



Teledyne Continental Motors, Inc.
A Teledyne Technologies Company

ENGINE ANALYSIS REPORT

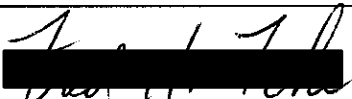
ENGINE MODEL IO-470-U (Right)

ENGINE SERIAL 118267-R

AIRCRAFT MODEL Cessna 310I

SERIAL NUMBER 310I0145

REGISTRATION NUMBER N8145M

INVESTIGATOR	SIGNATURE	DATE
FRED H. FIHE		10-7-02



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GENERAL INFORMATION

EXAMINATION		ACCIDENT/INCIDENT (AI)	
Date	9-4-02	Aircraft Model	Cessna 310I
Facility	Teledyne Continental Motors	Serial Number	310I0145
Address	P.O. Box 90	Registration	N8145M
City	Mobile	Date of AI	7-4-02
State and Zip	Alabama, 36601	AI Location	San Dimas, CA

ENGINE INFORMATION

Make	TCM
Model	IO-470-U
Serial No.	118267-R
Total Time	Unknown
Time SOH	850
Engine Build Date	3-12-70 (rebuilt)

Significant Logbook Information:

Original logbooks lost. New logbook indicates estimated time as 850 SMOH.

Disposition of engine following exam:

Engine residuals were packed in cardboard box and placed in storage awaiting disposition instructions.

RECEIVING INFORMATION

Received at:	TCM
Date Received:	9-4-02
FAA/NTSB Tagged:	NTSB
Box Sealed:	Yes
Receiver No.	A67642
Remarks:	



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ATTENDEES

Name	Jason Ragogna	Name	Fred Fihe
Address	Arlington, TX	Address	P.O. Box 90, Mobile, AL 36601
Organization	NTSB	Organization	Teledyne Continental Motors
Phone No	[REDACTED]	Phone No	[REDACTED]
Name	Henry Soderlund	Name	W.G. Roebuck, J.M. Little
Address	Wichita, KS	Address	P.O. Box 90, Mobile, AL 36601
Organization	Cessna Aircraft Co.	Organization	Teledyne Continental Motors
Phone No	[REDACTED]	Phone No	[REDACTED]

REPORT SUMMARY:

This was the right engine on the above referenced aircraft.

Engine received heavy impact damage splitting the front of the crankcase open and bending the front of the crankshaft. Engine disassembly exhibited some minor metal contamination to the bearing surfaces, loose number 1 connecting rod piston pin bushing and minor bearing wear. None of these problems were causing a serviceability problem at time of this accident.

The fuel system components were flow tested on TCM production flow bench as received. The fuel system was placed on the left engine and run. See attached Aircraft Engine Test Log for data taken on the left engine run.

No problems were observed during the disassembly and functional check to indicate any loss of engine power.

EXTERNAL INSPECTION OF ENGINE

The engine exhibited heavy impact damage.

1. The crankshaft propeller flange was bent upward. The crankcase was broken out at the forward section.
2. Left magneto was broken off the accessory mounting pad.
3. Manifold valve mounting bracket was broken.
4. Oil cooler was broken off the engine.
5. Starter motor was broken off the starter adapter mounting pad.
6. Starter adapter rear pulley was broken.
7. Number 2 and 6 rocker covers were broken.
8. Engine oil sump was crushed.
9. Right rear engine mount leg was broken.
10. Induction tubes were broken at number 1, 2, 4 and 6 cylinders.
11. Induction balance tube was crushed.
12. Exhaust runner was torn off the right cylinders. Exhaust tubing was crushed and damaged.

ENGINE TEARDOWN AND EXAMINATION

INDUCTION SYSTEM

Induction balance tube was crushed and tubes at cylinders 1, 2, 4 and 6 were broken.



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EXHAUST SYSTEM

Exhaust system tubing was crushed and damaged. The runner was torn off the right side and a piece was hanging on the number 4 cylinder.

IGNITION SYSTEM:

MAGNETOS:

The "P" leads attached to both magnetos were separated from the wire shielding. Silicone material was on one lead, see attached photolog. The left magneto mounting flange was broken at the attachment points. Both magnetos were tested on the magneto Test stand and functioned normally across a 7MM sparkgap. The Left magneto exhibited arcing signatures at the rear ignition harness connection to distributor block. See pictures in photolog.

IGNITION HARNESS:

Cut and damaged. The magnetos were tested with slave harness.

SPARK PLUGS:

Number 2, 4 and 6 lower sparkplugs were oily. Number 4 bottom exhibited foreign debris around electrode. Plug electrodes appeared normal to worn out normal as compared to Champion Check-a-plug chart.

FUEL SYSTEM:

FUEL PUMP:

The fuel pump inlet fitting was broken. The pump drive was intact and pump turned normally. The fitting was replaced and pump functionally tested on TCM production flow bench. See chart below for data recorded.

RPM	FLOW - PPH	TARGET DISCHARGE PRESSURE - PSI	OBSERVED DISCHARGE PRESSURE- PSI
600	6.5 - 7.0	10.5 - 12.0	7.1
1600	37 - 38	18.5 - 21.5	33.4
2600	149 - 151	29	53.1
600	6.5 - 7.0	10.5 - 12.0	7.1
350	5.0 - 7.0	8 MINIMUM	2.8

Front fuel pump seal was leaking on test bench.

The fuel pump exhibited damage at the rear low pressure adjustment screw.



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FUEL PUMP continued:

This fuel pump was put on left engine at TCM test cell and run on that engine. The engine ran normally. Three runs were made at 1200, 2625 and 2380 RPM. See attached Aircraft Engine Test Log attached for data.

MANIFOLD VALVE:

The engine mounting bracket was broken from impact. The valve exhibited normal signatures. The manifold valve, lines and nozzles were put on TCM production flow bench for functional testing. See table below for those results.

SET FLOW	10 PPH	50 PPH	100 PPH	150 PPH
TARGET INLET PRESSURE	2.0 - 3.0	4.8 - 5.2	10.5 - 10.9	18.9 - 19.5
OBSERVED INLET PRESSURE	3.1	5.4	11.3	20.5

The engine had D12D nozzles installed. The specification for this manifold valve is D12C nozzles.

The manifold valve, lines and nozzles were installed on the left engine for functional test run. See Aircraft Engine Test Log for this recorded data.

INJECTOR LINES:

Injector lines were all intact.

NOZZLES:

All nozzles were visually inspected for obstructions. All nozzles were clear.

The nozzles were flowed with the manifold valve and also run on the left engine.

THROTTLE BODY/METERING UNIT:

The throttle link rod (throttle shaft to metering unit) was bent from impact. The throttle body was broken up. The mixture return fitting was broken off the metering unit.

The metering unit was removed from the damaged throttle body and installed on a slave unit. The link rod was straightened and the mixture return fitting replaced. The unit was placed on TCM production flow bench for functional testing. See table below for data recorded.



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THROTTLE BODY/METERING UNIT Continued:

THROTTLE ANGLE-SET	INLET PRESSURE-SET	FLOW PPH TARGET	OBSERVED FLOW TEST 1	OBSERVED FLOW TEST 2
0	7.8 - 8.2	6.6 - 7.1	9.8	4.5
8	13.4 - 14.0	30.6 - 34.6	41.5	31.8
16	14.8 - 15.6	57.3 - 61.3	70.2	59
21	15.5 - 16.5	72.8 - 77.8	89	74
28	15.1 - 16.2	94.0 - 99.0	106	94.3
36	12.9 - 14.1	106.2 - 111.2	117.5	107.7
FULL THROTTLE	9.8 - 11.0	130 - 134.5	134	124

The mixture control lever stop pin was missing as received. The hole was oval shaped and the pin appeared to be missing for some time. The first test was made with fluid leaking from mixture shaft. Test number 2 was made after replacing the "O" ring on the mixture shaft. Due to impact damage the "O" ring was damaged. There was no fuel stain around the shaft as received.

The throttle was placed on the left engine and functionally tested. See Aircraft Engine Test log sheet for the recorded results.

LUBRICATION SYSTEM:

OIL PUMP:

The oil pump drive shaft was intact. The pump cavity and gear edges were scratched from particle passage during service. The oil pressure relief valve was unobstructed. The tachometer generator pad was broken off the pump housing.

OIL SUMP:

The oil sump was crushed from impact. The sump contained some dirt and debris. The inside color was dark. No metallic debris was observed.

OIL PICKUP TUBE & SCREEN:

The pickup tube was damaged from impact crushing the oil sump. The pickup screen was unobstructed.



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CYLINDERS:

P/N: #1 - No numbers on flange, steel bores, head date 82
#3 - No numbers on flange, steel bores, head date 80
#5 - No numbers on flange, steel bores, head date 81

#2 - No numbers on flange, steel bores, head date 82
#4 - No numbers on flange, steel bores, head date 82
#6 - No numbers on flange, steel bores, head date 83

All steel cylinder bores had rusty spots due to lack of preservation. The combustion chamber exhibited dark colored deposits. Some fibrous debris was observed at the number 4 cylinder lower spark plug area.

VALVES:

The valves were not removed from the cylinders. After visually inspecting in cylinders, all the valves appeared normal.

VALVE SPRINGS:

The valve springs were not removed from the cylinders. All springs were intact and oily.

PISTONS:

Number 1 piston exhibited some damage to the piston pin boss due to a loose connecting rod pin bushing. The damage observed was not causing an operational problem at time of this inspection.

All piston crowns exhibited dark deposits.

RINGS:

All piston rings were free in their respective ring grooves.

PISTON PINS:

All piston pins exhibited normal operational signatures. The aluminum extruded plug ends were tight in the piston pins.

CRANKCASE ASSEMBLY:

CRANKCASE:

The crankcase exhibited massage damage at the nose from impact. The crankshaft was bent upward breaking away the front main bearing area. Fretting was observed at the number 2 and 3 main bearing boss parting surfaces. No bearing movement was observed at these areas.



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MAIN BEARINGS:

Main bearing exhibited wear exposing some of the copper layer. The surfaces were mostly intact except for the slightly worn areas.

CRANKSHAFT ASSEMBLY:

CRANKSHAFT:

The crankshaft was bent and fractured at the rear thrust face surface, due to impact. The number 1 connecting rod was removed to inspect its bearing and journal condition. All main journals and number 1 connecting rod journal exhibited normal lubrication signatures.

TRANSFER COLLAR:

The transfer collar was broken as a result of the nose impact damage.

COUNTERWEIGHTS:

Counterweights at crankshaft cheeks number 2 and 5 movements were free and unrestricted. The counterweights were not removed.

CONNECTING RODS:

All connecting rods moved freely on crankshaft journals and were securely fastened in place. Number 1 connecting rod piston pin bushing was loose in the connecting rod. The bushing had moved into the piston pin boss removing some aluminum.

ROD BEARINGS:

The rod bearing surface for number 1 connecting rod was intact with minor scratches from particle passage. The bearings exhibited normal lubrication.

CAMSHAFT:

The camshaft front governor bevel gear was bent due to the nose impact on the engine. The camshaft lobes exhibited normal operational signatures.

LIFTERS:

The lifter bodies exhibited rust etching signatures. The faces exhibited some pitting. No spalling had occurred at time of this inspection.

GEAR TRAIN:

Other than the impact damage to the camshaft governor drive gear, all gears established continuity and normal operational signatures. All gears were oily.



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ACCESSORIES:

STARTER ADAPTER:

Starter adapter drive gear was intact.

STARTER MOTOR:

Starter drive was intact. The drive turned normally.

GENERATOR:

The engine had a belt driven 50-Ampere generator. The generator exhibited impact damage and turned with resistance.

VACUUM PUMP:

The wet vacuum pump drive was intact and the pump rotated normally.

PROPELLER GOVERNOR:

Propeller governor drive turned freely.



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ENGINE COMPONENT LOG

COMPONENT	MANUFACTURER	PART NUMBER	SERIAL NUMBER
Crankcase	TCM	629257/629258 casting	Case broken at nose
Crankshaft	TCM	639664 forging	570
Main Bearing	Superior Air Parts	SA630464	
Connecting Rod	TCM	40742 forging	
Rod Bearings	Superior Air Parts	SA630826	
Camshaft	TCM	535661	
Lifters (Intake)	Superior Air Parts	SA628488	
Lifters (Exhaust)	Superior Air Parts	SA628488	
Cylinders	TCM	No part number on flange - steel	
Pistons	TCM	P/N 631481F inside pin boss	
Left Magneto	TCM	S6RN-201	969?09
Right Magneto	TCM	S6RN-205	927755
Spark Plug	Champion	RHB32E	
Fuel Pump	TCM	638156-3	4484R
Metering Unit	TCM	629904-2	18239
Manifold Valve	TCM	631427-A1	M1020RA
Nozzles	TCM	D12D	
Starter Motor	Delco-Remy	1105057	3375
Vacuum Pump	Garwin	G-450	No serial number found
Propeller Governor	Woodward	210444	1625089F

TYPE OF TEST ACC INVEST
 SL RATED 260 H.P. @ 2625 RPM
 TCM TEST SPEC. NO. 743011
 TEST STAND NO. 43 TYPE 100
 TEST CLUB NO. DIA. 4 1/2
 IGN. TIMING
 FUEL INJECTION MISC. TEMP
 NOZZLE INDENT.

AIRCRAFT ENGINE TEST LOG

N 814501

START DATE 9-6-07
 SHEET 1 OF 1

TCM MODEL J0470 L1
 TCM SERIAL NO 115276
 COLLAR LEAKAGE CHECK
 TEMPERATURE
 DIFFERENTIAL PRESSURE

ENGINE PERFORMANCE TEST
 BOTH MAGS 22100 R.P.M.
 R.H. 1975 L.H. 1950
 DROP R.H. 125 L.H. 150
 FUEL CUT OFF OK

TIME			R.P.M.		INTAKE PRESS.		OIL SYSTEM			FUEL SYSTEM				ATMOSPHERE				CYLINDER TEMP - F					
READING	A.M. P.M.	MIN.	DESIRED	ACTUAL	ADMP IN HG	INLET IN H2O	PRESS P.S.I.	TEMP °F	FLOW LBS/HR	NOZZLE PRESS	PUMP PRESS.	FUEL °F	ROOM °F	TURBO PRESS	MISC	COFF BARO	NO. 1	NO. 2	NO. 3	NO. 4	NO. 5	NO. 6	
1		5	1200	2316	116		62		2302.7	16.9	86	87					238	182	225	168			
2		5	1600	2569	119		57		379.35	19.0	86	87					290	222	272	189			
3		5	1600	2570					Magneto's Drop Check								356	344	340	284			
4		10	2100	2600	29.0		36		1328	17.2	29.9	94	93				356	346	345	286			
5		10	2500	2390	26.0		35		1000	11.4	300	94	93				356	323	334	277			
6		5	1600	2572	15		50		814	1.6	8.9	94	93				295	267	272	284			
With Right Engine Fuel Pump																							
1		5	1200	1138	18		10		24	2.5	16.5	87	89				207	169	201	142			
2		5	2600	2608	29.0		40		1308	16.9	29.3	96	96				256	338	337	285			
3		5	2330	2339	26.1		36		988	10.3	28.4	96	97				358	326	338	280			
With Right Engine Watering Unit + Magneto's / Nozzles																							
1		5	2250	2500	24.9		50		138	19.4	33	95	97				324	314	316	289			
1		5	2135	2500	28.9		38		138	19.6	33	95	97				343	340	338	274			

SPECIFIC OIL CON. AT _____ R.P.M. _____ LBS PER HR. TEST OPERATOR _____
 H P CORRECTED TO 29.92" HG. INLET AIR PR. & 60° F INLET TEMP. #1 _____
 REMARKS: #2 _____
 ACCEPTED DATE _____
 ACCEPTED TIME _____



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PHOTOLOG N8145M IO-470-U SERIAL 118267-R (RIGHT)

1. ENGINE CRATE



2. FRONT OF ENGINE IN CRATE



3. RIGHT SIDE



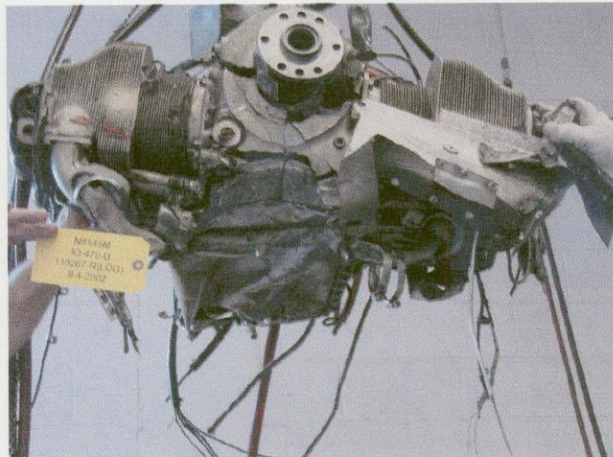
4. LEFT SIDE



5. REAR



6. FRONT UNDERSIDE





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PHOTOLOG N8145M IO-470-U SERIAL 118267-R (RIGHT)

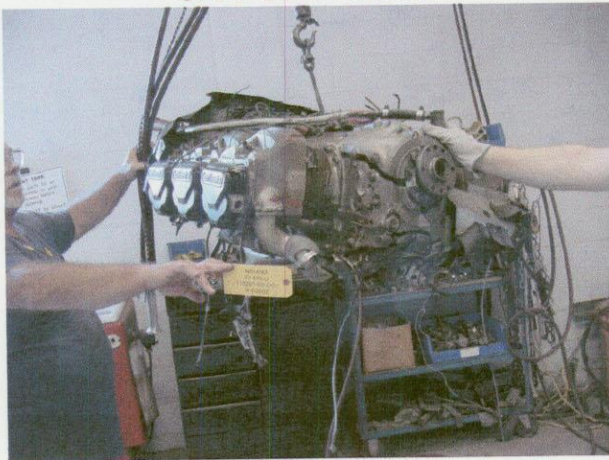
7. REAR UNDERSIDE



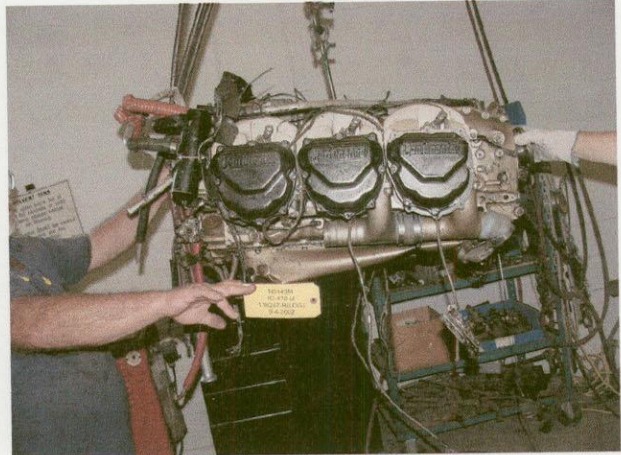
8. FRONT ON HOIST



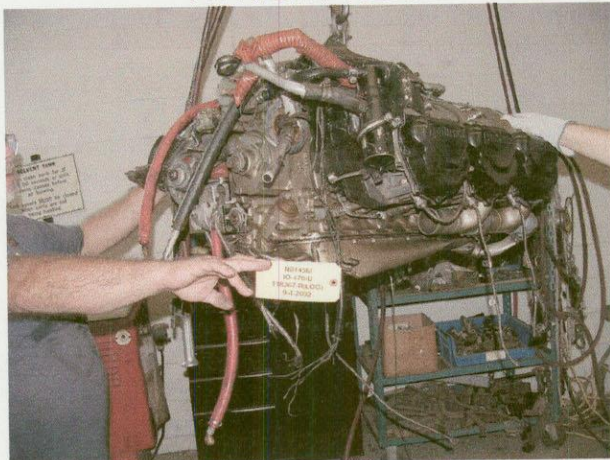
9. FRONT RIGHT



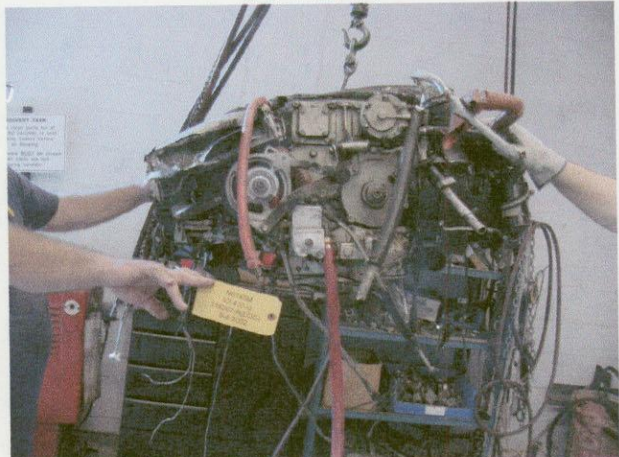
10. RIGHT SIDE



11. RIGHT REAR



12. REAR

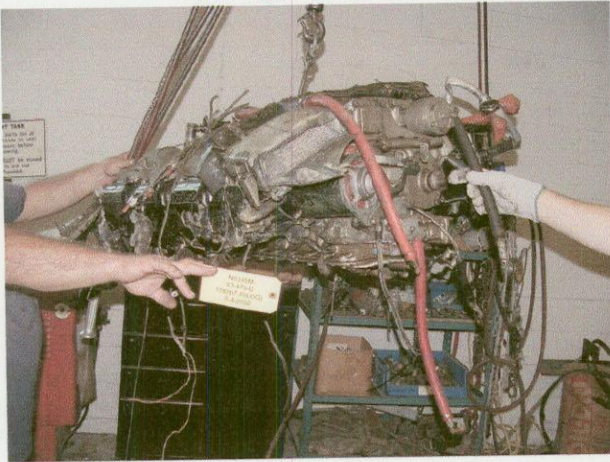




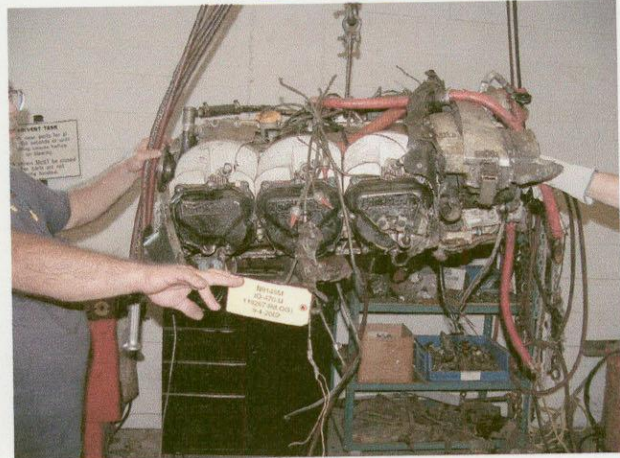
Teledyne Continental Motors, Inc.
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PHOTOLOG N8145M IO-470-U SERIAL 118267-R (RIGHT)

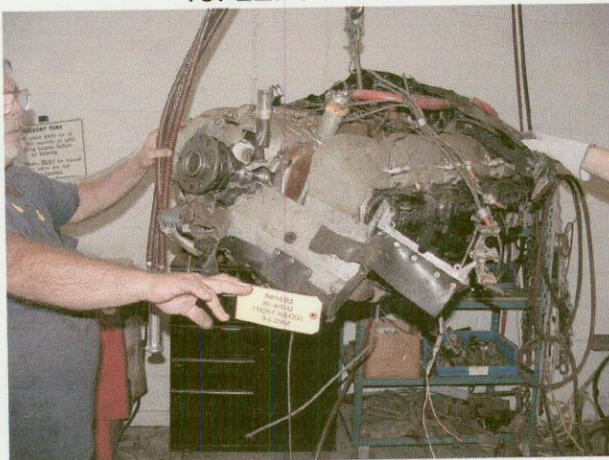
13. LEFT REAR



14. LEFT SIDE



15. LEFT FRONT



16. FRONT ON ENGINE STAND



17. CRANKCASE SPLIT OPEN



18. RIGHT SIDE





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PHOTOLOG N8145M
IO-470-U SERIAL 118267-R (RIGHT)

19. LEFT SIDE



20. REAR



21. LOOSE PARTS



22. LOOSE PARTS FROM BOX



23. ENGINE OIL SUMP



24. ENGINE OIL PUMP

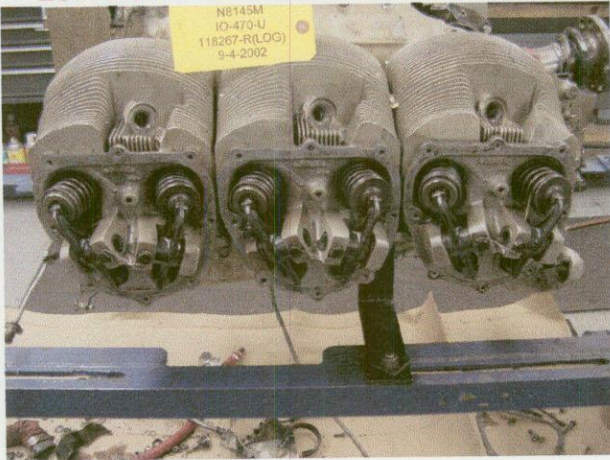




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A BENTLEY INTRACORP COMPANY

PHOTOLOG N8145M IO-470-U SERIAL 118267-R (RIGHT)

25. RIGHT CYLINDER OVERHEADS



26. LEFT CYLINDER OVERHEADS



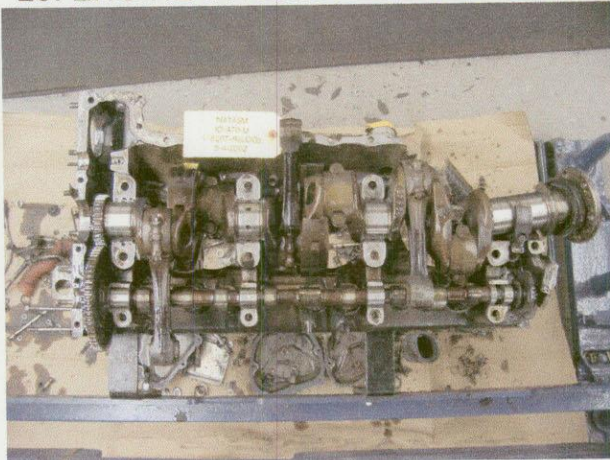
27. RIGHT CYLINDERS AND PISTONS



28. LEFT CYLINDERS AND PISTONS



29. ENGINE INTERIOR COMPONENTS



30. DAMAGED CRANKSHAFT





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31. CRANKSHAFT AND CON RODS



32. FRACTURED AT THRUST FACE



33. NUMBER 2 CON ROD BEARINGS



34. PROPELLER TRANSFER COLLAR



35. DAMAGE TO CAM GEAR



36. RUST ETCHING ON LIFTER BODY





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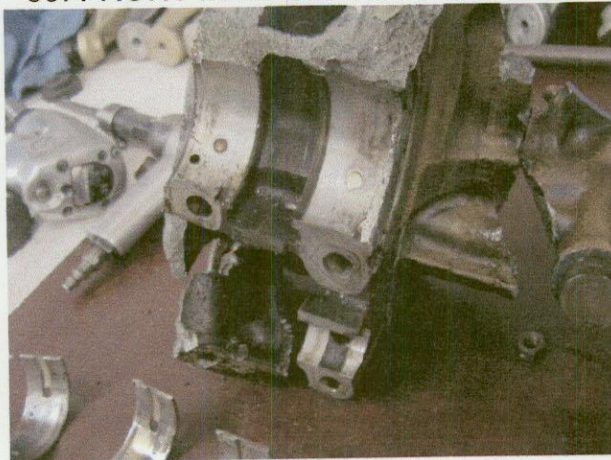
37. RIGHT CRANKCASE EXTERIOR



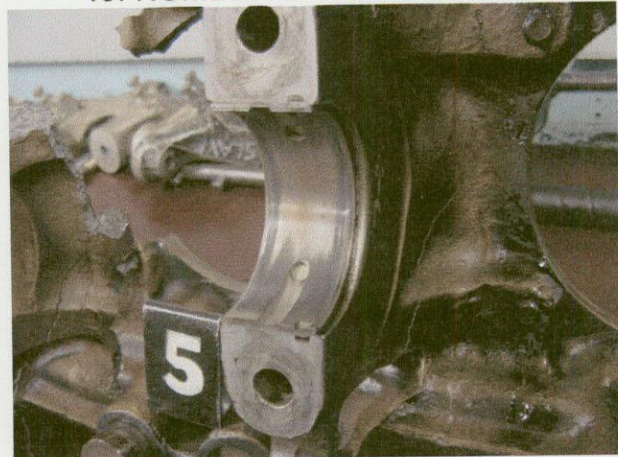
38. RIGHT CRANKCASE INTERIOR



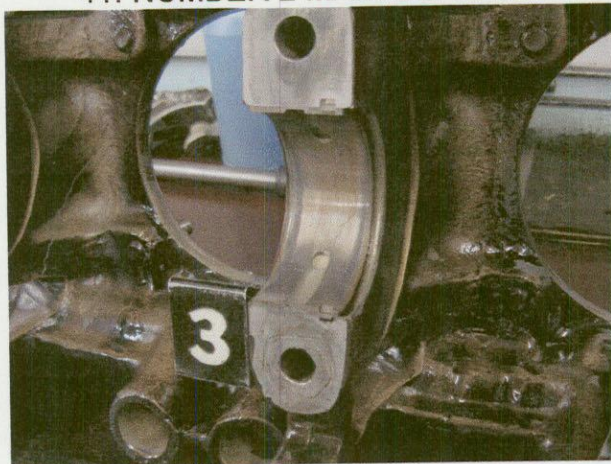
39. FRONT MAIN BEARING SADDLES



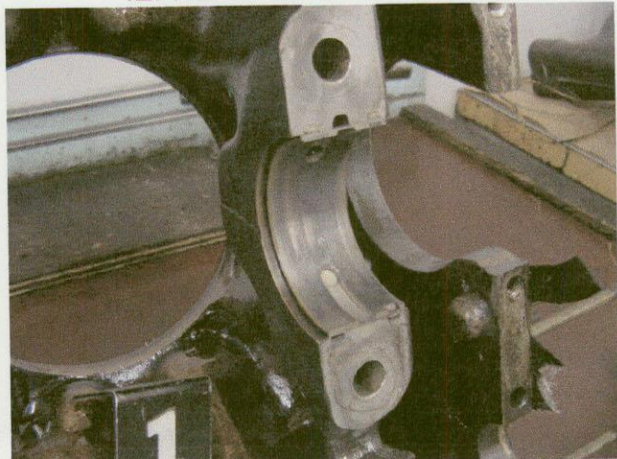
40. NUMBER 3 MAIN BEARING



41. NUMBER 2 MAIN BEARING



42. REAR MAIN BEARING

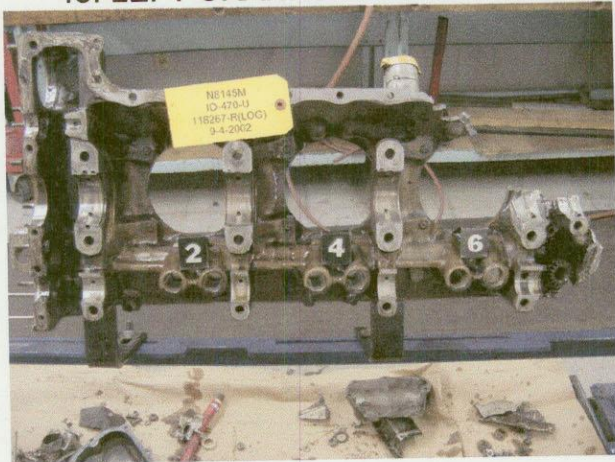




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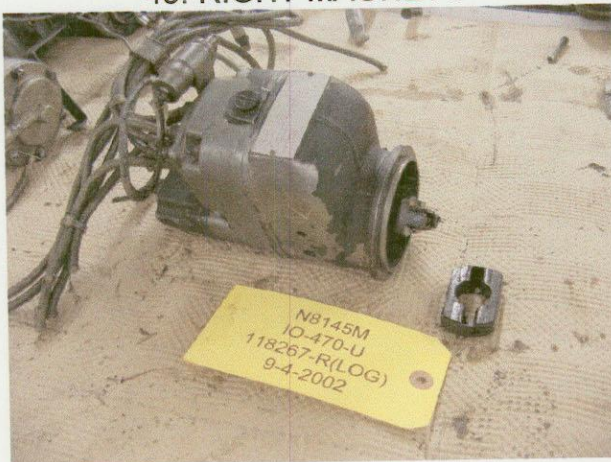
43. LEFT CRANKCASE INTERIOR



44. SPARK PLUGS



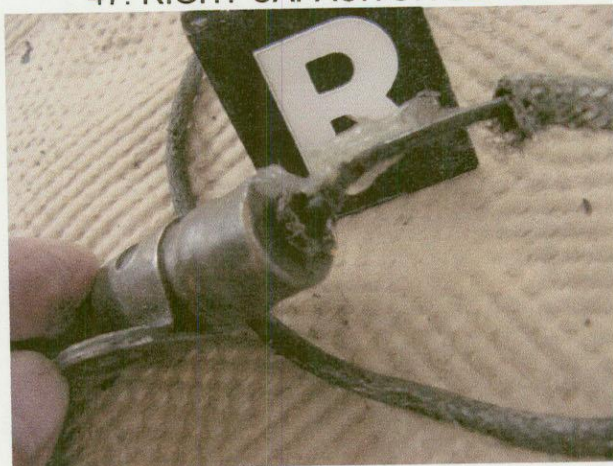
45. RIGHT MAGNETO



46. RIGHT MAGNETO ON TEST STAND



47. RIGHT CAPACITOR LEAD



48. LEFT MAGNETO ON TEST STAND

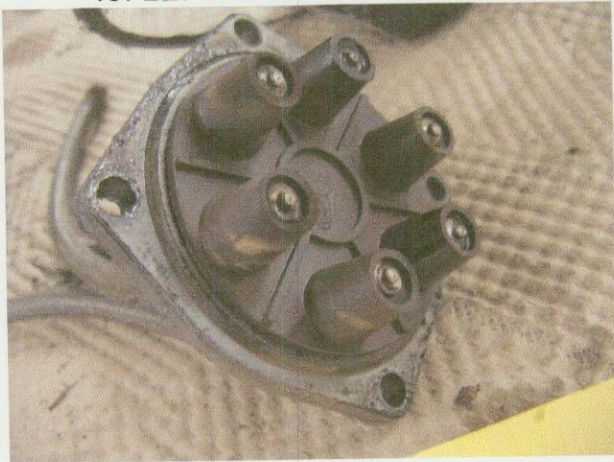




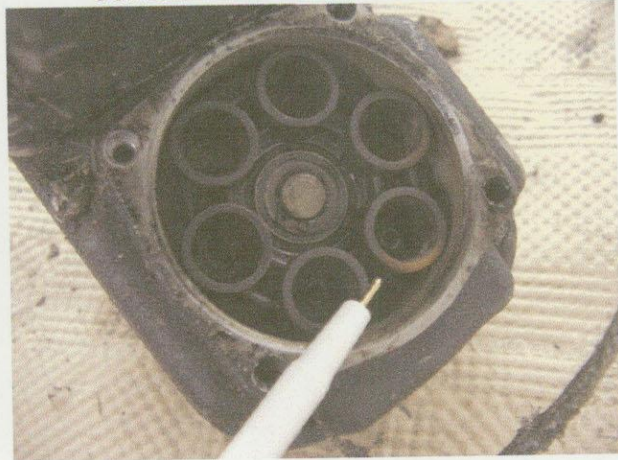
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PHOTOLOG N8145M IO-470-U SERIAL 118267-R (RIGHT)

49. LEFT MAGNETO ARCING



50. LEFT MAGNETO ARCING



51. STARTER ADAPTER



52. STARTER ADAPTER



53. OIL COOLER



54. STARTER MOTOR





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PHOTOLOG N8145M IO-470-U SERIAL 118267-R (RIGHT)

55. PROPELLER GOVERNOR



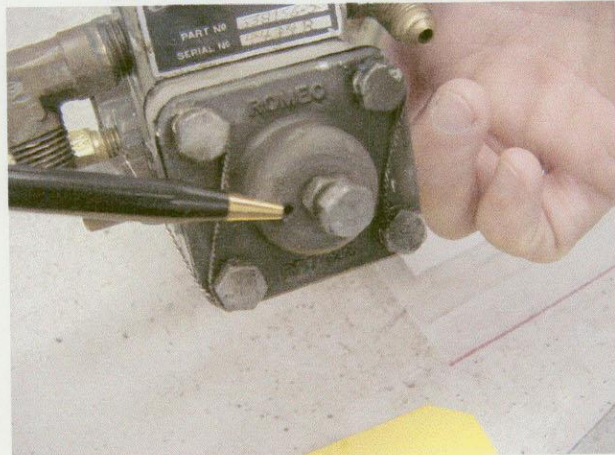
56. VACUUM PUMP



57. ENGINE FUEL PUMP



58. FUEL PUMP DAMAGED



59. FUEL PUMP



60. FUEL PUMP ON FLOW STAND





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PHOTOLOG N8145M IO-470-U SERIAL 118267-R (RIGHT)

61. MANIFOLD VALVE



62. FUEL METERING UNIT SCREEN



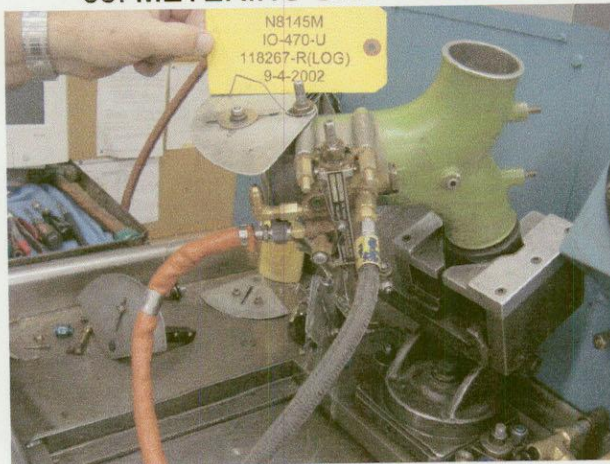
63. FUEL METERING UNIT



64. MISSING STOP PIN



65. METERING UNIT FLOWED



66. "O" RING LEAKING





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67. REPLACE "O" RING TO FLOW



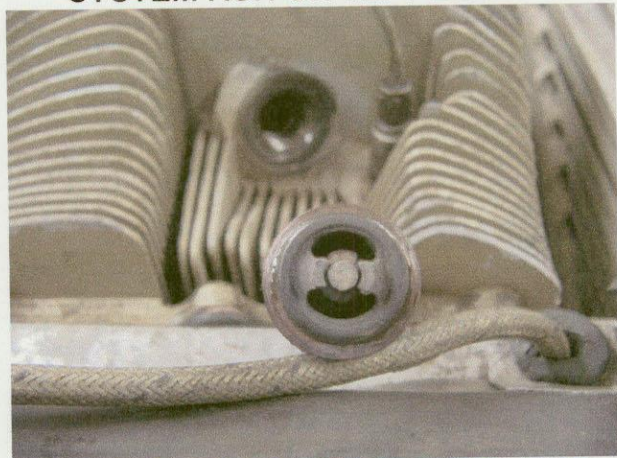
68. RETAINING PIN



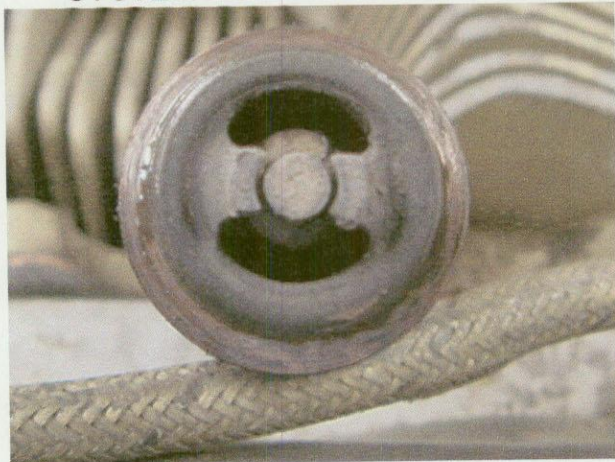
68. FUEL PUMP RAN ON LEFT ENGINE



69. SPARK PLUG AFTER RIGHT FUEL SYSTEM RUN ON LEFT ENGINE



70. SPARK PLUG AFTER RIGHT FUEL SYSTEM RUN ON LEFT ENGINE



71. SPARK PLUG AFTER RIGHT FUEL SYSTEM RUN ON LEFT ENGINE

