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SUBJECT

Proof and Operation Tests of Flight and Trim Controls

MODEL: XC-120

FAIRCHILD AIRCRAFT
Division of
FAIRCHILD ENGINE & AIRPLANE CORPORATION
HAGERSTOWN, MARYLAND

Test Date - 12/19/49 to 5/2/50

Report Date: 1/24/50

No. Pages: 70

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Approved By F. E. Howard
Chief of Design Testing

REVISIONS

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Subject: Proof and Operation Tests of Flight and Trim Controls

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References

Specifications
(a) USAF Spec. R-1803-7B "Control Systems."
(b) USAF Spec. R-1815B, "Flying Qualities of Piloted Airplanes."

Reports
(c) Fairchild Eng. Report R107-720 "Control System Analysis XC-120."
### Drawings

- (f) 107-720111 - Aileron Control System - Isometric.
- (g) 107-720109 - Rudder Control System - Isometric.
- (h) 107-720110 - Elevator Control System - Isometric.
- (i) 107-720111a - Trim Tab Control System.
- (j) 107-720112 - Lock System - Surface Controls.
- (k) T78-713 - Dummy Loading Fixture - Outboard Aileron.
- (l) T78-714 - Dummy Loading Fixture - Inboard Aileron.

### Photographs

- 18047 - View Showing Method Used to Apply a Hinge Moment on the Elevator or Elevator Trim Tab Through a Whiffle Tree Attached to the Trim Tab.
- 18051 - Setup View of Method Used to Apply a Side Load on Both Rudders Simultaneously.
- 18052 - View of Device Used to Apply a Forward Load on the Rudder Pedal. Nose Section of Airplane was Removed to Permit this Type of Loading.
- 18055 - View of Loading Device Attached to the Rudder Pedal for Application of Simulated Braking Forces at the Tip of the Brake Pedal. Note Dial Gages Used to Determine Structural Deflections.
- 18158 - View of Cockpit Loading Fixture Used to Apply Simulated Aileron Control Wheel Forces. Note Dummy Wheel and Quadrant Which Replaced Pilot's Wheel.
- 18160 - View Showing Installation of Dummy Ailerons on Left Hand Wing and Method of Applying a Down Load on Them.
- 18162 - View Showing Dummy Ailerons Installed on Right Hand Wing and Method of Applying an Up Load on Them.
- 18164 - View of Setup Used to Determine the Friction of the Pulleys in the Loading System Used During Some of the Control Systems Tests.
- 18563 - View of Engine Control Pedestal Showing Control System Locking Handle and Method Used to Apply Load to it.
The purposes of the tests conducted on the flight and trim controls were:

1. To determine the behavior of the flight and trim control systems under static proof loads and to observe deflections in the system for proof of conformance to the rigidity requirements of U.S.A.F. Spec. R1803-TB.

2. To perform operational tests of the flight and trim control systems to check their conformance to friction requirements as set forth in U.S.A.F. Spec. R1815-B.

3. To observe the structural behavior, alignment, clearances, etc., of the component parts of the control system while in operation under load.

4. To establish the method and forces required to engage the surface control locks, and to observe the uniformity of operation of the complete control locking system. Also to observe the rigidity and structural integrity of the system in general, when a limit design handle force of 50 lbs. was applied.

SUMMARY AND CONCLUSIONS:

a. In general, all tests were conducted using the same test setups and equipment as used on the C-119Q flight and trim controls tests. Ref. (c). Operational tests of the aileron, rudder, elevator, and elevator trim tab control systems were conducted by applying dead weight to achieve the limit surface hinge moments and balancing cockpit control loads in 20% increments up to full test load. After applying each balanced increment of load, the control was operated using a spring scale to measure the additional force required to move the control through neutral in both directions. This was done to determine the system friction which was taken as the average of the added force in both directions.

b. Operational tests of the electrically actuated aileron and rudder trim tabs were conducted under load, applied to the tabs in 20% increments, up to the proof load. Data on voltage and current required by the actuator motor to operate the loaded tabs were taken to determine the power input to the systems and operating times.

c. Proof tests of the entire control systems were performed by first placing the control system under test in the most critical deflected position and then loading both the surfaces and the control units by dead weight computed from the geometry of the system to be in balance. In this manner the entire system was most effectively loaded under the full proof load. The control unit was returned to a fixed reference position at each loading position and the deflections of the surfaces determined. Proof tests of surface or control stops, brake pedals and other detail portions of the system were conducted by placing the control or surface in the required attitude and applying dead weight loads to them in 20% increments.
d. Rigging loads were maintained as closely as practicable to the values as specified in R107-024 "Rigging Specifications, XC-120." Cable tension readings were recorded before and after each proof and deflection test. Cable tensions were in general, near the high end of the range of tolerance before test, and near the middle or low end of the range after test. No cable tensions changed sufficiently during test to require re-rigging to reasonably meet minimum specification conditions.

e. The proof and operation tests of the flight and trim controls of the XC-120 airplane, as reported herein, indicate that the control systems are satisfactory from a strength, rigidity and operational standpoint. The friction forces required to operate the primary flight controls were, at the time of test, in excess of the allowances set forth in U.S.A.F. Spec. R1815-3, "Flying Qualities of Piloted Airplanes." These higher friction forces are due to the facts that:

1. The tests were conducted immediately after completion of installation and rigging of the controls and prior to any repeated operation which would "run in" the controls and reduce the friction.

2. The subject airplane has an unusual configuration, employing a dual set of controls and using a larger number of pulleys and fairleads than usually employed in a conventional airplane. The relatively large number of pulleys and fairleads is necessary because of the necessity of routing the cables through crew nacelle, wings and booms to transmit the necessary forces from the pilot's and copilot's controls to the surface.

A complete summary of the procedure for and results of each test is given in the following Table I.
<table>
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<th>Table I - Summary of Tests</th>
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<td><strong>Aileron Control System</strong></td>
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<tr>
<td>1. Test A-1 - Proof and Deflection Test</td>
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<tr>
<td>2. Test A-2 - Test of Wheel Stops</td>
</tr>
<tr>
<td>3. Test A-3 - Operation Test of the Entire Aileron Control System</td>
</tr>
<tr>
<td>Test Condition</td>
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</tbody>
</table>
| Test A-1 - Proof Load Test of Partially Shot-Out System - Pilots fuselage cables disconnected and control surface locks engaged - 100% pilot effort (160#) and 50% copilot effort (80#) applied simultaneously and resisted by surface locks. This loaded locks to 150% max. single pilot effort. | 160 lbs. rim force on pilots wheel. 80 lbs. rim force on copilot's wheel. | None | System sustained load satisfactorily. System carried 75% of double pilot load normally carried by complete system as per requirements of Par. D-3a of Spec. R1803-7B. Deflection of the entire system (pilot's fuselage cables disconnected) resulted in 86° rotation of pilot's wheel and 63° rotation of copilot's wheel. This amounted to 55° and 41° respectively of the total available angular travel (150°) of the control wheels. Permanent sets at 20% after 100% were 5° in both pilot's and copilot's wheel. These sets represent 3% of total wheel travel in either direction. Control surface locks withstood 150% max. single pilot effort (240#). Diagram of System. |}

**II Rudder Control System**

1. **Test B-1 - Operation Test of Entire Rudder Control System.** All cables hooked up for purpose of determining friction losses and observing the operation of the system under load - 50% double pilot effort - Hinge moment applied to each rudder surface with load resisted in cockpit on pilot's and copilot's right pedals - Surfaces operated under load.

<table>
<thead>
<tr>
<th>Load Applied In Cockpit Lbs.</th>
<th>Moment Applied at Surface In-Lbs.</th>
<th>Results of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 lbs. per rudder pedal, applied simultaneously</td>
<td>1630 in. lbs. to the left,</td>
<td>System functioned satisfactorily. Friction varies from 19.4 lbs. at no load to 33.5 lbs. at 50% of double pilot limit load. Max. allowable friction load is 15# (Ref. (b)). Friction should decrease as systems are further run in.</td>
</tr>
<tr>
<td>Test Condition</td>
<td>Load Applied in Cockpit Lbs.</td>
<td>Moment Applied at Surface In-lbs.</td>
</tr>
<tr>
<td>----------------</td>
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<td>---------------------------------</td>
</tr>
<tr>
<td>2. Test H-2 - Proof and Deflection Test. To determine the deflection of the complete system at a surface load producing 70% double pilot effort (420#) equally applied at pilot's and copilot's right rudder pedals - Rudder pedals in critical full fwd. length adjustment - rudders far enough to right of neutral to avoid hitting left hand stops under full load - spring tab controls not blocked - copilot's right hand pedal maintained at a constant position.</td>
<td>210 lbs. fwd. to the left on each rudder.</td>
<td>System sustained load satisfactorily. Max. average surface deflection due to control system stretch at 70% limit load was 9.7°. Maximum permissible deflection is 10° (Ref. (a)). Pilot's pedal deflection, relative to copilot's pedal, was not large enough to permit accurate measurement.</td>
</tr>
<tr>
<td>3. Test R-3 - Test of Surface Locks Under Ground Loading - Surface locks on one rudder locked in place - upper and lower surfaces loaded in 20% increments to 100% limit hinge moment.</td>
<td>None</td>
<td>Surface and surface locks sustained load satisfactorily. At 100% proof load, upper surface deflected 1.9°, while lower surface deflected 2.8°. Permanent sets negligible.</td>
</tr>
<tr>
<td>4. Test R-4 - Test of Typical Rudder Pedal Stop - 100% single pilot's right rudder effort (300#) on pilot's right pedal. All surface and pedal stops, except that carrying the load, backed out of contact.</td>
<td>300 lbs. on pilot's right rudder pedal</td>
<td>None</td>
</tr>
<tr>
<td>Item Tested and Test Condition</td>
<td>Load Applied in Cockpit Lbs.</td>
<td>Moment Applied at Surface In-lbs.</td>
</tr>
<tr>
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</tr>
<tr>
<td><strong>5. Test R-5 - Test of Mechanical Portion of Pilot's Brak System</strong> - Load applied at tip of pilot's left and right pedals at right angles to pedal pivot axes - rudder pedals locked in neutral and placed in the critical full fwd. length adjustment - level of oil in one brake cylinder set so that cylinder would deflect 1 1/6&quot;, when the pedal was loaded, and come to a solid stop on the head of oil at that point - other brake cylinder replaced by a solid link. Load not carried beyond master brake cylinders.</td>
<td>300 lbs. at tip of both pilot's pedals simultaneously.</td>
<td>None</td>
</tr>
</tbody>
</table>
| **6. Test R-6 - Proof Test of a Partially Shot Out System - Rudder pedals set in critical fwd. length adjustment - cables in right hand boom disconnected - rudders deflected 14° right prior to loading and a corresponding fixed position noted for copilot's left pedal - position of copilot's left pedal maintained throughout test while measuring surface deflection.** | 300 lbs. fwd. on copilot's right pedal. | 3360 in. lbs. applied to the left on the right rudder. | Deflection of entire control system at 100% proof load, corrected for spring tab control deflection, was equivalent to 12° at the left rudder and 13.7° at the right rudder. Permanent sets were no more than 0.2° of rudder deflection. System sustained load satisfactorily - Defl. of rudder pedals relative to copilot's left pedal at 100% load:  
Copilot right - 2° fwd.  
Pilot right - 3° aft.  
Pilot left - 3° fwd. |
### III Elevator Control System

1. **Test E-1 - Proof and Deflection Test**
   - Deflection test of entire system at 70% double pilot effort applied equally at the two columns. - Copilot's control column held fixed at all levels of loading.
   - Load Applied in Control Column: 210 lbs. aft
   - Moment Applied at Surface Column: 6560 in. lbs.
   - Results of Tests:
     - Diagram of System.
     - System sustained load satisfactorily. Overall deflection at 70% limit load was 11.0°. Max. specified deflection is 10° (Ref. (a)) Permanent set in terms of elevator deflection, was 1.5° indicating some permanent stretching of the cables. At max. load the top of the copilot's column deflected 0.28 inches relative to the fixed base of the column.

2. **Test E-2 - Operation Test of Entire Elevator Control System**
   - 50% double pilot effort - Hinge moment applied to surface with load resisted at pilot's and copilot's columns. Surface operated under load.
   - Load Applied in Control Column: 150 lbs. aft
   - Moment Applied to the Elevator Column (down): 4670 in. lbs.
   - Results of Tests:
     - System functioned satisfactorily. Friction varied from 14 1/2# at no load to 19.7# at 50% double pilot limit load. Max. permissible friction is 8# (Ref. (b)) Friction should decrease after system is run in.

3. **Test E-3 - Proof Test of a Partially Shot Out System**
   - Copilot's fuselage cables and left hand boom cables disconnected - hinge moment applied to surface column resisted by load on both control columns - elevator deflected up 2° at no load. The copilot's column was held in fixed position while loading system.
   - Load Applied in Control Column: 300 lbs. aft
   - Moment Applied at Copilot's Column (downward on the elevator): 7000 in. lbs.
   - Results of Tests:
     - System sustained load satisfactorily. Deflection of elevator at max. load was 26° (adjusted for deflection due to spring tab) Permanent set was 1° after loading to max. load. Torsional deflection of connecting tube between the two columns was about 2.25° at 300# column load.

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<table>
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<tr>
<th>Test Case</th>
<th>Test Condition</th>
<th>Load Applied in Cockpit Lbs.</th>
<th>Moment Applied at Surface In-Lbs.</th>
<th>Results of Tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test E-4</td>
<td>Test of Control Column Stop - 100% single pilot effort - fuselage cables on copilot's side disconnected - columns moved aft until stop at sector on the pilot's side was contacted. Load applied on copilot's column and reacted at pilot's side stop. All other stops backed off - out of contact.</td>
<td>300 lbs. aft on copilot's column only.</td>
<td>None</td>
<td>Stop sustained load satisfactorily. Deflection between base of pilot's column and sector, due to deflection in linkage was 0.8° column rotation at full pilot effort.</td>
</tr>
</tbody>
</table>

### IV Aileron Trim Tab Controls

**Proof and Operation Test of Tab Actuator and Connecting Linkage**
Outboard tab of inboard right hand aileron loaded - aileron surface locked in neutral - tab operated to both extremes of travel.

<table>
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<tr>
<th></th>
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<th>480 in. lbs.</th>
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Diagram of System
System functioned satisfactorily. Current to operate from neutral to full up increased from 1.6 amps at zero load to 1.82 amps at 100% proof load. The corresponding times were 7 seconds at zero load and 8.5 seconds at 100% proof load. The structural deflection of fully deflected tab at 100% proof load was 1.36°.

### V Rudder Trim Tab Controls

**Proof and Operation Test of Tabs Actuator and Connecting Linkage**
Left hand tab loaded - right hand actuator disconnected - rudder control surface locked in neutral - tab operated to both extremes of travel.

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<th>527 in. lbs.</th>
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Diagram of System.
System functioned satisfactorily. Current to operate surface from neutral to fully deflected varied from 1.56 amps at no load to 1.85 amps at 100% proof load. The corresponding times were 7.5 seconds to 9.9 seconds. The deflection of the rudder trim surface at 100% proof load was 0.9° in neutral and 0.7° in the fully deflected position.
## Elevator Tab Controls

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<th>Test #1</th>
<th>Test #2</th>
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<td><strong>Proof and Deflection Test of Elevator Spring Tab Controls</strong></td>
<td><strong>Proof Test of Elevator Trim Tab Control Fwd. Stop.</strong></td>
</tr>
<tr>
<td>Elevator control surface control horn just in contact with stop on horn support bracket.</td>
<td>Load applied, with spring scale, to rim of copilot's tab control wheel, and reacted at pilot's control wheel stop.</td>
</tr>
</tbody>
</table>

### Test #1
- Sufficient to hold elevator surface control horn just in contact with stop on horn support bracket.
- Diagram of System
  - System sustained load satisfactorily. Max. tab deflection, relative to elevator, was 4.9° at 100% limit load. There was no permanent set in the system.

### Test #2
- 75 lbs tangentially applied to rim of elevator trim tab control.
- System sustained load satisfactorily. Max. angular deflection of copilot wheel, at 100% limit load, was 8.93°. There was no permanent set in the system.
<table>
<thead>
<tr>
<th>Item Tested and Test Condition</th>
<th>Load Applied in Cockpit Lbs.</th>
<th>Moment App. at Surface In-lbs.</th>
<th>Results of Tests</th>
<th>Tables Figures Photos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test #3 - Friction and Operation Test of Elevator Trim Tab Control System - Elevator trim tab moved to full up tab (nose down) position - copilot's tab control wheel operated in a nose down direction, by means of webbing and a spring scale, against the load - repeated with wheel moving in a nose up direction through neutral.</td>
<td>Sufficient to operate system.</td>
<td>822 in. lbs. at tab.</td>
<td>System functioned satisfactorily. Operating torque on copilot's wheel was 76 in. lb. at 100% limit load.</td>
<td>Fig. 40</td>
</tr>
</tbody>
</table>

**VII Control Lock System**

| | 50 lb Max. |
| | - |

Description of System

It was found that the control locks could be readily engaged when the control surfaces were in neutral or were gently oscillated about neutral. Under these conditions the average force needed to engage the locks varied from 42 to 43 lbs. applied at the center of the pistol grip.

| | Migs. 41 and 42 |
DESCRIPTION OF SPECIMEN: 1. During these tests (Dec. 19, 1949 to May 2, 1950) the airplane was in the factory in a nearly completed state. Before testing each system, the system was checked and certified correct by the Fairchild Inspection Dept., as to installation, adjustment and rigging tensions, in conformance with Ref. (d).

On this aircraft, ailerons, rudders, elevator, elevator trim tab, and the control locks are cable operated while the aileron and rudder trim tabs are electrically actuated.

The primary control surfaces of this airplane are actuated by duplicate control systems with interconnects provided at several locations, between the pilot's and copilot's control systems. All primary flight controls have an interconnection between the pilot and copilot's system at the rear spar by means of cables and sectors, and the automatic pilot is connected to the control system at this point. The operation of the various control systems is as follows:

a. Ailerons - A wheel control on the control column transmits load through a chain and sprocket to cables, which in turn transmit load to sectors at the rear spar. Cables from these sectors carry the load to bellcranks and push-pull tubes that operate the inboard and outboard ailerons. The pilot's system is interconnected with that of the copilot at the rear spar and at the control columns; in both cases the interconnection is by cables (Fig. 1 and 2, Dwg. 107-72011).

b. Rudders - The rudder control system consists of conventional pedal hangers which actuate a walking beam forward of the pedals through a system of horns and links. (See Fig. 9 and 10 or Dwg. 107-720109). When rotated, the sector end of the walking beam transmits load to a cable which in turn transmits the load to a sector at the rear spar. This sector transmits the load to another cable which carries it to a sector in the tail cone where the load is transferred to the surface by a horn and torque tube.

The pilot's and copilot's systems are interconnected by cables at the rear spar and also in the stabilizer. There is no interconnection at the copilot's and pilot's station.

c. Elevator - The control column is connected by a push-pull tube to a sector whose plane is perpendicular to that of the control column. Fore and aft motion of the control column causes rotation of the sector in the plane of the cable system. (See Fig. 20 and 21 or Dwg. 107-720110) The sector transmits the load to a cable which transmits the load to another sector at the rear spar. Here another cable carries the load to a sector in the tail cone which actuates a push-pull tube thereby transmitting the force to the elevator horn.
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The pilot's and copilot's systems are interconnected at the rear spar and also in the stabilizer by cables. In addition the control columns are interconnected by a torque tube.

d. Elevator Trim Tab - This tab is manually operated from a control unit on the cockpit pedestal. Load is carried by a cable system to a drum and screw type actuator mounted in the stabilizer and elevator and thence to the trim tab horn by a push-pull rod (Fig. 30 and 35).

e. Aileron Trim Tab - This is an electrically actuated tab controlled from a switch on the cockpit pedestal. The actuating motor is in the right inboard aileron and operates the one tab, which is on the right inboard aileron only, by a push pull tube connected to the tab horn. See Figs. 30 and 31.

f. Rudder Trim Tab - There is an electrically actuated tab on each rudder with the actuating motors mounted in the rudder forward of the tab hinge line. The motor operates the tabs through a push pull tube connected to the tab horn. The electrical actuators are synchronized to each other being self-centering on neutral. See Figs. 30 and 33.

g. Elevator Spring Tab - The elevator spring tab controls are a self-contained system, installed and operating entirely in the elevator. When the pilot operates the control column, the spring and push pull rods of the system are actuated and cause the tab surface to move, thus automatically assisting the operation of the elevator surfaces. See Figs. 36 and 37.

h. Control Lock System - The surface lock system is operated by a handle on the pilot's pedestal. Pulling on the handle imposes a torque on a pulley connected to the handle. This pulley transmits the torque to a cable connected to a differential pulley, which in turn transmits it to a set of pulleys at the rear spar (See Figs. 41 and 42). These pulleys transmit the force to a set of take-off pulleys in each engine nacelle at the rear spar, where the force is transmitted each to a differential pulley at the stabilizer and out to the ailerons. The force transmitted to the ailerons locks the ailerons by means of locking cams located at the inboard aileron surface, while the force transmitted to the stabilizer actuates a differential pulley having two cams as integral parts of the pulley. As these two cams rotate toward closed position, they limit the motion of elevator and rudder sectors and consequently the motion of the respective surfaces. This permits the engagement of the "free motion spring tab lock cams" located at each end of the elevator surface and at each rudder horn spring tab mechanism. These "free motion lock cams" have retarded motion in relation to the main locking cams which actuate them, thereby permitting the entrance of the free motion cams within their mating jaws.
These jaws are an integral part of the surface so that when the "free motion" cams are actuated the surface is locked and no surface loads can enter the system to strain it.

Spring retraction safety mechanisms are part of the control lock system. These mechanisms are mounted in tandem close to the main locking cams at the extremities of each system, and each "free motion lock cam" is equipped with a torsion spring on the hub. These retraction mechanisms hold all lock cams in open position during flight, thereby, eliminating the possibility of surfaces locking in flight. In addition they serve as an aid in opening the cams during normal operation.

**DISCUSSION**

1. **Aileron Control System (See Fig. 1 and 2)**

Dummy ailerons (T78-713 and T78-714) were installed on both wings in place of the regular ailerons. This was done because it would be difficult to produce the necessary hinge moment with dead weight loads without damaging the regular surfaces. The dummy ailerons, made from steel channel, were easier to load and more convenient to use. The aileron control system was tested in the following critical conditions. (Photo 18160 and 18162).

   a. **Test A-1 - Proof and Deflection of System.**

   This test was conducted to prove conformance with Spec. R1803-7B, D3 (Ref. (a)) which requires that the deflection at any aileron shall not exceed 10° when the system is loaded to 70% of limit load (70% two pilot max. effort.) It also constituted a proof test of the aileron control system under maximum flight airloads in which the ailerons were fully deflected at 212 MPH, 1G load factor, pack off, left aileron down about 12°, right aileron up about 24°. The maximum test loads applied to the ailerons (Pg. 16, Ref. (c)) were:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinge Moment</td>
<td>2880 in. lb.</td>
<td>5980 in. lb.</td>
<td>5980 in. lb.</td>
<td>3360 in. lb.</td>
</tr>
<tr>
<td>Direction of Load</td>
<td>Down</td>
<td>Down</td>
<td>Up</td>
<td>Up</td>
</tr>
</tbody>
</table>

   The above loads were reacted by the following loads on the rim of the dummy control wheels (equiv. diameter as actual diameter.)

   - **Pilot's wheel = 115 lbs. (single rim load)**
   - **Copilot's wheel = 160 lbs. (single rim load)**

   The ailerons were placed in the "left bank" attitude (corresponding to the above loading) with the copilot wheel approximately 5° from the left stop to prevent the stop from taking any load. The copilot wheel was returned to this same position at each increment of load and the relative deflection of each of the four surfaces and the pilot's wheel was recorded. This data is plotted on Figs. 3 and 4 respectively.
Subject: Proof and Operation Tests of Flight and Trim Controls

The systems meet the requirements of Spec. R1803-7B, D3 in that the maximum deflection is less than 10 degrees at 70% of maximum double pilot effort (9.75° - See Fig. 3).

The rigging loads before and after test were as follows:

<table>
<thead>
<tr>
<th>Cable</th>
<th>Before Test</th>
<th>After Test</th>
<th>Rigging Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot's fuselage</td>
<td>122</td>
<td>123</td>
<td>135 ± 10%</td>
</tr>
<tr>
<td>Copilot's fuselage</td>
<td>122</td>
<td>113</td>
<td>135 ± 10%</td>
</tr>
<tr>
<td>Left Aileron cable</td>
<td>127</td>
<td>124</td>
<td>135 ± 10%</td>
</tr>
<tr>
<td>Right Aileron cable</td>
<td>123</td>
<td>128</td>
<td>135 ± 10%</td>
</tr>
</tbody>
</table>

b. Test A-2 - Test of Control Wheel Stops.

The object of this test was to demonstrate the ability of the wheel stops to withstand 100% pilot effort on the control wheel. The system was rigged to permit the pilot's wheel to hit the stop before the copilot's wheel touched the stop. This condition was maintained throughout the test. 100% pilot effort (160# single rim force) was applied in increments, and angular deflection of the pilot's wheel was recorded. This data is plotted on Fig. 5. No appreciable permanent set occurred after removal of load (.10° at 20% after 100%). The test limit load was supported without noticeable distortion of any part.

c. Test A-3 - Operation Test.

This was an operation test of the entire aileron system, with all cables hooked up, for the purpose of determining friction losses and observing the operation of the system under load. The system was operated back and forth at increments of load up to 50% of double pilot effort. The cables had been rigged to the rigging spec. requirements prior to the test. The max. single rim load applied to each control wheel simultaneously was 80 lbs. (See Photo 18158) The corresponding load on the aileron surfaces was as follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Moment (#)</td>
<td>1122</td>
<td>2330</td>
<td>1720</td>
<td>3530</td>
</tr>
<tr>
<td>Direction of Load</td>
<td>Down</td>
<td>Down</td>
<td>Up</td>
<td>Up</td>
</tr>
</tbody>
</table>

At each load increment, which was in balance throughout the system, the force (friction) required to move the controls back and forth through the neutral position was measured. These friction forces, corrected for friction losses in the test loading fixtures, are plotted on Fig. 6. (Note - the stabilizing springs in the outer wings were disconnected.)
The friction losses in the test loading fixtures are plotted on Fig. 7. The friction of the three pulley cockpit loading fixture was used directly, the friction of the cable over a single pulley (90° wrap) was used after correcting for the number of pulleys so used and the mechanical advantage of the system. (The 90° wraps were used on the surface end of the system).

The friction was found to be from 10 to 16.3 lbs. when the surface moved through neutral with corresponding loads of zero to 50% double pilot effort. The comparable forces on the C-119B airplane were 9.5 to 15.5 lbs. It may be expected that the friction force will decrease somewhat as the system is worn in.

d. Test A-4 - Proof Test of a Partially Shot Out System.

This test was a proof load test of a partially broken system to prove conformance to the requirements of Par. D-3b (2) of Spec. RL803-7B which requires that, with one system inoperative, the remaining system be capable of carrying 75% of the load normally carried by the complete control system. This test also demonstrates the ability of the control surface locks to withstand 150% max. single pilot effort. The pilot's fuselage cables were disconnected and the control surface locks were engaged. Since the control surface lock system was not connected at the time of the test, it was necessary to manually engage these locks and secure them with safety wire.

The max. loads applied (simultaneously) were:

Pilot's wheel 150# rim force (single force)
Copilot's wheel 80# rim force (single force)

The load was applied in increments and following each increment the angular deflections of both control wheels were recorded. This data is plotted on Fig. 8. The deflection of both inboard aileron surfaces was also checked at each increment as a means of judging lock deflection. The maximum angular deflection recorded was .3° at 100% load.

The deflection of the entire system (with pilot's fuselage cables disconnected) resulted in 82° rotation of the pilot's wheel and 61° rotation of the copilot's wheel. This amounted to 55% and 41% respectively of the total available angular travel of the control wheels. (150° available.)
The permanent set recorded at 20% after 100% was as follows:

Pilot's wheel 5°  These sets represent only 3% of the Copilot's wheel 5° total wheel travel in either direction.

Cable tensions before and after this test were as follows:

<table>
<thead>
<tr>
<th>Cable</th>
<th>Before Test</th>
<th>After Test</th>
<th>Spec. Req'd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot's</td>
<td>Disconnected</td>
<td>131</td>
<td>135 ± 10%</td>
</tr>
<tr>
<td>Copilot's</td>
<td>131</td>
<td>117</td>
<td>135 ± 10%</td>
</tr>
<tr>
<td>Left Aileron</td>
<td>122</td>
<td>126</td>
<td>135 ± 10%</td>
</tr>
<tr>
<td>Right Aileron</td>
<td>112</td>
<td>127</td>
<td>135 ± 10%</td>
</tr>
</tbody>
</table>

2. Rudder Control System (See Figs. 9 and 10)

Prior to the tests on the rudder control system, the relationship between rudder movement, spring tab movement, and rudder hinge moment was determined (See Fig. 12) This was done with the rudder surface locks free and the rudder tail cone, quadrant locked. In all tests, loads were applied to the rudder and rudder pedals in the manner shown on Photos 18051, 18052 and 18055.

a. Test R-1 - Operation Test.

This was an operation test of the entire rudder control system, with all cables hooked up, for the purpose of determining friction losses and observing the operation of the system under load. The system was operated back and forth at increments of load up to 50% of double pilot effort. The cables had been rigged to the rigging spec. requirements prior to test. Maximum test loads were: (Pg. 29, Ref. (c))

1630 in. lb. moment applied to the left on each rudder. 150 lb. applied forward on each right hand pedal.

At each load increment, which was in balance throughout the system, the force (friction) required to move the controls back and forth through the neutral position was measured. These friction forces, corrected for friction losses in the test loading fixtures are plotted on Fig. 11.

Friction losses on the first C-119B airplane at the time of first tests were: 31# at zero load and 47# at 50% double pilot effort. These values were reduced somewhat by refinements made during final cleanup so that the zero load friction on this airplane was reduced to 24.5# several days after the first tests. Similar reductions can probably be made on the XC-120 rudder controls, but it is doubtful that the 15# specification limit can be met on a loaded system.
b. Test A-2 - Proof and Deflection Test of System.

In this test the entire cable system was hooked up and rigged to specification requirements. The object of the test was to determine the deflection of the complete system at a surface load which produced 70% of double pilot effort (H20W) applied equally distributed at pilot's and co-pilot's pedals. The max. test loads were: (Pg. 29, def. (c))

2390 in. lb. moment applied to the left on each rudder.
210 lb. applied forward on each right hand pedal.

The rudder pedals were placed in the full forward length adjustment, which was critical. The rudders were placed just far enough to the right of neutral under no load so that they would not hit the left hand stops under full load. The spring tab controls were not blocked, therefore, the initial deflection of the rudder resulted from the spring tab control arrangement. The copilot's right hand pedal was returned to a fixed position at each increment of load and the deflection of the rudders and the pilot's pedal were measured. The pilot's pedal deflection relative to a fixed copilot's pedal was not large enough to be accurately measured. The surface deflections, which are indicative of deflection of the entire rudder control system, are plotted on Fig. 13. Fig. 12 is a plot determining that portion of the rudder deflection which results from deflection of the spring tab controls. The rudder deflections, relative to a fixed horn were 5.2° and 6.6° for the left and right hand spring tab control systems respectively in the position of adjustment at the time of test. (Note - Specified correct setting is 7° ± 1°) These values must be subtracted from the overall deflections at 70% limit load on Fig. 13 and result in an average deflection of 9.4° for the control system exclusive of the spring tab controls.

Par. D-3 of Spec. R1803-7B requires that the deflection at 70% limit load be no more than 10°. The test value, therefore, meets the specification requirement.

The permanent set at 20% load after applying the full test load was less than could be accurately measured and is, therefore, not recorded on Fig. 13.
Subject—Proof and Operation Tests of Flight and Trim Controls

The rigging loads before and after the test were as follows:

<table>
<thead>
<tr>
<th>Cable</th>
<th>Before Test</th>
<th>After Test</th>
<th>Rigging Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot's fuselage</td>
<td>95</td>
<td>85</td>
<td>85# ± 10%</td>
</tr>
<tr>
<td>Co-pilot's fuselage</td>
<td>89</td>
<td>85</td>
<td>&quot;</td>
</tr>
<tr>
<td>Servo. Intercon.</td>
<td>84</td>
<td>90</td>
<td>&quot;</td>
</tr>
<tr>
<td>L.H. Boom</td>
<td>98</td>
<td>95</td>
<td>&quot;</td>
</tr>
<tr>
<td>R.H. Boom</td>
<td>98</td>
<td>94</td>
<td>&quot;</td>
</tr>
<tr>
<td>Stab. Intercon.</td>
<td>100</td>
<td>105</td>
<td>&quot;</td>
</tr>
</tbody>
</table>

In general, the rigging loads were slightly above the upper limit of the specified values prior to the test. Loss of rigging load in the loaded cables was slight. The interconnecting cables, which were not loaded in this test, showed a slight gain in tension after the test as compared to before test. The rigging tensions in the loaded cables were sufficiently within the specification values as to justify the deflection figures quoted above.

c. Test R-3 - Ground Load Test of Surface Locks.

This was a test of the surface locks under ground loading. The surface locks on one rudder were locked in place and the upper and lower surfaces loaded in 20% increments up to the following maximum loads: (Fig. 219, Ref. (c))

- 2310 in. lb. moment to the upper rudder.
- 1210 in. lb. moment to the lower rudder.

The resulting surface deflections are plotted on Fig. 14 and show normal elastic behavior and no permanent set. The test loads were supported without noticeable distortion of any part.

d. Test R-4 - Test of Rudder Pedal Stop.

This was a test of a typical rudder pedal stop to demonstrate its ability to sustain loads due to single pilot effort. The test was conducted with the right pilot's pedal under load and all pedal and surface stops except that which carries forward load on the loaded pedal were backed out of contact. A load of 300# forward (in 20% increments) was applied to the pedal while in the forward length adjustment. Angular deflection of the rudder pedal hanger, forward deflection at the brake pedal pivot, and deflection of the walking beam and its supports were recorded. (See Photo 15052).

Fig. 15 - Shows the deflection of the forward control sector (walking beam) and its support point under a tension load applied at the rod attachment point "C" and reacted at stop point "A". The dial gages which recorded these deflections were mounted on the fixed frames of the nose section.
Subject: Proof and Operation Tests of Flight and Trim Controls

Fig. 16 - Shows the forward deflection at the base of the pedal hanger and the equivalent average rotation of the hanger in degrees.

The pedal system, up to and including the stop structure, supported limit load without noticeable permanent deformation.

e. Test 6-5 - Brake System Test (Photo 13088)

This was a test of the mechanical portion of the pilot’s brake system (typical of copilot’s) from the pedal through the master control cylinders, to determine the ability of the system to sustain single pilot limit loads of 300# applied to the top tip of both pedals simultaneously and at right angles to the pedal pivot axes. The rudder pedals were locked in neutral and placed in the full forward length adjustment which was critical. One brake cylinder (a test unit) was filled with oil and the ports sealed shut. The level of the oil was so set that the cylinder would deflect 1 1/3" when the pedal was loaded, and come to a solid stop on the head of oil at that point. The other cylinder was left out of the system and replaced with a rigid steel link. (It was not desired to load the units which would subsequently be used on the airplane as the adequacy of the Warner units to sustain loads compatible with a 300# pedal force had not been established at the time of test.)

Angular deflection of the brake pedals was read at 20% increments of the 300# loads. Four dial gauges, supported on fixed structure of the nose section, were made to bear at the lower ends of the rudder pedal hanger support arms, at right angles to the axis of rotation of the rudder pedal hangers. The deflection data is plotted on Figs. 17 and 18 which also show that permanent distortion after proof testing was of negligible magnitude. The mechanical portion of the brake system and its supports, sustained limit loads without distress.

f. Test 6-6 - Proof Test of a Partially Shot Out System.

This test was a proof load test of a partially broken system to prove conformance to the requirements of Par. D-3a (2) of Spec. 1303-73 which requires that, with one system inoperative, the remaining system be capable of carrying 15% of the load normally carried by the complete control system. The maximum loads applied were: (Pg. 29, Ref. (c)).

3360 in. lb. moment applied to the left on the right rudder.
1650 in. lb. moment applied to the left on the left rudder.
300 lb. applied forward on the copilot’s right pedal.
150 lb. applied forward on the pilot’s right pedal.
Subject: Proof and Operation Tests of Flight and Trim Controls

The rudder pedals were placed in the forward length adjustment and the cables in the right hand boom were disconnected. All load from the right rudder was, therefore, carried through the stabilizer interconnect where it joined with left rudder loads to be carried through the left boom cables into the crew nacelle. The servo interconnect then carried 2/3 of the load, or single pilot effort, into the co-pilot's fuselage cables.

The rudders were deflected 11° to the right prior to loading and a corresponding fixed position noted for the co-pilot's left pedal. This position of the pedal was maintained throughout the test, while the angular deflections of the rudders and the other pedals were read at 20% increments of load. Deflections of the rudders are plotted on Fig. 19. Deflections of the three pedals (other than the fixed co-pilot's left pedal) at full test load were:

- Co-pilot right - 2° forward
- Pilot right - 3° aft
- Pilot left - 3° forward.

The deflection of the entire control system at full proof load, exclusive of the deflection resulting from the spring tab control, was equivalent to 12° at the left rudder and 13.7° at the right rudder. The entire system sustained the proof load without noticeable distress. Permanent sets averaged only 0.2° of rudder deflection and are, therefore, not noted on Fig. 19.

3. Elevator Control System (See Fig. 20 and 21)

Prior to conducting these tests, the relationship between surface movement, spring tab movement, and elevator hinge moment was established (See Fig. 22). This was done with the elevator locks free and the elevator boom quadrant locked. In all tests, loads were applied to the elevator and the control columns in the manner shown on Photos 130H:5 and 130H:7.

a. Test 3-1 - Proof and Deflection Test of System

In this test, the entire cable system was hooked up and rigged to rigging spec. requirements. The purpose of the test was to determine the deflection characteristics of the complete system at a load on the surface which produced 70% of double pilot effort (420#) applied equally to the two wheels. Loads applied were:

- 6560 in. lb. moment on elevator surface applied downward with the elevator in neutral trail prior to loading (to balance control column load).
- 210# aft to each control column.
The copilot's column was held in fixed position throughout the
test and the angular rotation of the elevator and pilot's column
read at 20% load increments. The pilot's column deflection
relative to the fixed copilot's column was not large enough to be
measurable. The surface deflection, which is indicative of
deflection throughout the control system is plotted on Fig. 23.
Fig. 22 evaluates that portion of the surface deflection which
results from deflection of the spring tab controls. The maximum
elevator deflection relative to a fixed horn proved to be 10°.
This value is subtracted from the overall deflection at 6560 in.
lb. load on Fig. 23 and results in a deflection of 11.0° in the
system exclusive of the spring tab.

Par. 1-3 of Spec. 11-03-76 requires that the deflection at 70%
limit load be not more than 10°. The test value, therefore,
slightly exceeds the specification limit. Permanent set in terms
of elevator deflection was 1.5°, indicating some permanent
elongation in the cable system. The rigging loads before and
after the test were as follows:

<table>
<thead>
<tr>
<th>Cable</th>
<th>Before Test</th>
<th>After Test</th>
<th>Rigging Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot fuselage</td>
<td>111</td>
<td>90</td>
<td>100# ± 10%</td>
</tr>
<tr>
<td>Copilot fuselage</td>
<td>110</td>
<td>85</td>
<td>100# ± 10%</td>
</tr>
<tr>
<td>Servo Intercon</td>
<td>98</td>
<td>96</td>
<td>85# ± 10%</td>
</tr>
<tr>
<td>L.H. Boom</td>
<td>96</td>
<td>96</td>
<td>85# ± 10%</td>
</tr>
<tr>
<td>N.H. Boom</td>
<td>82</td>
<td>85</td>
<td>85# ± 10%</td>
</tr>
<tr>
<td>Stab. Intercon.</td>
<td>10h</td>
<td>99</td>
<td>85# ± 10%</td>
</tr>
</tbody>
</table>

All cables were rigged on the high side at the time of test but
the rigging tensions dropped, particularly in the fuselage cable,
as a result of loading.

Fig. 24 is a plot of the bending deflection at the top of the
control column relative to a fixed base at the pivot.

b. Test 2-2 - Operation Test.

In this test, the control system was operated back and forth
through neutral at zero load and in increments of load up to
50% of double pilot effort applied in balance to the control
column (aft) and the elevator (down). Max. loads applied were:

- 670 in. lb. moment applied to the elevator (to balance control
column load.)
- 150# applied aft on each control column.

At each increment of load, which was in balance throughout the
system, the force (friction) required to move the controls back
and forth through the neutral position was determined. These
friction forces are plotted on Fig. 26 and are corrected for
friction losses in the test loading fixtures. The latter are
plotted on Fig. 25. The friction varies from 14.5# at no load

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on the system, to 19.7# at 50% of double pilot limit load.

Friction losses on the first C-119j production airplane were 12.3 lbs. at zero load and 16.5# at 50% double pilot effort when first tested. These values were somewhat reduced by final cleanup of interferences after completion of the airplane and it is likely that reductions can be made on the XC-120 also. However, it is doubtful that the 8# limit can be met.

c. Test E-3 - Proof Test of a Partially Shot Out System

This was a proof test of a partially broken system to prove conformance to the requirements of Par. D-3a (2) of Spec. 12053-7B which requires that, with one system inoperative, the remaining system be capable of carrying 75% of the load normally carried by the complete control system. The maximum loads applied in this test were: (Pg. 27, Ref. (c))

7000 In. lb. moment applied downward on the elevator (to balance load of control column.
300# aft applied at the copilot's column.
150# aft applied at the pilot's column.

The copilot's fuselage cables and left hand boom cables were disconnected so that all load was routed through the right hand boom cables, fuselage, crossover and left hand fuselage cables to the pilot's column. The torque tube between the two columns was made to carry torque due to single pilot effort. Deflection in the entire control system in terms of elevator deflection relative to a fixed copilot's column is plotted on Fig. 27. The elevator was placed in the 24° up position at no load. The deflection of the entire control system at the maximum test load was 20°, exclusive of the deflection due to the spring tab. The percent set was only 1°. The rigging loads before and after the test were:

<table>
<thead>
<tr>
<th>Cable</th>
<th>Before Test</th>
<th>After Test</th>
<th>Rigging Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot's Fuselage</td>
<td>100</td>
<td>93</td>
<td>100# ± 10%</td>
</tr>
<tr>
<td>Servo Intercon</td>
<td>91</td>
<td>69</td>
<td>85# ± 10%</td>
</tr>
<tr>
<td>R.F. Boom</td>
<td>95</td>
<td>88</td>
<td>85# ± 10%</td>
</tr>
<tr>
<td>Stab. Intercon.</td>
<td>90</td>
<td>93</td>
<td>85# ± 10%</td>
</tr>
</tbody>
</table>

The load in the servo interconnect, which was loaded for the first time in this test, was the only one which dropped markedly.

Torsional deflection of the connecting tube between the two columns is plotted on Fig. 28, and equaled about 2 1/4° at 300# load.
d. Test E-4 - Test of Control Column Stop.

This was a test of a typical control column stop for ability to sustain single pilot effort loads. The fuselage cables on the co-pilot's side were left disconnected and the columns moved aft until the stop at the sector on the pilot's side was contacted. All other stops, including surface stops, were backed off out of contact. A load of 350 lbs, in increments, was applied on the co-pilot's column and reacted on the stop. The resulting deflections are plotted on Fig. 47 which shows the angular rotation at the base of each column and the linear motion of the cable immediately aft of the sector at the stop. The deflection between the base of the pilot's column and the sector, which includes the push-pull rod, was only .3° of column motion at full pilot effort.

4. Aileron Trim Tab (See Figs. 30 and 31)

This tab is electrically actuated, and during this test it was operated under 20% incremental loadings up to 100% limit hinge moment. These loads were applied by means of dead weight.

The purpose of this test was to demonstrate the structural integrity of the trim tab operating mechanism and to determine the operational characteristics of its actuating unit. The tab in question is the outboard tab of the inboard right hand aileron. The design limit hinge moment is 480" (Ref. (c), Pg. 310) which was applied on an 8 5/8" arm, measured when the tab was in neutral.

The aileron surface was locked in neutral by means of the control locking system. Without any hinge moment, the trim tab surface was operated to both extremes of travel. While so doing, the current and time required was recorded. The recording ammeter was used throughout the test. Starting with the trim tab in neutral, the hinge moment was applied in 20% increments up to 100% proof load. This load was acting in a down direction simulating load on an upward deflected trim tab. The deflection of the surface under the incremental load was recorded. Allowances were made for the deflection of the aileron surface itself. The trim tab was then actuated in an upward direction until motion was halted by the cutoff switches. The current and time for this operation was recorded as was the deflection caused by the load in the fully deflected upward position.

The maximum current required to operate from neutral to full up increased from 1.5 amps at 0 load to 1.32 at 100% proof load. The time varied from 7 seconds at 0 load to 9.5 seconds at 100% proof load. The deflection of the fully deflected flaps was 1.36° at 100% proof load. (See Fig. 32). The system operated in a satisfactory manner throughout the test and no permanent set was recorded.
5. Rudder Trim Tab (See Figs. 30 and 33)

Like the aileron trim tabs, this trim tab is electrically actuated. During this test it was loaded, in 20% increments, to full limit load by means of dead weight. The tab was operated against the load at each increment.

The purpose of this test was to demonstrate the structural integrity of the rudder trim tab operating mechanism and to determine the operational characteristics of the actuating unit at loads from 0 to 100% proof load. The rudder trim tab is the upper tab located on the rudder surface. There is one trim tab on each rudder; however, only one (left hand) was loaded and operated during this test. The right hand actuator was disconnected from the electric circuit. The limit design hinge moment as specified by the Structures Section (Pg. 308, Ref. (c)) is 527#", which was applied in this test on a 7 3/4" arm, measured when the surface was neutral. With the rudder control surface locked by use of the locking system, and with the trim surface in neutral, the tab was deflected to both extremes of travel. Starting at neutral and with the hinge moment applied in 20% increments from 0 to 100% proof load (the load operated to the left with respect to the airplane) the trim tab was operated to the right, to the full extremes of travel. The deflection of the trim tab with respect to the rudder was recorded both in neutral position and the fully deflected position. The current and time to operate from neutral to fully deflected was recorded.

The current required to operate the surface from neutral to fully deflected varied from 1.56 amps at 0 load to 1.85 at 100% proof load. The time varied from 7.5 seconds to 9.9 seconds respectively. The deflection of the rudder trim surface at 100% proof load was .9° and .7° in the neutral and fully deflected positions respectively. (See Fig. 34) The rudder trim tab actuating system operated in a satisfactory manner throughout the test. No permanent set of the trim tab surface was produced.

6. Elevator Tab Controls (See Figs. 30, 35, 36, and 37)

a. Test T-1 - Proof and Deflection Test of Elevator Spring Tab Controls.

The purpose of this test was to demonstrate the structural integrity of the spring tab operating mechanism under limit load of 724#" (Pg. 256, Ref. (c)) about the tab hinge line and to measure the deflection of the tab control mechanism in terms of deflection of the tab.

By locking the elevator control surface at the leading edge and pulling on the elevator control horn by means of the elevator control system, the spring cartridge was fully extended and the spring tab actuated to its full up position. The elevator surface and the elevator control horn were held in this fixed position so that there would be no motion of the spring cartridge except by deflection in the tab control linkage.
Dead weight load was applied to the tab and its position away from the no load position recorded. The deflection so recorded is the accumulated deflection in the tab control system between the elevator horns and the tab.

The tab deflection relative to the elevator is plotted in Fig. 38. Maximum deflection at 100% limit load was 4.9°. After several operations of the tab at zero load after 100% load, a second reading at 20% load showed that no permanent set had occurred in the system. No signs of distress were noted during the test.

b. Test T-2 - Proof Test of Elevator Trim Tab Control Forward Stop.

The purpose of this test was to demonstrate the structural integrity of the trim tab control wheel, the wheel interconnecting torque tube, and the wheel stop mechanism under a limit load of 75 lb. (Pg. 235, Ref. (c)) applied tangentially to the rim of the copilot's elevator trim tab control wheel.

Load was applied with a spring scale in a nose down, tab up, direction to a cotton strap wrapped around the copilot's tab control wheel. This load was carried through the interconnecting shaft to the pilot's tab control wheel and was reacted at the stop on the pilot's control wheel rim. The angular deflection of the copilot wheel was recorded and is plotted in Fig. 39. Maximum deflection at 100% limit load was 8.93° with no permanent set recorded. Inspection of the system revealed no failures or other signs of distress.

c. Test T-3 - Friction and Operation Test of Elevator Trim Tab Control System.

The purpose of this test was to measure the operating forces of and the efficiency of the elevator trim tab control system. It was also desired to observe the entire tab control system when operating under load for evidence of binding, yielding, sagging cables, or other malfunction due to deflection. Limit load applied to the tab was 822 in. lbs. (Pg. 235, Ref. (c)).

The elevator trim tab was moved to the full up tab (nose down) position and the tab control wheel then returned 1/2 turn in the nose up position. Dead weight load was applied in increments to the tab in a down direction to give the required hinge moment. The copilot's tab control wheel was then moved, in a nose down direction, by means of webbing and a spring scale. This test was repeated with the tab being moved through the tab neutral position, moving up against the same loads used in the first test.

Since the operating forces were slightly higher with the tab neutral, this data is presented in Fig. 40, which also shows a graph of theoretical frictionless operating force. The ratio between the two curves is the total efficiency of the system.
An inspection of the system after test disclosed no points of failure or signs of distress.

7. Control Lock System

The purpose of this test was to determine the method and forces required to engage the surface control locks. It was also the purpose of this test to observe the structural integrity of the system when a limit design handle force of 50 lbs. was applied.

Prior to the test, the control lock system had been thoroughly checked out and certified correct by the Inspection Dept. in accordance with Ref. (d). The control rigging was checked by the Test Laboratory and found to be within rigging specifications except as noted.

<table>
<thead>
<tr>
<th>System</th>
<th>Cable Tension Rigging Spec.</th>
<th>Cable Tension Measured at Start of Test (Lbs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestal</td>
<td>65# + 10#</td>
<td>65</td>
</tr>
<tr>
<td>Fuselage</td>
<td>65# + 10#</td>
<td>68</td>
</tr>
<tr>
<td>Fus. Interconnect</td>
<td>85# + 10#</td>
<td>88</td>
</tr>
<tr>
<td>L. Fuse. to Boom</td>
<td>&quot;</td>
<td>98</td>
</tr>
<tr>
<td>R. Fuse. to Boom</td>
<td>&quot;</td>
<td>82</td>
</tr>
<tr>
<td>Left Wing</td>
<td>&quot;</td>
<td>85</td>
</tr>
<tr>
<td>Right Wing</td>
<td>&quot;</td>
<td>85</td>
</tr>
<tr>
<td>Left Boom</td>
<td>&quot;</td>
<td>87</td>
</tr>
<tr>
<td>Right Boom</td>
<td>&quot;</td>
<td>87</td>
</tr>
<tr>
<td>Left Rudder</td>
<td>70# + 10#</td>
<td>79</td>
</tr>
<tr>
<td>Right Rudder</td>
<td>&quot;</td>
<td>75</td>
</tr>
<tr>
<td>Left Elevator</td>
<td>&quot;</td>
<td>80</td>
</tr>
<tr>
<td>Right Elevator</td>
<td>&quot;</td>
<td>97</td>
</tr>
</tbody>
</table>

*While this tension was slightly above specification value the tension was not altered.

The force required to engage the control locks was found to vary from 42 to 43 lbs. The handle travels a total of 57° from the unlocked to the locked position. The surface locks are fully locked within the final degree of travel. Unlocking motion of the cam commences within 5.5 to 6.25° unlocking travel of the operating handle.

The system sustained the 50# proof handle load without permanent distortion of any part.

RESTRICTED
WHEEL CLOCKWISE
LEFT ALL DOWN - LEFT WING UP
RIGHT ALL UP - RIGHT WING DOWN

WHEEL ROTATION - 150° EITHER
SIDE OF NEUTRAL,
360° TOTAL ROTATION.

NOTE:
ALL RIGGING TO BE DONE WITH AILERON
AND ELEVATOR CONTROLS IN NEUTRAL
AS SHOWN.
* RIG TO 155°+10°-10° TENSION SEE
NOTE UNDER CABLE TENSIONS B-2
RE. F-1 SERVO CABLES.
XC-120 AIRPLANE TEST A-1
DEFLECTION OF AILERONS VS
PILOT EFFORT - CO-PILOT WHEEL
HELD 5° OFF LEFT STOP

TOTAL EFF (100% PILOT)
-% OF TOTAL (30% CO-PILOT)

% OF MAX & PILOT
EFFORT

RIGHT INBOARD

RIGHT OUTBOARD

LEFT INBOARD

LEFT OUTBOARD

20% AFTER 100%
NC-120 AIRPLANE TEST P-1
Defl. of Pilot's Wheel w/r
Respect to Co-Pilot's Wheel
Vs. Pilot Effort

Direction of Defl. Held

Pilot

Co-Pilot

42% 58%

Deflection - Degrees -

RESTRICTED
XC-120 AILERON CONTROLS TEST A-2
PROOF TEST OF PILOT'S LEFT CONTROL WHEEL STOP
DEFLECTION OF CONTROL WHEEL VS. LOAD.

**DEFL. AT 20% AFTER 100%**

**DEFL. OF PILOT'S CONTROL WHEEL — DEGREES.**

**LOAD ON PILOT'S WHEEL**

**F107-722, Page 33**

**TESTED: 2/3/50**

**DRAWN: 2/3/50**
FIG. 6
XC-120 AILERON CONTROLS TEST. (A-3)
FRICITION IN AILERON CONTROL SYSTEM
VS. PILOT EFFORT.
FRICITION MEASURED AS CONTROLS
MOVED THROUGH NEUTRAL AND
CORRECTED FOR FRICITION IN THE
LOADING DEVICES.

SURFACE WING MOMENTS AT 100%
R.O.B. = 1720 M-LB.
R.A.B. = 3530 M-LB.
L.O.B. = 2860 M-LB.
L.O.A. = 1422 M-LB.
BALANCED WITH 60 LB. WHEEL RIM LOAD
PER PILOT & CO-PILOT WHEEL.

LOAD ON EACH WHEEL, RIM = LBS.
% SINGLE PILOT EFFORT

FRICITION - LBS. AT RIM OF WHEEL
(AVERAGED FROM MOTION IN BOTH DIRECTIONS)

RESTRICTED

GFK 2-7-50
FIG. 7
XC-120 AILERON CONTROLS TEST
LOADING FIXTURE FRICTION
FOR THREE PULLEY &
ONE PULLEY SYSTEMS.
CABLE TENSION VS FRICTION
AN 210-5A PULLEYS
3/8" DIA. 7X19 STEEL CABLE (PRE-FORMED).

CABLE TENSION - LBS.

FRICTION - LBS.

ONE PULLEY SETUP

THREE PULLEY SETUP

ONE PULLEY SETUP

THREE PULLEY SETUP

RESTRICTED

0.7 - 7-50
FIG. 8

XC-120 AILERON CONTROL TESTS (A-4)
PROOF TEST OF AILERON CONTROL SYSTEM
WHEEL DEFLECTION VS TEST LOAD
PILOT'S FUSELAGE CABLES DISCONNECTED
SURFACES LOCKED IN NEUTRAL
150% MAX. SINGLE PILOT EFFORT
150 LB. ON PILOT WHEEL RIDGE = ONE PILOT EFFORT
300 LB. ON CO-PILOT WHEEL RIDGE = ONE-HALF PILOT EFFORT
REACTION BY WING AILERON LOCKS.

TOTAL ROLL FORCE - LBS.
120 80 60 40 20 0
% TOTAL TEST LOAD
40 20 10 0
TOTAL ROLL FORCE - DEGREES
0 20 40 60 80 100
WHEEL DEFLECTION - DEGREES

READING AFTER 100%
PILOT'S WHEEL
READING AFTER 100%
CO-PILOT'S WHEEL

REstricted

GFK 2-3-50
NOTE: ALL RIGGING TO BE DONE IN NEUTRAL AS SHOWN RIGHT 65°+10°-10° TENSION

OPERATION:
LEFT PEDAL FWD - SURFACE LEFT - NOSE LEFT.
RIGHT PEDAL FWD - SURFACE RT - NOSE RIGHT.

MOTION:
RUDDER MOTION 15°±2° LEFT & 20°±2° RIGHT.
SEE SPRING TAG DIAGRAM 107-728575 REF.

NOTES:
2.00 FORE & AFT ADJ. OF PEDALS POSSIBLE FROM STA 80.75
LEFT PEDAL TRAVELS 3,101 FWD & 4,347 AFT.
RIGHT PEDAL TRAVELS 4,547 FWD & 3,801 AFT TO
PRODUCE Rudder MOTION.

SEE 107-722000 FOR PEDAL
POSITION & BRAKE VALVE ADJ.

4.556 CABLE TRAVEL

6,839 CABLE TRAVEL

11,502 CABLE TRAVEL

12361 - A SERVO ECLIPSE - PIONEER
18,999 DIA.

7.525 DIA.

9/2/49
Fig. 11

XC-120 Airplane, Test R.
Rudder Hinge Moment vs Friction in Controls

Entire cable system connected.
Friction at 50% double pilot effort as surfaces operated through neutral.
50% Limit Hinge Moment = 1680 in. lbs.
Applied to each rudder and balanced by 150 lb. load on each pilot and control right rudder pedal.

Rudder Hinge Moment - in. lbs. per rudder x 1000

1680 in. lbs. (50% Limit Load)

Friction - lbs. at one pedal
(To move all pedals backward and forth through neutral)

Restricted
FIG 12
XC-120 AIRPLANE TEST
Rudder deflections due to spring tabs
with tail plane sector wheel locked
(surfaces not locked).
Hinge moments vs. deflection.

Rudder hinge moment in lbs. per rudder

Rudder deformation - degrees

Spring tab locked

Arc in lbs. to fully deflect spring tab

Rudder tab locked

Spring tab fully deflected at these points.

6.5° defl. due to spring tab

5.2° defl. due to spring tab

Restricted

GF 12-30-99
FIG. 3
KC-120 AIRPLANE, TEST R2
PLOT OF GROSS DEFLECTIONS
(SPRING TAB & CONTROL SYSTEM)
FOR 90% LIMIT LOAD (90% OF
TWO PILOTS' MAX. EFFORT)
2350 IN. LB. HINGE MOMENT
PER RUDDER SURFACE.
XC-120 RUDDER CONTROL SYSTEM

TEST: R9 - PROOF TEST OF RUDDER SURFACE LOCKS

% LIMIT SURFACE H.M. = SURFACE DEFLECTION

GAL 1 = 2000 LBS UPP RUDDER
GAL 1 = 1240 LBS LOWER RUDDER

DEFLECTION OF RUDDER - DEGREES

RESTRICTED
FIG. 15
ACRO AIRPLANE, TEST R4
PROOF TEST OF RUDDER PEDAL STOPS
DEFLECTION OF RUDDER CONTROL SECTOR
("WALKING BEAM") 107-722-009

DEFORMATION - INCHES

DEFLECTION - DEGREES

LOAD

VIEW, LOOKING ACROSS PLATE SIDE
POINTS A, B, AND C ARE LOCATIONS OF DEFLECTION MEASUREMENTS WITH DIAL GAUGES.

RESTRICTED
FIG. 17
XC-120 AIRPLANE, TEST RUN
PROOF TEST OF BRAKE MECHANISM
PEDAL TIP LOAD VS PEDAL DEFLECTION
LOAD REACTED BY BRAKE CONTROL VALVE FILLED WITH HYDRAULIC OIL
PEDAL IN NEUTRAL

PEDAL LOAD - LBS. PER PEDAL

% EFFICIENT LOAD

PEDAL LOAD AT PEDAL TIP

20% AFTER 100%
FIG 18
XC-120 AIRPLANE TEST RE5
PROOF TEST OF BRAKE MECHANISM
PEDAL TIP LOAD & HANGER SUPPORT DEFLECTION
RIGHT HAND PEDAL LOAD REACTED BY BRAKE CONTROL
VALUE FILLED WITH OIL. LEFT HAND PEDAL
LOAD REACTED BY STEEL LINK IN PLACE OF
BRAKE CONTROL VALVE. PEDALS IN NEUTRAL.

PEDAL LOAD
LBS PER PEDAL TIP
300
100
240
80
180
60
120
40
60
20
0
20% AFTER 100%
DIAL GAGES 1, 2, 3, 4

DEFLECTION - INCHES
VIEW LOOKING FORWARD
PILOT'S SIDE
RUNG HORN THIS SIDE
RUNG HORN THIS SIDE
FIG 19
XC-120 AIRPLANE, TEST R6
PROOF TEST OF ENTIRE RUDDER CONTROL SYSTEM
HINGE MOMENT Vs RUDDER DEFLECTION
RIGHT BOOM CABLES DISCONNECTED
150\% PILOT EffORT APPLIED TO SYSTEM
100\% LIMIT H.M. ON RIGHT RUDDER = 2310 IN. LB.
50\% LIMIT H.M. ON LEFT RUDDER = 1680 IN. LB.
RESISTED IN CAGE PIT WITH
100\% LIMIT LOAD ON CO-PILOT'S LEFT PEDAL = 300 LB.
50\% LIMIT LOAD ON PILOT'S LEFT PEDAL = 150 LB.

100 IN. LB. R.H. RUDDER
≤ 1680 IN. LB. L.H. RUDDER

% LIMIT RUDDER HINGE MOMENT

6.0° DEFL. DUE TO SPRING TAB
737 IN. LBS. TO FULLY DEFLECT SPRING TAB

13.0° MAX. NET SYSTEM DEFL.
895 IN. LBS. TO FULLY DEFLECT SPRING TAB

5.2° DEFL. DUE TO SPRING TAB
12.0° MAX. NET SYSTEM DEFL.

RUDDER DEFLECTION - DEGREES

RESTRICTED
NOTE -

CONTROL COLUMN LINEAR MOVEMENTS SEE PAGE F-38
OF THIS SPEC.

STOP PIVOT
ST4 95
3.25 ARM ON HOUSING

NOTE -

91° TO 100° + 10° - 10% CABLE TENSION
(FWD OF REAR SPAR) =
85° + 10° - 10% (AFT OF REAR SPAR)
FIG 22

TEST 2. PROOF TEST OF ELEVATOR CONTROL -
FLOT OF ELEVATOR DEFLECTIONS DUE TO
SPRING TAB WITH FULL TAKE-UP SETTED LOCKED

HINGE MOMENT VS DEFLECTION

XC-120 AIRPLANE

257% OF Rated LOAD

1480° HINGE MOMENT TO FULLY DEFLECT
SPRING TAB

100° DEFLECTED DUE TO SPRING TAB

ELEVATOR DOWN ELEVATOR DEFLECTION - DEGREES

RESTRICTED
Fig. 23

LOAD TEST G - PROOF TEST OF ELEVATOR CONTROL.

Out of Gross Deflections
(Spring Tab and Control Ejector) For 20% Limit Load (30% of Two Plugs Max. Effort) Used as Average Moment on Elevator Surface.

Aircraft: KC-130 Airplane.

Elevator Moment in. lb

Deflection at 130° Moment after 70% L.L.

Spring Tab

10° Defl. Due to 1000 lb Max. Net System Defl.

Down Elevator Deflection - Degrees
FIG. 24
TEST E1 - PROOF TEST OF ELEVATOR CONTROLS XC-120

DEFLECTION OF THE TOP
OF THE CO-PILOT'S CONTROL
COLUMN RELATIVE TO BASE

1. BASE PIVOT HELD FIXED
2. LOAD APPLIED AFT. FROM
   CENTER OF CONTROL
   WHEEL

LOAD ON CONTROL
COLUMN - LBS

320
240
160
0

0.28" AT 210#

DEFLECTION OF CO-PILOT'S CONTROL COLUMN
INCHES

RESTRICTED
Cable - 3/16" Dia. #419 Steel (Forged)

Elevator Control Loading Fixture Friction
For Three Pulley & One Pulley Systems
Cable Tension vs Friction

Fig. #25

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
<td>200</td>
<td>300</td>
<td>400</td>
<td>500</td>
</tr>
</tbody>
</table>

Pulley Setup

1 Pulley Setup

2 Pulley Setup

3 Pulley Setup

RESTRICTED
FIG. 26
TEST E-2: 10-120 ELEVATOR
HINGE MOMENT VS FRICTION
ENTIRE CABLE SYSTEM COMPUTER
FRICITON AT 50% CONTROL POD EFFORT AS
SURFACES OPERATED THROUGH REVALS
50% LIMIT HINGE MOMENTS AS TO IN ERS
APPLIED TO SURFACES BALANCED BY
150 LB LOAD ON EACH 1002 AND
COPILOT CONTROL COLUMN

FRICTION - IBS. AT WHEEL
(AVERAGE TO MOVE BOTH COLUMNS & ALL CONTROLS
BACK OR FORTH THROU NEUTRAL)

RESTRICTED  EF 8K 10-03-49
XC780 AIRPLANE E60-27

TEST E11. PROOF TEST OF ELEVATOR CONTROLS
PROOF LOAD OF GROUND DEFL (SERVO CAGE) CONTROL SYSTEM)

1. REMOVE CABLES DISCONNECTED
2. REMOVE FUSELAGE CABLES DISCONNECTED
3. TEST SINGLE EFFORT ON FLAT COLUMN
4. SINGLE EFFORT ON 2-FLAT COLUMN
75% (ELEVATOR LIMIT LOAD) 7000 lb
MAXIMUM BENDING ON SURFACE.

MAXIMUM BEND- Giải thích
1200 lb
(MAX. NET RIGID TANGENT TO SPRING TAG (REF. FIG. 7))

1/4 INCH MOVEMENT TO FULL DEFL SPRING TAG

DEFLECTION AT 1100 lb.
INSTANT AFTER REMOVING LOAD

ELEVATOR DEFL - DEGREES

RESTRICTED

12-24-97
XC-120 AIRPLANE

Fig. 28

This curve shows angular deflection of pivot of control column due to 300 lb (100% single pilot effort) applied to center of control wheel with other control wheel pivot held fixed and cables disconnected. This defl. occurred in the torque tube interconnect.

Load on control column at center of wheel:

- 0 lb
- 50 lb
- 100 lb
- 150 lb
- 200 lb
- 250 lb
- 300 lb
- 350 lb
- 400 lb

Pilot control column defl. - degrees aft (Co-pilot column held in fixed angular position at pivot.)

2.25° defl. at 100% single pilot effort.
4.90 (FOR NEUTRAL SETTING) (SEE 110-726215)

AIL. TRIM TAB

4.90 AF

1.56 WORKING STROKE (.78 EITHER SIDE OF NEUTRAL)

ELECTRICAL HARNESS
107-740000-CT

AIL. TAB CONTROL SWITCH

CUS ROLLER

AIL. SPAR
Fig. 38
Ailgran Trim Tab XC-120
Proof & Operation Tests

These curves show deflections due to load, actuator current, and operation time from Neutral to 14.5° Up. Working against loads up to limit hinge moment.

100% Proof Load = 420 in-lbs.
Operating Voltage was 28.0 to 26.8 VDC.
NOTE:

TABS MAY BE 2° OUT OF SYMMETRY AT EXTREMITIES OF MOTION BUT SURFACES MUST BE ON NEUTRAL WHEN COCKPIT INDICATOR READS 0°.
Rudder Trim Tab (L.H.) XC120 Proof & Operation Tests

These curves show deflection due to load with tab in neutral. Actuator current & time of operation from neutral to 15.5° Right.

Working against loads up to 15° Hinge Moment

100% Proof load = 550 lb in 16s.

Operating Voltage was 28.4 to 28.6 volts.

Deflected Tab
To Deflection to Proof Load

Deflection (Tab in Neutral)

Current - Amperes
Deflection - Degrees

Time - Seconds

RESTRICTED
Subject: BASIC DATA, ELEV TRIM TAB CONT SYSTEM

Note: Rig in neutral position as shown - rigid to 30$^\circ \pm 5^\circ$ tension.

A = 3.74 & cable dia.
B = 2.60 actuator travel (with overtravel)
C = 2.34 actuator travel (without overtravel)

Motion:
- Tab 12$^\circ$, up + 2$^\circ$ overtravel
- Tab 22$^\circ$, down + 2$^\circ$ overtravel

Gear ratio = 4:1

Fig 35

Cable travel = 39.16
ELEVATOR SPRING TAB CONTROL SYSTEM

MOTION:
- SPRING CARTRIDGE IN ELEV.
- PRELOAD = 8 IN.
- MOTION:
  - ELEV. HORN = 0.5\(\pm\)1/2 IN.
  - FREE MOTION: FWD OF NEUTRAL = 4.5\(\pm\)1/2 IN.

REMARKS:
- SPRING TAB SURFACE:
  - 14\(\pm\)15° UP
  - 20\(\pm\)2° DOWN

Fig 37

REMARKS:
- RESTRICTED
XC-120 CONTROL SYSTEMS

Fig 58

PROOF-LOAD DEFLECTION TEST
OF ELEV. SPRING TAB CONTROL
SYSTEM

ANGULAR DEFLECTION OF SPRING
DUE TO LOAD, CORRECTED
FOR SMALL DEFL. OF ELEV.
SURFACE
ELEV. SURFACE LOCKED IN
NEUTRAL WITH SURFACE LOCKS

724 "# TAB HINGE MOMENT

TAB IN FULL UP POSITION

ELEV. SPRING TAB HINGE MOMENT

% LIMIT

20% AFTER 100% "NO PERMANENT SET"

NET SPRING TAB DEFL. - DEGREES DOWN
(RELATIVE TO ELEVATOR)

RESTRICTED
FIG. 39
XC-120 AIRPLANE, TEST T2
PROOF TEST OF ELEV TRIM TAB CONTROL FWD. STOP:
LOAD APPLIED TANGENTIALLY AT RIM OF CO-PILOT'S
WHEEL, THRU INTERCONNECTING TUBE TO STOP
AT PILOT'S WHEEL.

LOAD AT RIM OF CO-PILOT ELEV TRIM TAB CONTROL WHEEL - LBS

% LIMIT LOAD

ANGULAR DEFLECTION OF CO-PILOT WHEEL - DEGREES

20% AFTER 100%
XC-120 CONTROL SYSTEMS
ELEV. TRIM TAB CONTROL SYSTEM TEST
Both curves based on force at control wheel
Producing motion of tab (against load) through neutral tab position.
SURFACE LOCK CONTROL SYSTEM - BASIC DATA

Fig 42

A = 3.953 DIA (L.E. ROTATION = 15° 24.5')
B = 4.093 DIA (L.E. ROTATION = 30°)
C = 2.590 DIA (L.E. ROTATION = 45°)
D = 2.812 DIA (L.E. ROTATION = 57° 36.5')
18045 - View of Cockpit Loading Fixture Showing Method of Determining Elevator Control System Friction under Load.
13047 - View showing Method Used to apply a Hinge Moment on the Elevator or Elevator Trim Tab Through a Whiffle Tree Attached to the Trim Tab.
18051 - Setup View of Method Used to Apply a Side Load on Both Rudders Simultaneously
18052 - View of Device Used to Apply a Forward Load on the Rudder Pedal. Nose Section of Airplane was removed to permit this type of loading.
18055 - View of Loading Device Attached to the Rudder Pedal for Application of Simulated Braking Forces at the Tip of the Brake Pedal. Note Dial Gages Used to Determine Structural Deflections.
18.156 - View of Cockpit Loading
Fixture Used to Apply Simulated
Aileron Control Wheel Forces. Note
Dummy Wheel and Quadrant Which
Replaced Pilot's Wheel.
18160 - View showing Installation of Dummy Ailerons on Left Hand Wing and method of applying a Down Load on them.
18162 - View showing Dummy Ailerons Installed on Right Hand Wing and Method of Applying an Up Load on Them.
18164 - View of Setup Used to Determine the Friction of the Pulleys in the Loading System Used During Some of the Control Systems Tests.
18563 - View of Engine Control Pedestal Showing Control System Locking Handle and Method Used to Apply Load to it.

RESTRICTED
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FAIRCHILD ENGINE AND AIRPLANE CORP., FAIRCHILD AIRCRAFT
DIV., HAGERSTOWN, MD. (ENGINEERING REPORT NO. R107-722)

PROOF AND OPERATION TESTS OF FLIGHT AND TRIM CONTROLS -
MODEL XC-120

M.M. CUTLER; C.S. HUBER 24 JULY 50 80PP. PHOTOS, DIAGRS,
GRAPHS, DRUGS

STRUCTURES (7) CONTROL SYSTEMS - STRUCTURAL TESTS
DESIGN AND C-120 - STRUCTURAL TESTS
DETAILS (3) C-120 AIRCRAFT

AD-B801 374