

APPENDIX A

Bell Helicopter Company

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November 12, 1970

Sequence of disintegration of the main transmission gearbox

- 1 More than 30 hours prior to the accident a sub-surface fatigue crack may have originated and developed into spalling in one of the planet pinion gears, P/N 206-040-035-5, bearing races. The area of spalling increased in size and severity with time. The alloy steel fragments dispersed throughout gear box.
- 2 Another pinion P/N 206-040-035-5 possibly started to spall, adding to the steel particles inside the transmission case. The spalling of this pinion P/N 206-040-035-5 may have been initiated by the metallic trash thrown off from the first pinion going through this pinion's bearing.
- 3 Continued roughening and spalling caused wear and eventual fracturing of the pinion P/N 206-040-035-5 bearing cage. As the silver plated aluminium cage fragmented and the particles flooded the oil system (lodging in significant quantities in the oil filter), the rollers started to rub against each other causing additional alloy steel debris, heat and oil contamination.
- 4 Some rollers may have turned sideways and produced intermittent locking between the inner and outer bearing races. Other than changes in oil temperature and pressure, this may have been the first operational indication of malfunction. The possible occasional locking caused the inner bearing race to spin on its mounting pin, P/N 206-040-043. Later, the inner race P/N 206-040-035-5, and the pin P/N 206-040-043, galled and seized. The nut, P/N 206-040-044 backed off the pin, P/N 206-040-043. There was no evidence of a cotter pin having been installed.
- 5 The loosened nut impacted all of the cap screws, P/N NAS1305-IH fastening the spiral bevel gear to the gear carrier or shaft.
- 6 Heating above a red heat, metal shredding, the final deterioration of the cage, and the migration of the rollers to one side continued. As the rollers became free to mass on one side of the bearing, the extra freedom would allow the planet pinion P/N 206-040-035-5, and the spider P/N 206-040-041-1, or pinion carrier to displace relative to each other. This would provide room for the nut, P/N 206-040-044 to drop off and for the rollers to leave the pinion, P/N 206-040-035-5.

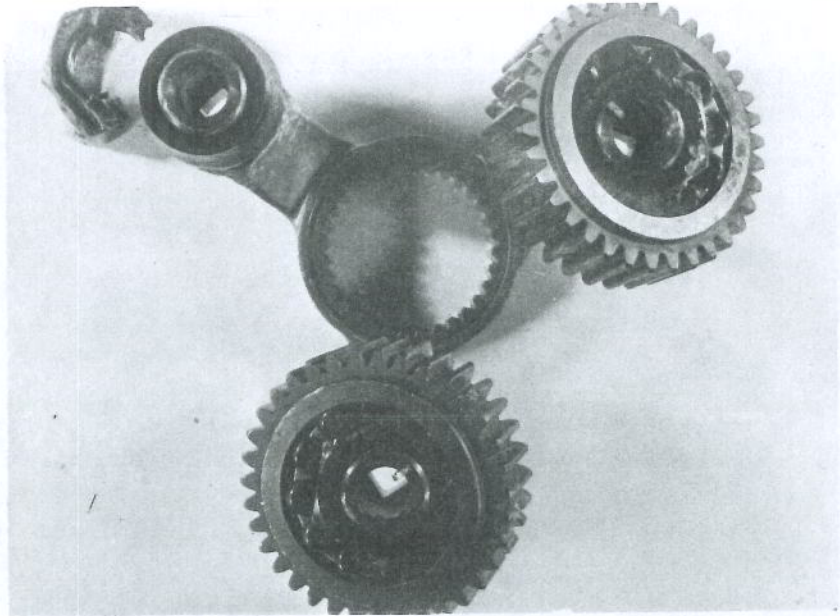
- 7 The nut P/N 206-040-044 and rollers thrashed around the gear case, occasionally entering the mesh, chipping and flaking off pieces of gear tooth. This proceeded for some time. Finally the nut P/N 206-040-044, or the pinion P/N 206-040-035-5 or a group of rollers did cause a major jam. This most likely occurred at the ring gear, P/N 206-040-006. The side of the cases, P/N's 206-040-151 and 206-040-150 burst and many lower case studs P/N AN 126114, fractured in tension. It has not been determined if the missing ring gear P/N 206-040-006 fractured or simply distorted. The gear cases P/N's 206-040-151 and 206-040-150 probably did not completely separate at this instant.
- 8 As the transmission partially opened, the sun gear P/N 206-040-122, rose with the mast disconnecting it from the spline in the spiral bevel carrier P/N 206-040-040. This disconnected the engine from the rotor and the pilot may have gone into autorotation. No further case separation occurred for some time as indicated by the extensive machining on the inside of the spiral bevel carrier P/N 206-040-040, by the end of the mast. These marks and the marks made on the sun gear P/N 206-040-122, by the spiral bevel carrier P/N 206-040-040 indicate a period of no further separation or at best very slow separation.
- 9 A second major jam or the pilot's application of collective control to flare caused the remaining studs, P/N AN 126114, to fracture and the transmission cases separated.

It is hoped the above satisfies your requirements.

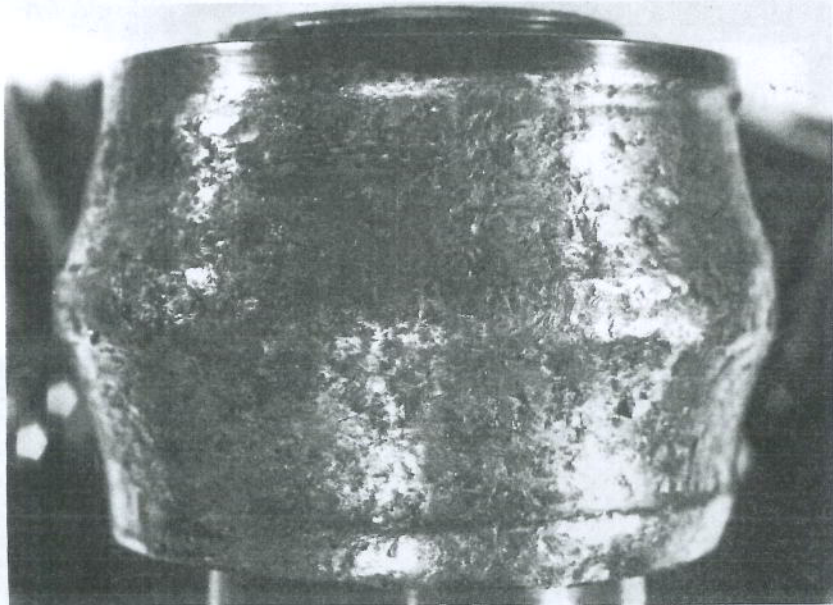
Very truly yours

BELL HELICOPTER COMPANY
(sgd) *W P Rollings*
Chief Production Project Engineer

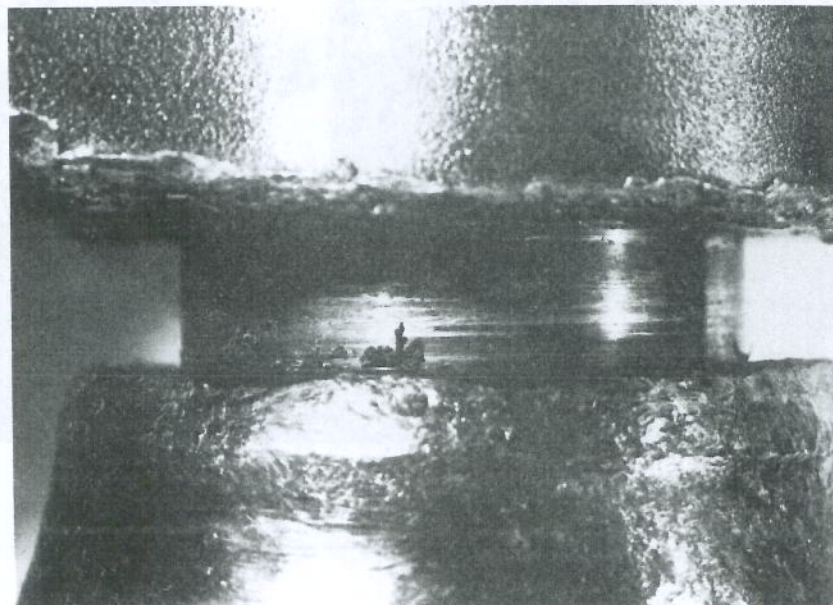
Planetary Assembly



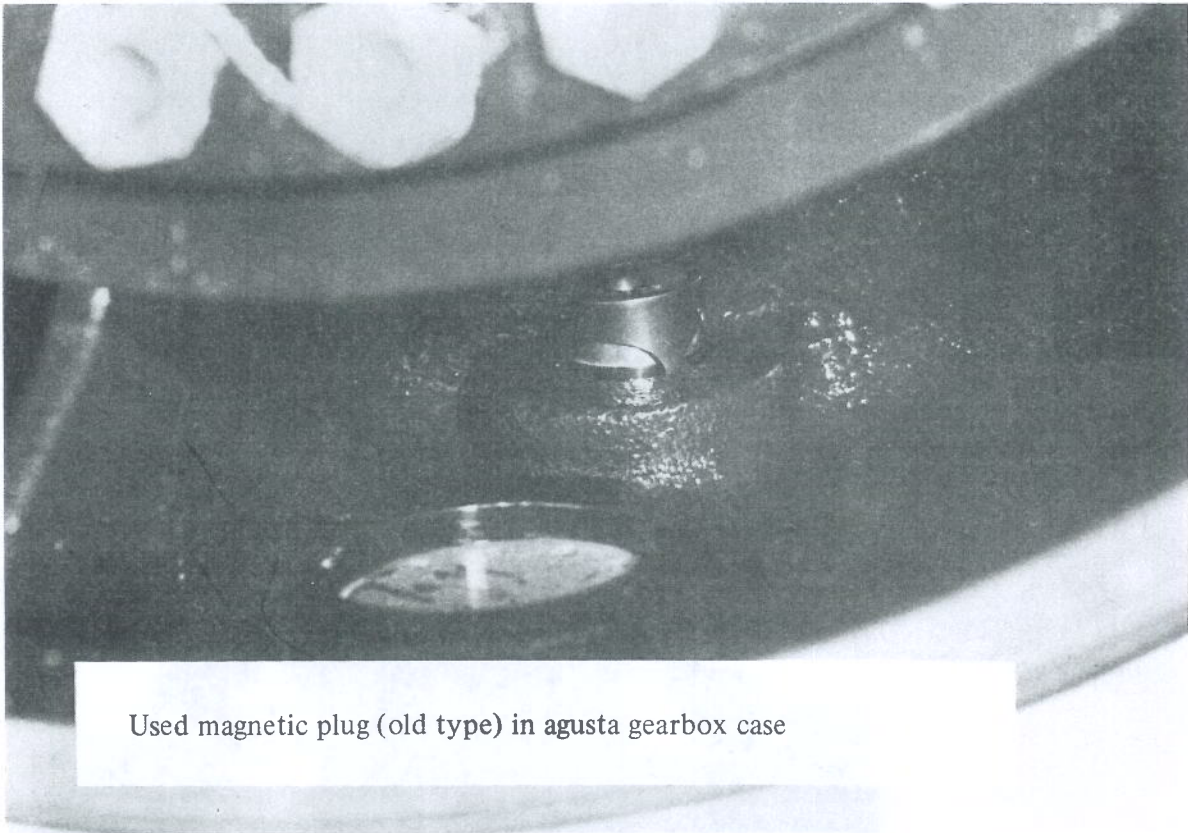
Inner Race No.3



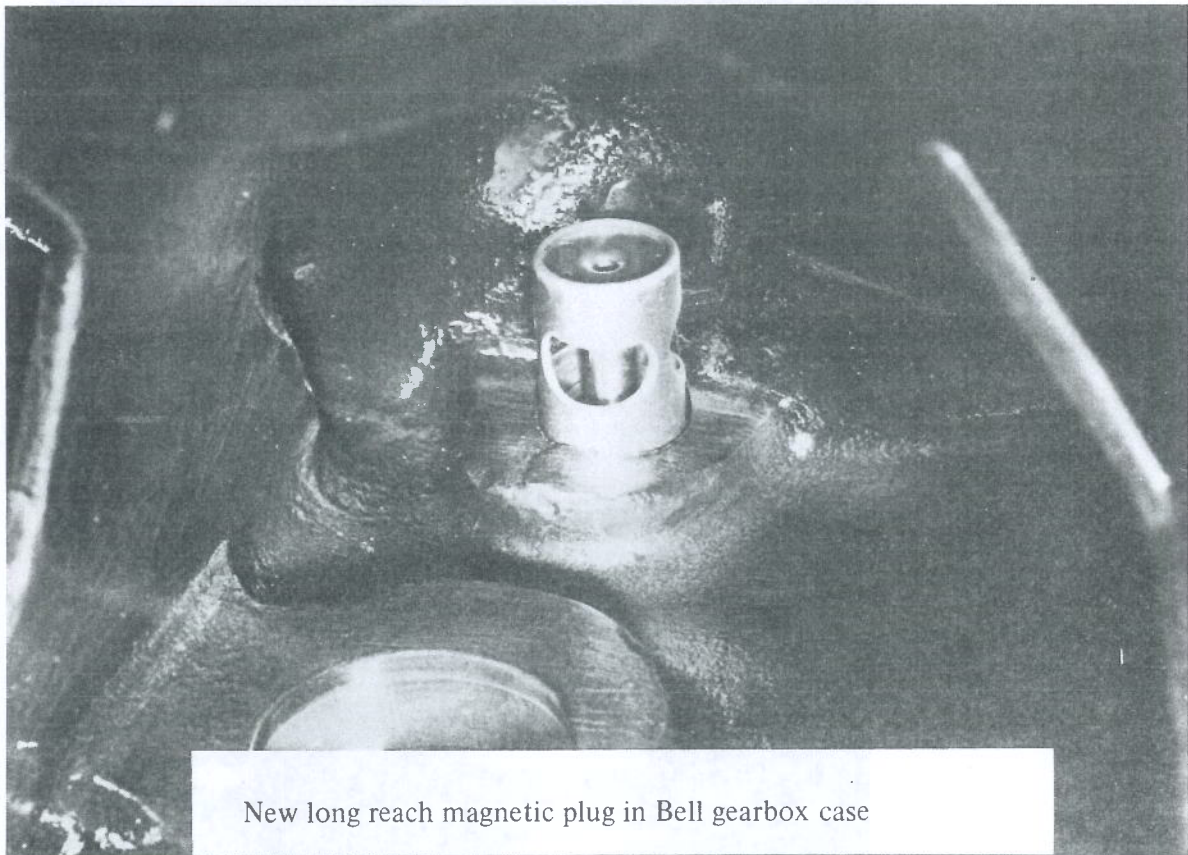
Shaft No.1



APPENDIX C



Used magnetic plug (old type) in agusta gearbox case



New long reach magnetic plug in Bell gearbox case