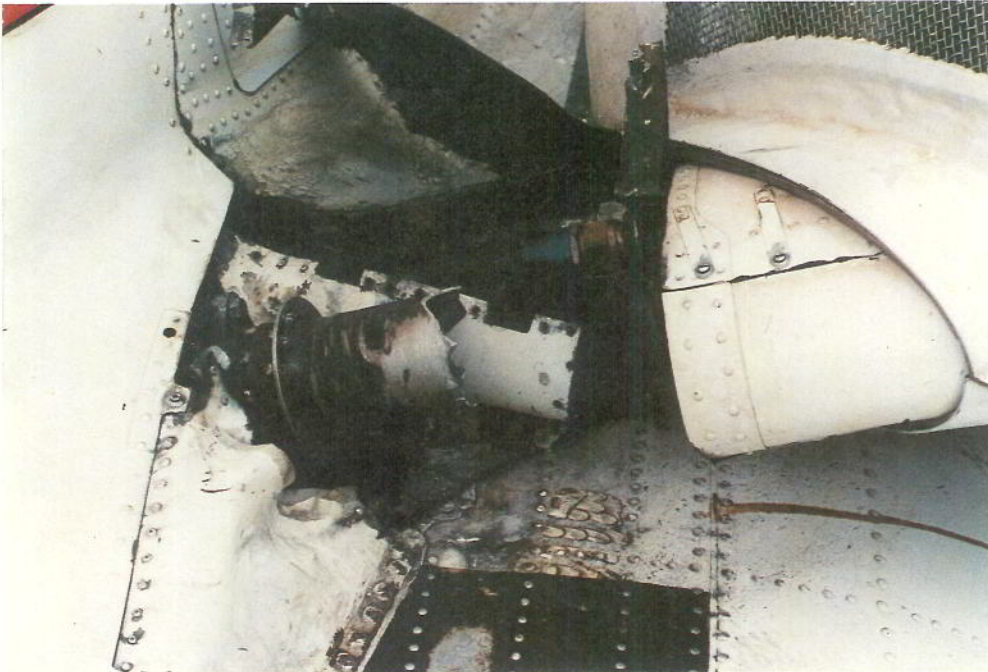


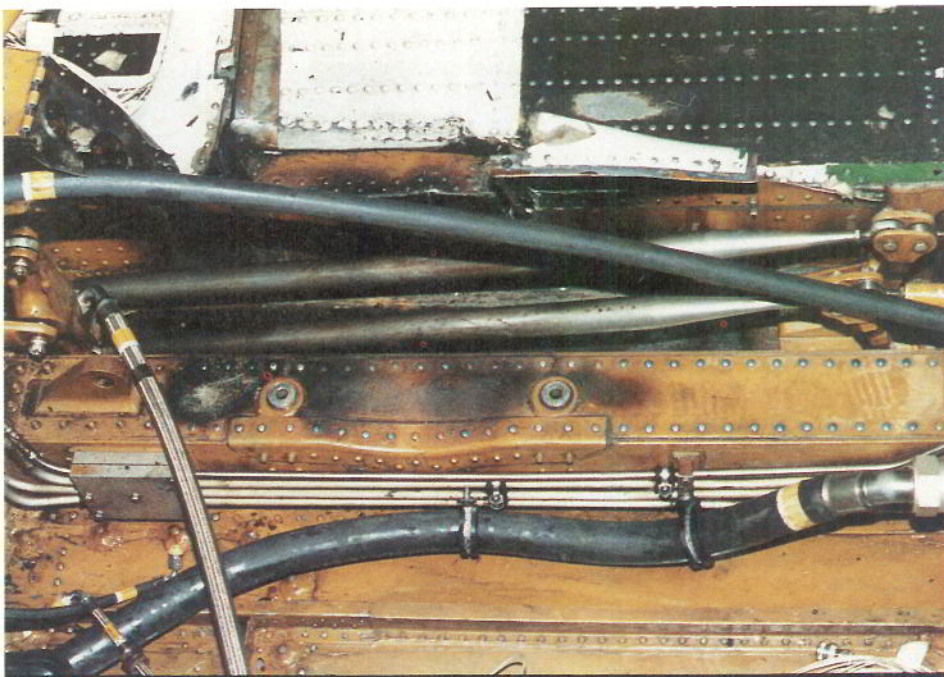
(i) G-BWFC – No 1 engine and transmission gearbox installation
External indications of fire damage



(ii) Fire damage: No 1 engine transmission gearbox fairing

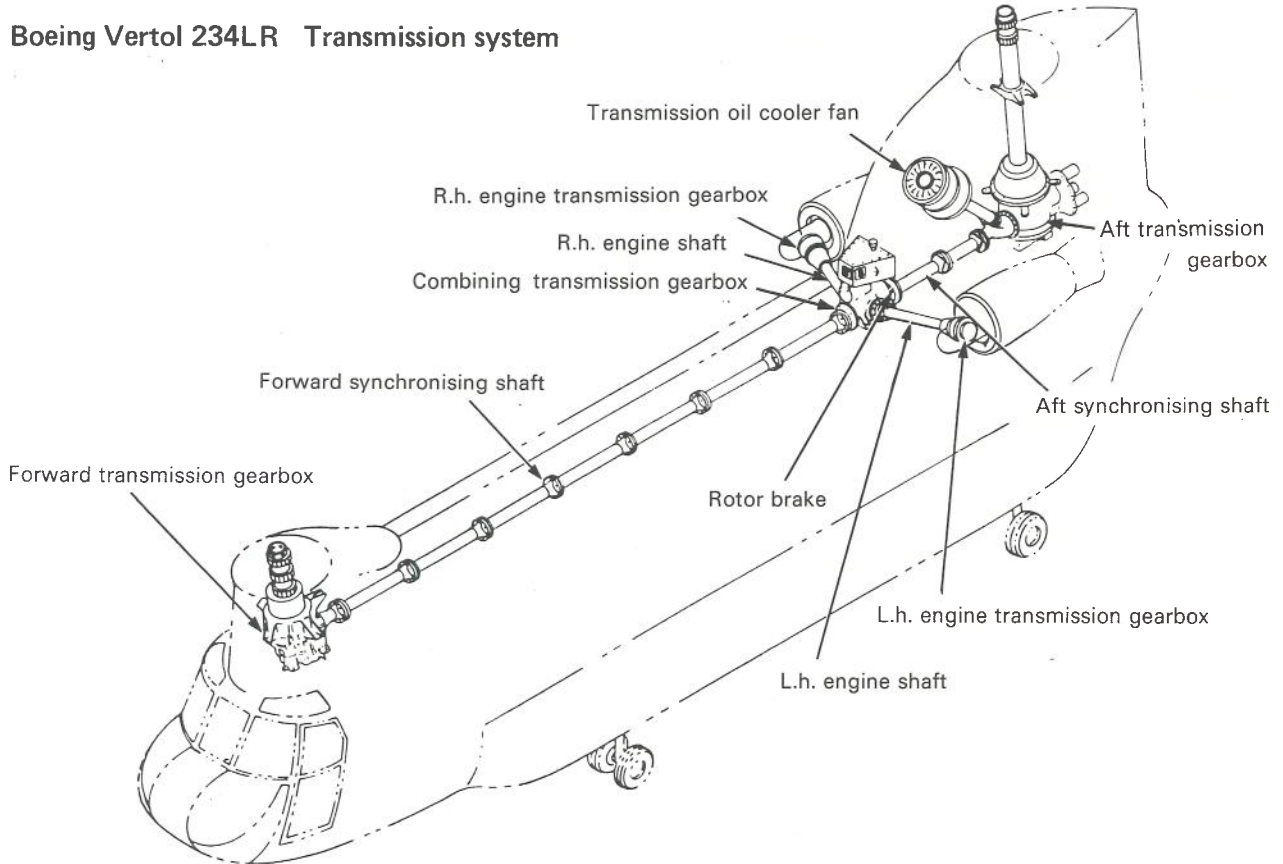


(iii) No 1 engine transmission driveshaft failure

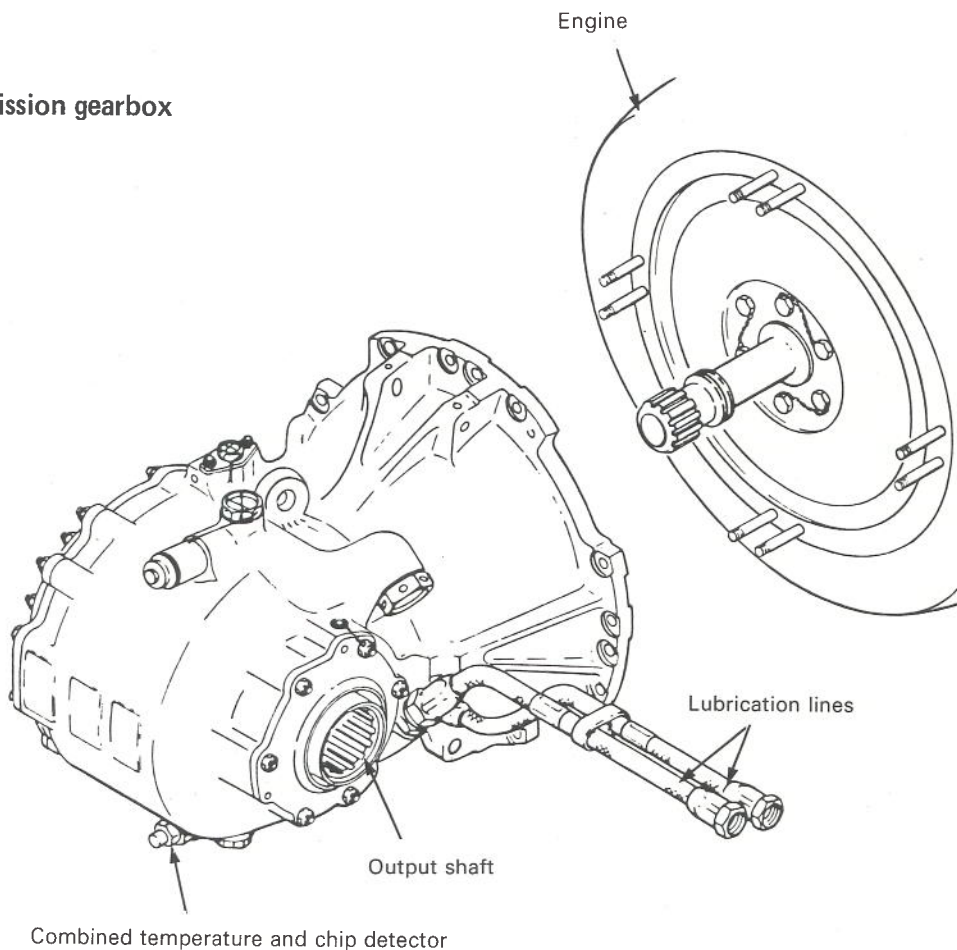


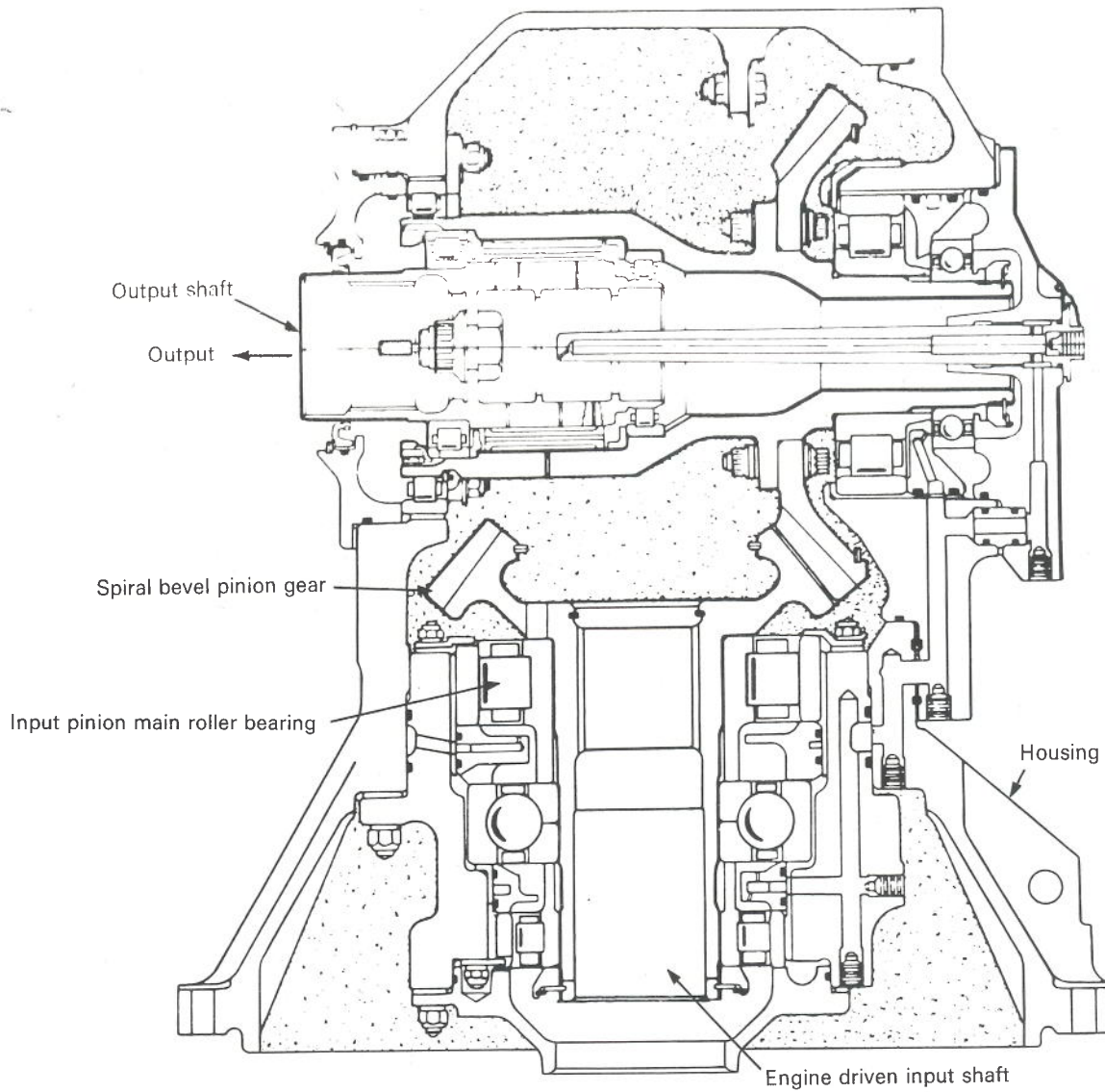
**(iv) Fire damaged structure in area of combining gearbox mounting
(Note damage to flight controls and transmission lubrication hoses)**

Boeing Vertol 234LR Transmission system

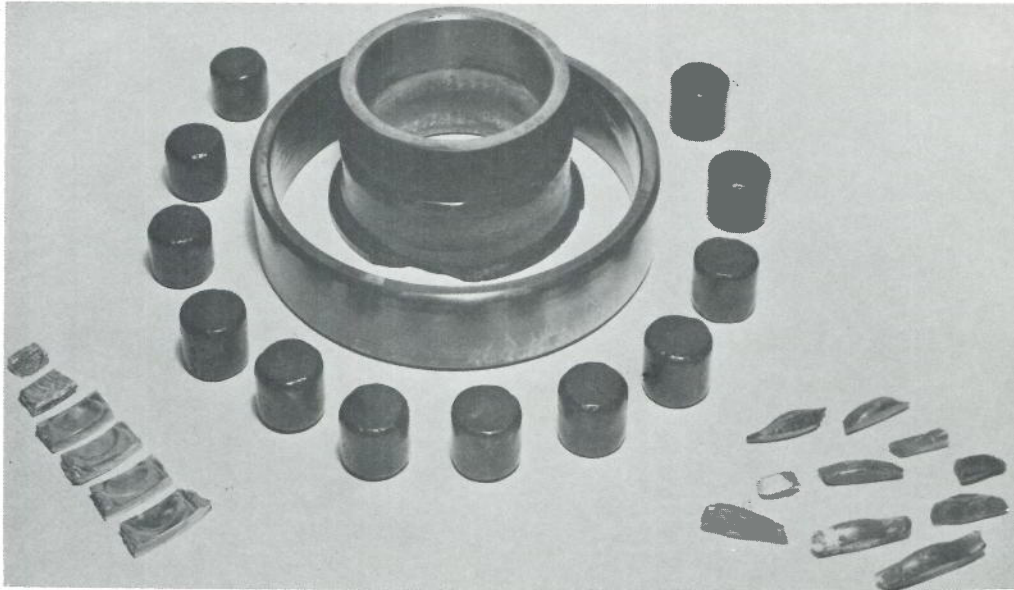


Engine transmission gearbox

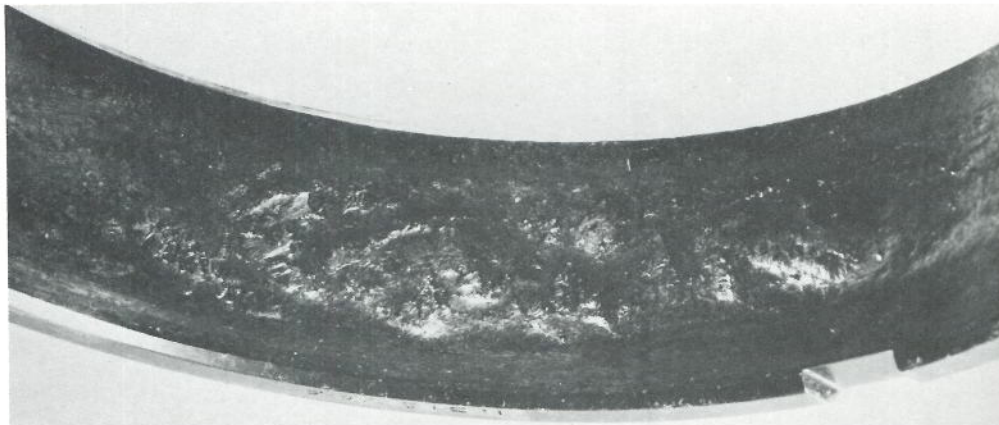




Engine transmission gearbox – sectional drawing



(i) Components and fragments from failed bearing

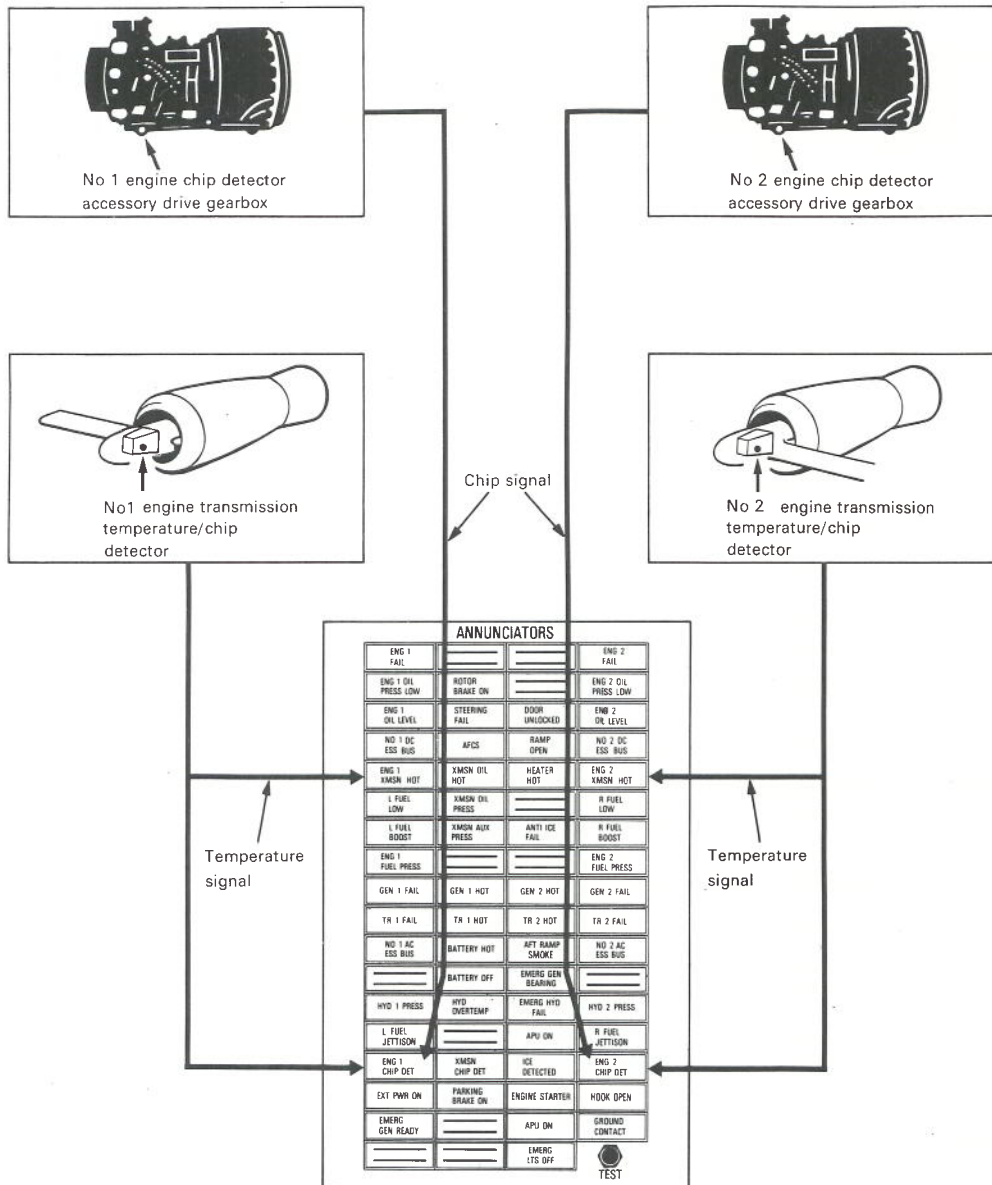


(ii) Damaged rolling surface of outer race

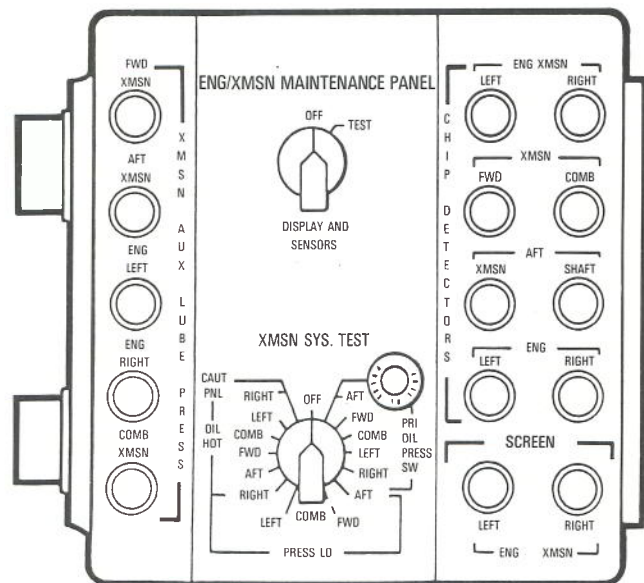


(iii) Typical example of roller damage

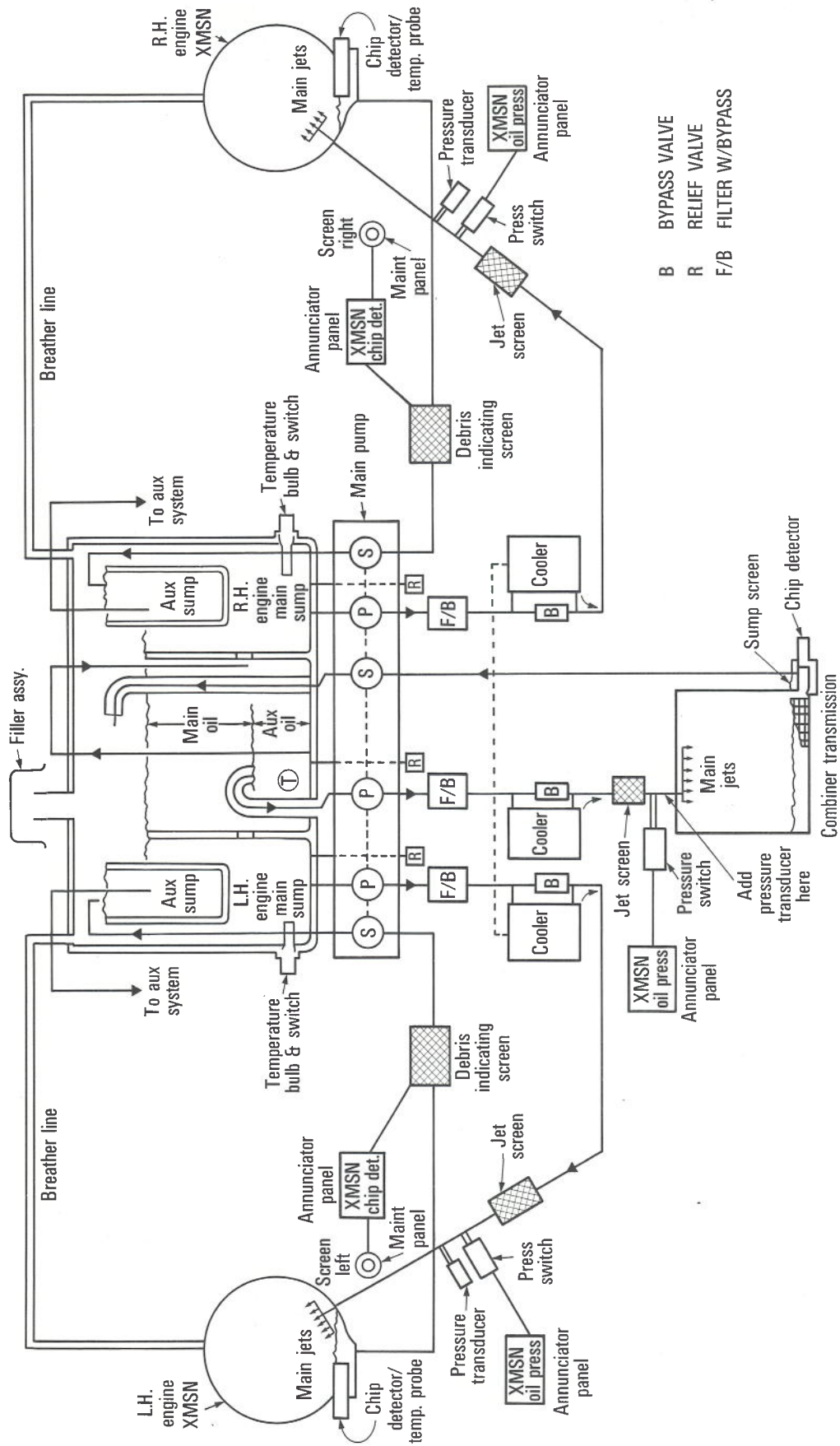
No 1 engine transmission gearbox input pinion main roller bearing



Engine and engine transmission gearbox chip/temperature detector indications



The maintenance inspection panel located in the ramp area of the passenger cabin



Engine transmission and combining gearbox main lubrication and sensor systems
(Schematic diagram)

Following an accident to a military CH47 (Military predecessor of the BV234) in 1965 the helicopter manufacturer conducted a series of tests to examine material decomposition and spontaneous ignition temperatures for cold and hot transmission oil (MIL-L-7808) on hot metal and non-metal surfaces.

TEST 1 Decomposition of Polyvinyl Chloride Wire Coating (MIL-L-5036)

180°C – Vinyl odor liberated
 190°C – Softening
 191°C – Fumes
 208°C – Char - discoloration
 217°C – Char - smoke
 220°C – Melting vinyl - wire exposed
 Short Circuit Sparking possible at this point
 260°C – Boiling vinyl
 280°C – Complete char

TEST 2 Decomposition of Teflon

290°C – Relaxing and Curling noted
 325°C – Frosty appearance of Teflon turning transparent
 385°C – Sublimation begins
 Teflon goes from solid to gaseous state
 Teflon coated wires would be exposed at this point to sparking

TEST 3 Decomposition of Polyester Fiberglass Laminate

222°C – Discoloration, traces of smoke
 243°C – Delamination, buckling and smoking
 305°C – Start of charring and decomposition resin volatilizing
 385°C – Complete char

TEST 4 Spontaneous Ignition of Cold Oil Sprayed onto a Hot Aluminium Surface

Metal plate was 490°C when cold oil burst into flame. Prior contact of cold oil on surface below 490°C only produced white smoke.

TEST 5 Spontaneous Ignition of Hot Oil Sprayed onto a Hot Metal Surface

<i>Oil Temp</i>	<i>Metal Surface Temp</i>	<i>Reaction</i>
155°C	155°C	White Smoke
240°C	255°C	Dense White Smoke
350°C	365°C	Instant Fire on Contact

The oil was heated in a laboratory flask which was provided with a spray attachment and controlled by a rubber bulb. The heated oil was periodically sprayed as a fine mist onto the heated aluminium surface. Temperature controls were attached to both the oil and the metal surface.

APPENDIX 6

Previous cases of Input Pinion Main Roller Bearing Failure

Date	Aircraft Type	Description	Prime Failure	Hours
4.3.65	CH 47A	No 1 engine power lost, shut down, landing initiated, white smoke seen from another aircraft, 20/30 seconds later aircraft crash landed, rolled to left. Fatal	No 1 engine XMSN oil return line (quick disconnect type) blocked	Unknown
4.10.69	CH 47C 16000 C Serial No S/N 68	While in hover, tower saw No 1 engine on fire. Helicopter landed, ground crew extinguished fire.	665-1 bearing failure, outer race spalled, cage failed. Possible fatigue on inner race	27
16.9.70	CH 47C 17100 C S/N 69 RVN	No 2 engine suffered fourth stage turbine failure due to ingestion of oil venting from No 2 engine XMSN	665-1 bearing failure, return line blocked	Unknown
8.6.79	CH 47A 07983A S/N 65	No 2 engine chip light illuminated, smoke in aircraft, shut down, descent, No 2 extinguisher fired, landed in field	665-1 bearing failure	Unknown
1979	CH-47D Transmission (Ground Rig Overload Test)	Sound change noted by operator, shut down	665-1 bearing failure, SKF unable to determine cause. Marginal lubrication suggested, cage failure, inner race aft flange disintegrated, forward flange extremely worn	203 + 92 at over-load conditions

Date	Aircraft Type	Description	Prime Failure	Hours
17.4.80	CH-47C 15030 S/N 70 (West Germany)	No 2 chip light plus hot light illuminated oil pressure fell to 5 psi, torque increased, low oil pressure light illuminated, no fire.	665-1 bearing failure	649
22.2.81	CH-47C 15031C S/N 70	Vibration and fire in No 1 engine XMSN during landing	665-1 bearing failed. Return line blocked. Fatigue failure of inner race, drive shaft intact.	387
13.5.81	CH-47C 001C S/N A15 (Australia)	No 2 chip light, severe vibration, smoke and fire, No 2 shut-down, immediate landing, fire extinguished.	665-1 bearing failure, return line blocked	234 TSO
3.8.81	RAF HC1 S/N ZA 670	No 2 engine chip light, unusual XMSN noises, No 2 XMSN hot, smoke in aft cabin, No 2 torque fell, No 2 shut down, No 2 fire drill initiated, No 2 XMSN chip on MIP, finally XMSN oil pressure warning lit.	665-1 failure. "Galling" on inner race due to pinion aft deflection and one fatigue area found on cage.	307.35 TSN
20.8.81	CH-47D Transmission (Ground Rig Testing)	Noise, chip light, screen light.	665-1 bearing failure, cage broken up, inner race flanges broken away.	431

Date	Aircraft Type	Description	Prime Failure	Hours
17.9.81	CH-47D Transmission (Ground Rig Testing)	Noise, chip light, screen light.	665-1 bearing failure, cage broken up, bearing flange failed in fatigue.	867
11.8.82	RAF HC 1 S/N ZA 671	No 1 torque loss, 'XMSN hot' lit. Note: Engine 1 chip did not illuminate, but engine 1 XMSN chip magnetic indicator was on after shut down (Crew men heard "bang" just after shut down)	665-1 bearing failure	
21.2.83	British Airways BV 234 G-BWFC	No 1 engine chip light illuminated frequently, No 1 XMSN chip MI re-set twice, No 2 torque eventually increased engine shut down, smoke/fire, then 'rotor brake on', 'XMSN OIL Press'; 'AUX PRESS' illuminated followed by transmission oil pressure gauge falling to zero, transmission oil temperature gauge rising to Max, left and right transmission temperature lights illuminated.	665-1 bearing failure: outer race spalled, cage broken up, aft flanges disintegrated off inner race, one section broken away from forward flange, cross-shaft failed, fire damage.	1241 (4900 hrs authorised life, limited by bearing scrap life)