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

By Theodore Theodorsen and Arthur A. Regier

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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 Theodore Theodorsen 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:

Sketch	Cycles per second	Remarks
A	33	Tab locked, driver at light as shown. Mainly bending - two nodal lines.
B	48	Bending plus substantial torsion, two nodal lines.
C	77	Mainly bending, some torsion present, three nodal lines.
D	108	Mainly bending, three nodal lines.
E	135	Apparently four nodal lines present
F	103	Driver placed as shown; mainly bending plus tip torsion, three nodal lines.
G	121	Mainly bending plus more of the tip torsion, three nodal lines.
H	143	Much torsion present, three (or four) nodal lines.
I	247	High-order bending torsion, seven or eight nodal lines.

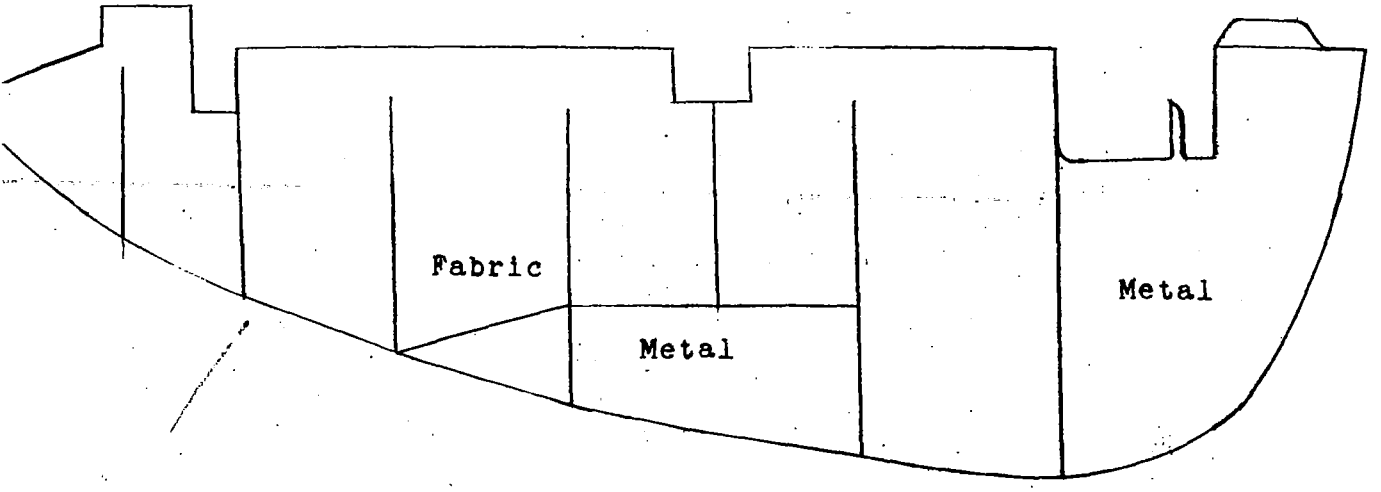
II. All-Metal Rudder without Fin:

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

III. All-Metal Rudder with Reinforced Metal Fin:

Sketch	Cycles per second	Remarks
A	17	
B	50	
C	64	
D	74	

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:

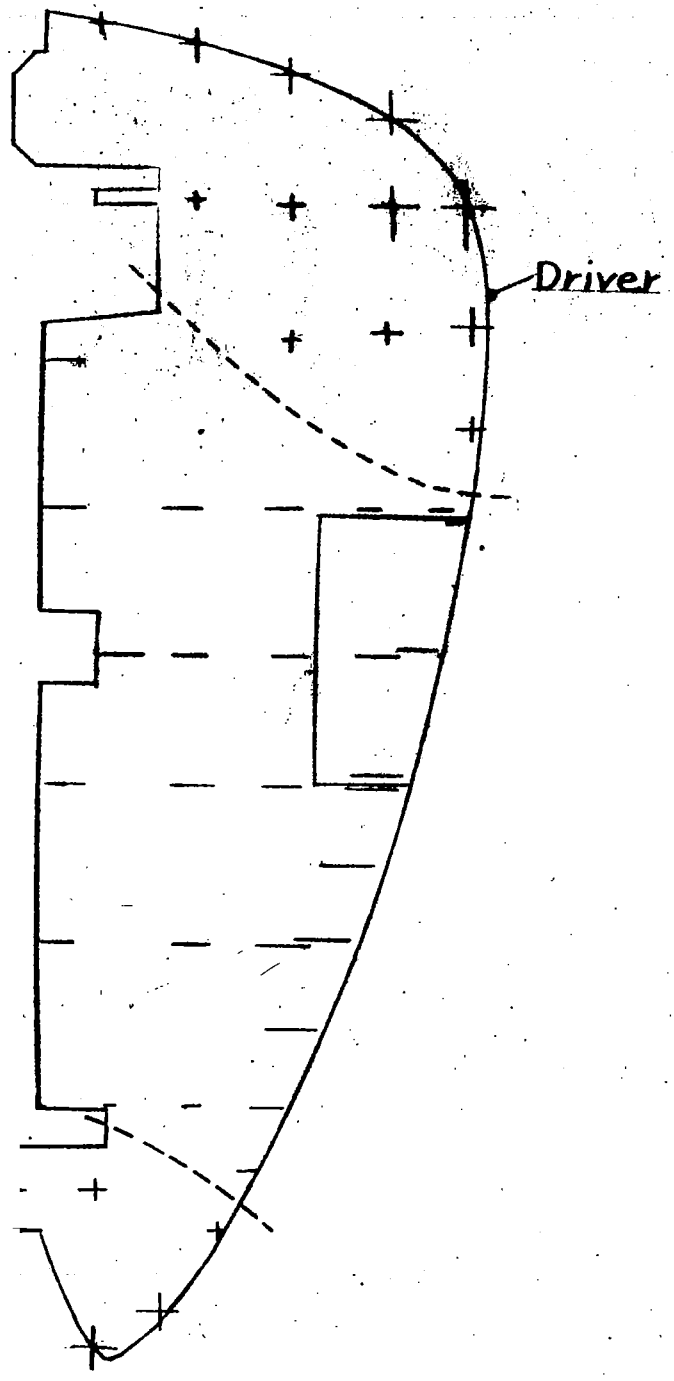
Cycles per second - 33, 48, 77, 108, 135, 103, 121, 143, 247

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.

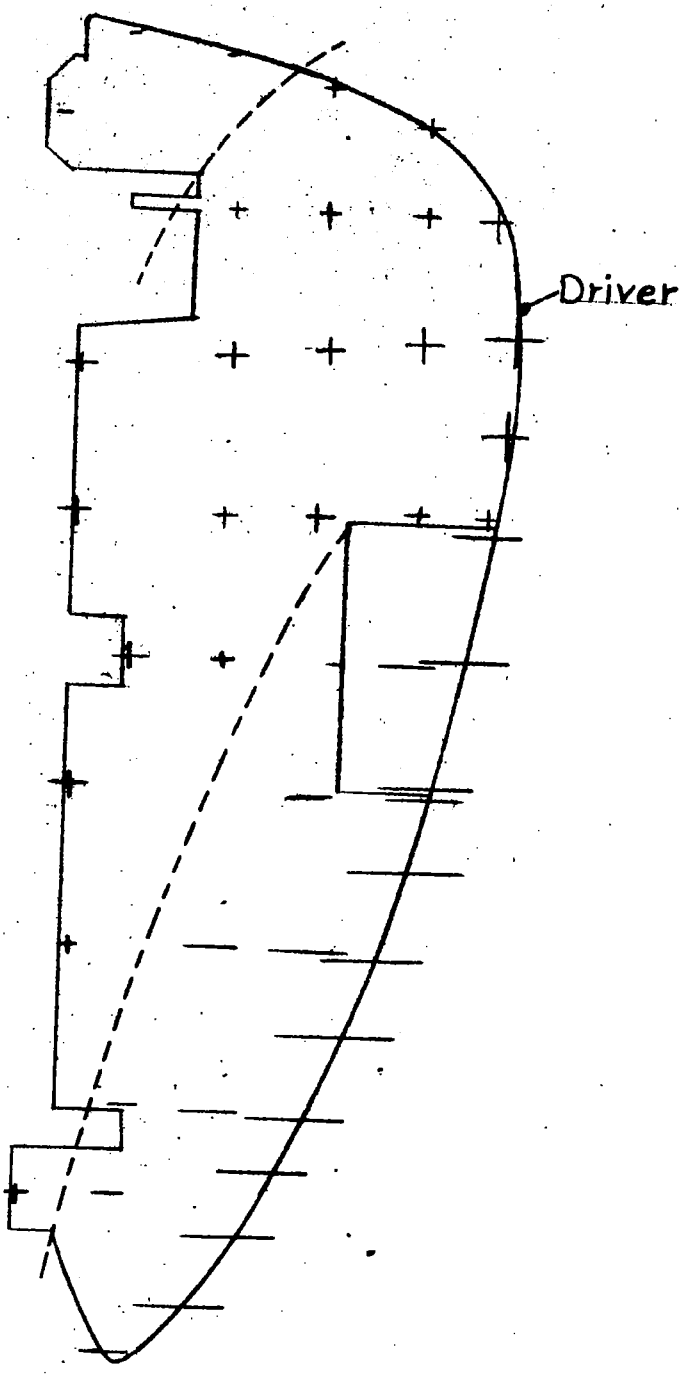
New Fabric Rudder - 89R5400
Suspended in Rubber

Tab Fast

33~ 48~ Sept. 8, 1942



A



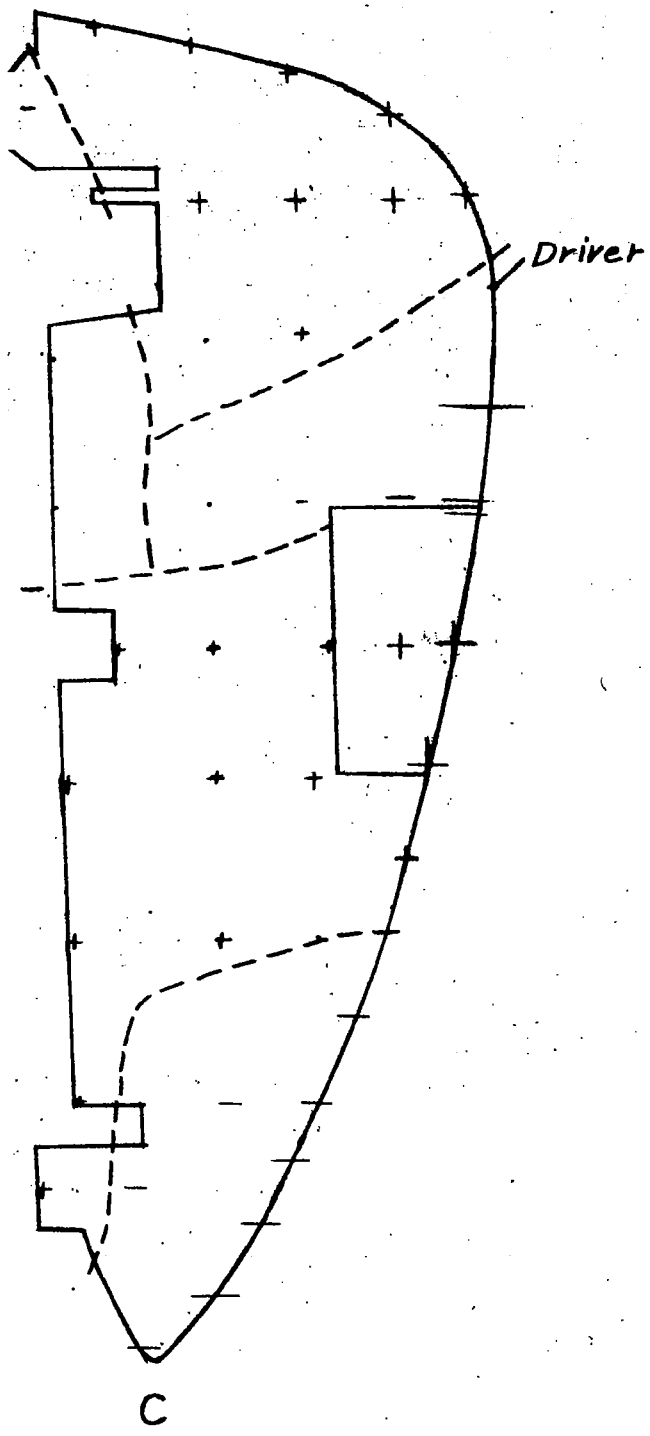
B

New Fabric Rudder
Suspended in Rubber
Tab Fast

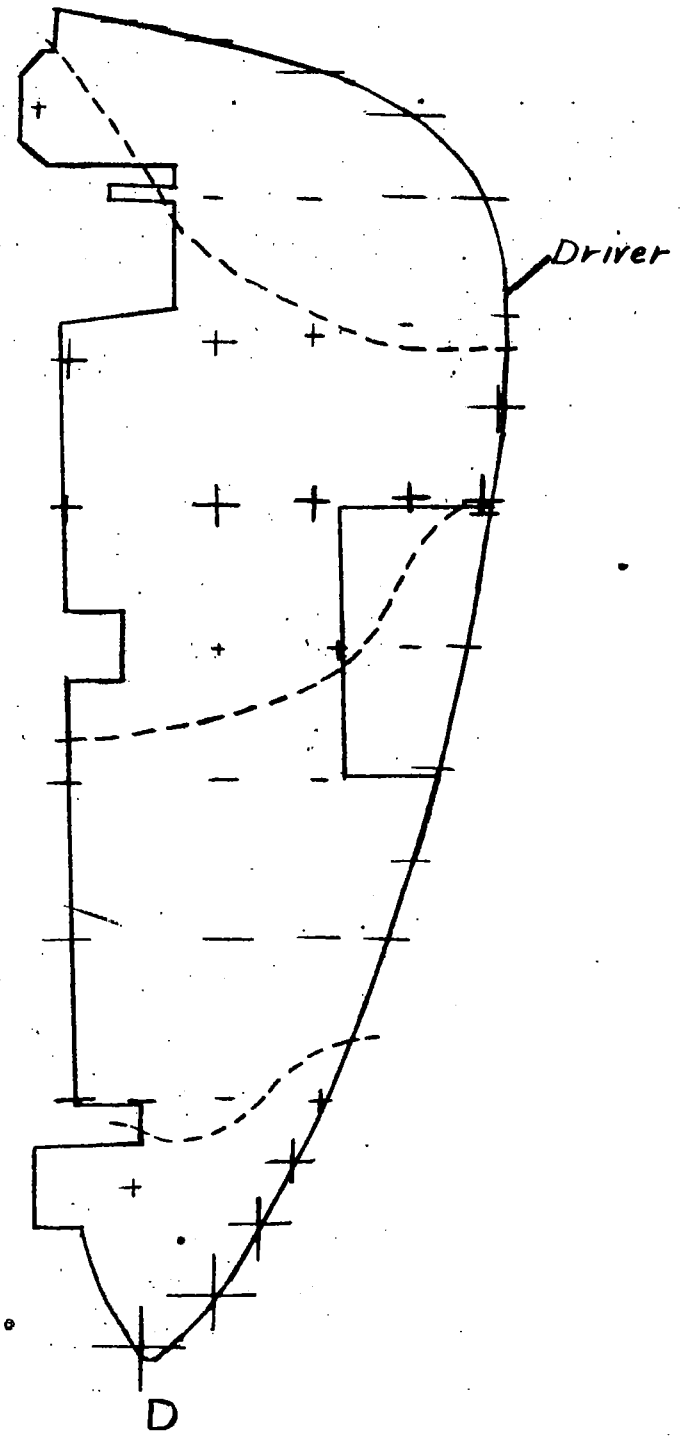
89 R 54000

Sept. 9, 1942

77 ~



108 ~

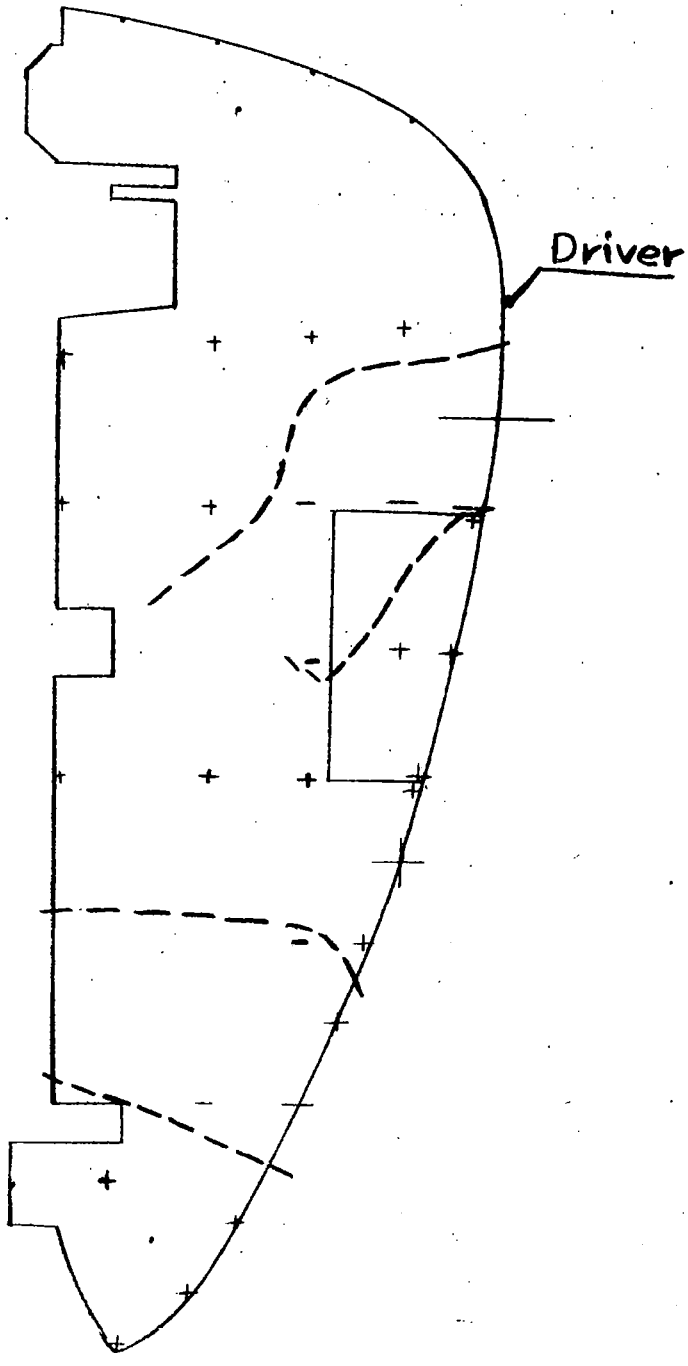


New Fabric Rudder
Suspended in Rubber
Tab tight to center hinge post.

89 R 54000

Sept. 10, 1942

135 ~



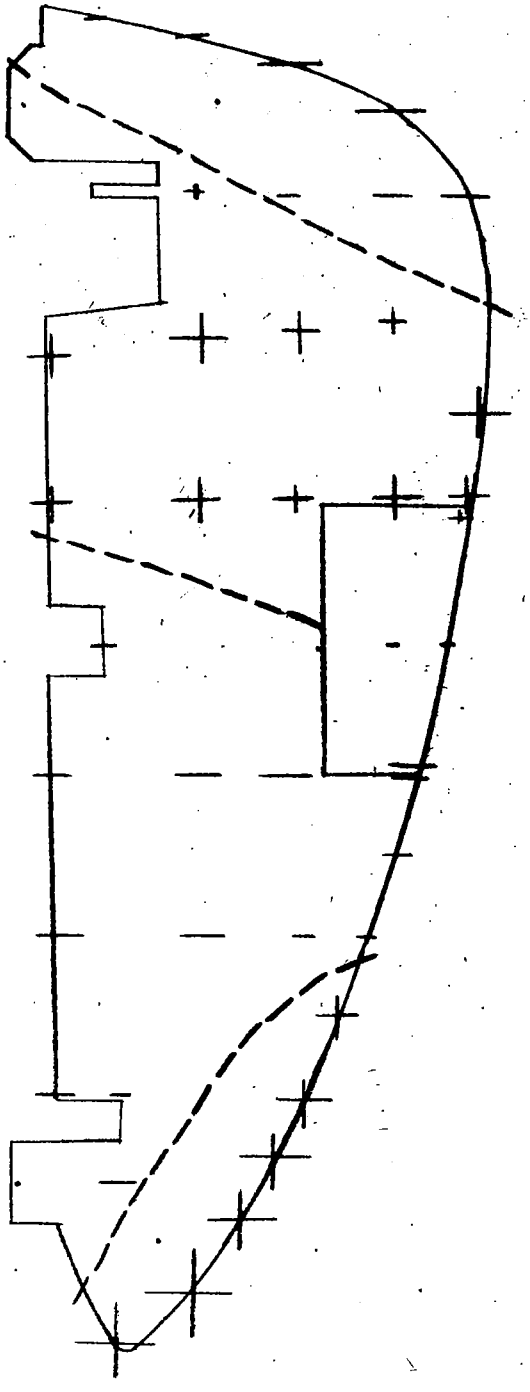
E

New Fabric Rudder
Suspended in Rubber
Tab Fast

89 R 54000

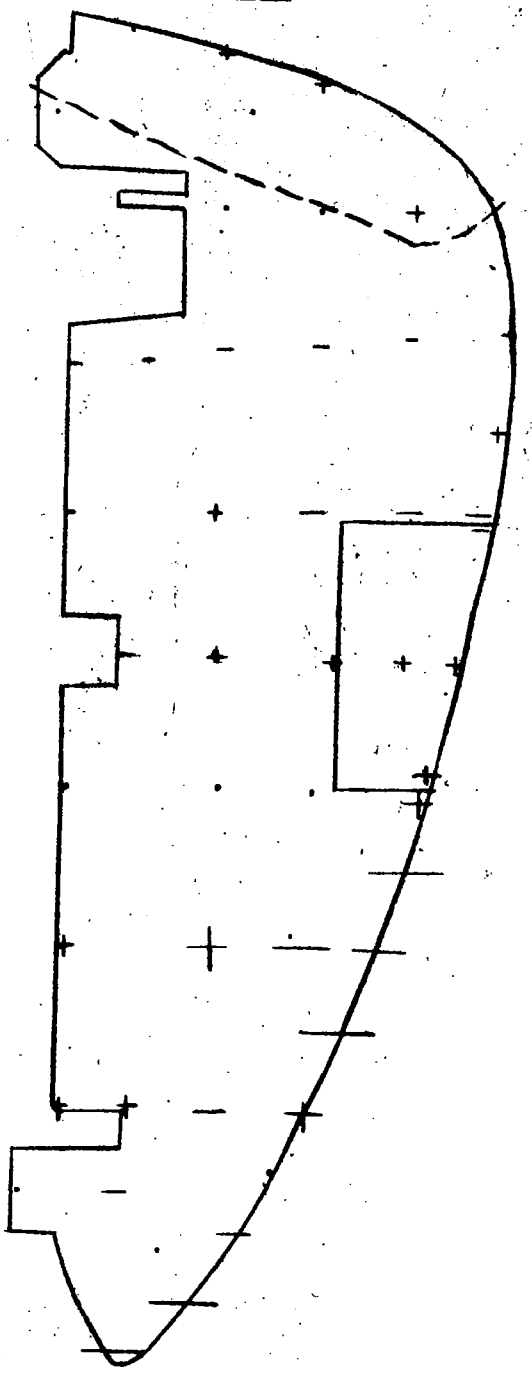
Sept. 10, 1942

103 ~



F

143 ~

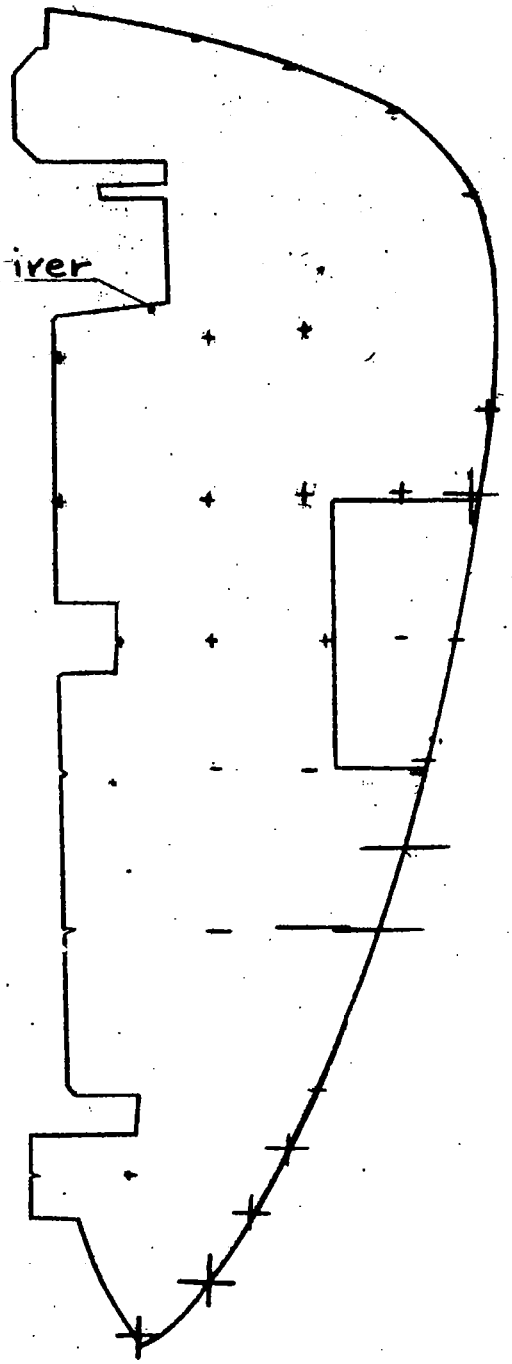


H

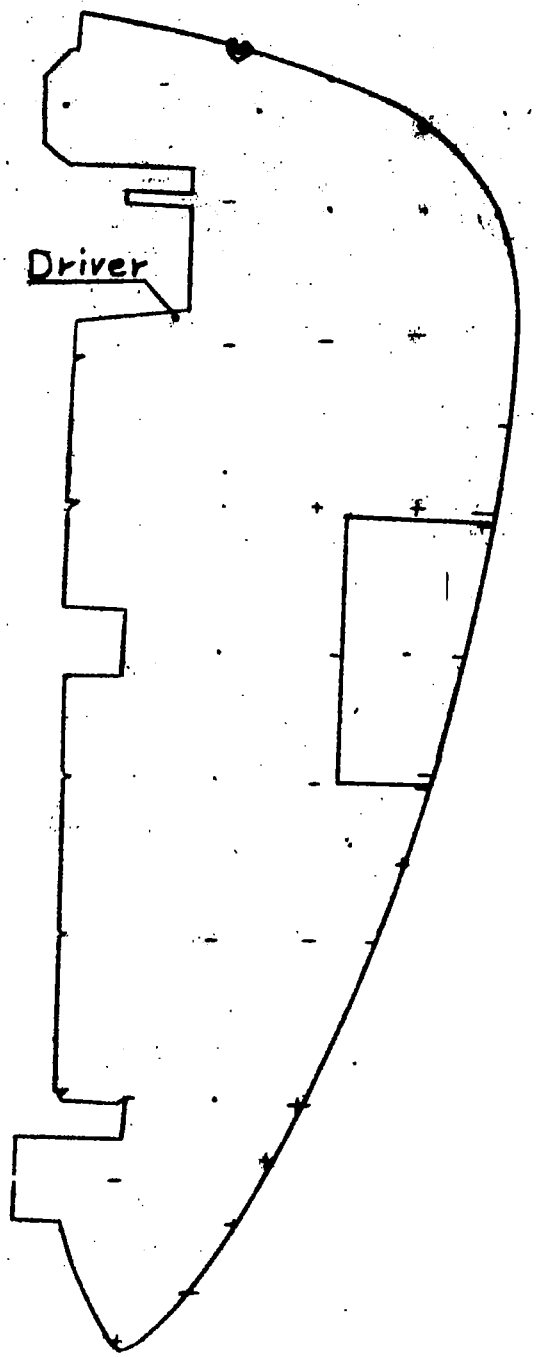
New Fabric Rudder- 89 R 5400
Suspended in Rubber

Tab Fast

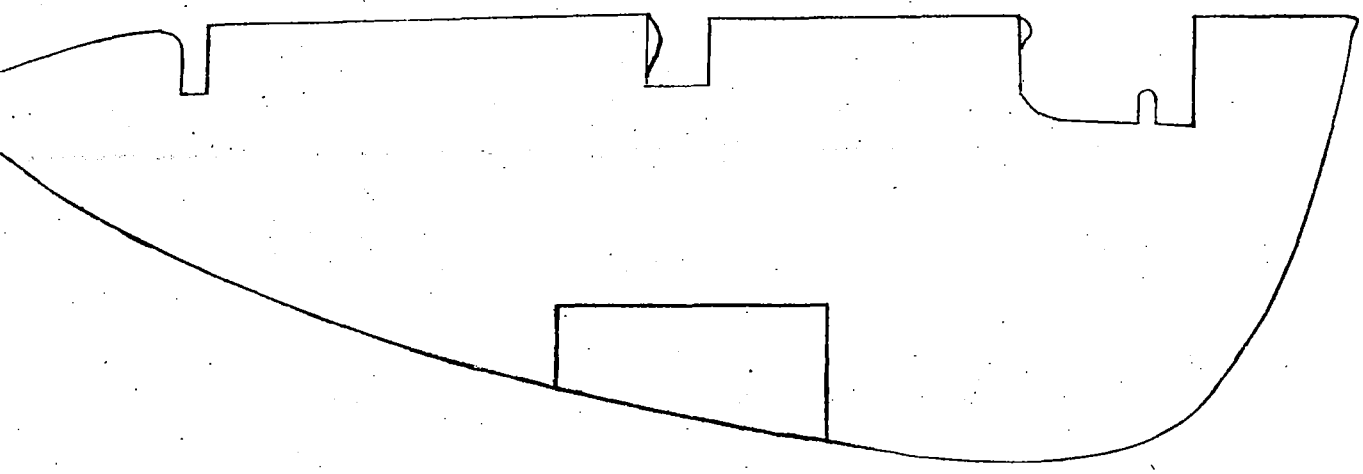
121~ 247~ Sept. 10, 1942



G



I



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,

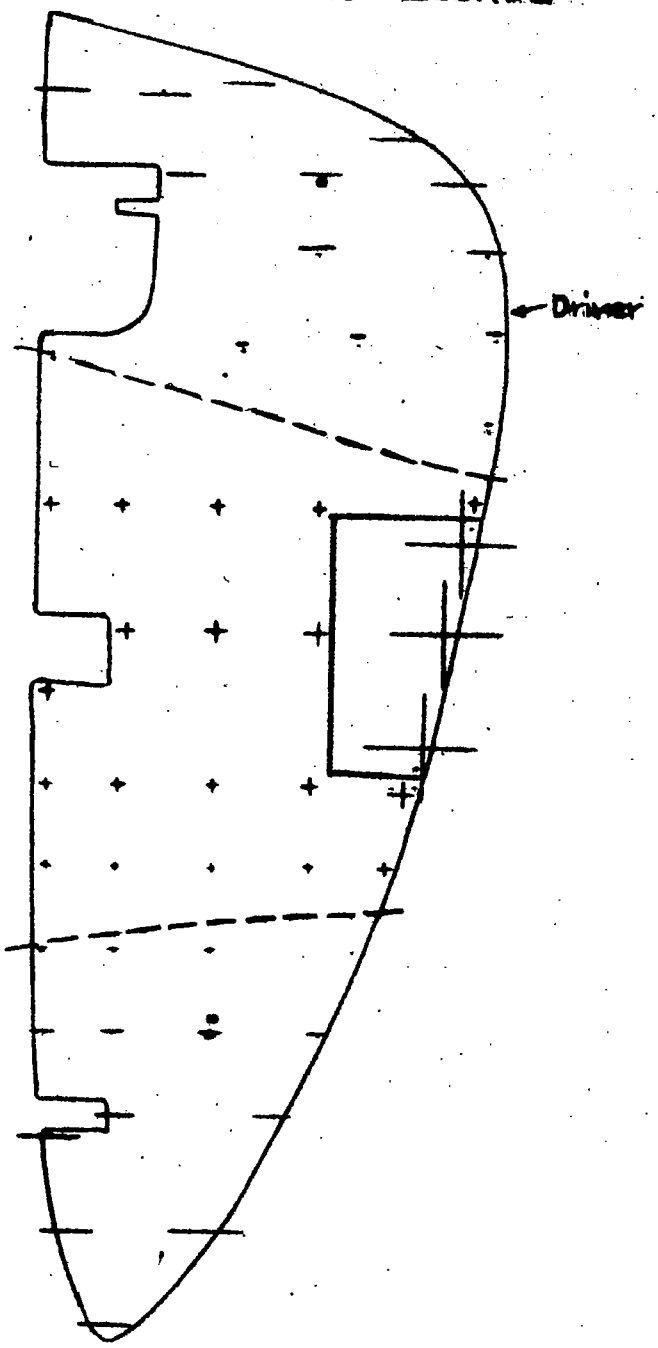
All-Metal Rudder 93R54500

Suspended in Rubber

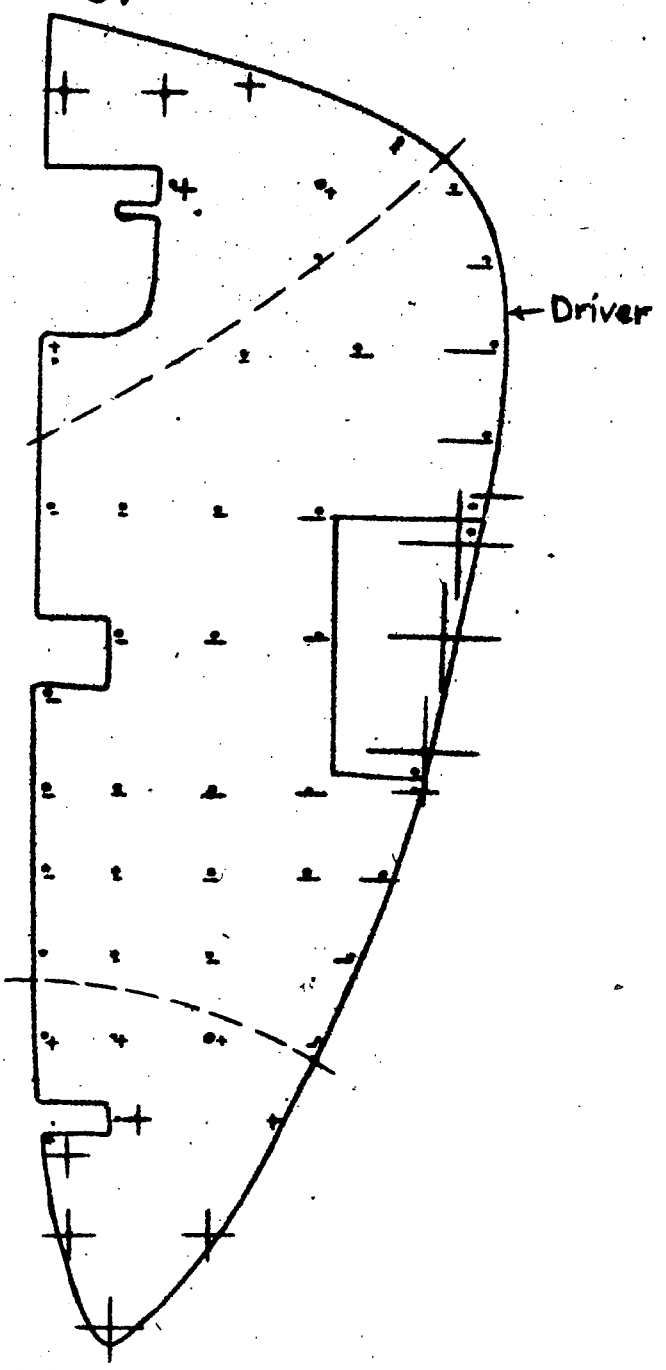
Sept. 10, 1942

47 ~ Tab Locked

57 ~



A



B

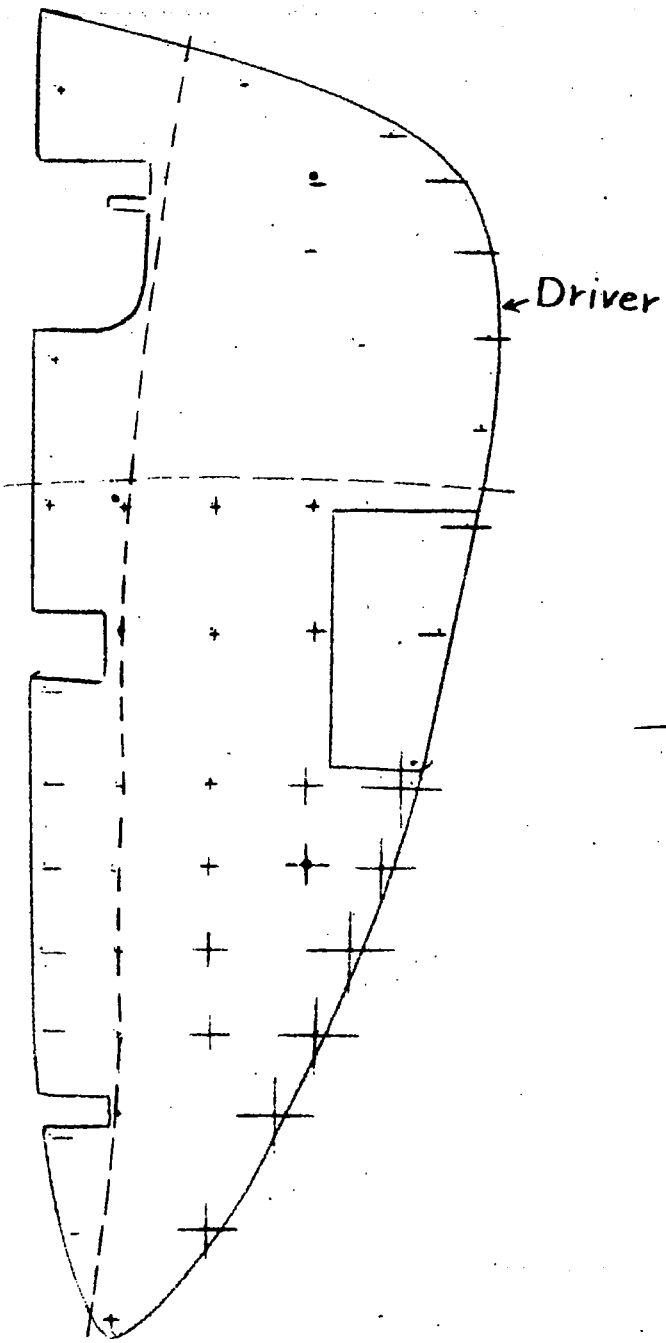
All-Metal Rudder 93R54500

Suspended in Rubber

Sept 10, 1942

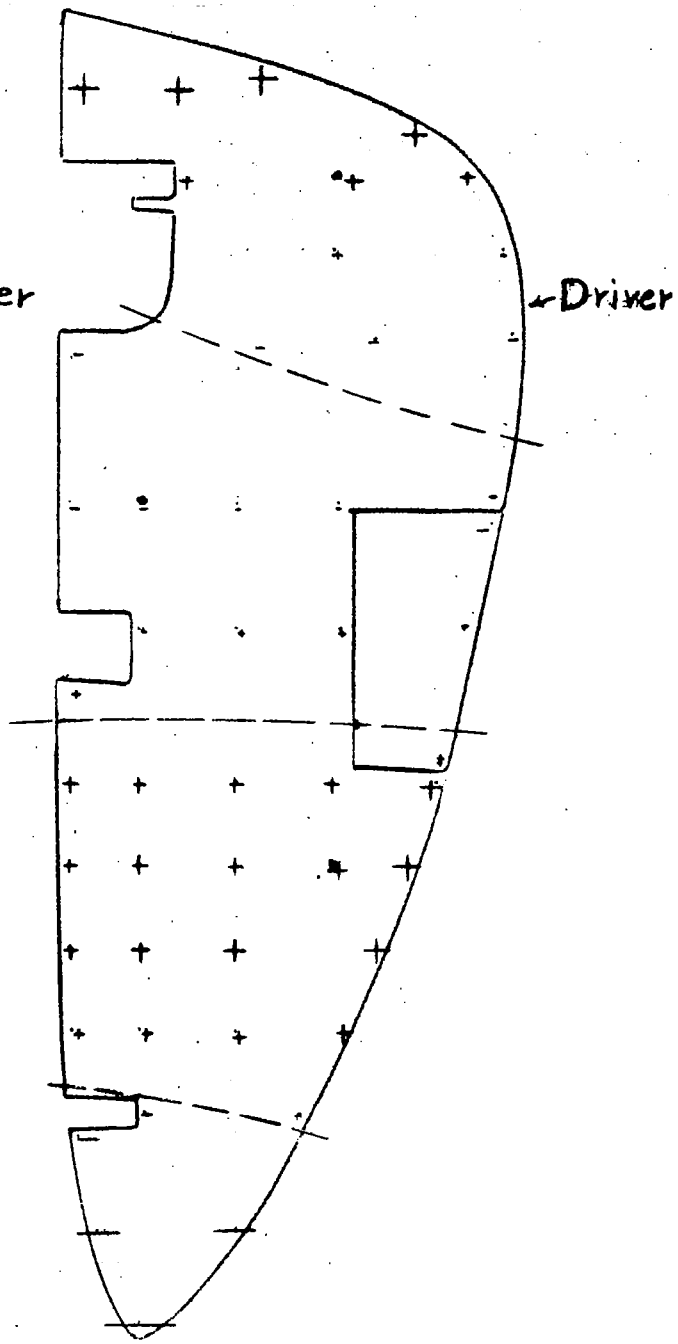
Tab Locked

85 ~



C

100 ~



D

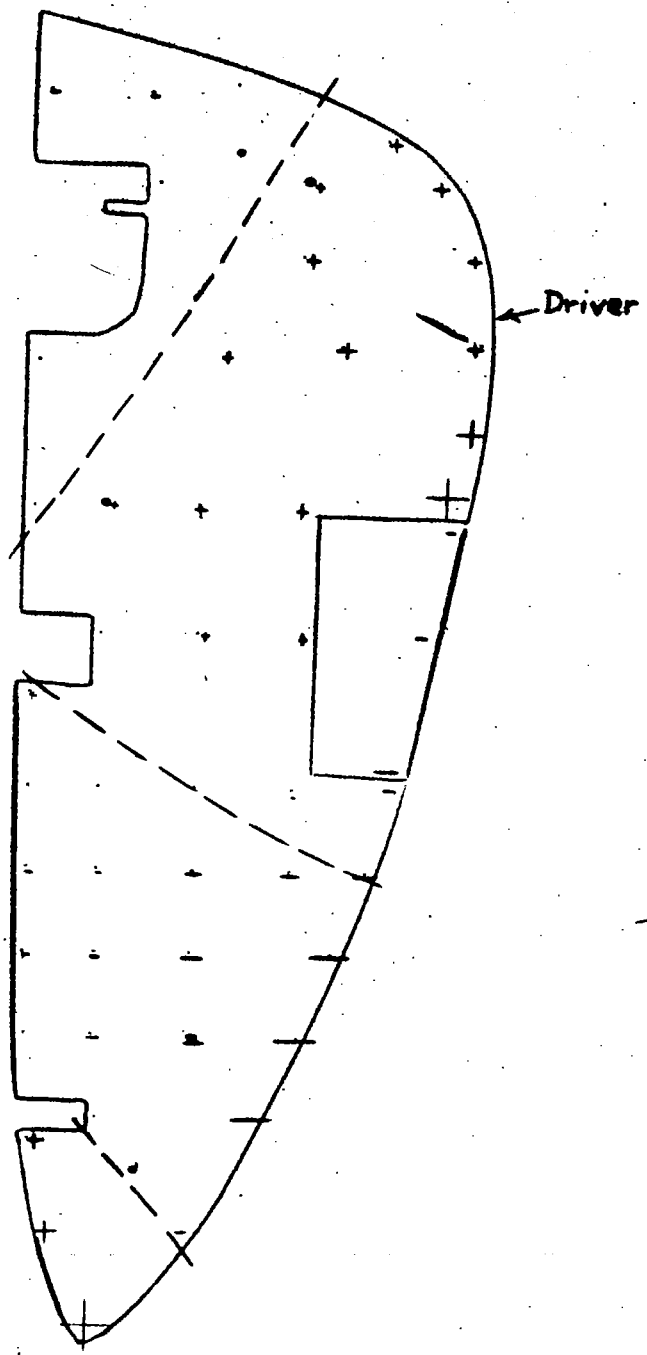
Tab Tight

All-Metal Rudder 93R54500
Suspended in Rubber

Sept 10, 1942

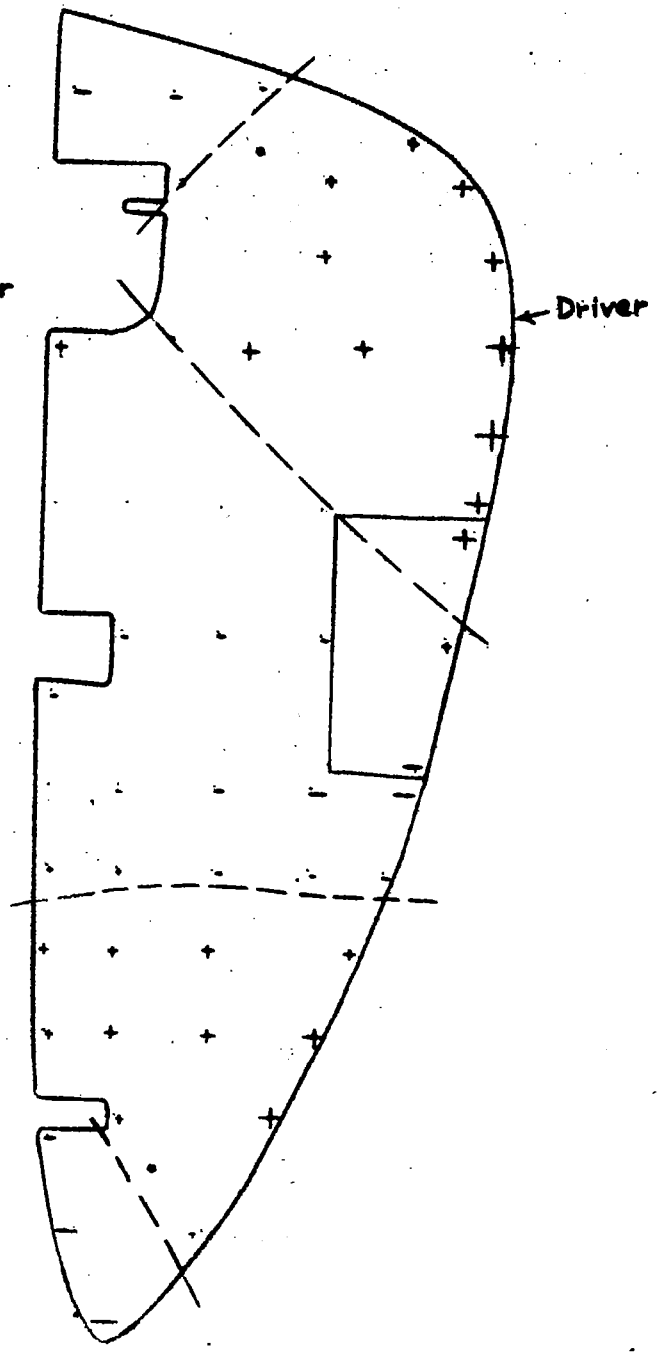
Tab Locked

128~



E

161~



I

Tab Tight

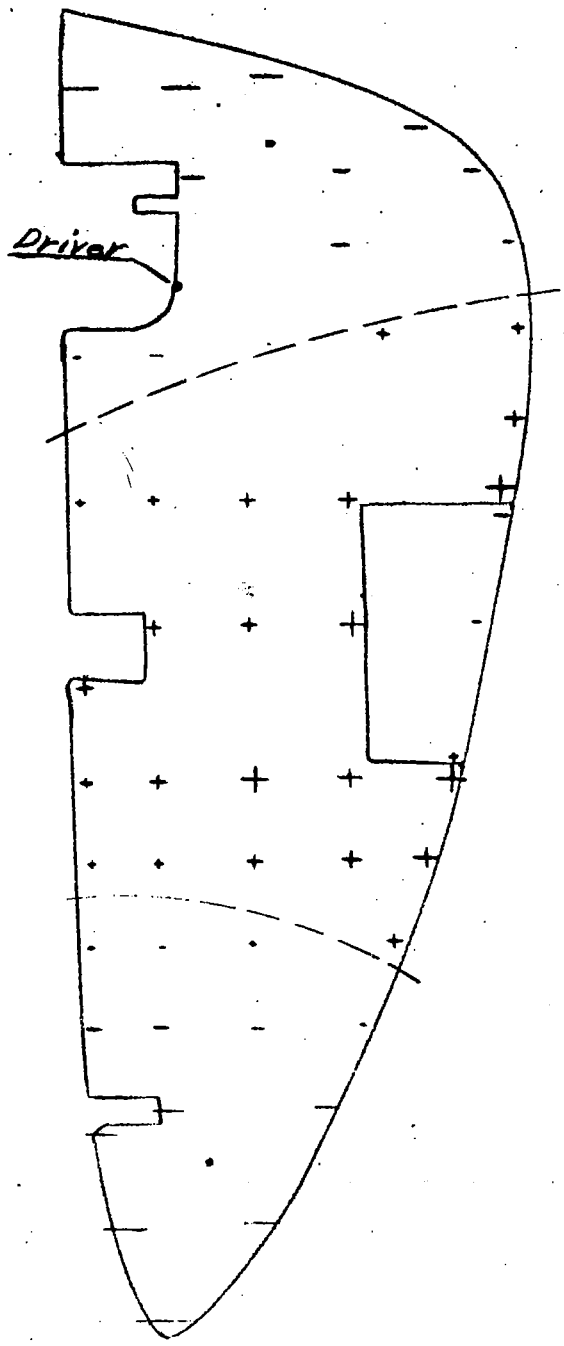
All Metal Rudder

93 R 54500

Tab Loose

Sept. 10, 1942

50 ~



G

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:

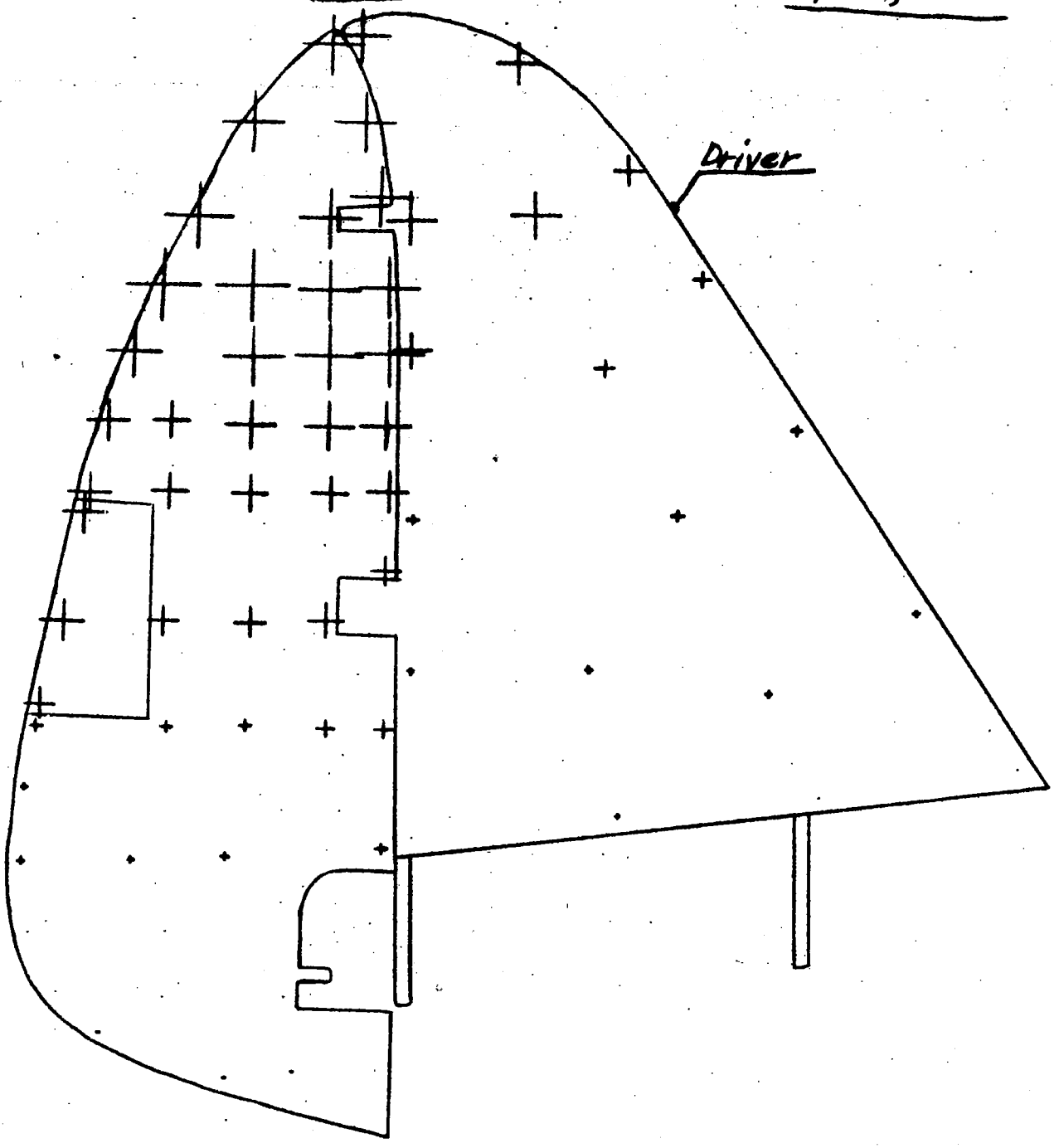
17, 50, 64, 74

All Metal Rudder

93 R 54500

17 ~

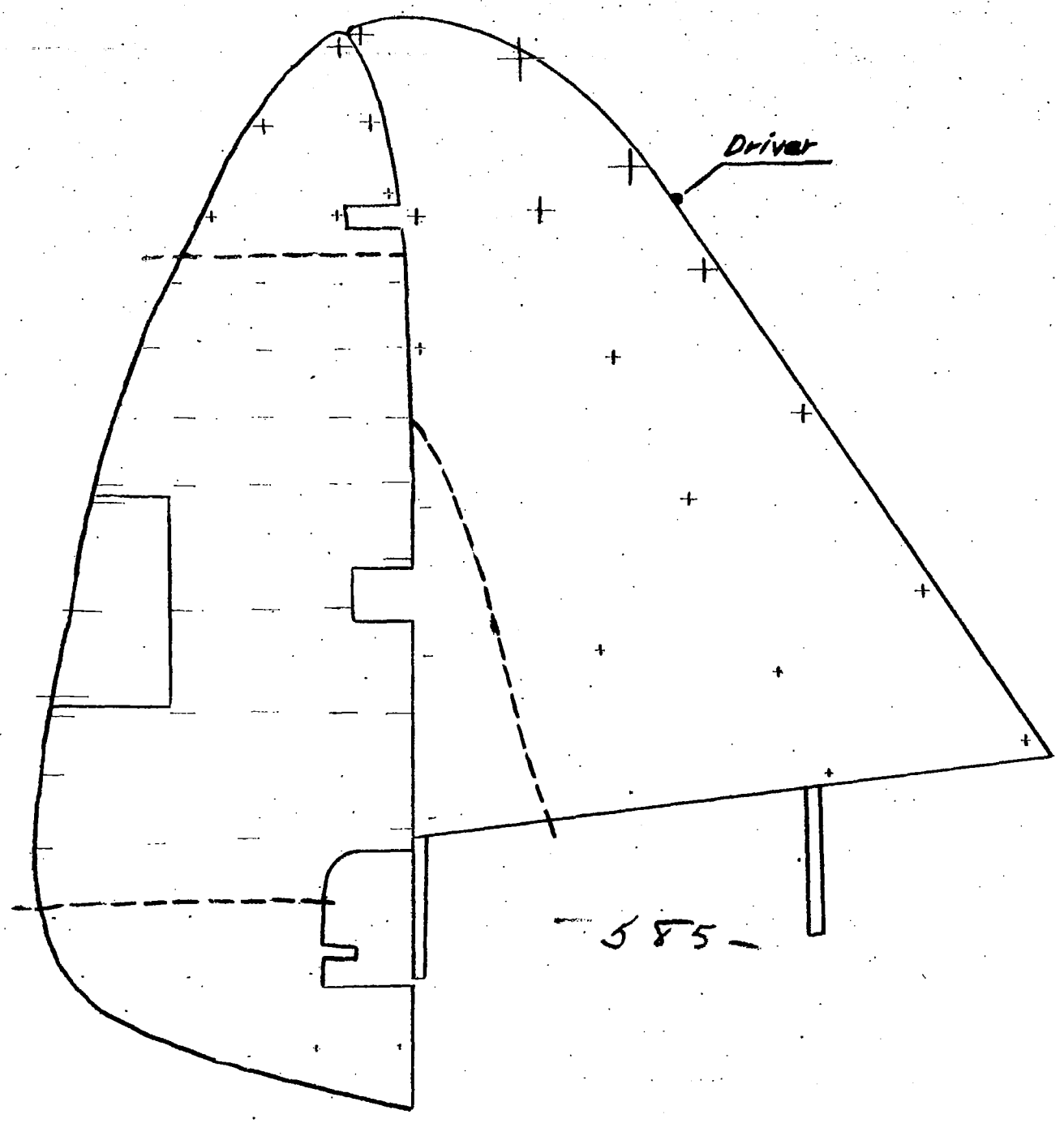
Sept. 17, 1942



A

All Metal Rudder 93 R 54500

50 ~ Sept. 16, 1942



B

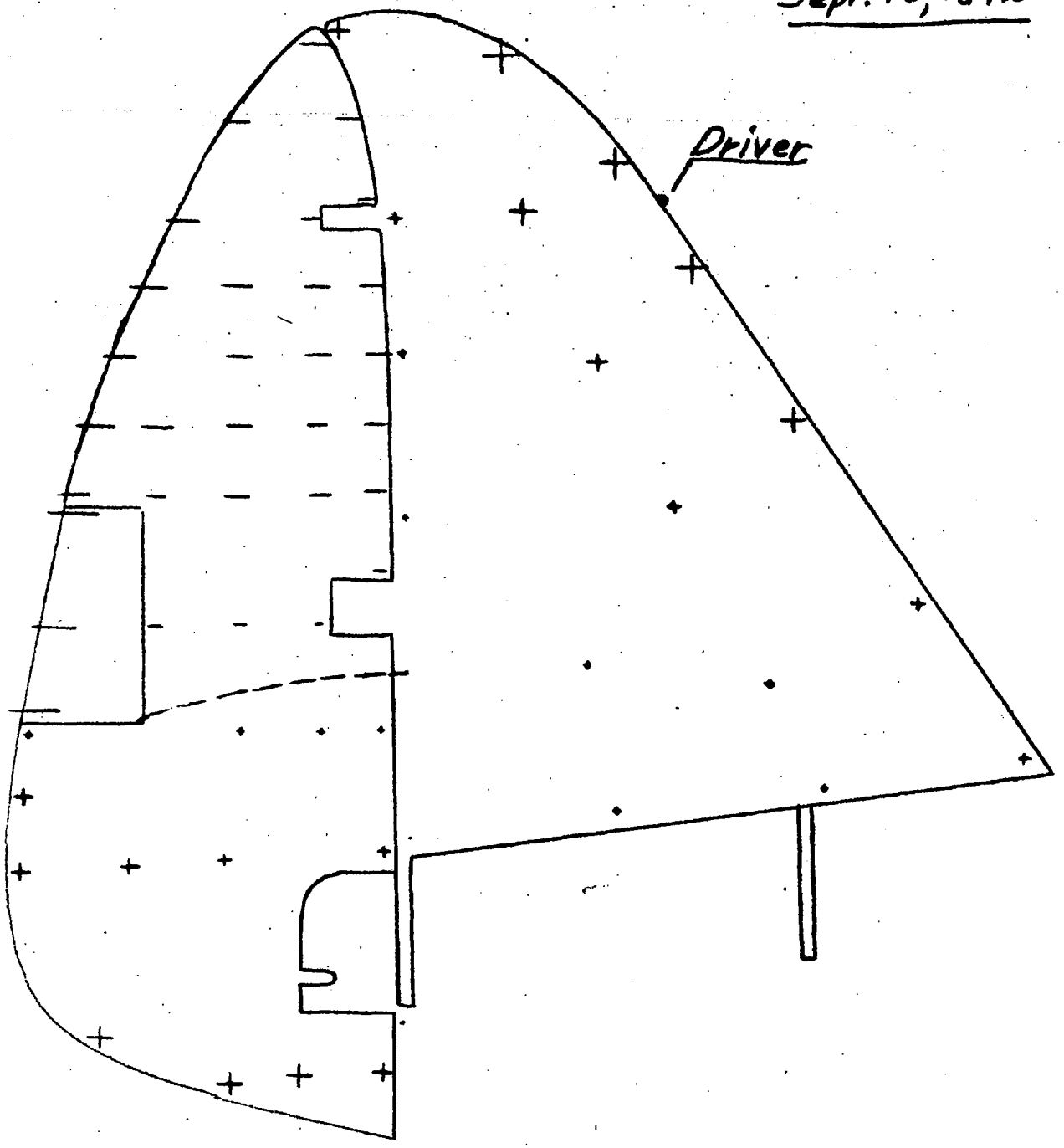
1

All Metal Rudder

93 R 54500

64 ~.

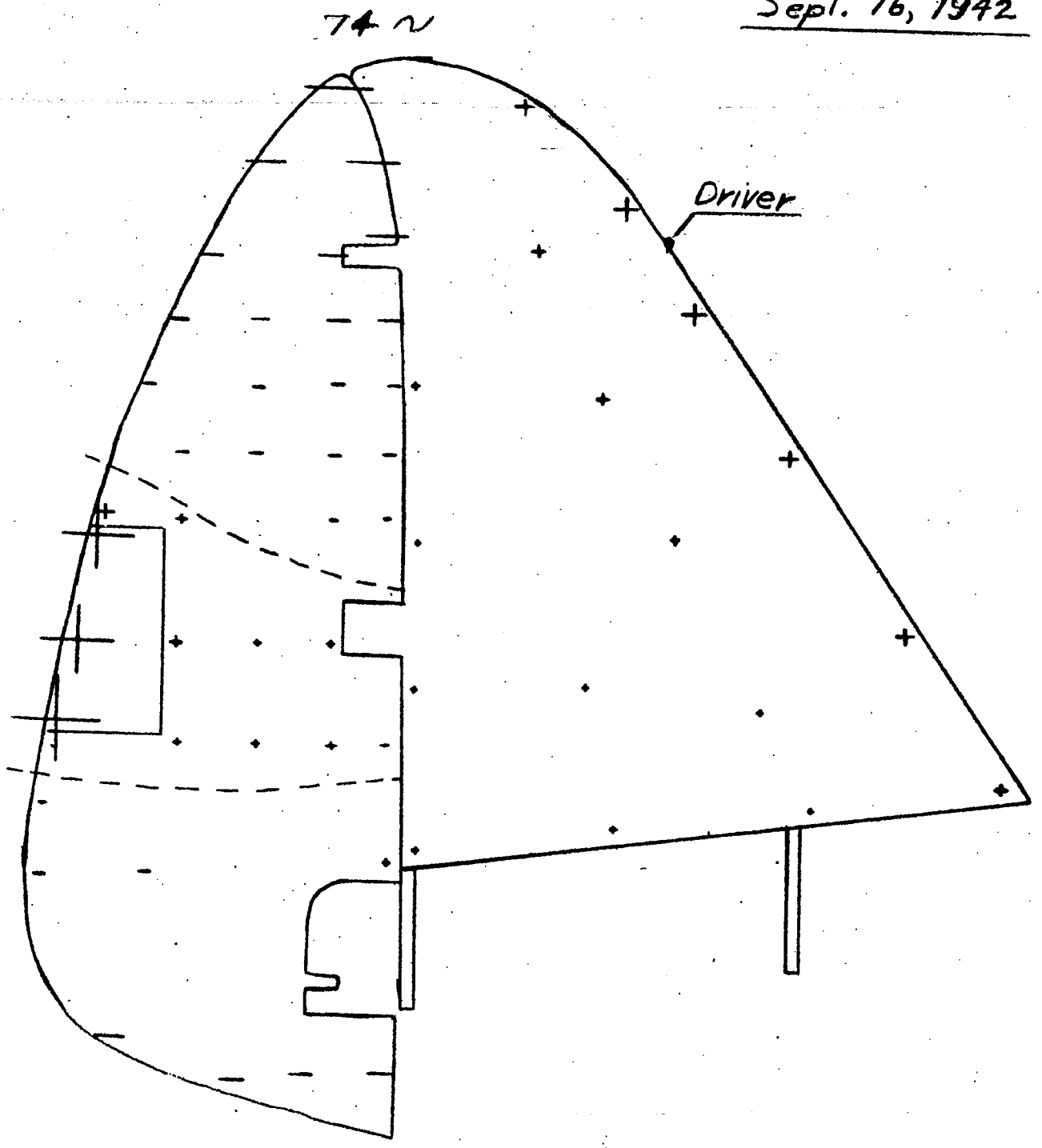
Sept. 16, 1942



C

All Metal Rudder 93 R 54500

Sept. 16, 1942



D

P-47-B rudder and fin-rudder assembly.

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