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RESULTS OF GROUND VIBRATION TESTS ON A YF-12 AIRPLANE

by Ronald J. Wilson, Frank W. Cazier, Jr., and Richard R. Larson

Flight Research Center
Edwards, Calif. 93523

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16. Abstract

Ground vibration tests were conducted on a YF-12 airplane. To approximate a structural free-free boundary condition during the tests, each of the landing gears was supported on a support system designed to have a low natural frequency. The test equipment and the procedures used for the ground vibration tests are described.

The results are presented in the form of frequency response data, measured node lines, and elastic mode shapes for the wing/body, rudder, and fuselage ventral fin. In the frequency range between 3.4 cps and 28.8 cps, nine symmetrical wing/body modes, six antisymmetrical wing/body modes, two rudder modes, and one ventral fin mode were measured.

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INTRODUCTION

Programs projected for the YF-12 research airplane encompass many areas of dynamic analysis that require baseline data on airframe frequency response and elastic mode shapes. To provide the required data, a ground vibration test was conducted on a YF-12 airplane at the NASA Flight Research Center. The results of this test were used to assess calculated results from a YF-12 NASTRAN dynamic analysis and will also be available for studies related to aircraft dynamic response.

This report presents test results in the form of frequency response curves, node lines, and elastic mode shapes for the wing/body, rudder, and fuselage ventral fin. Also presented are descriptions of the ground vibration test procedures and the equipment used.

NOMENCLATURE

Physical quantities in this report are given in the International System of Units (SI) and parenthetically in U.S. Customary Units. The measurements were taken in Customary Units. Factors relating the two systems are presented in "The International System of Units—Physical Constants and Conversion Factors" (NASA SP-7012, 1969) by E. A. Mechtly.

C	chine
E	elevon
F	fuselage
F.S.	fuselage station
I	inboard

M	middle
N	nacelle
O	outboard
R	rudder
rms	root mean square
S	shaker
V	ventral
W	wing
W.S.	wing station

AIRPLANE STRUCTURAL DESCRIPTION

The YF-12 airplane (fig. 1) has a modified delta-wing planform with two turboramjet engines mounted integrally within the wing at approximately midsemispan. Twin all-movable rudders are mounted on fixed stubs atop the engine nacelles. The rudders are canted inboard approximately 15° from the vertical. A foldable ventral fuselage fin, which is located aft on the fuselage, is folded down during flight.

The forebody fuselage, F.S. 228 cm to 1810 cm (F.S. 90 in. to 715 in.), is basically a ring-stiffened cylinder with longerons at the top, bottom, and sides, as represented in figure 2. (Note that figure 2(a) is a general representation of the structure only.) The forebody cylinder is modified for the inclusion of personnel, equipment compartments, the nose gear wheel well, and two fuel compartments. The fuel compartments in this area are noncircular in cross section, as shown in figure 2(b). The middle and aft sections of the fuselage, from F.S. 1810 cm to 3320 cm (F.S. 715 in. to 1310 in.) (fig. 2(a)), are cylindrical fuel tanks interrupted by the main wheel well from F.S. 2320 cm to 2420 cm (F.S. 914 in. to 954 in.). Bending is carried by the longerons at the top and bottom centerlines (fig. 2(a)) and by the wing-attaching structure at the sides. Circumferential ring stiffeners, not shown, are used to provide the structure with general stability. Fairings between the fuselage shell and the wing enclose areas used for electrical and plumbing lines. These fairings carry local airloads only.

The primary wing structure is a multibeam box with beams normal to the airplane centerline. The beams carry spanwise bending moments and shear and a portion of the wing torsion. Nacelle frames transfer the spanwise bending moments from the outer wing to the inner wing. The wing multibeam box has three sections (fig. 2(a)): the box section outboard of the nacelle, from W.S. 541 cm to 745 cm (W.S. 213 in. to 293.5 in.); the aft box section inboard of the nacelle, from

W.S. 89 cm to 323 cm (W.S. 35 in. to 127 in.) and from F.S. 2423 cm to 3114 cm (F.S. 954 in. to 1226 in.); and the forward box section inboard of the nacelle, from W.S. 89 cm to 323 cm (W.S. 35 in. to 127 in.) and from F.S. 1874 cm to 2322 cm (F.S. 738 in. to 914 in.). The forward and aft wing box sections inboard of the nacelle are separated by the main landing gear bay. This bay is covered by the main landing gear doors on the lower surface and a section of wing skin on the upper surface. The main landing gear is supported by the forward beam of the aft box and the aft beam of the forward box. Because of the open bay at the main gear, the forward and aft boxes are structurally independent of each other except at the root and the outboard end. Fuel is carried in the wing in three separate tanks (fig. 2(b)), two in the aft box and one in the forward box. These tanks are continuous across the fuselage, and they occupy the entire fuselage in the wing area.

The engine nacelle between W.S. 340 cm and 523 cm (W.S. 134 in. and 206 in.), which is also considered to be a primary structure, is basically a structural cylinder located near the midsemispan of the wing. The outboard wing section applies most of its load at the aft part of the nacelle. The nacelle then acts as a chordwise beam and torque tube in transmitting the outboard loads forward and redistributing them to the inboard wing beams.

TEST EQUIPMENT

The block diagram of the ground vibration test equipment shown in figure 3 illustrates the system used to excite the airplane and the data acquisition system used to measure airplane response. Characteristics of the individual components of the test equipment are listed in table 1.

The vibration excitation system consists of an oscillator, four transistorized power amplifiers, four electromagnetic shakers, and a frequency counter. A sinusoidal signal from the oscillator was fed to the frequency counter for visual display of frequency and to the four transistorized power amplifiers. Each of the amplifiers supplies power to an electromagnetic shaker rated at 222.4 N (50 lb) force. The shaker force was transmitted to the airplane structure through an adjustable driving rod attached to the airplane. Two to four shakers were energized at any one time.

The data acquisition system utilized velocity pickups, accelerometers, accelerometer amplifier modules, an oscilloscope, an ac voltmeter, an eight-channel recorder, and a two-channel recorder. Structural vibratory motion was sensed by the velocity pickups and accelerometers. The output of the velocity pickups was directed through a patch panel, which branched the signal to an ac voltmeter for measuring signal amplitude, an oscilloscope for visual display, and an eight-channel recorder. Each accelerometer output was connected through a patch panel to an amplifier. The amplified signal was displayed on an oscilloscope, and its amplitude was displayed on an rms voltmeter. The amplified signal was also recorded on a two-channel recorder.

TEST CONFIGURATION AND PROCEDURE

Test Configuration

The characteristics of the YF-12 ground vibration test configuration are given in table 2. Part of the total configuration was the landing gear support system (figs. 4(a) and 4(b)). A support consisting of a support structure, a support plate, safety stops, and an airspring was placed beneath each gear. With the airspring, each support had a natural frequency of 1.5 cps. During the vibration tests the airspring was inflated, lifting the top plate and the airplane 2.54 cm to 5.08 cm (1 in. to 2 in.) above the support structure. Horizontal fore and aft restraint was supplied by cables attached to the main landing gear.

The support system was designed to obtain, as accurately as possible, free-free structural modes. With the airplane lifted above the support structure, the restraint due to the landing gear was reduced and a free-free boundary condition was approximated because of the separation between the support natural frequency and the lowest structural mode natural frequencies.

Test Procedure

To determine mode shapes, the grid system shown in figure 5 was marked on the airplane with tape. Data were recorded at the stations thus indicated by a roving accelerometer. These stations corresponded to specific NASTRAN identification points used in the analytical YF-12 structural model for computer analysis. Precise locations are listed in table 3 along with the shaker locations. Permanently located velocity pickup and accelerometer positions are also shown in figure 5(a).

The test had two parts. The first was a frequency sweep to obtain frequency response curves. The response of the airplane measured at the locations of the fixed velocity pickups was plotted versus frequency for increments of 0.2 cps to 0.5 cps. As resonant peaks were approached, additional readings were taken at smaller increments of frequency. The velocity pickup on the left wingtip was used as the input phase reference. Amplitude and phasing data were obtained from signals recorded on the eight-channel strip chart recorder.

The frequency response curves made it possible to select approximate resonant frequencies for the second part of the test. In this part the frequency of excitation was slowly increased or decreased near a resonant peak until the maximum amplitude registered by a reference pickup was noted on the recorder. The roving accelerometer was then used to obtain the mode shape data. Signal amplitude and approximate phasing were recorded at most of the points shown in figure 5. The amplitude of the signals was obtained from rms meters. Phasing data were obtained by examining the signals on a two-channel recorder from the roving accelerometer pickup and the permanently located reference sensor at the selected location.

Three shaker locations, listed in table 3, were used during the ground vibration test. Four of the fixed pickups shown in figure 5(a) were used as references at various times during the test. These were the (1) left wingtip accelerometer, (2) right wingtip accelerometer, (3) nose velocity pickup, and (4) left spike tip velocity pickup. Shaker location S 1 and the left wingtip accelerometer were used during most of the test. However, because of the location of the node line with respect to the shaker and the permanently located instruments, it was necessary to shift shaker locations and occasionally to use alternate instruments to excite and survey some modes. These modes would otherwise have been overlooked. Locations S 2 and S 3 were tried while searching for antisymmetrical elastic modes, and location S 3 was finally used to map some of them. Initially, two 222-N- (50-lb-) force shakers were connected to each wingtip to apply as large a force as possible. Later, because of shaker phasing problems, only one shaker was attached to each wingtip. Consequently, all the data presented in this report were taken with one shaker on each wingtip.

RESULTS

Frequency Response

The symmetrical and antisymmetrical frequency response curves obtained from the initial frequency sweeps are presented in figures 6 and 7.

A comparison of the frequency response peaks obtained during the first part of the test with the frequencies finally selected to map the elastic modes during the second part of the test reveals some differences which were due primarily to the landing gear support system. Upon completion of the frequency sweeps, it was discovered that a slight contact between the nose landing gear support plate and the landing gear support structure had prevented detection of the first symmetrical and antisymmetrical modes. Under these circumstances, the lower structural modes could not be excited at all. However, the initial frequency sweeps were not repeated because of time scheduling. During the symmetrical frequency sweep it became apparent that the airplane did not respond symmetrically to some symmetrical excitation. This may have been because the extensive instrumentation and the accompanying wire bundles in the left wing affected the weight distribution. Weighing the airplane after the tests revealed that the weight over the left main gear was 1 percent of the total weight greater than over the right main gear. The lack of symmetrical mass distribution in the airplane prevented absolute symmetrical or antisymmetrical response.

Resonant Frequencies and Elastic Mode Shapes

The structural resonant frequencies from 3.4 cps to 28.8 cps for symmetrical and antisymmetrical elastic modes as determined from the frequency response sweeps, with final tuning, are listed in table 4. In this frequency range nine symmetrical wing/body modes, six antisymmetrical wing/body modes, two rudder modes, and one fin mode were measured.

The node lines measured for the symmetrical elastic modes are presented in figures 8(a) to 8(k). The corresponding results for the antisymmetrical elastic modes are presented in figures 9(a) to 9(h).

Figures 10(a) to 10(k) show the measured wing/body elastic modes with normalized test point amplitudes (listed in table 5) for symmetrical excitation, and figures 11(a) to 11(k) show these mode shapes for antisymmetrical excitation. The elastic modes for the rudders or fuselage ventral fin, or both, are shown along with the wing/body elastic modes whenever significant excitation occurred on these surfaces. All of the test point amplitudes shown for the elastic mode shapes (also listed in table 5) are normalized to the maximum amplitude occurring on the airplane for the specified mode.

The symmetrical and antisymmetrical mode shapes show the low frequencies to be highly coupled modes involving wing and fuselage bending. Wing torsion was found to occur at higher frequencies on the outer wing.

The maximum motion on the 8.1-cps symmetrical (fig. 10(d)) and 8.2-cps antisymmetrical (fig. 11(c)) modes is less than half the motion experienced on the 8.7-cps symmetrical (fig. 10(e)) and 8.7-cps antisymmetrical (fig. 11(d)) modes. The phase between the various fuselage stations and the selected reference was poor for the 8.1-cps symmetrical mode; that is, most of the fuselage stations were neither clearly in phase nor 180° out of phase with the selected reference. In addition, for the 8.1-cps symmetrical mode, the left rudder was 90° out of phase with the selected reference. In contrast, the phasing between the fuselage and selected reference for the 8.2-cps antisymmetrical mode was very strong; that is, the fuselage was usually in phase or 180° out of phase with the selected reference. Because of the stronger phasing of the 8.2-cps antisymmetrical mode, it is possible that the 8.1-cps symmetrical mode is the 8.2-cps antisymmetrical mode excited symmetrically. However, the existence of either of these modes could be due to the difference in response between the left and right rudders. At some frequencies the left and right rudders responded differently. It was noted that there appeared to be greater free play in the right rudder than the left. No attempt was made to locate the source, however.

Both the 8.7-cps symmetrical mode and the 8.7-cps antisymmetrical mode were considered to be the rudder modes for the following reasons. First, the amplitude of the fuselage for both of the modes was small with respect to the rudder motion. Second, the rudders moved symmetrically for both symmetrical and antisymmetrical shaker input at the wingtips.

The antisymmetrical modes at frequencies greater than 10 cps show more asymmetry than one would expect. Two pronounced instances of this are the deviation of the node line from the fuselage centerline and the dissimilarity of the mode shapes on the right and left wings. These results are probably a result of the unsymmetrical weight condition and shaker phasing mentioned previously.

Attempts were made to insure that other modes did not exist by using more than one shaker location. The three shaker locations used in the ground vibration test were thought to be free of node lines. However, because of the limitations of the system other modes may not have been identified.

CONCLUDING REMARKS

A ground vibration survey was conducted on a YF-12 airplane, serial number 06935. For the vibration survey, the airplane was configured to simulate a free-free structural condition by utilizing a landing gear support system with inflatable airsprings. The test configuration airspring had a natural frequency of 1.5 cps.

Airplane frequency response data, node lines, and elastic modes for the wing/body, rudder, and fuselage ventral fin were measured and recorded in the frequency range between 3.4 cps and 28.8 cps. In this frequency range nine symmetrical wing/body modes, six antisymmetrical wing/body modes, two rudder modes, and one fuselage ventral fin mode were measured. Several shaker locations were used in the survey to minimize the possibility of attaching the shaker to a node line and hence failing to identify other modes.

Flight Research Center
National Aeronautics and Space Administration
Edwards, Calif., June 1, 1973.

TABLE 1. — CHARACTERISTICS OF THE GROUND VIBRATION TEST EQUIPMENT

Vibration excitation system —	
Oscillator:	
Frequency range	0.01 to 100,000 cps
Frequency response	±1 percent, 0.01 to 10,000 cps
Distortion	<1 percent, 0.01 cps
Accuracy	±1 percent (1 minor division), 0.01 to 10,000 cps
Exciter amplifier:	
Frequency range	5 to 20,000 cps
Frequency response	±1 dB, 5 to 20,000 cps
Distortion	<1 percent, 5 to 3000 cps
Exciter:	
Frequency range	5 to 10,000 cps
Frequency counter:	
Frequency range	0 to 300,000 cps
Accuracy	±1 count, ±time base
Data acquisition system —	
Velocity pickup:	
Frequency range	5 to 2000 cps
Natural frequency	4.75 cps
Sensitivity	$2.45 \frac{mV}{m/sec}$ ($96.3 \frac{mV}{in/sec}$)
Damping	0.65
Accelerometer:	
Frequency response	±5 percent, 2 to 5000 cps
Natural frequency	60,000 cps
Sensitivity	$20 \frac{mV}{g}$
Amplifier module:	
Frequency response	±3 dB, 0.5 to 20,000 cps
Distortion	0.5 percent
Accuracy	1 m ±2 percent full scale, 1 V ±1 percent
Linearity	±1 percent
Oscilloscope:	
Frequency range	dc to 500,000 cps
Phase shift	±1° to 100,000 cps
ac voltmeter:	
Frequency range	5 to 600,000 cps
Eight-channel recorder:	
Frequency response	±2 percent, dc to 35 cps
Linearity	<0.5 percent
Two-channel recorder:	
Frequency response	±2 percent, dc to 35 cps
Linearity	<0.5 percent

TABLE 2. — PHYSICAL CHARACTERISTICS OF THE YF-12 GROUND VIBRATION TEST CONFIGURATION

Weight on each gear, percent of total weight —	
Left main gear	44
Right main gear	43
Nose gear	13
Ballast, per cockpit	1330 N (300 lb)
Hydraulic system	Operative, control stick tied down
Electrical system	Operative
Fuel distribution	Trapped fuel
Engine spike position	Retracted
Engine turbines	Rotated every 30 minutes
Landing gear strut position —	
Main	Compressed and locked with strut collar
Nose	Extended to level airplane
Tire pressure, normal	2,860,000 N/m^2 (415 lb/in^2)
Fuselage ventral fin position	Down and locked

TABLE 3. — YF-12 TEST POINT LOCATIONS

Test point	Fuselage station, cm (in.)	Butt line	Wing station, cm (in.)
F 1	452.1 (178.0)	0	- - - - - - - -
F 2	765.8 (301.5)	0	- - - - - - - -
F 3	1099.2 (432.75)	0	- - - - - - - -
F 4	1397.0 (550.0)	0	- - - - - - - -
F 5	1701.8 (670.0)	0	- - - - - - - -
F 6	1908.8 (751.5)	0	- - - - - - - -
F 7	2112.0 (831.5)	0	- - - - - - - -
F 8	2233.9 (879.5)	0	- - - - - - - -
F 9	2306.3 (908.0)	0	- - - - - - - -
F 10	2440.9 (961.0)	0	- - - - - - - -
F 11	2660.7 (1047.5)	0	- - - - - - - -
F 12	2823.2 (1111.5)	0	- - - - - - - -
F 13	3026.4 (1191.5)	0	- - - - - - - -
F 14	3173.7 (1249.5)	0	- - - - - - - -
F 15	3276.6 (1290.0)	0	- - - - - - - -
*FC 2	765.8 (301.5)	Edge of chine	- - - - - - - -
*FC 3	1099.2 (432.75)	Edge of chine	- - - - - - - -
*FC 4	1397.0 (550.0)	Edge of chine	- - - - - - - -
*FC 5	1701.8 (670.0)	Edge of chine	- - - - - - - -
*WI 1	2118.4 (834.0)	- - -	182.9 (72.0)
*WI 2	2240.3 (882.0)	- - -	182.9 (72.0)
*WI 3	2321.6 (914.0)	- - -	182.9 (72.0)
*WI 4	2423.2 (954.0)	- - -	182.9 (72.0)
WI 5	2667.0 (1050.0)	- - -	182.9 (72.0)
*WI 6	2829.6 (1114.0)	- - -	182.9 (72.0)
*WI 7	3032.8 (1194.0)	- - -	182.9 (72.0)
*WM 1	2118.4 (834.0)	- - -	322.6 (127.0)
WM 2	2240.3 (882.0)	- - -	322.6 (127.0)
WM 3	2321.6 (914.0)	- - -	322.6 (127.0)
*WM 4	2423.2 (954.0)	- - -	322.6 (127.0)
WM 5	2667.0 (1050.0)	- - -	322.6 (127.0)
*WM 6	2829.6 (1114.0)	- - -	322.6 (127.0)
WM 7	2992.1 (1178.0)	- - -	322.6 (127.0)
WM 8	3032.8 (1194.0)	- - -	322.6 (127.0)
*S 1	2992.0 (1178.0)	- - -	747.0 (294.0)
*S 2	2936.0 (1156.0)	- - -	711.0 (280.0)
*S 3	2952.8 (1162.5)	- - -	610.0 (240.0)

*Denotes location on both left and right side.

TABLE 3. — Continued

Test point	Fuselage station, cm (in.)	Wing station, cm (in.)
*WO 1	2423.2 (954.0)	541.0 (213.0)
*WO 2	2667.3 (1050.13)	567.3 (223.34)
*WO 3	2829.6 (1114.0)	541.0 (213.0)
*WO 4	2829.6 (1114.0)	656.4 (258.42)
WO 5	2911.0 (1146.05)	698.6 (275.03)
*WO 6	2992.1 (1178.0)	541.0 (213.0)
*WO 7	2992.1 (1178.0)	612.1 (241.0)
*WO 8	2992.1 (1178.0)	683.3 (269.0)
*WO 9	2992.1 (1178.0)	745.5 (293.49)
*WO 10	2992.1 (1178.0)	812.0 (319.68)
*N 1	2118.4 (834.0)	431.8 (170.0)
*N 2	2240.3 (882.0)	431.8 (170.0)
*N 3	2423.2 (954.0)	431.8 (170.0)
*N 4	2667.0 (1050.0)	431.8 (170.0)
*N 5	2829.6 (1114.0)	431.8 (170.0)
N 6	2992.3 (1178.0)	431.8 (170.0)
*N 7	3037.8 (1196.0)	431.8 (170.0)
*EI 1	3163.5 (1245.47)	102.1 (40.186)
*EI 2	3141.2 (1236.69)	196.1 (77.186)
*EI 3	3124.3 (1230.05)	267.2 (105.186)
EI 4	3221.7 (1268.37)	115.9 (45.622)
EI 5	3199.4 (1259.60)	209.9 (82.625)
EI 6	3182.5 (1252.95)	280.9 (110.618)
*EI 7	3301.9 (1299.95)	101.9 (40.111)
*EI 8	3277.7 (1290.45)	203.6 (80.178)
*EI 9	3263.7 (1284.93)	262.7 (103.432)
*EO 1	3015.2 (1187.10)	542.4 (213.539)
*EO 2	3011.9 (1185.44)	613.2 (241.431)
*EO 3	3006.9 (1183.83)	684.1 (269.325)
*EO 4	3003.3 (1182.39)	747.4 (294.242)
*EO 5	3001.7 (1181.78)	777.8 (306.209)
*EO 6	2999.7 (1181.00)	829.9 (326.756)
EO 7	3119.4 (1228.11)	549.7 (216.432)
EO 8	3102.8 (1221.57)	619.7 (243.977)
EO 9	3085.9 (1214.93)	689.6 (271.510)
EO 10	3071.3 (1209.19)	752.1 (296.120)
EO 11	3043.4 (1198.18)	780.7 (307.356)
*EO 12	3193.6 (1257.32)	557.6 (219.514)
*EO 13	3179.0 (1251.69)	620.1 (244.115)
*EO 14	3162.9 (1245.23)	691.1 (272.096)
*EO 15	3127.7 (1231.37)	804.9 (316.889)

*Denotes location on both left and right side.

TABLE 3. — Continued

Test point	Fuselage station, cm (in.)	Waterline, cm (in.)
V 1	2864.1 (1127.592)	176.5 (69.497)
V 2	2872.1 (1130.762)	162.6 (64.0)
V 3	2886.8 (1136.534)	137.2 (54.0)
V 4	2901.5 (1142.304)	111.8 (44.0)
V 5	2916.1 (1148.074)	86.4 (34.0)
V 6	2933.7 (1155.0)	55.9 (22.0)
V 7	2934.7 (1155.411)	182.0 (71.654)
V 8	2942.8 (1158.586)	162.6 (64.0)
V 9	2953.3 (1162.735)	137.2 (54.0)
V 10	2963.9 (1166.883)	111.8 (44.0)
V 11	2974.4 (1171.031)	86.4 (34.0)
V 12	2987.1 (1176.01)	55.9 (22.0)
V 13	3008.6 (1184.483)	187.7 (73.905)
V 14	3014.9 (1186.954)	162.6 (64.0)
V 15	3018.7 (1189.449)	137.2 (54.0)
V 16	3027.5 (1191.944)	111.8 (44.0)
V 17	3033.9 (1194.439)	86.4 (34.0)
V 18	3041.5 (1197.434)	55.9 (22.0)
V 19	3126.6 (1230.957)	196.9 (77.502)
V 20	3126.4 (1230.87)	162.6 (64.0)
V 21	3126.2 (1230.806)	137.2 (54.0)
V 22	3126.1 (1230.741)	111.8 (44.0)
V 23	3125.9 (1230.677)	86.4 (34.0)
V 24	3125.7 (1230.600)	55.9 (22.0)
V 25	3127.7 (1270.760)	204.7 (80.578)
V 26	3218.6 (1267.148)	162.6 (64.0)
V 27	3213.0 (1264.969)	137.2 (54.0)
V 28	3207.5 (1262.791)	111.8 (44.0)
V 29	3202.0 (1260.612)	86.4 (34.0)
V 30	3195.3 (1258.00)	55.9 (22.0)

TABLE 3. — Concluded

Test point (a)	Nacelle station, cm (in.)	Fin station, cm (in.)
R 1	2906.8 (1144.41)	330.2 (130)
R 2	2876.4 (1132.46)	270.8 (106.6)
R 3	2825.5 (1112.41)	241.0 (94.9)
R 4	2802.7 (1103.41)	215.9 (85.5)
R 5	2767.5 (1089.56)	177.3 (68.8)
R 6	2734.5 (1076.56)	141.0 (55.50)
R 7	2944.5 (1159.26)	330.2 (130.0)
R 8	2909.8 (1145.6)	275.6 (108.5)
R 9	2870.2 (1130.01)	213.2 (83.94)
R 10	2852.3 (1122.96)	184.8 (72.75)
R 11	2824.7 (1112.09)	141.0 (55.50)
R 12	2893.7 (1139.26)	213.2 (83.94)
R 13	2893.7 (1139.26)	184.8 (72.75)
R 14	2893.7 (1139.26)	141.0 (55.5)
R 15	2907.7 (1144.76)	213.2 (83.94)
R 16	2907.7 (1144.76)	184.8 (72.75)
R 17	2907.7 (1144.76)	141.0 (55.50)
R 18	2995.1 (1179.16)	330.2 (130.0)
R 19	3006.5 (1183.66)	275.6 (108.5)
R 20	3019.6 (1188.81)	213.2 (83.94)
R 21	3025.4 (1191.11)	184.8 (72.75)
R 22	3034.8 (1194.8)	141.0 (55.50)
R 23	3067.3 (1207.61)	330.2 (130.0)
R 24	3078.9 (1212.16)	275.6 (108.5)
R 25	3092.3 (1217.46)	213.2 (83.94)
R 26	3098.3 (1219.81)	184.8 (72.75)
R 27	3107.8 (1223.55)	141.0 (55.5)
R 28	3145.4 (1238.36)	330.2 (130.0)
R 29	3156.9 (1242.86)	275.6 (108.5)
R 30	3170.2 (1248.11)	213.2 (83.94)
R 31	3176.4 (1250.56)	184.8 (72.75)
R 32	3185.6 (1254.19)	141.0 (55.5)

[a] Test points R 1 through R 32 for left and right rudder.

TABLE 4. — YF-12 STRUCTURAL RESONANT FREQUENCIES FOR SYMMETRICAL AND ANTISYMMETRICAL ELASTIC MODES

Mode	Frequency, cps
Rigid body —	
Plunge (calculated)	1.5
Pitch (test)	.8
Symmetrical —	
Wing/body:	
1	3.4
2	4.1
3	6.7
4	8.1
5	10.5
6	11.1
7	12.2
8	14.7
9	22.0
Rudder:	
1	8.7
2	20.2
Antisymmetrical —	
Wing/body:	
1	4.3
2	7.1
3	8.2
4	9.5
5	22.7
6	28.8
Rudder:	
1	8.7
2	19.9
Ventral:	
1	13.2

TABLE 5. — NORMALIZED TEST POINT AMPLITUDES FOR YF-12 WING-BODY ELASTIC MODES

(a) 3.4 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	0.78	- - -	N 1	-0.89	-0.45
F 2	.41	- - -	N 2	-.54	- - -
F 3	.34	- - -	N 3	-.80	- - -
F 4	-.28	- - -	N 4	-.58	.47
F 5	-.61	- - -	N 5	.44	.31
F 6	-.59	- - -	N 6	.61	.20
F 7	-.61	- - -	N 7	.77	.62
F 8	-.51	- - -	WO 1	-.63	- - -
F 9	-.44	- - -	WO 2	.22	- - -
F 10	-.52	- - -	WO 3	.23	.16
F 11	-.20	- - -	WO 4	.32	.50
F 12	.17	- - -	WO 5	.52	- - -
F 13	.28	- - -	WO 6	.23	- - -
F 14	.47	- - -	WO 7	.61	- - -
F 15	.38	- - -	WO 8	.48	- - -
FC 2	.41	- - -	WO 9	.66	- - -
FC 3	.22	- - -	WO 10	.73	1.00
FC 4	-.31	- - -	EI 1	.34	- - -
FC 5	-.28	- - -	EI 2	-.34	- - -
WI 1	-.61	- - -	EI 3	.53	- - -
WI 2	-.47	- - -	EI 7	1.00	- - -
WI 3	-.54	- - -	EI 8	.81	- - -
WI 4	-.31	-0.38	EI 9	1.00	- - -
WI 5	-.16	- - -	EO 1	.70	- - -
WI 6	.16	-.20	EO 2	.58	- - -
WI 7	.29	- - -	EO 3	.39	- - -
WM 1	-.66	-.56	EO 4	.97	- - -
WM 2	-.56	- - -	EO 5	.97	- - -
WM 3	-.88	- - -	EO 6	.88	- - -
WM 4	-.47	- - -	EO 12	.91	- - -
WM 5	-.41	- - -	EO 13	.84	- - -
WM 6	.20	- - -	EO 14	.72	- - -
WM 7	.25	- - -	EO 15	1.00	- - -
WM 8	.29	- - -			

TABLE 5. — Continued

(b) 4.1 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	-0.035	- - -	N 4	0.17	0.15
F 2	-.030	- - -	N 5	.12	- - -
F 3	-.045	- - -	N 6	-.042	- - -
F 4	-.025	- - -	N 7	-.17	-.10
F 5	-.025	- - -	WO 1	.37	- - -
F 6	-.040	- - -	WO 2	.25	- - -
F 7	-.035	- - -	WO 3	.15	.22
F 8	-.070	- - -	WO 4	.54	.55
F 9	-.070	- - -	WO 5	.78	- - -
F 10	-.11	- - -	WO 6	.24	- - -
F 11	-.11	- - -	WO 7	.40	- - -
F 12	-.23	- - -	WO 8	.55	- - -
F 13	-.15	- - -	WO 9	.90	- - -
F 14	-.22	- - -	WO 10	.90	- - -
F 15	-.295	- - -	EI 1	-.52	- - -
FC 2	-.065	- - -	EI 2	-.44	- - -
FC 3	-.050	- - -	EI 3	-.38	- - -
FC 4	-.040	- - -	EI 7	-.66	- - -
FC 5	-.075	- - -	EI 8	-.49	- - -
WI 1	-.175	- - -	EI 9	-.44	- - -
WI 2	-.14	- - -	EO 1	.26	- - -
WI 3	-.105	- - -	EO 2	.47	- - -
WI 4	-.28	-0.20	EO 3	.62	- - -
WI 5	-.175	- - -	EO 4	.75	- - -
WI 6	-.15	- - -	EO 5	.95	.78
WI 7	-.15	- - -	EO 6	.95	- - -
WM 1	-.135	-.37	EO 12	.42	- - -
WM 2	-.22	- - -	EO 13	.62	- - -
WM 3	-.47	- - -	EO 14	.75	- - -
WM 4	-.35	- - -	EO 15	1.00	- - -
WM 5	-.11	- - -	R 18	-.7	- - -
WM 6	-.06	-.09	R 19	-.65	- - -
WM 7	-.052	- - -	R 20	-.54	- - -
WM 8	-.22	- - -	R 21	-.7	- - -
N 1	.21	.32	R 22	-.4	- - -
N 2	.40	- - -			
N 3	.20	.15			

TABLE 5. — Continued

(c) 6.7 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	-1.00	- - -	N 4	-0.24	-0.23
F 2	-.39	- - -	N 5	.17	.11
F 3	.23	- - -	N 6	.17	- - -
F 4	.53	- - -	N 7	.33	.31
F 5	.50	- - -	WO 1	-.70	- - -
F 6	.36	- - -	WO 2	-.12	- - -
F 7	.16	- - -	WO 3	.12	.12
F 8	.09	- - -	WO 4	.23	.24
F 9	.06	- - -	WO 5	.39	- - -
F 10	-.27	- - -	WO 6	.22	- - -
F 11	-.12	- - -	WO 7	.33	- - -
F 12	-.16	- - -	WO 8	.53	- - -
F 13	-.19	- - -	WO 9	.55	- - -
F 14	-.19	- - -	WO 10	.64	.66
F 15	-.24	- - -	EI 1	-.13	- - -
FC 2	-.39	- - -	EI 2	-.10	- - -
FC 3	.14	- - -	EI 3	.10	- - -
FC 4	.30	- - -	EI 7	-.24	- - -
FC 5	.30	- - -	EI 8	-.23	- - -
WI 1	.10	- - -	EI 9	.20	- - -
WI 2	-.08	- - -	EO 1	.26	- - -
WI 3	-.12	- - -	EO 2	.34	- - -
WI 4	-.16	-0.17	EO 3	.46	- - -
WI 5	-.15	- - -	EO 4	.64	- - -
WI 6	-.11	-.08	EO 5	.81	- - -
WI 7	-.11	- - -	EO 6	.86	- - -
WM 1	-.33	-.28	EO 12	.61	- - -
WM 2	-.39	- - -	EO 13	.64	- - -
WM 3	-.55	- - -	EO 14	.80	- - -
WM 4	-.48	- - -	EO 15	1.00	- - -
WM 5	-.28	- - -	R 18	-.44	- - -
WM 6	.10	- - -	R 19	-.32	- - -
WM 7	.08	- - -	R 20	-.28	- - -
WM 8	.09	- - -	R 21	-.19	- - -
N 1	-.41	-.38	R 22	-.24	- - -
N 2	-.30	- - -			
N 3	-.27	- - -			

TABLE 5. — Continued

(d) 8.1 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	-0.18	- - -	WO 5	0.16	- - -
F 2	-.12	- - -	WO 6	-.10	- - -
F 3	.16	- - -	WO 7	.10	- - -
F 4	.14	- - -	WO 8	.19	- - -
F 5	.09	- - -	WO 9	.30	- - -
F 6	.06	- - -	WO 10	.58	0.40
F 7	.06	- - -	EI 1	-.09	- - -
F 8	.08	- - -	EI 2	-.14	- - -
F 9	.09	- - -	EI 3	-.20	- - -
F 10	.31	- - -	EI 4	-.10	- - -
F 11	.30	- - -	EI 5	-.13	- - -
F 12	.08	- - -	EI 6	-.12	- - -
F 13	.23	- - -	EI 7	-.33	- - -
F 14	-.19	- - -	EI 8	-.30	- - -
F 15	-.13	- - -	EI 9	-.50	- - -
FC 2	.25	- - -	EO 1	-.18	- - -
FC 3	.28	- - -	EO 2	.15	- - -
FC 4	.23	- - -	EO 3	.21	- - -
FC 5	.43	- - -	EO 4	.30	- - -
WI 1	.16	- - -	EO 5	.46	- - -
WI 2	.10	- - -	EO 6	.50	- - -
WI 3	.14	- - -	EO 7	.21	- - -
WI 4	.11	0.19	EO 8	.25	- - -
WI 5	-.16	- - -	EO 9	.50	- - -
WI 6	-.13	.08	EO 10	.38	- - -
WI 7	-.16	- - -	EO 11	.43	- - -
WM 1	.48	.03	EO 12	.70	- - -
WM 2	.63	- - -	EO 13	.40	- - -
WM 3	-.43	- - -	EO 14	.50	- - -
WM 4	-.58	- - -	EO 15	.63	- - -
WM 5	-.25	- - -	R 7	.26	.60
WM 6	-.15	- - -	R 8	.23	.25
WM 7	-.11	- - -	R 9	.16	.30
WM 8	-.19	- - -	R 10	.18	.25
N 1	-.48	.27	R 11	.21	.38
N 2	-.35	- - -	R 18	.46	.75
N 3	-.65	- - -	R 19	.35	.63
N 4	-.35	-.25	R 20	.23	.48
N 5	-.33	-.13	R 21	.39	.38
N 6	-.15	- - -	R 22	.20	.25
N 7	-.30	-.44	R 28	.38	1.00
WO 1	-.69	- - -	R 29	.39	.88
WO 2	-.31	- - -	R 30	.38	.73
WO 3	-.13	-.15	R 31	.40	.60
WO 4	.17	-.30	R 32	.30	.43

TABLE 5. — Continued

(e) 8.7 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	0.06	- - -	WO 3	-0.04	-0.05
F 2	.04	- - -	WO 4	.07	-.09
F 3	.06	- - -	WO 5	.08	- - -
F 4	-.04	- - -	WO 6	-.04	- - -
F 5	-.02	- - -	WO 7	.05	- - -
F 6	.02	- - -	WO 8	.09	- - -
F 7	.03	- - -	WO 9	.12	- - -
F 8	.03	- - -	WO 10	.20	-.33
F 9	.04	- - -	EI 1	.05	- - -
F 10	.13	- - -	EI 2	.08	- - -
F 11	.05	- - -	EI 3	-.06	- - -
F 12	.04	- - -	EI 5	.05	- - -
F 13	.09	- - -	EI 6	-.10	- - -
F 14	.19	- - -	EI 7	.10	- - -
F 15	.86	- - -	EI 8	.15	- - -
FC 2	.06	- - -	EI 9	-.16	- - -
FC 3	.07	- - -	EO 1	-.18	- - -
FC 4	-.08	- - -	EO 2	.05	- - -
FC 5	-.09	- - -	EO 3	.10	- - -
WI 1	.05	- - -	EO 4	.15	- - -
WI 2	.05	- - -	EO 5	.19	- - -
WI 3	.04	- - -	EO 6	.29	- - -
WI 4	.04	0.09	EO 7	.18	- - -
WI 5	.05	- - -	EO 8	.10	- - -
WI 6	.03	.07	EO 12	.23	- - -
WI 7	.04	- - -	EO 13	.15	- - -
WM 1	-.14	.20	EO 14	.16	- - -
WM 2	-.13	- - -	EO 15	.30	- - -
WM 3	-.13	- - -	R 7	-.47	-.62
WM 4	-.25	- - -	R 8	-.31	-.38
WM 5	-.06	- - -	R 9	-.16	-.22
WM 6	-.05	.98	R 10	-.09	-.12
WM 7	-.05	- - -	R 11	-.08	-.16
WM 8	-.04	- - -	R 18	-.55	-.70
N 1	.13	- - -	R 19	-.43	-.52
N 2	-.06	-.07	R 20	-.33	-.41
N 3	-.09	- - -	R 21	-.25	-.32
N 4	-.11	-.12	R 22	-.20	-.20
N 5	-.11	-.53	R 28	-.77	-1.00
N 6	-.06	- - -	R 29	-.66	-.66
N 7	-.12	-.12	R 30	-.55	-.68
WO 1	-.12	- - -	R 31	-.47	-.51
WO 2	-.04	- - -	R 32	-.35	-.52

TABLE 5. — Continued

(f) 10.5 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	0.16	- - -	WO 5	0.16	- - -
F 2	.03	- - -	WO 6	-.02	- - -
F 3	-.06	- - -	WO 7	.09	- - -
F 4	-.04	- - -	WO 8	.21	- - -
F 5	.02	- - -	WO 9	.32	- - -
F 6	.05	- - -	WO 10	.56	0.76
F 7	.06	- - -	EI 1	-.06	- - -
F 8	.07	- - -	EI 2	-.06	- - -
F 9	.08	- - -	EI 3	-.06	- - -
F 10	.09	- - -	EI 4	-.08	- - -
F 11	.05	- - -	EI 5	-.08	- - -
F 12	.03	- - -	EI 6	-.08	- - -
F 13	-.04	- - -	EI 7	-.11	- - -
F 14	-.06	- - -	EI 8	-.11	- - -
F 15	-.06	- - -	EI 9	-.11	- - -
FC 2	.02	- - -	EO 1	.04	- - -
FC 3	-.06	- - -	EO 2	.13	- - -
FC 4	-.05	- - -	EO 3	.23	- - -
FC 5	.02	- - -	EO 4	.48	- - -
WI 1	.06	- - -	EO 5	.60	- - -
WI 2	.06	- - -	EO 6	.64	- - -
WI 3	.07	- - -	EO 7	.15	- - -
WI 4	.05	-0.06	EO 8	.27	- - -
WI 5	.04	- - -	EO 9	.48	- - -
WI 6	-.02	-.02	EO 10	.60	- - -
WI 7	-.03	- - -	EO 12	.20	- - -
WM 1	.05	.08	EO 13	.36	- - -
WM 2	.04	- - -	EO 14	.60	- - -
WM 3	.08	- - -	EO 15	1.00	- - -
WM 4	.16	- - -	R 7	.13	- - -
WM 5	-.04	- - -	R 8	.07	- - -
WM 6	-.03	- - -	R 9	.04	- - -
WM 7	-.03	- - -	R 10	.04	- - -
WM 8	-.03	- - -	R 11	.04	- - -
N 1	.09	.05	R 18	.16	- - -
N 2	.02	.03	R 19	.12	- - -
N 3	-.06	-.12	R 20	.09	- - -
N 4	-.06	-.07	R 21	.08	- - -
N 5	-.05	-.06	R 22	.06	- - -
N 6	-.04	- - -	R 28	.32	- - -
N 7	-.07	-.08	R 29	.24	- - -
WO 1	-.12	- - -	R 30	.20	- - -
WO 2	-.06	- - -	R 31	.18	- - -
WO 3	-.04	-.06	R 32	.16	- - -
WO 4	.04	.06			

TABLE 5. — Continued

(g) 11.1 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	0.12	- - -	N 5	-0.06	-0.07
F 2	.02	- - -	N 6	-.05	- - -
F 3	-.06	- - -	N 7	-.07	-.08
F 4	-.02	- - -	WO 1	-.15	- - -
F 5	.02	- - -	WO 2	-.06	- - -
F 6	.04	- - -	WO 3	-.05	-.06
F 7	.05	- - -	WO 4	.06	.05
F 8	.04	- - -	WO 5	.16	- - -
F 9	.04	- - -	WO 6	-.04	- - -
F 10	.04	- - -	WO 7	.08	- - -
F 11	.03	- - -	WO 8	.20	- - -
F 12	.06	- - -	WO 9	.35	- - -
F 13	.09	- - -	WO 10	.53	.64
F 14	.16	- - -	EI 1	.14	- - -
F 15	.16	- - -	EI 2	.10	- - -
FC 2	.03	- - -	EI 3	.08	- - -
FC 3	-.05	- - -	EI 6	.83	- - -
FC 4	-.02	- - -	EI 7	.22	- - -
FC 5	.06	- - -	EI 8	.17	- - -
WI 1	.04	- - -	EI 9	.14	- - -
WI 2	.04	- - -	EO 1	-.54	- - -
WI 3	.04	- - -	EO 2	.10	- - -
WI 4	.04	0.03	EO 3	.24	- - -
WI 5	.03	- - -	EO 4	.35	- - -
WI 6	.04	.03	EO 5	.50	- - -
WI 7	.07	- - -	EO 6	.60	- - -
WM 1	.06	.10	EO 7	.17	- - -
WM 2	.12	- - -	EO 12	.34	- - -
WM 3	.19	- - -	EO 13	.41	- - -
WM 4	.07	- - -	EO 14	.58	- - -
WM 5	-.04	- - -	EO 15	1.00	- - -
WM 6	-.03	-.04	R 18	-.15	- - -
WM 7	-.03	- - -	R 19	-.07	- - -
WM 8	-.03	- - -	R 20	-.06	- - -
N 1	.06	.08	R 21	-.05	- - -
N 2	.04	.04	R 22	-.09	- - -
N 3	-.14	-.04	R 28	-.25	-.68 (top)
N 4	-.07	-.06			

TABLE 5. — Continued

(h) 12.2 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	-0.13	- - -	N 4	-0.12	-0.17
F 2	-.04	- - -	N 5	-.13	-.08
F 3	-.05	- - -	N 6	-.08	- - -
F 4	-.05	- - -	N 7	-.10	-.08
F 5	-.04	- - -	WO 1	-.17	- - -
F 6	-.06	- - -	WO 2	-.06	-.11
F 7	-.07	- - -	WO 3	-.06	-.05
F 8	-.05	- - -	WO 4	.06	.08
F 9	-.05	- - -	WO 5	.15	.16
F 10	-.09	- - -	WO 6	-.05	-.08
F 11	.08	- - -	WO 7	.07	- - -
F 12	.06	- - -	WO 8	.18	- - -
F 13	.11	- - -	WO 9	.33	- - -
F 14	.16	- - -	WO 10	.48	.49
F 15	.19	- - -	EI 1	.15	- - -
FC 2	-.05	- - -	EI 2	.11	- - -
FC 3	-.10	- - -	EI 3	.06	- - -
FC 4	-.06	- - -	EI 6	.10	- - -
FC 5	-.11	- - -	EI 7	.30	- - -
WI 1	-.05	-0.06	EI 8	.21	- - -
WI 2	-.08	- - -	EI 9	.18	- - -
WI 3	-.04	-.05	EO 1	-.04	- - -
WI 4	-.03	-.05	EO 2	.10	- - -
WI 5	.03	- - -	EO 3	.21	- - -
WI 6	.04	.03	EO 4	.35	- - -
WI 7	.08	- - -	EO 5	.44	- - -
WM 1	.11	.15	EO 6	.55	- - -
WM 2	.37	- - -	EO 7	.18	- - -
WM 3	.36	- - -	EO 12	.34	.27
WM 4	.20	- - -	EO 13	.47	- - -
WM 5	-.06	- - -	EO 14	.64	- - -
WM 6	-.05	-.05	EO 15	1.00	- - -
WM 7	-.04	- - -	R 19	.10	- - -
WM 8	-.06	- - -	R 20	.08	- - -
N 1	.13	.12	R 21	-.05	- - -
N 2	.12	.07	R 22	-.09	- - -
N 3	.10	.06	R 28	.54 (top)	- - -

TABLE 5. — Continued

(i) 14.7 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	0.17	- - -	N 2	- - -	0.13
F 2	0	- - -	N 3	0.05	.05
F 3	-.04	- - -	N 4	.06	.07
F 4	.13	- - -	N 5	-.07	-.06
F 5	.27	- - -	N 7	-.14	-.08
F 6	.09	- - -	WO 1	.19	- - -
F 7	0	- - -	WO 2	.07	- - -
F 8	-.08	- - -	WO 3	.06	- - -
F 9	-.04	- - -	WO 4	.38	.27
F 10	-.16	- - -	WO 5	.35	- - -
F 11	-.07	- - -	WO 6	0	- - -
F 12	.07	- - -	WO 7	-.10	- - -
F 13	.30	- - -	WO 8	-.24	- - -
F 14	.32	- - -	WO 9	-.40	- - -
F 15	.26	- - -	WO 10	-.27	-.26
FC 2	0	- - -	EI 1	.41	- - -
FC 3	-.09	- - -	EI 2	.26	- - -
FC 4	.09	- - -	EI 3	.18	- - -
FC 5	.12	- - -	EI 6	.31	- - -
WI 1	.03	- - -	EI 8	.70	- - -
WI 2	-.10	- - -	EI 9	.63	- - -
WI 3	-.20	- - -	EO 1	-.19	-.20
WI 4	-.16	-0.13	EO 2	-.28	-.31
WI 5	-.14	- - -	EO 3	-.43	- - -
WI 6	-.07	-.03	EO 4	-.41	- - -
WI 7	.21	- - -	EO 5	-.41	- - -
WM 1	0	- - -	EO 6	-.68	- - -
WM 2	-.25	- - -	EO 7	-.56	-.63
WM 3	-.02	- - -	EO 8	-.58	- - -
WM 4	-.08	- - -	EO 9	-.61	- - -
WM 5	-.13	- - -	EO 10	-.72	-.83
WM 6	-.17	-.20	EO 11	-.44	-.63
WM 7	-.13	- - -	EO 12	-.89	- - -
WM 8	-.09	- - -	EO 13	-.89	- - -
Inlet spike	.38	.45	EO 14	-1.00	- - -
			EO 15	-.71	- - -
N 1	.11	.15			

TABLE 5. — Continued

(j) 20.2 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	-0.02	- - -	WO 7	-0.03	- - -
F 2	-.01	- - -	WO 8	.14	- - -
F 3	.04	- - -	WO 9	.32	- - -
F 4	.02	- - -	WO 10	.51	0.20
F 5	-.01	- - -	EI 1	.02	- - -
F 6	-.02	- - -	EI 2	.03	- - -
F 7	-.02	- - -	EI 3	-.04	- - -
F 8	-.01	- - -	EI 4	.04	- - -
F 9	.02	- - -	EI 5	.05	- - -
F 10	.03	- - -	EI 6	-.05	- - -
F 11	.03	- - -	EI 7	.08	- - -
F 12	.02	- - -	EI 8	-.07	- - -
F 13	.02	- - -	EI 9	-.08	- - -
F 14	.03	- - -	EO 1	-.11	- - -
F 15	.02	- - -	EO 2	-.04	- - -
FC 2	-.03	- - -	EO 3	.10	- - -
FC 3	.02	- - -	EO 4	.27	- - -
FC 4	.02	- - -	EO 5	.38	- - -
FC 5	-.02	- - -	EO 6	.55	- - -
WI 1	-.03	-0.03	EO 7	-.56	- - -
WI 2	.02	- - -	EO 8	-.44	- - -
WI 3	.02	- - -	EO 9	-.29	- - -
WI 4	.02	.01	EO 10	-.12	- - -
WI 5	.02	- - -	EO 11	.21	- - -
WI 6	.01	.01	EO 12	-1.00	-.34
WI 7	.02	- - -	EO 13	-.83	- - -
WM 1	-.05	-.04	EO 14	-.68	-.27
WM 2	-.08	- - -	EO 15	-.29	-.25
WM 3	-.08	- - -	R 7	.38	- - -
WM 4	-.01	- - -	R 8	.28	- - -
WM 5	-.03	- - -	R 9	.20	- - -
WM 6	-.02	-.03	R 10	.09	- - -
WM 7	-.03	- - -	R 11	.08	- - -
WM 8	-.09	- - -	R 14	.27	.17
Inlet spike	-.04	-.08	R 17	.02	- - -
			R 18	.27	.15
N 1	-.05	-.07	R 19	.13	.08
N 2	-.02	-.01	R 20	-.02	-.02
N 3	-.06	- - -	R 21	-.08	-.05
N 4	-.05	-.05	R 22	-.16	-.09
N 5	-.03	-.03	R 23	.16	- - -
N 6	-.06	- - -	R 24	-.04	- - -
N 7	-.12	-.07	R 26	-.15	- - -
WO 1	-.04	- - -	R 28	-.14	-.10
WO 2	.03	- - -	R 29	-.23	-.13
WO 3	-.01	-.03	R 30	-.38	- - -
WO 4	.13	.04	R 31	-.46	- - -
WO 5	.29	- - -	R 32	-.54	- - -
WO 6	-.06	- - -			

TABLE 5. – Continued

(k) 22.0 cps, symmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	0.02	- - -	WO 7	0.10	- - -
F 2	-.01	- - -	WO 8	.23	- - -
F 3	.04	- - -	WO 9	.33	- - -
F 4	.02	- - -	WO 10	.61	.62
F 5	-.03	- - -	EI 1	-.04	- - -
F 6	-.02	- - -	EI 2	.04	- - -
F 7	-.03	- - -	EI 3	.07	- - -
F 8	-.03	- - -	EI 7	-.14	- - -
F 9	-.04	- - -	EI 8	.14	- - -
F 10	-.07	- - -	EI 9	.14	- - -
F 11	-.03	- - -	EO 1	-.05	- - -
F 12	-.03	- - -	EO 2	-.06	-.04
F 13	-.04	- - -	EO 3	.16	- - -
F 14	-.07	- - -	EO 4	.30	- - -
F 15	-.07	- - -	EO 5	.41	- - -
FC 2	-.03	- - -	EO 6	.64	- - -
FC 3	.03	- - -	EO 7	-.57	- - -
FC 4	.04	- - -	EO 8	-.46	- - -
FC 5	-.03	- - -	EO 9	-.34	- - -
WI 1	-.04	-0.05	EO 10	-.15	- - -
WI 2	-.04	- - -	EO 11	.15	.21
WI 3	-.03	- - -	EO 12	-.99	-1.00
WI 4	.04	.05	EO 13	-1.00	- - -
WI 5	.03	.01	EO 14	-.92	- - -
WI 6	.02	.02	EO 15	-.36	-.73
WI 7	.03	- - -	R 7	-.76	-.31
WM 1	.06	.05	R 8	-.34	-.11
WM 2	.12	- - -	R 9	-.12	-.05
WM 3	.18	- - -	R 10	.09	-.03
WM 4	.06	- - -	R 11	.13	.04
WM 5	.04	- - -	R 13	.04	- - -
WM 6	.07	.05	R 14	.08	- - -
WM 7	.07	- - -	R 17	.09	- - -
WM 8	.08	- - -	R 18	-.90	-.37
N 1	.06	.18	R 19	-.36	-.15
N 2	.03	.02	R 20	.06	.02
N 3	-.07	-.03	R 21	.29	.12
N 4	.07	.05	R 22	.53	.22
N 5	.06	.04	R 23	-.56	- - -
N 6	.07	- - -	R 24	-.20	- - -
N 7	.14	.08	R 26	.32	- - -
WO 1	-.08	- - -	R 28	-1.00	-.41
WO 2	-.05	-.04	R 29	-.49	-.20
WO 3	.03	.02	R 30	.41	.17
WO 4	.18	.22	R 31	.59	.24
WO 5	.32	- - -	R 32	.99	.41
WO 6	.05	- - -			

TABLE 5. — Continued

(l) 4.3 cps, antisymmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
FC 2	-0.16	0.28	WO 1	-0.43	- - -
FC 3	-.21	- - -	WO 2	.17	-0.16
FC 4	-.17	- - -	WO 3	.23	- - -
FC 5	-.25	.31	WO 4	.34	- - -
WI 1	-.25	.30	WO 5	.39	- - -
WI 2	-.25	- - -	WO 6	.43	- - -
WI 3	-.25	- - -	WO 7	.47	- - -
WI 4	-.18	- - -	WO 8	.57	- - -
WI 6	.12	-.12	WO 9	.82	- - -
WI 7	.16	- - -	WO 10	.71	-.71
WM 1	-.54	.74	EI 1	.12	- - -
WM 2	-.49	- - -	EI 2	.23	- - -
WM 3	-.57	- - -	EI 3	.28	- - -
WM 4	-.51	- - -	EI 7	.24	- - -
WM 5	.12	- - -	EI 8	.41	- - -
WM 6	.22	-.10	EI 9	.46	-.41
WM 7	.35	- - -	EO 1	.57	- - -
WM 8	.38	- - -	EO 2	.64	- - -
Inlet spike	-.85	.90	EO 3	.62	- - -
			EO 4	.66	- - -
N 1	-.72	.67	EO 5	.61	- - -
N 2	-.59	.54	EO 6	.85	- - -
N 3	-.57	.29	EO 12	.54	-.41
N 4	.25	-.31	EO 13	.67	- - -
N 5	.36	-.26	EO 14	.82	- - -
N 6	.46	- - -	EO 15	1.00	- - -
N 7	.66	-.39			

TABLE 5. — Continued

(m) 7.1 cps, antisymmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude right	Test point	Normalized amplitude, left	Normalized amplitude, right
WI 1	-0.024	0.024	EO 2	0.062	-0.051
WI 2	-.027	- - -	EO 3	.103	- - -
WI 3	-.020	- - -	EO 6	.176	- - -
WI 4	-.028	.029	EO 7	.094	-.057
WI 5	-.039	- - -	EO 8	.097	- - -
WI 6	-.049	.034	EO 9	.135	- - -
WI 7	-.049	- - -	EO 11	.226	-.206
WM 1	-.029	.032	EO 12	.147	-.109
WM 2	-.050	- - -	EO 14	.174	- - -
WM 3	-.071	- - -	R 1	-.294	.647
WM 4	-.034	.034	R 2	-.238	.500
WM 5	-.042	- - -	R 3	-.174	.382
WM 6	-.050	.062	R 4	-.135	.235
WM 7	-.044	- - -	R 5	-.088	.153
WM 8	-.063	- - -	R 6	-.084	.259
Inlet spike	.049	-.063	R 7	-.197	.485
			R 8	-.147	.294
N 1	.041	-.026	R 9	-.094	.153
N 2	.028	-.025	R 10	-.109	.103
N 3	.162	.044	R 11	-.053	.100
N 4	-.047	-.050	R 18	-.247	.662
N 5	-.041	.041	R 19	-.209	.559
N 6	-.048	- - -	R 20	-.168	.426
N 7	-.074	.051	R 21	-.124	.271
EI 1	-.046	- - -	R 22	-.115	.338
EI 2	-.069	- - -	R 28	-.382	1.000
EI 3	-.084	- - -	R 29	-.324	.691
EI 7	-.079	- - -	R 30	-.338	.809
EI 8	-.109	- - -	R 31	-.250	.509
EI 9	-.124	- - -	R 32	-.224	.465
EO 1	.026	-.024			

TABLE 5. — Continued

(n) 8.2 cps, antisymmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 6	-0.05	- - -	WO 9	-0.22	- - -
F 7	-.05	- - -	WO 10	-.29	.26
F 8	-.06	- - -	EI 1	.06	.10
F 9	-.05	- - -	EI 2	.08	-.04
F 10	.14	- - -	EI 3	.09	-.14
F 11	.07	- - -	EI 4	- - -	.09
F 12	.09	- - -	EI 5	- - -	-.07
F 13	.15	- - -	EI 6	.12	-.13
F 14	.08	- - -	EI 7	.14	.19
F 15	.08	- - -	EI 8	.10	-.22
FC 2	-.21	0.23	EI 9	.27	-.16
FC 3	-.24	.31	EO 1	-.08	.07
FC 4	-.21	.18	EO 2	-.14	- - -
FC 5	-.19	.15	EO 3	-.18	- - -
WI 1	-.07	.09	EO 4	-.23	- - -
WI 2	-.18	.10	EO 5	-.35	- - -
WI 3	.14	-.07	EO 6	-.37	- - -
WI 4	.06	-.10	EO 7	- - -	.11
WI 5	.14	- - -	EO 11	- - -	.23
WI 6	.07	-.08	EO 12	-.23	.14
WI 7	.06	-.04	EO 13	-.34	- - -
WM 1	.11	- - -	EO 14	-.40	- - -
WM 2	.22	-.18	EO 15	-.46	- - -
WM 3	.55	- - -	R 1	.33	-.39
WM 4	.56	-.32	R 2	.33	-.38
WM 5	.14	- - -	R 3	.27	-.24
WM 6	.09	-.07	R 4	.18	-.14
WM 7	.06	- - -	R 5	.18	-.11
WM 8	.08	-.05	R 6	.20	.24
Inlet spike	.19	-.09	R 7	.39	-.57
			R 8	.26	-.35
N 1	.19	-.11	R 9	.22	-.21
N 2	.19	-.08	R 10	.14	-.12
N 3	- - -	-.22	R 11	.10	.10
N 4	.24	-.32	R 18	.45	-.48
N 5	.13	.09	R 19	.31	-.51
N 6	.08	- - -	R 20	.21	-.42
N 7	.08	-.11	R 21	.20	-.32
WO 1	.36	-.35	R 22	.15	-.24
WO 2	.13	-.10	R 28	.55	-1.00
WO 3	-.08	.04	R 29	.44	-.85
WO 4	-.11	.08	R 30	.43	-.67
WO 5	-.16	- - -	R 31	.35	-.62
WO 6	-.08	.06	R 32	.26	-.54
WO 7	-.11	- - -			
WO 8	-.15	- - -			

TABLE 5. — Continued

(o) 8.7 cps, antisymmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 10	-0.15	- - -	EI 2	-0.04	- - -
F 13	-.04	- - -	EI 3	-.07	- - -
FC 2	-.05	0.05	EI 5	-.06	-.06
FC 3	-.06	.04	EI 6	-.06	-.09
FC 4	-.04	.09	EI 8	-.13	- - -
FC 5	-.09	.12	EI 9	-.10	- - -
WI 1	-.04	-.06	EO 1	-.15	.04
WI 2	-.04	- - -	EO 2	-.09	.06
WI 3	-.08	- - -	EO 3	-.05	- - -
WI 4	-.08	-.06	EO 4	-.06	- - -
WI 5	-.04	- - -	EO 5	-.09	- - -
WI 6	-.03	-.04	EO 6	-.09	- - -
WI 7	-.03	- - -	EO 7	-.06	.07
WM 1	.13	- - -	EO 8	-.13	- - -
WM 2	.10	- - -	EO 9	- - -	.11
WM 3	.35	- - -	EO 12	-.14	.10
WM 4	.26	-.07	EO 13	-.17	- - -
WM 5	.09	- - -	EO 14	-.11	- - -
WM 6	.03	-.03	EO 15	-.18	.22
WM 7	.04	- - -	R 1	.43	.33
WM 8	.05	-.04	R 2	.36	.31
Inlet spike	.08	.04	R 3	.26	.20
			R 4	.20	-.18
N 1	.08	.10	R 5	.19	-.18
N 2	.04	-.03	R 6	.20	-.12
N 4	.09	-.10	R 7	.46	.39
N 5	.12	-.03	R 8	.28	.26
N 6	.05	- - -	R 9	.15	.16
N 7	.07	-.07	R 10	.09	-.10
WO 1	.13	.12	R 11	.09	-.10
WO 2	.04	.03	R 18	.54	.59
WO 3	.05	.02	R 19	.45	.45
WO 4	-.09	.06	R 20	.35	.30
WO 5	-.05	- - -	R 21	.24	.23
WO 6	-.03	- - -	R 22	.21	.16
WO 7	-.03	- - -	R 28	1.00	.83
WO 8	-.04	- - -	R 29	.83	.54
WO 9	-.07	- - -	R 30	.70	.54
WO 10	-.10	.18	R 31	.61	.47
EI 1	-.04	-.05	R 32	.48	.45

TABLE 5. — Continued

(p) 9.5 cps, antisymmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
WI 1	-0.01	0.01	EI 1	-0.05	- - -
WI 2	-.01	- - -	EI 2	-.05	- - -
WI 3	-.01	- - -	EI 3	-.06	- - -
WI 4	-.02	.03	EI 7	-.08	- - -
WI 5	-.03	- - -	EI 8	-.07	- - -
WI 6	-.04	.02	EI 9	-.10	0.06
WI 7	-.04	- - -	EO 1	.03	-.02
WM 1	.03	-.02	EO 2	.07	- - -
WM 2	.07	- - -	EO 3	.17	-.11
WM 3	-.04	- - -	EO 6	.40	- - -
WM 4	-.05	.05	EO 7	.14	- - -
WM 5	-.02	- - -	EO 12	.24	-.10
WM 6	-.03	.03	EO 15	.57	- - -
WM 7	-.04	- - -	R 1	.49	-.14
WM 8	-.04	.04	R 2	.34	-.10
Inlet spike	.05	-.05	R 3	.22	- - -
			R 4	-.32	.09
N 1	.03	-.02	R 5	-.26	.15
N 2	.03	-.01	R 6	-.29	.24
N 3	.04	-.01	R 7	.38	-.16
N 4	-.03	.02	R 8	.22	-.08
N 5	-.03	.02	R 9	.13	.05
N 6	-.03	- - -	R 10	-.10	.07
N 7	-.05	.03	R 11	-.15	.12
WO 1	.07	-.02	R 18	.55	-.25
WO 2	.02	-.04	R 19	.38	-.18
WO 3	-.02	.01	R 20	.32	-.10
WO 4	.07	-.06	R 21	.30	-.11
WO 5	.14	- - -	R 22	.50	-.11
WO 6	.01	- - -	R 28	1.00	-.44
WO 7	.07	- - -	R 29	.89	-.38
WO 8	.17	- - -	R 30	.93	-.34
WO 9	.29	- - -	R 31	.80	-.20
WO 10	.34	-.31	R 32	.71	-.38

TABLE 5. — Continued

(q) 13.2 cps, antisymmetrical excitation

Test point	Normalized amplitude
V 1	0.22
V 2	.22
V 3	.11
V 4	-.09
V 5	-.19
V 6	-.28
V 7	.09
V 8	-.10
V 9	-.12
V 10	-.19
V 11	-.07
V 12	-.42
V 13	-.05
V 14	-.12
V 15	-.22
V 16	-.32
V 17	-.44
V 18	-.63
V 19	-.20
V 20	-.38
V 21	-.49
V 22	-.63
V 23	-.84
V 24	-.79
V 25	-.42
V 26	-.63
V 27	-.68
V 28	-.84
V 29	-.89
V 30	-1.00

TABLE 5. — Continued

(r) 19.9 cps, antisymmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
FC 2	0.04	0.15	EI 5	-0.28	- - -
FC 3	-.05	- - -	EI 6	-.30	- - -
FC 4	.04	- - -	EI 7	-.45	- - -
FC 5	.09	-.09	EI 8	-.46	0.33
WI 1	.04	- - -	EI 9	-.50	.36
WI 2	.04	- - -	EO 1	-.14	- - -
WI 3	.04	- - -	EO 2	-.08	- - -
WI 4	.04	-.05	EO 3	.07	.04
WI 5	.04	-.04	EO 4	.27	- - -
WI 6	.03	-.04	EO 5	.38	- - -
WI 7	-.08	.09	EO 6	.59	- - -
WM 1	-.10	.14	EO 7	-.62	- - -
WM 2	-.16	- - -	EO 8	-.51	- - -
WM 3	.16	- - -	EO 9	-.38	- - -
WM 4	.14	- - -	EO 10	-.25	- - -
WM 5	.06	- - -	EO 11	.22	- - -
WM 6	-.06	-.04	EO 12	-1.00	.46
WM 7	-.08	- - -	EO 13	-.96	- - -
WM 8	-.11	.08	EO 14	-.85	.45
Inlet spike	-.36	.25	EO 15	.63	-.62
			R 1	.30	.18
N 1	-.13	.10	R 2	.27	.16
N 2	-.05	.06	R 3	.21	.11
N 3	.18	-.09	R 4	.17	.12
N 4	.07	-.07	R 5	.15	.08
N 5	-.06	.05	R 6	.15	.16
N 6	-.09	- - -	R 7	.25	.16
N 7	-.15	.10	R 8	.19	.09
WO 1	.14	.11	R 9	.13	.06
WO 2	.06	.04	R 10	.10	.04
WO 3	-.04	.05	R 11	.09	.03
WO 4	.15	.09	R 18	.22	.14
WO 5	.27	- - -	R 19	.11	.09
WO 6	-.08	.09	R 20	.05	.03
WO 7	-.04	- - -	R 21	-.08	-.05
WO 8	.13	.04	R 22	-.14	-.09
WO 9	.33	- - -	R 28	.13	.14
WO 10	.54	-.19	R 29	-.15	.11
EI 1	-.10	- - -	R 30	-.25	-.10
EI 2	-.16	- - -	R 31	-.33	-.16
EI 3	-.18	- - -	R 32	-.41	-.20
EI 4	-.24	- - -	- - -	- - -	- - -

TABLE 5. — Continued

(s) 22.7 cps, antisymmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 2	0.01	- - -	N 4	0.05	-0.04
F 3	-.02	- - -	N 5	.05	-.04
F 4	.01	- - -	N 6	.07	- - -
F 5	.01	- - -	N 7	.09	-.07
F 6	.01	- - -	WO 1	-.05	.05
F 7	-.01	- - -	WO 2	-.03	.03
F 8	-.01	- - -	WO 3	.03	-.02
F 9	-.01	- - -	WO 4	.21	-.22
F 10	.02	- - -	WO 5	.34	- - -
F 11	.03	- - -	WO 6	.06	-.17
F 12	.04	- - -	WO 7	.10	- - -
F 13	.04	- - -	WO 8	.21	- - -
F 14	.03	- - -	WO 9	.32	- - -
F 15	.03	- - -	WO 10	.54	-.91
FC 2	.03	-0.06	EI 1	-.14	- - -
FC 3	-.03	.03	EI 2	-.13	.11
FC 4	-.03	- - -	EI 3	-.12	-.07
FC 5	-.03	.03	EI 4	-.42	- - -
WI 1	.02	-.02	EI 6	-.35	-.14
WI 2	.02	- - -	EI 7	-.92	- - -
WI 3	.02	- - -	EI 8	-.80	- - -
WI 4	.02	-.03	EI 9	-.75	.30
WI 5	.03	.02	EO 1	-.08	.08
WI 6	.03	.02	EO 2	.05	-.09
WI 7	-.03	.05	EO 3	.15	-.15
WM 1	.05	-.04	EO 4	.28	- - -
WM 2	.10	- - -	EO 5	.38	- - -
WM 3	.08	- - -	EO 6	.56	- - -
WM 4	.08	-.09	EO 7	-.51	1.00
WM 5	.03	- - -	EO 8	-.43	- - -
WM 6	.05	-.06	EO 9	-.29	- - -
WM 7	.05	- - -	EO 10	-.16	- - -
WM 8	.02	-.04	EO 11	.18	-.24
Inlet spike	.15	-.10	EO 12	-1.00	1.00
			EO 13	-.87	- - -
N 1	.04	-.02	EO 14	-.79	- - -
N 2	-.03	.01	EO 15	-.49	.95
N 3	-.07	.02			

TABLE 5. — Continued

(s) 22.7 cps, antisymmetrical excitation — Concluded

Test point	Normalized amplitude
V 1	0.37
V 2	.40
V 3	.49
V 4	.48
V 5	.53
V 6	.51
V 7	.16
V 8	.20
V 9	.27
V 10	.33
V 11	.39
V 12	.47
V 13	.08
V 14	.09
V 15	.12
V 16	.12
V 17	.17
V 18	.30
V 19	-.08
V 20	-.07
V 21	-.04
V 22	.03
V 23	.03
V 24	.08
V 25	-.33
V 26	-.27
V 27	-.22
V 28	-.14
V 29	-.13
V 30	0

TABLE 5. — Continued

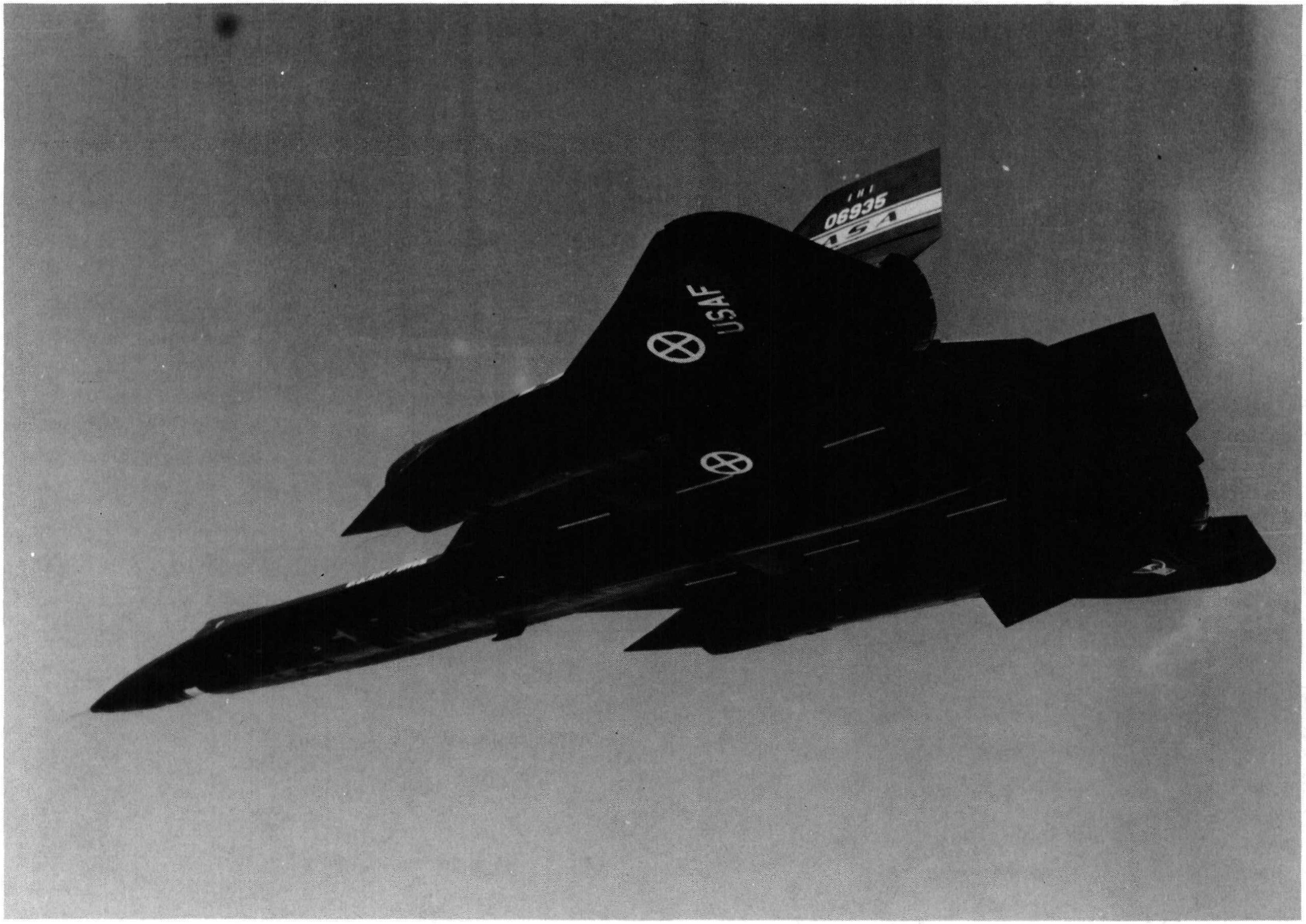
(t) 28.8 cps, antisymmetrical excitation

Test point	Normalized amplitude, left	Normalized amplitude, right	Test point	Normalized amplitude, left	Normalized amplitude, right
F 1	0.01	- - -	WO 8	0.09	-0.14
F 2	-.01	- - -	WO 9	.13	- - -
F 3	-.00	- - -	WO 10	.09	-.08
F 4	-.00	- - -	EI 1	.01	-.02
F 5	-.01	- - -	EI 2	-.02	.01
F 6	-.01	- - -	EI 3	-.03	- - -
F 7	-.00	- - -	EI 4	.06	- - -
F 8	.01	- - -	EI 5	.02	-.03
F 9	.03	- - -	EI 6	-.02	.02
F 10	.01	- - -	EI 7	.19	-.02
F 11	.01	- - -	EI 8	.11	- - -
F 12	.01	- - -	EI 9	.06	-.05
F 13	-.02	- - -	EO 1	.04	-.07
F 14	-.02	- - -	EO 2	.06	- - -
FC 2	.02	-0.02	EO 3	.08	- - -
FC 3	.01	.02	EO 4	.07	- - -
FC 4	-.01	.01	EO 5	.07	-.06
FC 5	-.02	.02	EO 6	-.10	.10
WI 1	-.01	-.02	EO 7	.15	- - -
WI 2	.01	- - -	EO 8	.12	- - -
WI 3	.01	-.02	EO 9	.03	- - -
WI 4	.01	-.02	EO 10	-.10	- - -
WI 5	.02	- - -	EO 11	-.08	- - -
WI 6	.01	.01	EO 12	.28	-.51
WI 7	-.02	.02	EO 13	.18	- - -
WM 1	-.02	.02	EO 14	-.07	.10
WM 2	-.02	.02	EO 15	-.51	1.00
WM 3	-.02	- - -	R 1	- - -	.03
WM 4	-.02	-.03	R 2	- - -	-.03
WM 5	-.01	- - -	R 3	- - -	-.04
WM 6	-.01	-.03	R 4	- - -	-.05
WM 7	-.02	- - -	R 5	- - -	-.05
WM 8	-.03	.03	R 6	- - -	.05
Inlet spike	.21	-.13	R 7	- - -	.04
			R 8	- - -	-.03
N 1	-.03	.02	R 9	- - -	-.03
N 2	-.02	.03	R 10	- - -	-.03
N 3	-.06	.03	R 11	- - -	-.02
N 4	-.03	.02	R 18	- - -	.09
N 5	-.02	.02	R 19	- - -	.02
N 6	-.01	- - -	R 20	- - -	-.02
N 7	-.03	.03	R 21	- - -	-.04
WO 1	-.06	.04	R 22	- - -	-.05
WO 2	-.02	.02	R 28	-.10	.15
WO 3	-.01	.02	R 29	- - -	.11
WO 4	.08	-.10	R 30	- - -	.03
WO 5	.11	- - -	R 31	- - -	-.09
WO 6	.02	-.03	R 32	.07	-.12
WO 7	.06	-.09			

TABLE 5. — Concluded

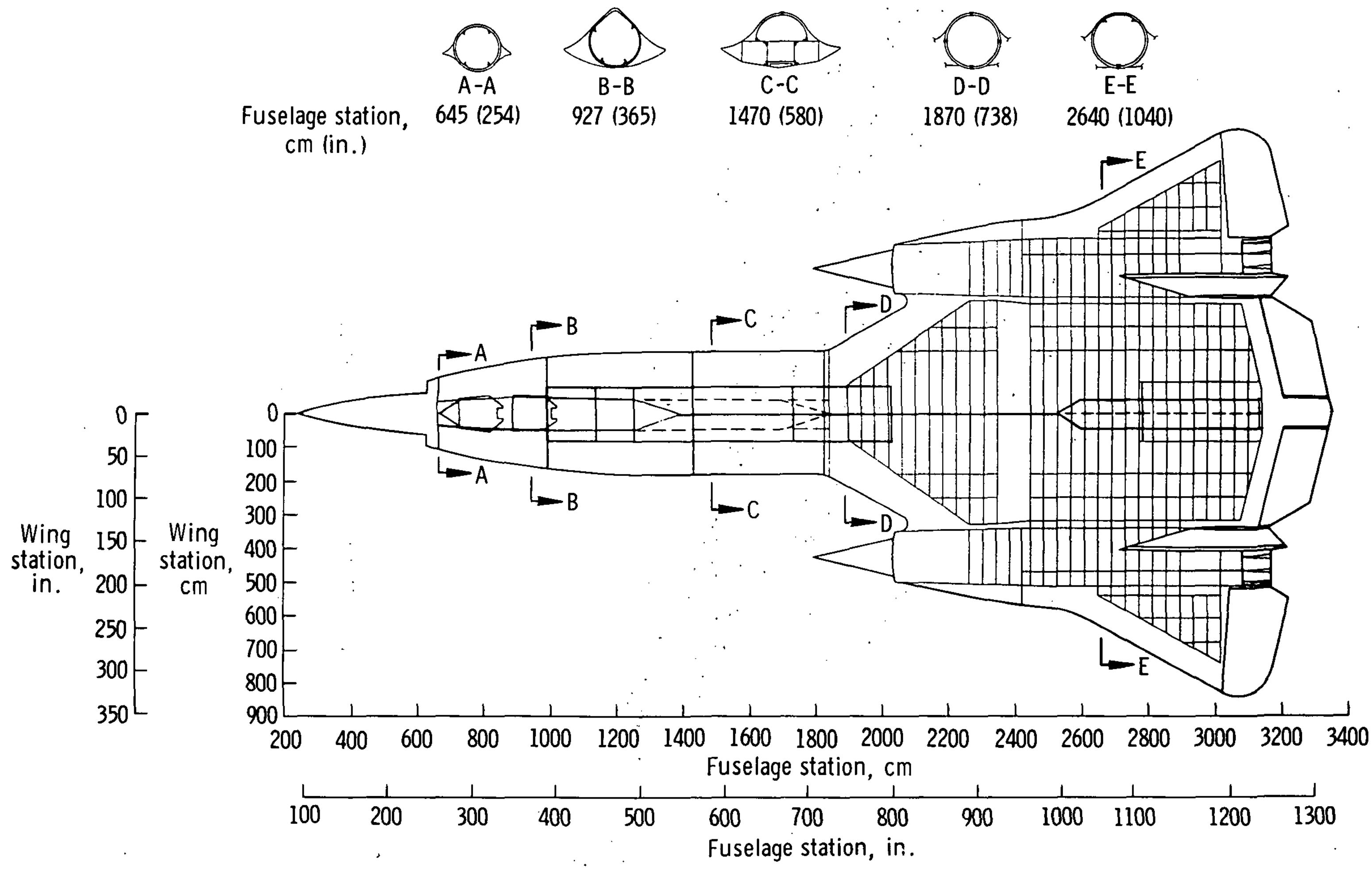
(t) 28.8 cps, antisymmetrical excitation — Concluded

Test point	Normalized amplitude
V 1	-0.10
V 2	-.11
V 4	-.12
V 6	-.16
V 13	-.01
V 14	-.02
V 16	-.03
V 18	-.04
V 19	.02
V 20	.02
V 24	.04
V 25	.07
V 26	.08
V 28	.10
V 30	.13



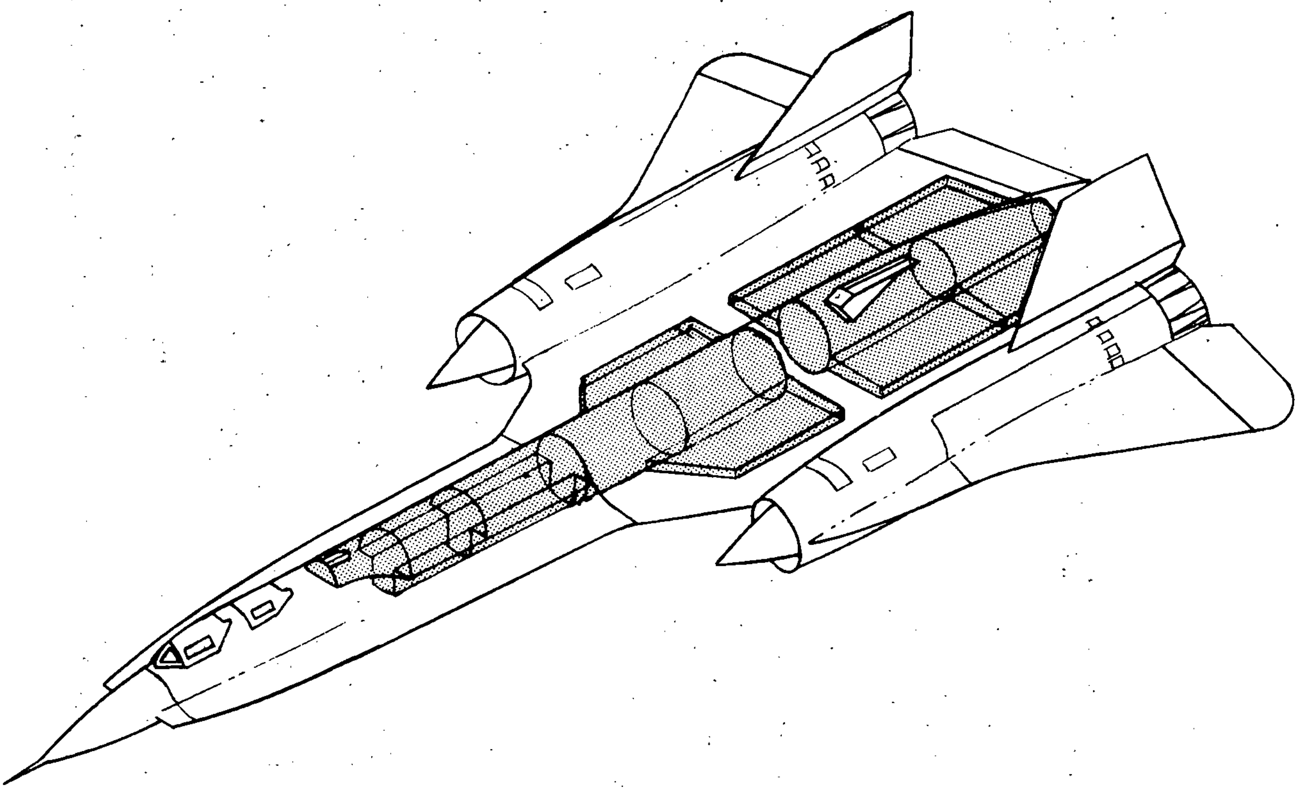
E-23095

Figure 1. YF-12 airplane.



(a) Airplane structure (generalized).

Figure 2. Structural representation and fuel compartment configuration of the YF-12 airplane.



(b) Fuel compartment configuration.

Figure 2. Concluded.

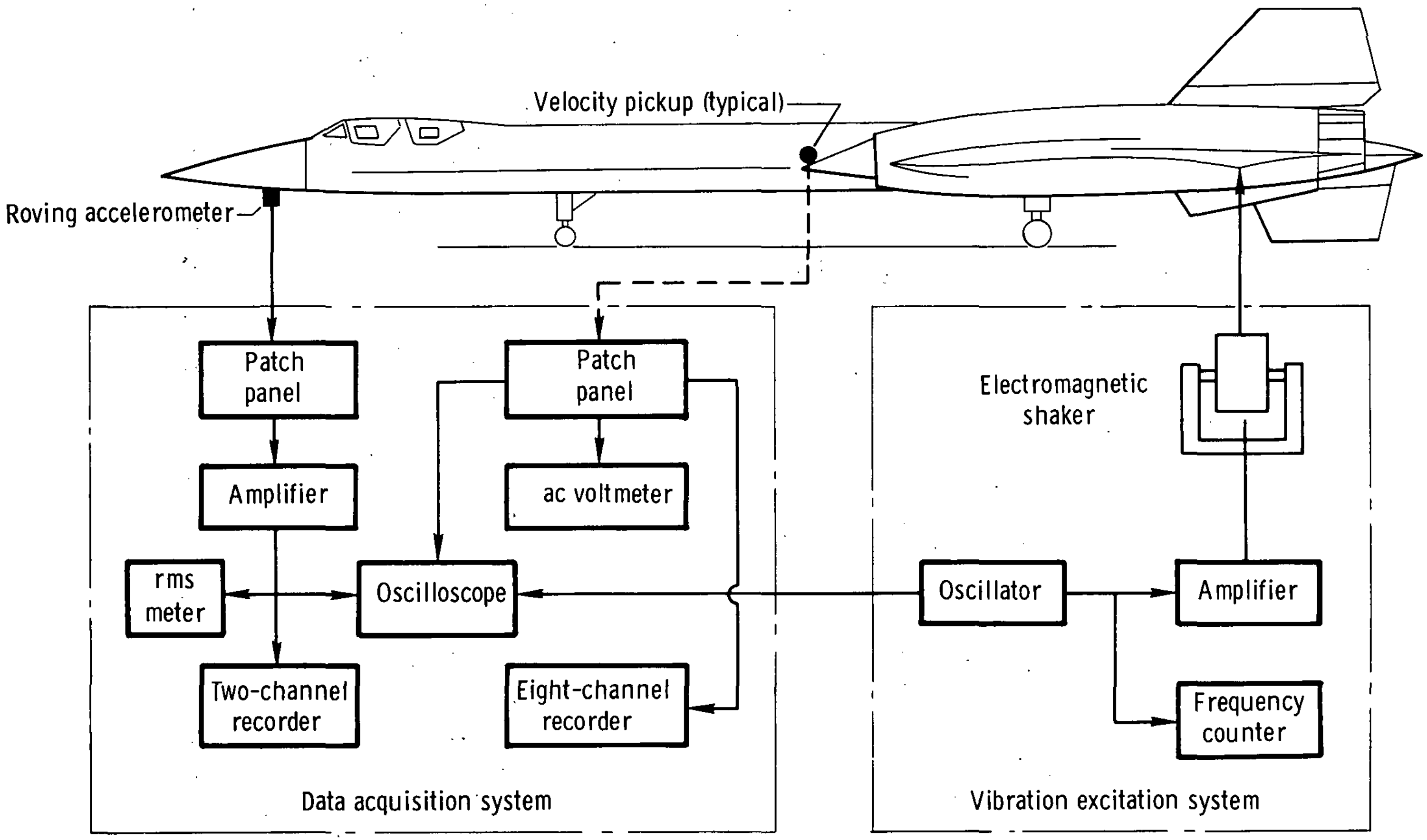
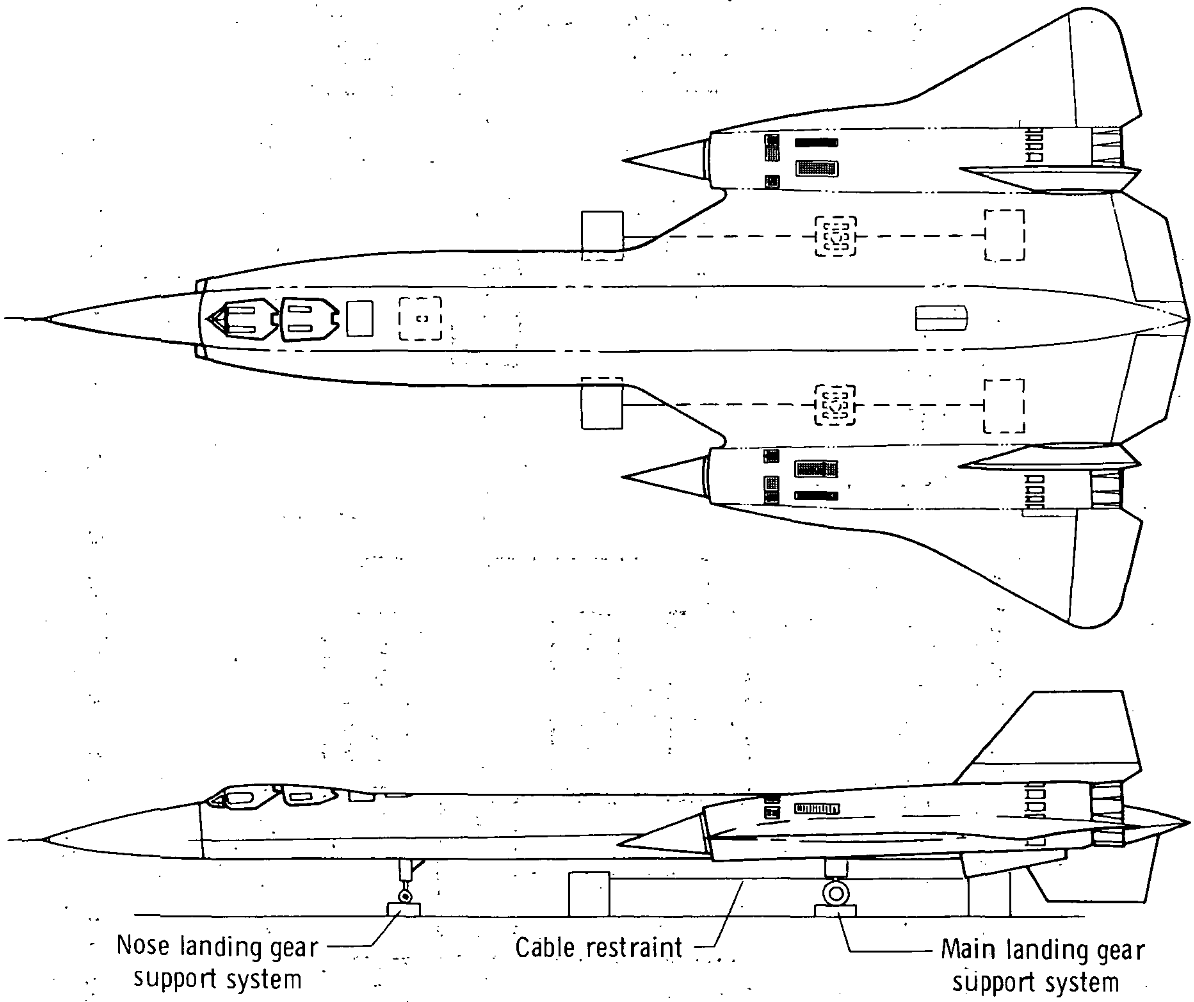
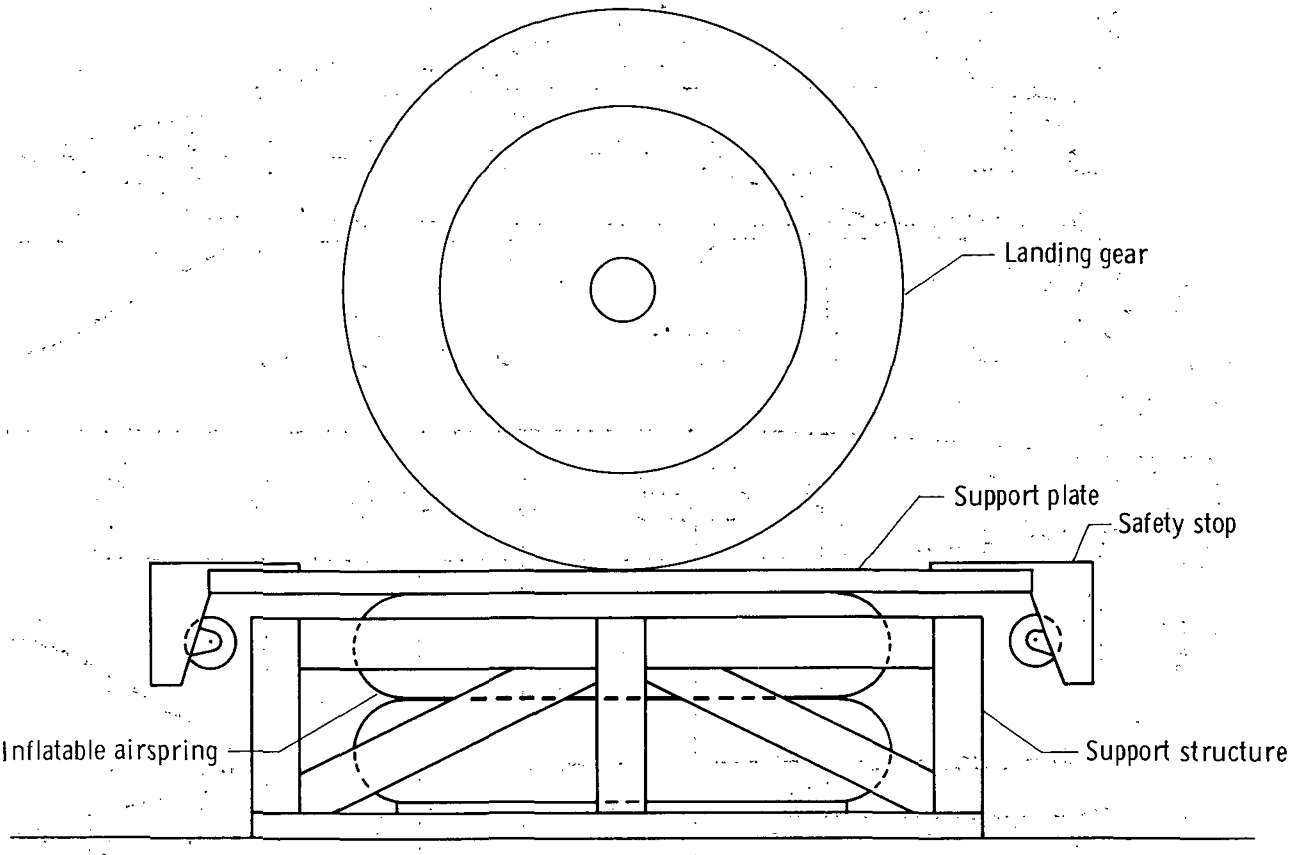


Figure 3. Block diagram of the data acquisition and vibration excitation systems used in the YF-12 ground vibration survey.



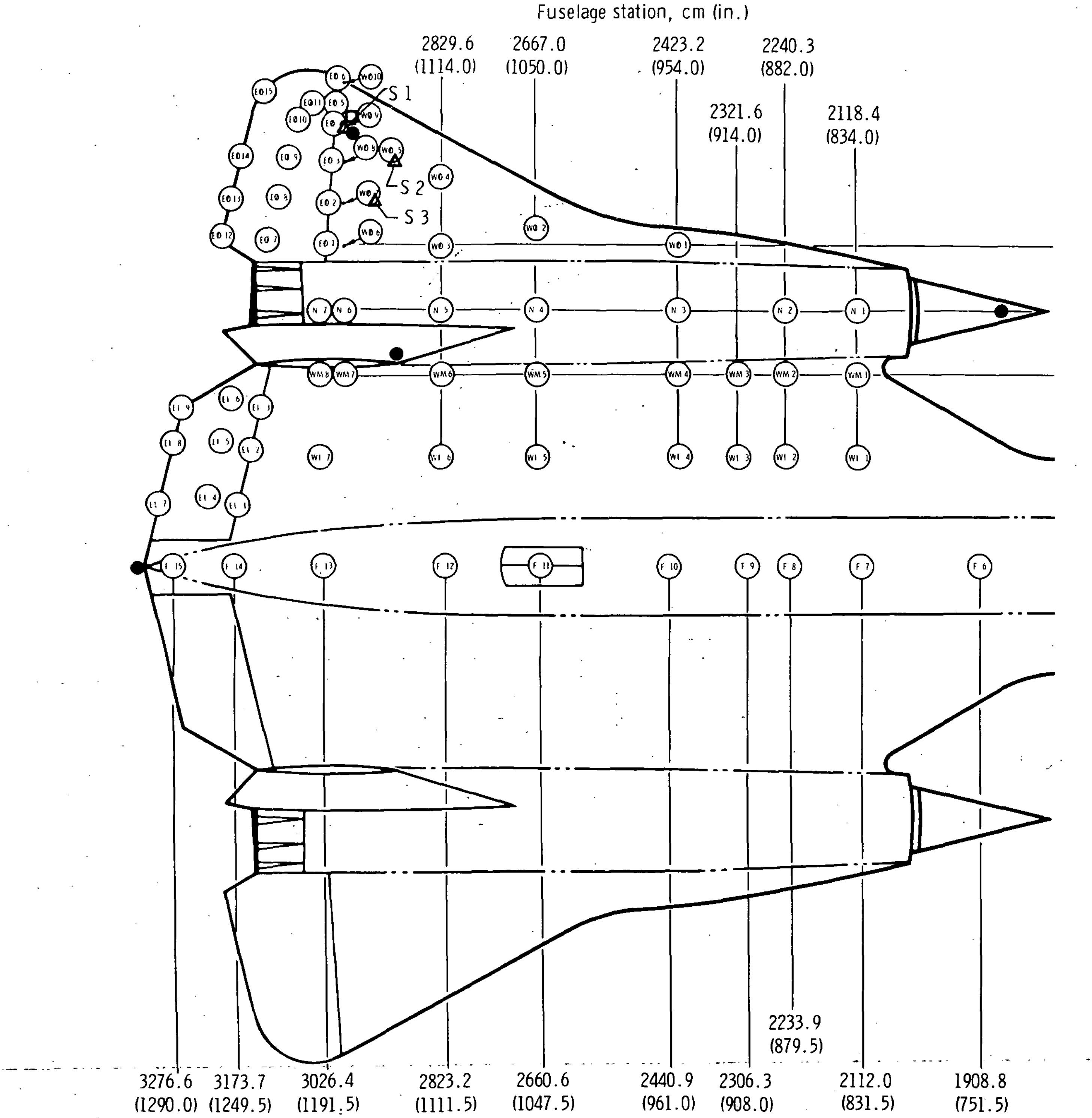
(a) Plan and side views.

Figure 4. Landing gear support system for the ground vibration tests.



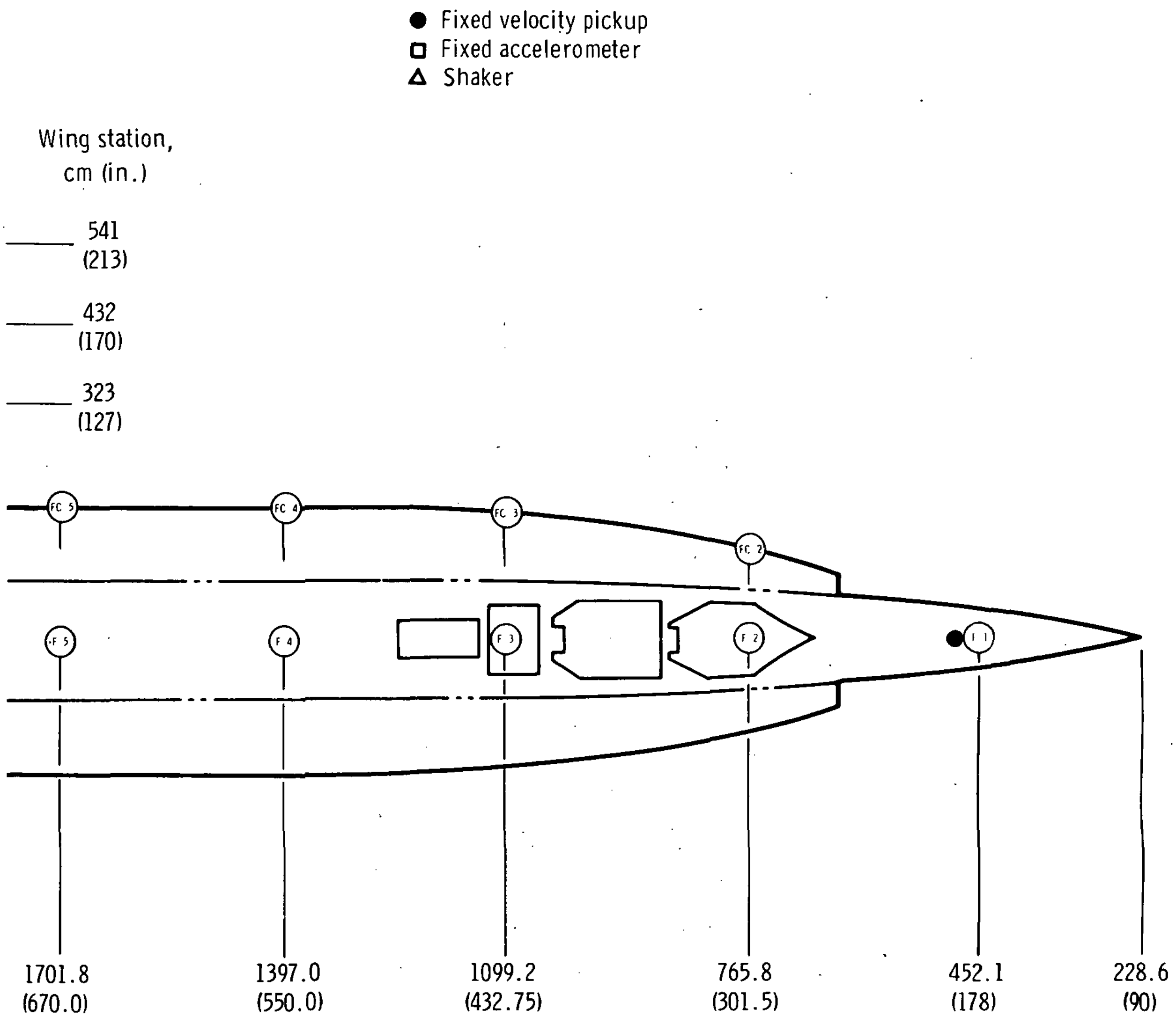
(b) Detail view.

Figure 4. Concluded.



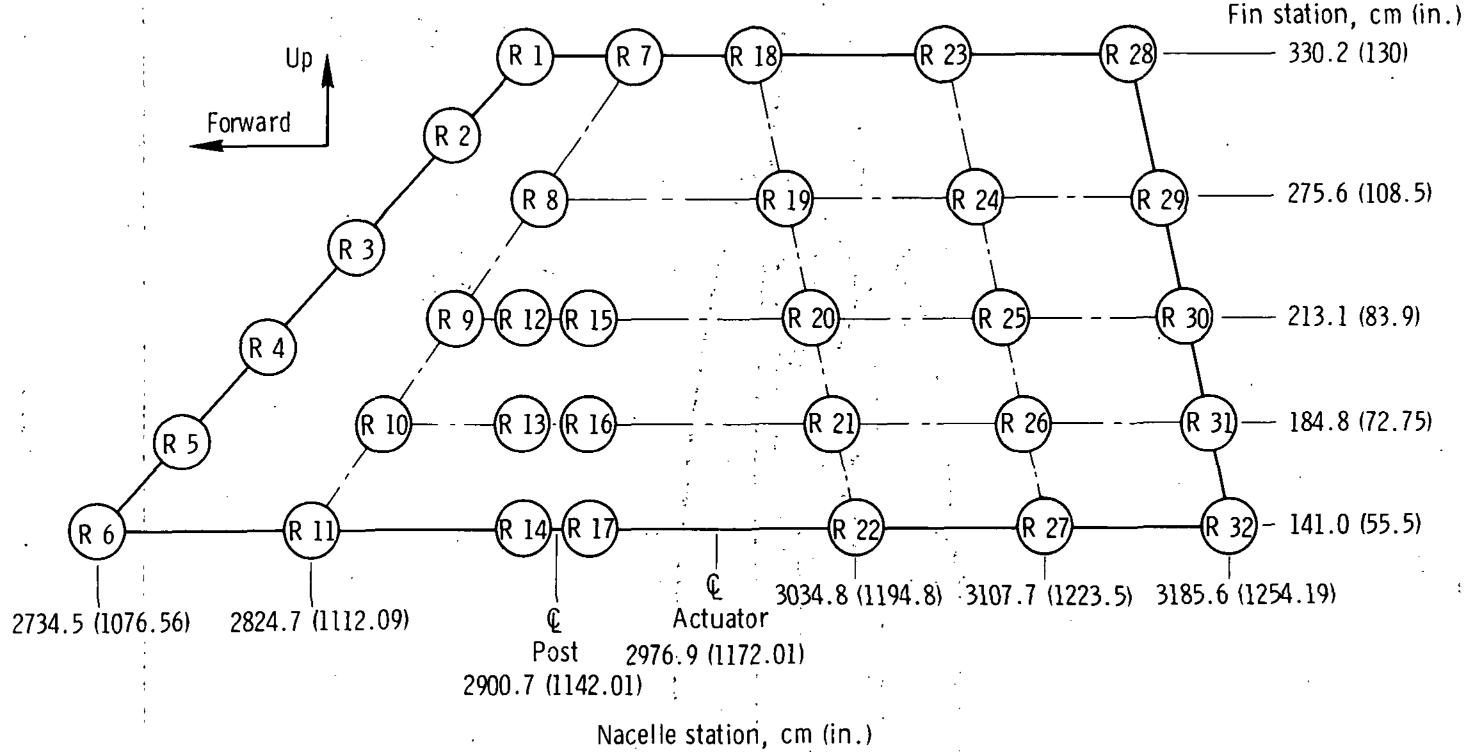
(a) Wing/body.

Figure 5. Test points for YF-12 ground vibration survey (shown for one side only).



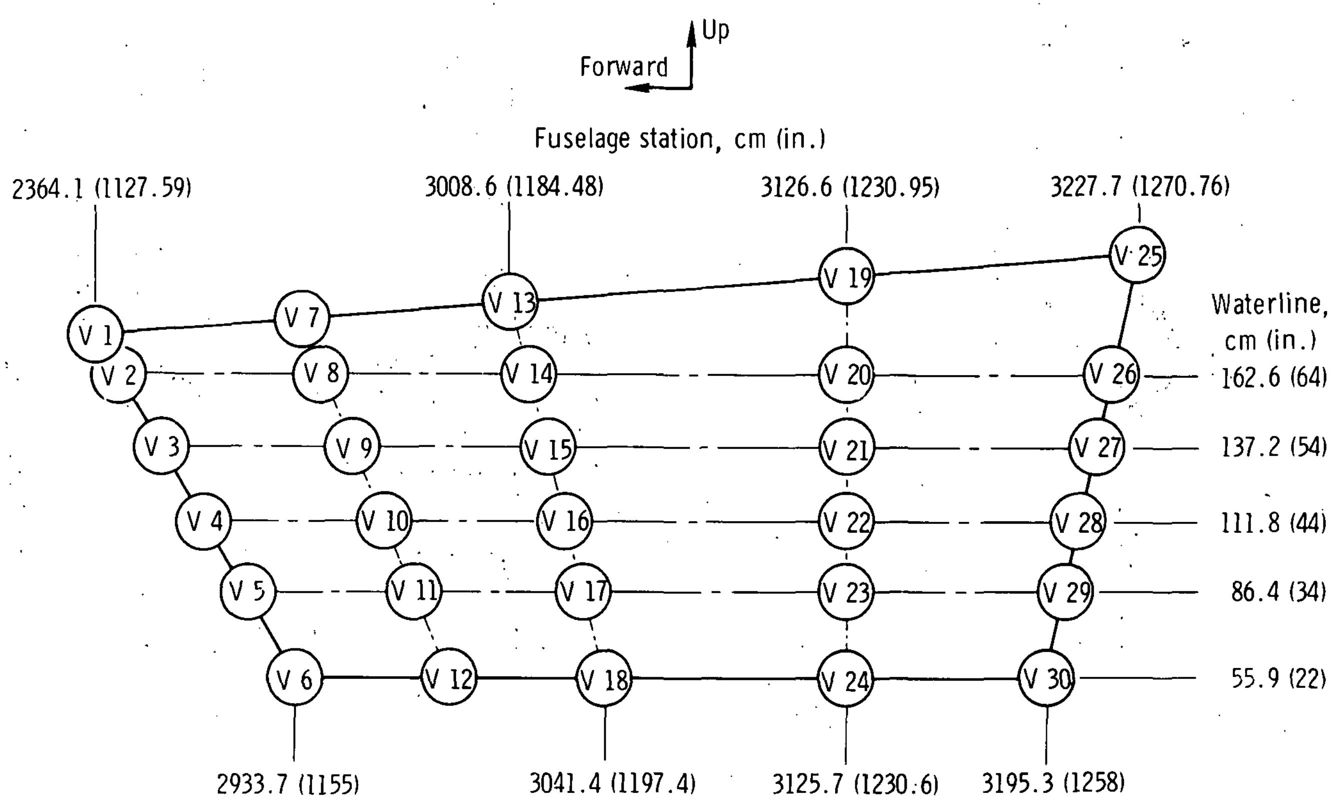
(a) Concluded.

Figure 5. Continued.



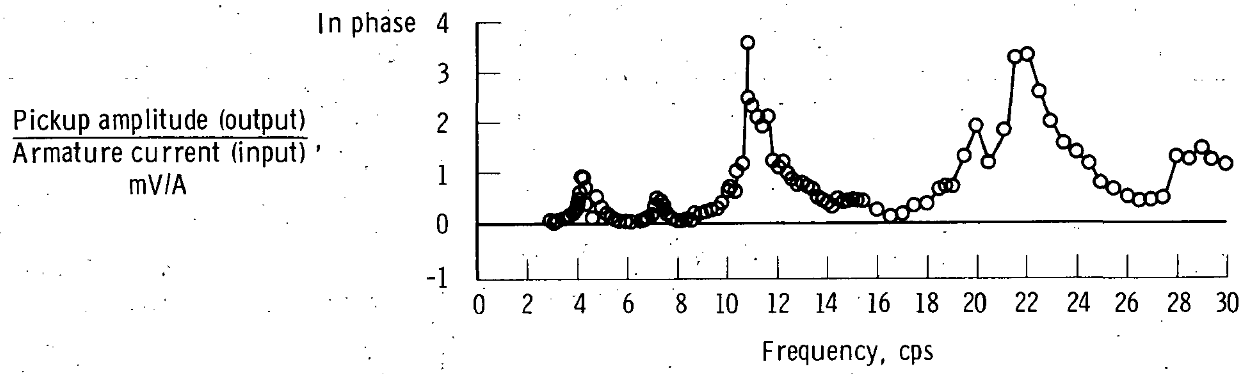
(b) Rudder.

Figure 5. Continued.

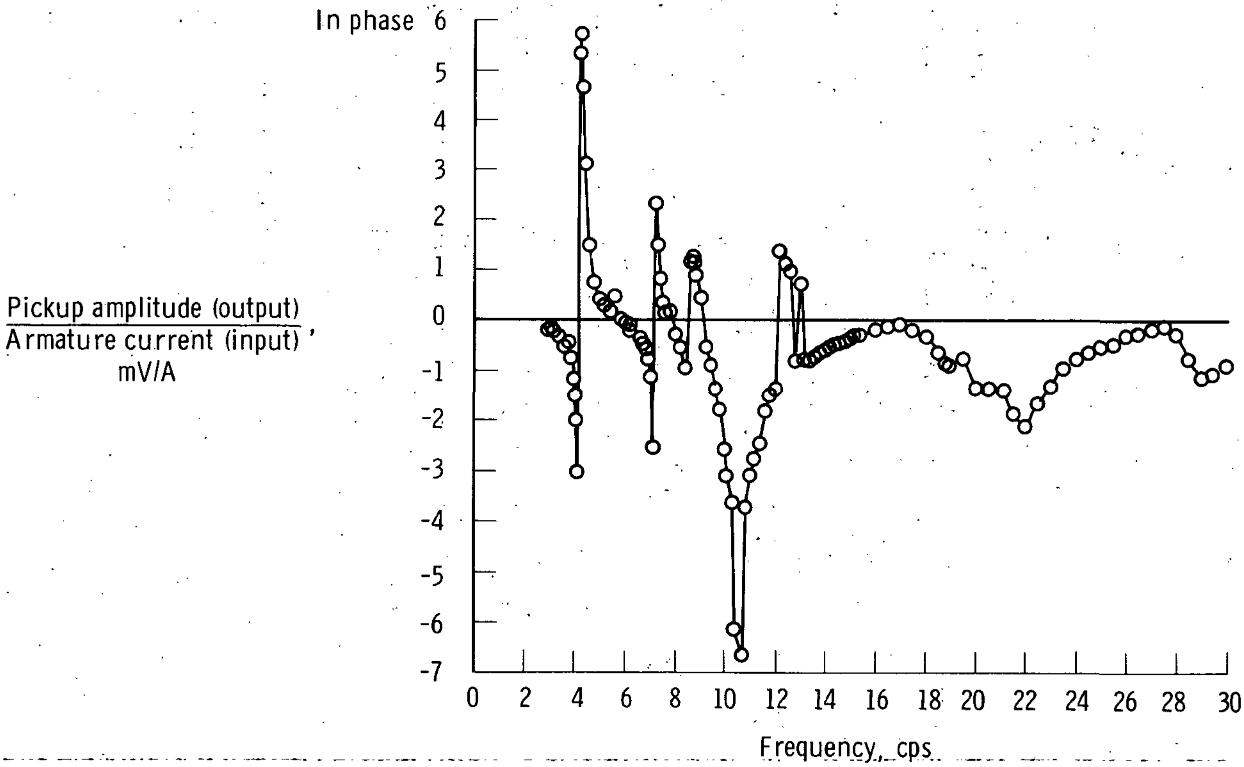


(c) Fuselage ventral fin.

Figure 5. Concluded.

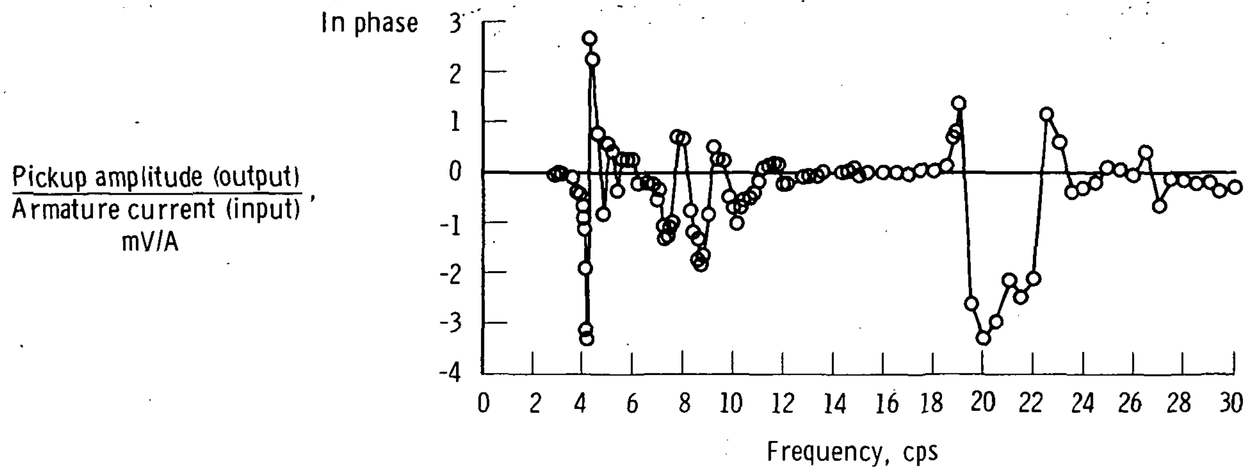


(a) Left wing.

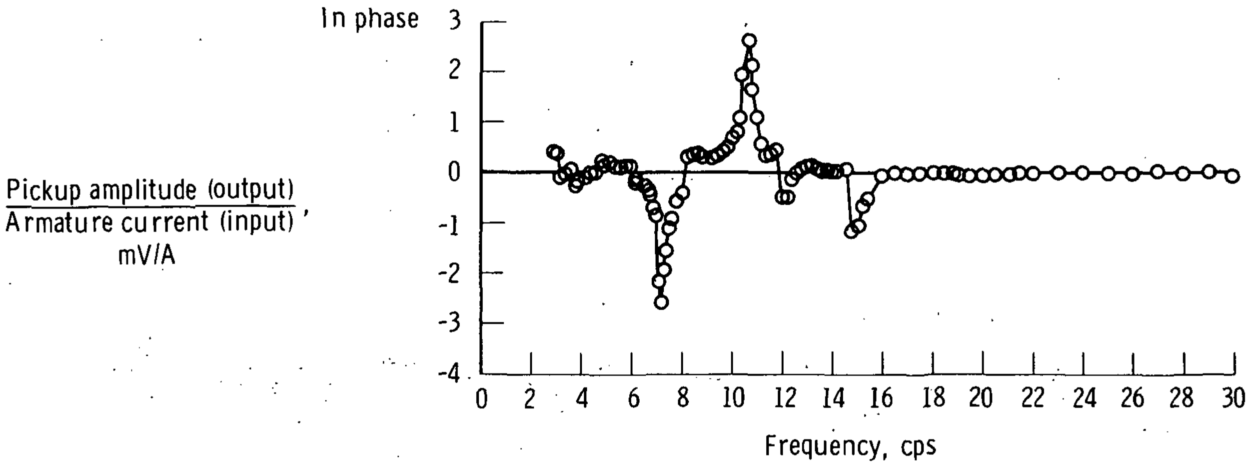


(b) Right wing.

Figure 6. Frequency response curve. Symmetrical excitation.

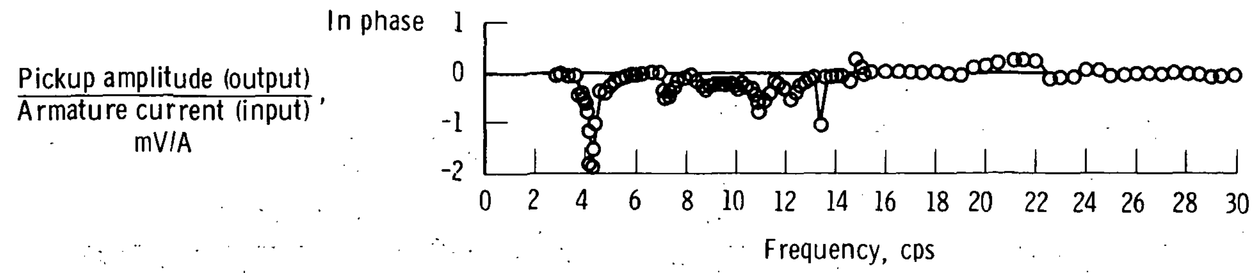


(c) Rudder.

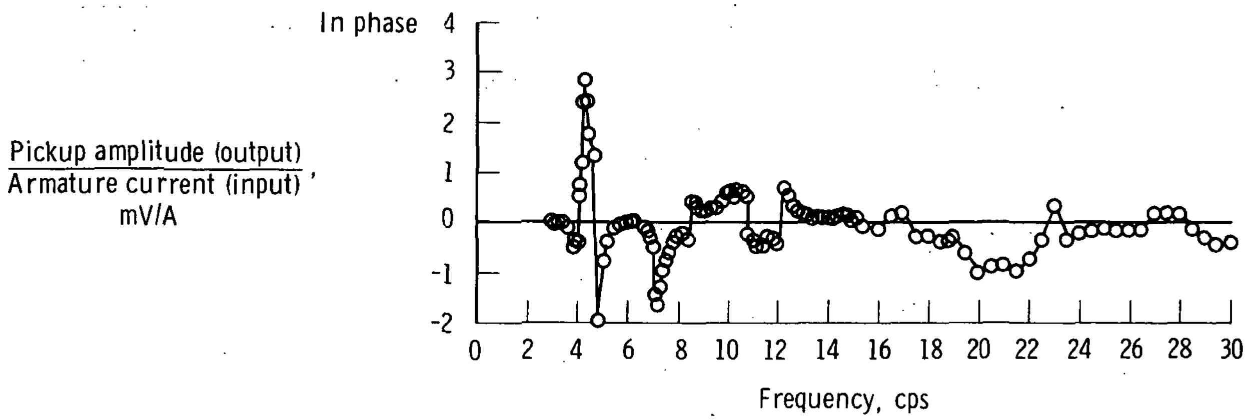


(d) F.S. 452 cm (F.S. 178 in.).

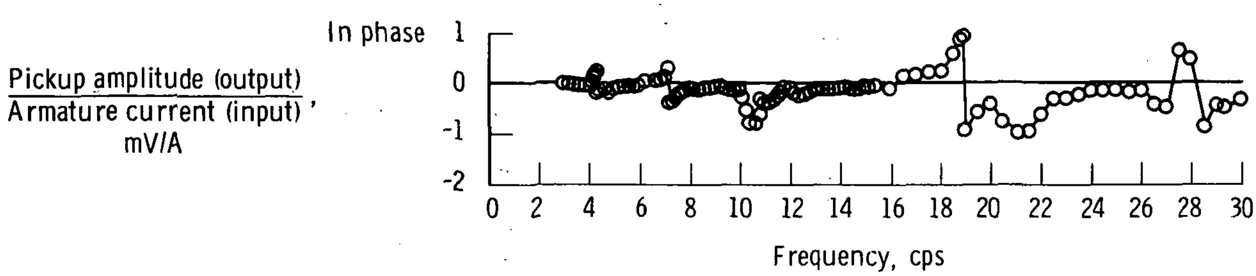
Figure 6. Continued.



(e) F.S. 3175 cm (F.S. 1250 in.).

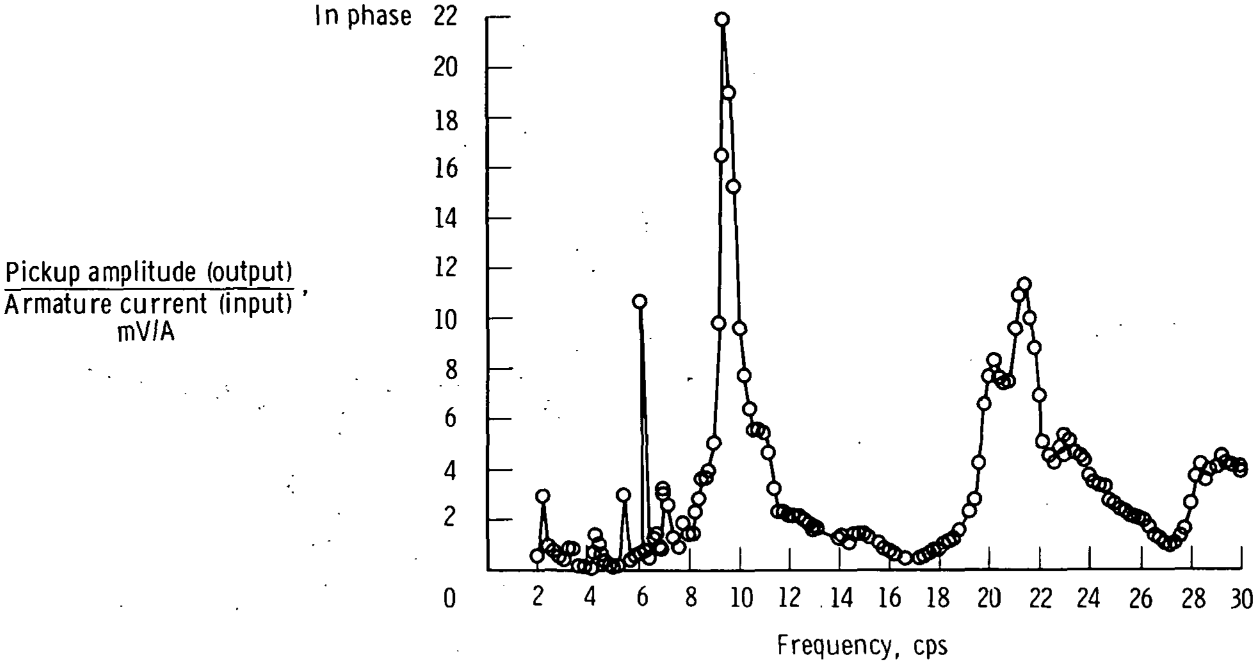


(f) Left inlet spike.

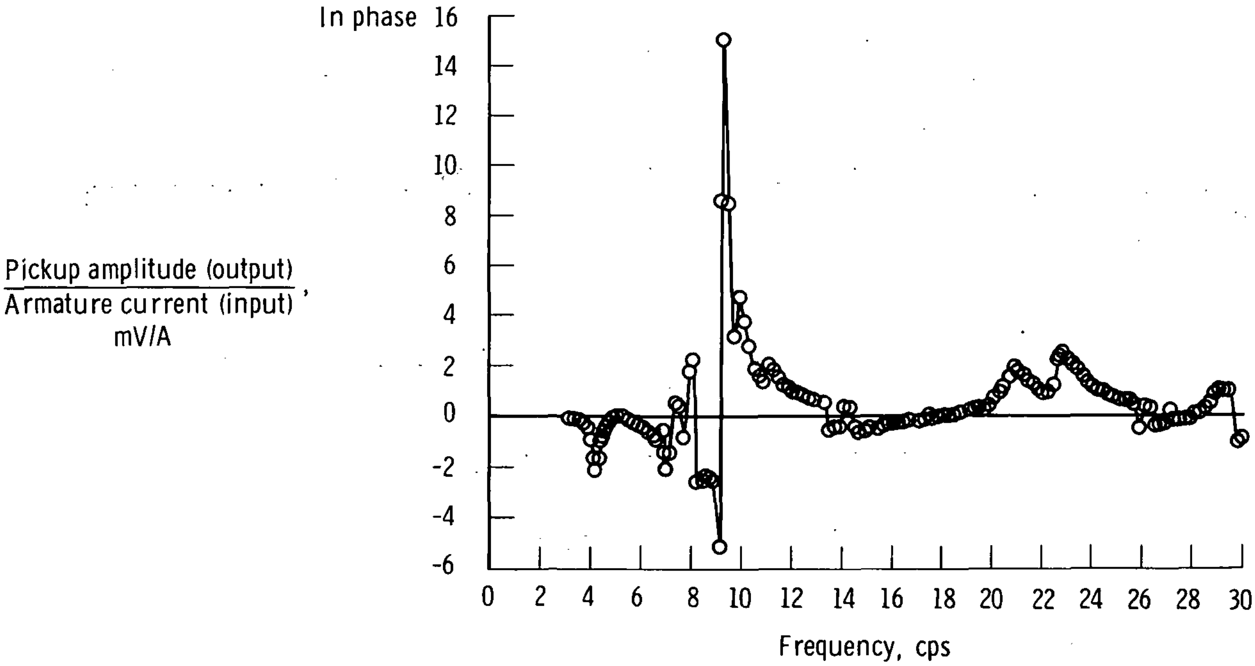


(g) Right inlet spike.

Figure 6. Concluded.

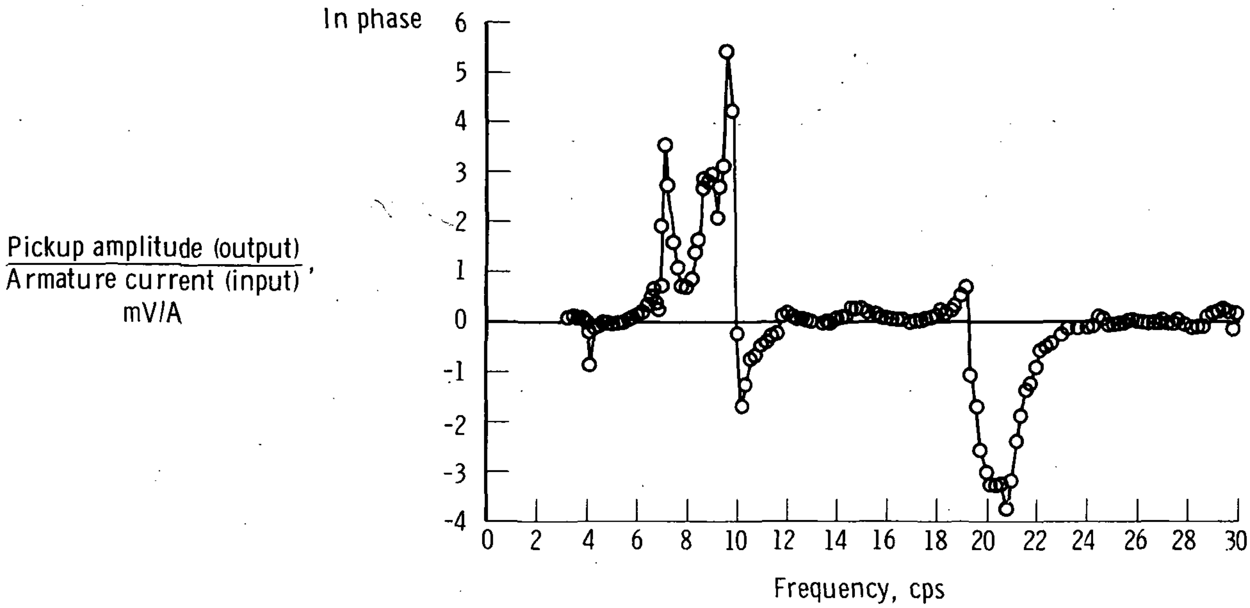


(a) Left wing.

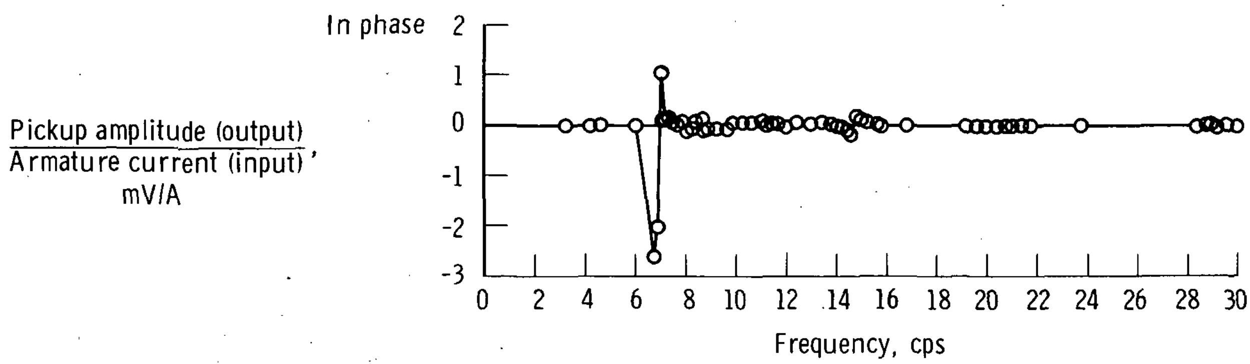


(b) Right wing.

Figure 7. Frequency response curve. Antisymmetrical excitation.

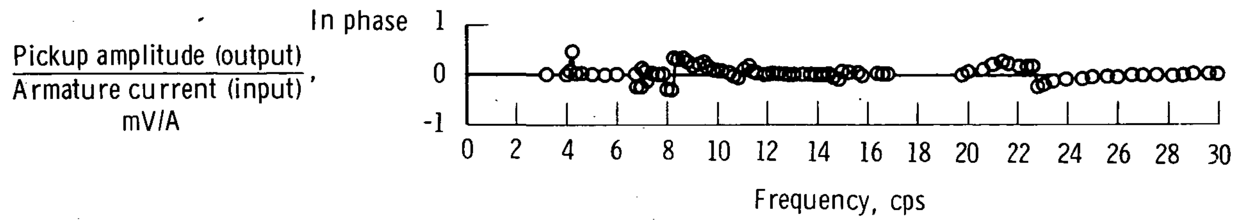


(c) Rudder.

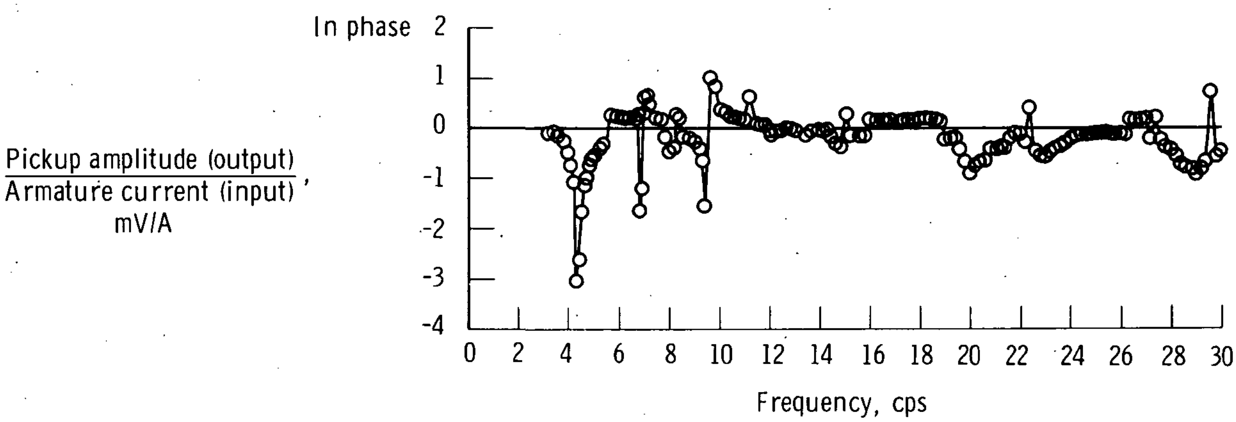


(d) F.S. 452 cm (F.S. 178 in.).

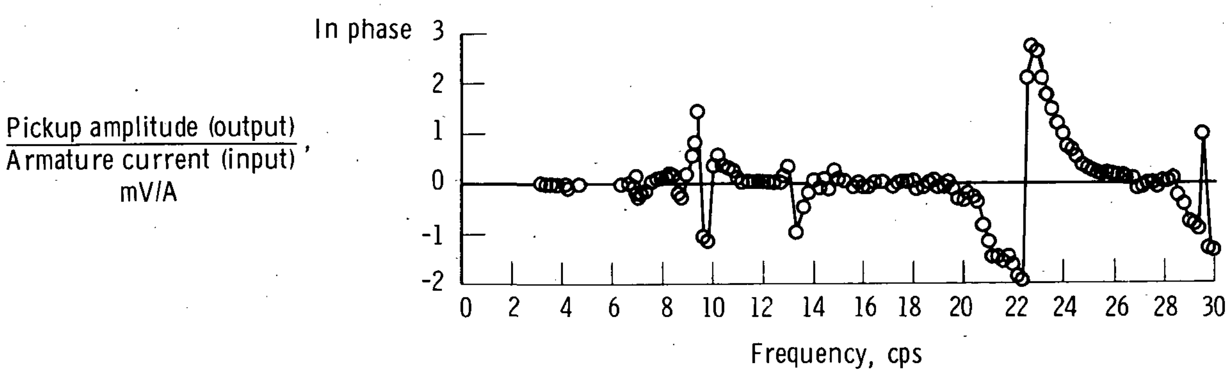
Figure 7. Continued.



(e) F.S. 3175 cm (F.S. 1250 in.).

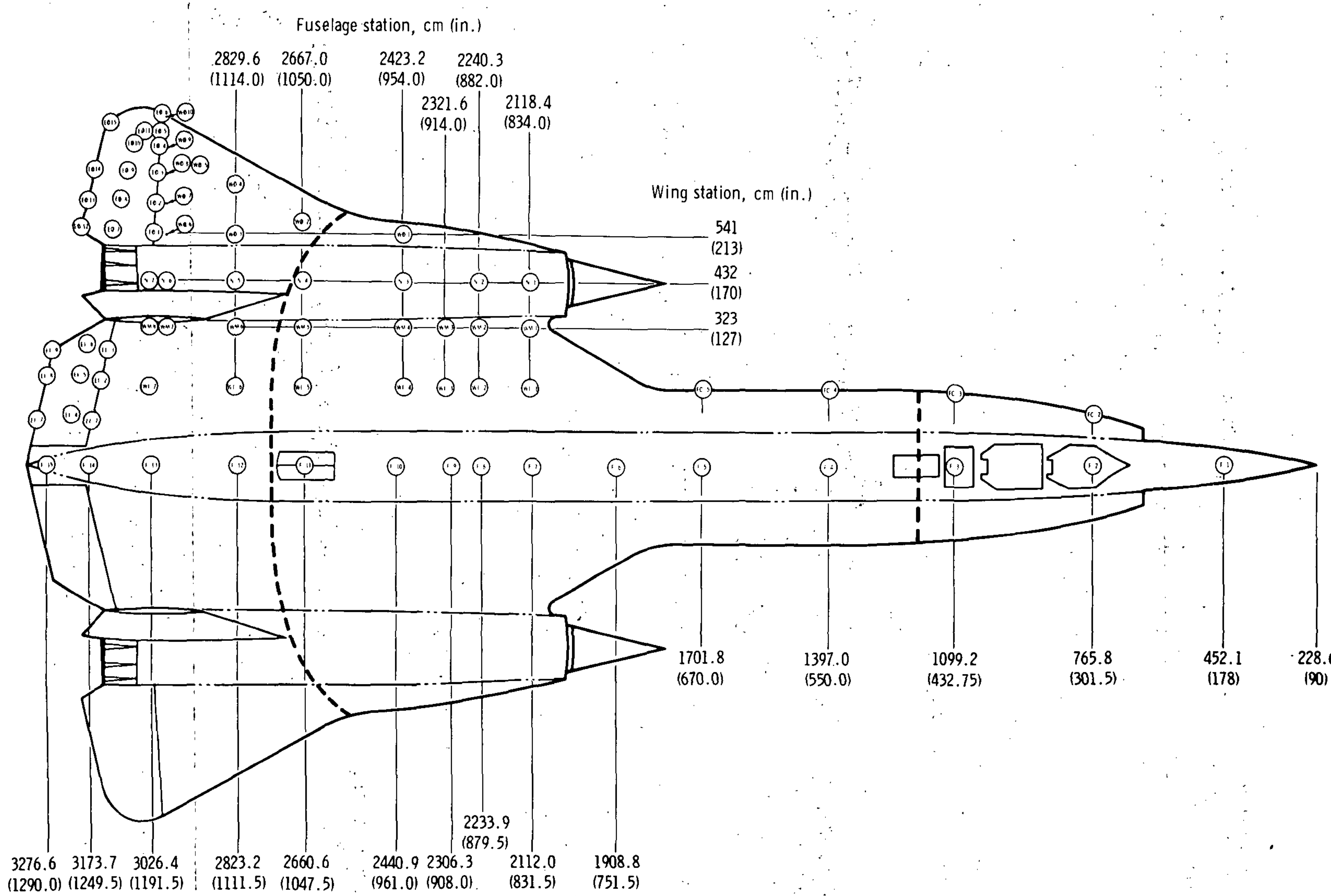


(f) Left inlet spike.



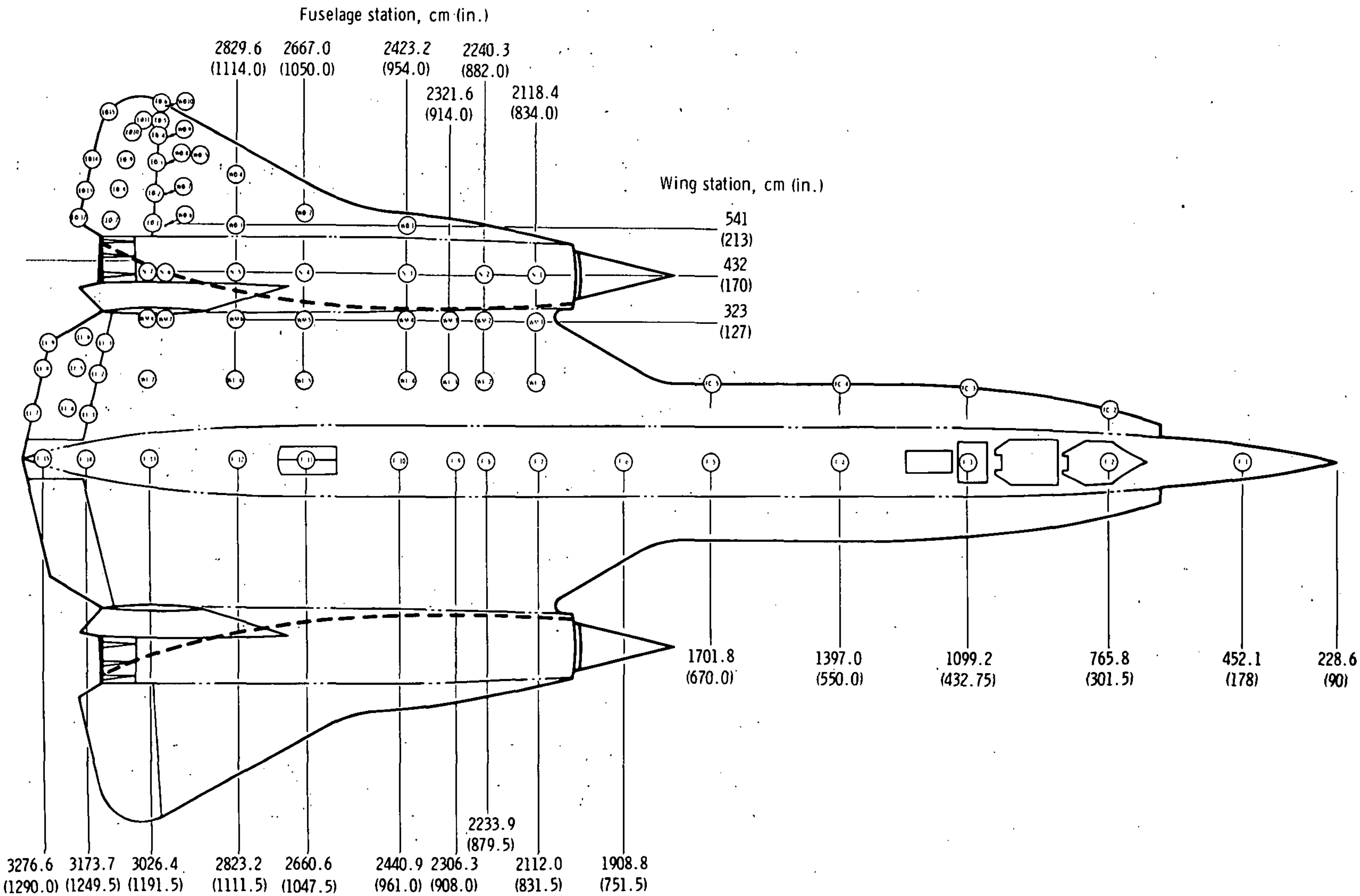
(g) Right inlet spike.

Figure 7. Concluded.



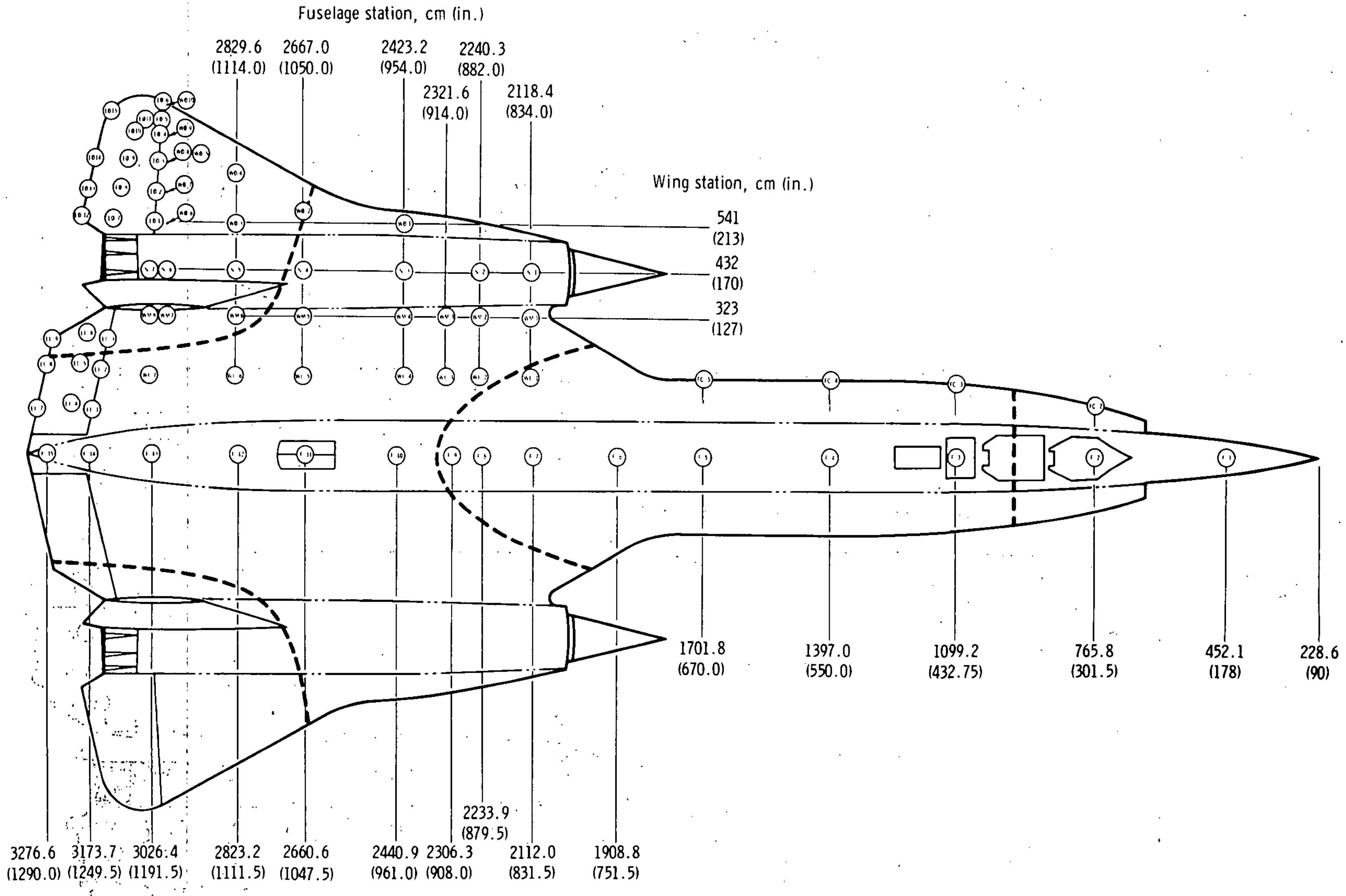
(a) 3.4 cps.

Figure 8. Node lines measured for the symmetrical elastic modes.



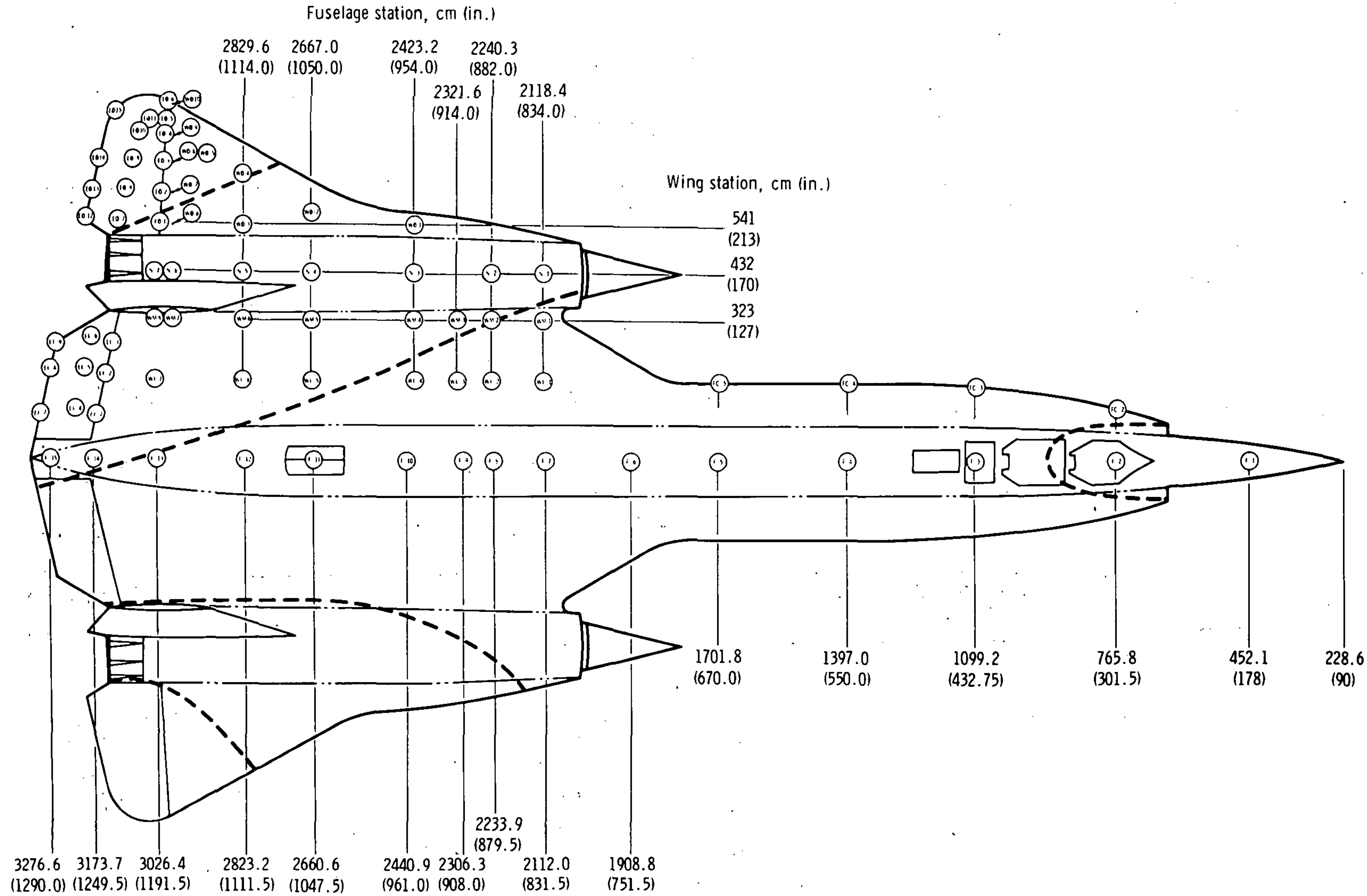
(b) 4.1 cps.

Figure 8. Continued.



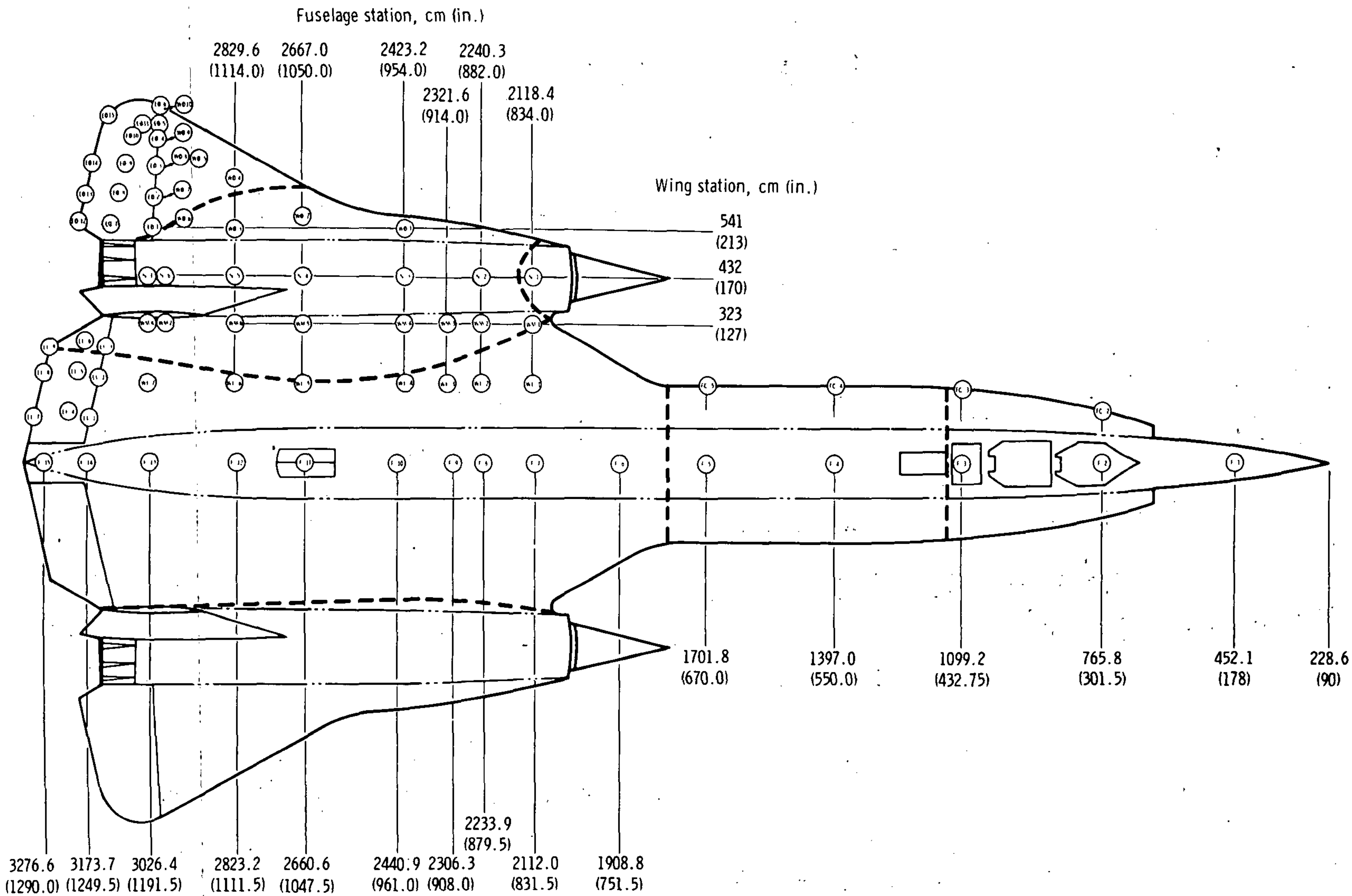
(c) 6.7 cps.

Figure 8. Continued.



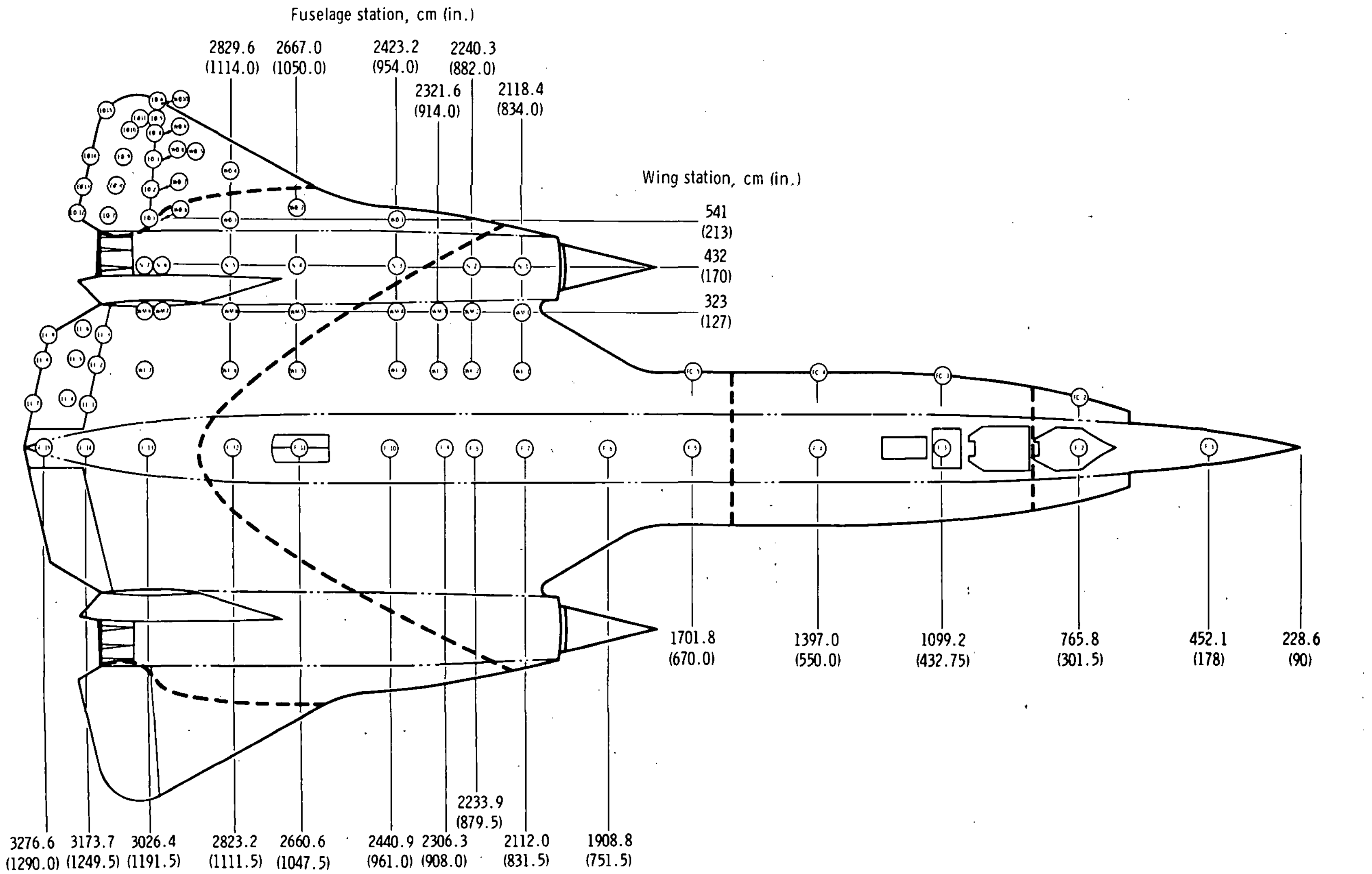
(d) 8.1 cps.

Figure 8. Continued.



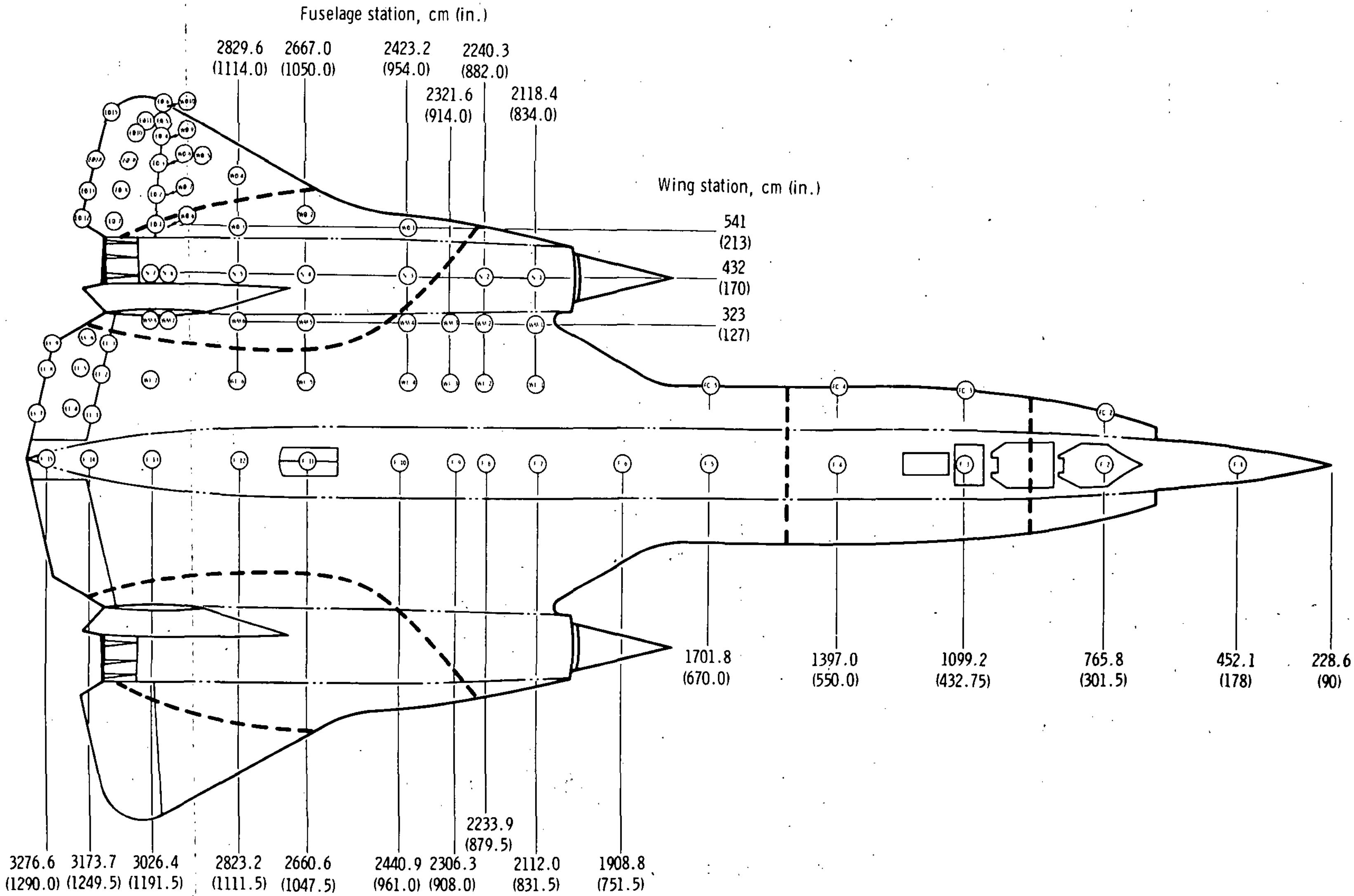
(e) 8.7 cps.

Figure 8. Continued.



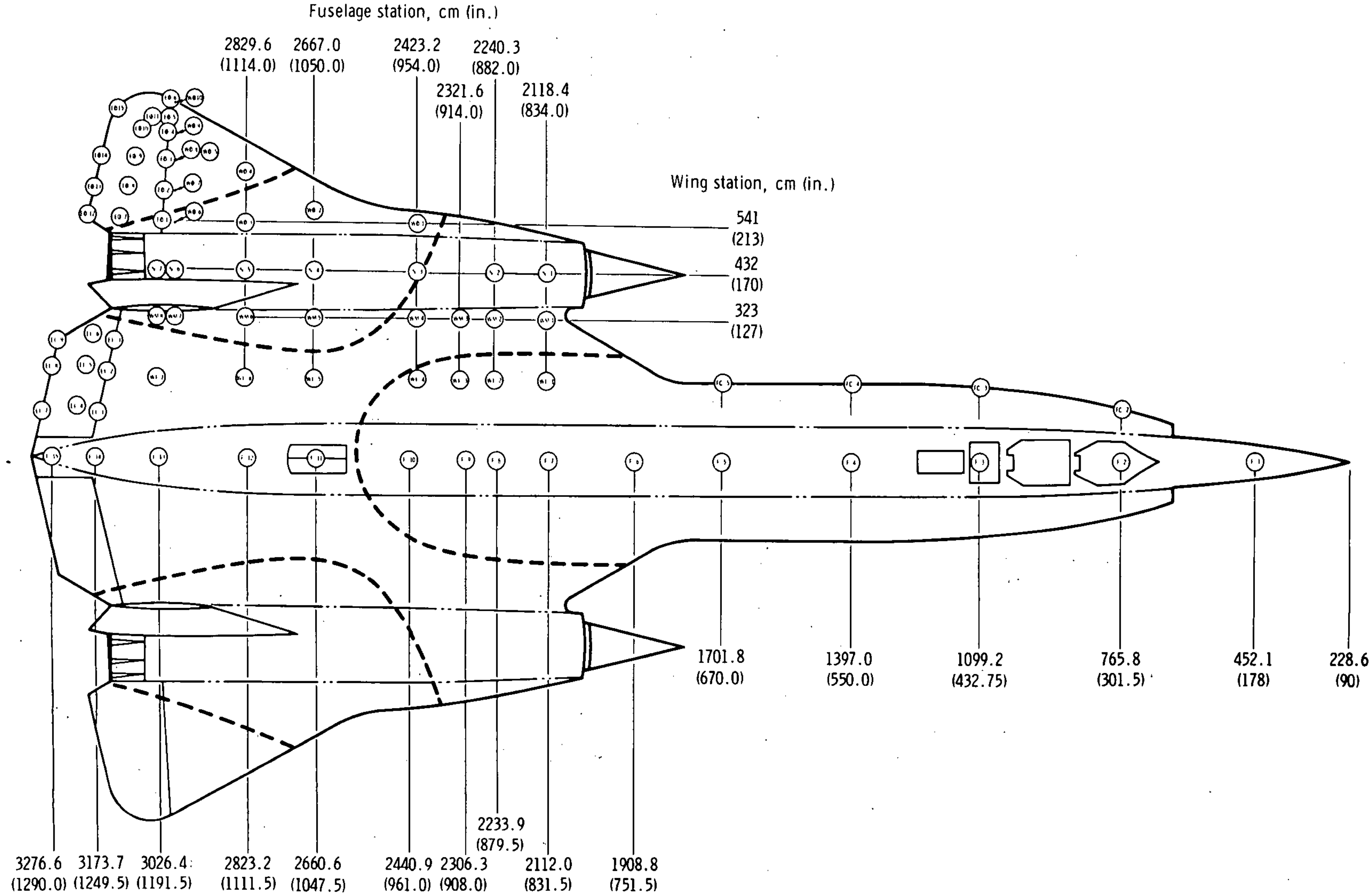
(f) 10.5 cps.

Figure 8. Continued.



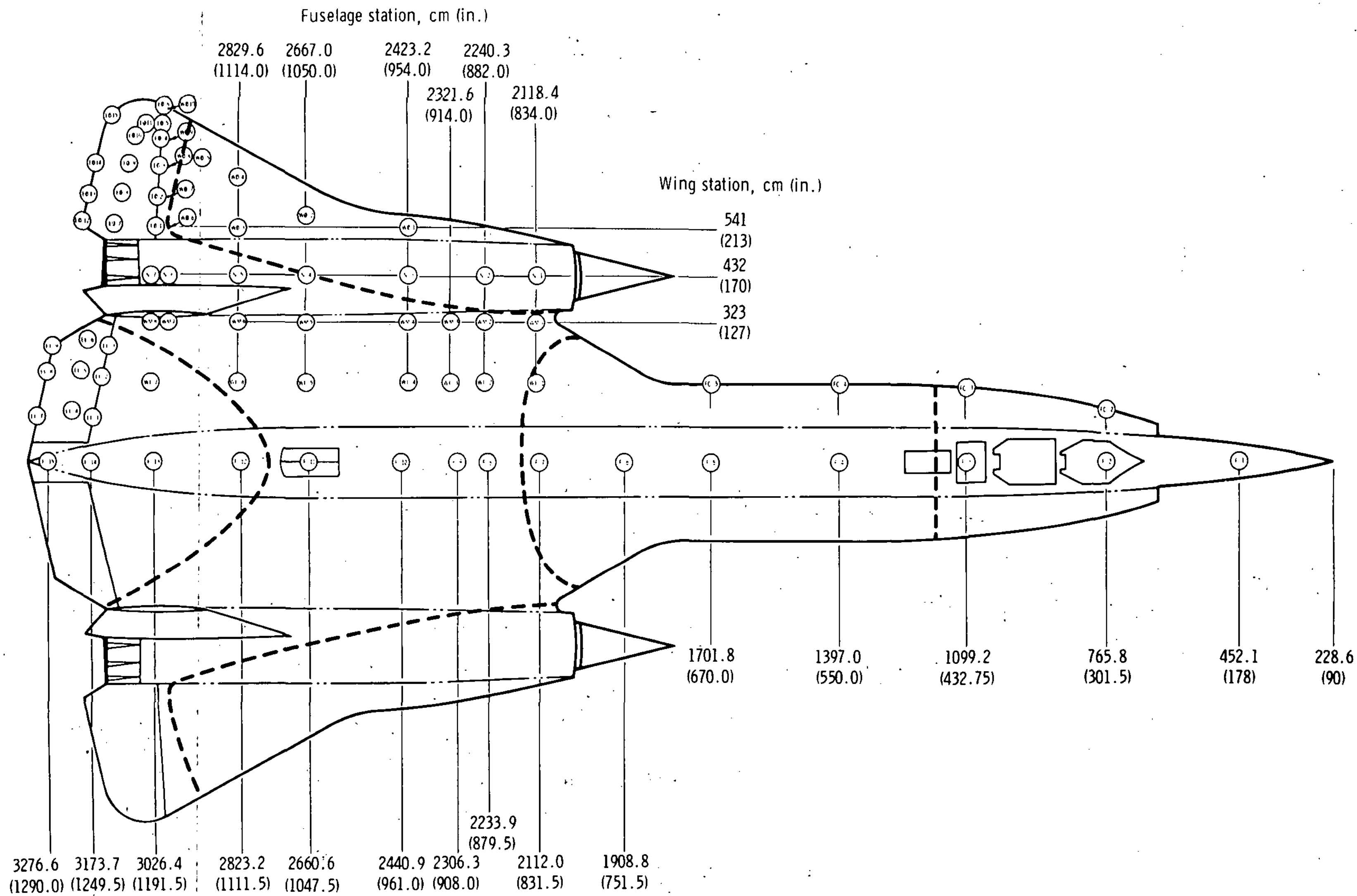
(g) 11.1 cps.

Figure 8. Continued.



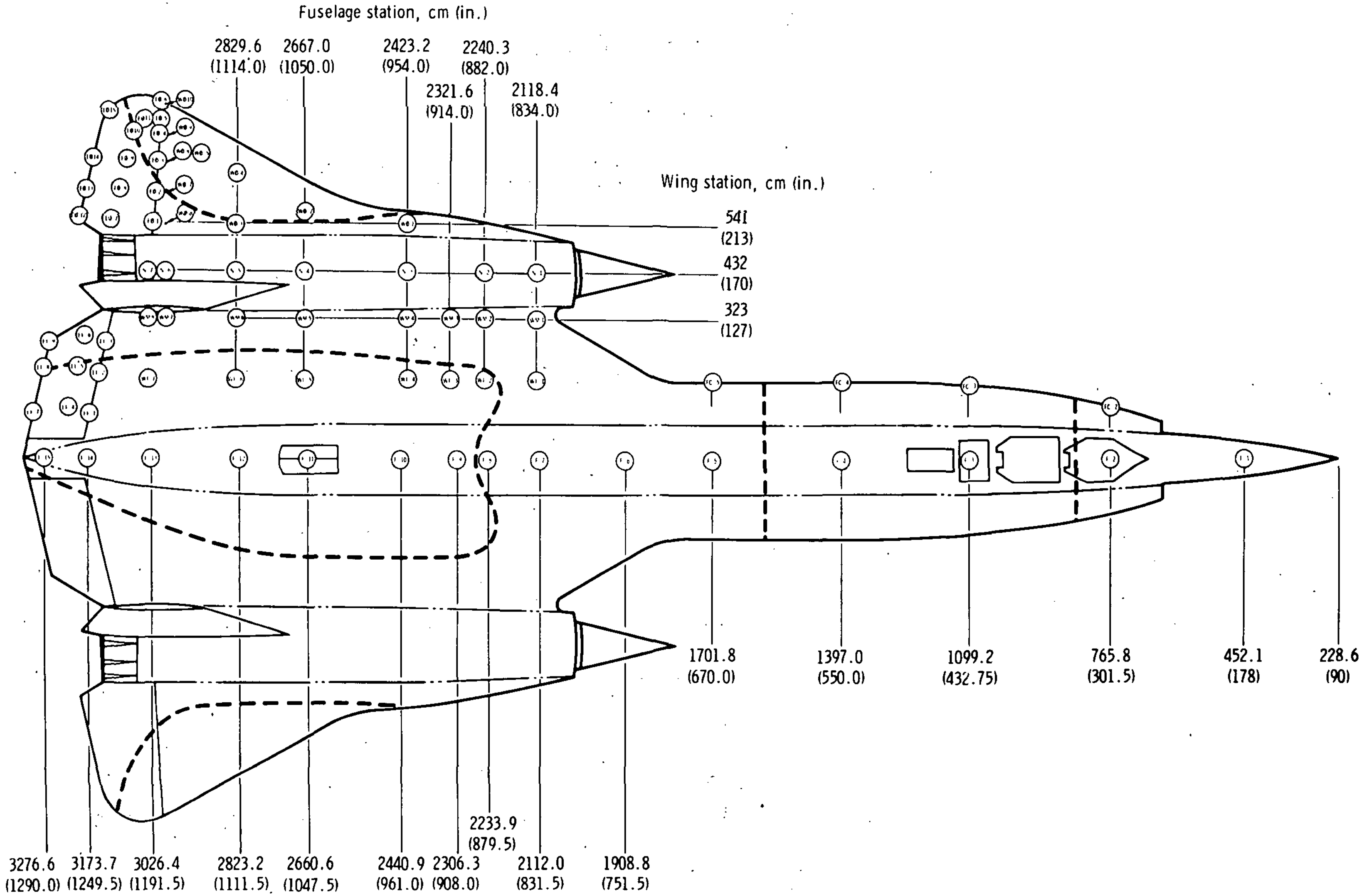
(h) 12.2 cps.

Figure 8. Continued.



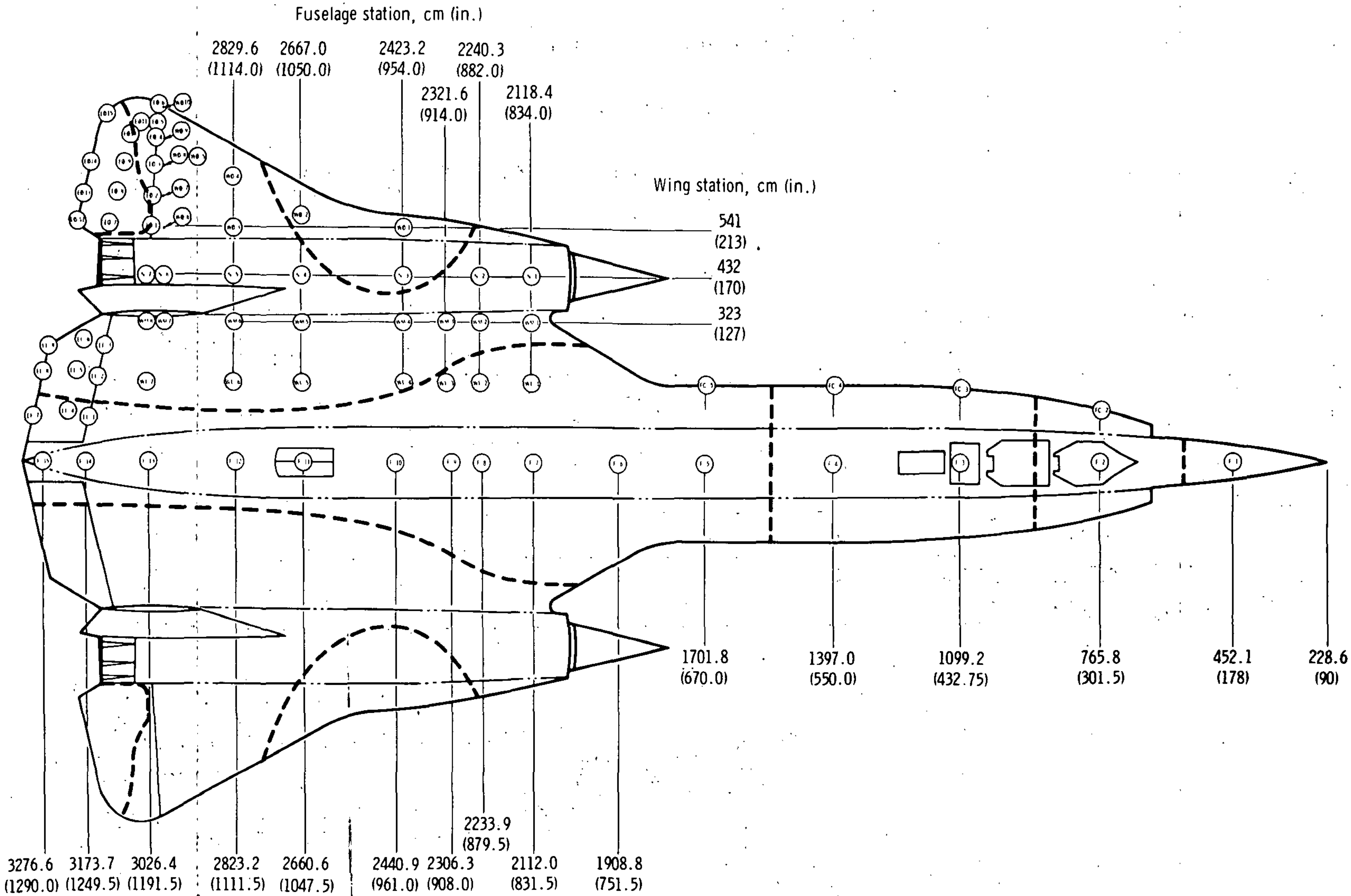
(i) 14.7 cps.

Figure 8. Continued.



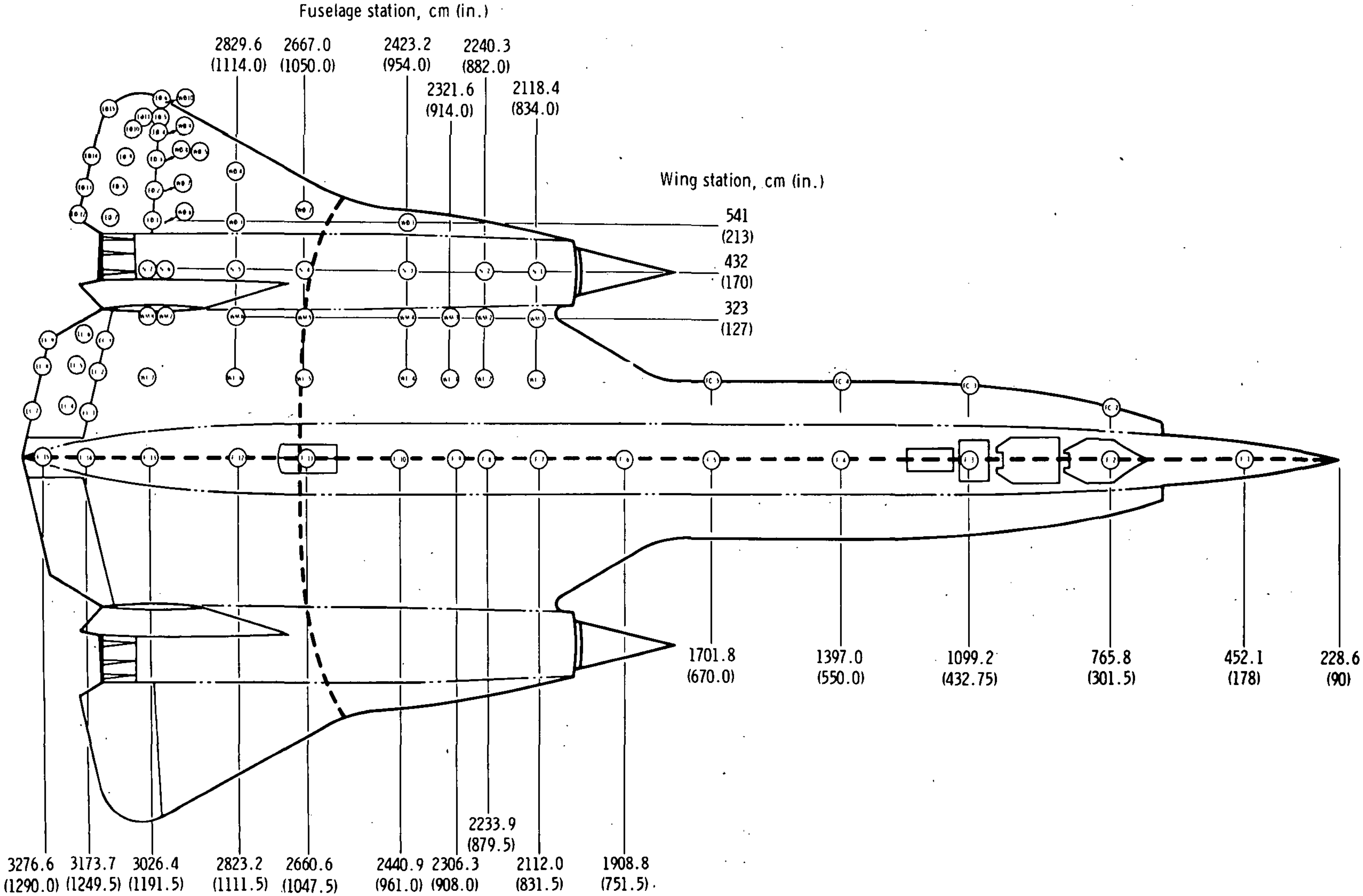
(j) 20.2 cps.

Figure 8. Continued.



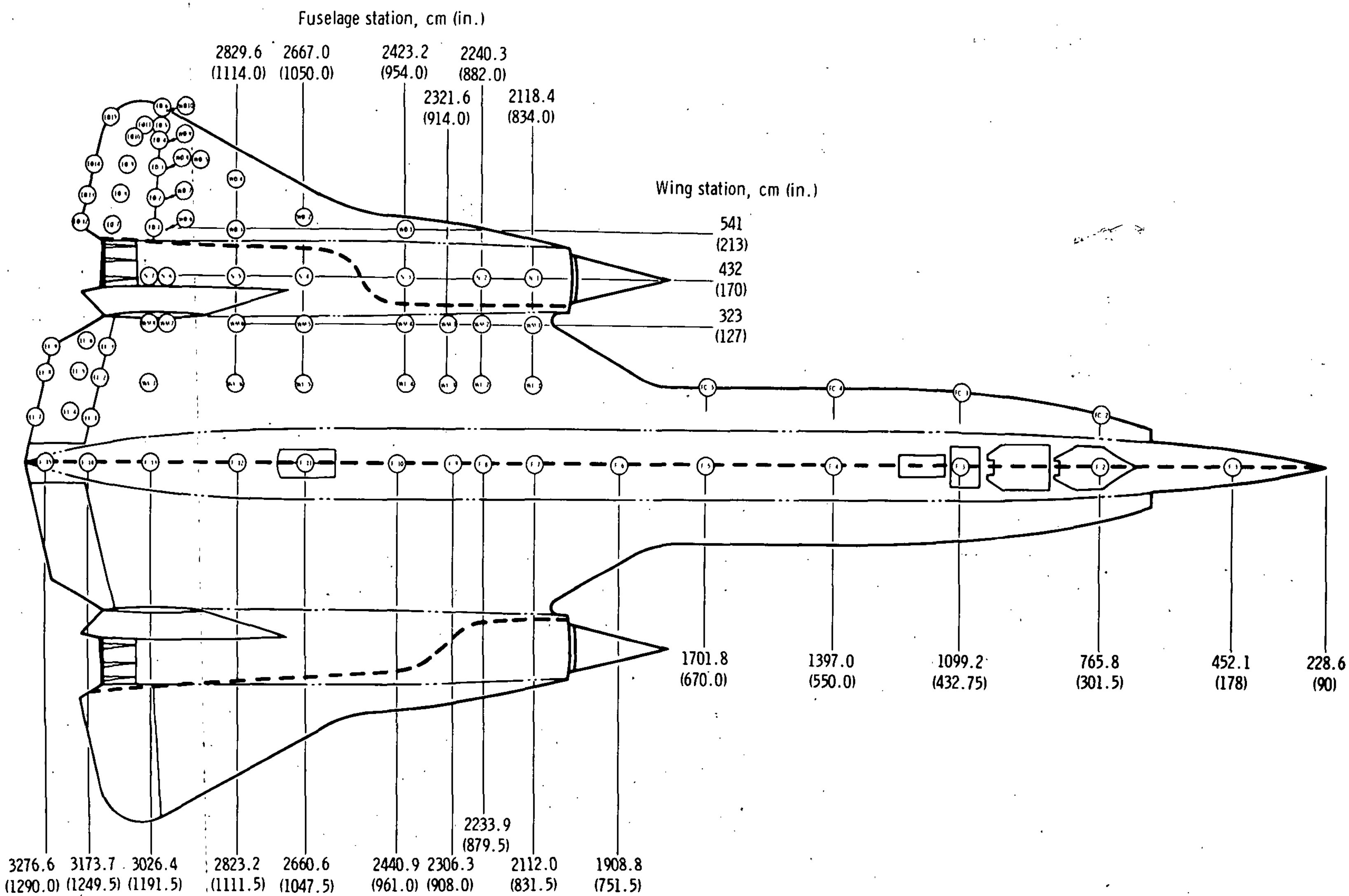
(k) 22.0 cps.

Figure 8. Concluded.



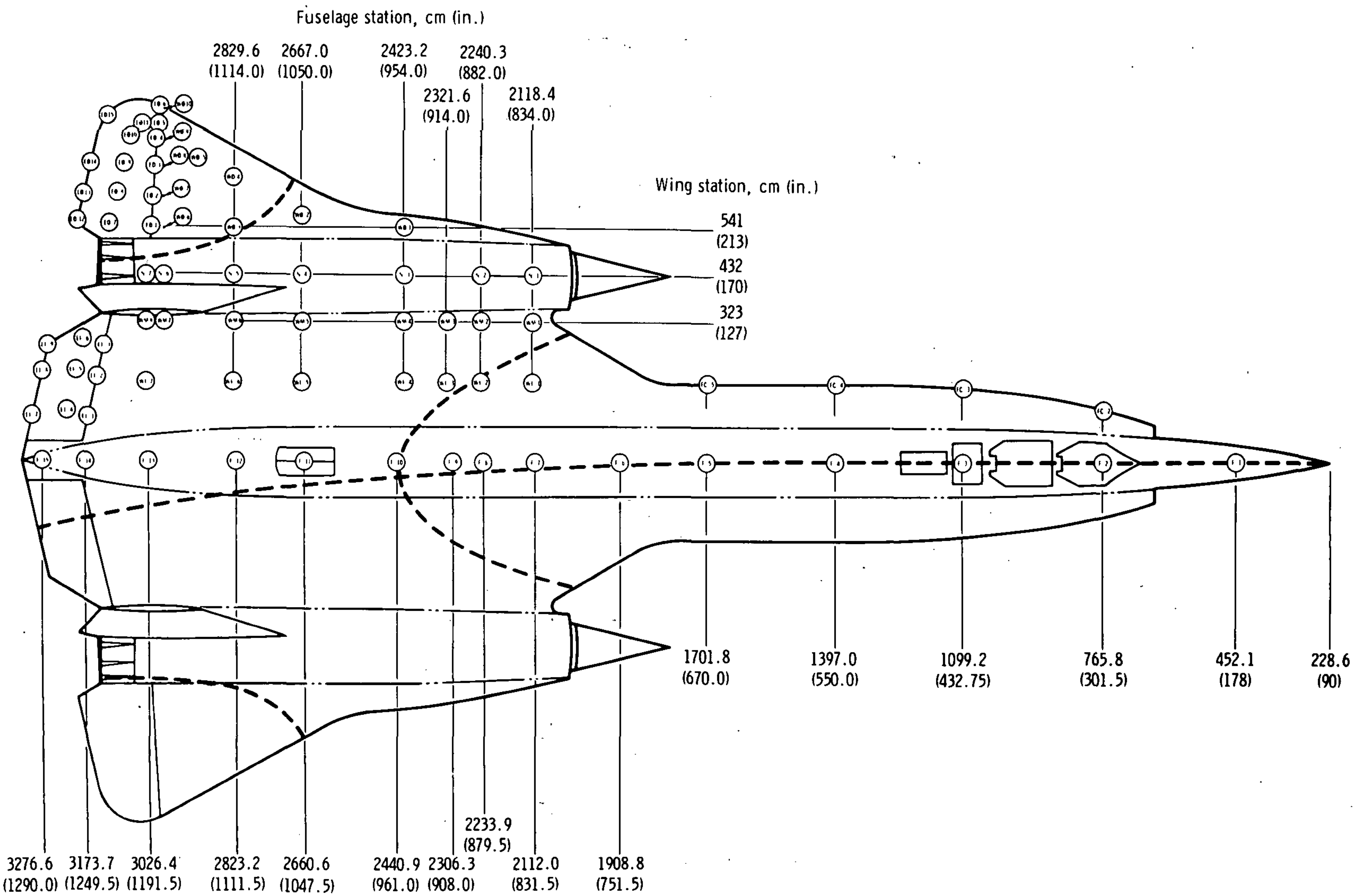
(a) 4.3 cps.

Figure 9. Node lines measured for the antisymmetrical elastic modes.



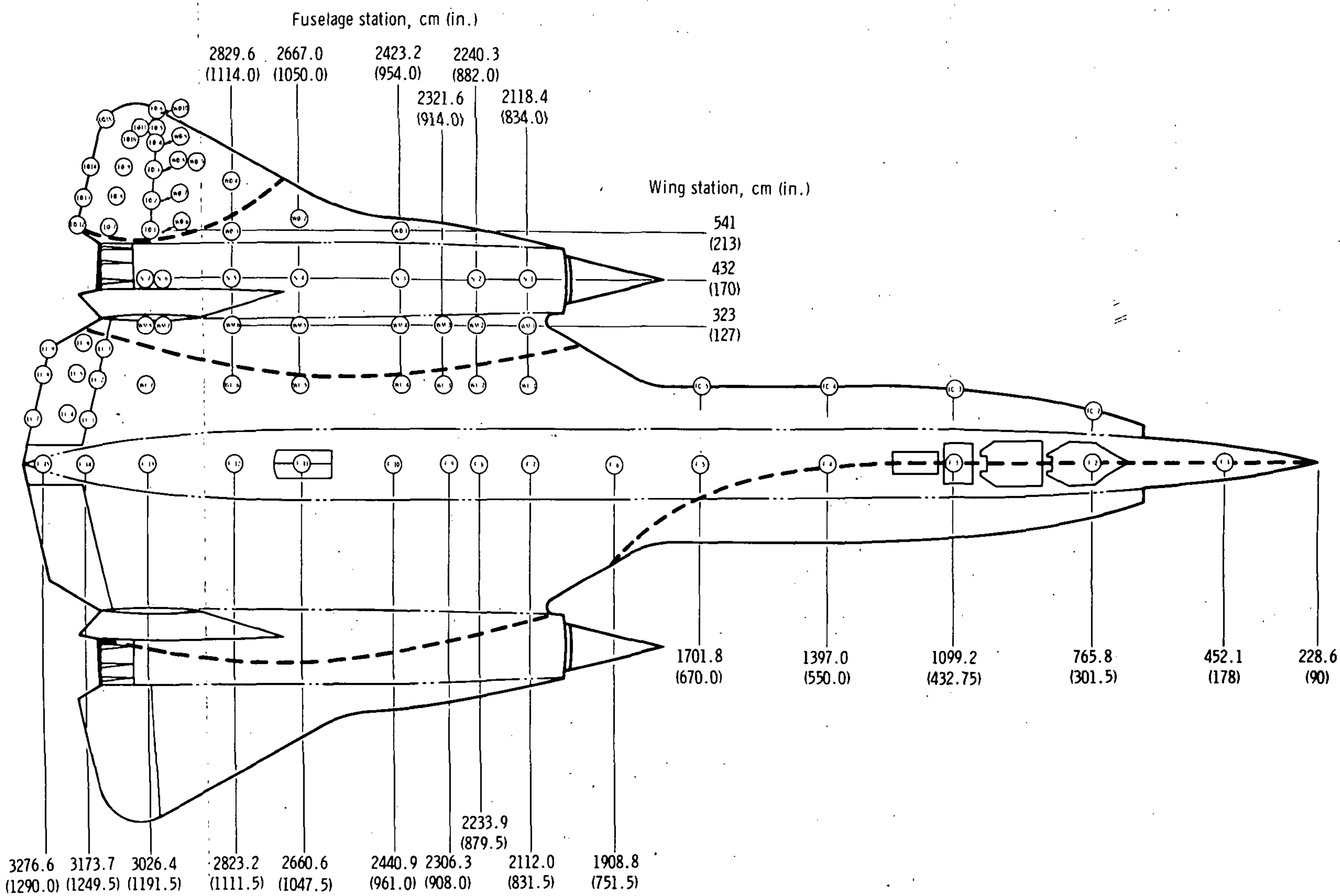
(b) 7.1 cps.

Figure 9. Continued.



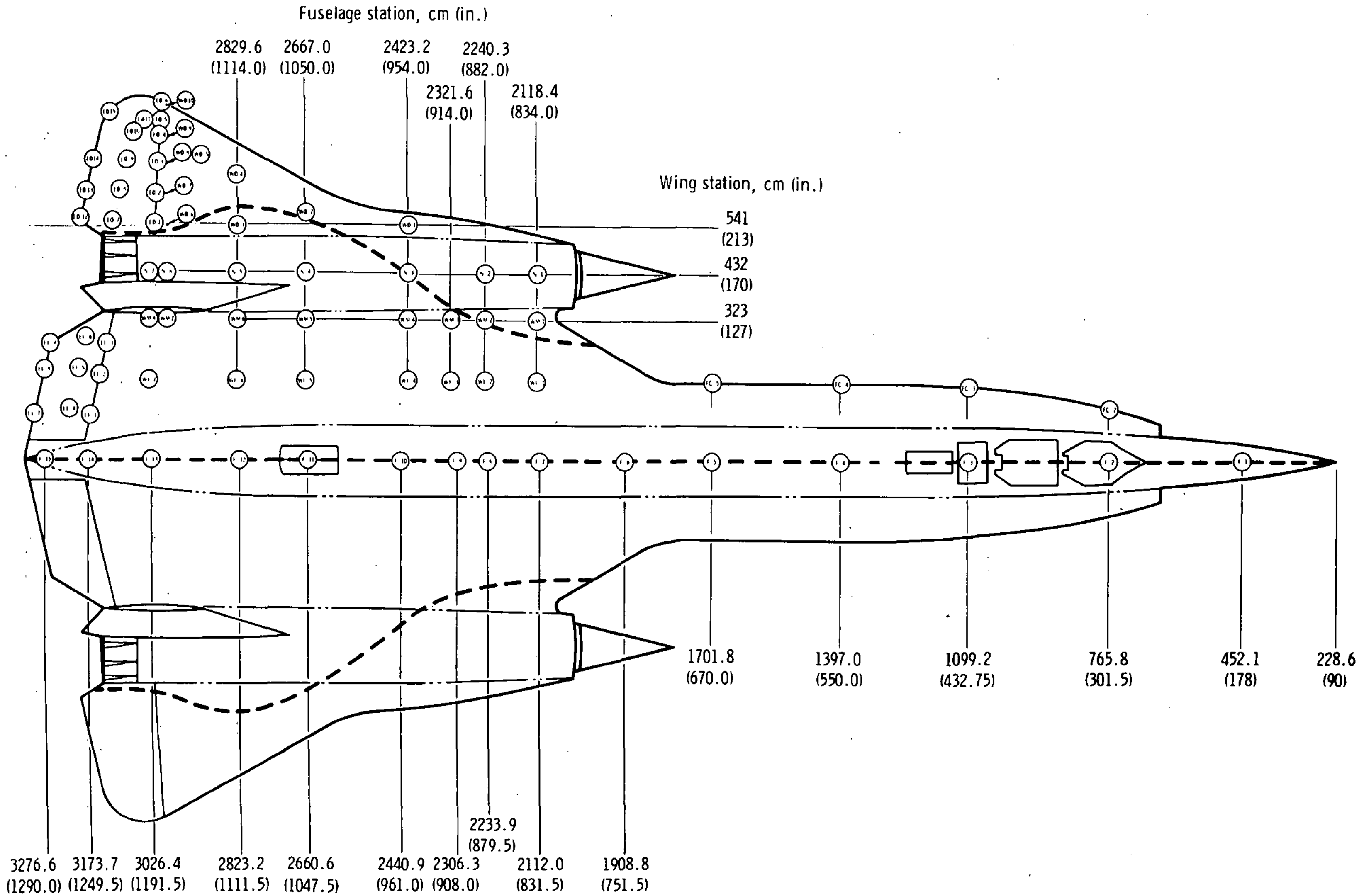
(c) 8.2 cps.

Figure 9. Continued.



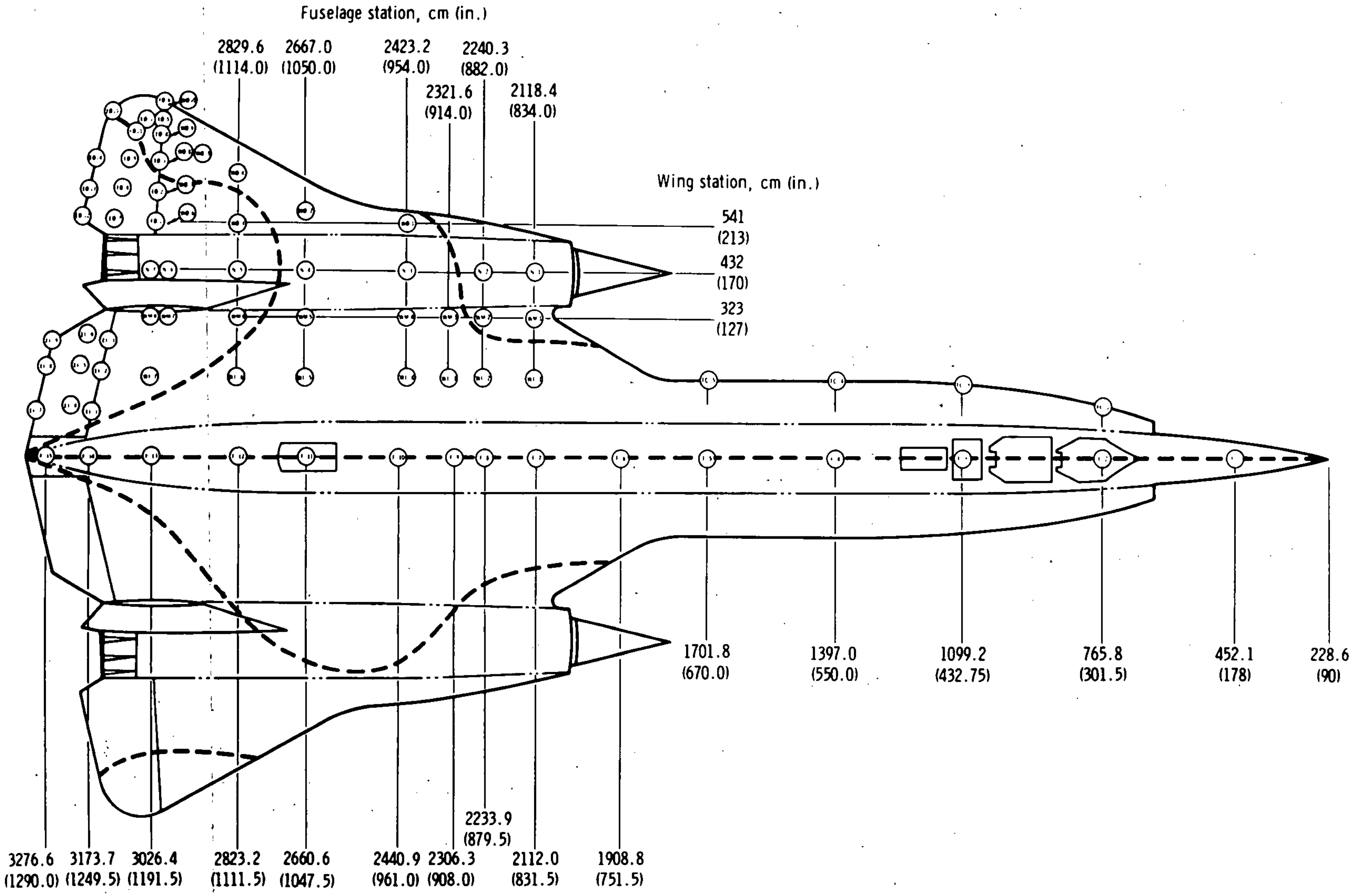
(d) 8.7 cps.

Figure 9. Continued.



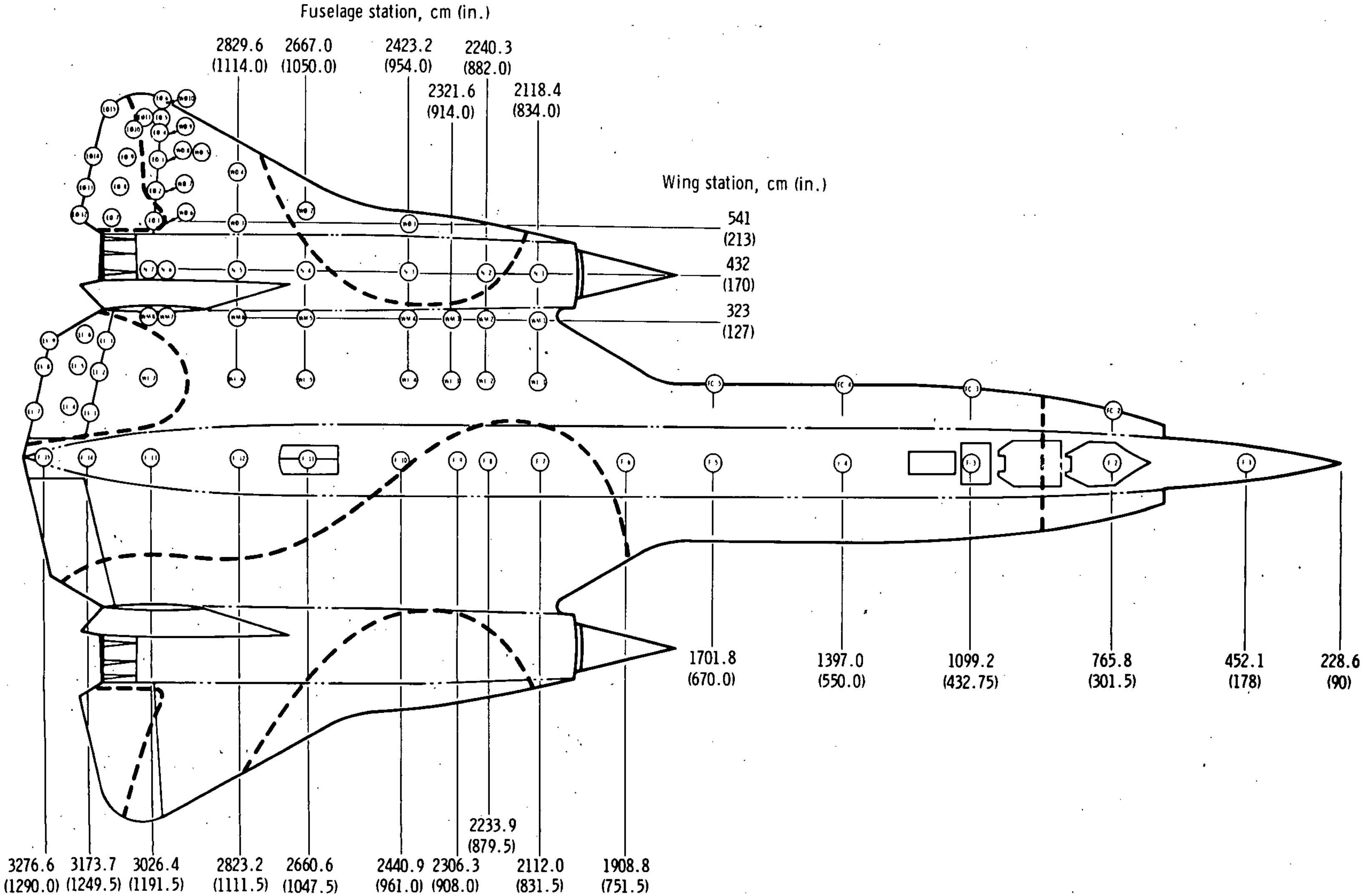
(e) 9.5 cps.

Figure 9. Continued.



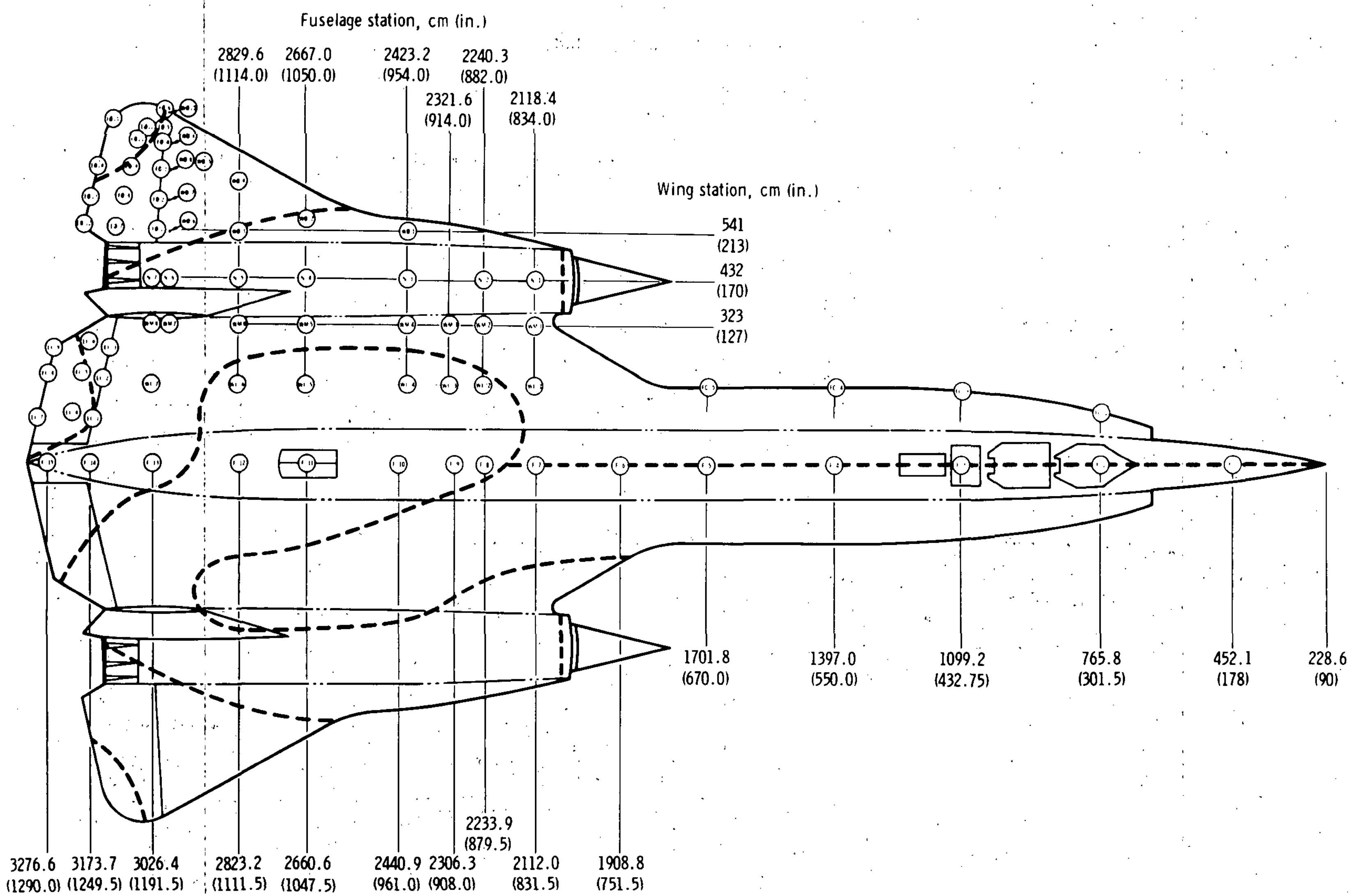
(f) 19.9 cps.

Figure 9. Continued.



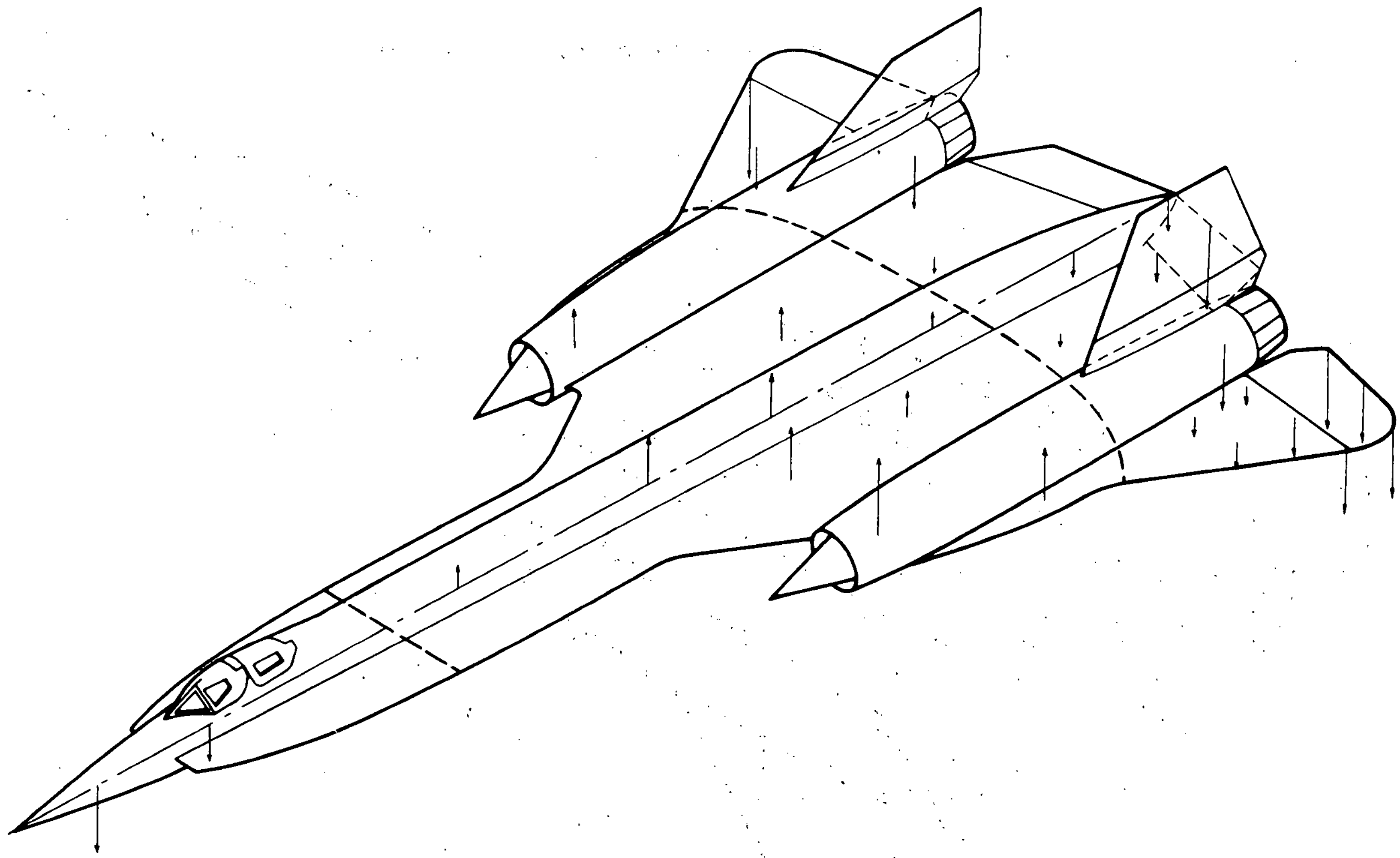
(g) 22.7 cps.

Figure 9. Continued.



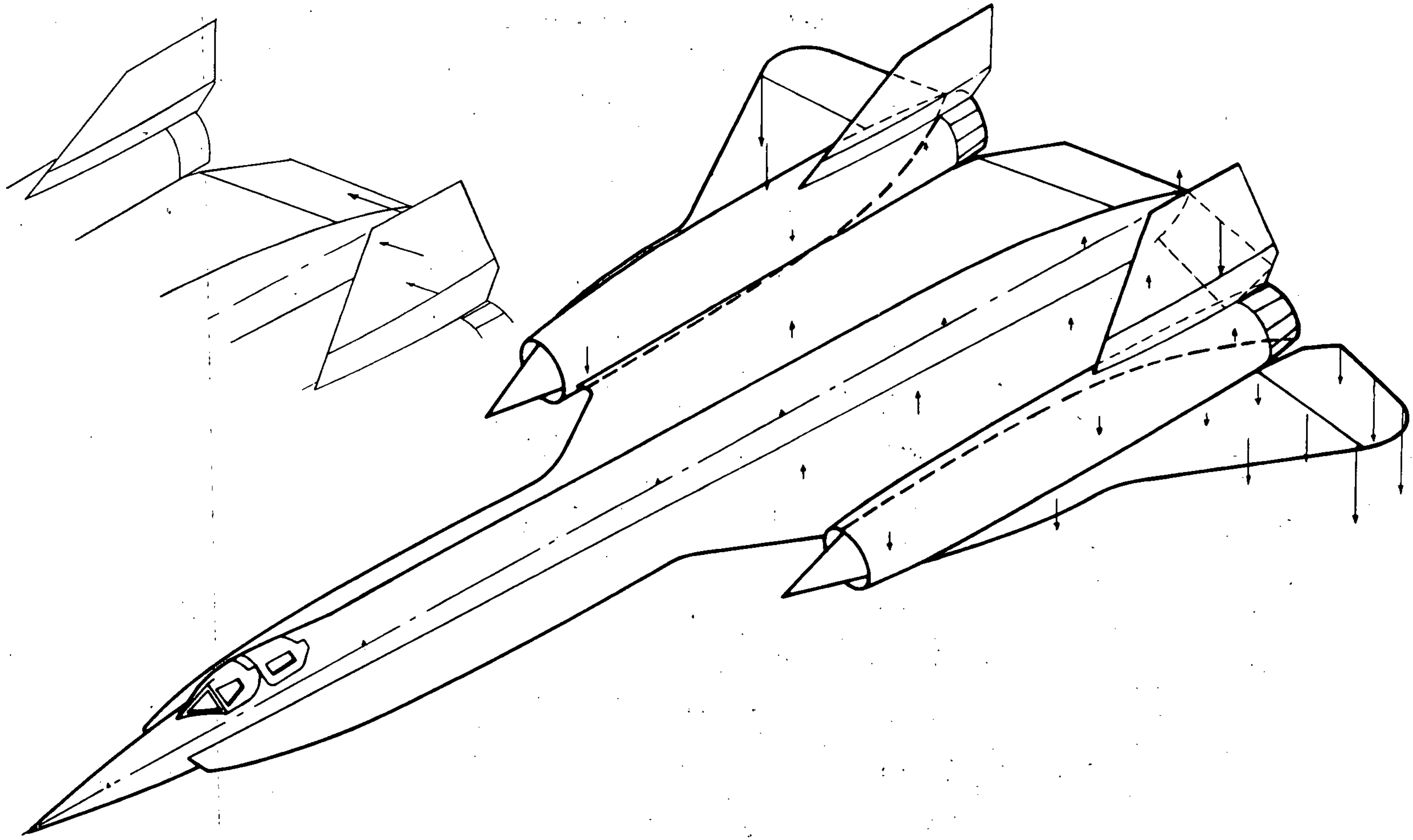
(h) 28.8 cps.

Figure 9. Concluded.



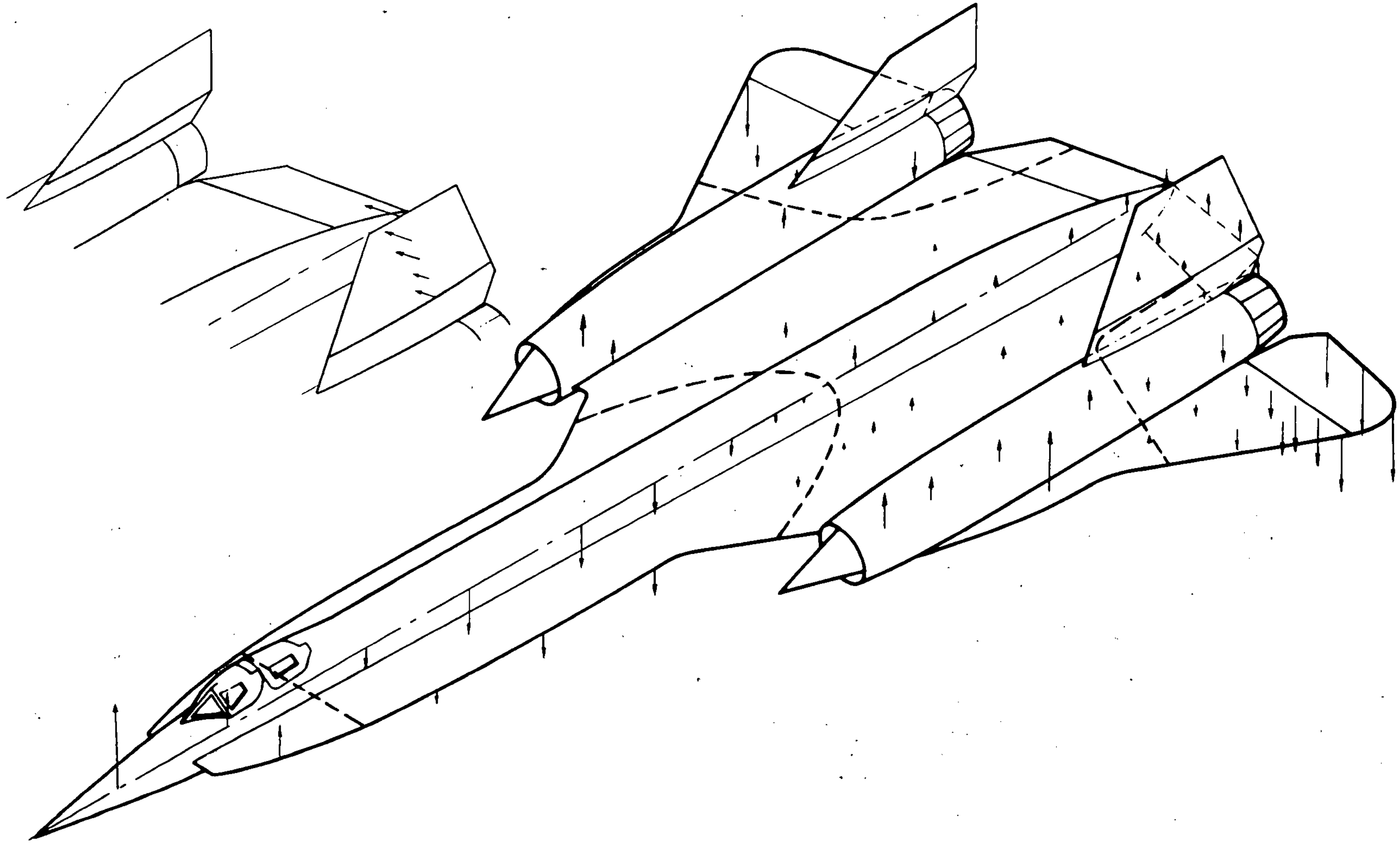
(a) 3.4 cps, normalized to test point EO 15 (left).

Figure 10. Wing/body elastic modes measured for symmetrical excitation.



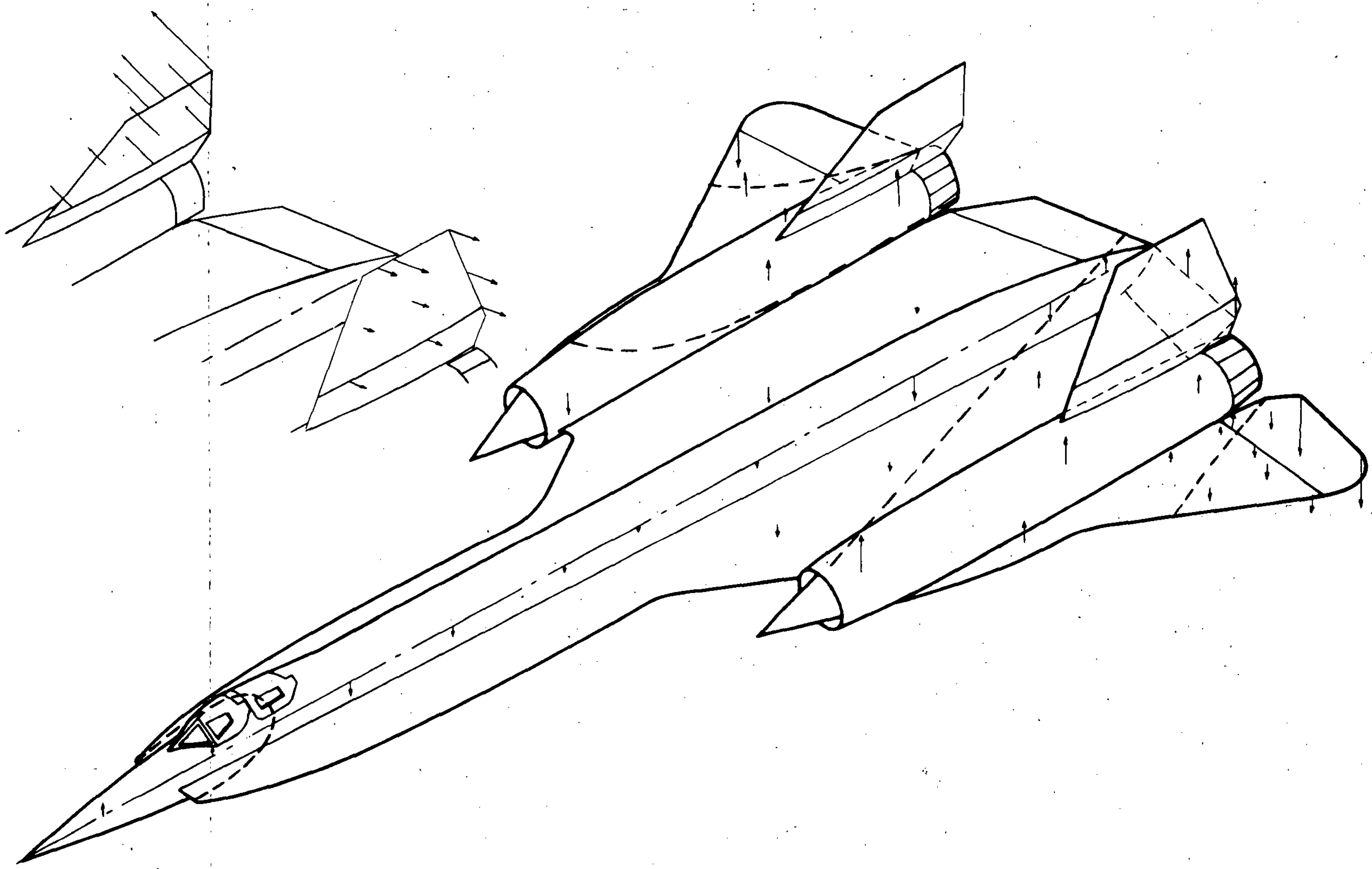
(b) 4.1 cps, normalized to test point EO 15 (left).

Figure 10. Continued.



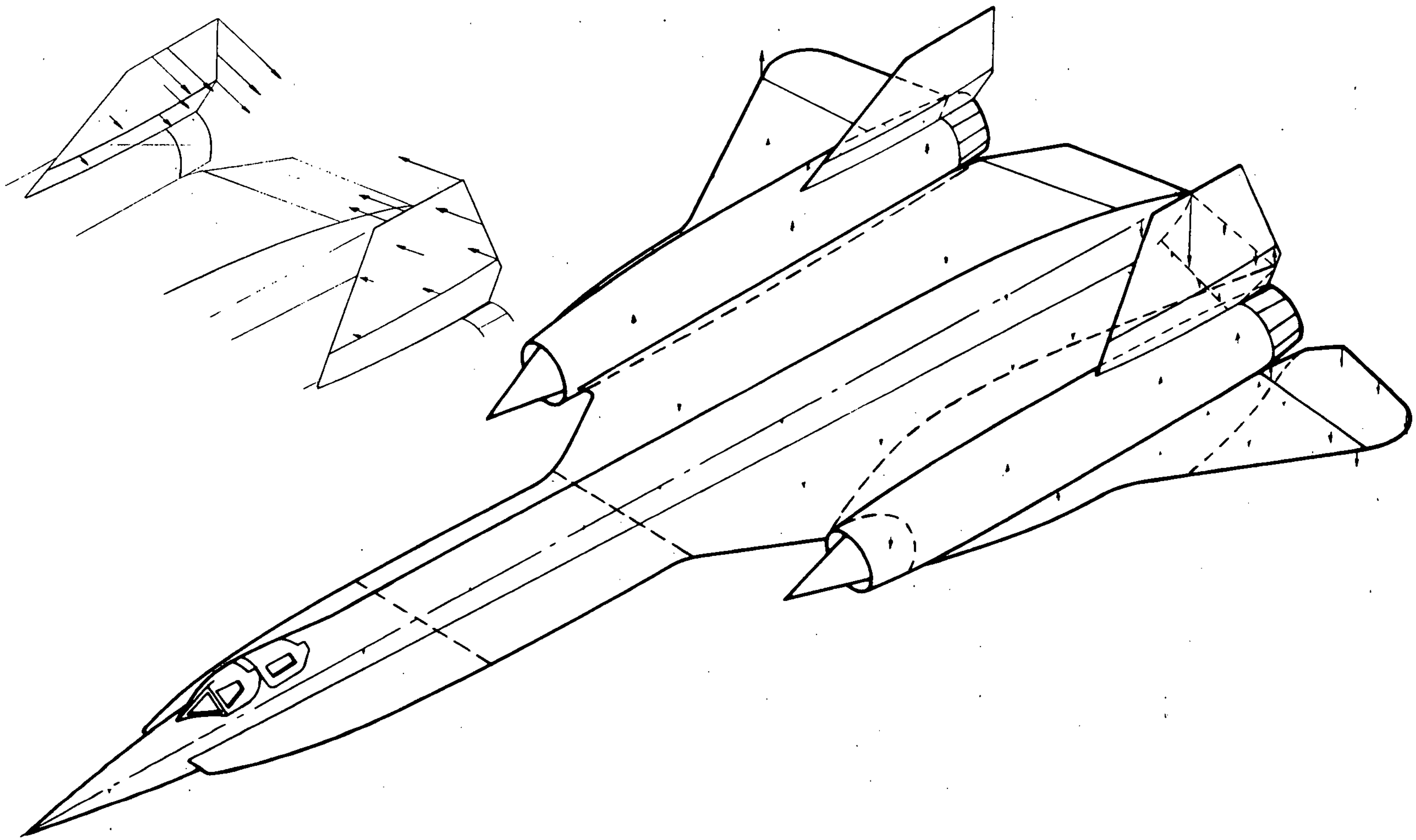
(c) 6.7 cps, normalized to test point EO 15 (left).

Figure 10. Continued.



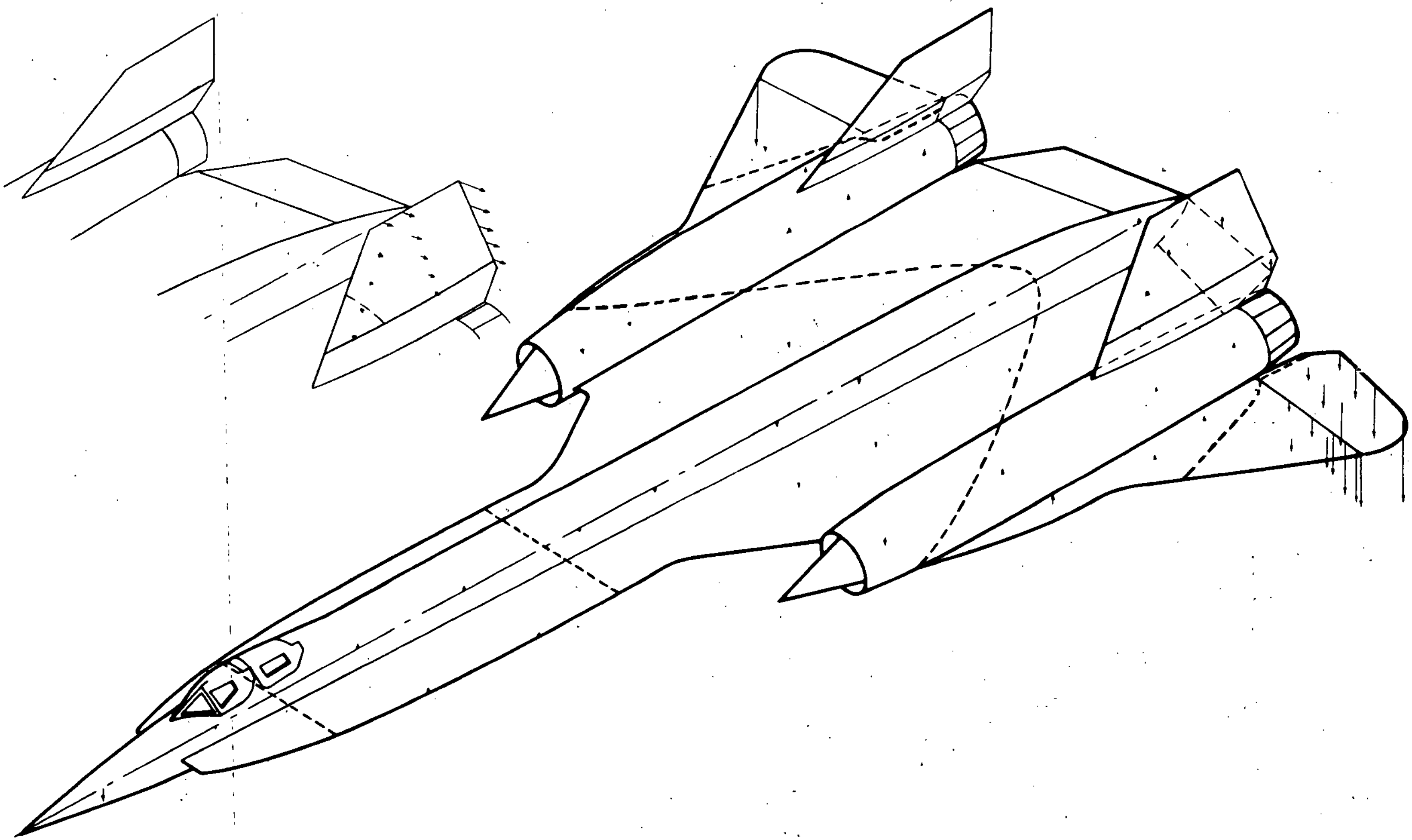
(d) 8.1 cps, normalized to test point R 28 (right).

Figure 10. Continued.



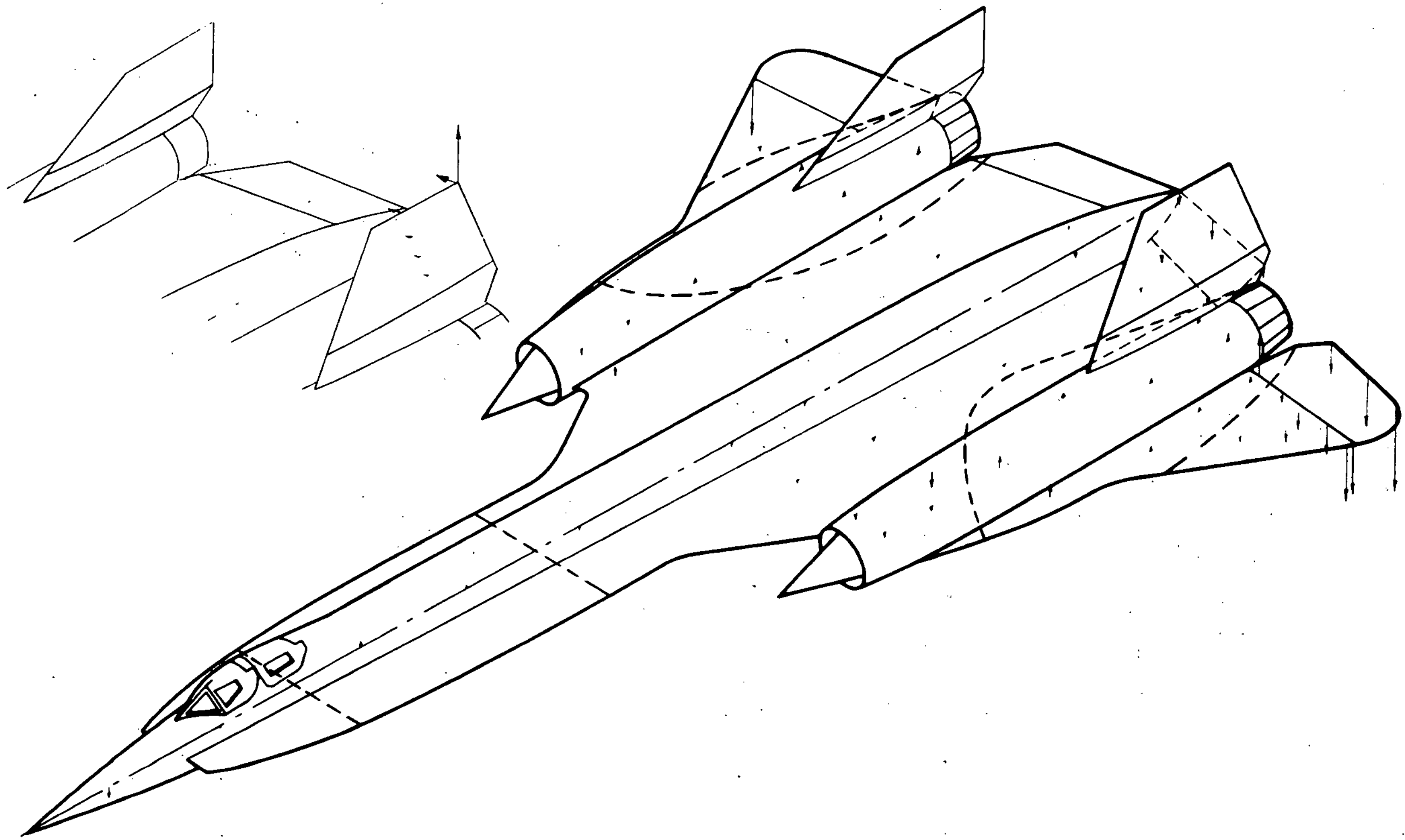
(e) 8.7 cps, normalized to test point R 28 (right).

Figure 10. Continued.



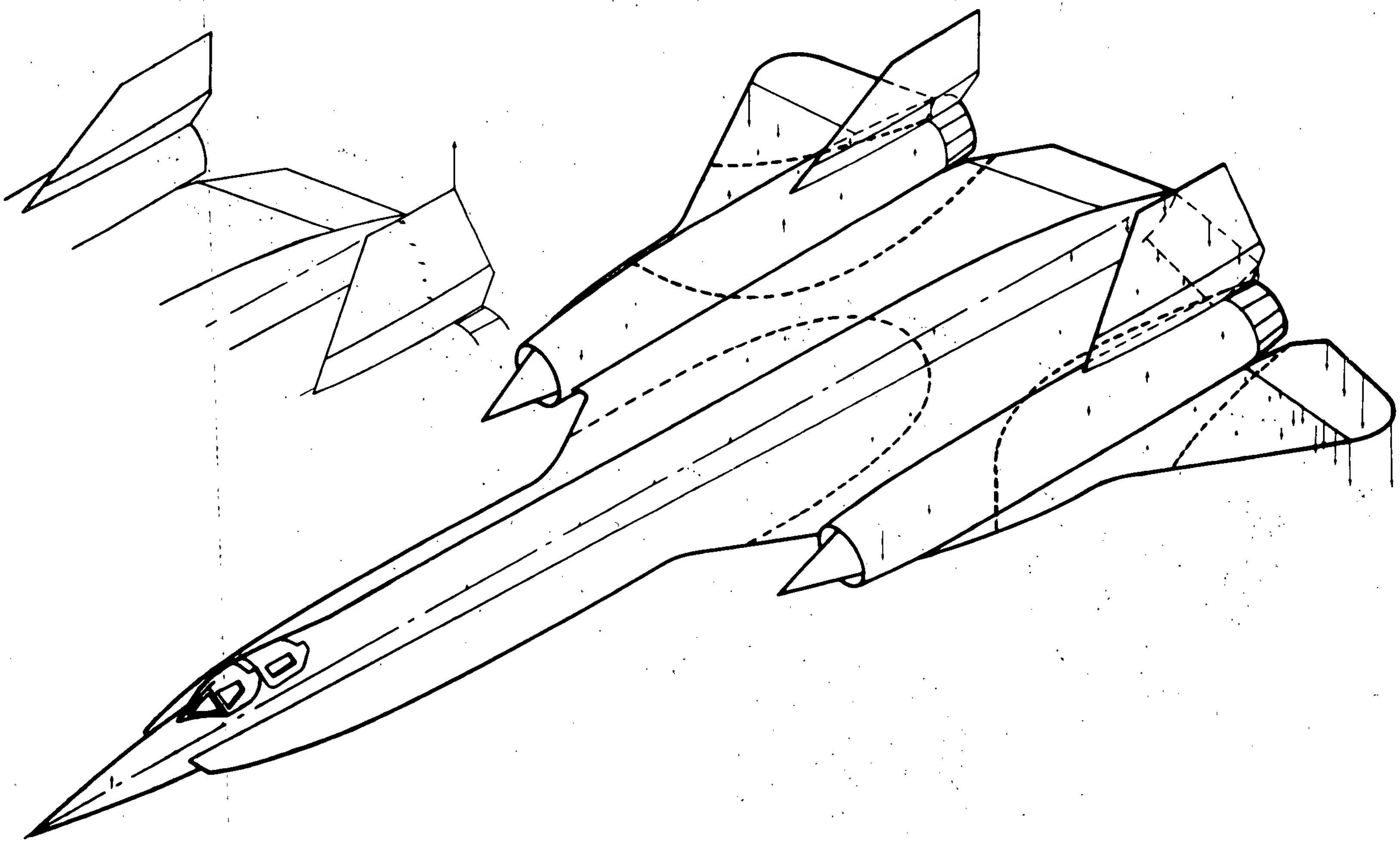
(f) 10.5 cps, normalized to test point EO 15 (left).

Figure 10. Continued.



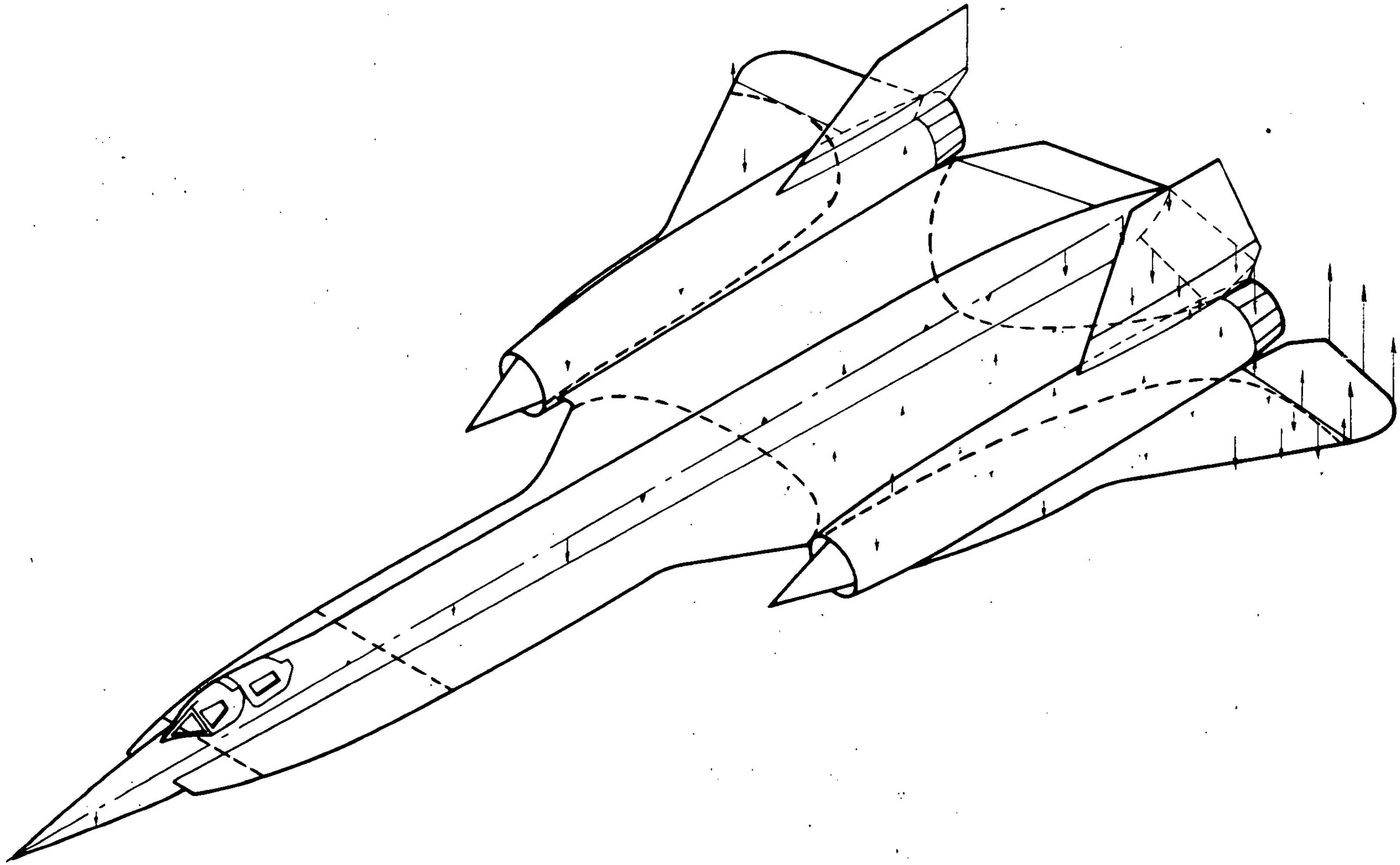
(g) 11.1 cps, normalized to test point EO 15 (left).

Figure 10. Continued.



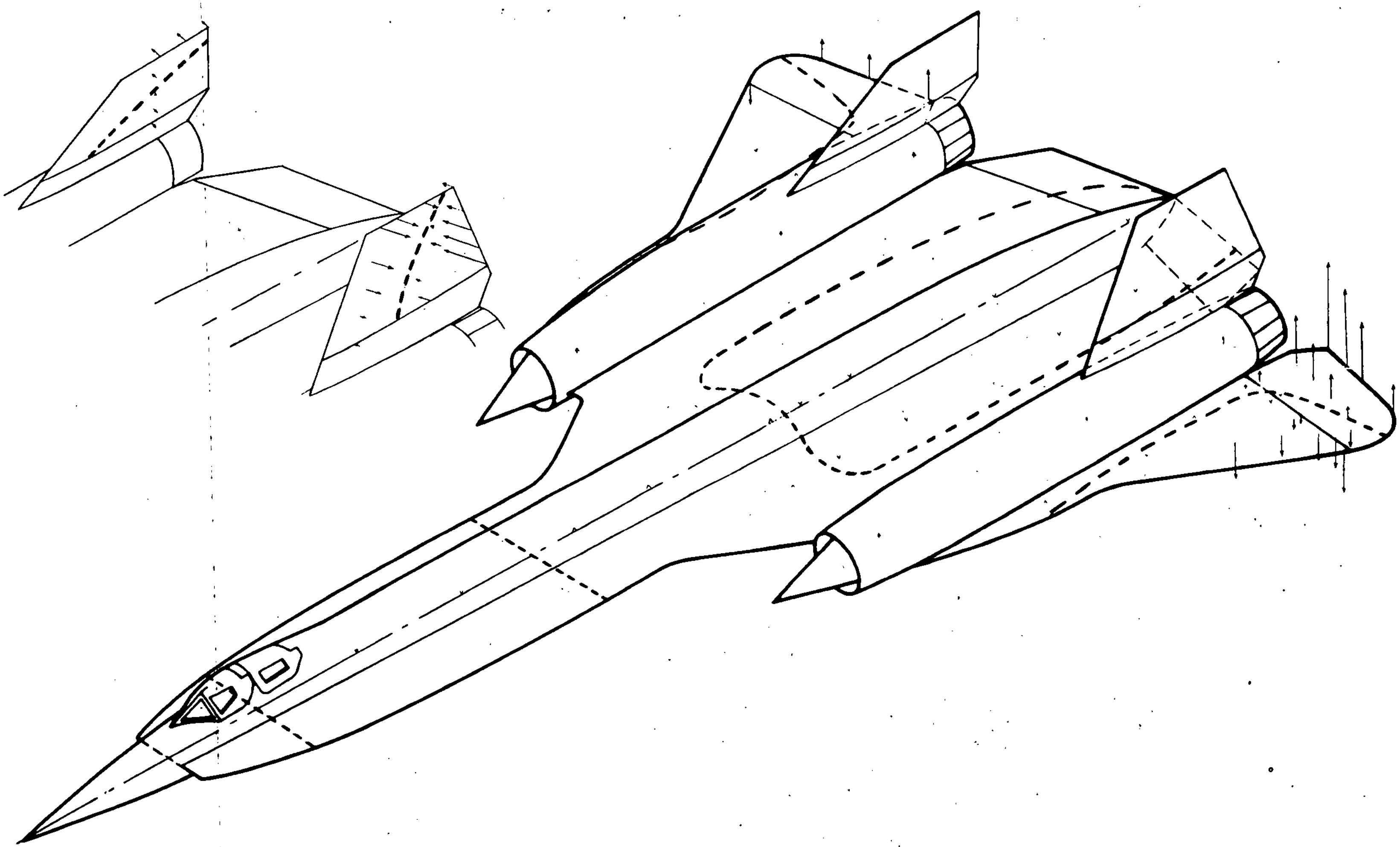
(h) 12.2 cps, normalized to test point EO 15 (left).

Figure 10. Continued.



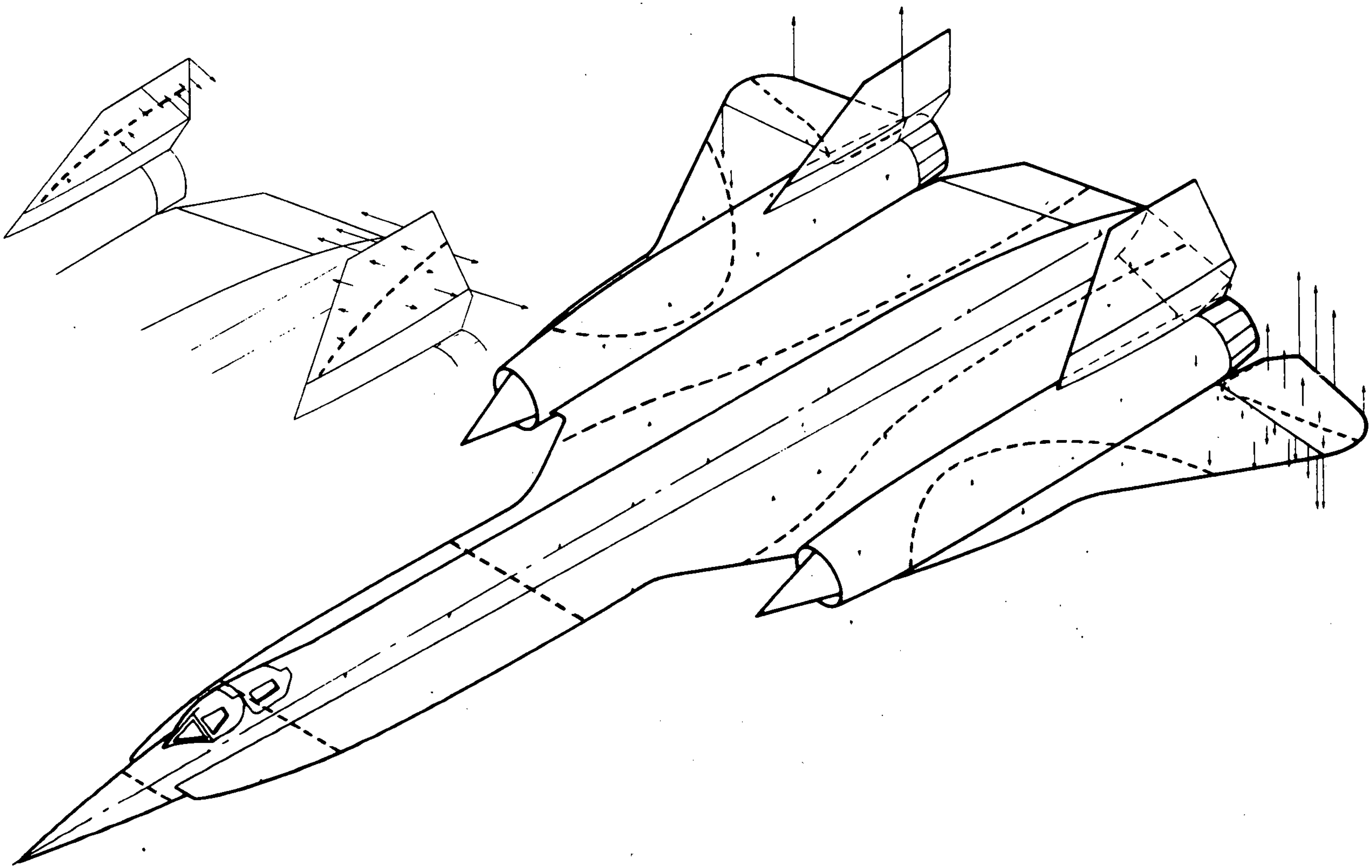
(i) 14.7 cps, normalized to test point EO 14 (left).

Figure 10. Continued.



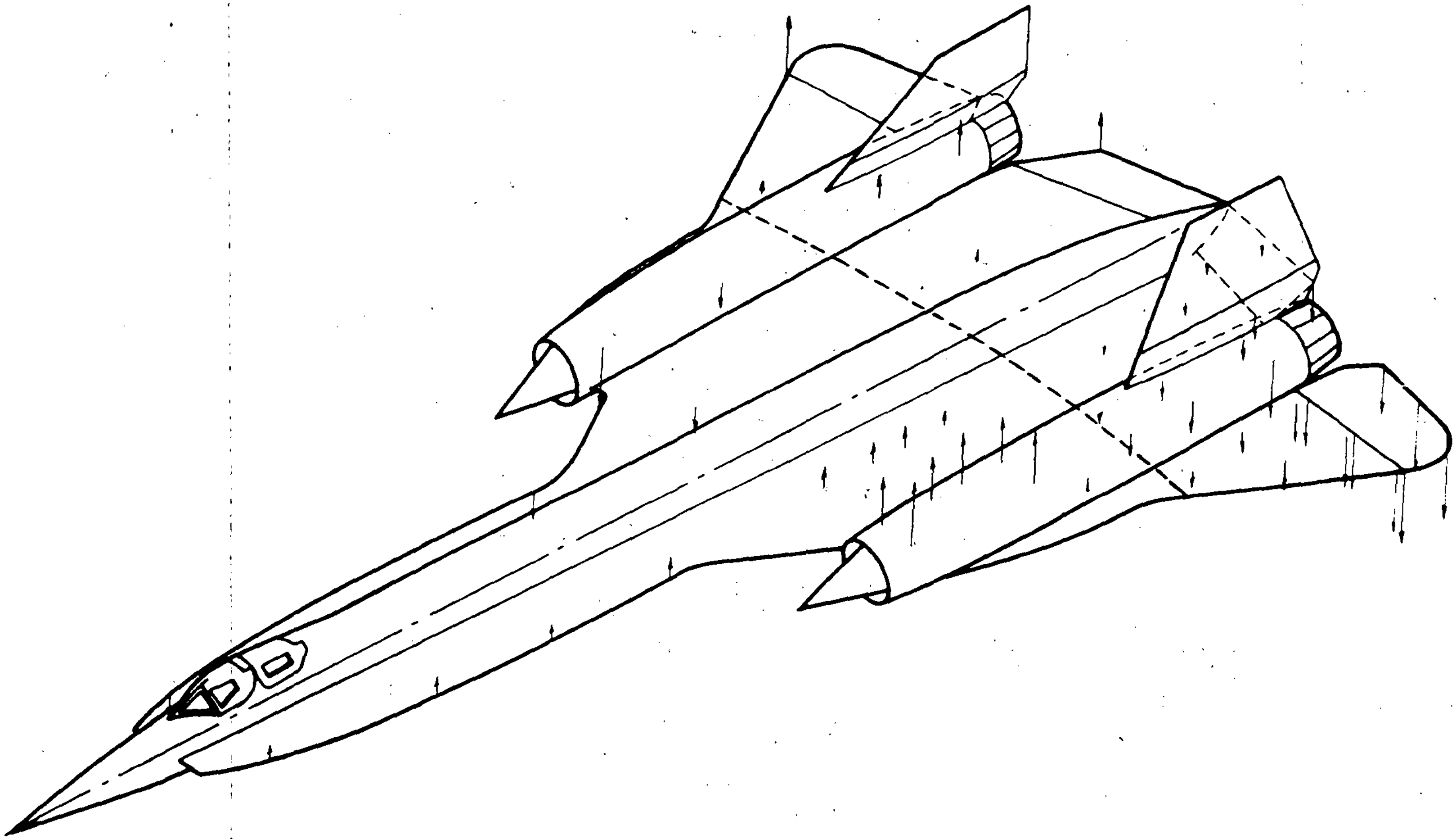
(j) 20.2 cps, normalized to test point EO 12 (left).

Figure 10. Continued.



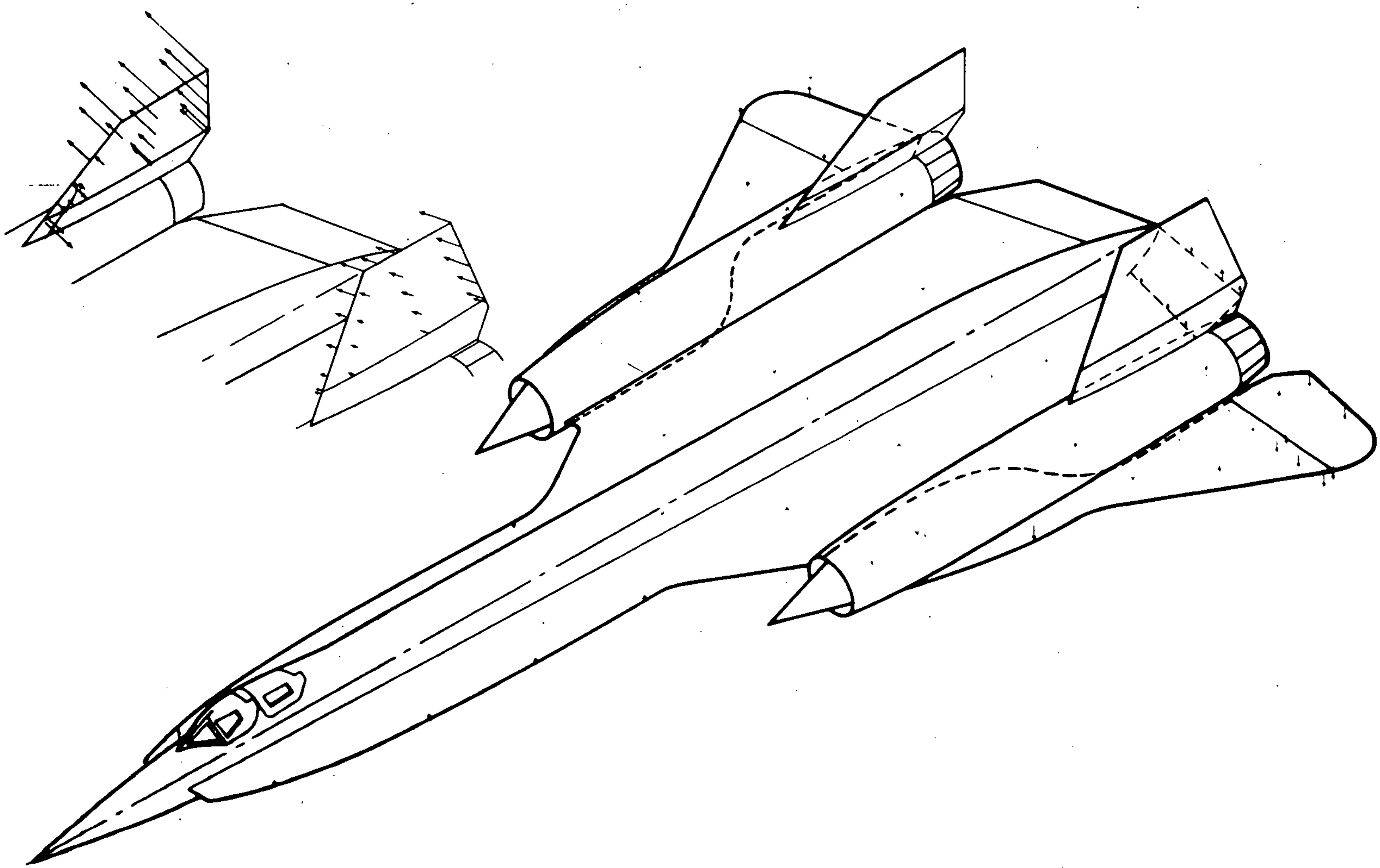
(k) 22.0 cps, normalized to test point EO 13 (left).

Figure 10. Concluded.



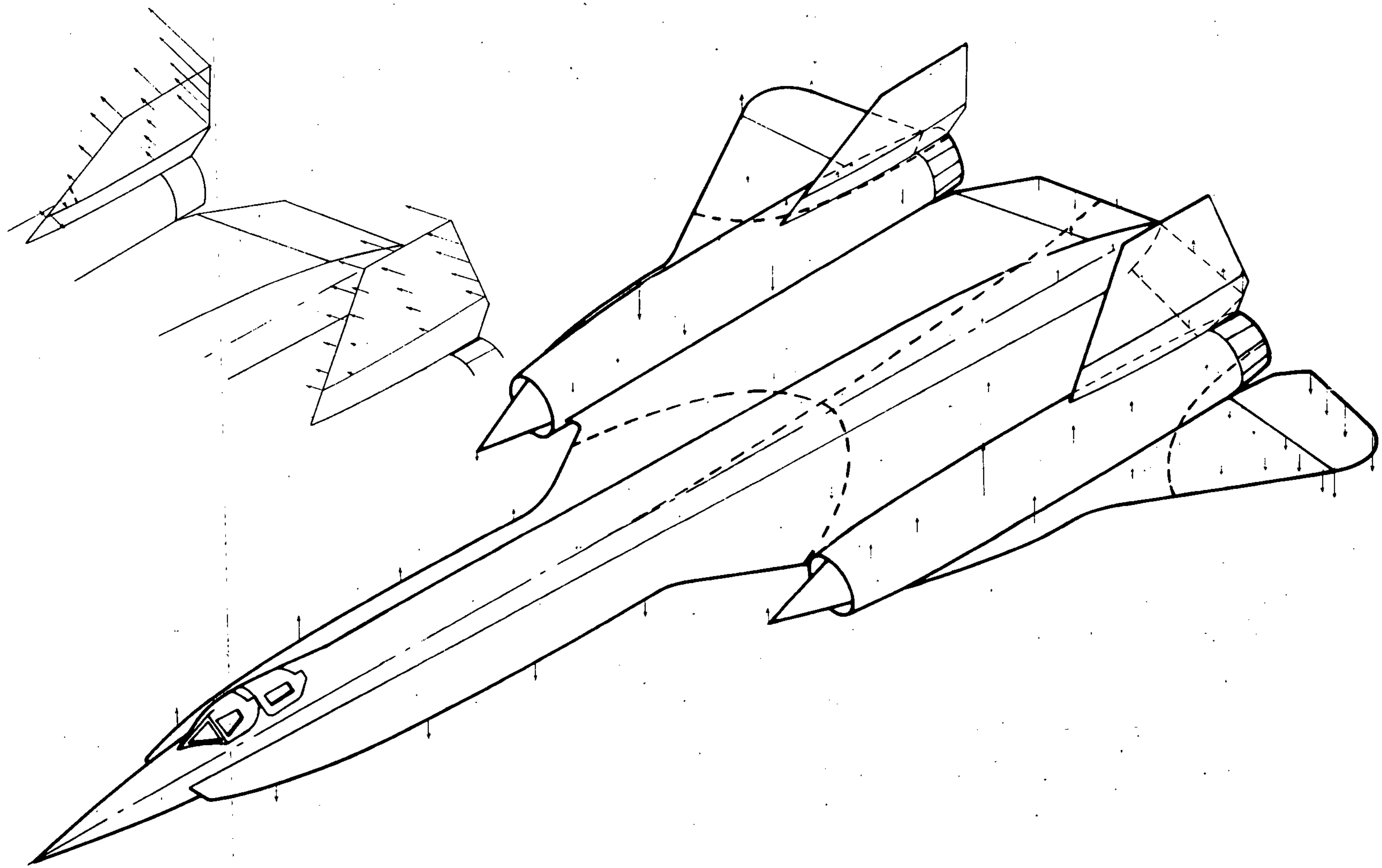
(a) 4.3 cps, normalized to test point EO 15 (left).

Figure 11. Wing/body elastic modes measured for antisymmetrical excitation.



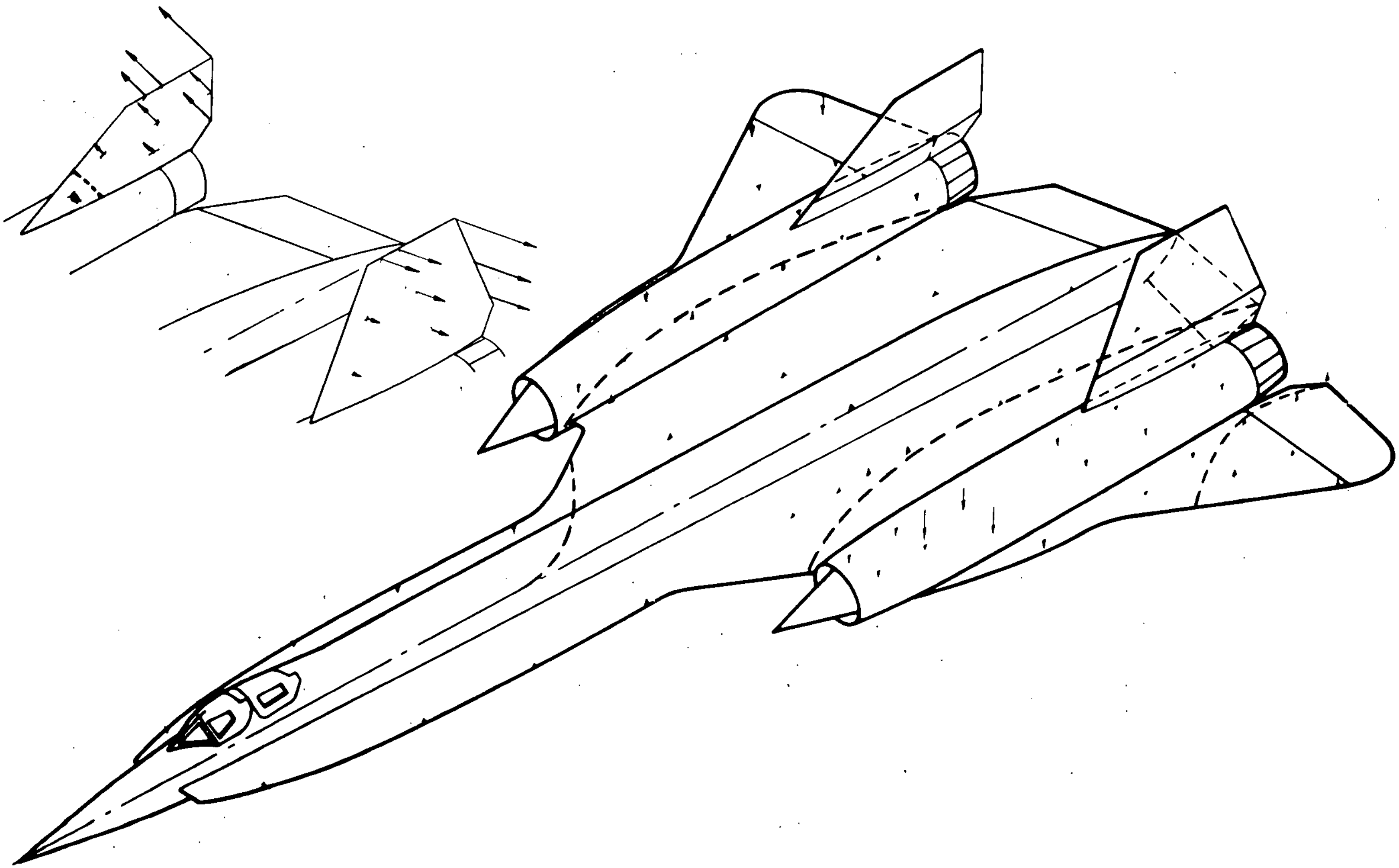
(b) 7.1 cps, normalized to test point R 28 (right).

Figure 11. Continued.



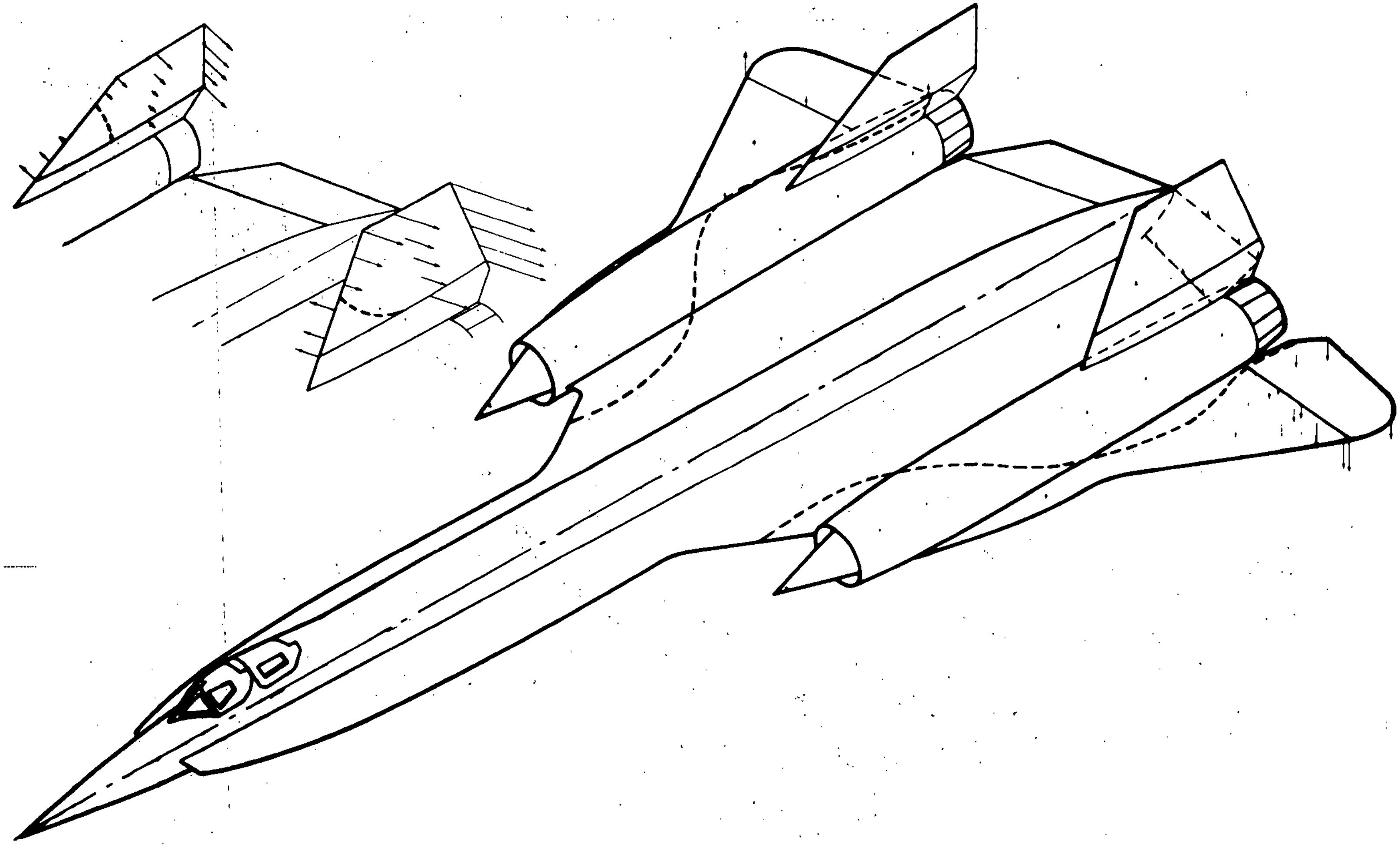
(c) 8.2 cps, normalized to test point R 28 (right).

Figure 11. Continued.



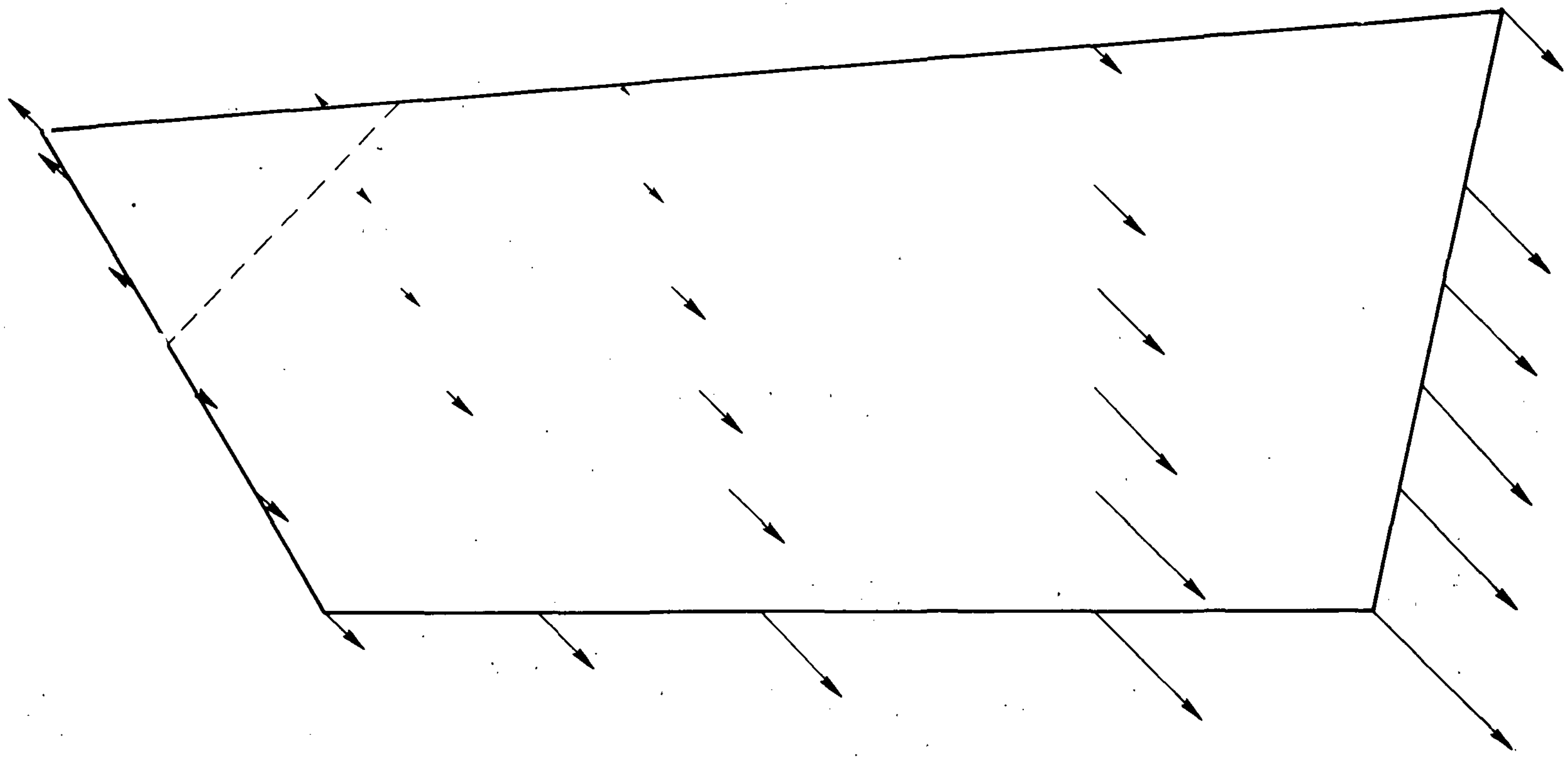
(d) 8.7 cps, normalized to test point R 28 (left).

Figure 11. Continued.



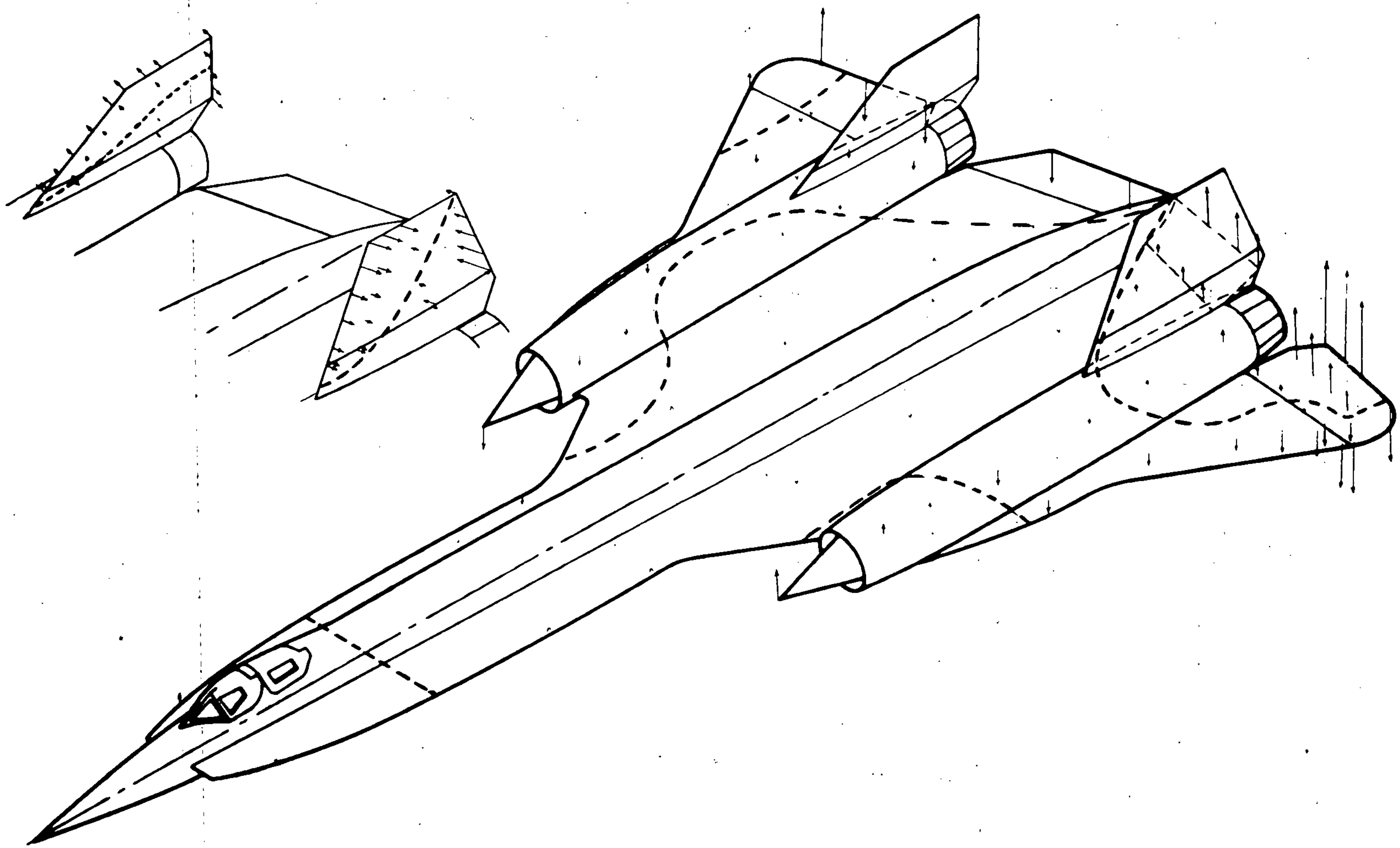
(e) 9.5 cps, normalized to test point R 28 (left).

Figure 11. Continued.



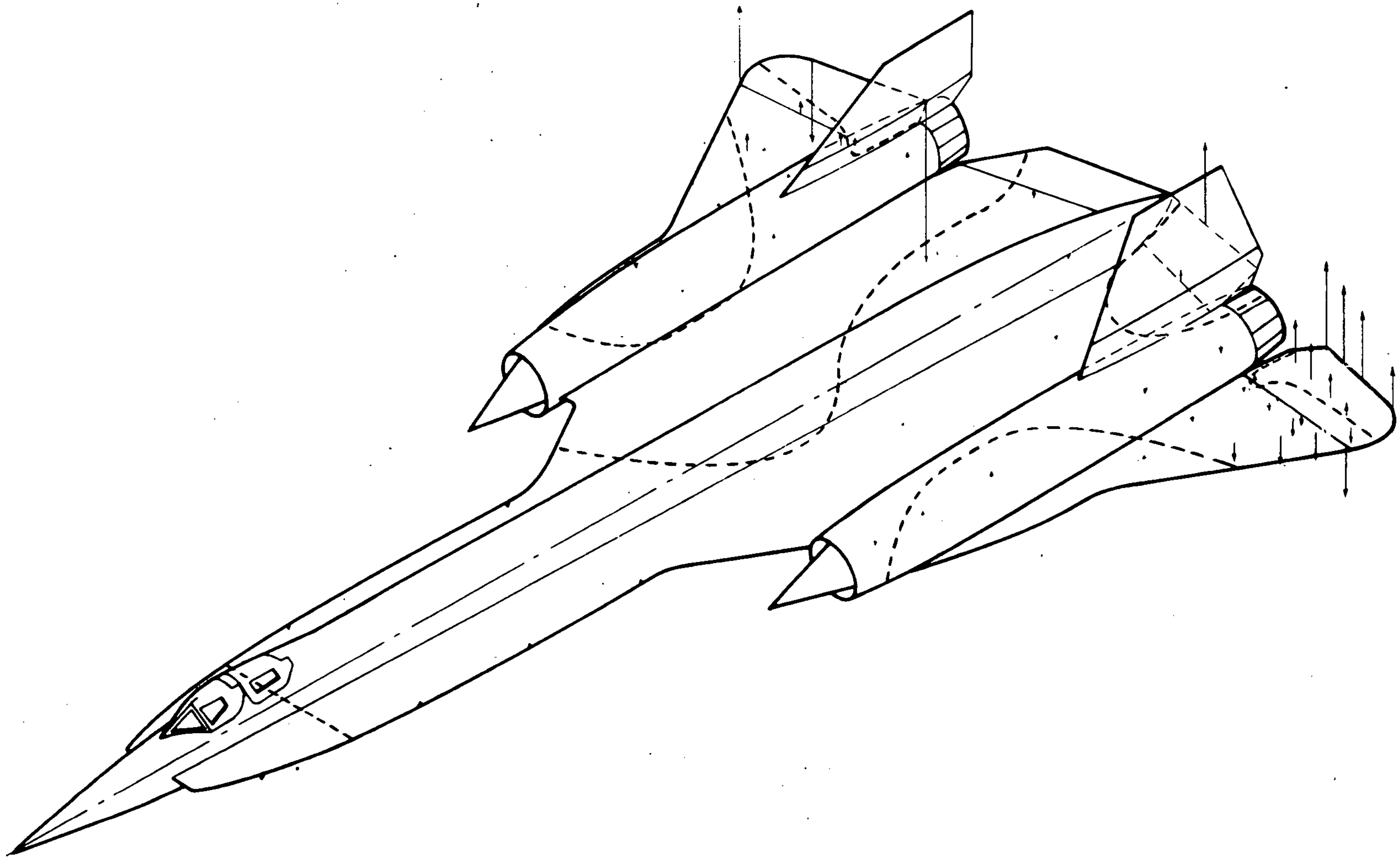
(f) Fuselage ventral fin, 13.2 cps, normalized to test point V 30.

Figure 11. Continued.



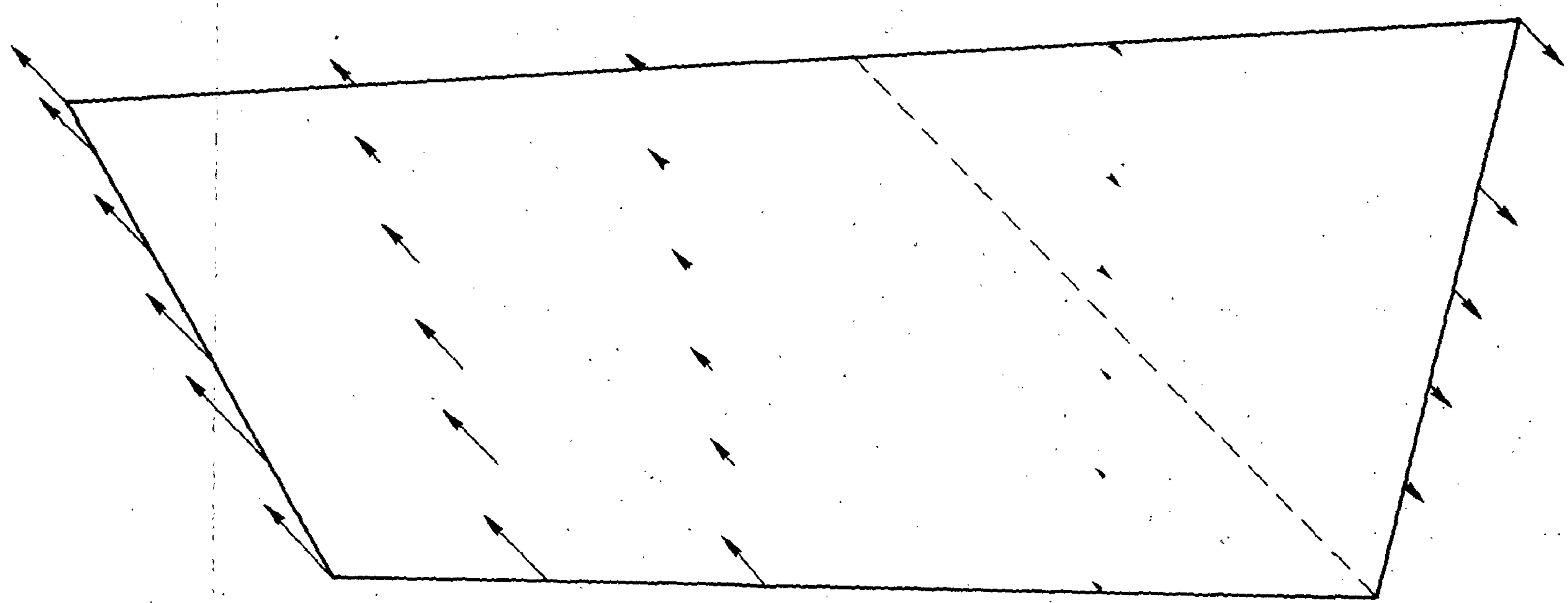
(g) 19.9 cps, normalized to test point EO 12 (left).

Figure 11. Continued.



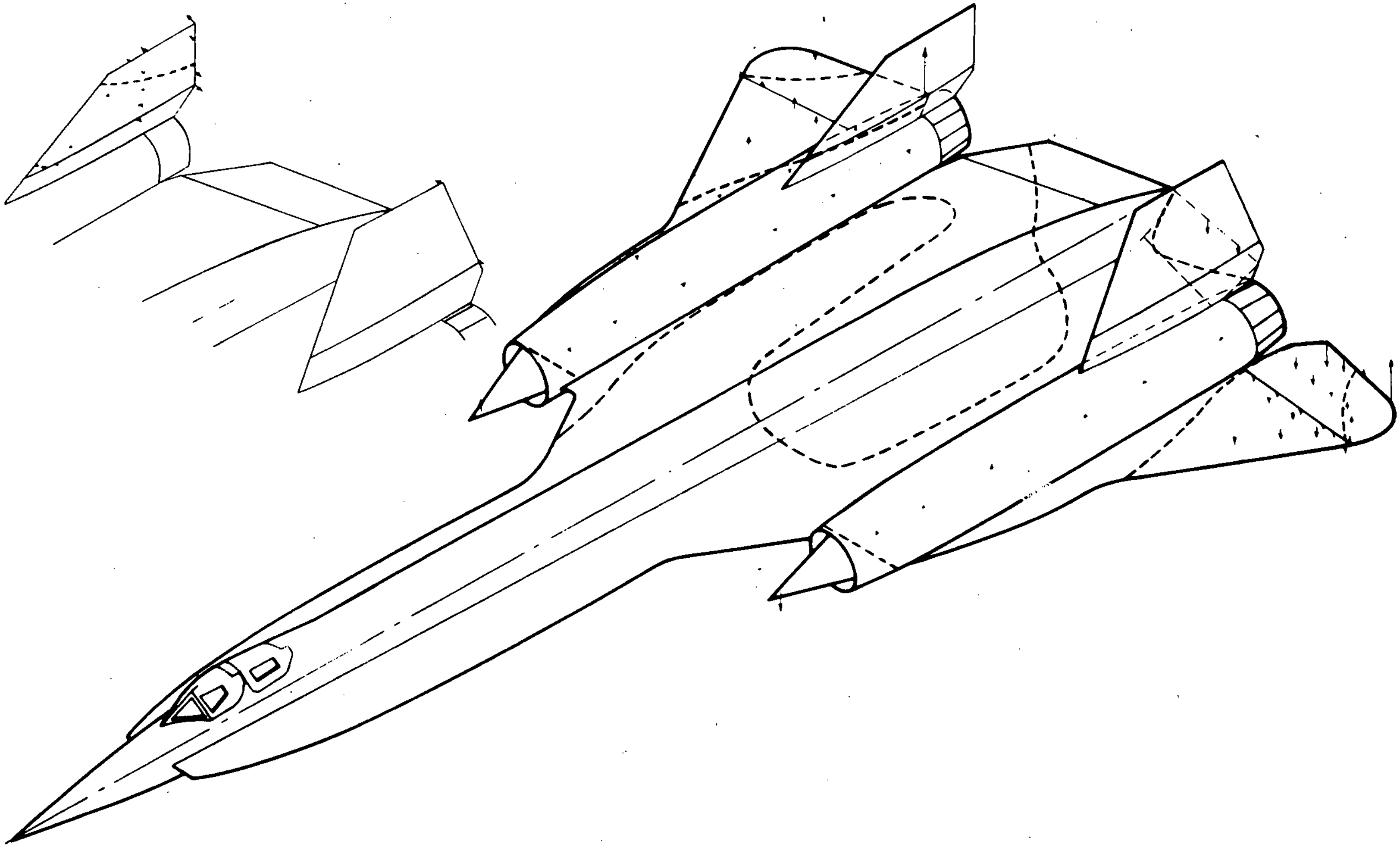
(h) 22.7 cps, normalized to test point EO 12 (left).

Figure 11. Continued.



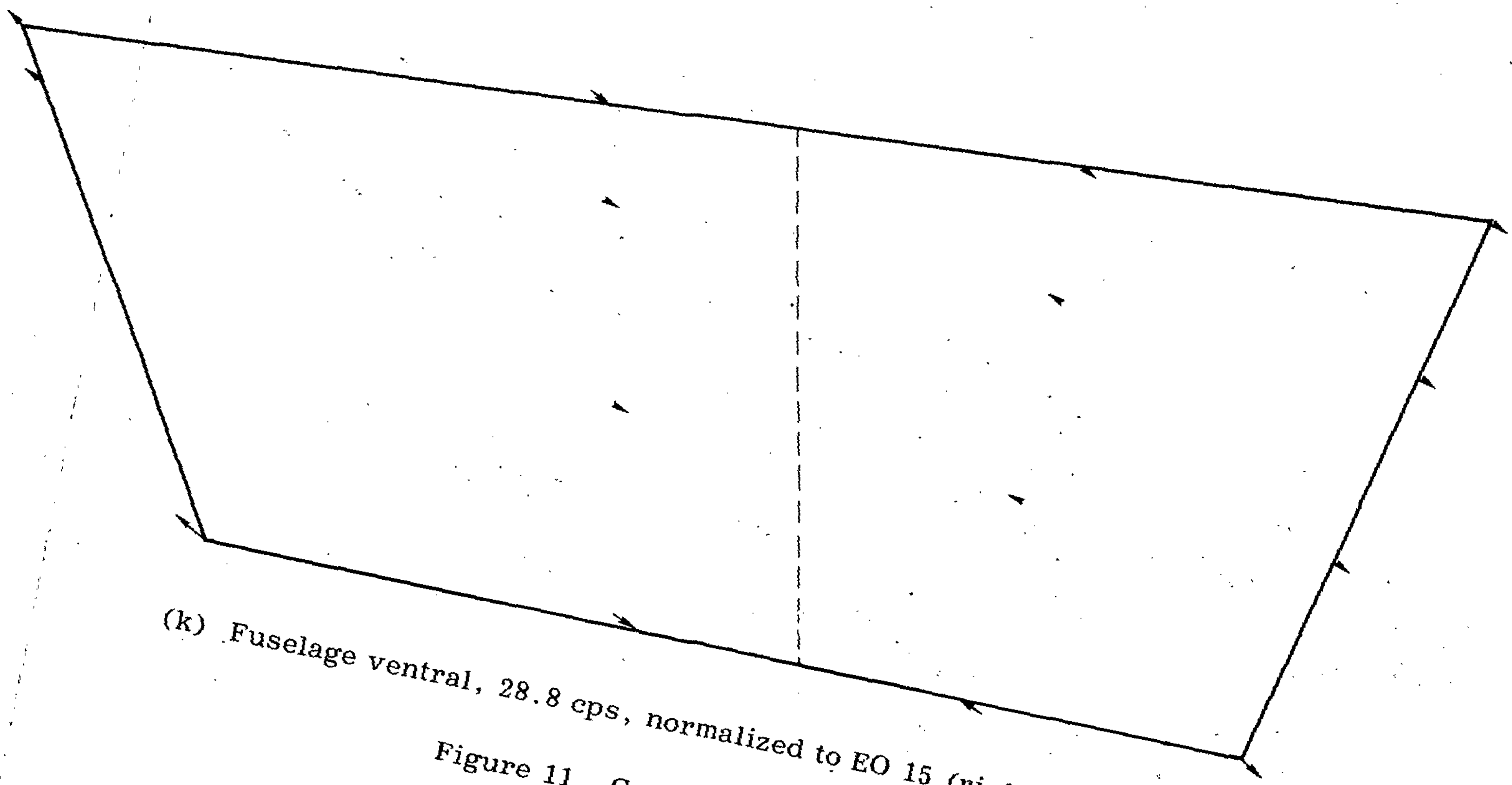
(i) Fuselage ventral, 22.7 cps, normalized to test point EO 15 (right).

Figure 11. Continued.



(j) 28.8 cps, normalized to test point EO 15 (right).

Figure 11. Continued.



(k) Fuselage ventral, 28.8 cps, normalized to EO 15 (right).

Figure 11. Concluded.

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