LONGITUDINAL DISTRIBUTION OF VIRTUAL MASS, VIRTUAL MOMENT OF INERTIA, DAMPING FORCE AND DAMPING MOMENT ON A PITCHING AND HEAVING SHIP

by

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and

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Prepared for
S-3 Panel
Hull Structure Committee
Society of Naval Architects and Marine Engineers
74 Trinity Place
New York 6, New York

Colorado State University Research Foundation
Civil Engineering Section
Fort Collins, Colorado

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NOTATION

B	Buoyancy
b	Beam
C	Equivalent buoyancy spring constant
C_θ	Buoyancy moment coefficient
d	Square law resistance coefficient
d_1	Square law resistance coefficient (upward average)
d_2	Square law resistance coefficient (downward average)
d_z'	Vertical square law coefficient (dimensionless)
F	Net force upward
F'	Total driving force
F_o	Force amplitude
F_o	Force at $\omega t = 0$
$F_{\pi/4}$	Force at $\omega t = \pi/4$
$F_{\pi/2}$	Force at $\omega t = \pi/2$
F_π	Force at $\omega t = \pi$
f	Damping coefficient
f_θ	Angular damping coefficient
f_θ'	Rotational damping coefficient (dimensionless)
f_z'	Vertical damping coefficient (dimensionless)
J	Apparent moment of inertia
J_o	Moment of inertia in a vacuum
k_1, k_2	Spring constants
k_z	Added mass coefficient (dimensionless)

NOTATION (cont'd)

k_θ	Added moment of inertia coefficient (dimensionless)
L	Lift
L	Length (waterline)
M	Net moment $(M' - M_L)$
M'	Measured moment
M_L	Moment due to ship forward motion
M_o	Moment at $\omega t = 0$
$M_{\pi/4}$	Moment at $\omega t = \pi/4$
$M_{\pi/2}$	Moment at $\omega t = \pi/2$
M_π	Moment at $\omega t = \pi$
m	Apparent mass of ship-water system
m_A	Added mass
m_o	Mass in a vacuum
r	Subscript representing the contribution of one segment
s	subscript representing the contribution of the whole ship
$u(t - a)$	Unit step function at $t \geqq a$
x	Moment arm
z	Vertical displacement, positive upward
z_o	Vertical displacement amplitude
Δ	Displacement
δ	Phase shift between force and displacement
θ	Angle in radians (pos. c.c.)
θ_o	Amplitude of θ
ω	Frequency

LONGITUDINAL DISTRIBUTION OF VIRTUAL MASS, VIRTUAL MOMENT OF INERTIA, DAMPING FORCE AND DAMPING MOMENT ON A PITCHING AND HEAVING SHIP

INTRODUCTION

This study, sponsored by the S-3 Panel of the Hull Structure Committee, Society of Naval Architects and Marine Engineers was undertaken as an experimental check of the theoretical forces and moments computed by Lewis (1) on a Model T2-SE-A1 Tanker. A series of tests were conducted in the Wave Basin at Colorado State University on a model divided into seven segments of equal water-line length. Each segment was suspended in such a fashion that it was structurally independent of other segments. The whole model was then subjected to forced oscillations in pitch or heave and the force on each segment measured by a strain-gage dynamometer. The recorded traces of force as a function of time were used to determine the virtual mass and moment of inertia coefficients and the damping coefficients. To obtain a better fit of measured data to the assumed equation, certain terms proportional to the square of the angular frequency were determined.

EXPERIMENTAL EQUIPMENT

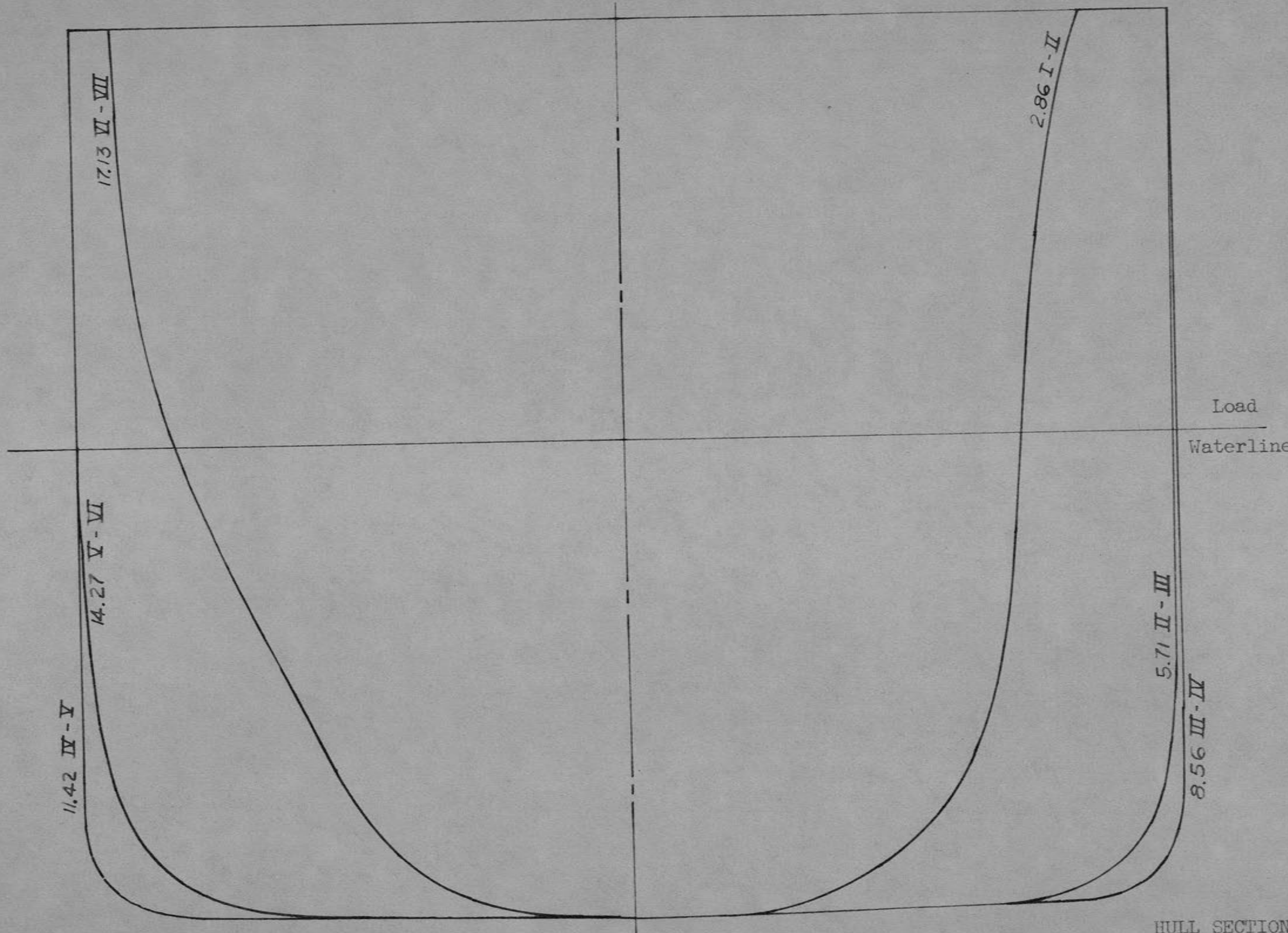
Model

To afford a direct comparison with tests and computations previously conducted by Lewis (1), a Model T2-SE-A1 Tanker hull was chosen for the tests. Constructed according to the lines shown in Figure 1, the model was molded from fiberglass laminate approximately 1/8-inch thick. (Model particulars are shown in Table 1). Since the model was expected to perform forced oscillations of nearly two inch amplitude, its freeboard was made large enough to prevent swamping (3.1 inches).

It was specified by the panel that the distribution of force and moments on the hull were to be studied. Ideally, it would have been necessary to slice the model in many thin segments. Cost and time prevented any extensive subdivision. It was decided to cut the five-foot-long hull into seven equal length segments (8.57 inches) as shown in Figure 2. Each hull segment was made water tight by sheet metal bulkheads fitted into the cut ends. (Segment particulars are shown in Table 2).

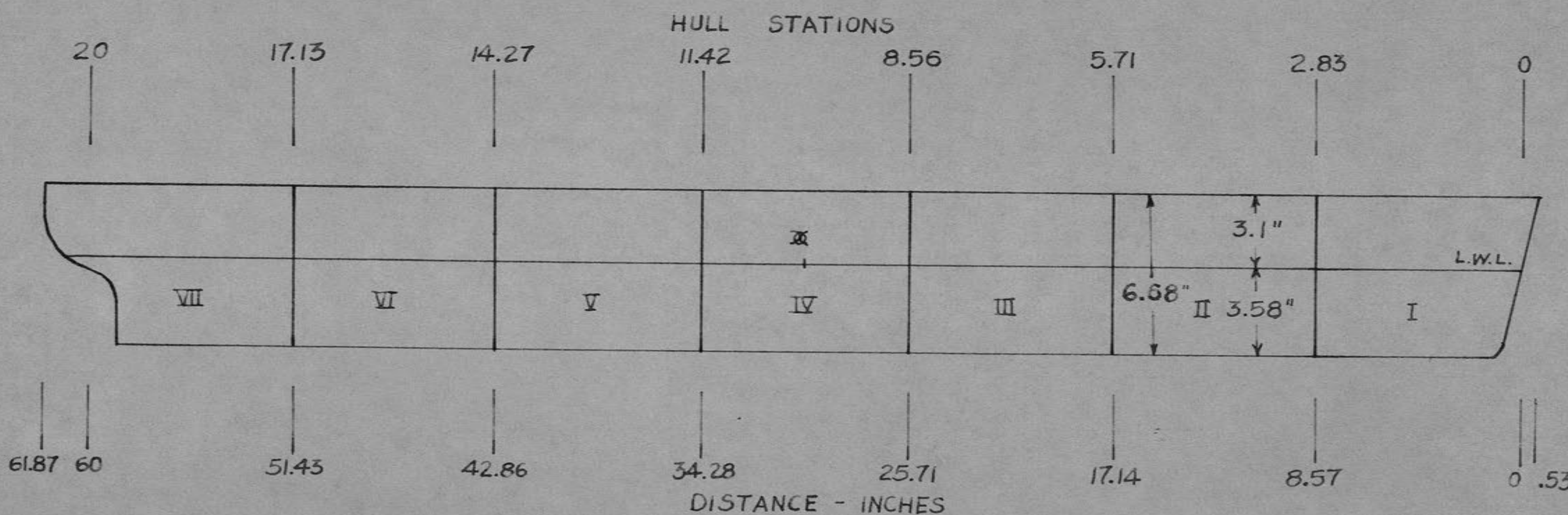
Force Balances

A phosphor bronze spring spanned each hull segment fore and aft along the model center line. At the center of each spring, a vertical column was attached firmly and the column was then connected to an aluminum beam or strongback (Figure 3). The segments were mounted in such a fashion that no contact existed with the adjoining segments (Figure 4). As a result of the foregoing precaution, it was assumed that the influence of a hull segment on other hull segments was purely hydrodynamic.



Figures are Hull Stations at ends of segments.
Roman Numerals refer to segment number.

HULL SECTIONS
AT END OF SEGMENTS
Full Scale
Fig. 1



Roman Numerals refer to segment numbers

MODEL PROFILE

T2-SE-A1 TANKER

Fig. 2

Photograph

Fig. 3 Segmental Force Springs, Segmented Model and Aluminum Strongback before Assembly.

Photograph

Fig. 4 Towing Carriage, Mechanical Oscillator and Segmented Model

The strain of the spring, and hence the force transmitted from the strongback to the hull was recorded by a strain-gage bridge mounted near the root of the cantilever spring. The electrical signal from the strain gages was transmitted through a television cable to a set of 5000 cps carrier amplifiers and then recorded by light beam type high performance galvanometers.

Calibration was done on the completed experimental unit. The model with its attendant instrumentation was mounted in a calibration tank and loaded with known forces and moments. The galvanometer deflection was then correlated with the load. As soon as the model was mounted on the towing carriage, and at frequent intervals thereafter, calibration checks were conducted in situ. The model was moved manually to a known depth or a known angle of pitch. Since the buoyancy forces and moments were known, the galvanometer deflection could be checked against the calibration curves.

Mechanical Oscillator

The strongback received its motion from a mechanical oscillator which was mounted on an aluminum towing carriage. Driven through a variable speed control and an 11 to 1 speed reducer, the oscillator operated within a range of 5 to 16 radians per second. The oscillator frequency could be maintained within close limits and could be obtained whenever needed.

A worm gear was connected to the variable speed drive with a double ended output shaft. Both ends of the shaft were fitted with an eccentric crank pin, each of which drove one end of the strongback. Heaving oscillations occurred whenever the crank pins were driven in phase while pitching motion resulted whenever the crank pins were driven 180 degrees out of phase. Amplitude of motion was adjusted by changing the eccentricity of the crank pins. (Both pins had the same eccentricity).

TEST PROGRAM

Sufficient tests were run to assure coverage of usual prototype behavior and a little beyond to establish trends. In both heave and pitch programs the model was oscillated on the following frequencies:

CPS	0,	0.8,	1.2,	1.4,	1.6,	1.8,	2.0,	2.5
Rad/sec	0,	5.0,	7.5,	8.8,	10.0,	11.3,	12.6,	15.7

The oscillator was set at one of the test frequencies and then the model was towed through a test program involving at least two runs for each forward speed. The speed runs were made at four speeds as follows:

Model Speed (fps)	0,	1.27,	2.54,	3.17
Froude Number (Fr)	0,	0.1,	0.2,	0.25
Fullscale Speed (knots)	0,	7.5,	15.1,	18.8,

The previously described experimental pattern was applied to the model three times, each set of tests was conducted with different amplitudes of oscillation:

Model (inches)	0.5,	1.0,	2.0	(1.75 for heave)
Fullscale (feet)	4.2,	8.2,	16.4	(14.3 for heave)

This amplitude is the half-cycle displacement of the water line in heave and the maximum half cycle vertical displacement of a point on the forward perpendicular in pitch.

In addition to the active run program several calibration static tests were conducted at frequent intervals. In general, the static calibration tests were consulted in reduction of the data.

BASIC THEORY

The Mathematical Model

In the past it has been assumed (2, 3, 4) that the forces and moments acting on a heaving or pitching ship can be represented by a simple mass spring system with damping. Such a simple model has the advantage of permitting easy and rapid reduction of data.

At the onset of this study, there seemed no reason for the authors to believe that the segments of the tanker model would not behave as assumed. Since the ship was constrained to heave or pitch sinusoidally, it seemed reasonable to assume that the two springs in each segment would also impart sinusoidal motion to the segment. Hence it was assumed that for the towed heaving ship, the dynamic constants could be obtained by the simplified model due to Haskind (2).

If the model is forced to go through a vertical displacement $2z_o$ and if the net force of buoyancy is called B, then it is assumed that

$$B = Cz$$

in which z is the vertical distance measured as positive upward from the

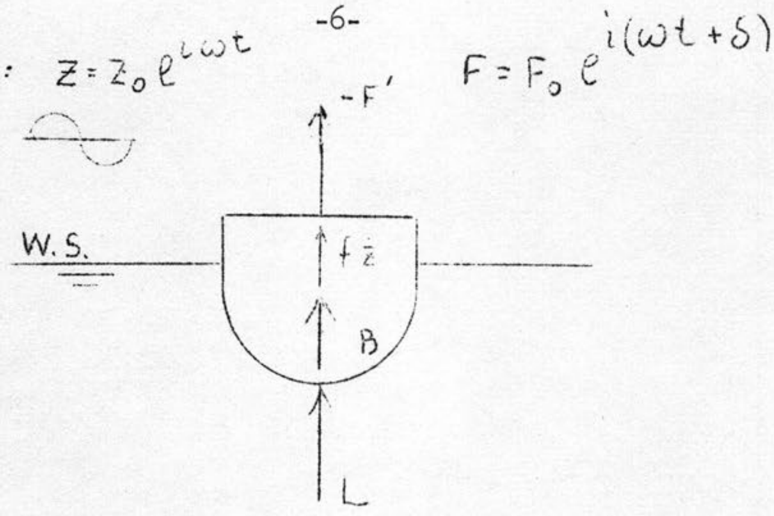


Fig. 5 Schematic Diagram of Forces on a Segment.

undisturbed water surface. This assumption of linearity is quite good for most ships. On the T-2 tanker only, the forces on the bow segment deviate from a straight line, and then not markedly.

Setting: L = upward force generated by forward motion of ship

m = apparent mass of ship-water system

f = damping coefficient

C = spring constant (buoyancy)

F' = driving force

z = vertical displacement

(The force F' is the sum of the forces measured by the forward and aft strain balances of each segment.)

Then a force balance (see Fig. 5) yields

$$m\ddot{z} + f\dot{z} + Cz = F' + L = F \tag{1}$$

If z is assumed to vary sinusoidally, it can be easily shown that F will also be sinusoidal. Indeed if

$$z = z_o e^{i\omega t}$$

then $F = F_o e^{i(\omega t + \delta)}$

in which ω = driving frequency

t = time

δ = phase shift

Substituting these values of z and F in Equation 1 gives

$$- mz_o\omega^2 e^{i\omega t} + if\omega z_o e^{i\omega t} + Cz_o e^{i\omega t} = F_o e^{i(\omega t + \delta)} \quad (2)$$

By separating real and imaginary parts, the following equations are obtained

$$- m\omega^2 + C = \frac{F_o}{z_o} \cos\delta \quad (3)$$

$$f\omega = \frac{F_o}{z_o} \sin\delta \quad (4)$$

Since C, ω, and z_o are known and F_o and δ can be measured, m and f may be easily computed from the oscillographs of driving force as a function of time (Fig. 6).

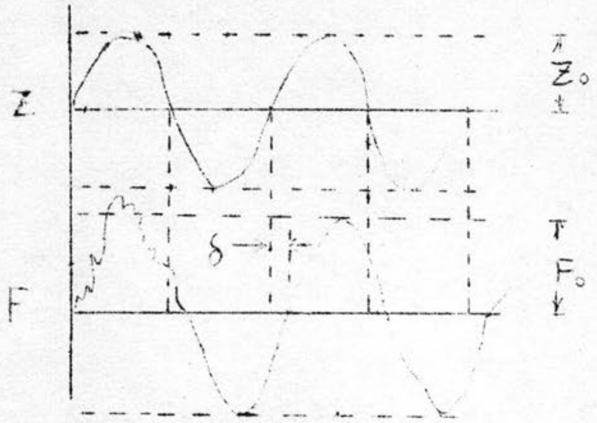


Fig. 6 Force in Relation to Displacement According to Equation 1.

Modification of the Equation

It is evident from Equation 2 that since z is symmetrical about the $z = 0$ axis, then F must be symmetrical about the $F = 0$ axis. It came as something of a surprise when the authors discovered that in the CSURF tests, F oscillated about a non-zero mean. Summing the forces for the whole ship also did not result in a zero mean force. This displacement of the zero axis could not be explained on the basis of the simple linear equation (1) for if z were symmetrical, so would be F .

The displacement of the axis of symmetry can be explained in one of the following ways:

(a) Instrumental error

(b) Unbalanced driving distance

(c) Constant force due to other causes than vertical oscillations

(d) Nonlinearity

Considerable care was taken to eliminate possibilities a and b . Although possible, instrumental error seemed unlikely. Similar results were obtained with two different instrumental techniques. Amplifier drift was kept under observation and each amplifier was balanced before each run. Static calibrations were run (by changing the position of the ship manually) at frequency intervals. Unbalanced driving (upstroke different from downstroke) was controlled by careful maintenance of the water level.

It was assumed, therefore, that either c or d or both were responsible for the zero shift. It is well known that a moving ship experiences lift (or suction) along its hull. By examining oscillographs of the model being towed without oscillations, an estimate of this lift force was obtained.

Unfortunately this lift was insufficient to account for the shift and often was small enough to be neglected.

The investigators were forced to concede that there existed nonlinearities. It was assumed that there existed "square law" forces analogous to drag. In fact since the flow regime on the downstroke is completely different from the flow on the upstroke, it was assumed that the vertical square law resistance could be approximated by

$$d|\dot{z}|\dot{z} = D\left[a + \cos(\omega t)\right]|\dot{z}|\dot{z} \tag{5}$$

However, the data was not good enough to obtain D and a with any accuracy. Under the circumstances, it was decided to use a cruder approximation, i.e., to assume that the vertical resistance coefficient was a constant d_1 on the upstroke and a different constant d_2 on the downstroke.

$$\begin{aligned} d &= d_1\left[u(t) - u(t - \tfrac{\pi}{2\omega}) + u(t - \tfrac{3\pi}{2\omega}) - u(t - \tfrac{5\pi}{2\omega}) + \ldots.\right] \\ &\quad + d_2\left[u(t - \tfrac{\pi}{2\omega}) - u(t - \tfrac{3\pi}{2\omega}) + u(t - \tfrac{5\pi}{2\omega} + \ldots\right] \\ d &= d_1\, u(t) + (d_2 - d_1) \sum_{n=0} u\left[t - \frac{(2n+1)\pi}{2\omega}\right] \end{aligned} \tag{6}$$

in which $u(t - \tau)$ is the unit step function at $t \geqq \tau$.

Then the equation of motion becomes

$$m\frac{d^2z}{dt^2} + f\frac{dz}{dt} + d(\text{signum } \dot{z})\,\dot{z}^2 - Cz + F' - l = F \tag{7}$$

in which F' is the driving force, L the "lift", and F the net force.

It is interesting to note that the phase shift-amplitude method does not work at all with Equation 7. The form of F is given by

$$F = F_o(t)\, e^{i\left[t + \delta(t)\right]} \tag{8}$$

Since only two equations can be obtained from Equation 8, it is impossible to determine the four variables m, d_1, d_2, and f. A more logical technique is to obtain four values of F and solve by the standard algebraic methods. If F is measured at $\omega t = 0, \frac{\pi}{4}, \frac{\pi}{2}$, and π, the following equations be can easily obtained

$$m = \frac{Cz_o - F_{\pi/2}}{z_o\omega^2} \tag{9}$$

$$f = \frac{2F_{\pi/4} - F_o - 1.414\, F_{\pi/2}}{0.4142\, \omega z_o} \tag{10}$$

$$d_1 = \frac{1.414\, F_{\pi/2} + 1.414\, F_o - 2\, F_{\pi/4}}{0.4142\, (\omega z_o)^2} \tag{11}$$

$$d_2 = d_1 - \frac{F_o + F_\pi}{(\omega\, z_o)^2} \tag{12}$$

Coefficients for the Whole Ship (in Heave)

Let the subscript r represent the force contribution of a single segment. Then it is assumed that

$$m_r\ddot{z}_r + f_r\dot{z}_r + d_r\dot{z}_r\dot{z}_r + C_rz_r = F_r \tag{13}$$

If the ship moves in pure heave, it is seen that the total force is simply the sum of the individual forces or

$$F = \sum_{r=1}^{7} F_r = \Sigma(m_r\ddot{z}_r + f_r\dot{z}_r + d_r\dot{z}_r\dot{z}_r + C_rz_r) \tag{14}$$

In this instance $z_1 = z_2 = \cdots z_7$

hence assuming that

$$F = m_s\ddot{z} + f_s\dot{z} + d_s \quad \dot{z}\,\dot{z} + C_s z$$

We obtain

$$m_s = \Sigma\, m_r \tag{15}$$

$$f_s = \Sigma\, f_r \tag{16}$$

$$d_s = \Sigma\, d_r \tag{17}$$

$$K_s = \Sigma\, k_r \tag{18}$$

i.e., the values of the hydrodynamic constants for the whole ship are simply the sum of the hydrodynamic constants of the individual segments.

Neglect of Base Line Shift

It was requested by members of the S-3 Panel that some computations be made by assuming that the shift of the zero line was spurious, i.e., by use of Equations 1, 2, 3, and 4. Due to the nature of the data, an additional technique had to be introduced. Each segment force was measured at two different points, fore and aft.

Hence, assuming that each force measurement obeyed Equation 1, it was necessary to write

$$F = F_{oA}\, e^{j(\omega t + \delta_A)} + F_{oF}\, e^{j(\omega t + \delta_F)}$$

or

$$F = F_o\, e^{j\omega t + \delta} = e^{j\omega t}\left[F_{oA}\, e^{j\delta_A} + F_{oF}\, e^{j\delta_F}\right] \tag{19}$$

$$F_o = \left[(F_{oA} \cos \delta_A + F_{oF} \cos \delta_F)^2 + (F_{oA} \sin\delta_A + F_{oF} \sin \delta_F)^2\right] \quad (20)$$

$$\tan \Delta = \frac{F_{oA} \sin \delta_A + F_{oF} \sin \delta_F}{F_{oA} \cos \delta_A + F_{oF} \sin \delta_F}$$

In the equations above, the subscript A means "aft" while subscript F means "forward."

Reduction of Data in the Pitch Plane

The moment on each segment may be represented by a mathematical model similar to the previous one

$$J\ddot{\theta} + f_\theta \dot{\theta} + d_\theta(t) \left|\dot{\theta}\right|\dot{\theta} + C_\theta \theta = M' - M_L \quad (21)$$

where J = apparent moment of inertia

f_θ = angular damping coefficient

d_θ = drag-moment coefficient

C_θ = buoyancy moment coefficient

M' = induced (measured) moment

M_L = moment due to ship forward motion

θ angle in radians

All angles and moments are assumed positive counter-clockwise. The moment axis is located at a point on the water line midway between station 0 and the stern and is perpendicular to the axis of symmetry of the ship.

If the forces on the aft and fore balances of each segment are F_A and F_F respectively and the distances to the rotational axis of the ship from the points of force application are x_F and x_A, then

$$M' = F_A x_A + F_F x_F$$

where F is positive upward, x positive forward, and M positive counterclockwise. Since in this model the angular motion is obtained by driving the bow and the stern linearly but 180° out of phase, we can write for the elevation of any point.

$$z = z_o \sin (\omega t)$$

If the distance from the point in question to the axis is x_o, then (for small angles)

$$\theta \approx \frac{z_o}{x_o} \sin (\omega t) = \theta_o \sin (\omega t)$$

It is obvious, therefore, that Equation 21 may be written as

$$\begin{aligned} &- j\omega^2 \sin \omega t + f_\theta \omega \cos \omega t \\ &\quad + d_\theta(t)\, \omega^2 \theta_o \cos (\omega t) \cos (\omega t) + C_\theta \omega \sin \omega t = \frac{M}{\theta_o} \end{aligned} \qquad (22)$$

Obviously the solution of this equation for J, f_θ, and d_θ yield equations completely similar to Equations 9, 10, 11, and 12 with M_o, $M_{\pi/4}$, $M_{\pi/2}$, M_π substituted in place of F_o, $F_{\pi/4}$, $F_{\pi/2}$, and F_π.

The Moment and Force Parameters for the Whole Ship

Since the moment and force of each segment is referred to the same axis, it is obvious that the stability coefficients for the whole ship can be obtained by summing the coefficients of the individual segments.

Non-dimensional Forms

If the mass of the ship is m_o , it is possible to write

$$m_A = m - m_o$$

Then we write a dimensionless coefficient

$$k_z = \frac{m_A g}{\Delta}$$

where g = acceleration of gravity

Δ = segmental or total model displacement at water line.

This term is plotted as a function of "angular Froude number"

$$f = \omega \sqrt{\frac{b}{g}} = 0.144\omega$$

where b is the model's beam.

The damping term is plotted in the form

$$f'_z = \frac{f}{\Delta} \sqrt{g b_1}$$

where b_1 is the segmental or total beam.

The vertical resistance term is given by

$$d'_z = d_z \frac{gb}{\Delta}$$

In pitch we obtain

$$k_\theta = \frac{(J - J_o)g}{\Delta L^2}$$

$$f'_\theta = f_\theta \sqrt{\frac{g}{\Delta^2 L^3}}$$

$$d'_o = \frac{d_\theta g}{\Delta L^2}$$

in which L is the total or segmental length at the water line.

PRESENTATION OF DATA

Heave Motion

Figures 8 through 16 indicate the behavior of the added mass coefficients as functions of dimensionless frequency and of Froude number. These data were obtained with Equation 9. Figures 8, 9, 10, and 11 show the variation of the added mass coefficient with frequency and Froude number for the whole ship. As a comparison Golovato's curves (3) have been drawn on Figure 8. It can be seen that the CSURF data are comparable to the DTMB data although consistently lower.

Comparison of individual segment contribution to the added mass of the whole ship is given in Figures 17 through 32 for a representative selection of Froude numbers and of heave frequencies. The graphs are presented as ratios of local added mass to ship added mass. IT MUST BE UNDERSTOOD THAT A CURVE MUST NOT BE DRAWN THROUGH THE POINTS SINCE ALL THAT HAS BEEN PRESENTED IS AN INTEGRATED VALUE OF THE ADDED MASS. The actual distribution of added masses over the segment is unknown.

Damping coefficients for pure heave motions appear in Figure 33 through 40. In these Figures it can be seen that the damping coefficients become negative for the whole ship. This implies that the configuration is dynamically unstable and that the water introduces energy into the model. This result seems far fetched and is not to be trusted.

In Figure 41 through 56 the ratio of local damping to total ship damping is presented. THE SAME PRECAUTIONARY STATEMENT APPLIED TO FIGURE 17 IS VALID HERE.

Pitch Motion

The added moment of inertia coefficients appears by segment in Figures 57 through 74. Moment of inertia coefficients for the whole ship are given in Figures 57 through 60.

Although the moment of inertia coefficients for each segment have been made dimensionless in terms of the segment characteristics, the center of rotation has been kept as the minor axis of the ship water plane. The measured information was too inaccurate to permit translation of moment characteristics to beam axis on the segment water planes. For comparison with theoretical strip computations, the results should be adequate.

Figures 75 through 90 show a representative collection of approximate longitudinal distributions of added moments of inertia, as a ratio to the added moment of inertia of the whole ship model.

Rotational damping coefficients are given in Figures 91 through 124. Damping coefficients for the whole model are given in Figures 91 through 94. The square law resistance coefficients d'_z , d'_θ are shown in Figures 125 through 142.

Comparison with Simple Reduction Method

Although the oscillograms did not logically admit use of the simple reduction method, some added masses and damping coefficients were computed by Equations 3 and 4 as a comparison with the more general technique. To carry out the computation, it was assumed that the zero shift did not exist and that the axis of symmetry of the oscillograph was the axis of zero force. Phase and amplitude were measured and the added masses and damping coefficients were computed (Figures 143 through 148).

VALIDITY OF TESTS

Instrumentation

Although great care was taken to reduce instrumental errors to a minimum, it was apparent that the instrumentation did not yield the complete information needed. The problem of coupling was not resolved.

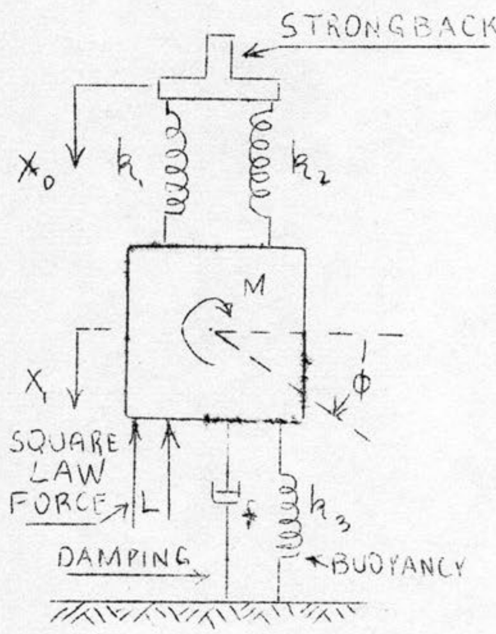


Fig. 7 Actual Mounting of Segment.

The actual mounting of the model segment is symbolized in Figure 7. k_1 and k_2 are the dynamometer springs while f and k_3 represent the damping and buoyancy of the water respectively. This system has two degrees of freedom in the response elements, the linear displacement X, and the angular displacement ϕ . As long as the moment M is zero, the coupling effects will vanish in time.

Careful examination of oscillograms leads one to believe that if M has a coupling effect, it is small enough to be neglected. However, this conclusion cannot be proved and further tests are needed to clarify the situation.

A major source of lack of confidence was the scatter of force distribution between the two springs of each segment. In some instances where the test conditions were identical, the total forces on both tests were comparable, but the contribution of each spring to the total varied widely. This seemed to indicate that either the moment system had not yet reached the ultimate state or that even in pure heave, no steady moment existed.

The best way to determine the coupling effects is to run a set of tests with only one degree of freedom movements, i.e., to conduct experiments in which rotation is restrained and then similar experiments in which vertical displacement is discouraged. With the resulting data, it will become possible to end at least a portion of the confusion.

Another major instrumental problem is the separation of the signal from the background noise. In the tests conducted at CSURF, considerable hand fairing of oscillogram curves was needed. It was found that two computists would obtain amplitudes which differed by over 10 per cent and phase shifts separated by at least 15 per cent. This last was quite noticeable at high frequency. Such high degree of error cannot be tolerated since a difference of 15 per cent at high frequencies will make the phase shift over 180 degrees, and hence will make the damping term negative and occasionally will also yield a negative added mass. No solution is possible to this difficulty without a change in instrumental technique. A new filtering system has been developed at CSURF, and it is believed that if applied to the segmented tanker model, more acceptable data would be obtained.

Mathematical Models

In a problem of this nature the mathematical model chosen is of primary importance. As was indicated in this study, more than one mathematical model is possible for the physical phenomenon of the oscillating ship. NO CONCLUSION IS POSSIBLE AS TO WHICH MATHEMATICAL MODEL IS VALID. According to the previous section, a complete model would include coupling between displacement and rotation. Evidence of square law damping has been found by several workers (for example, ref. 3). It is entirely possible that square law damping and coupling both exist. Thus, before any conclusions can be drawn from the tests, a clarification of the true mathematical model must be obtained. The authors submit that further repeated tests of the type employed in this study are not useful until it is established that the simple mathematical representation used by most workers in the field is valid.

Suggestions for Further Work

A. Run through a limited set of runs in heave and pitch with a modified instrumental setup consisting of a one degree of freedom dynamometer and a low pass filter. Great care should be taken to obtain the forces and moments which exist whenever the model is not oscillating and restrained in all modes. From these tests the true location of the zero force axis should be obtained. The existence of non-uniform square law damping may be deduced if the oscillograms exhibit zero shifts which cannot be explained in terms of lift and moment.

B. Measurements of the true lift and moments may be used to determine an approximate distribution per unit length of the forces and moments. This last result cannot be obtained from the current tests since the moment vs. force relationship is not known.

C. Tests should be made of the model mounted with no driving oscillator but restricted to move freely in only one mode. From such tests, the natural frequency of the entire dynamical system as well as the damping constant should be obtained. A comparison of free vs. forced oscillations should then indicate the adequacy of the simple mathematical model.

D. Run similar tests on simplified models such as the Haskind's ship to permit a generalized theory to be obtained by comparison with an "ideal" theory.

CONCLUSIONS

The longitudinal distribution of ship forces and moments has been studied. Certain unusual findings were obtained:

(a) Phase shifts were often greater than 180°.

(b) The mean force in heave and the mean moment in pitch were not equal to zero.

As a result of these findings, it was surmised that a non-linear term should be included in the equations. The data were reduced with these modified equations. It was found that added masses and damping for the whole ship conformed to the findings of other researchers (2, 3, 4) at low frequency. At high frequency of oscillation, the results were doubtful and were disregarded.

It was discovered that although the overall model damping coefficient was positive, the local coefficient was often negative. This was gratifying since P. Kaplan had reported orally that his theoretical results indicated the possibility of local energy sources.

It is obvious that these tests can give only a qualitative check of the validity of the "strip" method since the results are given as integrated values over a non-infinitesimal portion of the hull. Nevertheless, it is expected that the information obtained may be used to obtain an approximation of the relative contribution of each segment to the total ship coefficients. As a final conclusion, it must be admitted that further test are needed to develop a firm comparison of experiment to strip theory.

REFERENCES

1. Lewis, E.V. "Ship Model Tests to Determine Bending Moments in Waves," Trans. SNAME, Vol. 62, 1954, pp. 426-490.

2. Haskind, M.D. "Oscillation of a Ship on a Calm Sea," Bulletin de l'Academic des Sciences de l'URSS 1946, No. 1. Translation from Russian to English by J. V. Wehausen, Brown University, Providence, Phode Island and published as part of Tech. and Res. Bul. No. 1-12, Society of Naval Architects and Marine Engineers, New York, New York.

3. Golovato, P. "A Study of the Forces and Moments on a Surface Ship Performing Heaving Oscillations," 1957 Taylor Model Basin Report No. 1074, Washington, D. C.

4. Gerritsma, J. "Experimental Determination of Damping, Added Mass and Added Mass Moment of Inertia of a Ship Model," 1957, Netherlands Research Centre TNO for Shipbuilding and Navigation Report No. 25S, Delft, Netherlands.

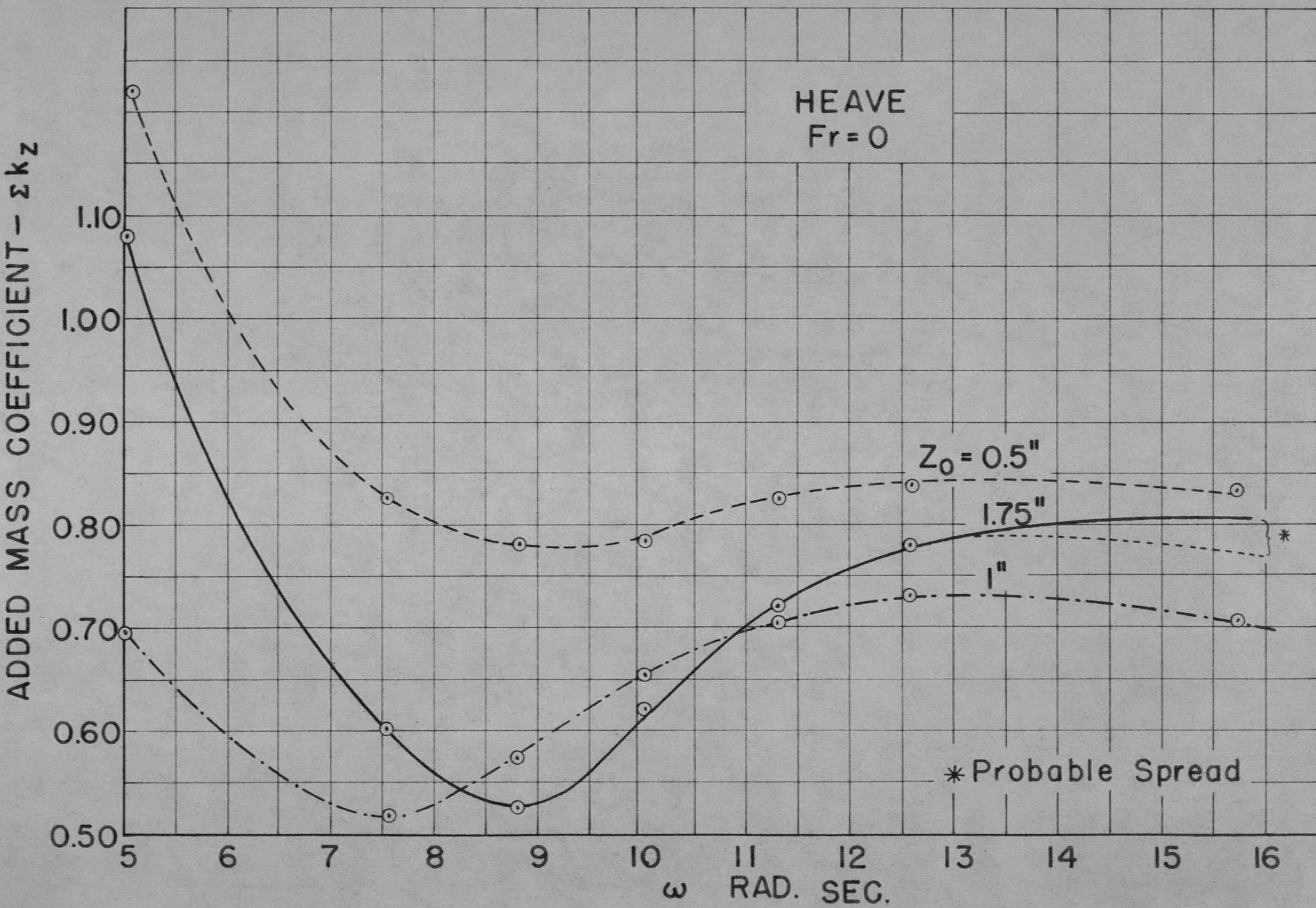

HEAVE
Fr = 0
Z0 = 0.5"
1.75"
1"
*
* Probable Spread
ADDED MASS COEFFICIENT – εkz
1.10
1.00
0.90
0.80
0.70
0.60
0.50
5
6
7
8
9
10
11
12
13
14
15
16
ω RAD. SEC.

FIG. 8

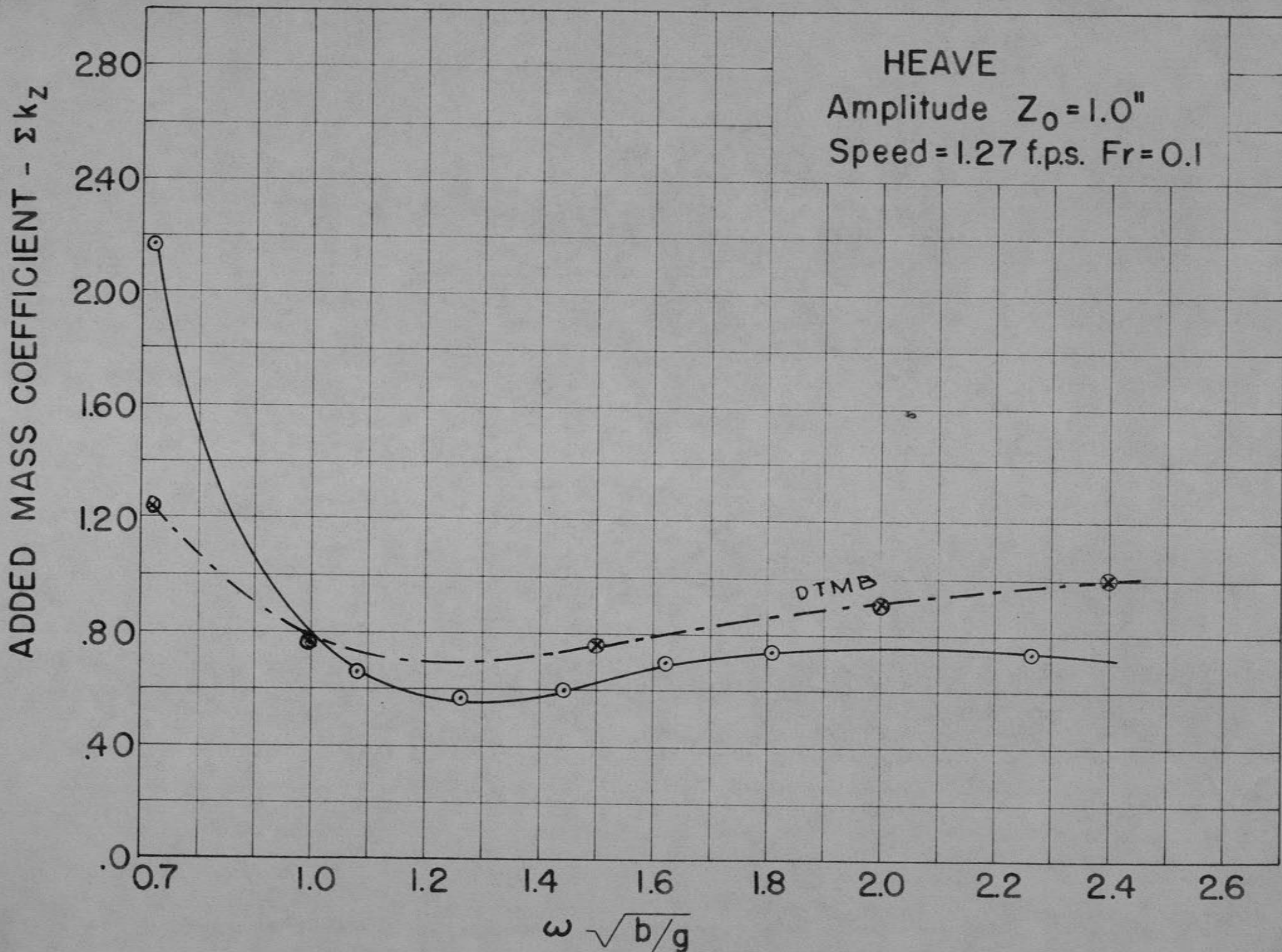

HEAVE
Amplitude Z0 = 1.0"
Speed = 1.27 f.p.s. Fr = 0.1
DTMB
ADDED MASS COEFFICIENT - Σ kz
2.80
2.40
2.00
1.60
1.20
.80
.40
.0
0.7
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
ω √b/g

FIG. 9


HEAVE
Amplitude $Z_0 = 1.0''$
Speed = 2.52 f.p.s., Fr. = 0.2
ADDED MASS COEFFICIENT – Σk_z
1.00
.80
.60
.40
.20
0
.7
1.0
1.2
1.4
1.6
1.8
2.0
2.2
$\omega\sqrt{b/g}$

FIG. 10

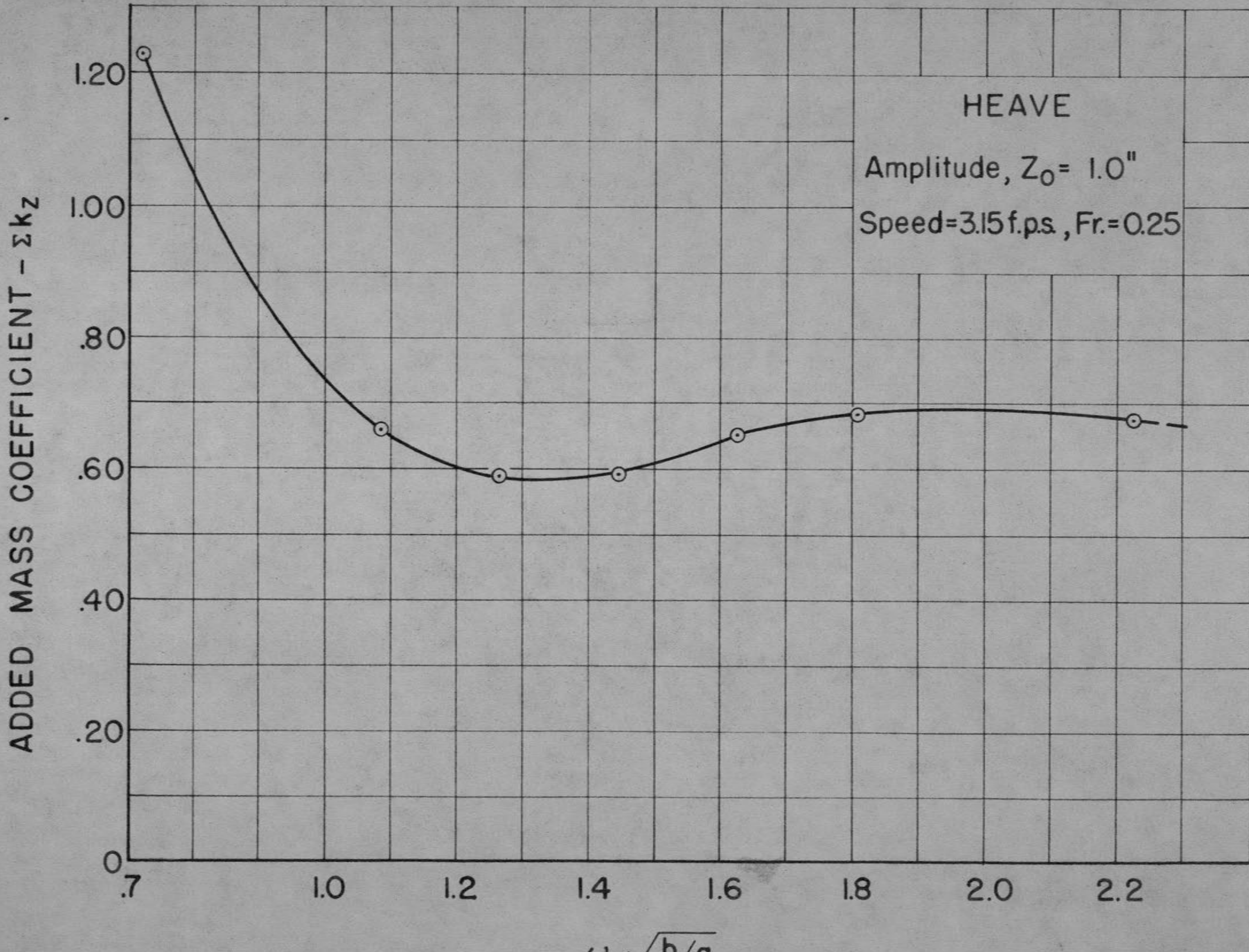

HEAVE
Amplitude, Z_0 = 1.0"
Speed=3.15 f.p.s. , Fr.=0.25
ADDED MASS COEFFICIENT - Σk_z
1.20
1.00
.80
.60
.40
.20
0
.7
1.0
1.2
1.4
1.6
1.8
2.0
2.2
$\omega \sqrt{b/g}$

FIG. 11

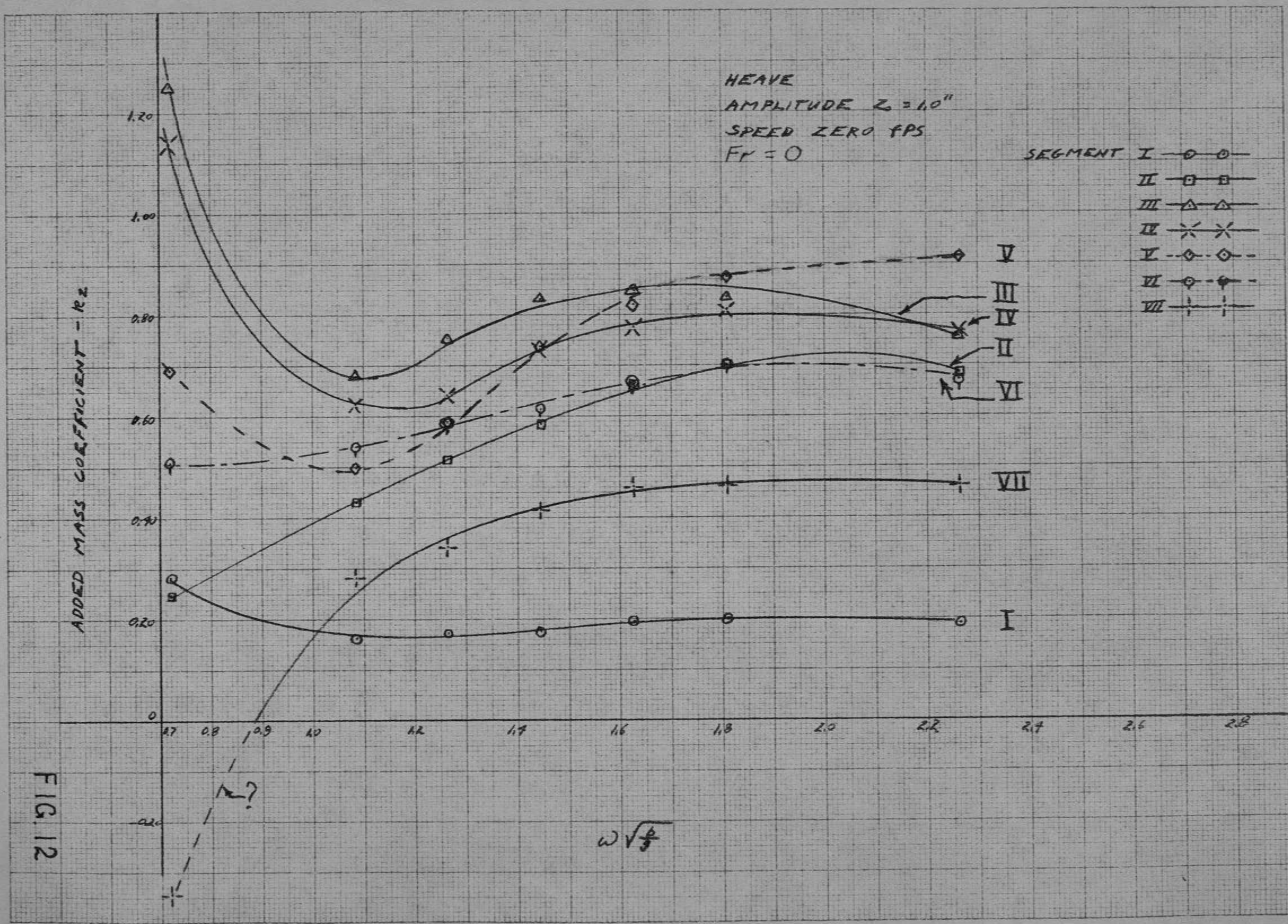

HEAVE
AMPLITUDE Z = 1.0"
SPEED ZERO FPS
Fr = 0
SEGMENT I
II
III
IV
V
VI
VII
ADDED MASS COEFFICIENT - kz
1.20
1.00
0.80
0.60
0.40
0.20
0
-0.20
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
k?

FIG. 12

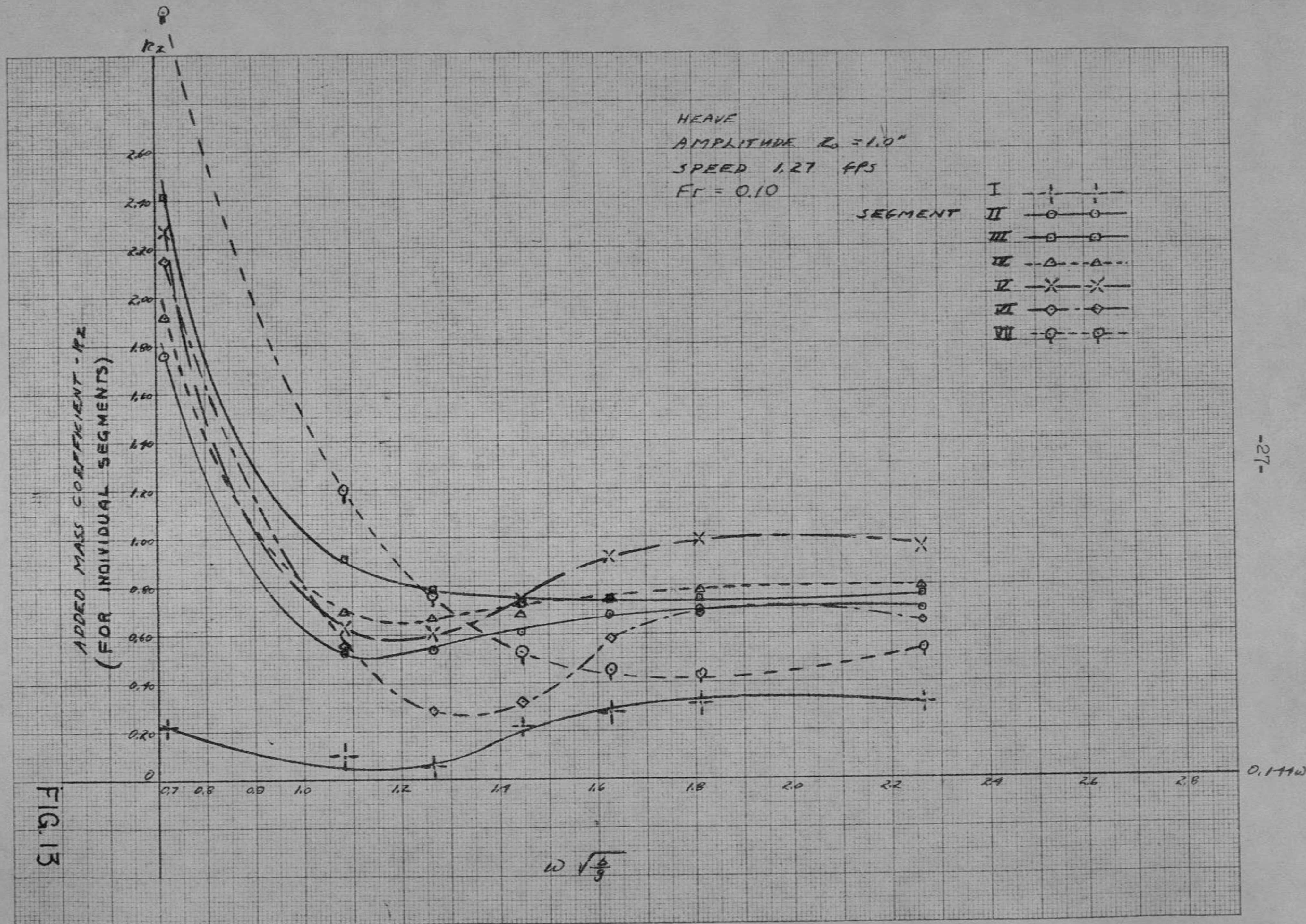
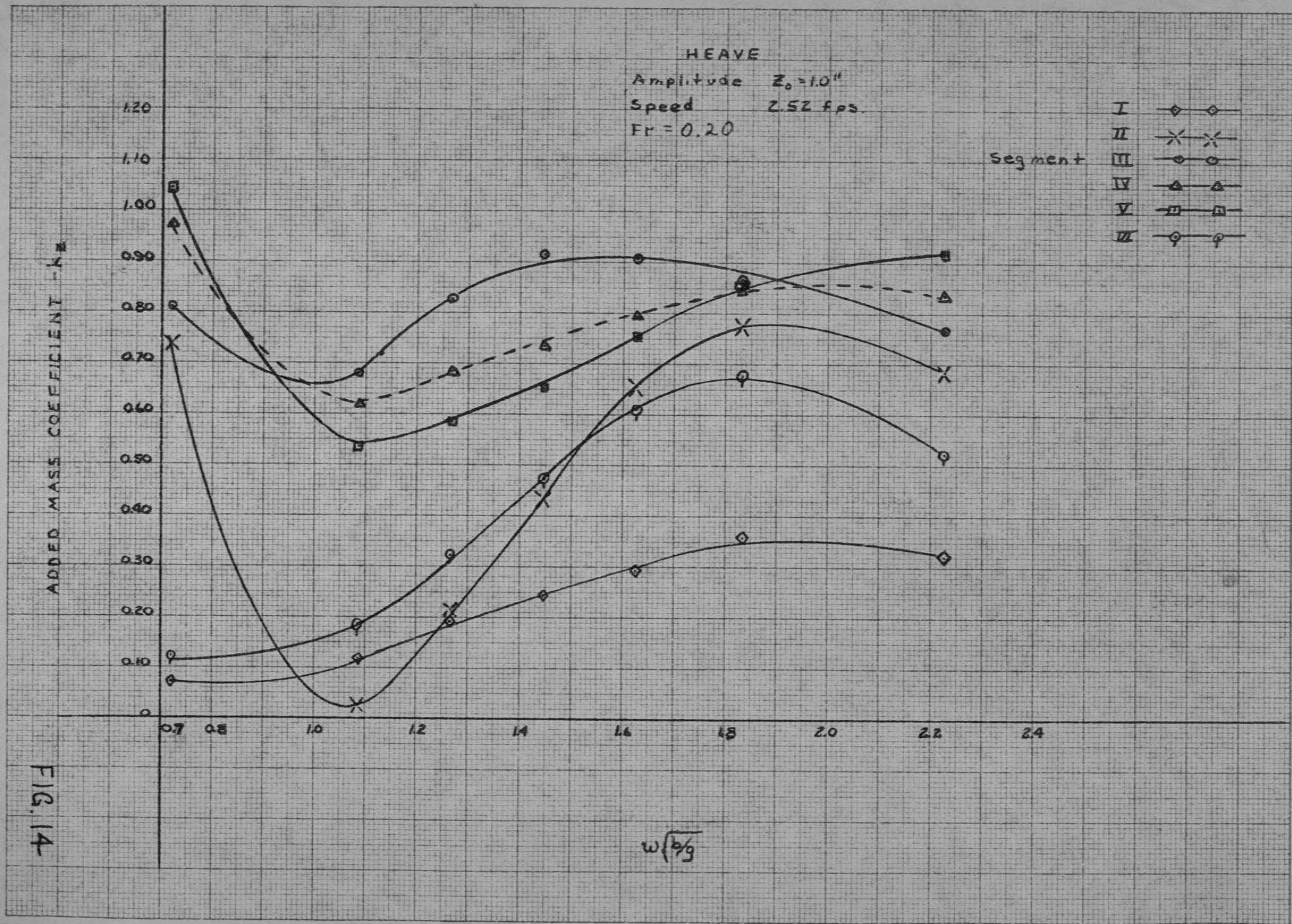

HEAVE
AMPLITUDE Z_0 = 1.0"
SPEED 1.27 FPS
Fr = 0.10
SEGMENT
I
II
III
IV
V
VI
VII
ADDED MASS COEFFICIENT - K_z
(FOR INDIVIDUAL SEGMENTS)
K_z
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0.144ω
$\omega\sqrt{\frac{L}{g}}$

FIG. 13



HEAVE
Amplitude $Z_0 = 1.0''$
Speed 2.52 fps
Fr = 0.20
Segment
I
II
III
IV
V
VI
ADDED MASS COEFFICIENT $-k_z$
1.20
1.10
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega\sqrt{b/g}$

FIG. 14

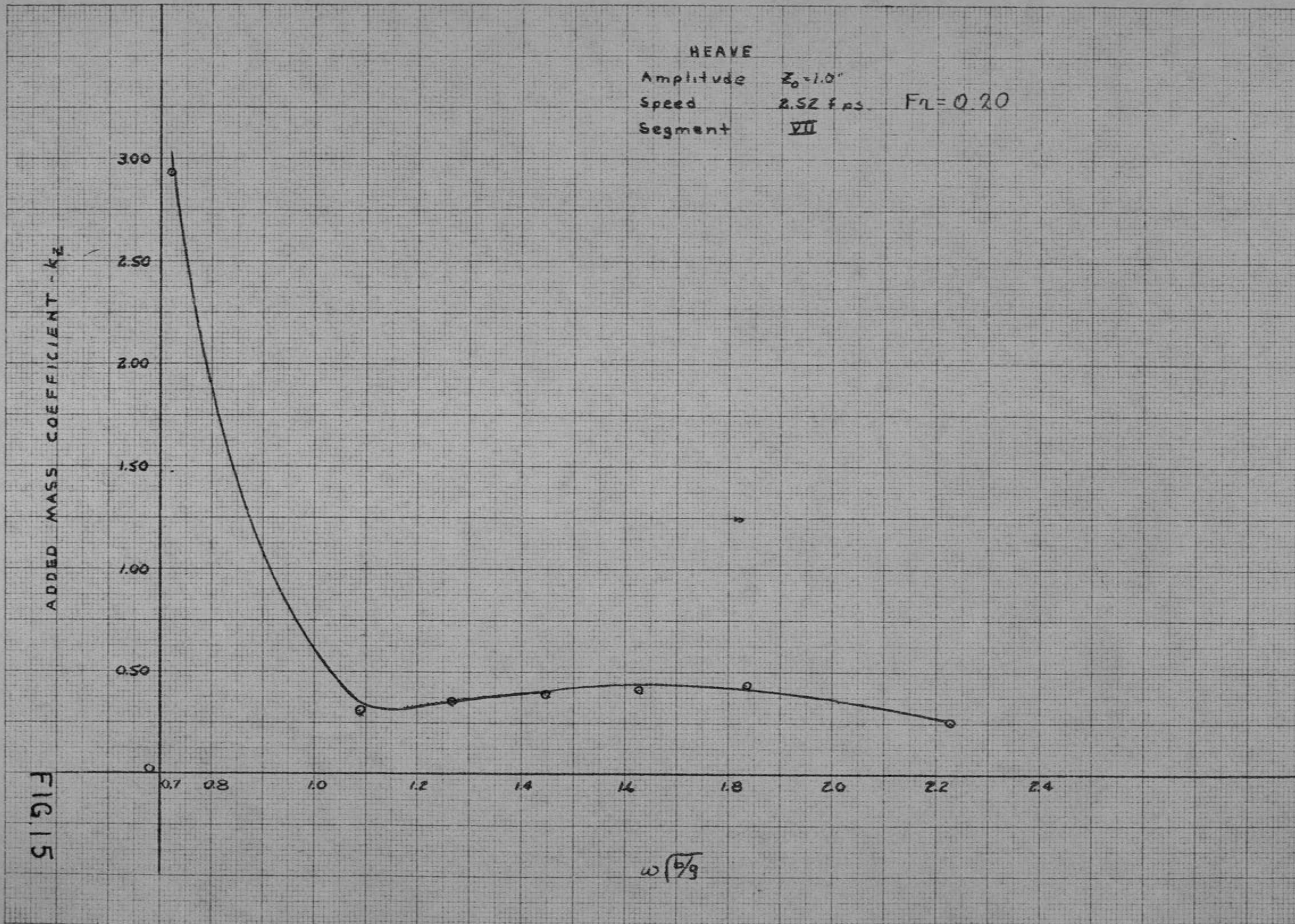

HEAVE
Amplitude $Z_0 = 1.0''$
Speed 2.52 fps. $F_n = 0.20$
Segment VII
ADDED MASS COEFFICIENT - k_z
3.00
2.50
2.00
1.50
1.00
0.50
0
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega\sqrt{b/g}$

FIG. 15

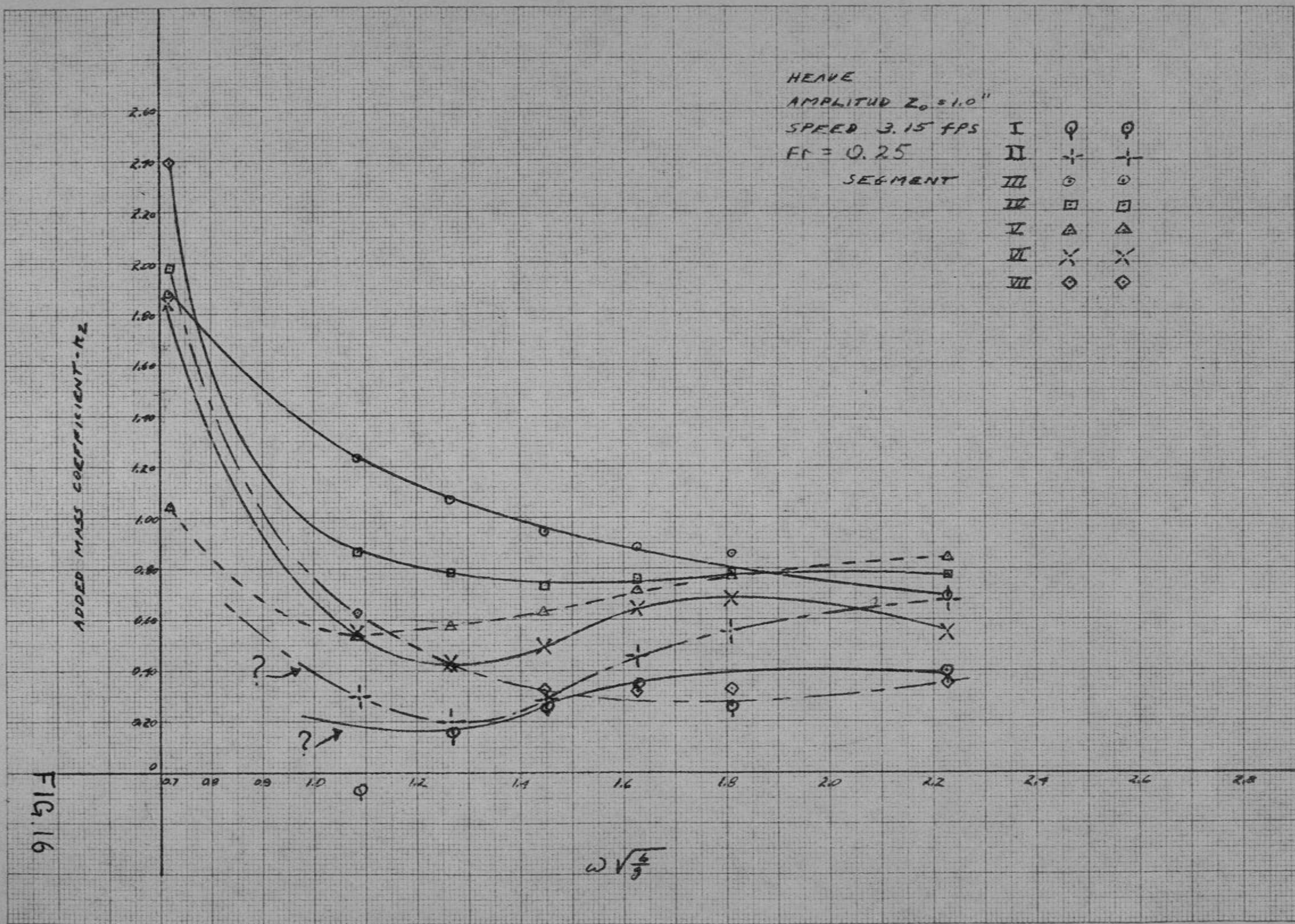

HEAVE
AMPLITUD $Z_0 = 1.0''$
SPEED 3.15 FPS
Fr = 0.25
SEGMENT
I
II
III
IV
V
VI
VII
ADDED MASS COEFFICIENT - Kz
$\omega\sqrt{\frac{L}{g}}$
2.60
2.40
2.20
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
?
?

FIG. 16

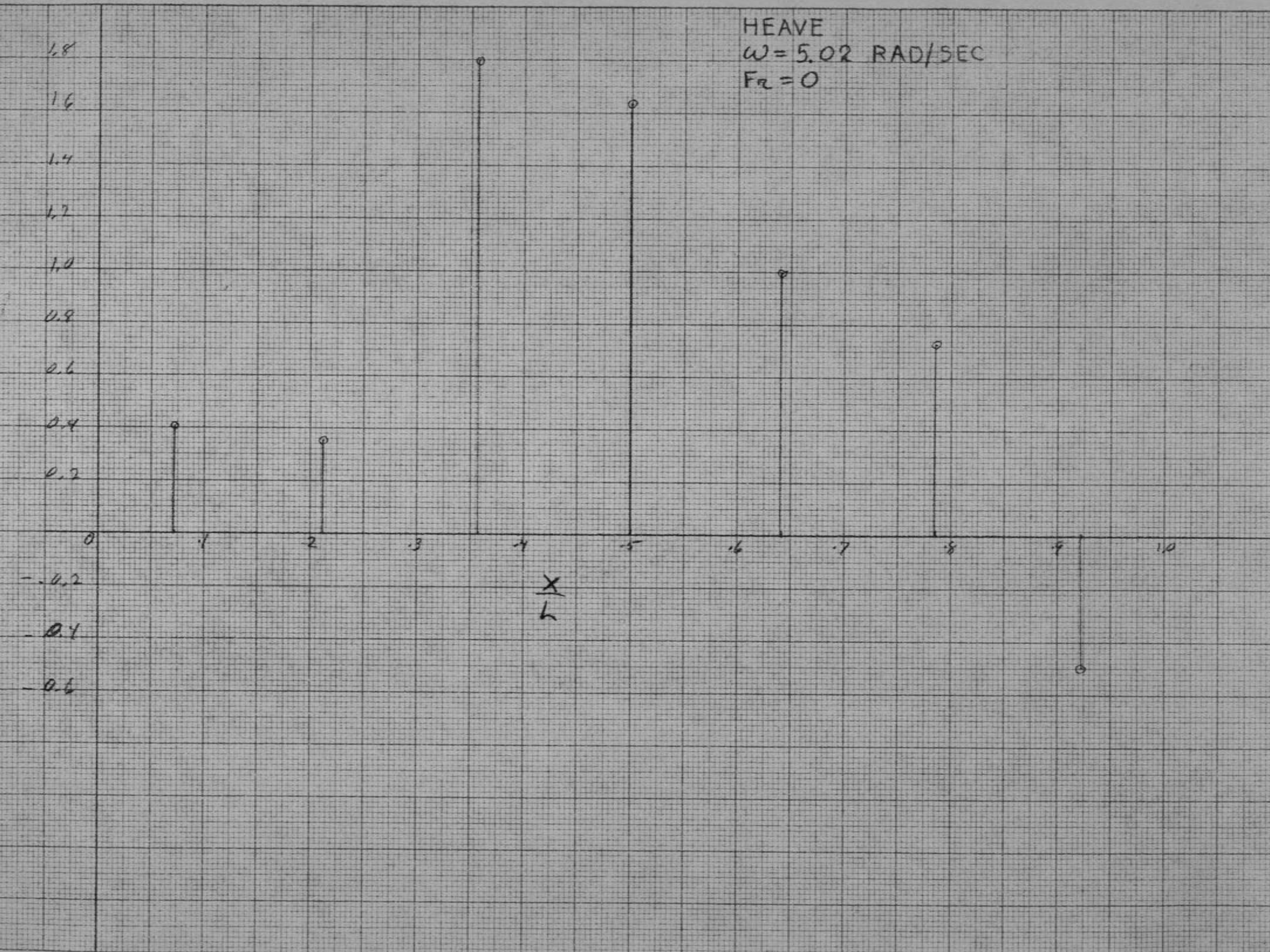
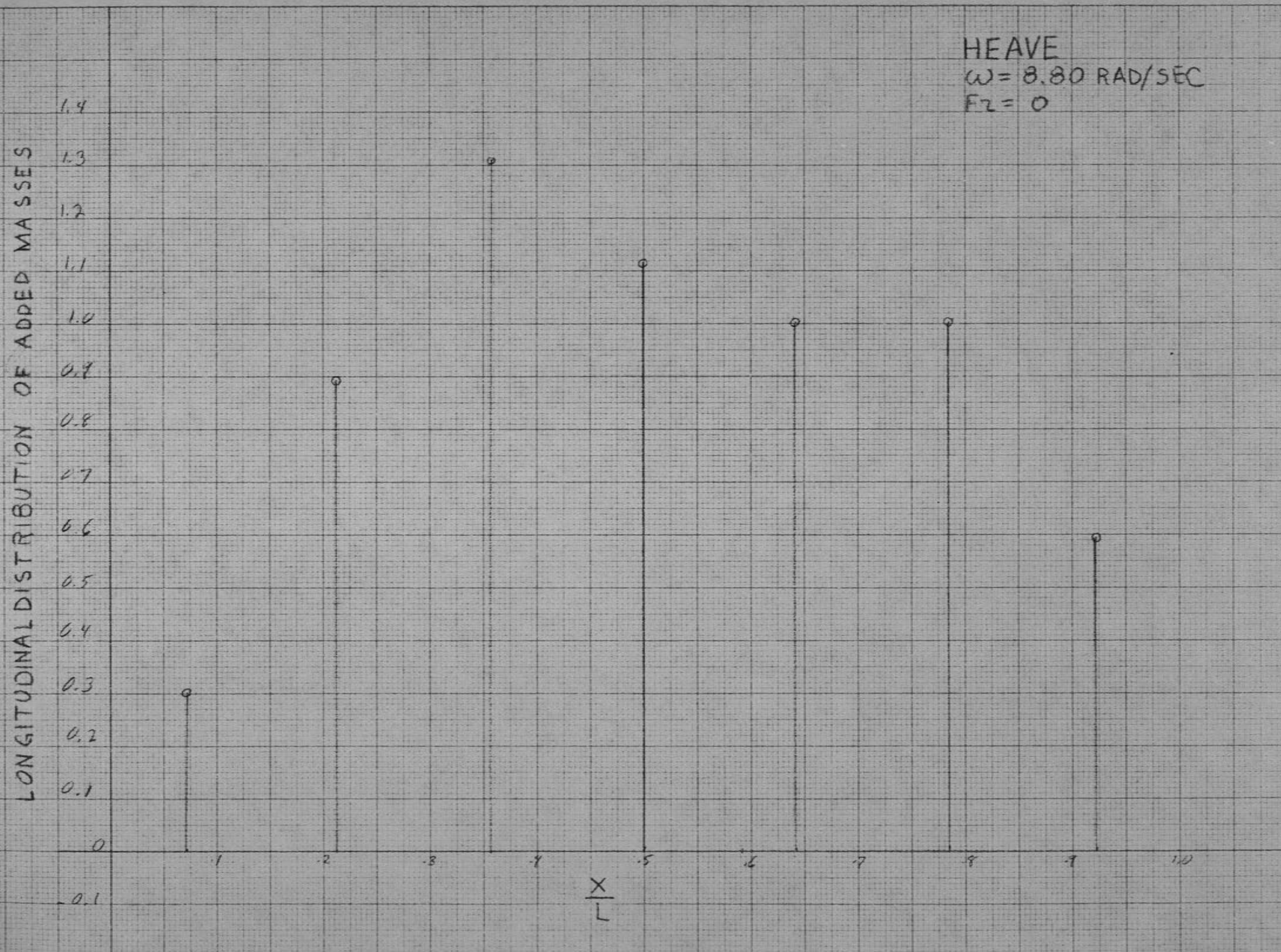


FIG 17 LONGITUDINAL DISTRIBUTION OF ADDED MASSES



HEAVE
ω = 8.80 RAD/SEC
Fz = 0
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 18

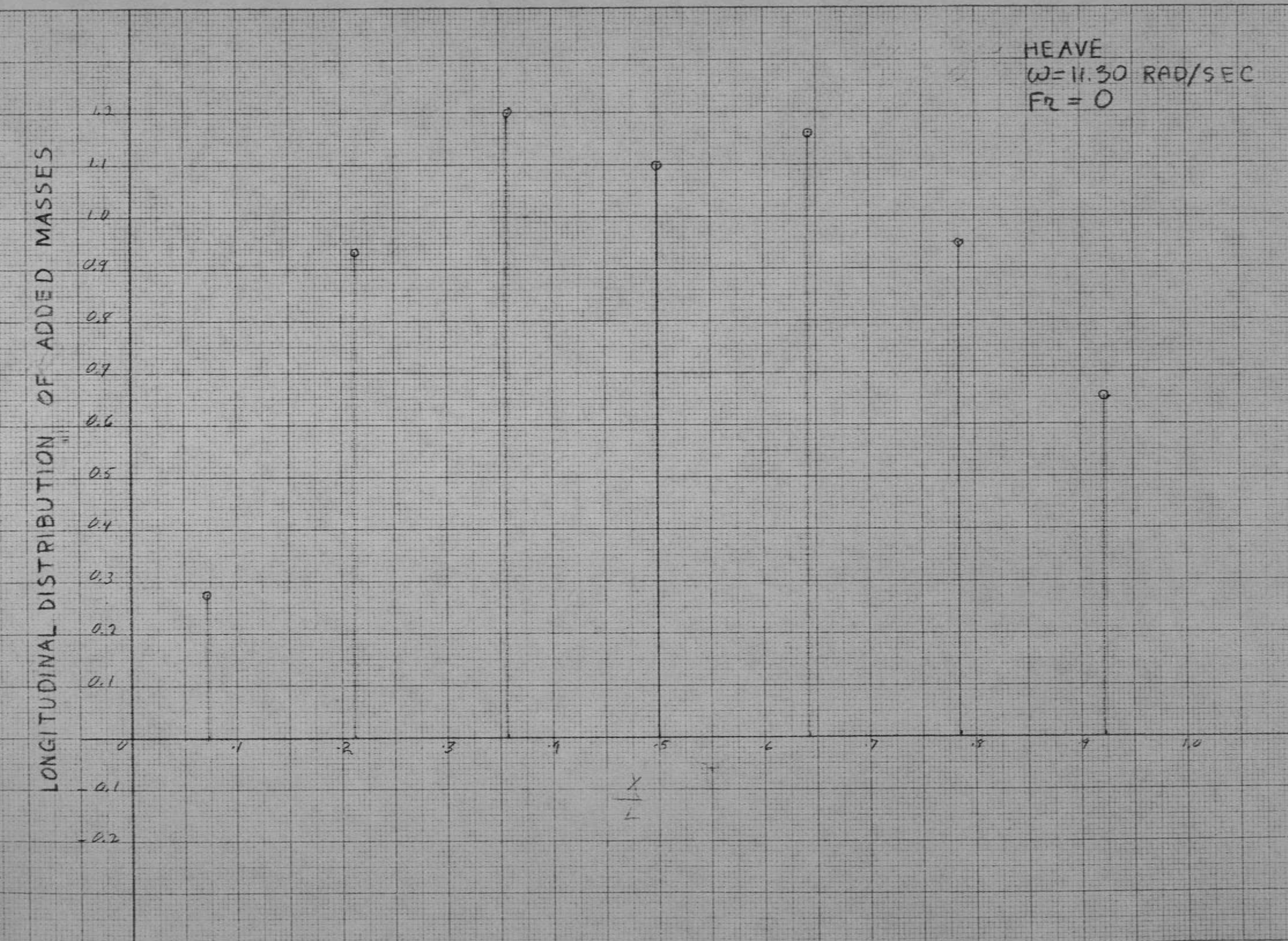

HEAVE
ω=11.30 RAD/SEC
Fr = 0
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
-0.1
-0.2
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 19

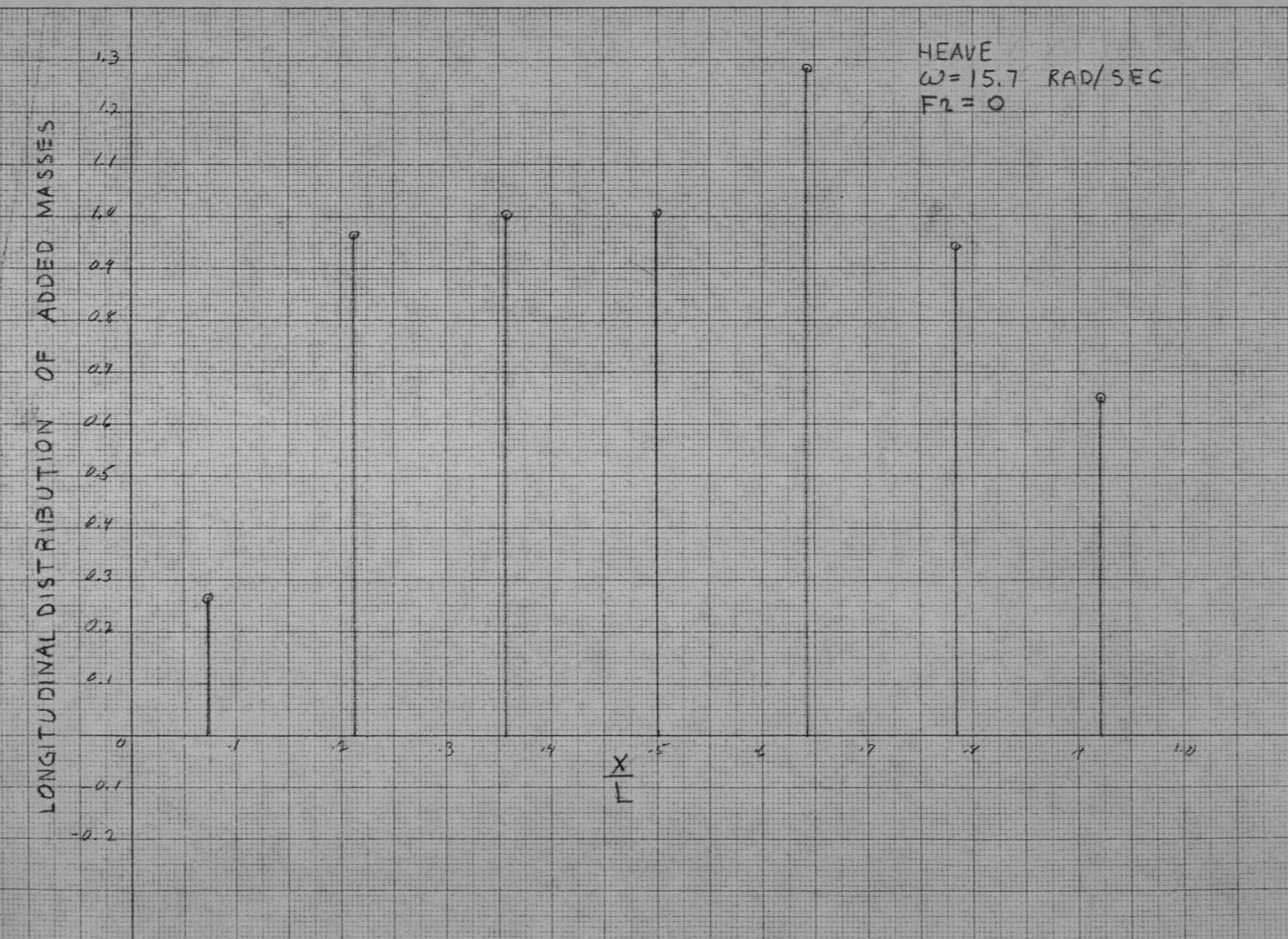

HEAVE
ω = 15.7 RAD/SEC
Fn = 0
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 20

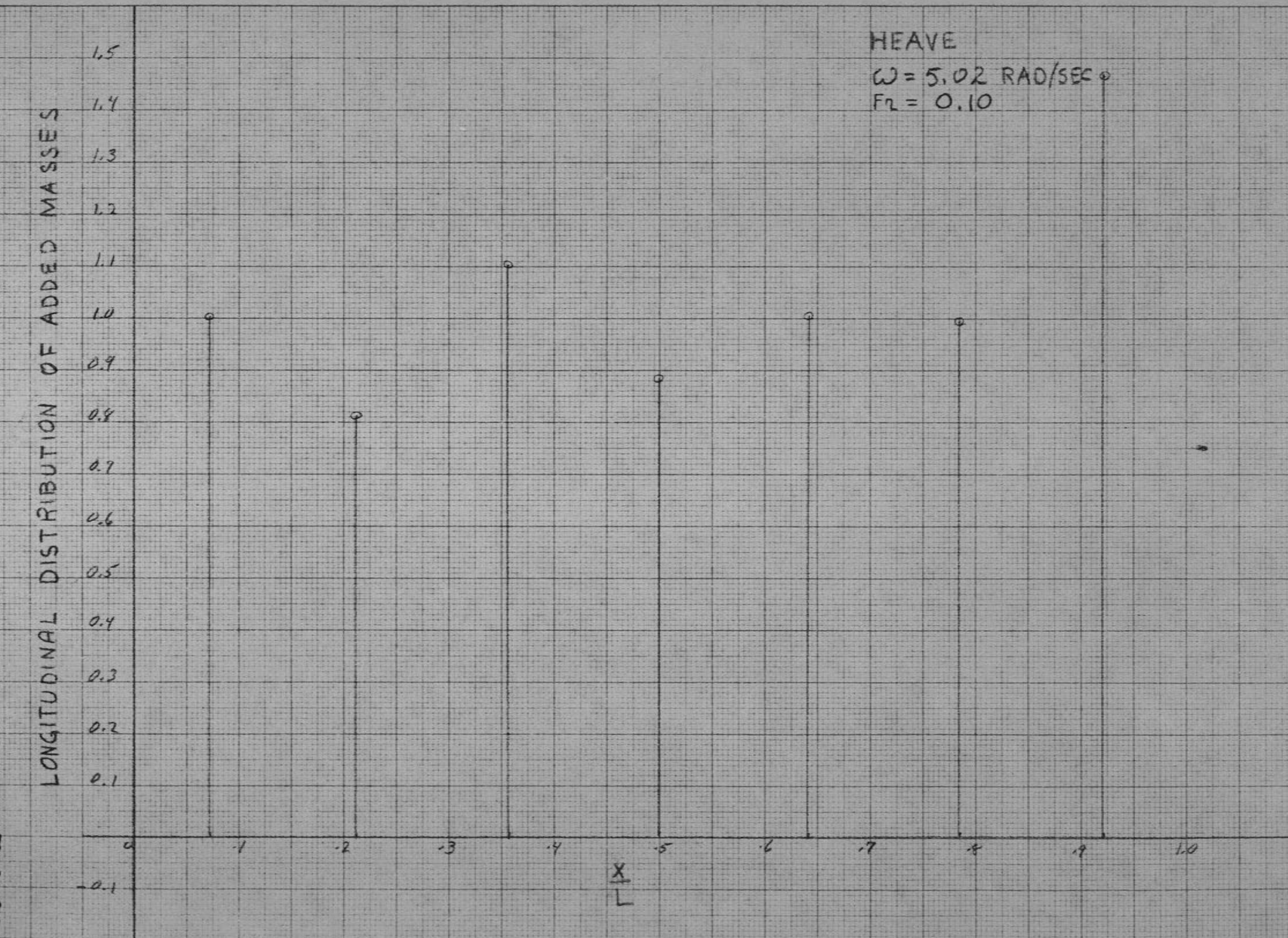

HEAVE
ω = 5.02 RAD/SEC
Fn = 0.10
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 21

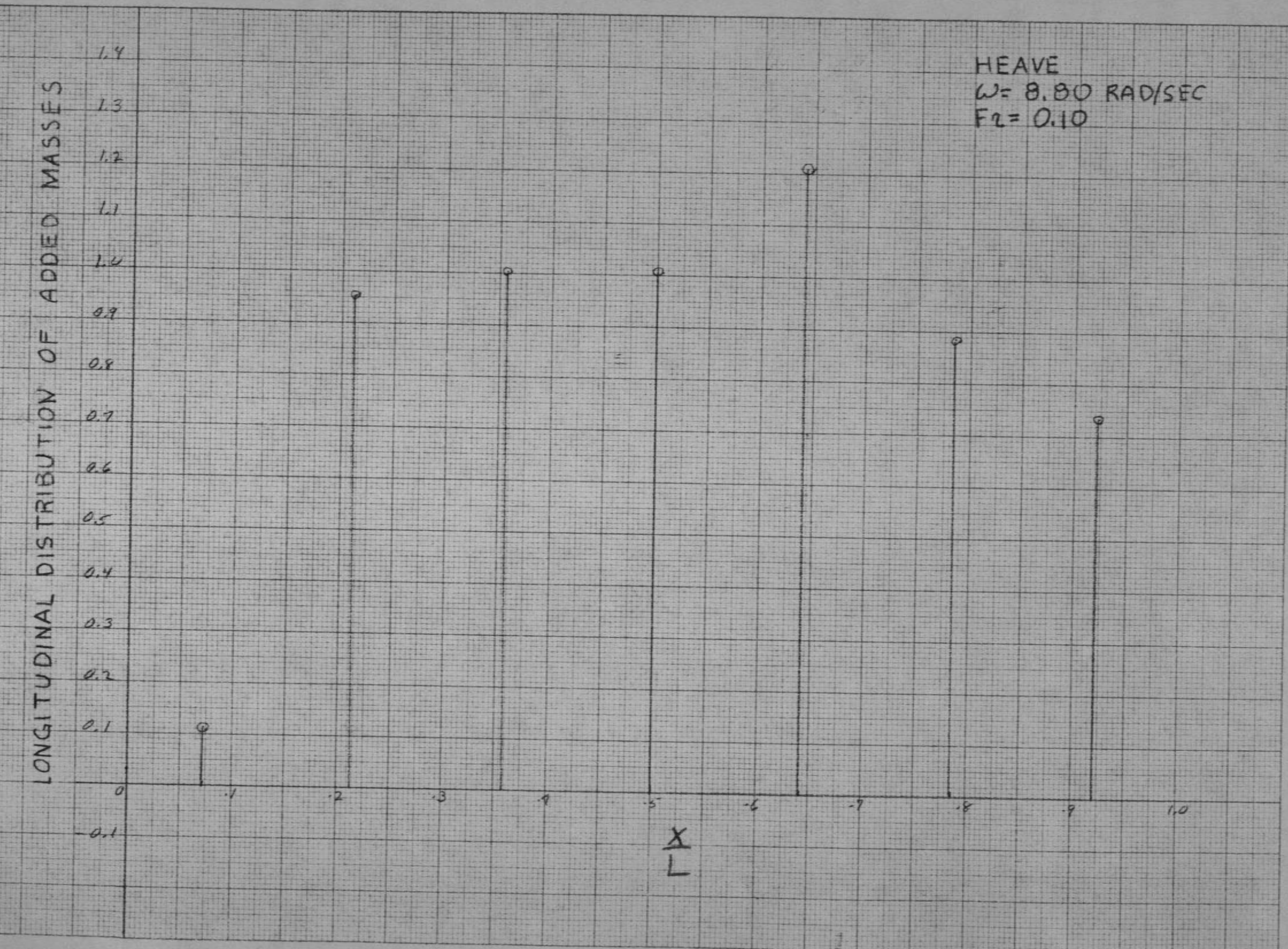

HEAVE
ω= 8.80 RAD/SEC
Fr= 0.10
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
X/L
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 22

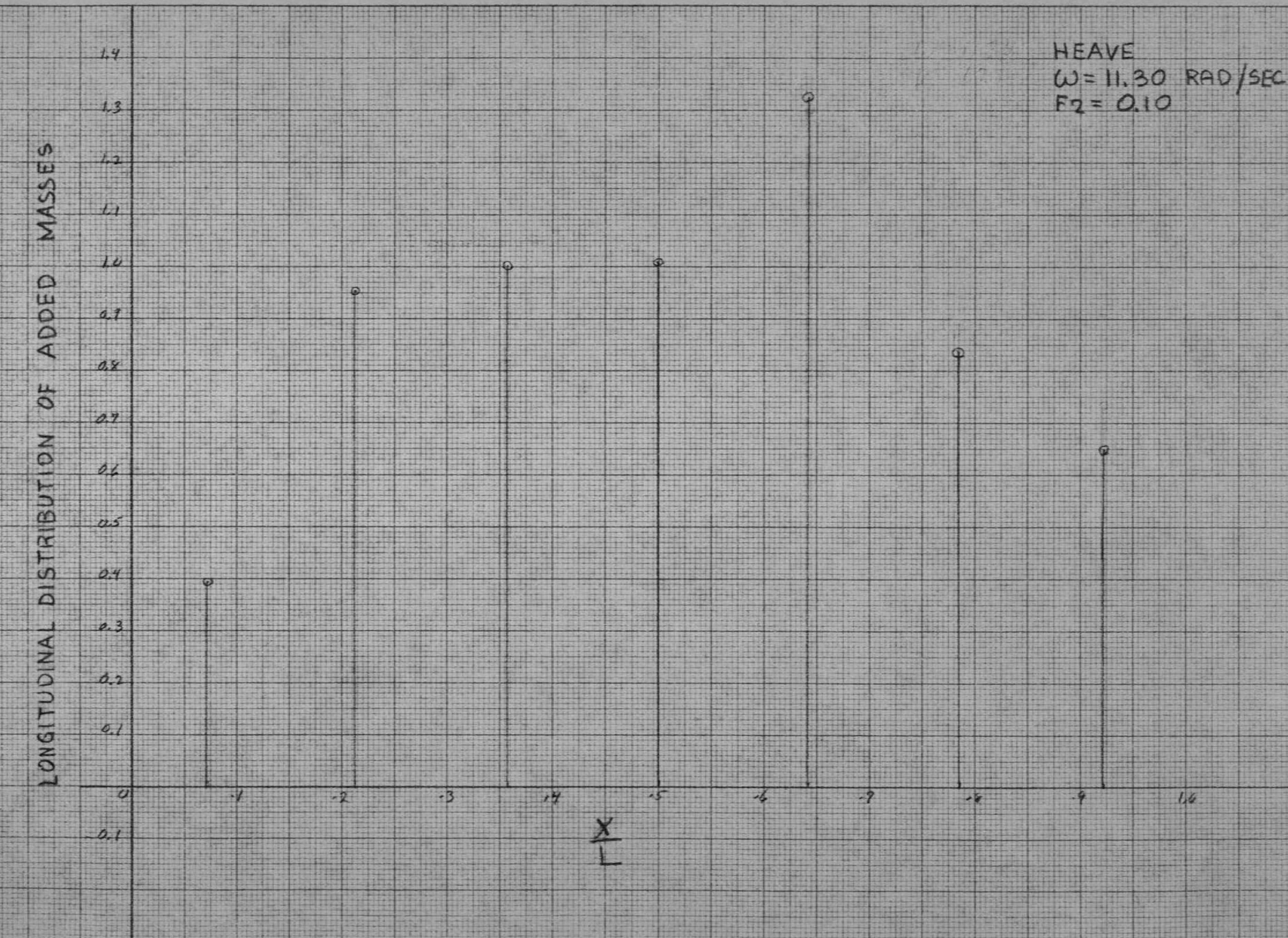

HEAVE
ω = 11.30 RAD/SEC
F2 = 0.10
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 23

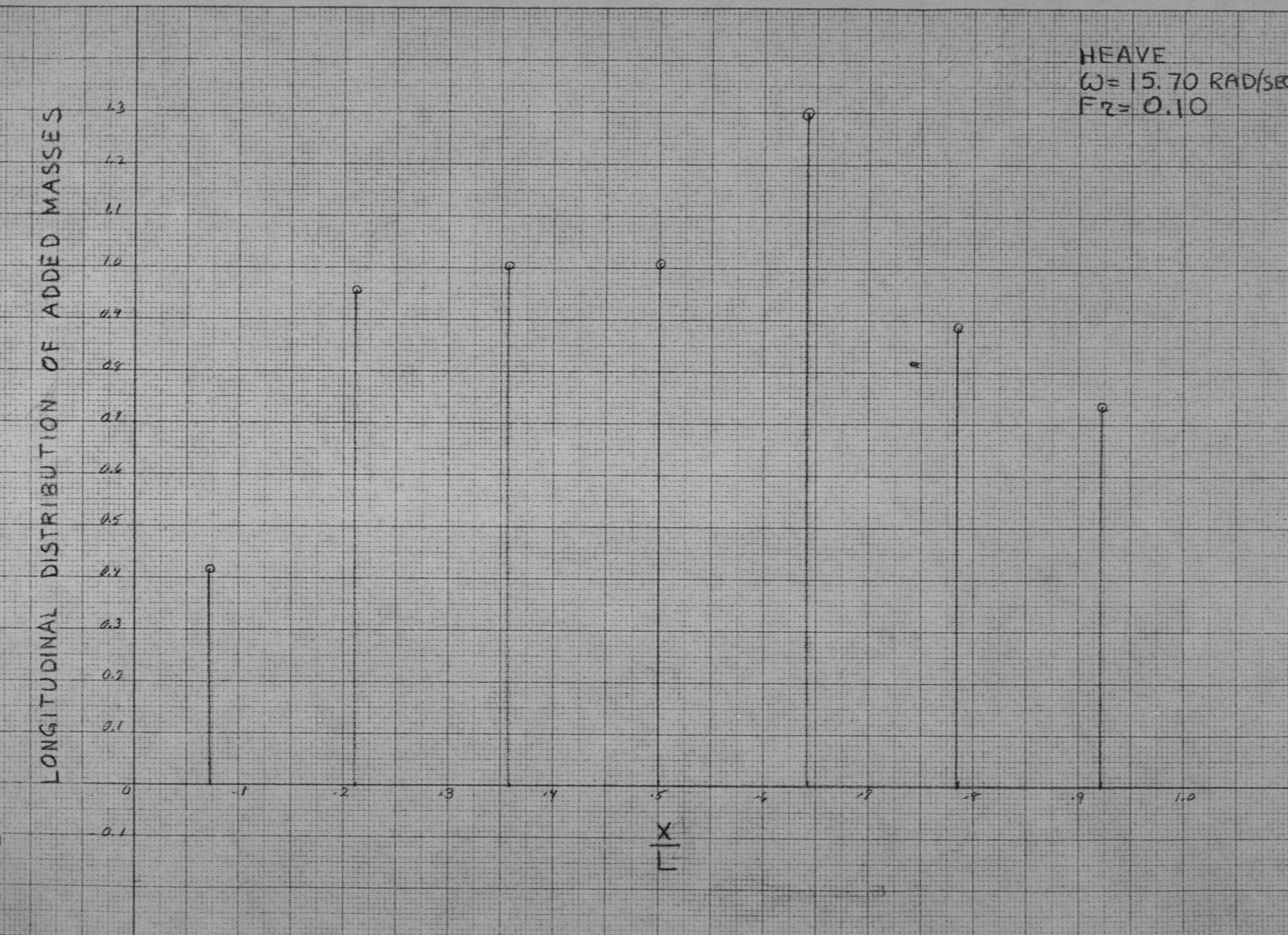

HEAVE
ω= 15.70 RAD/SEC
Fr= 0.10
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 24

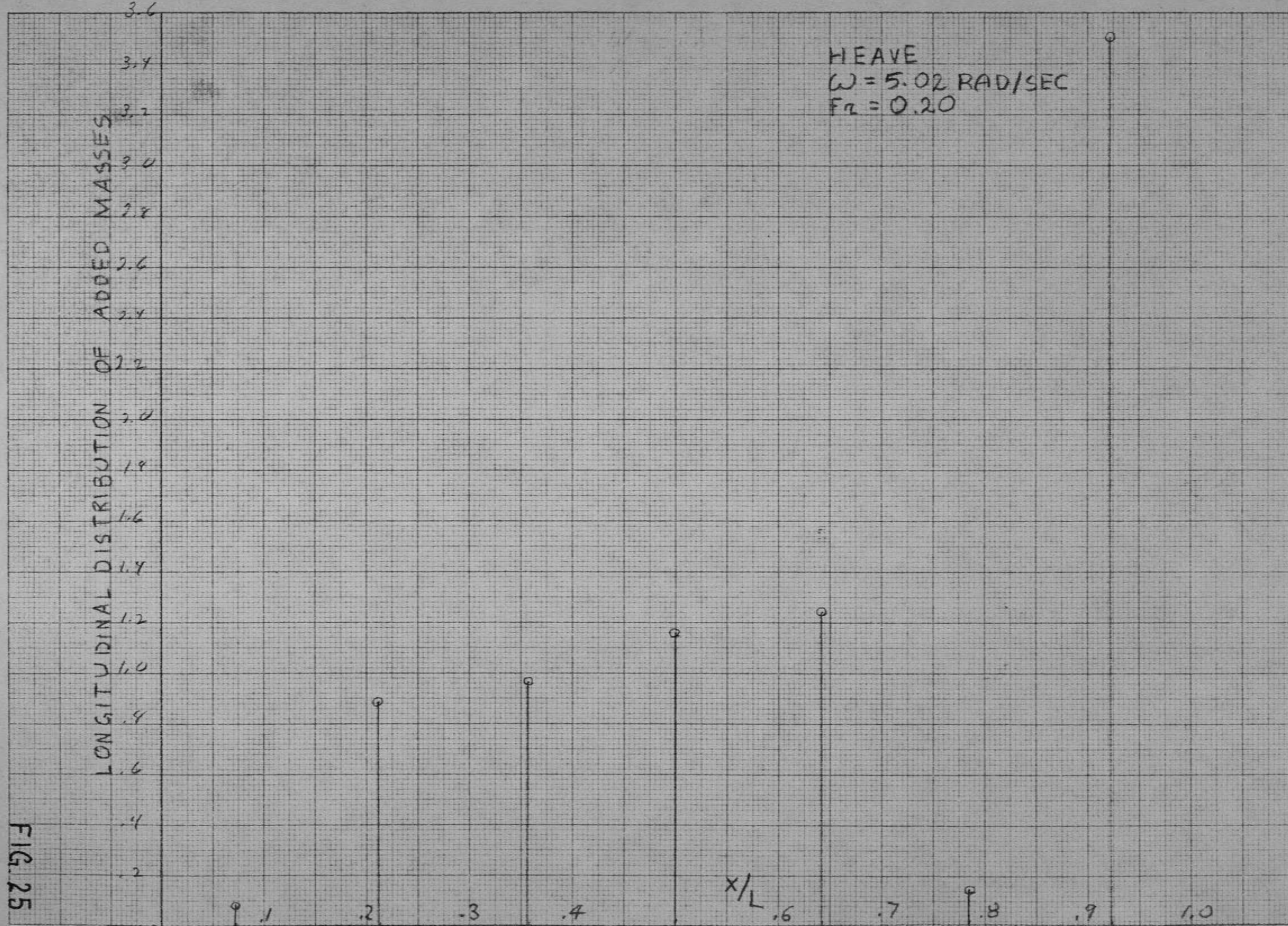

HEAVE
ω = 5.02 RAD/SEC
Fn = 0.20
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
X/L
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
.6
.4
.2
.1
.2
.3
.4
.6
.7
.8
.9
1.0

FIG. 25

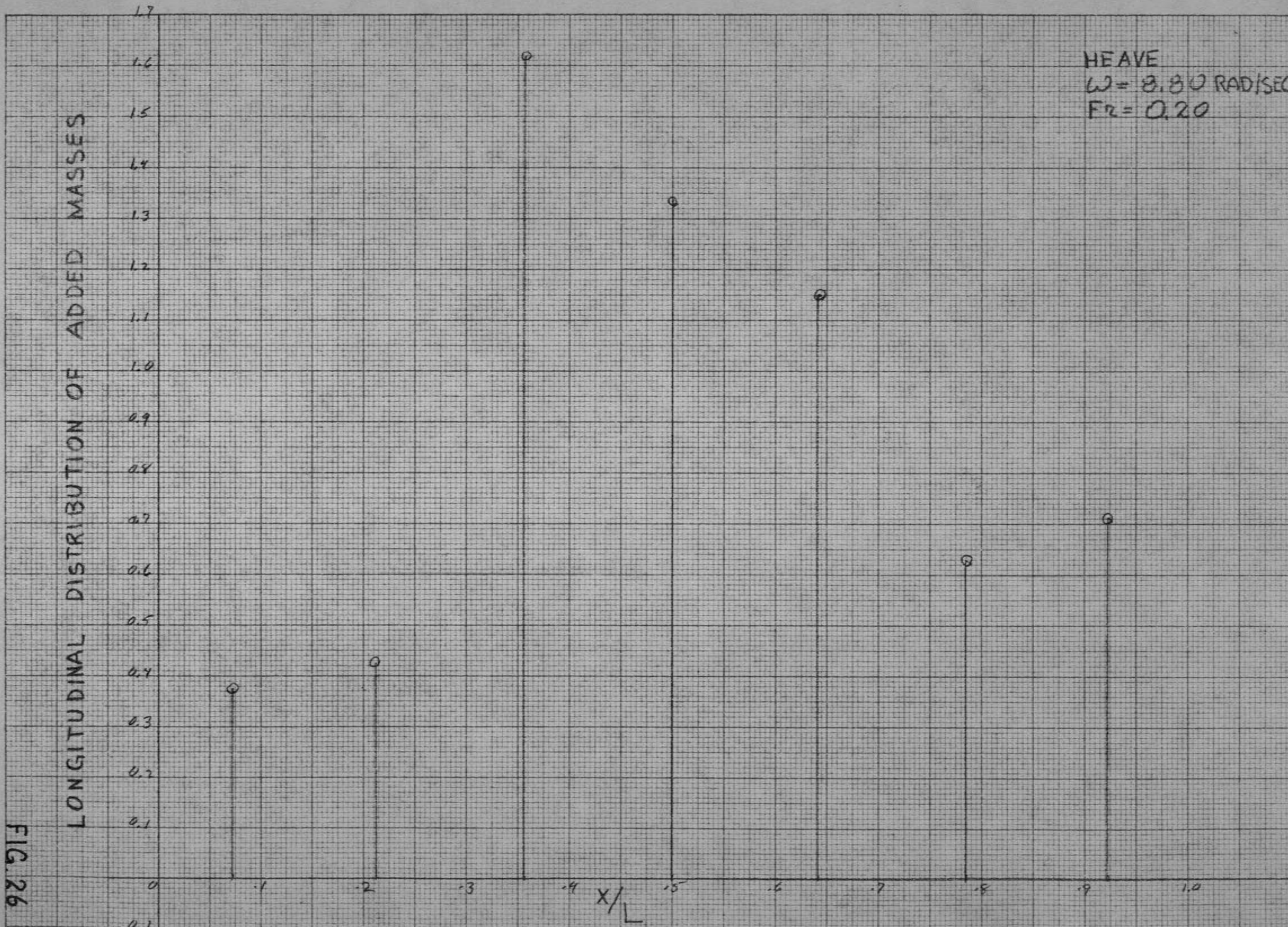

HEAVE
ω = 8.80 RAD/SEC
Fr = 0.20
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
X/L
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
·1
·2
·3
·4
·5
·6
·7
·8
·9
1.0

FIG. 26

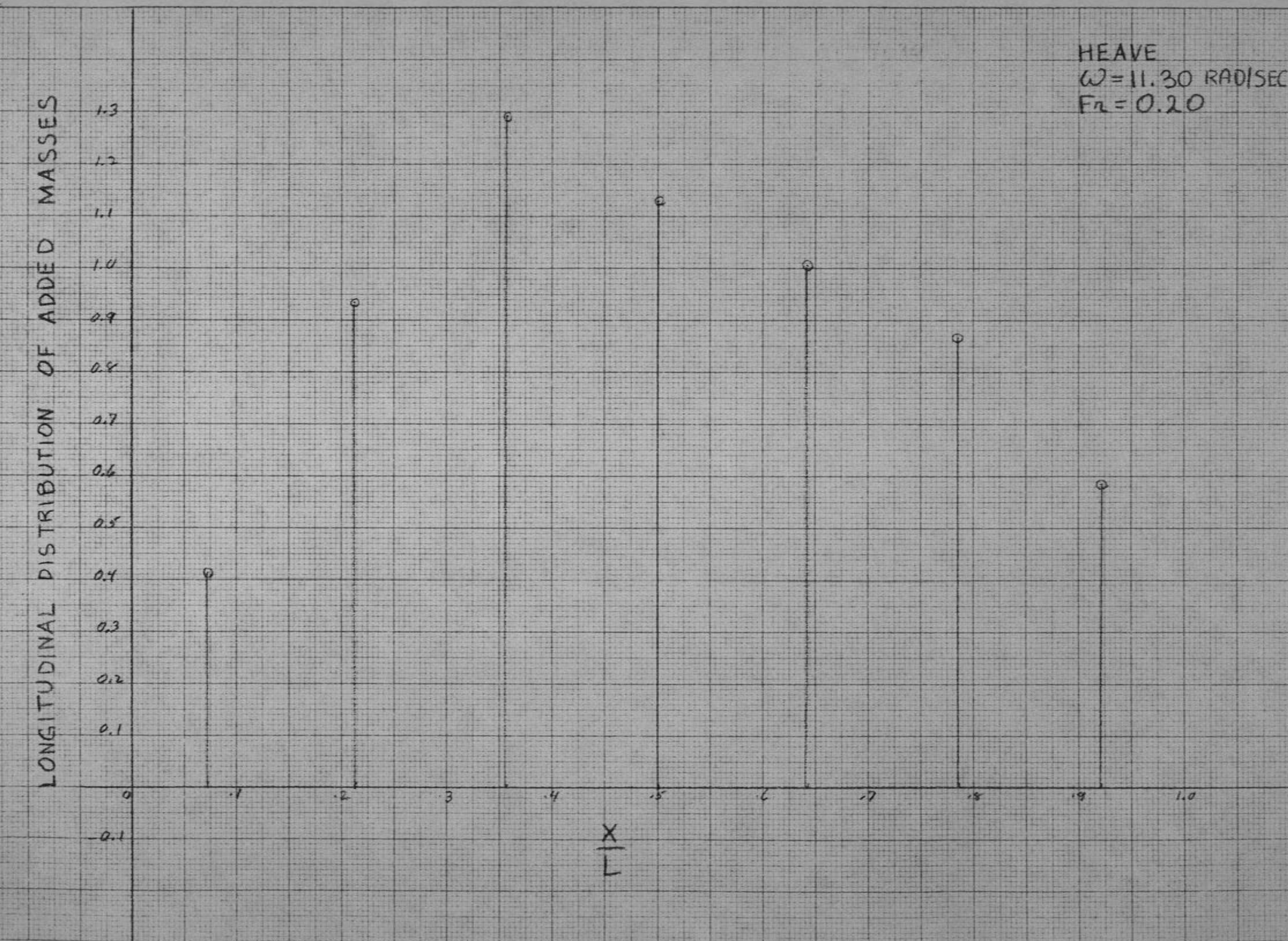

HEAVE
ω = 11.30 RAD/SEC
Fn = 0.20
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 27

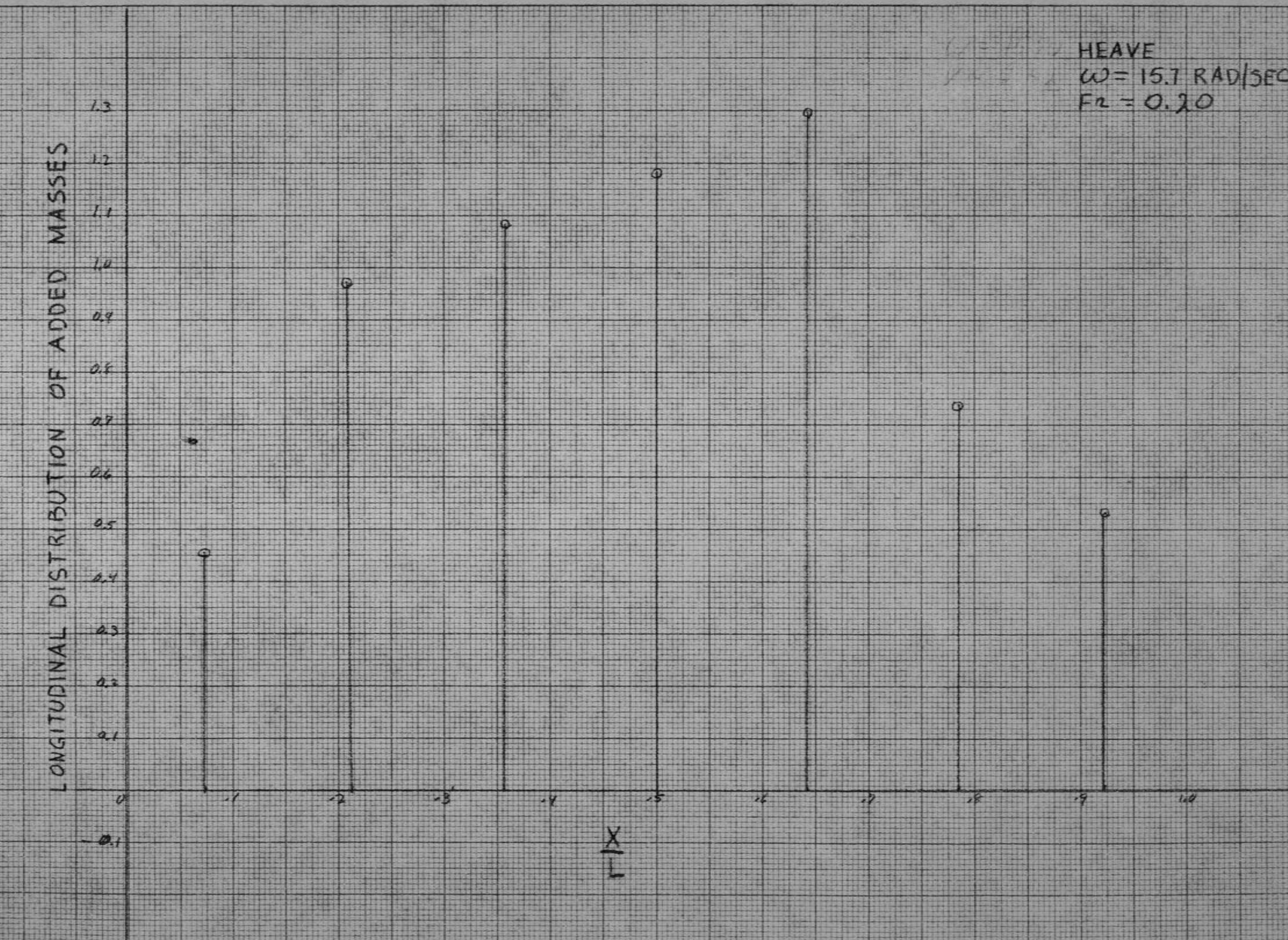

HEAVE
ω = 15.7 RAD/SEC
Fr = 0.20
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
X/L
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 28

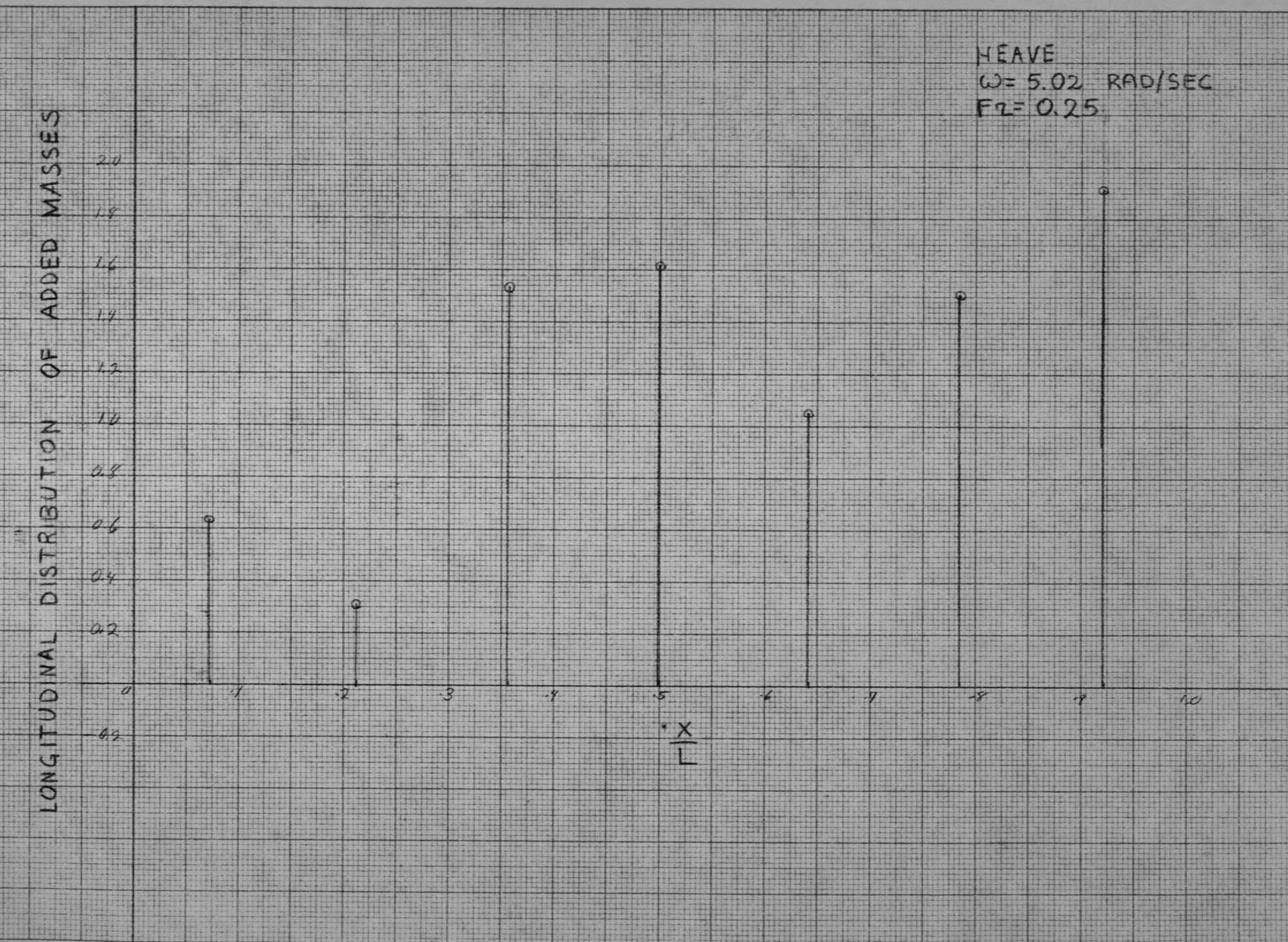

HEAVE
ω= 5.02 RAD/SEC
Fz= 0.25
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 29

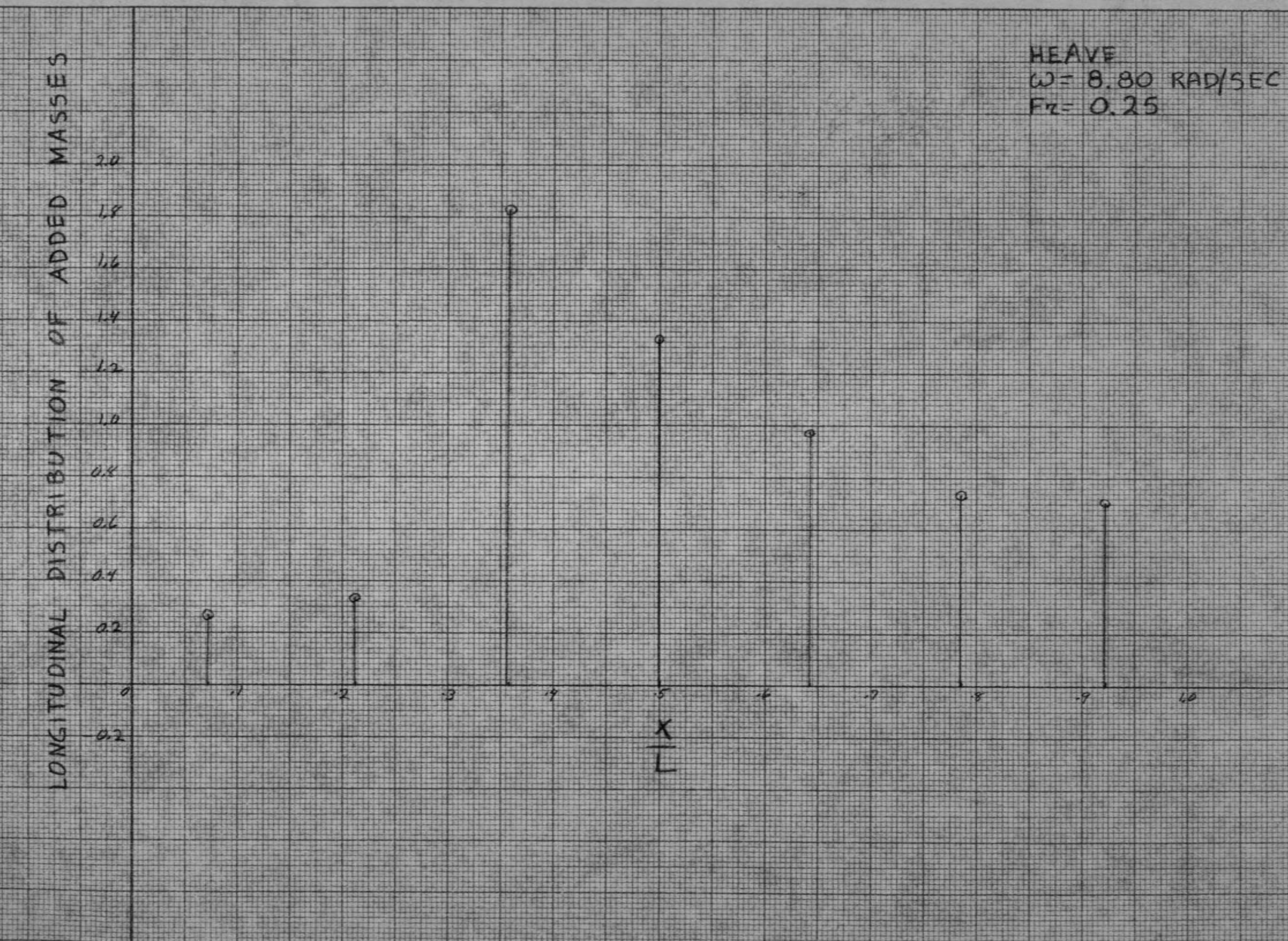

HEAVE
ω= 8.80 RAD/SEC
Fr= 0.25
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 30

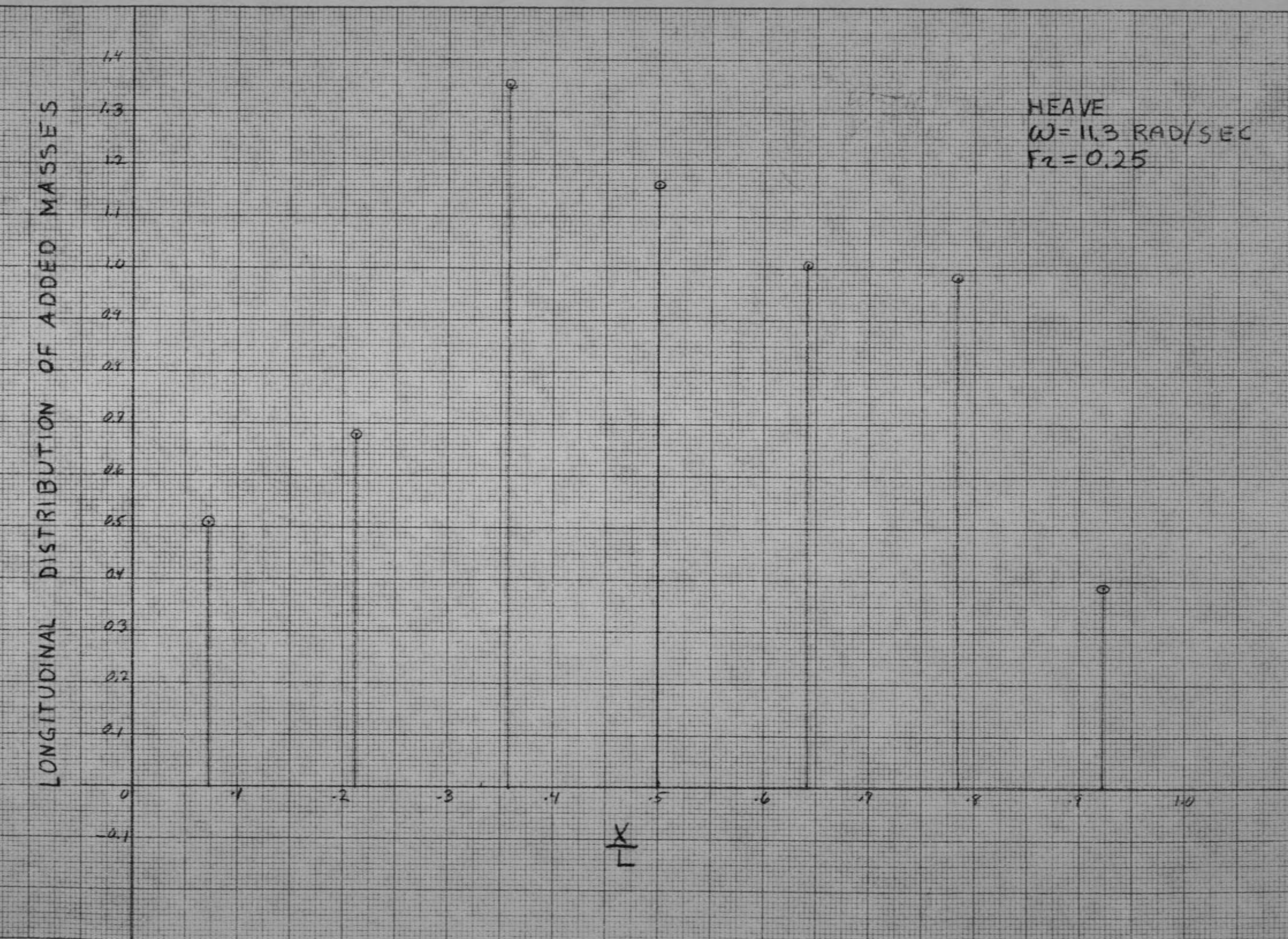

HEAVE
ω = 11.3 RAD/SEC
Fr = 0.25
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 31

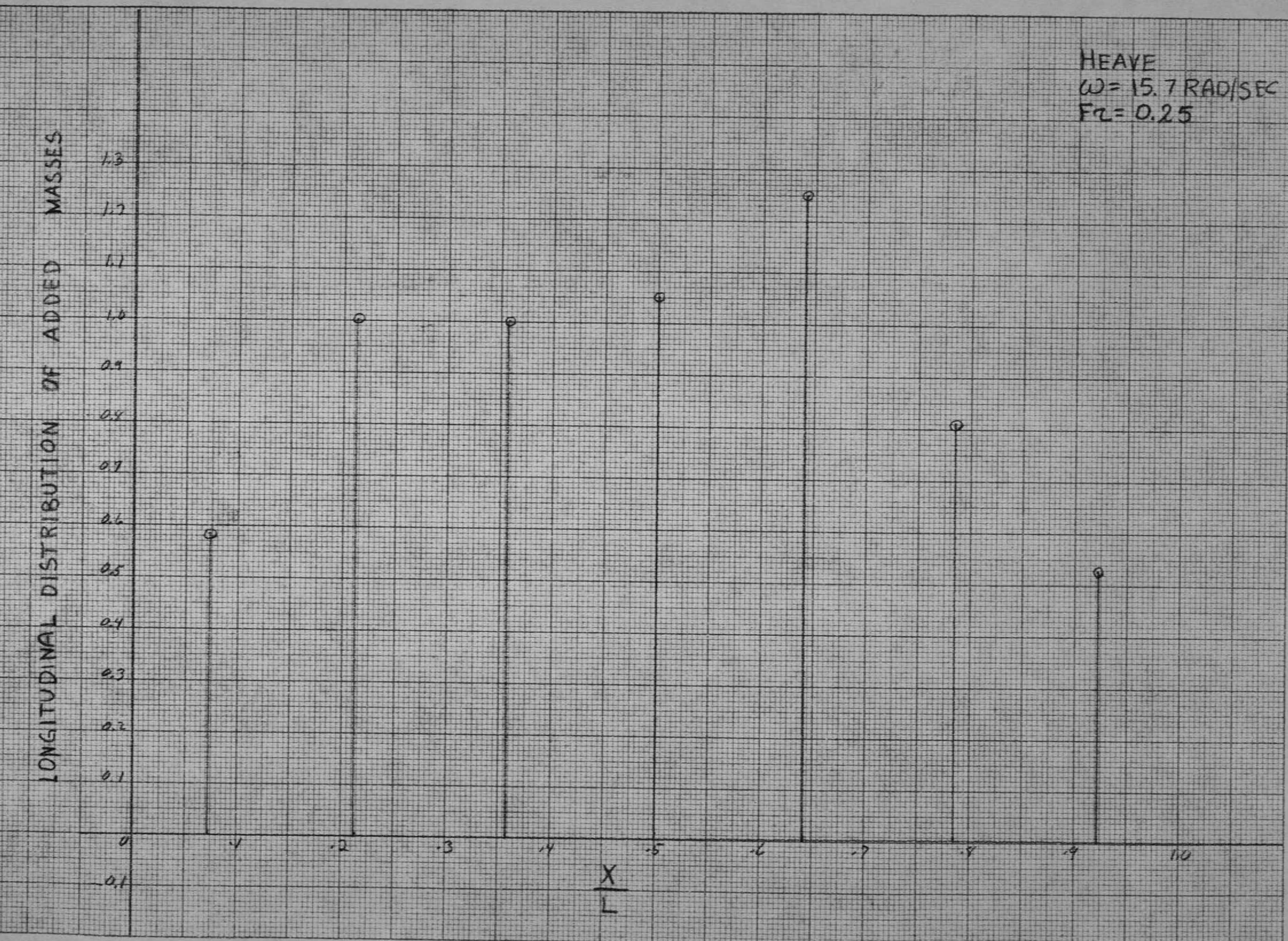
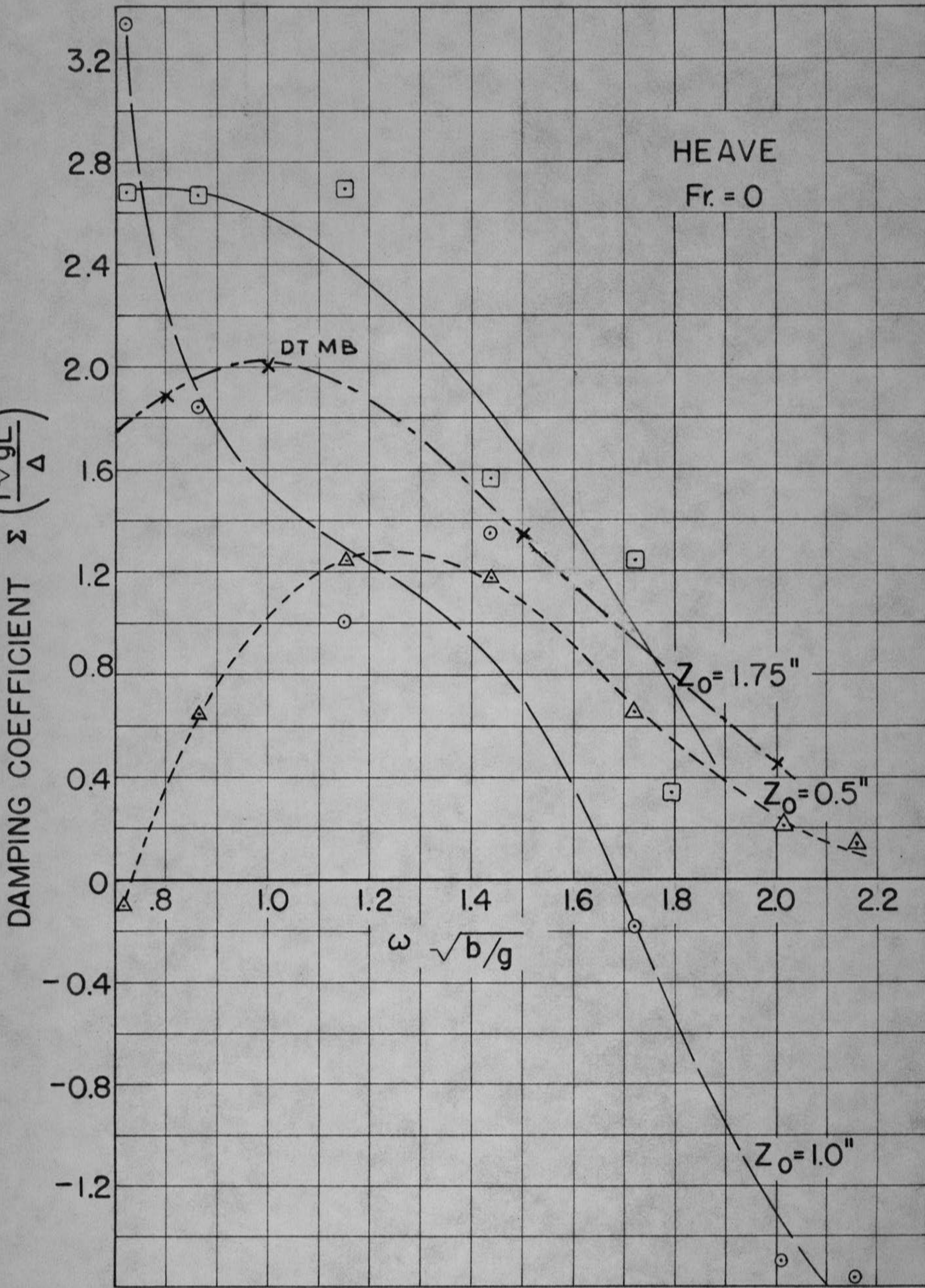

HEAVE
ω = 15.7 RAD/SEC
Fr = 0.25
LONGITUDINAL DISTRIBUTION OF ADDED MASSES
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 32



HEAVE
Fr. = 0
DAMPING COEFFICIENT $\Sigma \left(\frac{f\sqrt{gL}}{\Delta}\right)$
$\omega \sqrt{b/g}$
DT MB
$Z_0 = 1.75"$
$Z_0 = 0.5"$
$Z_0 = 1.0"$
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
0
-0.4
-0.8
-1.2
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2

FIG. 33

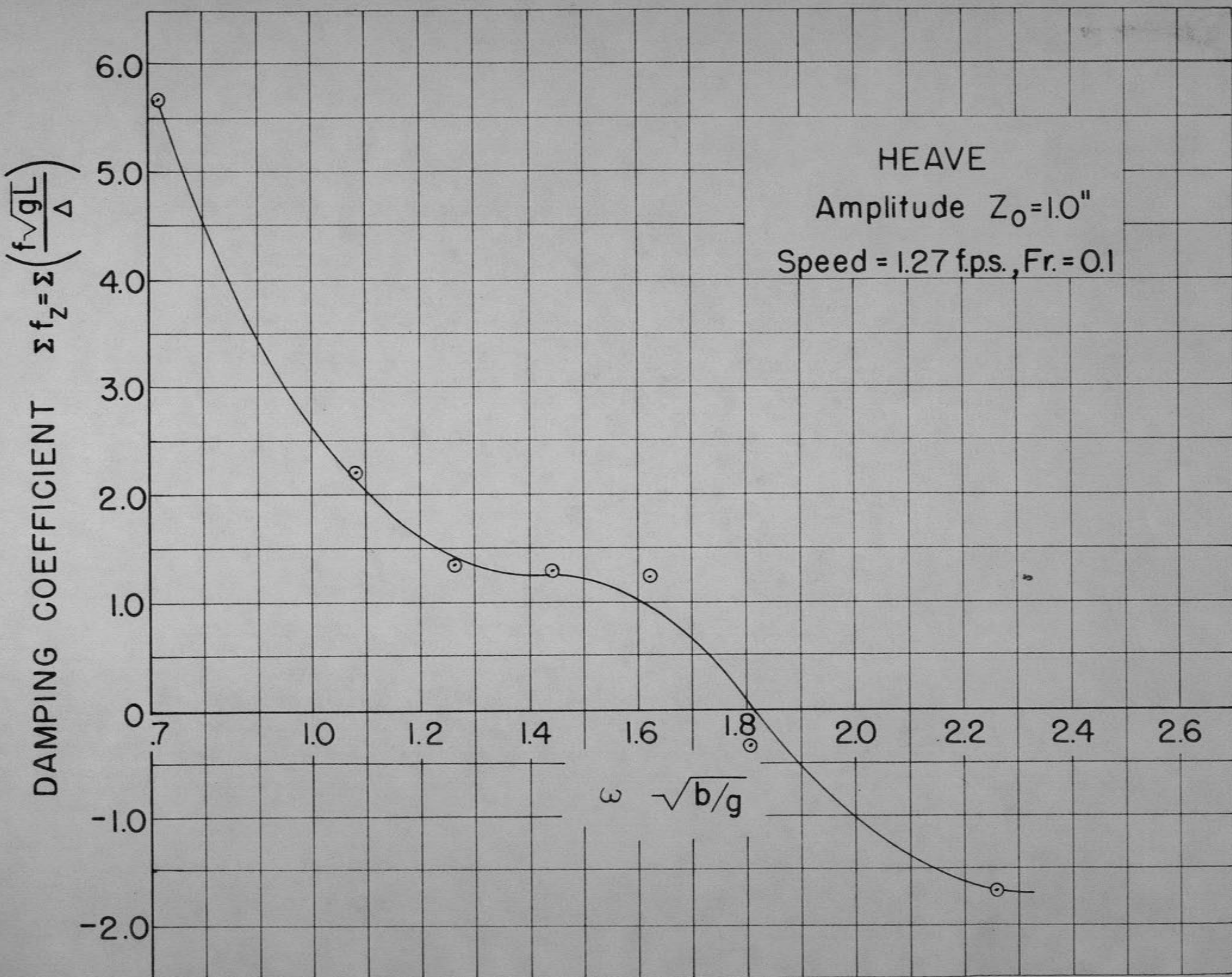

HEAVE
Amplitude Z_0=1.0"
Speed = 1.27 f.p.s., Fr. = 0.1
DAMPING COEFFICIENT $\Sigma f_z = \Sigma\left(\frac{f\sqrt{gL}}{\Delta}\right)$
$\omega \sqrt{b/g}$
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
.7
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6

FIG 34

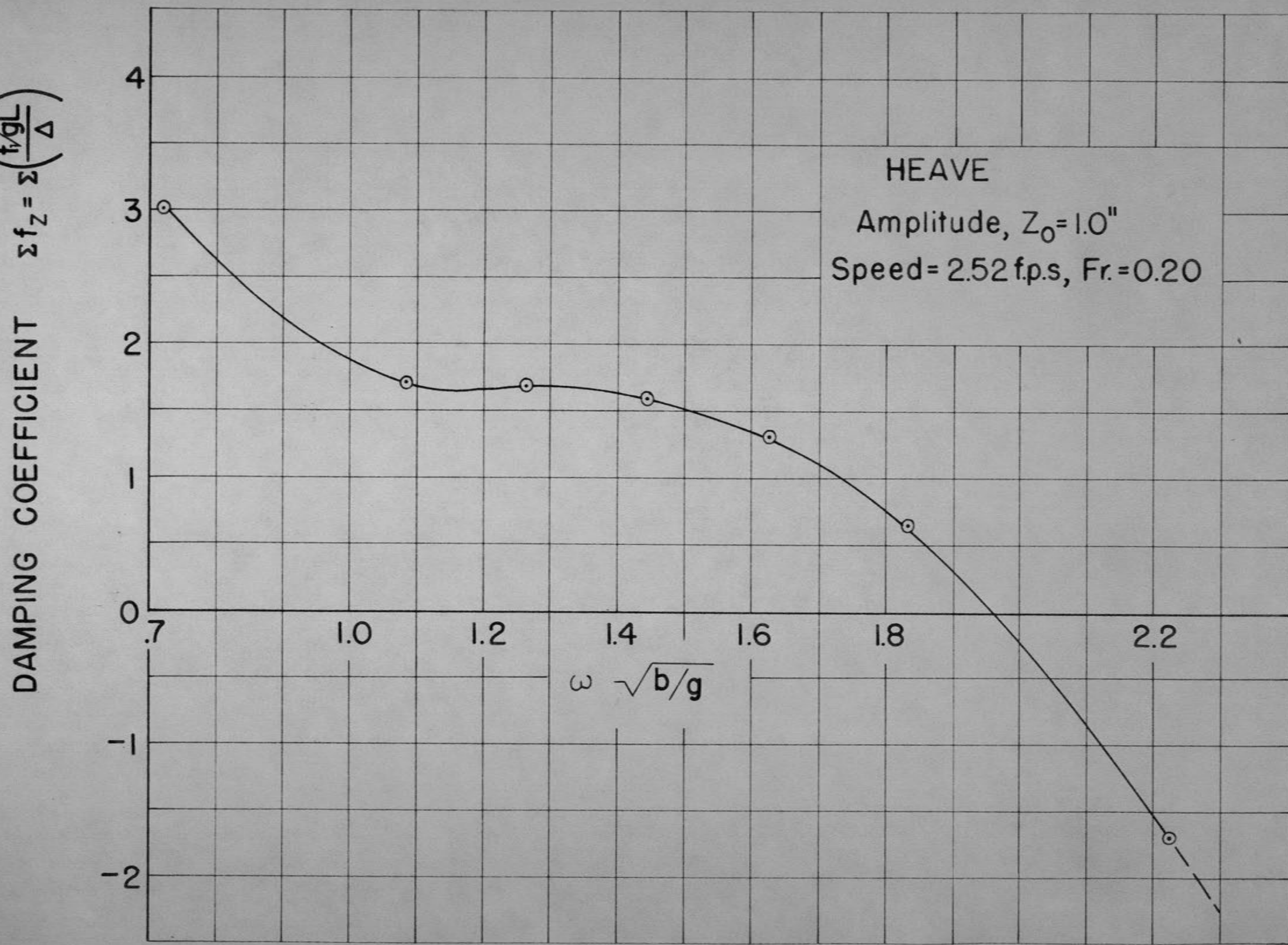
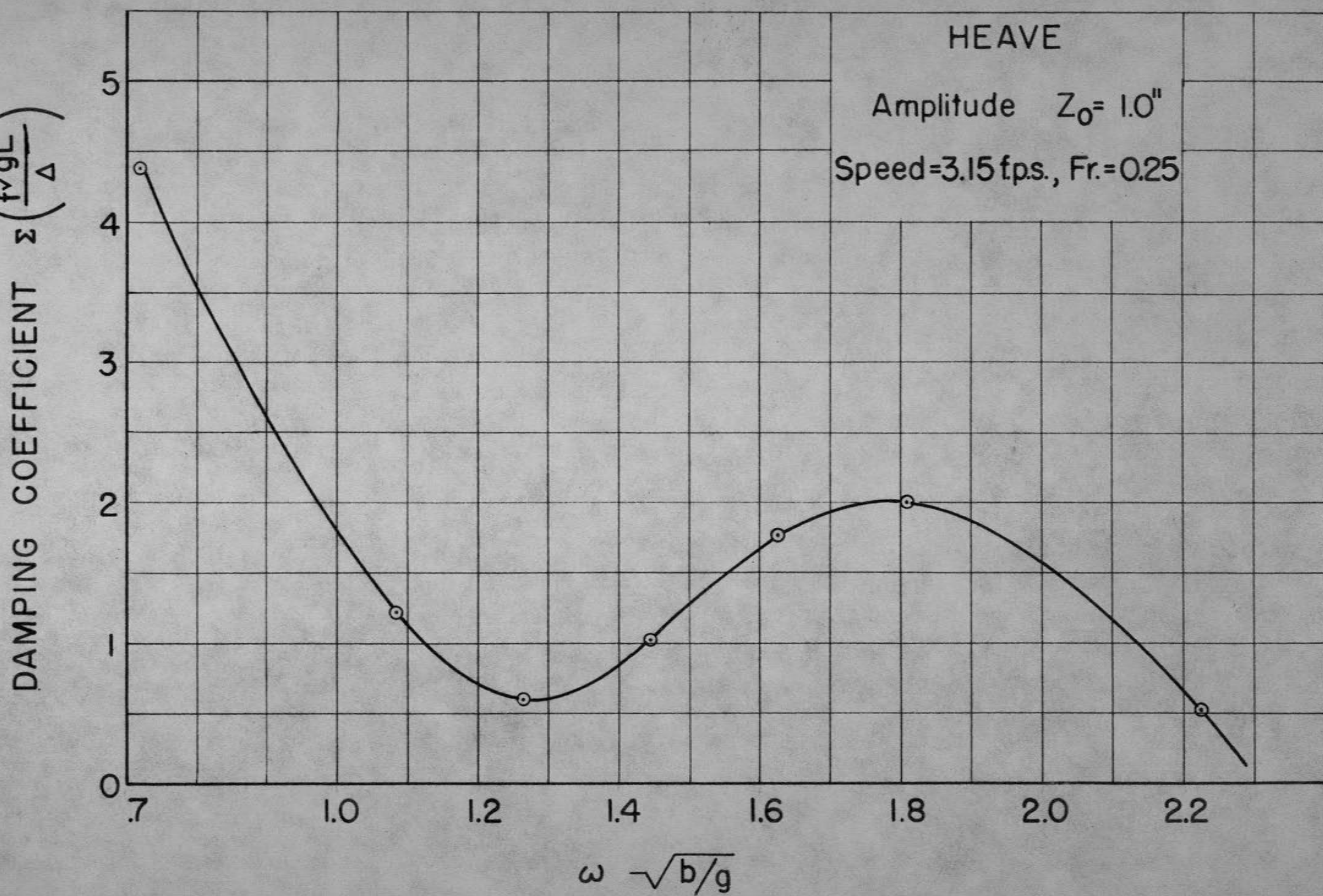

DAMPING COEFFICIENT $\Sigma f_Z = \Sigma\left(\frac{f\sqrt{gL}}{\Delta}\right)$
HEAVE
Amplitude, Z_0= 1.0"
Speed= 2.52 f.p.s, Fr.= 0.20
$\omega\sqrt{b/g}$
4
3
2
1
0
-1
-2
.7
1.0
1.2
1.4
1.6
1.8
2.2

FIG. 35



HEAVE
Amplitude $Z_0 = 1.0''$
Speed=3.15 f.p.s., Fr.=0.25
DAMPING COEFFICIENT $\Sigma\left(\frac{f\sqrt{gL}}{\Delta}\right)$
0
1
2
3
4
5
.7
1.0
1.2
1.4
1.6
1.8
2.0
2.2
$\omega\sqrt{b/g}$

FIG. 36

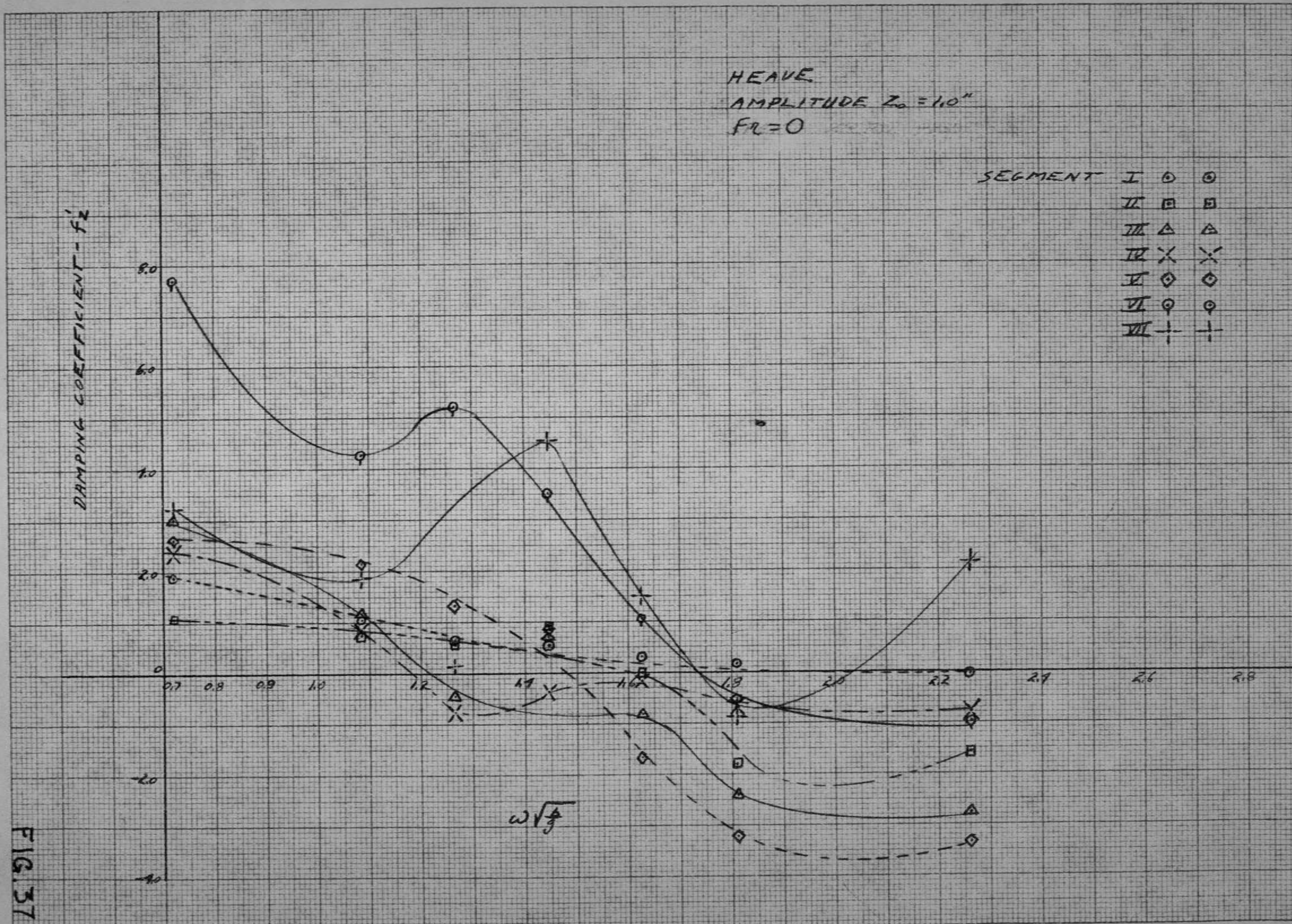

HEAVE
AMPLITUDE $Z_o = 1.0''$
$Fr = 0$
SEGMENT I
II
III
IV
V
VI
VII
DAMPING COEFFICIENT - f'_z
8.0
6.0
4.0
2.0
0
-2.0
-4.0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
$\omega\sqrt{\frac{L}{g}}$

FIG. 37

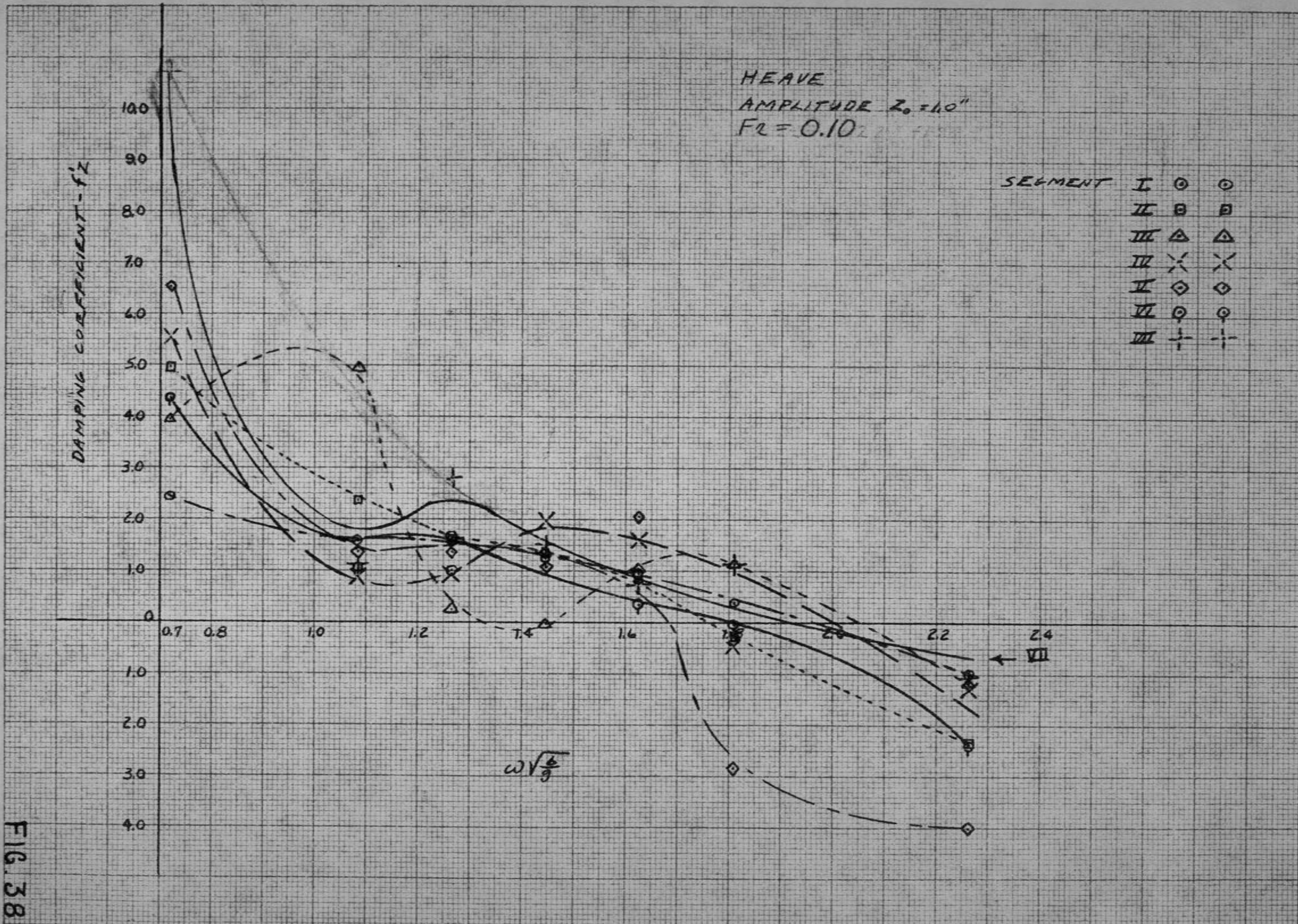

HEAVE
AMPLITUDE Z₀ = 1.0"
Fr = 0.10
SEGMENT I II III IV V VI VII
DAMPING COEFFICIENT - f'z
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
1.0
2.0
3.0
4.0
0.7 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4
VII
ω√(L/g)

FIG. 38

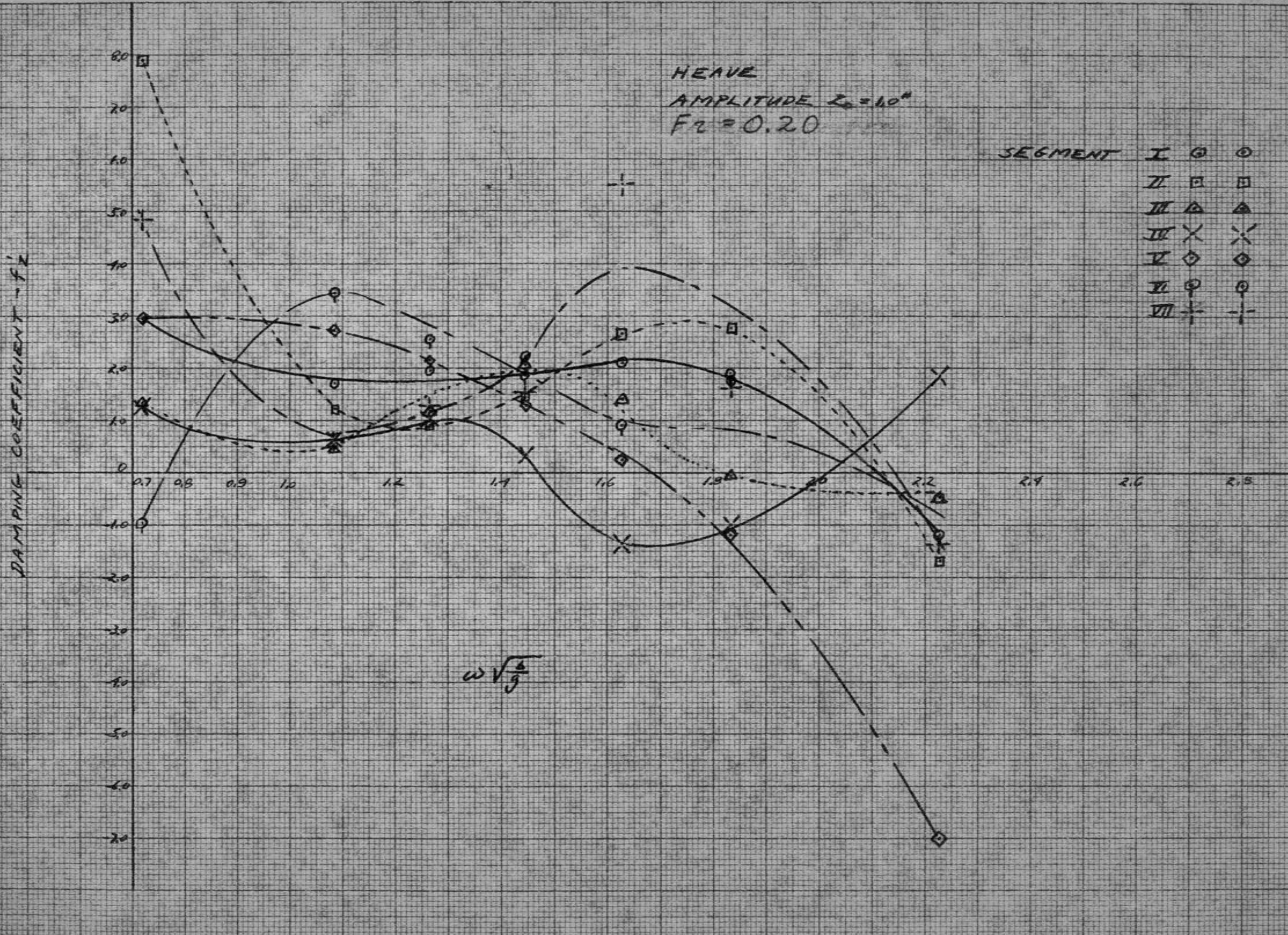

HEAVE
AMPLITUDE Z_0 = 1.0"
Fr = 0.20
SEGMENT
I
II
III
IV
V
VI
VII
DAMPING COEFFICIENT - f'_z
$\omega\sqrt{\frac{L}{g}}$
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8

FIG. 39

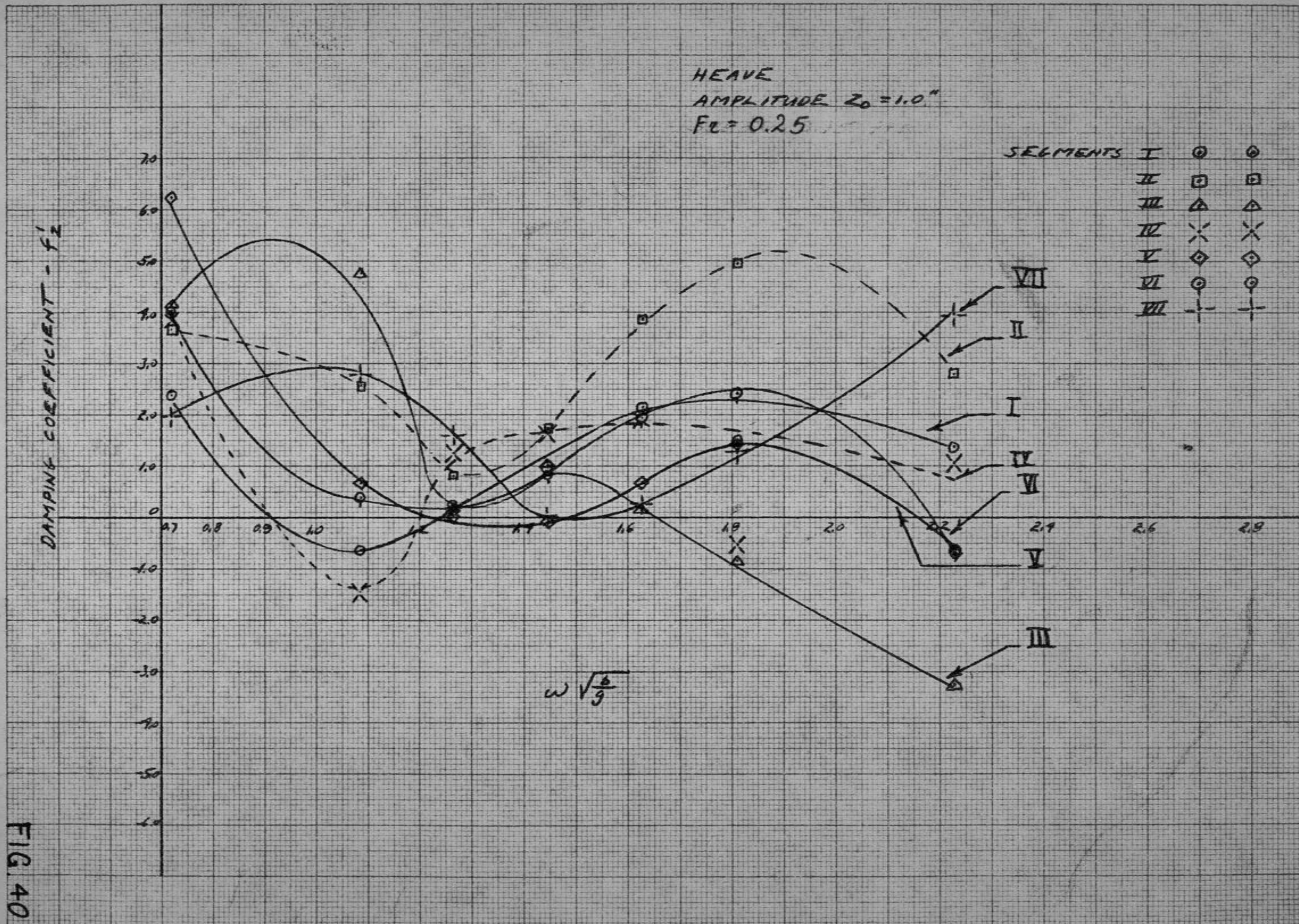

HEAVE
AMPLITUDE $z_0 = 1.0''$
Fr = 0.25
SEGMENTS I II III IV V VI VII
DAMPING COEFFICIENT - F_z'
$\omega\sqrt{\frac{b}{g}}$
VII
II
I
IV
VI
V
III

FIG. 40

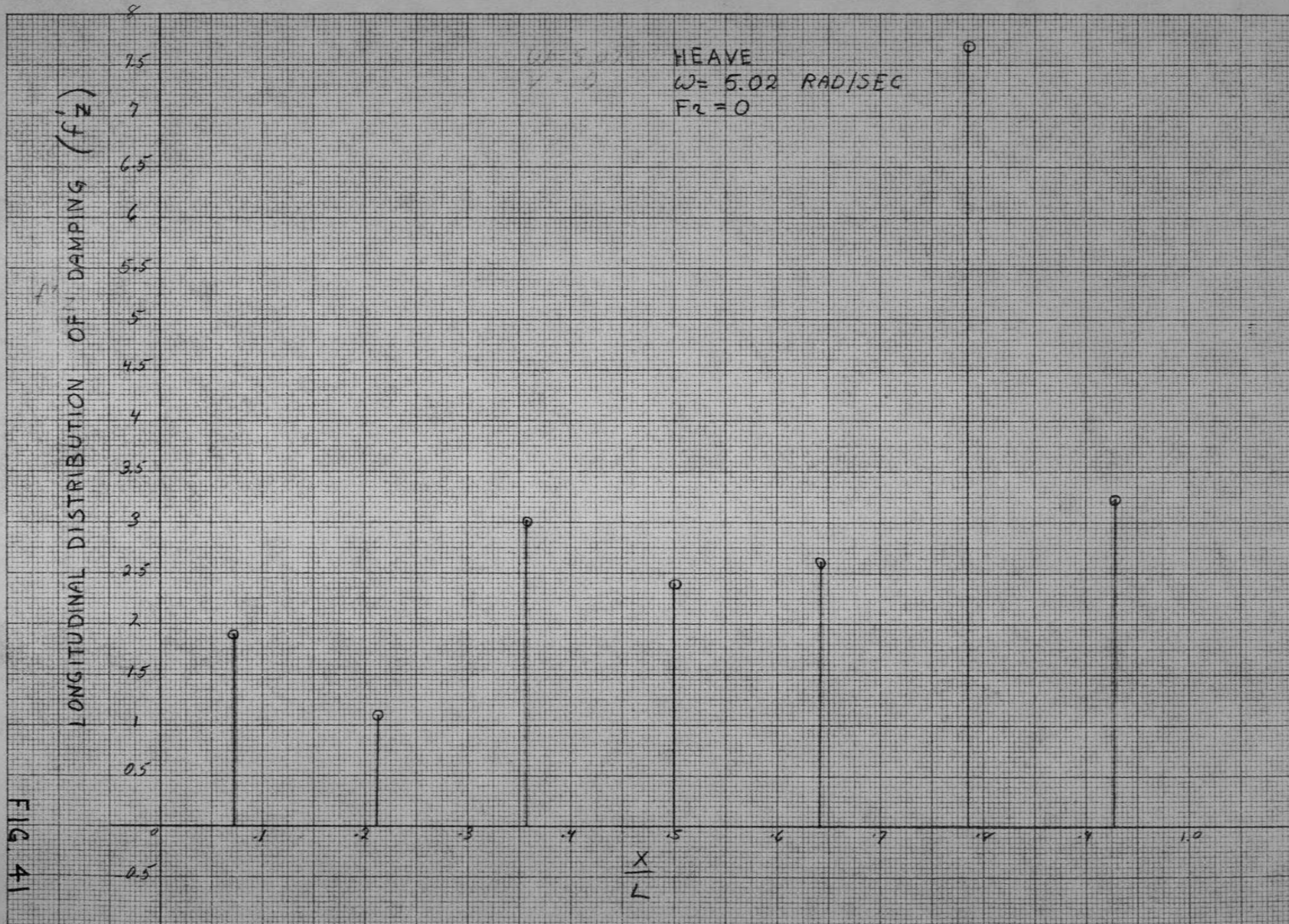

HEAVE
ω= 5.02 RAD/SEC
Fz = 0
LONGITUDINAL DISTRIBUTION OF DAMPING (f'z)
X/L
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
-0.5
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
8

FIG. 41

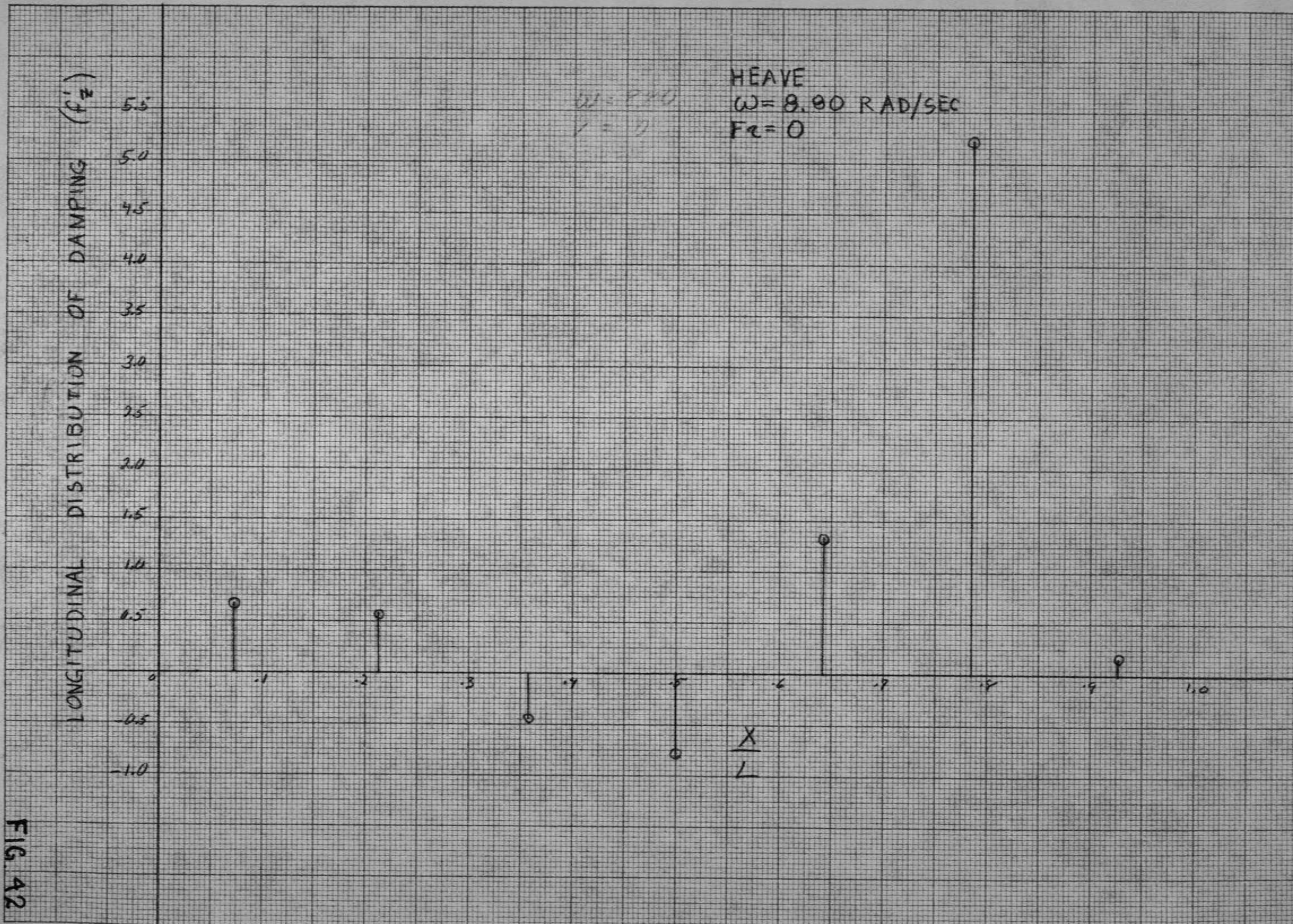

HEAVE
ω= 8.80 RAD/SEC
Fz= 0
LONGITUDINAL DISTRIBUTION OF DAMPING (f'z)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 42

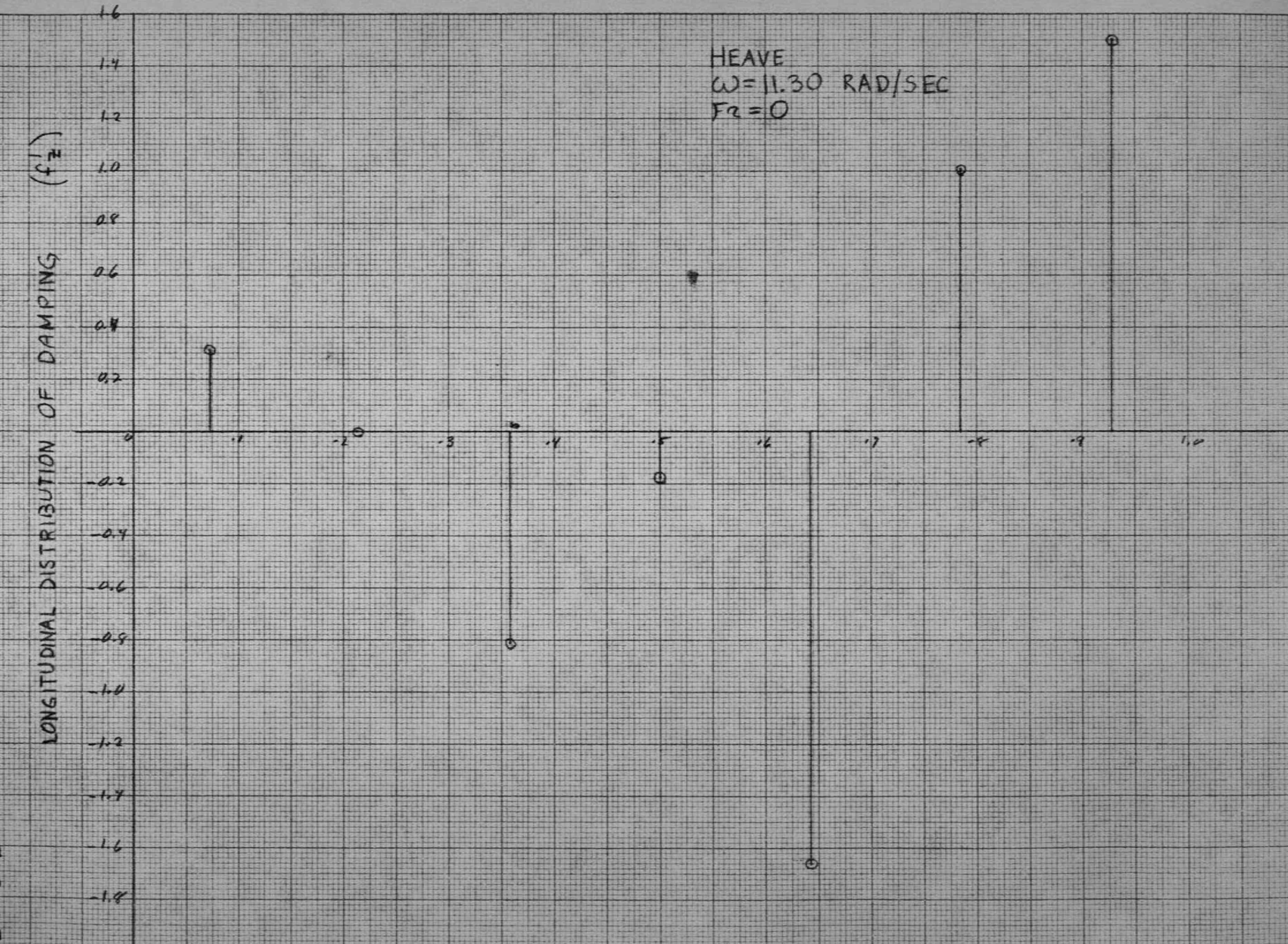

HEAVE
ω = 11.30 RAD/SEC
Fr = 0
LONGITUDINAL DISTRIBUTION OF DAMPING
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1.0
-1.2
-1.4
-1.6
-1.8
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 43

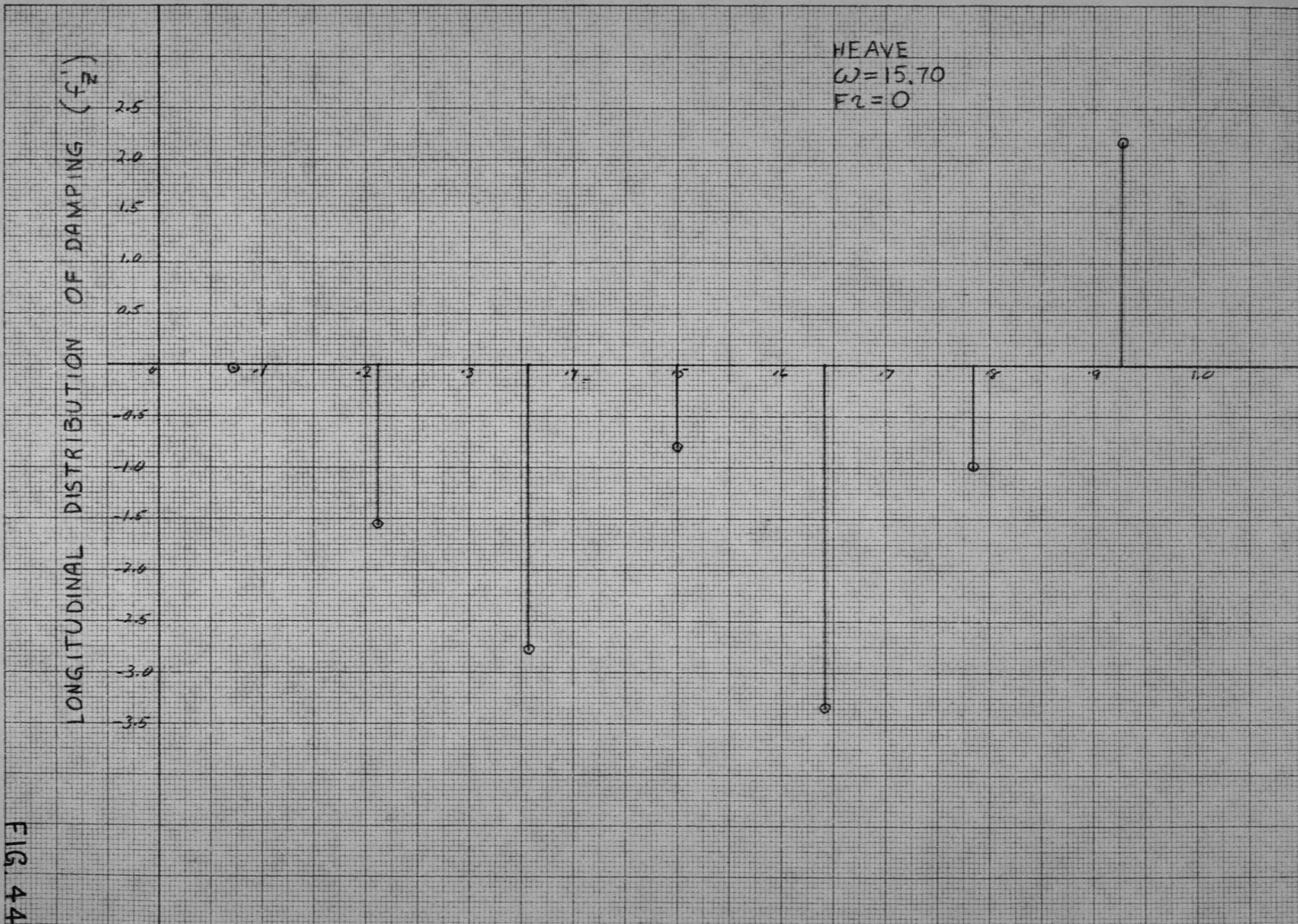

HEAVE
ω=15.70
F2=0
LONGITUDINAL DISTRIBUTION OF DAMPING (F_z')
2.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 44

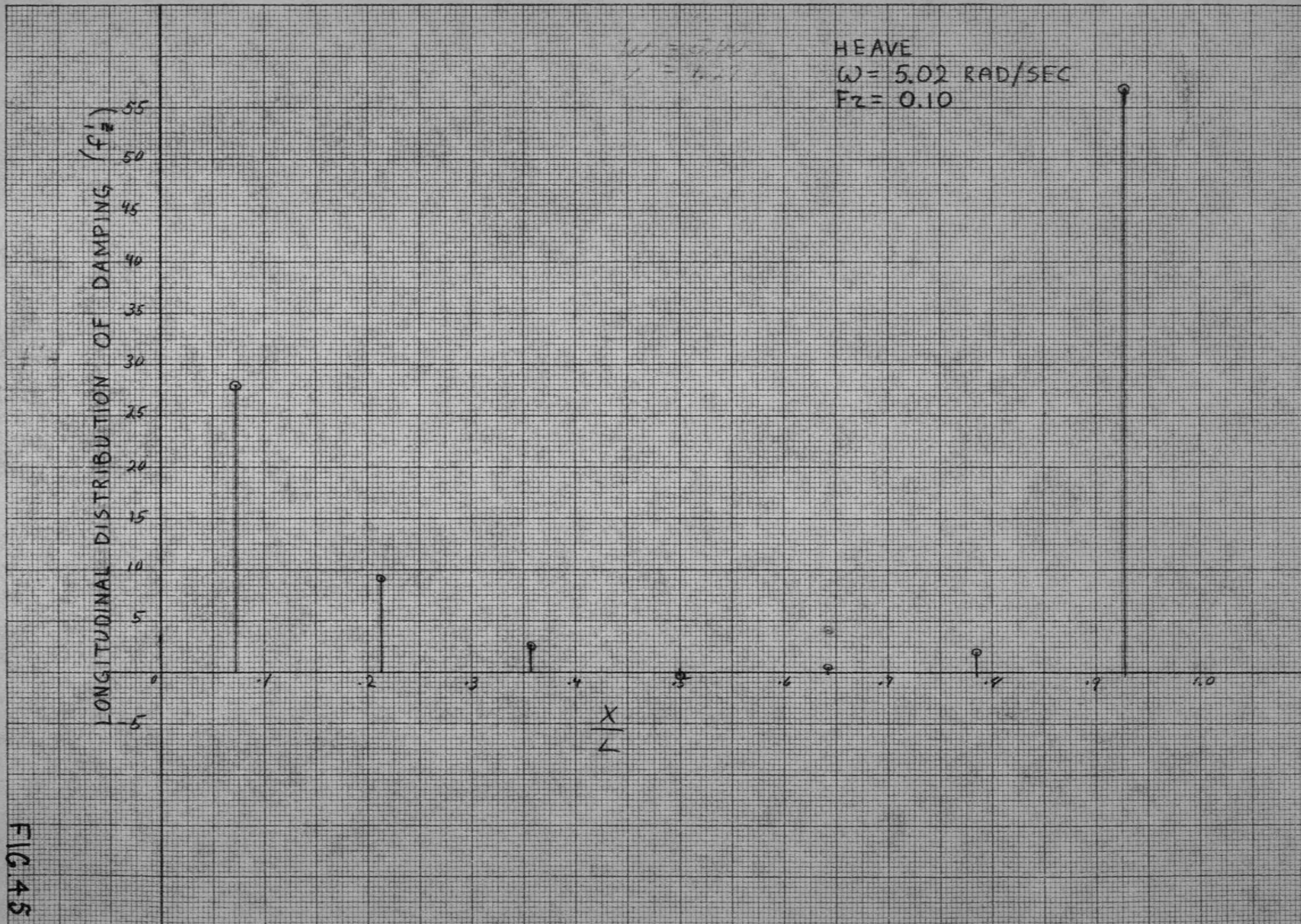

HEAVE
ω = 5.02 RAD/SEC
Fz = 0.10
LONGITUDINAL DISTRIBUTION OF DAMPING (c'z)
X/L
55
50
45
40
35
30
25
20
15
10
5
0
-5
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 45

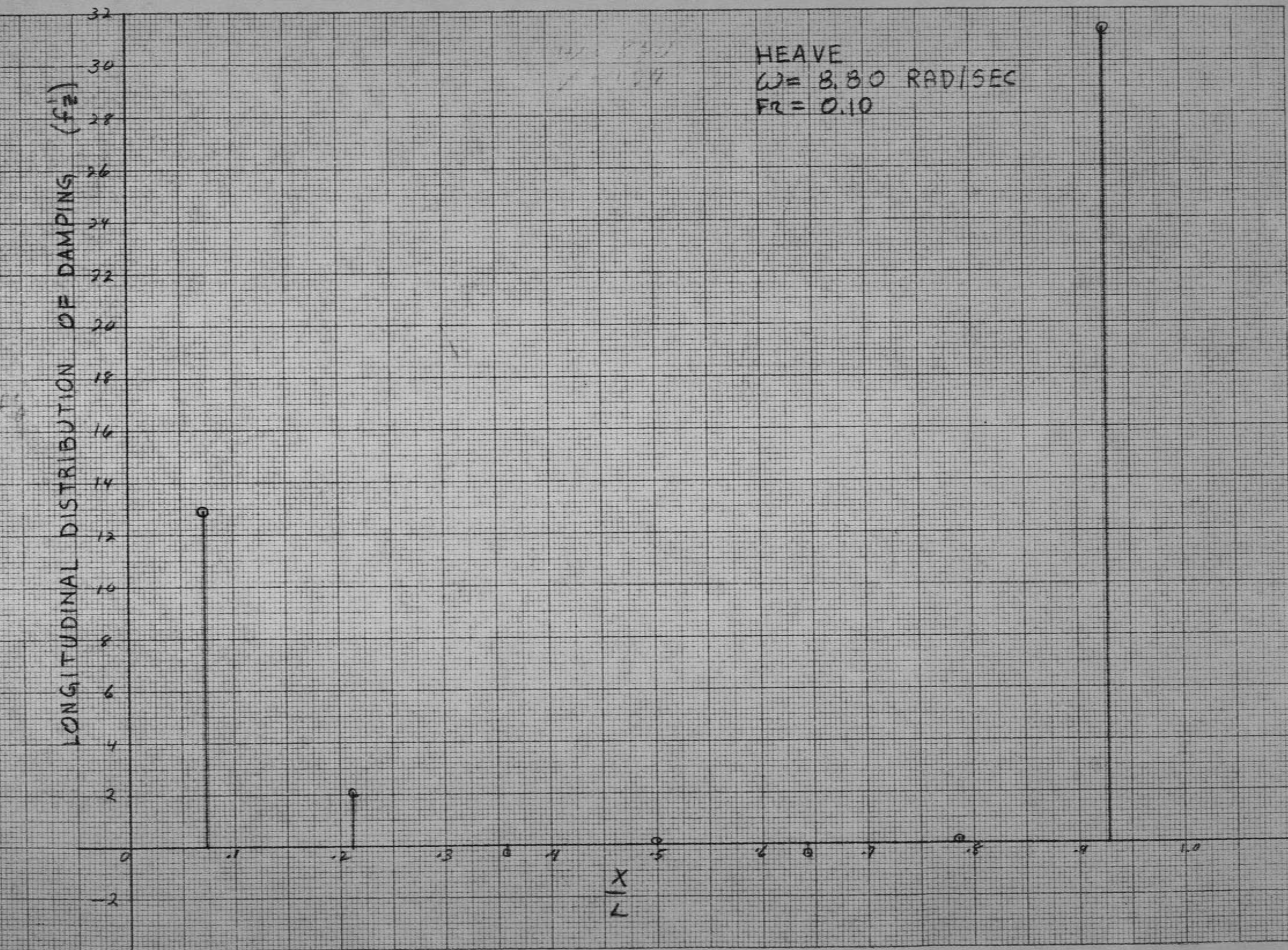

HEAVE
ω= 8.80 RAD/SEC
Fr = 0.10
LONGITUDINAL DISTRIBUTION OF DAMPING
X/L
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
-2

FIG. 46

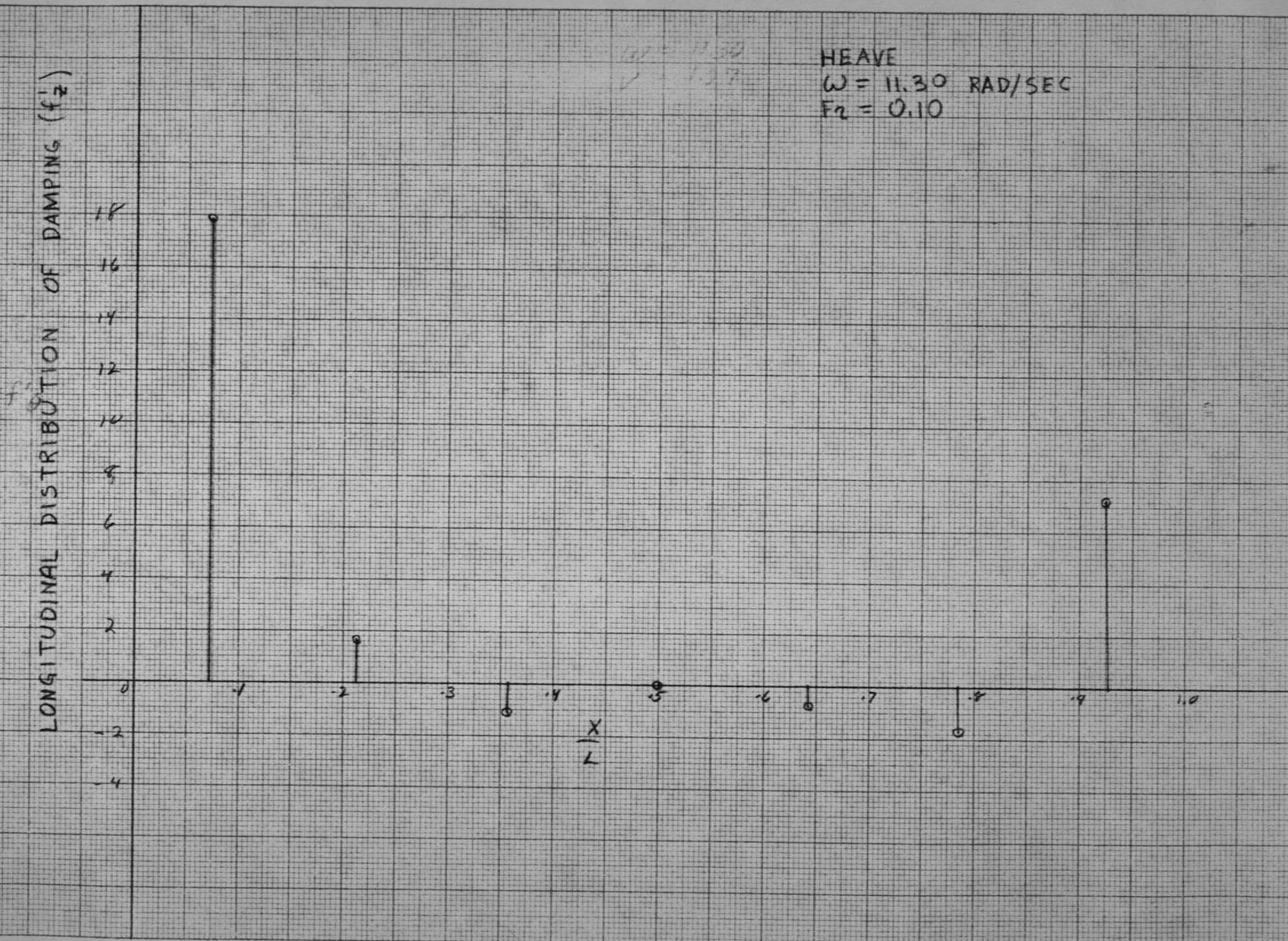

HEAVE
ω = 11.30 RAD/SEC
Fn = 0.10
LONGITUDINAL DISTRIBUTION OF DAMPING (f_z')
X/L
18
16
14
12
10
8
6
4
2
0
-2
-4
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 47

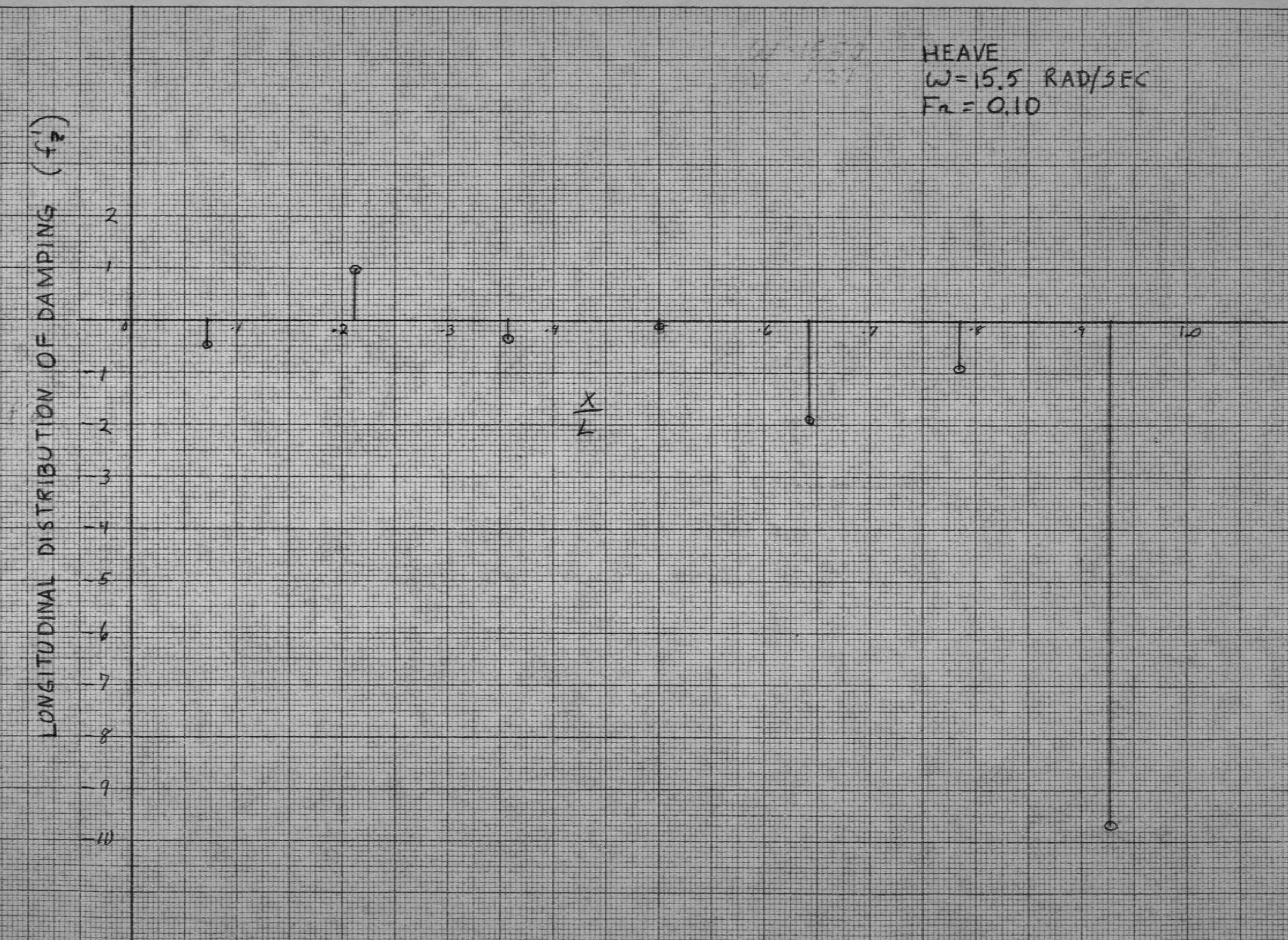

HEAVE
ω = 15.5 RAD/SEC
Fn = 0.10
LONGITUDINAL DISTRIBUTION OF DAMPING (f_2')
X/L
0
.1
.2
.3
.4
.6
.7
.8
.9
1.0
2
1
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10

FIG. 4.8

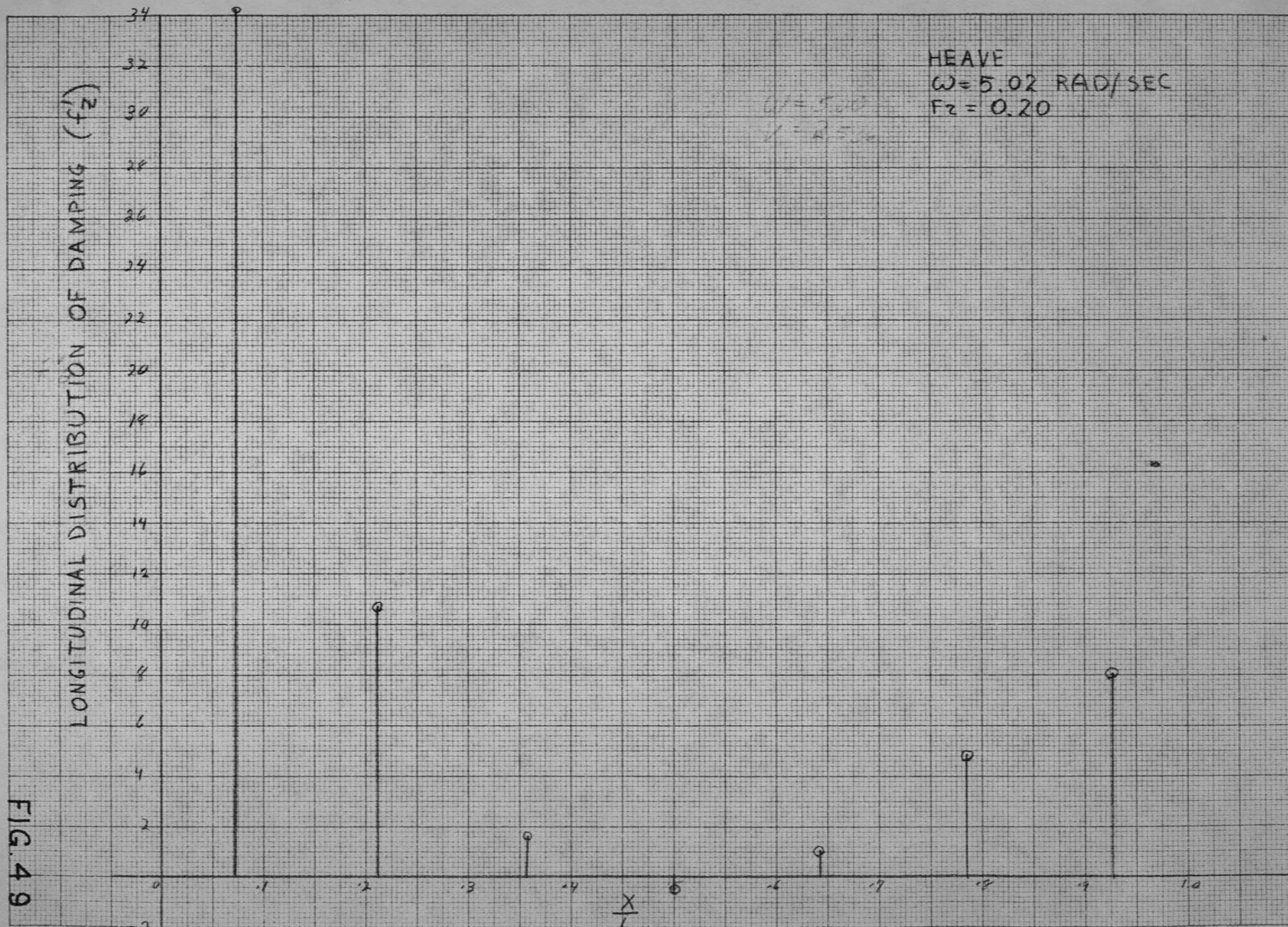
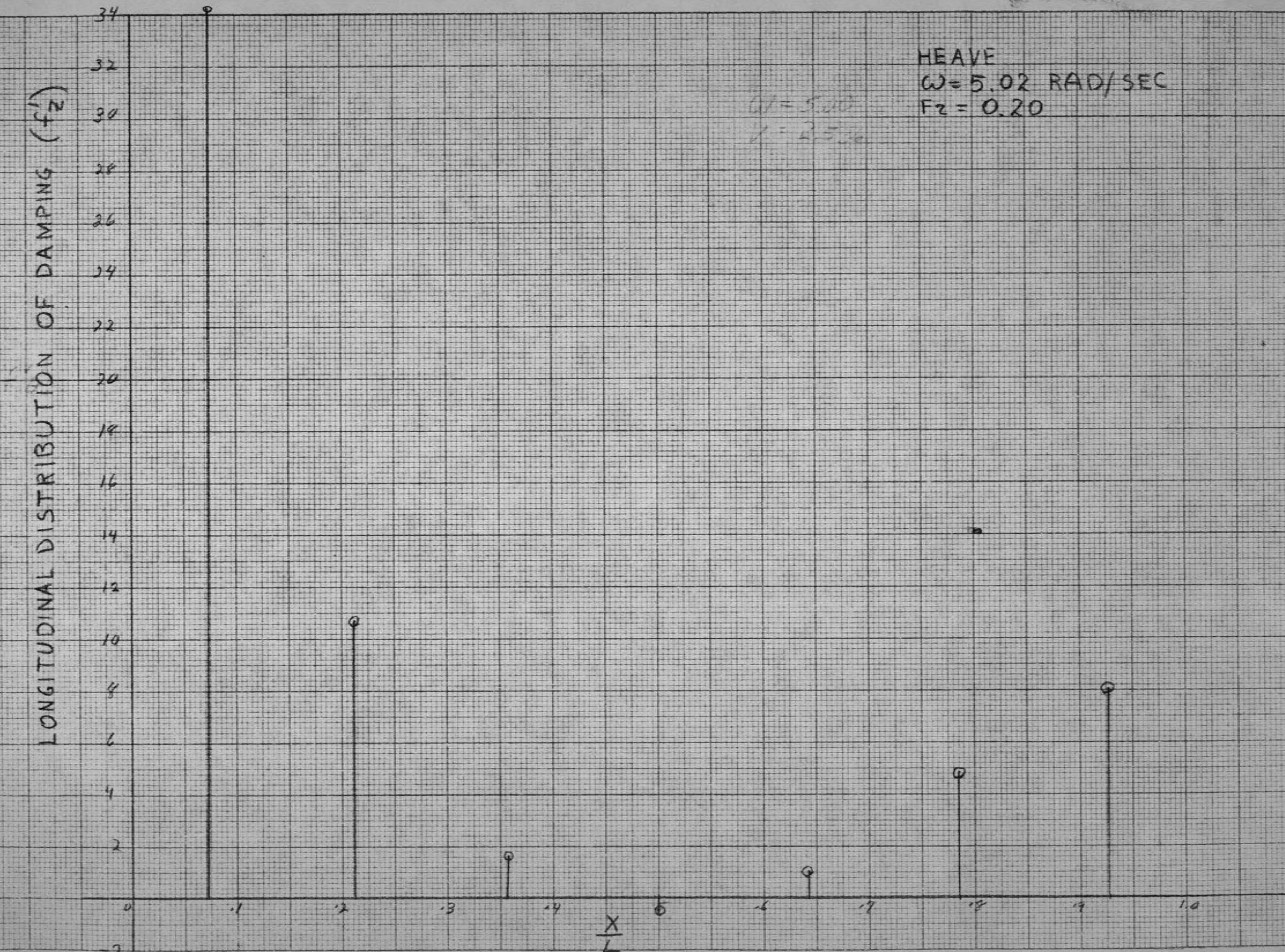

HEAVE
ω = 5.02 RAD/SEC
Fz = 0.20
LONGITUDINAL DISTRIBUTION OF DAMPING (f_z')
X/L
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
·1
·2
·3
·4
·5
·6
·7
·8
·9
1.0

FIG. 49



HEAVE
ω = 5.02 RAD/SEC
Fz = 0.20
LONGITUDINAL DISTRIBUTION OF DAMPING (f'z)
X/L
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
-2
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 4.9

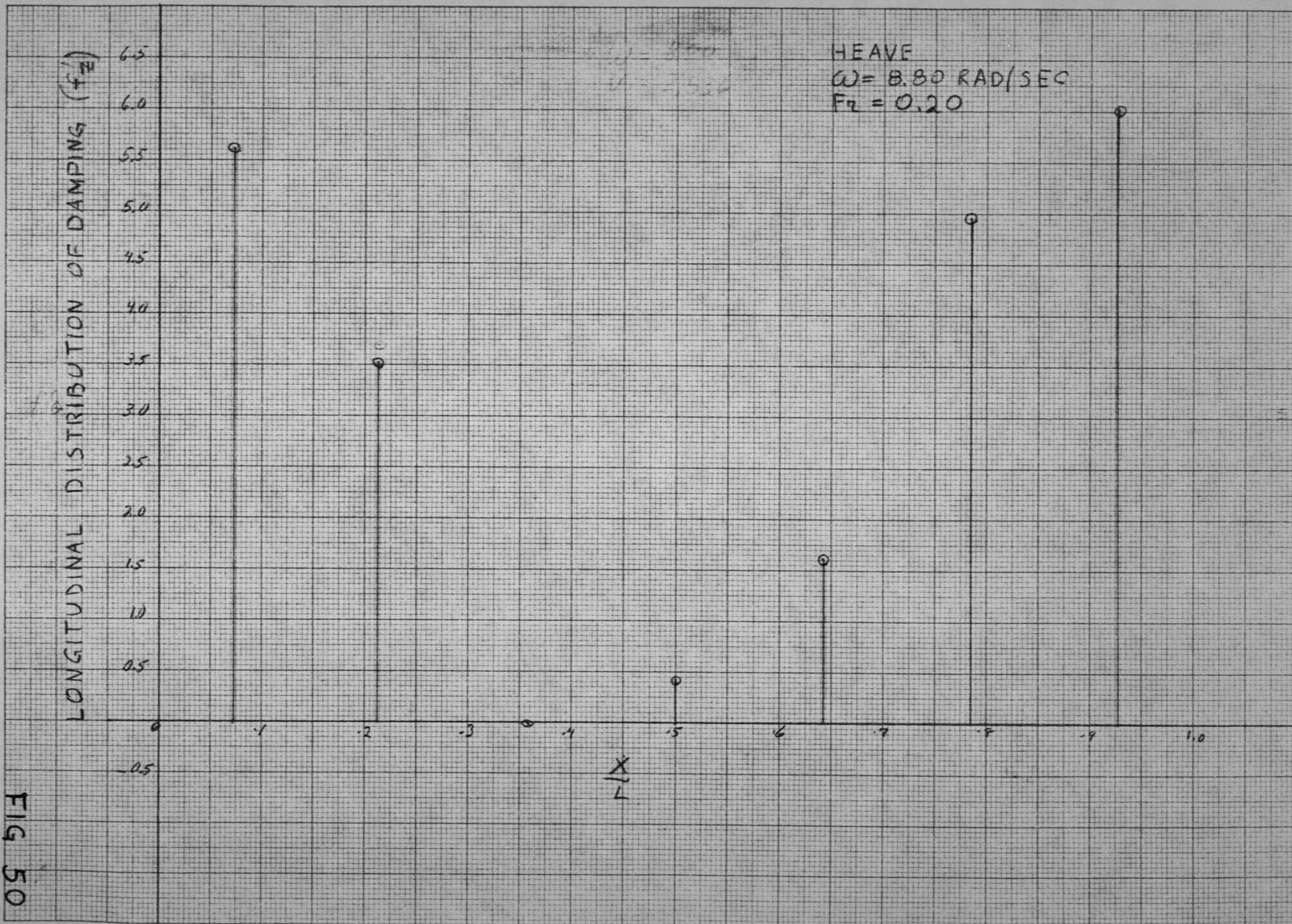

HEAVE
ω= 8.80 RAD/SEC
Fr = 0.20
LONGITUDINAL DISTRIBUTION OF DAMPING
X/L
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG 50

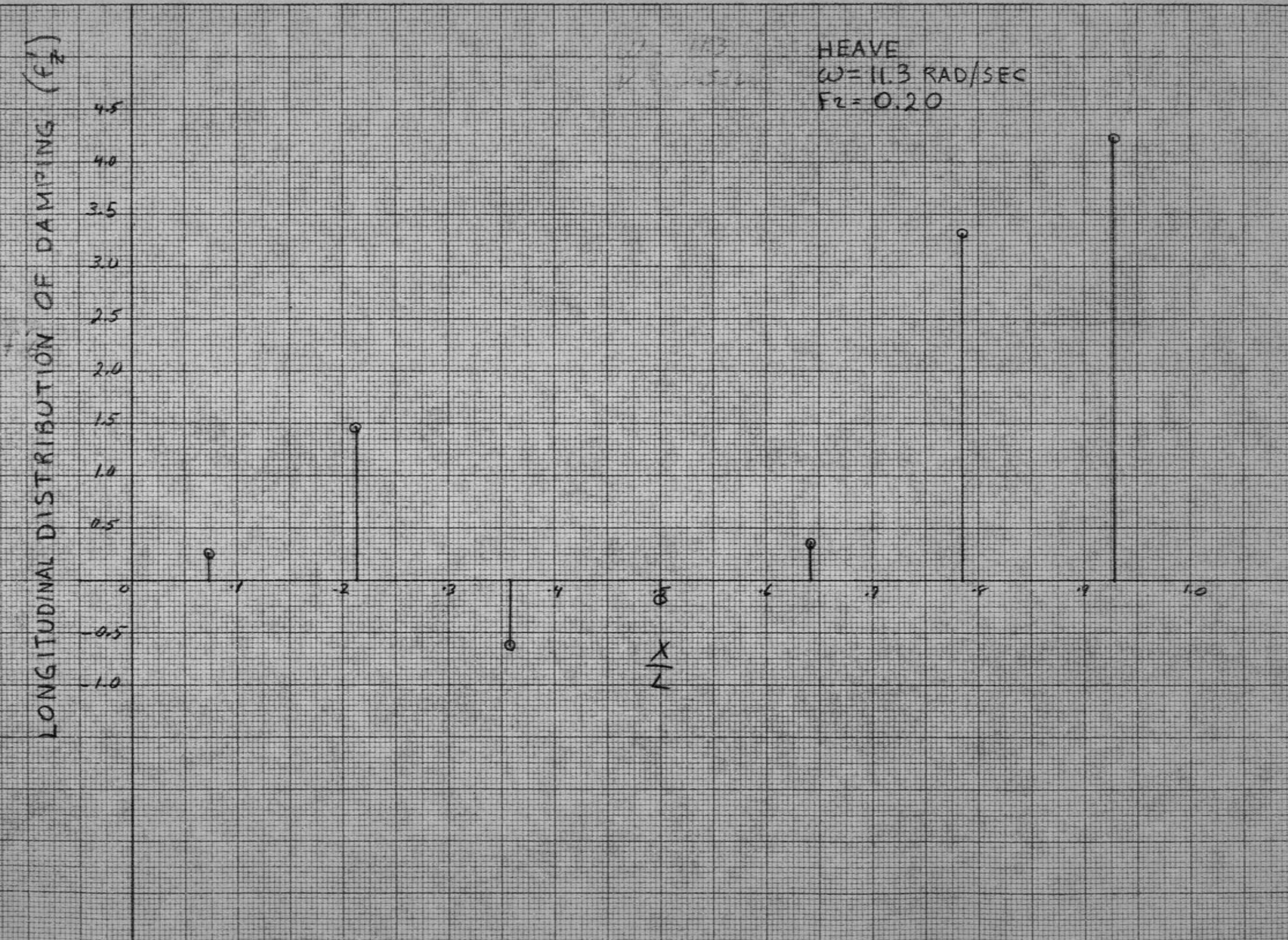

HEAVE
ω = 11.3 RAD/SEC
Fz = 0.20
LONGITUDINAL DISTRIBUTION OF DAMPING (F'z)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 51

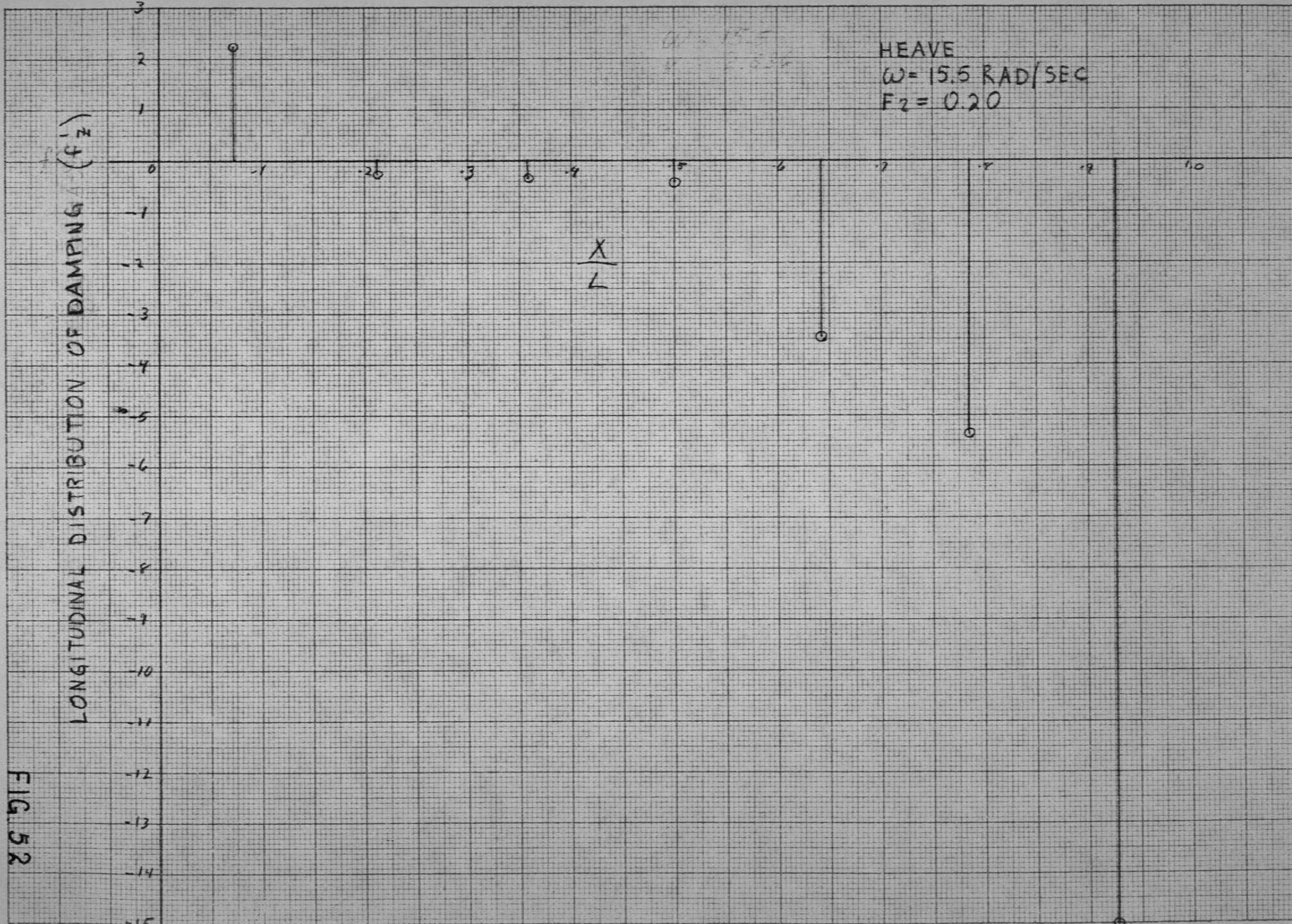

HEAVE
ω= 15.5 RAD/SEC
F2 = 0.20
X/L
LONGITUDINAL DISTRIBUTION OF DAMPING (f'z)

FIG. 52

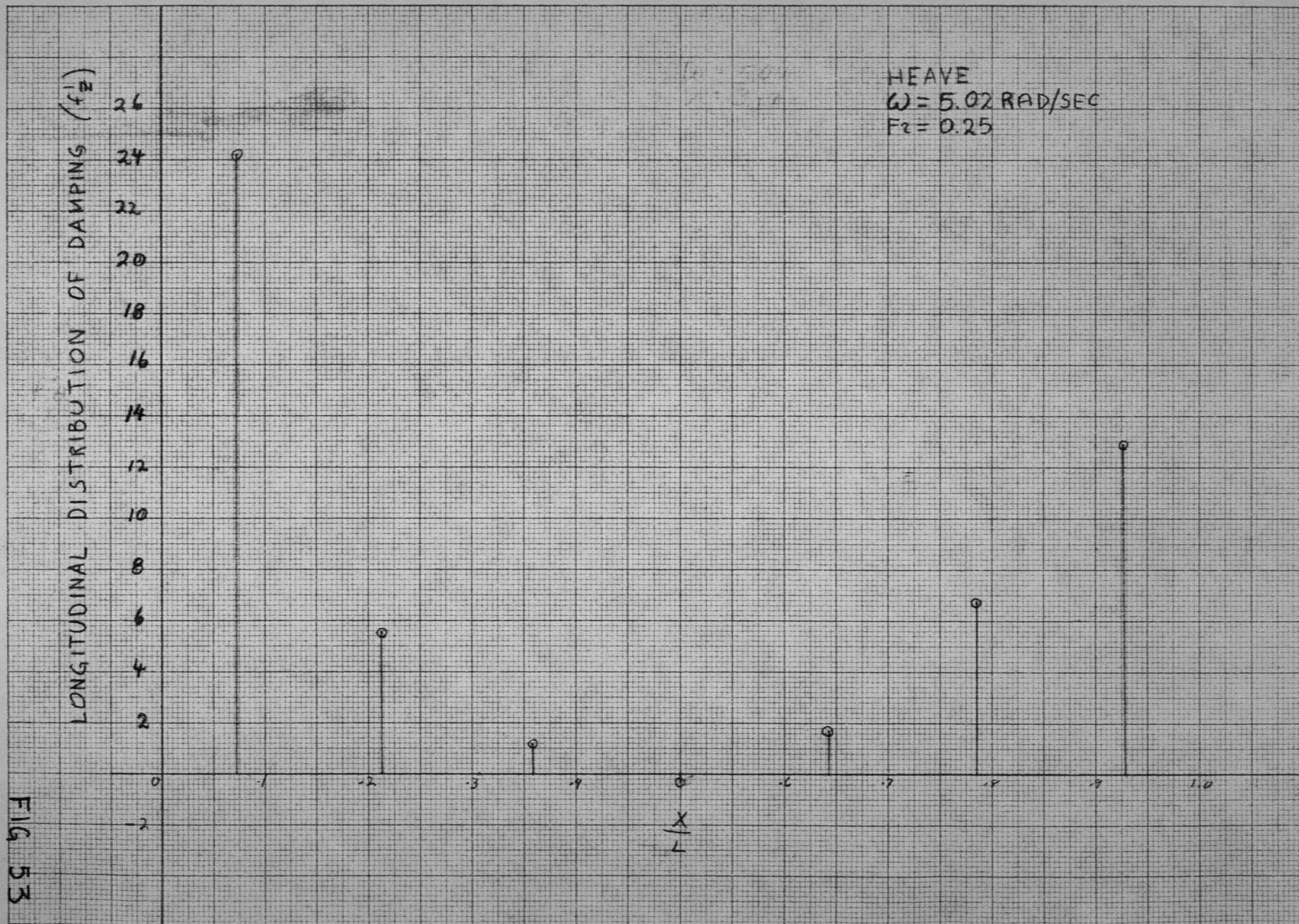

HEAVE
ω = 5.02 RAD/SEC
Fr = 0.25
LONGITUDINAL DISTRIBUTION OF DAMPING
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG 53

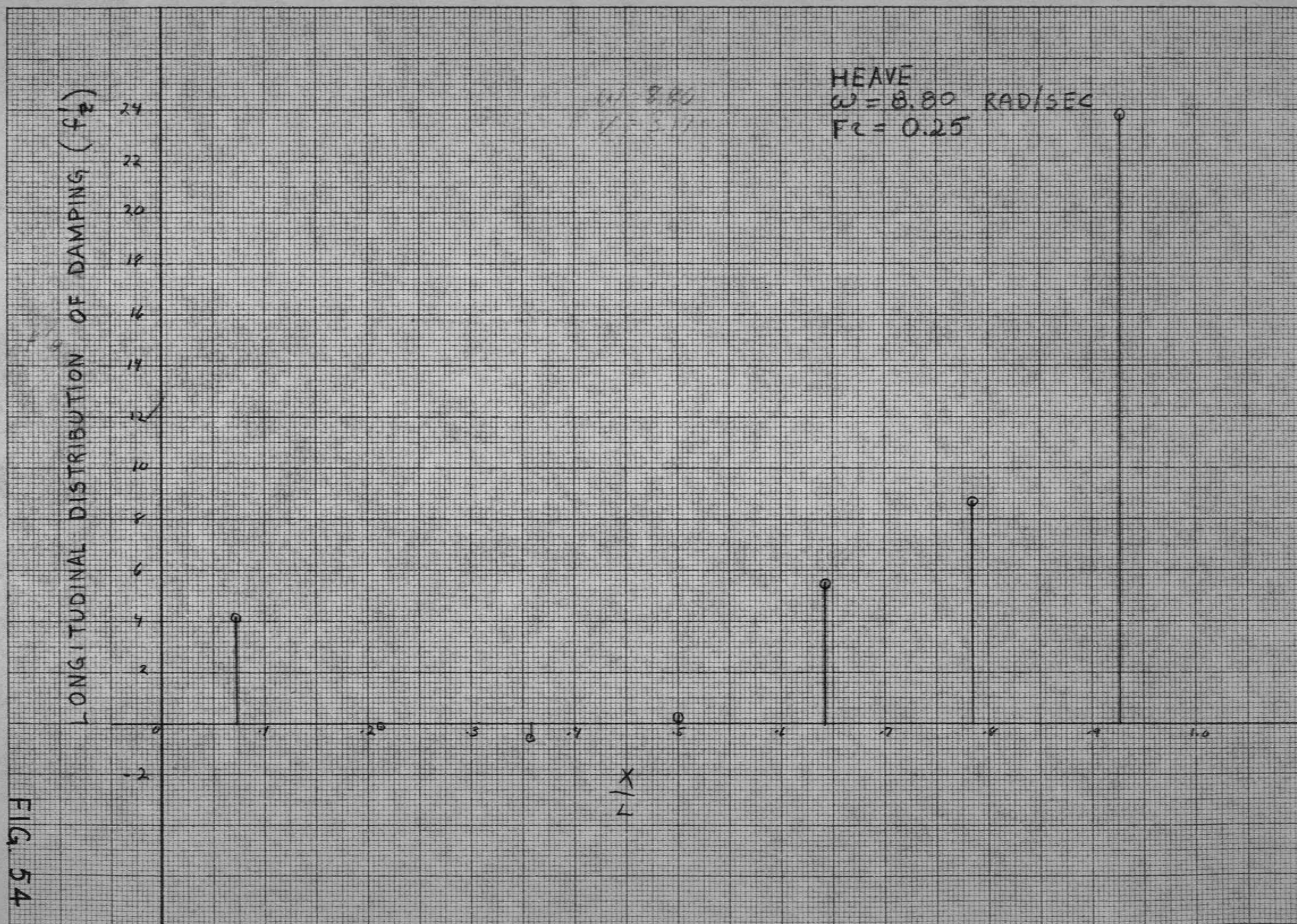
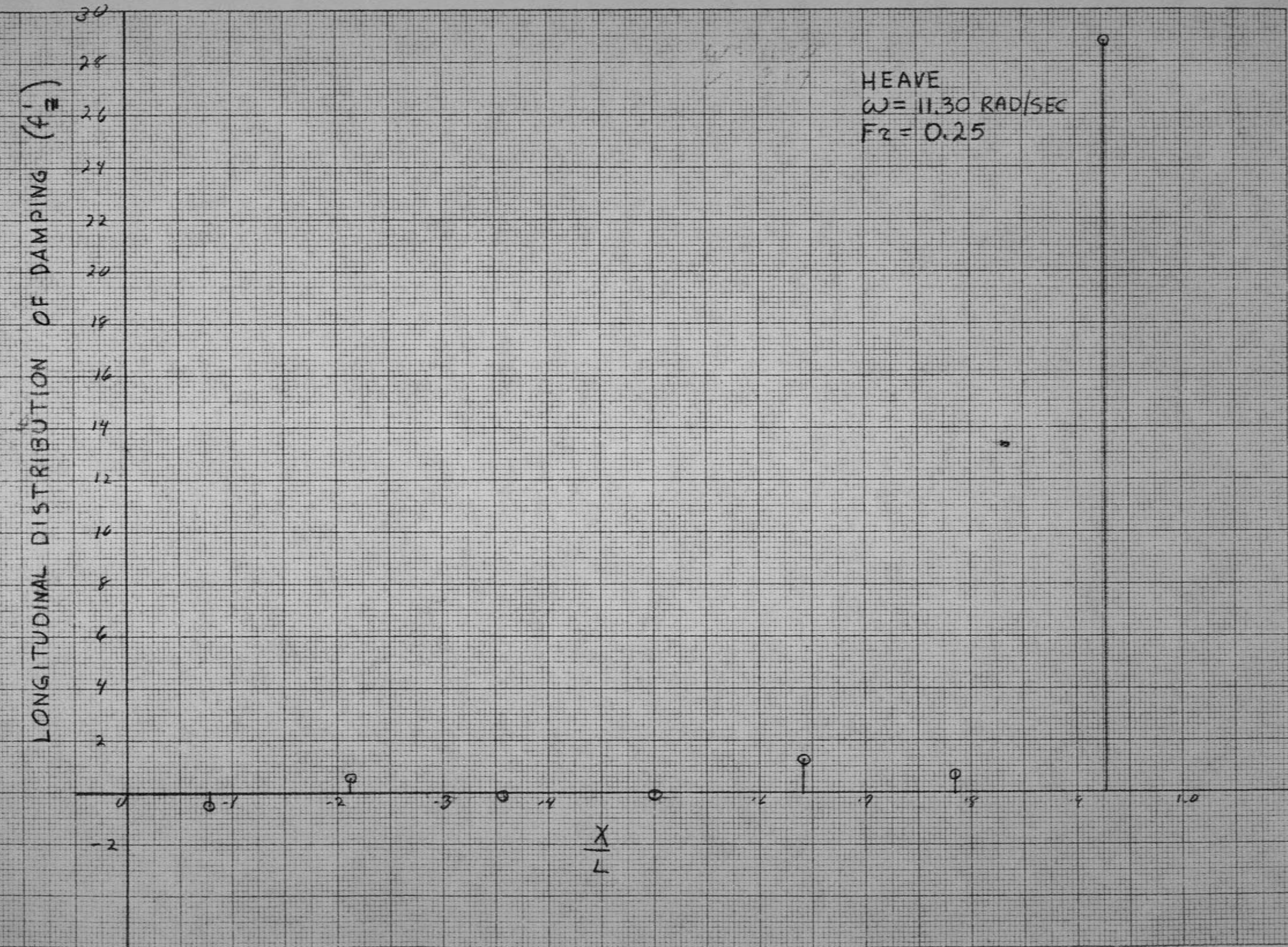

HEAVE
ω = 8.80 RAD/SEC
Fr = 0.25
LONGITUDINAL DISTRIBUTION OF DAMPING (f'_2)
x/L
24
22
20
18
16
14
12
10
8
6
4
2
-2
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 54



LONGITUDINAL DISTRIBUTION OF DAMPING (f_z')
HEAVE
ω = 11.30 RAD/SEC
Fz = 0.25
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
.1
.2
.3
.4
.6
.7
.8
.9
1.0
X/L

FIG. 55

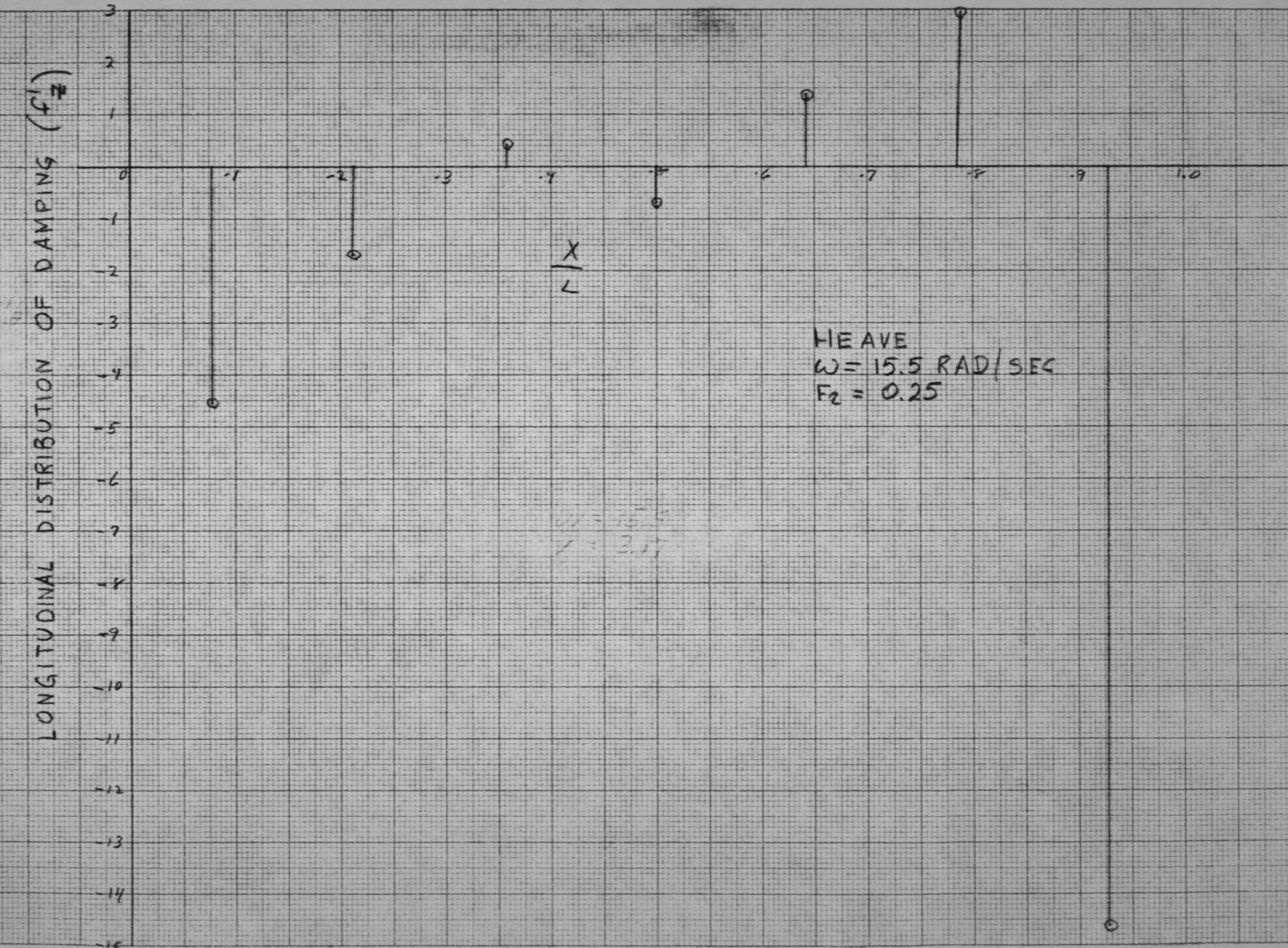

LONGITUDINAL DISTRIBUTION OF DAMPING (c'_z)
3
2
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
-11
-12
-13
-14
-15
·1
·2
·3
·4
·5
·6
·7
·8
·9
1.0
$\frac{X}{L}$
HEAVE
ω = 15.5 RAD/SEC
F_2 = 0.25

FIG. 56

V=0

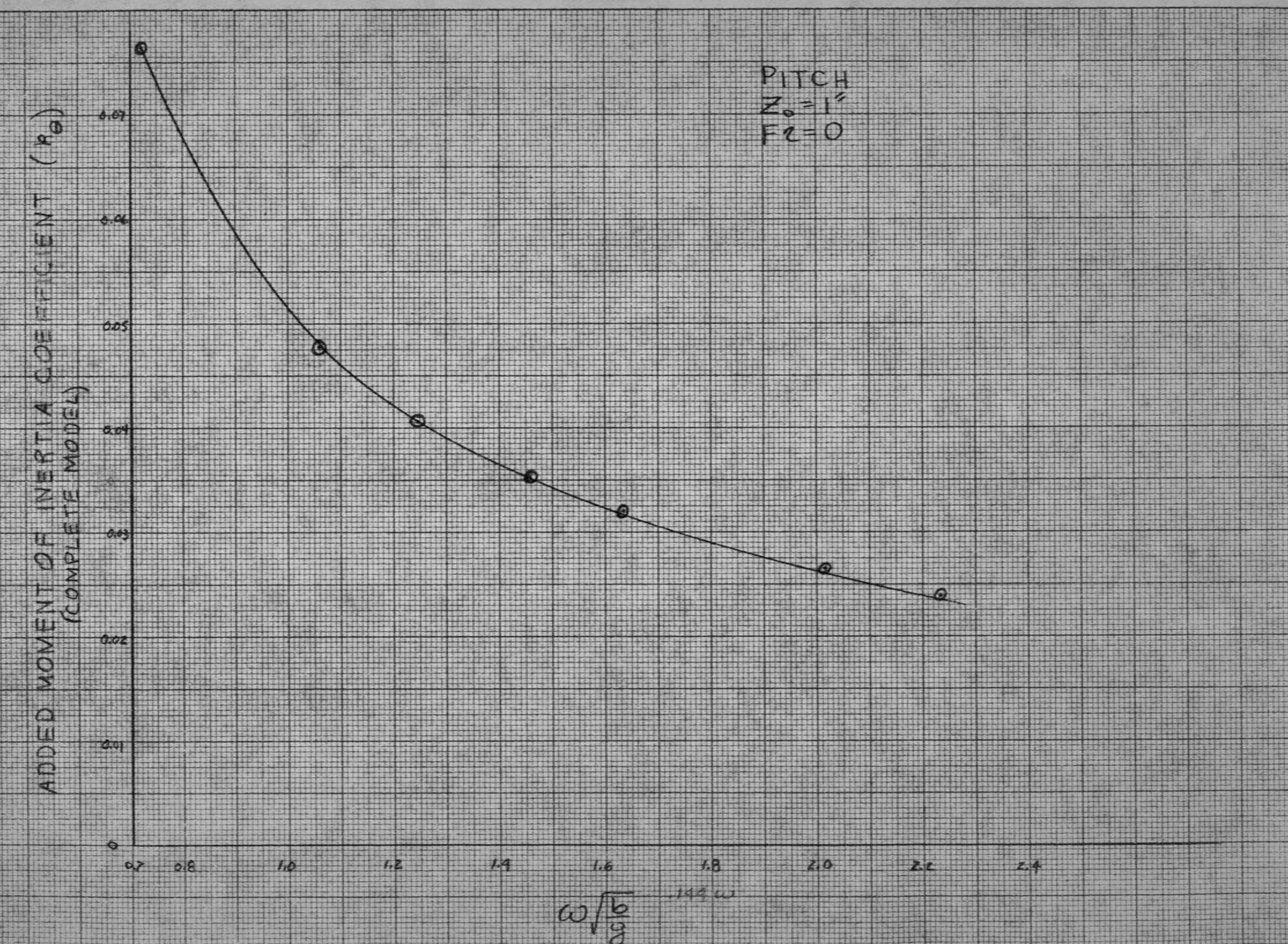

PITCH
Z₀ = 1"
Fz = 0
ADDED MOMENT OF INERTIA COEFFICIENT (k_θ)
(COMPLETE MODEL)
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega\sqrt{\frac{b}{g}}$
.144 ω

FIG. 57

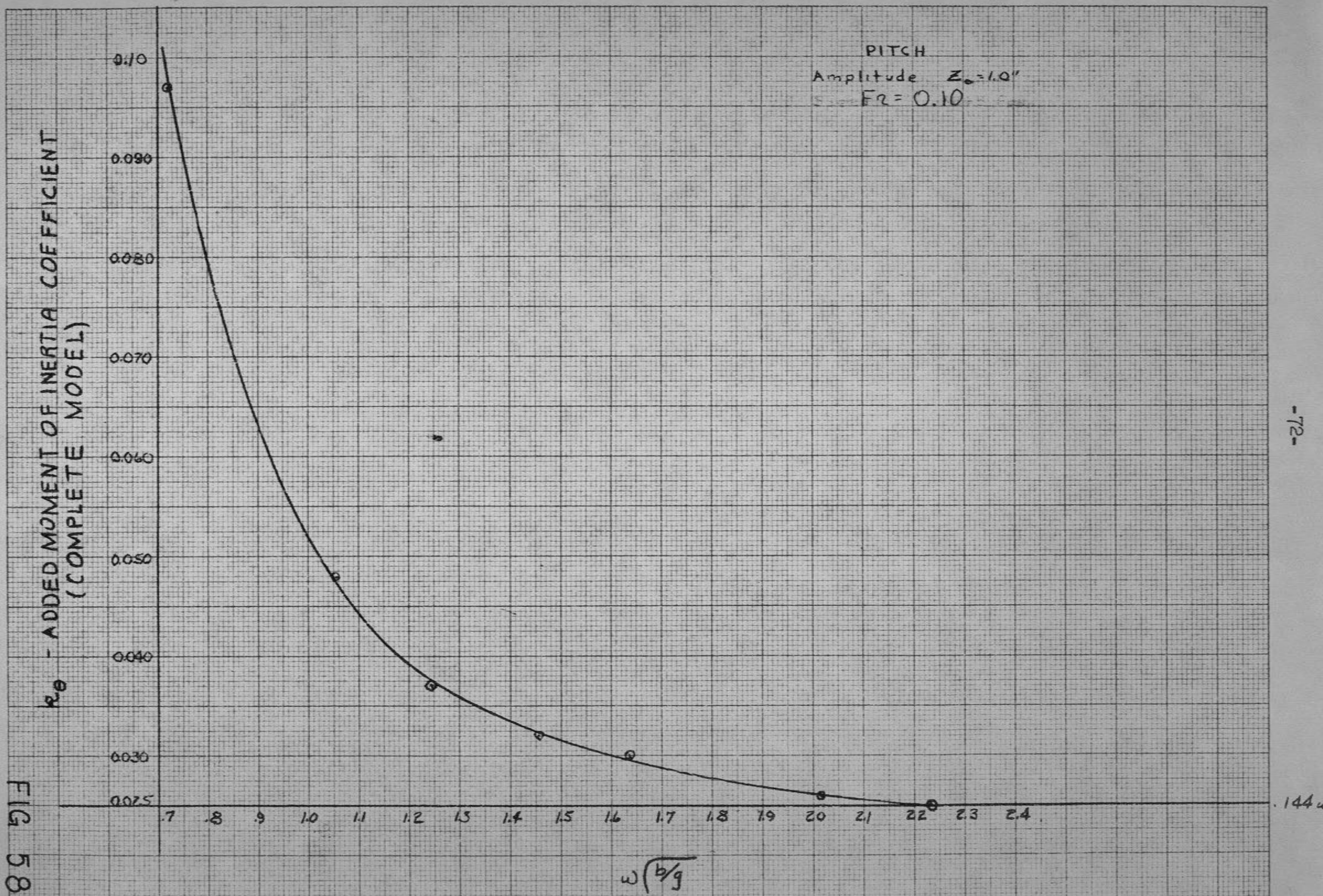

PITCH
Amplitude $Z_o = 1.0''$
$Fr = 0.10$
k_θ - ADDED MOMENT OF INERTIA COEFFICIENT
(COMPLETE MODEL)
0.10
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.025
.7
.8
.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.1
2.2
2.3
2.4
$\omega\sqrt{b/g}$
.144 ω

FIG 58

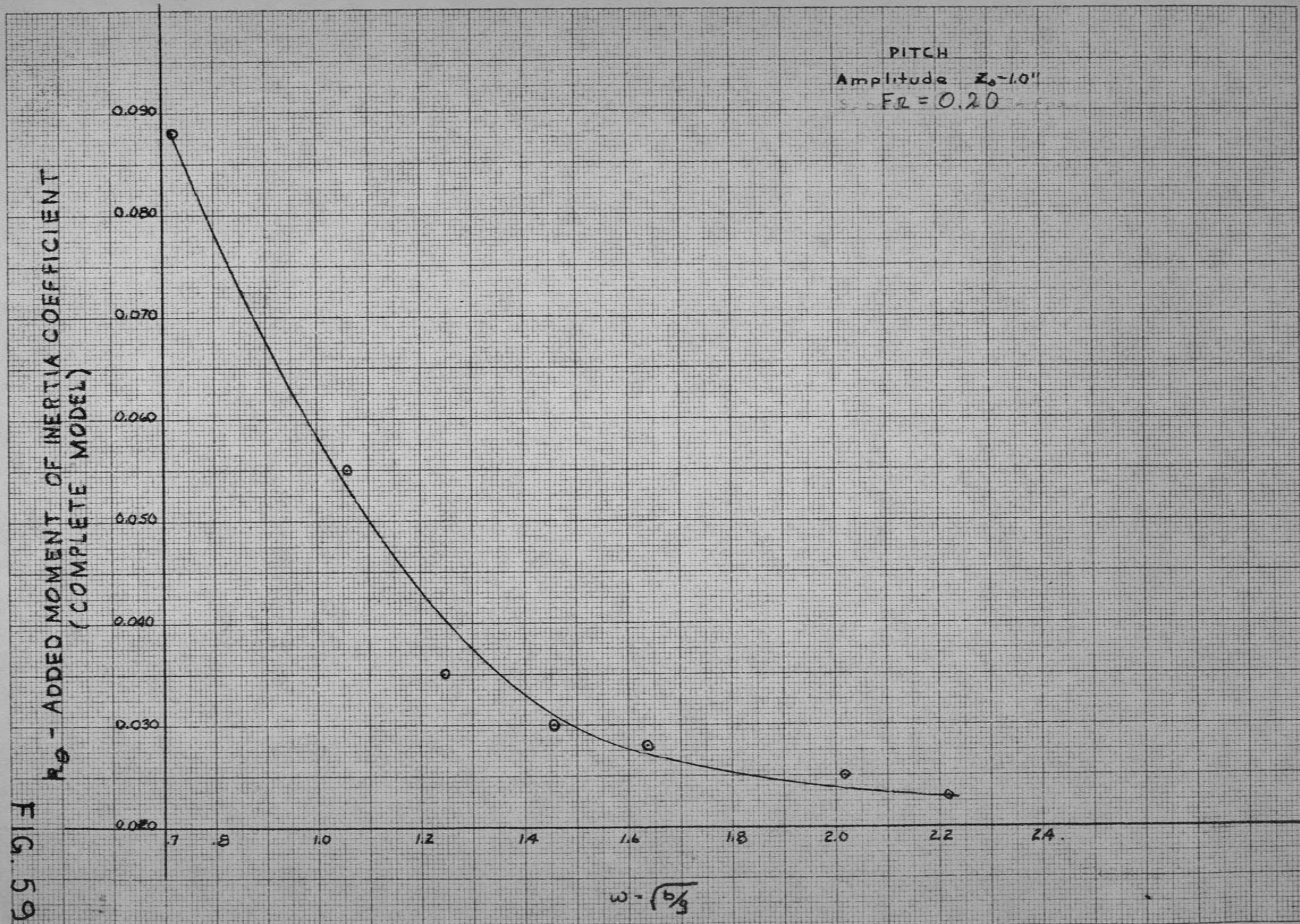

PITCH
Amplitude Z_0 - 1.0"
F_R = 0.20
k_θ - ADDED MOMENT OF INERTIA COEFFICIENT
(COMPLETE MODEL)
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
.144ω
$\omega \sqrt{b/g}$

FIG. 59

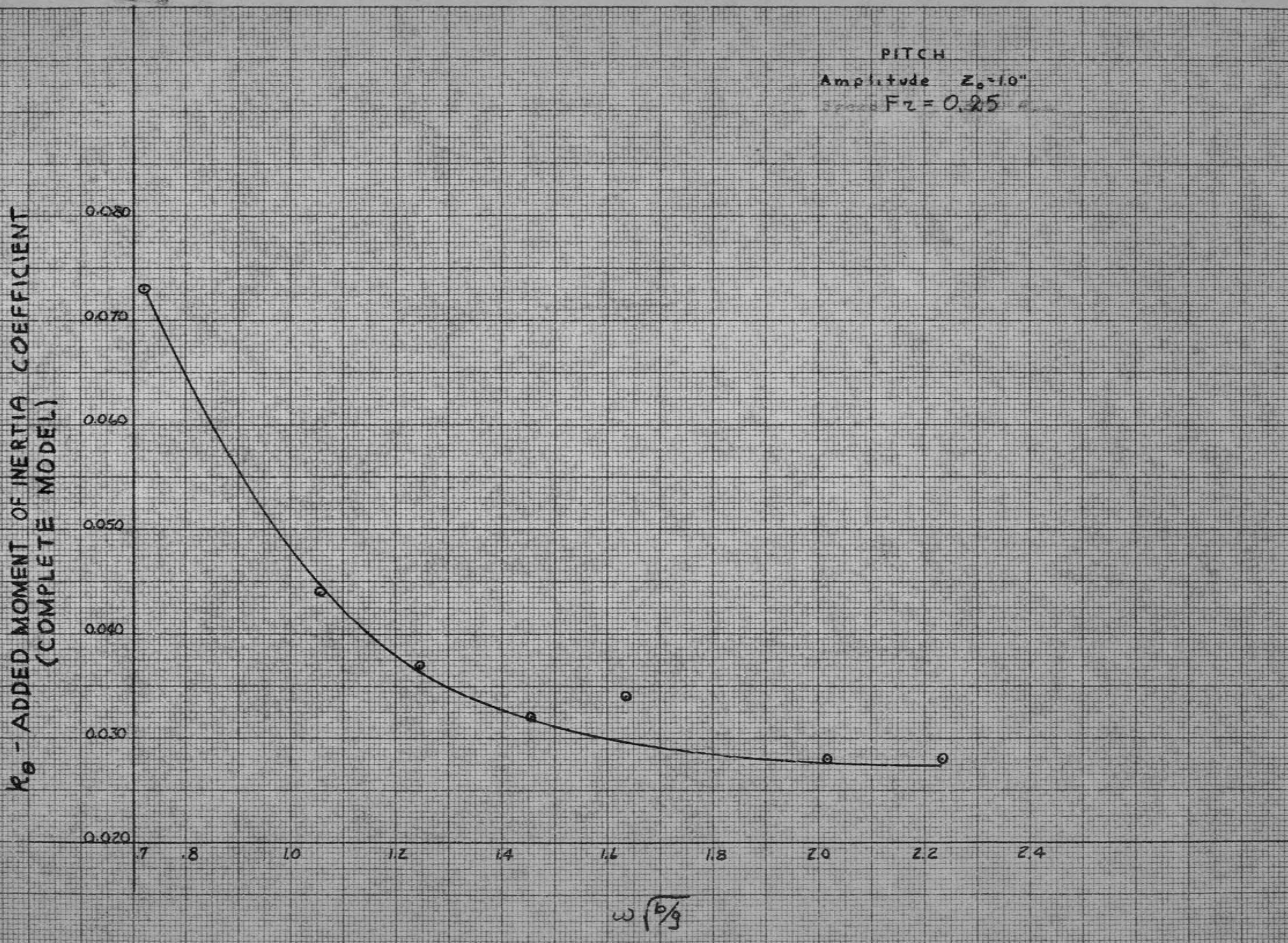
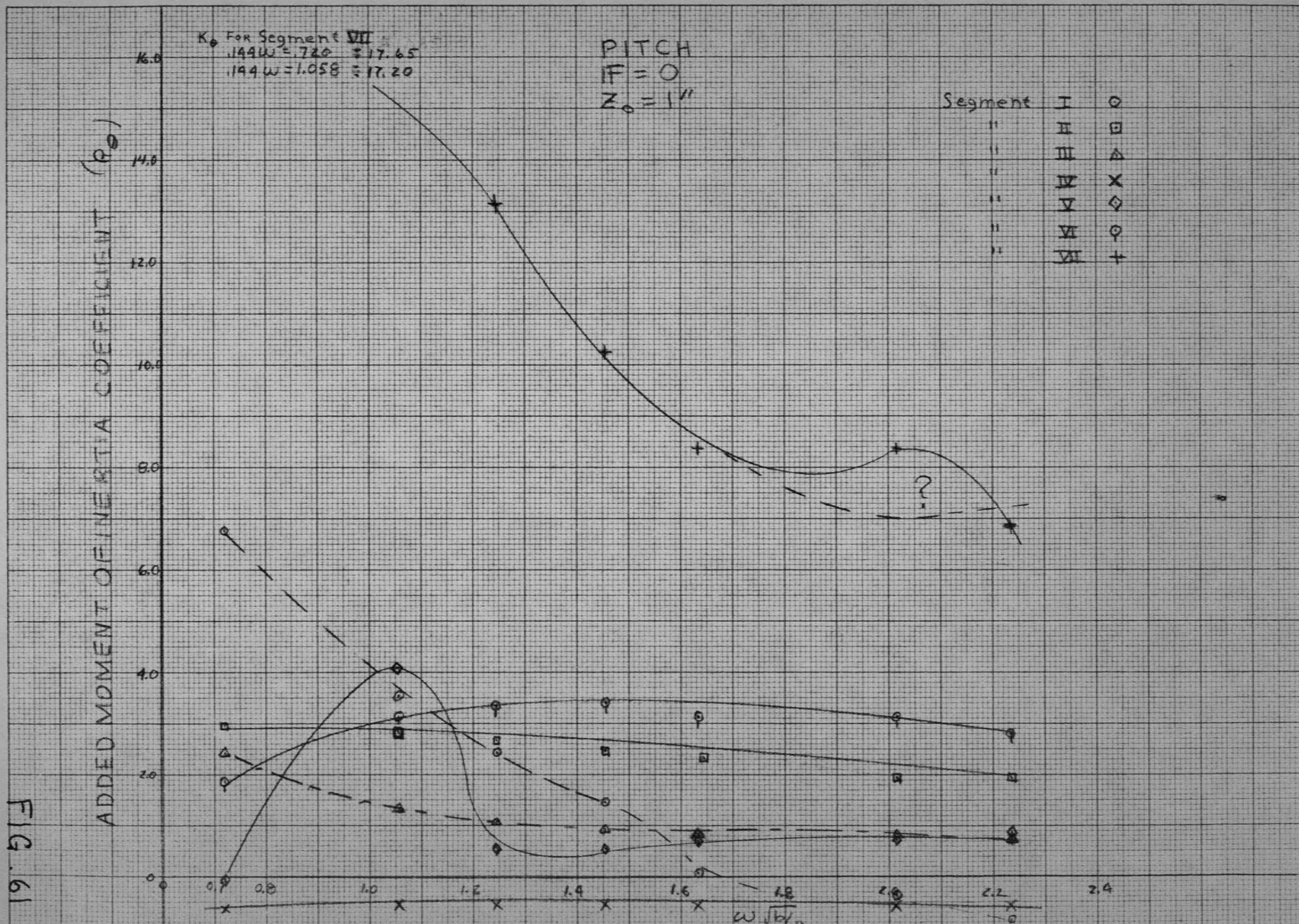

PITCH
Amplitude Z_0 = 1.0"
Fr = 0.25
k_θ - ADDED MOMENT OF INERTIA COEFFICIENT
(COMPLETE MODEL)
0.080
0.070
0.060
0.050
0.040
0.030
0.020
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega\sqrt{b/g}$
.144 ω

FIG. 60



K_ϕ For Segment VII
.144 ω = .720 = 17.65
.144 ω = 1.058 = 17.20
PITCH
IF = 0
$Z_0 = 1''$
Segment I
" II
" III
" IV
" V
" VI
" VII
ADDED MOMENT OF INERTIA COEFFICIENT (P_ϕ)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
?
$\omega\sqrt{b/g}$

FIG 19

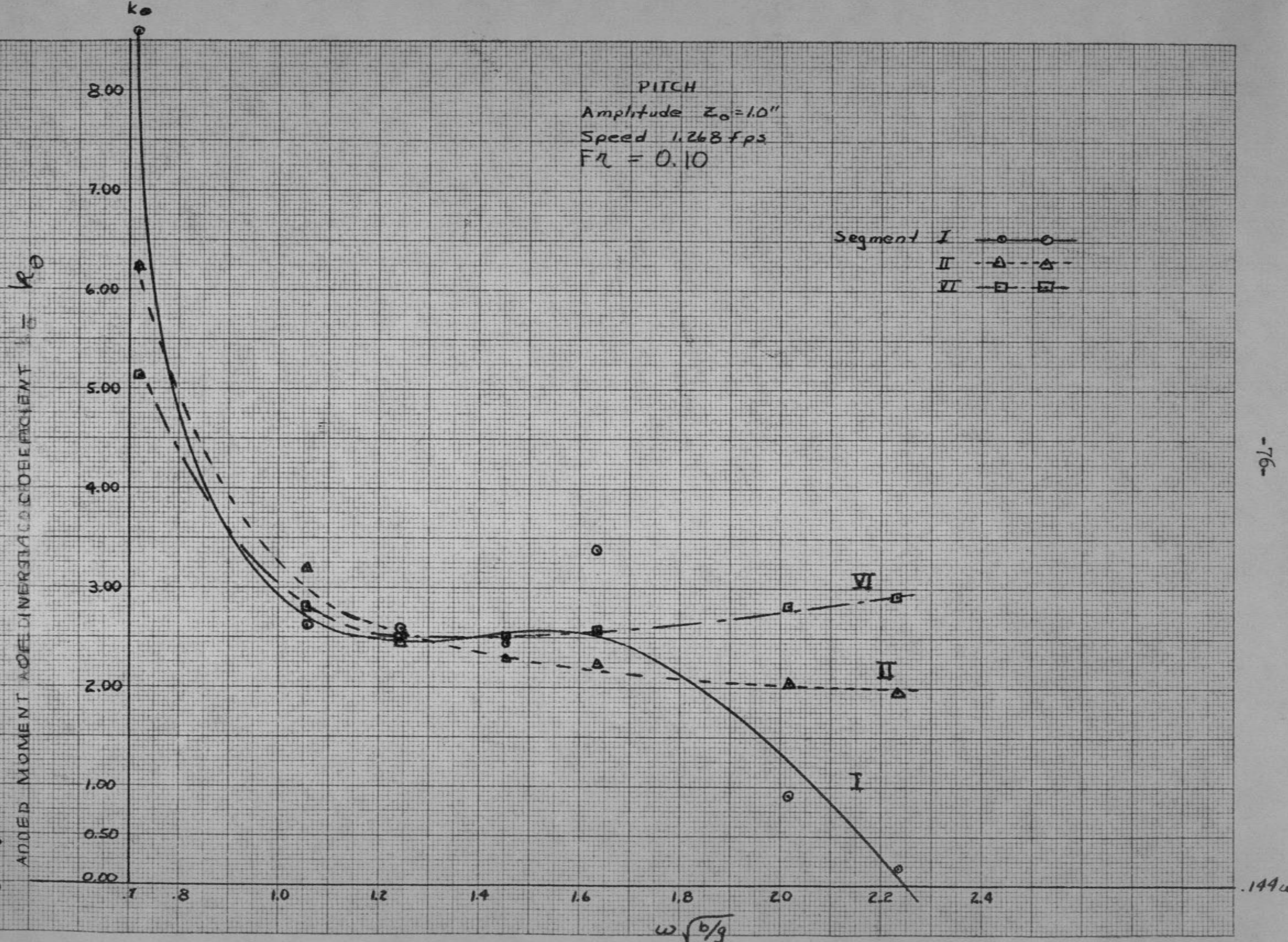

PITCH
Amplitude $z_o = 1.0''$
Speed 1.268 fps
Fr = 0.10
Segment I
II
VI
ADDED MOMENT OF INERTIA COEFFICIENT k_θ
k_θ
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.50
0.00
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
.144ω
$\omega\sqrt{b/g}$

FIG. 62

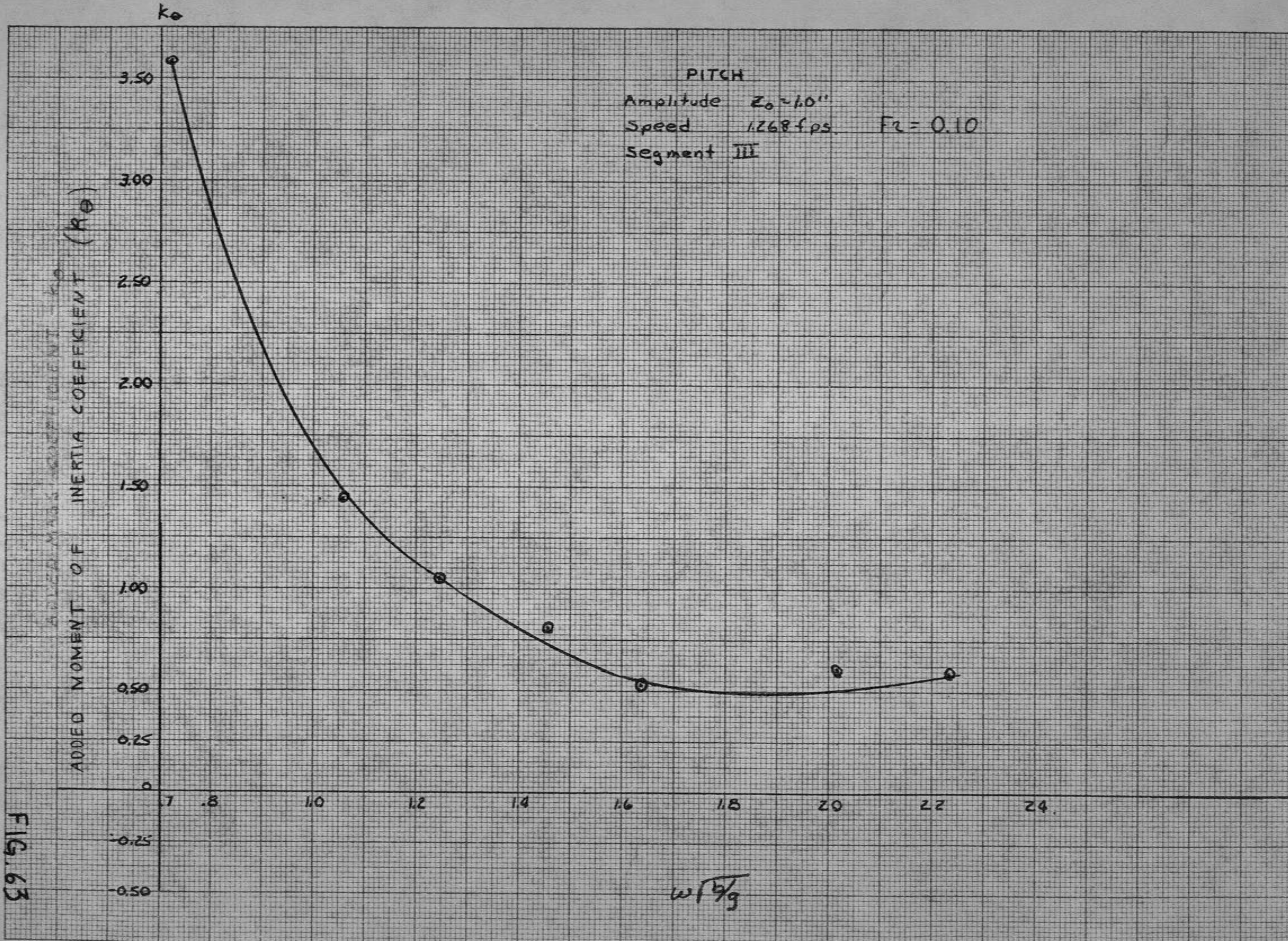
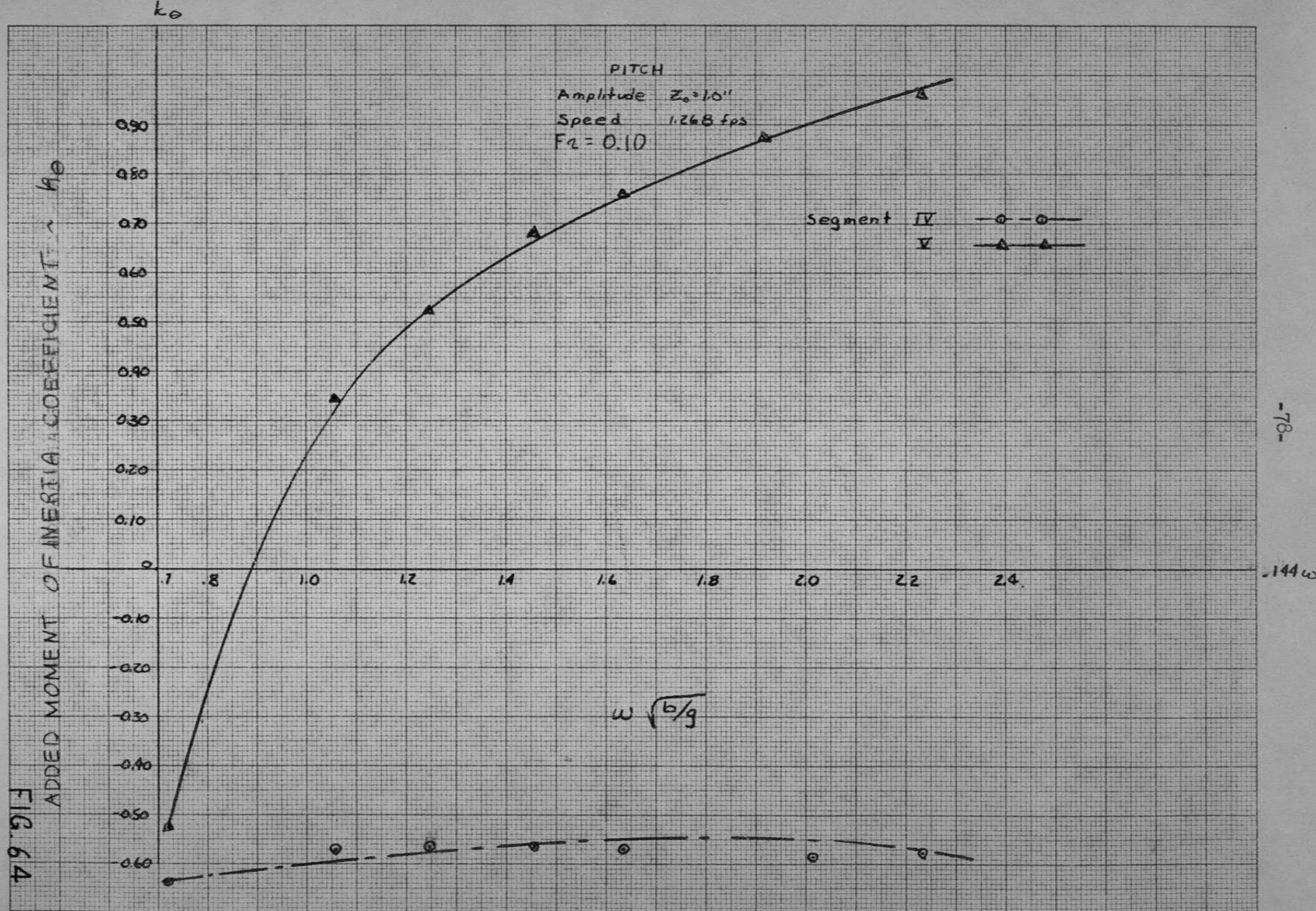
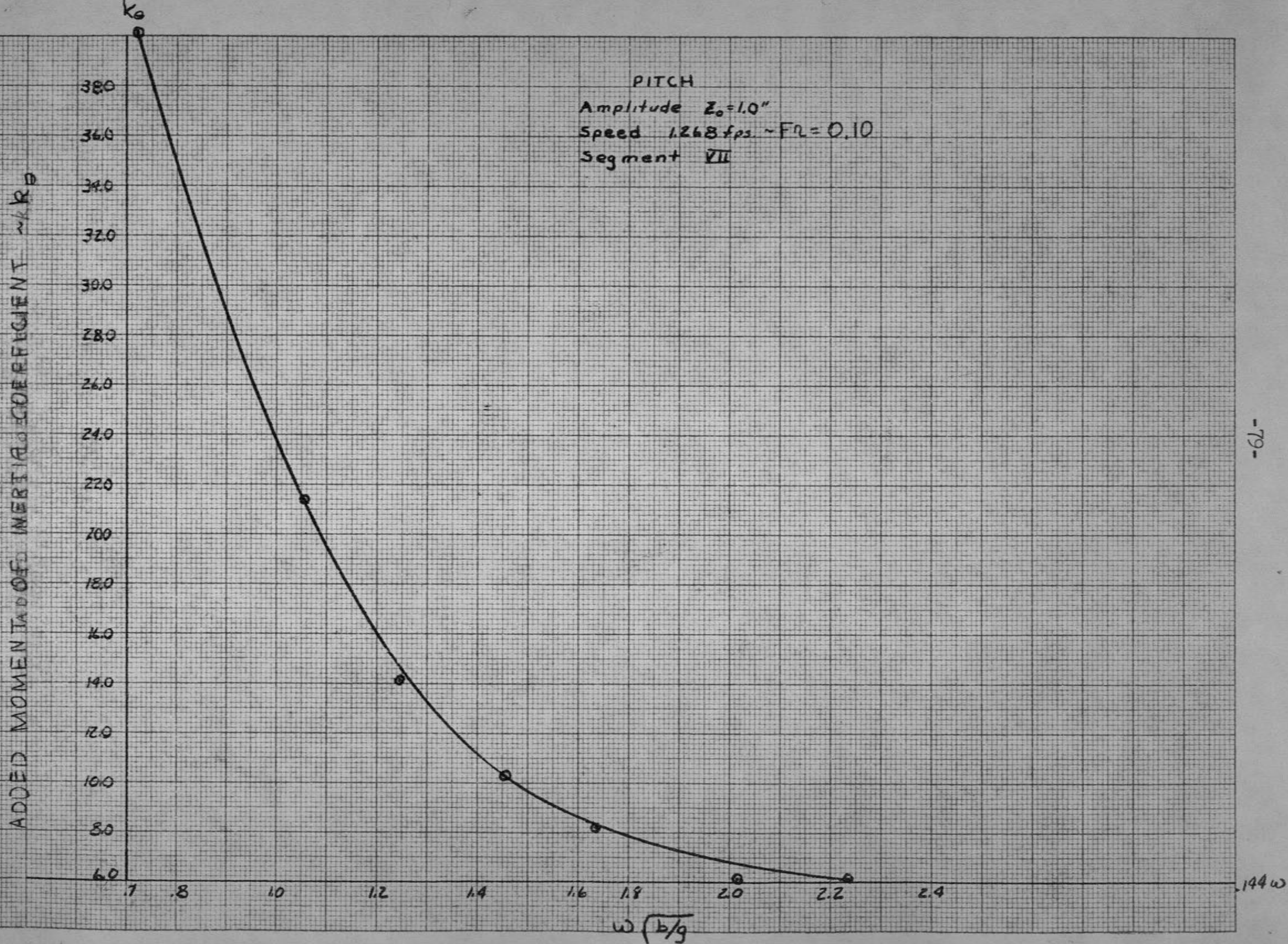

kθ
PITCH
Amplitude z0 ~ 1.0"
Speed 1.268 fps
Fr = 0.10
Segment III
ADDED MOMENT OF INERTIA COEFFICIENT (kθ)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.25
0
-0.25
-0.50
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
ω√(b/g)
.144ω

FIG. 63



k_θ
PITCH
Amplitude $Z_0 = 1.0''$
Speed 1.268 fps
Fr = 0.10
Segment IV
V
ADDED MOMENT OF INERTIA COEFFICIENT ~ k_θ
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
.144 ω
$\omega \sqrt{b/g}$

FIG. 64



k_θ
PITCH
Amplitude $Z_0 = 1.0"$
Speed 1.268 fps ~ Fn = 0.10
Segment VII
ADDED MOMENT OF INERTIA COEFFICIENT ~ k_θ
38.0
36.0
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
.144 ω
$\omega\sqrt{b/g}$

FIG 65

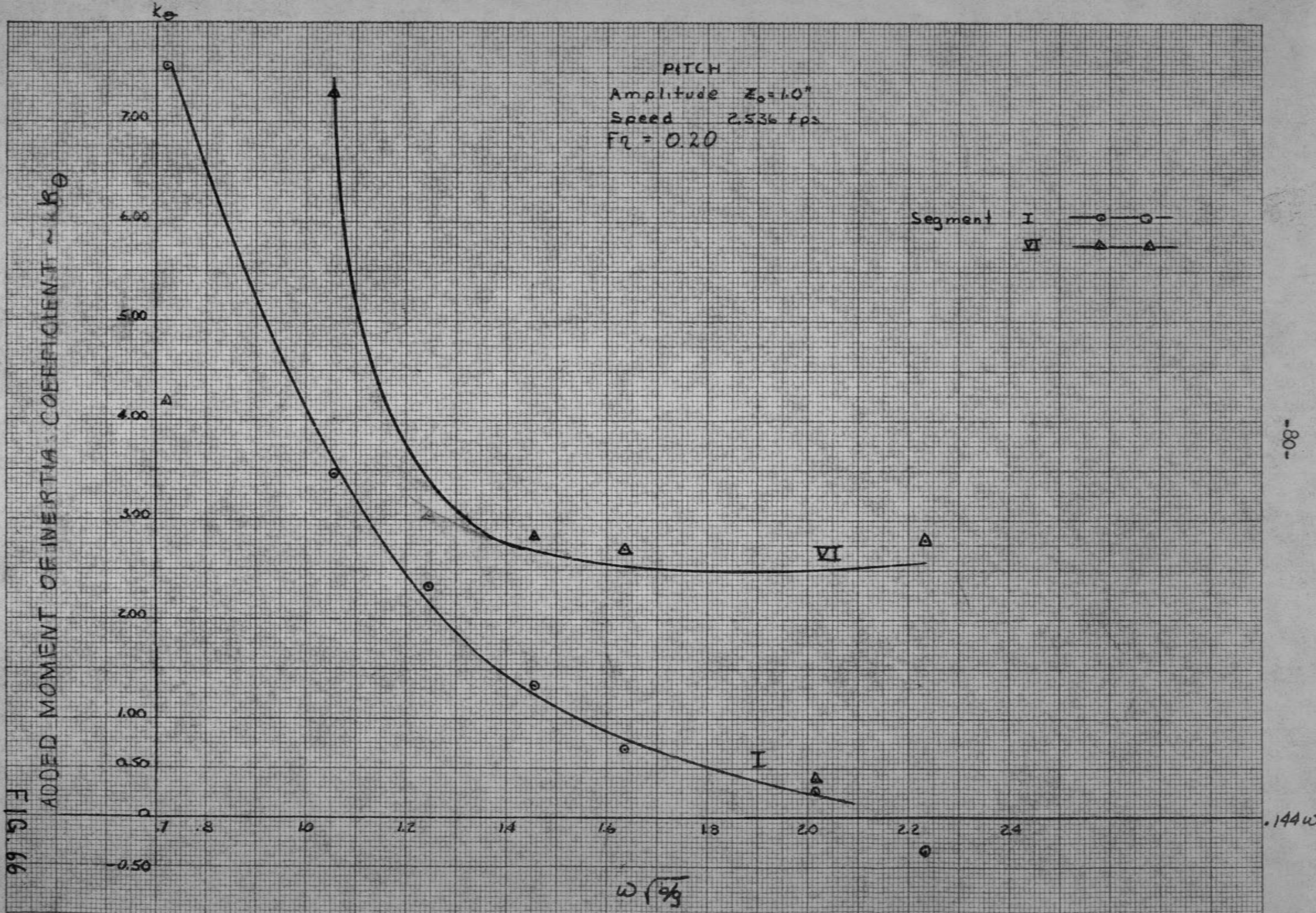
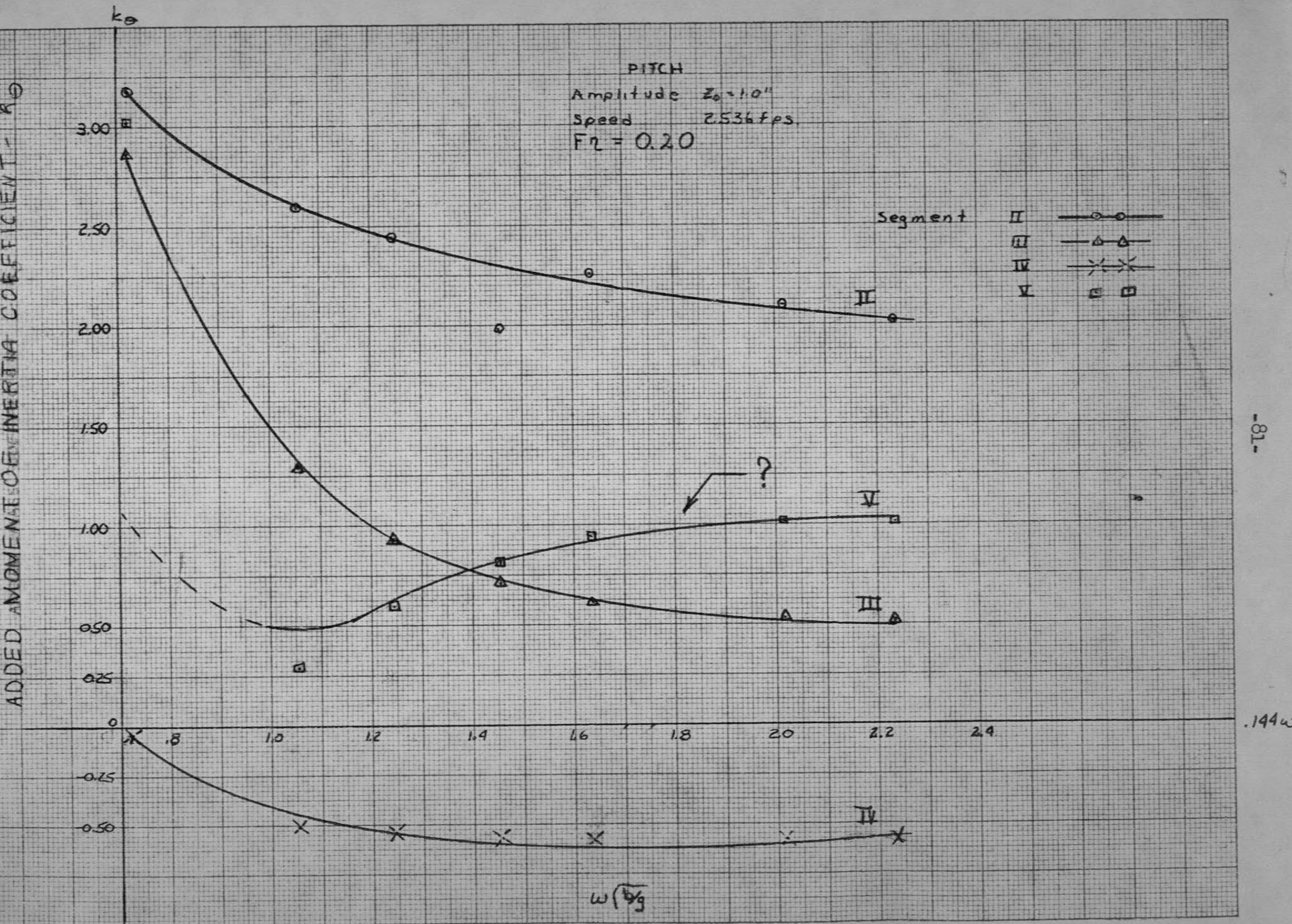

PITCH
Amplitude Z₀ = 1.0"
Speed 2.536 fps
Fr = 0.20
Segment I
VI
ADDED MOMENT OF INERTIA COEFFICIENT ~ kθ
kθ
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.50
0
-0.50
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
.144 ω
I
VI
ω √(l/g)

FIG. 66



PITCH
Amplitude Z₀ = 1.0"
Speed 2.536 fps
Fn = 0.20
Segment II
III
IV
V
?
II
III
IV
V
ADDED MOMENT OF INERTIA COEFFICIENT - k_θ
k_θ
3.00
2.50
2.00
1.50
1.00
0.50
0.25
0
-0.25
-0.50
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
.144ω
ω√(b/g)

FIG. 67

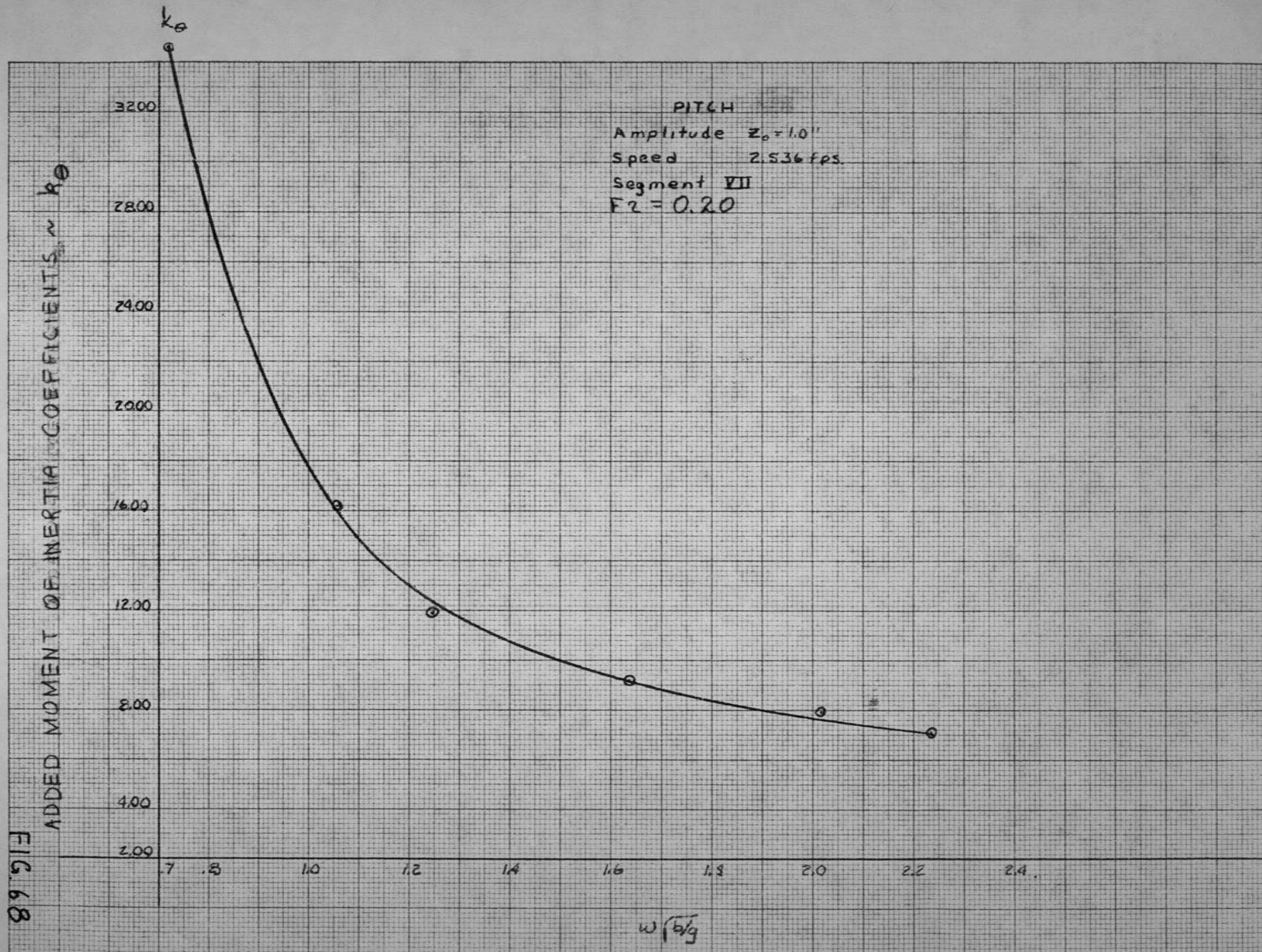

k_θ
PITCH
Amplitude $Z_0 = 1.0''$
Speed 2.536 fps.
Segment VII
$F_z = 0.20$
ADDED MOMENT OF INERTIA COEFFICIENTS ~ k_θ
3200
2800
2400
2000
1600
1200
800
400
200
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega\sqrt{b/g}$

FIG. 68

.144 ω

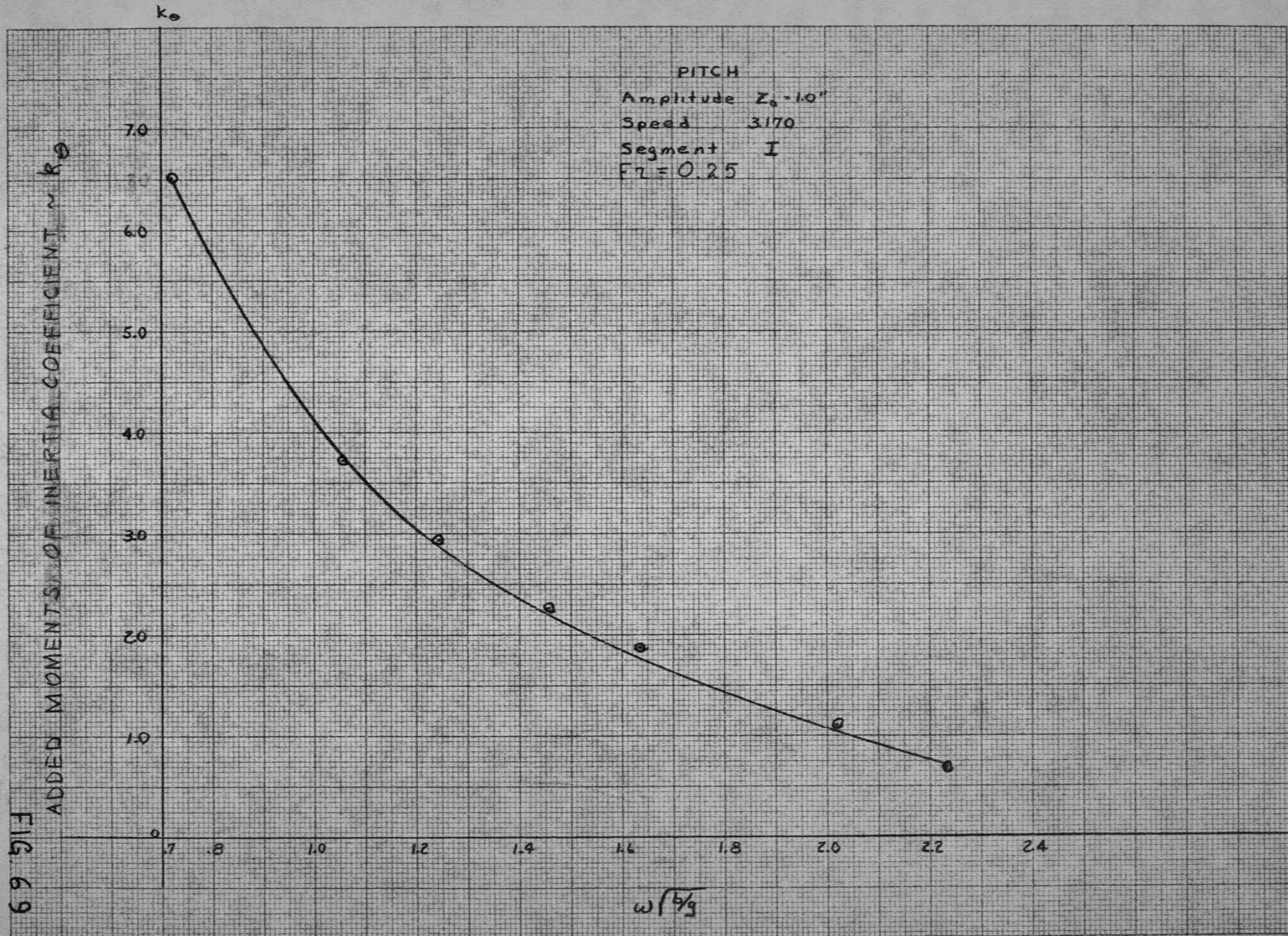

k_θ
PITCH
Amplitude Z_0 - 1.0"
Speed 3170
Segment I
Fr = 0.25
ADDED MOMENTS OF INERTIA COEFFICIENT ~ k_θ
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
.144 ω
$\omega\sqrt{b/g}$

FIG 69

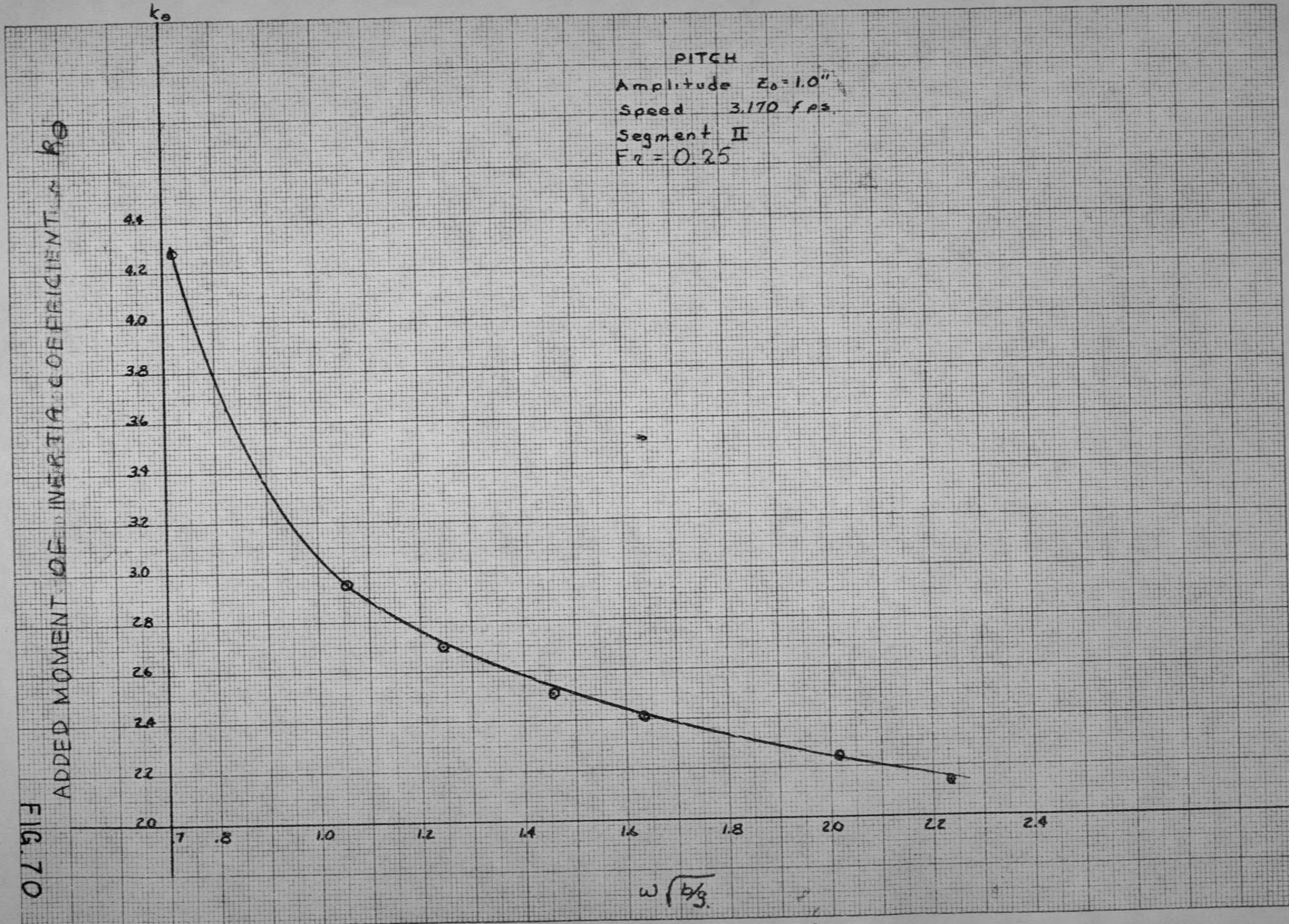

PITCH
Amplitude $Z_0 = 1.0''$
Speed 3.170 fps
Segment II
Fr = 0.25
k_θ
ADDED MOMENT OF INERTIA COEFFICIENT ~ k_θ
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
2.0
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
.144 ω
$\omega\sqrt{b/g}$

FIG. 70

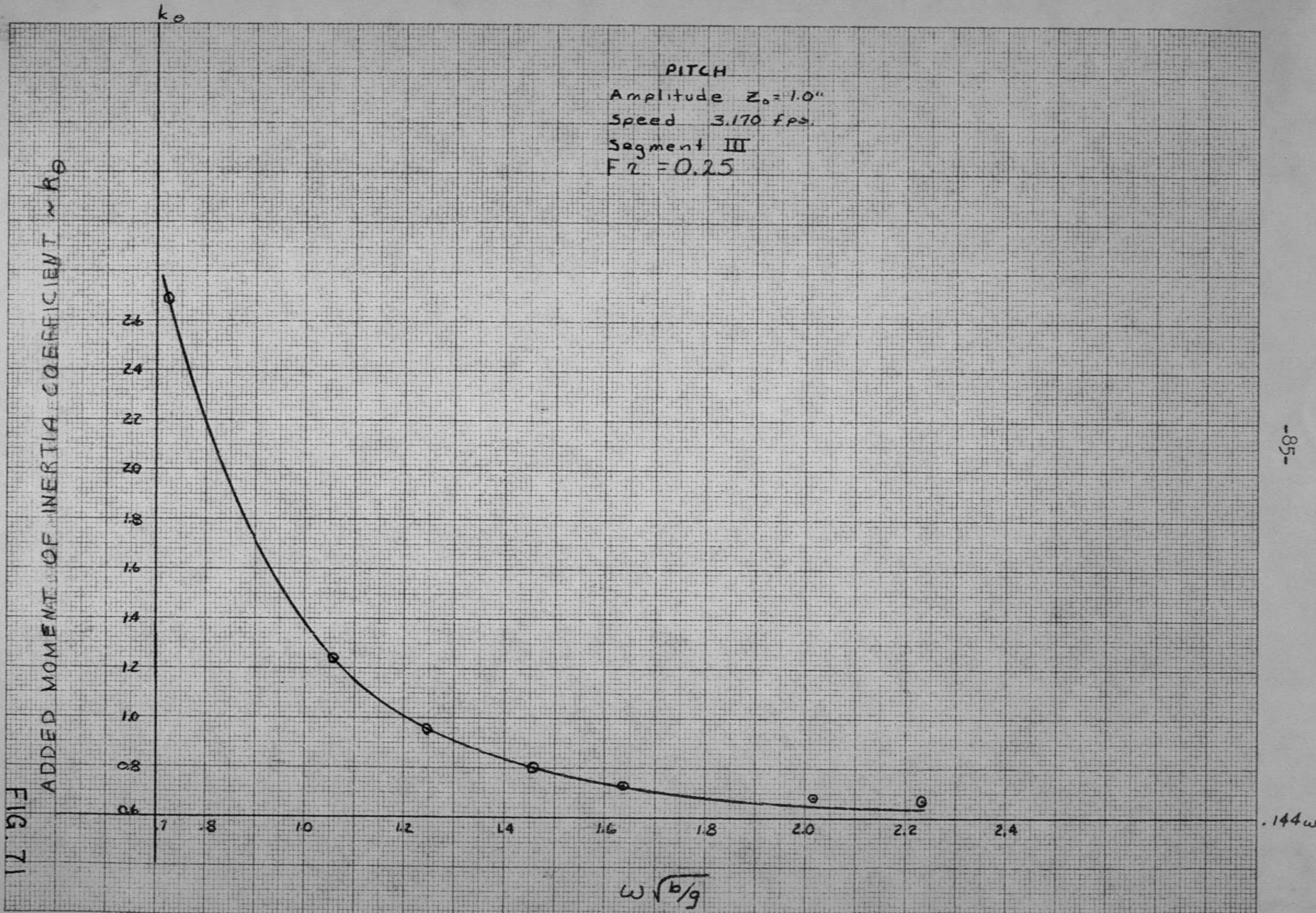

PITCH
Amplitude $z_0 = 1.0''$
Speed 3.170 fps.
Segment III
Fr = 0.25
k_θ
ADDED MOMENT OF INERTIA COEFFICIENT ~ k_θ
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega\sqrt{b/g}$
.144 ω

FIG. 71

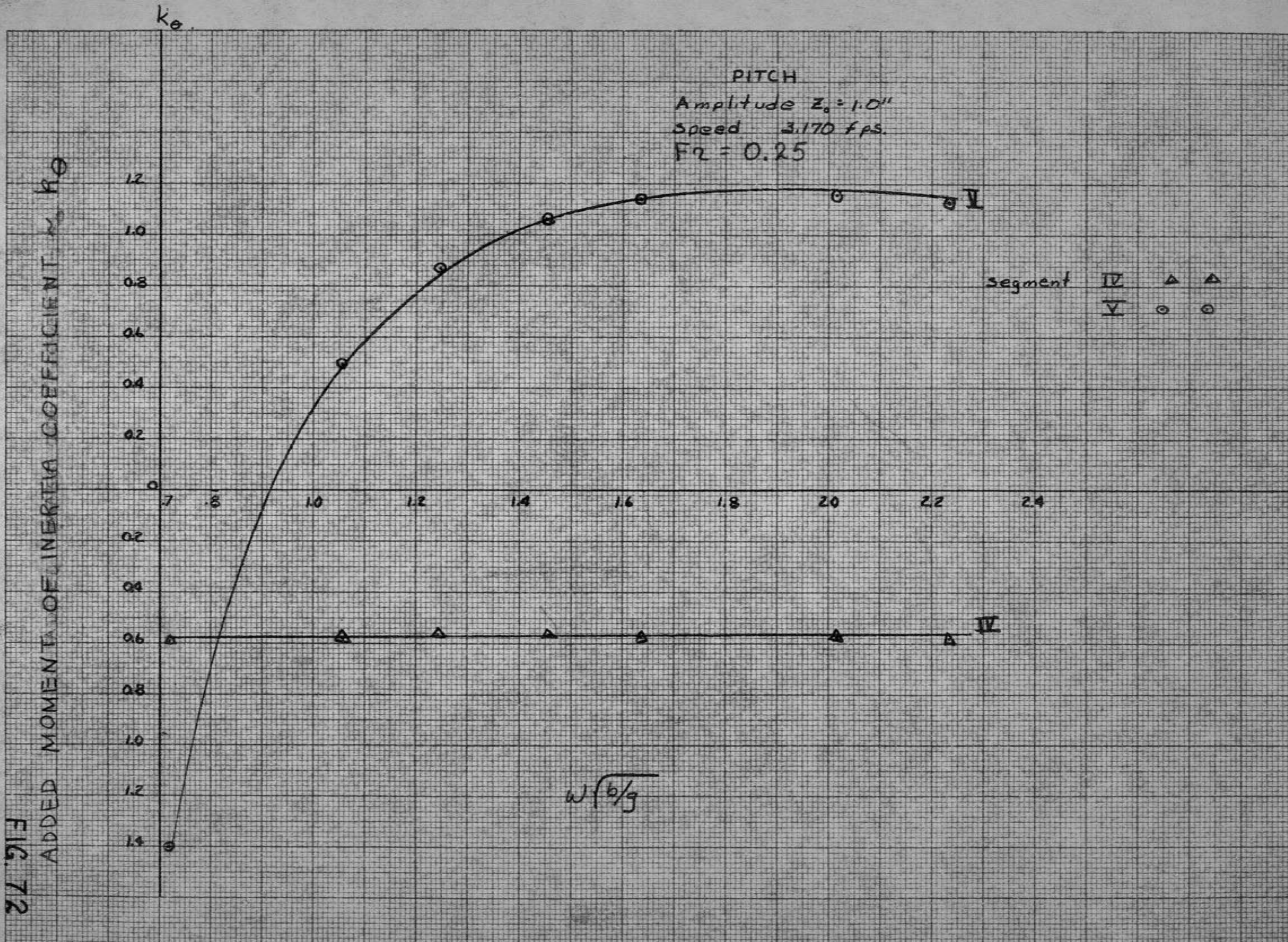
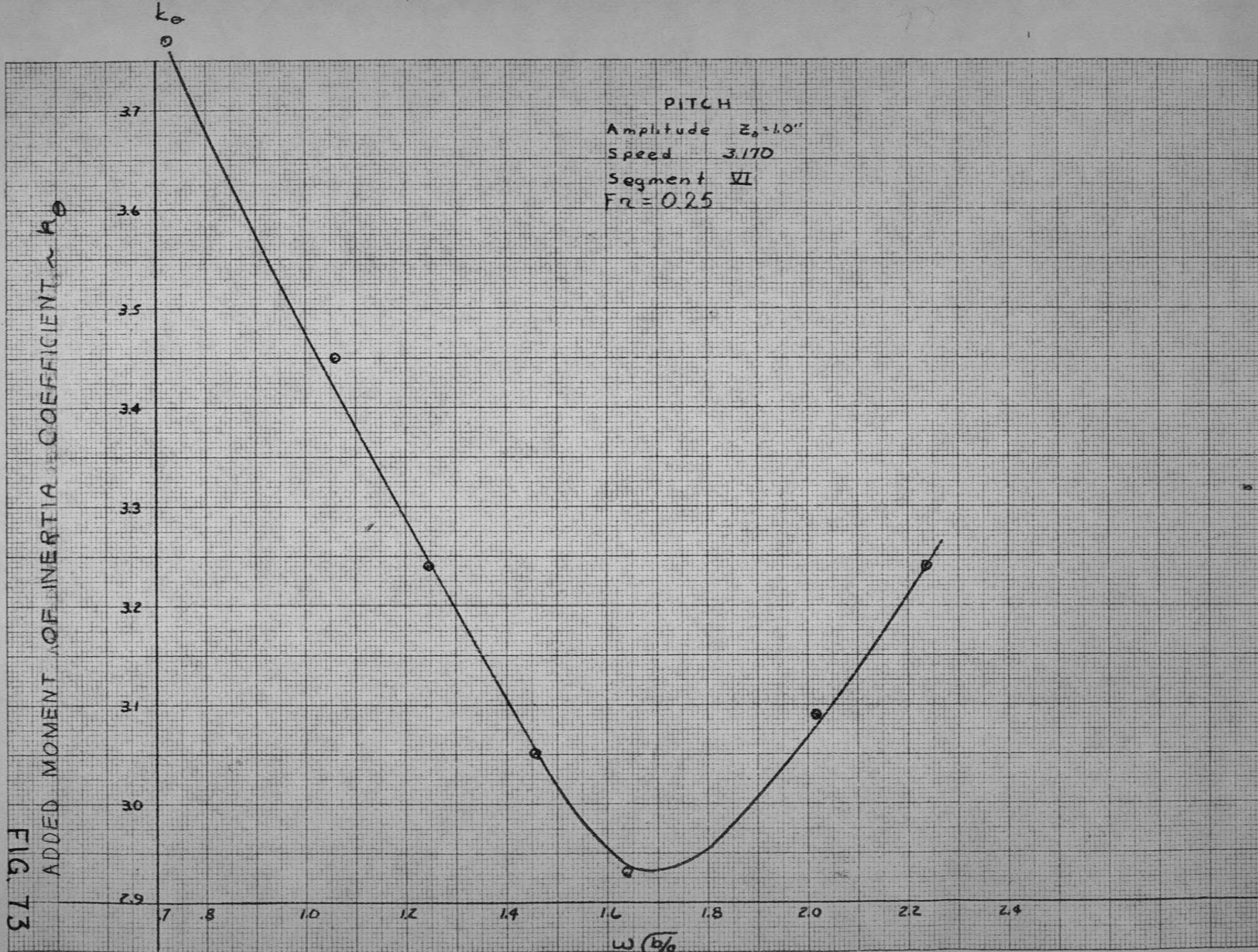


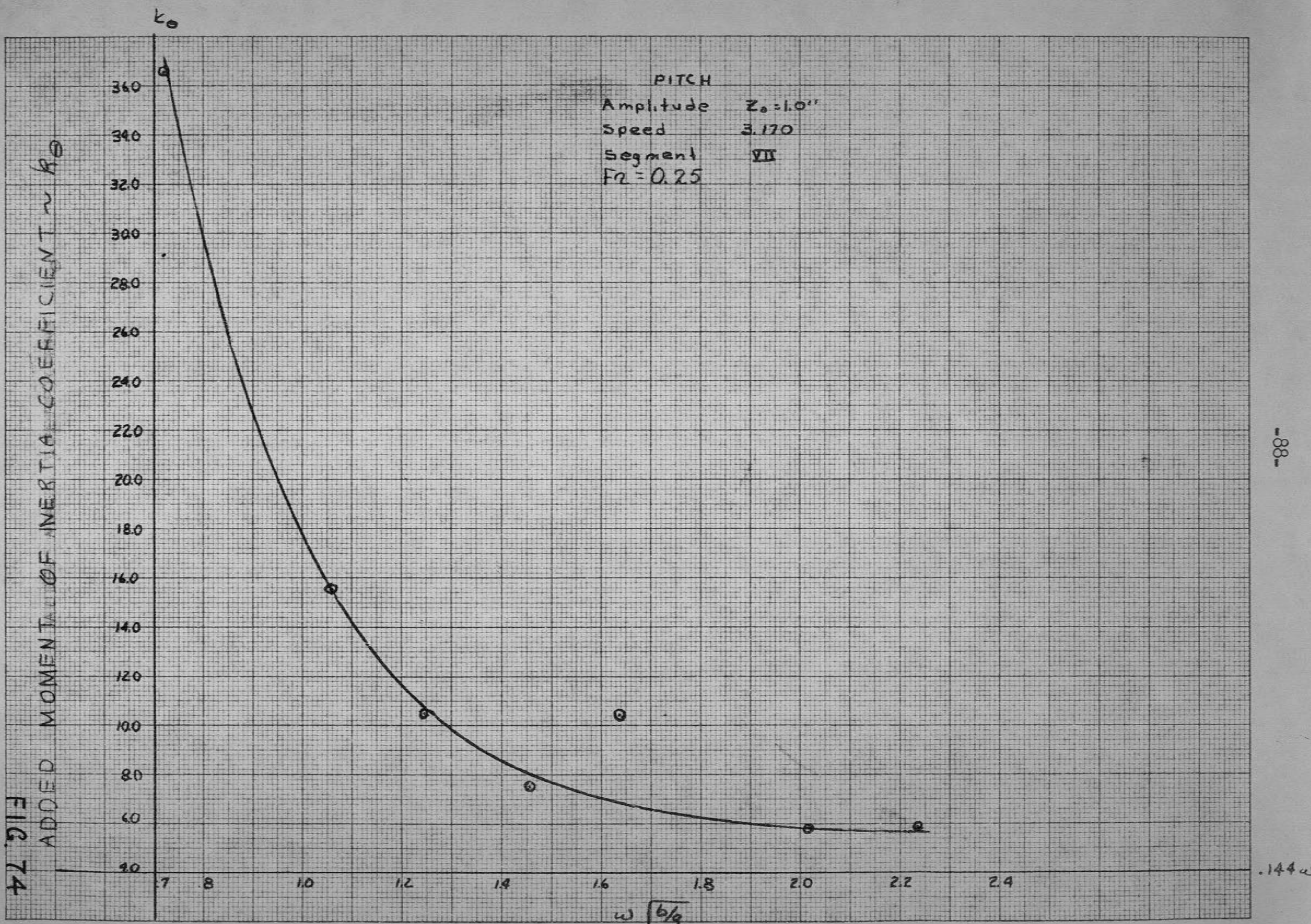
FIG. 72

$\mathfrak{J} 44 \omega$.



kθ
PITCH
Amplitude Z0=1.0"
Speed 3.170
Segment VI
Fr = 0.25
ADDED MOMENT OF INERTIA COEFFICIENT ~ kθ
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
2.9
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
ω√(b/g)
.144ω

FIG. 73



k_θ
PITCH
Amplitude $Z_0 = 1.0''$
Speed 3.170
Segment VII
$Fr = 0.25$
ADDED MOMENT OF INERTIA COEFFICIENT ~ k_θ
36.0
34.0
32.0
30.0
28.0
26.0
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega \sqrt{b/g}$
$.144\omega$

FIG. 74

75

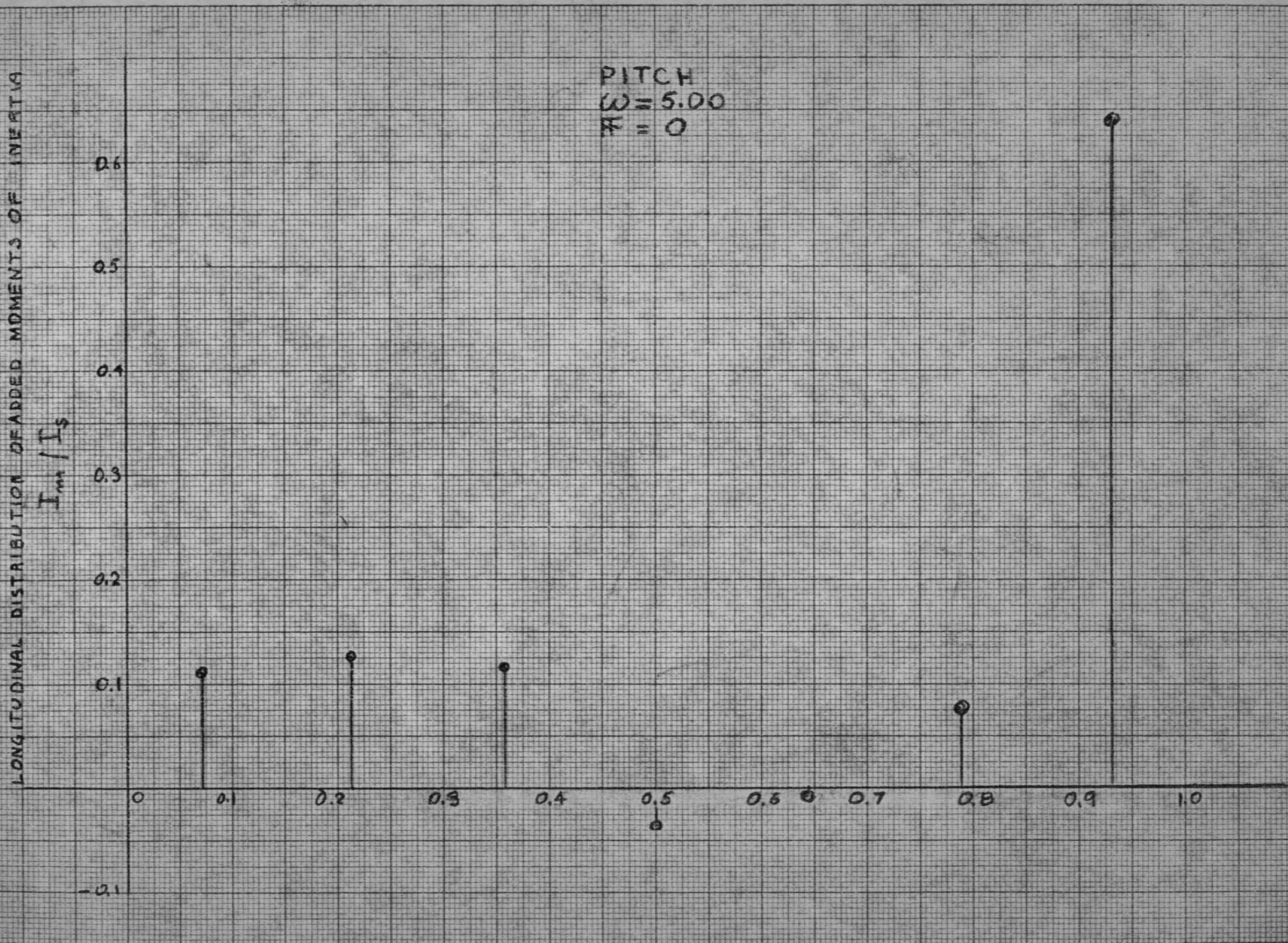

PITCH
ω = 5.00
F = 0
LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
0.6
0.5
0.4
0.3
0.2
0.1
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

FIG. 75

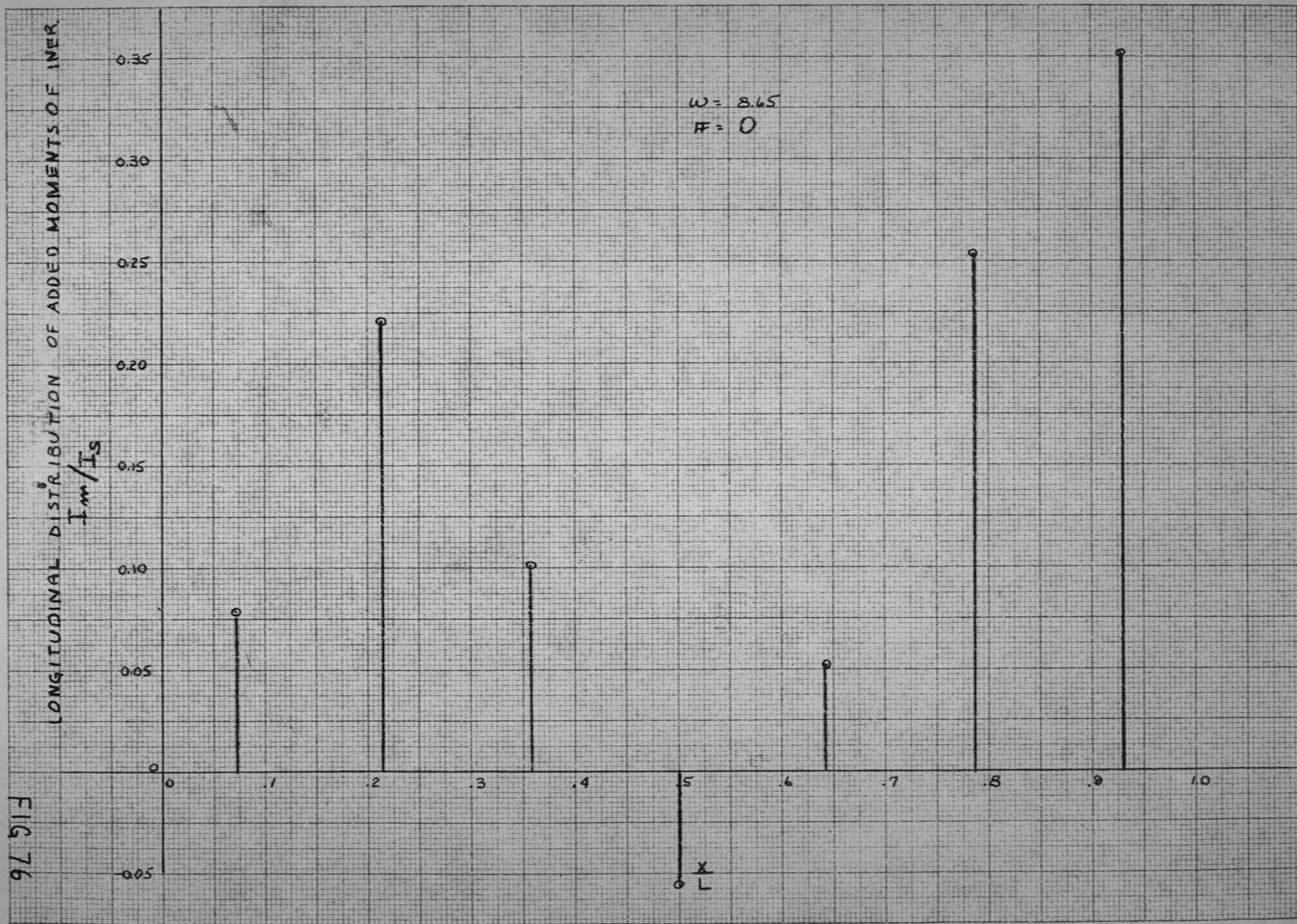
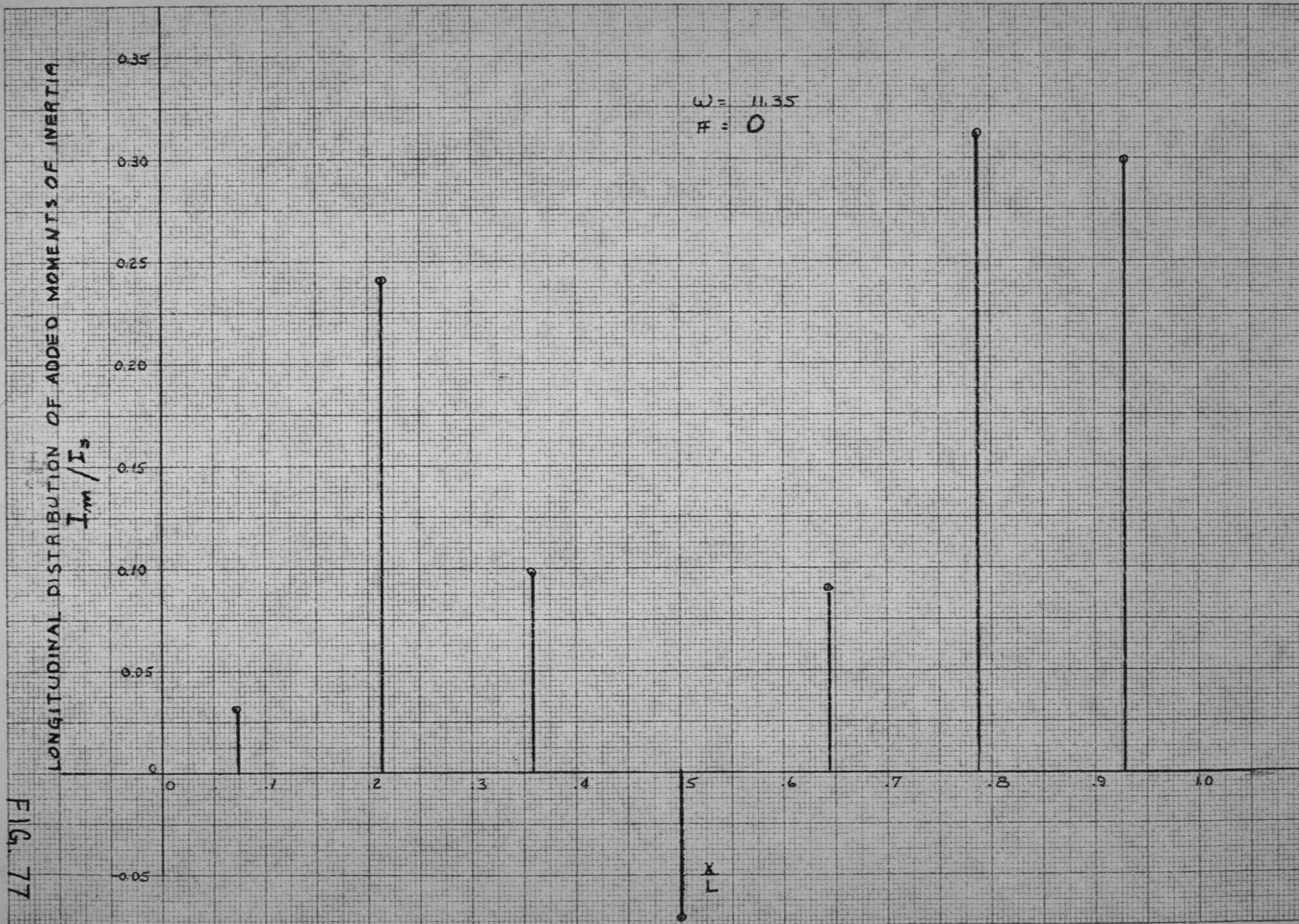

LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INER.
Im/Is
ω = 8.65
F = 0
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
-0.05
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG 76

77



LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0
-0.05
ω = 11.35
F = 0
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
$\frac{X}{L}$

FIG. 77

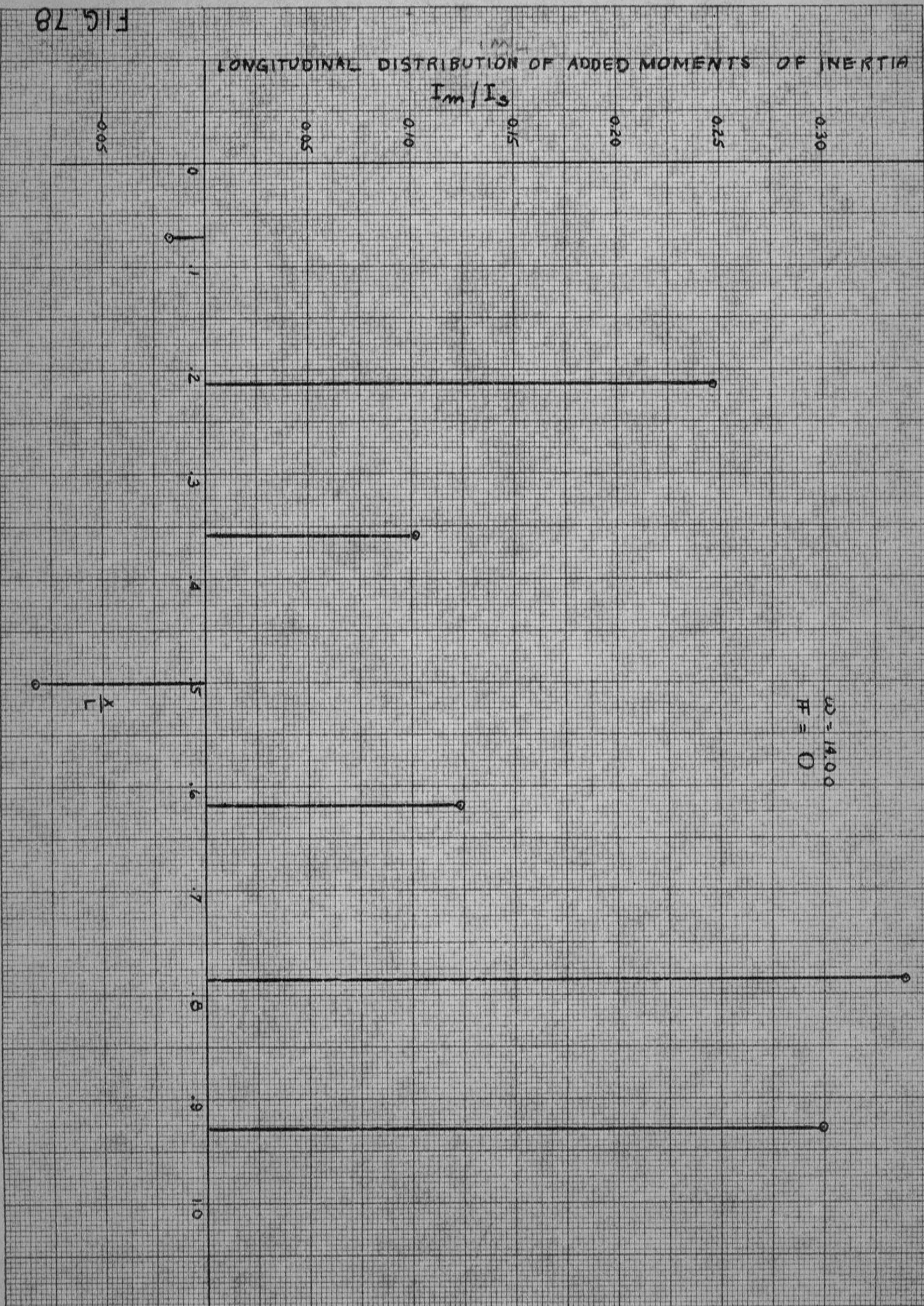


FIG. 78
LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
-0.05
0.05
0.10
0.15
0.20
0.25
0.30
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
$\frac{x}{L}$
$\omega = 14.00$
$F = 0$

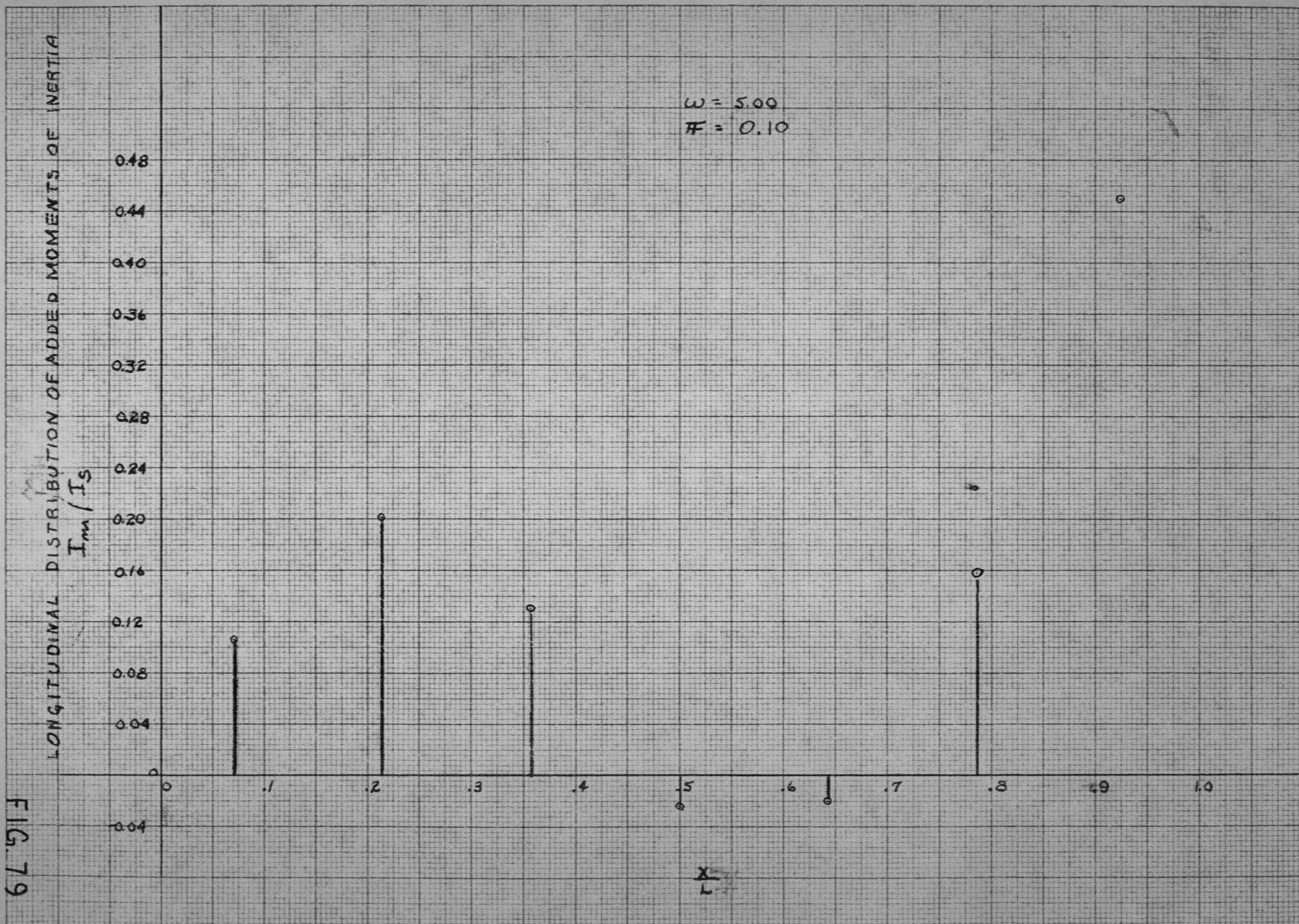
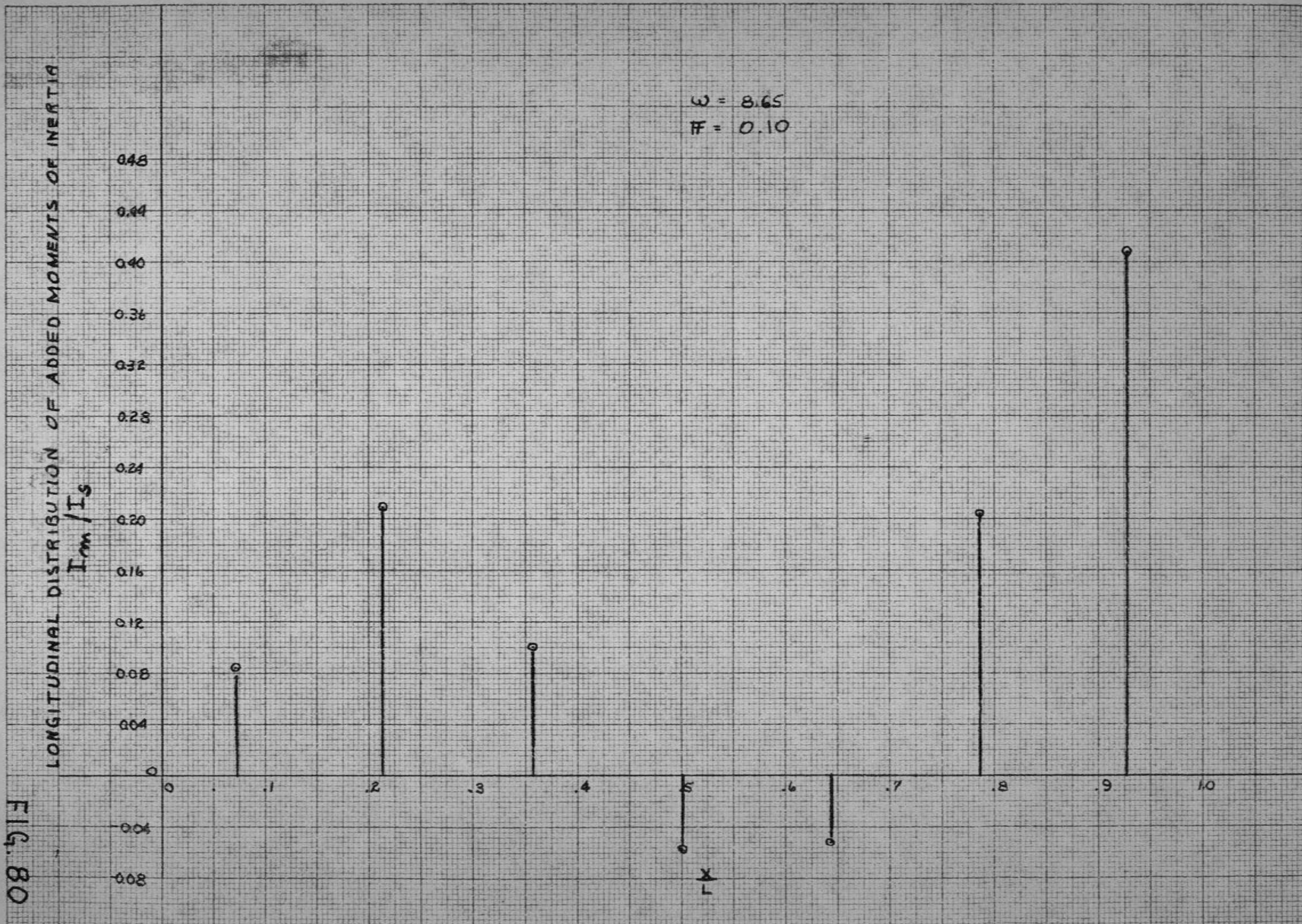

LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
ω = 5.00
F = 0.10
0.48
0.44
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
-0.04
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
$\frac{X}{L}$

FIG. 79



LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
ω = 8.65
F = 0.10
0.48
0.44
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0
-0.04
-0.08
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
$\frac{X}{L}$

FIG. 80


LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
Im/Is
ω = 11.35
F = 0.10
0.30
0.25
0.20
0.15
0.10
0.05
-0.05
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG 81

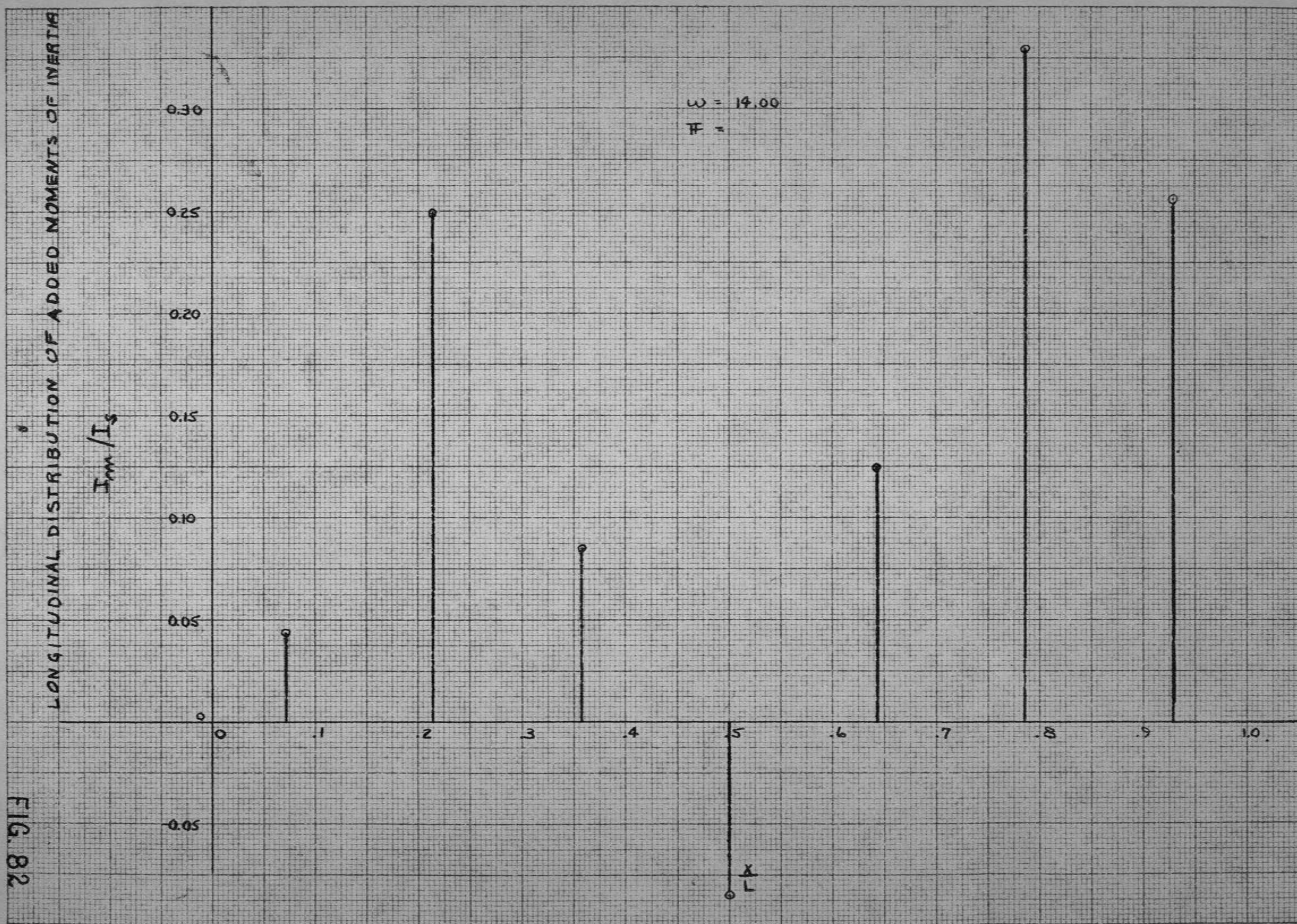

LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
ω = 14.00
₣ =
0.30
0.25
0.20
0.15
0.10
0.05
0
-0.05
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
$\frac{x}{L}$

FIG. 82

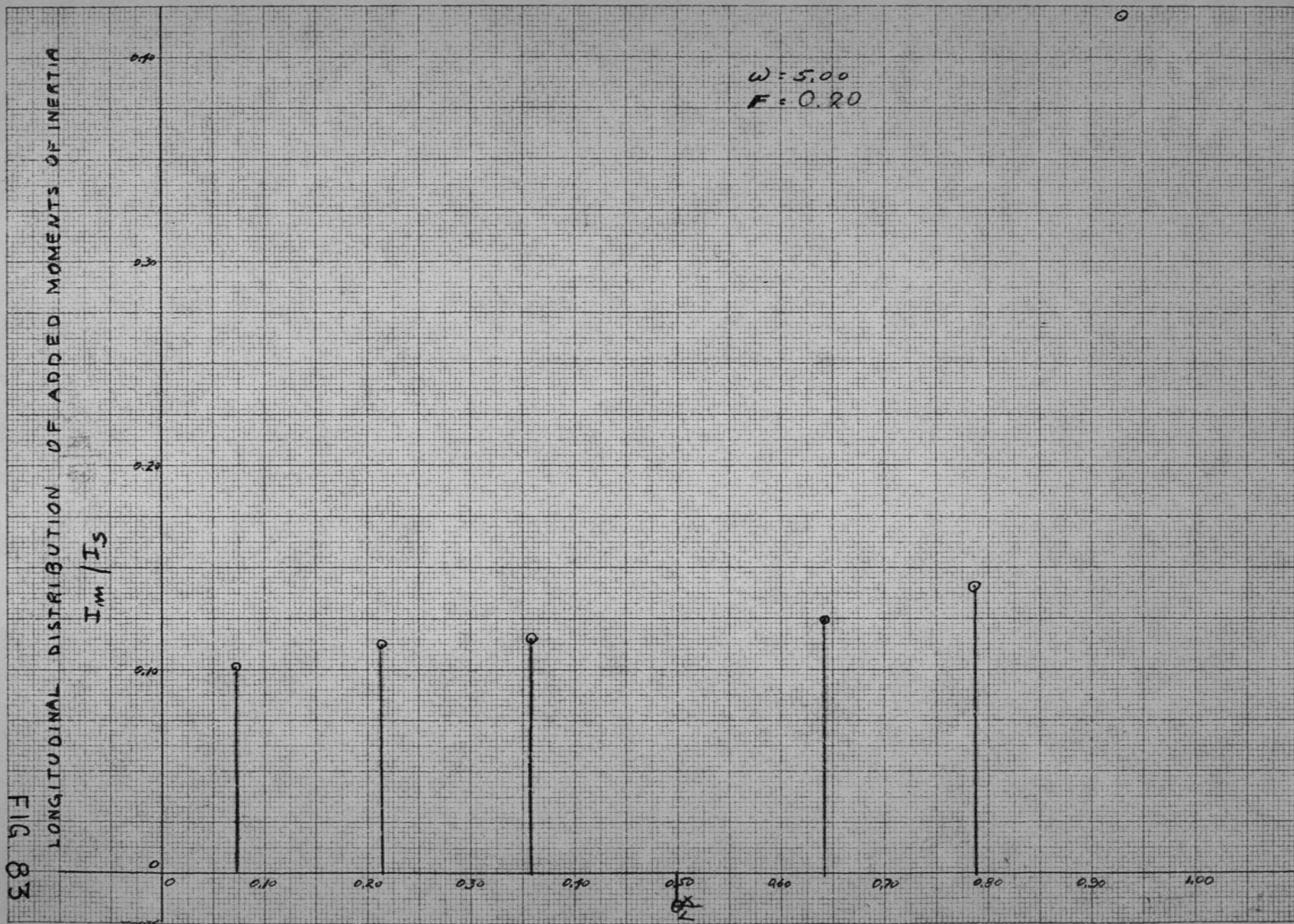


FIG 83 LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA

LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
ω = 8.65
F = 0.20
0.30
0.20
0.10
-0.05
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
x/L

FIG. 84

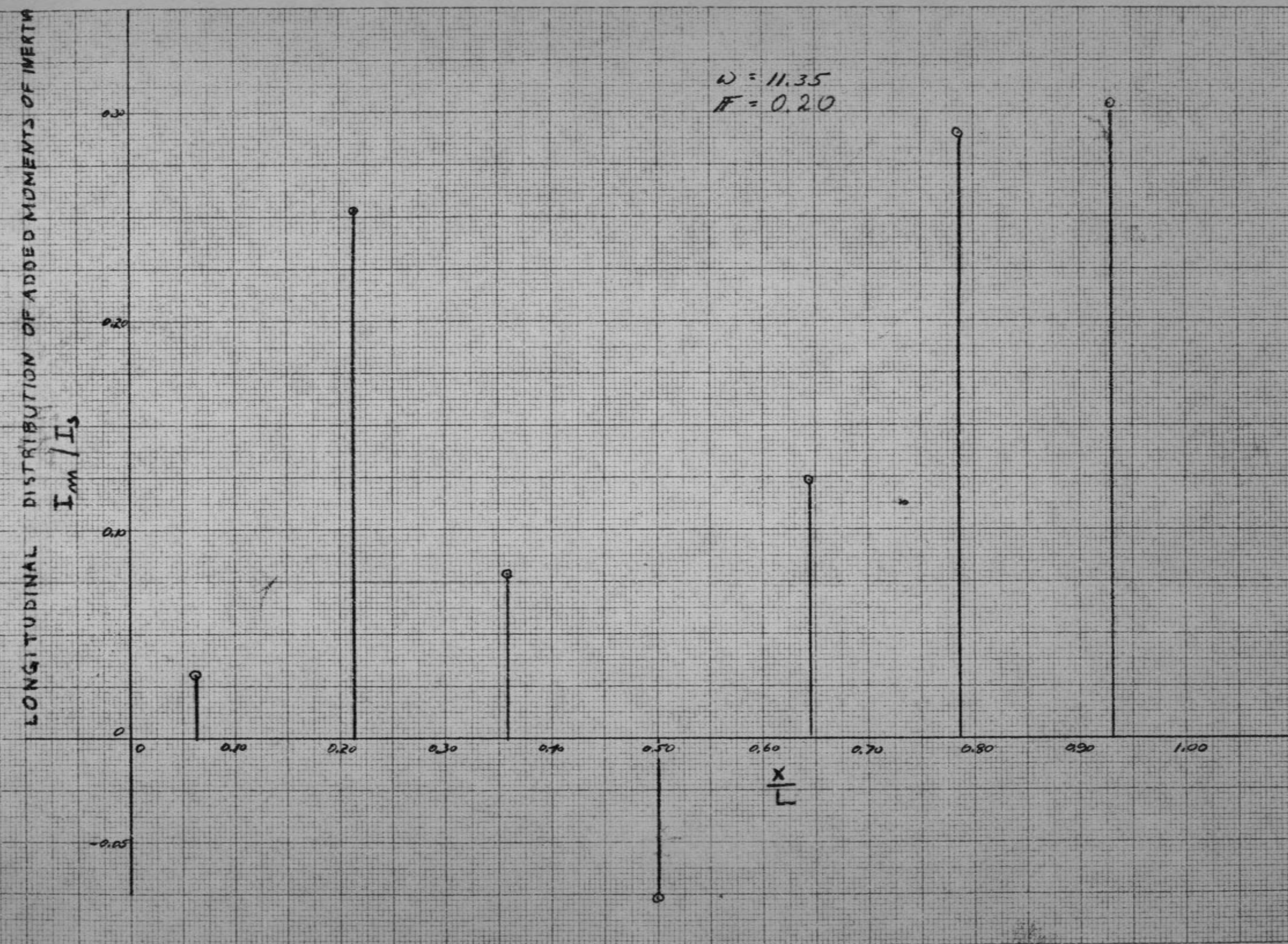
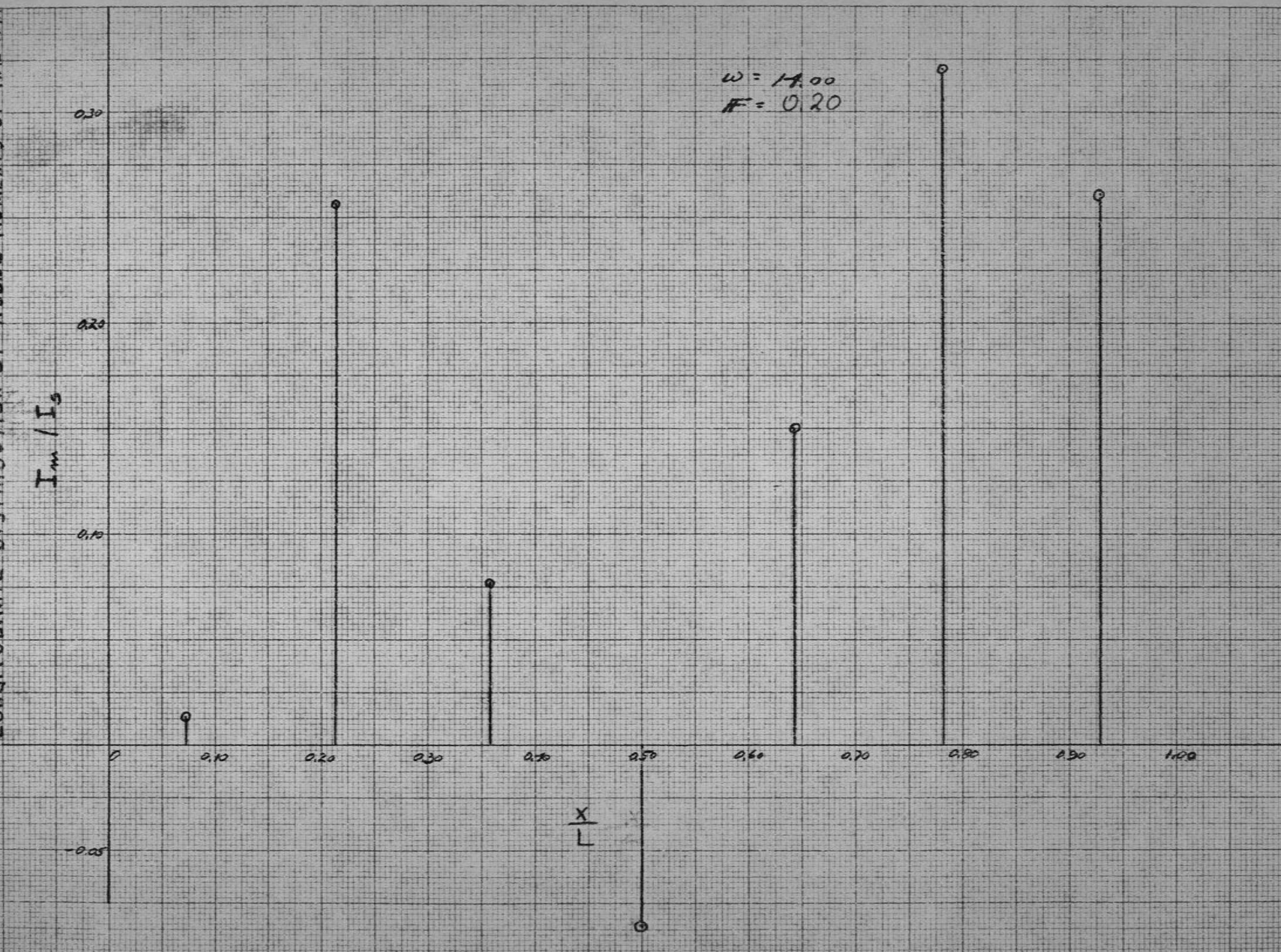
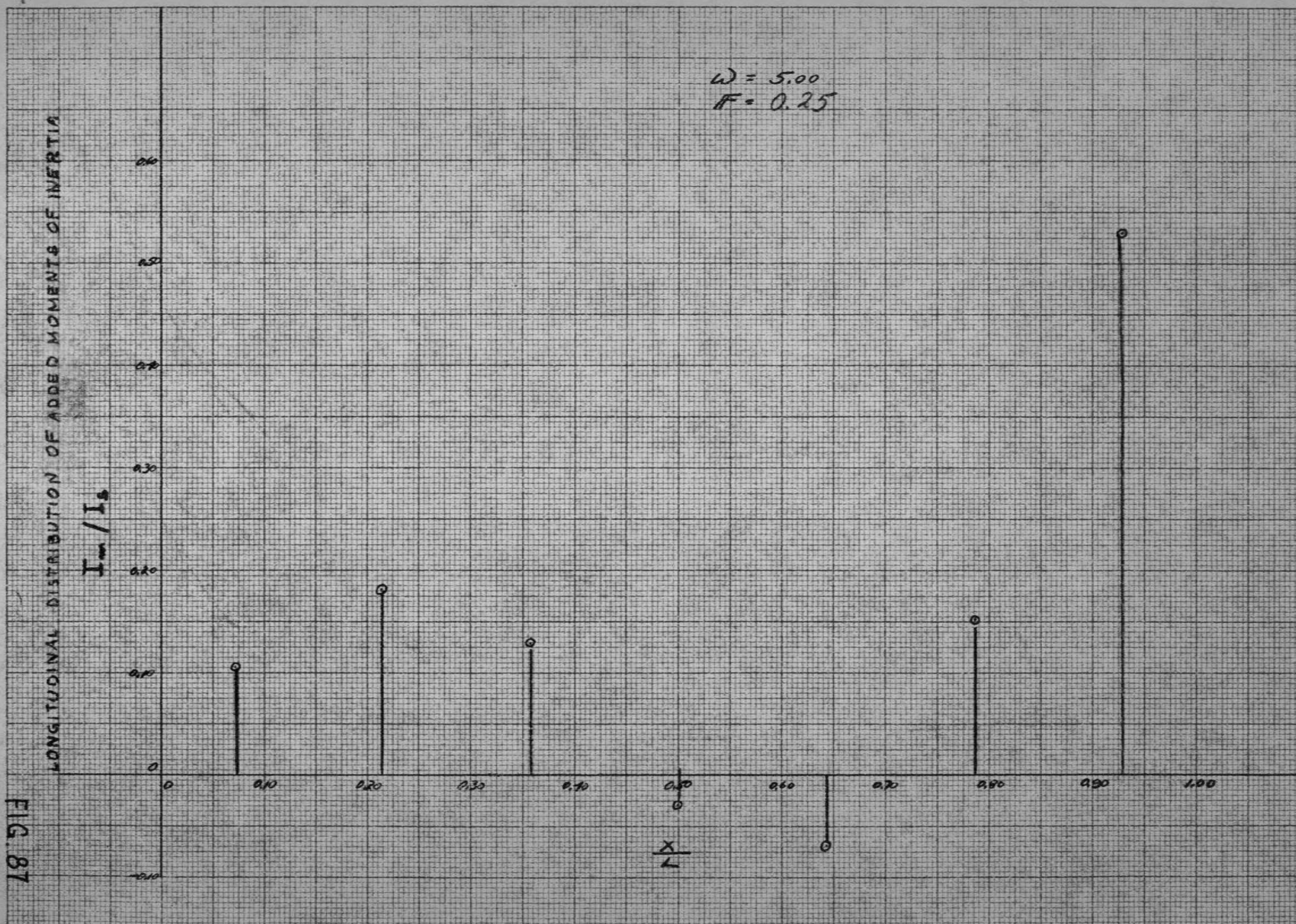

LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
ω = 11.35
F = 0.20
0.30
0.20
0.10
0
-0.05
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
x/L

FIG. 85



LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA

FIG. 86



LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
$\omega = 5.00$
$F = 0.25$
I_m / I_s
0.60
0.50
0.40
0.30
0.20
0.10
0
-0.10
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
$\frac{x}{L}$

FIG. 87

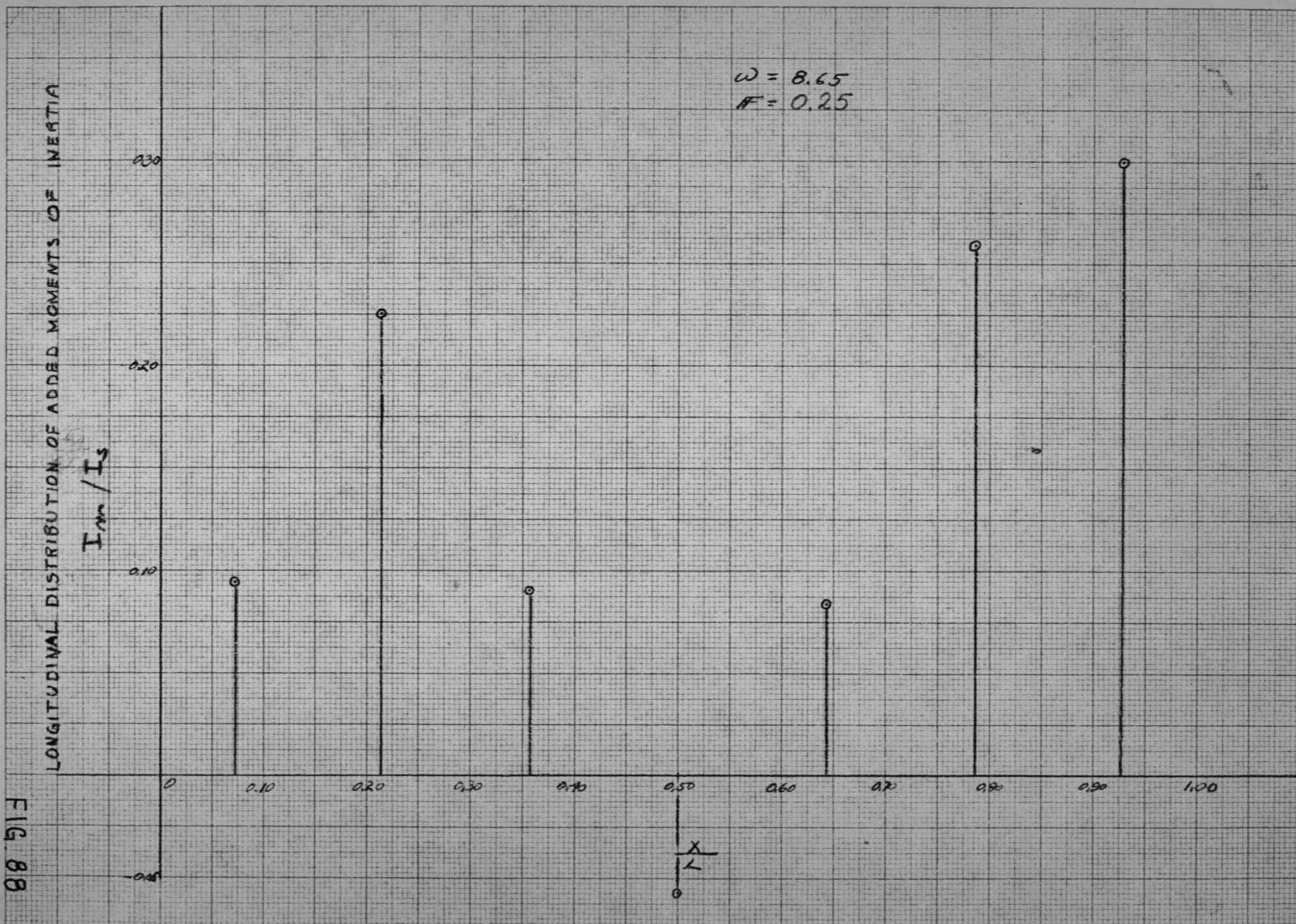

LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
I_m / I_s
ω = 8.65
F = 0.25
0.30
0.20
0.10
-0.05
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
X / L

FIG. 88

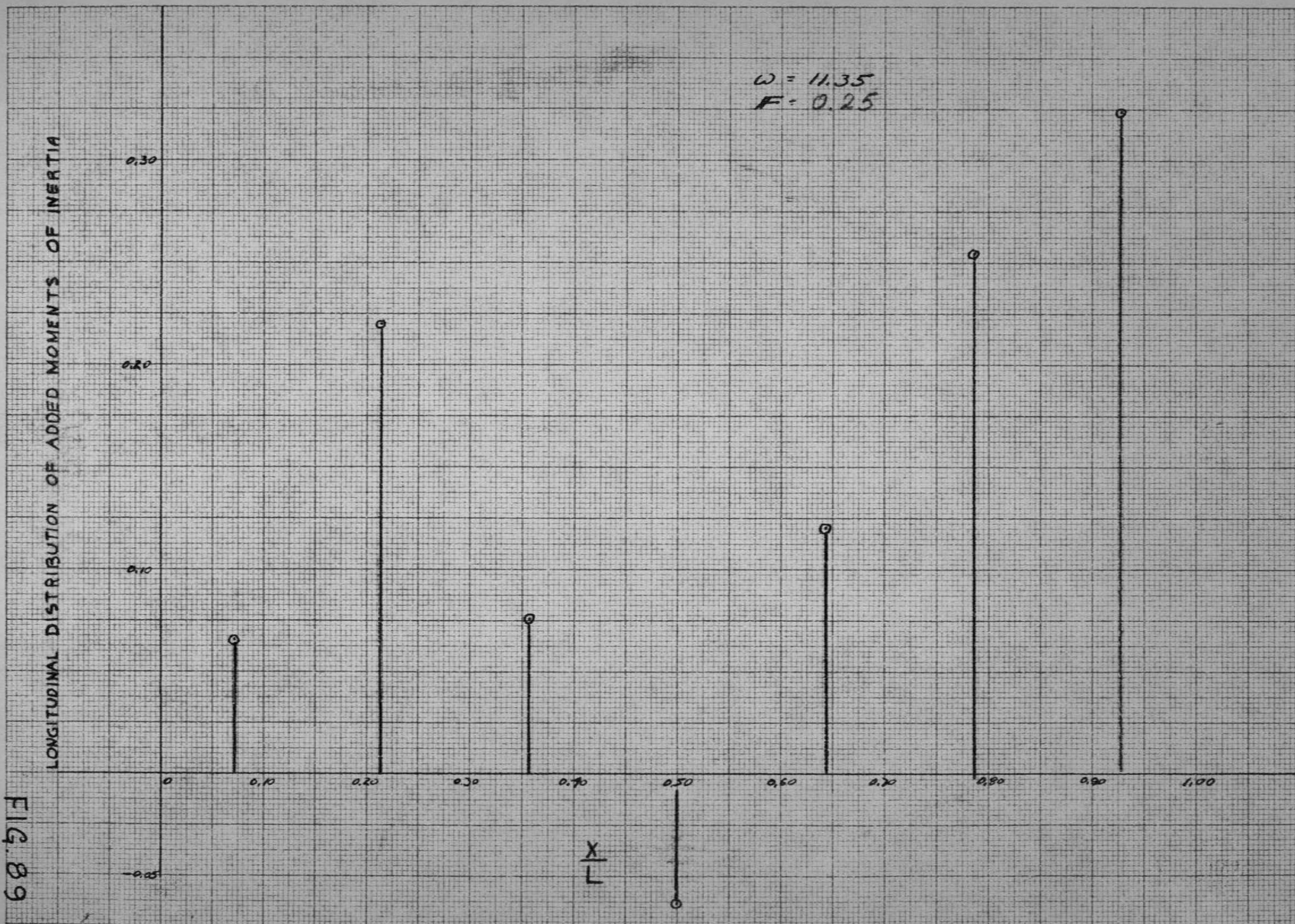

ω = 11.35
F = 0.25
LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
0.30
0.20
0.10
-0.05
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
X/L

FIG. 89

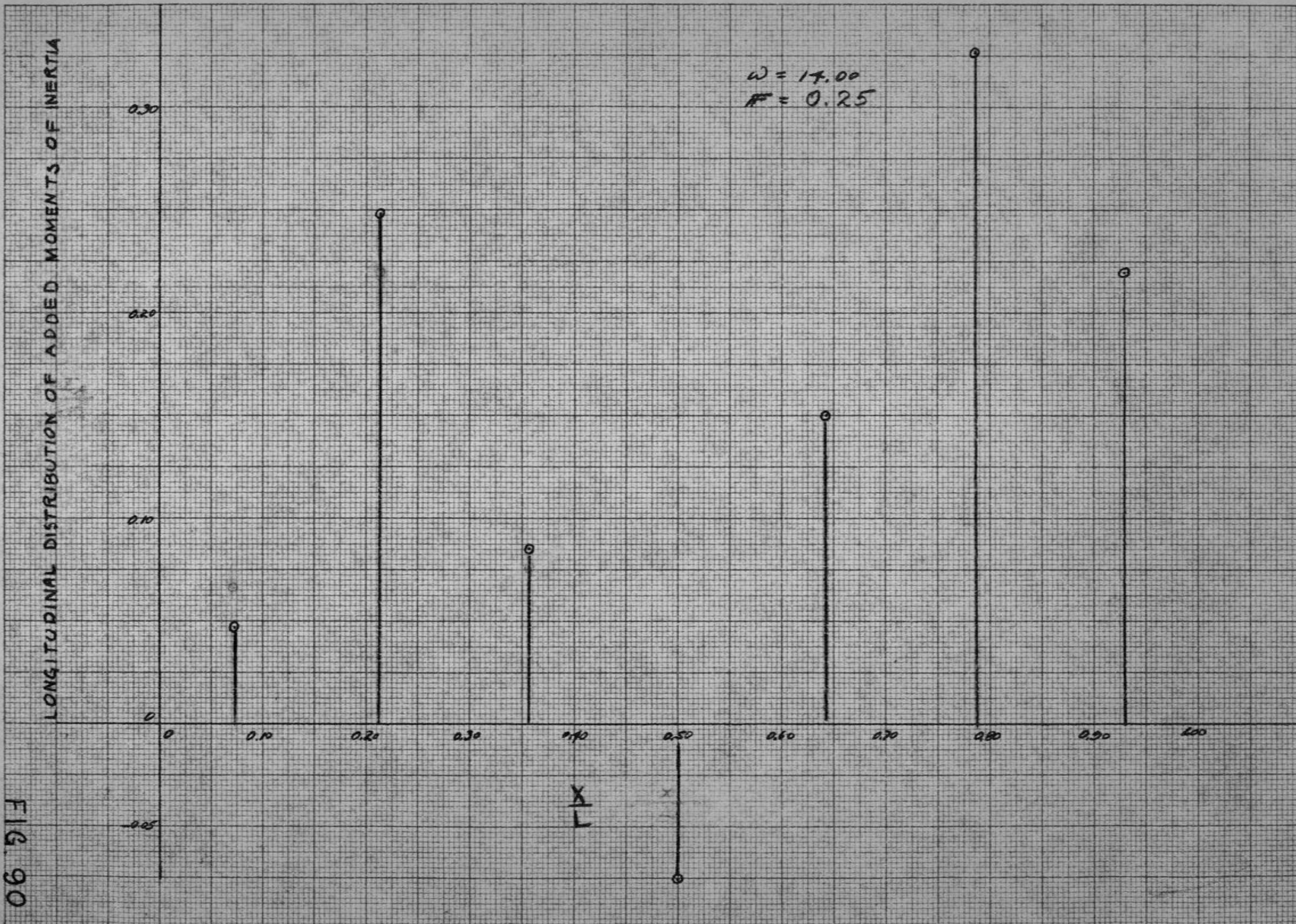
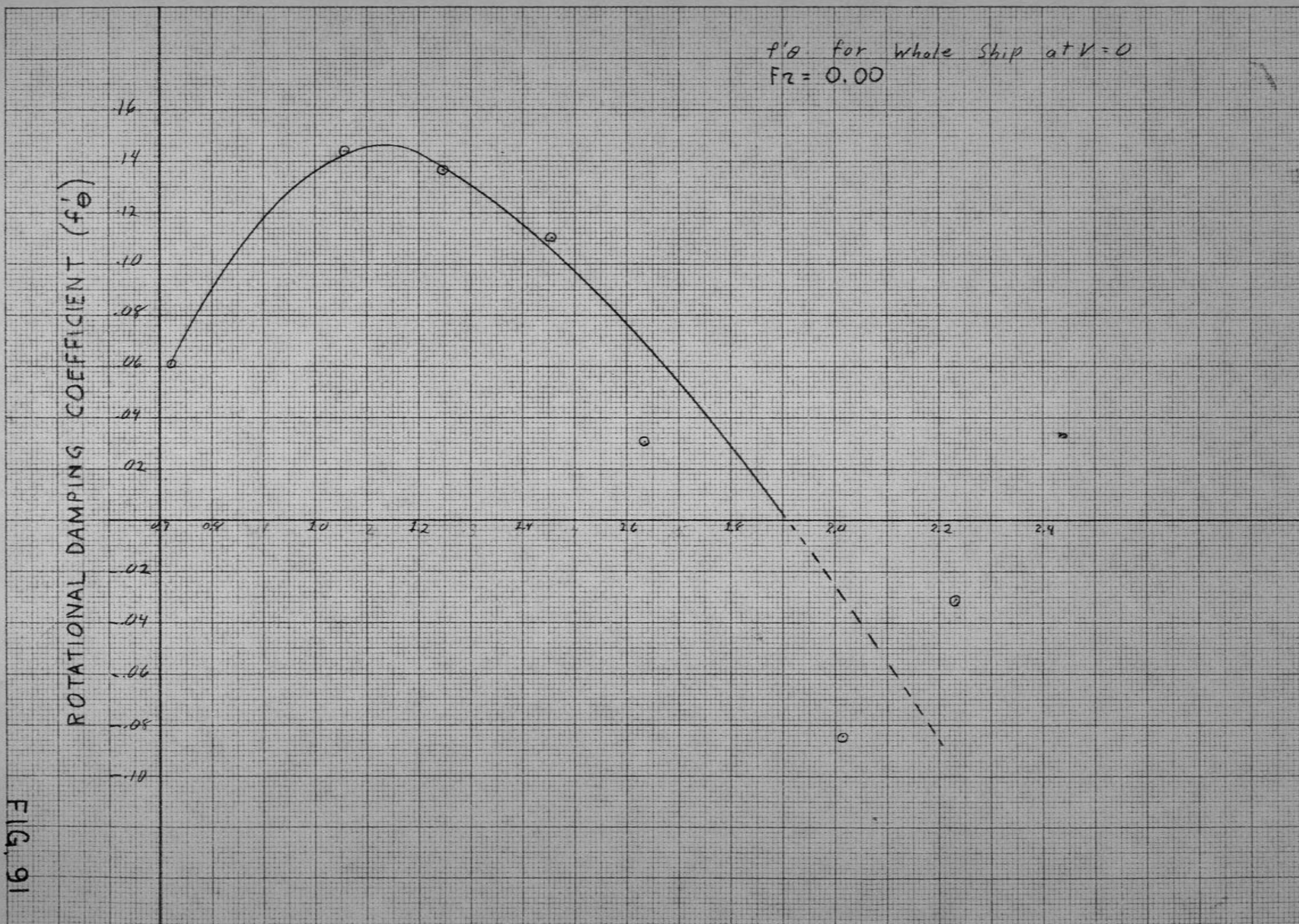

LONGITUDINAL DISTRIBUTION OF ADDED MOMENTS OF INERTIA
ω = 14.00
F = 0.25
0.30
0.20
0.10
0
-0.05
0
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
X/L

FIG. 90



f'θ for Whole Ship at V = 0
Fr = 0.00
ROTATIONAL DAMPING COEFFICIENT (f'θ)
.16
.14
.12
.10
.08
.06
.04
.02
-.02
-.04
-.06
-.08
-.10
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

FIG. 91

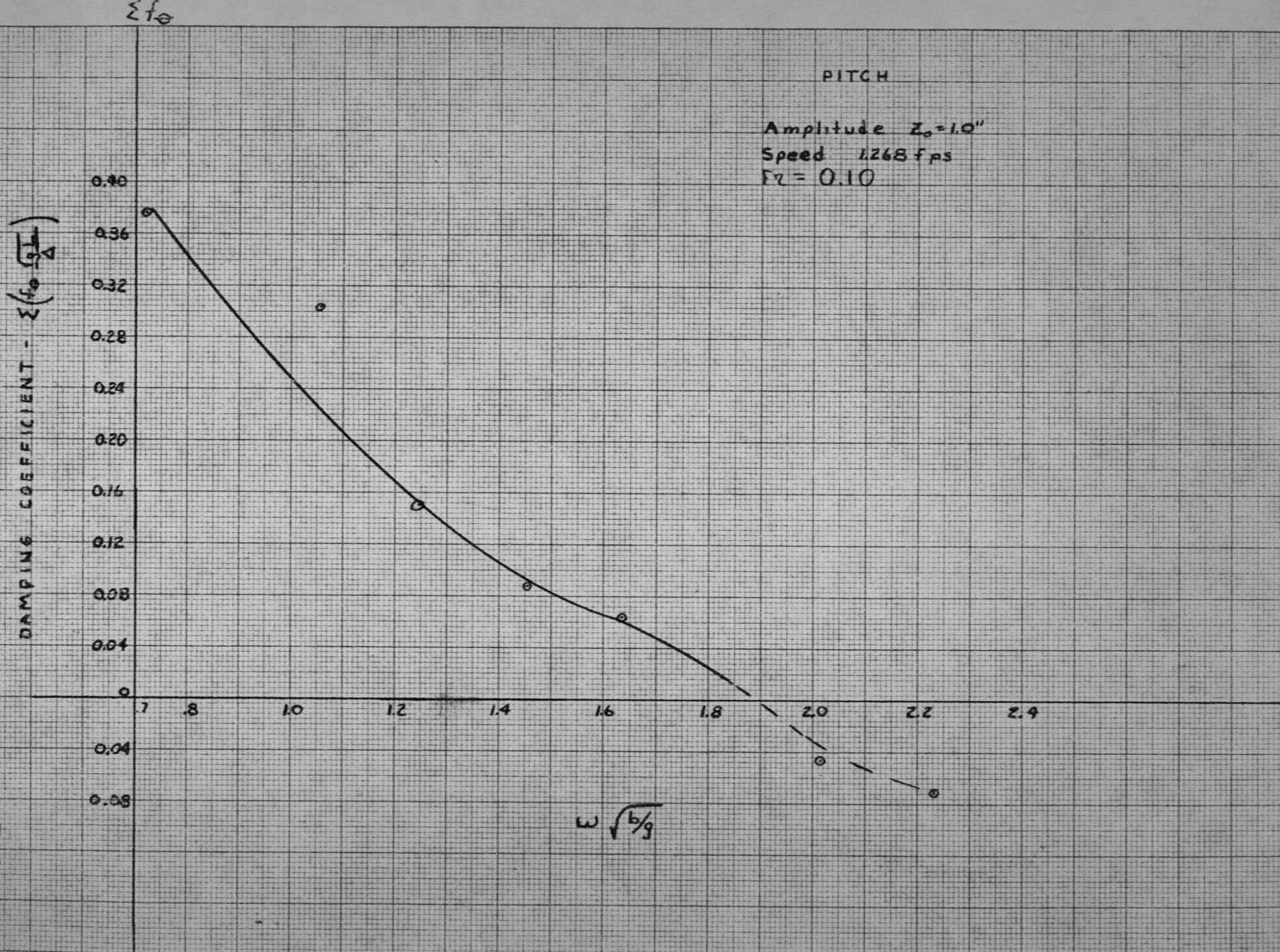

Σf$_\theta$
PITCH
Amplitude Z_o = 1.0"
Speed 1.268 fps
Fr = 0.10
DAMPING COEFFICIENT
0.40
0.36
0.32
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0
0.04
0.08
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
ω √(b/g)

FIG. 92

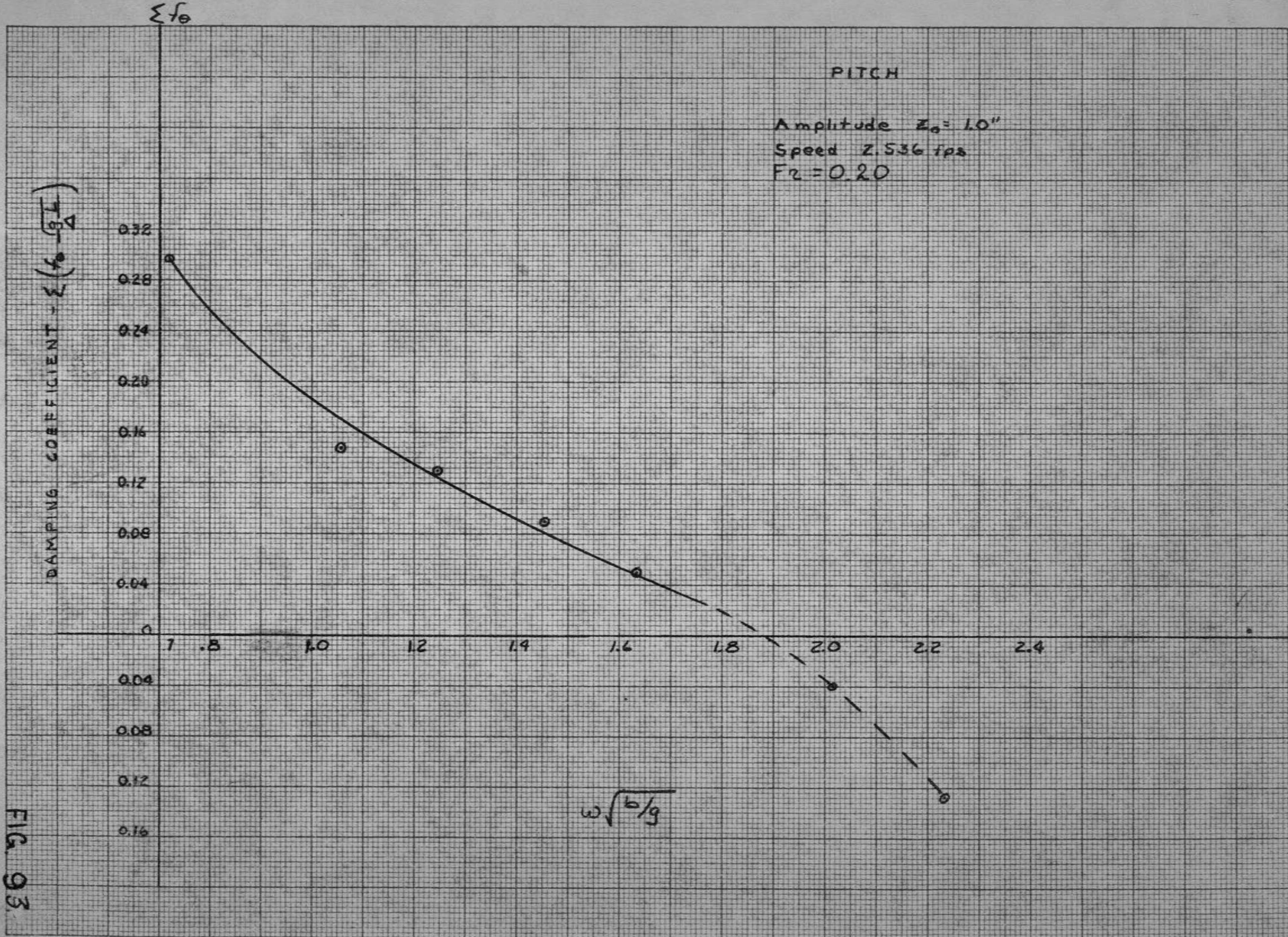


FIG. 93

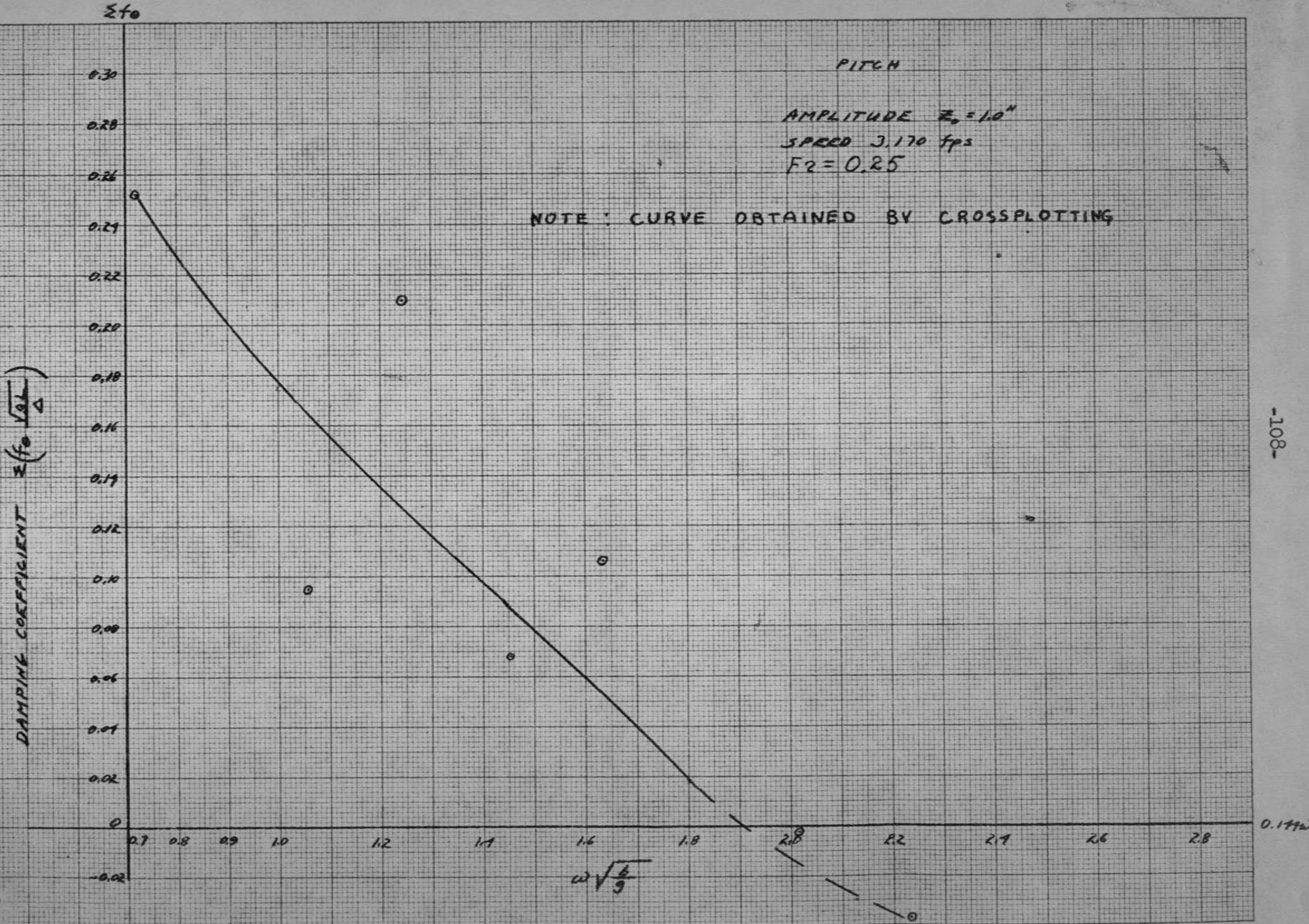
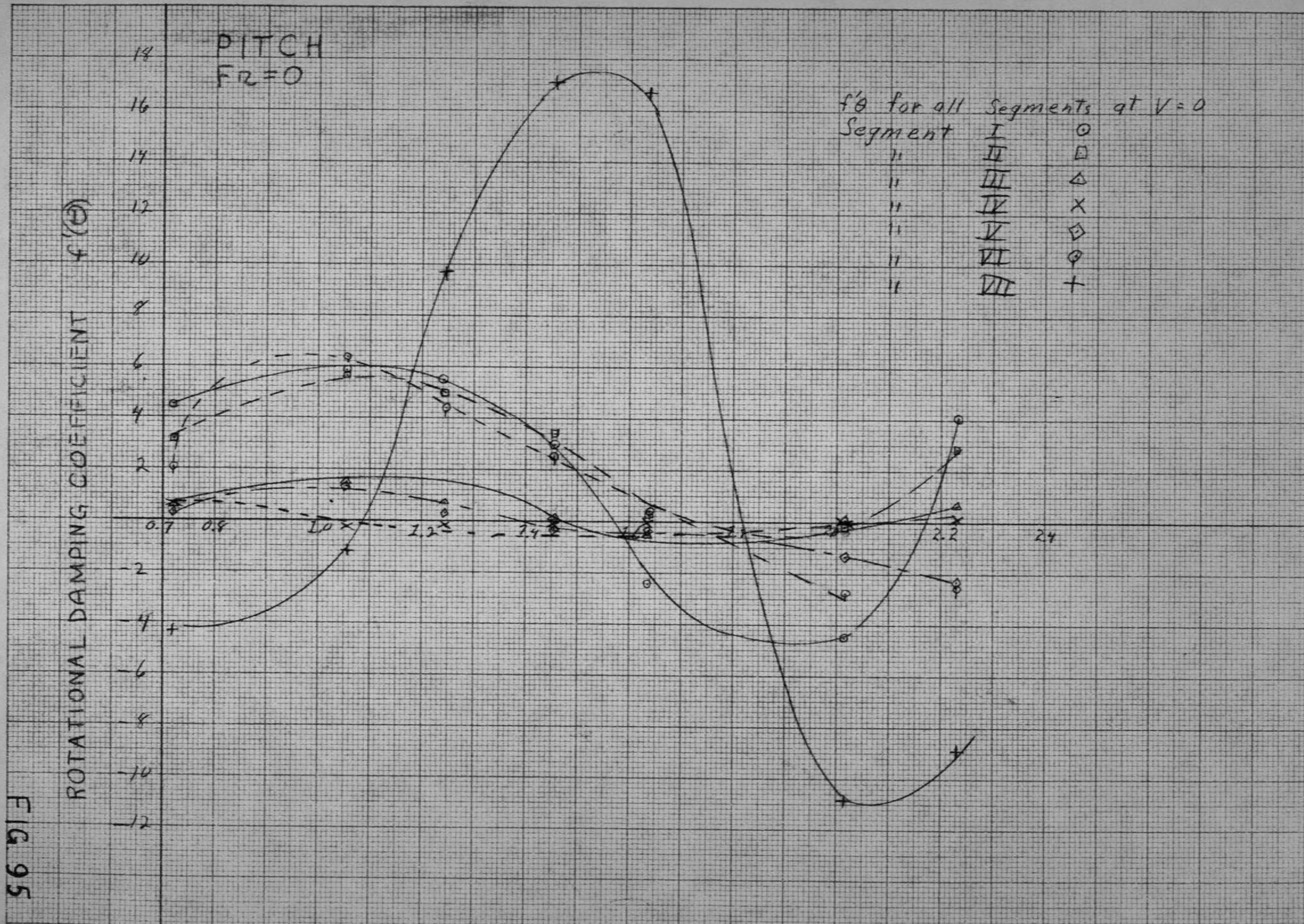
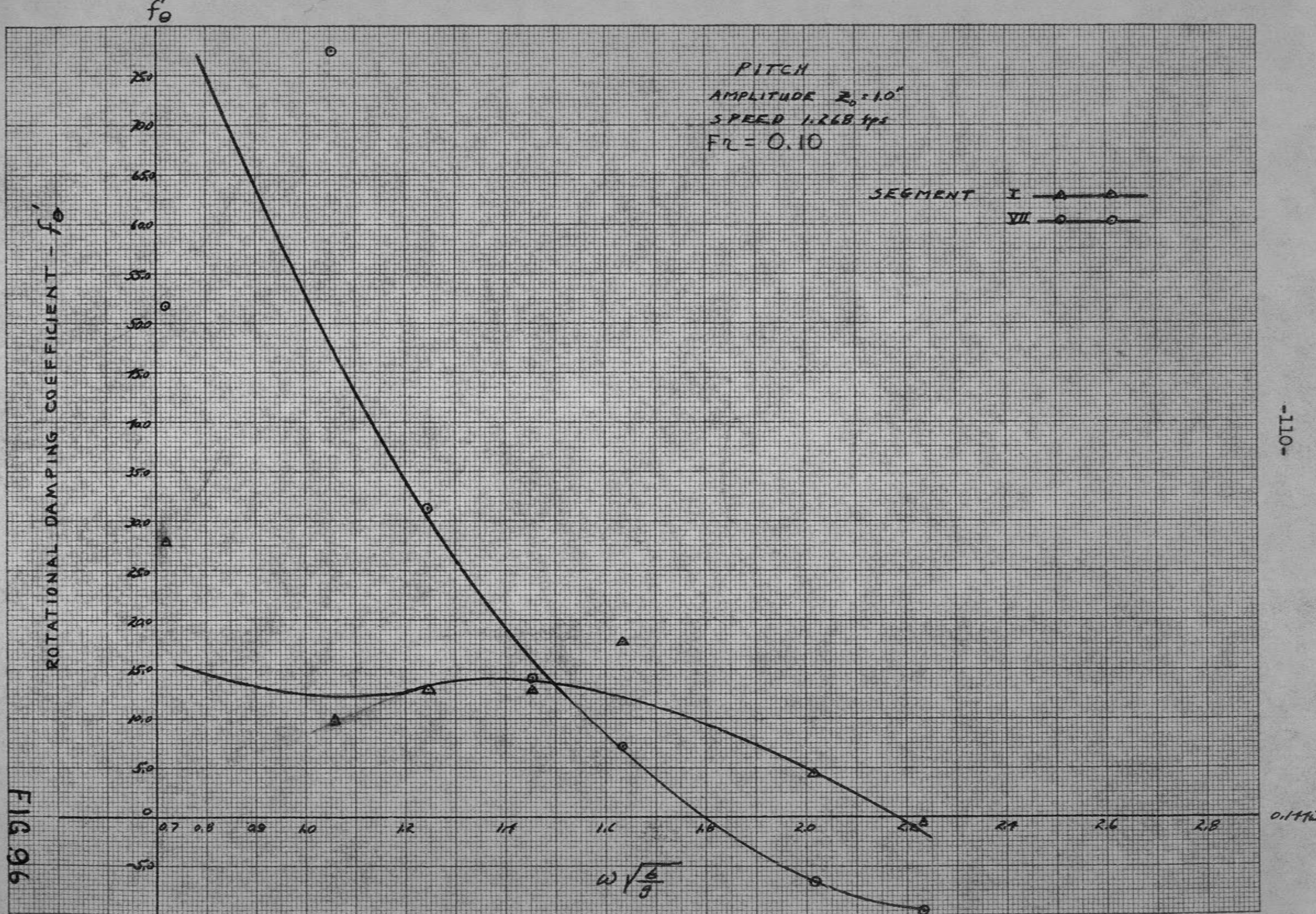

PITCH
AMPLITUDE Z₀ = 1.0"
SPEED 3.170 fps
F2 = 0.25
NOTE : CURVE OBTAINED BY CROSSPLOTTING
Σf₀
DAMPING COEFFICIENT
0.30
0.28
0.26
0.24
0.22
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0
-0.02
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0.149ω

FIG. 94



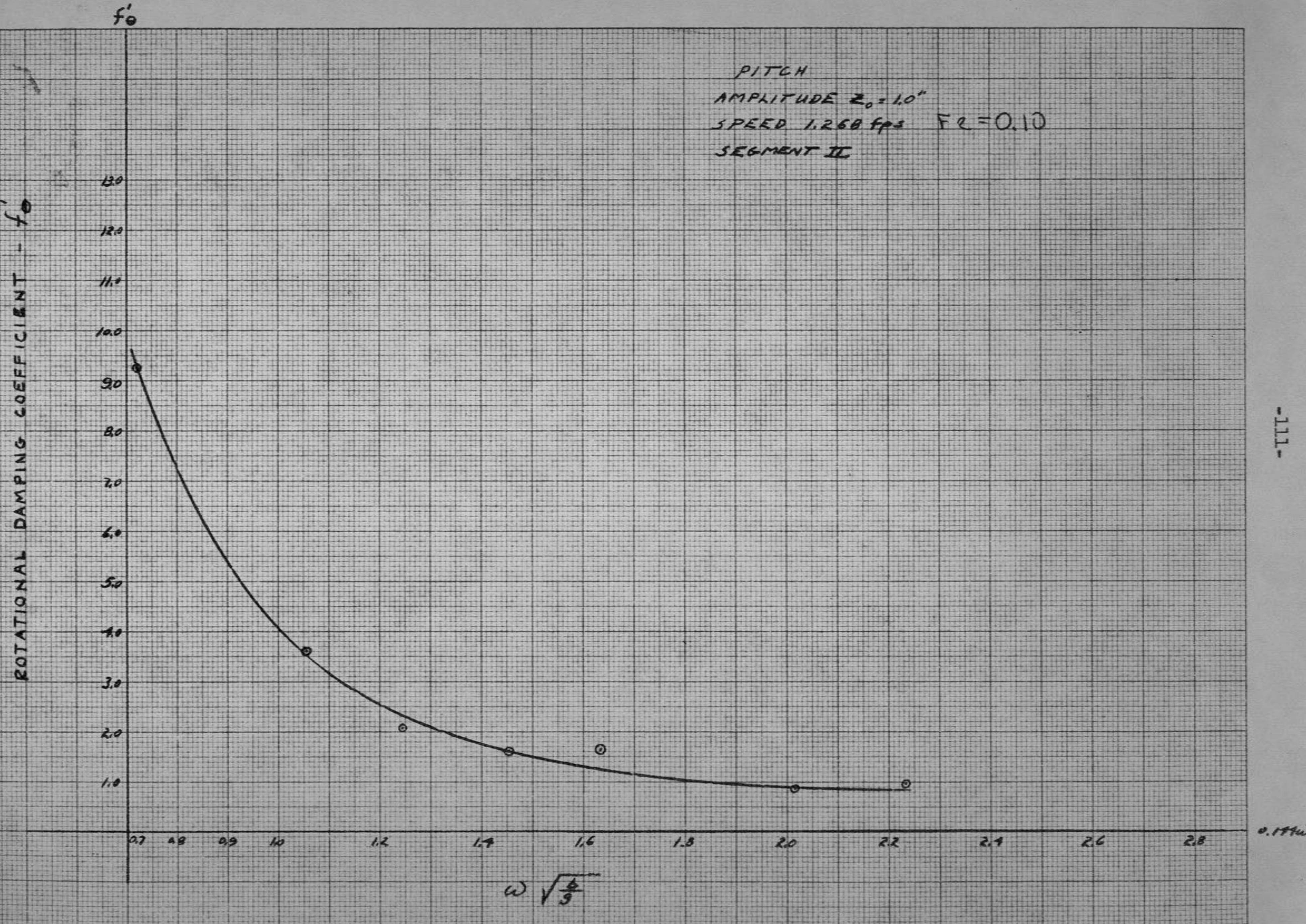
PITCH
Fr=0
f'θ for all Segments at V=0
Segment I ⊙
" II
" III
" IV ×
" V
" VI
" VII +
ROTATIONAL DAMPING COEFFICIENT f'(Θ)
18
16
14
12
10
8
6
4
2
-2
-4
-6
-8
-10
-12
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

FIG. 95



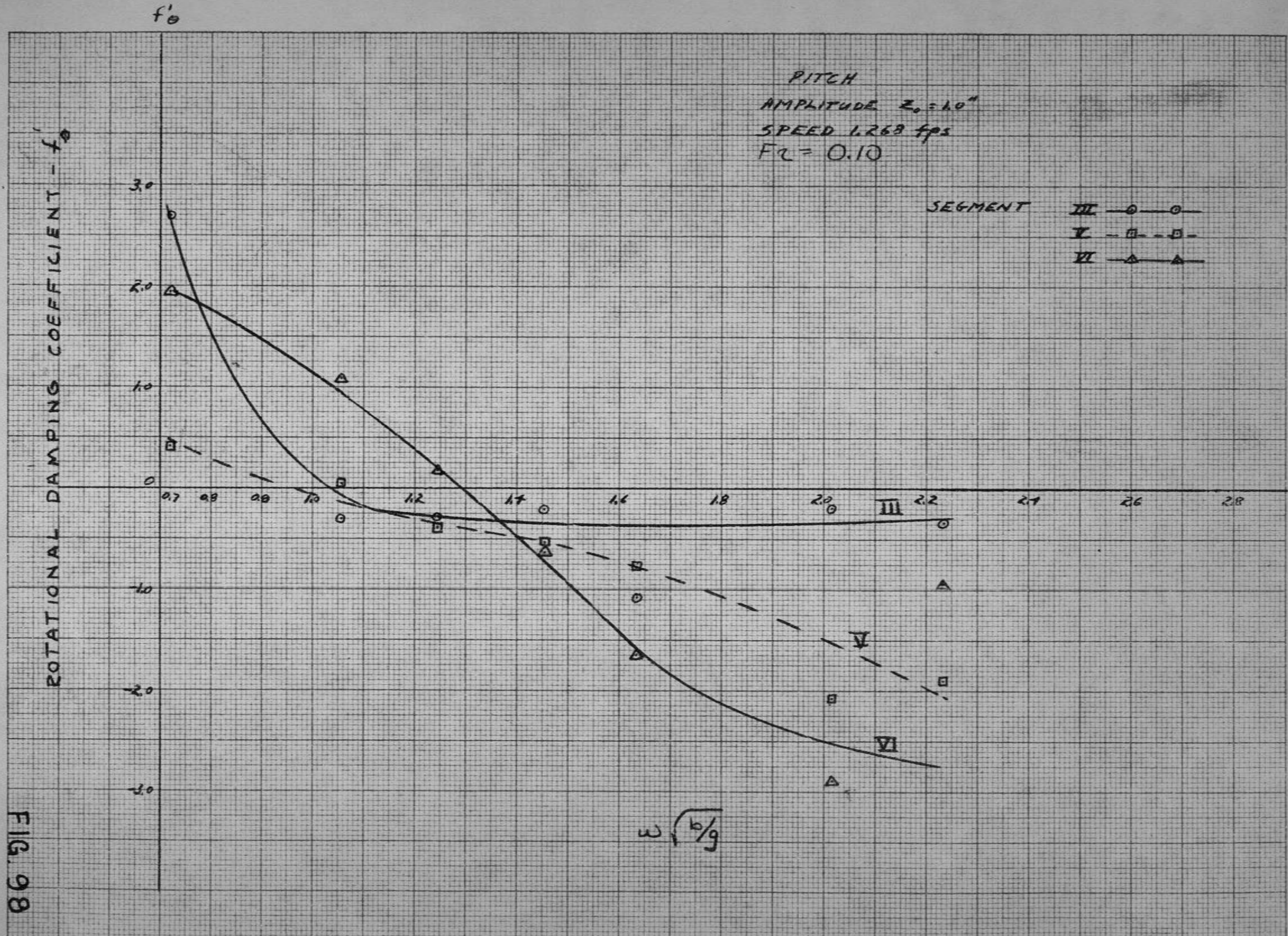
f'_θ
PITCH
AMPLITUDE $Z_0 = 1.0''$
SPEED 1.268 fps
Fr = 0.10
SEGMENT I
VII
ROTATIONAL DAMPING COEFFICIENT - f'_θ
25.0
20.0
15.0
10.0
5.0
0
-5.0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
$\omega\sqrt{\frac{L}{g}}$

FIG 96



PITCH
AMPLITUDE Z₀ = 1.0"
SPEED 1.268 fps
Fr = 0.10
SEGMENT II
ROTATIONAL DAMPING COEFFICIENT - f'θ
f'θ
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0.144ω
ω √(b/g)

FIG. 97



PITCH
AMPLITUDE z_0 = 1.0"
SPEED 1.268 fps
Fr = 0.10
SEGMENT
III
V
VI
ROTATIONAL DAMPING COEFFICIENT - f'_θ
f'_θ
3.0
2.0
1.0
0
-1.0
-2.0
-3.0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0.141ω
$\omega\sqrt{b/g}$

FIG. 98

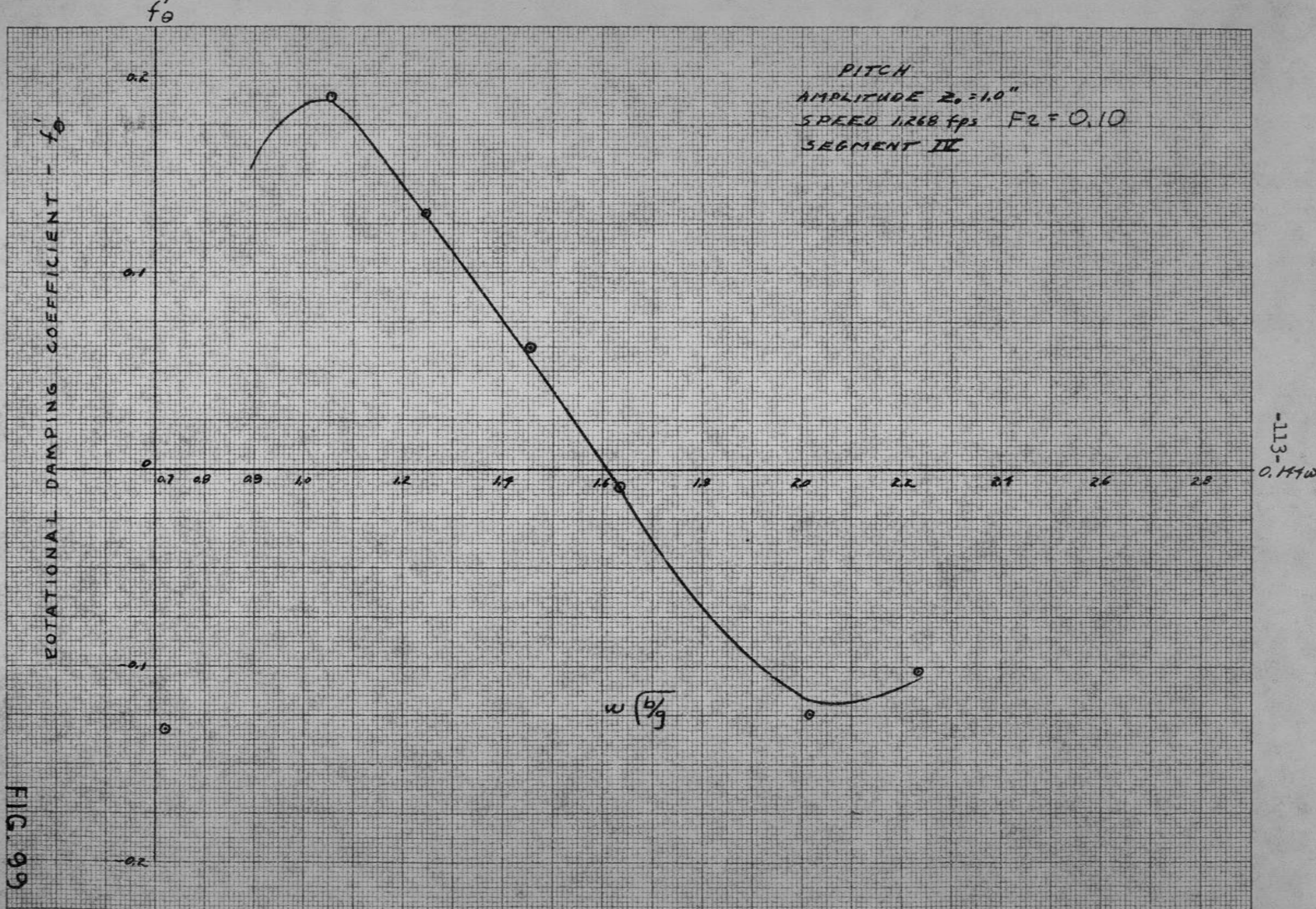
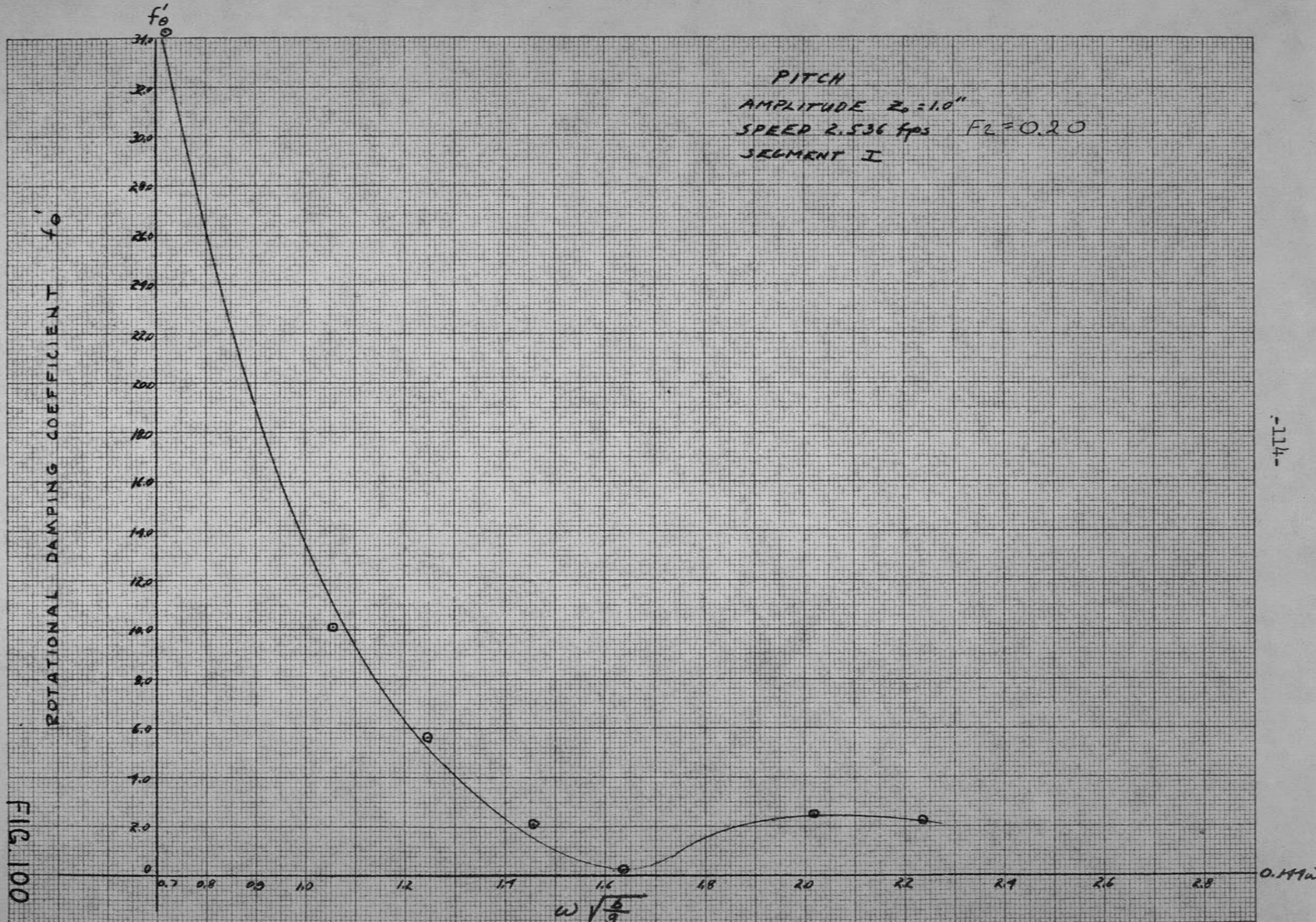
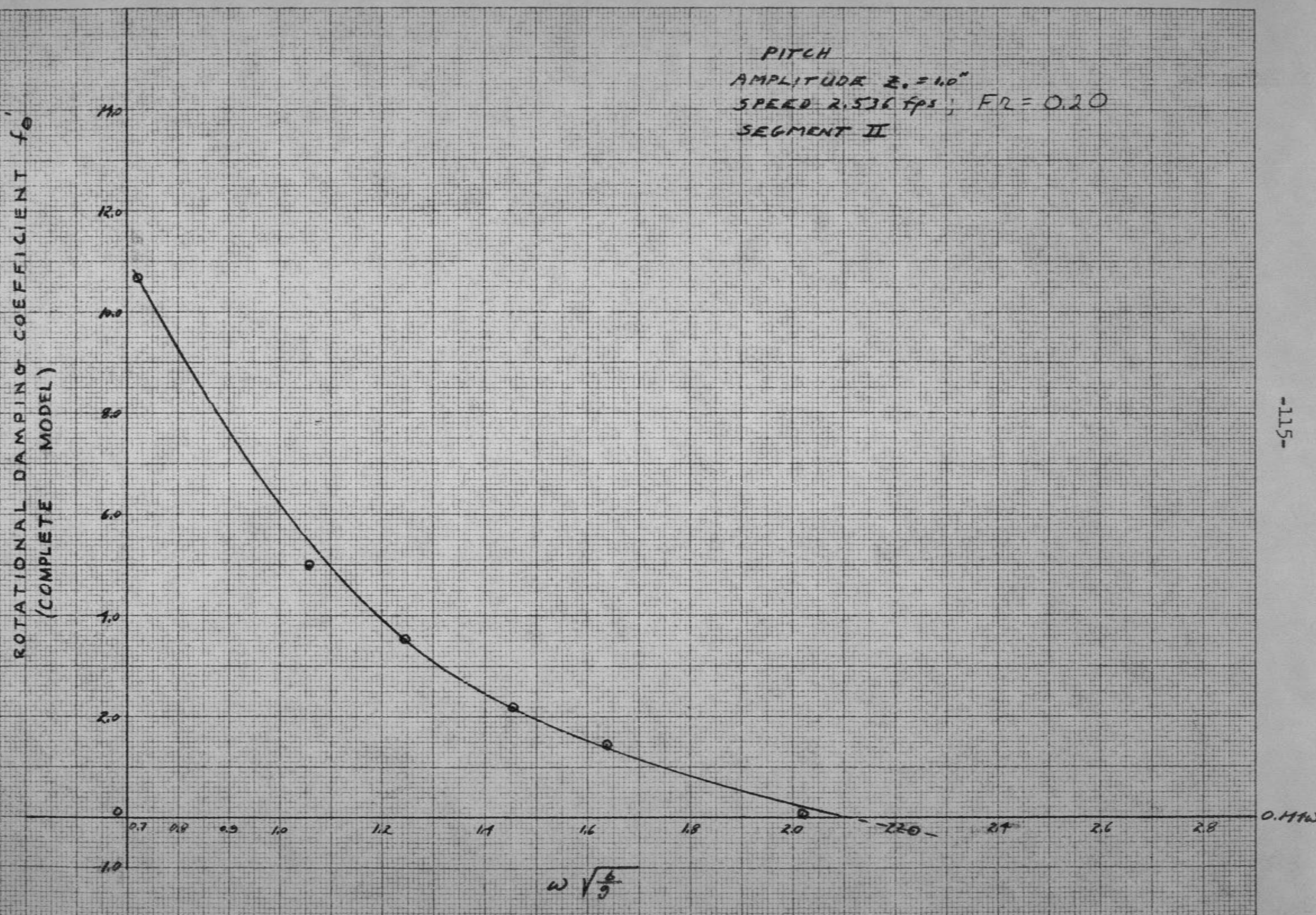

PITCH
AMPLITUDE z_0 = 1.0"
SPEED 1.268 fps   Fr = 0.10
SEGMENT IV
ROTATIONAL DAMPING COEFFICIENT - f'_θ
f'_θ
0.2
0.1
0
-0.1
-0.2
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
$\omega\sqrt{b/g}$
0.144ω

FIG. 99



f'_θ
PITCH
AMPLITUDE $Z_0 = 1.0"$
SPEED 2.536 fps
$F_r = 0.20$
SEGMENT I
ROTATIONAL DAMPING COEFFICIENT f'_θ
0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
22.0
24.0
26.0
28.0
30.0
32.0
34.0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0.144ω
$\omega\sqrt{\frac{b}{g}}$

FIG. 100



PITCH
AMPLITUDE $z_0 = 1.0"$
SPEED 2.536 fps ; Fr = 0.20
SEGMENT II
ROTATIONAL DAMPING COEFFICIENT f_θ'
(COMPLETE MODEL)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0
-1.0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0.414ω
$\omega\sqrt{\frac{L}{g}}$

FIG. 101

-115-

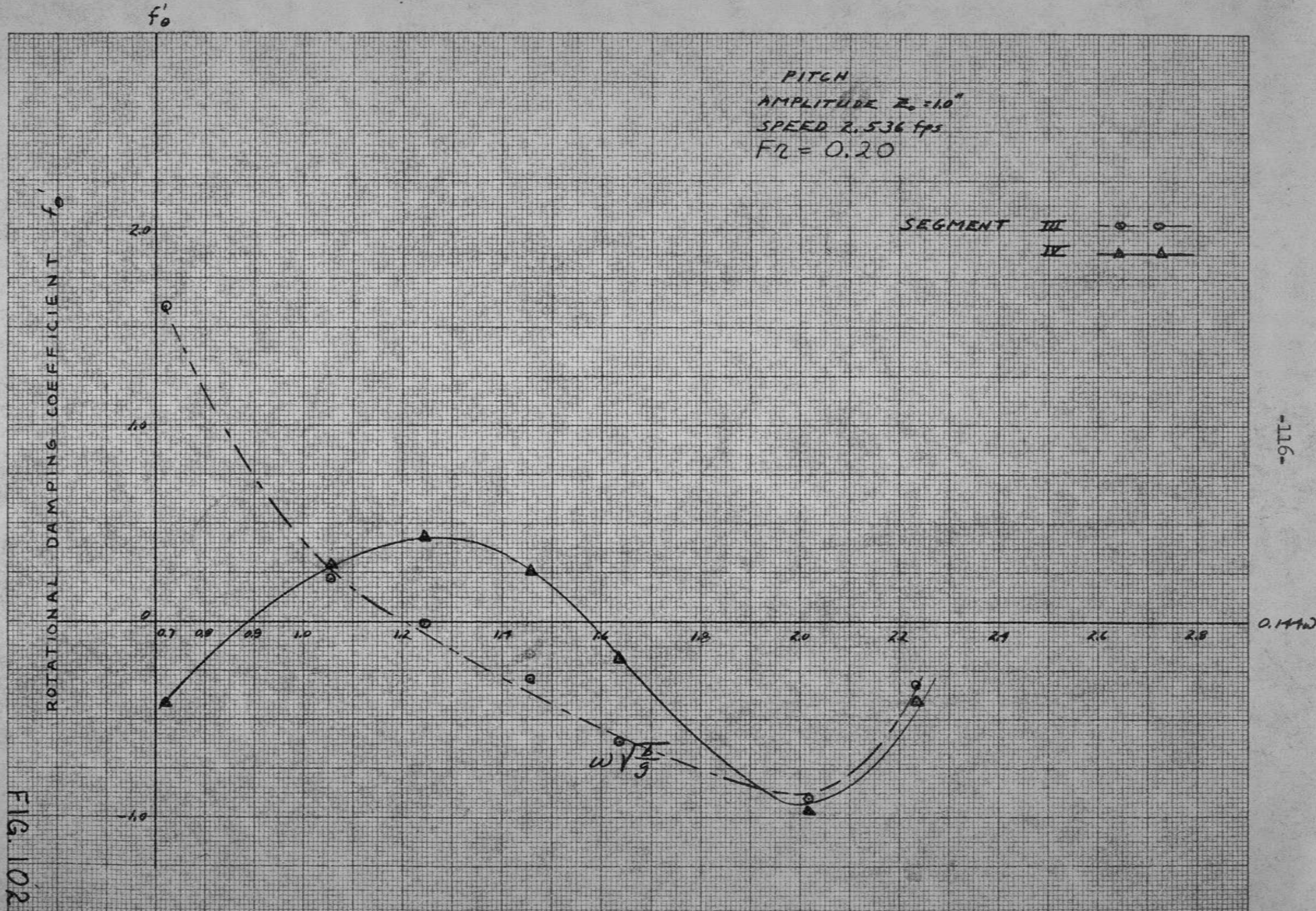

f'_θ
PITCH
AMPLITUDE $Z_0 = 1.0"$
SPEED 2.536 fps
$Fr = 0.20$
SEGMENT
III
IV
ROTATIONAL DAMPING COEFFICIENT f'_θ
2.0
1.0
0
-1.0
0.7
0.8
0.9
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
0.144ω
$\omega\sqrt{\frac{L}{g}}$

FIG. 102

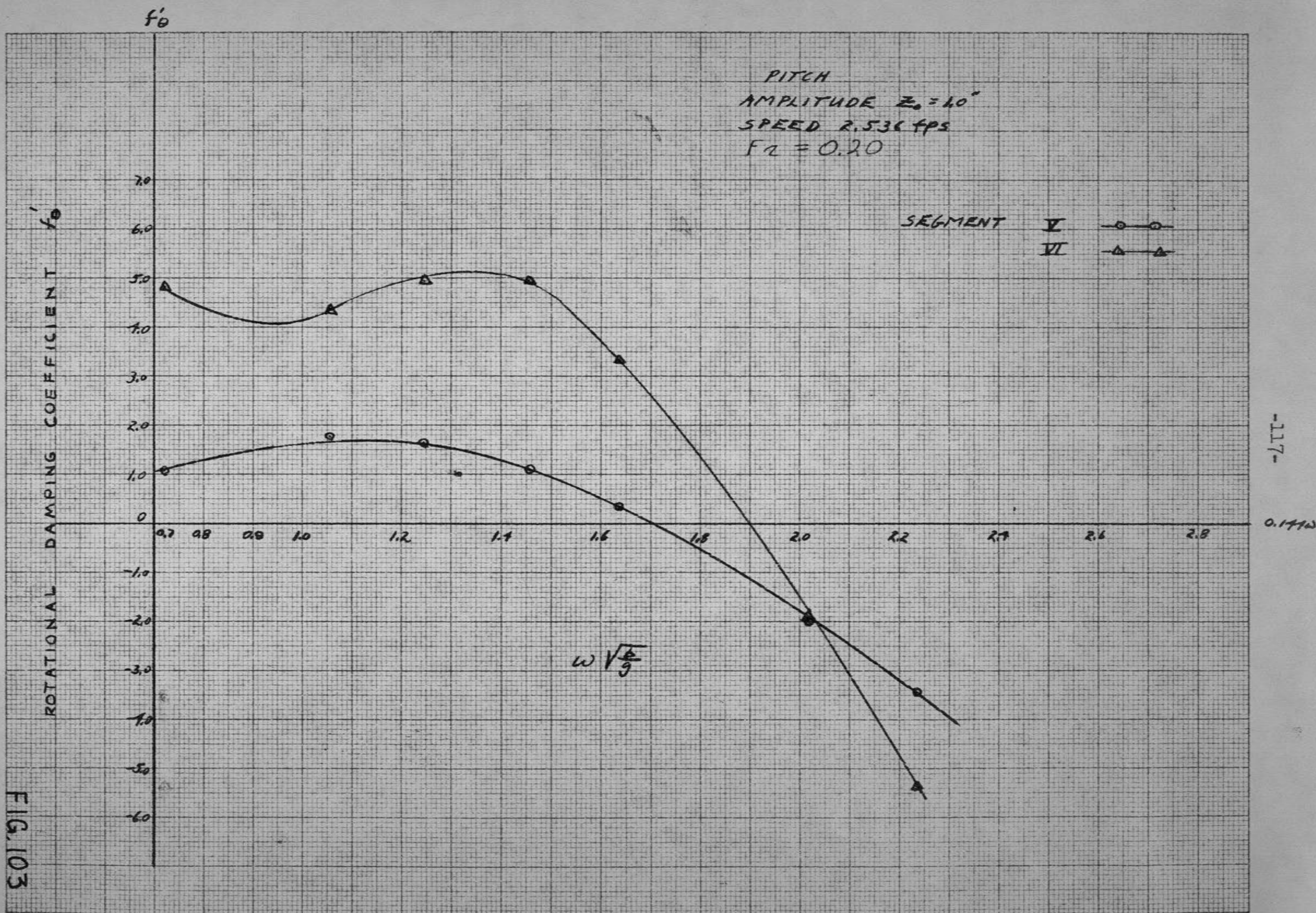
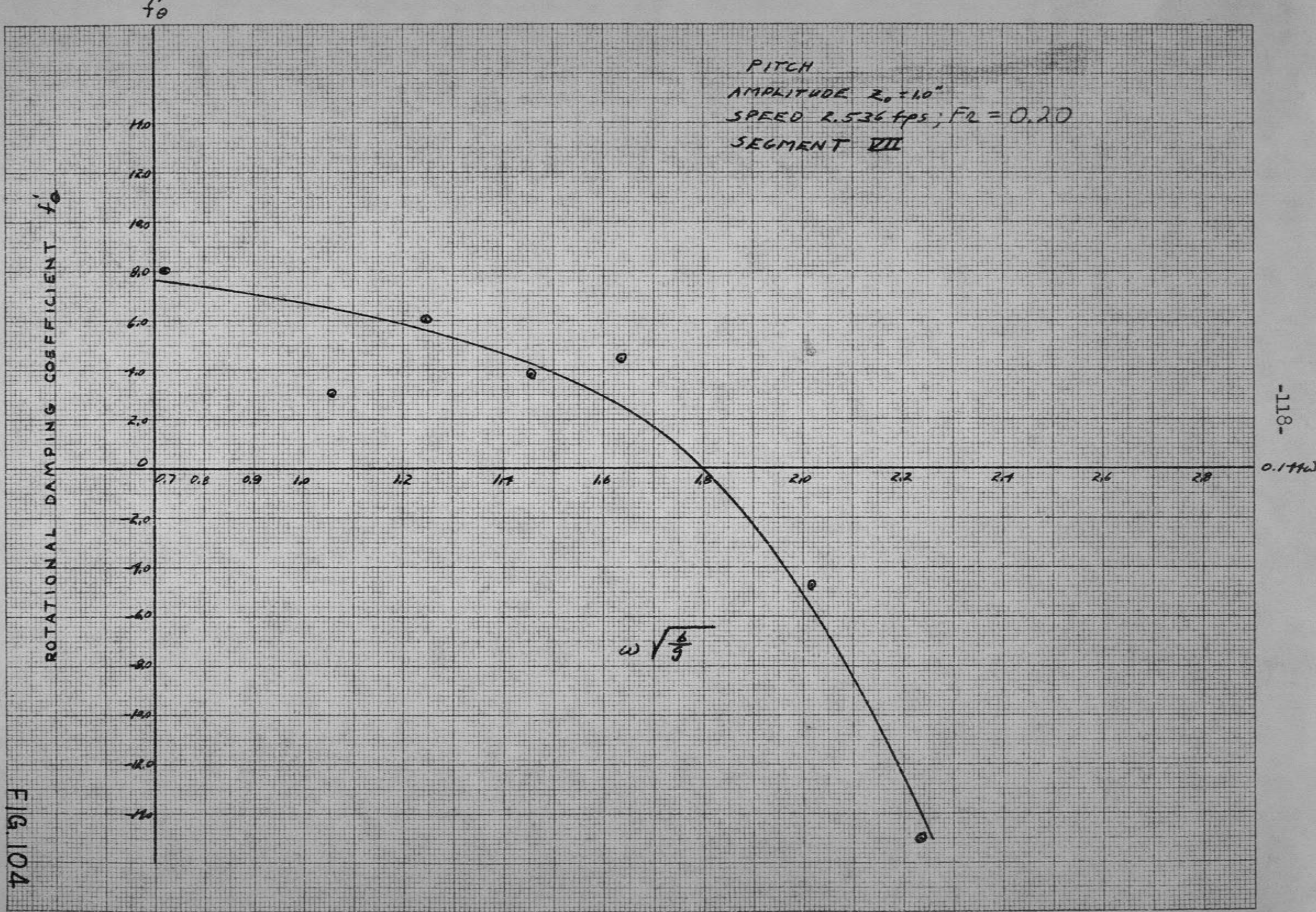

f'_θ
PITCH
AMPLITUDE z_0 = 1.0"
SPEED 2.536 fps
Fr = 0.20
SEGMENT V
VI
ROTATIONAL DAMPING COEFFICIENT f'_θ
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
0.7 0.8 0.9 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4 2.6 2.8
$\omega\sqrt{\frac{L}{g}}$
0.144ω

FIG. 103



PITCH
AMPLITUDE z_0 = 1.0"
SPEED 2.536 fps ; Fr = 0.20
SEGMENT VII
ROTATIONAL DAMPING COEFFICIENT f'_θ
f'_θ
$\omega\sqrt{\frac{L}{g}}$
0.144ω

FIG. 104

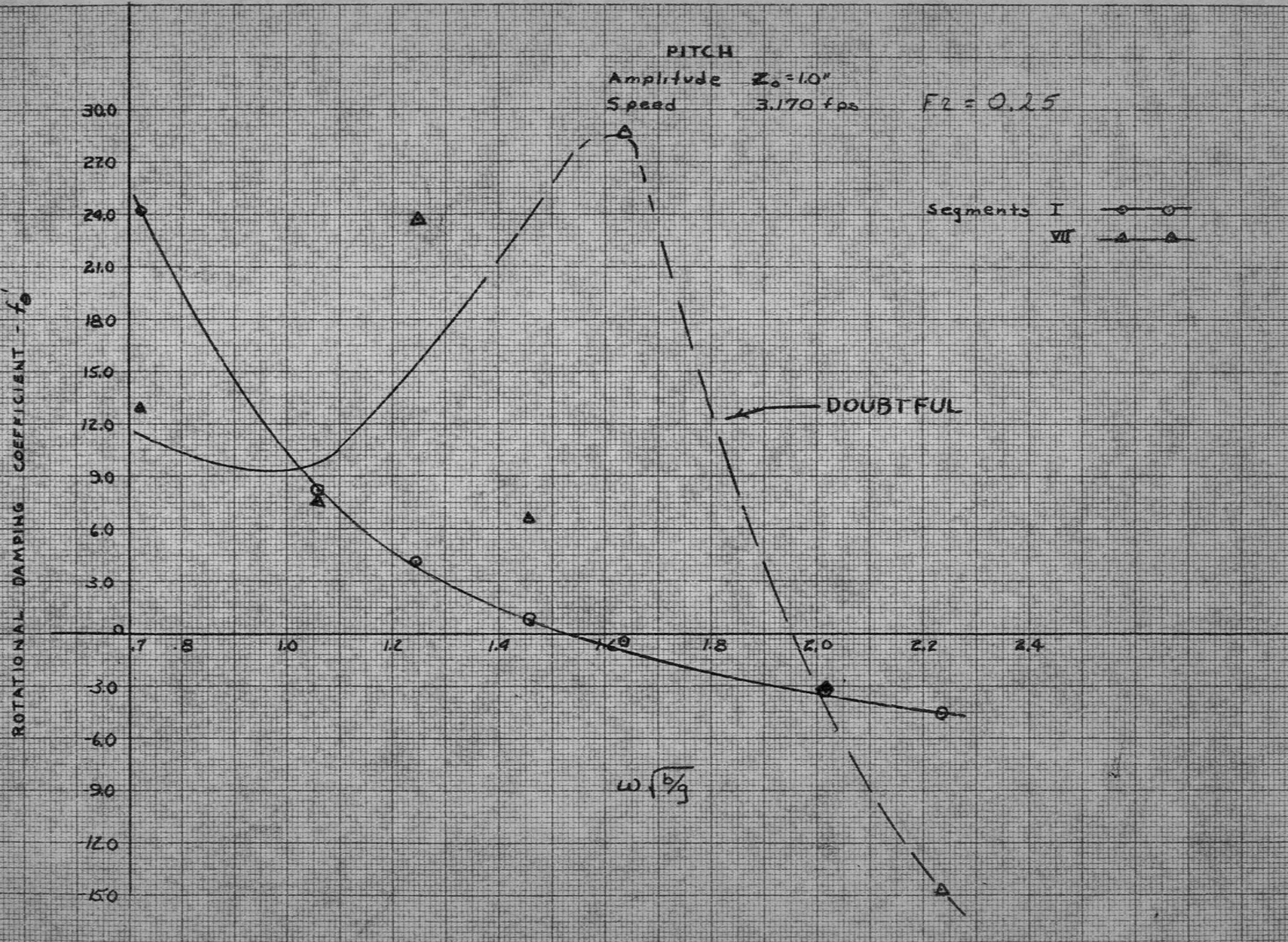

PITCH
Amplitude z_0 = 1.0"
Speed 3.170 fps
Fz = 0.25
Segments I
VII
DOUBTFUL
ROTATIONAL DAMPING COEFFICIENT - f'_θ
$\omega\sqrt{b/g}$
.144ω
30.0
27.0
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0
-3.0
-6.0
-9.0
-12.0
-15.0
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

FIG. 105

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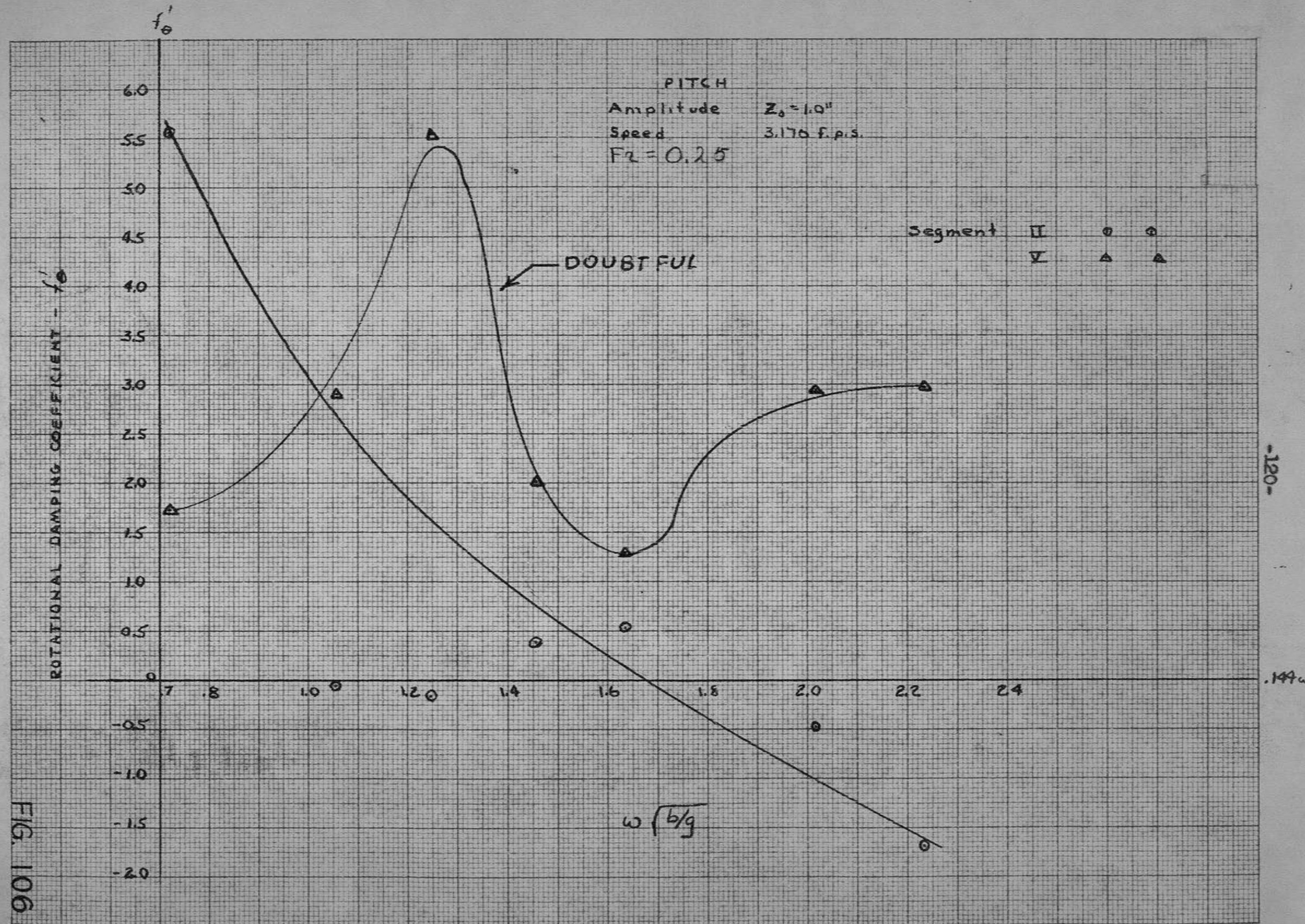


FIG. 106

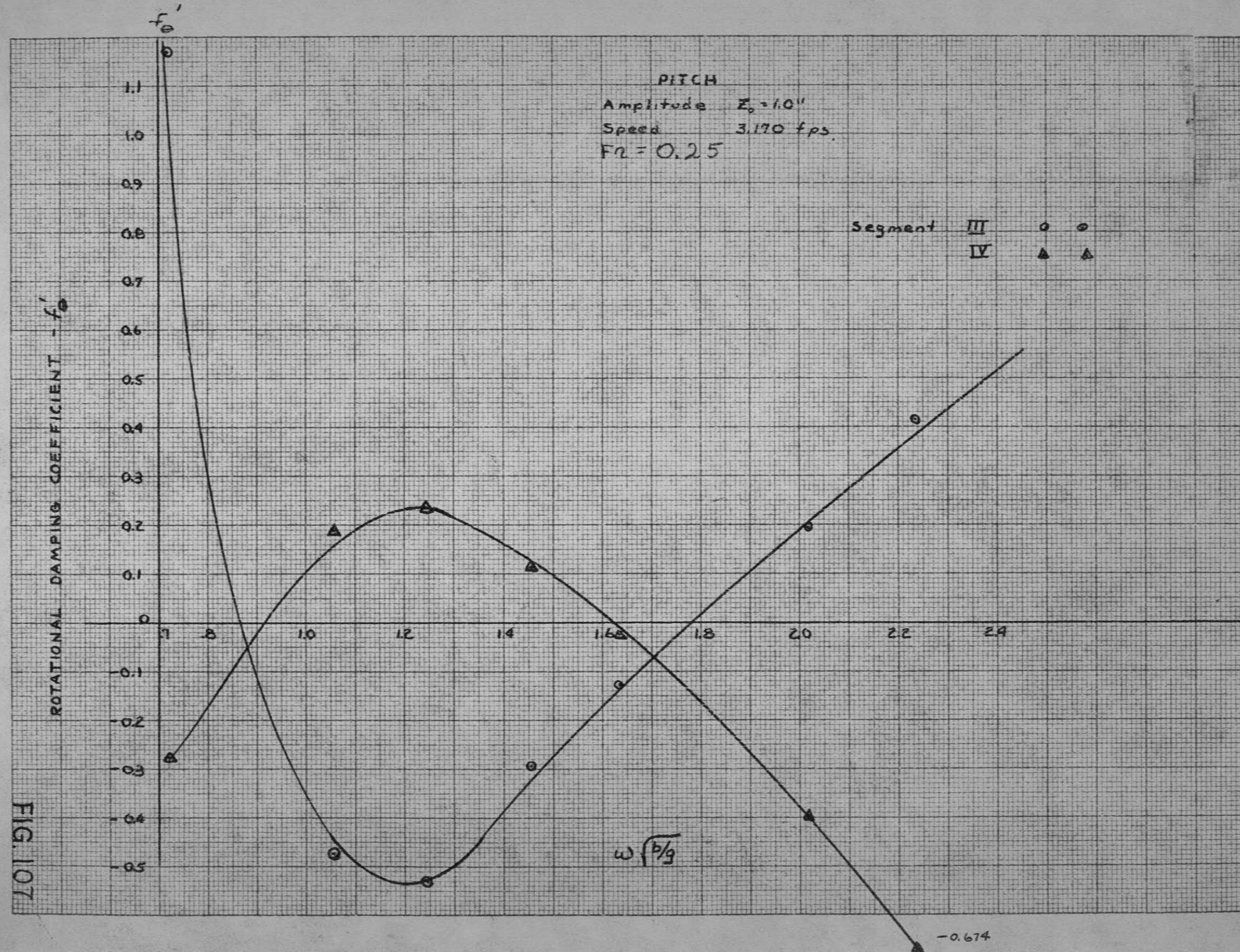
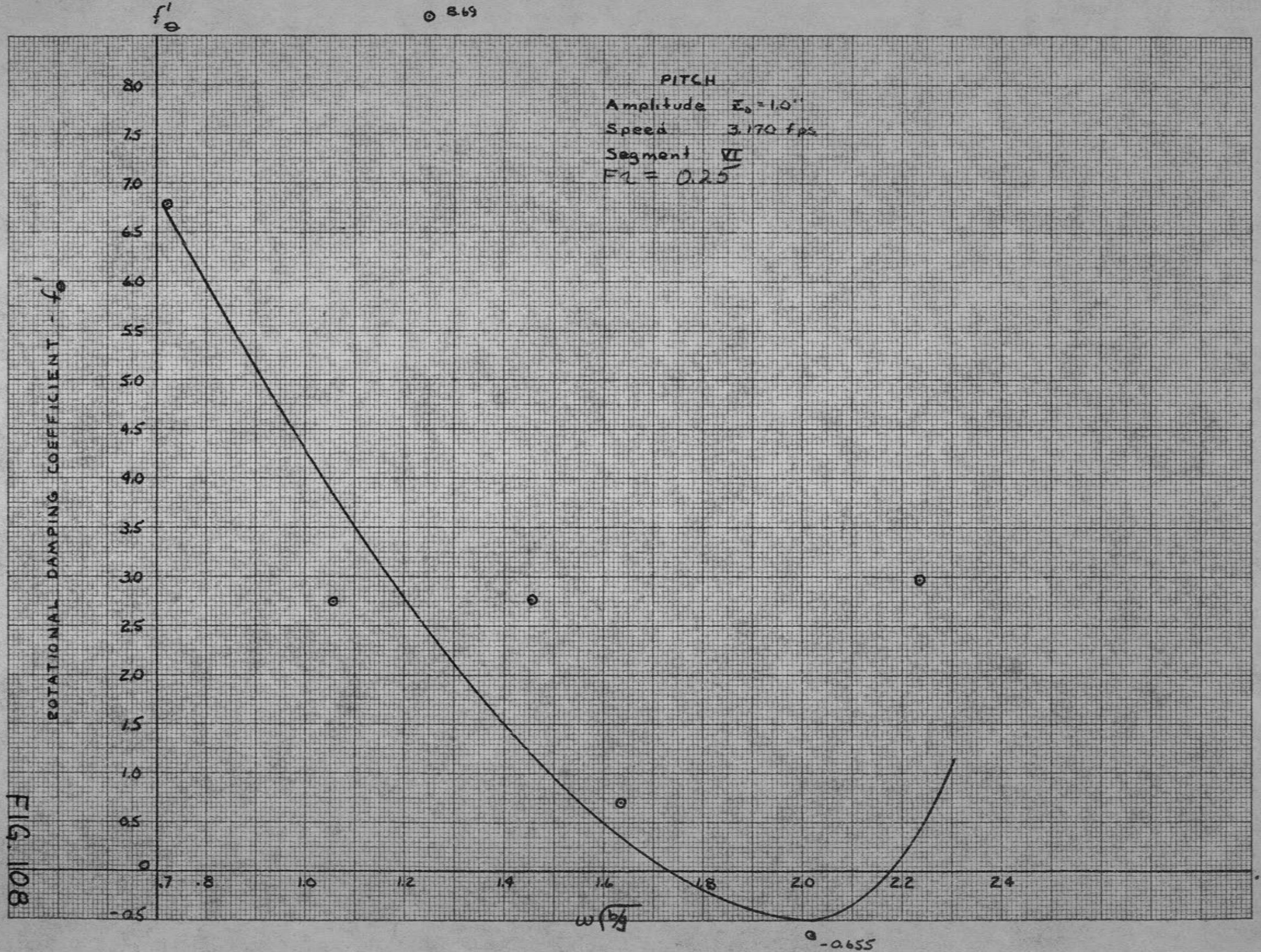

f_θ'
PITCH
Amplitude $Z_0 = 1.0''$
Speed 3.170 fps
Fn = 0.25
Segment III
IV
ROTATIONAL DAMPING COEFFICIENT - f_θ'
$\omega\sqrt{b/g}$
-0.674
.144ω

FIG. 107



PITCH
Amplitude $\Sigma_0 = 1.0°$
Speed 3.170 fps
Segment VI
Fr = 0.25
ROTATIONAL DAMPING COEFFICIENT - f'_θ
f'_θ
8.69
-0.655
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
.7
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega\sqrt{b/g}$
.144ω

FIG. 108

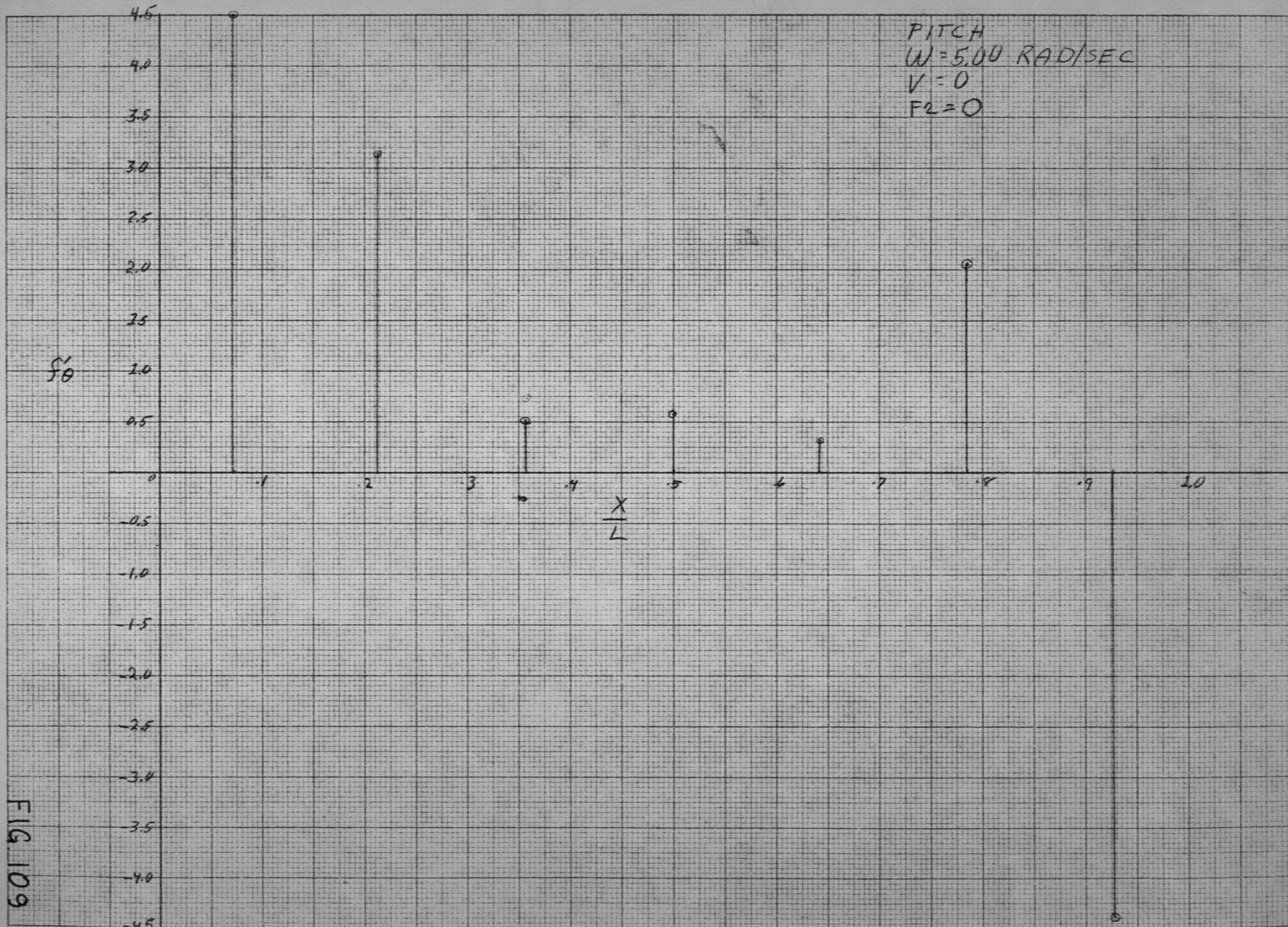

PITCH
W = 5.00 RAD/SEC
V = 0
F2 = 0
f'_θ
$\frac{X}{L}$
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 109

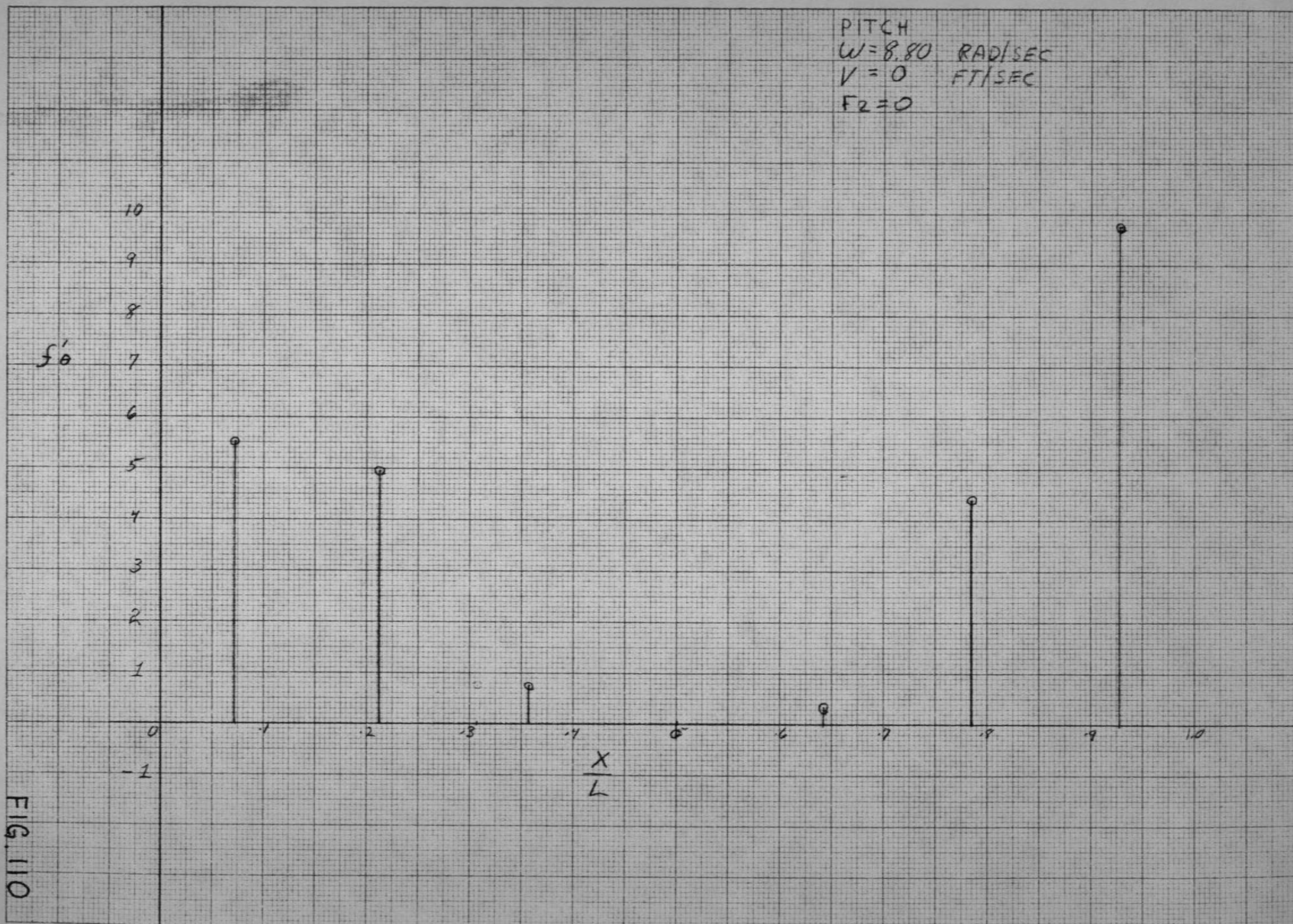

PITCH
ω = 8.80 RAD/SEC
V = 0 FT/SEC
F2 = 0
f′θ
10
9
8
7
6
5
4
3
2
1
0
-1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
X/L

FIG. 110

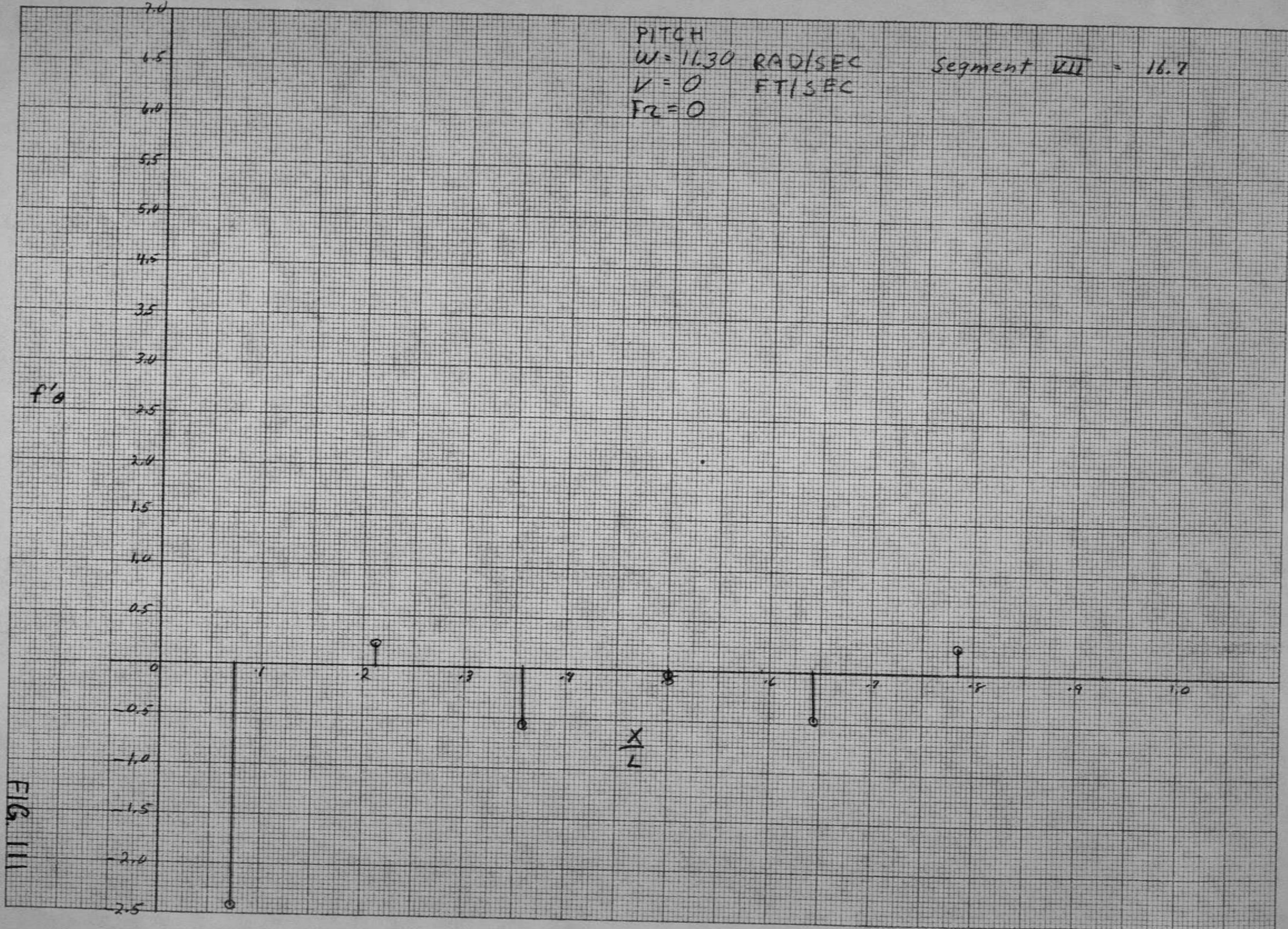
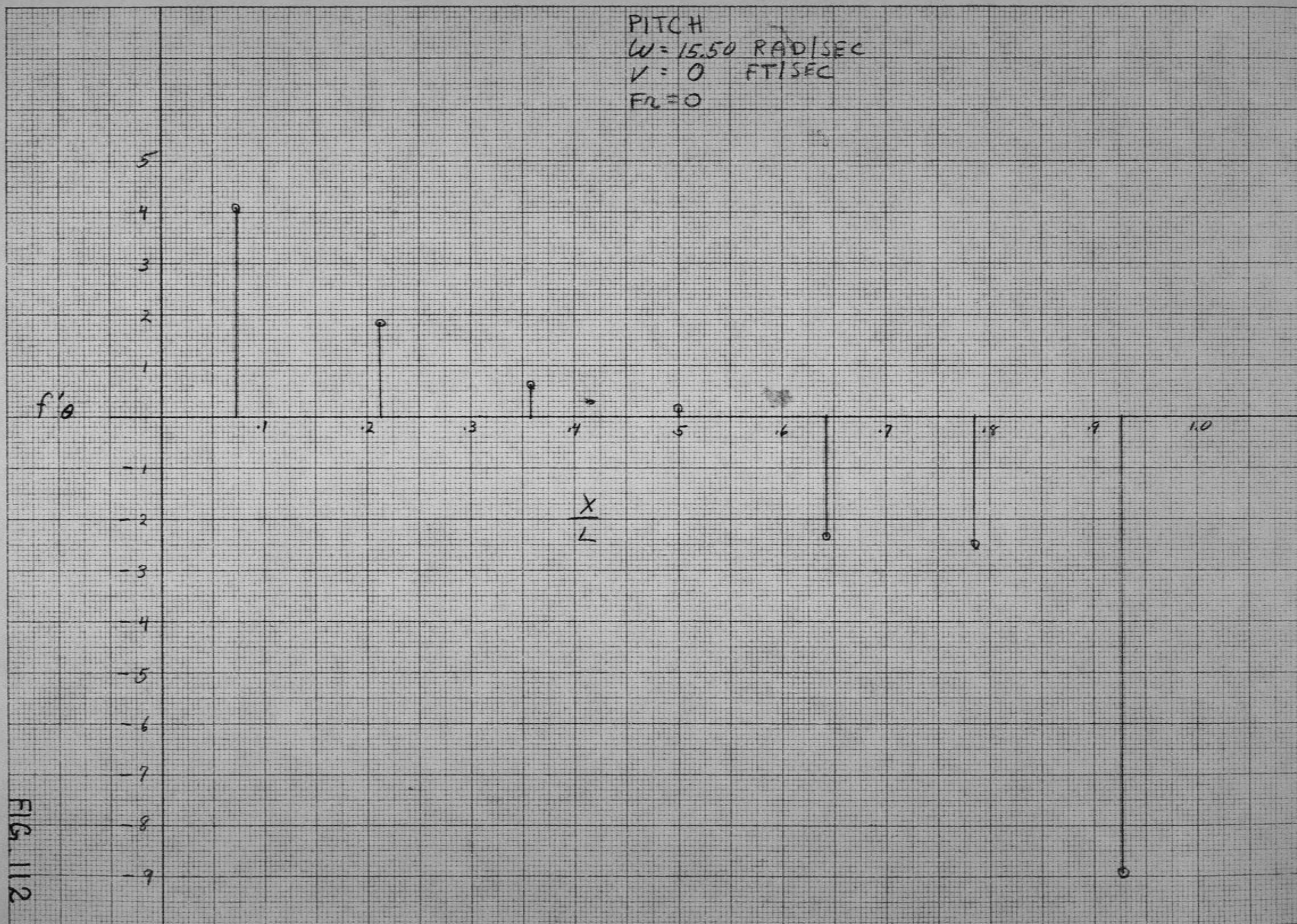

PITCH
W = 11.30 RAD/SEC
V = 0 FT/SEC
Fz = 0
Segment VII = 16.7
f'θ
X/L
7.0
6.5
6.0
5.5
5.0
4.5
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
-2.5
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. III


PITCH
ω = 15.50 RAD/SEC
V = 0 FT/SEC
Fn = 0
f'θ
X/L
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0
5
4
3
2
1
-1
-2
-3
-4
-5
-6
-7
-8
-9
FIG. II 2

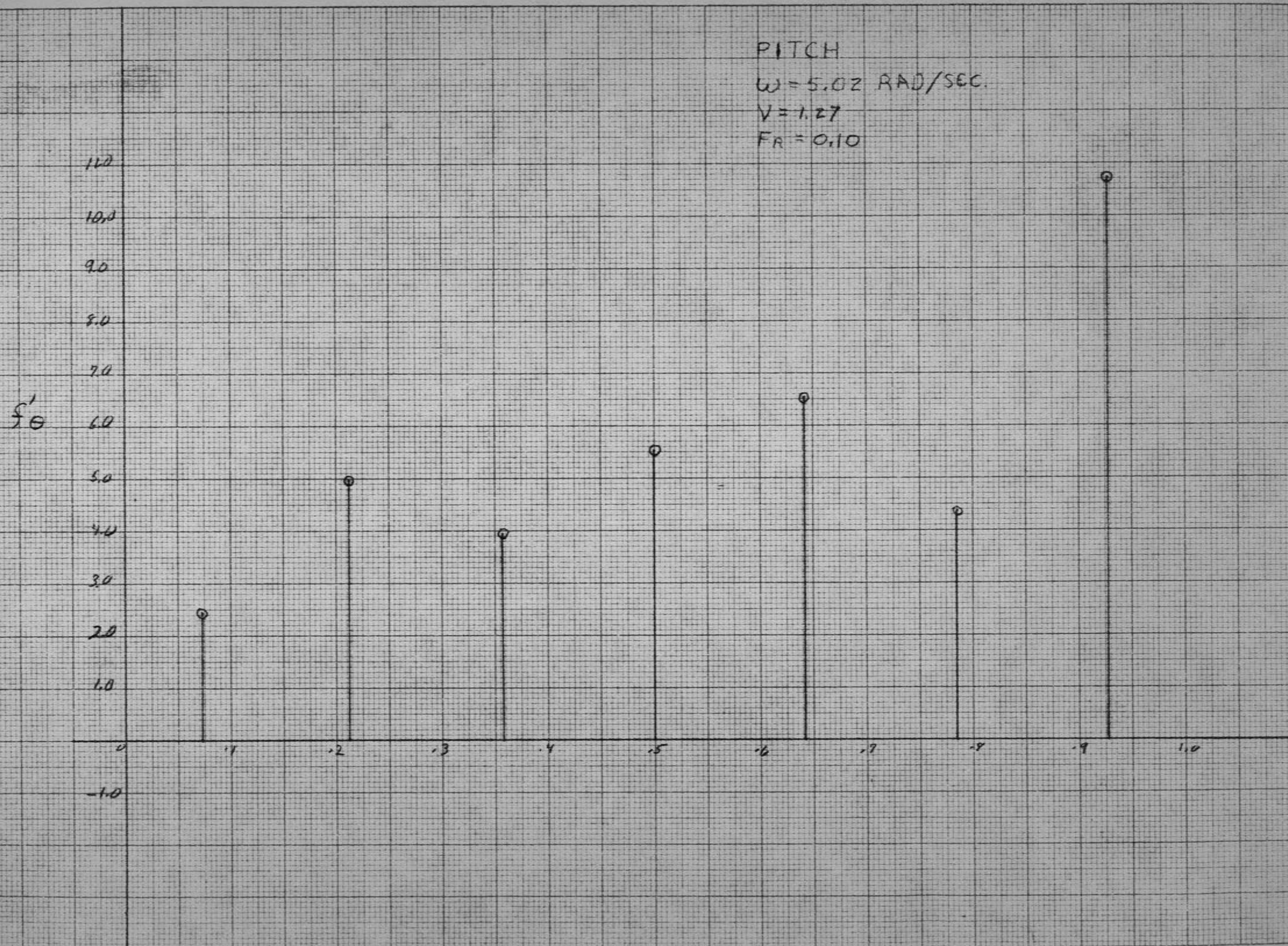

PITCH
ω = 5.02 RAD/SEC.
V = 1.27
F_R = 0.10
f'_θ
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
-1.0
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 113

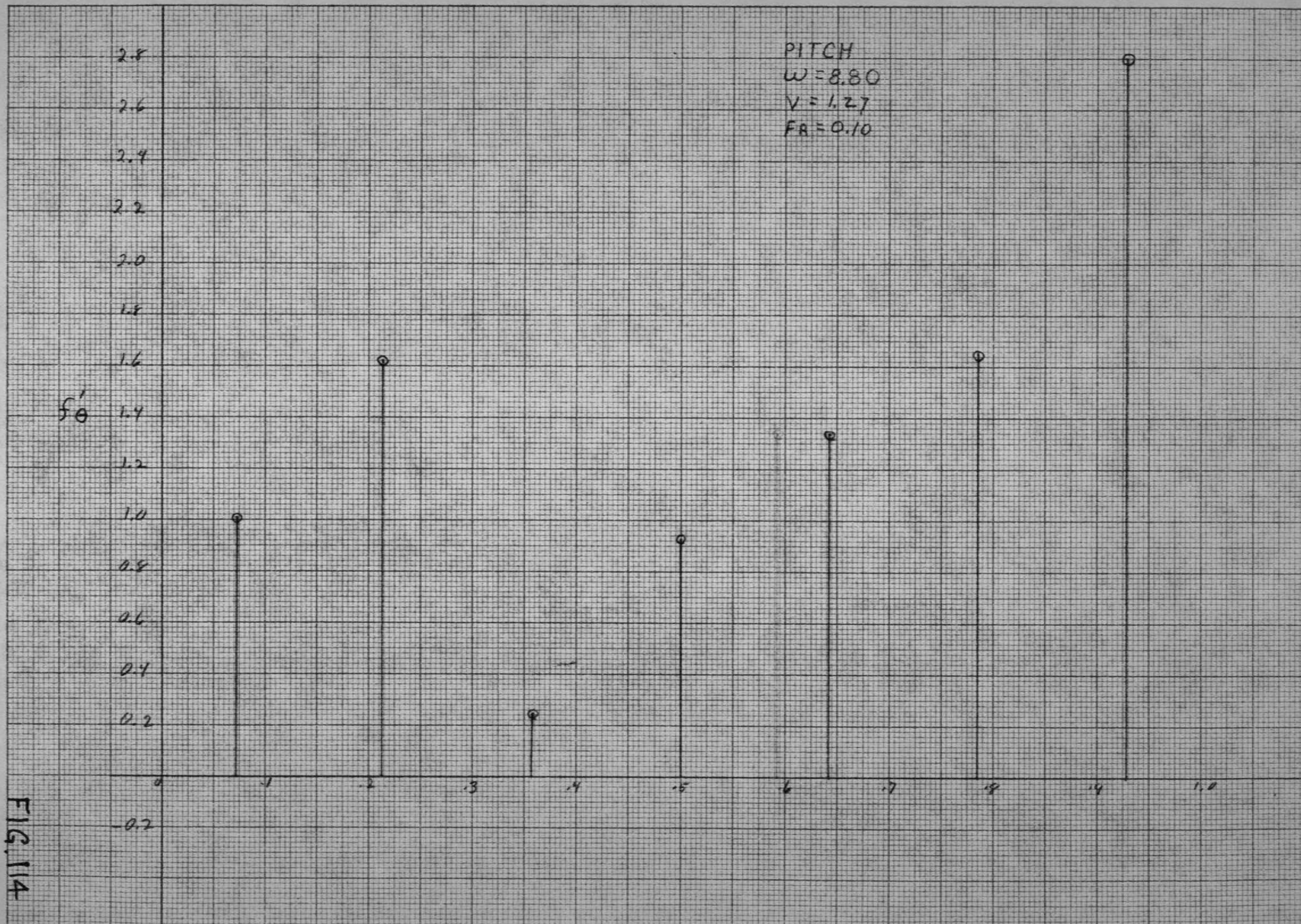
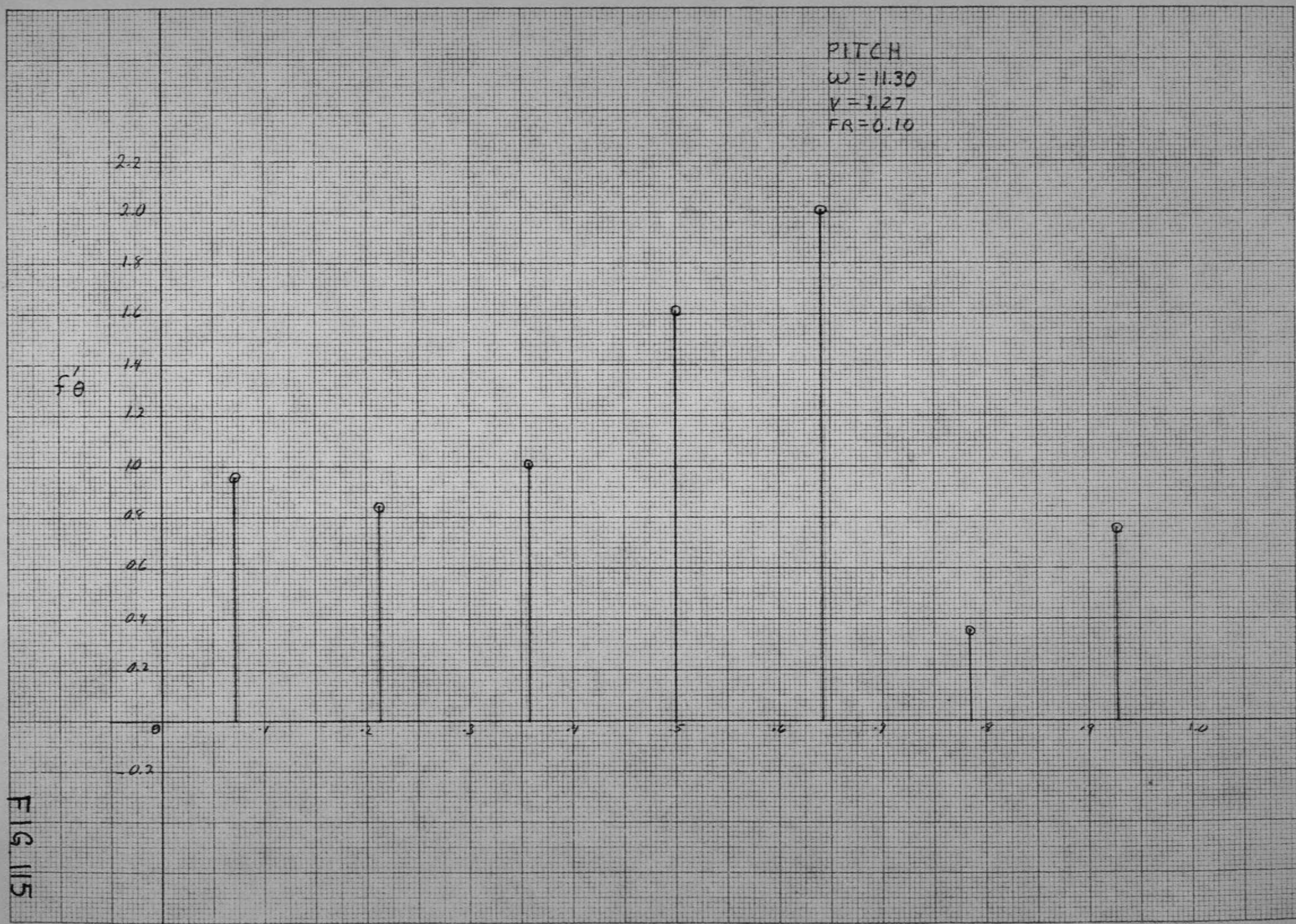

PITCH
ω = 8.80
V = 1.27
F_R = 0.10
f'_θ
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-0.2
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 114



PITCH
ω = 11.30
V = 1.27
FR = 0.10
f'θ
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-0.2
0
·1
·2
·3
·4
·5
·6
·7
·8
·9
1.0

FIG 115

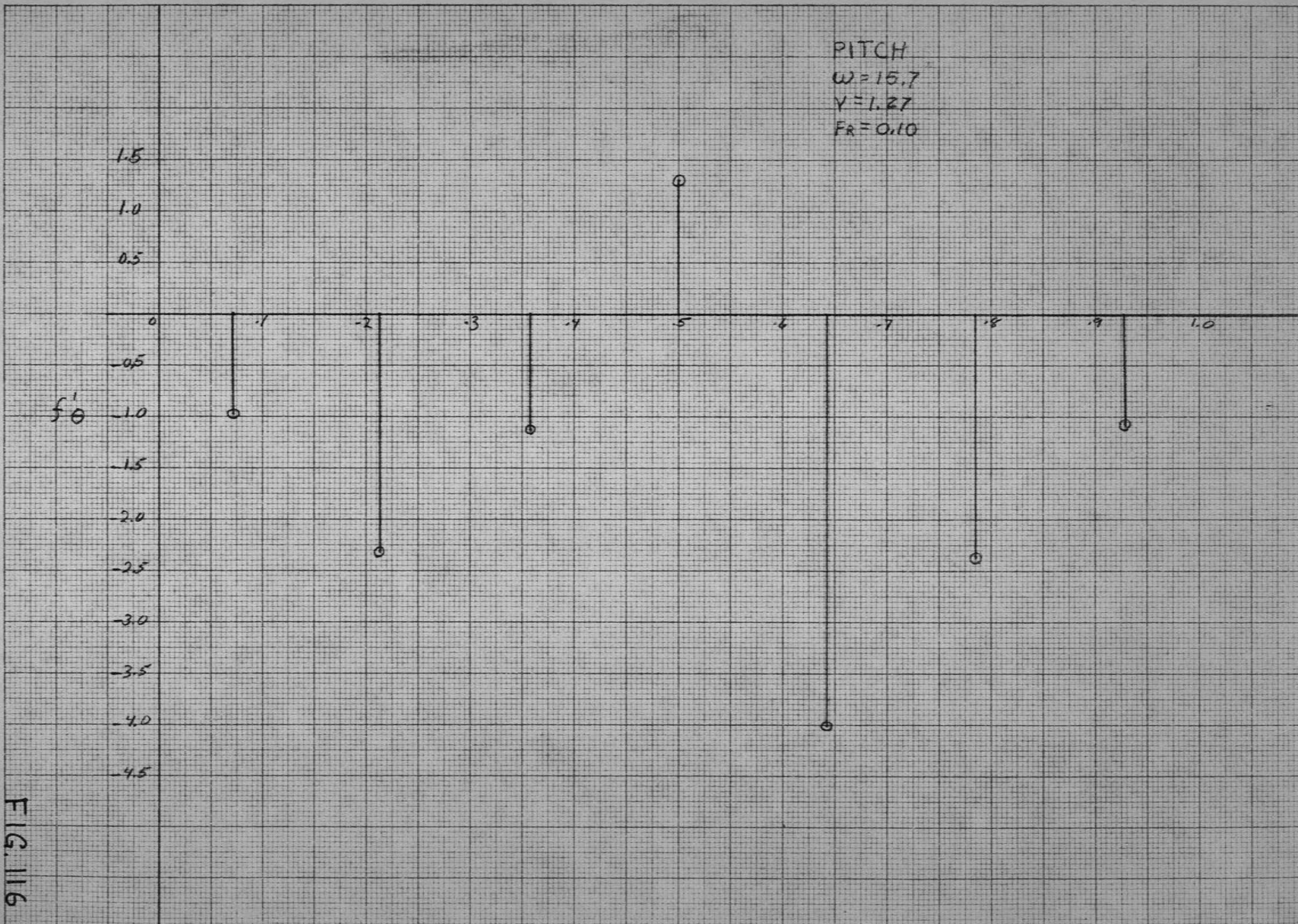

PITCH
ω = 15.7
γ = 1.27
FR = 0.10
f'θ
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 116

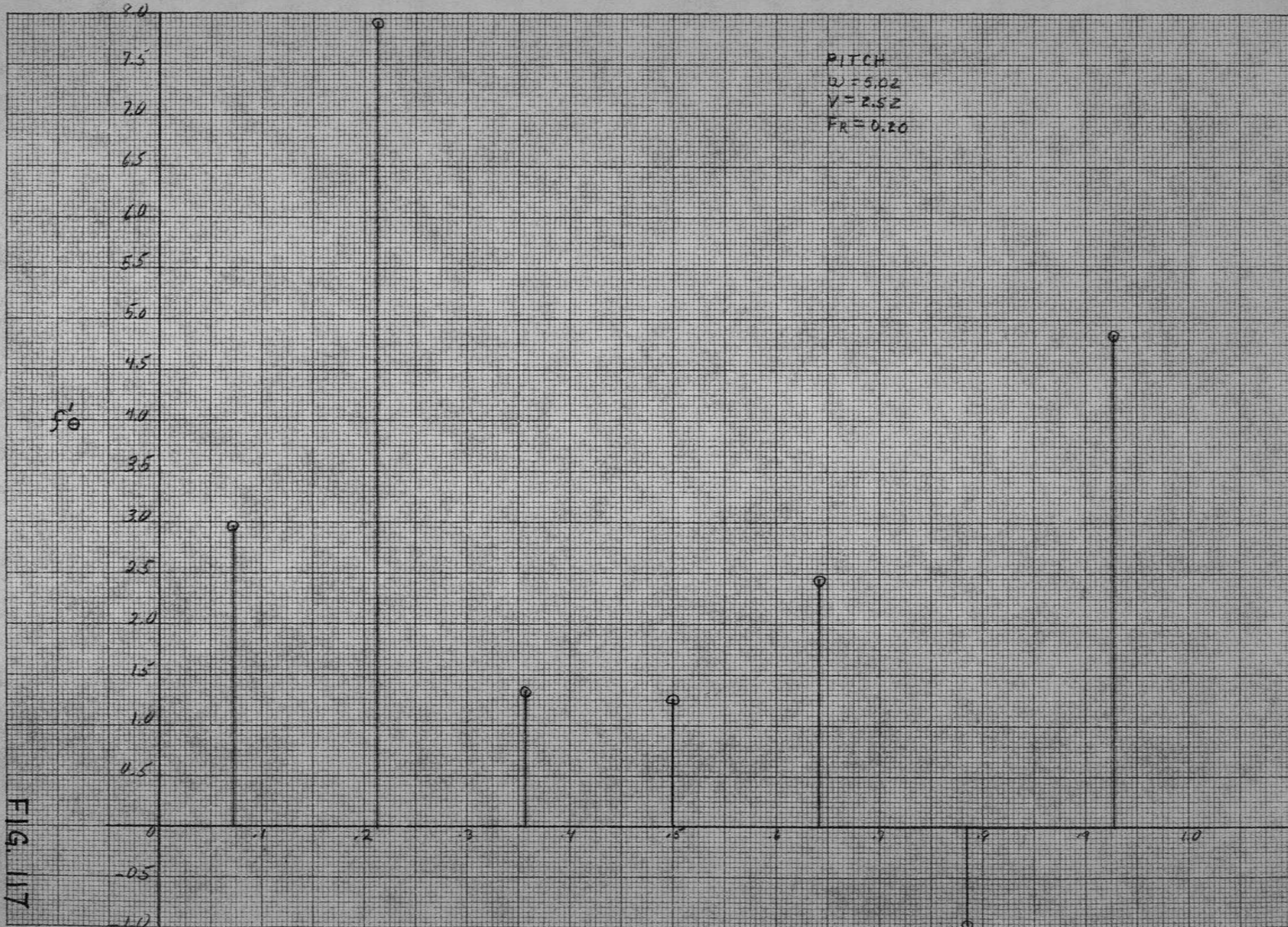

PITCH
ω = 5.02
V = 2.52
F_R = 0.20
f'θ
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
-1.0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 117

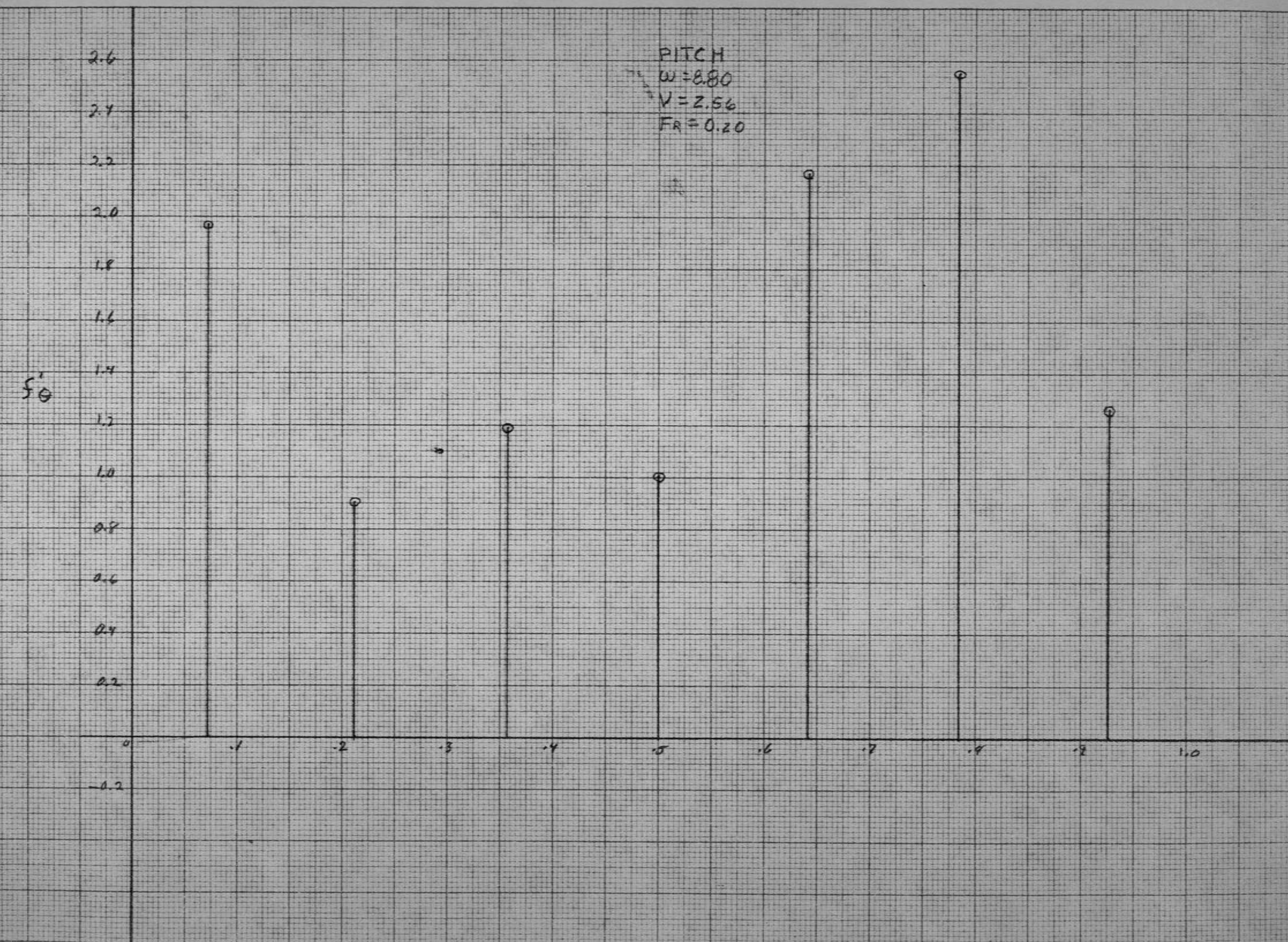

PITCH
ω = 8.80
V = 2.56
FR = 0.20
f'θ
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
-0.2
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 118

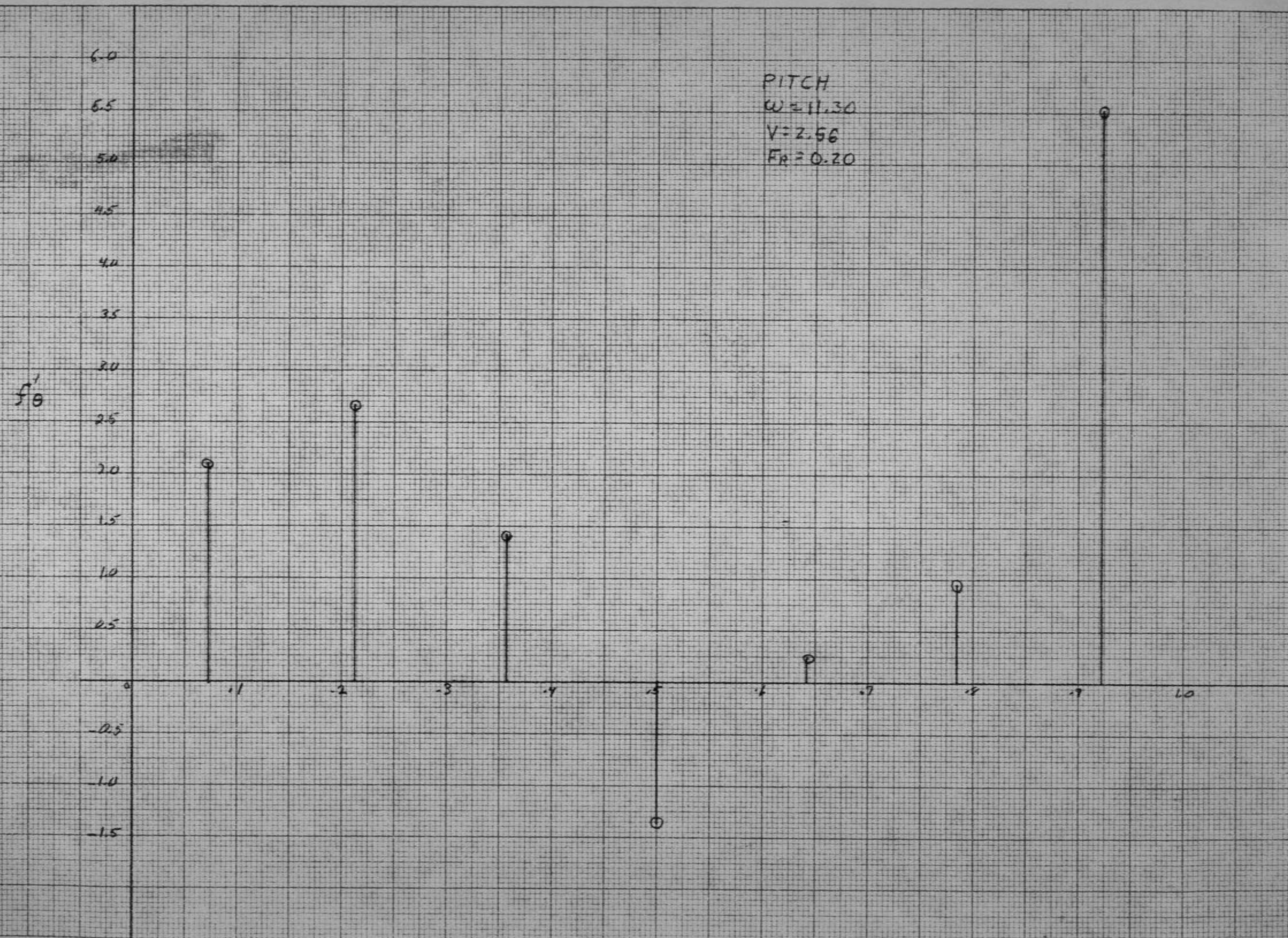

PITCH
ω = 11.30
V = 2.56
F_R = 0.20
f'_θ
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-0.5
-1.0
-1.5
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 119

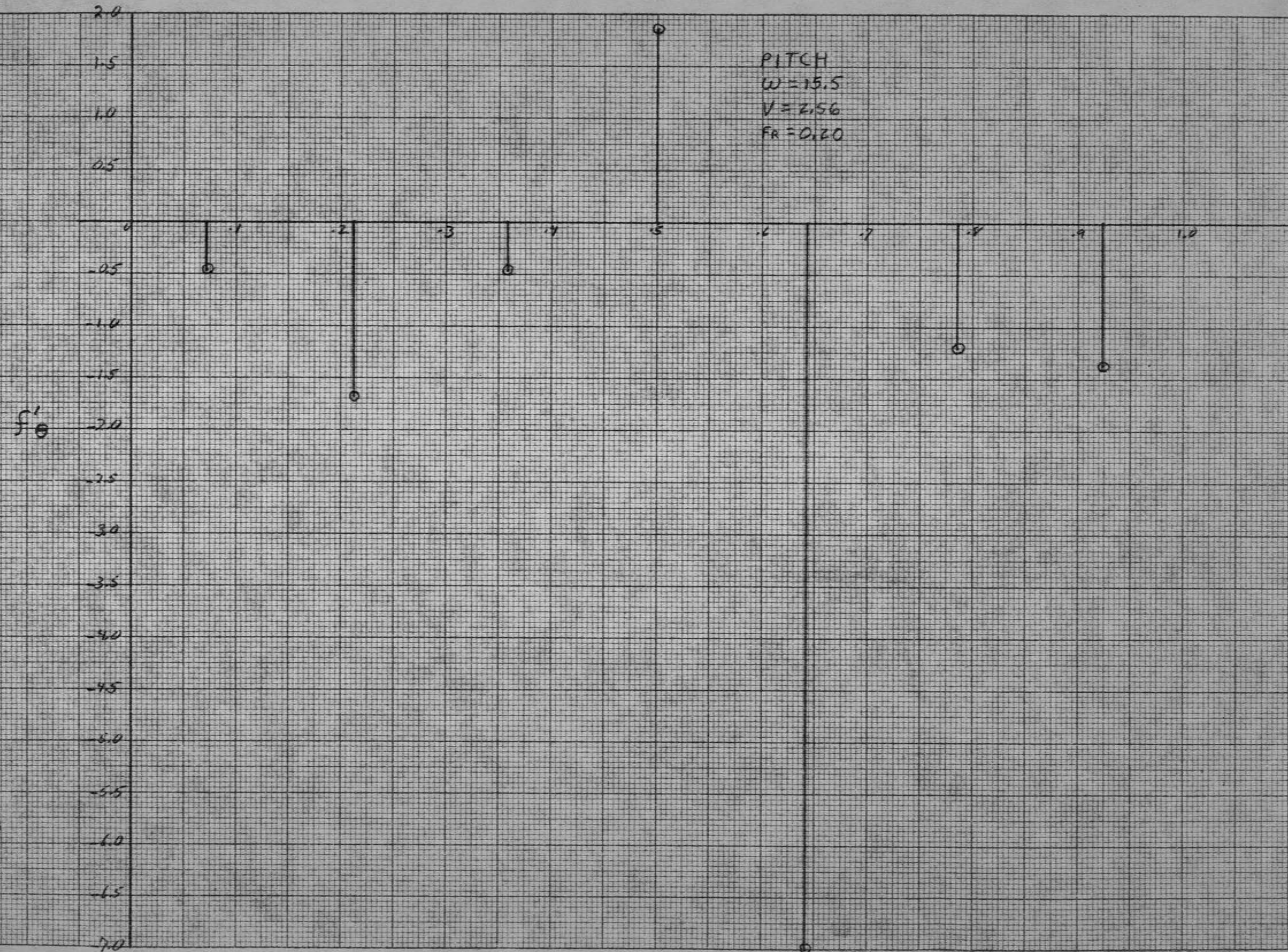
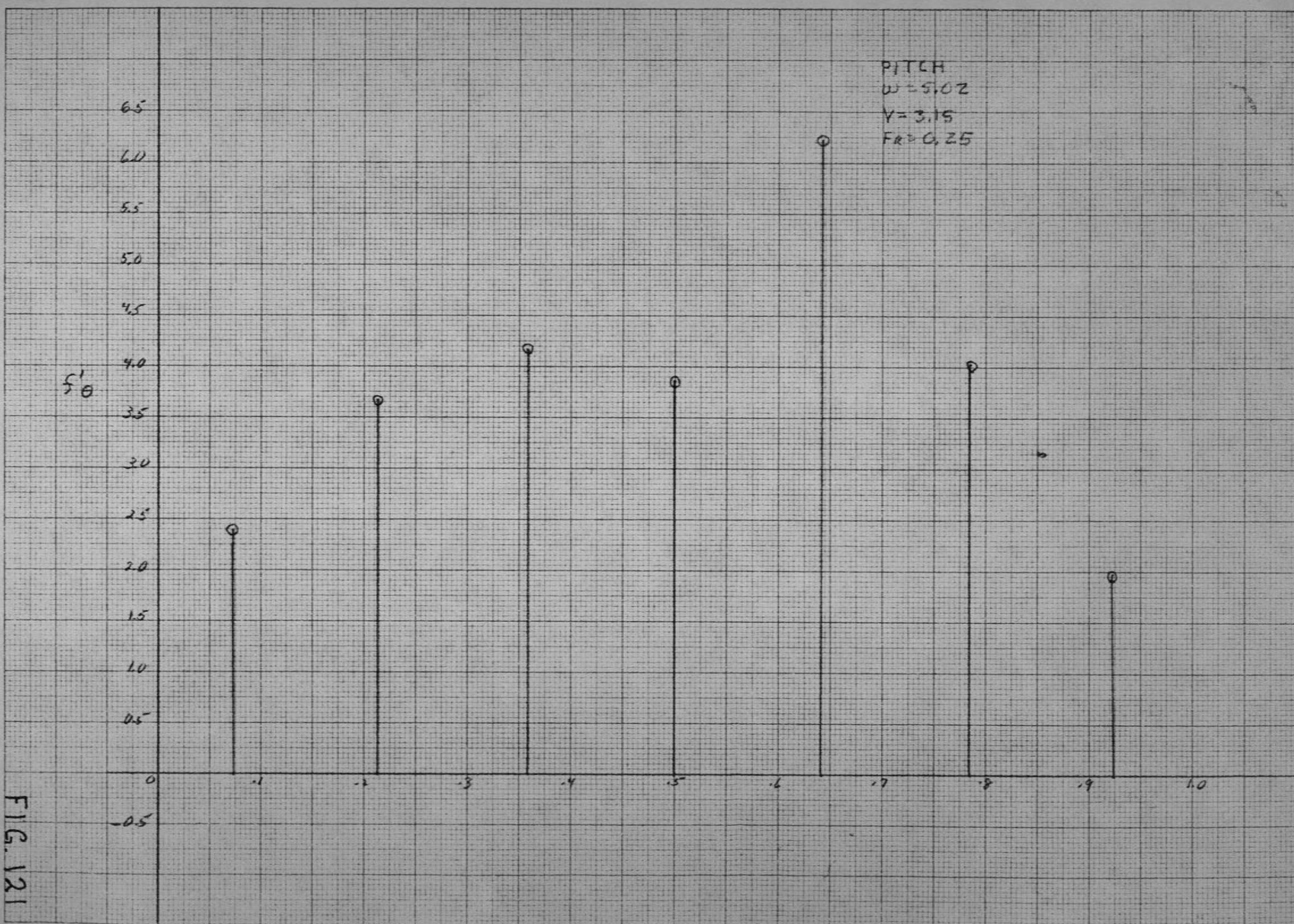

PITCH
ω = 15.5
V = 2.56
FR = 0.20
f'θ
2.0
1.5
1.0
0.5
0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
-5.5
-6.0
-6.5
-7.0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 120



PITCH
ω = 5.02
V = 3.15
Fr = 0.25
f'_θ
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
-0.5
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 121

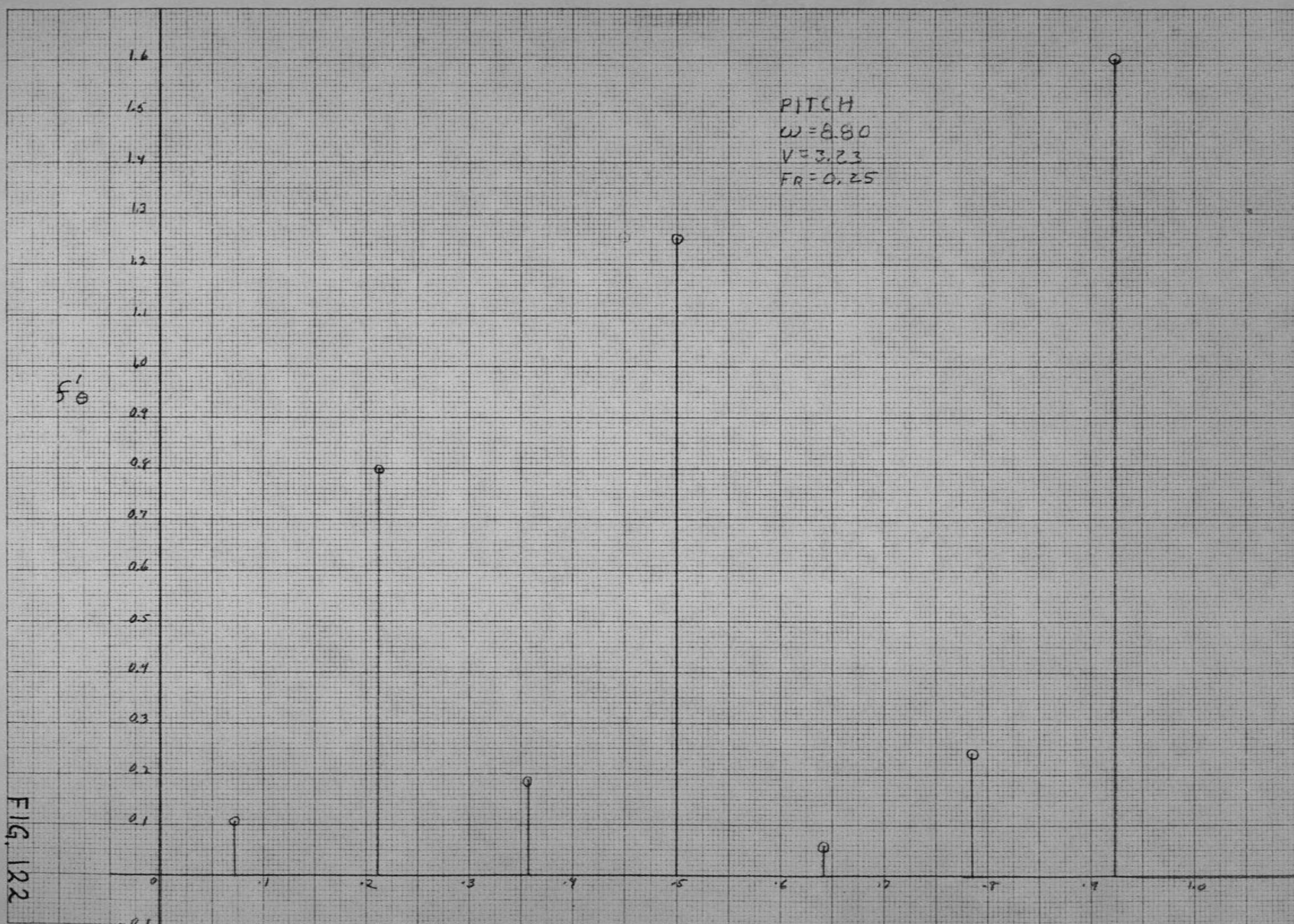

PITCH
ω = 8.80
V = 3.23
F_R = 0.25
ζ'_θ
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 122

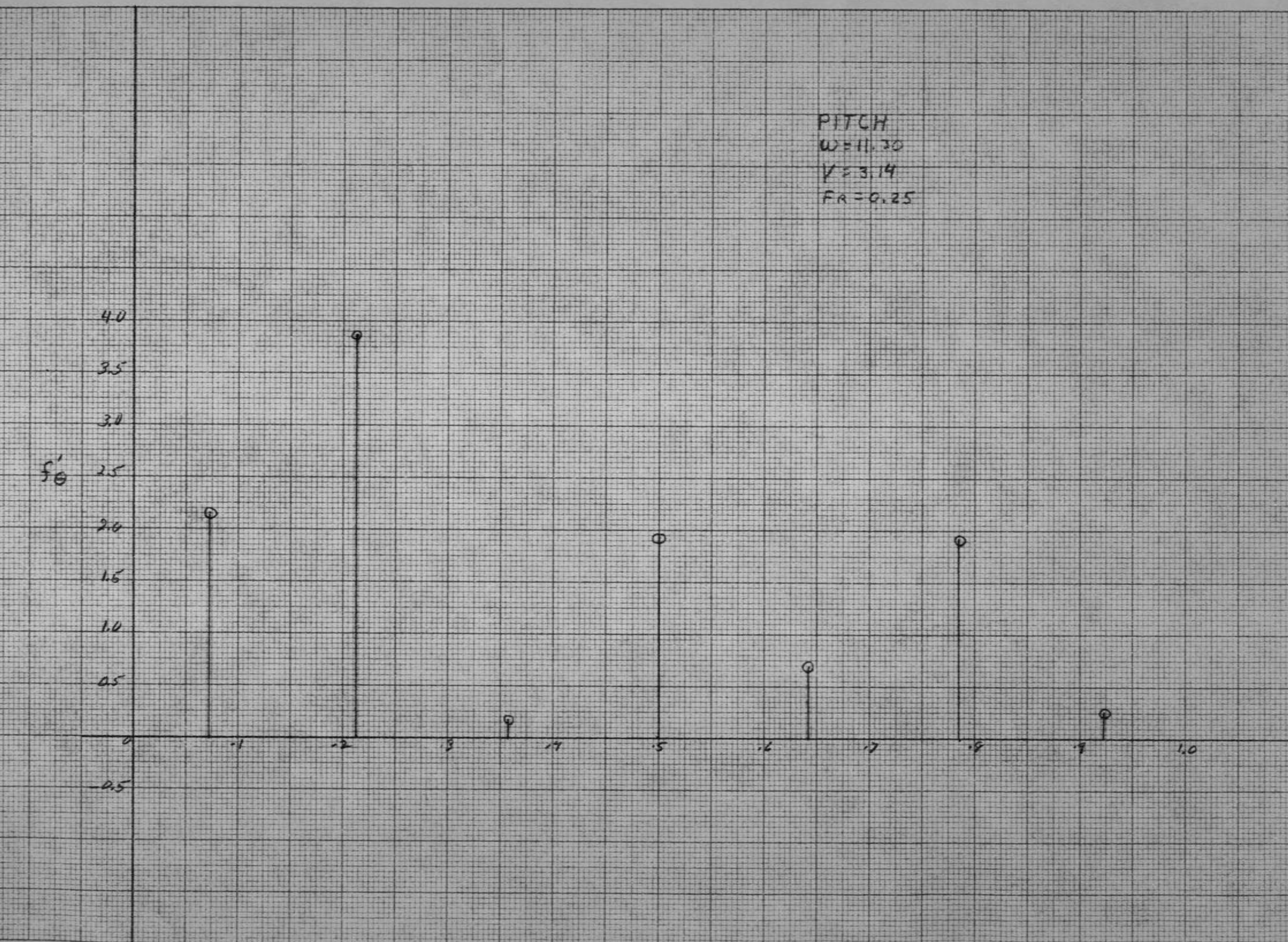
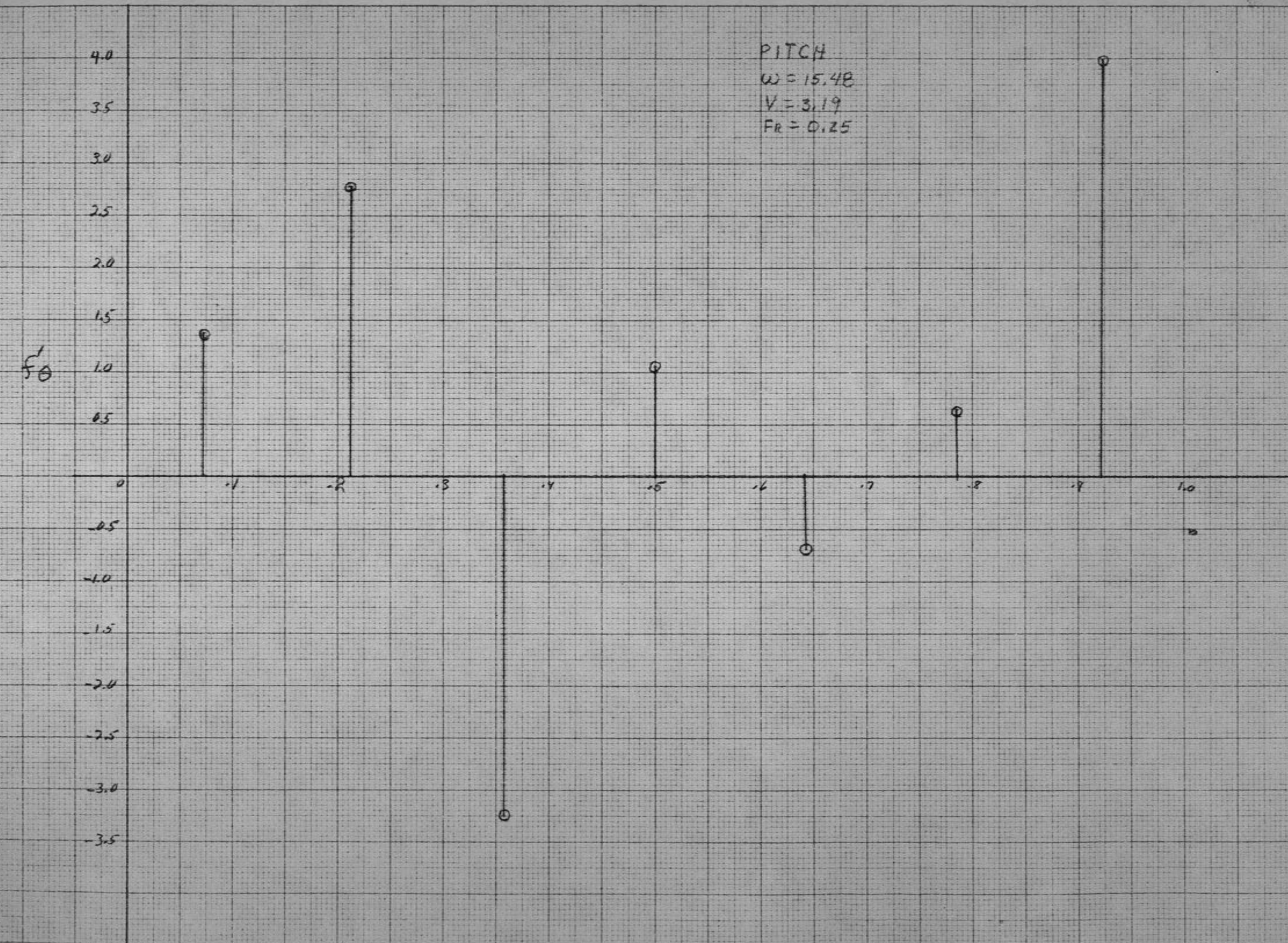

PITCH
ω = 11.30
V = 3.14
FR = 0.25
f'_θ
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-0.5
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 123



PITCH
ω = 15.48
V = 3.19
FR = 0.25
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIG. 12.4

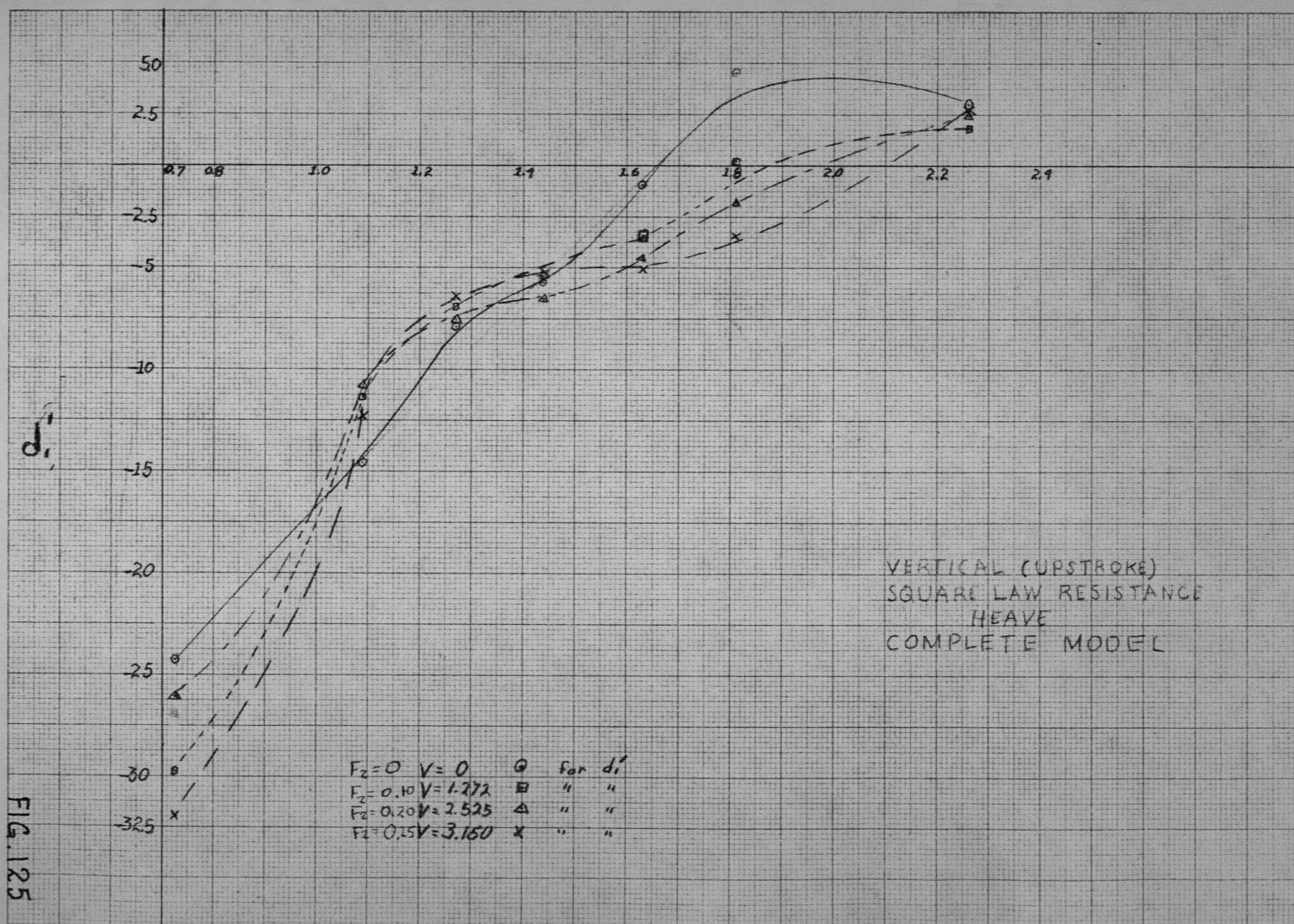

VERTICAL (UPSTROKE)
SQUARE LAW RESISTANCE
HEAVE
COMPLETE MODEL
d_1'
5.0
2.5
-2.5
-5
-10
-15
-20
-25
-30
-32.5
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$F_z = 0$ $V = 0$ ⊙ for d_1'
$F_z = 0.10$ $V = 1.272$ ⊡ " "
$F_z = 0.20$ $V = 2.525$ △ " "
$F_z = 0.25$ $V = 3.160$ × " "

FIG. 125

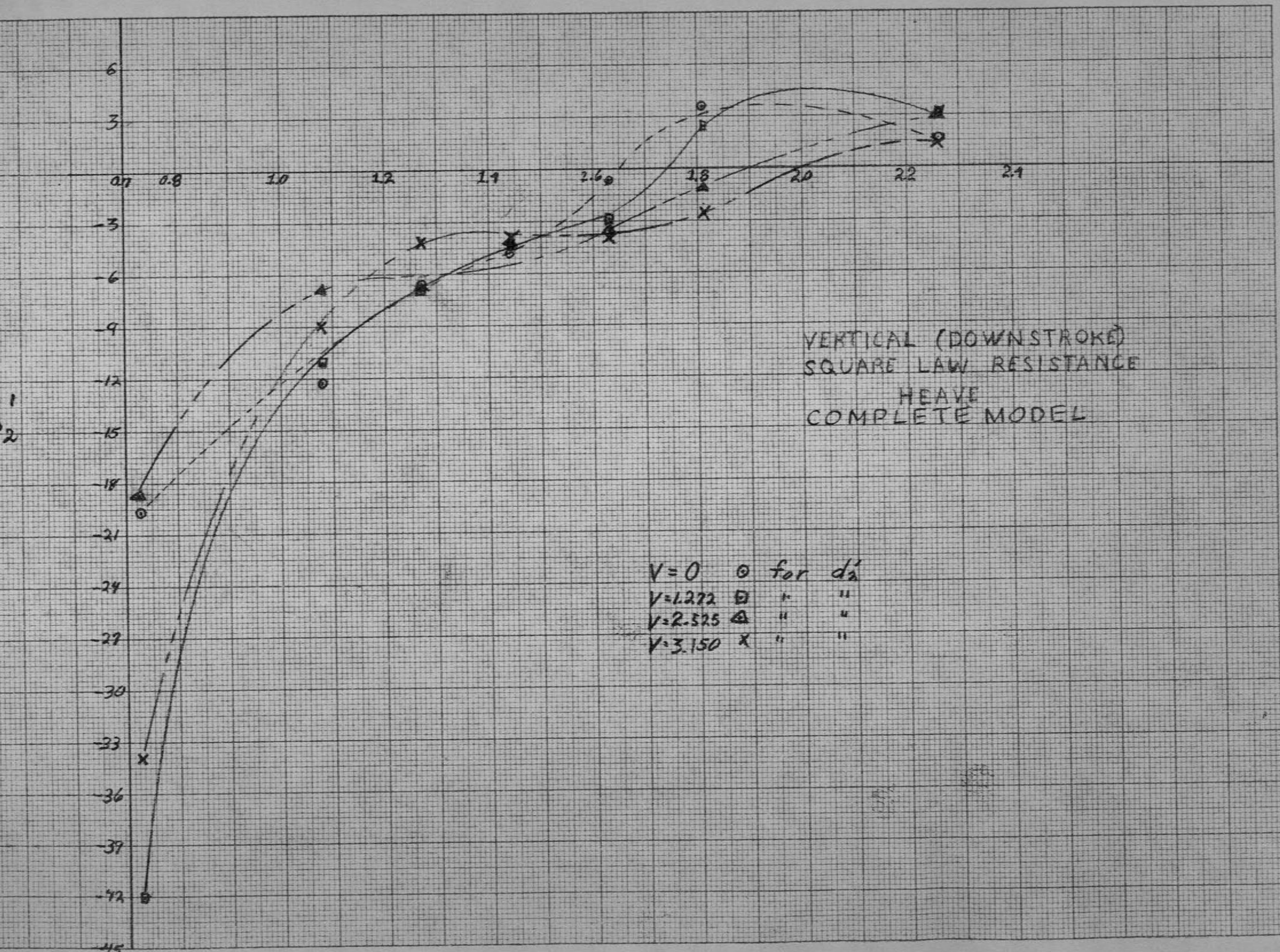

VERTICAL (DOWNSTROKE)
SQUARE LAW RESISTANCE
HEAVE
COMPLETE MODEL
V = 0 ⊙ for d₂'
V = 1.272 ⊡ " "
V = 2.525 △ " "
V = 3.150 X " "
d_2'
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
6
3
-3
-6
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
-39
-42
-45

FIG. 12 b

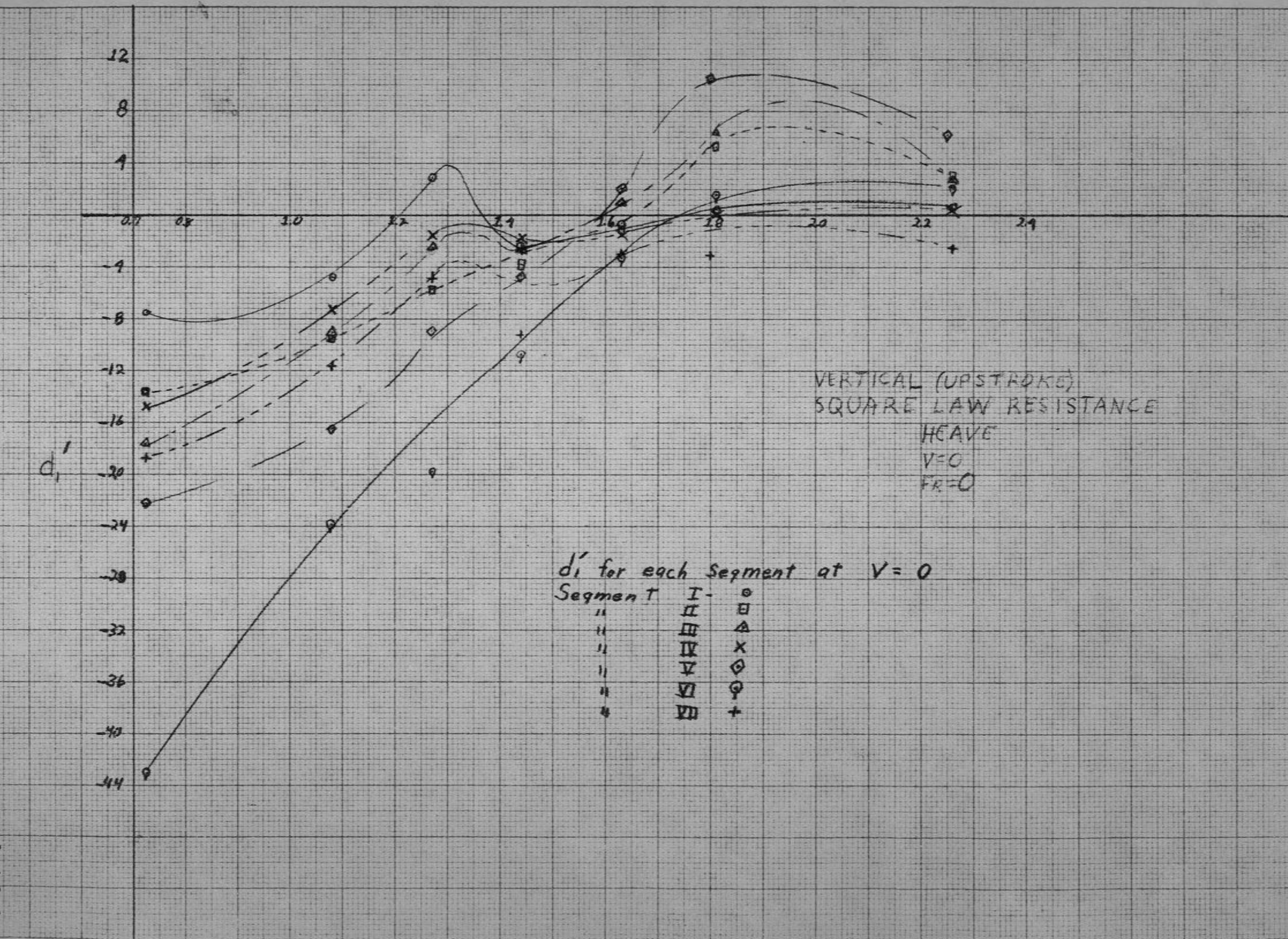

12
8
4
-4
-8
-12
-16
-20
-24
-28
-32
-36
-40
-44
d_1'
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
VERTICAL (UPSTROKE)
SQUARE LAW RESISTANCE
HEAVE
V=0
F_R=0
d_1' for each Segment at V = 0
Segment I - ⊙
" II ⊡
" III △
" IV ×
" V ◇
" VI ♀
" VII +

FIG. 127

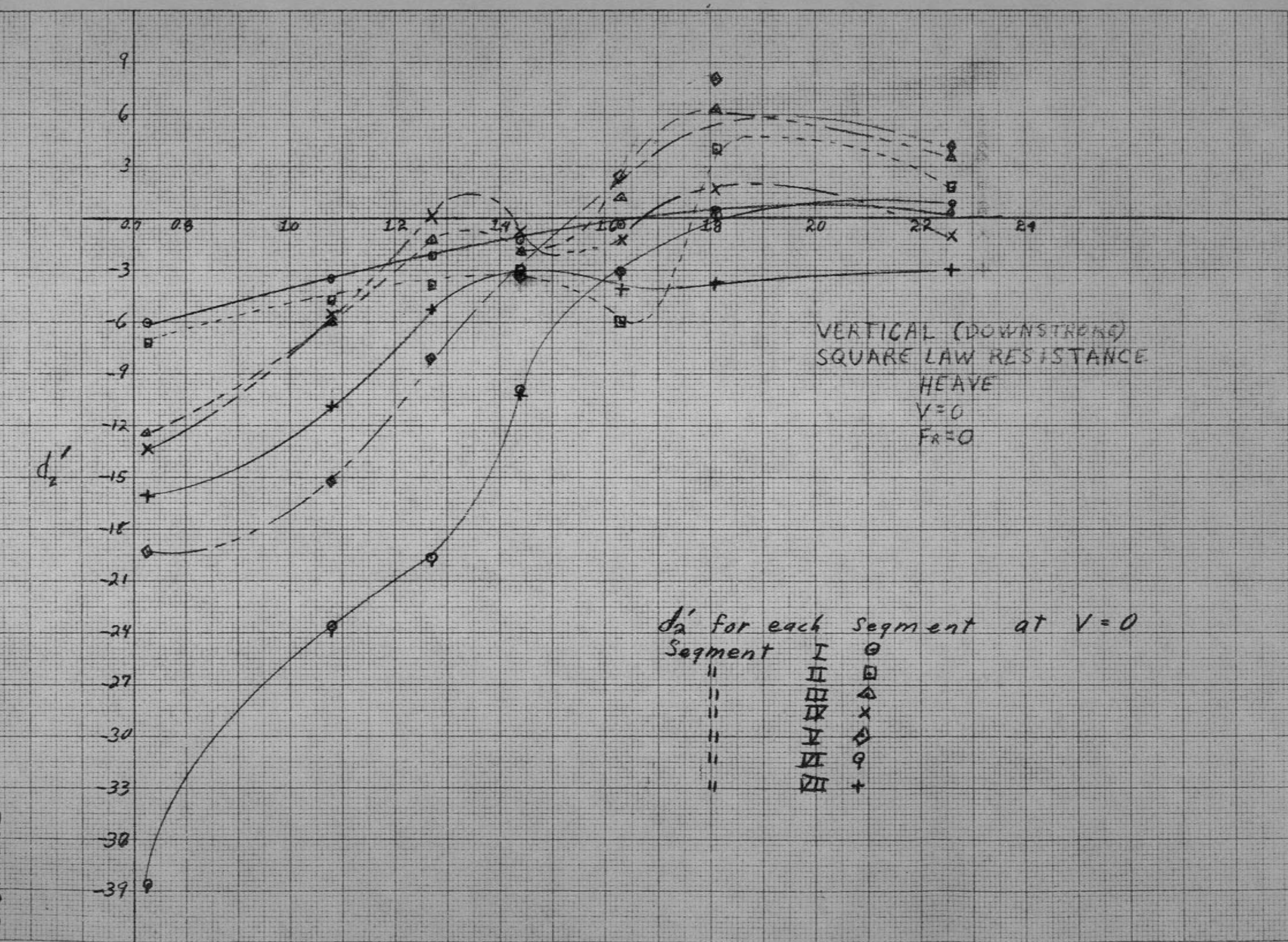

VERTICAL (DOWNSTREAM)
SQUARE LAW RESISTANCE
HEAVE
V=0
Fx=0
d_z'
9
6
3
-3
-6
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
-39
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
d_z' for each Segment at V=0
Segment I
" II
" III
" IV
" V
" VI
" VII

FIG. 12.8

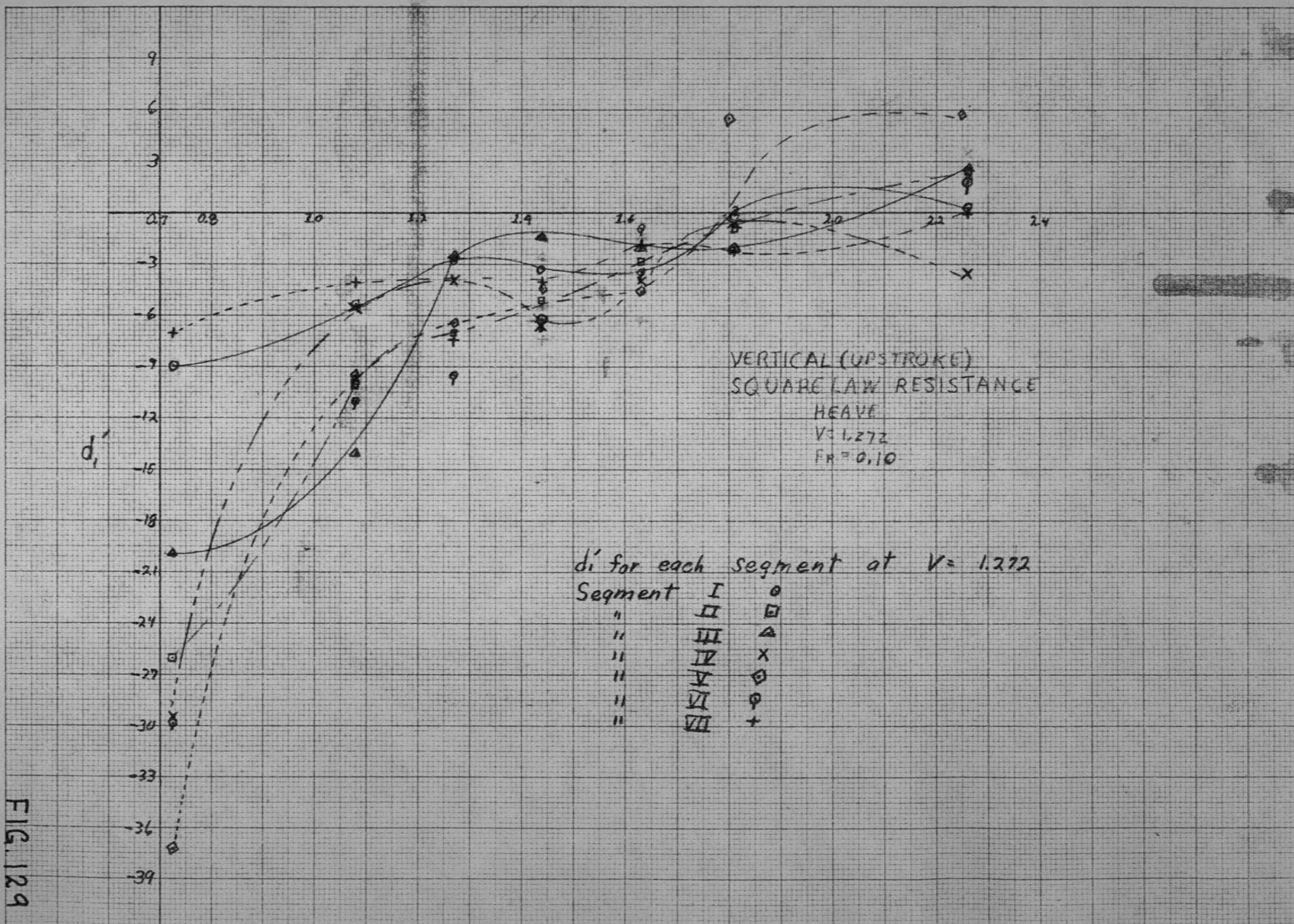

VERTICAL (UPSTROKE)
SQUARE LAW RESISTANCE
HEAVE
V = 1.272
F_R = 0.10
d_1' for each segment at V = 1.272
Segment I
" II
" III
" IV
" V
" VI
" VII
d_1'
9
6
3
-3
-6
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
-39
0.7
0.8
1.0
1.2
1.4
1.6
2.0
2.2
2.4

FIG. 129

K+E 10 X 10 TO THE CM. 359-14G
KEUFFEL & ESSER CO. MADE IN U.S.A.

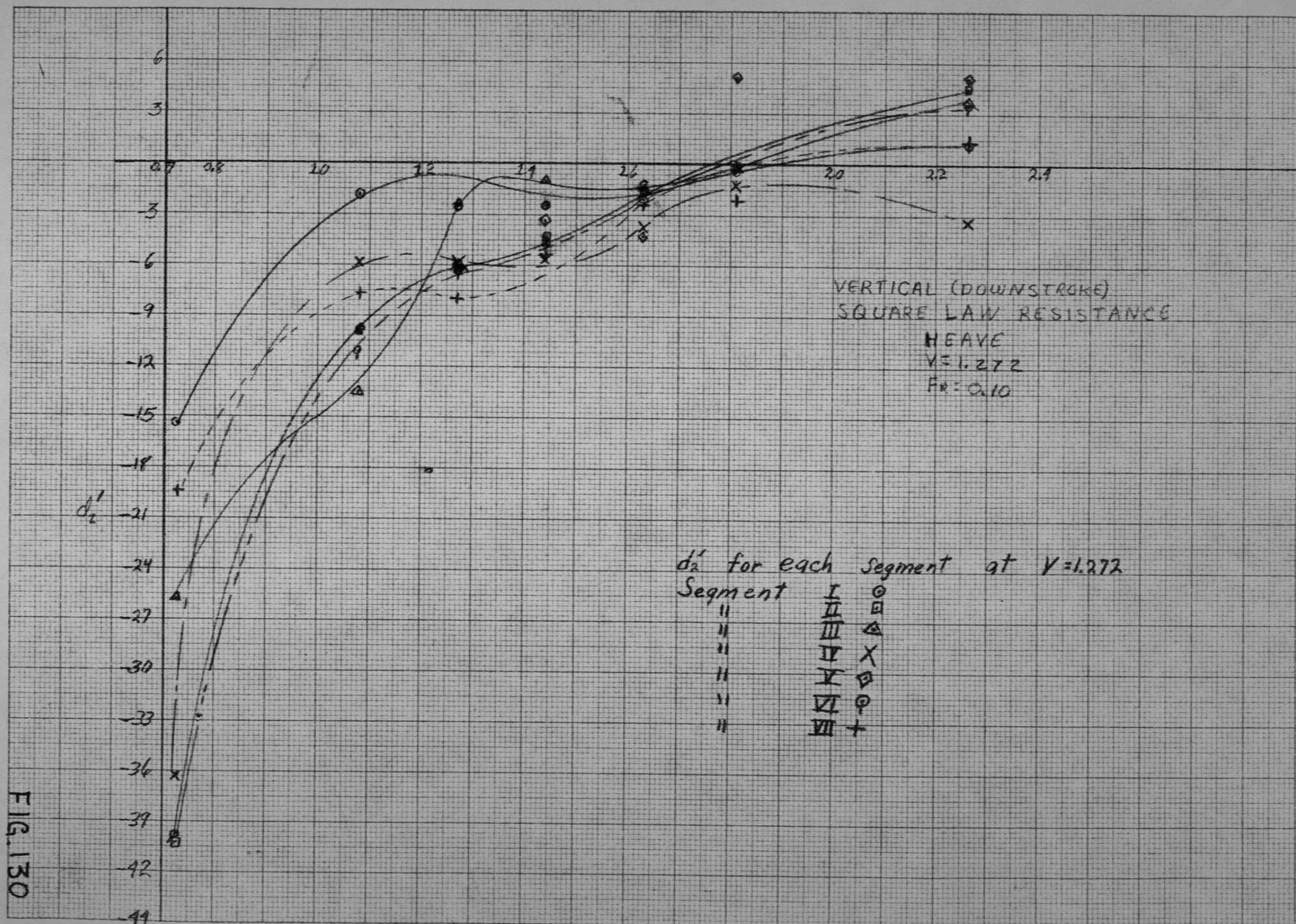
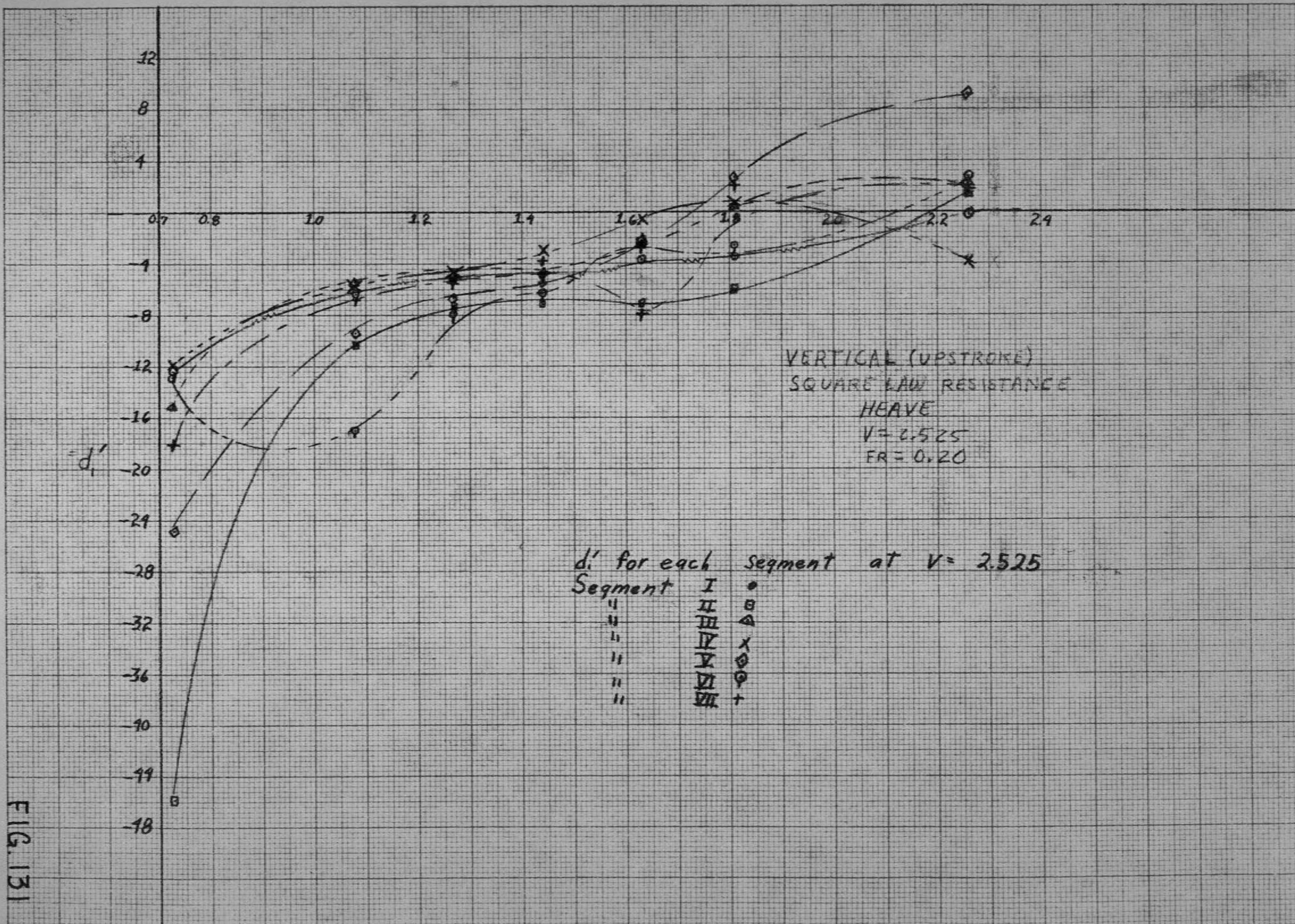


FIG. 130



12
8
4
-4
-8
-12
-16
-20
-24
-28
-32
-36
-40
-44
-48
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
d_1'
VERTICAL (UPSTROKE)
SQUARE LAW RESISTANCE
HEAVE
V = 2.525
FR = 0.20
d_1' for each segment at V = 2.525
Segment I
" II
" III
" IV
" V
" VI
" VII

FIG. 131

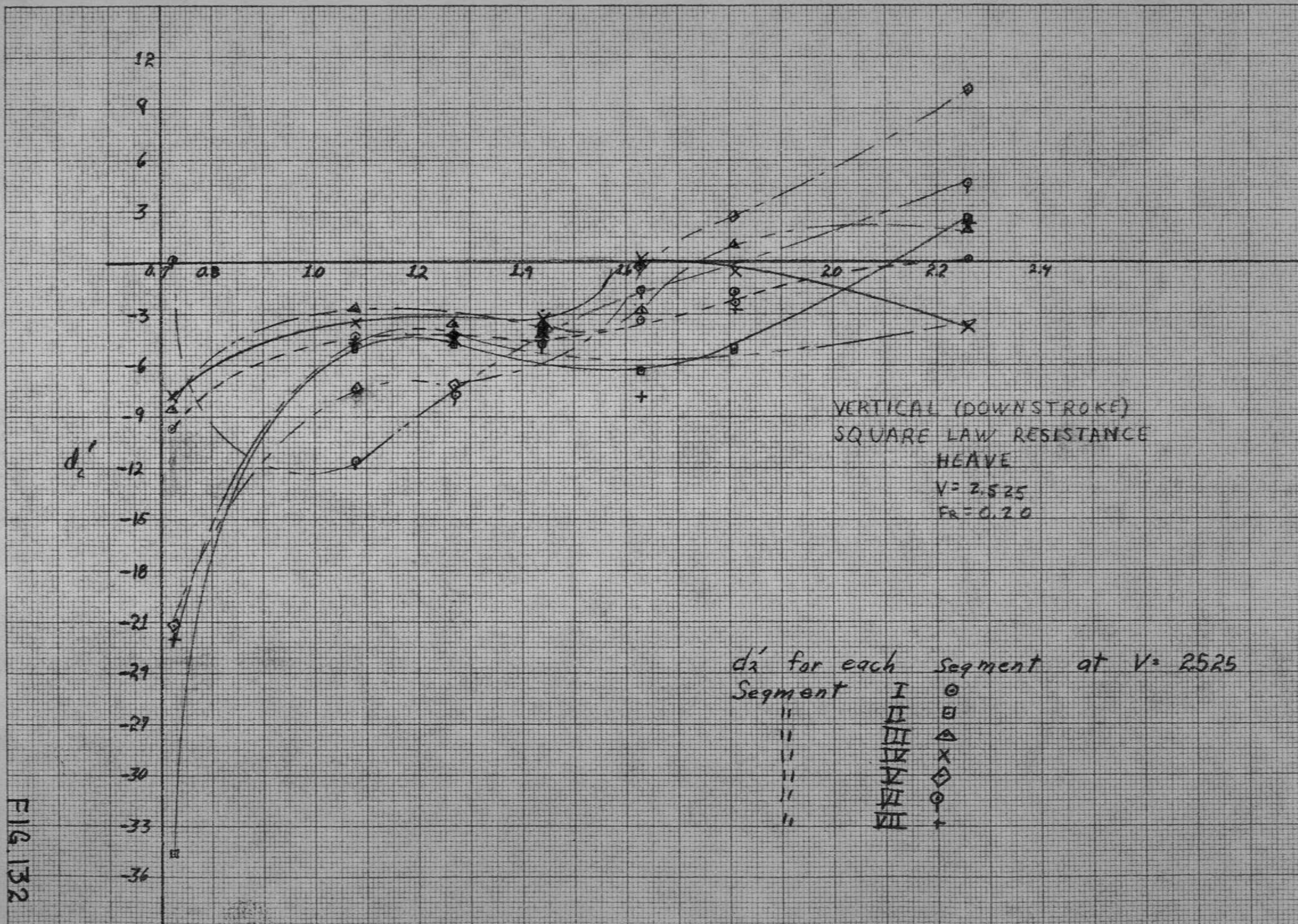

12
9
6
3
-3
-6
-9
-12
-15
-18
-21
-24
-27
-30
-33
-36
0.7
0.8
1.0
1.2
1.4
1.6
2.0
2.2
2.4
d_2'
VERTICAL (DOWNSTROKE)
SQUARE LAW RESISTANCE
HEAVE
V = 2.525
Fr = 0.20
d_2' for each Segment at V = 2.525
Segment I ⊙
" II ⊡
" III △
" IV ×
" V ◇
" VI ⌽
" VII +

FIG. 132

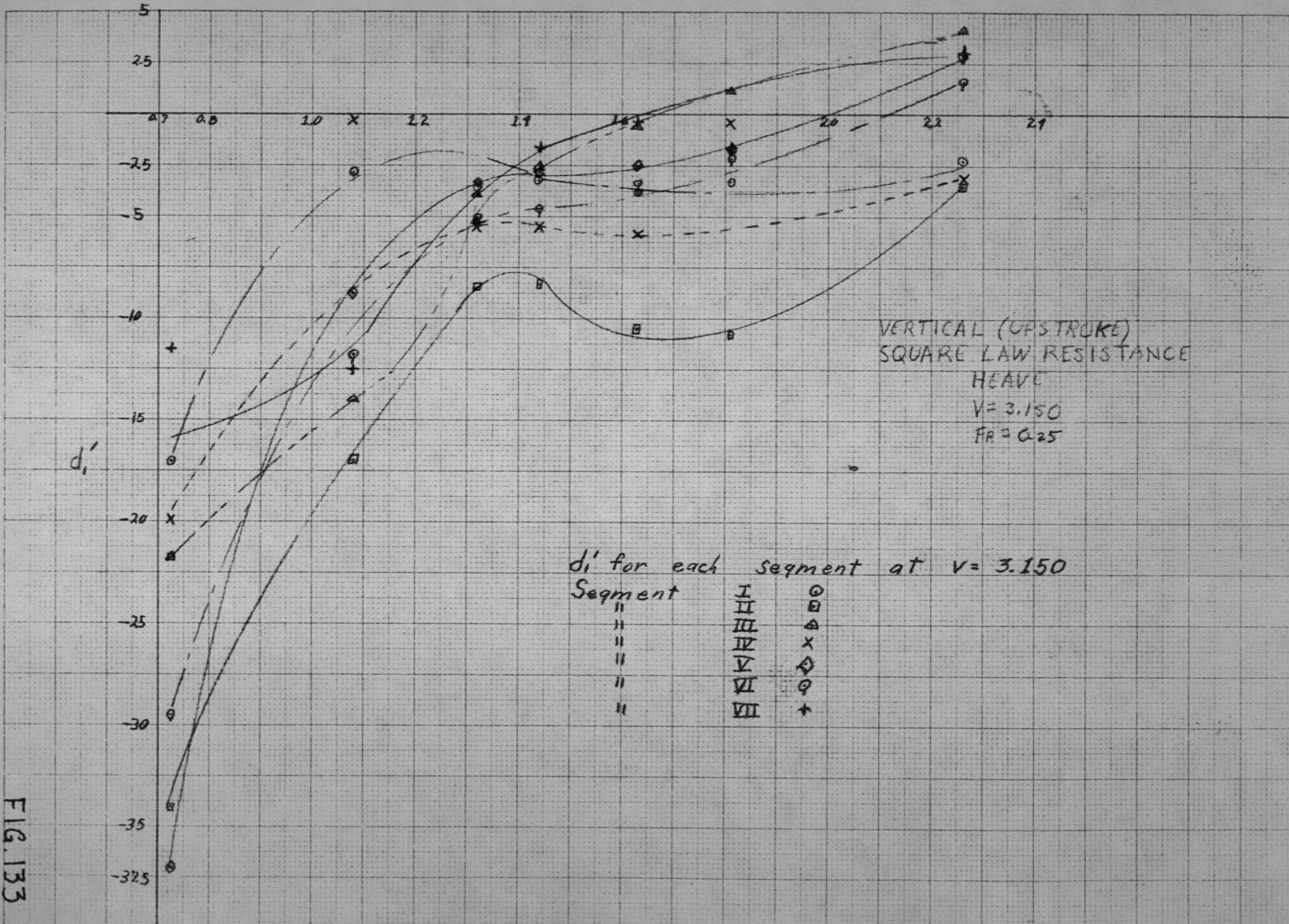

VERTICAL (UPSTROKE)
SQUARE LAW RESISTANCE
HEAVE
V= 3.150
FR = 0.25
d₁' for each segment at V= 3.150
Segment I
" II
" III
" IV
" V
" VI
" VII
d₁'

FIG. 133

-147-

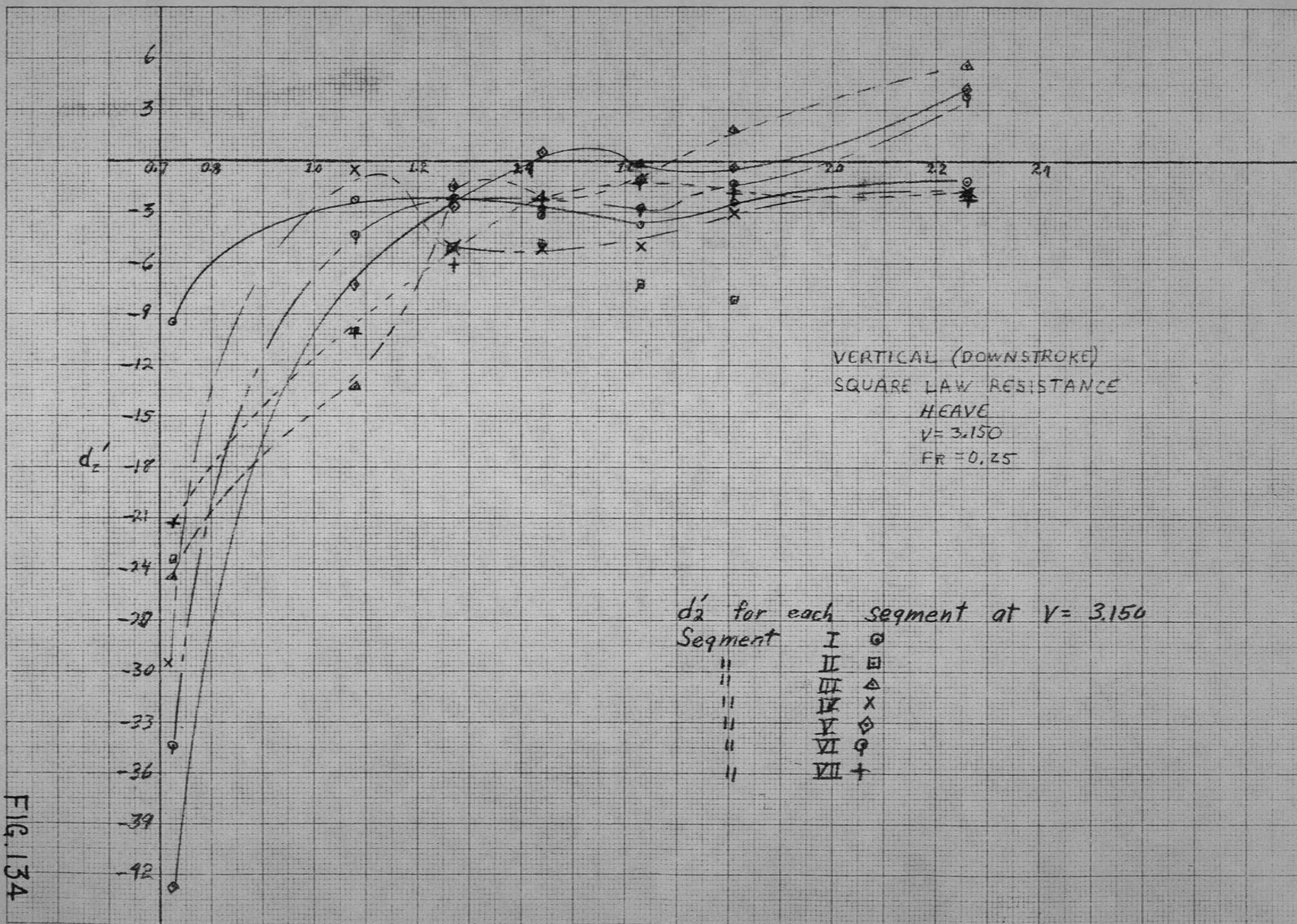

KEUFFEL & ESSER CO.
6
3
-3
-6
-9
-12
-15
-18
-21
-24
-30
-33
-36
-39
-42
0.7
0.8
1.0
1.2
1.4
2.0
2.2
2.4
d_z'
VERTICAL (DOWNSTROKE)
SQUARE LAW RESISTANCE
HEAVE
V= 3.150
FR = 0.25
d_2' for each segment at V= 3.150
Segment I
" II
" III
" IV X
" V
" VI
" VII

FIG. 134

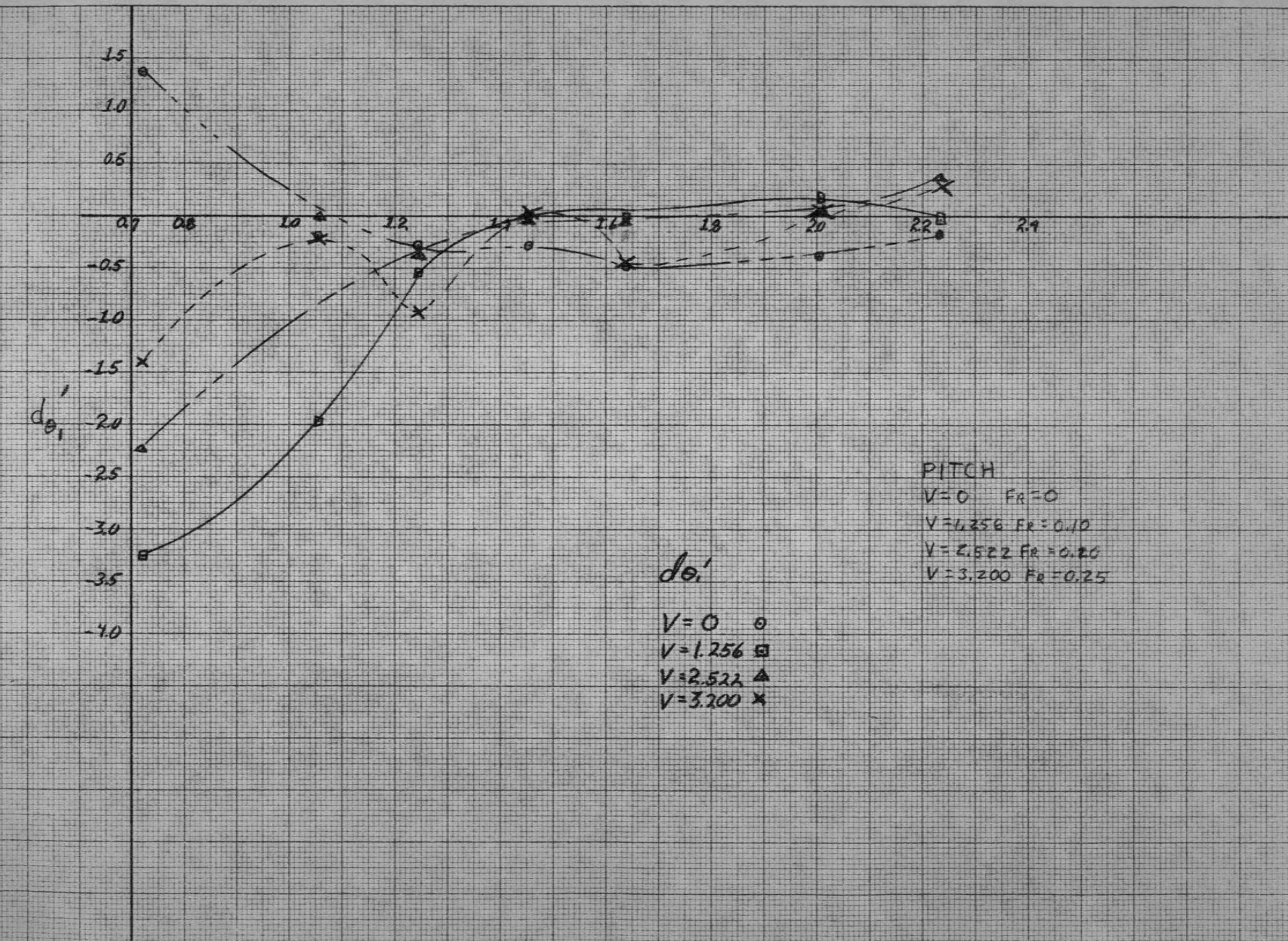
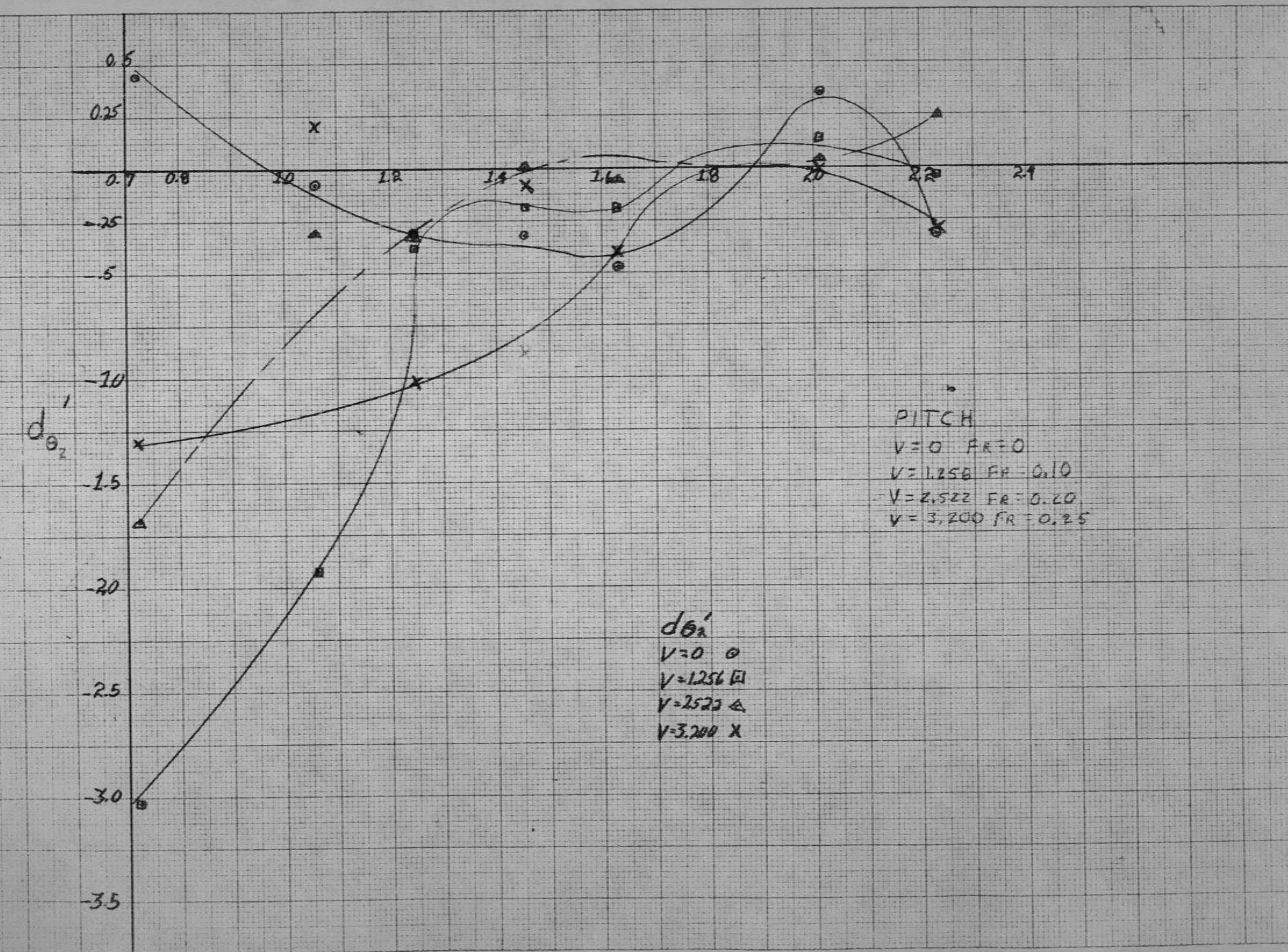
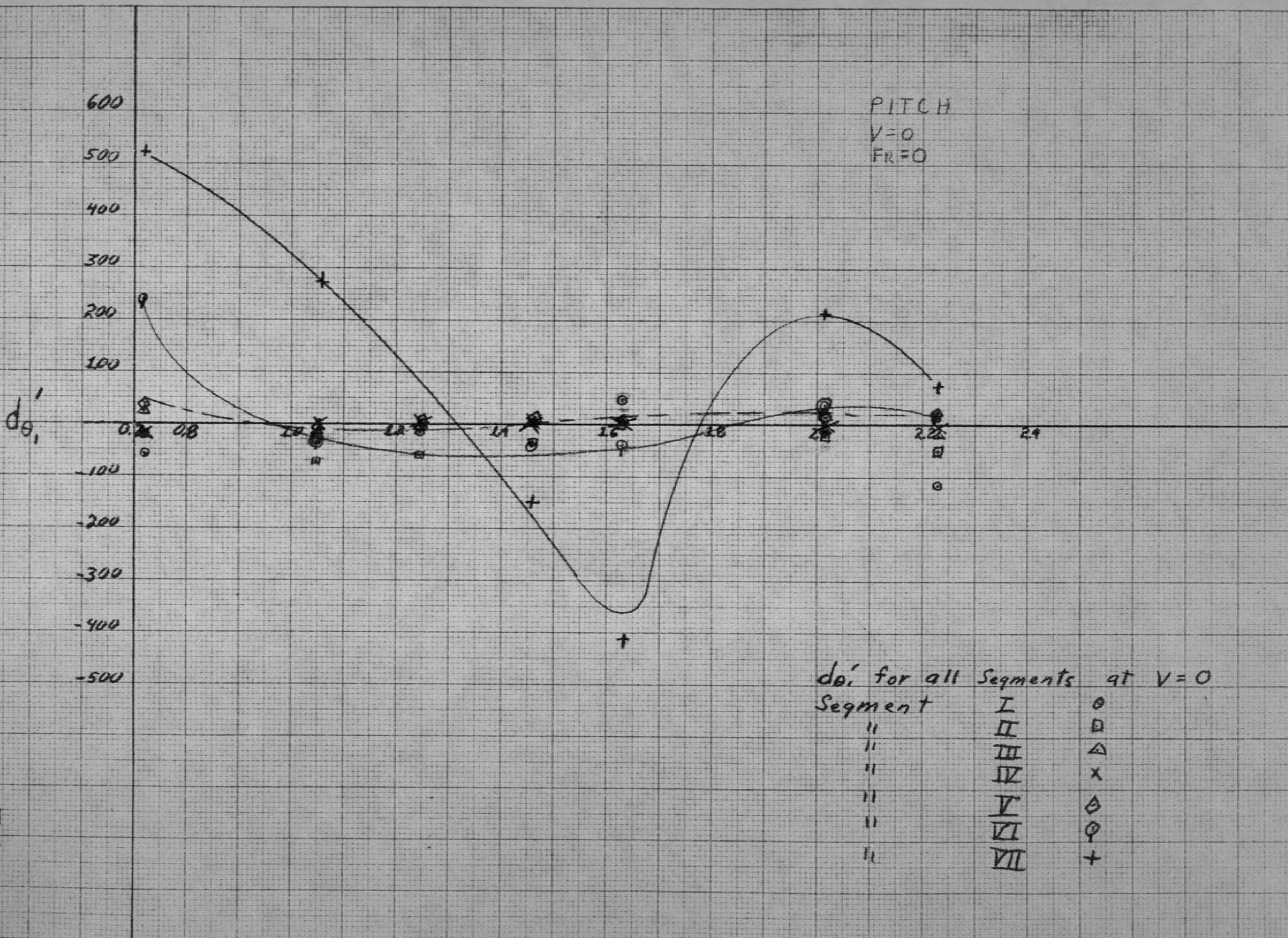

1.5
1.0
0.5
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
d_{θ_1}'
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
d_{θ_1}'
V = 0
V = 1.256
V = 2.522
V = 3.200
PITCH
V = 0 FR = 0
V = 1.256 FR = 0.10
V = 2.522 FR = 0.20
V = 3.200 FR = 0.25

FIG 134a



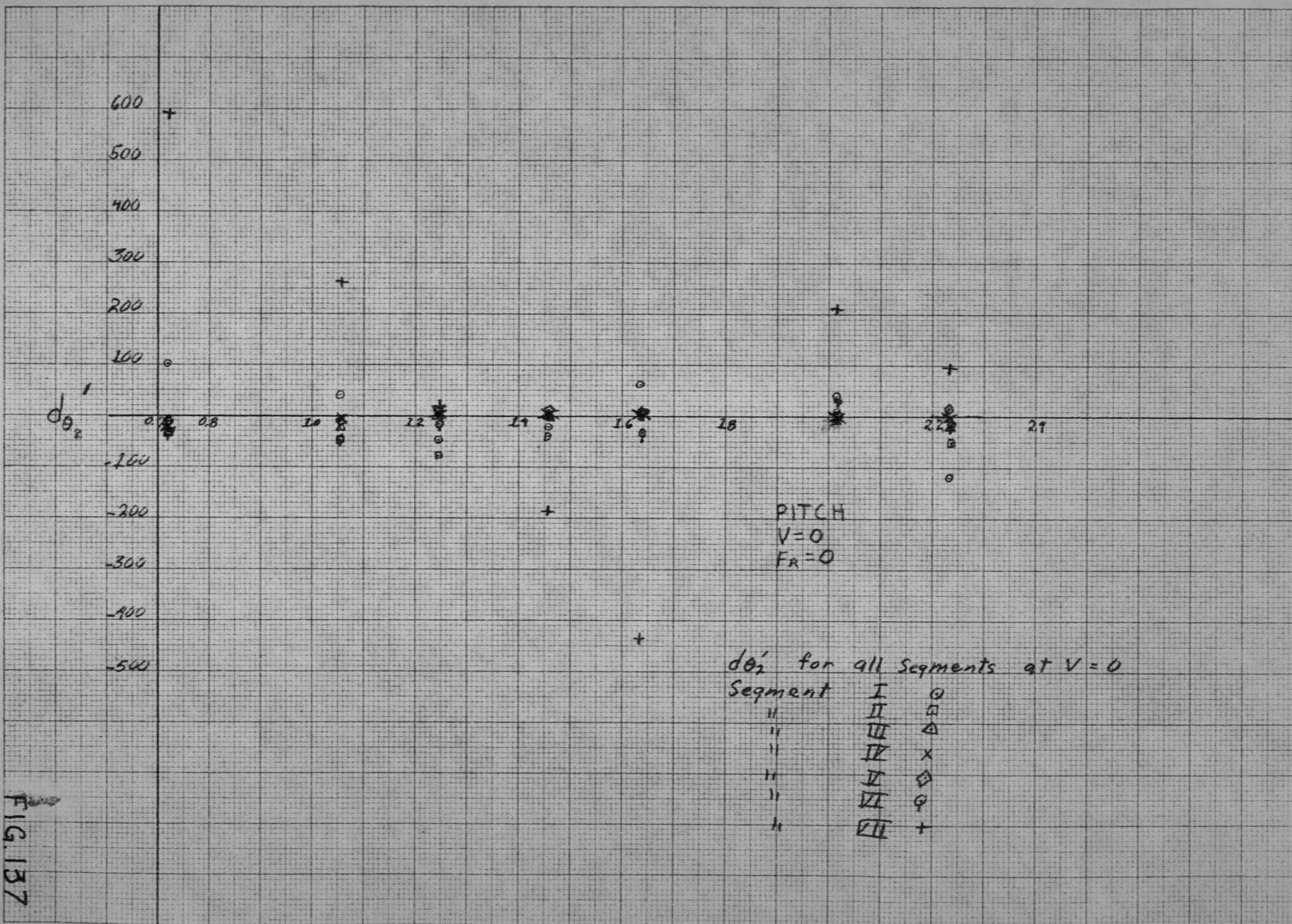
0.5
0.25
-.25
-.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
0.7 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4
d_{θ_2}'
PITCH
V = 0 FR = 0
V = 1.256 FR = 0.10
V = 2.522 FR = 0.20
V = 3.200 FR = 0.25
d_{θ_2}'
V = 0 ⊙
V = 1.256 ▣
V = 2522 △
V = 3.200 X

FIG. 135



PITCH
V=0
FR=0
600
500
400
300
200
100
-100
-200
-300
-400
-500
0.8
d_{θ_1}'
$d_{\theta i}'$ for all Segments at V = 0
Segment I
" II
" III
" IV
" V
" VI
" VII

FIG. 136



600
500
400
300
200
100
-100
-200
-300
-400
-500
d_{θ_2}'
0.8
1.0
1.2
1.4
1.6
1.8
2.2
2.4
PITCH
V=0
F_R=0
$d\theta_2'$ for all Segments at V = 0
Segment I
" II
" III
" IV
" V
" VI
" VII

FIG. 137

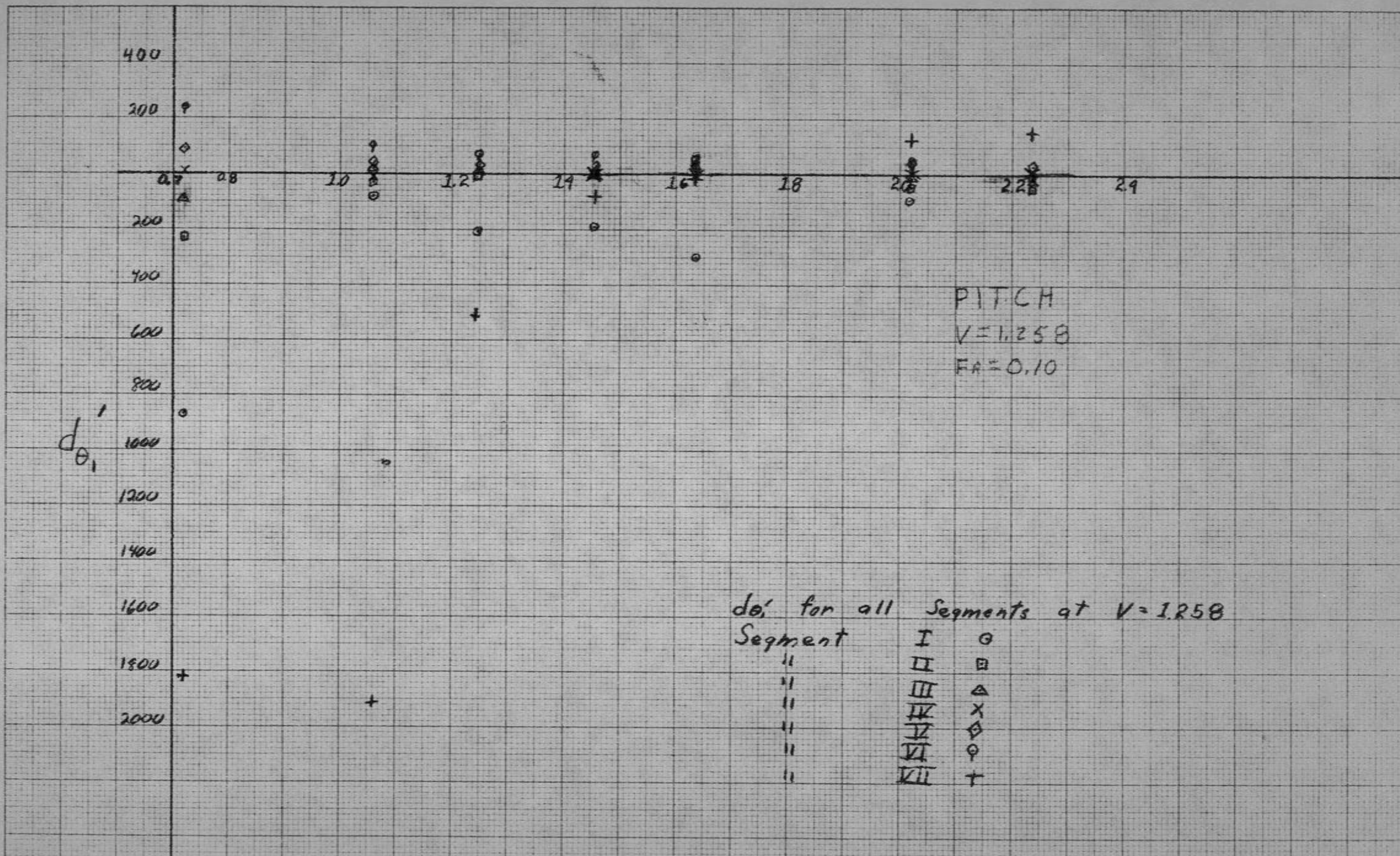
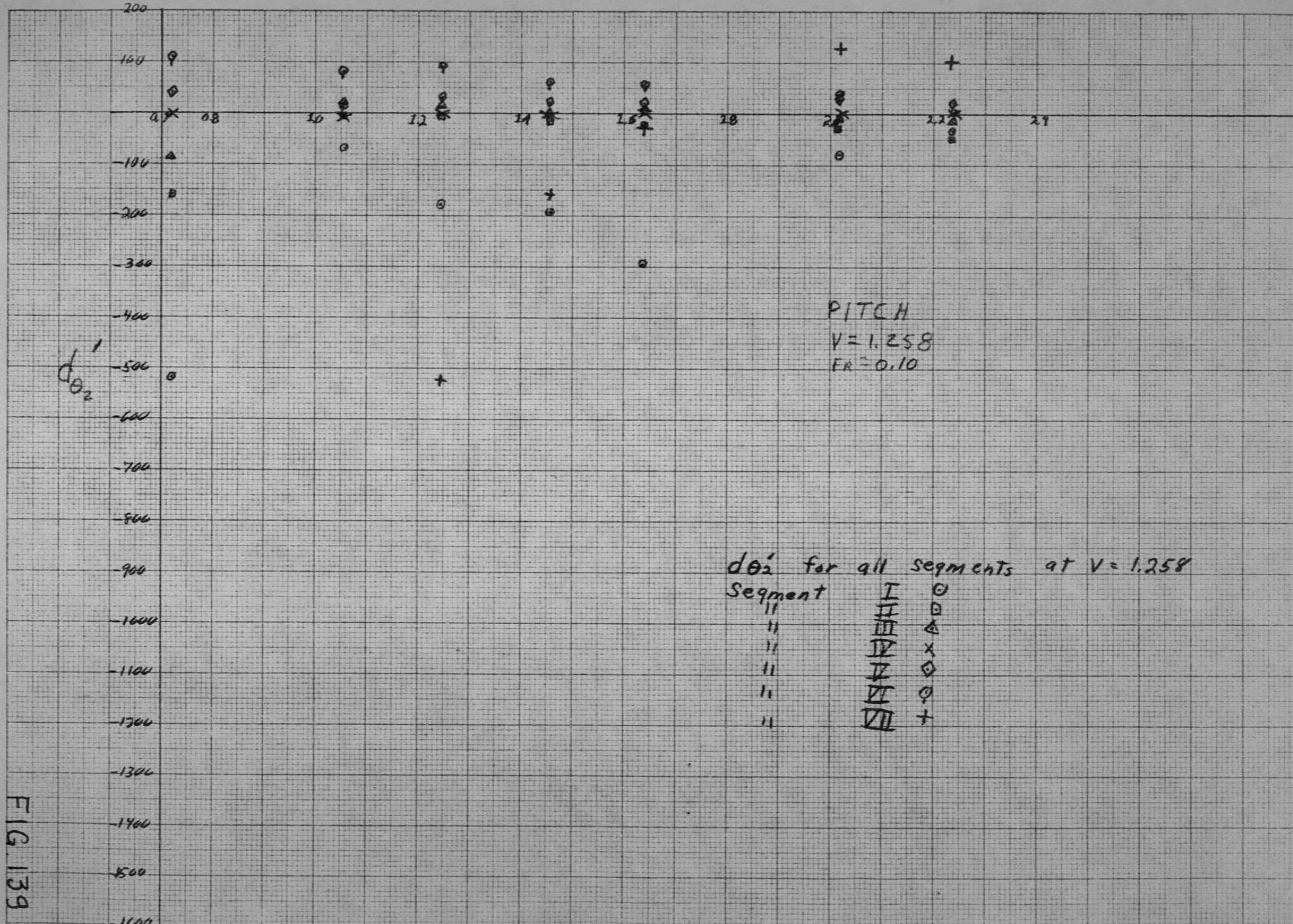

400
200
200
400
600
800
1000
1200
1400
1600
1800
2000
d'_{θ_1}
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
PITCH
V=1.258
FA=0.10
dθ' for all Segments at V=1.258
Segment I
" II
" III
" IV
" V
" VI
" VII

FIG. 138



Segment VII Pt. at −1702.8 at ω = 5
" VII Pt. at −1896.3 at ω = 1.45

FIG. 139

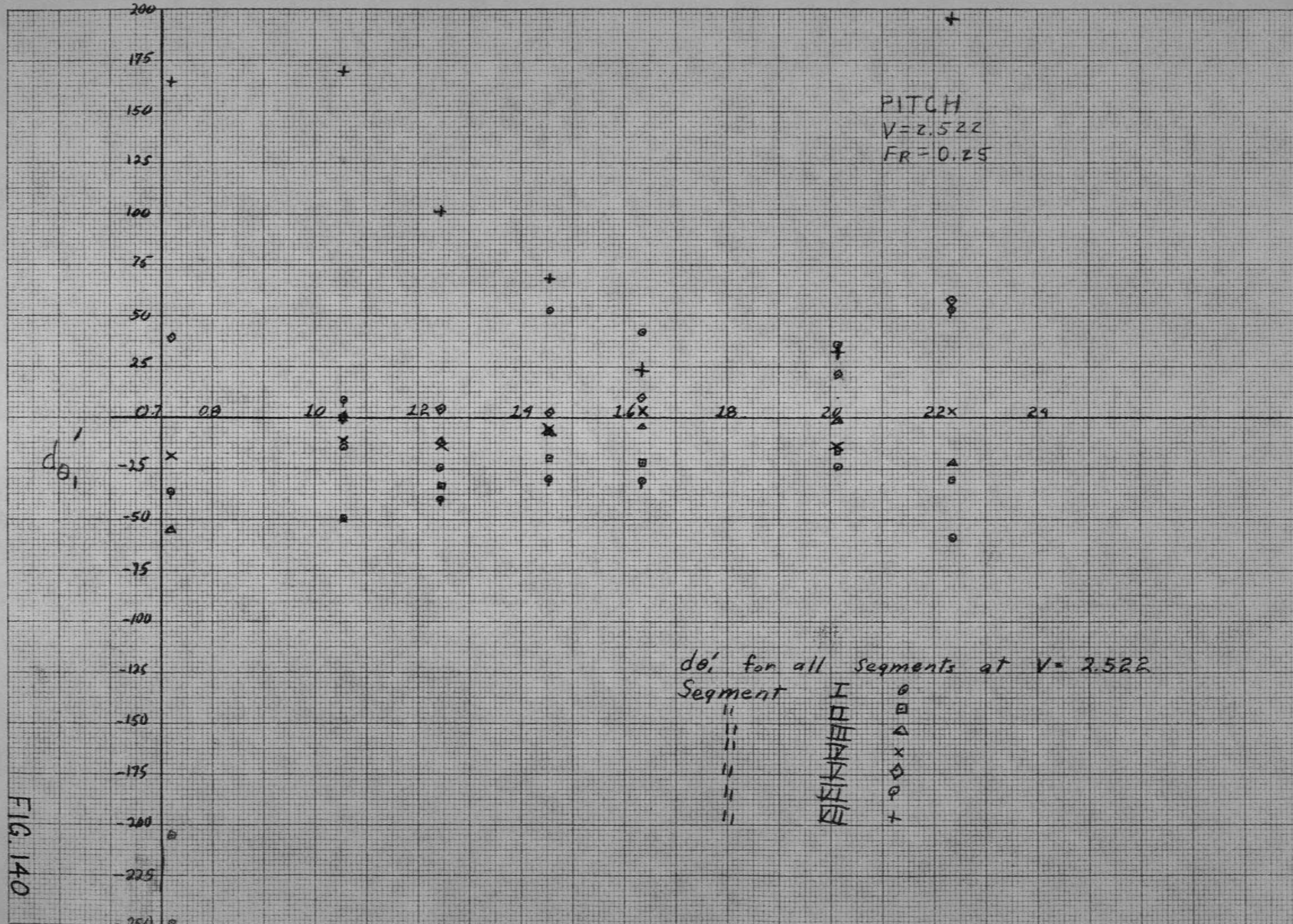
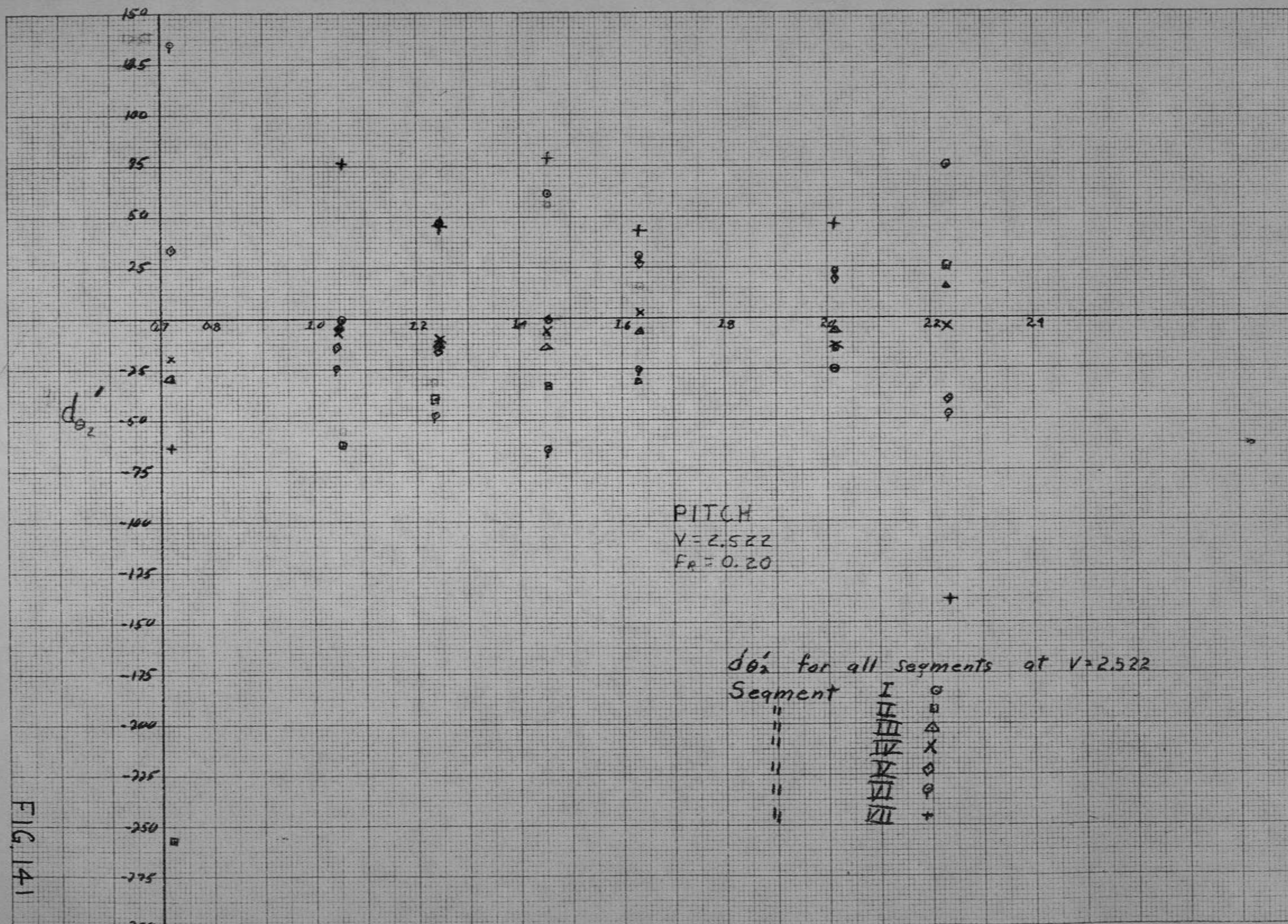


FIG. 140

Segment I Pt. at -981 at W = 5
" II Pt. at -262 " "



Segment I Pt. at -839.3 at w = 5

FIG. 141

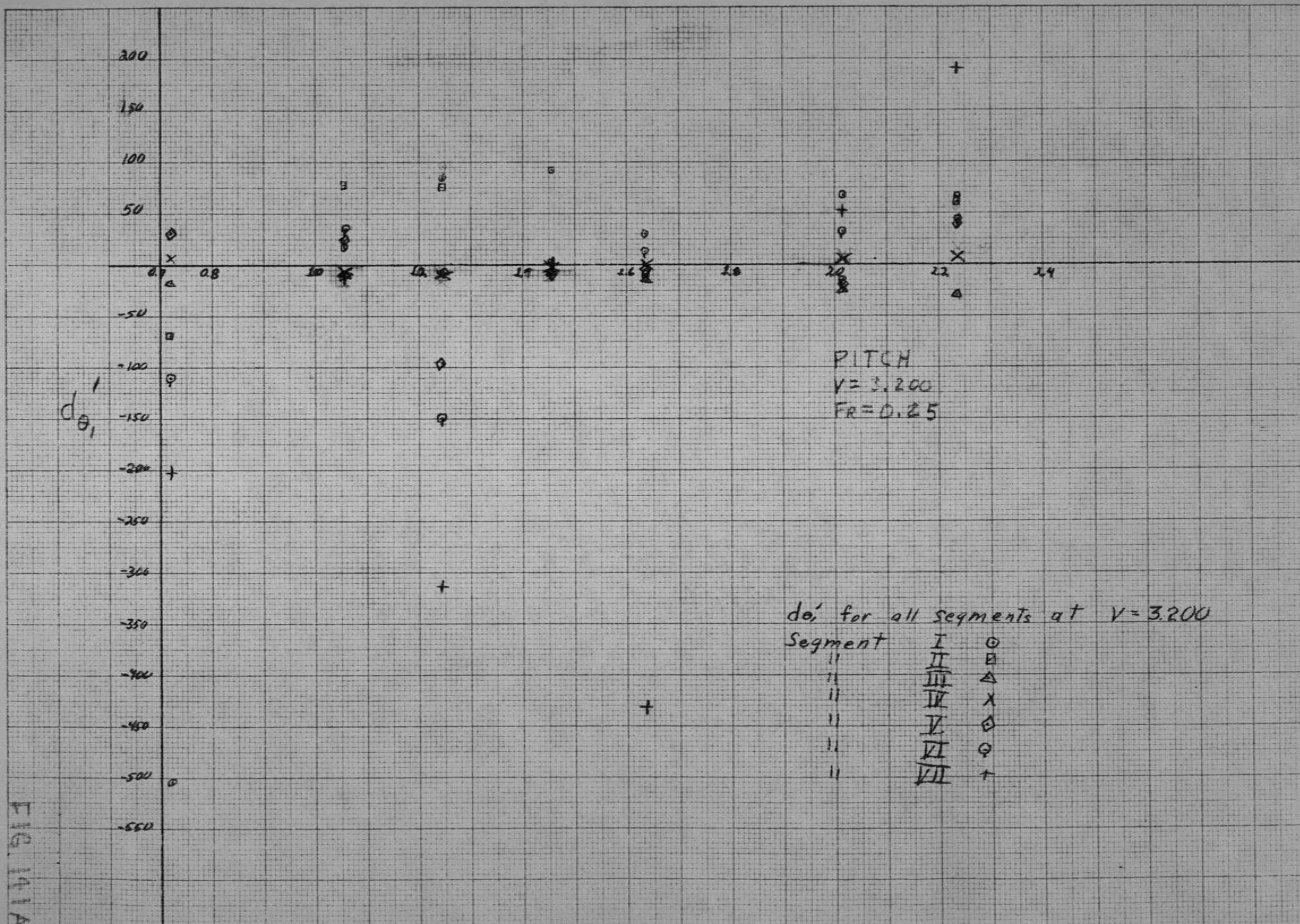

200
150
100
50
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
-550
d_{θ_1}'
PITCH
V = 3.200
FR = 0.25
$d\theta_1'$ for all segments at V = 3.200
Segment I ⊙
" II ⊡
" III △
" IV X
" V ◇
" VI Q
" VII +

FIG 14A

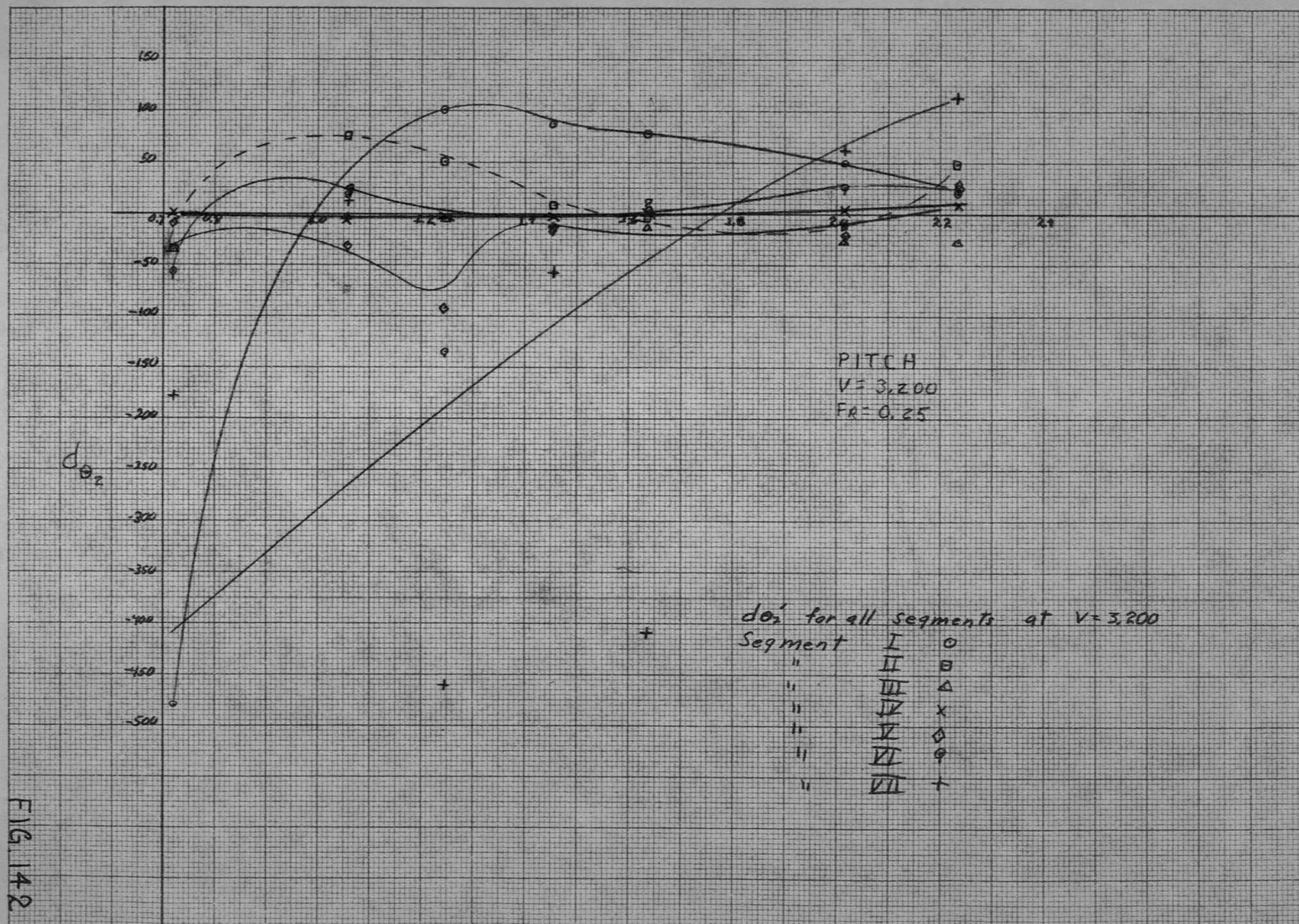
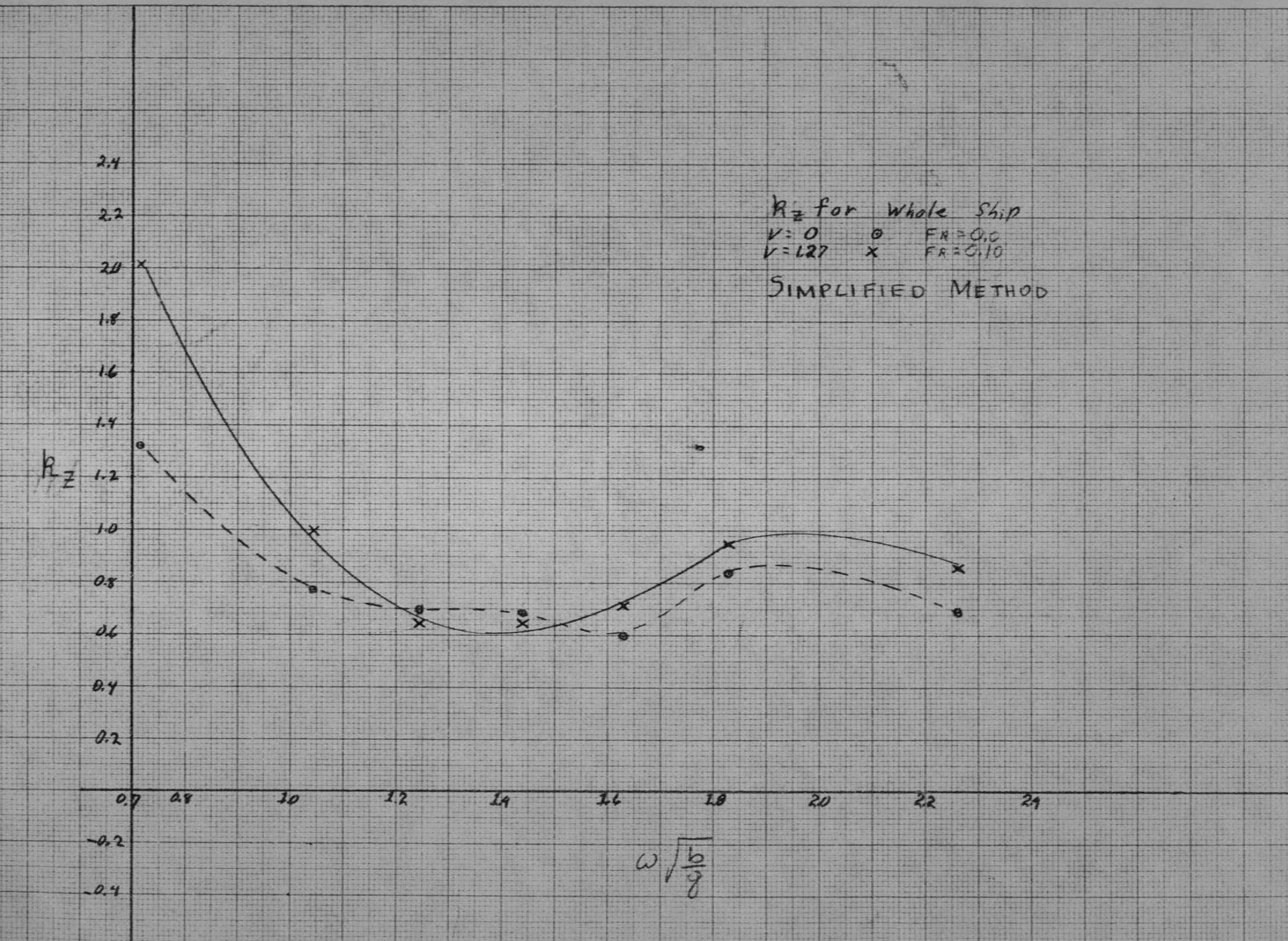
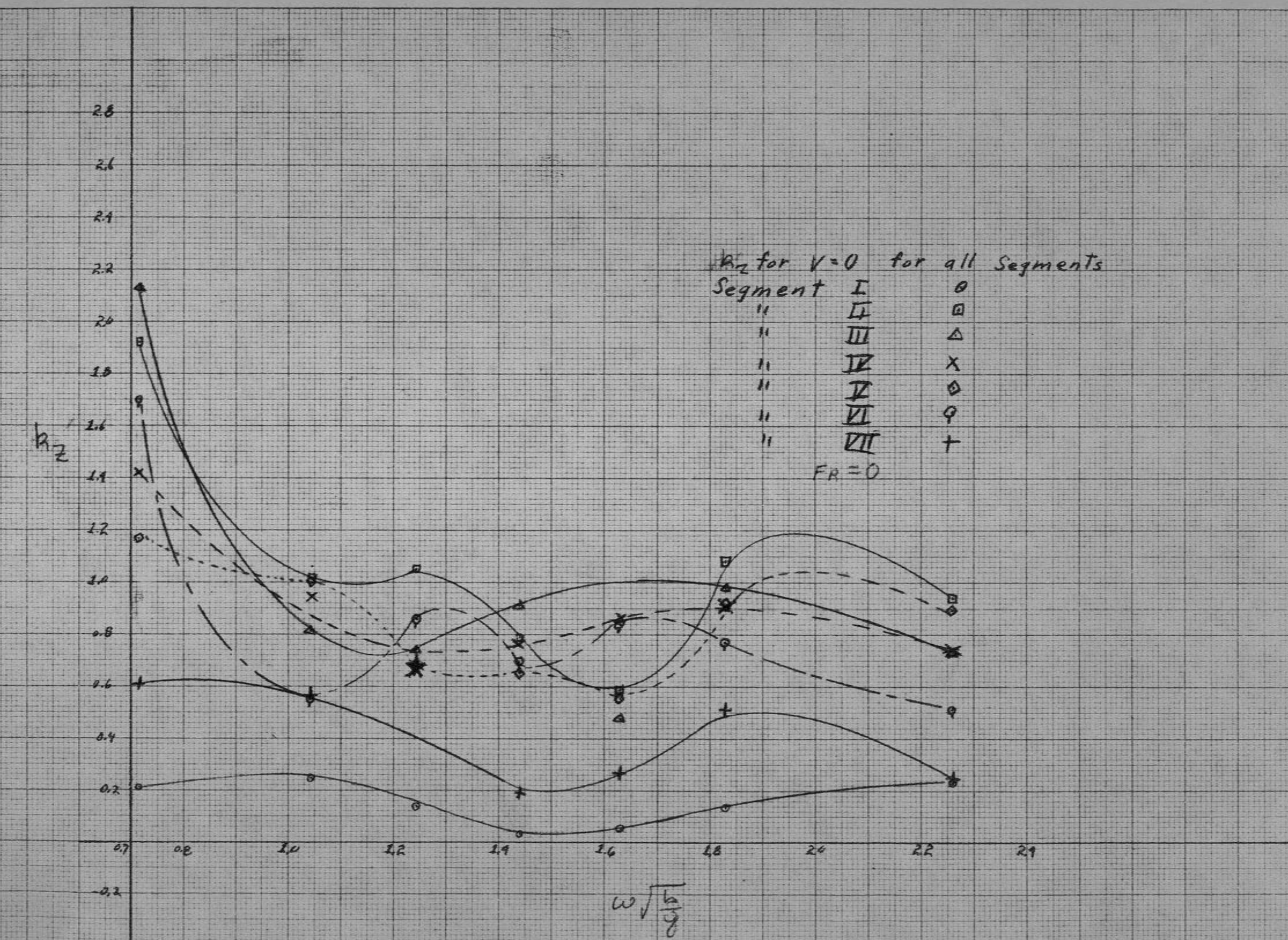

150
100
50
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
d_{θ_2}
PITCH
V = 3,200
F_R = 0.25
d_{θ_2}' for all segments at V = 3,200
Segment I ○
" II ⊟
" III △
" IV ×
" V ◇
" VI ⊘
" VII +

FIG. 142



k_z for Whole Ship
V: 0 ⊙ FR = 0.0
V = 1.27 × FR = 0.10
SIMPLIFIED METHOD
k_z
ω √(b/g)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-0.2
-0.4
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

FIG. 143



k_z for $V=0$ for all Segments
Segment I
" II
" III
" IV
" V
" VI
" VII
$F_R = 0$
k_z
$\omega\sqrt{\frac{b}{g}}$
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
-0.2
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

FIG. 144

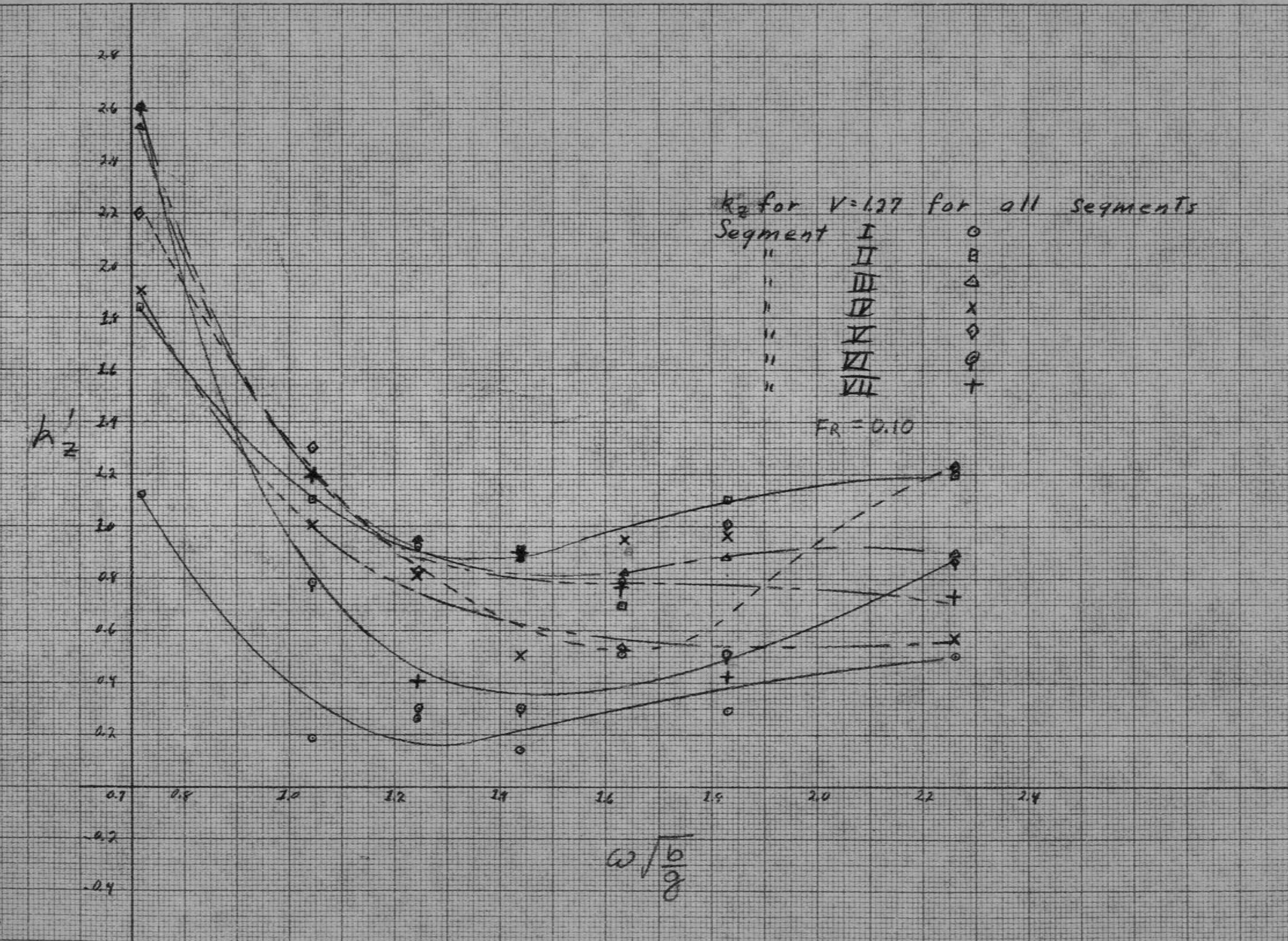
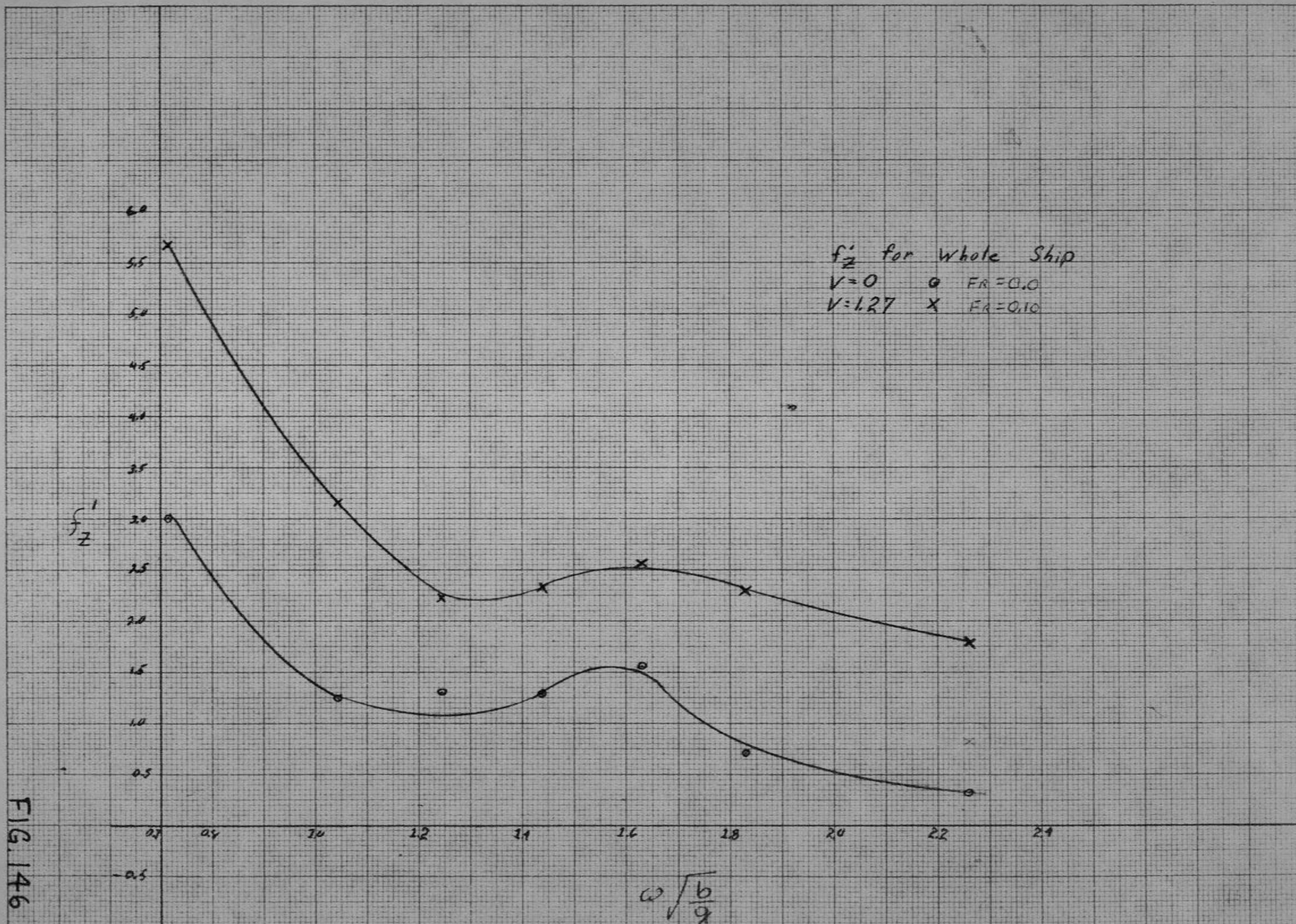

k_z for V=1.27 for all segments
Segment I ○
" II □
" III △
" IV ×
" V ◇
" VI ♀
" VII +
F_R = 0.10
k'_z
ω √(b/g)
2.8 2.6 2.4 2.2 2.0 1.8 1.6 1.4 1.2 1.0 0.8 0.6 0.4 0.2 -0.2 -0.4
0.7 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2 2.4

FIG. 145



f'z for Whole Ship
V=0 o FR=0.0
V=1.27 X FR=0.10
f'z
ω √(b/g)
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-0.5
0.2
0.4
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

FIG. 146

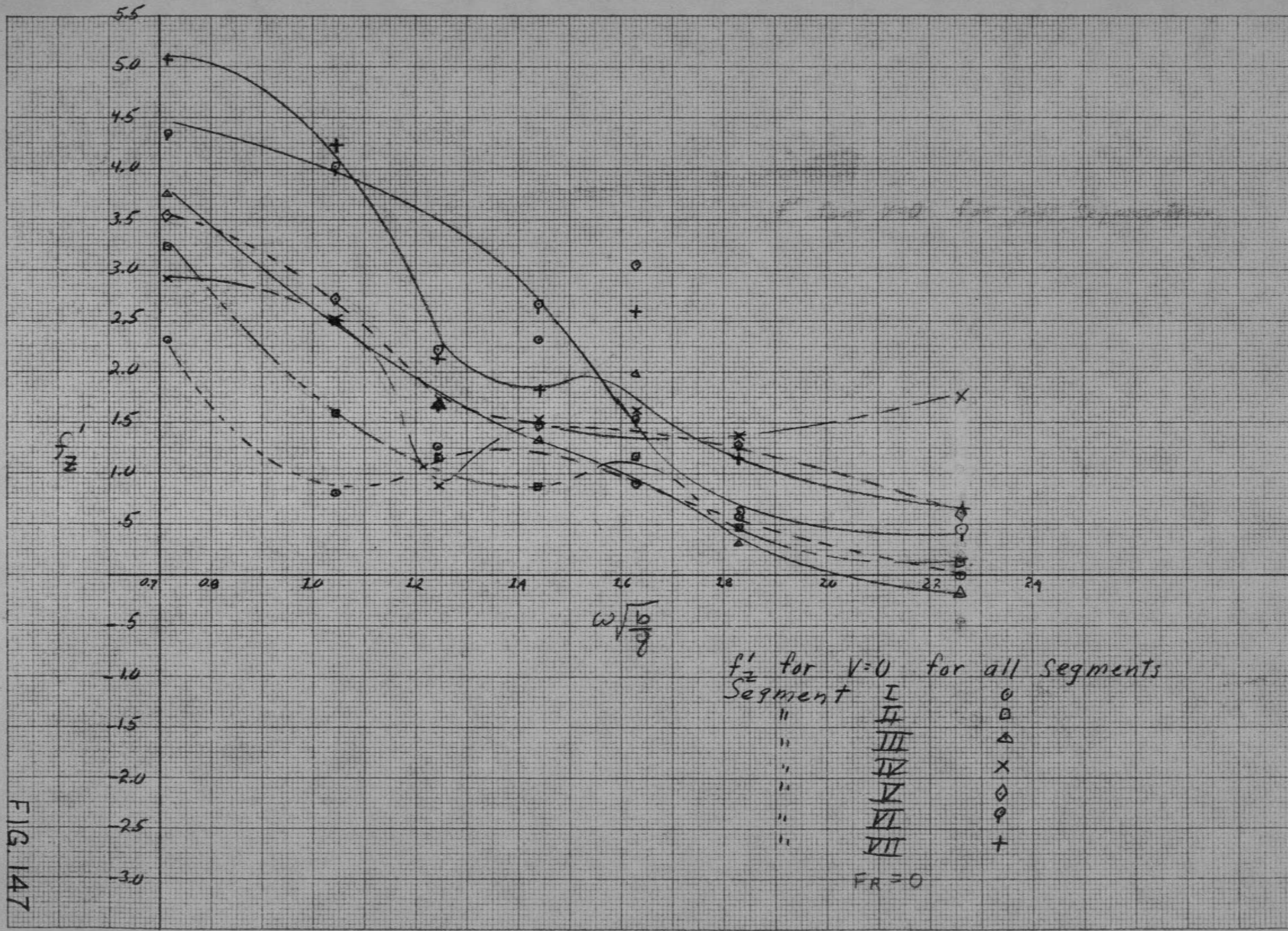
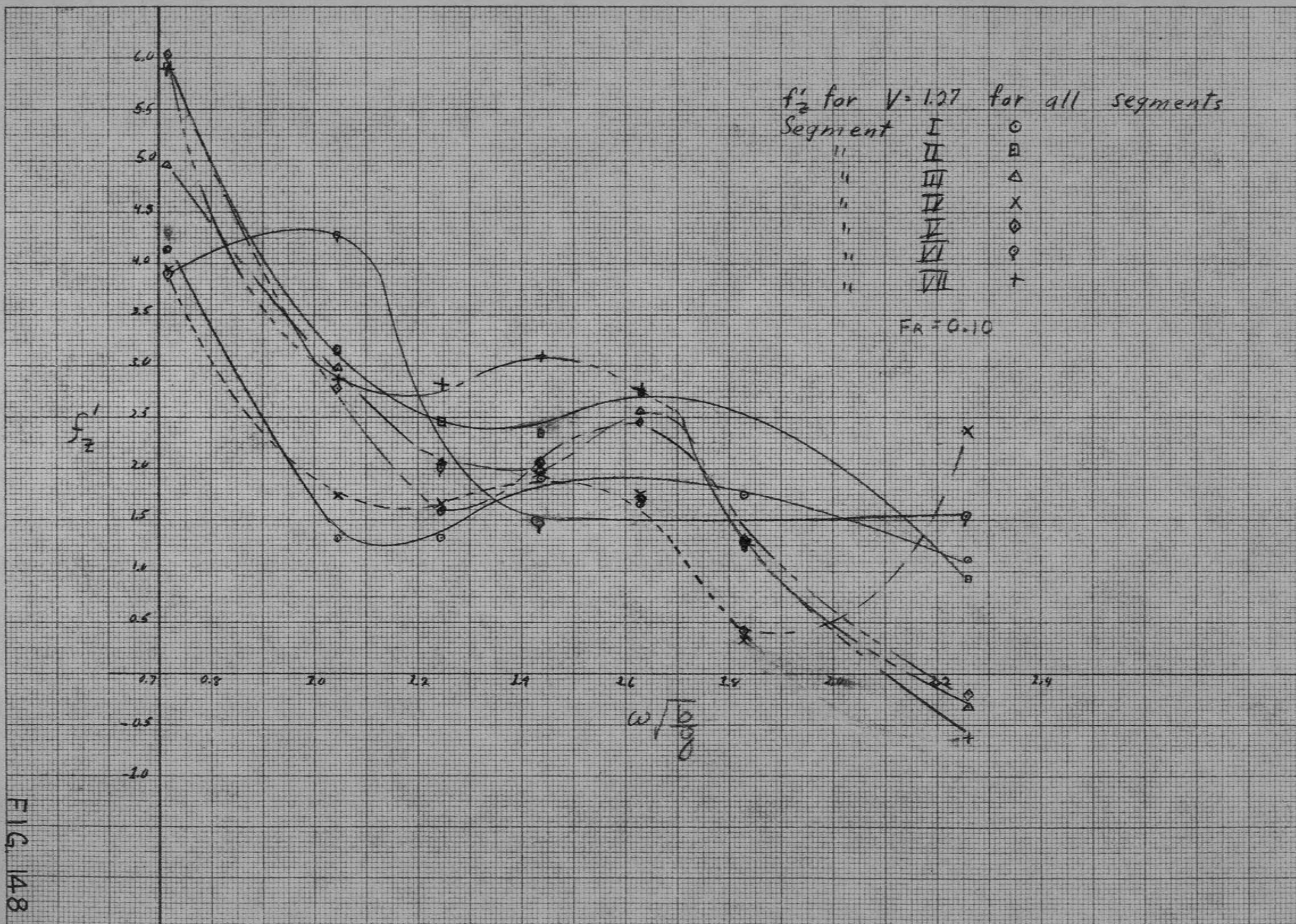

5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
-.5
-1.0
-1.5
-2.0
-2.5
-3.0
f_z'
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
$\omega\sqrt{\frac{b}{g}}$
f_z' for V=0 for all Segments
Segment I
" II
" III
" IV
" V
" VI
" VII
$F_R = 0$

FIG. 147



f'_z for V = 1.27 for all segments
Segment I ⊙
" II ⊡
" III △
" IV X
" V ◇
" VI ϙ
" VII +
FR = 0.10
f'_z
$\omega\sqrt{\frac{b}{g}}$
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-0.5
-1.0
0.7
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4

FIG. 148

TABLE 1.

MODEL PARTICULARS

	Model	Prototype
Scale Ratio	1:100.6	
L_{BP}	60"	503.0'
L_{WL}	61.17"	512.8'
Beam	8.11"	68'
Draft	3.58"	30'
Displacement, Δ	46.5 lb.	21,770 tons
	(FW)	(SW)

TABLE II

SEGMENT PARTICULARS

Segment	Weight (lb)	Mass (slugs)	Buoyancy (lb/ft)	Av. Beam (in.)	Mom. of In.* ($lb\text{-}ft^2$)	Displacement (lb)
I	2.24	0.0696	10.4	2.91	0.417	2.89
II	2.86	0.0888	26.1	6.45	0.236	2.54
III	3.00	0.0937	29.8	8.09	0.086	8.58
IV	3.09	0.0960	30.2	8.10	0.106	8.96
V	3.09	0.0960	30.0	8.11	0.086	8.78
VI	2.98	0.0919	26.9	8.02	0.244	7.20
VII	2.26	0.0702	15.3	3.96	0.322	2.58

* About WL axis through center of ship model

TABLE III

Observed Forces in Pounds (Heave)

Run 26407

ω 5.02 Rad/Sec

Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.776	-0.272	-0.291	0.0194
I A	-0.167	-0.376	-0.397	0.0209
II F	-0.269	-0.745	-0.787	0
II A	-0.427	-0.983	-1.07	0.175
III F	-0.365	-0.771	-0.751	0.122
III A	-0.347	-0.857	-0.796	0.102
IV F	-0.123	-0.676	-0.717	0.143
IV A	-0.376	-0.931	-1.01	0.119
V F	-0.410	-0.902	-0.922	0.185
V A	-0.485	-0.950	-0.907	0.380
VI F	-0.330	-0.865	-0.846	0.103
VI A	-0.453	-1.00	-0.982	0.378
VII F	-0.281	-0.617	-0.580	0.187
VII A	-0.0776	-0.310	-0.388	0.097

Run 26410

ω 5.02 Rad/Sec

Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.0970	-0.310	-0.233	0.0776
I A	-0.146	-0.397	-0.481	0.104
II F	-0.311	-0.766	-0.890	0.0621
II A	-0.446	-1.01	-1.10	0.272
III F	-0.365	-0.751	-0.751	0.142
III A	-0.388	-0.898	-0.872	0.143
IV F	-0.164	-0.554	-0.676	0.246
IV A	-0.277	-0.851	-0.931	0.00
V F	-0.348	-0.943	-0.943	0.205
V A	-0.401	-0.950	-0.950	0.464
VI F	-0.268	-0.803	-0.803	0.185
VI A	-0.453	-1.04	-1.04	0.453
VII F	-0.355	-0.729	-0.692	0.149
VII A	-0.097	-0.310	-0.427	0.136

Run 26462

ω 7.54 Rad/Sec

Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.078	-0.194	-0.213	0.058
I A	-0.209	-0.314	-0.251	0.125
II F	-0.373	-0.642	-0.621	0.124
II A	-0.601	-0.815	-0.770	0.349
III F	-0.467	-0.751	-0.670	0.386
III A	-0.428	-0.734	-0.653	0.285
IV F	-0.308	-0.656	-0.595	0.308
IV A	-0.059	-0.317	-0.277	0.693
V F	-0.420	-0.760	-0.680	0.440
V A	-0.547	-0.865	-0.781	0.422
VI F	-0.436	-0.847	-0.597	0.433
VI A	-0.529	-0.926	-0.718	0.605
VII F	-0.334	-0.468	-0.393	0.280
VII A	-0.039	-0.175	-0.194	0.097

Run 26465

ω 7.54 Rad/Sec

Fr 0

I F	-0.078	-0.175	-0.175	0.058
I A	-0.209	-0.314	-0.293	0.063
II F	-0.248	-0.745	-0.725	0.083
II A	-0.504	-0.776	-0.640	0.388
III F	-0.487	-0.629	-0.609	0.284
III A	-0.449	-0.673	-0.612	0.143
IV F	-0.246	-0.497	-0.697	0.226
IV A	-0.158	-0.554	-0.554	0.416
V F	-0.500	-0.780	-0.700	0.440
V A	-0.485	-0.844	-0.738	0.506
VI F	-0.350	-0.762	-0.515	0.453
VI A	-0.548	-0.983	-0.718	0.548
VII F	-0.393	-0.486	-0.393	0.262
VII A	-0.019	-0.175	-0.175	0

Run 26468

ω 8.80 Rad/Sec

Fr 0

I F	-0.058	-0.136	-0.097	0.116
I A	-0.042	-0.250	-0.209	0.063
II F	-0.290	-0.393	-0.310	0.124
II A	-0.640	-0.834	-0.460	0.428
III F	-0.386	-0.386	-0.345	0.183
III A	-0.265	-0.408	-0.285	0.285
IV F	-0.287	-0.410	-0.410	0.123
IV A	-0.238	-0.416	-0.390	0.158
V F	-0.560	-0.640	-0.440	0.280
V A	-0.589	-0.717	-0.338	0.338
VI F	-0.391	-0.597	-0.185	0.494
VI A	-0.737	-0.945	-0.397	0.567
VII F	-0.505	-0.561	-0.393	0.281
VII A	-0.058	-0.155	-0.177	0.233

Run 26471

ω 8.80 Rad/Sec

Fr 0

I F	-0.078	-0.116	-0.078	0.097
I A	-0.188	-0.272	-0.230	0.125
II F	-0.186	-0.352	-0.373	0.228
II A	-0.369	-0.679	-0.621	0.291
III F	-0.365	-0.420	-0.345	0.183
III A	-0.326	-0.449	-0.204	0.143
IV F	-0.266	-0.410	-0.390	0.185
IV A	-0.337	-0.396	-0.455	0.218
V F	-0.380	-0.480	-0.400	0.380
V A	-0.464	-0.570	-0.506	0.253
VI F	-0.433	-0.597	-0.412	0.536
VI A	-0.510	-0.794	-0.643	0.491
VII F	-0.411	-0.449	-0.393	0.411
VII A	-0.058	-0.058	-0.097	0.272

TABLE III (cont'd)

Run 26510
ω 10.03 Rad/Sec
Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	0	-0.058	-0.019	0.058
I A	-0.209	-0.230	-0.167	0.084
II F	-0.228	-0.228	-0.207	0.104
II A	-0.427	-0.543	-0.194	0.272
III F	-0.304	-0.244	0.142	0.183
III A	-0.224	-0.102	0.184	0.162
IV F	-0.554	-0.410	-0.164	0.144
IV A	-0.376	-0.139	0.178	0.297
V F	-0.380	-0.360	0.100	0.140
V A	-0.443	-0.295	0.084	0.274
VI F	-0.350	-0.453	0.227	0.330
VI A	-0.359	-0.472	-0.284	0.359
VII F	-0.411	-0.449	-0.262	0.337
VII A	-0.039	-0.040	-0.019	0.252

Run 26513
ω 10.03 Rad/Sec
Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.078	-0.058	-0.039	0.058
I A	-0.209	-0.209	-0.125	0.125
II F	-0.228	-0.186	-0.180	0.062
II A	-0.543	-0.460	-0.155	0.252
III F	-0.284	-0.162	-0.041	0.122
III A	-0.222	-0.102	-0.061	0.102
IV F	-0.472	-0.266	-0.082	0.184
IV A	-0.257	-0.099	0.059	0.455
V F	-0.320	-0.240	0.120	0.188
V A	-0.380	-0.253	0.021	0.316
VI F	-0.433	-0.391	-0.124	0.309
VI A	-0.510	-0.472	-0.151	0.370
VII F	-0.411	-0.355	-0.168	0.355
VII A	-0.078	-0.078	-0.078	0.213

Run 26516
ω 11.30 Rad/Sec
Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.039	0.019	0.058	-0.039
I A	-0.188	-0.084	0.021	0.063
II F	-0.207	0.062	0.269	0.083
II A	-0.427	-0.233	0.130	0.194
III F	-0.264	0.264	0.426	-0.041
III A	-0.122	0.184	0.387	-0.143
IV F	-0.369	0.164	0.430	0.246
IV A	-0.515	-0.079	0.238	0.178
V F	-0.160	0.280	0.440	0.100
V A	-0.401	0.190	0.422	0.169
VI F	-0.330	-0.185	0.144	0.288
VI A	-0.510	-0.284	0.170	0.302
VII F	-0.299	-0.224	0.056	0.449
VII A	0	0.019	0.078	0.310

Run 26519
ω 11.30 Rad/Sec
Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.019	0.039	0.058	-0.058
I A	-0.209	-0.140	-0.042	0.084
II F	-0.248	-0.104	0.041	-0.041
II A	-0.427	-0.233	0.279	0.155
III F	-0.304	0.081	0.410	0
III A	-0.245	0.224	0.428	-0.265
IV F	-0.472	0.0410	0.308	0.164
IV A	-0.218	0.198	0.475	0.370
V F	-0.200	0.200	0.420	0
V A	-0.401	-0.106	0.316	0.169
VI F	-0.350	-0.144	0.082	0.247
VI A	-0.491	-0.189	0.094	0.359
VII F	-0.393	-0.337	-0.150	0.430
VII A	-0.155	-0.175	-0.116	0.194

Run 26562
ω 12.58 Rad/Sec
Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	0.097	0.175	0.136	-0.155
I A	-0.230	0.0209	0.230	-0.0418
II F	-0.373	0.248	0.393	0
II A	-0.272	0.369	0.757	0
III F	-0.183	0.690	0.853	0
III A	0.0408	0.898	1.061	-0.122
IV F	-0.348	0.492	0.922	0.082
IV A	-0.614	0.376	0.911	0.356
V F	-0.14	0.800	1.08	-0.16
V A	-0.886	0.738	0.971	0
VI F	-0.206	0.371	0.597	0.144
VI A	-0.284	0.529	0.775	0.265
VII F	-0.337	-0.150	0.168	0.187
VII A	-0.0388	0.0388	0.0776	0.0388

Run 26565
ω 12.58 Rad/Sec
Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	0.0776	0.116	0.136	-0.136
I A	-0.125	0.0418	0.230	0.167
II F	0.104	0.207	0.435	0.207
II A	-0.155	0.504	0.737	0.0776
III F	0.0812	0.467	0.731	0.183
III A	0.612	1.000	1.224	-0.0816
IV F	-0.308	0.656	0.902	0.348
IV A	-0.277	0.455	0.871	0.495
V F	0.26	1.00	1.20	0.
V A	0.	0.928	1.097	0.126
VI F	0.	0.391	0.618	0.0824
VI A	-0.132	0.359	0.756	0.189
VII F	-0.280	-0.187	0.187	0.299
VII A	-0.0380	0.0776	0.116	0.0582

TABLE III (cont'd)

Run 26603
ω 15.70 Rad/Sec
Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	0.388	0.388	0.349	-0.310
I A	0.042	0.376	0.439	0.104
II F	0.228	0.849	0.828	-0.290
II A	0.854	1.785	1.765	0.175
III F	0.325	1.644	1.56	-0.203
III A	0.347	1.897	1.979	0.775
IV F	-0.758	1.312	2.030	1.456
IV A	-0.911	1.010	1.683	1.287
V F	0	2.220	2.280	0.360
V A	0.992	2.216	2.237	1.456
VI F	0.515	1.504	1.524	0.103
VI A	-0.113	1.096	1.096	0.586
VII F	-0.280	0.430	0.598	0.524
VII A	0	0.330	0.427	0.252

Run 26606
ω 15.70 Rad/Sec
Fr 0

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	0.330	0.466	0.388	-0.446
I A	0.314	0.460	0.522	0.104
II F	0.290	0.828	0.849	0.083
II A	1.440	2.130	2.110	0
III F	0.528	1.725	1.604	-0.771
III A	0.877	1.938	1.938	-0.592
IV F	-0.779	1.558	2.132	0.738
IV A	-0.990	1.069	1.663	0.495
V F	0.200	2.320	2.400	0.080
V A	1.667	2.237	2.237	0.211
VI F	0.680	1.586	1.504	0
VI A	0.662	1.077	1.153	0
VII F	-0.280	0.580	0.692	0.243
VII A	0.155	0.407	0.485	-0.0388

Run 27006
ω 5.02 Rad/Sec
Fr 0.1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.0194	-0.175	-0.175	0.233
I A	-0.063	-0.209	-0.167	0.418
II F	-0.104	-0.538	-0.497	0.538
II A	-0.543	-1.030	-0.873	0.582
III F	-0.365	-0.589	-0.447	0.609
III A	-0.326	-0.673	-0.551	0.490
IV F	-0.246	-0.676	-0.554	0.492
IV A	-0.158	-0.693	-0.554	0.436
V F	-0.440	-0.760	-0.600	0.640
V A	-0.464	-0.823	-0.675	0.781
VI F	-0.309	-0.577	-0.494	0.494
VI A	-0.548	-0.926	-0.775	0.529
VII F	-0.206	-0.224	-0.262	0.393
VII A	0	-0.175	-0.213	0.252

Run 27009
ω 5.02 Rad/Sec
Fr 0.1

I F	-0.097	-0.252	-0.272	0.194
I A	-0.146	-0.293	-0.251	0.293
II F	-0.186	-0.600	-0.538	0.518
II A	-0.310	-0.679	-0.563	0.892
III F	-0.264	-0.548	-0.386	0.650
III A	-0.245	-0.632	-0.551	0.449
IV F	-0.348	-0.779	-0.656	0.390
IV A	-0.139	-0.673	-0.614	0.455
V F	-0.160	-0.580	-0.360	0.840
V A	-0.211	-0.675	-0.443	0.844
VI F	-0.124	-0.412	-0.330	0.659
VI A	-0.359	-0.737	-0.586	0.832
VII F	-0.112	-0.299	-0.281	0.355
VII A	0	-0.213	-0.252	0.330

Run 26455
ω 7.54 Rad/Sec
Fr .1

I F	-0.194	-0.272	-0.272	-0.388
I A	-0.355	-0.502	-0.481	0.0627
II F	-0.186	-0.621	-0.497	0.310
II A	-0.388	-0.970	-0.737	0.504
III F	-0.365	-0.710	-0.406	0.548
III A	-0.367	-0.714	-0.510	0.306
IV F	-0.226	-0.656	-0.554	0.266
IV A	-0.277	-0.634	-0.653	0.238
V F	-0.380	-0.640	-0.480	0.620
V A	-0.485	-0.759	-0.570	0.528
VI F	-0.371	-0.556	-0.433	0.577
VI A	-0.491	-0.699	-0.586	0.586
VII F	-0.187	-0.299	-0.187	0.411
VII A	0	-0.136	-0.175	0.116

Run 26458
ω 7.54 Rad/Sec
Fr .1

I F	-0.174	-0.310	-0.252	-0.388
I A	-0.334	-0.418	-0.376	0.0627
II F	-0.352	-0.704	-0.642	0.0828
II A	-0.485	-0.795	-0.679	0.543
III F	-0.406	-0.771	-0.508	0.244
III A	-0.388	-0.775	-0.571	0.143
IV F	-0.266	-0.594	-0.472	0.328
IV A	-0.238	-0.495	-0.574	0.297
V F	-0.440	-0.660	-0.620	0.360
V A	-0.528	-0.844	-0.802	0.422
VI F	-0.453	-0.721	-0.618	0.433
VI A	-0.567	-0.883	-0.775	0.340
VII F	-0.206	-0.318	-0.224	0.374
VII A	0	-0.097	-0.213	0.175

TABLE III (cont'd)

Run 26474
ω 8.8 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.213	-0.291	-0.233	-0.039
I A	-0.230	-0.314	-0.251	0.167
II F	-0.269	-0.393	-0.310	0.331
II A	-0.601	-0.795	-0.466	0.369
III F	-0.426	-0.487	-0.365	0.162
III A	-0.286	-0.326	-0.245	0.184
IV F	-0.246	-0.287	-0.246	0.410
IV A	-0.099	-0.198	-0.218	0.535
V F	-0.340	-0.440	-0.340	0.300
V A	-0.380	-0.717	-0.506	0.211
VI F	-0.536	-0.906	-0.680	0.165
VI A	-0.624	-0.945	-0.775	0.246
VII F	-0.355	-0.393-	-0.280	0.374
VII A	-0.039	-0.116	-0.136	0.116

Run 26477
ω 8.8 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.012	-0.194	-0.175	0.058
I A	-0.146	-0.230	-0.167	0.272
II F	-0.310	-0.373	-0.269	0.186
II A	-0.601	-0.660	-0.504	0.485
III F	-0.386	-0.426	-0.264	0.223
III A	-0.143	-0.224	-0.082	0.326
IV F	-0.246	-0.348	-0.328	0.369
IV A	-0.218	-0.356	-0.337	0.317
V F	-0.420	-0.420	-0.280	0.320
V A	-0.253	-0.274	-0.211	0.549
VI F	-0.556	-0.680	-0.618	0.206
VI A	-0.416	-0.737	0.567	-0.284
VII F	-0.374	-0.486	-0.393	0.299
VII A	0	-0.078	-0.019	0.136

Run 26504
ω 10.03 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.175	-0.136	-0.078	-0.019
I A	-0.230	-0.188	-0.084	0.230
II F	-0.166	-0.083	0.062	0.310
II A	-0.524	-0.427	-0.155	0.349
III F	-0.386	-0.284	-0.061	0.148
III A	-0.163	-0.082	0.183	0.183
IV F	-0.554	-0.512	-0.348	0.041
IV A	-0.317	-0.257	-0.119	0.227
V F	-0.420	-0.240	0.060	0.060
V A	-0.359	-0.316	-0.148	0.106
VI F	-0.350	-0.494	-0.330	0.144
VI A	-0.510	-0.624	-0.491	0.265
VII F	-0.393	-0.374	-0.243	0.337
VII A	0	-0.058	-0.019	0.194

Run 26507
ω 10.03 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.155	-0.116	-0.078	0.019
I A	-0.251	-0.314	-0.167	0.167
II F	-0.269	-0.248	-0.083	0.228
II A	-0.679	-0.382	-0.233	0.310
III F	-0.183	-0.102	0.102	0.264
III A	-0.286	-0.163	0.041	0.082
IV F	-0.266	-0.246	-0.102	0.348
IV A	-0.238	-0.257	-0.059	0.218
V F	-0.140	-0.020	0.200	0.180
V A	-0.211	-0.169	0.063	0.253
VI F	-0.371	-0.515	-0.350	0.165
VI A	-0.529	-0.699	-0.567	0.302
VII F	-0.224	-0.224	-0.112	0.374
VII A	-0.019	0	0.019	0.194

Run 26523
ω 11.30 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.019	0	0.058	0.019
I A	-0.355	-0.251	-0.042	0.167
II F	-0.455	-0.310	-0.062	0
II A	-0.776	-0.272	0.077	0.213
III F	-0.426	-0.264	0.020	0
III A	0	0.245	0.408	0
IV F	-0.389	0.184	0.451	0.369
IV A	-0.436	0.059	0.337	0.277
V F	-0.580	-0.220	0.040	-0.160
V A	-0.063	0.359	0.675	0.443
VI F	-0.144	-0.041	0.144	0.165
VI A	-0.019	0.132	0.208	0.624
VII F	-0.355	-0.205	-0.019	0.337
VII A	-0.019	0	0.019	0.233

Run 26556
ω 12.56 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	0.058	0.155	0.213	0
I A	-0.251	-0.063	0.167	0.272
II F	-0.331	0.062	0.352	0.228
II A	0	0.388	0.757	0.213
III F	0	0.365	0.650	-0.203
III A	0.184	0.673	0.938	-0.347
IV F	-0.472	0.492	0.943	0.472
IV A	-0.495	0.396	0.871	0.416
V F	-0.160	1.160	1.260	-0.260
V A	0.274	1.055	1.139	0.190
VI F	0.062	0.330	0.494	-0.103
VI A	0.038	0.454	0.510	0.246
VII F	-0.299	-0.206	0.019	0.094
VII A	0.097	0.097	0.097	0.019

TABLE III (cont'd)

Run 26559
ω 12.56 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.175	-0.097	0.038	-0.194
I A	-0.460	-0.314	-0.063	0.021
II F	-0.352	-0.124	0.310	-0.041
II A	-0.407	0	0.660	0
III F	-0.508	0.102	0.365	-0.386
III A	-0.265	0.204	0.469	-0.204
IV F	-0.102	0.636	1.025	0.410
IV A	-0.238	0.455	0.752	0.535
V F	0.240	0.960	1.120	-0.160
V A	0.401	0.654	0.907	-0.232
VI F	-0.062	0.144	0.391	-0.206
VI A	0	0.208	0.491	0.189
VII F	-0.299	-0.187	0.075	0.168
VII A	0.116	0.116	0.155	0.155

Run 26609
ω 15.7 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	0.116	0.272	0.388	-0.349
I A	-0.376	0.125	0.543	0
II F	-0.248	0.662	0.828	-0.580
II A	-0.213	1.164	1.862	-1.048
III F	0.203	1.380	1.360	-1.340
III A	0	1.652	1.673	-1.489
IV F	0.512	0.984	1.988	1.086
IV A	-1.208	0.752	1.584	0.713
V F	-0.280	1.840	2.180	-0.520
V A	0.190	1.561	2.173	0
VI F	0.247	1.236	1.627	-0.556
VI A	0	0.850	0.850	-1.190
VII F	-0.168	0.187	0.598	-0.168
VII A	0.116	0.407	0.466	-0.155

Run 26612
ω 15.7 Rad/Sec
Fr .1

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	0.097	0.485	0.524	-0.310
I A	-0.481	0.334	0.522	0.146
II F	-0.145	0.911	1.076	-0.476
II A	0.136	1.804	2.056	-0.601
III F	0.974	1.644	1.806	-0.995
III A	1.102	1.714	1.958	-0.816
IV F	-1.066	1.189	2.112	0.184
IV A	-0.911	0.950	1.960	0.297
V F	0.660	2.580	2.600	1.020
V A	0.232	2.384	2.469	-0.717
VI F	0.948	1.566	1.710	-0.721
VI A	0.662	0.926	0.945	-1.190
VII F	-0.411	0.447	0.598	-0.262
VII A	0.213	0.562	0.660	-0.194

Run 26423
ω 5.02 Rad/Sec
Fr .2

I F	-0.116	-0.291	-0.291	0.058
I A	-0.188	-0.376	-0.355	0.251
II F	-0.538	-0.952	-0.952	0.041
II A	-0.854	-1.436	-1.261	0.136
III F	-0.406	-0.893	-0.812	0.142
III A	-0.551	-1.000	-0.979	0.204
IV F	-0.328	-0.861	-0.861	0.020
IV A	-0.337	-0.832	-0.990	-0.079
V F	-0.440	-0.860	-0.820	0.200
V A	-0.549	-0.950	-0.928	0.211
VI F	-0.350	-0.700	-0.680	0.165
VI A	-0.416	-0.850	-0.832	0.284
VII F	-0.150	-0.299	-0.299	0.187
VII A	-0.058	-0.136	-0.194	0.078

Run 26426
ω 5.02 Rad/Sec
Fr .2

I F	-0.310	-0.291	-0.330	0.019
I A	-0.042	-0.732	-0.710	-0.063
II F	-0.310	-0.869	-0.911	0.145
II A	-0.621	-1.067	-1.183	0.369
III F	-0.487	-0.893	-0.914	0.203
III A	-0.408	-0.938	-1.000	0.163
IV F	-0.144	-0.717	-0.738	0.287
IV A	-0.099	-0.673	-0.851	0.099
V F	-0.240	-0.780	-0.740	0.380
V A	-0.422	-0.992	-0.928	0.422
VI F	-0.515	-0.989	-0.927	0.
VI A	-0.586	-1.247	-1.210	0
VII F	-0.131	-0.337	-0.318	0.187
VII A	0.039	-0.175	-0.252	0.155

Run 26449
ω 7.54 Rad/Sec
Fr .2

I F	-0.233	-0.330	-0.291	0.019
I A	-0.355	-0.481	-0.397	0.188
II F	-0.435	-0.807	-0.745	0.166
II A	-0.718	-1.222	-0.989	0.291
III F	-0.487	-0.690	-0.589	0.244
III A	-0.388	-0.816	-0.694	0.082
IV F	-0.308	-0.697	-0.676	0.266
IV A	-0.277	-0.574	-0.653	0.040
V F	-0.540	-0.980	-0.880	0.140
V A	-0.549	-0.907	-0.823	0.253
VI F	-0.433	-0.886	-0.824	0.185
VI A	-0.605	-1.304	-1.266	0.057
VII F	-0.580	-0.673	-0.561	0.112
VII A	-0.039	-0.233	-0.272	0.155

TABLE III (cont'd)

Run 26452

ω 7.54 Rad/Sec

Fr .2

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.252	-0.349	-0.310	0
I A	-0 209	-0.418	-0.314	0.251
II F	-0.518	-0.807	-0.725	0.083
II A	-0.873	-1.145	-0.989	0.155
III F	-0.508	-0.771	-0.629	0.264
III A	-0.408	-0.857	-0.714	0.143
IV F	-0.389	-0.636	-0.594	0.184
IV A	-0.257	-0.594	-0.614	0.099
V F	-0.380	-0.700	-0.680	0.340
V A	-0.528	-0.886	-0.823	0.316
VI F	-0.494	-0.845	-0.762	0.185
VI A	-0.624	-0.945	-0.926	0.246
VII F	-0.411	-0.468	-0.411	0.243
VII A	-0.039	-0.213	-0.219	0.155

Run 26480

ω 8.80 Rad/Sec

Fr .2

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.349	-0.388	-0.291	0
I A	-0.314	-0.355	-0.230	0.251
II F	-0.538	-0.580	-0.393	0.352
II A	-0.718	-0.854	-0.660	0.504
III F	-0.386	-0.365	-0.223	0.325
III A	-0.388	-0.367	-0.224	0.245
IV F	-0.328	-0.512	-0.348	0.226
IV A	-0.099	-0.297	-0.277	0.297
V F	-0.520	-0.660	-0.440	0.340
V A	-0.359	-0.528	-0.485	0.232
VI F	-0.536	-0.762	-0.659	0.124
VI A	-0.642	-1.020	-0.850	0.132
VII F	-0.393	-0.542	-0.449	0.168
VII A	-0.058	-0.213	-0.252	0.058

Run 26483

ω 8.80 Rad/Sec

Fr .2

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.116	-0.213	-0.175	0.077
I A	-0.272	-0.355	-0.104	0.293
II F	-0.518	-0.518	-0.310	0.228
II A	-0.757	-1.028	-0.543	0.310
III F	-0.386	-0.406	-0.223	0.142
III A	-0.388	-0.428	-0.245	0.163
IV F	-0.430	-0.472	-0.348	0.144
IV A	-0.218	-0.455	-0.317	0.198
V F	-0.640	-0.760	-0.400	0.180
V A	-0.422	-0.549	-0.338	0.232
VI F	-0.556	-0.742	-0.577	0.247
VI A	-0.378	-0.794	-0.662	0.265
VII F	-0.430	-0.467	-0.355	0.224
VII A	0	-0.155	-0.155	0.155

Run 26498

ω 10.03

Fr .2

I F	-0.136	-0.078	0	0.116
I A	-0.397	-0.355	-0.209	0.230
II F	-0.621	-0.518	-0.228	0.166
II A	-0.737	-0.757	-0.407	0.291
III F	-0.203	-0.081	0.162	0.264
III A	-0.286	-0.020	0.143	0.040
IV F	-0.410	-0.205	0.020	0.390
IV A	-0.178	-0.158	0	0.317
V F	-0.440	-0.340	-0.020	0.020
V A	-0.253	-0.274	-0.063	0.106
VI F	-0.268	-0.412	-0.268	0.103
VI A	-0.397	-0.643	-0.416	0.113
VII F	-0.187	-0.355	-0.224	0.243
VII A	0	-0.039	-0.058	0.136

Run 26501

ω 10.03

Fr .2

I F	-0.136	-0.116	-0.039	0.136
I A	-0.439	-0.355	-0.167	0.272
II F	-0.600	-0.538	-0.331	0.186
II A	-0.795	-0.737	-0.446	0.272
III F	-0.304	-0.162	0.102	0.284
III A	-0.367	-0.183	0	0.102
IV F	-0.410	-0.184	0.020	0.430
IV A	-0.317	-0.158	-0.019	0.336
V F	-0.460	-0.360	-0.060	0.220
V A	-0.316	-0.295	-0.021	0.232
VI F	-0.144	-0.412	-0.268	0.206
VI A	-0.416	-0.529	-0.435	0.113
VII F	-0.299	-0.337	-0.187	0.337
VII A	-0.078	-0.116	-0.116	0.155

Run 26532

ω 11.30

Fr .2

I F	-0.213	-0.116	-0.039	0.039
I A	-0.397	-0.334	-0.042	0.334
II F	-0.600	-0.373	0.062	0.393
II A	-0.485	-0.097	0.543	0.543
III F	-0.426	-0.162	0.304	0.061
III A	0.041	0.408	0.592	0
IV F	-0.369	0.	0.533	0.430
IV A	-0.238	-0.059	0.416	0.495
V F	-0.420	-0.140	0.240	-0.120
V A	-0.654	0.021	0.190	-0.253
VI F	-0.041	-0.103	0.082	-0.103
VI A	-0.132	0	0.076	0.038
VII F	-0.205	-0.243	-0.112	0.112
VII A	0	-0.019	-0.019	0

TABLE III (cont'd)

Run 26535

ω 11.30 Rad/Sec

Fr .2

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.097	-0.019	0.058	0.058
I A	-0.397	-0.292	-0.042	0.292
II F	-0.414	-0.207	0.145	0.310
II A	-0.757	-0.369	0.155	0.369
III F	-0.142	0.081	0.466	0.264
III A	0.082	0.530	0.673	0.122
IV F	-0.472	-0.123	0.348	0.348
IV A	-0.297	0.059	0.356	0.396
V F	-0.180	0.200	0.500	0.080
V A	-0.084	0.100	0.338	0
VI F	-0.082	-0.103	0.062	-0.103
VI A	-0.208	-0.151	0	0.170
VII F	-0.243	-0.205	-0.093	0.187
VII A	-0.019	0	-0.019	0.078

Run 26550

ω 12.72 Rad/Sec

Fr .2

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.349	0	0.097	-0.058
I A	-0.460	-0.355	0.188	0.272
II F	-0.497	-0.166	0.518	0.373
II A	-0.543	0.213	0.892	0.175
III F	-0.162	0.670	0.792	0.102
III A	-0.041	0.775	0.918	-0.122
IV F	-0.308	0.656	0.902	0.390
IV A	-0.079	0.535	0.931	0.437
V F	-0.340	0.660	0.800	-0.340
V A	0.148	0.781	0.928	-0.232
VI F	0.041	0.227	0.288	-0.330
VI A	0.076	0.378	0.416	-0.189
VII F	-0.094	-0.056	0.075	0.094
VII A	0.078	0.058	0.058	0

Run 26553

ω 12.72 Rad/Sec

Fr .2

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.155	0.039	0.078	-0.039
I A	-0.460	-0.251	0.251	0.355
II F	-0.310	0.186	0.683	0.352
II A	-0.524	0.136	0.737	0
III F	0.081	0.528	0.771	-0.386
III A	0.204	0.530	0.653	-0.714
IV F	-0.226	0.718	1.046	0.431
IV A	-0.277	0.574	0.891	0.614
V F	0.340	0.980	1.120	-0.140
V A	0.446	0.717	0.865	0
VI F	0.124	0.268	0.330	-0.330
VI A	0	0.227	0.265	-0.227
VII F	-0.243	-0.112	0.075	-0.094
VII A	0.078	0.136	0.155	0.116

Run 26615

ω 15.39 Rad/Sec

Fr .2

I F	-0.097	0.310	0.330	-0.213
I A	-0.481	0.167	0.543	0
II F	-0.290	0.518	1.035	0
II A	-0.194	1.668	1.843	-0.291
III F	0.325	1.482	1.644	-0.264
III A	0.979	1.754	1.877	-1.040
IV F	-0.800	1.496	2.214	0.410
IV A	-0.752	0.871	1.822	0.337
V F	-0.800	2.520	2.560	0.200
V A	0.992	2.237	2.279	-0.485
VI F	0.494	1.360	1.401	-0.762
VI A	0.529	0.813	0.643	-1.058
VII F	-0.131	0.411	0.393	-0.224
VII A	0.446	0.601	0.601	-0.131

Run 26618

ω 15.47 Rad/Sec

Fr .2

I F	0.078	0.466	0.504	-0.039
I A	0	0.397	0.899	0.606
II F	-0.373	0.600	0.973	0
II A	0.175	1.630	1.998	-0.640
III F	0.832	1.705	1.726	-0.893
III A	1.020	1.877	1.928	-0.510
IV F	0.061	0.964	2.091	0.882
IV A	-0.515	0.673	1.624	0.436
V F	0	2.200	2.220	-0.680
V A	0	2.131	2.173	-0.506
VI F	0.124	1.195	1.236	-0.536
VI A	0.378	0.510	0.529	-0.643
VII F	0.150	0.355	0.374	-0.131
VII A	0.233	0.446	0.524	-0.310

Run 27012

ω 5.02 Rad/Sec

Fr .25

I F	-0.252	-0.524	-0.524	0.019
I A	-0.293	-0.564	-0.439	0.251
II F	-0.518	-1.076	-0.932	0.207
II A	-0.834	-1.513	-1.319	0.446
III F	-0.304	-0.751	-0.609	0.887
III A	-0.326	-0.755	-0.775	0.306
IV F	-0.082	-0.554	-0.472	0.574
IV A	-0.119	-0.614	-0.693	0.317
V F	-0.520	-1.040	-0.880	0.280
V A	-0.127	-0.781	-0.781	0.675
VI F	-0.391	-0.639	-0.639	0.433
VI A	-0.340	-0.775	-0.775	0.548
VII F	-0.299	-0.393	-0.337	0.262
VII A	0	-0.233	-0.310	0.272

TABLE III (cont'd)

Run 27015

ω 5.02 Rad/Sec

Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.485	-0.563	-0.563	-0.078
I A	-0.355	-0.585	-0.481	0.230
II F	-0.745	-0.994	-0.828	0.248
II A	-0.892	-1.300	-1.145	0.524
III F	-0.386	-0.731	-0.508	0.609
III A	-0.388	-0.755	-0.673	0.428
IV F	-0.041	-0.451	-0.410	0.677
IV A	-0.238	-0.752	-0.772	0.277
V F	-0.500	-1.040	-0.820	0.460
V A	-0.274	-0.865	-0.738	0.760
VI F	-0.288	-0.721	-0.639	0.453
VI A	-0.435	-0.851	-0.737	0.605
VII F	-0.243	-0.337	-0.280	0.318
VII A	0.078	-0.194	-0.233	0.407

Run 26998

ω 7.54 Rad/Sec

Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.252	-0.310	-0.252	0.097
I A	-0.314	-0.397	-0.188	0.502
II F	-0.724	-0.828	-0.600	0.269
II A	-1.377	-1.416	-0.834	0.272
III F	-0.304	-0.447	-0.183	0.548
III A	-0.469	-0.469	-0.286	0.245
IV F	-0.369	-0.472	-0.287	0.369
IV A	-0.396	-0.455	-0.297	0.396
V F	-0.540	-0.660	-0.260	0.520
V A	-0.549	-0.654	-0.380	0.591
VI F	-0.721	-0.824	-0.639	0.144
VI A	-0.775	-0.775	-0.624	0.378
VII F	-0.505	-0.524	-0.374	0.262
VII A	-0.252	-0.310	-0.310	0.291

Run 27001

ω 7.54 Rad/Sec

Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_π
I F	-0.213	-0.272	-0.213	0.136
I A	-0.376	-0.502	-0.272	0.251
II F	-0.559	-0.745	-0.476	0.269
II A	-1.086	-1.203	-0.698	0.466
III F	-0.508	-0.528	-0.365	0.264
III A	-0.388	-0.408	-0.286	0.224
IV F	-0.348	-0.492	-0.328	0.308
IV A	-0.099	-0.396	-0.356	0.396
V F	-0.560	-0.740	-0.600	0.300
V A	-0.570	-0.823	-0.760	0.338
VI F	-0.639	-0.886	-0.700	0.144
VI A	-0.756	-0.945	-0.869	0.227
VII F	-0.393	-0.468	-0.318	0.262
VII A	-0.233	-0.369	-0.388	0.116

Run 26486

ω 8.8 Rad/Sec

Fr .25

I F	-0.252	-0.291	-0.272	0.019
I A	-0.460	-0.460	-0.293	0.251
II F	-0.662	-0.787	-0.476	0.331
II A	-1.067	-1.183	-0.931	0.427
III F	-0.589	-0.467	-0.345	0.162
III A	-0.408	-0.408	-0.224	0.204
IV F	-0.328	-0.410	-0.308	0.308
IV A	-0.178	-0.416	-0.436	0.178
V F	-0.340	-0.480	-0.340	0.200
V A	-0.316	-0.464	-0.380	0.359
VI F	-0.309	-0.680	-0.577	0.082
VI A	-0.586	-0.850	-0.813	0.094
VII F	-0.243	-0.393	-0.299	0.337
VII A	0.019	-0.155	-0.175	0.291

Run 26489

ω 8.8 Rad/Sec

Fr .25

I F	-0.233	-0.310	-0.233	0.058
I A	-0.439	-0.439	-0.251	0.251
II F	-0.600	-0.683	-0.393	0.331
II A	-0.912	-1.086	-0.795	0.485
III F	-0.426	-0.629	-0.345	0.183
III A	-0.530	-0.571	-0.326	0.184
IV F	-0.369	-0.430	-0.308	0.246
IV A	-0.297	-0.436	-0.376	0.178
V F	-0.440	-0.620	-0.360	0.280
V A	-0.338	-0.549	-0.316	0.295
VI F	-0.330	-0.639	-0.474	0.124
VI A	-0.454	-0.869	-0.680	0.170
VII F	-0.374	-0.486	-0.318	0.206
VII A	-0.116	-0.194	-0.194	0.097

Run 26992

ω 10.03 Rad/Sec

Fr .25

I F	-0.175	-0.136	0	0.097
I A	-0.397	-0.397	-0.209	0.293
II F	-0.807	-0.683	-0.186	0.145
II A	-0.873	-0.951	-0.369	0.271
III F	-0.203	0.061	0.284	0.102
III A	-0.061	0.061	0.204	0
IV F	-0.369	0.041	0.328	0.308
IV A	-0.238	-0.099	0.158	0.178
V F	-0.800	-0.240	0.080	-0.260
V A	-0.316	-0.021	0.084	0.084
VI F	-0.309	-0.144	-0.041	0.165
VI A	-0.435	-0.624	-0.454	0.189
VII F	-0.337	-0.355	-0.206	0.112
VII A	0.019	-0.058	-0 039	0.213

TABLE III (cont'd)

Run 26995, ω 10.03 Rad/Sec, Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.155	-0.175	-0.058	0.155
I A	-0.314	-0.272	-0.104	0.460
II F	-0.704	-0.683	-0.310	0.290
II A	-0.757	-0.873	-0.485	0.349
III F	-0.203	-0.081	0.142	0.183
III A	-0.224	-0.102	0.224	0.102
IV F	-0.308	-0.082	0.184	0.328
IV A	-0.257	-0.218	0.059	0.317
V F	-0.440	-0.220	0.100	-0.220
V A	-0.127	-0.190	0.127	0.211
VI F	-0.268	-0.330	-0.288	0.103
VI A	-0.397	-0.624	-0.510	0.170
VII F	-0.355	-0.430	-0.393	0.056
VII A	0.136	0.019	0.039	0.310

Run 26538, ω 11.3 Rad/Sec, Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.175	-0.097	0.019	0.039
I A	-0.355	-0.251	0.042	0.460
II F	-0.766	-0.497	0.104	0.290
II A	-1.028	-0.892	0	0.175
III F	0.041	0.284	0.528	0.081
III A	-0.102	0.286	0.449	-0.184
IV F	-0.594	-0.041	0.390	0.226
IV A	-0.396	-0.040	0.238	0.257
V F	-0.280	0.060	0.380	0.040
V A	-0.190	-0.042	0.232	-0.105
VI F	0.165	0.082	0.103	-0.062
VI A	-0.094	-0.340	-0.265	0.019
VII F	-0.150	-0.243	-0.075	0.056
VII A	0.097	0.039	0.058	0.155

Run 26541, ω 11.3 Rad/Sec, Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.136	-0.078	0.039	0.097
I A	-0.355	-0.251	0.084	0.355
II F	-0.662	-0.352	0.041	0.228
II A	-0.912	-0.718	0.039	0.136
III F	-0.142	-0.183	0.447	0.041
III A	-0.163	0.224	0.408	-0.102
IV F	-0.431	-0.061	0.390	0.308
IV A	-0.317	-0.059	0.297	0.317
V F	-0.220	0.240	0.500	0.100
V A	-0.211	0.190	0.295	-0.084
VI F	-0.144	0.206	0.227	-0.041
VI A	0.132	-0.057	-0.132	-0.208
VII F	-0.112	-0.150	-0.075	0.131
VII A	0.097	0.078	0.058	0.097

Run 26544, ω 12.56 Rad/Sec, Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.175	-0.039	0.078	0
I A	-0.606	-0.334	0.021	0.460
II F	-1.035	-0.683	0.104	0.269
II A	-0.951	-0.640	0.427	0.485
III F	-0.122	0.571	0.877	0
III A	0.062	0.512	0.820	-0.308
IV F	-0.297	0.436	0.792	0.574
IV A	-0.257	0.376	0.693	0.653
V F	-0.040	0.480	0.700	-0.580
V A	0.380	0.485	0.612	-0.232
VI F	0.165	0.185	0.247	-0.515
VI A	0.491	0.378	0.321	-0.416
VII F	-0.037	0	0.037	0
VII A	-0.039	0	0.019	0.078

Run 26457, ω 12.56 Rad/Sec, Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.213	0.058	0.194	-0.019
I A	-0.522	-0.397	0.042	0.418
II F	-0.849	-0.435	0.290	0.145
II A	-0.776	-0.446	0.601	0.252
III F	0.061	0.426	0.792	-0.203
III A	0.102	0.554	0.738	-0.328
IV F	-0.257	0.475	0.911	0.475
IV A	-0.257	0.396	0.772	0.495
V F	-0.080	0.560	0.800	-0.640
V A	0.211	0.422	0.590	-0.401
VI F	0.124	0.391	0.350	-0.412
VI A	0.378	0.265	0.227	-0.435
VII F	-0.056	-0.037	0.037	0
VII A	-0.019	0	0.019	0.058

Run 26621, ω 15.48 Rad/Sec, Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	0	0.388	0.446	-0.213
I A	-0.502	0.084	0.773	0.418
II F	-0.518	0.373	0.952	0
II A	-0.213	0.912	1.804	-0.757
III F	0.345	1.624	1.847	-0.832
III A	0.367	1.754	1.816	-0.877
IV F	-0.758	1.394	2.112	0.184
IV A	-0.594	0.931	1.901	0.099
V F	-0.140	2.040	2.340	-0.800
V A	1.139	2.068	2.342	-0.971
VI F	0.371	1.051	1.112	-1.257
VI A	0.737	0.926	0.775	-1.172
VII F	0.187	0.393	0.430	-0.692
VII A	0.291	0.349	0.446	-0.155

TABLE III (cont'd)

Run 26624

ω 15.43 Rad/Sec

Fr .25

Segment	F_o	$F_{\pi/4}$	$F_{\pi/2}$	F_{π}
I F	-0.291	0.194	0.388	-0.310
I A	-0.543	-0.021	0.711	0.397
II F	-0.662	0.435	0.869	-0.331
II A	0.660	0.737	1.727	0.601
III F	0.467	1.441	1.035	1.685
III A	0.449	1.754	1.795	-1.122
IV F	-0.594	0.615	2.009	0.512
IV A	-0.614	0.812	1.802	-0.297
V F	0.660	1.620	2.000	-1.680
V A	1.055	2.004	2.047	-1.329
VI F	0.906	1.092	1.298	-1.339
VI A	0.851	0.907	0.737	-1.644
VII F	0.094	0.280	0.636	-0.187
VII A	-0.039	0.155	0.330	-0.213

TABLE IV

Observed Moments in Foot-Pounds (Pitch)

Run 27203
ω 4.99 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.043	-0.395	-0.480	0.176
I A	-0.112	-0.486	-0.486	0.185
II F	-0.111	-0.553	-0.553	0.148
II A	-0.228	-0.540	-0.562	0.166
III F	-0.109	-0.174	-0.174	0.065
III A	-0.066	-0.087	-0.095	0
IV F	0	0	0	0
IV A	0	0	0	0
V F	-0.035	-0.100	-0.121	0.007
V A	-0.159	-0.316	-0.316	0
VI F	-0.100	-0.508	-0.530	0.110
VI A	-0.777	-1.182	-1.182	0.033
VII F	-0.300	-0.500	-0.468	0.334
VII A	-0.092	-0.503	-0.687	0.137

Run 27224
ω 7.38 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.219	-0.262	-0.219	0.131
I A	-0.186	-0.448	-0.411	0.261
II F	-0.073	-0.443	-0.259	0.480
II A	-0.375	-0.500	-0.354	0.292
III F	-0.152	-0.065	0	0.109
III A	-0.051	-0.066	-0.044	0.058
IV F	0.015	0.022	0.029	0
IV A	0.014	0.014	0.014	-0.042
V F	-0.064	-0.064	-0.057	0.043
V A	-0.159	-0.136	0	0.226
VI F	-0.221	-0.331	-0.265	0.287
VI A	-0.607	-0.811	-0.473	0.667
VII F	-0.368	-0.434	-0.268	0.534
VII A	-0.045	-0.458	-0.502	0.045

Run 27227
ω 7.35 Rad/Sec
F 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.131	-0.131	-0.088	0.350
I A	-0.150	-0.411	-0.278	0.373
II F	-0.370	-0.550	-0.443	0.370
II A	-0.354	-0.520	-0.332	0.397
III F	-0.109	-0.087	0.021	0.152
III A	-0.051	-0.116	-0.044	0.073
IV F	0.029	0.051	0.044	0.015
IV A	0.021	0.014	0.021	-0.035
V F	-0.064	-0.086	-0.086	0.050
V A	-0.226	-0.271	-0.090	0.204
VI F	-0.331	-0.508	-0.419	0.221
VI A	-0.709	-0.945	-0.607	-0.607
VII F	-0.634	-0.768	-0.468	0.234
VII A	-0.137	-0.321	-0.321	0.321

Run 27248
ω 8.65 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.088	-0.088	0	0.131
I A	-0.373	-0.448	-0.298	0.150
II F	-0.221	-0.370	-0.221	0.148
II A	-0.396	-0.418	-0.270	0.188
III F	-0.087	-0.087	0.044	0.131
III A	-0.029	-0.066	-0.036	0.036
IV F	0.022	0.051	0.066	0.029
IV A	-0.021	0.021	0.035	-0.021
V F	-0.050	-0.071	-0.057	0.021
V A	-0.136	-0.114	0	0.181
VI F	-0.287	-0.309	-0.154	0.331
VI A	-0.641	-0.675	-0.270	0.439
VII F	-0.400	-0.434	-0.134	0.500
VII A	-0.229	-0.732	-0.503	0.366

Run 27251
ω 8.66 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.176	-0.131	0	0.176
I A	-0.223	-0.298	-0.261	0.186
II F	-0.186	-0.332	-0.221	0.186
II A	-0.312	-0.436	-0.228	0.228
III F	-0.131	-0.065	0.044	0.152
III A	-0.021	-0.044	-0.036	0.044
IV F	0.007	0.029	0.036	0.015
IV A	0	0.021	0.028	-0.028
V F	-0.021	-0.050	-0.043	0.035
V A	-0.159	-0.136	-0.045	0.159
VI F	-0.354	-0.375	-0.221	0.243
VI A	-0.473	-0.539	-0.236	0.573
VII F	-0.468	-0.468	-0.200	0.534
VII A	-0.366	-0.779	-0.687	0.274

Run 27290
ω 10.12 Rad/Sec
Fr 0

Segment	M	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.176	0.176	0.219	-0.043
I A	-0.186	-0.186	-0.075	0.298
II F	-0.111	0.037	0.221	0.148
II A	-0.292	-0.228	0	0.292
III F	0	0.087	0.131	0.021
III A	-0.022	-0.022	-0.007	0.022
IV F	0.007	0.029	0.029	0
IV A	-0.014	0.021	0.035	-0.014
V F	0	-0.050	-0.036	0.014
V A	-0.068	0.114	0.181	0
VI F	-0.287	-0.221	-0.022	0.221
VI A	-0.539	-0.236	0.236	0.539
VII F	-0.734	-0.534	-0.168	0.434
VII A	-0.184	-0.413	-0.274	0.320

TABLE IV (cont'd)

Run 27293
ω 10.10 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.043	0.262	0.262	-0.131
I A	-0.223	-0.223	-0.075	0.261
II F	-0.148	-0.148	0	0.111
II A	-0.270	-0.292	-0.042	0.208
III F	-0.087	0.065	0.087	-0.021
III A	-0.007	-0.029	-0.022	0.022
IV F	0.007	0.044	0.051	0.029
IV A	-0.014	0.014	0.035	-0.007
V F	-0.043	-0.036	-0.029	0.021
V A	-0.090	0.136	0.159	0.068
VI F	-0.243	-0.198	-0.066	0.287
VI A	-0.371	-0.168	0.136	0.473
VII F	-0.434	-0.334	0	0.534
VII A	-0.413	-0.642	-0.458	0.137

Run 27296
ω 11.34 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.131	0.480	0.395	-0.088
I A	-0.223	-0.186	0	0.223
II F	0.111	0.332	0.443	-0.073
II A	-0.104	-0.020	0.104	0.124
III F	0.065	0.239	0.304	-0.021
III A	0.007	0.029	0.022	-0.022
IV F	0.014	0.036	0.022	-0.029
IV A	-0.007	0.035	0.035	-0.014
V F	-0.050	0	0.021	0.021
V A	-0.114	0.181	0.339	-0.090
VI F	-0.154	0	0.154	0.177
VI A	-0.202	0.168	0.473	0.338
VII F	-0.468	-0.234	0.168	0.500
VII A	-0.274	-0.274	-0.092	0.229

Run 27299
ω 11.36 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.176	0.350	0.307	-0.176
I A	-0.186	-0.150	0	0.298
II F	-0.073	0.259	0.332	-0.073
II A	-0.146	-0.084	0.084	0.166
III F	-0.044	0.152	0.218	0.044
III A	-0.007	0.029	0.036	0.007
IV F	0.044	0.066	0.058	0
IV A	0.021	0.050	0.071	0
V F	-0.014	0.014	0.021	-0.021
V A	-0.068	0.226	0.294	-0.022
VI F	-0.154	-0.044	0.088	0.265
VI A	-0.371	0.168	0.371	0.338
VII F	-0.534	-0.368	0	0.500
VII A	-0.366	-0.413	-0.184	0.137

Run 27320
ω 13.99 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.350	0.744	0.656	-0.395
I A	-0.075	0.223	0.336	0.186
II F	0.443	0.850	0.888	-0.111
II A	0.250	0.478	0.520	-0.020
III F	0.304	0.522	0.545	-0.131
III A	0.044	0.066	0.066	-0.073
IV F	0.036	0.066	0.066	-0.007
IV A	-0.021	0.028	0.078	0
V F	0.007	0.100	0.114	-0.078
V A	0.090	0.724	0.634	-0.316
VI F	-0.133	0.198	0.398	0
VI A	0.068	1.214	1.282	-0.136
VII F	-0.334	0.368	0.634	0.534
VII A	-0.299	0.366	0.503	-0.045

Run 27323
ω 13.66 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.131	0.787	0.787	-0.395
I A	0.075	0.336	0.486	0.112
II F	0.332	0.666	0.777	-0.186
II A	0.166	0.332	0.374	0.042
III F	0.217	0.370	0.414	-0.304
III A	0.051	0.051	0.044	-0.080
IV F	0.059	0.073	0.073	0.007
IV A	-0.035	0.056	0.085	-0.007
V F	-0.007	0.086	0.100	-0.043
V A	0.045	0.633	0.588	-0.362
VI F	-0.110	0.354	0.375	-0.066
VI A	0.034	0.979	1.012	-0.202
VII F	-0.300	0.400	0.702	0.668
VII A	-0.184	0.274	0.366	-0.184

Run 27372
ω 15.51 Rad/Sec
Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.875	1.006	1.051	-0.699
I A	-0.186	0.261	0.522	0
II F	0.480	1.072	1.109	-0.407
II A	0.188	0.604	0.790	-0.312
III F	0.414	0.587	0.718	-0.326
III A	0.036	0.095	0.109	-0.066
IV F	0.081	0.102	0.088	0
IV A	-0.007	0.035	0.092	-0.035
V F	-0.029	0.078	0.171	-0.078
V A	0	0.927	0.972	-0.497
VI F	-0.133	0.375	0.706	-0.309
VI A	0.102	1.282	1.620	-0.843
VII F	-0.534	0.234	0.836	0.268
VII A	0	0.732	0.961	-0.595

TABLE IV (cont'd)

Run 27375

ω 15.36 Rad/Sec

Fr 0

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.744	0.875	0.744	-1.094
I A	0.075	0.448	0.561	-0.038
II F	0.739	0.998	1.036	-0.666
II A	0.188	0.666	0.728	-0.396
III F	0.327	0.653	0.653	-0.545
III A	0.058	0.124	0.131	-0.116
IV F	0.073	0.081	0.073	-0.029
IV A	-0.014	0.050	0.099	-0.042
V F	-0.029	0.193	0.228	0.021
V A	0.271	1.063	1.041	-0.316
VI F	0.110	0.795	0.773	-0.309
VI A	0.877	1.824	1.552	-0.573
VII F	-0.300	0.534	0.868	0.334
VII A	-0.092	1.008	0.824	-0.458

Run 27206

ω 5.02 Rad/Sec

Fr .1

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.350	-0.656	-0.614	0.176
I A	-0.186	-0.634	-0.523	0.373
II F	-0.332	-0.666	-0.554	0.296
II A	-0.228	-0.582	-0.500	0.312
III F	0	-0.131	-0.109	0.065
III A	-0.036	-0.073	-0.080	0.015
IV F	0	0.022	0.015	-0.044
IV A	-0.014	-0.014	-0.007	0.021
V F	-0.064	-0.128	-0.128	0.029
V A	-0.294	-0.385	-0.316	0.204
VI F	-0.154	-0.442	-0.398	0.110
VI A	-0.877	-1.114	-0.979	0.371
VII F	-0.268	-0.434	-0.434	0.234
VII A	0.045	-0.274	-0.458	0.274

Run 27209

ω 5.02 Rad/Sec

Fr .1

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.043	-0.395	-0.307	0.219
I A	-0.075	-0.448	-0.373	0.523
II F	-0.148	-0.443	-0.407	0.407
II A	-0.188	-0.436	-0.396	0.396
III F	-0.021	-0.065	-0.065	0.087
III A	-0.022	-0.066	-0.066	0
IV F	0.022	-0.029	0.036	-0.044
IV A	-0.028	-0.021	-0.021	0.021
V F	-0.078	-0.114	-0.114	0.071
V A	-0.385	-0.452	-0.362	0.136
VI F	-0.198	-0.375	-0.398	0.243
VI A	-0.778	-1.046	-0.877	0.473
VII F	-0.300	-0.568	-0.500	0.268
VII A	-0.092	-0.550	-0.642	0.092

Run 27230

ω 7.33 Rad/Sec

Fr .1

I F	-0.307	-0.480	-0.350	0.176
I A	-0.150	-0.411	-0.261	0.448
II F	-0.073	-0.407	-0.332	0.407
II A	-0.332	-0.458	-0.312	0.292
III F	-0.088	-0.109	-0.044	0.065
III A	-0.022	-0.044	-0.044	0.022
IV F	0.022	0.036	0.029	-0.015
IV A	-0.021	0.007	0.015	-0.021
V F	-0.043	-0.086	-0.071	0.029
V A	-0.271	-0.204	-0.114	0.114
VI F	-0.354	-0.530	-0.442	0.177
VI A	-0.607	-0.843	-0.641	0.539
VII F	-0.434	-0.534	-0.300	0.468
VII A	-0.092	-0.458	-0.413	0.137

Run 27233

ω 7.45 Rad/Sec

Fr .1

I F	-0.350	-0.395	-0.219	0.219
I A	-0.223	-0.448	-0.336	0.261
II F	-0.259	-0.370	-0.186	0.332
II A	-0.270	-0.396	-0.292	0.292
III F	-0.131	-0.044	-0.021	0.087
III A	-0.007	-0.051	-0.036	0.051
IV F	0.022	0.044	0.036	-0.015
IV A	0	0.015	0.035	0.015
V F	-0.071	-0.100	-0.078	0.021
V A	-0.316	-0.271	-0.181	0.114
VI F	-0.375	-0.464	-0.375	0.221
VI A	-0.539	-0.743	-0.573	0.607
VII F	-0.500	-0.602	-0.334	0.368
VII A	0	-0.366	-0.458	0.137

Run 27254

ω 8.70 Rad/Sec

Fr .1

I F	-0.131	-0.131	0	0.176
I A	-0.261	-0.373	-0.261	0.298
II F	-0.148	-0.296	-0.073	0.221
II A	-0.292	-0.416	-0.312	0.188
III F	0.021	0	0.087	0.087
III A	-0.007	-0.029	-0.029	0.029
IV F	0.051	0.066	0.051	-0.007
IV A	-0.007	0.028	0.056	0.021
V F	-0.071	-0.071	-0.050	0.050
V A	-0.136	-0.022	0.136	0.226
VI F	-0.221	-0.309	-0.198	0.331
VI A	-0.573	-0.607	-0.304	0.539
VII F	-0.434	-0.500	-0.268	0.468
VII A	-0.184	-0.779	-0.779	0.137

TABLE IV (cont'd)

Run 27257

ω 8.75 Rad/Sec

Fr .1

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_{π}
I F	-0.088	-0.176	-0.131	0.131
I A	-0.261	-0.373	-0.186	0.336
II F	-0.111	-0.259	-0.073	0.221
II A	-0.250	-0.374	-0.354	0.250
III F	-0.021	0.021	0.065	0.065
III A	-0.007	-0.051	-0.043	0.015
IV F	0.051	0.051	0.029	-0.029
IV A	-0.007	0.028	0.050	0.007
V F	-0.057	-0.057	-0.029	0.043
V A	-0.204	-0.090	0.090	0.181
VI F	-0.221	-0.309	-0.198	0.331
VI A	-0.507	-0.507	-0.304	0.607
VII F	-0.602	-0.500	-0.200	0.534
VII A	-0.229	-0.687	-0.595	0.274

Run 27284

ω 10.17 Rad/Sec

Fr .1

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_{π}
I F	-0.088	0.088	0.219	-0.043
I A	-0.336	-0.261	-0.112	0.261
II F	-0.186	0	0.111	0.073
II A	-0.312	-0.250	-0.146	0.124
III F	0.087	0.065	0.087	-0.021
III A	0.044	-0.022	-0.029	-0.022
IV F	0.044	0.051	0.036	-0.029
IV A	-0.050	0.014	0.050	0.007
V F	-0.043	-0.021	0.021	0.050
V A	-0.186	-0.114	0.090	0.114
VI F	-0.309	-0.221	-0.066	0.221
VI A	-0.473	-0.304	0.034	0.439
VII F	-0.568	-0.534	-0.268	0.434
VII A	-0.274	-0.413	-0.321	0.229

Run 27287

ω 10.08 Rad/Sec

Fr .1

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_{π}
I F	0.043	0.131	0.176	0
I A	-0.261	-0.261	0	0.448
II F	-0.186	0.111	0.186	0.186
II A	-0.270	-0.188	-0.062	0.146
III F	0.021	0.152	0.131	-0.021
III A	0.007	-0.007	-0.029	-0.029
IV F	0.066	0.051	0.036	-0.029
IV A	-0.042	0.035	0.050	0.014
V F	-0.050	-0.043	0	0.064
V A	-0.271	0	0.181	0.159
VI F	-0.331	-0.265	-0.110	0.221
VI A	-0.573	-0.270	0.068	0.405
VII F	-0.734	-0.602	-0.334	0.334
VII A	-0.274	-0.458	-0.321	0.184

Run 27302

ω 11.47 Rad/Sec

Fr .1

I F	0.131	0.262	0.438	-0.176
I A	-0.186	-0.186	0.112	0.336
II F	0.111	0.332	0.370	-0.073
II A	-0.084	-0.124	0.124	0.208
III F	0.262	0.262	0.262	-0.131
III A	0.036	-0.015	-0.036	-0.044
IV F	0.073	0.059	0.029	-0.059
IV A	-0.078	0.007	0.064	0.035
V F	-0.071	0.021	0.050	0.050
V A	-0.136	0.204	0.339	0.068
VI F	-0.177	-0.022	0.133	0.243
VI A	-0.338	0.068	0.304	0.236
VII F	-0.400	-0.200	0.134	0.468
VII A	-0.321	-0.366	-0.137	0.137

Run 27305

ω 11.51 Rad/Sec

Fr .1

I F	0.131	0.219	0.438	-0.176
I A	-0.298	-0.223	0.112	0.298
II F	0.148	0.370	0.480	0
II A	0.146	-0.124	0.124	0.084
III F	0.239	0.239	0.218	-0.152
III A	0.058	0.036	0.015	-0.022
IV F	0.088	0.073	0.036	-0.051
IV A	-0.028	0.014	0.071	0.050
V F	-0.064	0.021	0.078	0.050
V A	-0.136	0.226	0.339	0.068
VI F	-0.177	-0.110	0.066	0.177
VI A	-0.168	0.168	0.371	0.270
VII F	-0.468	-0.334	0	0.400
VII A	-0.184	-0.137	0.092	0.184

Run 27326

ω 13.81 Rad/Sec

Fr .1

I F	0.350	0.832	0.744	-0.395
I A	-0.112	0.150	0.410	0.223
II F	0.407	0.777	0.813	-0.296
II A	0.166	0.396	0.500	-0.166
III F	0.304	0.522	0.457	-0.348
III A	0.080	0.066	0.022	-0.087
IV F	0.124	0.117	0.066	-0.036
IV A	-0.085	0.028	0.099	0.056
V F	-0.086	0.086	0.143	0.050
V A	-0.294	0.588	0.701	-0.114
VI F	-0.198	0.442	0.530	0.066
VI A	0.034	1.013	1.013	-0.304
VII F	-0.234	0.334	0.534	0.434
VII A	0.092	0.503	0.458	-0.092

TABLE IV (cont'd)

Run 27329

ω 13.81 Rad/Sec

Fr .1

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.350	0.699	0.744	-0.395
I A	0	0.186	0.523	0.261
II F	0.480	1.000	1.000	-0.221
II A	0.270	0.374	0.582	-0.188
III F	0.304	0.522	0.457	-0.326
III A	0.095	0.087	0.029	-0.080
IV F	0.088	0.081	0.036	-0.088
IV A	-0.106	0	0.056	0.035
V F	-0.100	0.057	0.107	0.050
V A	-0.249	0.565	0.701	-0.090
VI F	-0.287	0.353	0.486	0.110
VI A	0	0.945	1.114	-0.102
VII F	-0.400	0.168	0.368	0.400
VII A	0	0.274	0.413	-0.137

Run 27567

ω 15.44 Rad/Sec

Fr .1

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.744	1.225	1.182	-0.438
I A	-0.112	0.448	0.709	-0.038
II F	0.739	1.036	1.109	-0.554
II A	0.250	0.708	0.852	-0.292
III F	0.609	0.805	0.631	-0.304
III A	0.095	0.175	0.109	-0.102
IV F	0.139	0.132	0.088	-0.081
IV A	-0.106	-0.028	0.127	0.092
V F	-0.036	0.107	0.264	0.100
V A	-0.045	0.815	1.086	0.136
VI F	-0.177	0.662	0.839	0.022
VI A	1.248	1.991	1.755	-0.169
VII F	-0.066	0.434	0.702	0.200
VII A	0	0.779	0.732	-0.503

Run 27570

ω 15.55 Rad/Sec

Fr .1

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.875	1.225	1.137	-0.569
I A	-0.075	0.411	0.709	0.112
II F	0.666	1.182	1.220	-0.813
II A	0.624	0.832	0.832	-0.644
III F	0.784	0.805	0.674	-0.761
III A	0.109	0.138	0.080	-0.153
IV F	0.124	0.161	0.117	-0.132
IV A	-0.141	-0.056	0.106	0.085
V F	-0.136	0.107	0.235	0.014
V A	-0.588	0.724	1.041	-0.362
VI F	-0.309	0.508	0.750	-0.133
VI A	1.114	1.552	1.790	-0.304
VII F	-0.234	0.568	0.836	0.334
VII A	-0.274	0.824	0.871	-0.503

Run 27212

ω 5.00 Rad/Sec

Fr .2

I F	-0.350	-0.656	-0.526	0.131
I A	-0.223	-0.634	-0.411	0.448
II F	-0.296	-0.739	-0.666	0.259
II A	-0.396	-0.748	-0.708	0.228
III F	-0.044	-0.131	-0.131	0.131
III A	0.015	-0.058	-0.066	0.029
IV F	0.051	0.088	0.066	-0.015
IV A	-0.028	-0.028	-0.007	0.014
V F	-0.036	-0.093	-0.085	0.093
V A	-0.362	-0.475	-0.340	0.204
VI F	-0.221	-0.530	-0.508	0.354
VI A	-0.405	-0.979	-0.911	0.675
VII F	-0.534	-0.770	-0.634	0.234
VII A	-0.184	-0.687	-0.871	-0.045

Run 27215

ω 5.00 Rad/Sec

Fr .2

I F	-0.219	-0.568	-0.438	0.350
I A	-0.223	-0.634	-0.486	0.448
II F	-0.186	-0.591	-0.518	0.296
II A	-0.228	-0.666	-0.520	0.312
III F	-0.044	-0.152	-0.109	0.109
III A	-0.007	-0.066	-0.080	0
IV F	0.029	0.066	0.058	-0.022
IV A	-0.035	-0.028	-0.028	0
V F	-0.043	-0.100	-0.107	0.057
V A	-0.204	-0.407	-0.362	0.249
VI F	-0.177	-0.530	-0.530	0.287
VI A	-0.202	-0.945	-0.877	0.777
VII F	-0.300	-0.500	-0.400	0.400
VII A	-0.045	-0.687	-0.824	0

Run 27236

ω 7.40 Rad/Sec

Fr .2

I F	-0.438	-0.307	-0.262	0.219
I A	-0.373	-0.448	-0.298	0.448
II F	-0.143	-0.554	-0.407	0.186
II A	-0.332	-0.520	-0.416	0.208
III F	-0.021	0	-0.044	-0.021
III A	0	-0.029	-0.036	-0.015
IV F	0.051	0.073	0.051	-0.029
IV A	-0.021	-0.021	0.021	0.021
V F	-0.071	-0.086	-0.057	0.078
V A	-0.294	-0.316	-0.136	0.249
VI F	-0.331	-0.419	-0.442	0.154
VI A	-0.573	-0.640	-0.473	0.473
VII F	-0.568	-0.634	-0.434	0.300
VII A	0	-0.458	-0.550	0.045

TABLE IV (cont'd)

Run 27239

ω 7.47 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.219	-0.176	-0.043	0.438
I A	-0.411	-0.561	-0.411	0.411
II F	-0.221	-0.443	-0.259	0.296
II A	-0.250	-0.436	-0.374	0.374
III F	-0.065	-0.109	-0.065	0.044
III A	0	-0.022	-0.036	0.022
IV F	0.059	0.066	0.044	-0.029
IV A	-0.035	-0.007	0.028	0.042
V F	-0.057	-0.078	-0.036	0.078
V A	-0.385	-0.316	-0.159	0.181
VI F	-0.287	-0.419	-0.354	0.221
VI A	-0.573	-0.777	-0.641	0.473
VII F	-0.534	-0.634	-0.434	0.434
VII A	-0.137	-0.503	-0.550	0

Run 27260

ω 8.74 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.088	-0.088	0.088	0.262
I A	-0.261	-0.411	-0.150	0.373
II F	-0.296	-0.295	-0.148	0.259
II A	-0.166	-0.374	-0.249	0.228
III F	0.131	0.065	-0.021	-0.087
III A	0.022	-0.022	-0.044	0.
IV F	0.088	0.073	0.036	-0.044
IV A	-0.042	0.007	0.042	0.035
V F	-0.093	-0.057	0	0.078
V A	-0.362	-0.090	0.114	0.181
VI F	-0.221	-0.309	-0.154	0.265
VI A	-0.539	-0.539	-0.270	0.473
VII F	-0.400	-0.468	-0.268	0.500
VII A	-0.366	-0.779	-0.779	0.092

Run 27263

ω 8.70 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.131	-0.262	-0.131	0.219
I A	-0.336	-0.411	-0.186	0.486
II F	-0.259	-0.296	-0.186	0.148
II A	-0.228	-0.396	-0.270	0.208
III F	0.065	0.087	-0.021	-0.152
III A	0.036	-0.015	-0.051	-0.022
IV F	0.095	0.081	0.051	-0.044
IV A	-0.050	-0.014	0.035	0.042
V F	-0.100	-0.078	-0.043	0.050
V A	-0.430	-0.159	0.090	0.204
VI F	-0.265	-0.398	-0.287	0.133
VI A	-0.405	-0.675	-0.473	0.405
VII F	-0.602	-0.602	-0.300	0.400
VII A	-0.274	-0.732	-0.687	0.274

Run 27278

ω 10.18 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.176	0.131	0.176	0
I A	-0.373	-0.298	-0.075	0.411
II F	-0.148	0.073	0.221	0.038
II A	-0.124	-0.124	-0.042	0.124
III F	0.196	0.131	0.065	-0.260
III A	0.036	-0.007	-0.044	-0.051
IV F	0.066	0.066	0.029	-0.088
IV A	-0.056	-0.007	0.056	0.064
V F	-0.078	-0.021	0.036	0.086
V A	-0.226	0.022	0.271	0.271
VI F	-0.354	-0.221	-0.110	0.221
VI A	-0.473	-0.236	0.034	0.337
VII F	-0.500	-0.368	-0.134	0.468
VII A	-0.229	-0.413	-0.321	0.229

Run 27281

ω 10.17 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.131	0.219	0.395	0.176
I A	-0.298	-0.223	0	0.486
II F	-0.221	-0.111	0.111	0
II A	-0.146	-0.146	-0.104	0.104
III F	0.109	0.109	0.174	-0.260
III A	0.073	0.015	-0.022	-0.058
IV F	0.095	0.073	0.007	-0.066
IV A	-0.092	-0.035	0.042	0.042
V F	-0.093	-0.071	0	0.086
V A	-0.362	-0.090	0.204	0.226
VI F	-0.309	-0.354	-0.177	0.198
VI A	-0.641	-0.405	0.034	0.136
VII F	-0.400	-0.400	-0.134	0.434
VII A	-0.229	-0.458	-0.366	0.321

Run 27308

ω 11.47 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.088	0.219	0.262	-0.043
I A	-0.261	-0.112	0.186	0.336
II F	0.038	0.259	0.407	-0.148
II A	-0.084	0.042	0.124	0.042
III F	0.218	0.218	0.087	-0.326
III A	0.051	0.029	-0.007	-0.051
IV F	0.081	0.095	0	-0.110
IV A	-0.099	0.007	0.064	0.092
V F	-0.064	0.029	0.100	0.121
V A	-0.271	0.181	0.362	0.249
VI F	-0.154	-0.066	0.088	0.221
VI A	-0.202	0.167	0.371	0.371
VII F	-0.234	-0.100	0.134	0.168
VII A	-0.229	-0.274	-0.045	0.184

TABLE IV (cont'd)

Run 27311

ω 11.48 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.043	0.176	0.307	-0.043
I A	-0.411	-0.223	0.112	0.223
II F	0.038	0.221	0.370	-0.148
II A	-0.104	0.062	0.104	0.062
III F	0.283	0.304	0.218	-0.283
III A	0.058	0.029	0	-0.044
IV F	0.110	0.073	0.036	-0.095
IV A	-0.106	0	0.071	0.085
V F	-0.086	0.029	0.114	0.100
V A	-0.226	0.204	0.520	0.385
VI F	-0.198	0	0.177	0.243
VI A	-0.338	0.034	0.304	0.270
VII F	-0.468	-0.300	-0.100	0.300
VII A	-0.229	-0.229	-0.045	0.137

Run 27338

ω 13.51 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.176	0.787	0.787	-0.307
I A	-0.298	0.075	0.448	0.223
II F	0.370	0.925	0.998	-0.221
II A	0.228	0.458	0.540	-0.250
III F	0.414	0.609	0.501	-0.522
III A	0.124	0.073	-0.007	-0.146
IV F	0.132	0.139	0.073	-0.132
IV A	-0.127	-0.042	0.078	0.113
V F	-0.107	0.007	0.128	0.121
V A	-0.316	0.611	0.792	0.090
VI F	-0.309	0.221	0.331	-0.110
VI A	0.270	0.811	0.843	-0.439
VII F	-0.100	0.234	0.300	0.169
VII A	0.137	0.274	0.321	-0.184

Run 27341

ω 12.51 Rad/Sec

Fr .2

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.088	0.438	0.480	-0.043
I A	-0.223	-0.038	0.261	0.261
II F	0.111	0.443	0.629	-0.073
II A	0.104	0.250	0.208	-0.208
III F	0.218	0.262	0.152	-0.348
III A	0.087	0	-0.073	-0.087
IV F	0.124	0.095	0.014	-0.132
IV A	-0.092	0	0.106	0.092
V F	-0.057	0.071	0.178	0.136
V A	-0.090	0.316	0.588	0.114
VI F	-0.265	0.022	0.198	0.110
VI A	0.068	0.439	0.539	0.034
VII F	-0.234	0	0.234	0.368
VII A	-0.092	0.092	0.229	0.184

Run 27354

ω 15.44 Rad/Sec

Fr .2

I F	0.438	0.832	0.832	-0.787
I A	-0.223	0.336	0.784	0.186
II F	0.554	1.293	1.368	-0.407
II A	0.374	0.666	0.790	-0.416
III F	0.761	0.849	0.674	-0.587
III A	0.167	0.138	0.044	-0.167
IV F	0.190	0.212	0.102	-0.161
IV A	-0.120	0	0.113	0.134
V F	-0.150	0.093	0.207	0.121
V A	-0.362	0.837	1.041	-0.339
VI F	-0.198	0.575	0.795	0
VI A	0.573	1.789	1.688	-0.641
VII F	-0.200	0.702	0.702	-0.034
VII A	0.184	0.779	0.687	-0.595

Run 27357

ω 15.44 Rad/Sec

Fr .2

I F	0.656	0.875	0.918	-0.656
I A	-0.150	0.448	0.784	0.150
II F	0.702	1.220	1.109	-0.518
II A	0.520	0.770	0.748	-0.500
III F	0.826	0.849	0.587	-0.457
III A	0.153	0.124	0.022	-0.167
IV F	0.212	0.190	0.088	-0.124
IV A	-0.156	-0.035	0.085	0.099
V F	-0.157	0.107	0.250	0.164
V A	-0.316	0.972	1.086	-0.294
VI F	-0.265	0.662	0.795	-0.066
VI A	0.877	1.688	1.688	-0.675
VII F	-0.234	0.668	0.702	-0.034
VII A	0.229	0.824	0.732	-0.550

Run 27218

ω 4.99 Rad/Sec

Fr .25

I F	-0.307	-0.568	-0.526	0.176
I A	-0.448	-0.671	-0.522	0.336
II F	-0.221	-0.554	-0.480	0.407
II A	-0.270	-0.624	-0.582	0.228
III F	-0.152	-0.174	-0.152	0.044
III A	0	-0.066	-0.073	0.007
IV F	0.029	0.051	0.036	-0.051
IV A	0.014	-0.028	-0.021	0
V F	-0.057	-0.121	-0.114	0.086
V A	-0.407	-0.588	-0.520	0.045
VI F	-0.354	-0.640	-0.685	0.022
VI A	-0.304	-1.013	-0.979	0.507
VII F	-0.400	-0.534	-0.434	0.400
VII A	0.092	-0.642	-0.871	0.045

TABLE IV (cont'd)

Run 27221

ω 5.00 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.219	-0.526	-0.438	0.262
I A	-0.223	-0.523	-0.373	0.486
II F	-0.111	-0.480	-0.443	0.443
II A	-0.416	-0.728	-0.686	0.166
III F	-0.087	-0.152	-0.131	0.044
III A	0.022	-0.044	-0.073	-0.007
IV F	0.007	0.058	0.044	-0.044
IV A	-0.014	-0.021	-0.021	0.014
V F	-0.043	-0.150	-0.128	0.086
V A	-0.271	-0.452	-0.385	0.249
VI F	-0.110	-0.552	-0.552	0.243
VI A	-0.270	-0.709	-0.777	0.607
VII F	-0.234	-0.434	-0.300	0.468
VII A	-0.184	-0.732	-0.961	-0.137

Run 27242

ω 7.45 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.219	-0.307	-0.219	0.176
I A	-0.448	-0.561	-0.373	0.373
II F	-0.322	-0.332	-0.221	0.296
II A	-0.228	-0.436	-0.374	0.270
III F	0.087	-0.131	-0.174	-0.087
III A	0.058	-0.022	-0.029	-0.015
IV F	0.051	0.051	0.029	-0.058
IV A	-0.035	-0.021	0.035	0.042
V F	-0.086	-0.093	-0.064	0.057
V A	-0.339	-0.204	-0.045	0.294
VI F	-0.198	-0.221	-0.221	0.265
VI A	-0.473	-0.507	-0.539	0.405
VII F	-0.334	-0.434	-0.168	0.500
VII A	-0.184	-0.413	-0.550	0.045

Run 27245

ω 7.51 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.262	-0.307	-0.176	0.307
I A	-0.411	-0.448	-0.261	0.486
II F	-0.259	-0.296	-0.221	0.296
II A	-0.312	-0.478	-0.396	0.208
III F	0.196	0.109	-0.020	-0.131
III A	0.022	-0.007	-0.044	-0.029
IV F	0.073	0.073	0.051	-0.044
IV A	-0.050	0	0.035	0.035
V F	-0.093	-0.078	-0.029	0.064
V A	-0.271	-0.294	-0.114	0.249
VI F	-0.309	-0.375	-0.287	0.198
VI A	-0.473	-0.641	-0.539	0.405
VII F	-0.434	-0.500	-0.368	0.400
VII A	0	-0.366	-0.413	0.137

Run 27266

ω 8.63 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.307	-0.219	0.043	0.350
I A	-0.486	-0.448	-0.186	0.373
II F	-0.370	-0.221	-0.111	0.259
II A	-0.622	-0.250	-0.270	0.166
III F	0.131	0.174	0.087	-0.196
III A	0.022	0.015	-0.036	-0.036
IV F	0.081	0.058	-0.007	-0.073
IV A	-0.056	-0.028	0.028	0.071
V F	-0.086	-0.071	0	0.078
V A	-0.271	-0.271	-0.068	0.271
VI F	-0.198	-0.309	-0.265	0.110
VI A	-0.304	-0.641	-0.338	0.439
VII F	-0.400	-0.400	-0.268	0.468
VII A	-0.413	-0.732	-0.779	0.045

Run 27269

ω 8.66 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.219	-0.131	0.088	0.262
I A	-0.373	-0.336	-0.113	0.523
II F	-0.221	-0.221	0.038	0.259
II A	-0.208	-0.228	-0.188	0.250
III F	0.218	0.087	-0.021	-0.131
III A	0.066	-0.015	-0.044	-0.044
IV F	0.110	0.022	0.036	-0.058
IV A	-0.056	-0.050	0.021	0.071
V F	-0.107	-0.071	0.014	0.107
V A	-0.294	-0.136	0.068	0.362
VI F	-0.154	-0.221	-0.198	0.221
VI A	-0.338	-0.507	-0.270	0.539
VII F	-0.500	-0.568	-0.400	0.168
VII A	-0.321	-0.824	-0.871	-0.045

Run 27272

ω 10.03 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.176	0.088	0.219	0.176
I A	-0.373	-0.298	-0.075	0.373
II F	-0.148	-0.280	0.096	0.152
II A	0	-0.124	-0.124	-0.020
III F	0.152	0.196	0.087	-0.218
III A	0.072	0.058	0	-0.072
IV F	0.073	0.095	0.051	-0.110
IV A	-0.085	0	0.056	0.071
V F	-0.143	-0.071	0.007	0.078
V A	-0.385	-0.068	0.226	0.362
VI F	-0.198	-0.264	0.110	0.177
VI A	-0.539	-0.338	-0.034	0.405
VII F	-0.434	-0.500	-0.434	0.200
VII A	-0.321	-0.595	-0.687	0

TABLE IV (cont'd)

Run 27275

ω 10.08 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.307	-0.131	0.131	0.131
I A	-0.298	-0.373	-0.038	0.411
II F	-0.096	-0.038	0.096	0.259
II A	-0.020	-0.188	-0.146	0.062
III F	0.109	0.174	0.087	-0.218
III A	0.066	0.015	-0.029	-0.066
IV F	0.088	0.102	0.044	-0.095
IV A	-0.071	-0.014	0.071	0.106
V F	-0.086	-0.036	0.071	0.093
V A	-0.316	-0.022	0.181	0.249
VI F	-0.198	-0.154	-0.044	0.154
VI A	-0.270	-0.236	0.168	0.338
VII F	-0.268	-0.400	-0.200	0.368
VII A	-0.229	-0.642	-0.503	0.137

Run 27317

ω 11.48 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.131	0.438	0.568	0.088
I A	-0.373	-0.075	0.188	0.373
II F	0.073	0.259	0.480	0.073
II A	0.020	0.104	0.146	0.062
III F	0.261	0.304	0.131	-0.348
III A	0.066	0.022	-0.036	-0.066
IV F	0.195	0.102	0.036	-0.124
IV A	-0.078	0.007	0.092	0.120
V F	-0.107	0.007	0.110	0.128
V A	-0.090	0.181	0.520	0.362
VI F	-0.198	-0.022	0.154	0.198
VI A	-0.304	0.236	0.439	0.202
VII F	-0.200	-0.200	0.034	0.334
VII A	-0.229	-0.366	-0.321	0.137

Run 27576

ω 11.22 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	-0.043	0.307	0.438	-0.043
I A	-0.336	-0.075	0.188	0.486
II F	-0.038	0.221	0.370	-0.038
II A	-0.062	0.146	0.228	0.062
III F	0.261	0.261	0.131	-0.174
III A	0.102	0.036	-0.022	-0.073
IV F	0.117	0.102	0.036	-0.124
IV A	-0.120	-0.050	0.035	0.113
V F	-0.171	-0.014	0.064	0.164
V A	-0.316	0.022	0.362	0.316
VI F	-0.154	0.044	0.110	0.110
VI A	-0.202	0.034	0.202	0.236
VII F	-0.268	-0.268	-0.100	0.400
VII A	-0.229	-0.184	-0.448	0.321

Run 27341

ω 13.31 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.395	0.614	0.787	-0.043
I A	-0.486	0.038	0.523	0.186
II F	0.443	0.739	0.739	-0.221
II A	0.270	0.520	0.540	-0.166
III F	0.479	0.653	0.500	-0.545
III A	0.138	0.124	0.051	-0.109
IV F	0.190	0.183	0.088	-0.176
IV A	-0.134	-0.014	0.113	0.141
V F	-0.171	0	0.193	0.200
V A	-0.520	0.204	0.634	0.520
VI F	-0.419	0.154	0.442	0.375
VI A	-0.236	0	0.811	0.507
VII F	-0.134	0.068	0.200	0.234
VII A	0.137	-0.045	0.184	0.092

Run 27345

ω 13.31 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.307	0.699	0.699	-0.219
I A	-0.596	0.150	0.523	0.112
II F	0.296	0.888	0.850	-0.259
II A	0.188	0.582	0.374	-0.396
III F	0.609	0.740	0.545	-0.631
III A	0.116	0.124	0.029	-0.116
IV F	0.132	0.132	0.044	-0.190
IV A	-0.113	0.021	0.113	0.170
V F	-0.143	0.107	0.221	0.157
V A	-0.497	0.566	0.905	0.339
VI F	-0.486	0.354	0.596	0.309
VI A	0	0.843	1.013	-0.371
VII F	-0.200	0.200	0.268	0.168
VII A	0.045	0.274	0.274	-0.184

Run 27348

ω 15.44 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.395	1.006	1.051	-0.614
I A	-0.597	0.411	0.747	0.150
II F	0.407	1.182	1.293	-0.480
II A	0.124	0.832	0.894	-0.124
III F	0.697	0.849	0.653	-0.740
III A	0.175	0.153	0.080	-0.182
IV F	0.241	0.263	-0.139	-0.168
IV A	-0.156	-0.021	0.113	0.148
V F	-0.250	0	0.200	0.207
V A	-0.497	0.611	1.176	0.226
VI F	-0.198	0.442	0.883	0.154
VI A	0.136	1.957	1.991	-0.472
VII F	-0.100	0.568	0.634	-0.268
VII A	0	0.779	0.824	-0.642

TABLE IV (cont'd)

Run 27351

ω 15.5 Rad/Sec

Fr .25

Segment	M_o	$M_{\pi/4}$	$M_{\pi/2}$	M_π
I F	0.395	1.137	1.225	-0.568
I A	-0.373	0.597	0.970	0.112
II F	0.186	1.330	1.479	-0.111
II A	0.291	0.707	0.748	-0.374
III F	0.740	0.805	0.761	-0.500
III A	0.153	0.138	0.029	-0.197
IV F	0.176	0.234	0.205	-0.198
IV A	-0.156	-0.056	0.156	0.191
V F	-0.214	-0.036	0.243	0.278
V A	-0.679	0.860	1.290	0
VI F	-0.287	0.662	0.861	-0.110
VI A	0.102	1.447	1.991	-0.338
VII F	-0.168	0.802	0.734	-0.368
VII A	0.229	1.008	0.961	-0.366

TABLE V

ADDED MASS COEFFICIENTS (k_z)

Fr = 0

ω	5.02	7.54	8.80	10.03	11.30	12.57	15.71
Seg #							
I	0.284	0.164	0.174	0.177	0.196	0.200	0.190
II	0.249	0.431	0.515	0.586	0.661	0.701	0.686
III	1.254	0.679	0.755	0.832	0.849	0.836	0.758
IV	1.140	0.625	0.642	0.733	0.777	0.811	0.766
V	0.693	0.499	0.587	0.739	0.821	0.878	0.913
VI	0.509	0.540	0.589	0.614	0.666	0.701	0.670
VII	-0.343	0.282	0.343	0.416	0.461	0.464	0.462
SHIP	0.689	0.518	0.577	0.657	0.708	0.735	0.710

Fr = 0.10

ω	5.02	7.54	8.80	10.03	11.30	12.56	15.70
Seg #							
I	2.19	0.048	0.064	0.209	0.274	0.306	0.306
II	1.76	0.525	0.537	0.611	0.685	0.704	0.704
III	2.42	0.917	0.786	0.732	0.743	0.748	0.765
IV	1.92	0.695	0.670	0.690	0.742	0.784	0.794
V	2.27	0.630	0.604	0.742	0.922	0.991	0.959
VI	2.15	0.550	0.288	0.321	0.583	0.694	0.655
VII	3.18	1.193	0.759	0.524	0.452	0.434	0.542
SHIP	2.17	0.660	0.565	0.598	0.696	0.739	0.738

Fr = 0.20

ω	5.02	7.54	8.80	10.03	11.30	12.72	15.47
Seg #							
I	0.071	0.119	0.192	0.245	0.292	0.359	0.321
II	0.739	0.026	0.217	0.434	0.657	0.776	0.686
III	0.810	0.680	0.827	0.913	0.908	0.869	0.764
IV	0.972	0.620	0.682	0.733	0.793	0.845	0.834
V	1.044	0.539	0.588	0.652	0.751	0.863	0.916
VI	0.122	0.186	0.322	0.473	0.610	0.678	0.521
VII	2.93	0.311	0.363	0.399	0.412	0.435	0.376
SHIP	0.838	0.404	0.511	0.613	0.703	0.762	0.706

Fr = 0.25

ω	5.02	7.54	8.80	10.03	11.30	12.56	15.47
Seg #							
I	-0.778	-0.071	0.158	0.258	0.333	0.258	0.396
II	-0.381	0.298	0.197	0.296	0.444	0.548	0.681
III	1.883	1.237	1.078	0.945	0.884	0.858	0.690
IV	1.982	0.863	0.783	0.733	0.759	0.783	0.778
V	1.044	0.539	0.576	0.630	0.717	0.779	0.844
VI	1.849	0.551	0.435	0.495	0.644	0.684	0.548
VII	2.396	0.629	0.421	0.325	0.320	0.331	0.356
SHIP	1.231	0.659	0.590	0.592	0.653	0.684	0.675

TABLE VI

VERTICAL DAMPING COEFFICIENTS (f_z')

Fr = 0

ω	5.02	7.54	8.80	10.03	11.30	12.56	15.70
Seg #							
I	1.90	1.05	0.671	0.536	0.316	0.158	-0.0424
II	1.09	0.754	0.566	0.903	0	-1.80	-1.56
III	3.02	1.18	-0.443	0.709	-0.812	-2.40	-2.77
IV	2.38	0.851	-0.766	-0.373	-0.170	-0.652	-0.789
V	2.61	2.17	1.31	0.869	-1.66	-3.21	-3.34
VI	7.70	4.28	5.21	3.52	1.06	-0.532	-0.991
VII	3.23	1.86	0.155	4.54	1.51	0.885	2.17
SHIP	3.34	1.84	1.00	1.34	-0.180	-1.50	-1.56

Fr = 0.10

ω	5.02	7.54	8.80	10.03	11.30	12.56	15.70
I	2.45	1.06	1.01	1.37	0.953	0.395	-0.982
II	4.98	2.37	1.62	1.36	0.843	-0.242	-2.31
III	3.94	7.96	0.243	-0.016	1.07	1.14	-1.14
IV	5.52	0.886	0.927	1.98	1.61	-0.445	1.30
V	6.53	1.38	1.38	1.09	2.06	-2.83	-4.03
VI	4.38	1.60	1.65	1.27	0.358	-0.039	-2.36
VII	10.71	1.10	2.80	1.51	0.756	1.15	-1.08
SHIP	5.71	2.22	1.36	1.29	1.26	-0.327	-1.69

Fr = 0.20

ω	5.02	7.54	8.80	10.03	11.30	12.72	15.47
I	2.96	1.71	1.97	2.23	2.10	1.76	-0.472
II	7.91	1.22	0.904	1.46	2.66	2.76	-1.68
III	1.34	0.471	1.19	2.08	1.41	-0.087	-0.471
IV	1.2	0.632	1.03	0.337	-1.35	-1.00	1.85
V	2.94	2.74	2.17	1.30	0.244	-1.20	-7.00
VI	-0.976	3.45	2.55	1.87	0.905	1.91	-1.20
VII	4.85	0.605	1.26	1.52	5.52	1.63	-1.36
SHIP	3.02	1.70	1.69	1.60	1.32	0.670	-1.695

Fr = 0.25

ω	5.02	7.54	8.80	10.03	11.30	12.56	15.48
I	2.39	-0.626	0.106	0.973	2.15	1.51	1.37
II	3.67	2.58	0.799	1.73	3.87	4.96	2.78
III	4.17	4.77	0.184	1.01	0.173	-0.833	-3.25
IV	3.85	-1.44	1.25	1.64	1.94	-0.513	1.06
V	6.23	0.668	0.058	-0.085	0.694	1.44	-0.684
VI	4.04	0.397	0.241	0.827	1.93	2.40	0.605
VII	1.98	2.80	1.60	0.038	0.252	1.29	3.98
SHIP	4.38	1.213	0.607	1.032	1.778	2.004	0.530

TABLE VII

ADDED MOMENT OF INERTIA (k_θ)

Fr = 0

ω	5.00	7.35	8.65	10.10	11.35	14.00	15.50
Seg #							
I	6.78	3.51	2.42	1.48	0.806	-0.349	-0.871
II	2.98	2.85	2.68	2.49	2.31	1.95	1.76
III	2.41	1.32	1.075	0.914	0.825	0.707	0.649
IV	-0.612	- 0.576	- 0.570	- 0.570	-0.577	-0.584	-0.591
V	-0.646	0.409	0.539	0.660	0.740	0.834	0.862
VI	1.879	3.12	3.38	3.40	3.13	2.80	2.62
VII	7.65	17.2	13.2	10.25	8.38	6.89	6.46
SHIP	0.0765	0.0479	0.0406	0.0353	0.321	0.0266	0.240

Fr = 0.10

ω	5.00	7.35	8.65	10.10	11.35	14.00	15.50
Seg #							
I	8.59	2.62	2.59	2.44	3.38	0.916	0.916
II	6.24	3.20	2.47	2.29	2.24	2.04	1.96
III	3.58	1.44	1.05	0.810	0.530	0.611	0.596
IV	- 0.634	- 0.570	- 0.563	- 0.563	-0.570	-0.584	-0.577
V	- 0.524	0.345	0.524	0.682	0.761	0.876	0.962
VI	5.13	2.80	2.52	2.51	2.58	2.82	2.93
VII	40.8	21.4	14.1	10.3	8.21	6.15	6.15
SHIP	0.097	0.048	0.037	0.032	0.030	0.026	0.025

Fr = 0.20

ω	5.00	7.35	8.65	10.10	11.35	14.00	15.50
Seg #							
I	7.56	3.47	2.33	1.33	0.698	0.262	-0.327
II	3.18	2.59	2.44	1.98	2.26	2.10	2.02
III	2.87	1.29	0.927	0.707	0.611	0.530	0.523
IV	- 0.373	- 0.514	- 0.549	- 0.570	-0.577	-0.577	-0.577
V	3.02	0.287	0.596	0.817	0.491	1.02	1.01
VI	4.19	7.29	3.03	2.84	2.71	0.398	2.80
VII	34.9	16.2	11.9	9.19	7.94	0.909	5.37
SHIP	0.088	0.055	0.035	0.030	0.028	0.025	0.023

Fr = 0.25

ω	5.00	7.35	8.65	10.10	11.35	14.00	15.00
Seg #							
I	6.52	3.73	2.94	2.27	1.87	1.11	0.698
II	4.28	2.95	2.70	2.51	2.41	2.24	2.14
III	2.69	1.24	0.950	0.082	0.729	0.684	0.670
IV	- 0.584	- 0.577	- 0.570	-0.0570	- 0.577	-0.577	-0.584
V	- 1.40	0.495	0.869	1.06	1.14	1.16	1.13
VI	3.77	3.45	3.24	3.05	2.93	3.09	3.24
VII	36.6	15.5	10.5	7.47	10.39	5.81	5.90
SHIP	0.073	0.044	0.037	0.032	0.034	0.028	0.028

TABLE VIII

ROTARY DAMPING COEFFICIENTS ($f_\theta{}'$)

Fr = 0

ω	5.00	7.35	8.65	10.10	11.35	14.00	15.50
Seg #							
I	4.51	5.85	5.52	2.98	- 2.42	- 4.48	4.09
II	3.14	5.65	4.97	3.41	0.263	- 0.183	1.83
III	0.522	1.48	0.763	0.161	- 0.552	0.090	0.612
IV	0.567	-0.260	-0.183	-0.096	- 0.029	0.048	0.183
V	0.324	1.39	0.334	-0.226	- 0.481	- 1.37	-2.32
VI	2.06	6.37	4.40	2.55	0.279	- 2.78	-2.49
VII	-4.38	-1.20	9.74	17.1	16.7	-10.8	-8.90
SHIP	0.0609	0.1441	0.1365	0.1103	0.0357	-0.0843	-0.0330

Fr = 0.10

ω	5.00	7.35	8.65	10.10	11.35	14.00	15.50
I	28.0	9.79	12.9	12.4	17.85	1.363	-0.478
II	9.26	3.61	2.09	1.62	1.66	0.709	0.985
III	2.70	- 0.303	- 0.276	- 0.201	- 1.07	-0.176	-0.331
IV	- 0.132	0.189	0.131	0.062	- 0.0083	-0.118	-0.102
V	0.417	0.040	- 0.397	- 0.528	- 0.0766	-1.933	-1.90
VI	1.94	1.09	0.176	- 0.625	- 1.64	-2.222	-0.939
VII	51.8	77.5	31.3	14.2	7.22	-1.808	-9.64
SHIP	0.376	0.304	0.151	0.088	0.064	-0.046	-0.071

Fr = 0.20

ω	5.00	7.35	8.65	10.10	11.35	14.00	15.50
I	34.3	10.1	5.61	2.08	0.257	2.57	2.24
II	10.7	4.99	3.52	2.19	1.47	0.068	- 0.264
III	1.61	0.214	-0.10	-0.294	-0.619	-0.901	- 0.329
IV	- 0.416	0.287	0.429	0.259	-0.186	0.961	- 0.406
V	1.08	1.79	1.63	1.10	0.365	-2.00	- 0.345
VI	4.82	4.38	4.96	4.96	3.31	-1.95	- 5.37
VII	8.02	3.06	6.01	3.92	4.23	-4.37	-15.0
SHIP	0.296	0.147	0.130	0.090	0.050	-0.040	- 0.127

Fr = 0.25

ω	5.00	7.35	8.65	10.10	11.35	14.00	15.50
I	24.2	8.22	4.17	0.868	- 0.491	-3.34	- 4.54
II	5.55	-0.051	- 0.165	0.398	0.529	-0.476	- 1.69
III	1.17	-0.476	- 0.530	-0.294	- 0.126	0.194	0.413
IV	- 0.277	0.189	0.223	0.112	- 0.025	-0.398	- 0.674
V	1.73	2.59	5.53	2.01	1.29	2.94	1.40
VI	6.79	2.55	8.69	2.77	0.705	-0.655	2.97
VII	12.9	7.59	23.8	6.69	28.8	-3.10	-14.0
SHIP	0.252	0.095	0.210	0.068	0.106	-0.0023	- 0.037

TABLE IX

SQUARE LAW VERTICAL RESISTANCE

(UP STROKE d'_{z_1})

	Fr = 0							Fr = 0.10						
ω	5.00	6.00	8.00	10.00	12.00	14.00	15.47	5.02	7.54	8.80	10.03	11.30	12.56	15.70
Seg #														
I	- 7.50	- 4.75	- 2.80	- 2.24	-0.675	0.405	0.675	- 8.85	- 5.32	-2.89	-3.27	-2.62	-1.39	0.262
II	-13.5	- 9.62	- 5.57	- 3.89	-0.985	5.29	3.16	-26.0	- 9.85	-7.12	-5.22	-2.93	-0.788	2.36
III	-17.7	- 9.36	- 2.56	- 2.61	0.916	6.23	3.86	-19.9	-14.2	-2.67	-1.40	-1.95	-1.94	2.42
IV	-14.8	- 7.36	- 1.64	- 1.95	-1.55	0.099	0.588	-29.5	- 5.44	-3.94	-6.48	-4.02	-0.724	-3.58
V	-22.2	-16.4	- 8.94	- 4.72	2.06	10.5	6.15	-37.2	- 9.52	-6.42	-4.24	-4.61	5.46	5.83
VI	-43.2	-23.9	-19.2	-10.7	-3.35	1.80	2.20	-29.8	-11.2	-9.52	-6.26	-0.900	0.112	1.88
VII	-18.8	-11.7	- 4.91	- 9.30	-3.37	- 3.24	-2.66	- 7.07	- 4.15	-7.44	-4.07	-1.81	-2.01	-0.029
SHIP	-24.3	-14.6	- 7.83	- 5.71	-0.923	4.55	3.00	-29.8	-11.4	-6.91	-5.46	-3.50	-0.190	1.80

	Fr = 0.20							Fr = 0.25						
ω	5.02	7.54	8.80	10.03	11.30	12.72	15.47	5.02	7.54	8.80	10.03	11.30	12.56	15.48
Seg #														
I	-12.8	- 6.37	-5.37	-4.91	-3.78	-3.54	-0.032	-17.2	- 2.89	-3.62	-3.24	- 3.86	- 3.32	-2.15
II	-45.8	-10.3	-7.24	-7.21	-7.14	-5.98	1.46	-34.1	-17.1	-8.52	-8.34	-10.5	-10.8	-3.66
III	-15.2	-5.40	-4.91	-4.93	-2.67	0.179	2.26	-21.8	-14.1	-3.86	-2.57	- 0.640	1.13	4.13
IV	-11.8	- 5.49	-4.79	-3.00	-0.574	0.668	-3.80	-19.9	- 0.208	-5.54	-5.44	- 5.86	- 0.339	-3.15
V	-24.7	- 9.55	-6.74	-5.31	-2.30	2.65	9.13	-37.0	- 8.78	-3.42	-2.83	- 2.50	- 1.80	2.85
VI	-12.3	-17.1	-7.82	-6.32	-2.34	-2.72	2.79	-29.4	-11.8	-5.12	-4.62	- 3.47	- 2.21	1.61
VII	-18.1	- 6.70	-5.38	-3.86	-8.01	-2.19	1.85	-11.5	-12.5	-5.30	-1.64	- 0.477	- 1.73	-2.92
SHIP	-26.1	-10.8	-7.61	-6.51	-4.57	-1.84	2.47	-31.9	-12.3	-6.40	-5.37	- 5.16	- 3.45	-0.275

TABLE X

SQUARE LAW VERTICAL RESISTANCE

(DOWN STROKE d'_{z_2})

Fr = 0

ω	5.00	6.00	8.00	10.00	12.00	14.00	15.00
Seg #							
I	-6.09	-3.56	-2.13	-1.21	-0.378	0.248	0.432
II	-7.28	-5.77	-3.87	-3.00	-0.595	3.96	1.82
III	-12.4	-6.16	-1.32	-1.88	1.19	6.23	3.74
IV	-13.4	-5.61	0.109	-0.767	-1.21	-1.52	-0.929
V	-19.3	-15.2	-8.162	-3.29	2.41	8.12	4.12
VI	-38.7	-23.6	-19.7	-9.96	-3.03	0.0412	0.735
VII	-16.2	-10.8	-5.37	-10.4	-4.15	-3.69	-3.00
SHIP	-19.7	-12.2	-6.71	-4.79	-0.634	3.16	1.71

Fr = 0.10

ω	5.02	7.54	8.80	10.03	11.30	12.56	15.70
Seg #							
I	-15.4	-1.84	-2.54	-2.46	-1.32	-0.513	1.17
II	-40.2	-9.92	-6.27	-4.49	-1.62	-0.062	4.49
III	-25.7	-13.5	-2.05	-0.98	-1.48	-0.423	3.78
IV	-36.3	-5.81	-5.81	-5.61	-3.78	-1.29	-3.29
V	-50.7	-9.80	-6.37	-3.32	-4.12	5.11	5.41
VI	-40.0	-11.1	-6.14	-4.41	-1.92	1.06	3.41
VII	-19.4	-7.68	-8.06	-5.42	-2.26	-2.12	1.20
SHIP	-42.0	-11.14	-6.41	-4.59	-2.97	0.253	3.80

Fr = 0.20

ω	5.02	7.54	8.80	10.03	11.30	12.72	15.47
Seg #							
I	-9.67	-4.37	-4.29	-4.21	-3.35	-2.38	0.084
II	-34.6	-4.97	-4.81	-4.17	-6.32	-4.95	2.54
III	-8.54	-2.79	-3.70	-4.29	-2.88	1.10	2.01
IV	-7.70	-3.51	-4.31	-3.27	0.179	-0.406	-3.82
V	-21.5	-7.36	-7.29	-3.72	-0.040	2.78	10.1
VI	0.106	-11.6	-7.77	-4.85	-1.58	-1.60	4.06
VII	-21.9	-4.60	-4.36	-4.77	-7.81	-2.08	2.17
SHIP	-18.7	-6.85	-6.53	-5.24	-3.63	-1.20	3.06

Fr = 0.25

ω	5.02	7.54	8.80	10.03	11.30	12.56	15.48
Seg #							
I	-9.50	-2.34	-1.60	-3.16	-3.78	-2.52	-1.33
II	-23.6	-9.96	-4.99	-4.90	-7.26	-8.36	-2.05
III	-24.4	-13.2	-1.64	-2.14	-0.060	1.78	5.77
IV	-29.4	-0.576	-4.94	-5.37	-4.98	-1.57	-1.70
V	-42.6	-7.27	-2.73	0.506	-1.18	-0.255	4.34
VI	-34.4	-4.35	-1.82	-2.97	-2.88	-1.39	3.88
VII	-21.3	-10.2	-6.12	-2.11	-1.34	-1.70	-2.07
SHIP	-33.8	-8.90	-4.13	-3.89	-3.93	-2.47	1.60

TABLE XI

SQUARE LAW ROTATIONAL RESISTANCE

(UP STROKE d'_{θ_1})

Fr = 0

ω	4.99	7.35	8.65	10.11	11.35	13.80	15.43
Seg #							
1	- 58.9	- 35.3	- 15.7	- 41.4	50.4	40.1	-114.2
II	- 24.4	- 73.1	- 59.6	- 37.7	1.52	- 20.2	- 48.9
III	25.2	- 17.7	- 5.84	0.515	9.57	- 9.05	- 19.5
IV	- 22.8	2.34	3.89	0.620	1.77	- 1.30	- 4.11
V	37.2	- 7.68	i.04	10.8	3.66	17.5	27.1
VI	240.0	- 35.9	- 8.64	5.40	- 39.1	42.2	16.1
VII	521.8	274.4	- 11.2	-150.9	-411.6	213.6	73.0
SHIP	1.37	- 0.181	- 0.238	- 0.291	- 0.473	0.396	- 0.162

Fr = 0.10

ω	5.02	7.33	8.72	10.12	11.49	13.81	15.49
Seg #							
I	- 872.0	- 81.1	-202.5	-194.2	-300.8	- 93.1	- 52.3
II	- 236.9	- 33.5	- 8.35	3.10	30.2	- 38.2	- 48.5
III	- 98.6	23.6	7.08	- 0.780	3.80	- 10.4	- 17.7
IV	7.88	- 6.57	- 6.77	- 1.80	- 1.23	1.46	1.10
V	89.0	40.8	29.4	27.9	23.8	41.7	34.1
VI	238.3	106.9	- 76.0	73.8	55.5	50.8	- 18.6
VII	-1818	-1913	-514.5	- 83.3	- 10.6	125.4	151.4
SHIP	- 3.26	- 1.86	- 0.524	0	- 0.018	0.189	- 0.046

TABLE XI (cont'd)

Fr = 0.20

ω	5.00	7.43	8.72	10.18	11.48	13.00	15.44
Seg #							
I	-981.0	- 14.2	- 23.8	52.8	42.3	- 24.2	- 58.4
II	-262.0	- 49.5	- 33.9	-19.8	-22.8	- 16.0	- 30.3
III	- 54.6	- 0.611	- 11.0	- 7.51	- 4.63	- 1.21	- 22.0
IV	- 18.7	- 11.0	- 13.9	- 5.53	3.64	- 14.4	3.61
V	39.6	- 0.596	4.94	2.22	9.76	21.2	58.1
VI	- 36.6	8.17	- 40.6	- 30.6	-31.7	36.4	53.8
VII	164.5	169.3	101.9	68.6	24.1	32.8	195.3
SHIP	- 2.24	- 0.013	- 0.239	- 0.061	- 0.061	0.089	0.379

Fr = 0.25

ω	5.00	7.48	8.64	10.05	11.35	13.31	15.44
Seg #							
I	-503.6	18.2	84.4	93.7	55.8	67.1	66.3
II	- 69.6	78.2	75.3	1.84	- 9.12	-16.2	60.4
III	- 18.5	- 9.20	- 6.90	- 7.07	- 15.4	-25.5	- 29.7
IV	6.59	- 7.53	- 8.66	- 2.36	0.098	4.49	7.39
V	30.7	-23.5	- 96.2	-10.6	- 5.66	-20.4	40.1
VI	-110.4	35.9	-150.7	- 8.85	13.7	32.4	42.7
VII	-200.2	-19.9	-313.6	1.94	-431.2	53.2	191.6
SHIP	- 1.40	0.230	- 0.925	0.023	- 0.492	0.038	0.538

TABLE XII

SQUARE LAW ROTATIONAL RESISTANCE

(DOWN STROKE d'_{θ_2})

Fr = 0

ω	4.99	7.35	8.65	10.11	11.35	13.80	15.43
Seg #							
I	102.9	42.7	- 44.2	- 22.7	- 61.9	- 39.4	-128.2
II	- 32.0	- 47.4	- 78.5	- 39.8	- 0.469	- 2.61	- 51.7
III	- 3.97	- 22.5	- 1.59	- 1.82	10.3	- 11.3	- 22.5
IV	- 22.8	- 3.40	4.06	2.11	2.26	- 0.774	- 3.77
V	- 11.1	- 6.94	9.33	7.75	1.35	6.59	18.4
VI	- 36.9	- 47.3	- 17.6	8.50	- 31.8	31.3	- 17.2
VII	592.9	264.6	19.7	-187.7	-436.1	210.4	95.3
SHIP	0.441	- 0.072	- 0.308	- 0.323	- 0.473	0.365	- 0.317

Fr = 0.10

ω	5.02	7.33	8.72	10.12	11.49	13.81	15.49
Seg #							
I	- 619.1	- 67.6	-177.4	-192.3	-296.5	- 79.8	- 31.8
II	- 159.0	- 6.28	- 4.33	- 12.6	- 22.9	- 29.5	- 48.9
III	- 86.8	22.1	15.2	1.04	10.2	- 11.4	- 13.8
IV	- 0.507	- 7.25	- 3.39	- 2.36	- 0.246	1.26	0.845
V	40.1	15.5	30.8	22.8	19.5	28.0	23.2
VI	110.4	82.8	91.1	62.2	57.6	37.0	2.65
VII	-1703	-1896	-521.8	-155.8	- 26.5	128.9	103.6
SHIP	- 3.13	- 1.92	- 0.388	- 0.187	- 0.192	0.138	- 0.037

TABLE XII (cont'd)

Fr = 0.20

ω	5.00	7.43	8.72	10.18	11.48	13.00	15.44
Seg #							
I	-839.3	- 0.371	45.1	61.7	31.4	-25.3	74.1
II	-263.6	-62.2	- 39.2	-33.6	- 31.6	-15.4	25.4
III	- 29.7	- 4.05	- 12.8	-14.5	- 7.04	- 5.61	14.9
IV	- 19.8	- 7.60	- 10.5	- 6.64	2.60	-14.8	- 4.58
V	34.4	-13.8	- 15.9	- 0.696	15.0	19.4	- 40.1
VI	134.9	-24.2	- 48.8	-64.7	- 25.2	23.5	- 47.2
VII	- 63.4	75.5	46.6	78.6	43.4	46.8	-138.4
SHIP	- 1.68	- 0.303	- 0.325	- 0.024	- 0.055	0.040	- 0.249

Fr = 0.25

ω	5.00	7.48	8.64	10.05	11.35	13.31	15.44
Seg #							
I	-479.6	18.5	100.7	87.6	77.6	49.9	21.4
II	- 35.6	74.5	50.9	8.79	- 4.68	-13.2	48.0
III	- 35.5	- 2.94	- 5.67	-12.7	- 14.7	-26.5	- 27.8
IV	1.01	- 6.54	- 4.91	- 3.10	0.049	4.82	8.38
V	- 9.55	-30.9	- 93.3	-15.2	1.51	-22.2	27.9
VI	- 56.8	22.8	-134.0	-13.9	10.2	25.9	26.1
VII	-178.1	12.6	-460.6	-57.3	-409.2	62.0	114.7
SHIP	- 1.30	0.205	- 1.07	- 0.080	- 0.405	0.005	0.297

TABLE XIII

AMPLITUDE IN POUNDS AND PHASE SHIFT IN DEGREES

Run		26407		26410		26455		26458		26462		26465	
Velocity (fps)		0		0		1.268		1.268		0		0	
Freq. (rad/sec)		5.02		5.02		7.00		7.00		7.54		7.54	
Segment		δ	A	δ	A	δ	A	δ	A	δ	A	δ	A
I	F	-14.9	0.600	- 0	0.660	10.9	0.525	-56.5	0.505	-10.9	0.407	-10.8	0.330
	A	-28.4	0.815	-23.4	0.835	-13.0	0.722	-43.5	0.754	-21.4	0.627	-19.5	0.670
II	F	-48.4	1.40	-14.6	1.45	-32.6	1.26	-43.5	1.08	- 8.68	1.035	- 4.35	1.055
	A	-26.9	2.14	-24.9	1.94	-36.9	1.77	-56.5	1.65	-43.4	1.34	-39.1	1.36
III	F	-43.4	1.32	-35.1	1.26	-52.1	1.30	-63.0	1.24	-43.4	1.30	-32.6	1.44
	A	-31.4	1.41	-35.1	1.59	-34.8	1.24	-50.0	1.24	-34.7	1.12	-30.4	1.30
IV	F	-22.4	1.48	-13.2	1.56	-30.4	1.11	-30.4	1.11	-39.1	1.19	-21.7	1.39
	A	-31.4	1.35	-27.8	1.63	-30.4	1.07	-30.4	1.13	-56.6	1.25	-50.0	1.37
V	F	-25.4	1.82	-27.8	1.82	-54.3	1.56	-54.3	1.60	-41.2	1.38	-50.0	1.46
	A	-26.9	2.00	-24.9	1.96	-45.6	1.67	-54.3	1.79	-39.1	1.54	-23.9	1.54
VI	F	-26.9	1.65	-22.0	1.71	-45.6	1.54	-46.5	1.52	-45.5	1.38	-41.2	1.51
	A	-26.9	2.20	-24.9	2.12	-47.8	1.61	-36.9	1.68	-28.2	1.70	-45.5	1.87
VII	F	-37.4	1.12	-39.5	1.08	-67.4	0.880	-50.0	0.758	-34.7	0.897	-30.4	1.03
	A	-14.9	1.12	-13.2	1.14	-13.0	0.776	4.35	0.795	-39.0	0.815	-28.2	0.911

TABLE XIII (cont'd)

Run		26468		26471		26474		26477		26504		26507	
Velocity (fps)		0		0		1.271		1.271		1.271		1.271	
Freq. (rad/sec)		8.80		8.80		8.80		8.80		10.03		10.03	
Segment		δ	A	δ	A	δ	A	δ	A	δ	A	δ	A
I	F	-37.5	0.175	-54.5	0.310	18.0	0.378	-14.4	0.427	- 90.0	0.310	- 56.2	0.540
	A	-22.1	0.523	-37.9	0.523	-54.0	0.606	-99.10	0.626	- 66.8	0.585	- 65.0	0.627
II	F	-22.1	0.850	-37.9	0.684	-59.1	0.953	-48.0	1.04	-107	0.910	- 74.0	0.785
	A	-44.2	0.149	-45.0	1.03	-61.6	1.44	-52.8	1.09	- 78.5	1.26	- 63.0	1.28
III	F	-35.4	1.04	-45.0	0.834	-51.5	0.914	-48.0	1.09	- 78.5	1.12	-103	1.16
	A	-44.2	1.12	-49.7	0.836	-56.5	1.04	-50.4	1.00	-119	1.08	- 94.5	1.10
IV	F	-24.3	0.985	-33.2	0.698	-59.1	0.780	-48.0	0.880	- 20.3	0.965	- 79.7	1.15
	A	-15.5	0.771	-30.8	0.753	-64.3	0.830	-43.2	0.873	- 66.8	0.832	- 71.0	0.793
V	F	-28.7	1.16	-54.5	0.820	-51.5	1.10	-52.8	1.22	-104	1.12	-136	1.08
	A	-42.0	1.20	-40.3	0.950	-38.6	1.05	-91.0	1.14	- 61	1.10	-109	0.927
VI	F	-55.0	1.48	-52.1	0.134	-28.3	1.40	-28.8	1.28	- 78.5	0.905	- 50.2	0.865
	A	-50.7	1.49	-45.0	0.136	-25.7	1.38	-28.8	1.49	- 32.0	1.11	- 23.6	0.879
VII	F	-24.3	1.03	-30.8	0.860	-54.0	0.935	-36.0	0.954	- 52.3	0.898	- 74.0	0.841
	A	-28.7	0.737	-49.7	0.719	-23.1	0.640	-25.4	0.680	- 66.8	0.545	-130	0.310

Run		26510		26513		26516		26519		26523		26526	
Velocity (fps)		0		0		0		0		1.247		1.247	
Freq. (rad/sec)		10.03		10.03		11.30		11.30		11.30		11.30	
Segment		δ	A	δ	A	δ	A	δ	A	δ	A	δ	A
I	F	- 57.0	0.175	- 9.00	0.155	-155	0.350	-187	0.272	-131	0.525	POOR OSCILLOGRAPH	
	A	- 75.0	0.376	- 72.0	0.502	-108	0.355	-112	0.460	-128	0.690		
II	F	- 51.0	0.394	- 60.0	0.280	-151	0.520	-163	0.725	- 77.5	1.14		
	A	- 81.0	0.969	- 72.0	0.475	-108	1.12	-156	0.852	-104	1.65		
III	F	- 99.0	0.588	-129	0.792	-171	1.08	-187	1.06	- 91.0	1.85		
	A	-123	0.674	-117	0.653	-158	1.22	-235	1.26	-158	1.96		
IV	F	- 81.0	0.635	-102	0.759	-158	1.54	-174	1.35	-158	1.76		
	A	- 87.0	0.575	- 99.0	0.891	-128	1.60	-153	1.35	-134	1.62		
V	F	-105	0.740	-126	0.700	-175	1.58	-180	1.80	- 91.0	2.12		
	A	-102	0.760	-105	0.675	-158	1.48	-184	1.56	-168	2.08		
VI	F	- 75.0	1.01	- 93.0	0.865	-111	1.09	-109	1.07	-111	1.07		
	A	- 66.0	1.06	- 78.0	1.17	-104	1.21	-116	1.02	-151	1.04		
VII	F	- 63.0	0.879	- 78.0	0.841	- 81.0	0.75	- 81.7	0.840	- 84.0	0.880		
	A	- 6.00	0.563	- 72.0	0.564	- 60.6	0.35	- 68.0	0.388	-121	0.427		

TABLE XIII (cont'd)

Run		26556		26559		26562		26565		26603		26606	
Velocity (fps)		1.268		1.262		0		0		0		0	
Freq. (rad/sec)		12.56		12.56		12.56		12.56		15.70		15.70	
Segment		δ	A	δ	A	δ	A	δ	A	δ	A	δ	A
I	F	-178	1.24	-112	0.640	-193	0.446	-170	0.270	-171	1.03	-299	1.03
	A	-131	0.962	- 73.5	0.878	-136	0.606	-148	0.560	-148	1.23	-192	1.27
II	F	-150	1.38	-128	1.55	-163	1.20	-170	1.18	-144	2.42	-229	2.41
	A	-190	2.14	-151	2.52	-159	2.04	-186	1.90	-158	4.50	-202	4.20
III	F	-174	1.81	-155	2.42	-170	2.22	-178	1.89	-148	3.60	-215	3.40
	A	-202	2.53	-159	2.32	-185	2.59	-194	2.61	-158	4.50	-210	4.41
IV	F	-170	2.87	-182	2.09	-155	2.40	-170	2.25	-131	3.95	-178	5.09
	A	-170	2.48	-182	2.48	-155	2.34	-159	2.31	-131	3.35	-187	4.75
V	F	-190	3.22	-197	3.28	-159	2.76	-163	2.66	-144	5.86	-202	5.00
	A	-190	3.23	-201	3.06	-155	2.45	-178	2.47	-165	4.63	-206	4.22
VI	F	-186	1.81	-267	1.85	-151	1.36	-186	1.38	-165	2.79	-215	2.93
	A	-238	1.70	-205	1.89	-163	1.52	-182	1.38	-144	2.60	-215	2.78
VII	F	- 95.0	0.749	-136	0.730	- 98.5	0.785	-166	0.935	-131	1.46	-183	1.52
	A	-210	0.252	?	0.194	-159	0.136	-110	0.116	-152	0.74	-220	0.95

Run		26609		26612		27006		27009	
Velocity (fps)		1.279		1.279		1.272		1.274	
Freq. (rad/sec)		15.70		15.70		5.02		5.02	
Segment		δ	A	δ	A	δ	A	δ	A
I	F	-164	1.71	-159	1.24	-58.0	0.601	- 29.9	0.680
	A	-146	1.90	-138	1.67	-56.5	0.752	- 40.7	0.795
II	F	-178	3.23	-156	2.68	-36.2	1.68	- 38.0	1.68
	A	-159	5.76	-159	3.82	36.2	2.16	- 53.0	2.16
III	F	-195	4.23	-167	3.27	-49.3	1.60	- 47.5	1.56
	A	-196	4.84	-167	4.77	-33.4	1.67	-3616	1.67
IV	F	-159	5.10	-178	2.62	-49.3	1.60	- 28.5	1.46
	A	-105	4.85	-138	2.74	-30.4	1.62	- 31.2	1.58
V	F	-182	6.86	-156	3.80	-42.0	1.62	- 42.1	1.80
	A	-196	5.68	-159	5.06	-46.5	1.84	- 53.0	1.88
VI	F	-192	4.05	-167	3.44	-39.2	1.34	- 53.0	1.44
	A	-205	3.86	-171	2.97	-30.4	1.87	- 43.5	1.99
VII	F	-150	1.76	-149	1.70q	-45.0	0.805	- 40.7	0.823
	A	-196	1.11	-182	1.07	-34.8	0.970	- 29.9	1.05

TABLE XIV

ADDED MASS COEFFICIENTS BY

SIMPLIFIED METHOD

Fr = 0

ω	5.00	7.26	8.61	9.97	11.30	12.70	15.70
Seg #							
I	0.201	0.246	0.141	-0.035	0.052	0.138	0.230
II	1.93	1.01	1.05	0.791	0.588	1.07	0.939
III	2.13	0.814	0.745	0.916	0.476	0.982	0.733
IV	1.41	0.946	0.597	0.765	0.867	0.903	0.735
V	1.67	0.437	0.668	0.651	0.558	0.910	0.895
VI	0.805	0.559	0.859	0.695	0.842	0.769	0.592
VII	0.610	0.561	0.672	0.195	0.262	0.592	0.222
SHIP	1.32	0.778	0.697	0.684	0.598	0.840	0.689

Fr = 0.10

ω	4.88	7.00	8.68	9.85	11.40	12.80	15.40
Seg #							
I	1.12	0.269	0.263	0.141	0.511	0.294	0.499
II	1.84	1.10	0.924	0.914	0.698	1.10	1.19
III	2.53	1.19	0.706	0.875	0.825	0.883	0.904
IV	1.92	1.03	0.813	0.506	0.948	0.964	0.576
V	2.20	1.30	0.824	0.906	0.532	1.16	1.23
VI	2.60	0.787	0.301	0.304	0.787	0.514	0.865
VII	2.60	1.19	0.412	0.900	0.775	0.469	0.737
SHIP	2.08	1.00	0.646	0.643	0.713	0.944	0.858

TABLE XV

DAMPING COEFFICIENTS BY SIMPLIFIED METHOD

Fr = 0

ω	5.00	7.26	8.61	9.97	11.30	12.70	15.70
Seg #							
I	2.32	0.816	1.27	2.33	0.919	0.588	0
II	3.24	1.59	1.16	0.855	1.12	0.481	0.13
III	3.75	2.49	1.67	1.32	1.98	0.303	-0.195
IV	2.92	2.52	0.879	1.53	1.62	1.38	1.75
V	3.57	2.73	1.68	1.48	3.07	1.26	0.610
VI	4.34	4.02	2.24	2.68	1.53	0.628	0.455
VII	5.07	4.22	2.12	1.78	2.51	1.15	0.630
SHIP	3.01	2.21	3.42	1.28	1.57	0.707	0.330

Fr = 0.10

ω	4.88	7.00	8.68	9.85	11.40	12.80	14.40
Seg #							
I	4.13	1.32	1.27	1.90	1.66	1.75	1.11
II	5.92	3.17	2.45	2.34	2.73	1.24	0.921
III	4.95	2.88	4.06	1.87	2.56	1.32	-0.319
IV	3.95	1.74	1.65	1.94	1.75	0.327	2.37
V	6.05	2.77	1.59	2.06	2.46	1.37	-0.183
VI	3.90	4.28	2.03	1.48	1.76	1.28	-0.772
VII	5.90	2.88	2.82	3.10	2.76	1.27	-0.608
SHIP	5.68	3.15	2.23	2.33	2.56	1.29	1.33