BRISTOL SIDDELEY

AERO ENGINE SCHOOL

SECTION 3

GENERAL DESCRIPTION OF ENGINE

3.1. NOSE FAIRING & INTAKE CASING

3.2. L.P. COMPRESSOR ROTOR

3.3. L.P. COMPRESSOR CASING

3.4. FRONT BULKHEAD

3.5. INTERMEDIATE CASING

3.6. H.P. COMPRESSOR ROTOR & CASING

3.7. DELIVERY CASING

3.8. COMPRESSOR TURBINE COUPLINGS

3.9. THE REAR BULKHEAD

3.10. BEARINGS

3.11 COMBUSTION CHAMBER OUTER CASING

3.12 FLAME TUBE AND TURBINE CASING

3.13 TURBINE ASSEMBLY

3.14 EXHAUST ANNULUS AND CONE UNIT

3.1 NOSE FAIRING AND AIR INTAKE CASING

Nose Fairing

The Nose Fairing which surrounds the oil tank, is formed from light sheet alloy, and is of double skin construction, the space between the skins allowing passage of air for engine anti-icing. The fairing is attached to the front face of the air intake centre section by studs and nuts, the spacing between the studs being such that the fairing will be located in one position only. Slots around the mating faces line up to allow the anti-icing air to exhaust from the nose fairing to the front portions of the six hollow vanes of the intake casing.

Air Intake Casing

The casing is an alloy casting and is located on the front face of the low pressure compressor casing.

There are six hollow vanes which link the outer casing with the centre section. Passages between these vanes duct the Air from the Aircraft intake to the L.P. compressor. The oil tank is attached to the centre section.

A float type mechanism in the oil tank is connected to the oil tank contents indicator, positioned on the port side of the outer casing. The rear diaphragm supports the L.P. Compressor front bearing housing and the stationary member of the bearing seal, also housed in the centre section is the oil separator.

At the rear of the intake casing 26 hollow entry guide blades are fitted in recesses in the outer casing and are secured by set bolts which are screwed into the threaded base of each blade. At their inner ends the blades locate in the centre section.

A circumferential manifold located around the outer casing distributes hot air through the entry guide blades and nose fairing.

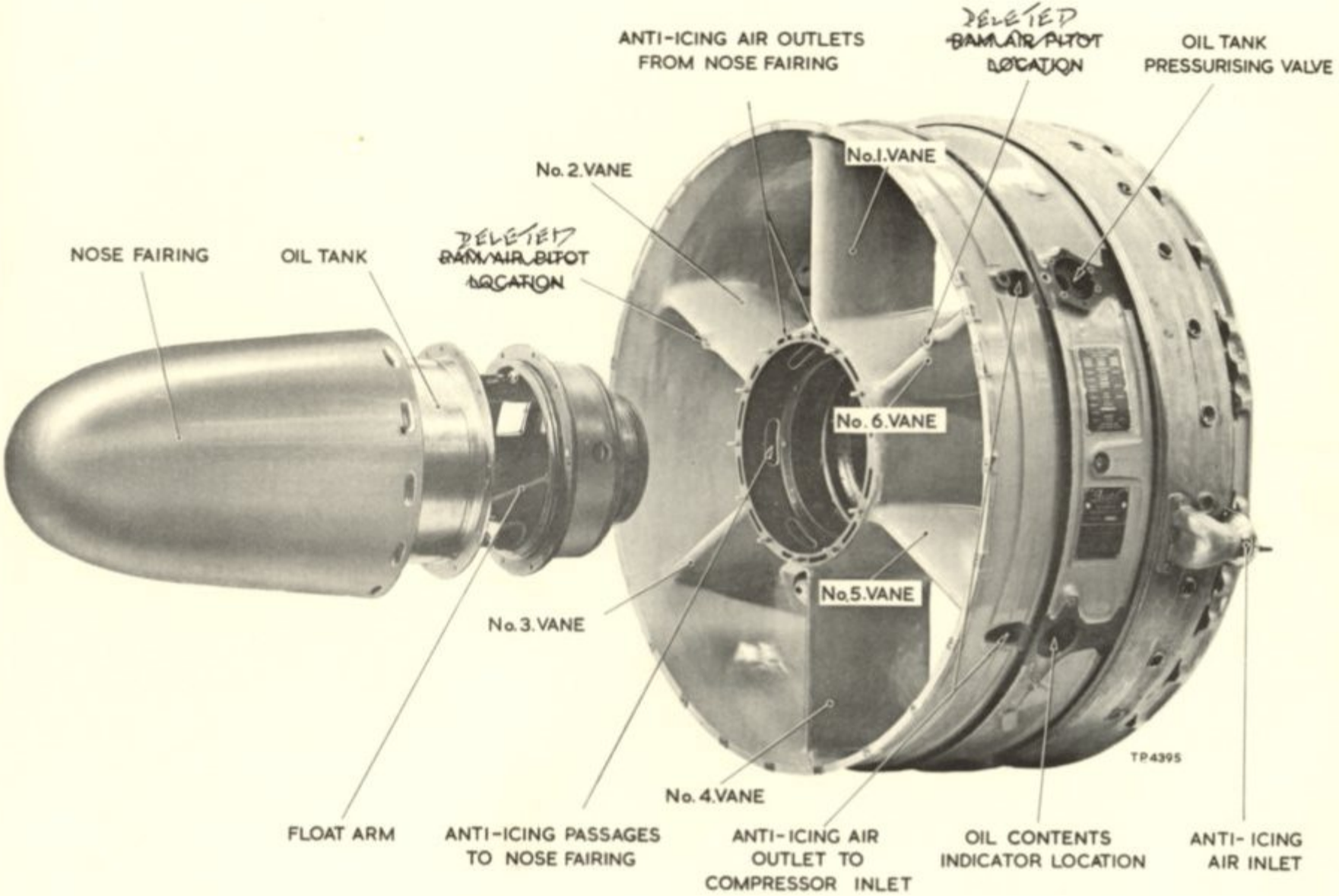
The aircraft ...

The aircraft intake duct is fitted by means of a manacle ring to the front flange of the casing thus facilitating speedy removal for inspection and engine changing.

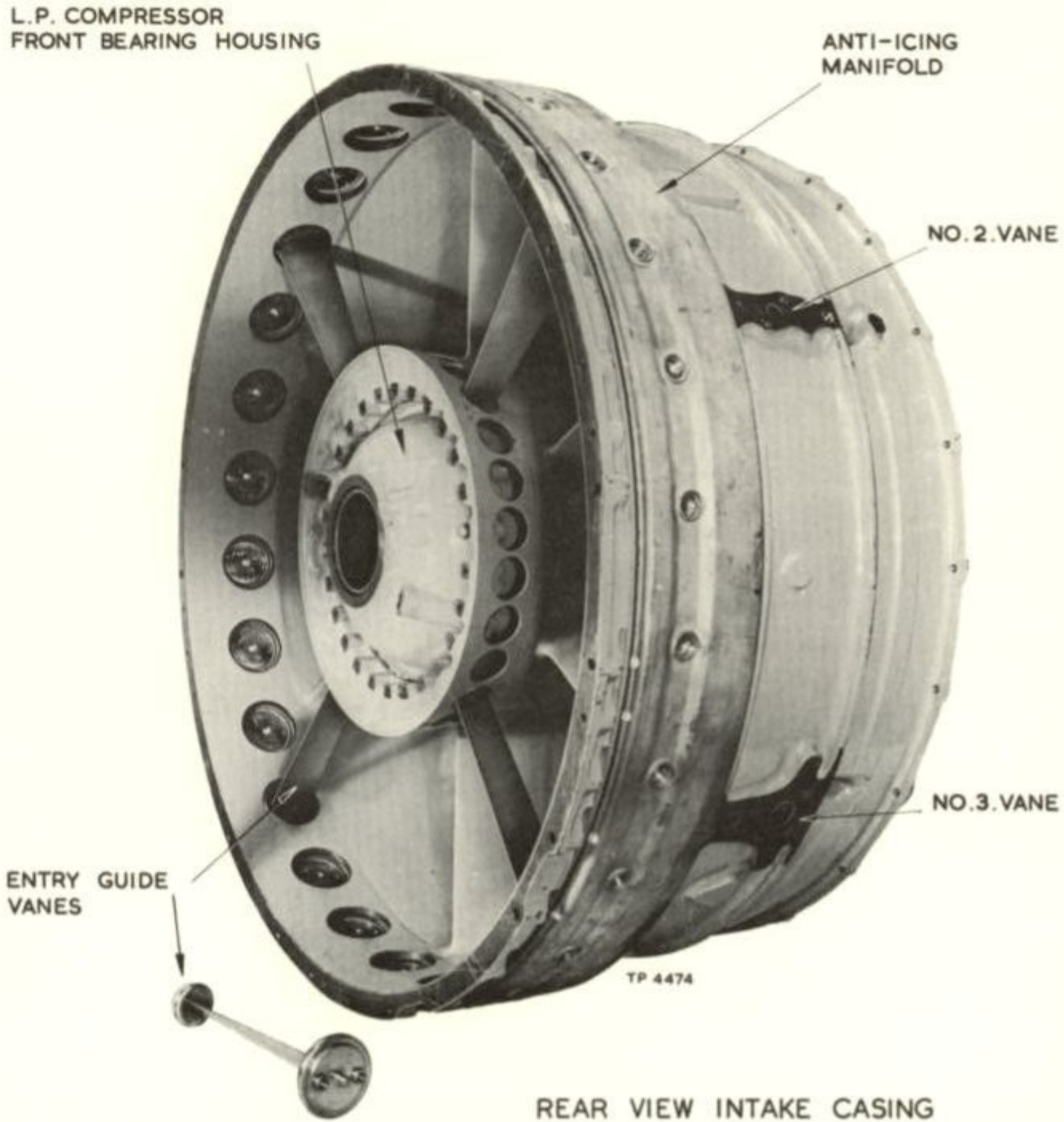
All vanes vent anti - icing air to the collector ring and the air is then exhausted into the compressor inlet.

For reference purpose the six hollow vanes are numbered one to six in a clockwise direction viewed from the rear of the engine, No.1 vane being at 12 o'clock position and are employed for the following purposes :

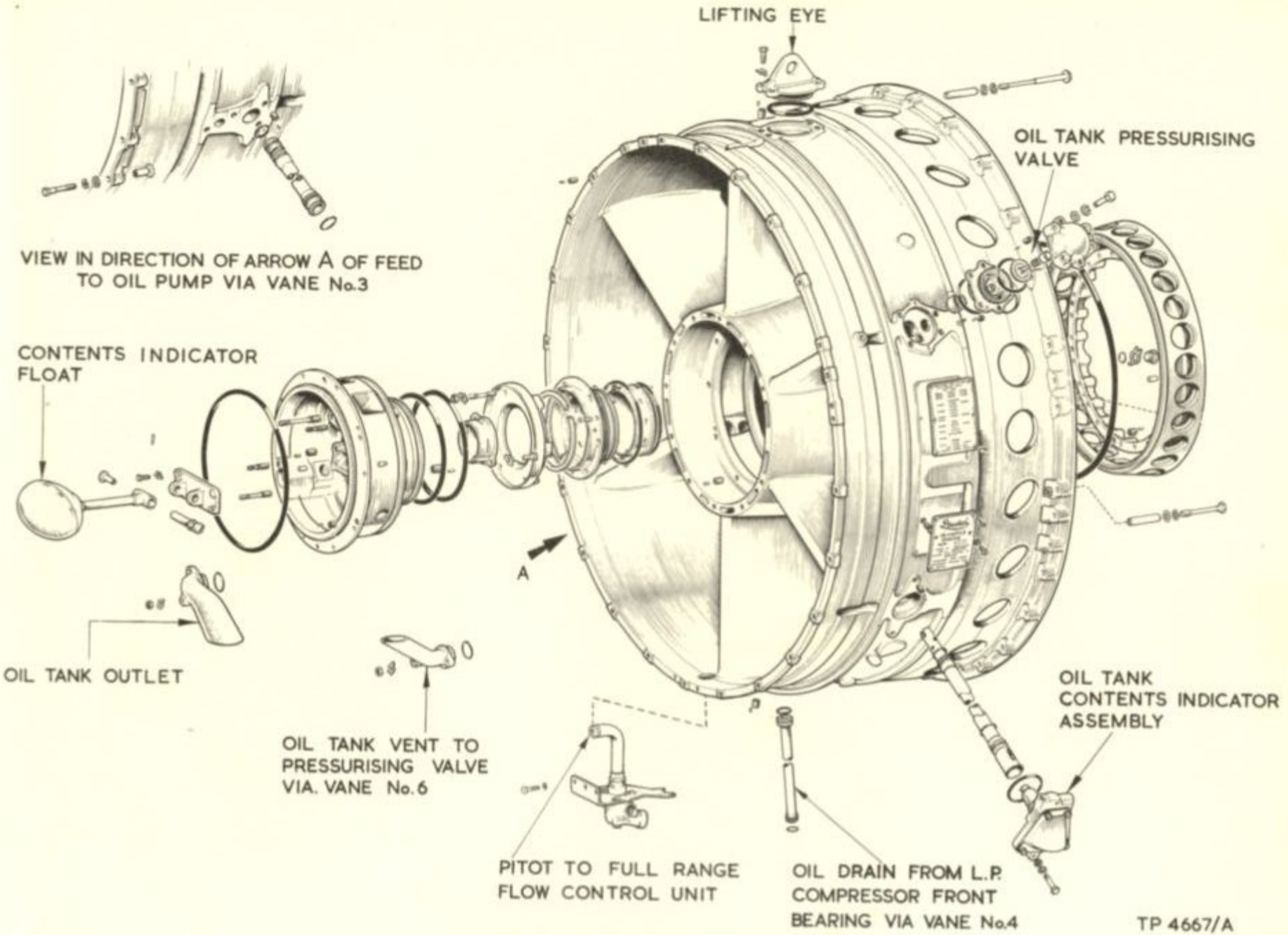
No.1 Vane	Lifting eye for front lifting hoist.
No.2 Vane	Oil feed to L.P. compressor front bearing.
No.3 Vane	Feed to oil pressure pump. Oil Scavenge return to tank.
No.4 Vane	Oil scavenge from front compressor bearing. Oil tank overflow - Avery coupling pipe.
	Vent from seal and oil separator.
No.5 Vane	Oil tank contents Indicator Shaft.
No.6 Vane	Oil Tank Pressurising Valve.



NOSE CONE AND INTAKE CASING



REAR VIEW INTAKE CASING



AIR INTAKE CASING

OLYMPUS 201

3.2 LOW PRESSURE COMPRESSOR ROTOR

The five stage L.P. compressor rotor, axial flow type, is driven by the second stage turbine wheel.

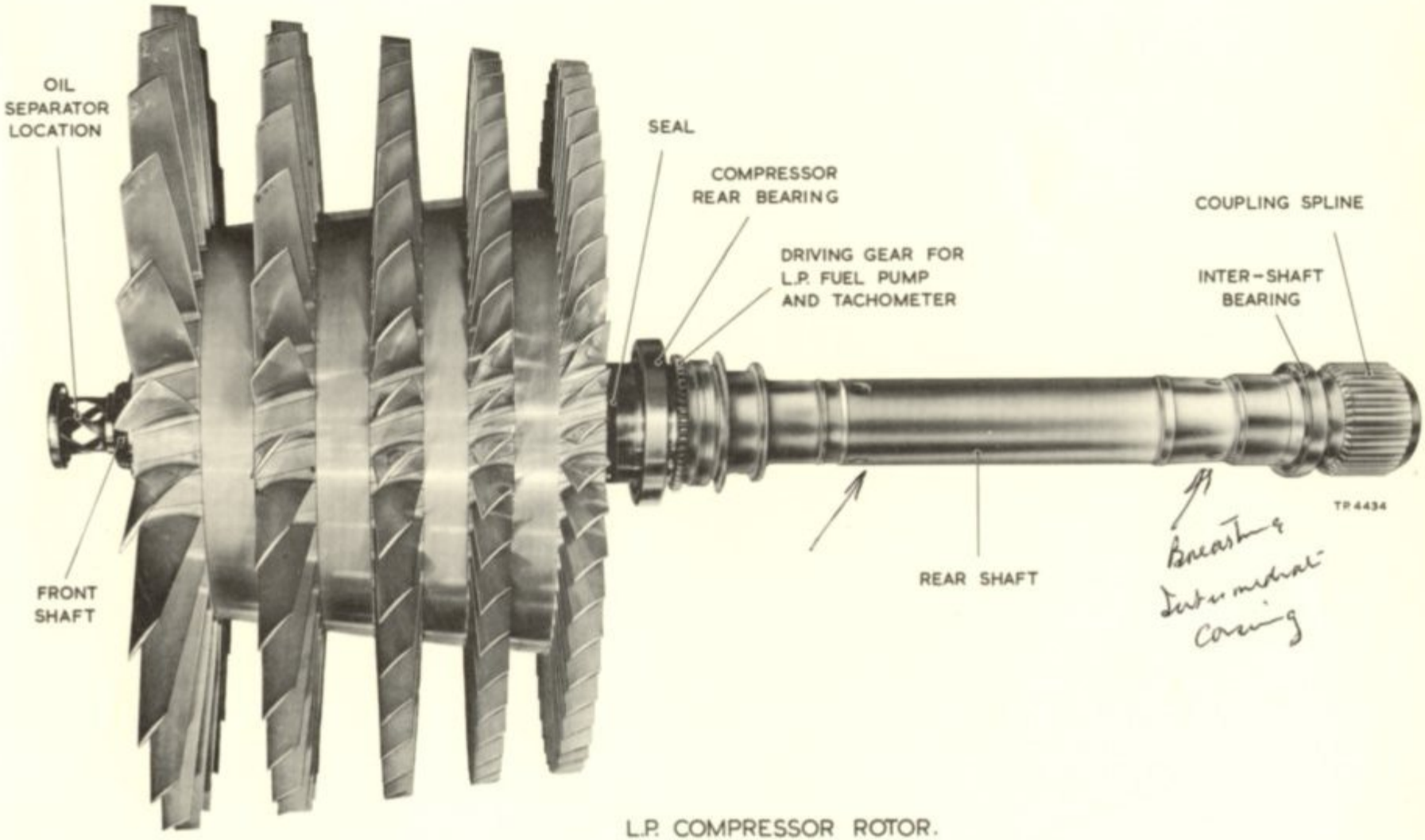
The main assembly consists of the front rotor shaft, the five rotor discs with the four spacer rings, the rotor driving shaft and rotor tail shaft.

Each stage of the compressor rotor blades is mounted in an aluminium alloy rotor disc, the fitting being of fir tree root form. The fifth and first stage blades are designed with a front and rear key respectively to the fir tree roots to provide end location, spacer rings bolted between each stage provide a positive location for stages two, three and four.

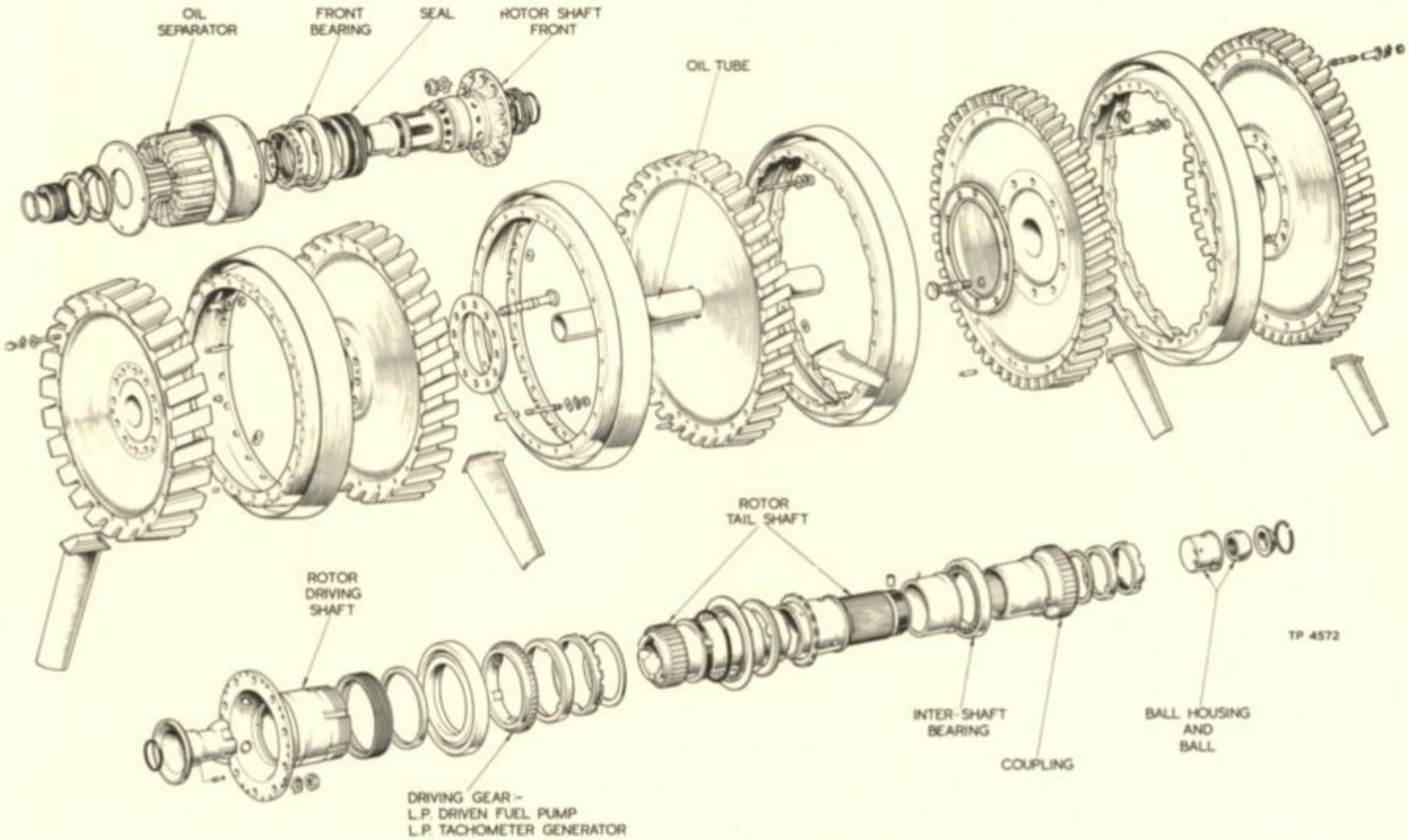
The compressor driving shaft is secured by its integral flange to the rear of the rotor by bolts passing through discs number four and five. A bearing seal is located to the rear of the flange followed by a single thrust bearing which locates the rear end of the compressor rotor within the intermediate casing.

The compressor driving gear, located on the driving shaft by serrations, the bearing and bearing seal, are all secured by tabwasher and ring nut. An adjusting washer locates the rotor assembly in relation to the intermediate and L.P. compressor casings.

Splined into the rear of the driving shaft is the rotor tail shaft, on to the rear of which is splined the L.P. compressor driven coupling. Located inside the rear of the tail shaft, by three retaining pins, is a threaded steel ball into which is screwed the forward end of the centre tube unit, the other end being locked to the rear of the L.P. turbine disc.



L.P. COMPRESSOR ROTOR.



L.P. COMPRESSOR ROTOR

3.3 L.P. COMPRESSOR CASING

The alloy casing is in two sections and secured by bolts along the centre lines.

The engine front mounting support is bolted to the top of the casing and is in the form of a forked bracket accommodating bronze bushes, and steadies the front end of the engine by means of a single adjustable link.

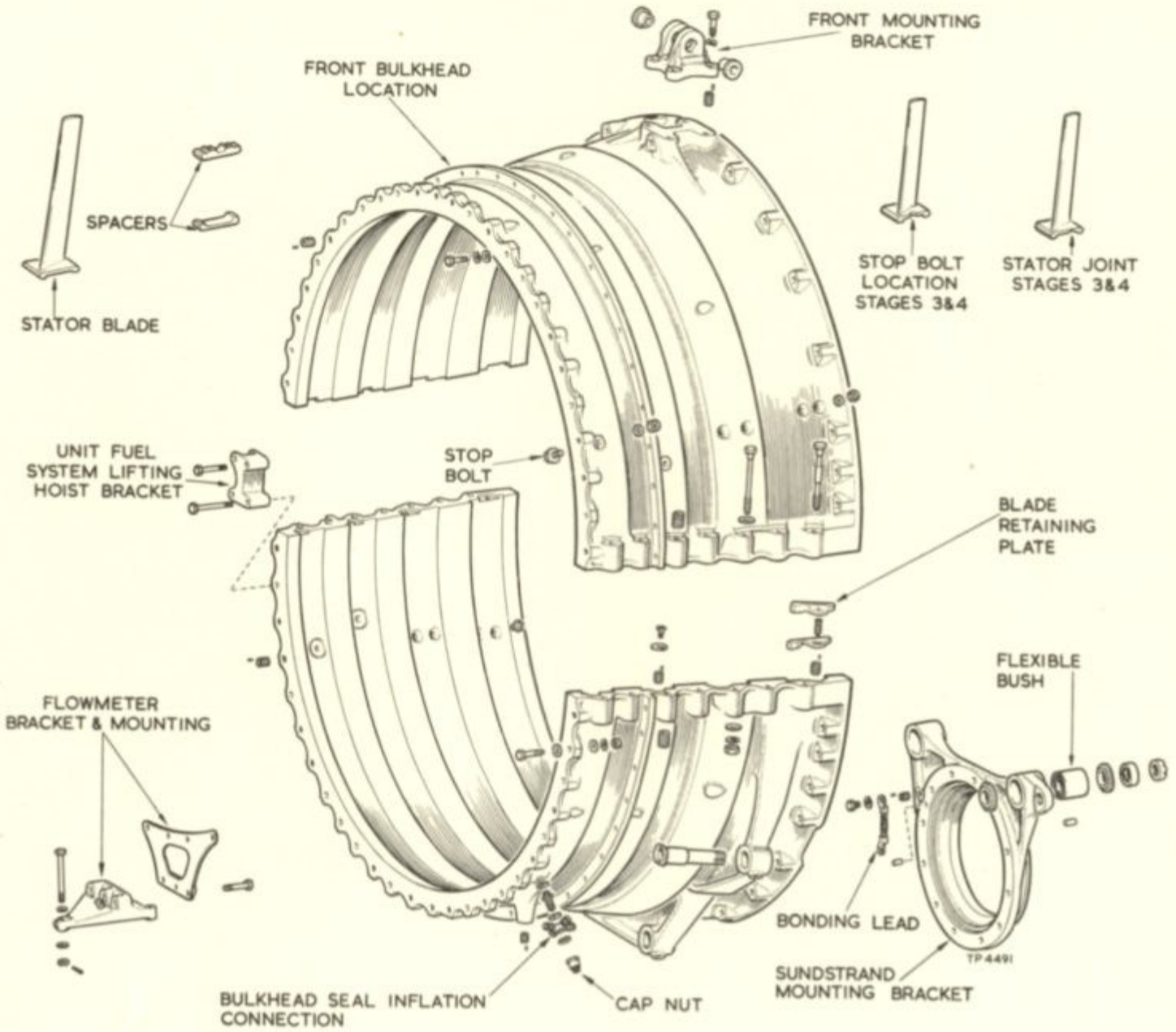
Grooves of dove-tailed section house the four rows of stator blades. Retaining plates, secured by countersunk head screws, to the casing joint faces at the ends of each half row of blades, retain, the blades in position when the casings are separated.

A mounting bracket on the starborad side lower half casing is the location for the Sundstrand Drive Unit and Alternator.

The front bulkhead is bolted to the flange on the casing, the Elliot fuel flowmeter is mounted on the rear port lower position.

A banjo standard, to which bolts a four way connection, is tapped into the rear of the L.P. lower half casing. L.P. delivery air from No. 1 Vane Intermediate casing is piped to the C.S.U. Oil tank and on to the banjo connection to pressurise the front and rear bulkhead seals.

A transportation and test bed attachment point is located on the lower half casing.



COMPRESSOR CASING ¾ REAR VIEW

3.4 THE FRONT BULKHEAD AND SEALS

This bulkhead, comprising top and bottom units, joined along its horizontal centre line, is attached to the mounting, formed on the outer surface of the Low Pressure Compressor Casing and forms the dividing wall between Zones Nos. 1 and 2A of the engine installation.

A Dunlop seal, inflated by L.P. delivery pressure at all times of engine running, is located around the bulkhead and so completes the efficient sealing between the two zones.

The air pressure in the seal is kept to a value of 5 p.s.i. by the action of the Blow-off valve assembly situated on the lower half bulkhead. Two covers are located on the lower half bulkhead, one for the Elliot Flow Meter, to the rear of the bulkhead and the other for the Constant Speed Drive Unit situated to the front of the bulkhead.

Provision is made for the location of the centre bearing supporting the throttle rod, and for the passage of Hydraulic Pipe-lines through the bulkhead, or, in the case of the engine being installed in a position that does not require the fitting of a hydraulic pump, the fitting of a blanking plate.

Air, oil, and fuel pipes also pass through the bulkhead, while Breeze connections for the following circuits are attached to the forward face lower unit:-

1. Two fire Detector connections
2. Inducer Valve, Oil Pressure transmitter, Fuel low Pressure Warning, Starter Control Valve and Starter over-speed switch.
3. Engine Anti-icing valve
4. L.P. Compressor Tachometer
5. Fuel Flowmeter
6. Electro Pressure Control

7. L.P. Compressor.....

7. LP Compressor Governor Solenoid.

Routine Servicing of Bulkhead Seals

Examine the bulkhead seals for condition, paying particular attention to the area of the seal contracted by the door corners. Carry out a pressure test as follows :

(1) Disconnect the compressor air supply pipe from each seal connection

(2) Using a suitable pressure gauge and connections, guide the two pressure lines through the fire door access panels

(3) Connect each pressure line to the seal connection

(4) Blank off the Blow-off valves

(5) Close the engine bay doors

(6) Attach an airline to the pressure gauge unit and raise the pressure to 5lb/in^2.

Note :

Over a period of 15 min. the pressure must not drop to less than 3lb/in^2

(7) To confirm an air leak in either seal, isolate each seal in turn and carry out the foregoing checks

(8) Remove the blank from the blow-off valves and the pressure connection from the valves.

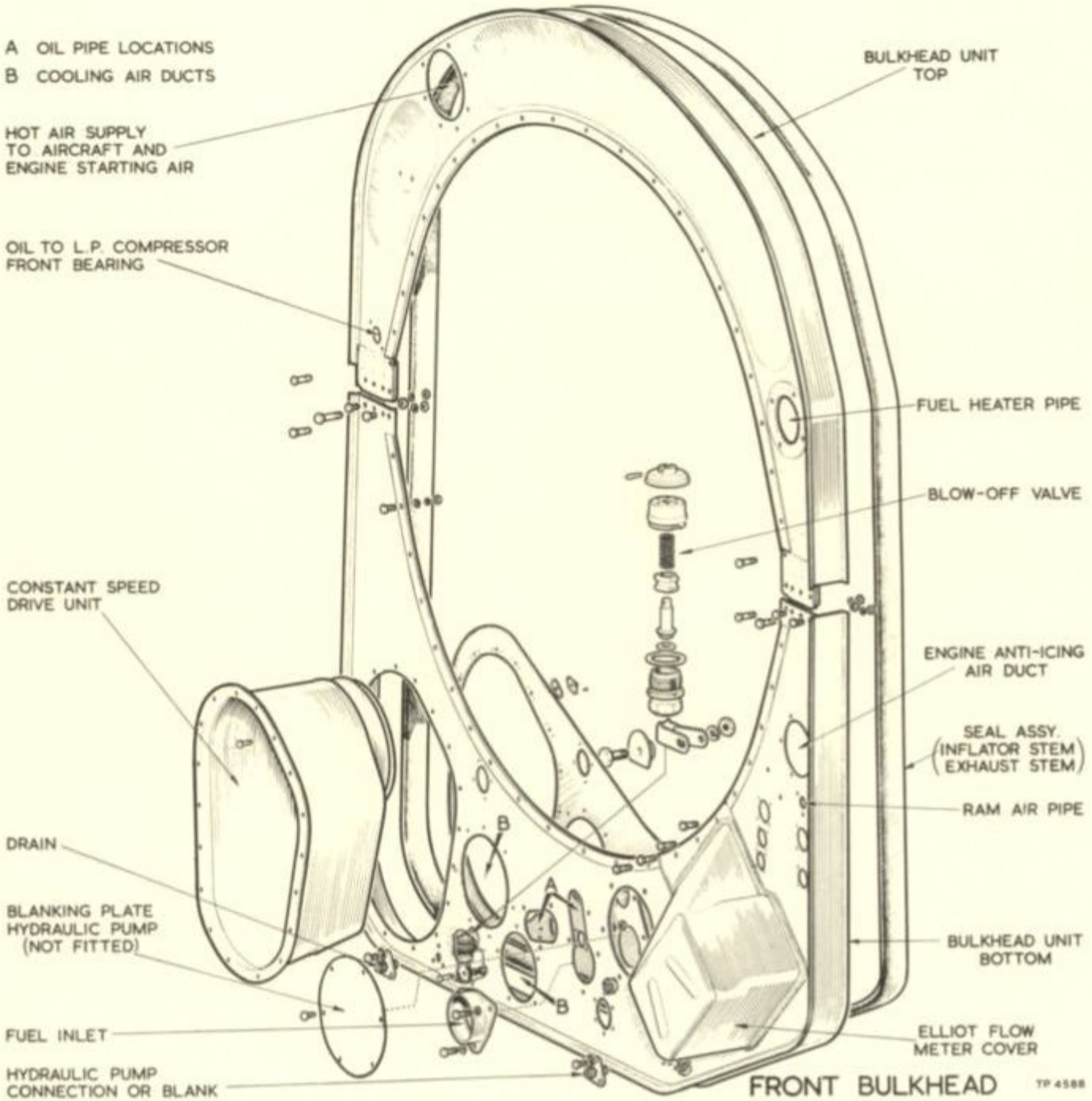
Note :

Reconnect the compressor air supply pipe to the seal connection and wire-lock to secure

(9) If either seal is rejected, disconnect and lower the engine as described in Section 10.

(10) Remove the rejected seal and fit a new one

(11) Refit the engine as detailed in section 10



FRONT BULKHEAD TP 4588

3.5 INTERMEDIATE CASING

The intermediate casing is situated between the two compressors and contains both the L.P. exit guide blades, and H.P. entry guide blades.

The central section of the casing is connected to the outer protion by eight cambered hollow vanes, the area between which is used to convey the L.P. delivery pressure air to the H.P. compressor inlet.

The rear L.P. compressor and front H.P. compressor bearings are accommodated within the front and rear walls of the casing. Spur gears mounted on the compressor shafts initiate drives which are conveyed through three of the hollow vanes to the outside of the casing.

Mounting faces for the auxiliaries are arranged around the outer casing, forming two groups, namely L.P. and H.P. driven. The former comprises the compressor Tachometer generator and L.P. driven fuel pump.

The latter comprises the following :

H.P. Driven Fuel Pump.
Main Oil Pump and four Scavenge Pumps.
Constant Speed Drive Unit.
Hydraulic Pump
H.P. Tachometer Generator (when fitted)

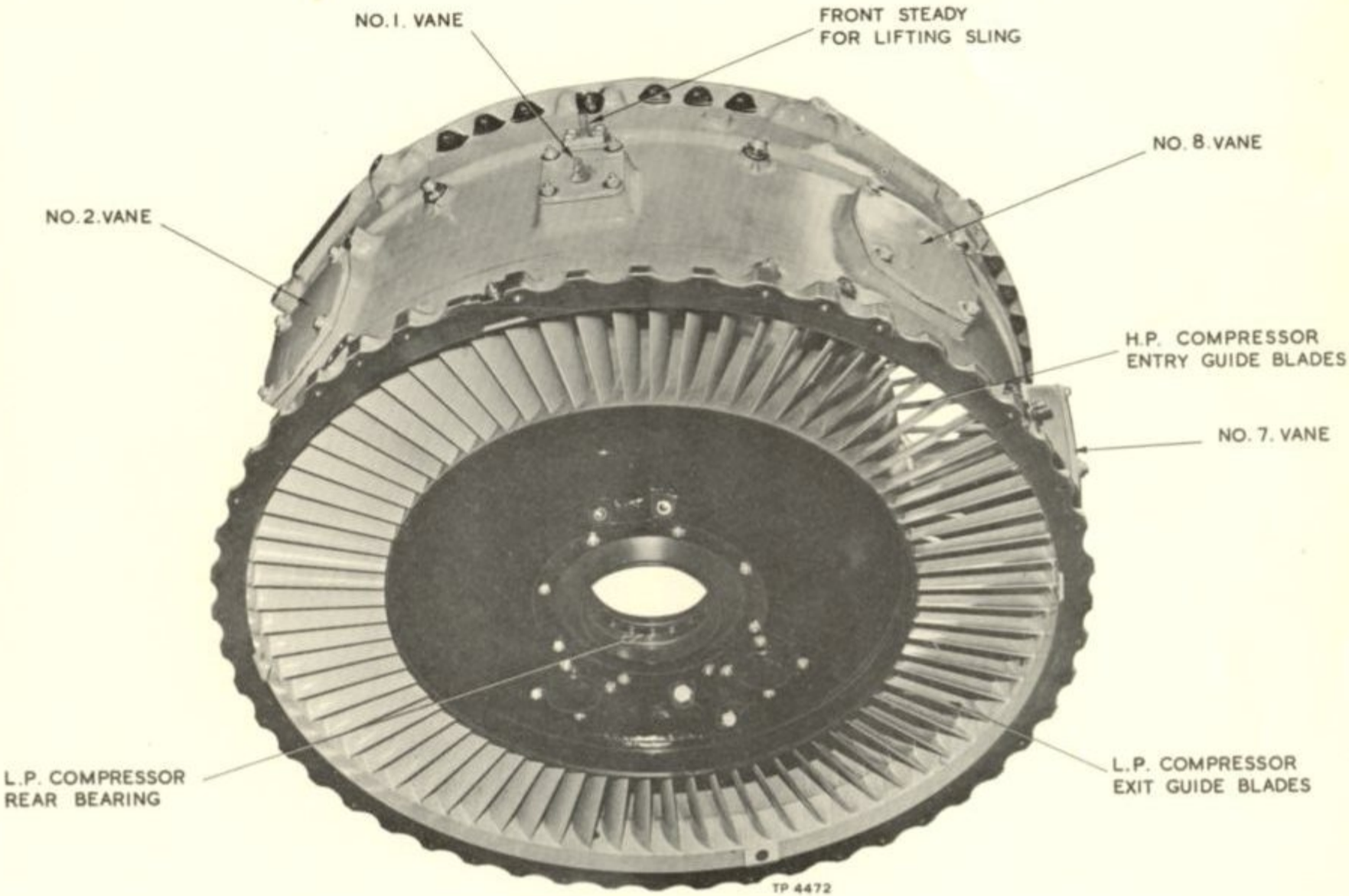
In addition, it transmits the drive from the starter to the H.P. compressor when the starter is in operation.

Vanes of the casing are used as follows :

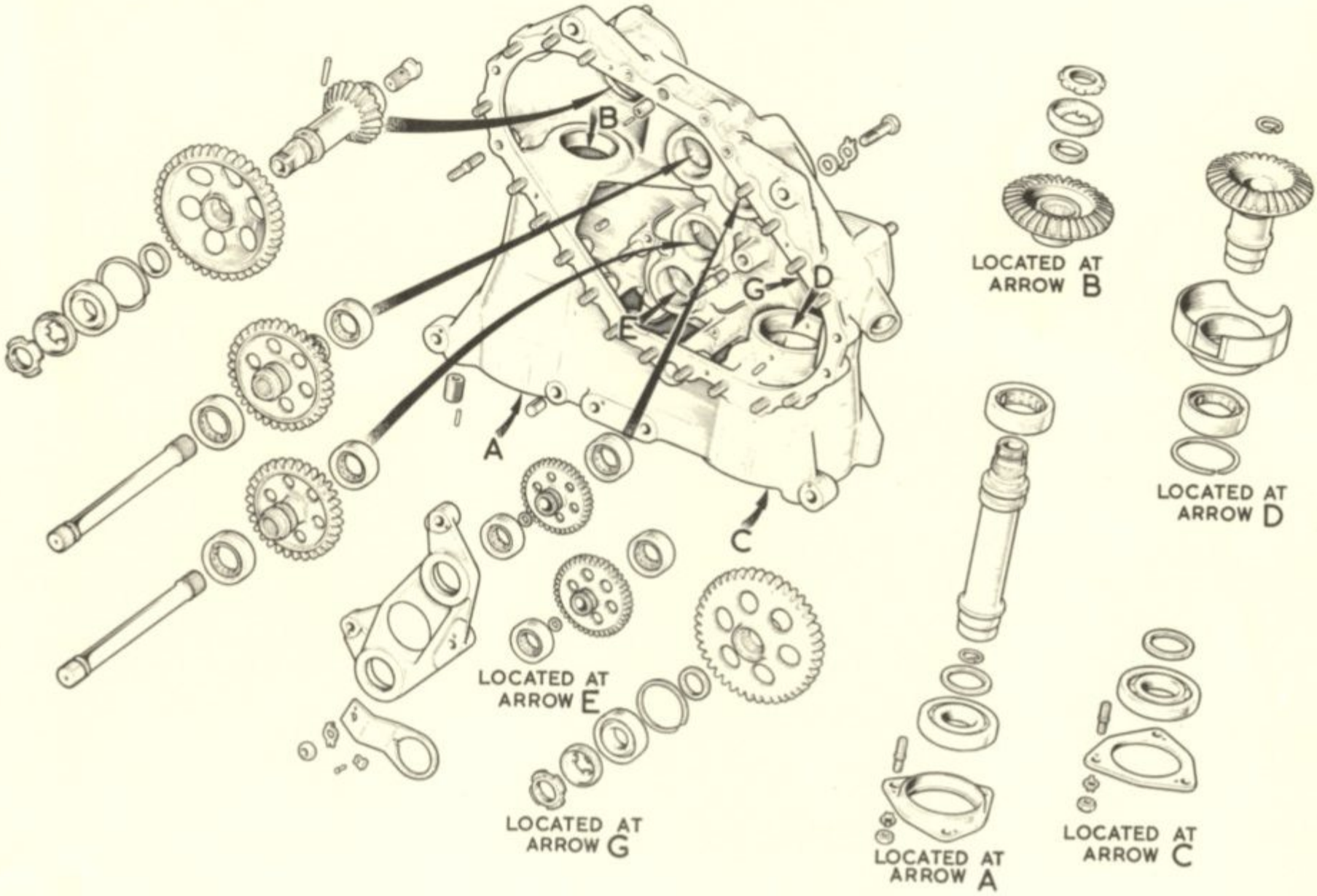
1. Banjo connection, piping L.P. delivery air to pressurise :
   a. Constant Speed Drive Unit
   b. Front bulkhead sealing ring
   c. Rear bulkhead sealing ring
2. Blank
3. Oil feed to L.P. compressor front bearing
4. Drive to constant speed unit and Starter
5. The Oil pumps and auxiliary drives. Oil Drain
6. Front - L.P. Driven Fuel Pump drive
   Rear - H.P. Driven Fuel Pump drive

   (L.P. and H.P. RPM Tachometer generators)

   (L.P. and H.P. Hand turning gears)
7. Blank
8. Blank

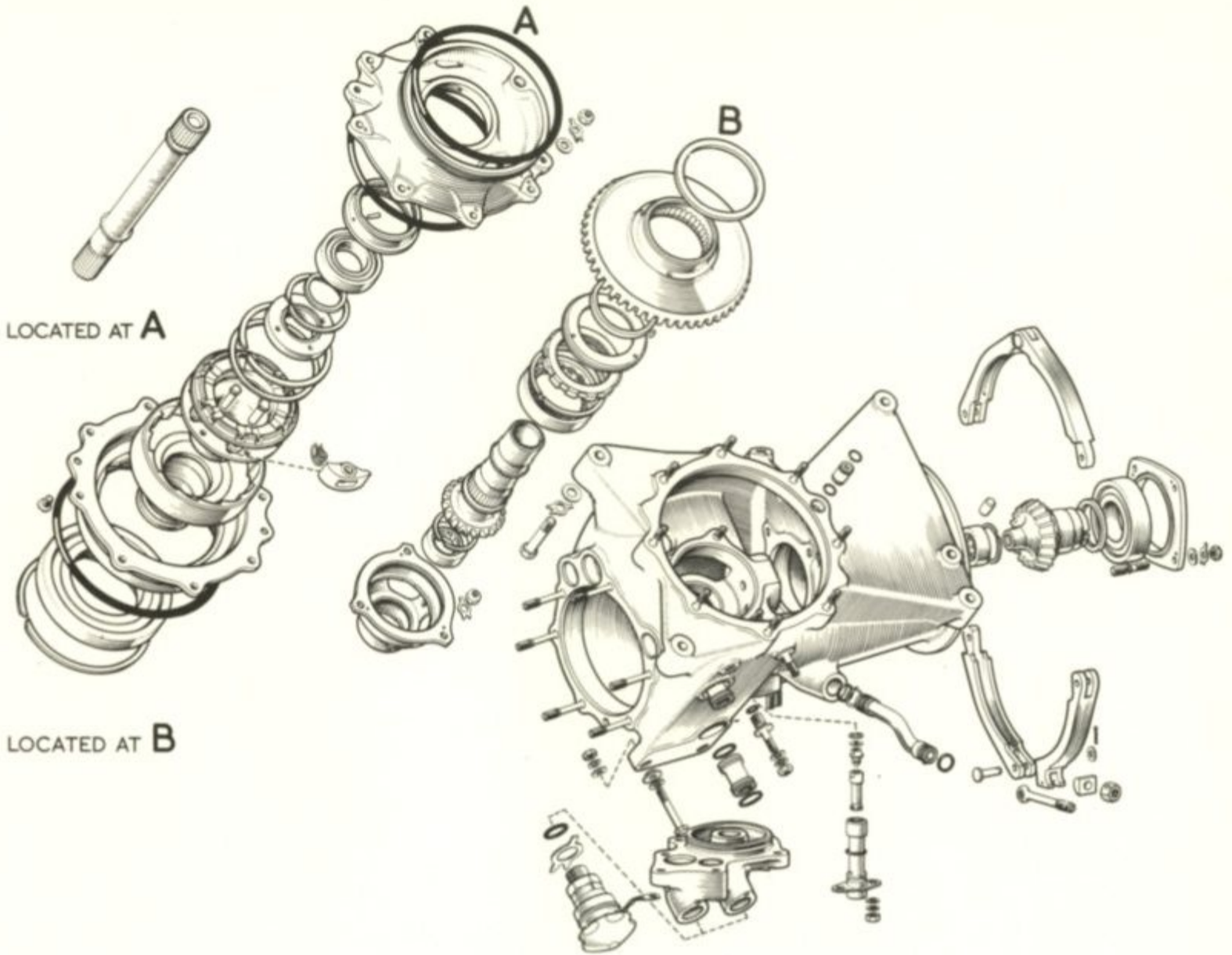


INTERMEDIATE CASING



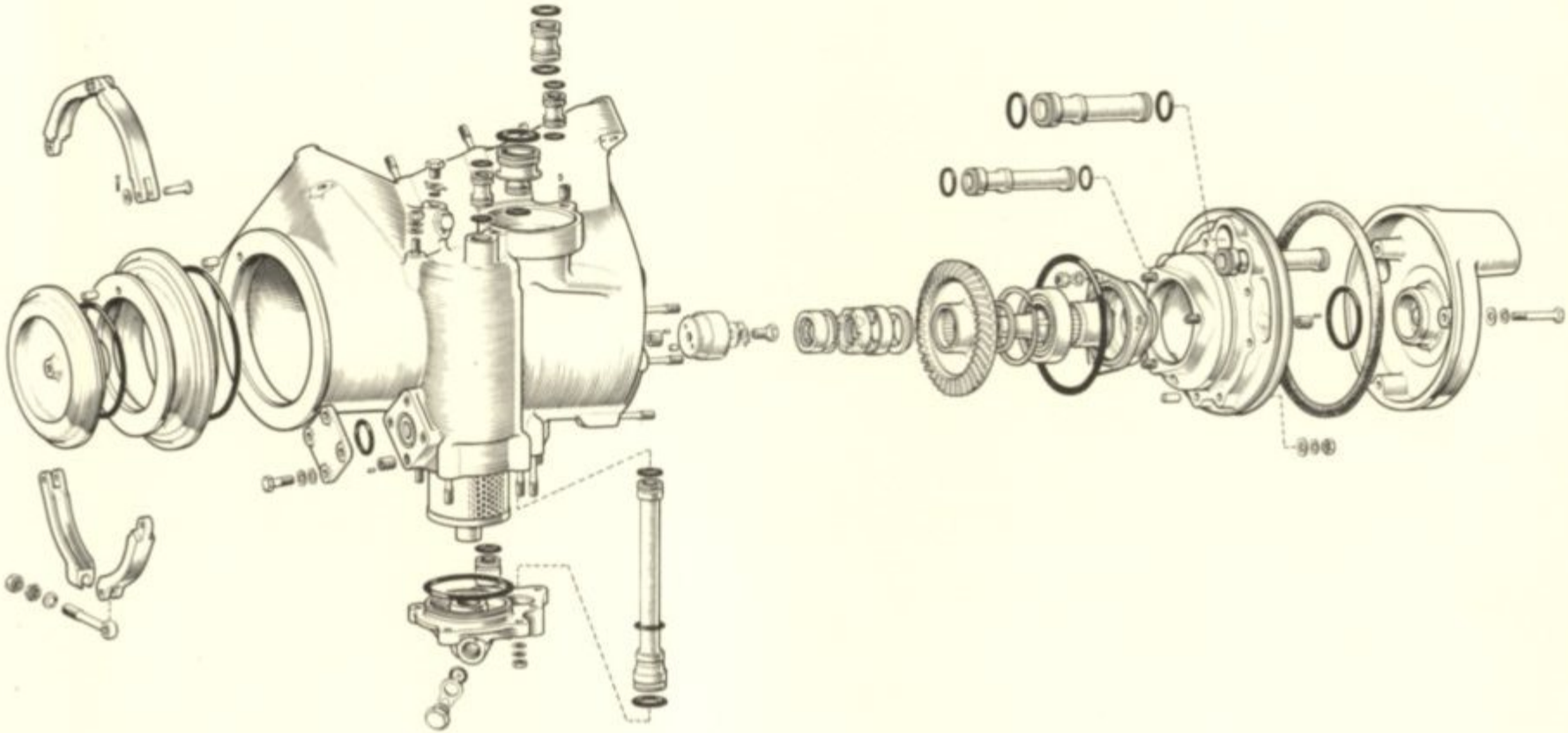
FUEL PUMP DRIVES (OUTER)

TP.4582/1



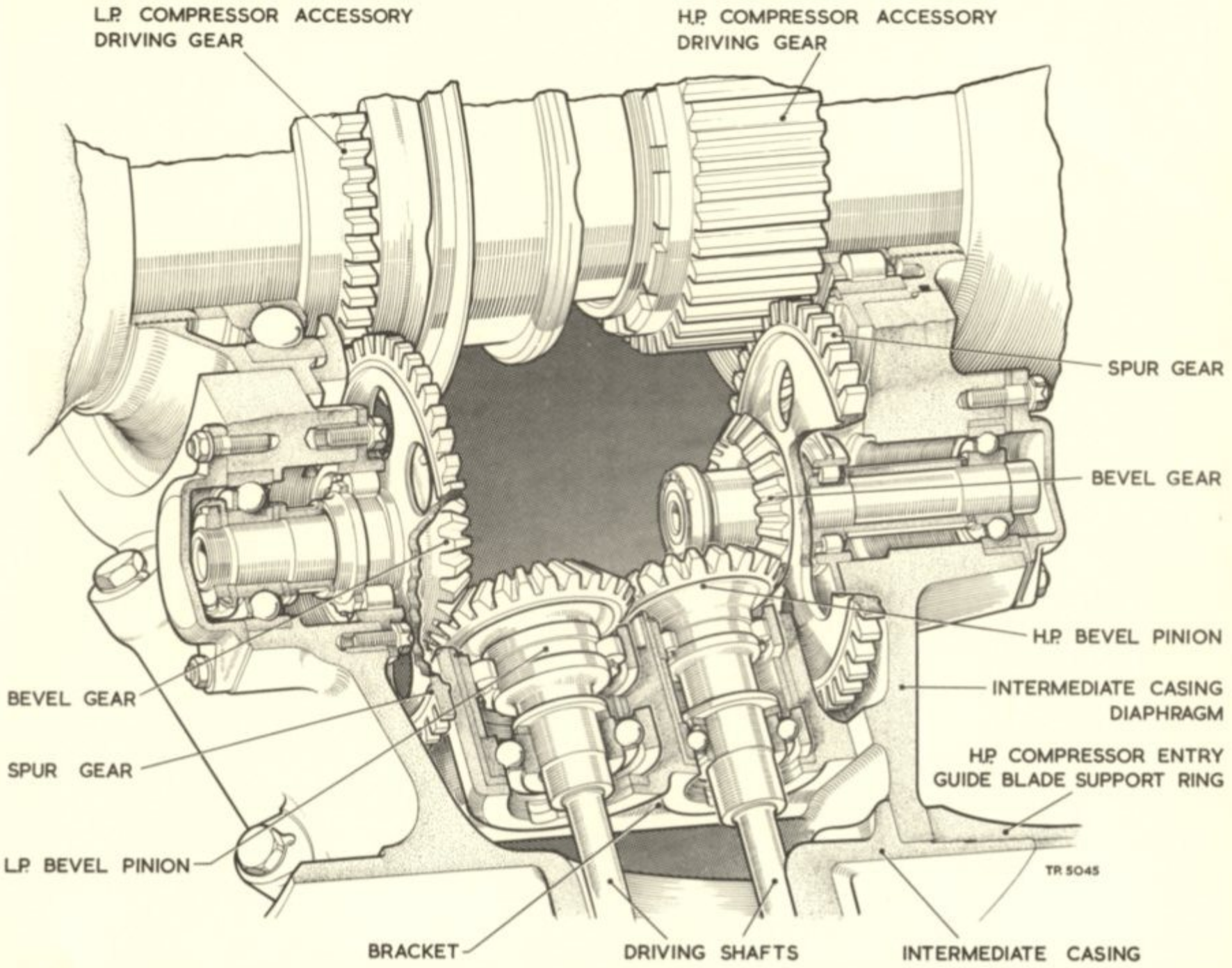
TP. 4576/1

STARTER & CONSTANT SPEED DRIVE (OUTER)

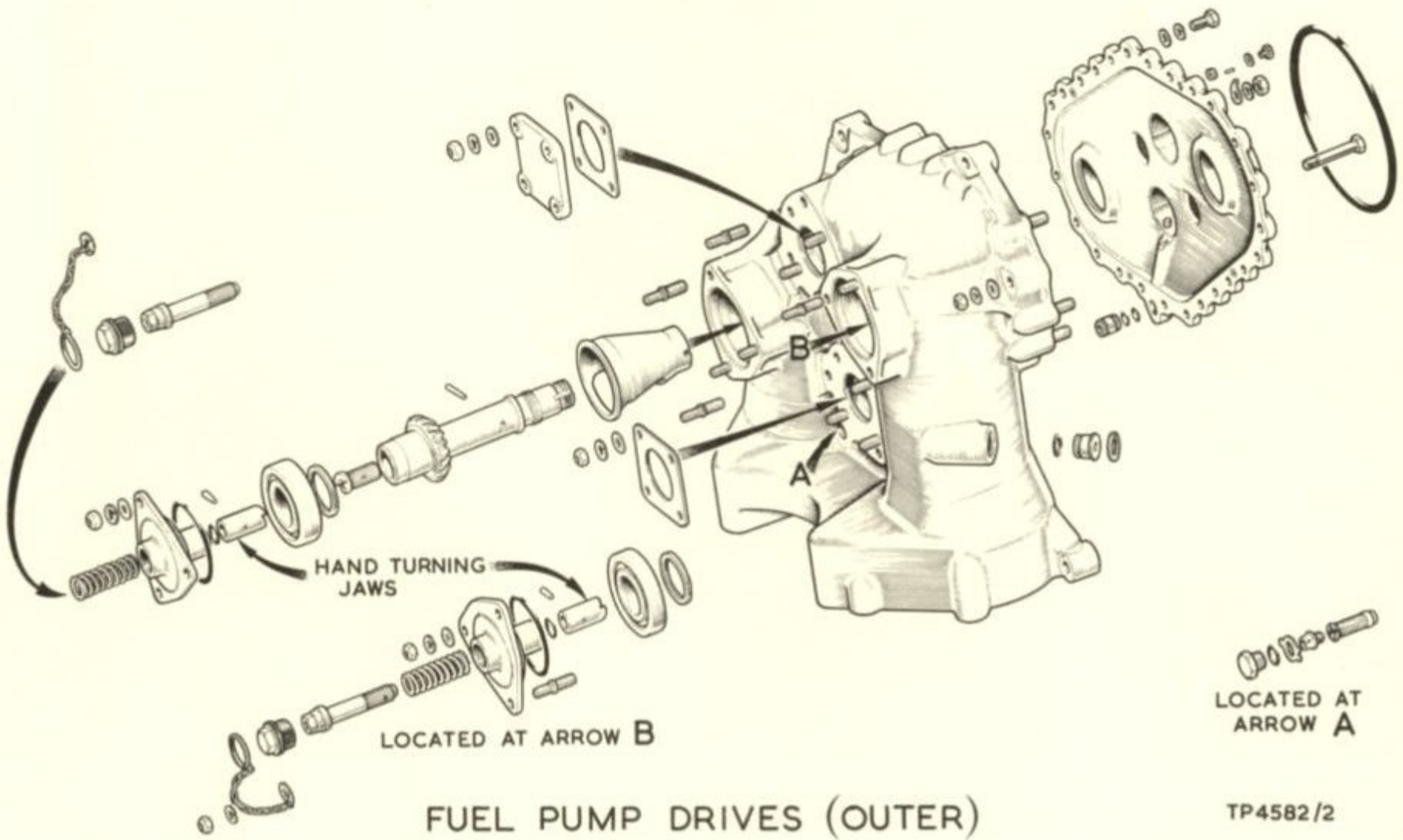


TP.4576/2

STARTER & CONSTANT SPEED DRIVE (OUTER)



FUEL PUMP DRIVES.



FUEL PUMP DRIVES (OUTER)

TP4582/2

3.6. HIGH PRESSURE COMPRESSOR ROTOR AND CASING

Rotor

The seven stage high pressure compressor is made of heat resisting steel.

The rotor blades are mounted, by fir tree root form, in the seven steel discs between which are bolted six spacer rings, the whole assembly being contained between the Front Rotor Shaft and the Rear Rotor Centre.

The front rotor shaft, which carries the compressor front bearing, bearing seal and driving gear, is bolted to stages one and two.

The rear rotor centre, which carries the double thrust bearing, bearing seal, compressor rear air seals and compressor driven coupling, is bolted to number six spacer ring and number seven rotor disc.

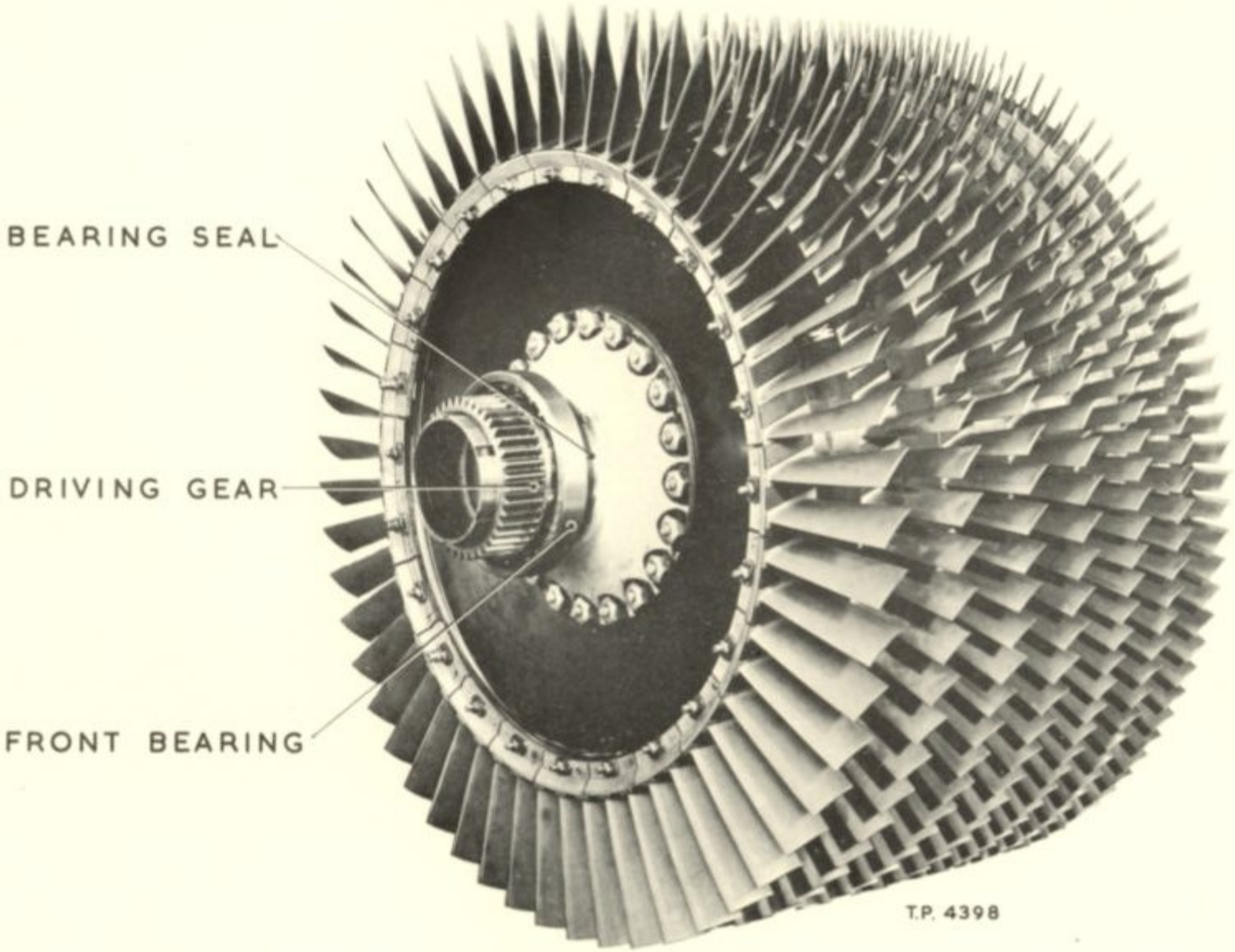
Inside the compressor are assembled concentrically an inner oil tube and an outer air transfer tube, both made of light alloy.

Casing

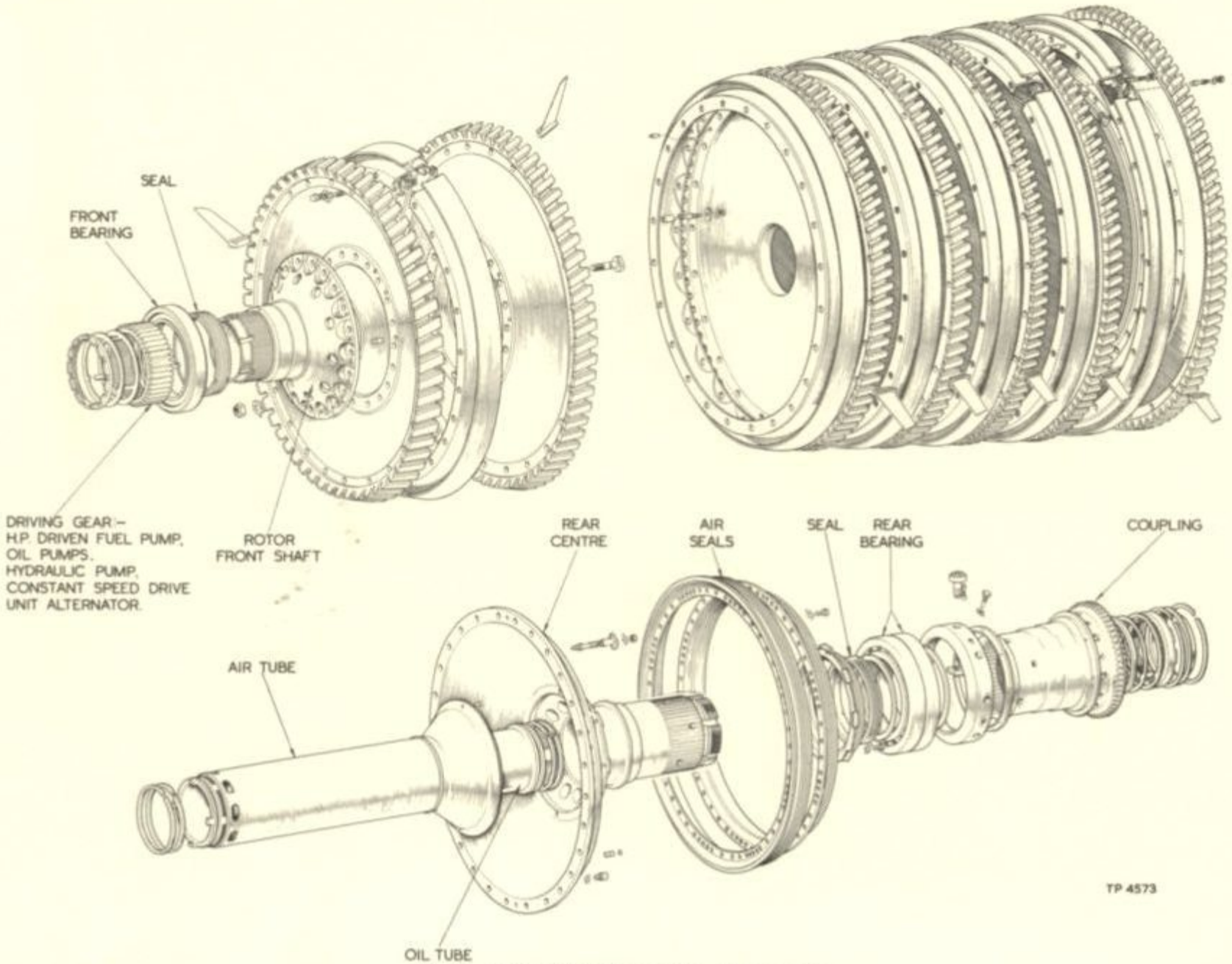
The cast steel casing is split on the horizontal centre line and has seven dove tailed grooves machined in its inner diameter to accept the seven stages of compressor stator blades.

Retaining plates secured by screws to the casing joint faces at the ends of each half row of blades, retain the blades in position when the casings are separated.

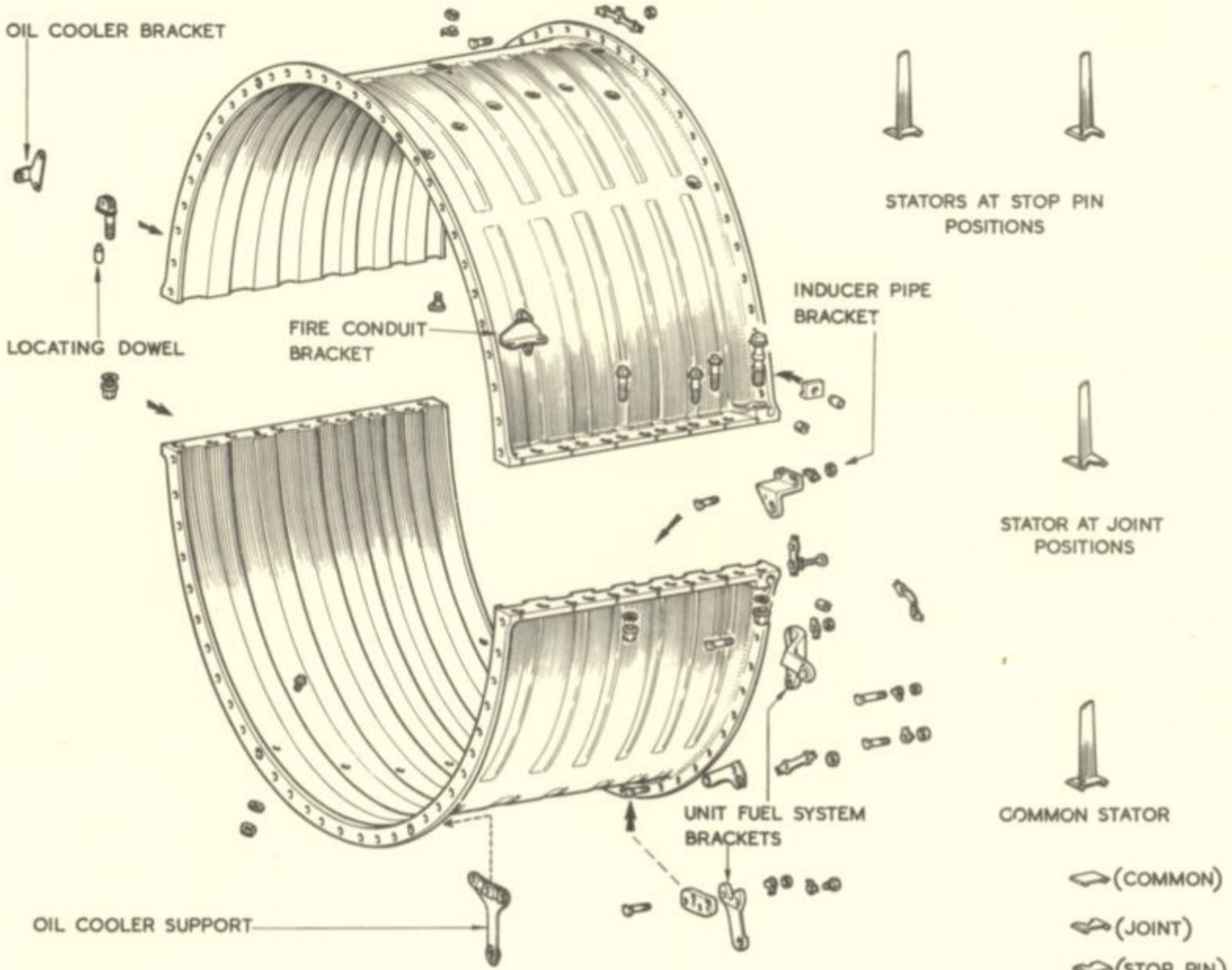
Air via an outlet from the third stage of the compressor casing upper half is used for cooling the rear face and pressurising the bearing seal of the L.P. Turbine.



HIGH PRESSURE COMPRESSOR ROTOR ¾ FRONT VIEW



H.P. COMPRESSOR ROTOR



H.P. COMPRESSOR CASING

TP 4529

3.7 DELIVERY CASING

The stainless steel delivery casing is situated between the rear face of the H.P. compressor casing and the combustion chamber outer casing. The inner and outer casings are linked together by eight hollow vanes.

Two mounting trunnions are bolted to the outer casing at the 3.o'clock and 9.o'clock positions and are two of the three attachment points for the engine sling. (The 3rd point being on the intermediate casing, 12.o'clock position).

The H.P. Compressor rear bearing support and Coupling Chamber unit is located on the front of the inner casing flange, the access hole to the eight locating bolts of the H.P. coupling being blanked by a cover plate with special seals. Mounted on the rear of the inner casing flange is the H.P. turbine rear bearing support unit.

Delivery casing external locations are P1/P3 switch tapping, Oil Cooler and Fuel Filter attachments, Unit Fuel System Brackets and eight Duplex Burners. The inner faces of the burner locations receive the heads of the eight flame tubes.

The hollow vanes are utilised in the following manner :-

No.1 Blanked

No.2 A/C Hot Air services and Air Starter Duct

No.3 Fuel Tank pressurising and Inducer Valve

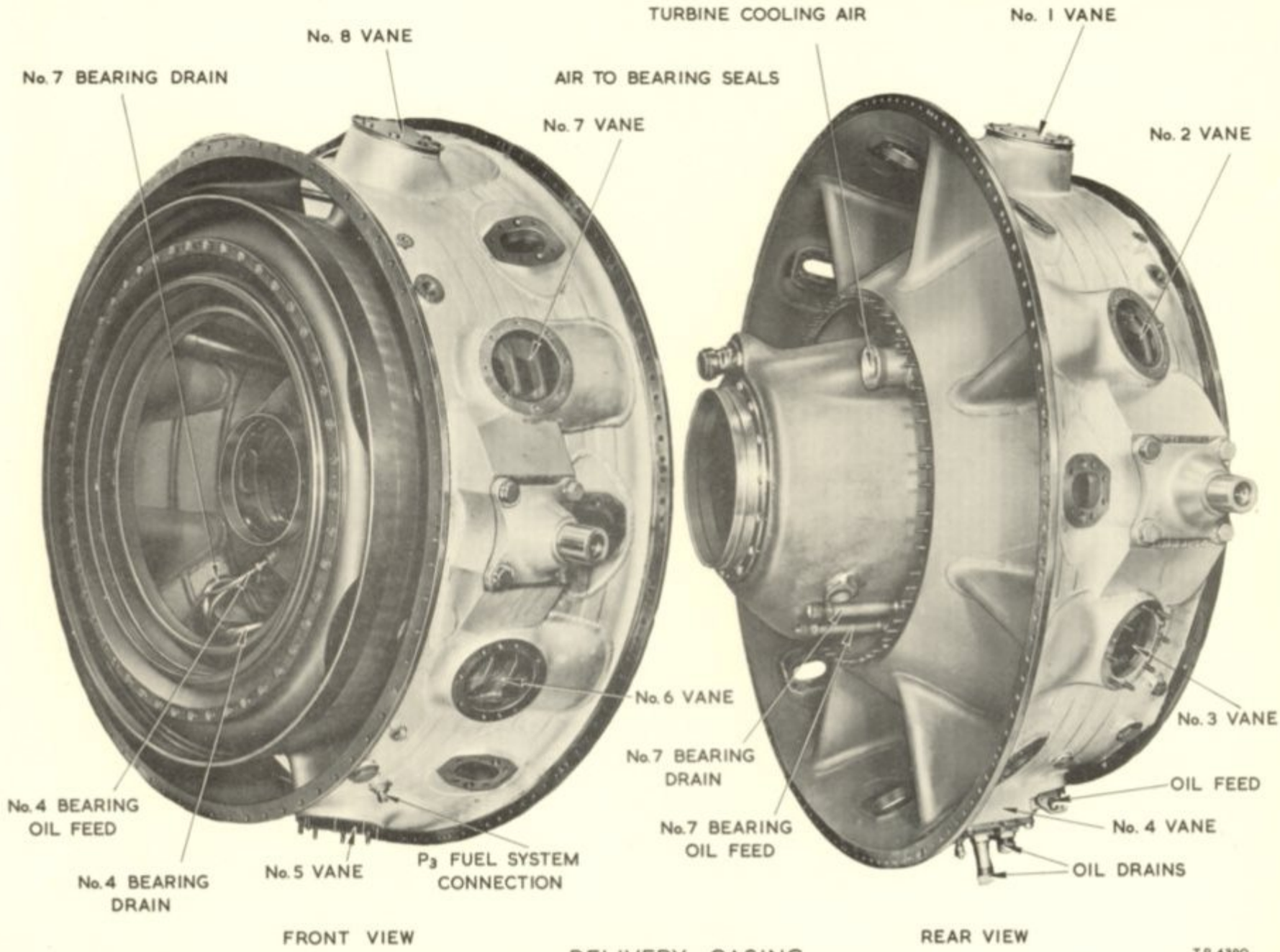
No.4 Oil feed pipe and Oil Drain pipes

No.5 Vent to Main Engine Breather

No.6 Engine Anti-icing Air Feed

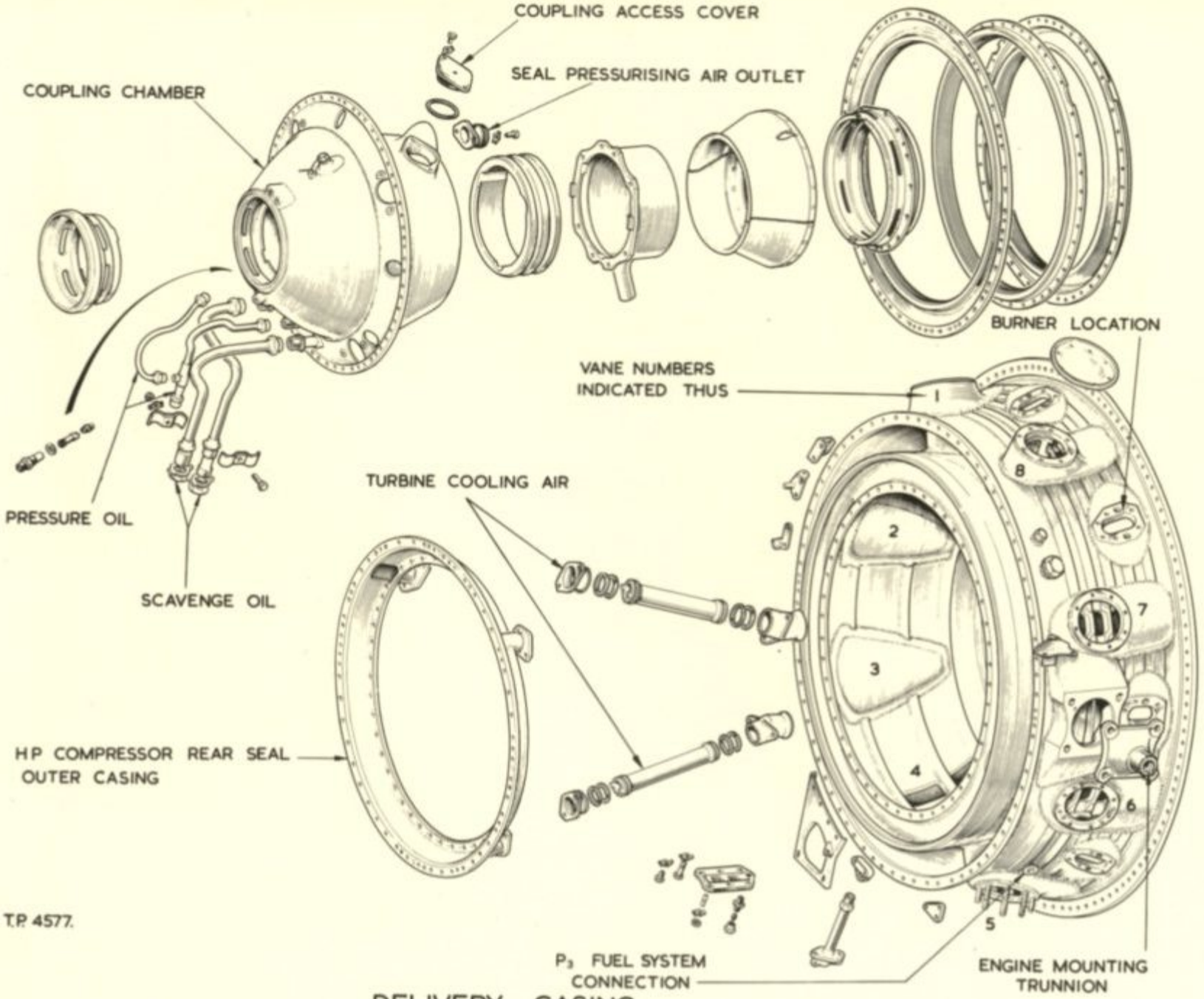
No.7 Fuel Heater Air outlet

No.8 Blanked



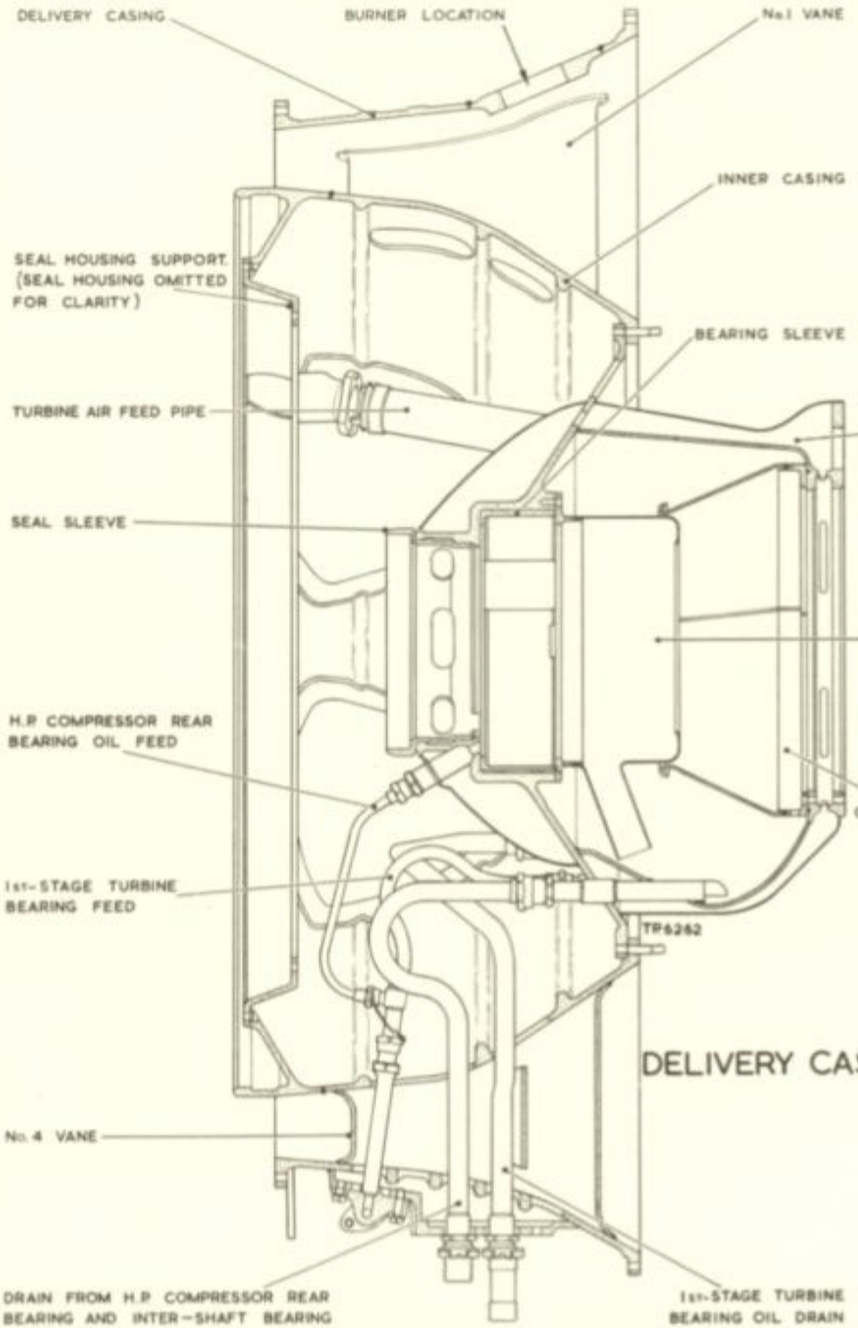
DELIVERY CASING

T.P. 4390



DELIVERY CASING

RESTRICTED



DELIVERY CASING DETAILS.

3.8 . COMPRESSOR TURBINE COUPLINGS

The compressor turbine coupling assembly is housed within the chamber in the delivery casing and connects the H.P. and L.P. compressors with the 1st and 2nd stage turbines respectively.

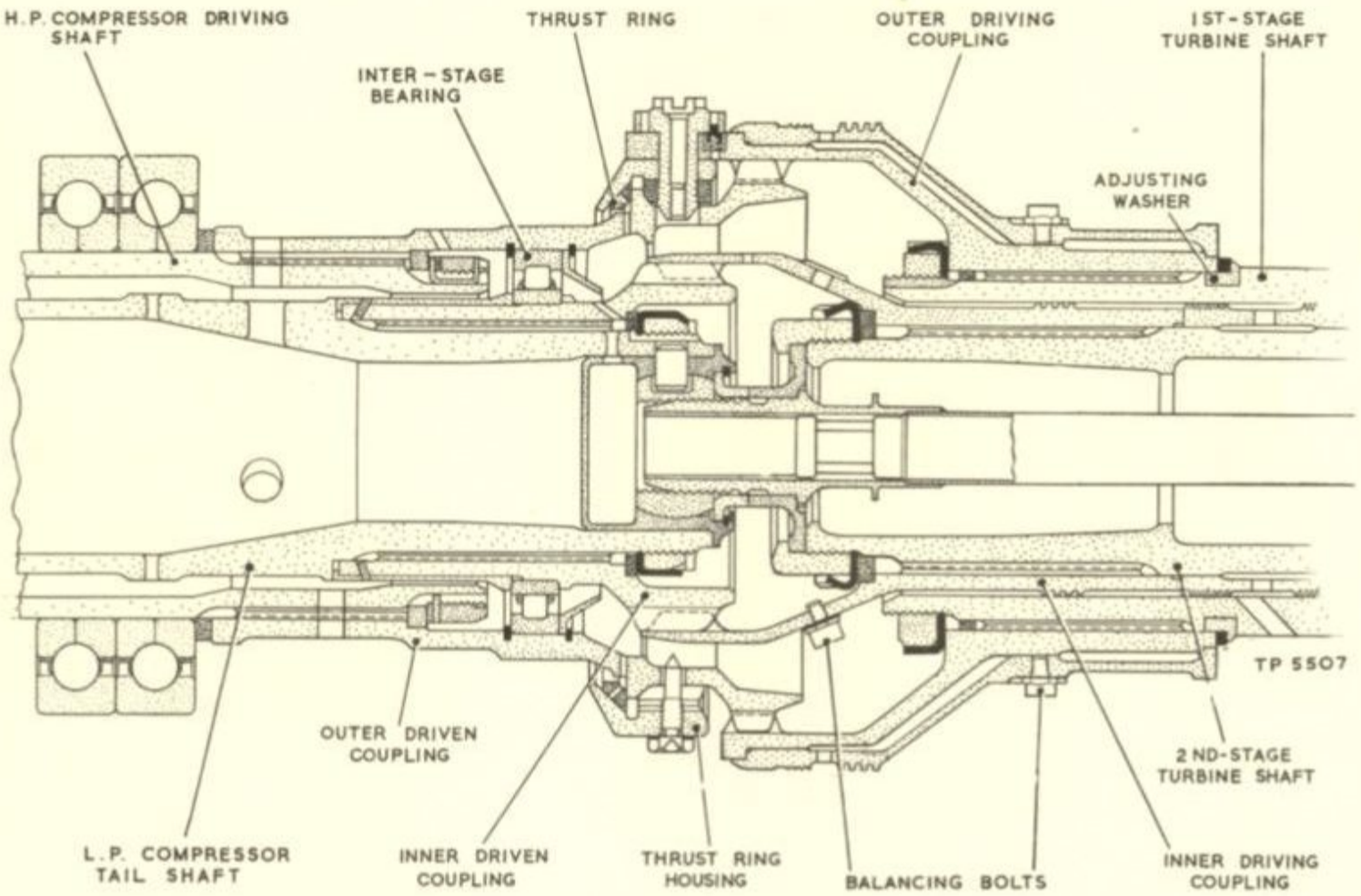
The inner coupling which drives the L.P. COMPRESSOR is situated within the H.P. coupling and rotates independently on the inter-shaft roller bearing. The external teeth of the compressor coupling engage with internal teeth of the L.P. turbine coupling and is secured by the fitting of the centre tube unit through the L.P. turbine shaft. This centre tube is located in the threaded steel ball in the compressor tail shaft, the swivelling of the ball allowing for any malalignment.

The outer driven coupling is fitted to the H.P. compressor rear shaft by the same means as the inner driven coupling i.e. splined and retained by a locked ring nut, and receives the drive from the outer turbine coupling internal teeth. The outer track of the inter shaft bearing is located between two circlips inside the H.P. compressor shaft coupling.

Eight lugs extend forward from the outer turbine coupling. Each carry a locating bolt and nut which secures a thrust ring housing to the coupling. The head of each bolt is drilled to engage with one of two spring loaded plungers fitted to each coupling lug.

This device and the special nuts ensures the security of the locating bolt assemblies. The thrust ring housing, being positioned by bolts of a smaller diameter than their locating holes in the coupling, permits a flexing of the H.P. rotating assembly.

An external labyrinth is carried on this coupling to form a seal with the coupling chamber housing.



COMPRESSOR TO TURBINE COUPLING DETAILS

3.9 THE REAR BULKHEAD

This bulkhead, comprising top and bottom units, joined along its horizontal centre line is attached to the Delivery Casing and forms the dividing wall between Zones 2A and 2B.

A Dunlop seal, inflated by L.P. Compressor delivery pressure at all times of engine running, is located around the bulkhead and so completes the efficient sealing between the Zones.

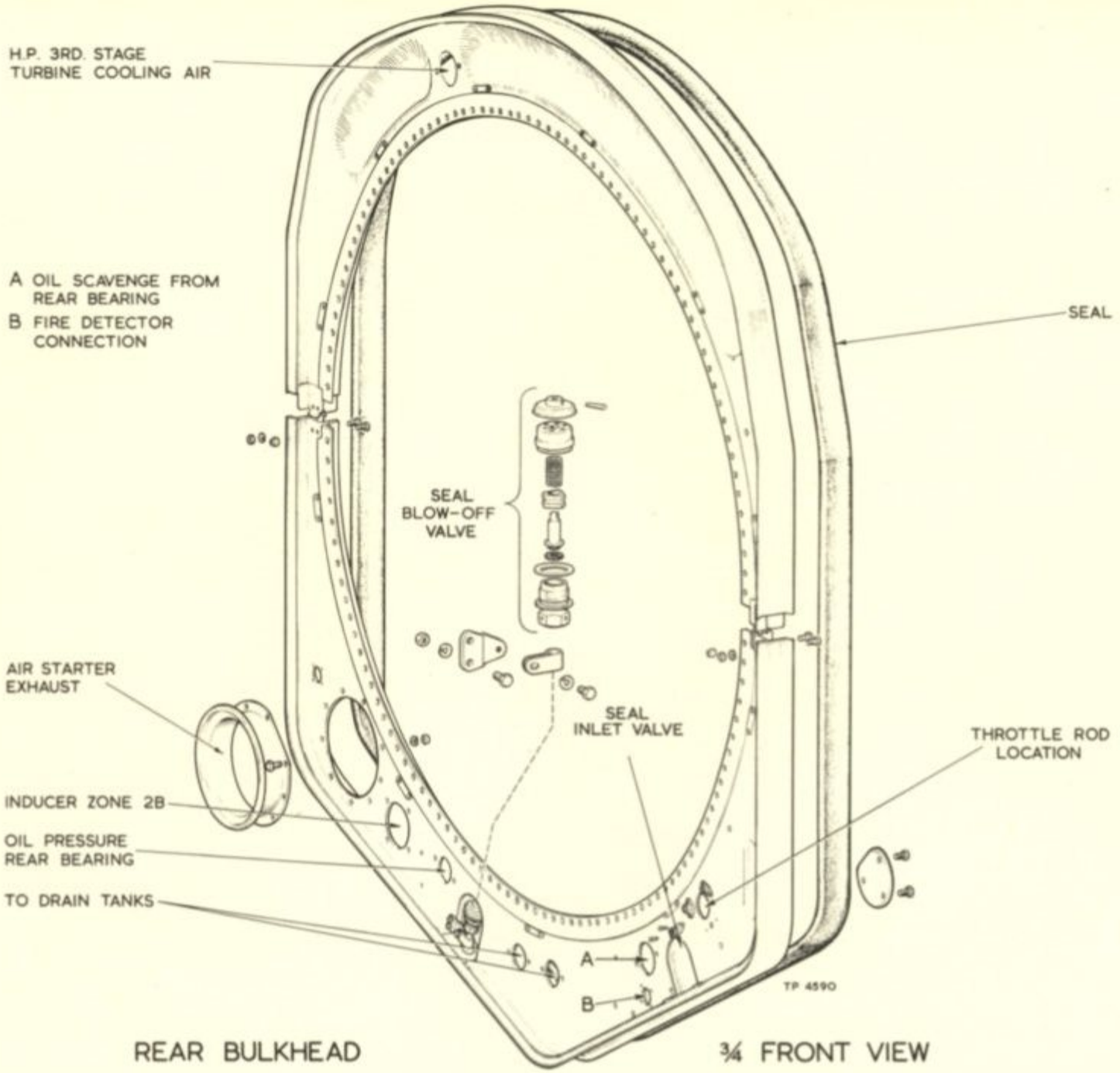
The air pressure in the seal is kept to a value of 5 p.s.i. by the action of the blow-off valve assembly.

Attached to the front surface of the bulkhead is the starter exhaust pipe, and the rear bearing of the throttle rod.

Provision is made for the passage of the following pipe-lines.

1. H.P. 3rd Stage Air.
2. Pressure oil to the L.P. turbine and Intershaft bearings.
3. Oil scavenge from the L.P. turbine bearing.
4. Drain and Dump Valve Fuel to the two outlets to the drain tanks.
5. P3 air to Zone 2B inducer.

Attached to the rear face of the lower unit are the two Breeze connections for the Fire Detectors in Zone 2A.



REAR BULKHEAD

¾ FRONT VIEW

3.10 BEARINGS

As indicated in the diagram there are seven main bearings located in the following positions.

L.P. compressor front bearing positioned in a housing at the rear of the intake casing. (Roller Bearing).

L.P. compressor rear bearing located in the front wall of the intermediate casing

(Ball Bearing).

H.P. compressor front bearing located in the intermediate casing rear diaphragm (Roller Bearing).

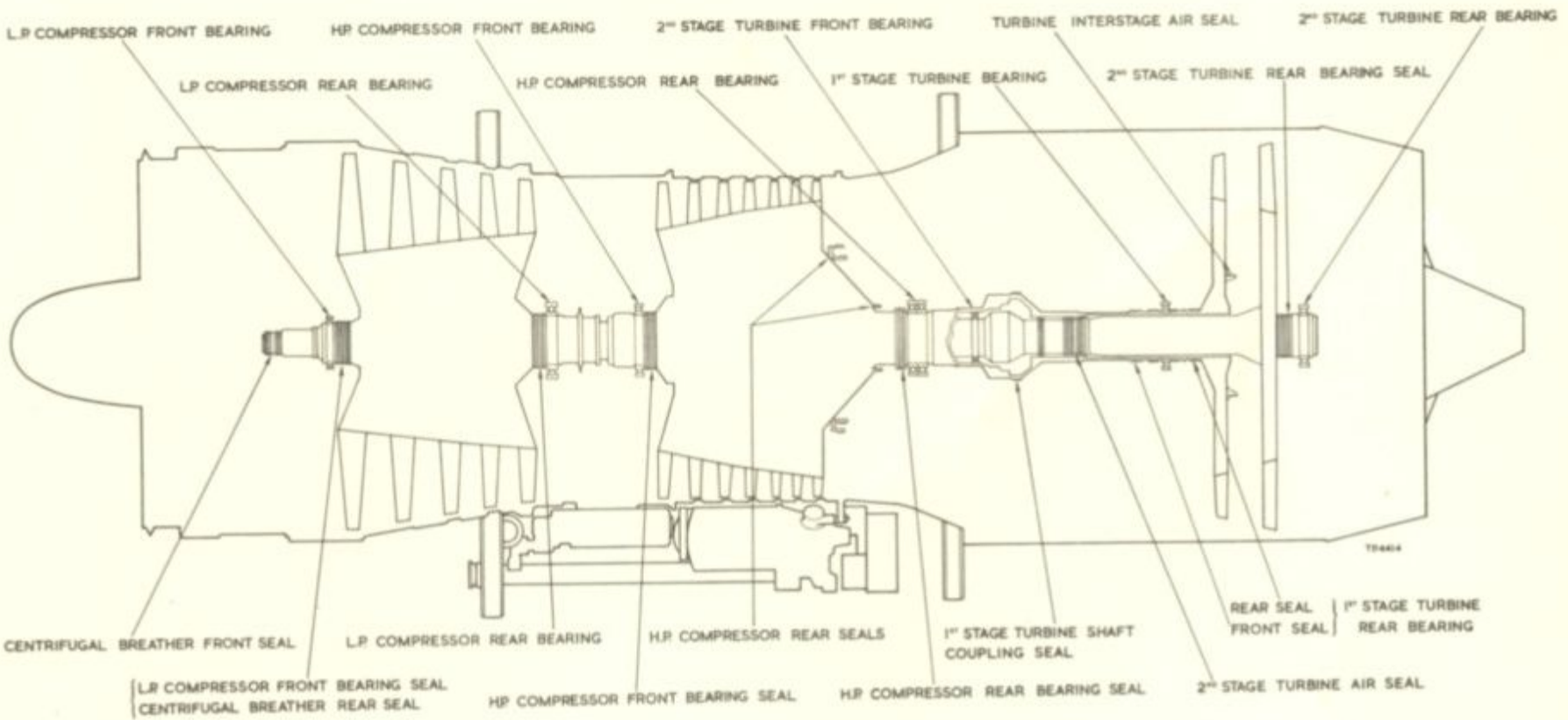
H.P. compressor rear bearing located in the housing in the front of the coupling chamber. (Double Ball Bearing).

Inter shaft bearing positioned between the L.P. and H.P. compressor couplings.

(Roller Bearing).

1st stage turbine bearing located in a housing at the rear of the turbine inner drum. (Roller Bearing).

2nd stage turbine bearing located in a housing in the exhaust annulus diaphragm. (Roller Bearing)



OLYMPUS 20101 E.C.U. BEARING AND AIR SEAL NOMENCLATURE

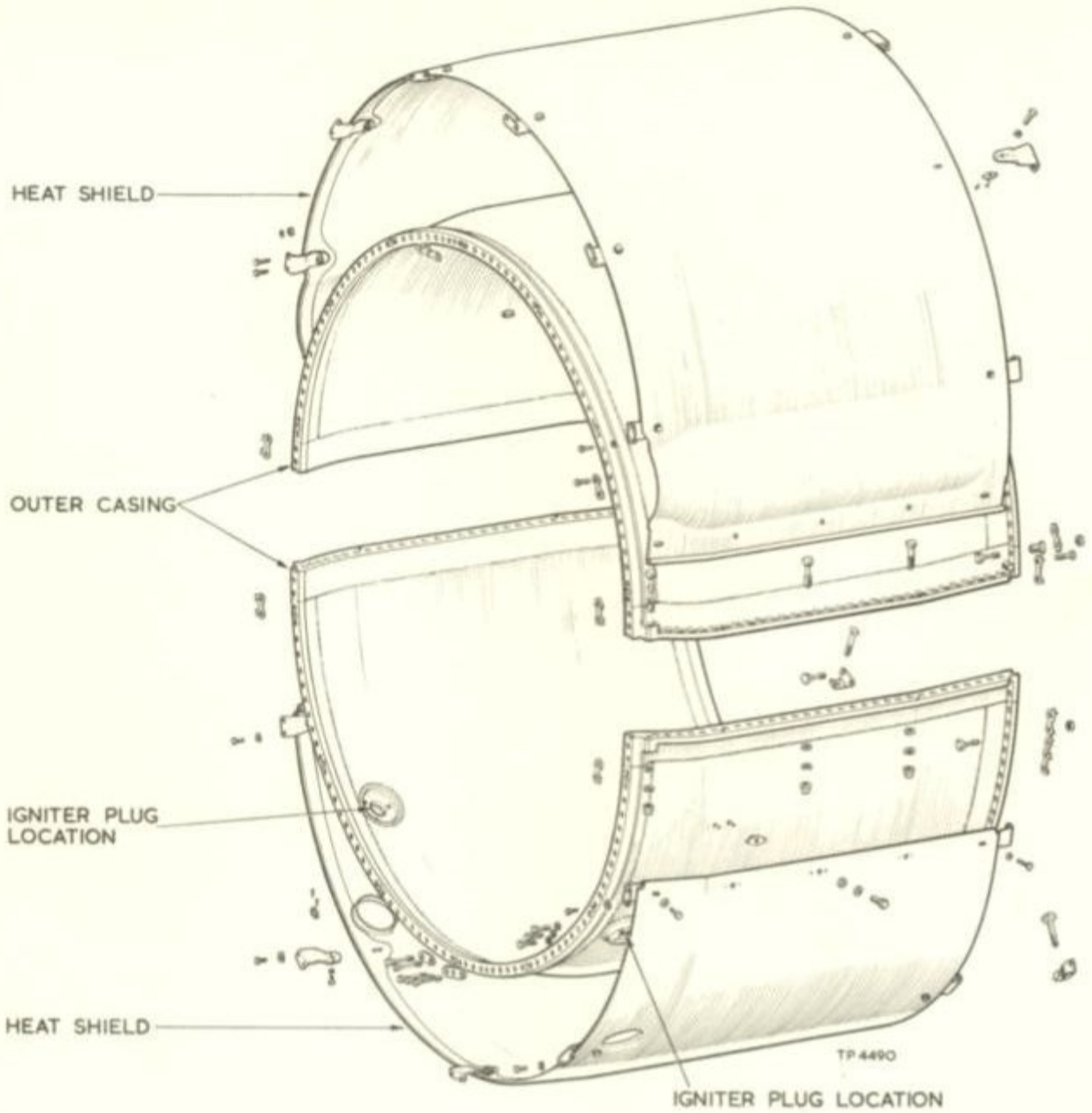
3.11 COMBUSTION CHAMBER OUTER CASING

This outer casing of steel, is fitted between the Delivery Casing rear flange and the front flange of the L.P. turbine casing, this rear joint has located between the flanges the turbine stator support ring.

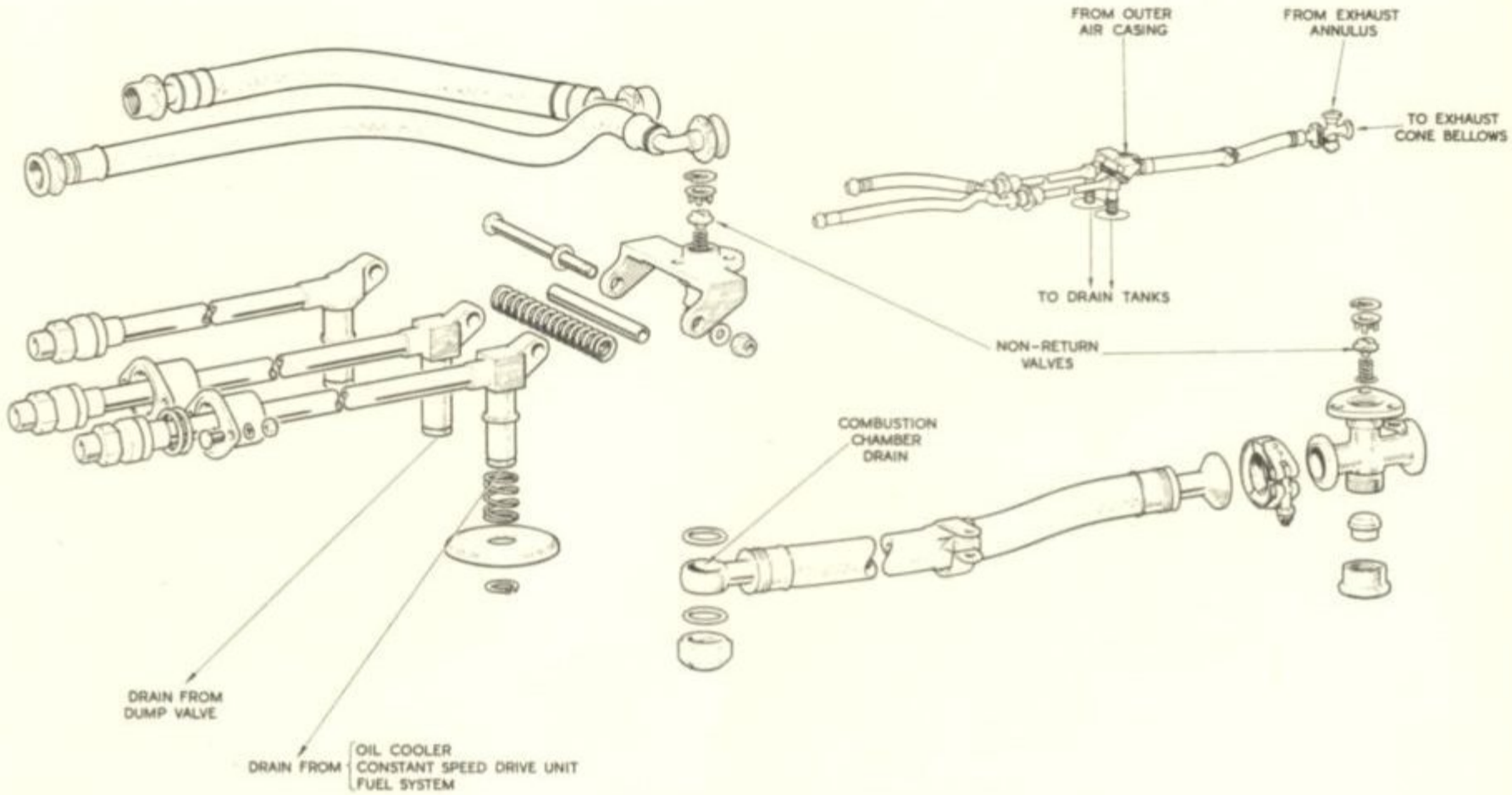
The casing comprises the top and bottom halves, joined along the horizontal flanges by bolts, spring washers and flanged nuts.

The bottom half casing has three mountings, two for the igniter plugs and the other for the turbine drain connection, also brackets for the two drain bosses for dump valve and fyel system seal drains.

When assembled the outer casing encloses the flame tubes, turbine entry duct, H.P. turbine stators and H.P. turbine casing in which rotates the H.P. turbine.



COMBUSTION CHAMBER OUTER CASING ¾ FRONT VIEW



DRAIN SYSTEM

TP 4578

3.12 FLAME TUBES & TURBINE ENTRY DUCT UNIT.

Flame Tubes

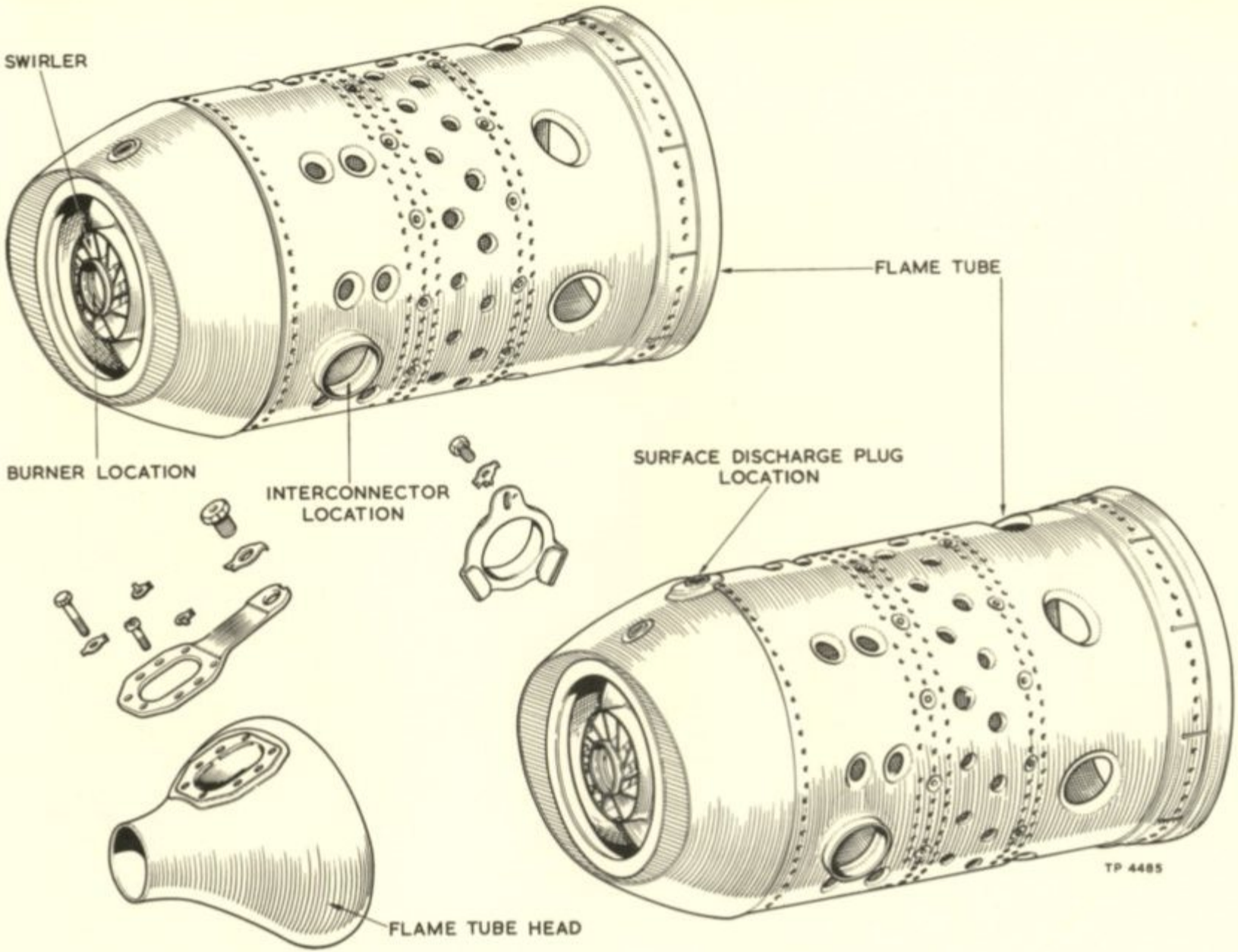
Eight flame tubes are situated in the annulus formed between the combustion chamber outer casing and turbine inner drum. Each combustion chamber comprises two main units, i.e. the flame tube head and the flame tube unit, Nos four and six tubes are fitted with steel inserts for the igniter plugs.

The flame tube head is of "streamline" form and has a flanged connection by which it is secured to the inner surface of the Delivery Casing, also a retaining strap which is bolted to a threaded boss on the flame tube.

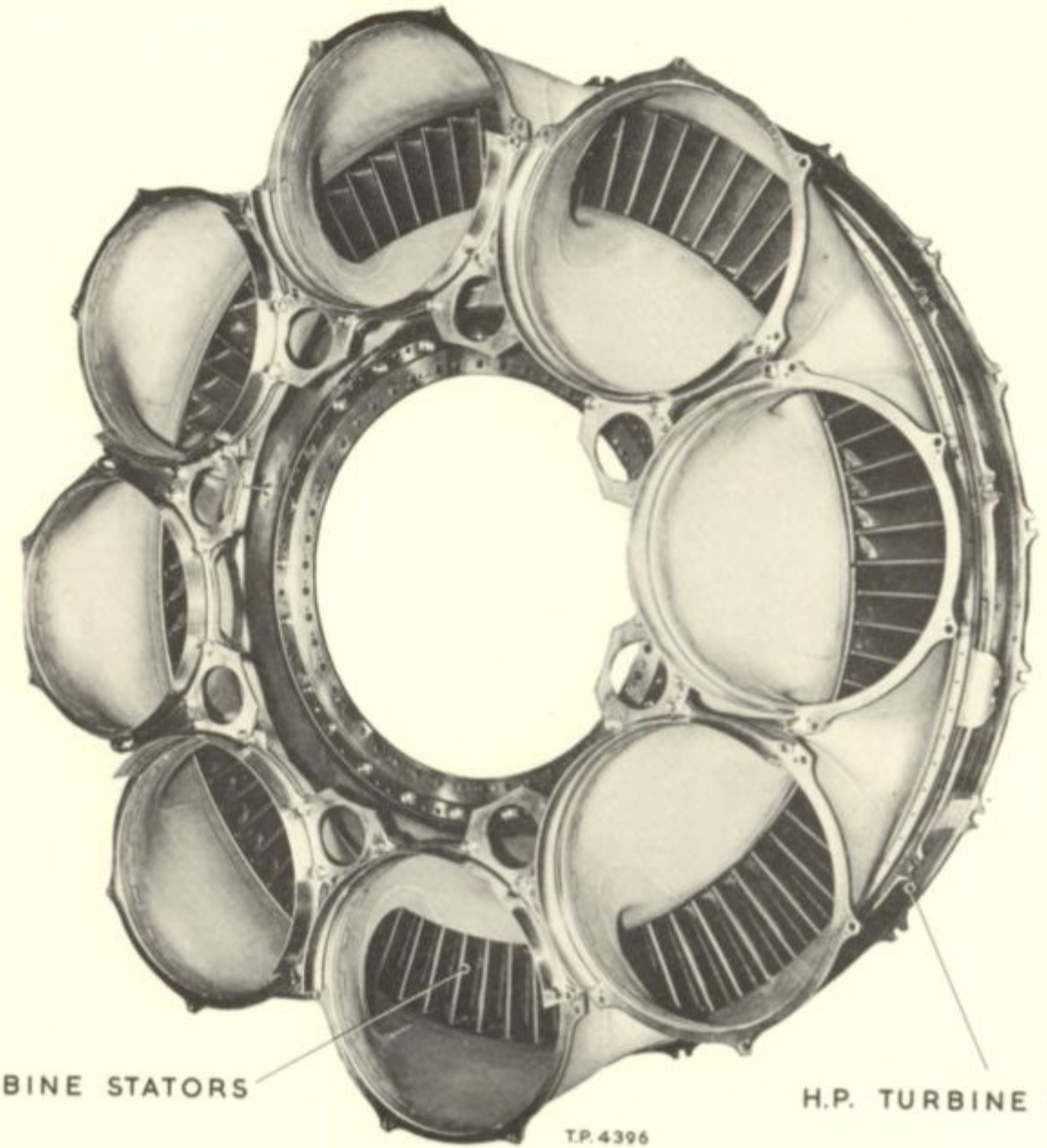
Each flame tube unit comprises four sections welded together to make a rigid assembly. The front section carries an outer joint ring at its forward end which locates on the inner ring of the flame tube head.

A flare of conical form is spot welded to the bore of the front section which carries a swirler at its apex, faces towards the front of the assembly, and in the bore of the swirler the "Duplex" burner is located Two inter connecting flanges positioned part way along the tube are fitted to link with the adjacent flame tubes. The rear end of the tube accommodates a locating ring which fits into the turbine entry duct.

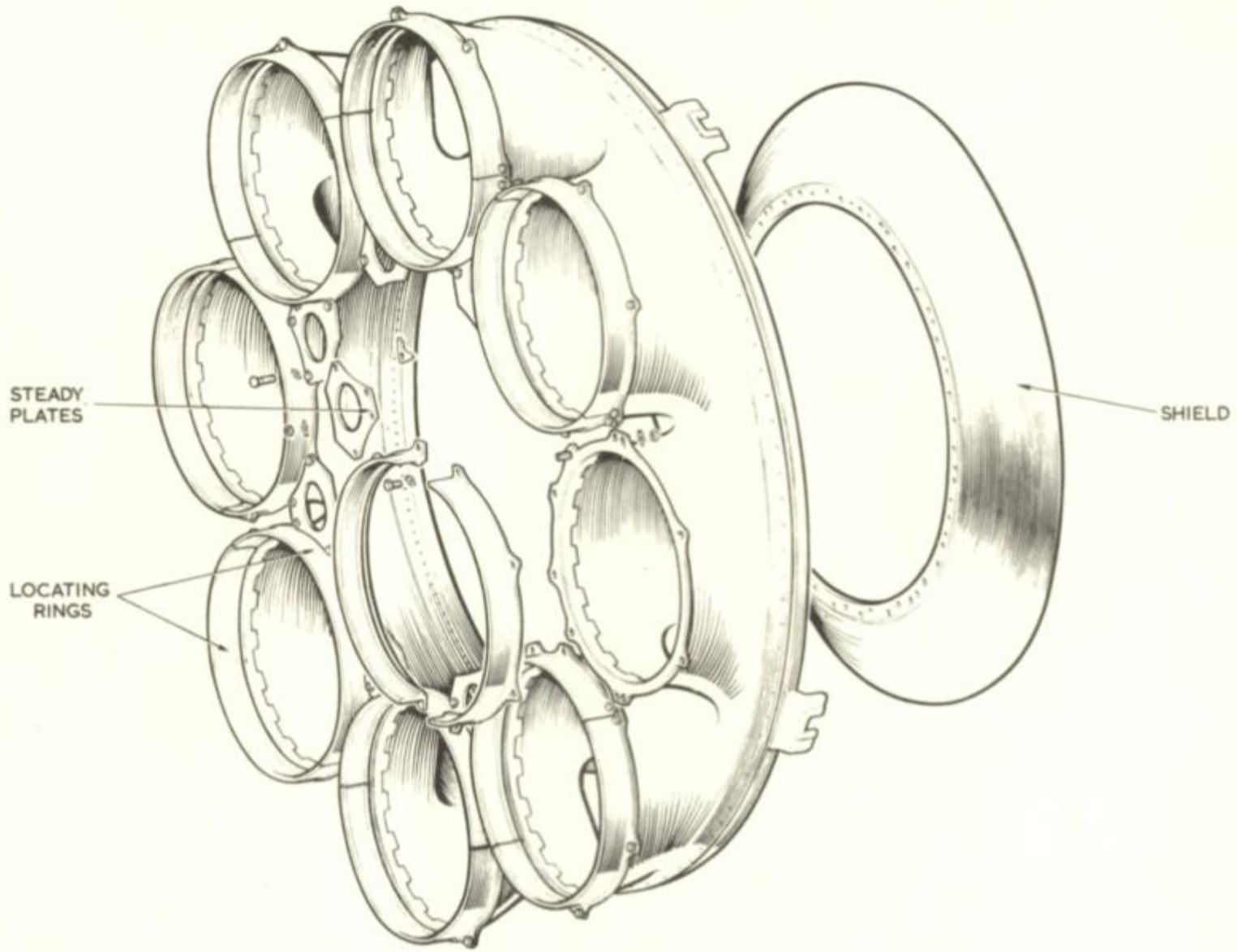
The turbine entry duct, housed in the rear of the combustion chamber outer casing is bolted to the H.P. turbine stator support cone. The entry duct is made of sheet metal and supports the downstream ends of the 8 flame tubes. 17 H.P. turbine stator segments are inserted into the rear of the entry duct, each segment being located by the H.P. turbine casing.



COMBUSTION CHAMBER



TURBINE ENTRY DUCT ¾ FRONT VIEW



TP 4592

TURBINE ENTRY DUCT ¾ FRONT VIEW

3.13 TURBINE ASSEMBLY

The main units of the turbine section are :-

1. H.P. Turbine Bearing support housing
2. H.P. Turbine Rotor
3. L.P. Turbine Rotor

H.P. Turbine Support Housing

The H.P. turbine bearing housing is carried in the Combustion Chamber unit casing which is secured at its front end to the rear face of the delivery casing.

The rear end of the casing accommodates the turbine bearing and housing, the stationary portion of the turbine bearing seal, the stator support cone and H.P. turbine stators.

An oil jet and filter assembly located in the housing provides bearing lubrication.

H.P. Turbine Rotor

The turbine disc is bolted to the large flange at the rear end of the hollow turbine shaft. Forward of this flange are the bearing and front and rear seals, all three components being secured to the shaft by a retaining nut.

At the front end of the shaft is the compressor driving coupling assembly.

The turbine blades are of aerofoil section and are shrouded at the tips. Each has a root of "fir tree" form which is located axially by a projection at the forward end of the root and a locking tab at the rear.

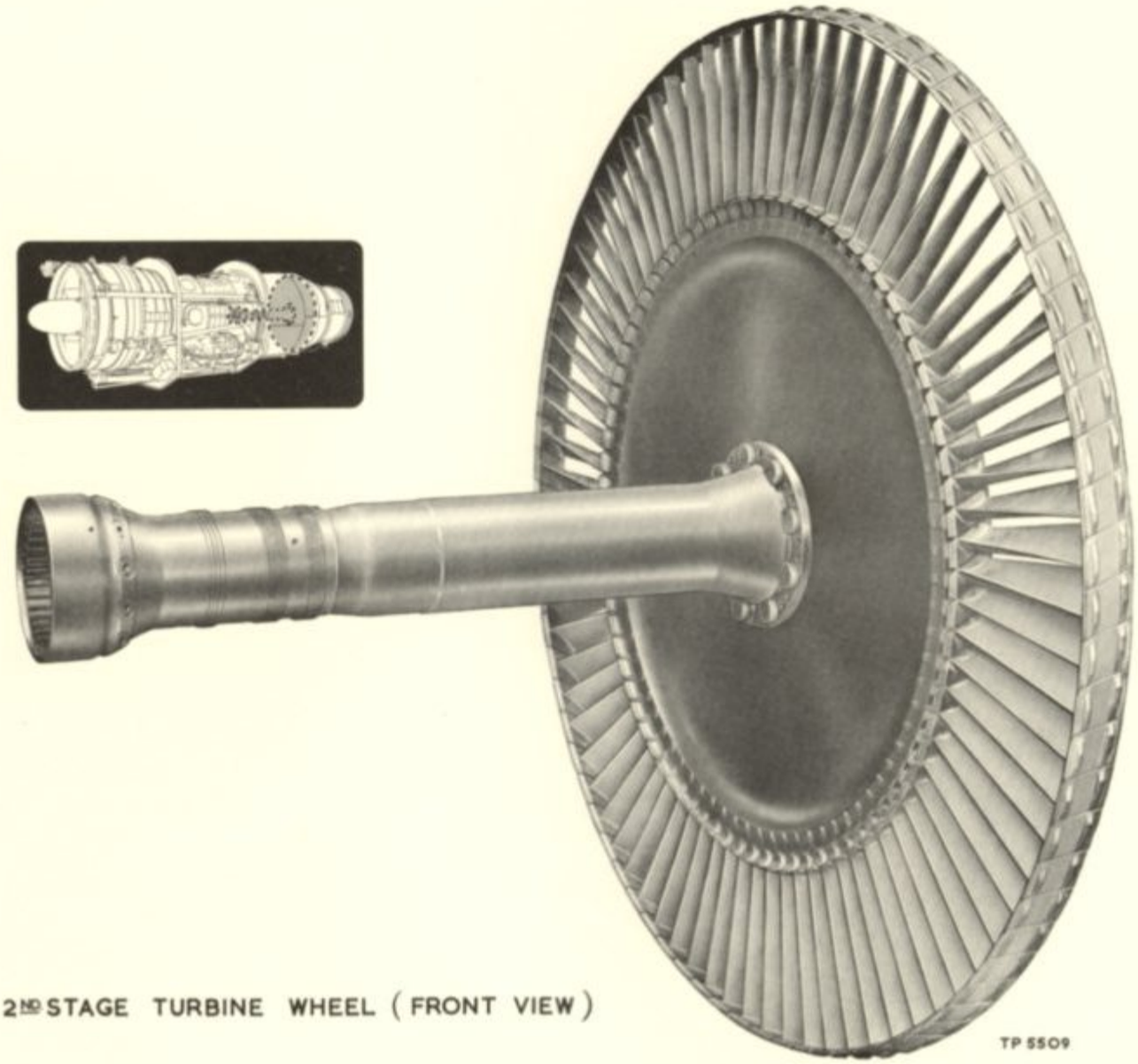
L.P. Turbine Rotor

The hollow L.P. turbine shaft passes through the bore of the H.P. turbine shaft. A seal at its forward end prevents hot air from the turbine passing between the shafts to the coupling chamber. Splines at the front end of the shaft carry the turbine coupling.

The turbine blades .....

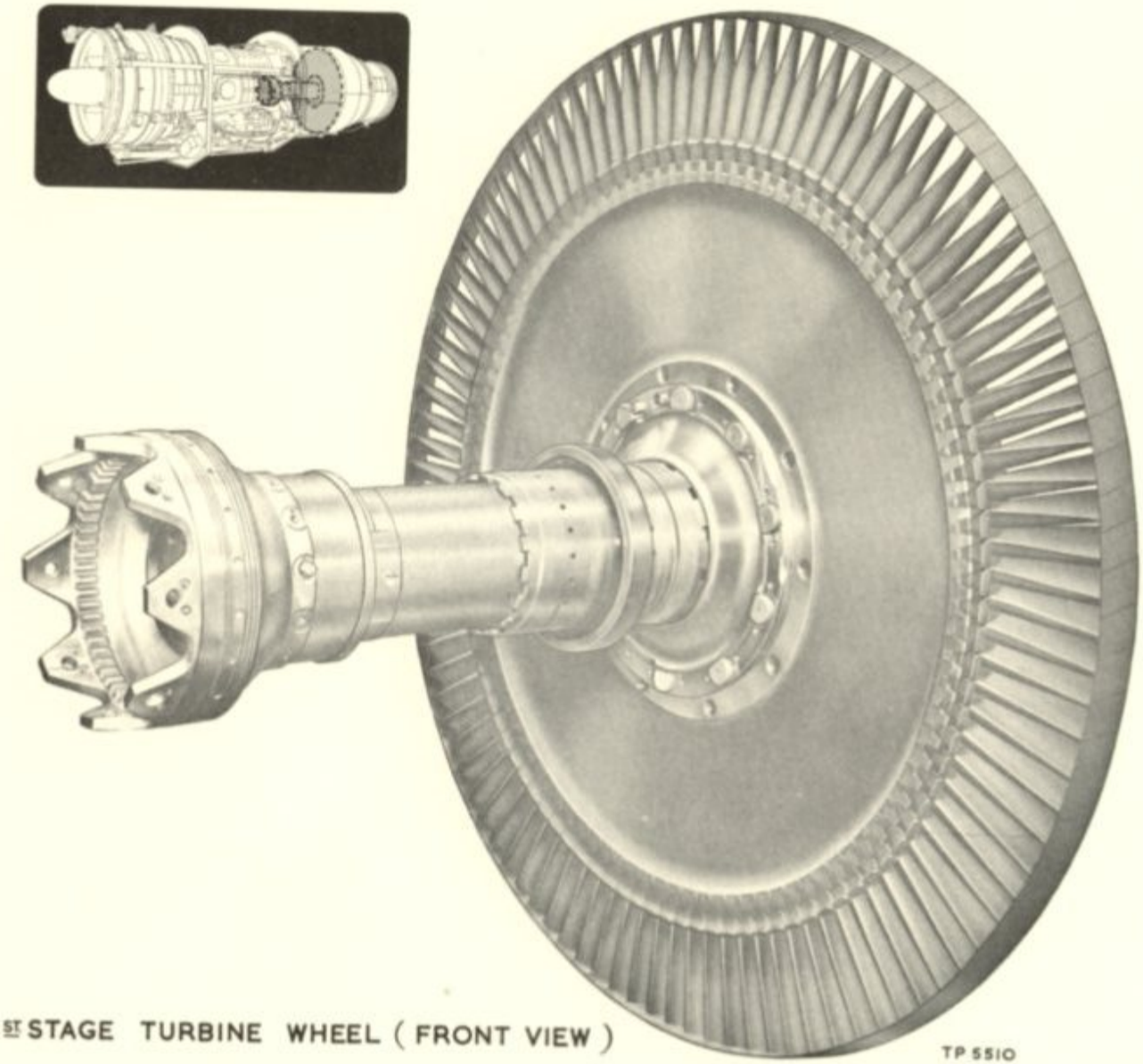
The turbine blades are shrouded at the tips and are fitted and secured in a similar manner to the H P. turbine blades.

The L.P. turbine bearing, together with the bearing seal, fitted between the bearing and disc, is secured to the wheel hub by a retaining nut. The centre tube passes through the bore of the shaft, and a connection piece at its forward end locates in the L.P. compressor shaft. The tube provides positive location between the L.P. turbine and compressor.



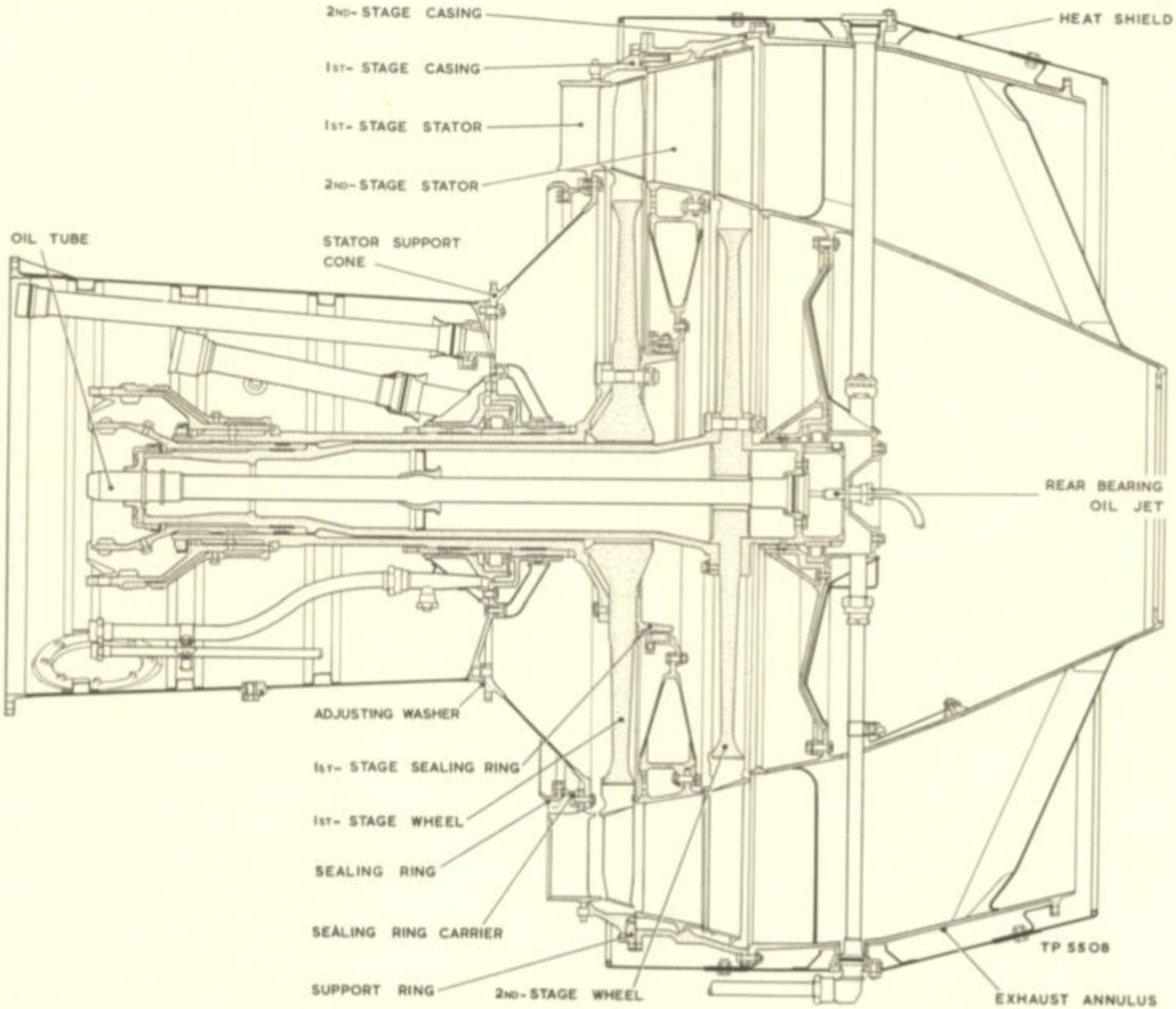
2ND STAGE TURBINE WHEEL (FRONT VIEW)

TP 5509



1ST STAGE TURBINE WHEEL (FRONT VIEW)

TP 5510



TURBINE ARRANGEMENT

3 14 EXHAUST ANNULUS AND CONE UNIT

Exhaust Annulus

The exhaust annulus is located on the rear face of the L.P. turbine casing. it consists of an inner and outer ring which are separated by eight radially disposed hollow vanes. A flange at the rear of the inner ring accommodates the exhaust inner cone, whilst a diaphragm at the front end supports the L.P. turbine bearing and housing.

Upper and lower connections on the rear of the bearing housing connect with the air and oil drain pipes respectively.

Three of the eight hollow vanes are utilised in the following manner :-

No.1 Vane. Conveys 3rd stage H.P. compressor air for L.P. turbine cooling and bearing seal pressurising

No.4 Vane Houses the oil feed pipe to oil jet assemblies in the rear bearing housing cover.

No.5 Vane Accommodates an oil drain pipe from the bearing housing.

A hole at the bottom of the annulus forms a drain which connects with the turbine drain system.

Upper and lower heat shields, attached by brackets, encase both combustion chamber casing and exhaust annulus

Exhaust Cone Unit

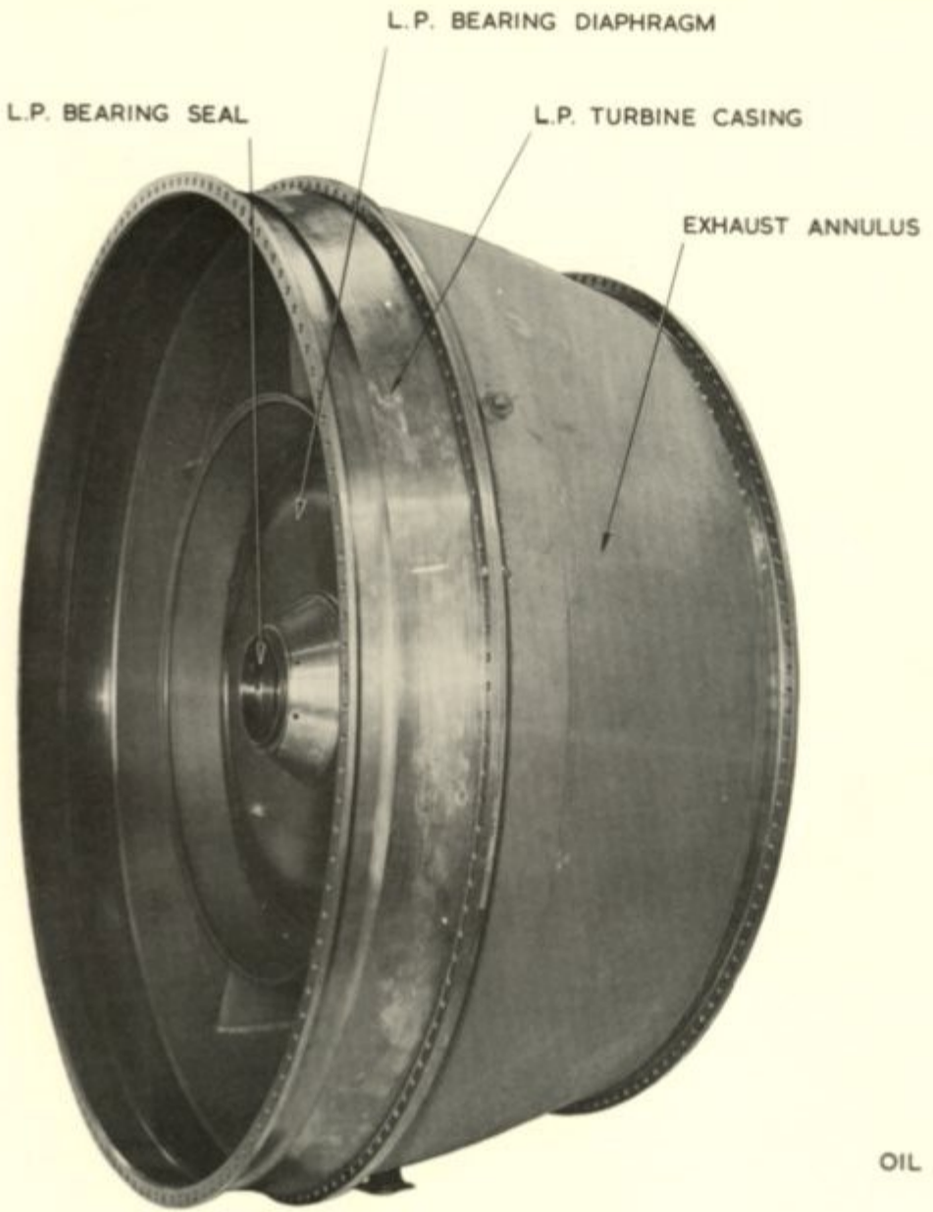
The exhaust outer cone, bolted to the turbine exhaust annulus rear flange, has front and rear flanged bellows units designed to permit a limited articulation which allow for malalignment between jet pipe and engine.

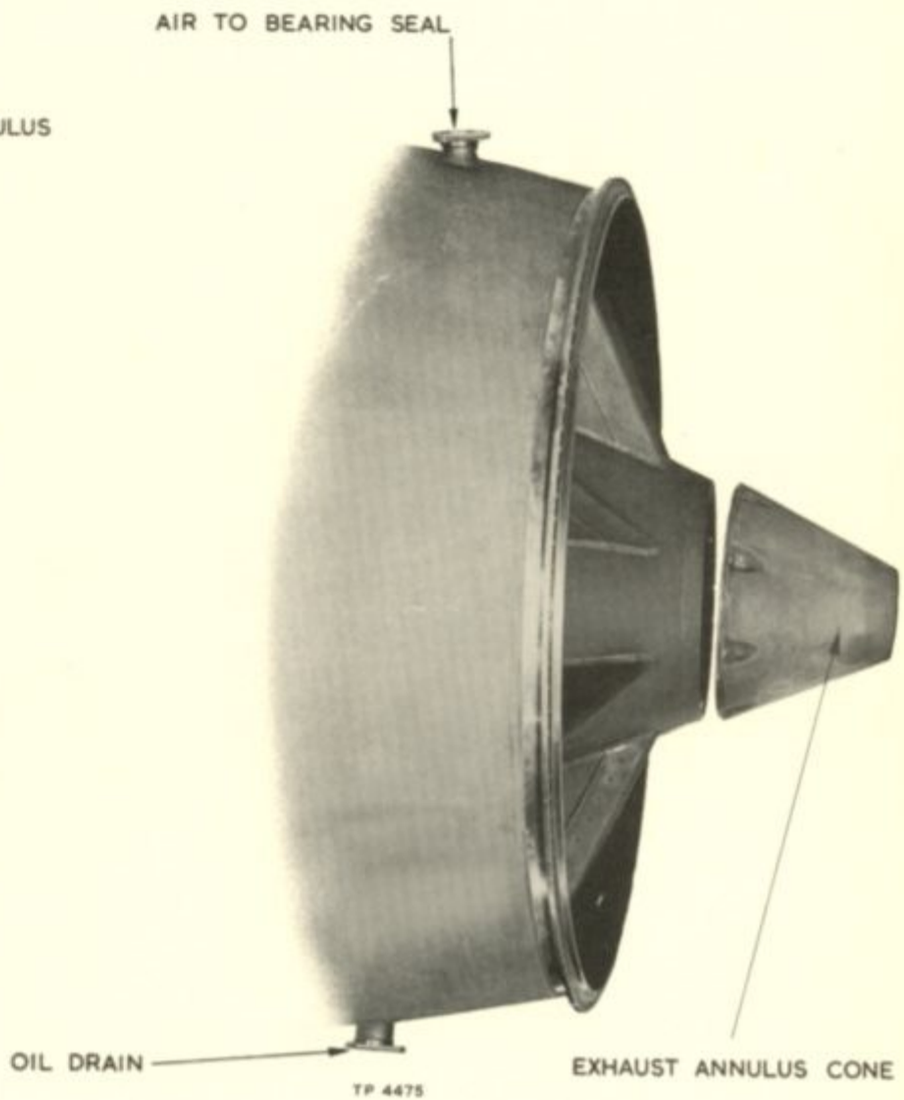
The Jet pipe is attached to the exhaust cone by two half clamps which are retained in position by the rear bellows unit surrounding them. This unit is located by the front manacle clamp to the exhaust cone and by the rear seating strap to the Jet Pipe.

Drainage collectors .....

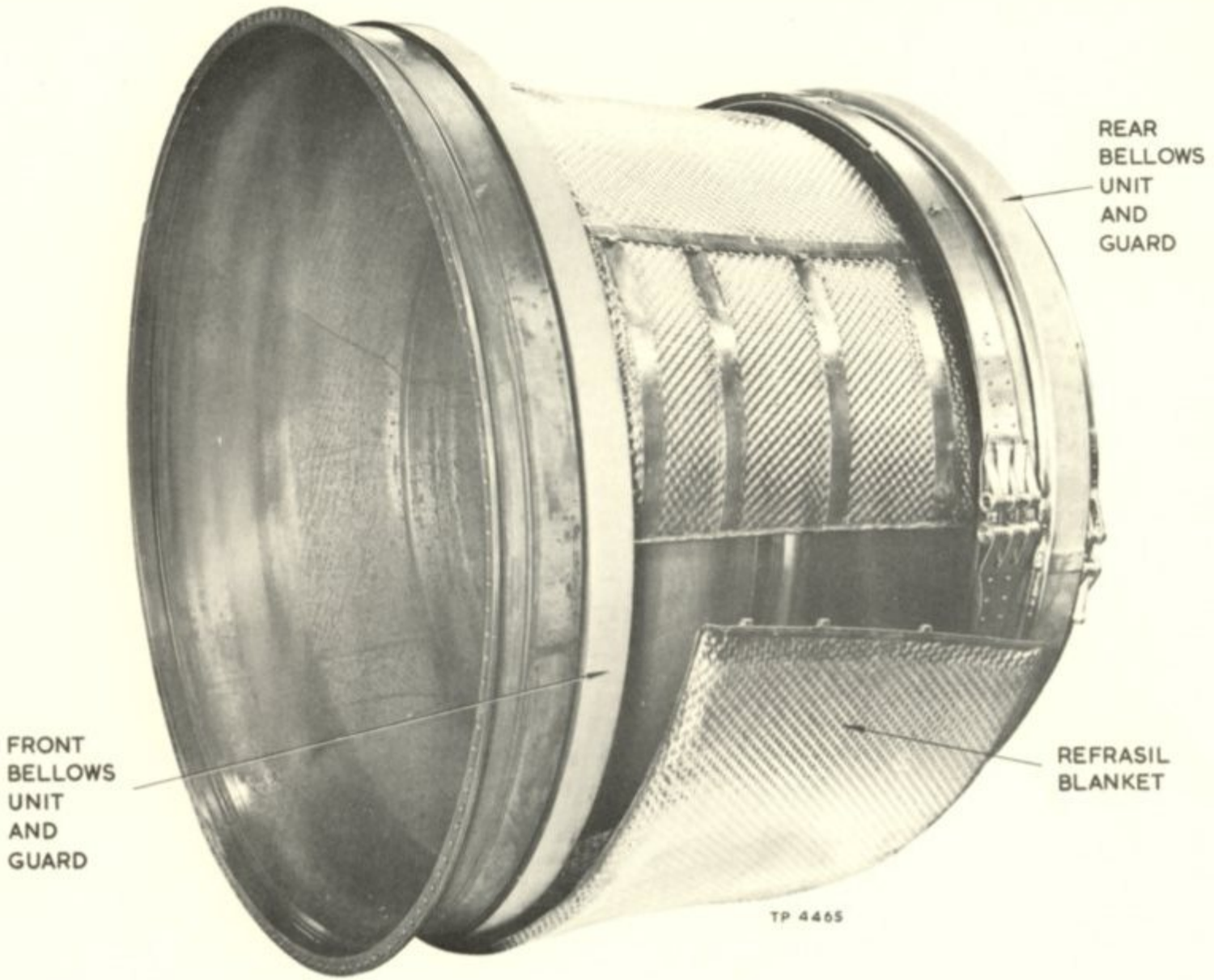
Drainage collectors are provided at the bottom of the bellows seals and are designed to drain away any fuel that may seep through the attachment joints.

Between the front and rear bellows units, the external surface of the exhaust cone is covered with a heat insulating blanket, located by springs on the port and starboard sides.

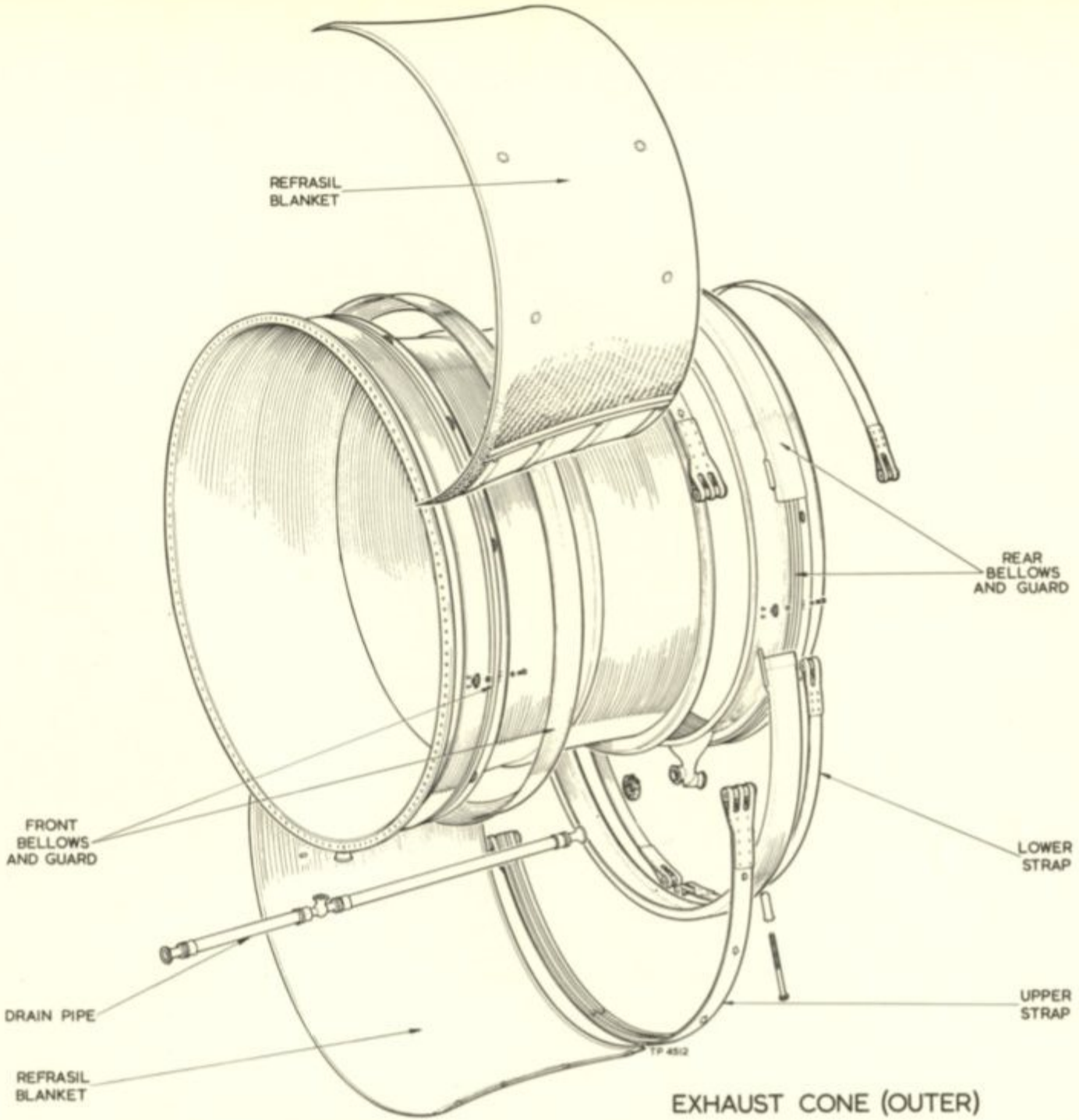




EXHAUST ANNULUS



EXHAUST CONE OUTER ¾ FRONT VIEW



EXHAUST CONE (OUTER)