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Structures Technical Memorandum 328

RESONANCE TESTS ON A PIPER PA-32R TAILPLANE BEFORE AND AFTER DAMAGE

A. GOLDMAN and B. QUINN

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RESONANCE TESTS ON A PIPER PA-32R TAILPLANE BEFORE AND AFTER DAMAGE

A. GOLDMAN and B. QUINN

SUMMARY

Investigations have been carried out, on the tailplane of a Piper PA-32R aircraft, to determine the effect of damage, in the form of a split in the underside skin, on the modes of vibration of the tailplane. Details and results of the investigations are described.

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1. INTRODUCTION

During investigations into the cause of the crash of a Piper PA-32R aircraft, to be reported in Ref. 1, Department of Transport inspectors found a split in the port lower skin of the all-moving tailplane. The tests described below were carried out to determine the effect of this split on the modes of vibration up to 50 hertz.

2. DESCRIPTION OF TESTS

An undamaged tailplane, without the control tab, was mounted on a central support in a similar manner to that in the aircraft. The tailplane was prevented from rotating by a rod attaching the control arm to the central support. The structure was excited, at the leading and trailing edges of each tip, by shakers connected to the surface by push rods. Refer Fig. 1.

An accelerometer was fixed to the top surface above each shaker attachment point, and measuring stations marked out as shown in Fig. 2. The shakers were driven by an oscillator and four amplifiers. The modes of vibration were tuned by adjusting frequency and excitation forces until the acceleration responses at all forcing stations were 90 degrees out of phase with the exciting force. This was monitored on an oscilloscope by use of a display of four Lissajous figures.

At each resonant frequency, determined as described above, the mode of vibration was plotted using a travelling accelerometer on a rubber suction cup to measure the acceleration response of the structure at the sixteen measuring stations shown on Fig. 2.

The signal from the accelerometer was fed to a transfer function analyser which measured the in-phase and quadrature components of the acceleration with reference to the forcing signal. Only the quadrature component was used to plot the mode shape.

On completion of the measurement of all modes of vibration up to 50 hertz, the tailplane was removed from the rig and, following other structural tests, a slit, 406 millimetres long, was made in the port lower skin as indicated in Figures 3 and 4.

The tailplane was remounted in the test rig and the modes of vibration measured again. In Figures 5 to 8 details are given of the individual mode shapes for both the undamaged and damaged conditions and the associated resonant frequencies are listed in Table 1.

3. DISCUSSION AND CONCLUSION

The frequencies of the various mode shapes plotted were well separated with the exception of the pitch mode where two identical modes were found quite close together by varying the force input. This was probably caused by non-linearity in the supporting rig.

The modes of vibration up to 50 hertz have been plotted for the undamaged and damaged tailplane; the changes brought about by the reduced stiffness are slight.

REFERENCE

1. Department of Transport Crash Investigation Report (in course of preparation), File Ref. M116/1/20.

TABLE 1

SUMMARY OF VIBRATION MODES AND RESONANT FREQUENCIES

MODE DESCRIPTION	FREQUENCY UNDAMAGED TAIL PLANE	FREQUENCY DAMAGED TAIL PLANE
Roll about Attachment Point	16.85 Hz	16.2 Hz
Fundamental Bending	18.55 Hz	18.25 Hz
Pitch about Attachment Point	26.8 Hz (not shown) 30.4 Hz	27.9 Hz (not shown) 29.5 Hz
Antisymmetric Torsion	50.03 Hz	48.8 Hz

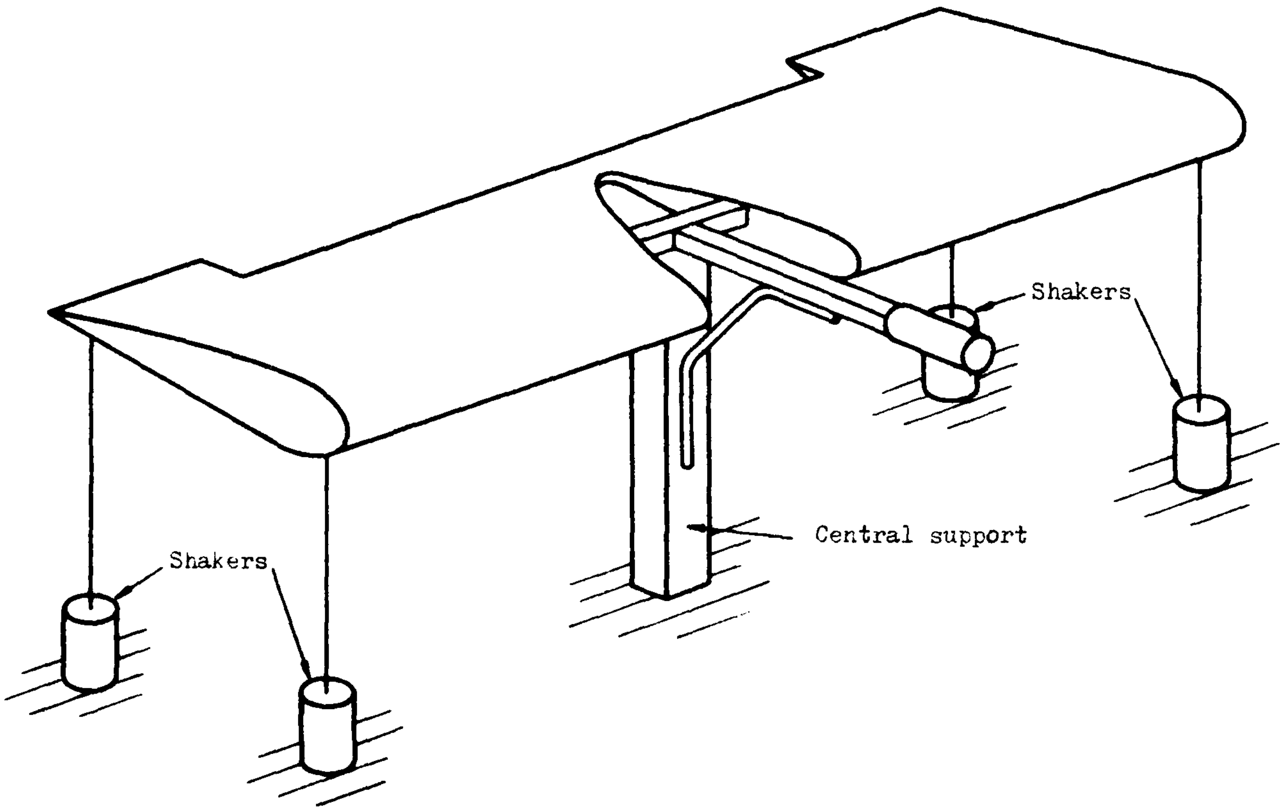
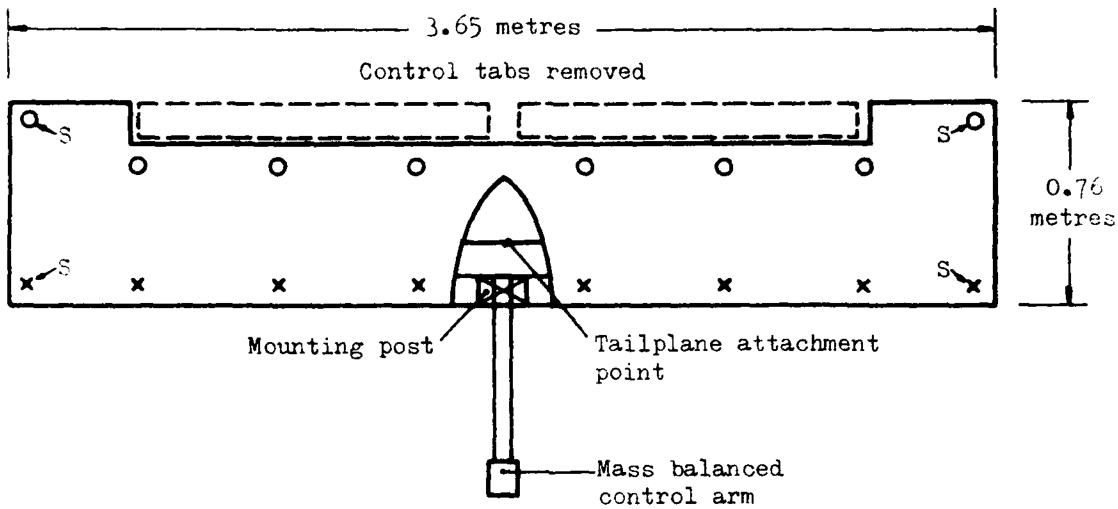


FIG.1 GENERAL ARRANGEMENT OF TAILPLANE, SUPPORT, AND SHAKERS



O and X indicate measuring stations for plotting of mode shapes.
Refer to Figs. 4 to 7.
Shakers and fixed accelerometers mounted at locations marked S.

FIG.2 PLAN OF TAILPLANE SHOWING LOCATION OF SHAKERS AND MEASURING STATIONS.

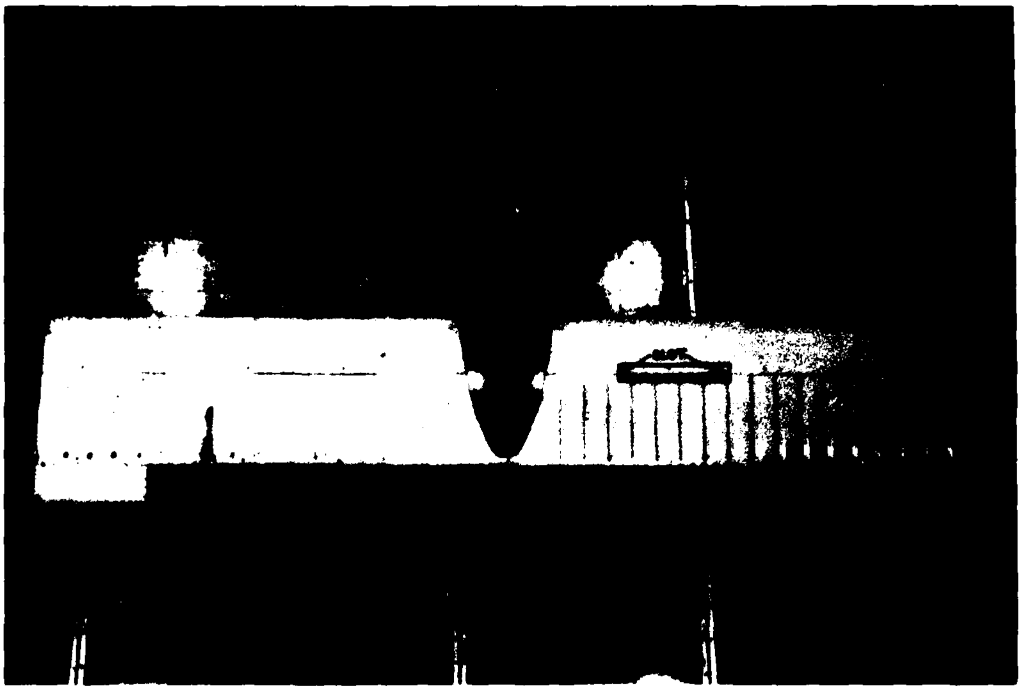


FIG.3 TAILPLANE SHOWING LOCATION OF SPLIT IN LOWER SKIN

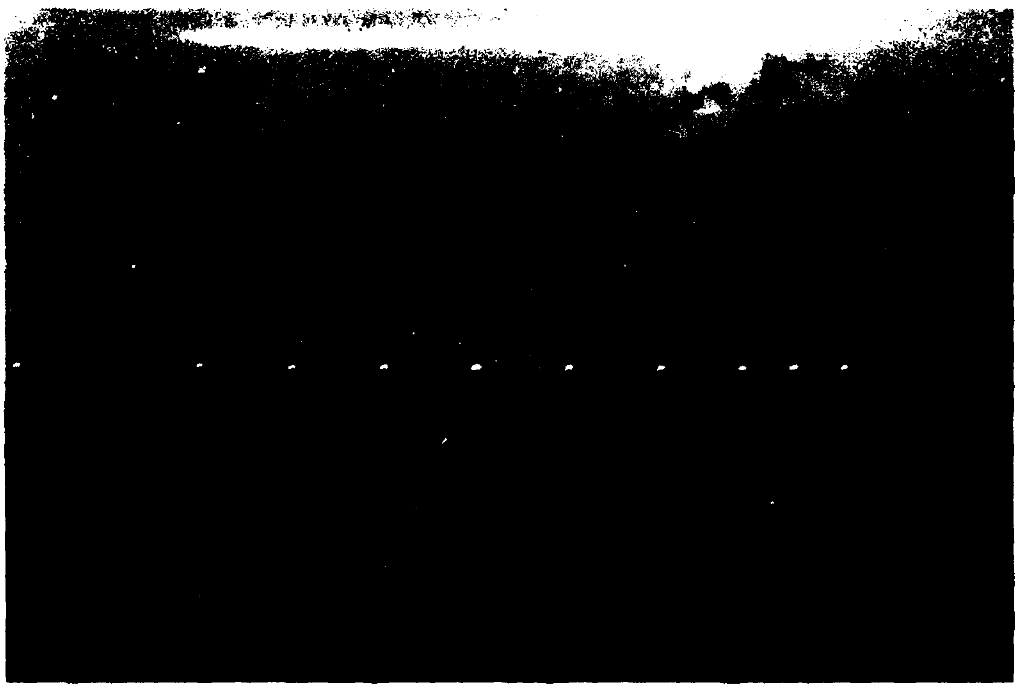


FIG.4 CLOSE-UP OF SPLIT IN LOWER SKIN ALONG A RIVETTED SEAM AT THE MAIN SPAR

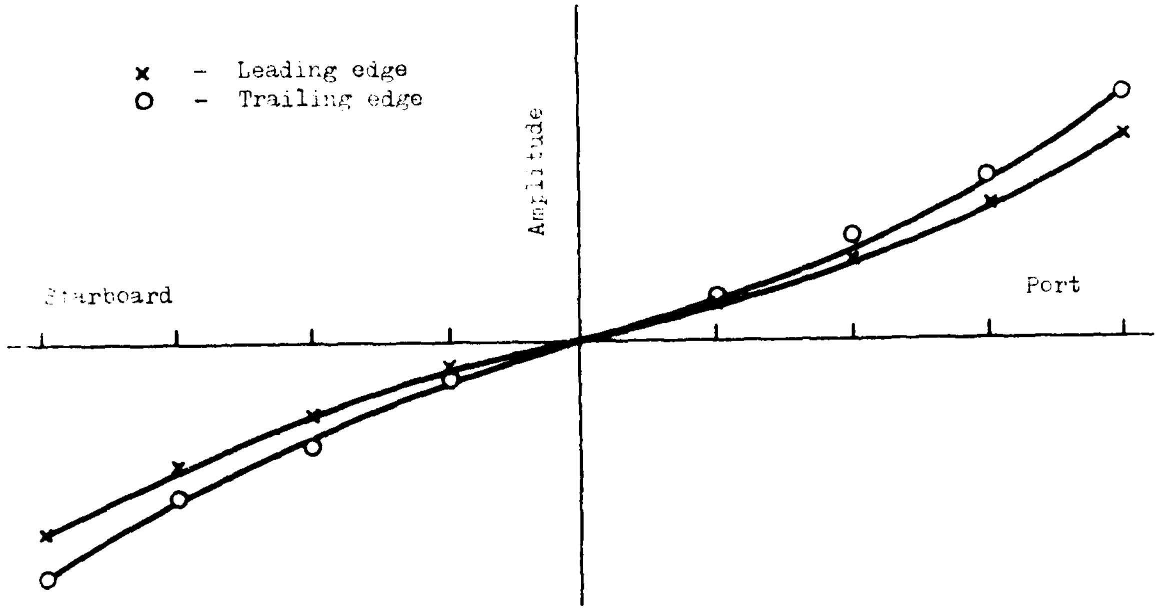


FIG.5 (a) UNDAMAGED TAILPLANE MODE AT 16.85 Hz

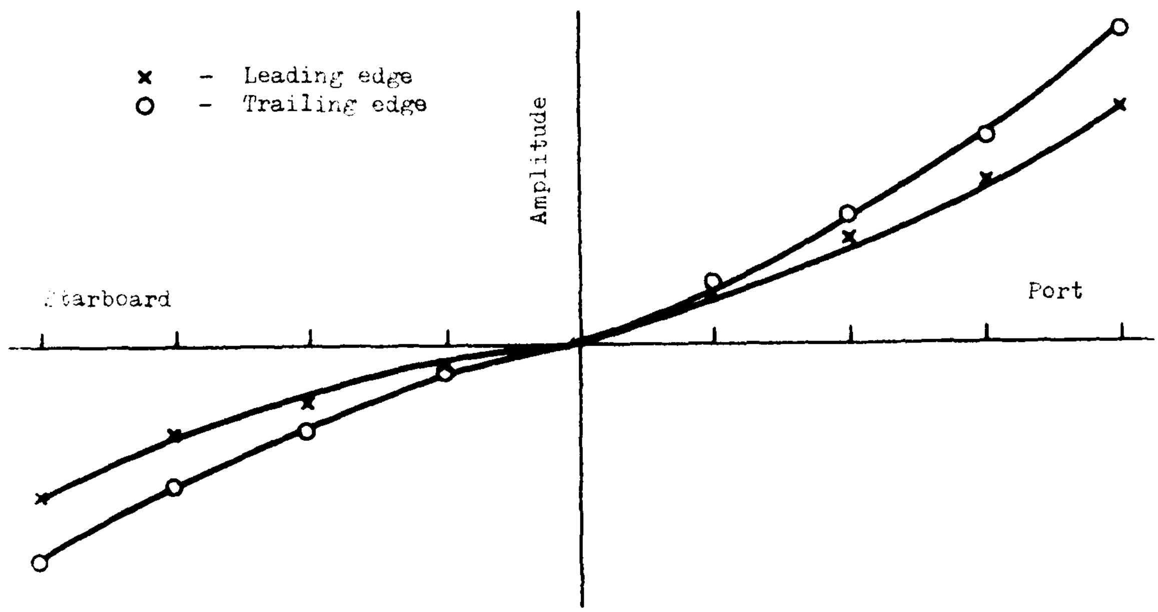


FIG.5 (b) DAMAGED TAILPLANE MODE AT 16.2 Hz

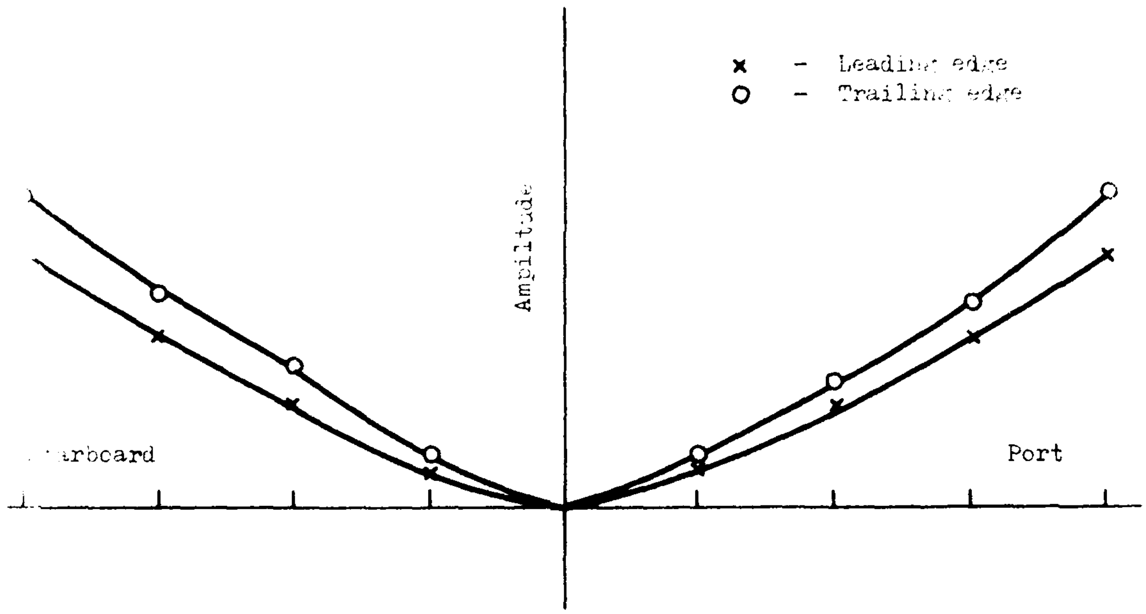


FIG.6 (a) UNDAMAGED TAILPLANE MODE AT 18.55 Hz

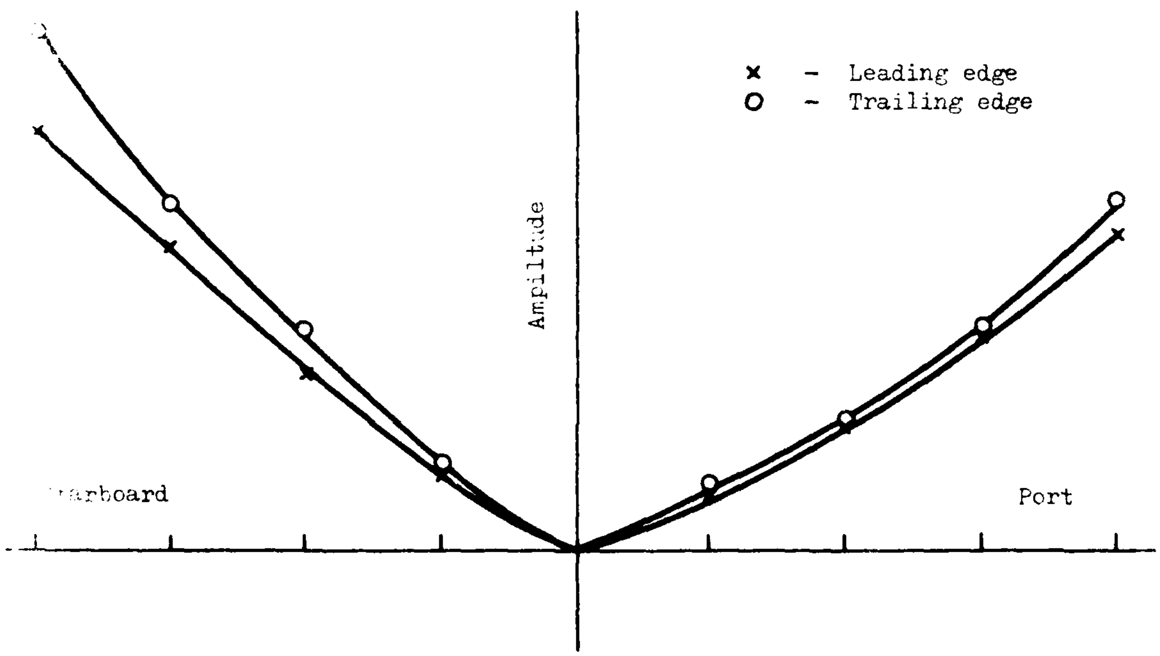


FIG.6 (b) DAMAGED TAILPLANE MODE AT 18.25 Hz

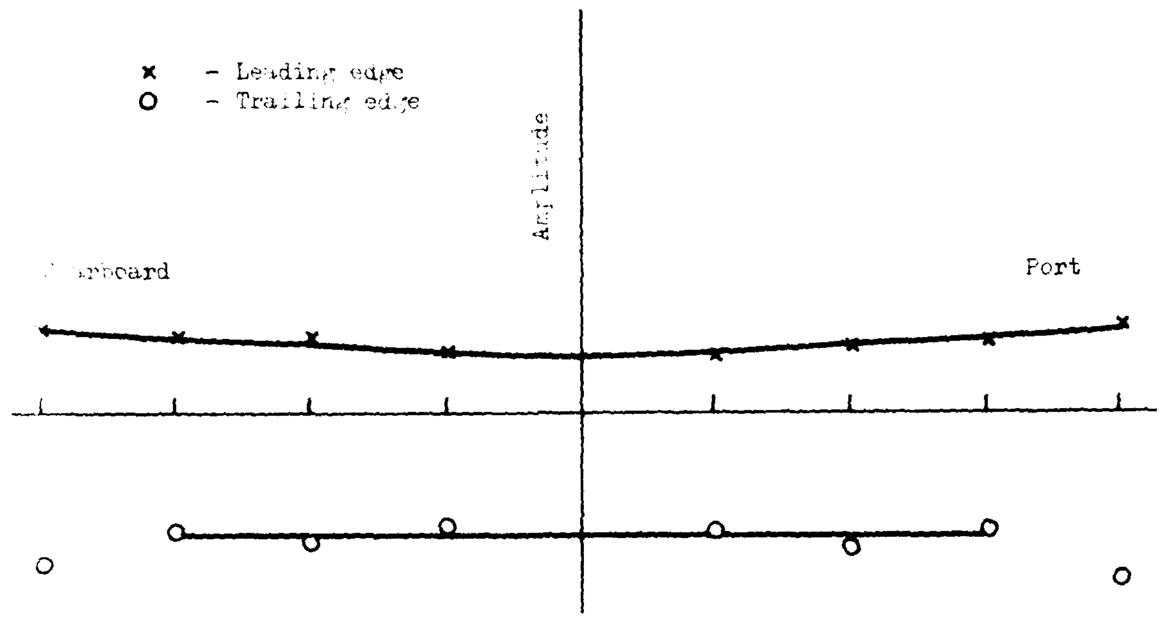


FIG.7 (a) UNDAMAGED TAILPLANE MODE AT 30.4 Hz

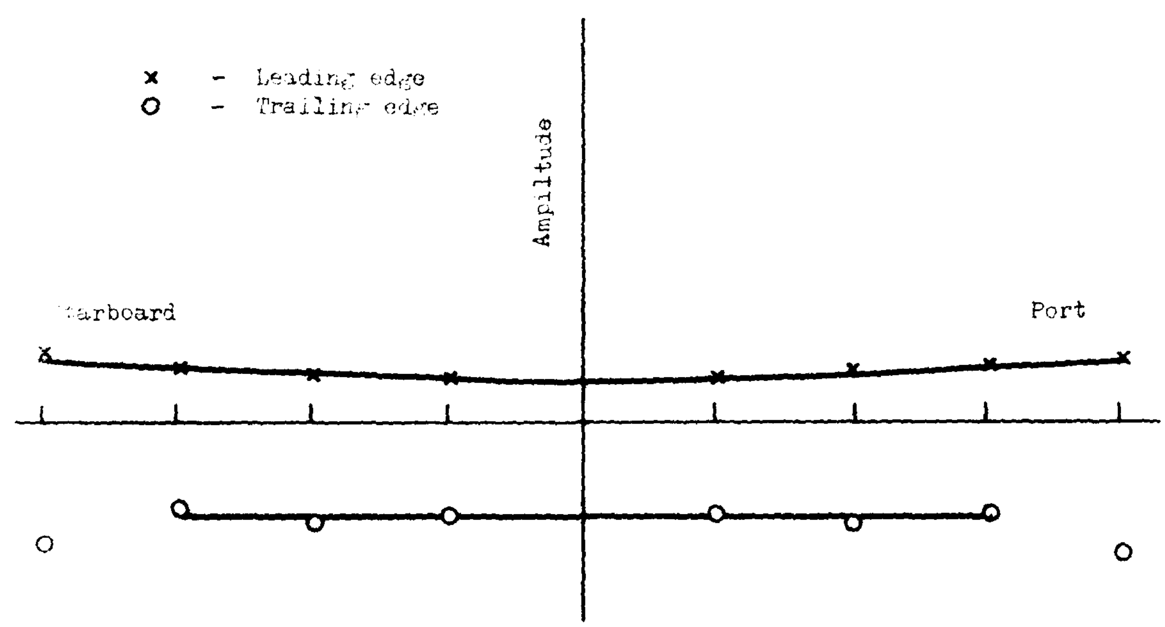


FIG.7 (b) DAMAGED TAILPLANE MODE AT 29.5 Hz

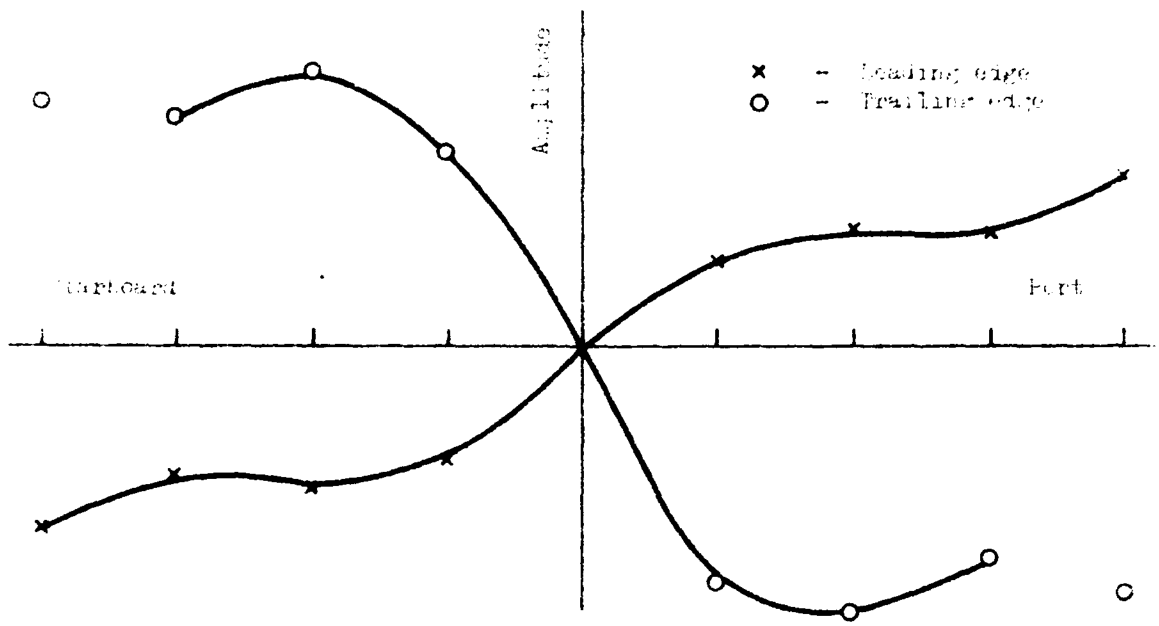


FIG.8 (a) UNDAMAGED TAILPLANE MODE AT 50.03 Hz

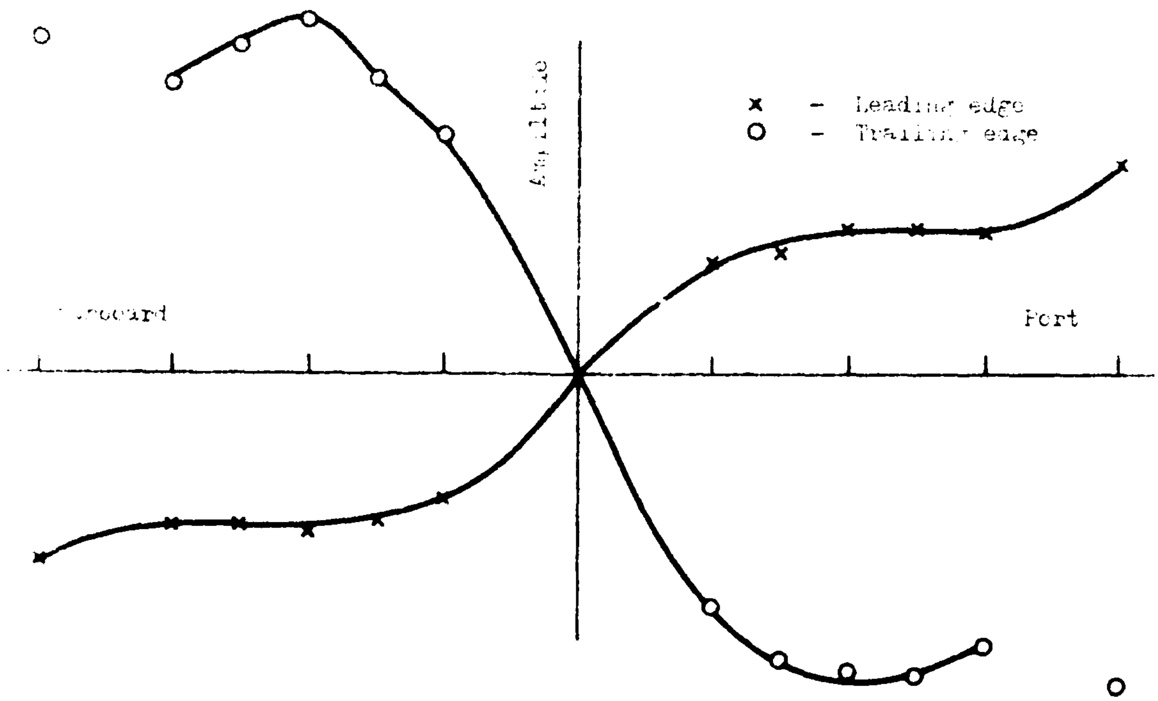


FIG.8 (b) DAMAGED TAILPLANE MODE AT 48.8 Hz

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