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VIBRATION SURVEYS OF THE P–47–B RUDDER
AND FIN–RUDDER ASSEMBLY

By Theodore Theodorsen and Arthur A. Regier

Langley Memorial Aeronautical Laboratory
Langley Field, Va.

NACA

WASHINGTON

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MEMORANDUM REPORT

for the

Army Air Forces, Materiel Command

VIBRATION SURVEYS OF THE P-47-B RUDDER
AND FIN-RUDDER ASSEMBLY

By Theodicy Theadersen and Arthur A. Regier

The present work was conducted in connection with a study of the flutter characteristics of the P-47 tail assembly. The original fabric-covered rudder designated by "I" was subsequently replaced by a metal-covered rudder designated by "II." The fin was also somewhat reinforced and the vibration results on the combination of this reinforced fin and the metal rudder is given under III. This combination, which is now in use (April 1943), proved completely satisfactory from a vibration standpoint and has subsequently been tested in flight to a true speed of the order of 600 miles per hour. As a matter of record the vibration survey is therefore given.

In these surveys, note that some tests were conducted with the tab link rigidly fastened to the center hinge post; some with the tab free. The rudder was tested suspended on a low-frequency rubber mounting, thus being in a "floating" condition. The fin-rudder unit was tested with the base of the rudder solidly fixed to a heavy base support,
In each figure the plus and minus sign designates opposite phases of the amplitude and the size of the sign, the approximate amplitude on an arbitrary but relatively correct scale. Nodal lines are drawn in some of the figures. The designation of each response mode is as usual a matter of conjecture. The figures are otherwise self-explanatory. It is hoped these may serve as a standard of comparison for new designs of high-speed rudder assemblies.

I. Fabric Rudder without Fin:

<table>
<thead>
<tr>
<th>Sketch</th>
<th>Cycles per second</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>33</td>
<td>Tab locked, driver at light as shown. Mainly bending - two nodal lines.</td>
</tr>
<tr>
<td>B</td>
<td>48</td>
<td>Bending plus substantial torsion, two nodal lines.</td>
</tr>
<tr>
<td>C</td>
<td>77</td>
<td>Mainly bending, some torsion present, three nodal lines.</td>
</tr>
<tr>
<td>D</td>
<td>108</td>
<td>Mainly bending, three nodal lines.</td>
</tr>
<tr>
<td>E</td>
<td>135</td>
<td>Apparently four nodal lines present.</td>
</tr>
<tr>
<td>F</td>
<td>103</td>
<td>Driver placed as shown; mainly bending plus tip torsion, three nodal lines.</td>
</tr>
<tr>
<td>G</td>
<td>121</td>
<td>Mainly bending plus more of the tip torsion, three nodal lines.</td>
</tr>
<tr>
<td>H</td>
<td>143</td>
<td>Much torsion present, three (or four) nodal lines.</td>
</tr>
<tr>
<td>I</td>
<td>247</td>
<td>High-order bending torsion, seven or eight nodal lines.</td>
</tr>
</tbody>
</table>
II. All-Metal Rudder without Fin:

<table>
<thead>
<tr>
<th>Sketch</th>
<th>Cycles per second</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>47</td>
<td>Tab fast, driver placed as shown; bending plus tab in phase; two nodal lines.</td>
</tr>
<tr>
<td>B</td>
<td>57</td>
<td>Bending plus tab out of phase; two nodal lines.</td>
</tr>
<tr>
<td>C</td>
<td>85</td>
<td>Coupled torsion and bending, two nodal lines.</td>
</tr>
<tr>
<td>D</td>
<td>100</td>
<td>Bending, three nodal lines.</td>
</tr>
<tr>
<td>E</td>
<td>128</td>
<td>Mainly bending plus tip torsion, three nodal lines.</td>
</tr>
<tr>
<td>F</td>
<td>161</td>
<td>Mainly bending plus slight tip torsion, four nodal lines.</td>
</tr>
<tr>
<td>G</td>
<td>50</td>
<td>Tab free, mainly bending; small tab movement out of phase, two nodal lines.</td>
</tr>
</tbody>
</table>

III. All-Metal Rudder with Reinforced Metal Fin:

<table>
<thead>
<tr>
<th>Sketch</th>
<th>Cycles per second</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>74</td>
<td></td>
</tr>
</tbody>
</table>

Langley Memorial Aeronautical Laboratory, National Advisory Committee for Aeronautics, Langley Field, Va., April 28, 1943.
I. NEW FABRIC RUDDER NO. 89R54000 FOR P-47-B AIRPLANE

Weight.................. 47.5 pounds
Balance.................. 1 inch-pound over balance
Center of gravity........ 4 feet 9.1 inches from top
                      2 feet 6.6 inches from bottom
Maximum dimensions...... 7 feet 3.7 inches by 2 feet
                      3.5 inches

Hinge line about 4 inches back from leading edge.

Natural frequencies, suspended in rubber and tab locked to center hinge post:

Cycles per second - 33, 48, 77, 108, 135, 103, 121, 143, 247

Rudder similar to this failed in the 8-foot high-speed tunnel at 460 miles per hour. Predominant frequency at failure about 140 cycles per second. Top part of rudder failed, fabric ripped, trailing edge gone.
New Fabric Rudder - 89R5400
Suspended in Rubber

33\textdegree\hspace{1cm} Tab Fast\hspace{1cm} 48\textdegree\hspace{1cm} Sept. 8, 1942

Diagram A

Driver

Diagram B

Driver
New Fabric Rudder
Suspended in Rubber
Tab Fast

77\(\text{\textdegree}\)

89 R 54000

Sept. 9, 1942

108\(\text{\textdegree}\)

Driver

C

D
New Fabric Rudder
Suspended in Rubber
Tab tight to center hinge post. Sept. 10, 1942

135°
New Fabric Rudder
Suspended in Rubber
Tab Fast

103

F

143

H

89 R 54000
Sept. 10, 1942
New Fabric Rudder - 89 R 5400
Suspended in Rubber
Tab Fast

247
Sept. 10, 1942
II. NEW ALL-METAL RUDDER NO. 93R54500 FOR P-47-B AIRPLANE

Weight ............................................ 42 pounds
Balance ............................................. 22 inch-pounds under balance
Center of gravity ................................. 4 feet 1.9 inches from top
                                             3 feet 1.2 inches from bottom
Maximum dimensions ............................. 7 feet 3 inches by 2 feet 6 inches

Hinge line about 4.5 inches from leading edge near tip
5.5 inches from leading edge near root

Radius of gyration about hinge line. 7.1 inches

Natural frequencies, suspended in rubber and tab locked to center hinge post, driver at light:
47, 57, 85, 100, 128, 161 cycles per second

Natural frequencies, suspended in rubber and tab loose:
50,
All-Metal Rudder 93R54500
Suspended in Rubber

47~ Tab Locked

57~

Sept. 10, 1942

Driver

A

B
All-Metal Rudder  93R54500
Suspended in Rubber  Sept 10, 1942

Tab Locked

Tab Tight
All-Metal Rudder 93R54500
Suspended in Rubber
Tab Locked

Sept 10, 1942

128~

Driver

161~

Driver

E

Tab Tight
All Metal Rudder

Tab Loose

50 N

Driver

93 R 54500

Sept. 10, 1942
III. REINFORCED METAL FIN AND ALL-METAL RUDDER FOR P-47B AIRPLANE

Fin Data

Part No. 89J55000, 3896

Weight.................. 47 pounds
Maximum height........... 66 inches
Maximum length.......... 49 inches
Maximum thickness...... 5.5 inches

Rudder Data

Part No. 93R54500, MFG 9-42

Weight.................. 42 pounds
Maximum height.......... 87 inches
Maximum chord.......... 29 inches

Natural frequencies of assembly as mounted on stand in sound laboratory:

17, 50, 64, 74
All Metal Rudder

Sept. 17, 1942

17~

Driver

A
All Metal Rudder

Sept. 16, 1942

Driver

74 N

93 R 54500
P-47-B rudder and fin-rudder assembly.