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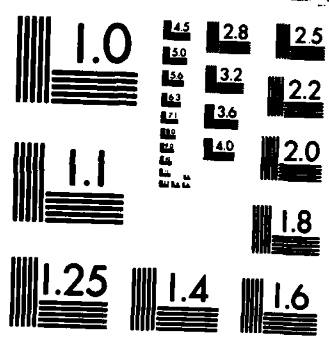

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Structures Technical Memorandum 392

FLIGHT TRIALS OF A MODIFIED GULFSTREAM COMMANDER CARRYING EXTERNAL STORES

by

P.A. FARRELL and A. GOLDMAN

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FLIGHT TRIALS OF A MODIFIED GULFSTREAM COMMANDER CARRYING EXTERNAL STORES

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Summary

The Department of Aviation has modified a Gulfstream G.695A aircraft to carry external stores on the fuselage. A vibration test followed by a series of flight trials were conducted to satisfy some of the requirements of certification. A description of these tests together with the results is given.

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CONTENTS

1. INTRODUCTION

The Victorian/Tasmanian Regional Flying Unit of the Department of Aviation modified a Gulfstream G.695A aircraft (Fig. 1) to carry up to four external stores on the fuselage. Sponsons were attached through the side of the fuselage to a tubular steel frame which in turn was attached to the floor of the baggage compartment (Fig. 2). The carriage of two types of stores was envisaged - the Life Raft Pod (LRP) and the Marine Supply Container (MSC). The dimensions and masses of these stores are given in Table 1. The carriage of the heaviest configuration (four LRP stores) thus represents an addition of some 280 kg to the aircraft. Further, since the stores are attached to the aircraft via a flexible frame the possibility of unfavourable couplings with the aircraft structural modes existed.

Certification of this modified aircraft required firstly the measurement of the natural frequencies and mode shapes of the frame holding the stores, followed by a series of flight trials. The flight trials would serve the twin purpose of demonstrating freedom from flutter and also of measuring the vibration levels to provide data for fatigue analysis of the frame.

2. GROUND VIBRATION TEST

To determine the natural frequencies and modes shapes of the store carriage system, the support frame was attached at the four mounting positions to the concrete floor of a hangar (reference 1). Masses equivalent to the fairings were attached at the appropriate locations, as were four simulated LRP stores. Four electromagnetic shakers were attached to the structure at the extremes of the sponsons and used to tune, in turn, each of the normal modes found below 28 hertz. The four modes found are listed in Table 2.

The results of this test were communicated to Gulfstream Aerospace Corporation, the aircraft's manufacturers, who replied (Reference 2) that the aircraft modes with which the store support system was likely to couple, would not produce flutter. On this basis a series of flight trials was planned.

3. FLIGHT TRIALS

In preparation for the flight trials, the aircraft, four LRP stores and support frame were instrumented as depicted in Figure 3. The aircraft carried two four-channel tape recorders and, with one accelerometer signal (accelerometer 0) being recorded on both recorders as a reference, this allowed seven accelerometer responses to be recorded.

In order to check the instrumentation and also to obtain base levels of vibration, two taxi-runs were made - one at 80 knots, the other at 100 knots. These were followed by two very brief flights of about seven seconds at 80 knots (full flap) and 100 knots (no flap). The largest accelerations measured during these preliminary tests were on the stores during the taxi runs and were less than 0.15 g (RMS) at a frequency of about 14 Hz which represents an amplitude of less than 0.2mm (RMS).

The aircraft was next flown without stores. Each of the accelerometers shown attached to the stores in Figure 3 was attached to the sponson in an adjacent position. Two speeds were flown, viz: 200 knots and 220 knots, with each speed being held constant for about four minutes whilst the response from the accelerometers was recorded on the on-board recorders.

Following spectral analysis of these data, four LRP stores were attached to the sponsons for the next part of the flight trials. This was the heaviest store configuration. The aircraft was flown at 100 knots, 120 knots, 130 knots and 140 knots in the one flight. The effect of flaps and undercarriage was investigated by flying at 120 knots with the undercarriage extended, and with 20 degrees and 30 degrees flap in turn. On the basis of the data gathered from this flight the next flight was authorised. This covered 160 knots and 185 knots. The effect of engine frequency was examined in this flight by increasing the engine speed from 96.5% to 98.5% of maximum. Again, based upon the spectral analysis of the recorded data, a flight was authorised at 200 knots with a second test point being flown at 180 knots at flight idle.

The final flight flown was with four MSC stores, this being the lightest four-store configuration. This final flight gathered data at four test points - 140 knots, 160 knots, 180 knots and 200 knots.

4. RESULTS AND DISCUSSION

Figure 4 shows the measured RMS averaged frequency response spectra for four accelerometers (Numbers 1, 3, 5 and 0) obtained from data measured at 220 knots for the aircraft without stores. These are essentially the same as those obtained at 200 knots. The sharp peak evident in three of these spectra (and in most of those in the following Figures) is at 76.8 Hz, the blade passing frequency. This is a forced response and when the engine speed was changed from 96.5% to 98.5%, the peak shifted to 78.4 Hz with the same amplitude. When the propeller thrust was changed to flight idle, the peak disappeared entirely. The small peak apparent in the bottom spectrum of Figure 4 corresponds to the engine frequency at 24.6 Hz.

The response of the aircraft, support frame and stores is shown in Figure 5 for the aircraft carrying four LRP stores, for the four highest speeds flown. The response of the accelerometer attached to the floor of the baggage compartment (Fig. 5a) shows only the peak at the blade passing frequency, as do the accelerometers attached to the support frame (Figs. 5b, 5d and 5f). Accelerometer 5 attached to the forward port store (Fig 5e) shows a peak at about 34 Hz which was a maximum at 160 knots and had virtually decayed by 200 knots. This peak (at 160 knots) corresponds to an amplitude of 0.04 mm (RMS). This amplitude is so small there is little point in speculating as to its cause. The aft port store (Fig. 5c) shows little response whilst the aft starboard store (Fig 5g) shows evidence of a peak decreasing in frequency from about 39 Hz at 140 knots to about 36 Hz at 200 knots whilst at the same time showing an increase in amplitude. At 200 knots the amplitude corresponds to approximately 0.05 mm (RMS) which is again exceedingly small. Since the two propellers rotate in the same sense the airflow impacting the port stores is not the same as that for the starboard stores.

The RMS averaged spectra for the aircraft carrying the lightest four-store combination (four MSC stores) are presented in Figure 6. The spectra are shown only for the highest speed flown (200 knots) but are typical for all the test point speeds. The responses from each accelerometer and the reference signals (accelerometer 0) are shown. The latter signals were recorded separately on each recorder. Other than the peaks at blade passing frequency (76.8 Hz) and at engine frequency (25.6 Hz), the responses are essentially flat and represent very small amplitudes.

5. CONCLUSIONS

The natural frequencies and mode shapes of the support frame with four LRP stores were measured and the results communicated to the aircraft's manufacturers Gulfstream, who indicated that carriage of this store/frame system would be unlikely to cause flutter. The two store configurations flown, being the heaviest and lightest four-store combinations, showed no evidence of any self-excited response. The overall response measured was extremely low and it seems unlikely that there will be any fatigue problem.

REFERENCES

1.	Goldman, A.	Tests on a proposed liferaft support for attachment to a Gulfstream Commander aircraft. Letter report B2/010 (5) of 31 July 1984.
2.	Jackson, C.	Telex from Gulstream Aerospace Corporation to Department of Aviation of 30 July 1984.

TABLE 1 MASS OF STORES AND SUPPORT SYSTEM

STORE	MASS (kg)	LENGTH (m)	DIAMETER (m)
LRP	45.4	0.94	0.04
MSC	25.9	1.19	0.03

ADDITIONAL STRUCTURE	MASS (kg)
SUPPORT FRAME	32.3
SPONSON AND FAIRING AND SMOKE-MARKER DISPENSER	33.2 PER SIDE

TABLE 2 MEASURED NATURAL FREQUENCIES OF FRAME WITH FOUR LRP STORES

MODE	NAT. FREQUENCY (Hz)	DAMPING RATIO (%)
SYMMETRIC BENDING	8.05	1.0
SYMMETRIC TORSION	8.80	1.2
ANTISYMMETRIC BENDING	9.13	2.5
ANTISYMMETRIC TORSION	9.36	1.4

GULFSTREAM COMMANDER MODEL 695A

WING AREA = 25.95 square metres

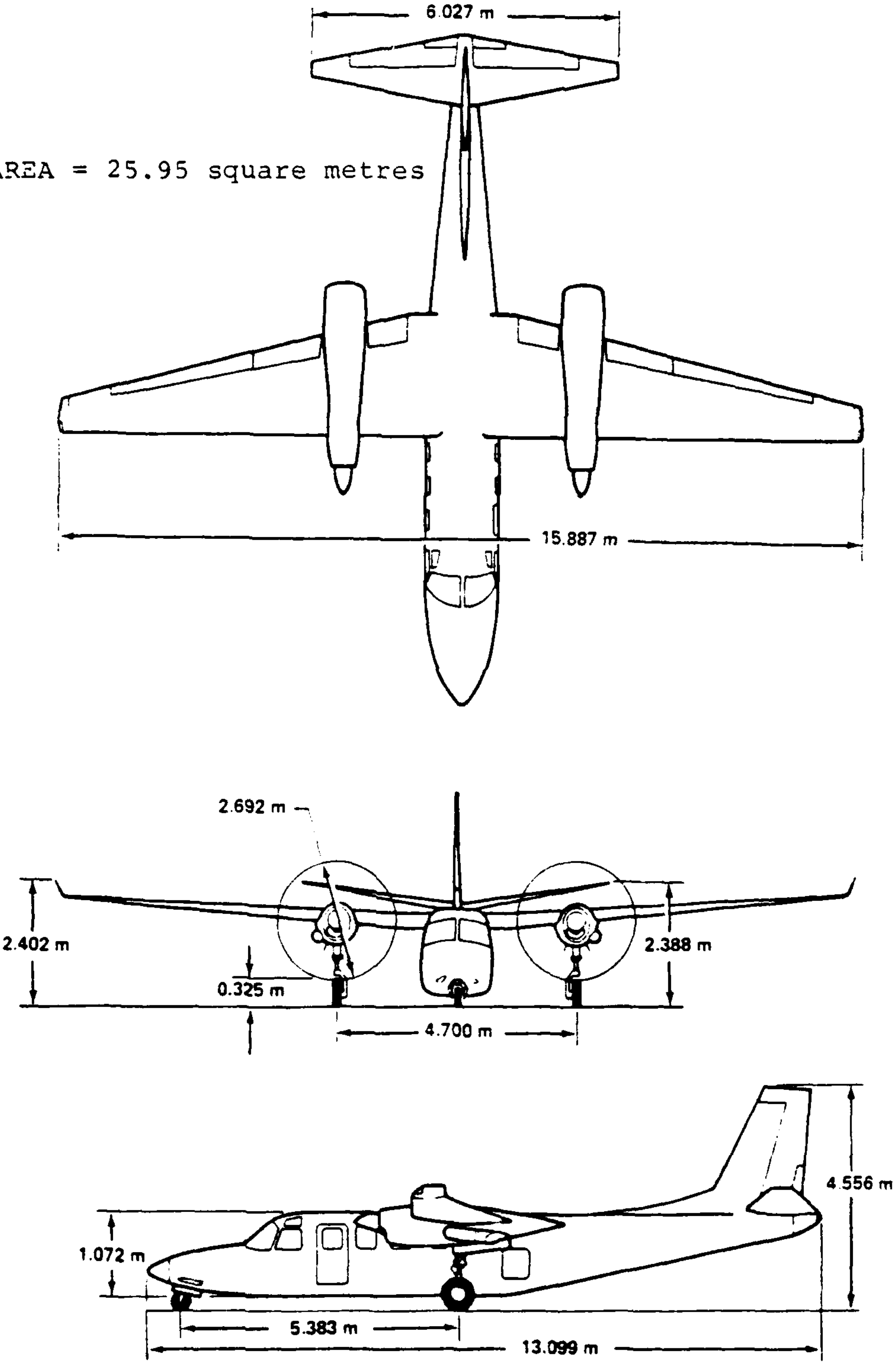

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FIG 1. GENERAL DIMENSIONS

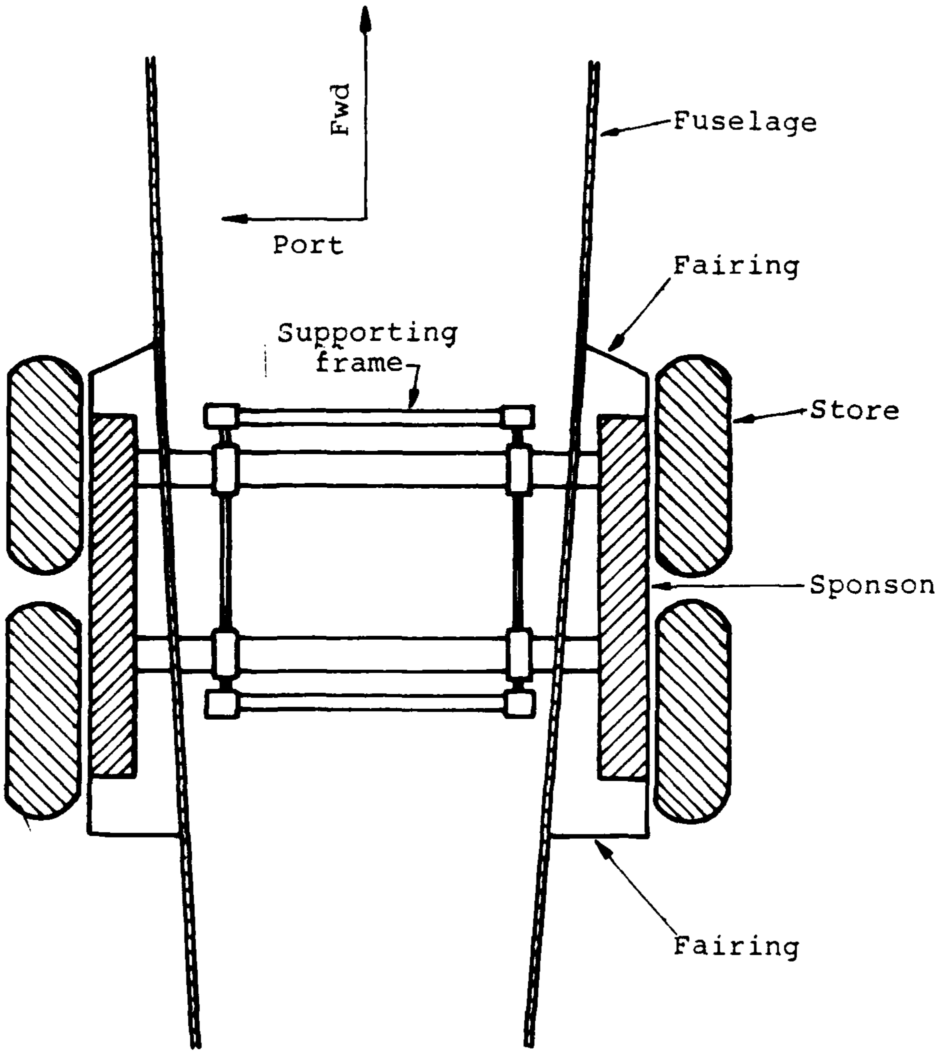
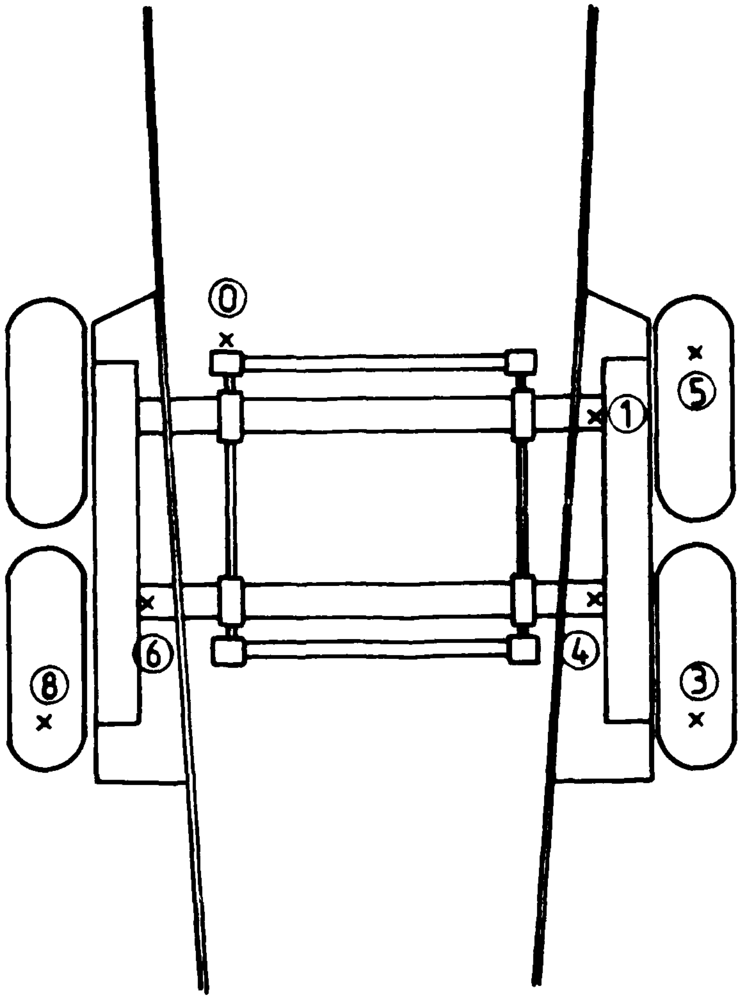


FIG. 2 SKETCH OF FRAME, SPONSONS AND STORES



x - Indicates accelerometer position
◯ - Indicates accelerometer number

FIG. 3 POSITION OF ACCELEROMETERS

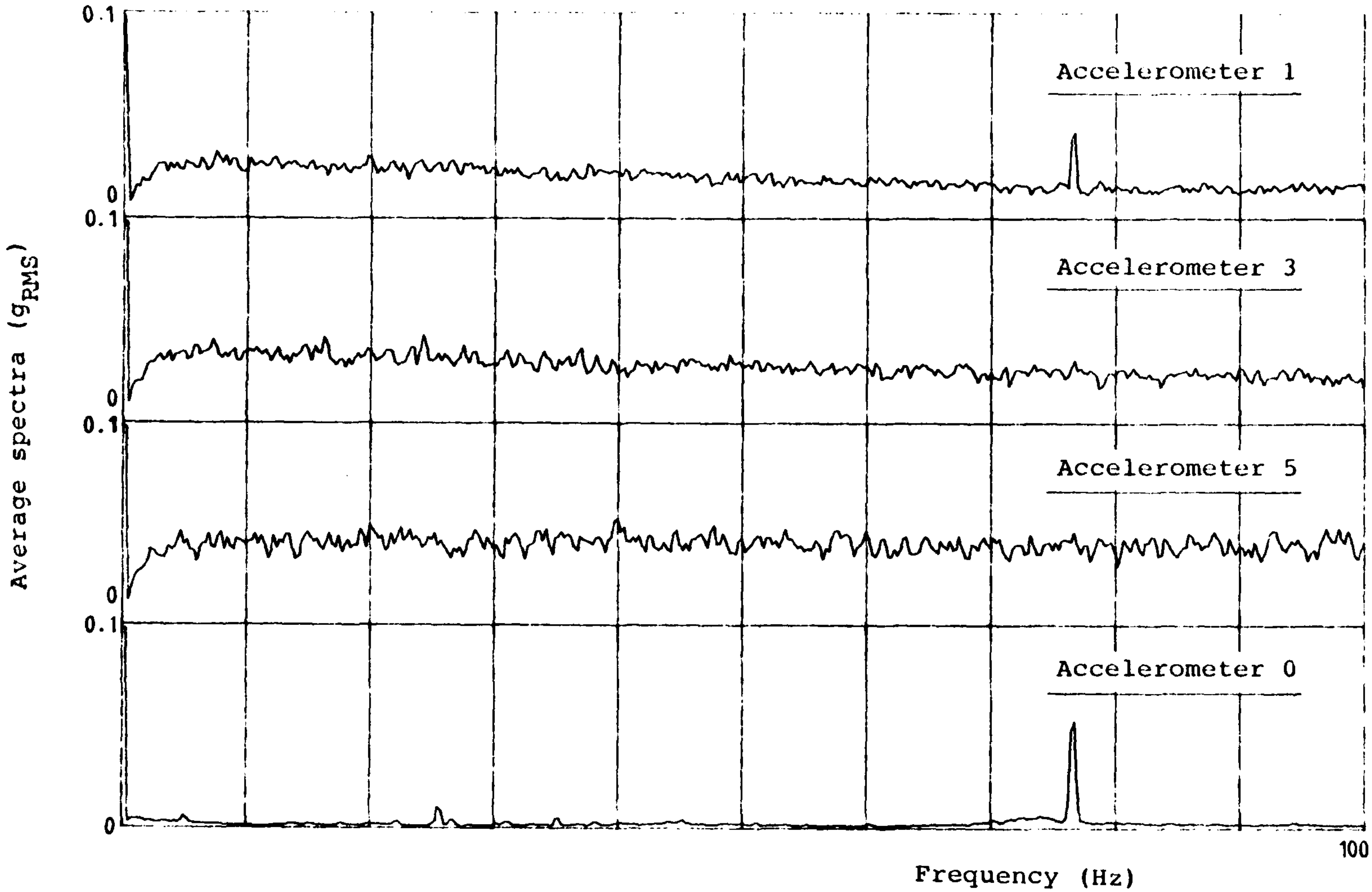


FIG. 4 AIRCRAFT WITHOUT STORES - 220 KIAS

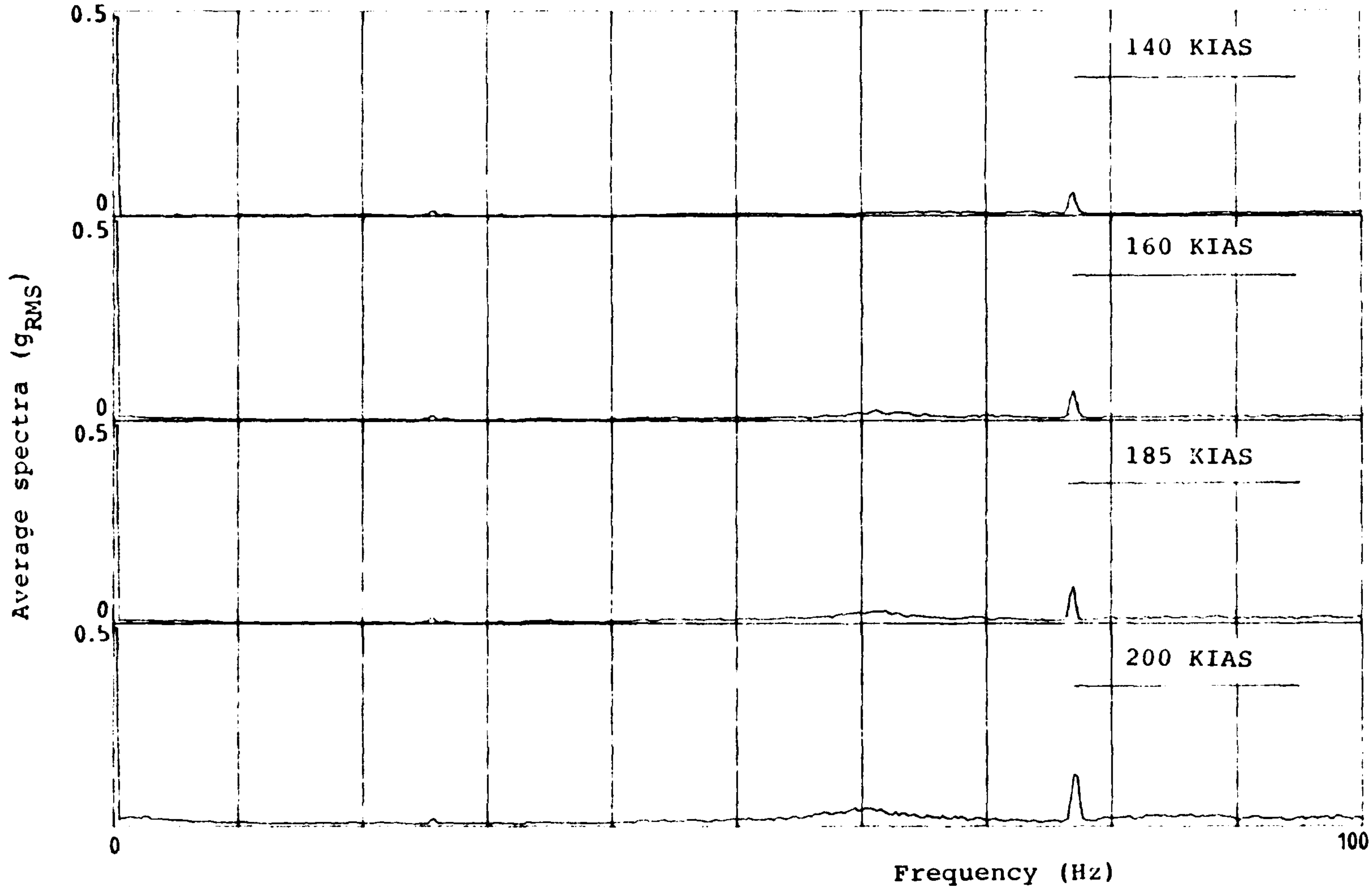


FIG. 5(a) AIRCRAFT WITH FOUR LRP STORES - ACCELEROMETER 0

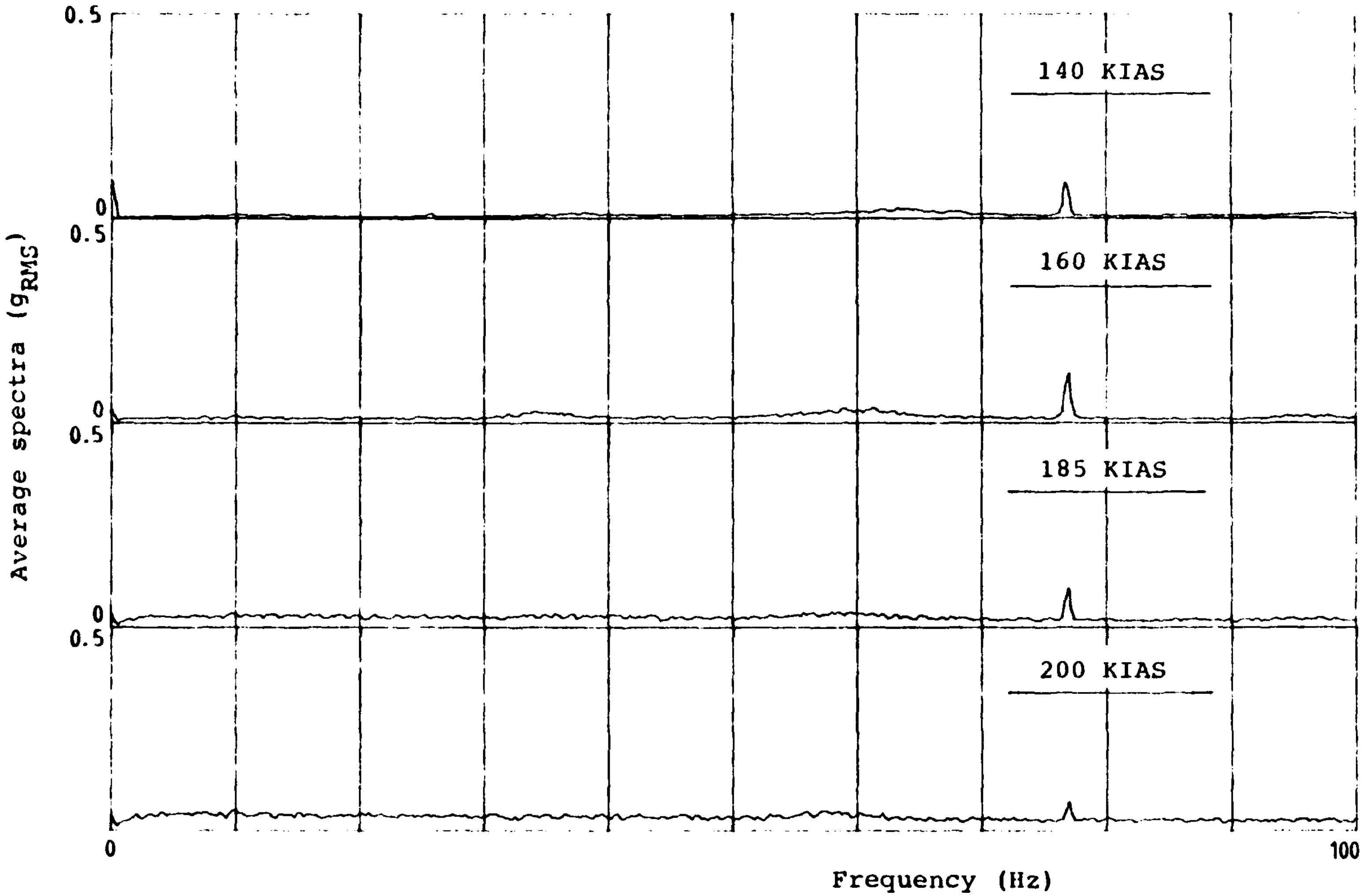


FIG. 5(b) AIRCRAFT WITH FOUR LRP STORES - ACCELEROMETER 1

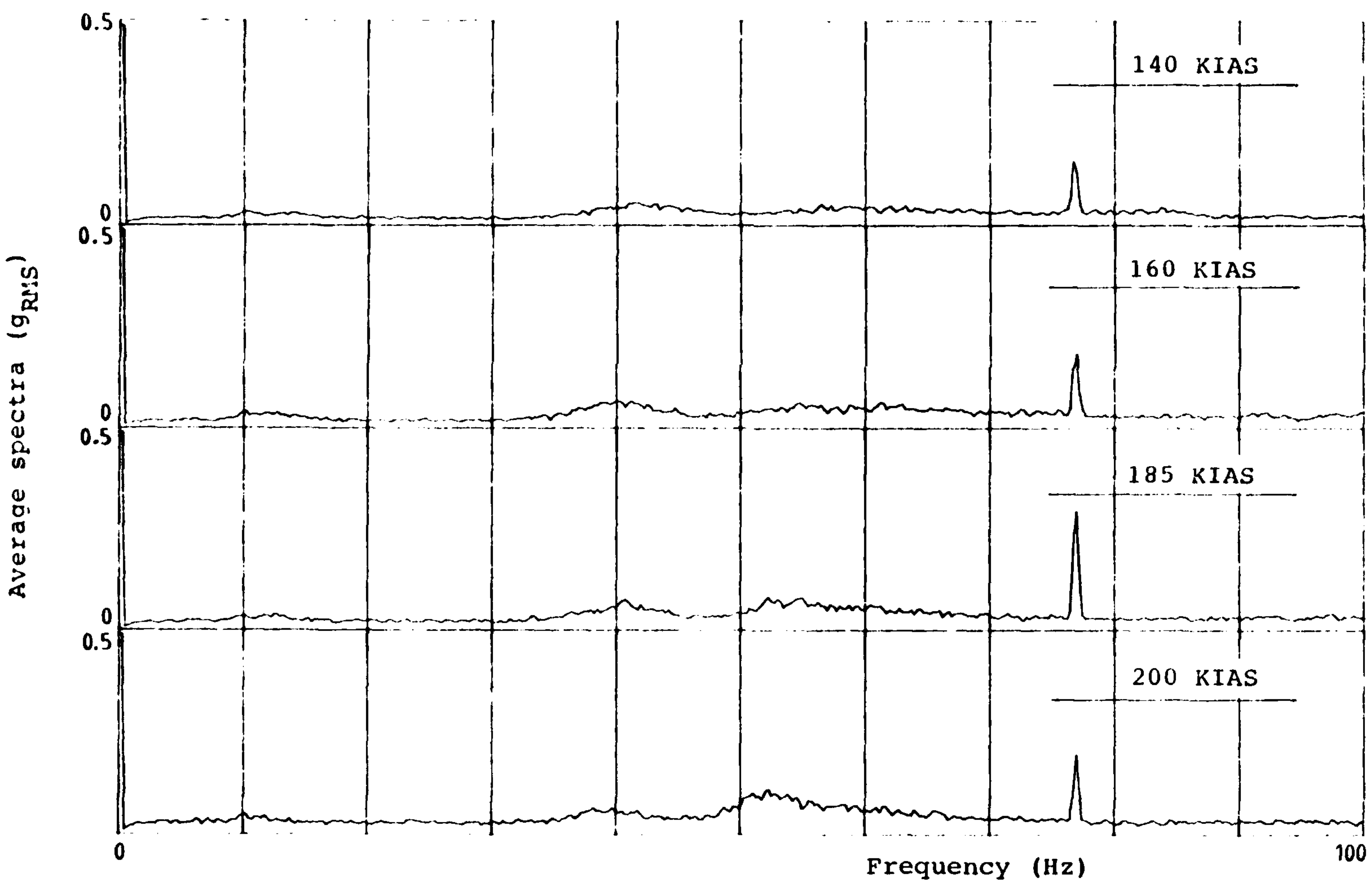


FIG. 5(c) AIRCRAFT WITH FOUR LRP STORES - ACCELEROMETER 3

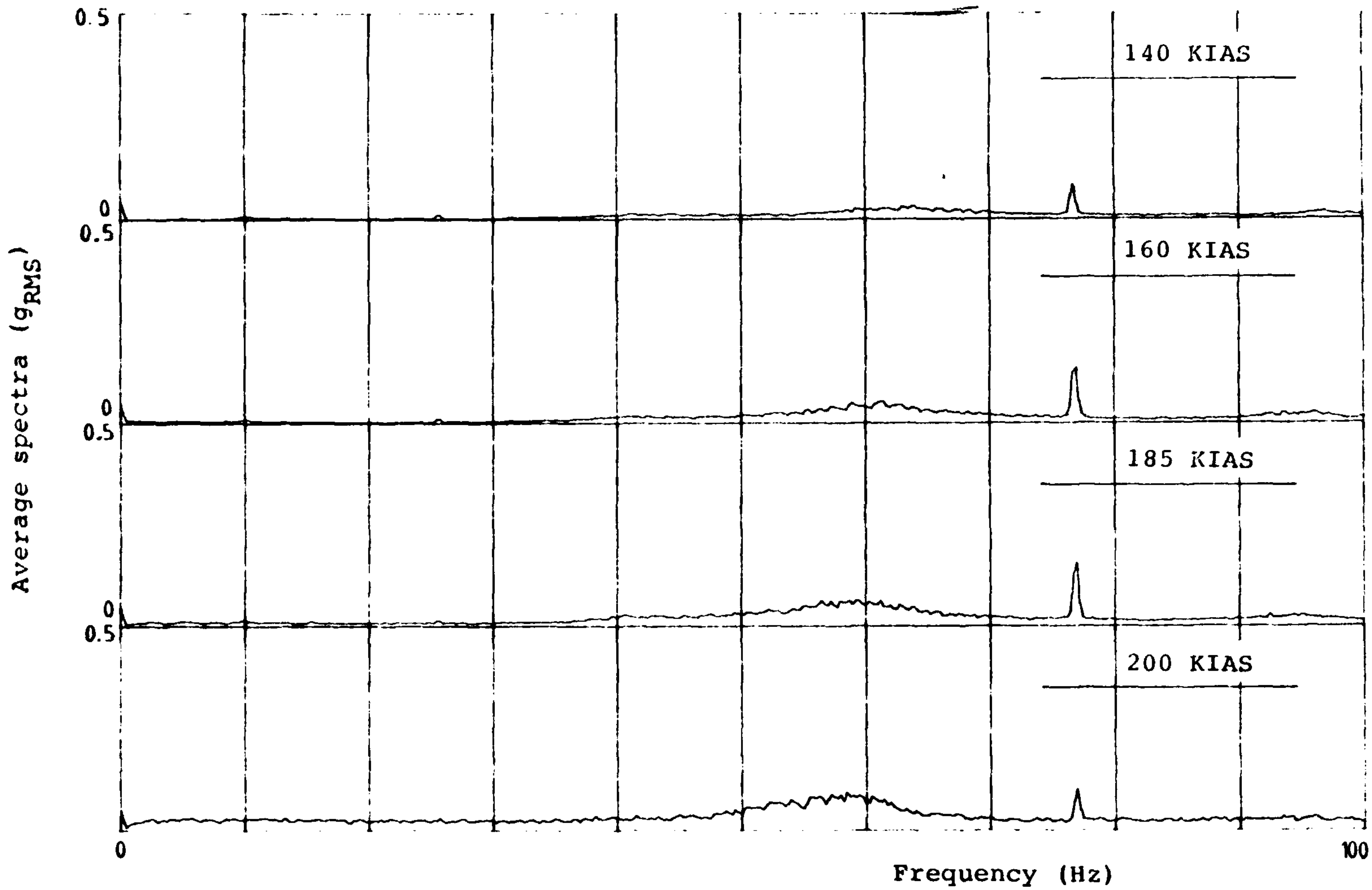


FIG. 5(d) AIRCRAFT WITH FOUR LRP STORES - ACCELEROMETER 4

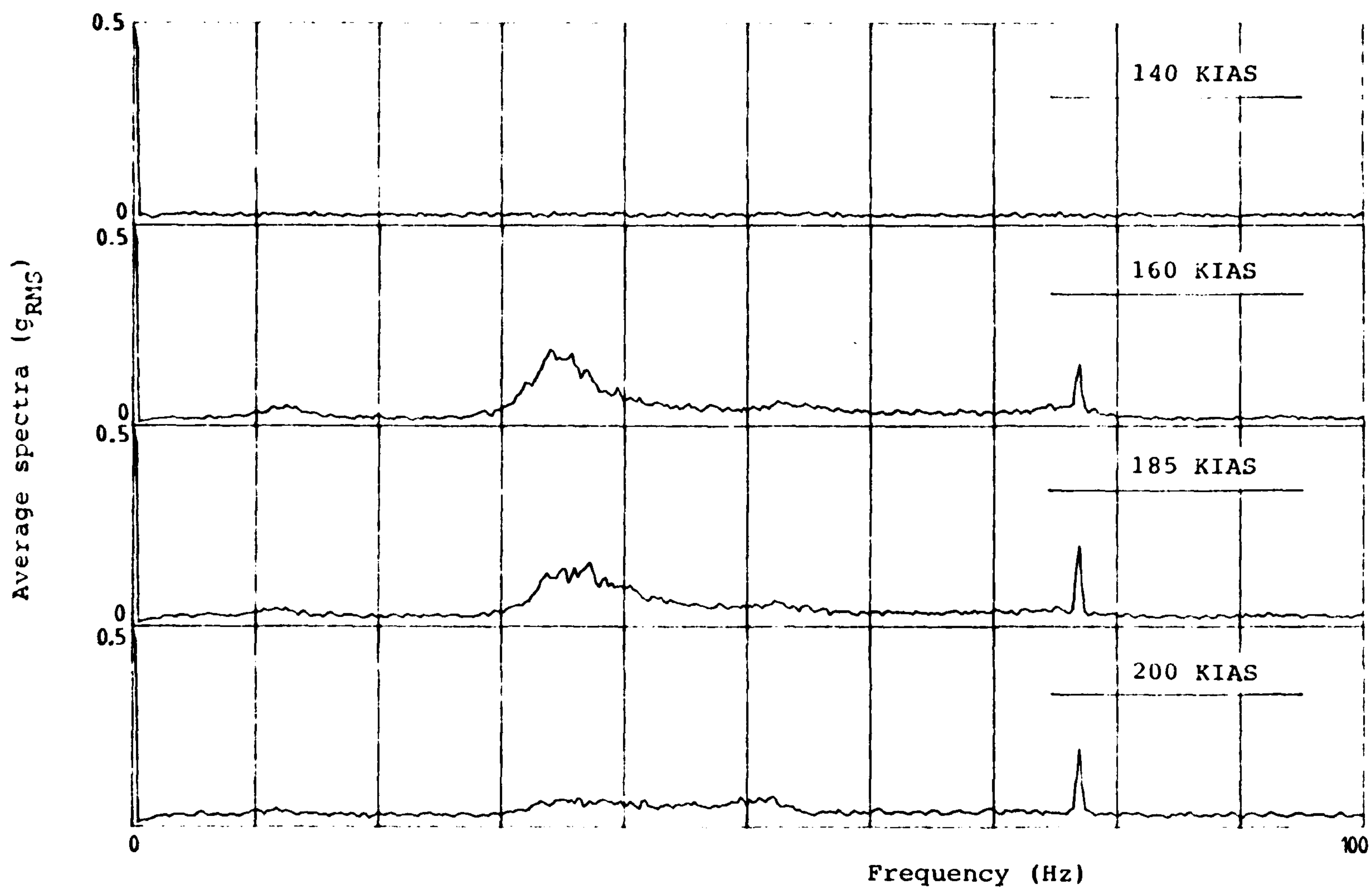


FIG. 5(e) AIRCRAFT WITH FOUR LRP STORES - ACCELEROMETER 5

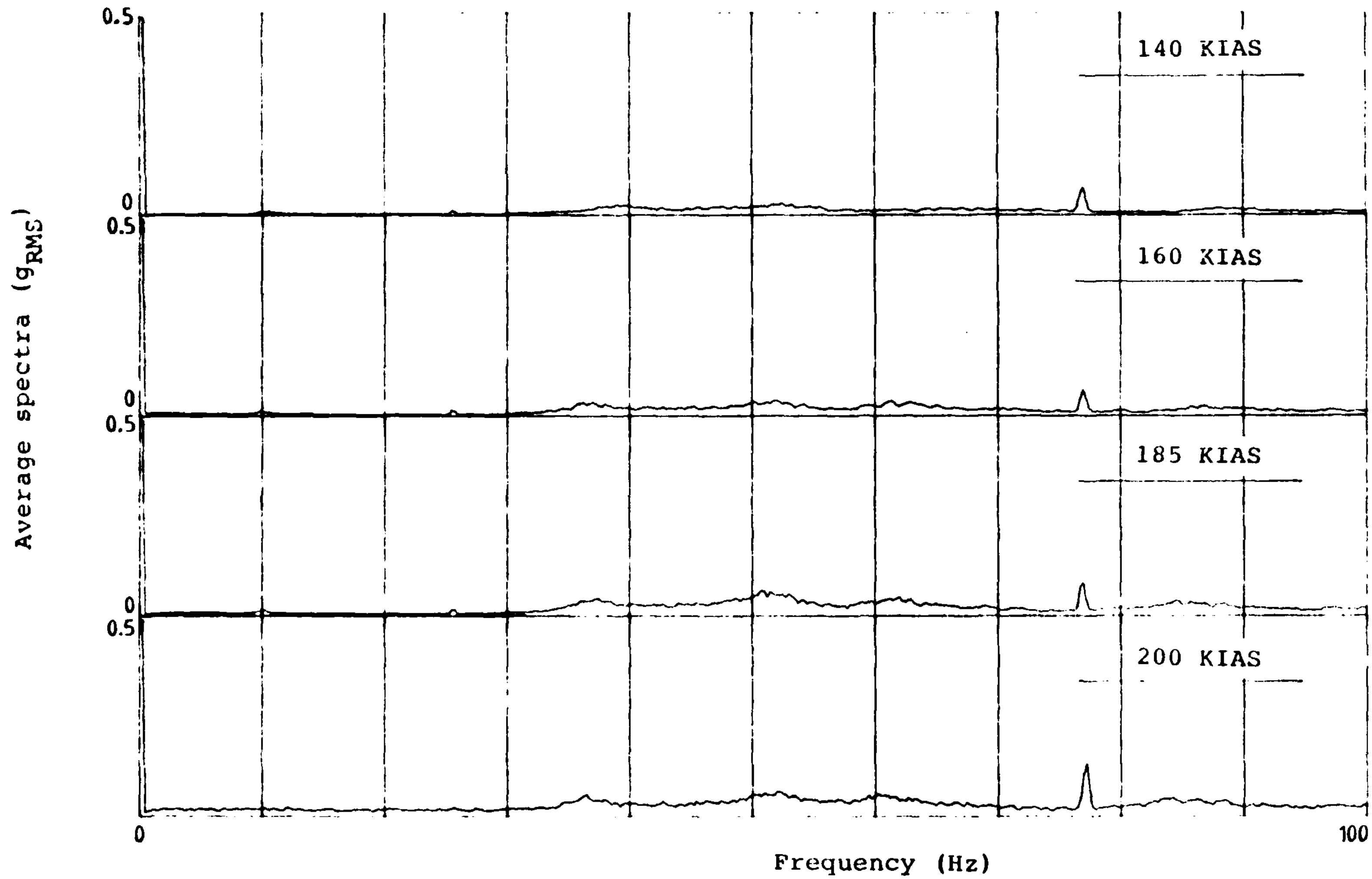


FIG. 5(f) AIRCRAFT WITH FOUR LRP STORES - ACCELEROMETER 6

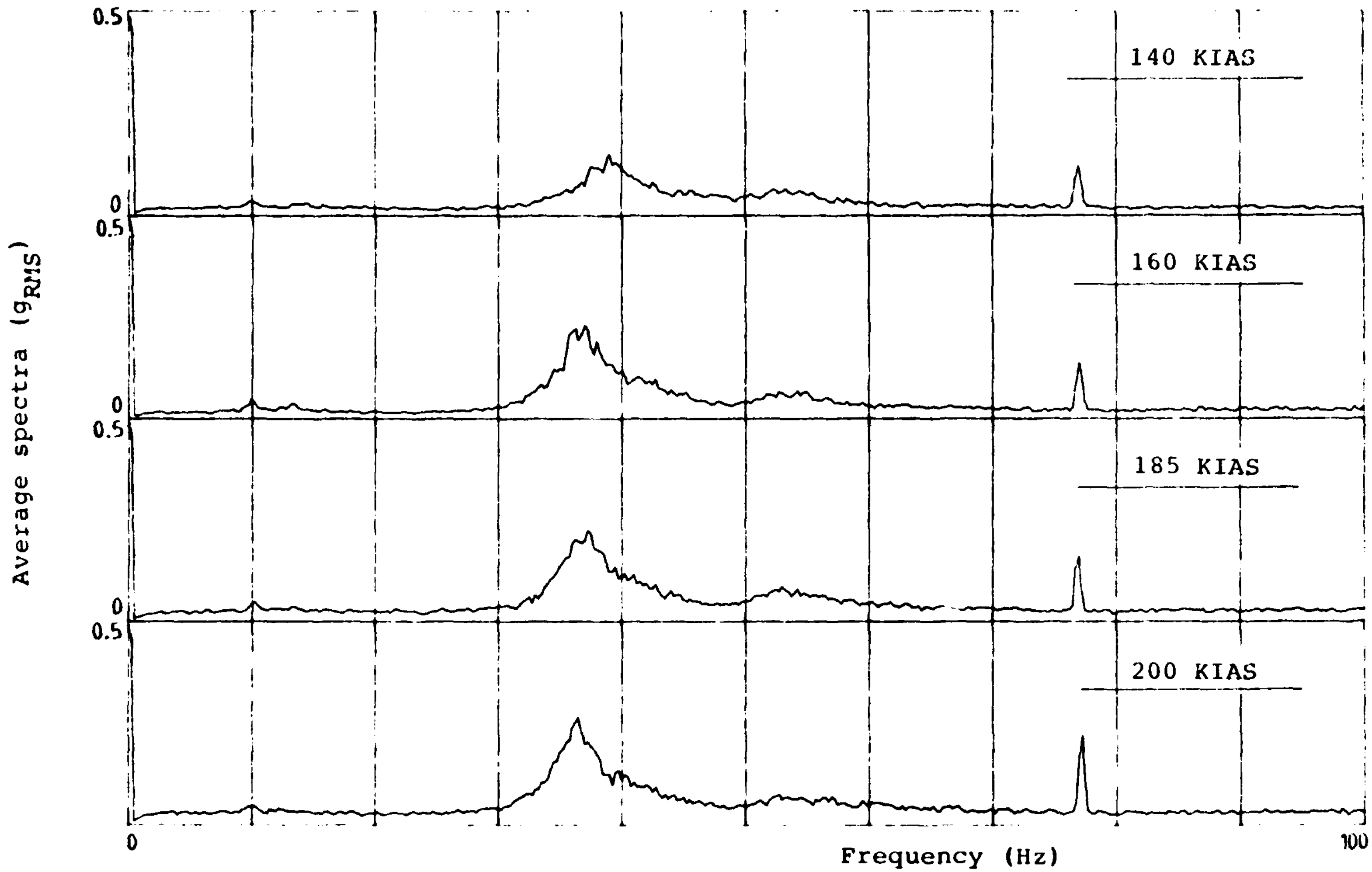


FIG. 5(g) AIRCRAFT WITH FOUR LRP STORES - ACCELEROMETER 8

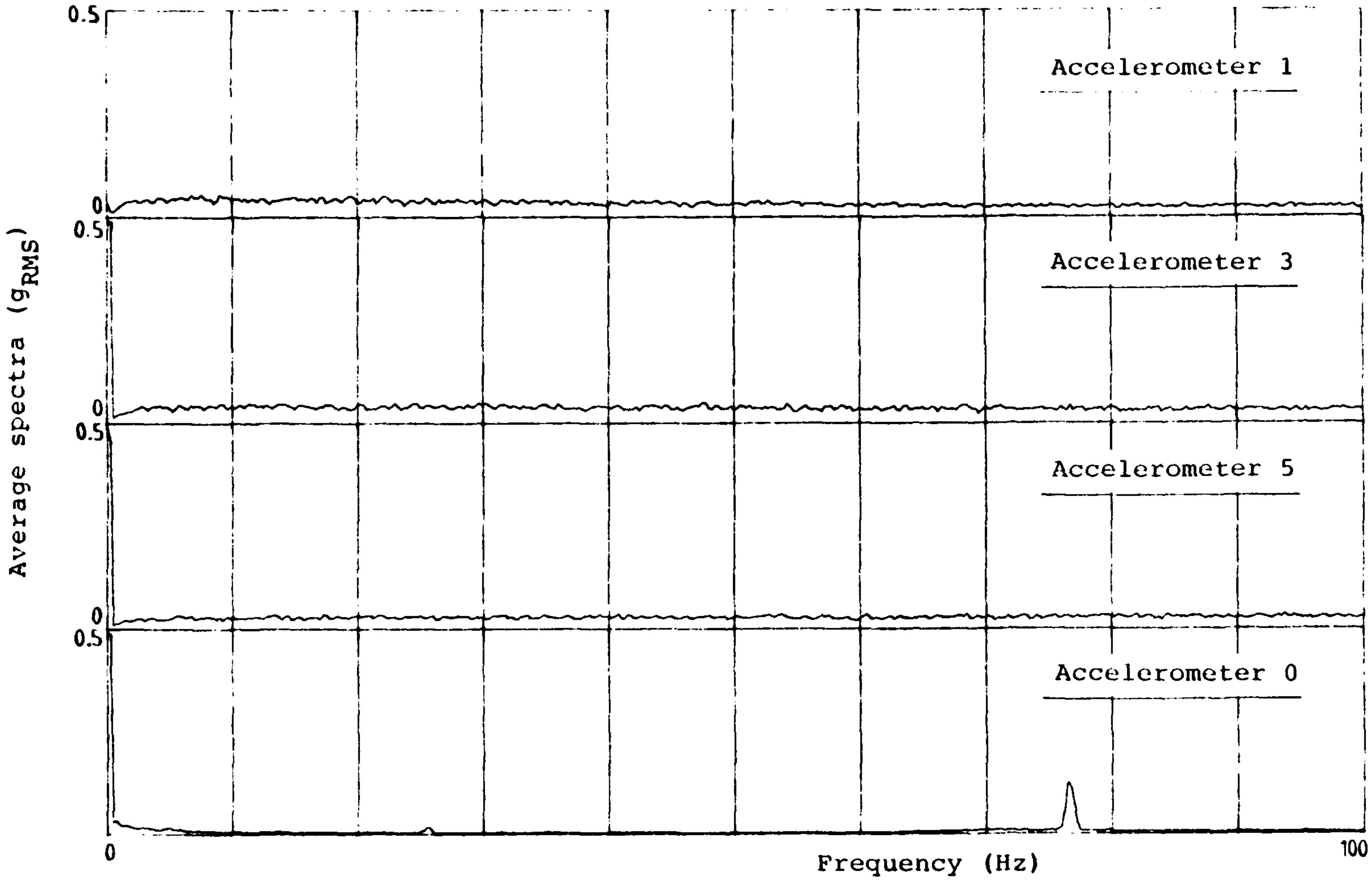


FIG. 6 AIRCRAFT WITH FOUR MSC STORES - 200 KIAS

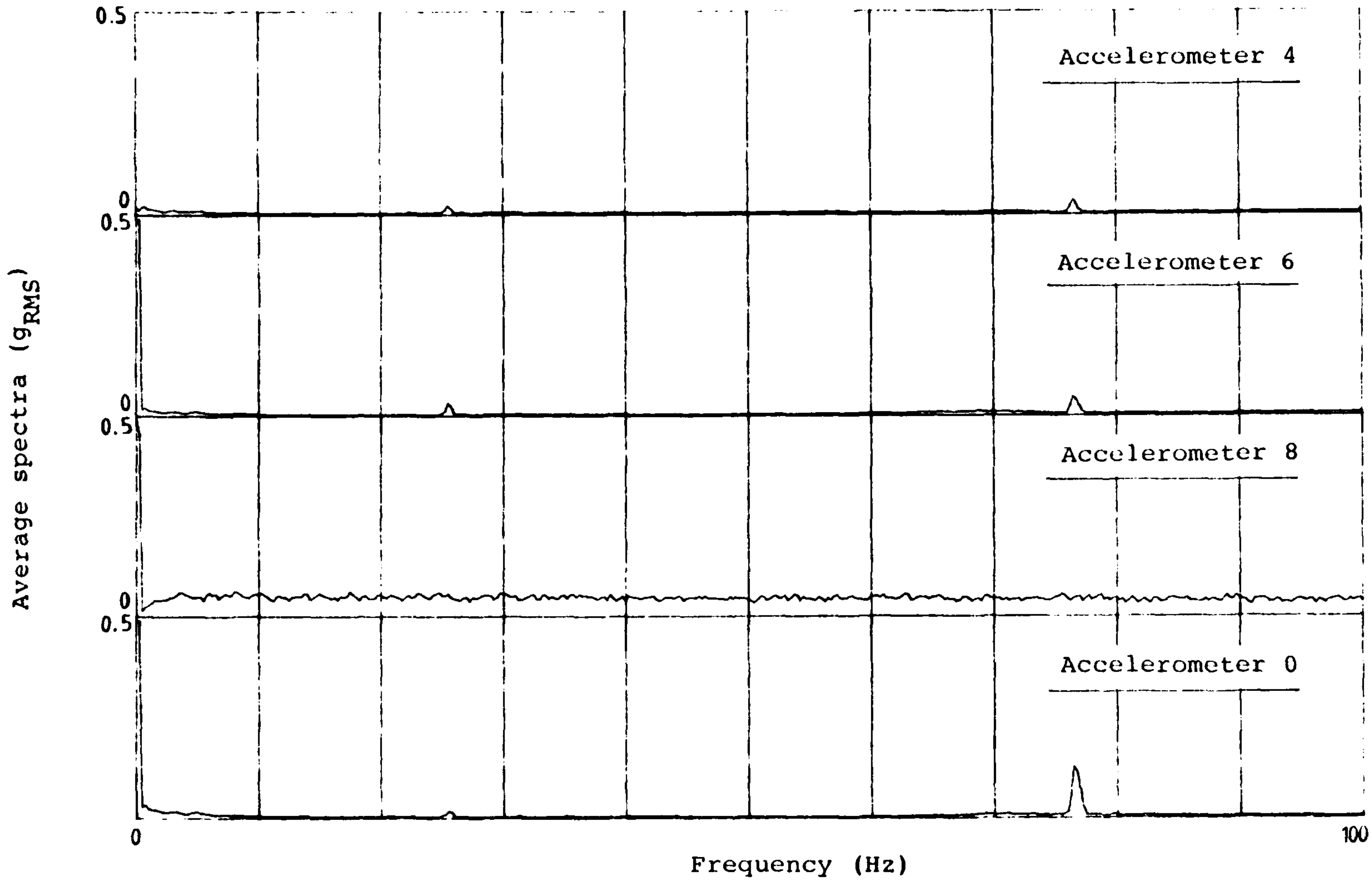


FIG. 6 (continued) AIRCRAFT WITH FOUR MSC STORES - 200 KIAS

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16. Abstract

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