gears at all operating conditions a continuous flow of clean oil, at an acceptable temperature is supplied by a system containing the following main items:-

An oil tank.

One pressure pump.

One metering pump.

Seven scavenge pumps.

Pressure and scavenge filters.

Relief and by-pass valves.

A breather system.

Magnetic chip detectors.

2. OPERATION.

A supply of oil is contained in a tank located on the lower left-hand side of the air intake manifold.

The pumps, relief valves etc., and the distribution and scavenging of oil is shown in the oil system diagram (TSp.352).

To ensure a satisfactory pressure to jets supplying oil to bearings a relief valve senses spring pressure (35 p.s.i.) plus scavenge pressure.

Low oil pressure warning is given by an indicator in the cockpit.

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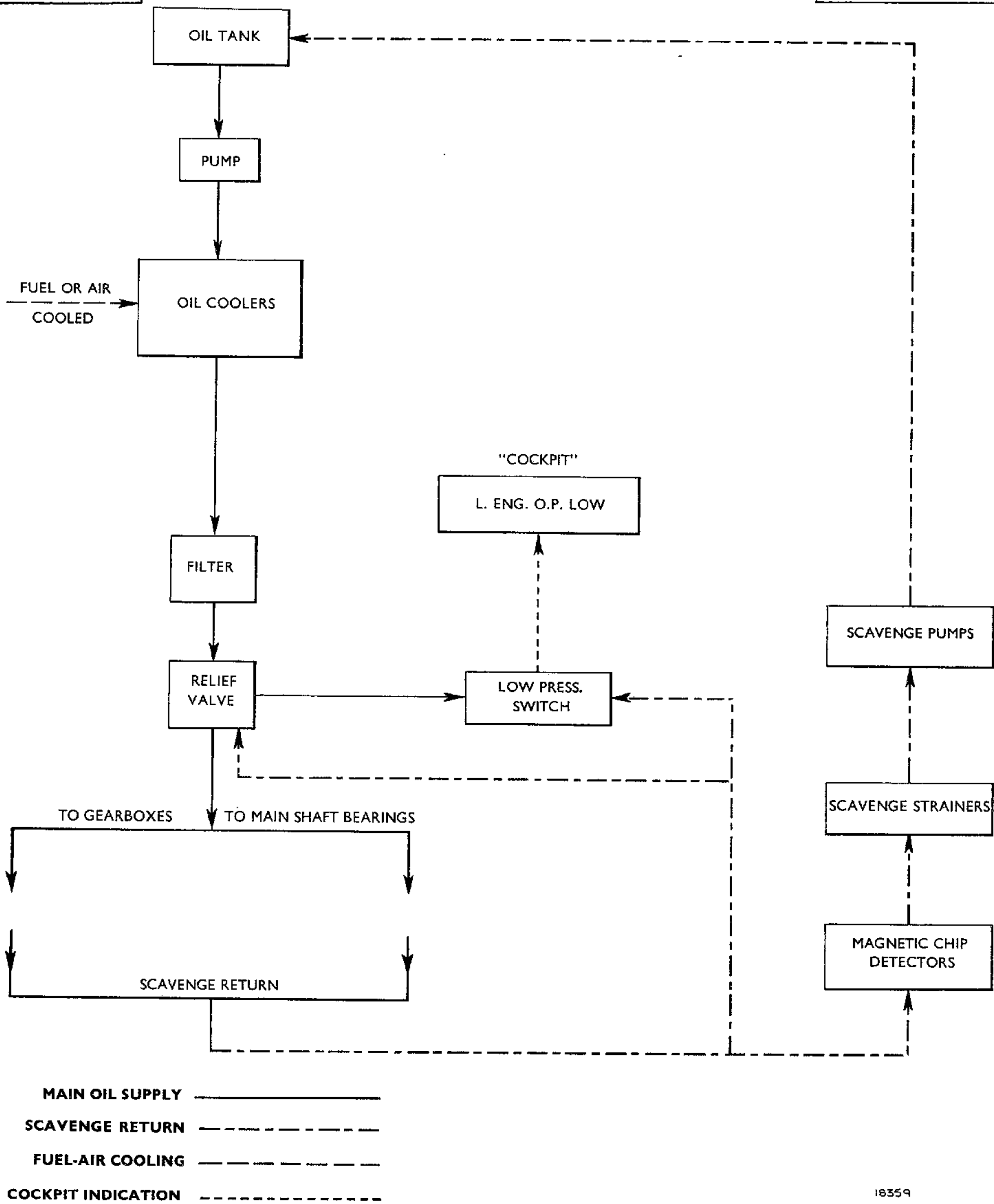
SPEY MK 201/202

ENGINE OIL SYSTEM

3. OPERATING LIMITS.

Type of Oil.	D.Eng.R.D.2487 (OX 38) D.Eng.R.D.2493 (RECLAIMED OIL)
Oil Capacity.	System Total 26.5 IMP : PTS Tank 9.5 IMP : PTS
Oil Consumption.	MAX.PERMISSIBLE 0.75 IMP:PTS/HR
Low Oil Pressure Warning Indicator.	Setting 15 p.s.i. P.D.



OIL SYSTEM - SPEY Mk. 201 & 202 BASIC PRESENTATION

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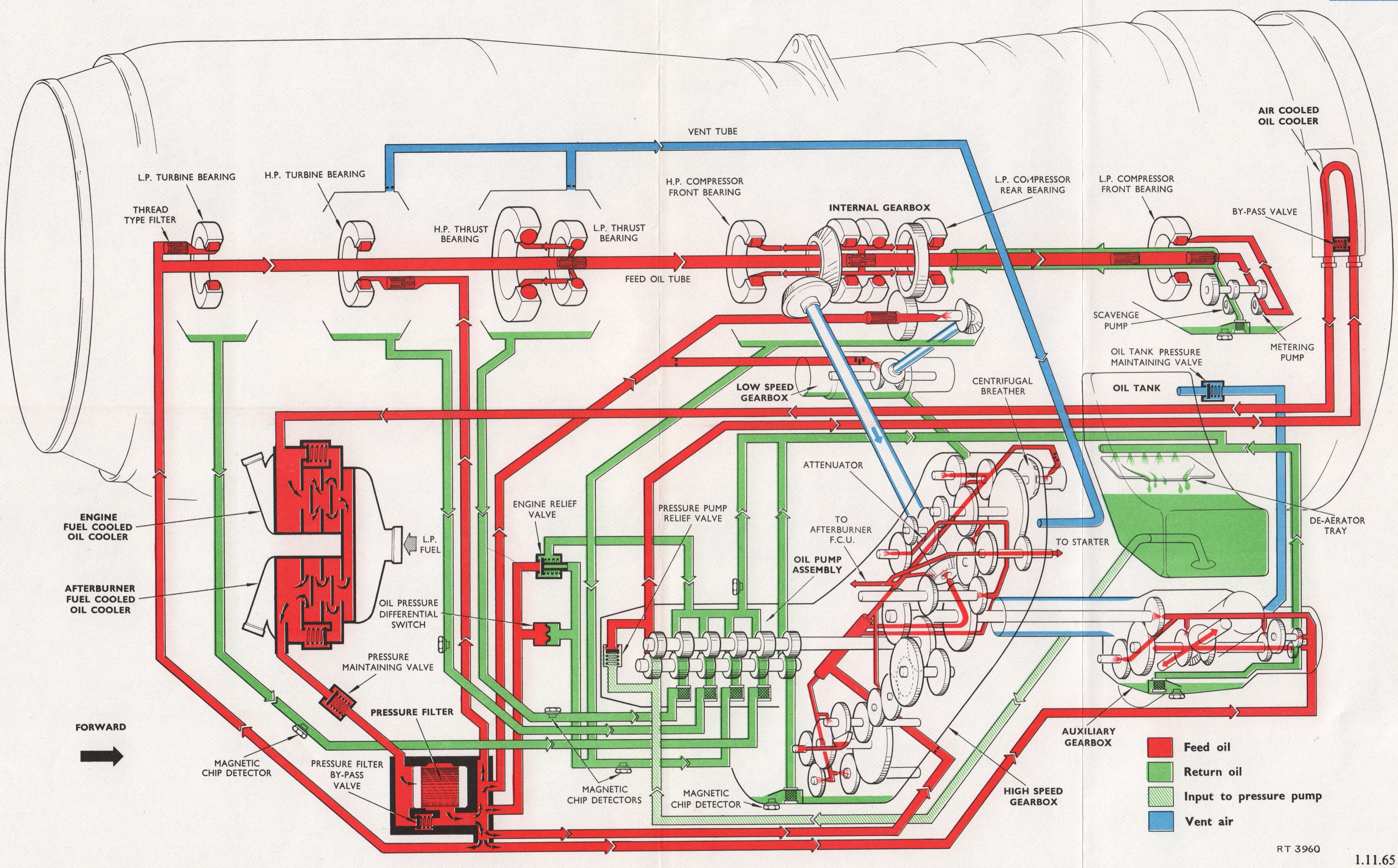

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OIL SYSTEM - SPEY Mk. 201

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SPEY MK 201/202

SEALING AND COOLING AIR SYSTEM

SEQUENCE HEADING CHART

1. REQUIREMENTS.

2. COCKPIT INSTRUMENTATION.

3. SEALING OF MAIN BEARING HOUSINGS.

   (a) Types of Seals.

   (b) Sealing Airflows.

4. COOLING OF INTERNAL COMPONENTS.

   (a) General Cooling.

   (b) 12th Stage H.P. Compressor Disc.

   (c) Turbine Discs.

   (d) H.P. Nozzle Guide Vanes.

   (e) H.P. Turbine Blades.

5. MAINTENANCE.

SPEY MK 201/202

SEALING AND COOLING AIR SYSTEM

1. REQUIREMENTS.

To provide sealing of the main bearing housings against loss of lubricating oil.

To improve reliability and thus the life of internal engine components by preventing excessive operating temperatures.

This is done by tapping sealing and cooling air supplies from the compressor system.

2. COCKPIT INSTRUMENTATION.

To give warning of cooling air over temperature condition a Graviner type overheat detector element is fitted in the outboard L.P. cooling air outlet.

The inboard L.P. cooling air outlet is blanked and a blank is also fitted over the detector element locating hole. To prevent loss the detector element blank is secured to a cable which in turn is attached to a bracket on the L.P. fuel filter housing.

3. SEALING OF MAIN BEARING HOUSINGS.

Due to the high shaft speeds, the use of seals with a clearance between stationary and rotating members is necessary.

(a) TYPES OF SEALS.

Oil Seals.

The types used are:-

Ring Seal - Consists of either a complete ring which will remain concentric around a sleeve or shaft having a smooth surface

OR

A split ring (piston ring).

Grooved Seal - has either a grooved stationary member surrounding a plain sleeve or shaft

OR

a plain stationary member surrounding the grooved rotating sleeve or shaft

These seals require a continuous airflow to be fully effective.

/continued.

Air Seals.

These are used as airflow restrictors to control airflows at various points within the engine.

They consist of a rotating and stationary member both of which are grooved.

The passage formed between the two members controls air leakage across the seal.

(b) SEALING AIRFLOWS.

To pressurize oil seals, air from three sources is used, namely:-

L.P. compressor delivery air.
By-pass stream.
Restricted H.P. air.

L.P. Compressor Delivery Air.

This is used to pressurize the following:-

- L.P. compressor front bearing ring seal (with an airflow restrictor).
- L.P. compressor rear bearing ring seal (with an airflow restrictor).
- H.P. compressor front bearing grooved seal (with an airflow restrictor).
- H.P. compressor thrust bearing grooved seals (with pressure balance tubes and an airflow restrictor).
- H.P. turbine bearing front grooved seal.

By-pass Air.

L.P. turbine bearing ring seal.

Restricted H.P. Air.

H.P. turbine bearing rear grooved seal.

L.P. thrust bearing ring seal.

4. COOLING OF INTERNAL COMPONENTS.

(a) General Cooling.

The airflow to the bearing housing seals provides general cooling for the components around which the air circulates.

This air is finally vented to atmosphere via hollow spokes and a manifold which surrounds the combustion outer case.

/continued.

Two outlets from the manifold which pass to the outside of the by-pass duct on opposite sides of the engine, permit handing of the engine.

The outlet not in use is blanked.

(b) Compressor 12th Stage Disc Cooling.

To cool the last stage disc of the H.P. compressor requires air from a higher pressure source than that used for general cooling.

H.P. compressor 5th stage air is used for this purpose.

(c) Turbine Cooling.

To keep the temperature of the turbine discs within acceptable limites, air from a high pressure source is used.

The air is tapped from around the front end of the combustion liners i.e. H.P. compressor delivery air.

The flow across the turbine disc faces is controlled by a number of airflow restrictors.

The air finally passes into the main gas stream.

(d) H.P. Nozzle Guide Vane Cooling.

A proportion of H.P. compressor delivery air from around the combustion liners is circulated through the vanes.

This finally returns to the gas stream through holes in the trailing edge of the vanes.

High turbine entry temperature can thus be used while still maintaining reliability.

(e) H.P. Turbine Blade Cooling.

The 1st stage H.P. turbine blades are cooled by air tapped from around the front end of the combustion liners.

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SPEY Mk. 201 COOLING AND SEALING AIR FLOW

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SPEY MK 201/202

DRAINS SYSTEM

The requirements of the drains system fall into two catergories:-

1. DRAINAGE OF UNWANTED FUELS.
2. DRAINAGE ASSOCIATED WITH UNIT FAILURES.

1. To minimise fire risks by collecting and disposing of unburnt fuels from Combustion Chambers, Turbine and Re Heat sections after,

    (a) False or abortive starts

    (b) Engine shut down

2. To indicate unit failure if excessive drainage is observed from Engine or Re heat nozzle oil system overboard tell tale drains.

DRAINAGE OF UNWANTED FUELS.

(a) After false or abortive starts.

(b) After engine shut down.

Fuels from the following units - see TSp 364 No's 10, 12, 13,14, 15 are conveyed from each unit via signal tubes to two connection blocks mounted on the bottom rear face of the by-pass duct casing and then via two rigid pipes to the aircraft drains collectors tank.

Fuels from the Combustion Chambers, Turbine, L.P. Turbine bearing housing, By-Pass duct and Mixer Assembly pass through a series of passages and drillings and then through a tube and hose assembly to a drains connection secured externally to the By-Pass duct. Spring loaded valves in the connection 'Open' when the engine stops allowing fuels to drain overboard.

Fuel drains from the Exhaust Collector via a overboard drain in the diffuser casing.

Fuel from the Ejector nozzle passes through two small holes directly overboard.

DRAINAGE ASSOCIATED WITH UNIT FAILURE.

(a) Engine.

A tell tale overboard drain connected to a drains block mounted on the underside of the High Speed wheelcase indicates failure if leakage is excessive from the following engine units.

See TSp 364 No's 1, 2, 3, 4, 5, 6, 7, 8, 9, 11.

/continued.

(b) Re-Heat Nozzle System.

A tell tale overboard drain mounted on the exhaust collector flange indicates failure if leakage is excessive from the following nozzle system units.

See TSp 364 No's 16, 17, (18 six off).

LEAKAGE LIMITATIONS.

(a) Engine.

Total Fluid drainage - 120 cc per minute max.

NOTE:- If fuel drainage exceeds this figure it will be necessary to determine where the excess originates by disconnecting the tubes to the engine drains block and checking individual unit drains.

Example.

Re-heat control unit - 50 cc per minute max, engine running.

Collector Tank Overflowing.

Disconnect drains tubes from drains blocks on by pass casing and check the following:-

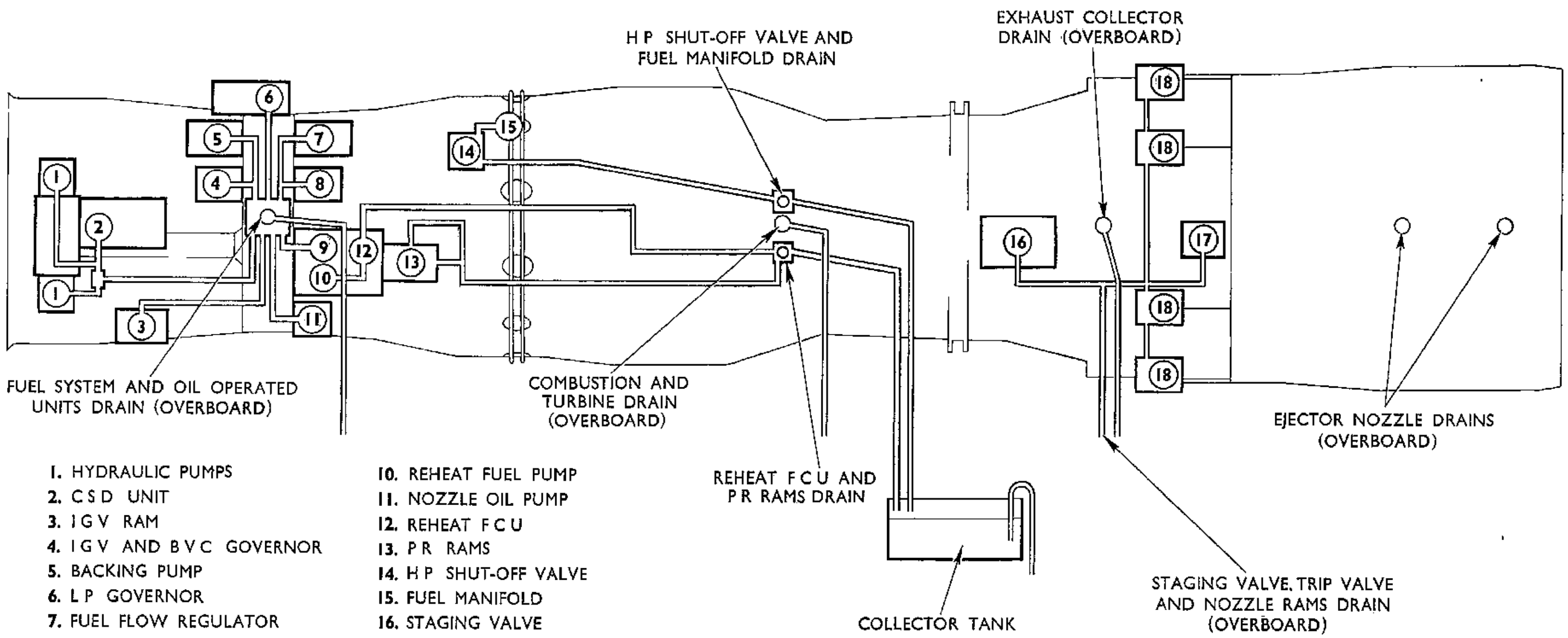
Pressure Ratio Ram - 20 cc per minute max, engine running

H.P. Shut Off Valve - 46 cc per minute max, engine running

Re-Heat Nozzle System.

Total fluid drainage 1.5 cc per minute with engine running.

If drainage exceeds this figure disconnect tubes to drains block on Re-heat casing to determine where excess originates.



1. HYDRAULIC PUMPS
2. C S D UNIT
3. I G V RAM
4. I G V AND B V C GOVERNOR
5. BACKING PUMP
6. L P GOVERNOR
7. FUEL FLOW REGULATOR
8. H P FUEL PUMP
9. REHEAT F C U
10. REHEAT FUEL PUMP
11. NOZZLE OIL PUMP
12. REHEAT F C U
13. P R RAMS
14. H P SHUT-OFF VALVE
15. FUEL MANIFOLD
16. STAGING VALVE
17. TRIP VALVE
18. NOZZLE OPERATING RAMS

SPEY Mk. 201 ENGINE – DRAINS SYSTEM

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