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Automatic Light Aircraft Readiness Monitor
Project ALARM

VOLUME II

Project 9R89-02-015-16
Contract DA 44-177-TC-641

January 1963

prepared by:
York Division of The Bendix Corporation
York, Pennsylvania
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Task 1D141812D18416
(Formerly Task 9R89-02-015-16)
Contract DA 44-177-TC-641
TRECOM Technical Report 63-10
January 1963

Project ALARM
AUTOMATIC LIGHT AIRCRAFT READINESS MONITOR
Phase II Test Program

VOLUME II
APPENDICES

Prepared by:
York Division of The Bendix Corporation
York, Pennsylvania

for:
U. S. ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS, VIRGINIA
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APPENDIX I

INSTALLATION DRAWINGS, ALARM

1. E1676475 - Installation, Interlocks, Control Display Box, Power Supply Supply

2. E1676492 - Installation, Engine Oil Level Sensors

3. C1676474 - Installation, Fuel Filter

4. C1676468 - Installation, XMSN Pressure Relief Valve

5. D1676466 - Installation, 42° Gear Box Sensors

6. D1676465 - Installation, 90° Gear Box Sensors

7. C1676487 - Installation, Engine Sensors

8. D1676467 - Installation, XMSN Accessory Gear Box Sensors

9. D1676469 - Installation, XMSN Temperature & Vibration Sensors

10. C1677335 - Installation, Tail Vibration Sensor

11. C1677334 - Installation, Low Frequency Vibration Sensor

12. C1677339 - Installation, Engine Oil Flowmeter

13. D1677336 - Installation, XMSN Input Quill Temperature Sensor

14. C1676470 - Installation, Swashplate Bearing Temperature Sensor

15. C1676464 - Installation, Hanger Bearing Temperature Sensor

These drawings will be furnished by USATRECOM upon written request to those agencies on the distribution list.
APPENDIX II

OPERATIONAL TEST DATA *

A. Transmission Top Vibration
B. Transmission Base Vibration
C. Aft Engine Vibration
D. Forward Engine Vibration
E. Tail Vibration

* All operational test data were recorded during the period of March 3, 1961, to June 16, 1961.
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**NOTE:** The table above lists various flight test data along with their corresponding vibration levels recorded as vector velocity (in/sec). Each entry includes the date, attitude during the test, and the vibration levels in different categories.
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APPENDIX III

MALFUNCTION TEST DATA *

A. Transmission Top Vibration
B. Transmission Base Vibration
C. Aft Engine Vibration
D. Forward Engine Vibration
E. Tail Vibration
F. Low Frequency Mast Vibration

* All malfunction test data were recorded during the period of June 6, 1961, to November 9, 1961.
## SECTION A

### MALFUNCTION TEST DATA-ALARM TRANSMISSION TOP VIBRATION

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Note: The table above shows the data recorded in G's (PK) for different conditions over several dates. Each condition is noted with corresponding G values for different frequency bands (0.5-1 kc, 1-2 kc, 2-4 kc, 4-8 kc, 8-12 kc, 12-16 kc, 16-20 kc, and ALL).
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CODE DESIGNATIONS:

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2. XMSN & Main Replaced (XMSN SN A12-142)  
3. Engine Replaced

ACCELEROMETER ORIENTATION:

* - 45° From Vertical  
** - Vertical  
*** - Lateral  
**** - Fore/AFT
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<td>All XMSN Oil Jets Blocked</td>
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<td>4B</td>
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**CODE DESIGNATIONS**

1. Flight Test Components (XMSN SN A12-20)

2. XMSN & Main Mast Replaced (XMSN SN A-12-142)

3. Engine Replaced

4. XMSN Replaced (XMSN SN A12-78)

4A. XMSN Input Quill Replaced (Annealed Gear & Bearing)

4B. .015" Flat Introduced on Lower Mast Bearing (Inner Race)
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<th>2-4kc</th>
<th>4-8kc</th>
<th>8-12kc</th>
<th>12-16kc</th>
<th>16-20kc</th>
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<td>4C.</td>
<td>Original Input Quill Re-Installed; Upper Planetary Gear Assembly Replaced</td>
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MALFUNCTION TEST DATA—ALARM
TRANSMISSION BASE VIBRATION (Cont'd)
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<td>Short Shaft Misalignment: 15 Shims Removed L. Rear Engine Mount. (≈.035&quot;)</td>
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<td>Tail Rotor Out of Track (4-1/2 Turns)</td>
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* Pick-up Output Directly into Meter (No Circuit Load)  ** All Data: 10-500 CPS
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* Pick-up Output Directly into Meter (No Circuit Load)  ** All Data: 10-500 CPS
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<td>4(x)</td>
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<td>0.09  0.11  0.195  0.185  0.145  0.16  0.44</td>
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<td>4(x)</td>
<td>Reference (''Bishop's Hat'' Installed)</td>
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### AFT ENGINE VIBRATION (Cont'd)

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#### MALFUNCTION TEST DATA-ALARM

**AFT ENGINE VIBRATION (Cont'd)**

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* Tail Rotor Torque Applied for Short Period During Run.
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** Unexplained Nominal Increase Noted This Date
## SECTION C (Cont'd)

### MALFUNCTION TEST DATA-ALARM

AFT ENGINE VIBRATION (Cont'd)

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### CONDITION CODE

**DESIGNATION**

1. Flight Test Components. (Eng. SN 00346)(XMSN SN A12-20)

2. XMSN and Main Mast Replaced. (XMSN SN A12-142)
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* All Data: 10-500 CPS  ** Original Pickup Mount (With Cantilever Resonance)
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* All Data: 10-500 CPS
** Original Pickup Mount (With Cantilever Resonance)
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**CONDITION CODE**

1. Flight Test Components: (Eng. SN-00346)(XMSN SN-A12-20)
## SECTION D (Cont'd)

### MALFUNCTION TEST DATA-ALARM

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### Section E

#### Malfunction Test Data – Alarm Tail Vibration

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***** CEC-4-118 Vibration Pick-Up Installed ≈ 30° From Vertical on 90° Gear Box
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**CONDITION CODE DESIGNATION:**

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<td>3</td>
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<td>10/17</td>
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<tr>
<td>10/20</td>
<td>3</td>
<td>Main Rotor Unbalance (2w.-W/Y)</td>
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<tr>
<td>10/20</td>
<td>3</td>
<td>Reference</td>
</tr>
<tr>
<td>10/23</td>
<td>3</td>
<td>Reference</td>
</tr>
<tr>
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<td>3</td>
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<tr>
<td>10/25</td>
<td>3</td>
<td>Uncentered Cyclic Control</td>
</tr>
<tr>
<td>10/30</td>
<td>3</td>
<td>Blade Set (Overtight Weekend Tie-Down)</td>
</tr>
<tr>
<td>10/30</td>
<td>3</td>
<td>Blade Set (2nd Run)</td>
</tr>
<tr>
<td>10/30</td>
<td>3</td>
<td>Uncentered Cyclic Control</td>
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<tr>
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<td>3</td>
<td>Main Rotor Unbalance (2w.-R/Y)</td>
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<td>10/30</td>
<td>3</td>
<td>Uncentered Cyclic Control</td>
</tr>
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<td>10/31</td>
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<td>Main Rotor Unbalance (1w.-R/Y)</td>
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<tr>
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<td>3</td>
<td>Main Rotor Unbalance (1w.-R/Y)</td>
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<td>CODE</td>
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<tr>
<td>10/31</td>
<td>3</td>
<td>Main Rotor Out of Track-4 Flats</td>
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<tr>
<td>10/31</td>
<td>3</td>
<td>Main Rotor Out of Track-4 Flats</td>
</tr>
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<td>3</td>
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<td>------</td>
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</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>Cyclic Beat</td>
</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>Cyclic Beat</td>
</tr>
<tr>
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<td>3</td>
<td>Main Rotor Unbalance (2w. - R/Y)</td>
</tr>
<tr>
<td>11/1</td>
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<td>Main Rotor Unbalance (2w. - R/Y)</td>
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<td>Main Rotor Unbalance (1w. - R/Y)</td>
</tr>
<tr>
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<td>Main Rotor Unbalance (2w. - W/Y)</td>
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<td>3</td>
<td>Main Rotor Unbalance 2w.-W/Y</td>
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<td>3</td>
<td>Main Rotor Unbalance 2w.-W/Y 1w.-R/Y</td>
</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>Main Rotor Unbalance 2w.-W/Y 1w.-R/Y</td>
</tr>
<tr>
<td>DATE</td>
<td>CODE</td>
<td>CONDITION(S)</td>
</tr>
<tr>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>Main Rotor Unbalance: 2w.-W/Y 1/2w.-R/Y</td>
</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>Main Rotor Unbalance: 2w.-W/Y 1/2w.-R/Y</td>
</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>2 Balance Wraps-W/Y Blade</td>
</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>2 Balance Wraps-W/Y Blade</td>
</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>2 Balance Wraps-W/Y; Out of Track - 1 Flat, PCL</td>
</tr>
<tr>
<td>11/1</td>
<td>3</td>
<td>As Above</td>
</tr>
<tr>
<td>11/3</td>
<td>3A</td>
<td>2 Balance Wraps - W/Y Blade</td>
</tr>
<tr>
<td>11/6</td>
<td>3B</td>
<td>2 Balance Wraps - W/Y Blade</td>
</tr>
<tr>
<td>11/7</td>
<td>3B</td>
<td>Balance Wraps Removed 1w. R/Y Blade</td>
</tr>
<tr>
<td>DATE</td>
<td>CODE</td>
<td>CONDITION(S)</td>
</tr>
<tr>
<td>------</td>
<td>------</td>
<td>----------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11/8</td>
<td>3B</td>
<td>1 w. - R/Y; 1/2 w-W/Y</td>
</tr>
<tr>
<td>11/8</td>
<td>3B</td>
<td>No Tape, Reference</td>
</tr>
<tr>
<td>11/9</td>
<td>3B</td>
<td>Reference: ≈ in-Balance</td>
</tr>
<tr>
<td>11/9</td>
<td>3B</td>
<td>Reference: ≈ in-Balance</td>
</tr>
<tr>
<td>11/9</td>
<td>3B</td>
<td>1/2 Wrap Tape - Unbalance</td>
</tr>
<tr>
<td>11/9</td>
<td>3B</td>
<td>1/2 Wrap Tape - Unbalance</td>
</tr>
<tr>
<td>11/9</td>
<td>3B</td>
<td>1 Wrap Tape - Unbalance</td>
</tr>
<tr>
<td>11/9</td>
<td>3B</td>
<td>1 Wrap Tape - Unbalance</td>
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### SECTION F (Cont'd)

**MALFUNCTION TEST DATA-ALARM**

**LOW FREQUENCY MAST VIBRATION (Cont'd)**

<table>
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<tr>
<th>DATE</th>
<th>CODE</th>
<th>CONDITION(S)</th>
<th>INDIC NOTED</th>
<th>DATA RECORDED AS VECTOR VELOCITY (IN/SEC)</th>
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<td>.2-3</td>
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**CODE DESIGNATIONS:**

1. **Flight Test Components**  
   (XMSN SN A12-20)

2. **XMSN & Main Mast Replaced**  
   (XMSN SN A12-143)

3. **XMSN Replaced**  
   (XMSN SN A12-357)

3A **Main Mast Pulled to Introduce .015" Flat on Lower Bearing Race**

3P **Main Mast Pulled to Replace Upper Planeta Gear System**
APPENDIX IV

OIL SAMPLE ANALYSES

The following samples of oil were filtered, and any material which was trapped on the filter paper was studied and tested.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Date Taken</th>
<th>Source of Sample</th>
<th>Observation of the Residue on Filter Paper</th>
<th>Magnetic Particles</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>9/6/61</td>
<td>Transmission before A.M. ground runs</td>
<td>Numerous black spots and some metallic flakes</td>
<td>None</td>
</tr>
<tr>
<td>B</td>
<td>9/6/61</td>
<td>Transmission after 2 runs</td>
<td>Some black particles</td>
<td>None</td>
</tr>
<tr>
<td>C</td>
<td>9/6/61</td>
<td>Engine before ground runs</td>
<td>No particles visible</td>
<td>None</td>
</tr>
<tr>
<td>D</td>
<td>9/6/61</td>
<td>Engine</td>
<td>No particles visible</td>
<td>None</td>
</tr>
<tr>
<td>E</td>
<td>9/7/61</td>
<td>Transmission</td>
<td>Some black spots</td>
<td>None</td>
</tr>
<tr>
<td>F</td>
<td>9/13/61</td>
<td>Engine</td>
<td>No deposits visible</td>
<td>None</td>
</tr>
<tr>
<td>G</td>
<td>9/13/61</td>
<td>Transmission</td>
<td>Some black particles and metallic flakes</td>
<td>None</td>
</tr>
<tr>
<td>H</td>
<td>9/15/61</td>
<td>Engine</td>
<td>No deposits visible</td>
<td>None</td>
</tr>
<tr>
<td>I</td>
<td>9/15/61</td>
<td>Transmission</td>
<td>Some black particles</td>
<td>None</td>
</tr>
<tr>
<td>J</td>
<td>9/25/61</td>
<td>Engine</td>
<td>No particles visible</td>
<td>None</td>
</tr>
<tr>
<td>K</td>
<td>9/25/61</td>
<td>Transmission</td>
<td>Some black particles</td>
<td>None</td>
</tr>
<tr>
<td>L</td>
<td>10/13/61</td>
<td>Engine</td>
<td>Some black particles</td>
<td>None</td>
</tr>
<tr>
<td>M</td>
<td>10/13/61</td>
<td>Transmission</td>
<td>Many black particles and some metallic particles</td>
<td>None</td>
</tr>
<tr>
<td>N</td>
<td>10/19/61</td>
<td>Engine</td>
<td>Some black particles</td>
<td>None</td>
</tr>
<tr>
<td>O</td>
<td>10/19/61</td>
<td>Transmission</td>
<td>Some black particles</td>
<td>None</td>
</tr>
<tr>
<td>Sample</td>
<td>Date Taken</td>
<td>Source of Sample</td>
<td>Observation of the Residue on Filter Paper</td>
<td>Magnetic Particles</td>
</tr>
<tr>
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<td>-------------</td>
<td>------------------------</td>
<td>-------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>P</td>
<td>10/20/61</td>
<td>Engine</td>
<td>Some black particles</td>
<td>None</td>
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<tr>
<td>Q</td>
<td>10/20/61</td>
<td>Transmission</td>
<td>Some black particles</td>
<td>None</td>
</tr>
<tr>
<td>R</td>
<td>10/24/61</td>
<td>Engine</td>
<td>No particles visible</td>
<td>None</td>
</tr>
<tr>
<td>S</td>
<td>10/24/61</td>
<td>Transmission</td>
<td>Numerous black particles</td>
<td>None</td>
</tr>
<tr>
<td>T</td>
<td>10/26/61</td>
<td>Transmission</td>
<td>Numerous black particles</td>
<td>None</td>
</tr>
<tr>
<td>U</td>
<td>10/26/61</td>
<td>Engine</td>
<td>No particles visible</td>
<td>None</td>
</tr>
<tr>
<td>V</td>
<td>10/26/61</td>
<td>42° - 90° Gear Box Detector Residue</td>
<td>Numerous black particles</td>
<td>None</td>
</tr>
<tr>
<td>W</td>
<td>10/26/61</td>
<td>42° Gear Box</td>
<td>Many yellow non-magnetic particles. Spot tests show copper present. Black particles are magnetic and give test for iron.</td>
<td>Black magnetic particles</td>
</tr>
<tr>
<td>X</td>
<td>10/26/61</td>
<td>42° Gear Box Flushing</td>
<td>Same as Sample W</td>
<td>Same as Sample W</td>
</tr>
<tr>
<td>Y</td>
<td>10/27/61</td>
<td>42° Gear Box Serviceable Flushing</td>
<td>Many black particles and some metallic flakes</td>
<td>None</td>
</tr>
<tr>
<td>Z</td>
<td>10/27/61</td>
<td>90° Gear Box Flushing</td>
<td>Many black particles and some yellow particles. Spot tests for iron and copper were negative</td>
<td>Few</td>
</tr>
<tr>
<td>101</td>
<td>11/3/61</td>
<td>Transmission</td>
<td>Some small black particles</td>
<td>None</td>
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<tr>
<td>102</td>
<td>11/4/61</td>
<td>90° Gear Box Flushing</td>
<td>Black gummy deposits</td>
<td>None</td>
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<td>Sample</td>
<td>Date Taken</td>
<td>Source of Sample</td>
<td>Observation of the Residue on Filter Paper</td>
<td>Magnetic Particles</td>
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<td>------------------</td>
<td>-------------------------------------------</td>
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</tr>
<tr>
<td>103</td>
<td>11/7/61</td>
<td>42° Gear Box</td>
<td>Many metallic chips. Spot test shows iron present.</td>
<td>None</td>
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<td>104</td>
<td>11/8/61</td>
<td>90° Gear Box</td>
<td>Black deposit. Metallic chips. Spot test shows iron present.</td>
<td>None</td>
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</tbody>
</table>
APPENDIX V

PROJECT HISTORY - DYNAMIC AIRCRAFT COMPONENTS

I. Transmissions:

A. S/N A12-20 - Serviceable as Received

All flight tests were performed with this gear box installed in A/C SN 57-6103. Total flight time can be referenced in flight records for this A/C.

Approximately 20 hours dynamic ground testing performed with this transmission installed.

No tests were performed that could be considered detrimental to the flight status of this component.

B. S/N A12-142 - Crash Damaged as Received

Installed for approximately 2 hours ground run time - vibration reference only.

Later disassembled for removal and use of various component parts in tests listed as follows:

1. Input Quill - Removed and annealed to approximately 1/2 hardness. Installed and tested for vibration and temperature in transmission S/N A12-78. Later removed from S/N A12-78 and will be shipped as a separate unit, painted red for purpose of identification.

2. Lubricating Jets Nos. 1, 2, & 4 - Removed and silver-soldered shut (jet holes and slots). Installed in transmission S/N A12-78 for specific tests and later removed. Note: These jets were not returned to normal condition and will be retained by BxY for possible future testing.

3. Upper Planetary Gear Assembly - Removed and installed in transmission S/N A12-78 as a result of bearing retainer failure in the gear assembly from that transmission. This original gear assembly from S/N A12-142 was not removed from S/N A12-78.

4. Sump Oil Drain Line - Removed and modified for installation of electrical chip detector in transmission S/N A12-78. Miscellaneous parts will be packed and shipped separately.

C. S/N A12-78 - 307 Hours as Received

This transmission presently installed on A/C S/N 57-6103. All potentially destructive tests were performed on this gear box. Specific tests performed and components effected as follows:

1. Approximately 6 hours ground run time with from 1 to 5 lubricating jets clogged. Original, unclogged jets are now reinstalled.

2. 0.015 inch flat filed on lower mast bearing inner race (Main Mast S/N C12-50). This mast is presently in this condition and installed in this transmission.

3. Approximately 30-minute ground run time with excessively low oil level for purpose of accelerated wear and resulting temperature and vibration effects.

4. Upper planetary gear assembly failure (bearing retainer) was an assumed direct result of tests outlined in paragraphs 1 and 3 above. This gear assembly was removed and replaced by an assembly from transmission S/N A12-142 for continuation of testing. The removed gear assembly will be shipped separately and painted red for purpose of identification.

5. Input quill assembly was removed and replaced by one which had gear and bearing annealed to 1/2 hardness. Upon completion of testing in this area, the original input quill was reinstalled.

6. Iron filings and chips were introduced in small increments as a quantitative evaluation of electrical chip detector operation. The total amount introduced in this manner is considered negligible in comparison to the particles present as a result of the bearing retainer failure outlined in paragraph 4 above.

7. Oil filter screen assembly was removed during a series of tests but has now been reinstalled.

II. Main Mast

A. S/N B12-39

Installed in transmission S/N A12-20 (Serviceable), used throughout flight testing and approximately 20 hours ground run time. Flight status of this mast has not been affected. Total flight time can be referenced in A/C flight records.

B. S/N C12-50

Presently installed in transmission S/N A12-78 which is now in the A/C, this mast was used in all tests conducted on that transmission (Ref. 1C). Paragraph
I. C. 2 should be specifically noted, where 0.015 inch flat had been filed on the lower mast bearing inner race. This was the only test performed that was specifically damaging to the mast itself.

III. Swashplate

A. S/N F19-12 - Serviceable as Received

Presently installed on A/C S/N 57-6103, this assembly was used throughout the testing program, both flight and dynamic ground tests. Just prior to the conclusion of testing, specific tests were performed to create an overheat condition by purging the swashplate bearing of as much lubricant as possible without complete disassembly. This attempt was unsuccessful, probably because of difficulty in removing sufficient lubricant by the method used. The bearing was not relubricated.

IV. Engines

A. S/N LE-00214 - Excessive Vibration as Received

This engine was never used during any phase of the test program. Presently canned and stored at NCGD.

B. S/N LE-00346 - Serviceable as Received

Used throughout flight tests and approximately 20 hours dynamic ground run time. Total flight time can be referenced in the flight log for A/C S/N 57-6103.

This engine came due for 200 hour inspection during the test program and is currently undergoing this inspection procedure at NCGD.

C. S/N LE-00112 - Due Overhaul as Received (500 Hour)

This engine is currently installed in the test bed A/C (S/N 57-6103) and was used for all tests which could be considered potentially damaging. Specific tests performed as follows:

1. Short-shaft misalignment - Shims removed from right and left rear engine mounts in different instances.

2. NII turbine unbalance, performed by rotation of NII wheel to out of balance positions at 90° and 180° from reference marks.

3. V band coupling (combustion chamber), loss of torque to the point of free rotation.
4. Short-shaft unbalance by the addition of a tape-attached weight to the outside of the shaft section.

The above specific tests involved ground runs of varying duration to reach the point of stable operation and then record applicable data.

One condition of unknown origin was noted during the course of testing. An intermittent, audible noise was present for 10 to 15 minutes after the start of a ground run from cold condition. This cycling noise was apparently caused by some abnormal condition in the aft section of the engine.

V. Gear Box (42°)

A. S/N A13-12 - Serviceable as Received

This gear box was retained as serviceable throughout flight tests and most of the dynamic ground test program. However, loss of the replacement gear box (S/N A13-68) due to extreme test conditions (to be listed in Paragraph VB) necessitated disassembly and reinstallation of the drive and driven gear quills into the modified housing of gear box S/N A13-68.

The housing from S/N A13-12 and the damaged component parts from S/N A13-68 have been packed and shipped as a unit.

B. S/N A13-68 - Due Overhaul as Received

All potentially damaging tests were performed on this gear box. Specific tests and components parts affected are as follows:

1. Gear box misalignment - Created by the installation of 1/2 inch spacers underneath the gear box at appropriate mounting points.

2. Input quill was removed and gear and bearing were annealed to approximately 1/2 hardness, then reinstalled and run for extended time intervals, noting resultant temperature and vibration changes.

3. Oil collector assembly has been removed and clogged in efforts to create an over-temperature condition. This condition was never cleared.

4. Two unexpected failures had occurred during the course of tests, probably resulting from repeated disassembly and extreme induced conditions as noted:
   a. Input quill duplex bearing failure consisting of a cracked retainer and rough operation.
   b. Loose input quill gear retainer nut allowed slippage of the input quill shaft.
5. Extreme low oil level condition created in efforts to accelerate wear on annealed components and fore valuation of resulting temperature increase.

All of the above noted tests involved ground runs of varying duration to allow A/C stabilization and accumulation of necessary data.

Cast quill retainers (external) were damaged on both input and output quills during the last of repeated disassembly and assembly operations. This necessitated disassembly and the use of quills from gear box S/N A13-12 for continuation of tests. (Note paragraph V. A.)

All internal components from this gear box have been removed and will be shipped along with the housing from S/N A13-12. The modified housing from this gear box and internal components from S/N A13-12 are presently installed on the A/C.

VI. Gear Box (90°)

A. S/N A13-15 - Serviceable as Received

It was the original intent to retain this gear box as a serviceable item. However, the input quill was removed by mistake and subsequent reassembly resulted in a cracked roller bearing. This bearing was removed and replaced by one from gear box S/N A13-90 and will be shipped in this condition.

B. S/N B13-510 - Due Overhaul as Received

This gear box was disassembled and the input quill gear and roller bearing removed and annealed to 1/2 hardness for installation and test in G/B S/N A13-90. The gear itself was later annealed for the second time to approximately 1/6 hardness and retested. Upon completion of this test, the gear was removed and will be shipped along with this donor gear box and the cracked roller bearing from S/N A13-15.

C. S/N A13-90 - Crash-Damaged as Received

All potentially damaging tests were performed on this gear box. Specific tests and component parts affected are as follows:

1. Input quill gear and roller bearing (removed from S/N B13-510), were annealed to 1/2 hardness and 1/6 hardness in separate tests and installed and run in this gear box. Gear was later removed (Ref. paragraph V.I.B.) and the original gear and heat treated bearing were reinstalled.

2. Metallic filings were introduced in small increments for quantitative analysis of chip detector operation. Upon test completion, the gear box was flushed and reserviced, however some residual particles may still be present.
3. Extreme low oil level tests were performed to accelerate wear on heat treated components and for over-temperature evaluation.

This gear box is presently installed on the A/C (S/N 57-6103). All original component parts have been reinstalled with the exception of the gear quill roller bearing which had previously been annealed.
CATEGORY: Design (Preliminary)  
SUBJECT: Automatic Light Aircraft Readiness Monitor (ALARM)
1.0 Scope: This specification is issued to establish the design, fabrication and test of an automatic light aircraft readiness monitoring system.

2.0 Applicable Documents:

2.1 Bxy Sales Order 616 (Statement of Work)
2.2 Bxy Installation Drawings (ALARM)
2.3 Project ALARM Phase I Report
2.4 Project ALARM monthly progress reports

3.0 Requirements:

3.1 General

3.1.1 The system shall automatically indicate the Go/No-Go status of all aircraft components or operational conditions considered amenable to electronic measurement techniques.

3.1.2 The resultant equipment shall be installed in the aircraft as part of the normal instrument array, and conveniently operable and observable by the pilot or co-pilot of the aircraft.

3.1.3 Solid-state circuitry and miniature components shall be used throughout to minimize overall system weight and volume.

3.1.4 The system shall perform as specified throughout an anticipated ambient temperature range of -20°C to +40°C.

3.1.5 The system shall perform as specified when subjected to vibration as follows:

a. 9 to 15 cps - .5 inch L. A. displacement
b. 15 to 500 cps - 5 g

3.1.6 The equipment shall be operated from the aircraft non-essential bus (provided this voltage is 28 VDC ± 20% and/or 105-125VAC, 400 cycle power from the Main Inverter. Power conversion modules (DC to DC or AC to DC) shall be of minimum size and weight and mounted in the battery or inverter compartments.
3.1.7 Design shall be fail-safe wherever possible to the degree that failure will result in a No Go indication.

3.2 Detailed Requirements

3.2.1 Control/Display Section

3.2.1.1 The Control/Display section shall consist of all switching and indicating components necessary to control monitor operation and indicate aircraft status.

3.2.1.2 Each monitoring channel shall be an independent electrical configuration from sensor to indicator lamp.

3.2.1.3 Illuminated legends shall be employed for each channel to identify the particular aircraft component or operational condition being monitored.

3.2.1.4 The illuminated legend shall light to warn of a No Go condition.

3.2.1.5 A single rotary switch shall be employed to select the following system modes of operation:

a. Off
b. Self-Check
c. Static
d. Dynamic
e. In-Flight

3.2.1.6 A self check mode shall be provided in which all legends are illuminated to pass in self check "High" and all are extinguished in self check "Low".

3.2.1.7 The Self-Check "High-Low" selector shall be a spring loaded toggle arrangement to prevent leaving this switch in "High" or "Low".

3.2.1.8 A satisfactory system condition when in self check "High" or "Low" shall illuminate a green indicator lamp labeled Self Check "Go".
3.2.1.9 The Static mode shall be used to interrogate all channels not requiring start-up of the aircraft power plant as part of their proper measurement.

3.2.1.10 Dynamic and In Flight modes shall be used for interrogation of all channels requiring start-up of the aircraft power plant as part of their proper measurement.

3.2.1.11 Dynamic and In Flight modes shall be identical with the singular exception that switching to In Flight changes No Go limits where necessary (See Para. 3.2.4.13).

3.2.1.12 Illumination of any legend indicating a channel No Go in any mode other than Self Check shall also cause the aircraft Master Caution light to illuminate.

3.2.1.13 Switching provision shall be provided to "lock-out" each individual channel separately at the operator's discretion to prevent the Master Caution light being energized by this channel.

3.2.1.14 Switching provision satisfying para. 3.2.1.13 requirement shall be capable of remaining in the "lock-out" position when subjected to shock approaching 50 g's, providing a record of switch positions if the aircraft crashes.

3.2.2 Interlocks/Continuity Channels

3.2.2.1 Channels indicating a No Go condition by operation of conventional switches shall be identified as Interlock channels.

3.2.2.2 If more than one switch is utilized in a particular channel to minimize wiring and/or number of separate indicator lamps, the maximum in such arrangements shall be six.

3.2.2.3 As a fail-safe consideration, operation of interlock switches shall be an open circuit indicating the No Go condition.
3.2.2.4 Channels indicating a No Go condition by providing continuity through sensing devices other than conventional switches shall be identified as Continuity Channels.

3.2.2.5 Each individual Continuity Channel shall have independent operation, including separate indicator lamp.

3.2.2.6 Self-Check of both Interlock and Continuity channels shall be such that complete continuity of wiring is checked and the indicator is energized by this continuity (may be independent of switch or sensor position).

3.2.2.7 The Go condition (complete continuity) shall hold a current sensitive DPDT relay energized; the contacts of this relay shall be utilized for controlling the illuminated legend.

3.2.3 Temperature Channels (Analog)

3.2.3.1 Channels indicating a No Go condition by operation of a thermostat or other temperature activated switching device shall be included as a Continuity Channel (See Para. 3.2.2).

3.2.3.2 Channels utilizing analog-type of temperature sensors such as thermocouples shall be identified as Temperature Channels.

3.2.3.3 All signal-conditioning circuitry and level detectors shall be of solid-state design and located in the main electronics chassis (with the Control/Display panel).

3.2.3.4 Detection levels of these channels shall be individually adjustable and of sufficient range to insure capability of measuring to any temperature above ambient required by the system.

3.2.3.5 Temperature detection levels shall be automatically adjusted +1°C for every +2°C change in ambient temperature.
3.2.3.6 The output circuitry shall hold a current-sensitive DPDT relay energized until the pre-set detection level is exceeded; the contacts of this relay shall be utilized for controlling the illuminated legend.

3.2.3.7 Self checking of these channels shall be performed by control of the ambient temperature generator such that all channels are caused to indicate No Go in "SC High" and Go in "SC Low", where these two conditions are ≥ 5% above the No Go condition and 25% below it, respectively.

3.2.4 Vibration Channels

3.2.4.1 Channels indicating a No Go condition by operation of an acceleration switch or other vibration-activated switching device shall be included as a Continuity Channel (See para. 3.2.2).

3.2.4.2 Channels utilizing analog-type of vibration transducers such as accelerometers shall be identified as Vibration Channels.

3.2.4.3 All signal-conditioning circuitry and level detectors shall be of solid-state design and located in the main electronics chassis (with the control/display panel).

3.2.4.4 There shall be provided Vibration Channels capable of detecting peak velocity in the 20 to 500 cycle per second range and adjustable to operate from .1 to at least 10 inches/second.

3.2.4.5 There shall be provided Vibration Channels capable of detecting peak velocity in the 100 to 500 cycle per second range and adjustable to operate from .1 to at least 10 inches/second.

3.2.4.6 There shall be provided Vibration Channels capable of detecting peak velocity in the 3 to 25 cycle per second range and adjustable to operate from .1 to at least 10 inches/second.

3.2.4.7 There shall be provided Vibration Channels capable of detecting peak acceleration in the 1 KC to 15 KC range, having a maximum sensitivity of .2 g at 15 KC and decreasing in sensitivity at the rate of 17 ± 1 db/octave below 15 KC and at the rate of 45 ± 2 db/octave above 15 KC.
3.2.4.8 The characteristic provided per Para. 3.2.4.7 shall be capable of adjustment such that the 15 KC sensitivity can be varied from .2 g to at least 2 g without affecting the specified attenuation characteristic.

3.2.4.9 Self-Check of channels specified in Para. 3.2.4.4 and 3.2.4.5 shall be accomplished by a 125 ± 5 cps signal introduced into the input in Self-Check High in place of the pick-up signal of an amplitude ≥5% above that required for a No Go indication at that frequency.

3.2.4.10 Self-Check of channels specified in Para. 3.2.4.6 shall also be accomplished as specified in Para. 3.2.4.9, with the exception that the signal shall be introduced into the channel immediately following the passive filter used to limit this channel's upper frequency response limit to 25 cps.

3.2.4.11 Self-Check of channels specified in Para. 3.2.4.7 shall be accomplished by a 7.5 ± 5 KC signal introduced into the input in Self-Check High in place of the pick-up signal of an amplitude ≥5% above that required for a No Go indication at that frequency.

3.2.4.12 Detection limits set into all vibration channels shall be held to within ± 3% over the specified ranges of environmental vibration and temperature (Para. 3.1.4 and 3.1.5).

3.2.4.13 All vibration channels shall be capable of having their No Go sensitivity reduced when the Mode Switch is moved from Dynamic to In-Flight.

3.2.4.14 All vibration Channels shall be delayed a minimum of 10 seconds after the detection limit has been exceeded (except in Self-Check) before indicating No Go.

3.2.5 Flow Monitoring Channel

3.2.5.1 A channel shall be provided capable of monitoring liquid rate-of-flow such as oil in the range of 2 to 7 GPM, with the flowmeter introducing no more than .75 psi pressure drop at a rate of 5 GPM.
3.2.5.2 The channel shall be capable of detecting a decrease in flow rate equal to 3% of the nominal flow, or 1 pint per minute, whichever is greater.

3.2.5.3 Self Check shall be accomplished as described in Para. 3.2.4.9, with the exception that the 125 ± 5 cps signal shall be introduced during Self-Check Low and the channel shall not indicate No Go (assuming flowmeter output is a frequency proportional to flow rate).

3.2.6 Engine Speed Monitoring Channel

3.2.6.1 A channel shall be provided capable of detecting when the aircraft engine power shaft RPM exceeds the maximum specified by the manufacturer.

3.2.6.2 This channel shall receive its input signal from the power shaft tachometer generator used in the normal cockpit RPM indicating system.

3.2.6.3 Accuracy of this channel shall be ± 1/4 of nominal RPM limit setting over the specified ranges of environmental vibration and temperature (Para. 3.1.1 and 3.1.2).

3.2.6.4 The channel shall be capable of retaining the No Go indication occurring as a result of engine over-speed until it is reset manually by operation of a Reset switch.

3.2.6.5 Self-Check shall be accomplished by introducing the 125 ± 5 cps signal into the system in place of the tachometer generator signal in Self-Check High to create the No Go indication (at this time the "lock-in" feature of Para. 3.2.4.4 shall be disabled.)

4.0 Materials and Workmanship

4.1 Materials used in the construction of the system shall be of a quality which is appropriate for the particular application.
4.2 Non-critical materials and standard parts shall be used whenever possible, provided such use in no way affects compliance with Para. 3.0 of this specification.

4.3 All items developed shall be fabricated and finished in a manner such that criteria of appearance, fit, and adherence to specified tolerances are observed.

4.4 Particular attention shall be given to neatness, thoroughness of soldering and wiring, plating, machine screw assemblage, and freedom of parts from burrs and sharp edges.

5.0 Inspection and Tests

5.1 Records of all inspection work and tests, giving the results of such tests, shall be available to the contracting agency at all times.