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FLIGHT VIBRATION SURVEY OF C-130A AIRCRAFT*CHARLES E. THOMAS*

TECHNICAL DOCUMENTARY REPORT No. ASD-TDR-62-267

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AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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FOREWORD

This technical report was prepared in the Environmental Criteria Branch, Environmental Division, Directorate of Engineering Test, Deputy for Test and Support, under Project 1309, Task 130906. The Project Engineer on this survey was Mr. Charles E. Thomas of the Environmental Criteria Branch. The survey covered by this technical report is one of a series conducted on operational aircraft by the Environmental Criteria Branch. The flights discussed in this report occurred during the period extending from December 1956 to June 1957. The information obtained from this effort was submitted as raw data to the requesting agency upon completion of the tests, and is now being presented in a formal report for the purpose of wider distribution.

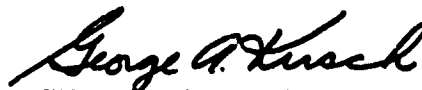
ABSTRACT

A C-130A aircraft, SN 53-3133, was surveyed at Wright-Patterson Air Force Base, Ohio to determine the vibration environment existing throughout the vehicle under all flight conditions expected in service. Approximately 50,700 data points were obtained from 21 separate locations on the vehicle during five test flights. The data obtained in this survey were evaluated to determine the adequacy of vibration test requirements for aircraft equipment as contained in Specification No. Mil-E-5272C. The data indicated that the vibration testing requirements of that specification were more than adequate with the exception of the very light pieces of equipment which are attached to the fuselage sidewalls in the vicinity of the prop plane.

PUBLICATION REVIEW

This report has been reviewed and is approved.

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SECTION I

INTRODUCTION

One of the major problems in the design, application, testing, and use of airborne equipment is the lack of sufficient data to define the actual dynamic environment in which the vehicle equipment must operate. In most cases this lack of data has resulted in either (1) overdesigning the equipment, with its attendant excessive development costs, time, specimen size, and weight, or (2) underdesigning the equipment with a resulting lack of reliability and limited service life. To acquire the needed information, the Environmental Criteria Branch, Environmental Division, Directorate of Engineering Test, Deputy for Test and Support, has implemented a comprehensive data acquisition program aimed at obtaining vibration data on all available aircraft and missiles.

This is one of a series of reports which present vibration data measured on the structure of aircraft and missiles. The primary objective of these reports is the dissemination of important dynamics data to those concerned with developing airborne accessories. These data can be used as the basis for preparing design and testing specifications, estimating environments on air vehicles in the "drawing-board" stage, establishing optimum locations and installation practices, etc. The data in this report have been interpreted only with respect to the specific vehicle of this study, i.e., C-130A, and no attempt has been made to assimilate this information with existing data on other similar vehicles or to present complete explanations of all the vibration phenomena involved. Reports will be published later to interpret the data and to draw comprehensive conclusions concerning vibration generation, propagation, structural response characteristics, and the like. However, the test instrumentation, procedures, and data reduction methods are covered in considerable detail in this report.

SECTION II

DISCUSSION

A. Description of the C-130A Aircraft

The C-130A is a high-wing, all metal construction, medium-range, land-based monoplane. It was designed and built by Lockheed Aircraft Corp. Marietta, Georgia. The mission of the airplane is to provide rapid transportation of personnel or cargo for delivery by parachute or by landing.

The airplane is powered by four Allison T56-A-1A turboprop, constant-speed engines which operate at a speed of 13,820 RPM. Each engine is rated at 3750 shp and drives a 3-blade, 15-ft. diameter, electro hydraulic, constant-speed propeller through a 12.5 to 1 reduction ratio gearbox. Table I presents the principal dimensions of the C-130A aircraft.

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TABLE I

C-130A GENERAL SPECIFICATION DATA

Wing Span	132 feet 7 inches
Length	95 feet 2 inches
Height	38 feet 4 inches
Stabilizer Span	52 feet 8 inches
Design Gross Weight	108,000 pounds

B. Test Instrumentation

The test instrumentation comprised the following: (1) forty-eight MB Manufacturing Co. Type 124 velocity pickups, (2) one Davies Laboratories, Inc. Model 501, 14-channel magnetic tape recorder, and (3) a remotely controlled pickup selector switch. The pickups were attached to the aircraft structure and engines at twenty-one points of interest. Thirty-six of the pickups were mounted in groups of three and oriented to sense vibration along each of the three major axes of the aircraft. Six of the pickups were mounted in pairs and oriented to sense vibration in the vertical and lateral directions. The remaining six pickups were mounted individually on the sidewall at various stations and heights to sense vibration in the lateral direction. The locations are shown in Figure I, Appendix A which presents a more detailed description of the instrumentation.

C. Test Procedure

Five flights were made during this survey. Vibration records were obtained during all of the normal conditions expected in service, such as taxi, ground runup, takeoff, climb, straight and level flight (at various altitudes, airspeeds, and power settings), descent, landing, and landing roll. Magnetic tape recordings were obtained from all test pickups for each of the specified test conditions. A reel of recorded magnetic tape data consisted of approximately 90 data samples, each having, generally, a length of 75 inches and covering a period of 5 seconds. Further information concerning the test procedure is contained in Appendix A.

D. Data Processing

The reels of recorded data were edited in the laboratory. Then, each data sample, which includes twelve channels of test data, was spliced into an endless loop. Next, each loop was placed on a Davies Model 502 tape playback system. Then, a narrow bandwidth (10 cycles per second) analysis was conducted simultaneously on six of the twelve data channels of the loop and the analyzed data were recorded on six modified Brown strip chart recorders in the form of a continuous spectrum of frequency (cps) versus transducer voltage (rms). This procedure was repeated to analyze and record the analyzed data of the other six data channels of the loop. The analyzer used is a heterodyne type, Davies Model 510.

The data points of interest were then extracted from the strip chart recording, tabulated, and punched into IBM cards. Corresponding decks of "master" cards which contain detailed descriptive information concerning pickup location, flight test conditions, and source and order of vibration were also produced. Next, the raw data together with the formula for computing double amplitude in inches and acceleration in g units and the appropriate descriptive information on the "master" cards were fed to an ERA 1103A computer. The completed data cards were then sorted into the desired order and the data were plotted by an automatic plotter having IBM card input capabilities.

E. Presentation of Data

The plots contained in this report are: (1) summary plots for each individual pickup for all of the flight test conditions, (2) summary plots for each cluster of pickups (2 or 3) at any given test point, and (3) summary plots for structural "zones" for all of the flight test conditions. These types of data presentation have proven satisfactory for use in establishing specification requirements and in estimating vibration environments in other similar vehicles. However, in instances where more detailed analysis of the vibration characteristics is required, graphs could be prepared to show variations of many parameters affecting the vibration conditions in the vehicle. For example, graphs can be made showing variation of vibration as a function of the following parameters: (1) indicated airspeed, (2) altitude, (3) power, (4) flight condition, (5) propeller order, etc. Plots of this type can be furnished if requested. A more detailed description of data handling procedures, data analysis, and presentation methods is contained in Appendix A.

SECTION III

RESULTS

Approximately 50,700 data points were obtained during the five test flights which comprised this survey. As expected and as shown by the graphs presented in Appendix A, the data are of the discrete frequency type. The dominant source of these frequencies is the propeller. However, in the case of the pickups mounted on the engine, vibration frequencies due to engine and accessory unbalance occurred constantly.

The frequencies produced by the propeller, both those due to propeller unbalance and to the blade passage past the fuselage, were observed over the frequency range of 15 to 500 cps. Only the fundamental of the propeller unbalance was detected; however, blade passage frequencies ranging from the fundamental up through the ninth order depending upon the structural zone were detected. The intensity of the fuselage vibration due to the propeller is greatest in the area adjacent to the propellers, and diminishes as the distance from the

propellers increases in either direction. The maximum vibratory acceleration (approximately ± 22 g) occurred on the fuselage sidewall at a frequency of 220 cps which corresponds to the fourth order of the blade passage frequency.

The vibration produced by the engines was also of the discrete frequency type. Only the first order (230 cps) and second order (460 cps) of the engine vibration were measured. The vibratory acceleration levels were generally below ± 5 g. The first and second orders of vibration due to propeller unbalance and the first and second orders of the propeller blade passage frequency were also observed on the engine.

The test data indicated that the following overall vibration test envelope would be satisfactory for equipment used on the C-130 aircraft:

5 to 8 cps	-	.15 in. double amplitude
8 to 22 cps	-	$\pm .5$ g vibratory acceleration
22 to 70 cps	-	.02 double amplitude
70 to 500 cps	-	± 5 g vibratory acceleration

However, this overall vibration envelope would require modifications when applied to the following items of equipment: (1) those rigidly mounted to an engine accessory and (2) those attached to the sidewall of the fuselage in the center half.

Modifications to overall vibration envelope for equipment rigidly mounted to an engine accessory:

22 to 110 cps	-	.02 double amplitude
110 to 500 cps	-	± 5 g vibratory acceleration

Modifications to overall vibration envelope for equipment attached to the sidewall of the fuselage in the center half.

5 to 10 cps	-	.15 in. double amplitude
10 to 22 cps	-	± 1 g vibratory acceleration
22 to 70 cps	-	.04 in. double amplitude
70 to 140 cps	-	± 10 g vibratory acceleration
140 to 220 cps	-	.01 in. double amplitude
220 to 500 cps	-	± 10 g vibratory acceleration

SECTION IV

CONCLUSIONS

The resonant frequency of any vibration isolators used should be in the 20-to 30-cps frequency band to have satisfactory operation and service life and to avoid resonant excitation.

APPENDIX A

Instrumentation

Forty-eight MB Type 124 velocity pickups were mounted in clusters (2 or 3) and individually at 21 separate test points on the aircraft engine and structure. The locations are summarized in Table II and shown in Figure 1. The Type 124 velocity pickup has the following characteristics:

Nominal sensitivity	-	96.4 mv(rms) per inch per sec. (rms)
Usable frequency range	-	5 to 2000 cps
Temperature range	-	-65 to 250° F

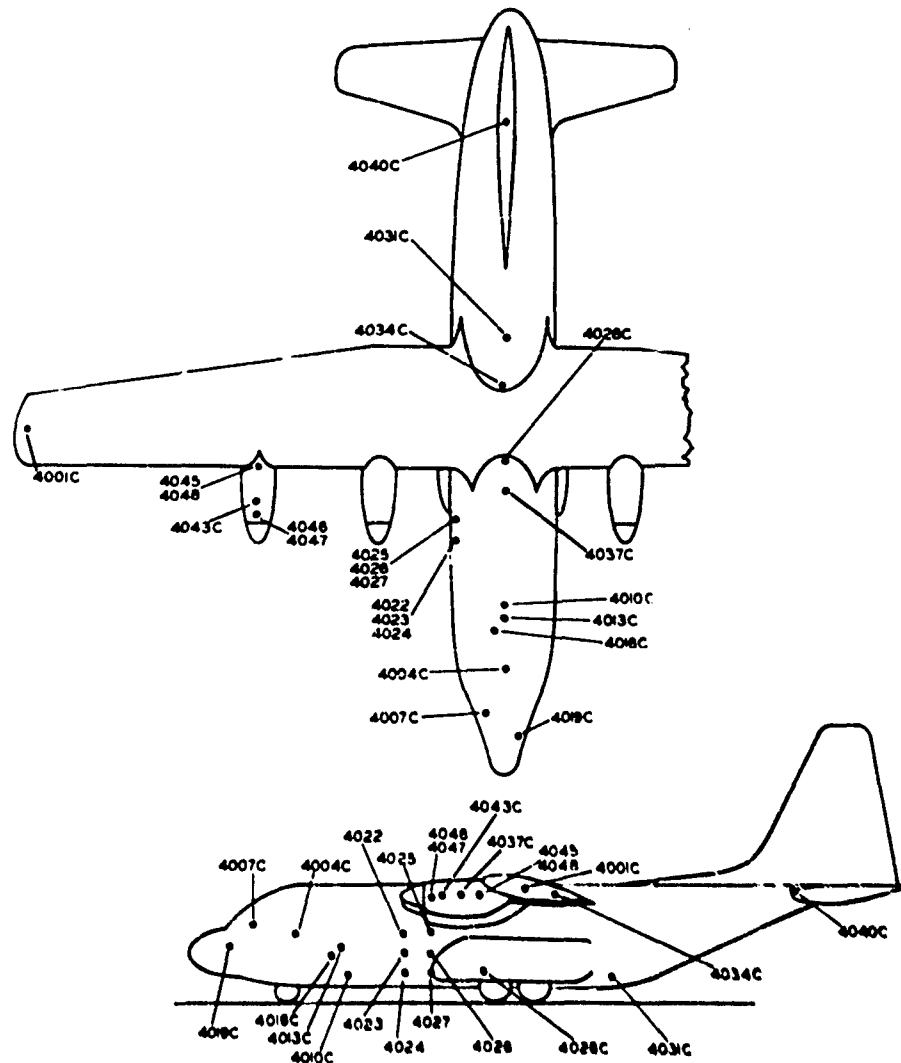


Figure 1. Schematic Presentation of Pickup Locations

TABLE II

PICKUP LOCATIONS					
PUID	Location	Direction	PUID	Location	Direction
01	Structure of Rt. Wing Tip	Vert	25	Structure of Left Side of A/C	Lat
02		Lat		Fuselage - F.S. 390 - 6 ft. above	
03		F/A		Floor	
04	Floor of Crew Compartment -	Vert	26	Structure of Left Side of A/C	Lat
05	F.S. 165	Lat		Fuselage - F.S. 390 - 4 ft. above	
06		F/A		Floor	
07	Lower Left Side of Pilot's Inst.	Vert	27	Structure of Left Side of A/C	Lat
08	Panel - F.S. 91	Lat		Fuselage - F.S. 390 - 2 ft. above	
09		F/A		Floor	
10	Structure of Forward End of	Vert	28	Structure of Mid-Center of Cargo	Vert
11	Cargo Deck - Sta. D-1, F.S. 245	Lat	29	Deck T.D. - Sta. D-12, F.S. 480	Lat
12		F/A	30		F/A
13	Structure of Equip. Rack -	Vert	31	Structure of Aft-Center of Cargo	Vert
14	F.S. 245	Lat	32	Deck T.D. - Sta. D-25, F.S. 690	Lat
15		F/A	33		F/A
16	Structure of Equip. Rack -	Vert	34	Structure of Aft Wing Spar -	Vert
17	F.S. 240	Lat	35	F.S. 597	Lat
18		F/A	36		F/A
19	Structure of Main Bulkhead in Radar	Vert	37	Structure of Equip. Rack Top -	Vert
20	Comp't (Left Side)	Lat	38	Center of Cargo Comp't - F.S.	Lat
21		F/A	39	440	F/A
22	Structure of Left Side of A/C	Lat	40	Structure, Center of Aft Section -	Vert
	Fuselage - F.S. 360 - 6 ft. above		41	F.S. 1000	Lat
	Floor		42		F/A
23	Structure of Left Side of A/C	Lat	43	Forward End of Comp. Section on	Vert
	Fuselage - F.S. 360 - 4 ft. above		44	#4 Engine	Lat
	Floor		45	Turbine Section of #4 Engine	Vert
24	Structure of Left Side of A/C	Lat	46		Lat
	Fuselage - F.S. 360 - 2 ft. above		47	Brush Band on G.E. D.C. Gen. on	Vert
	Floor			#4 Engine	Lat

A typical response curve is shown in Figure 2. The three-position mounting blocks used to attach the pickups to the vehicle structure have no resonances below 500 cps.

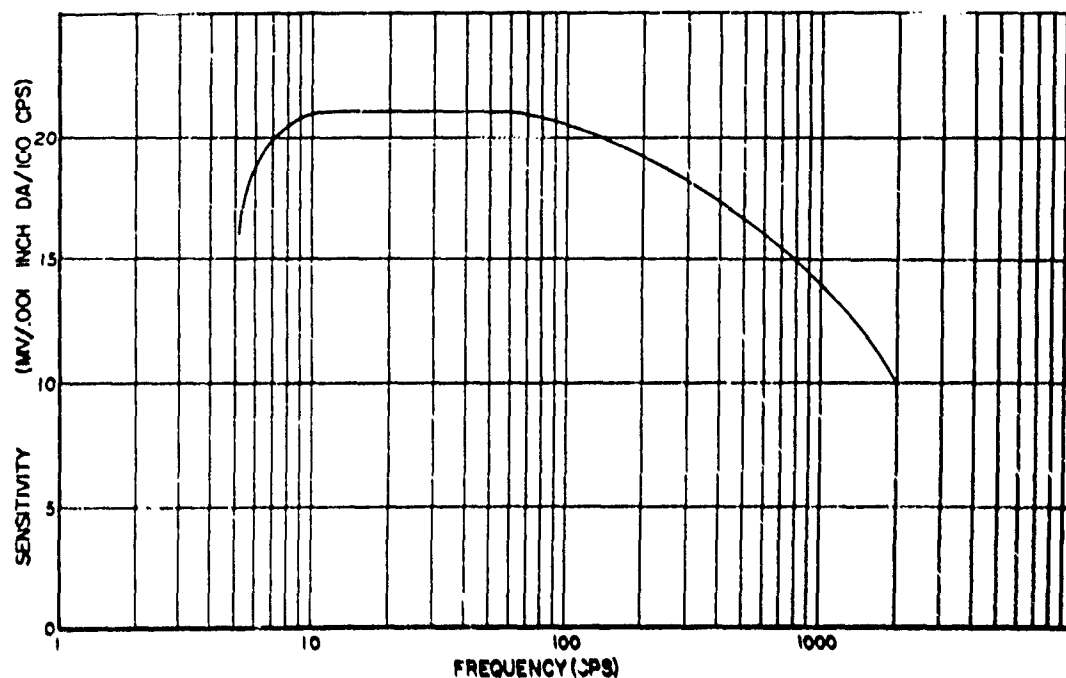


Figure 2. Frequency Response of MB Type 124 Vibration Pickup

A Davies Model 501, 14-channel magnetic tape recorder was used to record the outputs of the vibration pickups. The recorder, complete with control box and shock mount, and the pickup selector switch were installed in the nose section of the aircraft. The 26-to 28-volt DC power, required for operation of the recorder and the selector switch, was obtained from the aircraft's DC system. The recorder was preset for a recording time of five seconds. The Model 501 recorder is an FM type having the following characteristics: (1) FM carrier frequency of 10 KC, (2) intelligence frequency response of 3 to 2000 cps, (3) dynamic recording range of 45 db, (4) tape speed of 15 inches per second, (5) total recording time of approximately eight minutes, (6) weight of 55 lbs., and (7) overall dimensions, including shockmount, of 10-1/2 x 11 x 21 inches. The twelve data channels have an input impedance in excess of 100,000 ohms. The thirteenth channel has an input attenuation of approximately 45 to 1 and is designed for direct connection to the engine tachometer generator. The fourteenth channel is used to record the output from an internal, 10 KC. crystal-controlled oscillator. This channel is used during tape playback to control the playback speed by means of a servo, and it is also utilized in the electronic compensation of the tape playback and analysis system. The recorder uses 1-3/4-inch wide magnetic tape in 400-to 600-foot reels.

TABLE III
FLIGHT CONDITIONS FOR C-119A

Flight Attitude	%RPM	IAS	Alt x 10 ³	P. L. A. °	HP
Ground Runup	97-100	0	0	69-90	52-111
Ground Runup W/One or More Engines Out	96-102	0	0	90	12-100
Takeoff	100	150	0	90	111
Climb	100	150	2	76	75
Troop Doors Open	100	160	5	58	36
Straight and Level	100	140	5	21	15
Cruise W/One or More Engines Out	100	140	5	55	31
Normal Descent	99	145	1	41	13
Normal Descent W/Speed Brakes Extended	99	110	2	47	29
Landing Roll	99	0	0	0	38
Taxi	97	0	0	41	11
Touchdown	100	50	0	41	36
Cruise Speed Brakes Extended	100	120	6	58	25
Cruise (turbulent air)	100	260	5	75	72

*Power Lever Angle

Test Procedure

Five test flights were flown during this survey. A summary of the test conditions is shown in Table III. The test plan was based on requirements of interested laboratories at ASD and on information obtained from USAF flight test

pilots. Data were obtained during all of the normal operational configurations expected of the aircraft. Test conditions were also established which permitted the evaluation of variables, such as altitude, indicated airspeed, engine thrust at constant airspeeds and altitudes, and the effects of using the speed brakes gear and other control surfaces at various airspeeds. Prior to each flight, the test pilot was thoroughly briefed on the desired flight test conditions and was given the appropriate flight test data card. As soon as the desired flight test condition was attained, the output of each of the 48 pickups was recorded in successive groups of 12 each by means of a remotely controlled selector switch. The number of data samples acquired during the five test flights totaled 1477. The reels of recorded data were sent to the laboratory for analysis.

Data Processing

The reels of tape were edited and each five-second record (data sample) was spliced into a continuous loop and properly labeled. These records were analyzed by means of a Davies Model 510 automatic analyzer, which was used in conjunction with a Davies Model 502 magnetic tape playback system. The complete playback and analysis system is shown in Figure 3.



Figure 3. Automatic Tape Playback and Analysis Equipment

The Model 502 magnetic tape playback system had been modified to provide playback at either 15 or 30 inches per second. The tape playback contains a servo-control system which permits playback of the tape within very close tolerances of its originally recorded speed. During playback the output from all fourteen tracks is fed simultaneously into the fourteen FM playback discriminators. The output signal from each of the twelve data channels is a 1 to 1 reproduction of the original analog signal.

An important feature of the playback system, i.e., electronic compensation, should be discussed briefly at this point. During the data recording process, the input of the fourteenth channel is the voltage from a very stable, 10 KC, crystal-controlled, reference frequency oscillator contained within the recorder. During playback, a portion of this 10 KC signal is fed into a standard FM discriminator channel. Assuming there were no wow and flutter during playback, the output voltage from this particular discriminator, i.e., the fourteenth channel, would be zero. Therefore, if any voltage is obtained from this channel during playback, it is an "error" voltage produced by wow and flutter. This "error" voltage with its phase shifted 180 degrees is fed simultaneously into the output stage of each of the twelve data channels. In this manner, the extraneous voltages due to wow and flutter are eliminated from the signal output of the data channels. Prior to playback of data, each of the data channels is adjusted for optimum cancellation (approximately 40 db). Hence, an overall dynamic range of 45 db (record through playback) can be maintained consistently. Table IV contains a summary of facts pertinent to the Davies Model 502 magnetic tape playback system and the Davies Model 510 automatic wave analyzer.

TABLE IV
SPECIFICATIONS FOR DAVIES LABORATORIES
MODEL 502 MAGNETIC TAPE PLAYBACK
AND MODEL 510 AUTOMATIC ANALYZER

Frequency Range	1 cps to 2,000 cps
Frequency Accuracy	0.2 cps from 1 to 40 cps 0.5% from 40 to 2,000 cps
Input Voltage Range (2-position switch)	1.0 volt or 10 volts rms maximum
Amplitude Accuracy	5% of reading or 0.2% of full scale
Selectivity	Narrow Range - continuously variable from 1/2 to 8 cps Broad Range - continuously variable from 8 to 45 cps
Scanning Speeds, Motor Drive	Speed Range 25:1 - continuously adjustable Minimum Sweep Time - 15 minutes Maximum Sweep Time - 6 hrs. and 15 min.
Recorder Speed of Response	2 seconds for 90% full scale
Tape Speed	15 or 30 inches per second
Loop Length	Approx. 2-1/2 ft. to at least 25 ft.
Tape Width	1 and 1-1/4 inch

The Davies Model 510 automatic analyzer is a constant-bandwidth, heterodyne analyzer complete with motor-driven, variable frequency oscillator. The system has six separate analyzers and can analyze six data channels simultaneously. Both the oscillator scanning rate and analyzer bandwidth are adjustable over the following limits: (1) scan rate 0.3 to 3.0 cps/sec. and (2) bandwidth 1 to 40 cps. The output of the six wave analyzer channels was fed into six modified Brown strip chart recorders. A continuous spectrum plot of frequency (cps) vs voltage (rms) was produced by the strip chart recorders. The chart speed is servo-controlled and can be varied from 0.08 to 13.5 inches per minute. The voltage was plotted on a logarithmic scale and the time required for full-scale deflection, i.e., zero to one volt, was approximately two seconds. A sample analysis of a 100-cps square wave is shown in Figure 4.

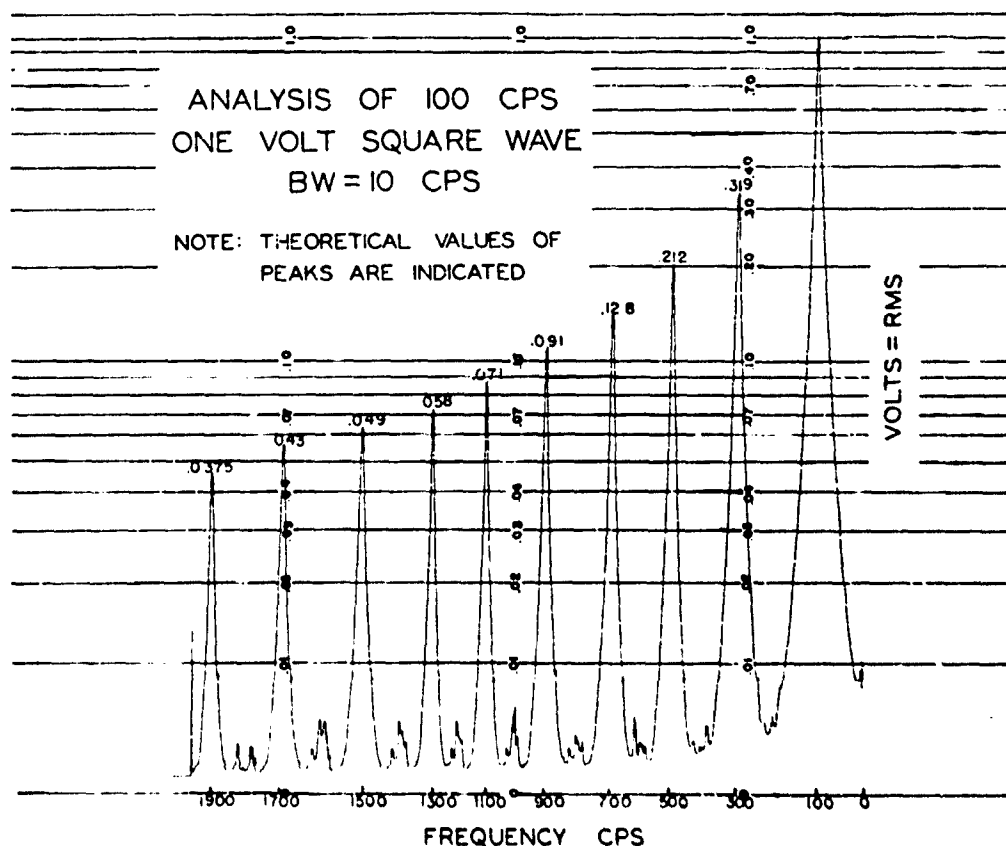


Figure 4. Analysis of 100 cps One Volt Square Wave

In selecting the bandwidth to be used in an analysis of this type, the following must be considered: (1) the frequency resolution desired, (2) the rate of scan, (3) the length of the data sample, (4) the time available for data analysis, (5) the quantity of data to be analyzed, (6) the type of data being analyzed, and (7) the type of presentation of the completed data. Based on a consideration of these variables, a bandwidth of ten cycles per second was selected for these analyses.

Following the harmonic analysis, the Brown strip chart recordings were edited and the voltage peaks of interest were marked. Each of these peaks constitutes a data point. The corresponding values of frequency and voltage for each of these peaks were tabulated, and subsequently punched into IBM cards. Each data point goes on a separate card. Then these cards were processed through the ERA 1103A computer at the rate of ninety cards per minute. Prior to processing each set or flight of data cards through the computer, a series of three sets of "master" cards was made and fed into the computer. These sets of "master" cards are:

- (1) The "Flight Condition Masters"; these contain all of the necessary flight parameters, i.e., altitude, IAS, power, etc., associated with each of the data cards. This information is obtained from the flight test data card.
- (2) The "Pickup Location Masters"; these contain the information required to identify each data point of each channel and record number with a particular pickup.
- (3) The "Source and Order Masters"; these contain sufficient information to identify specific vibration frequencies with known orders of engine and propeller unbalance and also blade passage frequencies of the propeller or rotor blades, as the case may be.

As the data cards are processed, a new and complete "answer" card having the following information is produced: (1) the computed values of double amplitude in inches, acceleration in g's, log of frequency, log of double amplitude, and log of acceleration, (2) all of the data on the original data card, and (3) all of the appropriate data obtained from the "Master" cards. The order and limits of the information in the final analysis are shown in Table V.

After the computations were completed, all of the data cards were arranged in the desired sequence by means of an IBM sorter. Then a multi-copy IBM listing was made of all data. These listings were used in detail studies of the data and in checking the accuracy of the completed graphs.

Automatic plotters utilizing IBM card input produced the graphs of frequency in cycles per second vs. vibratory double amplitude in inches. The plotting rate ranged from 30 to 60 points per minute. The three types of graphs plotted are:

- (1) Summary plots (all test conditions) for each individual vibration pickup,
- (2) Summary plots for each cluster of pickups (2 or 3),
- (3) Summary plots for each structural zone.

Each of the three types of graphs has all the appropriate data obtained from the five flights. No plots were made to indicate the effects of variables, such as power, altitude, IAS, etc.; however, such plots can be obtained upon request.

TABLE V
SUMMARY OF INFORMATION ON IBM CARDS

<u>Card Column</u>	<u>Range</u>	<u>Category</u>
1 - 2	0 - 99	Pickup Location
3 - 4	1 - 31	Day
5 - 6	1 - 12	Month
7 - 8	1 - 24	Time
9 - 10	1 - 12	Channel Number
11 - 12	0 - 99	Record Number
13 - 16	0 - 2000	Frequency in cps
17 - 20	0 - .9999	Voltage
21 - 23	0 - 285	Engine Speed
24 - 26	0 - 999	IAS in Knots
27 - 28	0 - 60	Altitude in 1000 feet
29 - 30	1 - 12	Source
31 - 32	0 - 24	Order
33 - 34	1 - 63	Flight Condition
35 - 36	N. A.	Blank
37 - 41	0 - .9999	Double Amplitude in Inches
42 - 45	0 - 99.99	Acceleration in g
46 - 50	N. A.	Log of Frequency
51 - 55	N. A.	Log of Double Amplitude
56 - 60	N. A.	Log of Acceleration
61 - 62	0 - 45	Aircraft I.D. Number
63 - 65	0 - 100	Man. Pres. -- in. Hg
66 - 68	0 - 150	Power Lever Angle in Degrees Percent of Rated H. P. Percent of Rated Thrust
69 - 70	1 - 27	Structural Zone
71 - 80	N. A.	Blank

The Type 1 graphs permit a detailed study of the vibration characteristics along a single axis at a particular location in the test vehicle.

The Type 2 graphs present the overall vibration environment, measured under all test conditions, at each of the test points where 2 or 3 pickups were mounted in a cluster.

The Type 3 graphs show the overall vibration environment for a structural zone, e.g., front quarter of the fuselage. The structure of the test vehicle has been arbitrarily divided into nine major areas. Each of these major areas has been further subdivided into the following three categories: (1) vehicle structure, (2) rigidly mounted equipment, and (3) shock mounted equipment. A complete listing of these structural zones is contained in Table VI. A diagram of seven of the nine major areas is shown in Figure 5.

TABLE VI
CODE FOR STRUCTURAL ZONE OF A/C

<u>Code Nr</u>	<u>Structural Zone</u>
01	Forward Quarter of Fuselage
02	Center Half of Fuselage
03	Aft Quarter of Fuselage
04	Vert. & Horiz. Stab. Incl. Rudder & Elevators
05	Outer one-third of Wing
06	Inner two-thirds of Wing
07	Engine
08	Rigidly Mounted Equipment in Forward Quarter of Fuselage
09	Rigidly Mounted Equipment in Center Half of Fuselage
10	Rigidly Mounted Equipment in Aft Quarter of Fuselage
11	Rigidly Mounted Equipment in Vert. & Horiz. Stab. Incl. Rudder & Elevators
12	Rigidly Mounted Equipment in Outer one-third of Wing
13	Rigidly Mounted Equipment in Inner two-thirds of Wing
14	Rigidly Mounted Equipment in Engine
15	Shock Mounted Equipment in Forward Quarter of Fuselage
16	Shock Mounted Equipment in Center Half of Fuselage
17	Shock Mounted Equipment in Aft Quarter of Fuselage
18	Shock Mounted Equipment in Vert. & Horiz. Stab. Incl. Rudder & Elevators
19	Shock Mounted Equipment in Outer one-third of Wing
20	Shock Mounted Equipment in Inner two-thirds of Wing
21	Shock Mounted Equipment in Engine
22	Engine Accessory Section
23	Main Rotor Transmission Case
24	Rigidly Mounted on Engine Accessory Section
25	Rigidly Mounted on Main Rotor Transmission Case
26	Shock Mounted on Engine Accessory Section
27	Shock Mounted on Main Rotor Transmission Case

All graphs are log-log (3 x 5 cycle) plots of frequency vs. vibratory double amplitude. As indicated previously, the logs of frequency, double amplitude, and acceleration were determined during the computation phase of data reduction. These

computations are necessary for the automatic plotting of frequency vs. double amplitude on a log-log scale. For the standard automatic plotters available can not accept linear input and then plot on a log scale. Therefore, by using the proper scale factors, the logarithms of the desired variables can be fed to any standard plotter to produce log-log plots of the original data. On these graphs of frequency vs. double amplitude, levels of vibratory acceleration appear as straight lines of constant slope. Reference lines having values of ± 0.5 , ± 1.0 , ± 5.0 , and ± 10.0 g are included on all graphs. This arrangement permits simultaneous readings of double amplitude and acceleration at any given frequency.

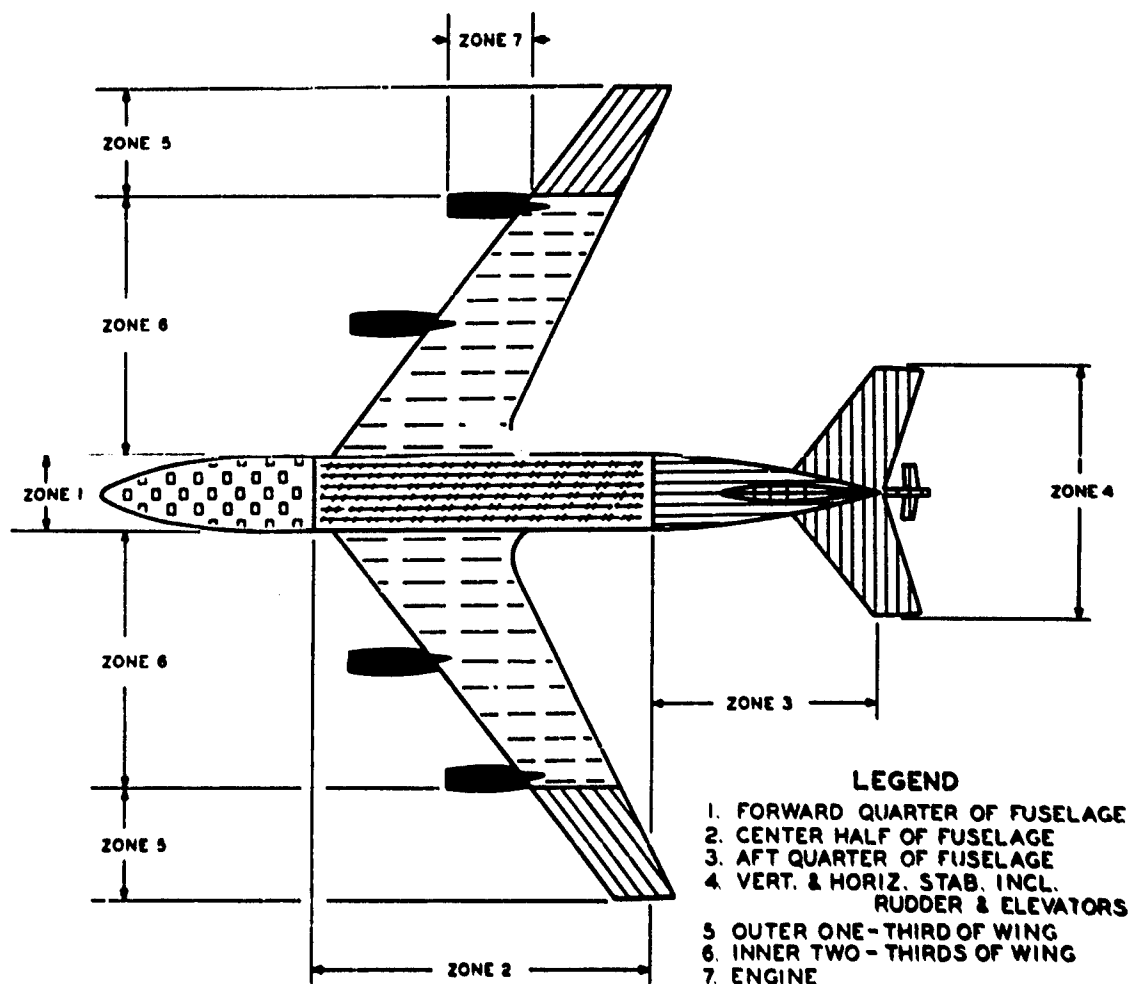


Figure 5. Aircraft Configuration Depicting Seven Structural Zones

A more detailed description of the data reduction processes used to reduce the vibration data is contained in WADC TN 59-44, ASTIA Document Nr. AD210478, dated February 1959, which is titled, "Data Reduction Techniques for Flight Vibration Measurements."

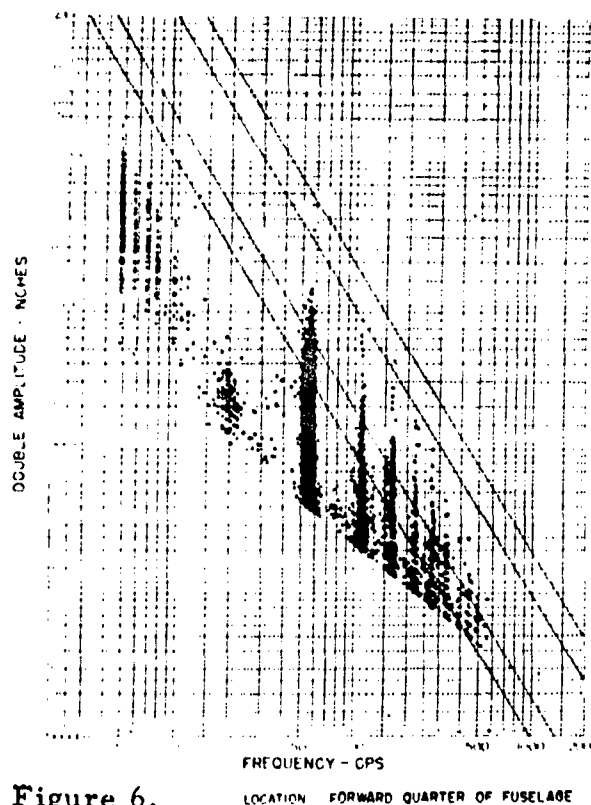


Figure 6.

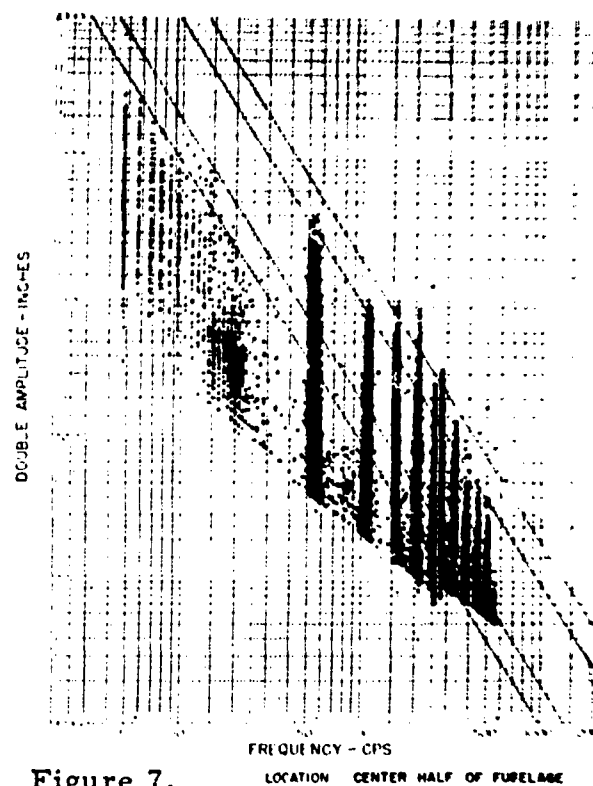


Figure 7.

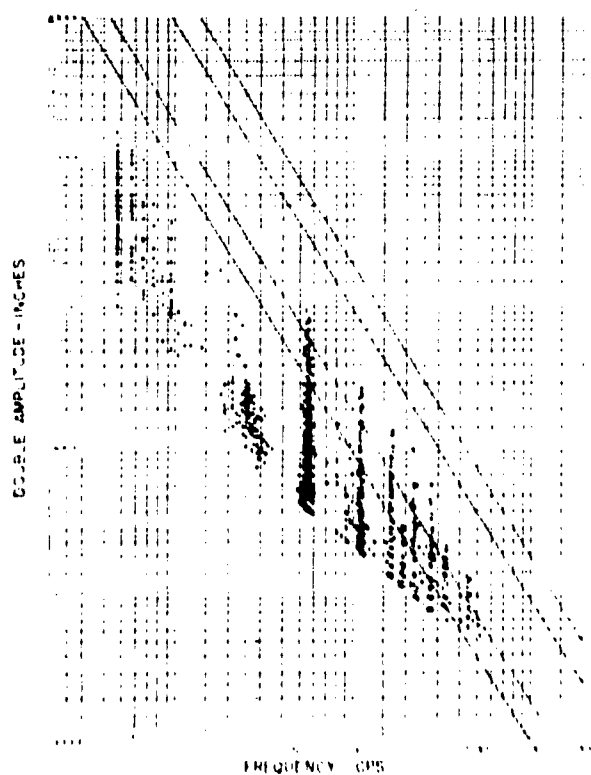


Figure 8.

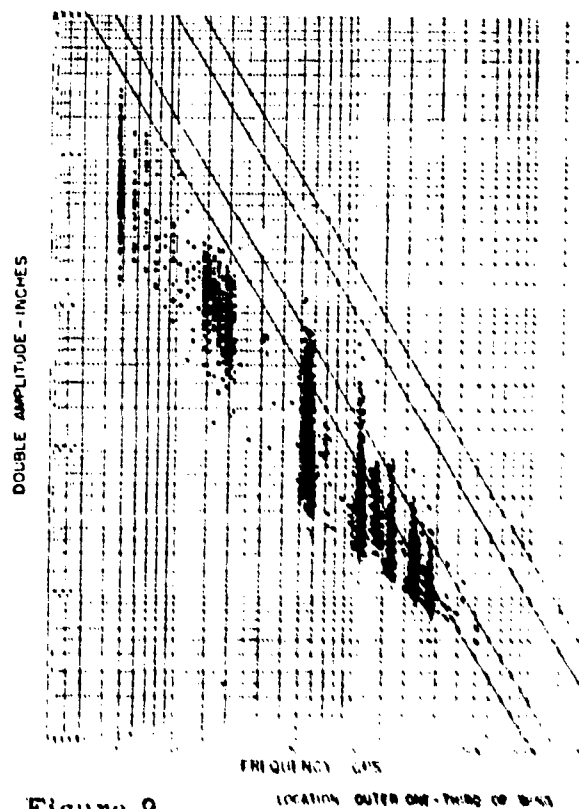


Figure 9.

Figures 6 to 9. Summary Plots for Structural Zones

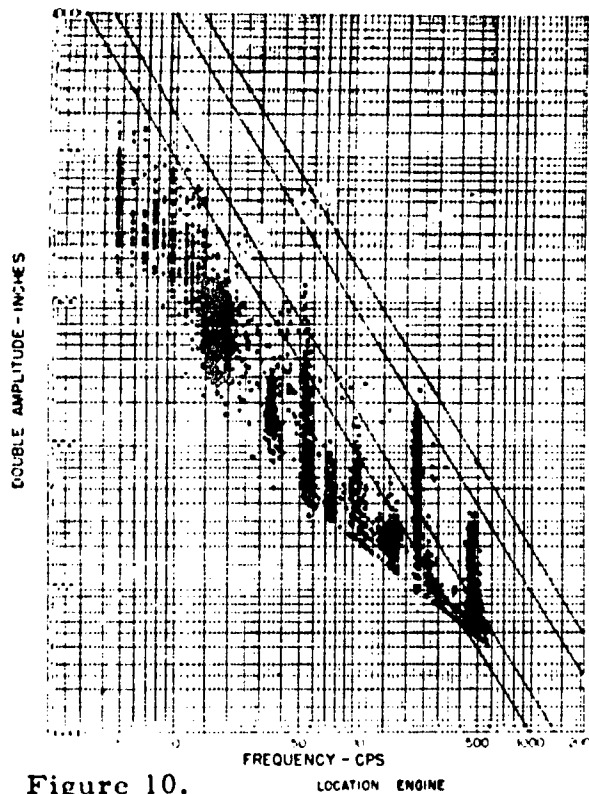


Figure 10.

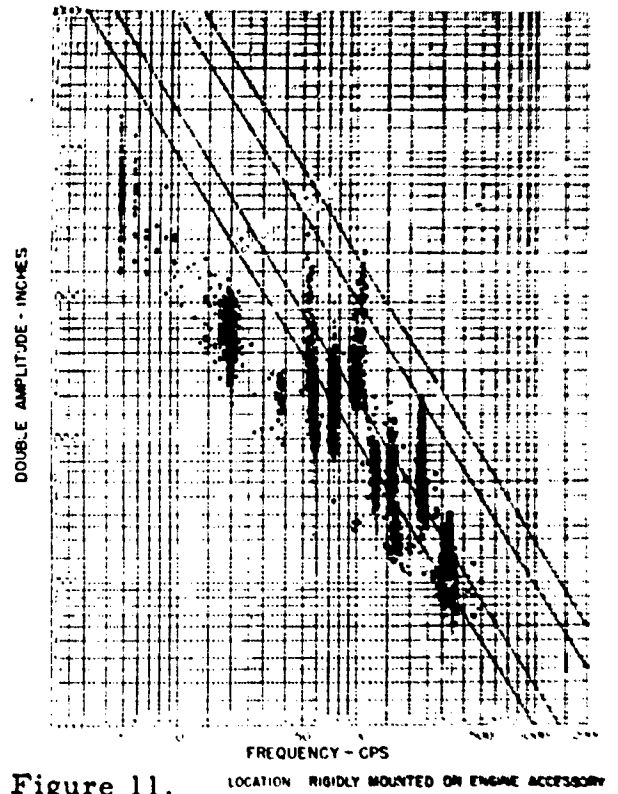


Figure 11.

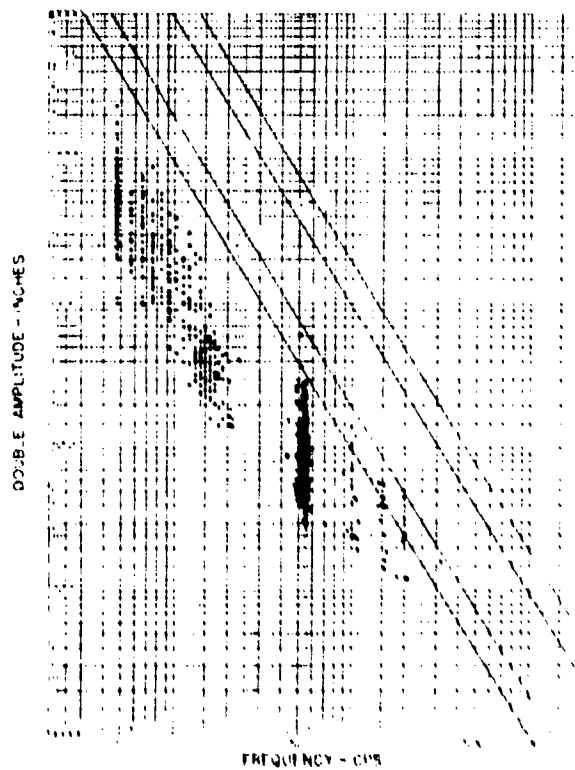


Figure 12.

Figures 10 to 12. Summary Plots for Structural Zones

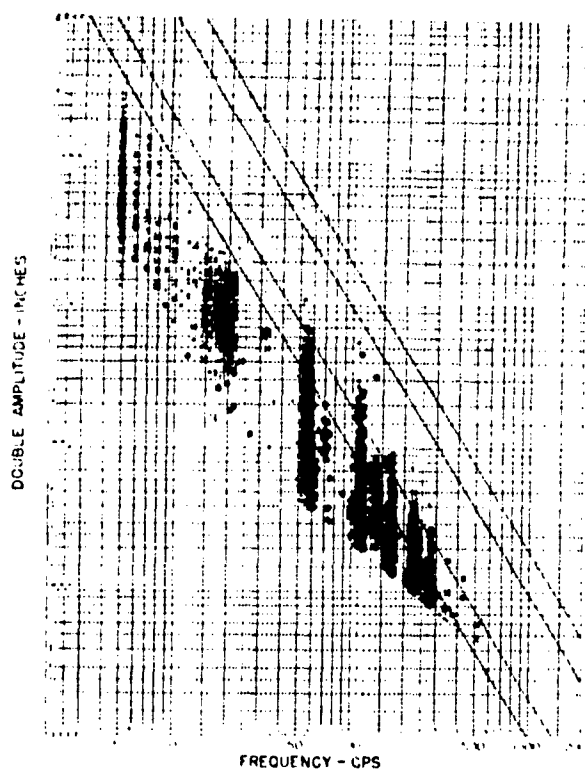


Figure 13.
DIRECTION - VERTICAL; * LATERAL; + F/A
LOCATION - STRUCTURE OF RIGHT WING TIP

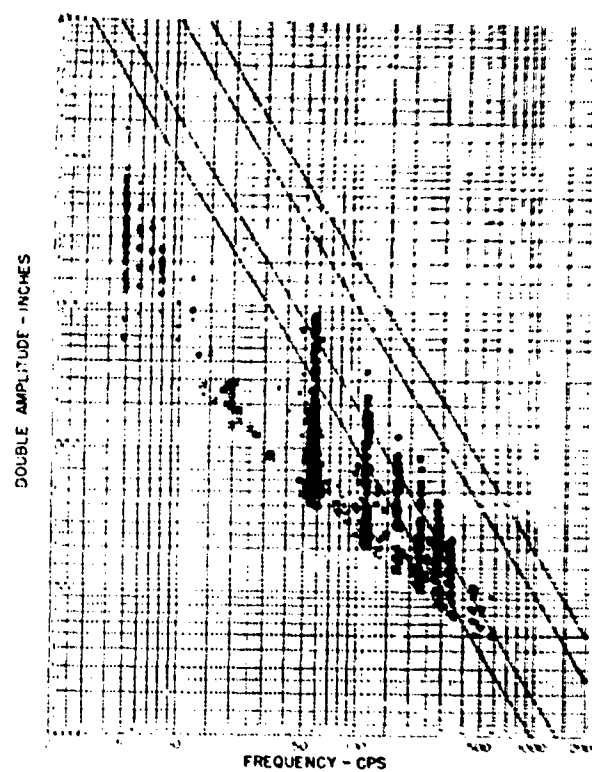


Figure 14.
DIRECTION - VERTICAL; * LATERAL; + F/A
LOCATION - FLOOR OF CREW COMPARTMENT FS 163

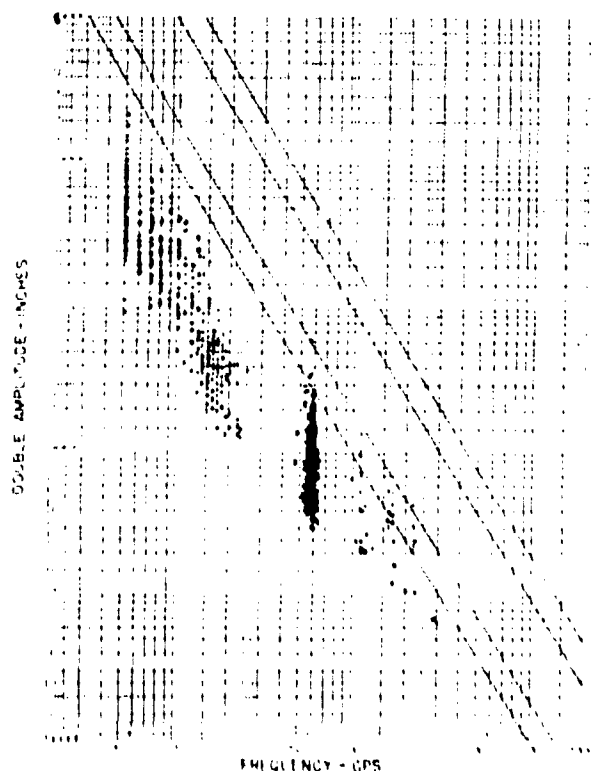


Figure 15.
DIRECTION - VERTICAL; * LATERAL; + F/A
LOCATION - LOWER LEFT SIDE OF PHOTO INSTRUMENT
PANEL FS 91

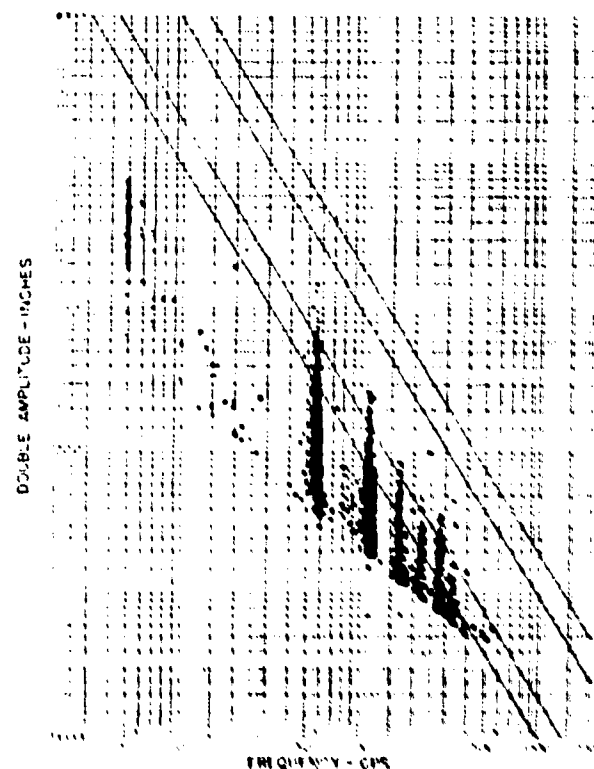


Figure 16.
DIRECTION - VERTICAL; * LATERAL; + F/A
LOCATION - STRUCTURE OF BOMBING END OF
CARGO DECK FS 114 FS 255

Figures 13 to 16. Summary Plots for Clusters of Two or Three Pickups

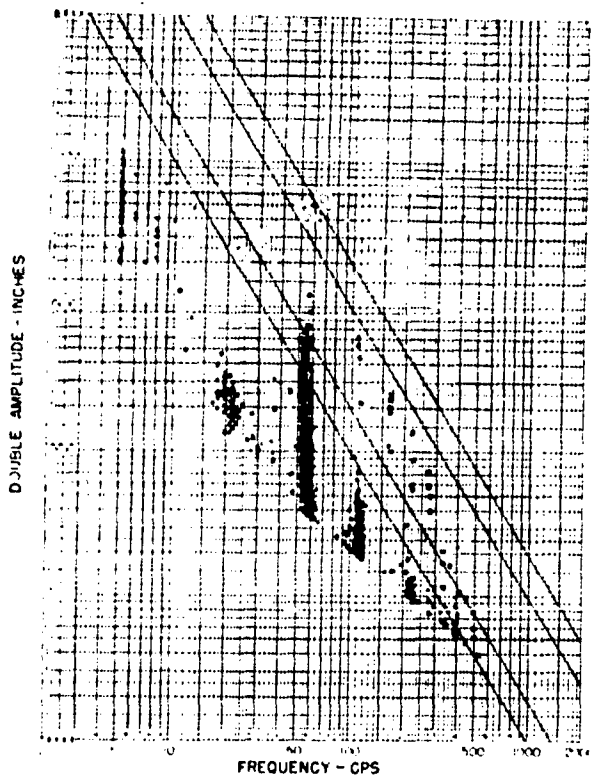


Figure 17.

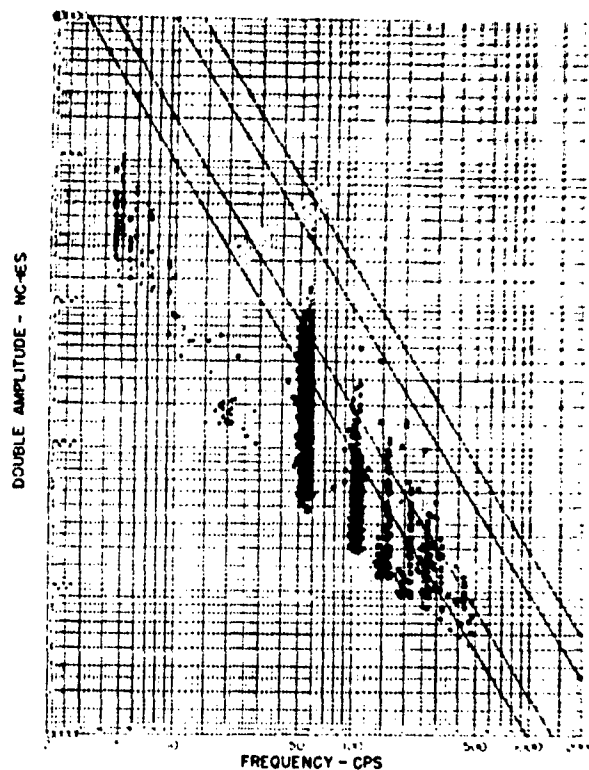


Figure 18.

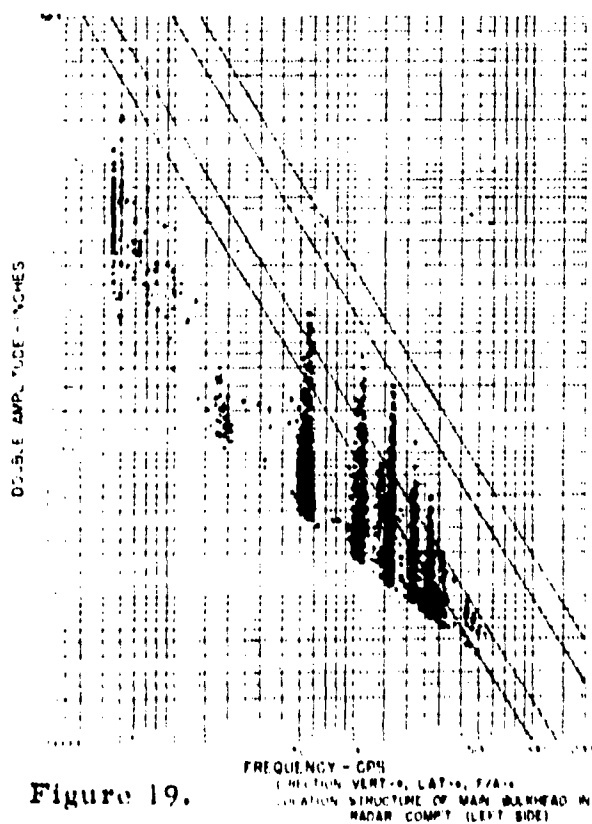


Figure 19.

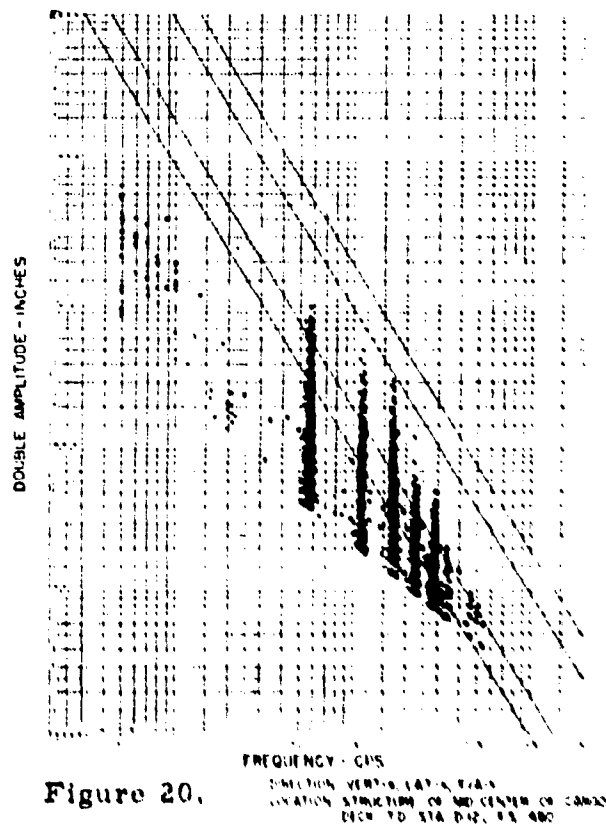


Figure 20.

Figures 17 to 20. Summary Plots for Clusters of Two or Three Pickups

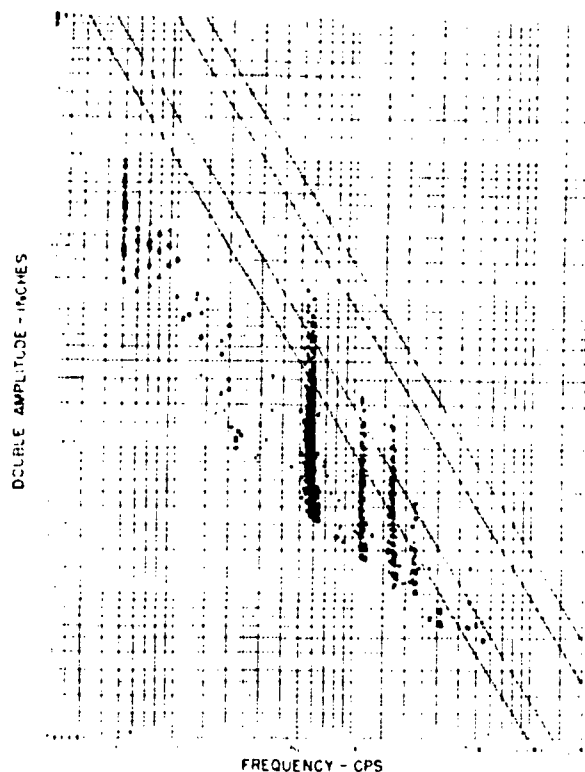


Figure 21.
 DIRECTION VERT-0, LAT-0, F/A-0
 LOCATION STRUCTURE OF AFT-CENTER OF CARGO
 DECK YD. STA. D 23 °S 620

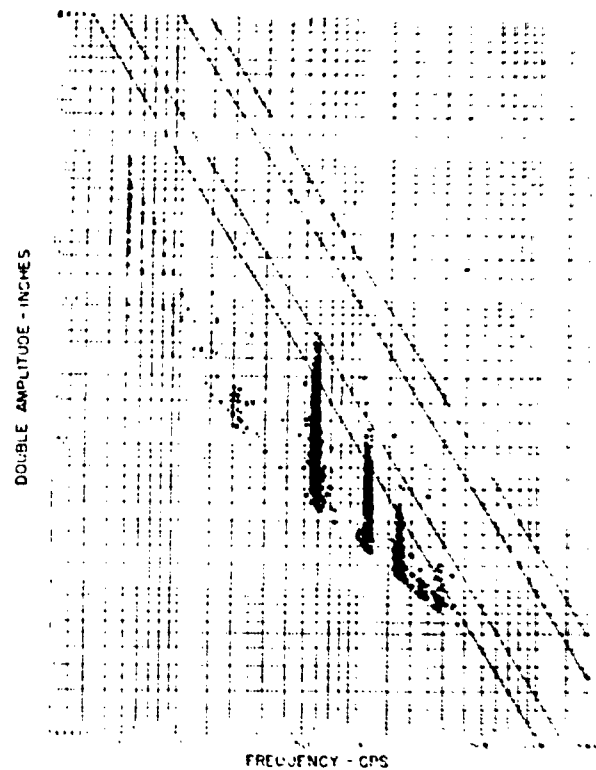


Figure 22.
 DIRECTION VERT-0, LAT-0, F/A-0
 LOCATION STRUCTURE OF AFT BARGE 1000 PS 500

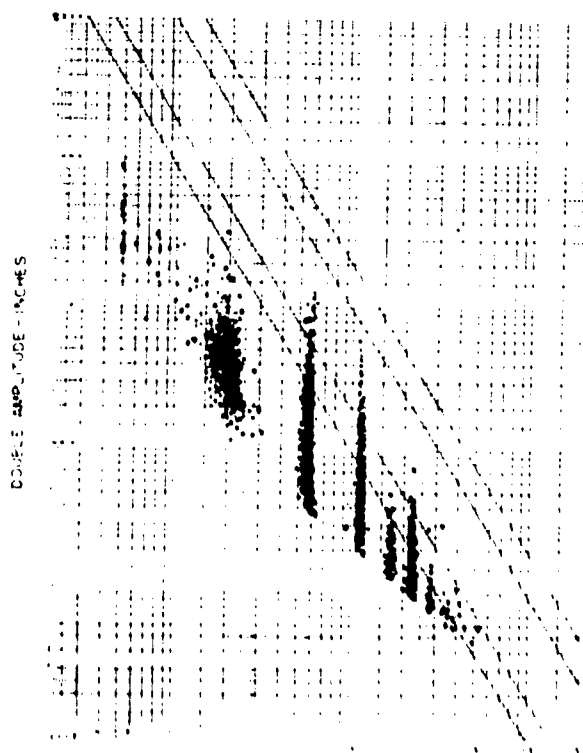


Figure 23.
 DIRECTION VERT-0, LAT-0, F/A-0
 LOCATION STRUCTURE OF EQUIP. RACK, TOP-CENTER
 OF CARGO COMPT. PS 440

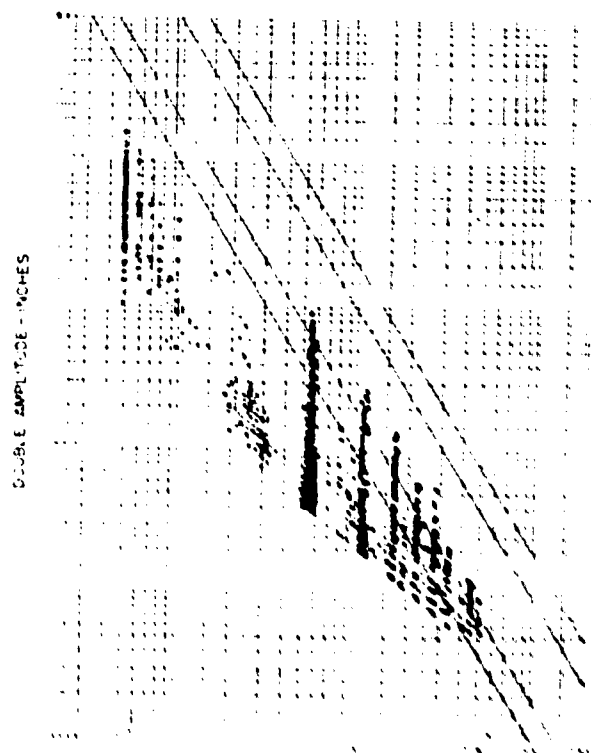


Figure 24.
 DIRECTION VERT-0, LAT-0, F/A-0
 LOCATION STRUCTURE, CENTER OF AFT SECTION PS 1000

Figures 21 to 24. Summary Plots for Clusters of Two or Three Pickups

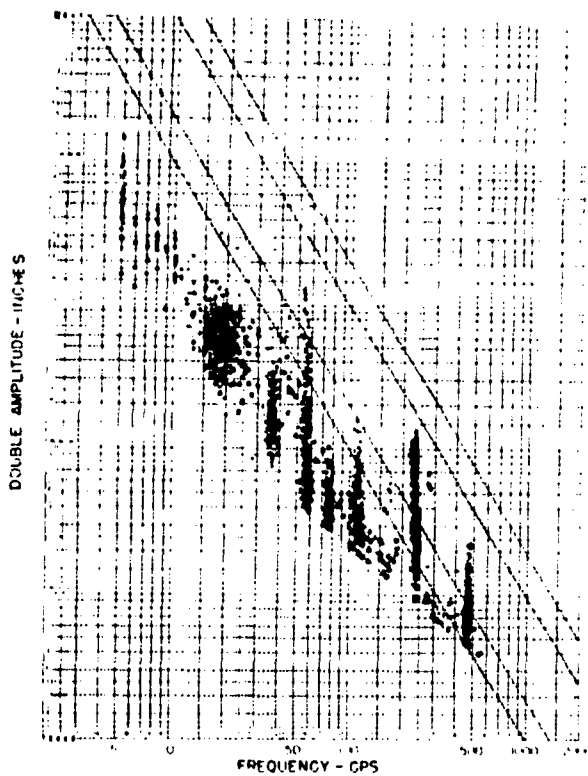


Figure 25. DIRECTION VERT-0, LAT-0
LOCATION FORWARD END COMP SECT ON NO 4 ENGINE

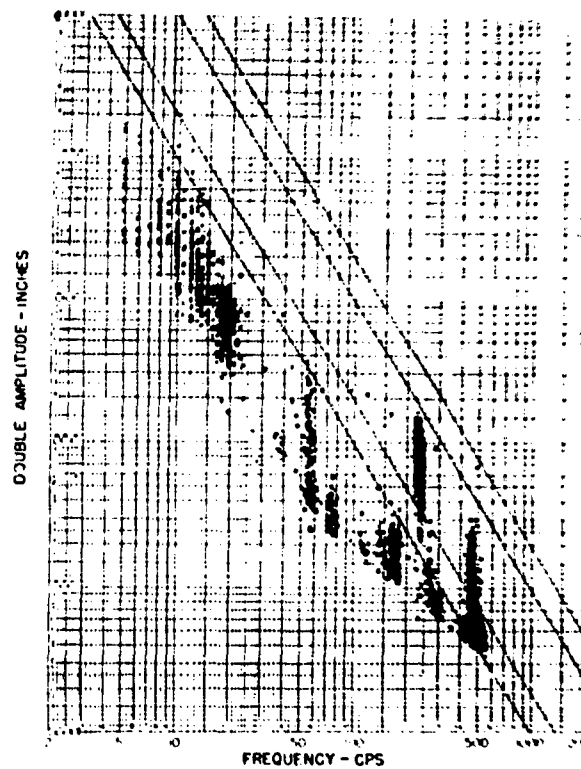


Figure 26. DIRECTION VERT-0, LAT-0
LOCATION TURBINE SECT OF NO 4 ENGINE

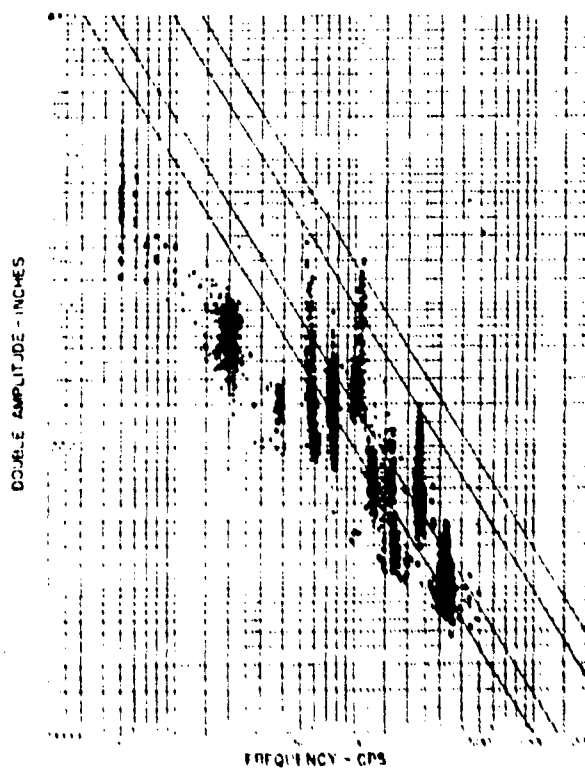


Figure 27. DIRECTION VERT-0, LAT-0
LOCATION BRUSH BAND ON JE DC GEN ON NO 4 ENGINE

Figures 25 to 27. Summary Plots for Clusters of Two or Three Pickups

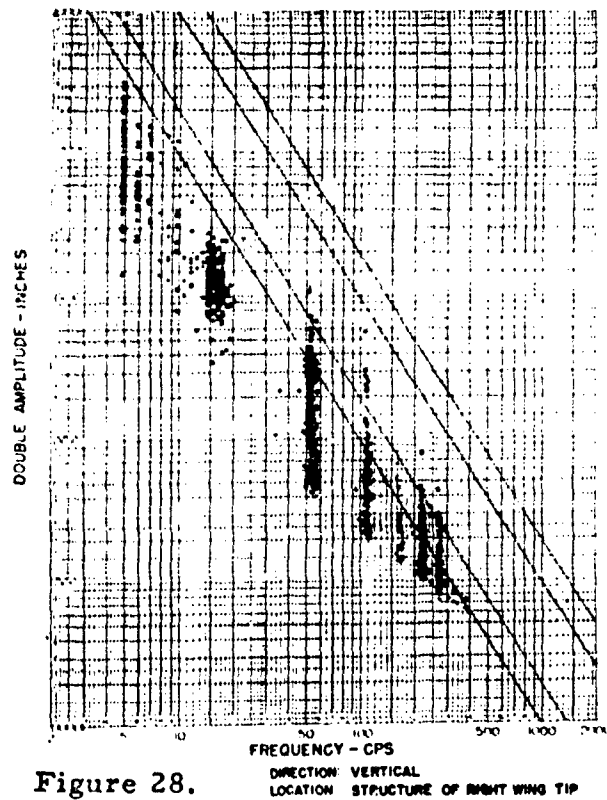


Figure 28.

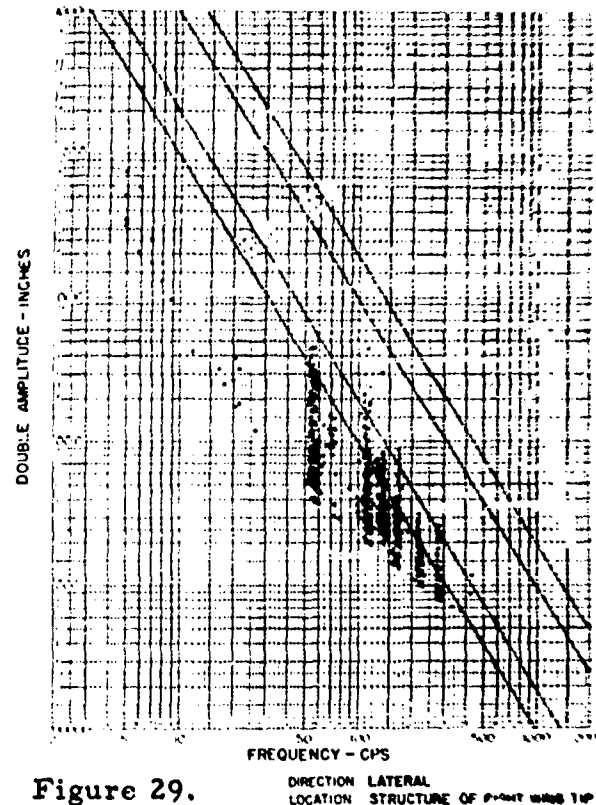


Figure 29.

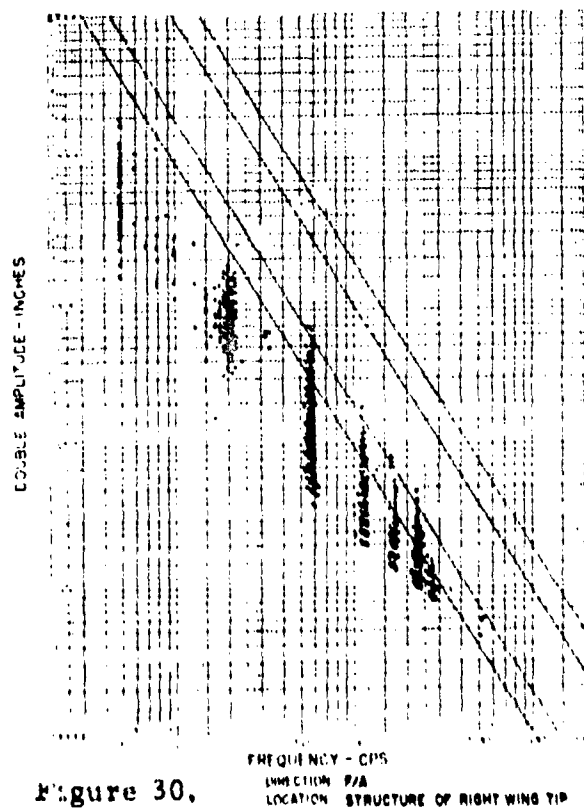


Figure 30.

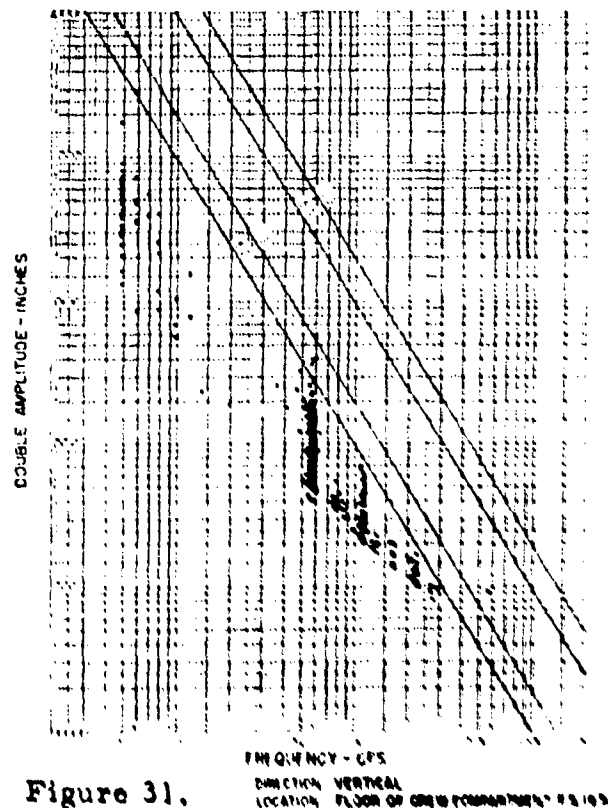


Figure 31.

Figures 28 to 31. Summary Plots for Individual Vibration Pickups

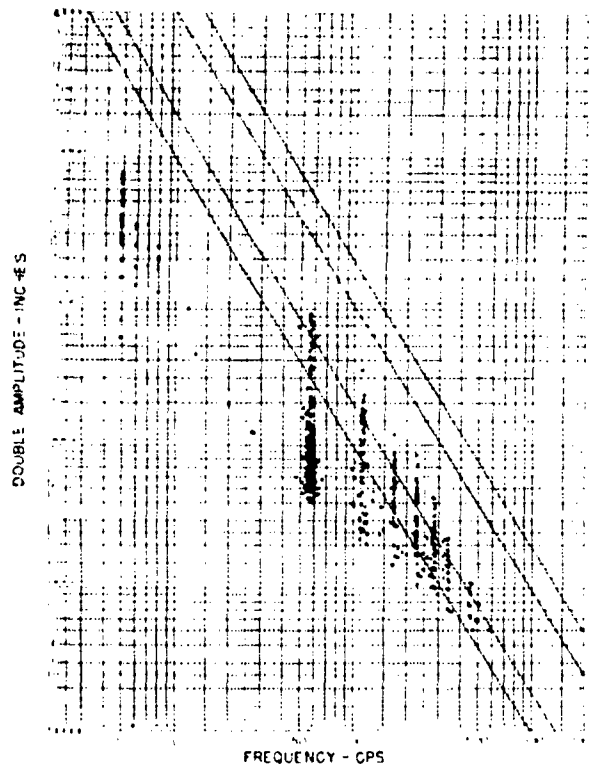


Figure 32.

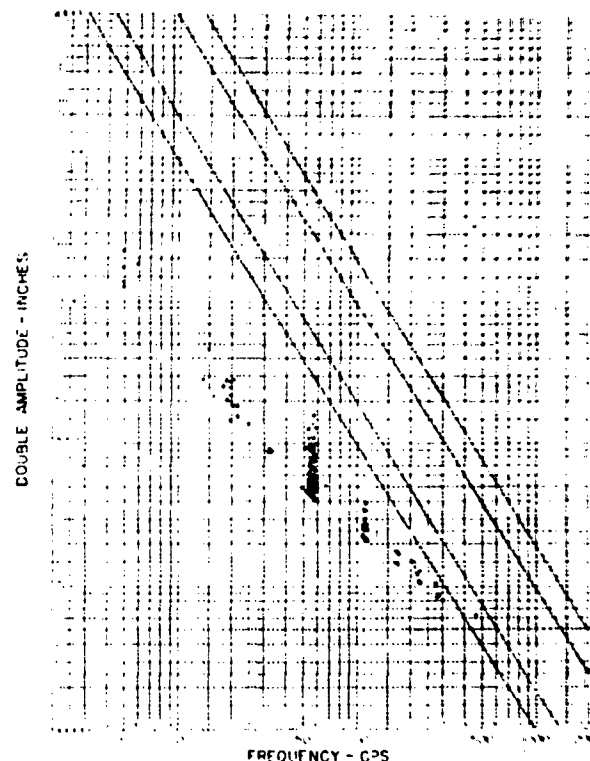


Figure 33.

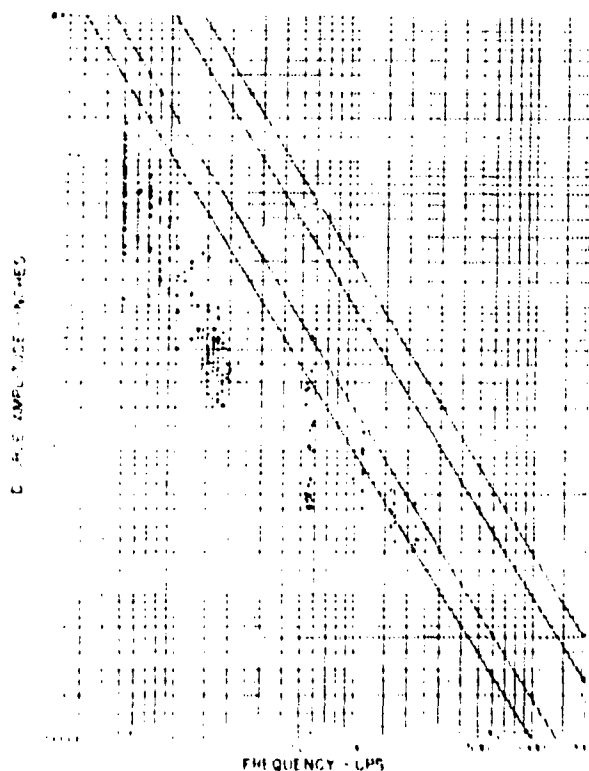


Figure 34.

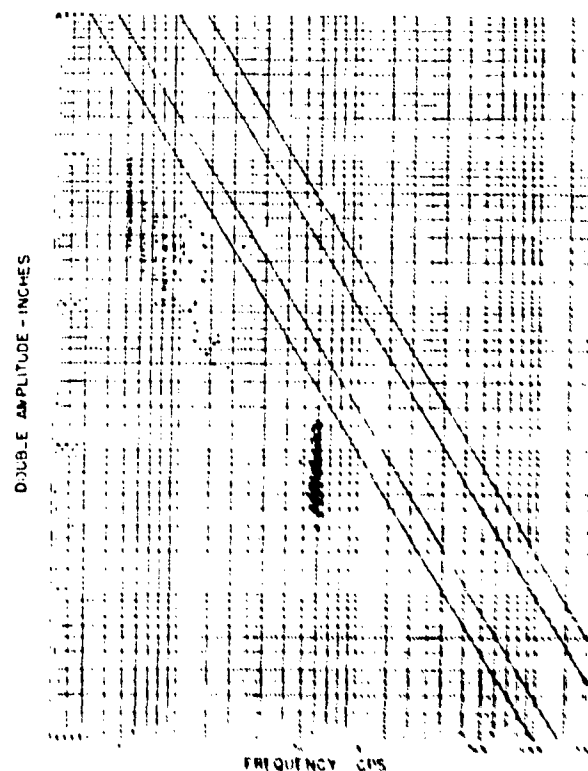


Figure 35.

Figures 32 to 35. Summary Plots for Individual Vibration Pickups

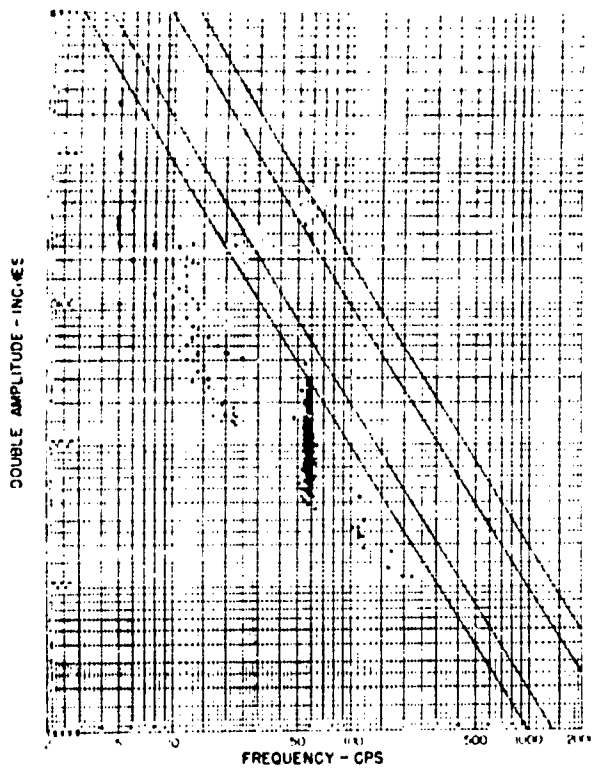


Figure 36.

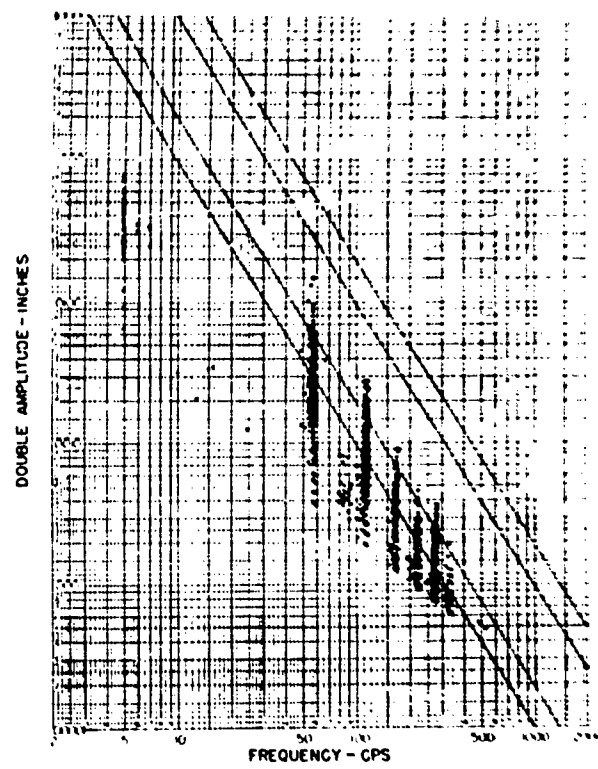


Figure 37.

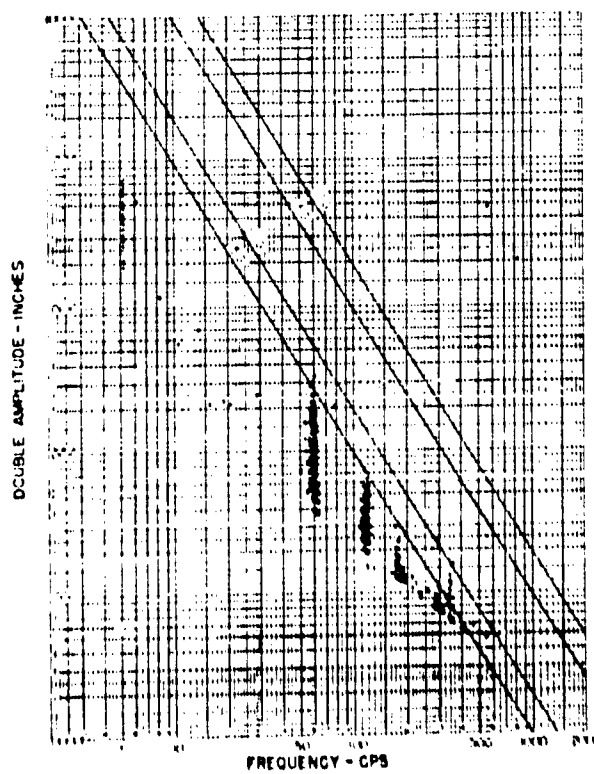


Figure 38.

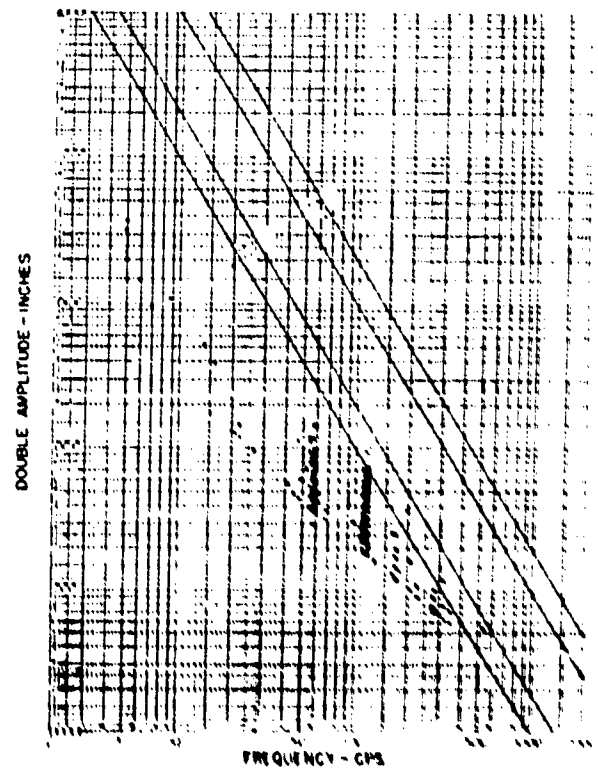


Figure 39.

Figures 36 to 39. Summary Plots for Individual Vibration Pickups

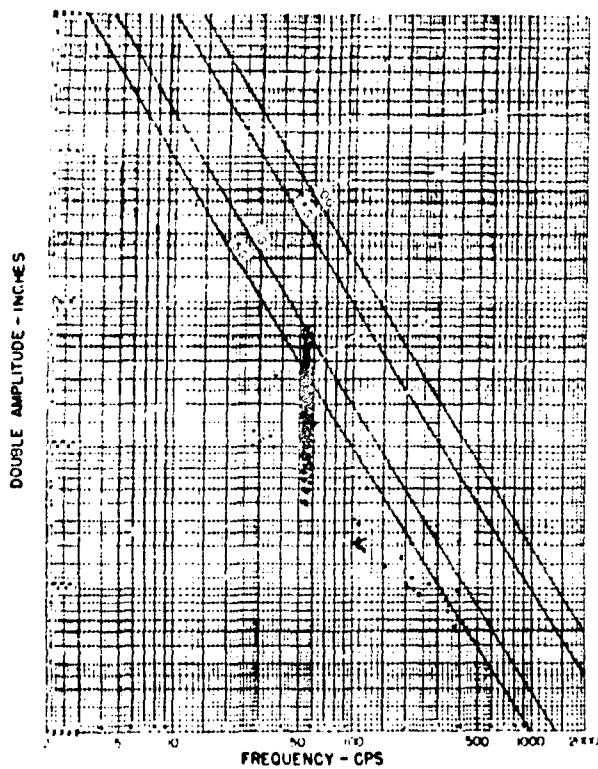


Figure 40. DIRECTION VERT
LOCATION STRUCTURE OF EQUIPMENT RACK FS 245

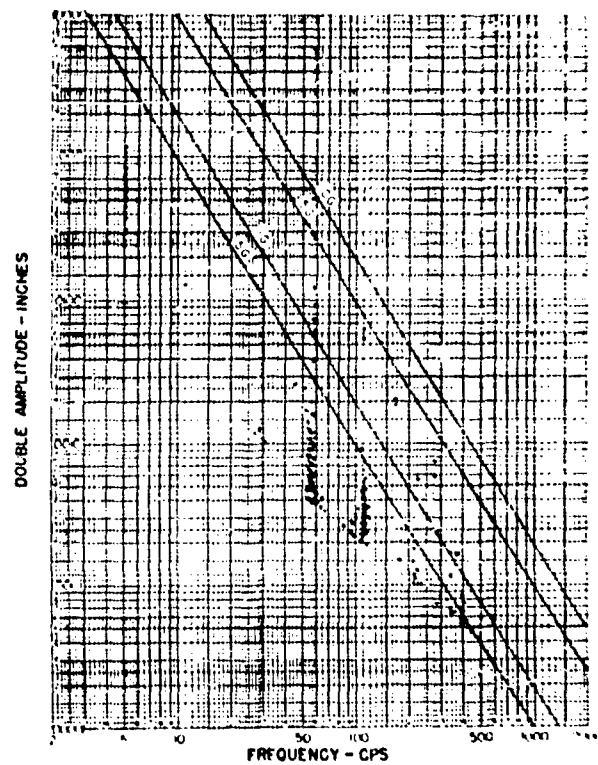


Figure 41. DIRECTION LAT
LOCATION STRUCTURE OF EQUIPMENT RACK FS 245

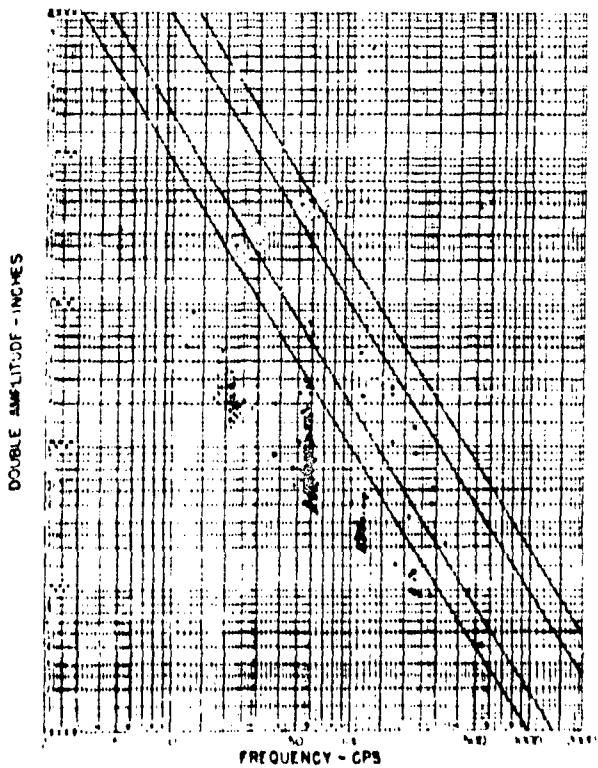


Figure 42. DIRECTION F/A
LOCATION STRUCTURE OF EQUIPMENT RACK FS 245

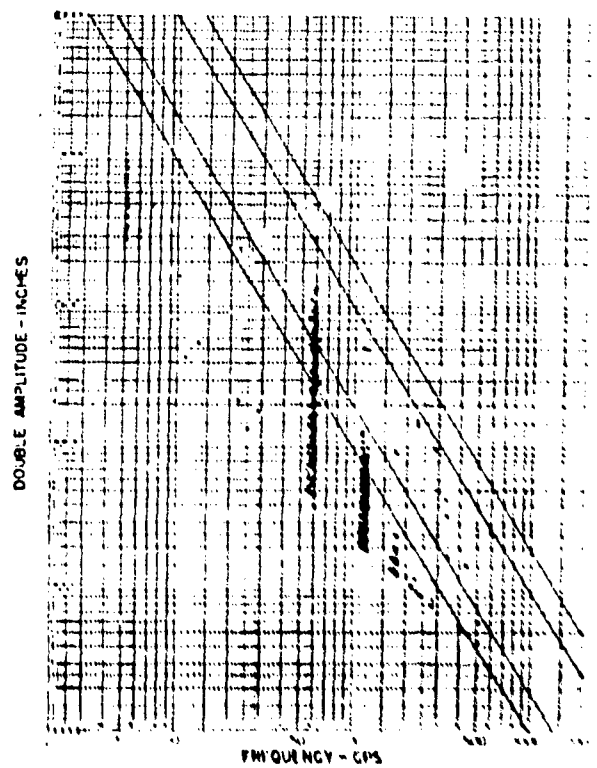


Figure 43. DIRECTION VERT
LOCATION STRUCTURE OF EQUIPMENT RACK FS 245

Figures 40 to 43. Summary Plots for Individual Vibration Pickups

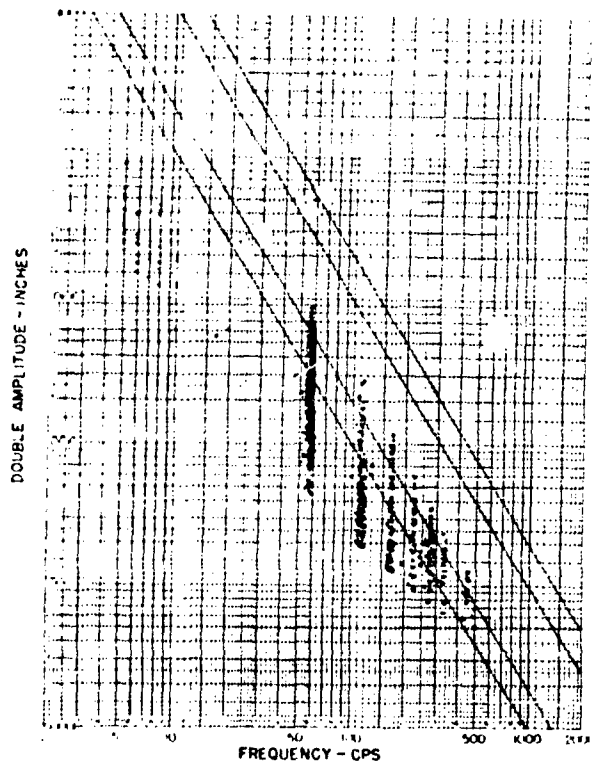


Figure 44. DIRECTION LAT
LOCATION STRUCTURE OF EQUIPMENT RACK FS 230

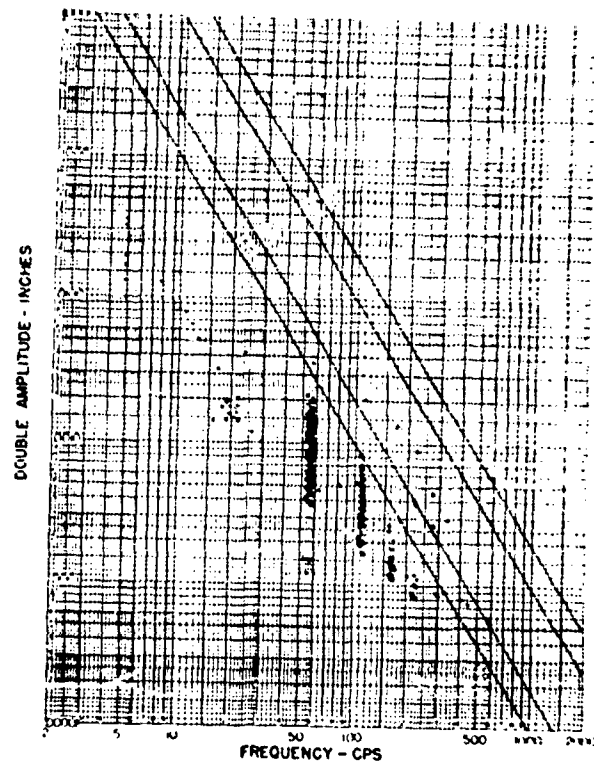


Figure 45. DIRECTION F/A
LOCATION STRUCTURE OF EQUIPMENT RACK FS 230

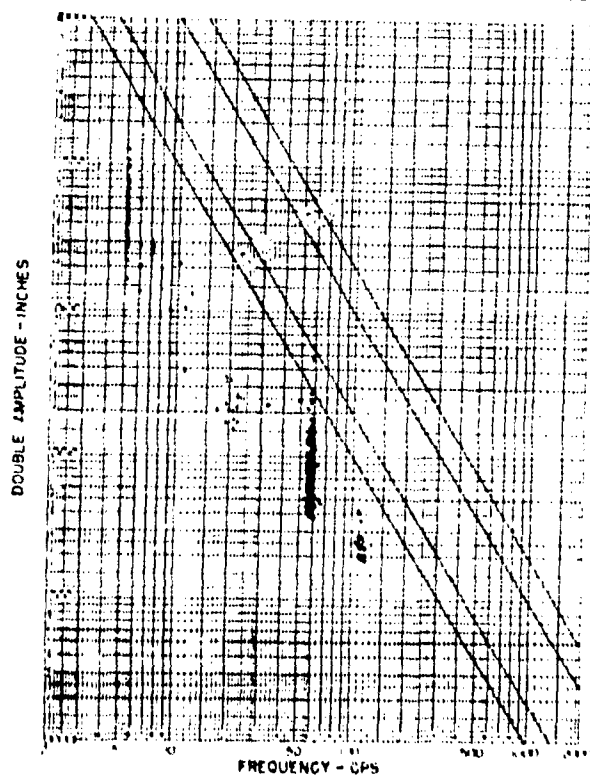


Figure 46. DIRECTION VERT
LOCATION STRUCTURE OF MAIN BULKHEAD
IN WADAN COMPT (LEFT SIDE)

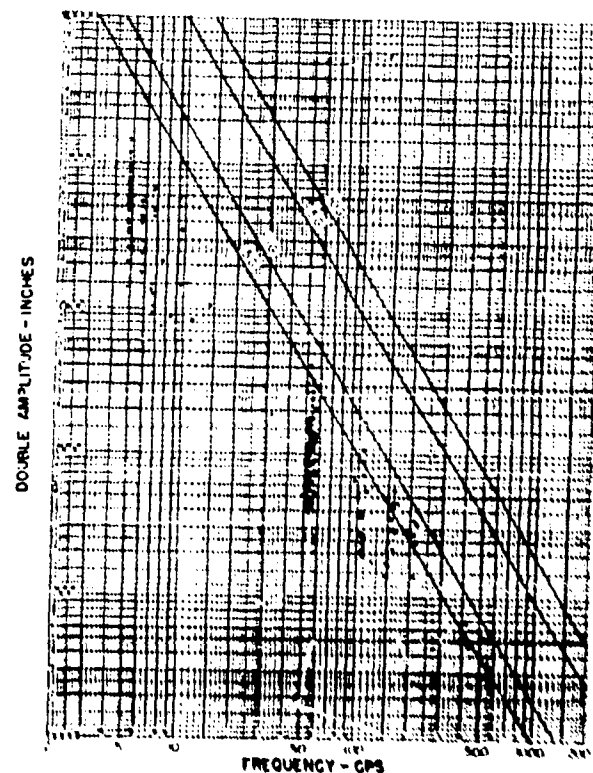


Figure 47. DIRECTION LAT
LOCATION STRUCTURE OF MAIN BULKHEAD
IN WADAN COMPT (LEFT SIDE)

Figures 44 to 47. Summary Plots for Individual Vibration Pickups

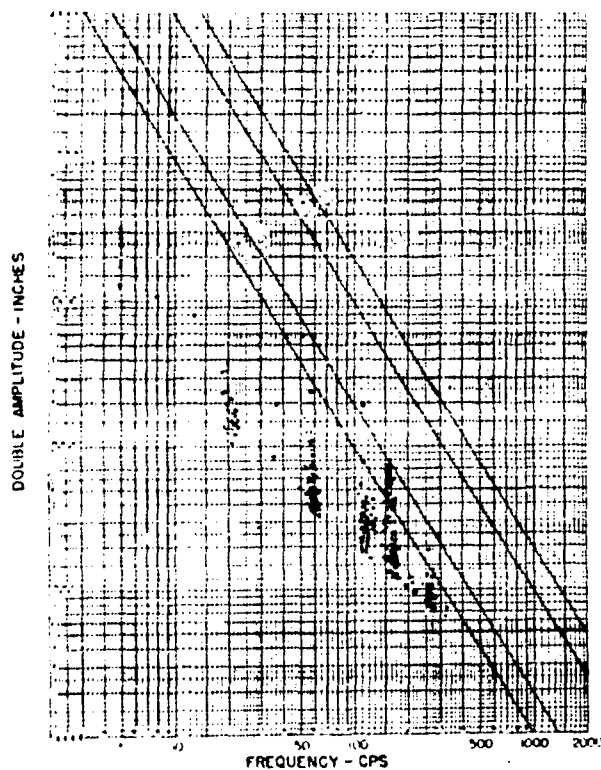


Figure 48.

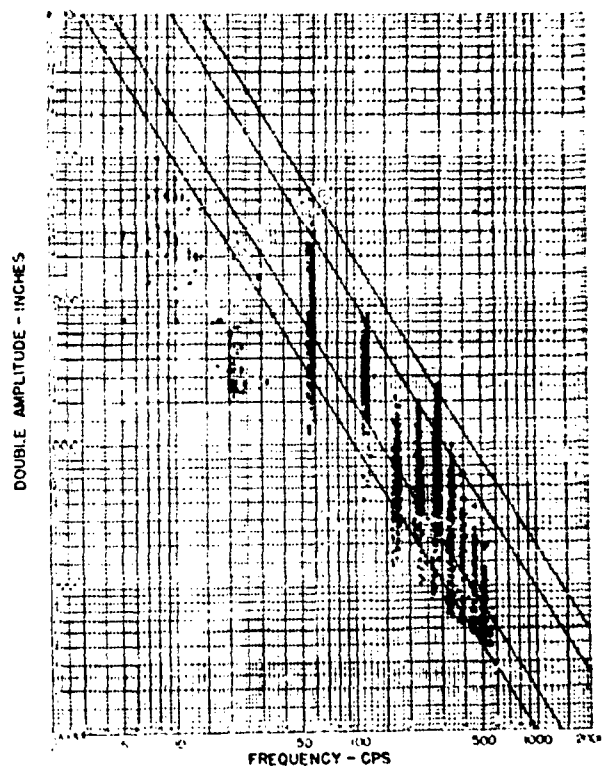


Figure 49.

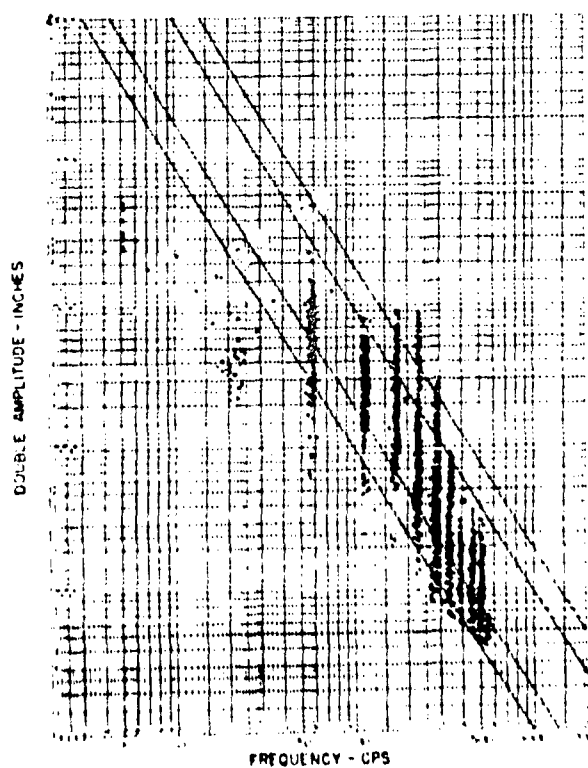


Figure 50.

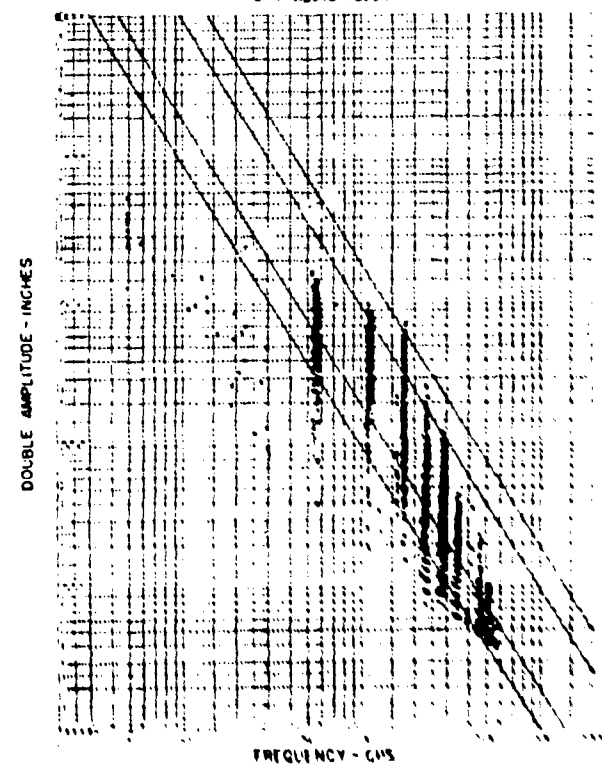


Figure 51.

Figures 48 to 51. Summary Plots for Individual Vibration Pickups

DOUBLE AMPLITUDE - INCHES

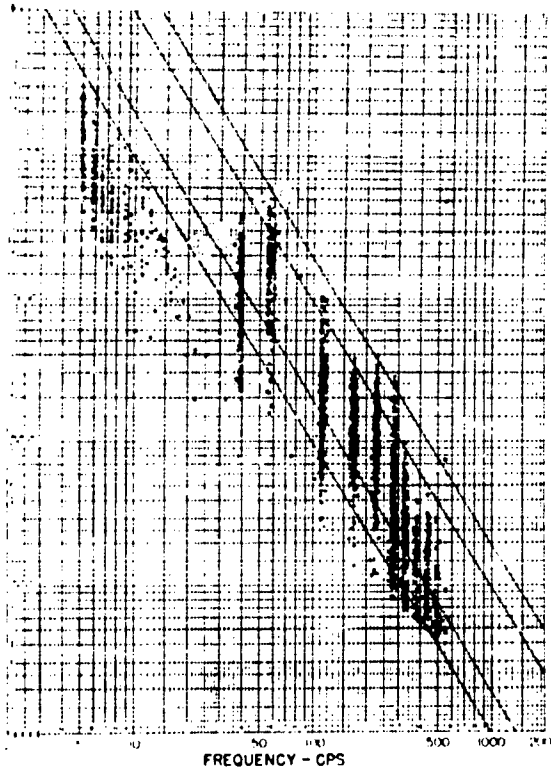


Figure 52. DIRECTION LAT
LOCATION STRUCTURE OF LEFT SIDE OF A/C FUSELAGE F.S. 390
6 FT. ABOVE FLOOR

DOUBLE AMPLITUDE - INCHES

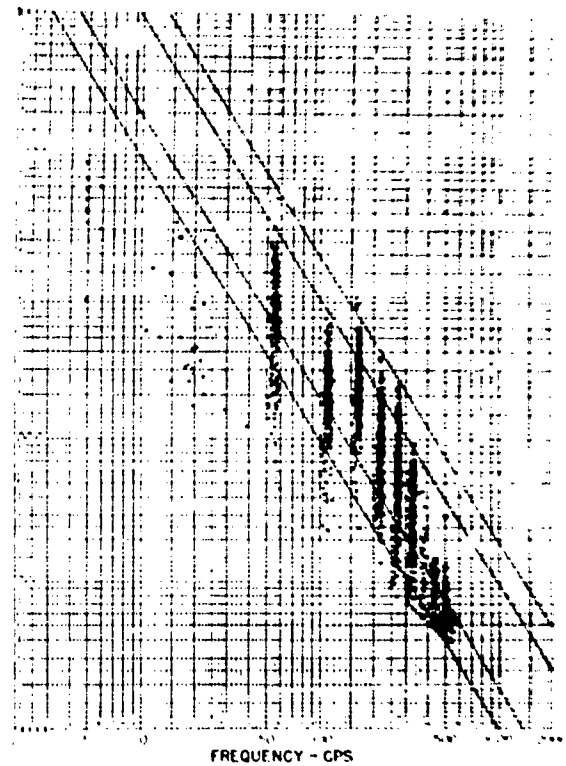


Figure 53. DIRECTION LAT
LOCATION STRUCTURE OF LEFT SIDE OF A/C FUSELAGE F.S. 390
4 FT. ABOVE FLOOR

DOUBLE AMPLITUDE - INCHES

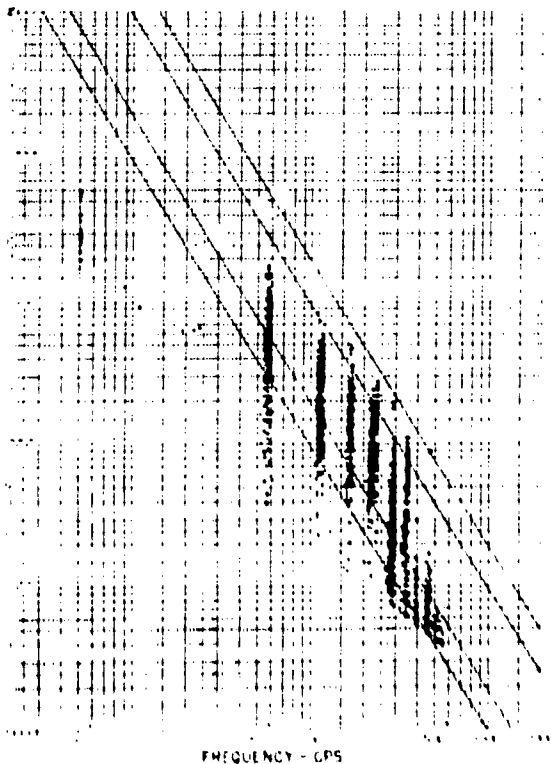


Figure 54. DIRECTION LAT
LOCATION STRUCTURE OF LEFT SIDE OF A/C FUSELAGE F.S. 390
6 FT. ABOVE FLOOR

DOUBLE AMPLITUDE - INCHES

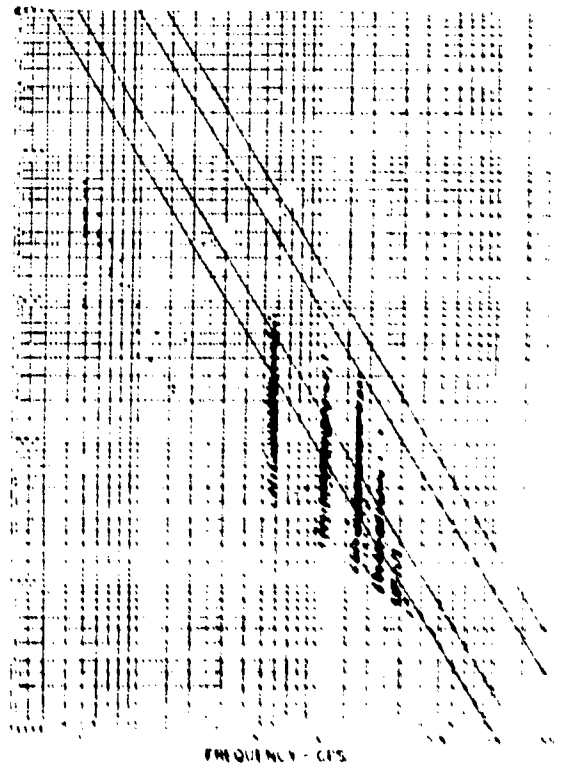


Figure 55. DIRECTION LAT
LOCATION STRUCTURE OF LEFT SIDE OF A/C FUSELAGE F.S. 390
4 FT. ABOVE FLOOR

Figures 52 to 55. Summary Plots for Individual Vibration Pickups

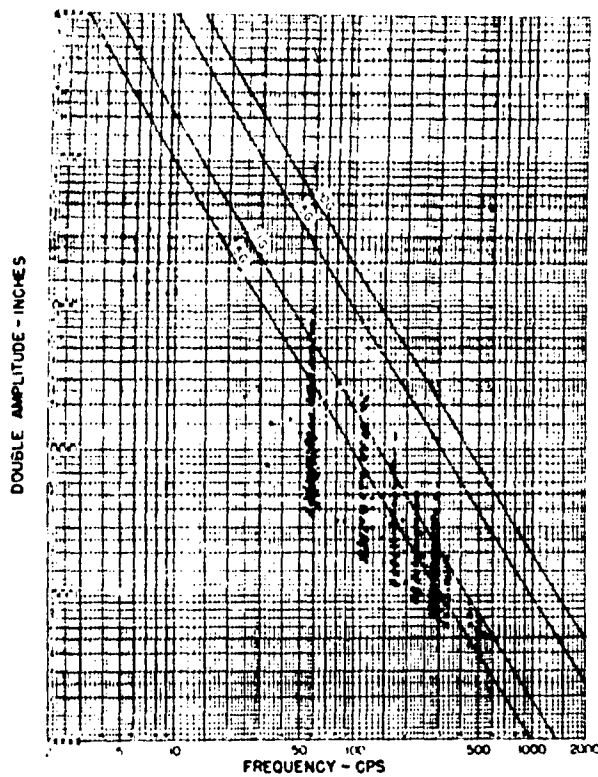


Figure 56. DIRECTION LAT
LOCATION STRUCTURE OF MID-CENTER OF CARGO DECK
TD STA D-12, F.S. 480

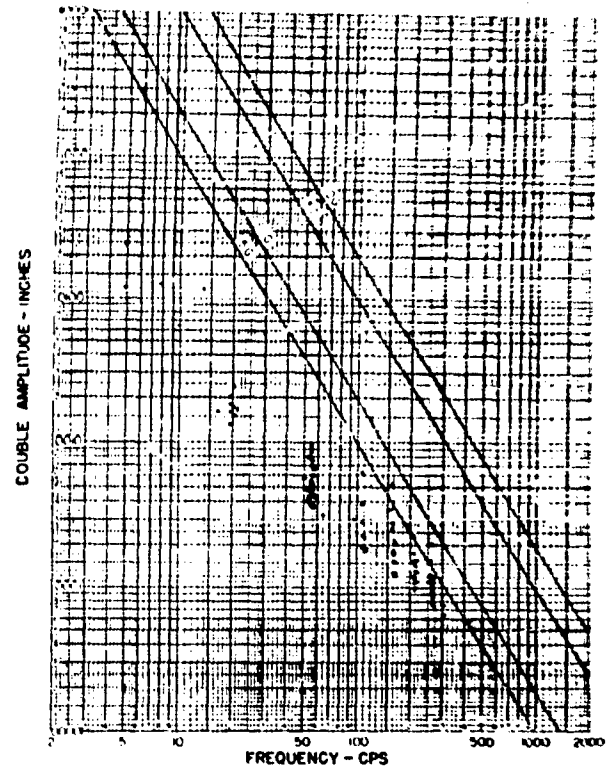


Figure 57. DIRECTION F/A
LOCATION STRUCTURE OF MID-CENTER OF CARGO DECK
TD STA D-12, F.S. 480

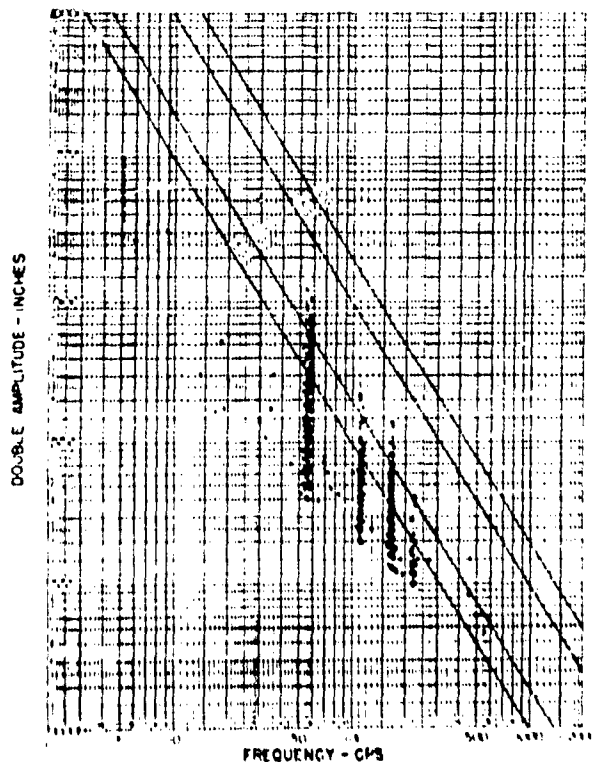


Figure 58. DIRECTION VERT
LOCATION STRUCTURE OF MID-CENTER OF CARGO DECK
TD STA D-25, F.S. 890

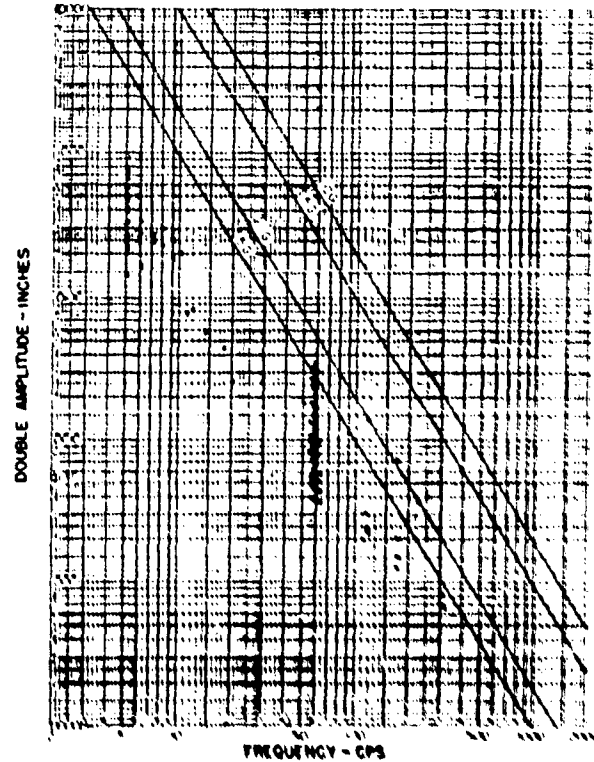


Figure 59. DIRECTION LAT
LOCATION STRUCTURE OF MID-CENTER OF CARGO DECK
TD STA D-25, F.S. 890

Figures 56 to 59. Summary Plots for Individual Vibration Pickups

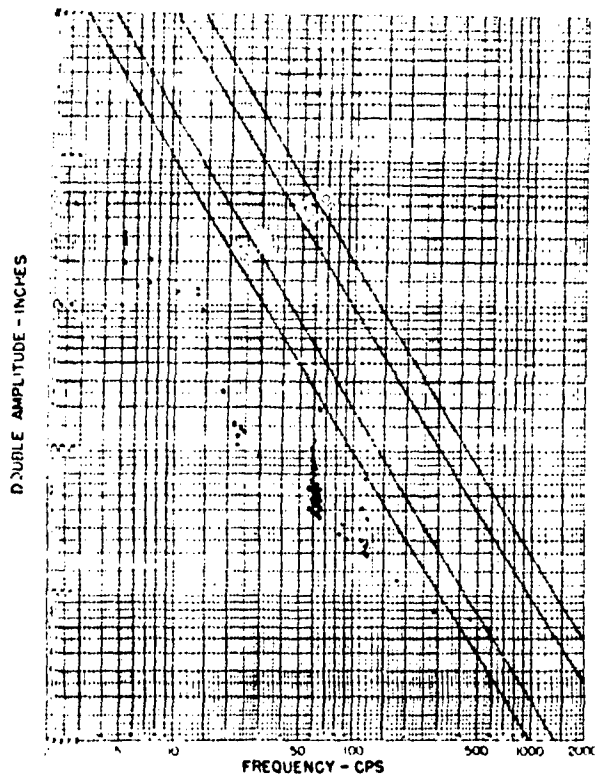


Figure 60.
DIRECTION F/A
LOCATION STRUCTURE OF AFT-CENTER OF CARGO DECK
TO STA D-25, F.S. 690

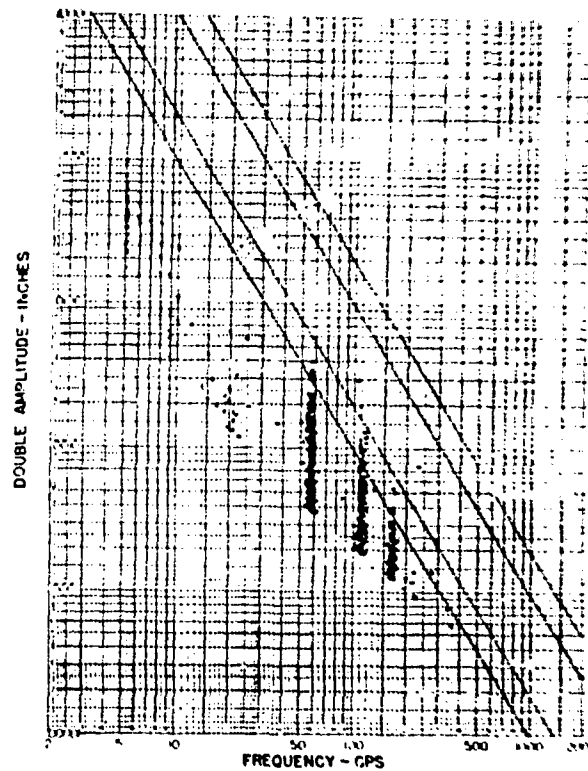


Figure 61.
DIRECTION VERT
LOCATION STRUCTURE OF AFT WING SPAR F.S. 590

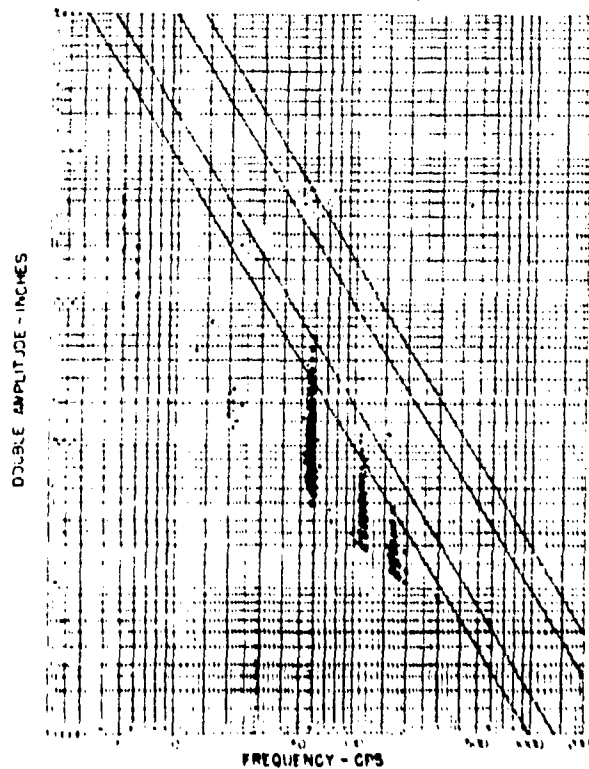


Figure 62.
DIRECTION LAT
LOCATION STRUCTURE OF AFT WING SPAR F.S. 590

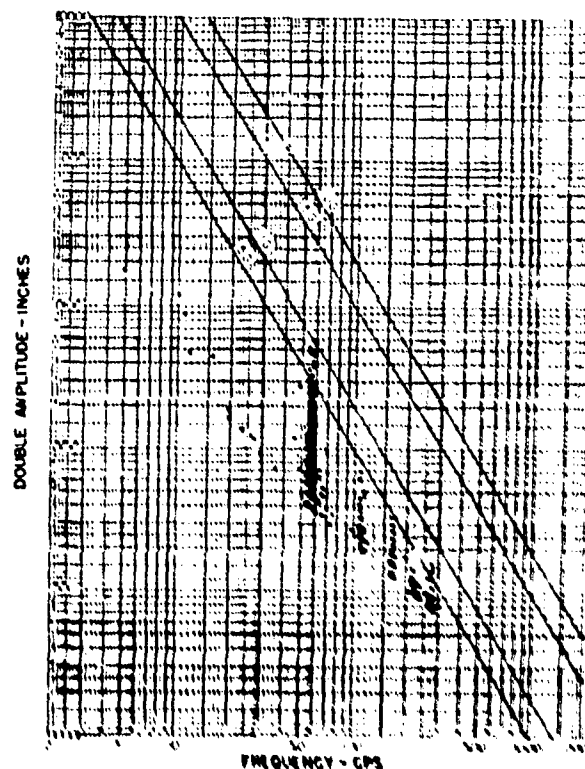


Figure 63.
DIRECTION PAR
LOCATION STRUCTURE OF AFT WING SPAR F.S. 590

Figures 60 to 63. Summary Plots for Individual Vibration Pickups

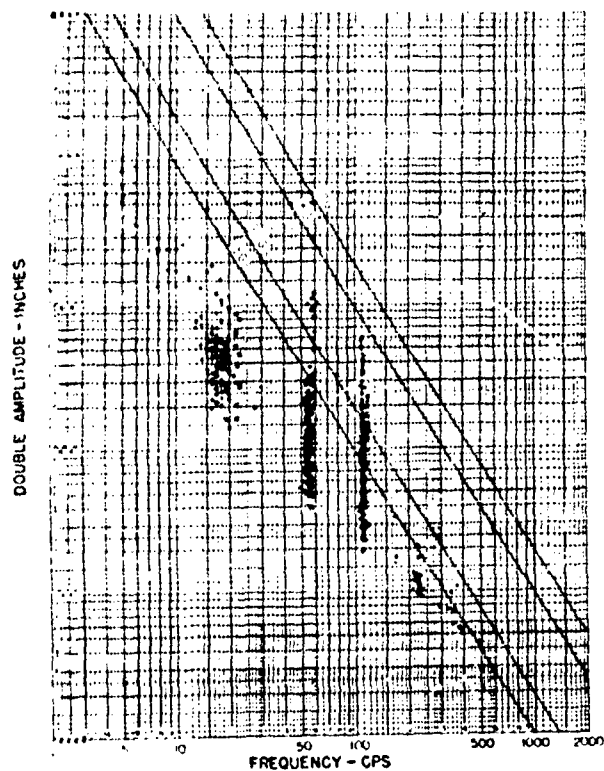


Figure 64.

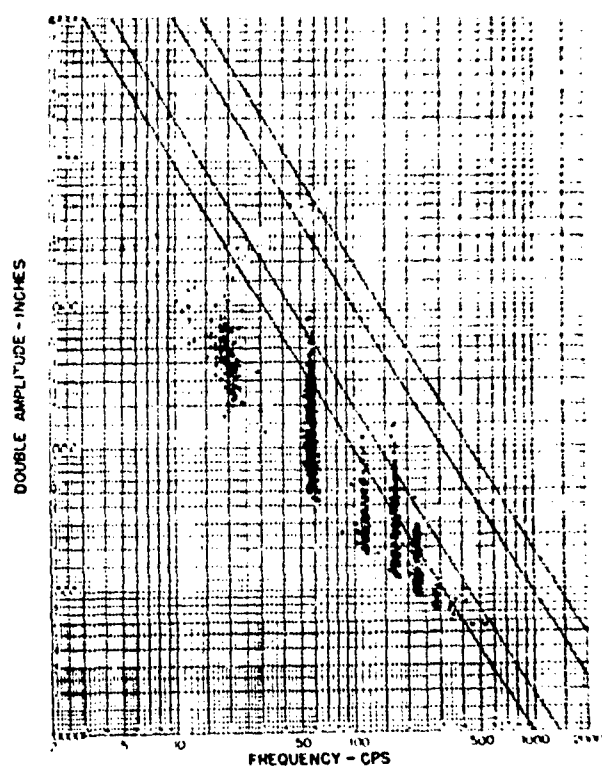


Figure 65.

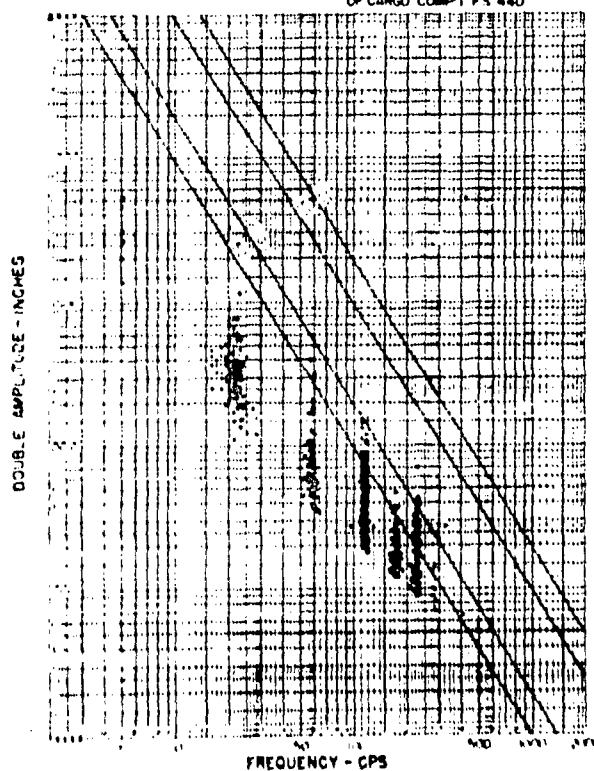


Figure 66.

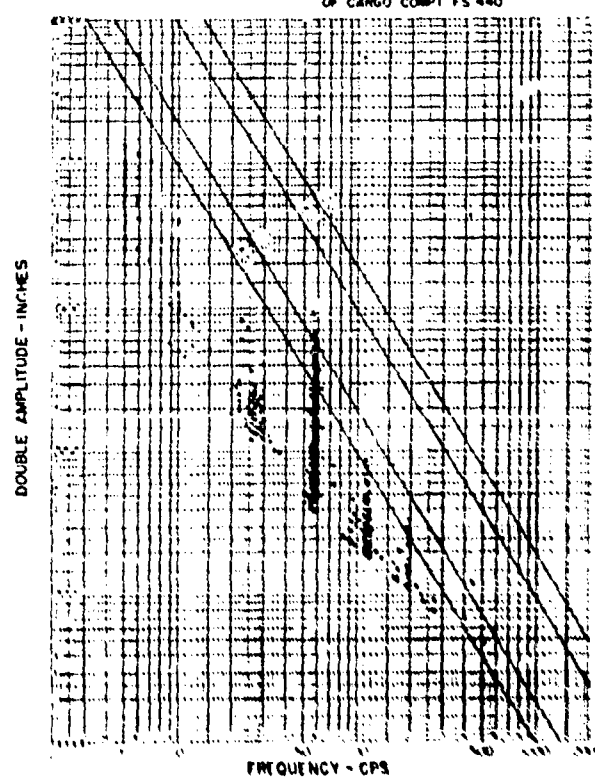


Figure 67.

Figures 64 to 67. Summary Plots for Individual Vibration Pickups

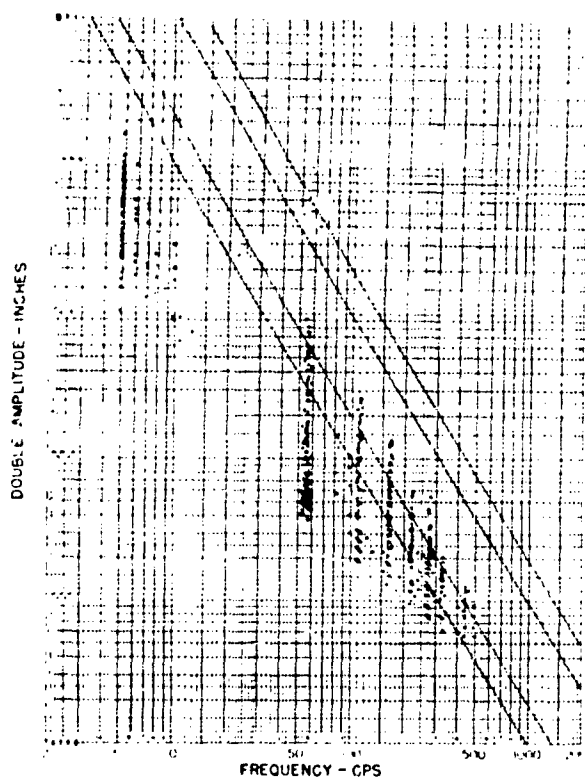


Figure 68. DIRECTION LAT
LOCATION STRUCTURE, CENTER OF AFT SECTION FS 1000

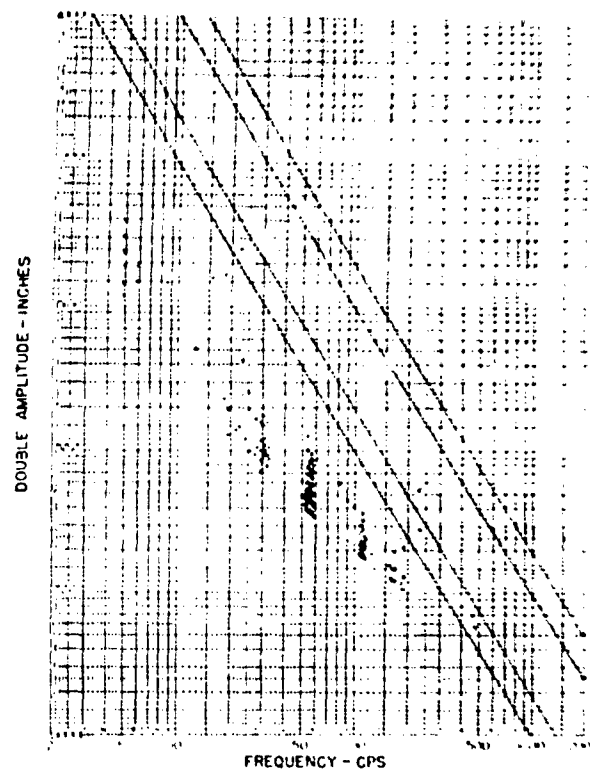


Figure 69. DIRECTION F/A
LOCATION STRUCTURE, CENTER OF AFT SECTION FS 1000

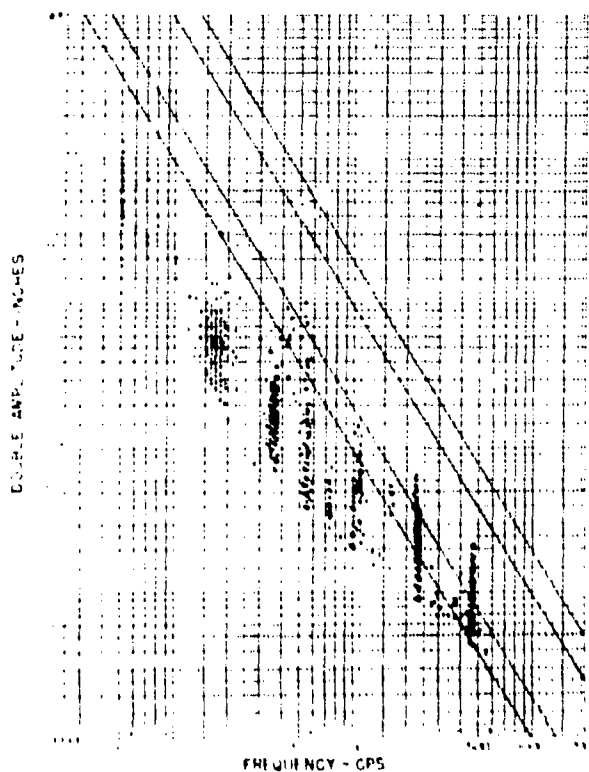


Figure 70. DIRECTION VERT
LOCATION FORWARD END OF COMB SECT
ON NO. 4 ENGINE

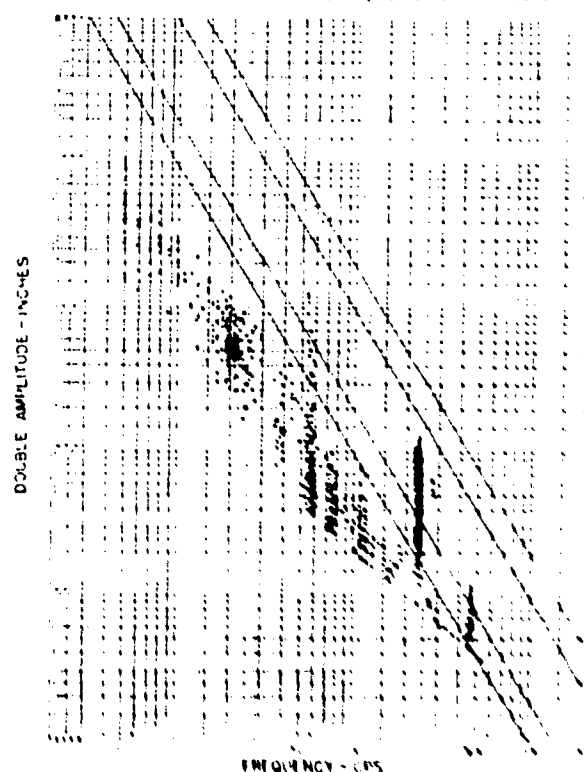


Figure 71. DIRECTION LAT
LOCATION FORWARD END OF COMB SECT
ON NO. 4 ENGINE

Figures 68 to 71. Summary Plots for Individual Vibration Pickups

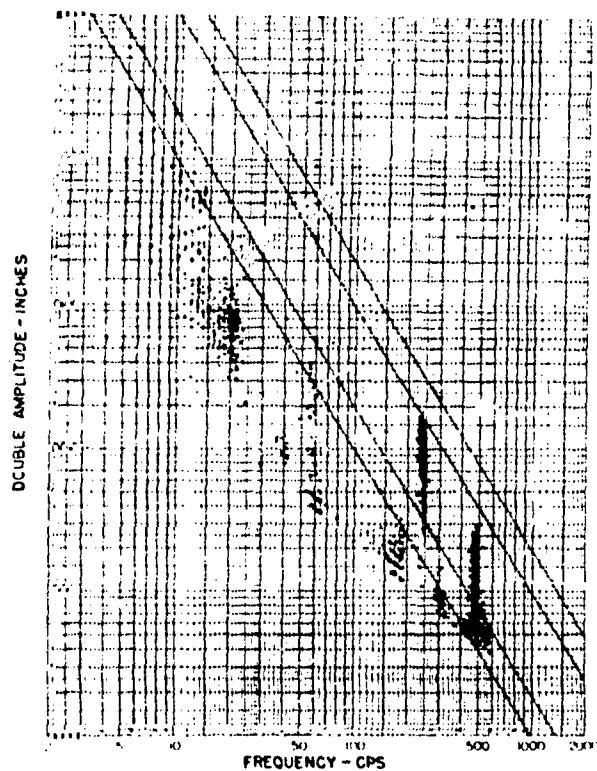


Figure 72.

DIRECTION VERT
LOCATION TURBINE SECT OF NO 4 ENGINE

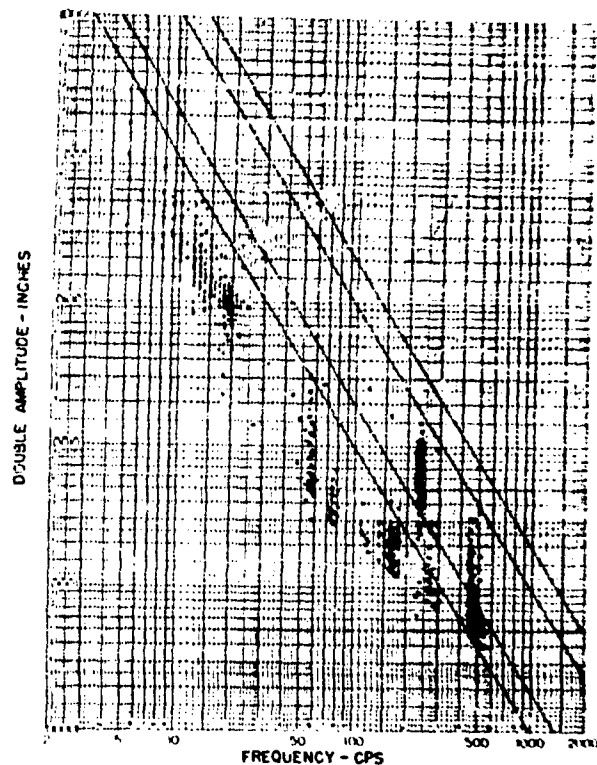


Figure 73.

DIRECTION LAT
LOCATION TURBINE SECT OF NO 4 ENGINE

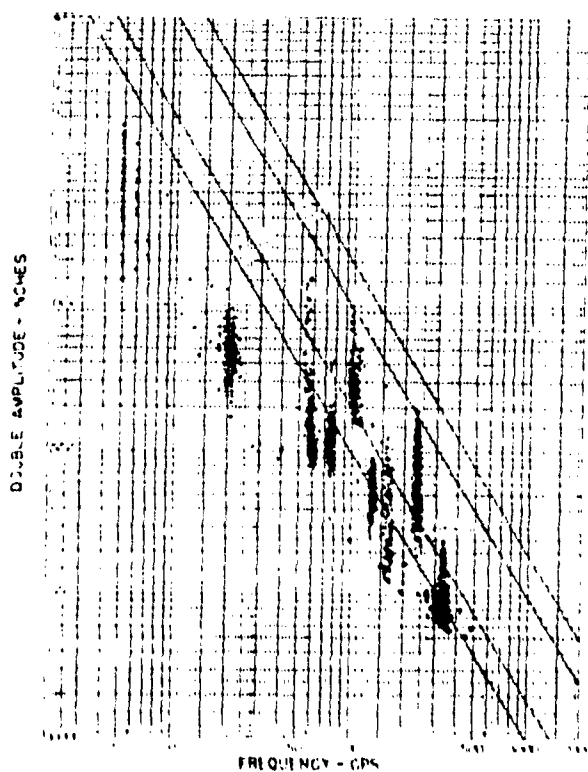


Figure 74.

DIRECTION VERT
LOCATION NO 4 ENGINE

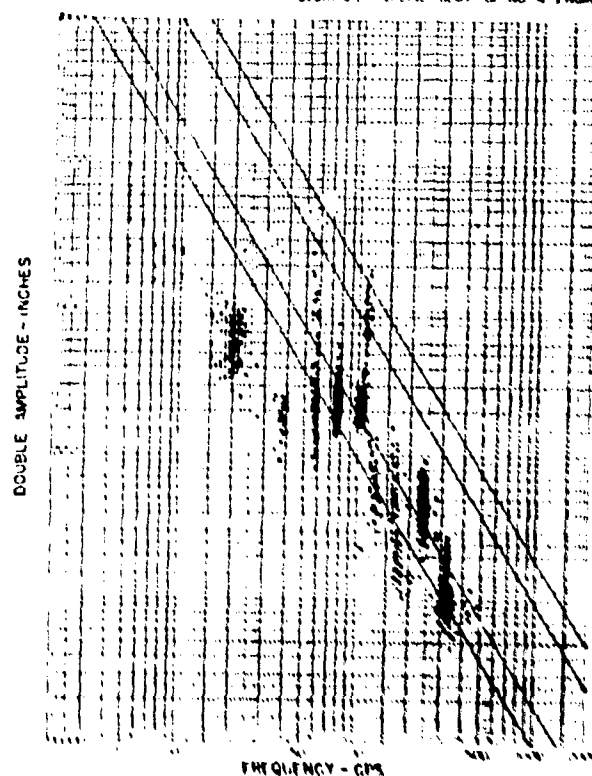


Figure 75.

DIRECTION LAT
LOCATION NO 4 ENGINE

Figures 72 to 75. Summary Plots for Individual Vibration Pickups

Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio
 Rpt No. ASD-TOR-62-267. FLIGHT VIBRATION
 SURVEY OF C-130A AIRCRAFT. Final report
 March 1962. 42 pages incl illus and tables.

Unclassified report

A C-130A aircraft, SN 53-3133, was surveyed at Wright-Patterson Air Force Base, Ohio to determine the vibration environment existing throughout the vehicle under all flight conditions expected in service. Approximately 50,700 data points were obtained from 21 separate locations on the vehicle during five test flights. The data obtained in this survey were evaluated to determine the adequacy of vibration test requirements for aircraft

(over)

equipment as contained in Specification No. Mil-S-5272C. The data indicated that the vibration testing requirements of that specification were more than adequate with the exception of the very light pieces of equipment which are attached to the fuselage sidewalls in the vicinity of the prop plane.

1. C-130A aircraft, flight testing
 2. Vibration

I. AFSC Project 1309 Task 130996

II. Charles E. Thomas
 III. Avl fr ONS
 IV. In ASTIA collection

Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio
 Rpt No. ASD-TOR-62-267. FLIGHT VIBRATION
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