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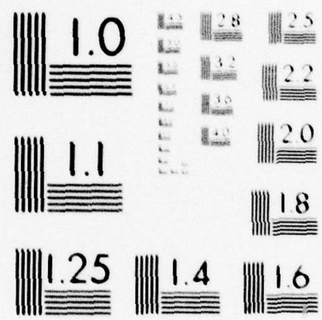

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SVIC NOTES

Many analytical and experimental techniques are available for solving shock and vibration problems; they range from the relatively simple to the highly sophisticated. The question of which type to use often arises and is frequently controversial.

To shed some light on this issue let us use mechanical signature analysis as an example. It is a good example of the range in the complexity of techniques that are available for solving shock and vibration problems. (Mechanical signature analysis is a method of determining the condition of a mechanical system by monitoring its vibration signature.) The techniques and equipment range from measuring the overall vibration level with a transducer and a meter to the use of the combination of a real time analyzer and mini-computer to perform a frequency analysis and store data.

Many question whether the use of highly sophisticated techniques and instruments is always necessary. There is no one answer to this question; it depends on the type of equipment that is being monitored and the data that are to be collected. The literature that has been published on this subject shows that both the simple and sophisticated methods and equipment have been used effectively. However cost effectiveness is another consideration. A simple technique whose initial cost may be low may end up being highly cost ineffective when it is considered in terms of the job to be done.

The preceding example only points out some of the very general considerations to help one to decide on the method(s) that should be used to solve a shock and vibration problem. However the decision may not always be clear; frequently several methods that are equally effective in solving a problem will exist. The previously-mentioned guidelines can help, however all techniques for doing a job must be carefully considered to avoid overcomplicating the problem or the blind use of overly sophisticated methods when equally effective but simpler techniques may be available.

R.H.V.

EDITORS RATTLE SPACE

The Future: A Challenge and an Opportunity

Recent spectacular accidents – Three Mile Island and the O'Hare DC-10 crash – contain a message for engineers: the need to be more vocal about the consequences of bad maintenance and operational practices. Today's engineer must do more than crunch numbers, provide designs, and evaluate test data. A design seldom fails on the drawing board; rather, it is the abuses a machine or structure is subjected to after operational installation that are fatal. It should be the responsibility of the engineer to examine his design for sensitivity to such abuses. If the design cannot be modified, management must be made aware of the situation. The design engineer of today must be familiar with field practices and aware of possible blunders – including short cuts in maintenance and/or operational processes. Perhaps the two recent accidents would not have happened if such warnings had been made and heeded. The challenge now facing engineers is to vocalize their concerns and make certain they're heard.

The current and anticipated shortages of engineers provide an opportunity for engineers: those with sound judgment will be heard. The typical retreat into engineering conservatism and indecisiveness that has tended to give engineers a black mark with management can no longer be tolerated. Rather, the engineer must be realistic and cautious -- aware of potential design flaws and slipshod maintenance practices -- and he must therefore evaluate more than stresses and strains or design. All of the tools available must be part of the decision-making process. Such effort will open the door to effective and professional engineering.

R.L.E.

RECENT DEVELOPMENTS FOR THE NONLINEAR DISTORTION OF NON-DISPERSIVE ACOUSTIC WAVES
Part II: Multidimensional Systems

J.H. Ginsberg[1]

Abstract - This two-part paper describes a perturbation procedure for investigating finite amplitude acoustic waves that depend on more than one spatial coordinate. The discussion focuses on wave motions that are non-dispersive in the linear approximation, in which case amplitude dispersion and self-refraction are the primary mechanisms for nonlinear distortion. Part I covered planar waves and the basic method. In Part II the results for a variety of systems are presented, and some types of further research are suggested.

CARTESIAN COORDINATES

Multidimensional waves can be classified according to the geometry of their wavefronts and rays in their linear approximation. Cartesian coordinate waves have wavefronts and rays that form an orthogonal set of straight lines in the approximation of an infinitesimal disturbance. Nonlinear effects in two systems of this type have been investigated thus far.

In the first system the waves occur within a semi-infinite half-space whose boundary is an elastic plate that is subjected to an exciting force. Initially, the double coordinate straining approach described earlier [51] was employed which uses Lighthill's technique for the potential function, followed by the method of renormalization for the particle velocity components. The excitation of the plate was considered to be harmonic with a sinusoidal spatial variation. Cases of resonant and nonresonant excitation led to slightly different results. The resonant response has been rederived [52] using the renormalization version of the direct method. Simultaneously, this approach was also used [53] to study the resonant and nonresonant responses jointly. The results of these studies are summarized as follows.

If an infinite elastic plate at $z = 0$ is subjected to a distributed force $F_0 \cos(\Omega t + \phi)\sin(N\pi x/L)$, its transverse displacement w will have the form

$$w = \epsilon L \cos(\Omega t)\sin(N\pi x/L) + O(\epsilon^2),\ \epsilon << 1 \qquad (9)$$

It was found that the relationship between the amplitude ϵ, phase angle ϕ, and frequency Ω can be established by using linear acoustic theory to describe the acoustical loading. Nonlinear theory for the plate is necessary only in the case of resonant Ω (provided that F_0 is sufficiently small).

After the structural response has been evaluated, the nonlinear acoustic response can be determined. Nonlinearities in the boundary condition, which arise because the components of velocity of the fluid and the plate normal to the deformed surface of the plate must match, are insignificant to the analysis.

The pressure signal p and component of particle velocity v_z normal to the plate were found to be in-phase[2] and are given by

$$v_z = \frac{kc_0^{\ 2}}{\gamma L \Omega \rho_0} p \qquad (10)$$

$$= -\epsilon L \Omega \sin(\Omega t - k\beta)\sin(N\pi\alpha) + O(\epsilon^2)$$

The velocity component v_x parallel to the plate was

$$v_x = -\epsilon L \Omega \left(\frac{N\pi}{k}\right)\cos(\Omega t - k\beta)\cos(N\pi\alpha) + O(\epsilon^2) \qquad (11)$$

The coefficient k in the foregoing is

$$k = \left[\left(\frac{L\Omega}{c_0}\right)^2 - N^2\pi^2\right]^{1/2} \qquad (12)$$

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[2] *The variables here are the dimensional ones, in contrast to the notation in the cited References*

and the parameters α and β are two strained coordinates replacing x and z

$$\frac{x}{L} = \alpha + \frac{1}{4}\,\frac{\gamma + 1}{N^2\pi^2 k}\,\frac{L\Omega}{c_o}\,\beta\,\frac{v_x}{c_o}$$

$$\frac{z}{L} = \beta + \frac{1}{4}\,\frac{\gamma + 1}{k^3}\,\frac{L\Omega}{c_o}\,\beta\,\frac{v_z}{c_o} \tag{13}$$

The foregoing is similar to the results for planar waves; the important difference is that two coordinates are involved in the distortion phenomena associated with the differences $x/L - \alpha$ and $z/L - \beta$. This distortion can be shown in several ways; typical spatial profiles along a line perpendicular to the plate are depicted in Figure 2. In addition to the forward

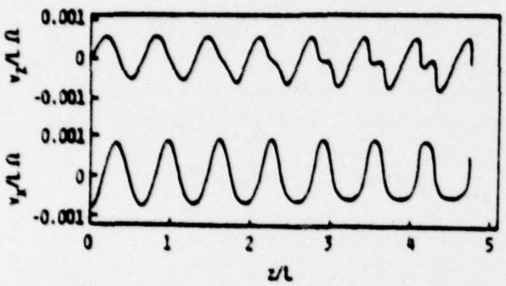

Figure 2. Waveforms Along x/L = 0.2/N Induced by Harmonic Vibration of an Infinite Flat Plate [53]

tilting of the velocity component in the direction of propagation (i.e., v_z), which was also found for a planar wave, other distortion phenomena arise. There is a gradual growth of a second harmonic in v_z and a clipping of the velocity component perpendicular to the direction of a propagation; i.e., v_x.

The physical explanation for these results was found [53] to lie in the fact that equations (10) and (11) indicate that, at any instant, lines of constant α and β represent rays and wavefronts of constant phase information, respectively. A typical set of such lines is shown in Figure 3. The deflection of these lines relative to the corresponding lines of constant x and z is found from equations (13) to be in the direction of the velocity component transverse to that line, with a severity that increases with increasing z. In other words, the wavefronts and rays are distorted by the response they represent; thus there is a self-refraction [54]. Such an effect was previously predicted in qualitative analyses [17, 18, 55, 56]. It is also a corollary of the postulate [35] that the coordinate straining in general should have an explicit dependence on the response variables in order for the response to have an implicit functional form in terms of the physical coordinates.

The two-dimensional wave motion in the foregoing system could be considered in linear theory to be a superposition of two sets of planar waves that propagate at equal but oppositely directed angles

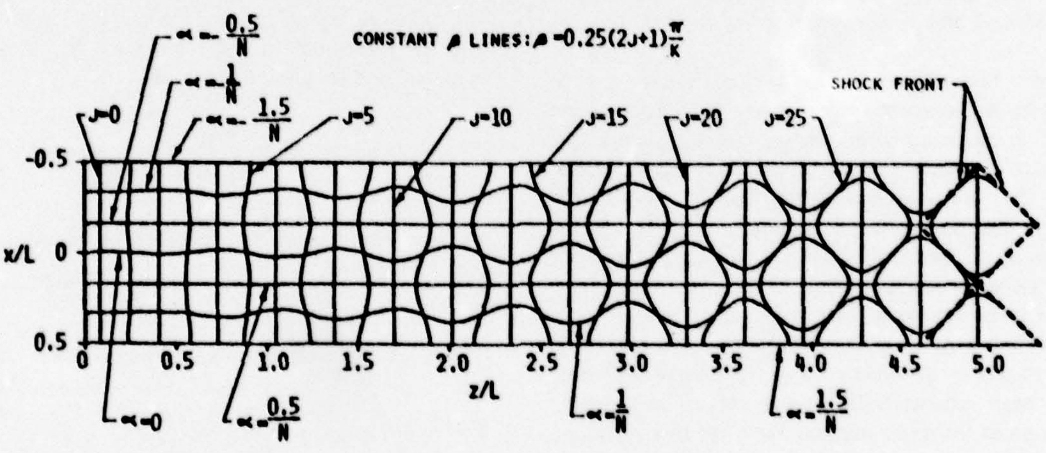

Figure 3. The Coordinate Straining Transformation When t = 0 for the Waves Induced by Harmonic Vibration of an Infinite Flat Plate [53]

relative to the normal to the plate surface. Such a superposition has been shown [57] to be partially valid for the nonlinear wave. The significant difference from a superposition of nonlinear planar waves of the type given by equation (4) is that the distortion of each set of planar waves in the plate problem depends only on the distance from the plate to a point on the wavefront, rather than on the distance from the excitation to the wavefront of each planar wave.

That the two-dimensional wave is a combination of planar waves was suggested by the result [53] that the shocks (i.e., vertical tangencies) formed along a series of straight lines, as shown in Figure 3. These straight lines were shown [57] to be parallel to the wavefronts of the two sets of equivalent planar waves.

Multi-harmonic excitations of an infinite flat plate bounding a fluid have been investigated [58]. The results are contained within those for the second system featuring Cartesian coordinates: hard-walled ducts with a rectangular cross section.

A duct with a non-rectangular cross section, as well as any duct having acoustically treated walls, is dispersive in general. The effects of nonlinearity on dispersive waves in ducts have been investigated [59-62] for several geometries, as well as for a variety of fluid theories; e.g., consideration of viscosity, boundary layers. These investigations determined the amplitude dependence in the dispersion relationship between phase speed and frequency. One study [62] also considered the multi-harmonic phenomenon of beats in an investigation of group velocity.

The situation in the aforementioned studies is contrasted by that for rectangular hard-walled ducts, which feature both dispersive and non-dispersive effects. These effects are manifested in a linearized analysis by the fact that the speed with which waves propagate along the axis of the duct depends only on the ratio of transverse to axial wavelengths. Thus, all harmonics for which this ratio is identical propagate as a group without dispersion.

The first investigation [63] of nonlinear effects in this problem was formulated in terms of equation (2) for the potential function. The analytical procedure entailed the method of multiple scales for the description of the dependence of the response on the axial coordinate. The dependence on the transverse coordinate was described by two Fourier series, one to describe the various harmonics and the other to account for nonlinear effects. The analysis was incomplete because the nonlinear ordinary differential equations for the modal amplitudes in the Fourier series were solved by numerical methods, without any accompanying consideration of the corresponding particle velocity and pressure responses.

A similar problem was solved [64] by utilizing the renormalization version of the direct method described earlier. The specific system investigated [64] was a semi-infinite duct ($0 < z < \infty$) with rigid hard walls at $x/L = 0$ and $x/L = 1$. The duct was subjected to a disturbance at $z = 0$ having a temporal period of $2\pi/\Omega$ and an arbitrary dependence on x. Uniformly accurate expressions for the particle velocity and pressure are obtained by introducing an infinite number of coordinate straining transformations involving both the axial and transverse coordinates.

The response of this system consisted of various groups of waves. One group of planar harmonics propagates according to equation (4). An infinite number of two-dimensional groups also occur, each of which is a summation of all harmonics of the type given by equations (10) and (11) which have the same phase speed. The coordinate straining for each group was essentially as given in equations (13). The significant difference from equations (13) is that the coordinate straining for each group depended only on the contribution of that group to the total response. The final contribution to the response was a non-propagating group of waves which originate from excitations that are below certain cut-off frequencies. This group decays exponentially with increasing distance from the excitation, and nonlinear effects are not important for it.

It was proven that the various groups combine in a simple superposition in a first approximation of the nonlinear effects. Although there might be nonlinear effects in the dispersion relation for the phase speed of the various groups, such effects will be found only in higher order, and therefore less significant, approximations.

The responses in Figures 4 and 5 are those of the transversely symmetric group having the largest axial and transverse wavelengths. The excitation leading

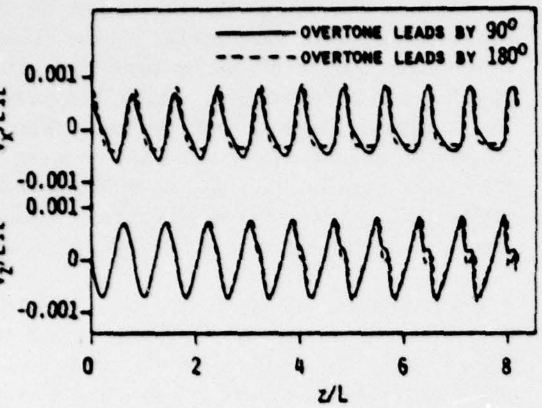

Figure 4. Axial Waveforms Along x/L = 3/8 Induced by Fundamental and First Overtone Excitation of a Duct [64]

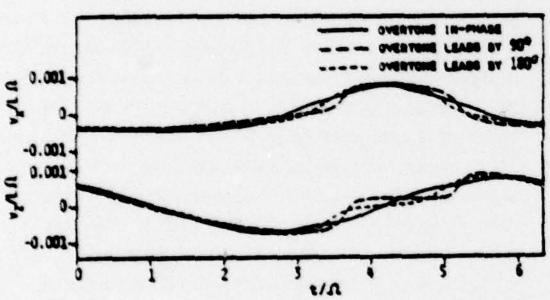

Figure 5. Temporal Response at z/L = 7 Induced by Fundamental and First Overtone Excitation of a Duct [64]

to these diagrams would, in a linear analysis, excite the second harmonic overtone of this group to 20 percent of the amplitude of the fundamental mode; no other harmonics would be excited. Figure 4 shows a typical set of axial profiles; Figure 5 is a typical temporal response at a fixed location. The distortion of the waveforms in the case of multi-harmonic excitations resembles that for monochromatic (i.e., single frequency) excitation. (The monochromatic response has been shown [64] to be identical to the response in the infinite plate system discussed earlier.) Despite the similarities, the multi-harmonic excitation also introduces new phenomena because the waveforms of that case are sometimes smoother than those of the monochromatic wave. The smoother waveform results from the fact that the harmonics generated by the excitation can cancel, rather than reinforce, the harmonics generated by self-refraction of a monochromatic wave. Thus it might be possible to suppress objectionable tones in ducts by exciting harmonics. Such noise control in planar waves has been explored [65-71].

CURVILINEAR COORDINATES

Systems whose boundaries are curved lead naturally to formulations of the spatial dependence of the wave motion in terms of the corresponding set of curvilinear coordinates. The first studies of such systems involved uniform cylindrical and spherical waves. Such waves arise when cylinders or spheres execute a breathing-mode type of vibration; the transverse displacement is the same from point to point on the curved boundary. The waves that result are one-dimensional because all points in the fluid at a specific distance from the vibrating surface have the identical response.

One analysis [29] began with a nonlinear equation for the pressure that was based on the far-field (i.e., large distance from the boundary) approximation that pressure is proportional to particle velocity. The particle velocity was normalized to account for spreading of the wave relative to a planar wave, and the length scale was redefined to transform the equations for finite amplitude uniform cylindrical and spherical waves in the far-field to the one solved by Earnshaw for planar waves. An in-phase relationship between particle velocity and pressure, which is characteristic of the far-field [2], has also been employed [28] to derive versions of Burger's equation for uniform cylindrical and spherical waves. This permits study of the effects of dissipation.

Nonuniform spherical waves were investigated [54-56, 72, 73] by using far-field approximations; nonlinear differential equations were obtained for pressure, density, or radial velocity. The restriction to the far-field inherently led to the additional assumption that the wave varied much more slowly in the transverse direction than in the radial direction. This made it possible in each analysis to separate the evaluation of the radial phase velocity from the evaluation of the dependence of the response on the transverse position. In other words, these analyses were essentially one-dimensional; a further limitation is that only the pressure response was derived, thus implying that the particle velocity components, particularly the transverse one, are not significant.

The obvious difficulty with any analysis that is founded on a far-field approximation is the question of where the far-field begins. Nor does the analysis address the importance of the effects of nonlinearity for the near-field response. These problems have been studied [74, 75]. The renormalization version of the direct method described earlier was used to study the finite amplitude waves induced by the vibration of an infinitely long cylinder of radius R whose transverse displacement is given by

$$w = -R\epsilon\cos(\Omega t)\cos(n\theta)\cos(\pi x/L),\ \epsilon << 1 \qquad (14)$$

The frequency Ω, circumferential wave number n, and axial half-wavelength L are specified parameters. The two-dimensional case $L = \infty$ [74] must be investigated separately from the three-dimensional one of finite L [75].

The linearized waves in either case resulting from equation (14) would feature the Bessel functions of the first and second kind of order n. Quadratic products of these functions would occur in the nonhomogeneous term of the linear wave equation governing the second perturbation ϕ_2 for the potential function. The difficulty of finding the corresponding particular solution was circumvented by resorting to the concept of inner and outer perturbation expansions.

The inner and outer regions were chosen as the near- and far-fields because the linear wave at large radial distances r behaves as a sinusoidal propagating wave whose amplitude decays as $r^{½}$. Outer expansions were obtained for the particle velocity and pressure. Uniform accuracy of those expansions required the introduction of a coordinate straining transformation for some of the spatial coordinates.

At that point, only the behavior of the response in the outer region had been obtained. The matching of the responses in the inner and outer regions was achieved by satisfying criteria drawn from two separate physical arguments. First, the distortional effects associated with a lack of dispersion in a wave generally accumulate as the wave propagates. The response in the near-field should, at least to a first order, be the same as that predicted by linear theory.

The second condition required for matching was drawn from earlier work on waves in Cartesian coordinates, as well as from qualitative analyses [17, 18]. Specifically, the coordinate straining transformation had to exhibit self-refraction. This means that the dependent variables of particle velocity and/or pressure were required to appear explicitly in the transformation. The self-refractive behavior and the progressive growth of the distortional phenomena were already evidenced in the outer expansion. Hence, both arguments were assumptions that trends established in the outer region are not unique to that region.

The waves resulting from two- and three-dimensional vibration of the cylinder had similar functional forms in terms of the strained coordinates. With the radial, circumferential, and axial components of particle velocity denoted as $R\Omega v_r$, $R\Omega v_\theta$, and $R\Omega v_x$, respectively, and the gage pressure denoted as $p_0(1+p)$, it was found that

$$\begin{aligned}
p &= -\gamma(R\Omega/c_0)^2\,\epsilon A_1\,[J_n(\mu\alpha)\cos(\Omega t-\Delta_1) \\
&\quad + Y_n(\mu\alpha)\sin(\Omega t-\Delta_1)]\cos(n\theta)\cos(\pi R\eta/L) \\
v_r &= \mu\epsilon A_1\,[J_n'(\mu\alpha)\sin(\Omega t-\Delta_1) \\
&\quad - Y_n'(\mu\alpha)\cos(\Omega t-\Delta_1)]\cos(n\theta)\cos(\pi R\eta/L) \\
v_\theta &= -n\epsilon A_1(R/r)[J_n(\mu\alpha)\sin(\Omega t-\Delta_1) \qquad (15) \\
&\quad - Y_n(\mu\alpha)\cos(\Omega t-\Delta_1)]\sin(n\theta)\cos(\pi R\eta/L) \\
v_x &= -(R/L)\epsilon A_1\,[J_n(\mu\alpha)\sin(\Omega t-\Delta_1) \\
&\quad - Y_n(\mu\alpha)\cos(\Omega t-\Delta_1)]\cos(n\theta)\sin(\pi R\eta/L)
\end{aligned}$$

The Bessel functions of the first and second kind of order n are denoted as J_n and Y_n; the derivatives of these functions with respect to their arguments are denoted by primes. The radial wave number μ, the amplitude A_1, and phase angle Δ_1 are the same as those predicted by linear theory for the excitation given by equation (14).

$$\mu = [(R\Omega/c_0)^2 - (\pi R/L)^2]^{1/2}$$

$$A_1 = (1/\mu)\left\{[J_n'(\mu)]^2 + [Y_n'(\mu)]^2\right\}^{-1/2} \tag{16}$$

$$\Delta_1 = \cos^{-1}[\mu A_1 J_n'(\mu)] = -\sin^{-1}[\mu A_1 Y_n'(\alpha)]$$

The parameters α and η are strained coordinates which are replaced in linear theory by the nondimensional radial and axial distances r/R, and x/R, respectively. The nonlinear transformations for these strained coordinates in the three-dimensional case were

$$\frac{r}{R} = \alpha + \frac{1}{2}(\gamma + 1)(R\Omega/c_0\mu)^3(\alpha - 1)(v_r/c_0)$$
$$\frac{x}{R} = \eta + \frac{1}{2}(\gamma + 1)(R\Omega/c_0)^3(L/\pi R)^2(\alpha - 1)(v_x/c_0\mu) \tag{17}$$

In the two-dimensional case, where there is no axial variation in the vibration of the cylindrical boundary, the functional dependence on x disappears and $v_x = 0$, as is evidenced by setting R/L = 0 in equations (15). Indeed, it might seem that the two-dimensional case could be obtained from the three-dimensional results by taking the limit $R/L \to 0$ in each relation. However, a significant result of the separate analyses of the two situations was that such a hypothesis is incorrect. The reason is that the transformation between r and α in the two-dimensional case, $R/L \equiv 0$, does not contain the 1/2 factor present in the first of equations (17) for $R/L \neq 0$. The distortional phenomena associated with the difference $r - \alpha$ are thus stronger for the two-dimensional wave than for the three-dimensional one in which L is large but finite. This apparent anomaly was resolved [75] by showing that certain wave modes which do not receive significant excitation through nonlinear coupling when L is finite coalesce when $R/L \equiv 0$ with modes that are always excited.

Equations (15) indicate that, at any instant, the surfaces of constant α are the wavefronts of constant phase; the lines of constant η and θ are the corresponding rays. The self-refraction phenomenon exhibited by equations (17) is thus one in which the wavefronts and rays are distorted in the direction of the velocity component transverse to these surfaces and lines. This is the type of self-refraction found in the Cartesian waves discussed earlier. However, note that the circumferential velocity v_θ plays no role in the self-refraction. This seems to be a consequence of the fact that, as the radial distance r increases, v_θ decays much more rapidly than either v_r or v_x. Note also that in the two-dimensional case $v_x \equiv 0$; the distortion phenomena thus reduce to a one-dimensional situation involving only r and v_r. This is the analog for cylindrical waves of the result [54] for spherical waves.

A typical set of radial profiles in the two-dimensional case are shown in Figure 6, which also shows the pressure response obtained when certain approximations for the far-field [54, 72] are applied to the cylindrical geometry. An analytical comparison of the two predictions, as well as several examples,

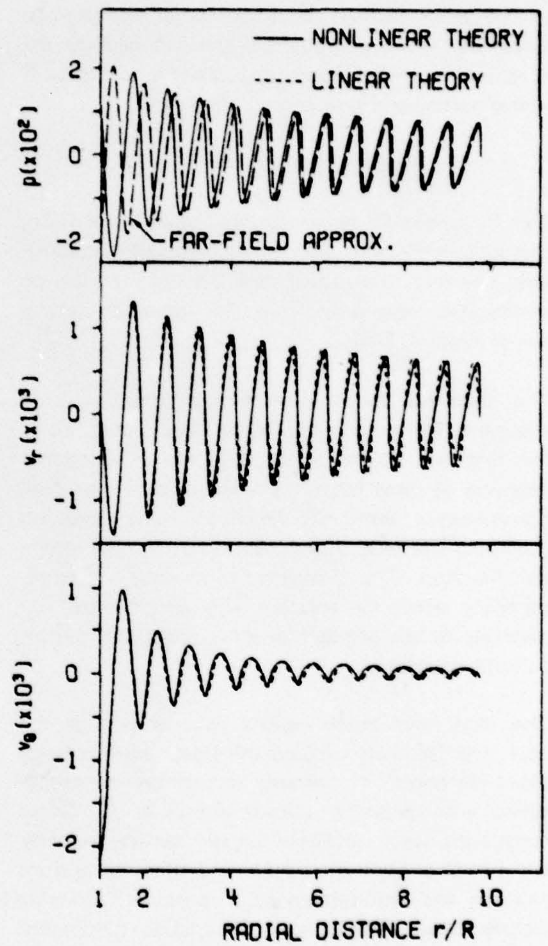

Figure 6. Radial Waveforms Along θ = π/4 n Induced by Two-Dimensional Vibration of a Cylinder [74]

indicated that far-field approximations lose validity as the frequency Ω decreases or the circumferential wave number n increases.

Figure 7 is a set of radial profiles in a three-dimensional case. The growth of a harmonic overtone in the radial direction, which is the direction in which the wave propagates, accompanied by clipping in the profiles of the velocity components perpendicular to the direction of propagation, are the new feature

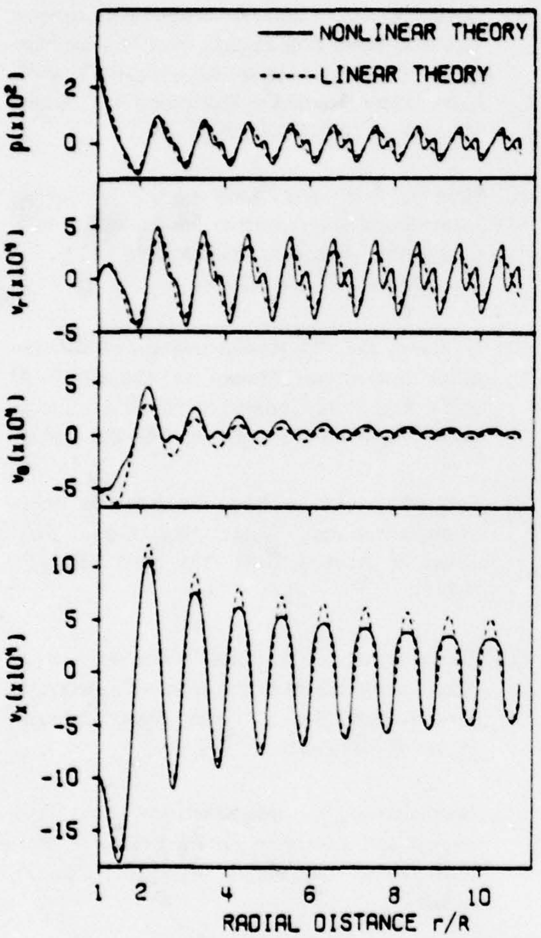

Figure 7. Radial Waveforms Along $\theta = \pi/4$ n $x/L = 3R/16L$ Induced by Three-dimensional Vibration of a Cylinder [75]

of the three-dimensional response. This type of distortion is characteristic of the self-refraction of rays, as it was for the Cartesian coordinate waves in Figure 2. Such distortion does not arise in the two-dimensional case because the self-refraction of the rays depends on v_x, which vanishes when $R/L = 0$.

The two-dimensional response resulting from vibration of the cylinder in a single mode [74] was extended [76] to cases in which the cylinder vibrates with several circumferential modes. All of the corresponding wave modes had the same radial phase velocity, independent of their temporal frequency and circumferential wave number. The radial coordinate r in the functional form for all wave modes was replaced by the same strained coordinate. The transformation for this coordinate was the same as before [74] for a single harmonic; the velocity v_r in the transformation was the sum of the contributions of all harmonics. In other words, the harmonics in the two-dimensional vibration of a cylinder generate a single group of non-dispersive waves, whose distortion is determined by the total response.

These results [76] and comparisons with the multi-harmonic effects in a duct [64] and the monochromatic waves from a plate [53] make it possible to conjecture about the response resulting from a three-dimensional, multi-harmonic vibration of a cylinder. Although the analysis has not yet been performed, it is likely that the response will resemble that in the duct, in which there is a superposition of separate non-dispersive groups. One such group for the cylinder would be the two-dimensional one [76]. According to this hypothesis the distortion of each non-dispersive group will depend only on the contribution of that group to the overall response.

FUTURE WORK

The profiles in Figures 2-7 have been terminated at the site of shock formation. Presumably, the analytical results can be extended into the shock region by employing weak-shock theory to cross the discontinuities. A different analysis of shocks, which utilizes Fourier series, has been presented [29], but the extension of that method to multidimensional phenomena has not been developed so far.

The role of viscosity requires further investigation, particularly as it pertains to the formation of shocks. As discussed earlier, the primary tool in such studies has been Burger's equation. It might be possible to develop an alternative formulation, parallel to the direct method presented here, by adding an additional linear term to equation (2) for the potential function. The term would account for the effects of shear stress. The effects of heat conduction, which may be as significant as viscosity for sound waves, could be accounted for by simultaneously satisfying another differential equation (probably linear) for the temperature. These matters have been discussed [1, 77].

Progress in the practical application of nonlinear acoustics requires further study of the ways in which waves distort as they interact. Each of the systems discussed above was infinite in extent; there was thus no reflection of radiating waves. When these waves are incident on another boundary, however, they will interact with their reflection [78]. Planar wave solutions have been carried out for the problem of resonant excitation of a finite column of gas [7, 10-16, 79-85]. This system exhibits a traveling shock wave, as opposed to a smooth standing wave, when excited resonantly. Such behavior has already been shown to occur in rectangular enclosures [86]. Further study of the interaction mechanism will provide valuable knowledge of the transient phenomena, particularly of the way in which shocks evolve. The means whereby the direct method can be applied to this problem with the aid of Laplace transform techniques has been addressed [87].

Interacting waves also occur when there are two sources [88-94]. The parametric acoustic array [95-104], in which two high-intensity, high-frequency beams are used to generate a wave at the difference frequency, is an important application to sonar systems of the effects of nonlinearity. The foregoing investigations have treated the region of nonlinear interaction, as well as the sound field scattered from the region of interaction. A feature shared by these studies is that they ignored the distortional effects arising from a lack of dispersion in the wave, on the grounds that the difference signal is generally weak. However, such a simplification is suspect in the regions where the primary signals form a shock [54, 94].

As has been demonstrated [57], the waves radiating from a flat plate [52, 53] are equivalent to two interacting planar waves. Similarly, the waves in ducts [64] can also be described in terms of planar waves that reflect from the walls of the duct. It therefore seems likely that the direct method described in this paper can be employed to investigate more general systems of interacting finite amplitude waves.

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LITERATURE REVIEW

survey and analysis of the Shock and Vibration literature

The monthly Literature Review, a subjective critique and summary of the literature, consists of two to four review articles each month, 3,000 to 4,000 words in length. The purpose of this section is to present a "digest" of literature over a period of three years. Planned by the Technical Editor, this section provides the DIGEST reader with up-to-date insights into current technology in more than 150 topic areas. Review articles include technical information from articles, reports, and unpublished proceedings. Each article also contains a minor tutorial of the technical area under discussion, a survey and evaluation of the new literature, and recommendations. Review articles are written by experts in the shock and vibration field.

This issue of the DIGEST contains review articles on the low wavenumber content of TBL pressure fields, and nonstationary and nonlinear vibration analysis.

Dr. L.D. Pope of Bolt Beranek and Newman, Inc. has written an update of a previously published article. This article summarizes results of measurements directed at the low wavenumber component of turbulent boundary layer (TBL) pressure fluctuations for the case of low subsonic flow.

Dr. B.N. Agrawal of COMSAT Laboratories and Dr. R.M. Evan-Iwanowski of Syracuse University have written a review of experiments that have been used to verify analyses for combination and internal resonances. Recent work on nonstationary and nonlinear vibrations in multiple-degree-of-freedom systems is also described.

UPDATE ON THE LOW WAVENUMBER CONTENT OF TBL PRESSURE FIELDS

L.D. Pope[1]

***Abstract** - This review article summarizes results of measurements directed at the low wavenumber component of turbulent boundary layer (TBL) pressure fluctuations for the case of low subsonic flow. Knowledge of the low wavenumber content is required to predict marine-structure response to TBL pressure fields.*

In a previous review[2] various measurement schemes were discussed, and results of initial measurement programs were presented. Three basic techniques were identified as useful for measuring the low wavenumber component: large transducers, wave-vector filtering with phased arrays, and wave-vector (spatial) filtering with plates (or membranes).

The first two techniques were discussed in the original review and will not be considered again. Results of early measurements made using those two methods were presented at that time.

Results available since the original review are presented in this article [4-6]. Efforts in this field continue because the low wavenumber component is difficult to measure, and various investigators obtain different answers for the low wavenumber content of the pressure spectrum. The range of measurements is more than 20 dB. Because each new experiment provides additional data to be plotted upon existing measurements, the more recent data should settle into a narrower range. This is occurring, but in a rather weak sense. An individual interested in using the present data for response predictions will have to select the test results that seem most appropriate for his application.

NEW MICROPHONE ARRAY RESULTS

The measurements by Farabee and Geib [4] utilized a microphone array and were similar to the measurements by Blake and Chase [2], except that a wind tunnel specifically designed to have very low background noise levels was used. The array consisted of six microphones (Blake and Chase used four microphones), and a wider range of experimental parameters was investigated over a narrower wavenumber band. In the range of Strouhal number S (= $\omega\delta^*/U_\infty$) from about S = 10 to 40, Farabee and Geib obtained an empirical fit for the data in the form

$$\phi(\omega)_{k_r} U_\infty / q^2 \delta^{*3} = 2 \times 10^{-9} S^{-4}, \quad (1)$$

where $\phi(\omega)_{k_r}$ is the low wavenumber component (δ^* is the boundary layer displacement thickness, q the free stream dynamic pressure).

The data that Farabee and Geib reported [4] were obtained for flow over a smooth boundary. A more extensive set of data was later obtained for both smooth and rough boundaries[3]. For the smooth wall, the best empirical fit in the range S = 3 to 30 was

$$\phi(\omega)_{k_r} U_\infty / q^2 \delta^{*3} = 2.18 \times 10^{-7} S^{-5.83} \quad (2)$$

The results given by equations (1) and (2) differ by about 2 to 5 dB over the range S = 10 to 30. For an intermediately rough wall (No. 40 Grit)

$$\phi(\omega)_{k_r} U_\infty / q^2 \delta^{*3} = 5.87 \times 10^{-7} S^{-5.85} \quad (3)$$

For a fully rough wall (gravel and barnacle)

$$\phi(\omega)_{k_r} U_\infty / q^2 \delta^{*3} = 8.34 \times 10^{-7} S^{-5.59} \quad (4)$$

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[2] *Shock and Vibration Digest, 8 (3) (1976)*
[3] *91st Meeting, Acoustical Society of America (1976)*

USE OF A PLATE OR MEMBRANE AS A SPATIAL FILTER

The principles of direct response measurement are summarized below.

The velocity response spectra of a plate (or a membrane) excited by a turbulent boundary layer pressure field are approximately given by the expression

$$\phi_v(\underline{x},\omega) = \sum_{mn} \frac{\chi^2_{mn}(\underline{x})}{|Z_{mn}(\omega)|^2} \iint_{-\infty}^{\infty} |S_{mn}(\underline{k})|^2 \, \phi_p(\underline{k},\omega) d\underline{k}, \quad (5)$$

where $\phi_p(\underline{k},\omega)$ is the wavenumber-frequency spectrum of the exciting pressure field and $S_{mn}(\underline{k})$ is a filter function. The mode shapes and frequency-dependent impedances are, respectively

$$\chi_{mn}(\underline{x}) = \chi_m(x_1)\chi_n(x_3)$$

and

$$|Z_{mn}(\omega)|^2 = \left(\frac{mL_1L_3}{4}\right)^2 \frac{\omega^4_{mn}}{\omega^2}\left[\left(1 - \frac{\omega^2}{\omega^2_{mn}}\right)^2 + \eta^2_{mn}\right] \quad (6)$$

where m is the surface density of the plate (or membrane) which is taken to be rectangular with dimensions $L_1 \times L_3$; L_1 is parallel to the direction of flow

The filter function is

$$|S_{mn}(\underline{k})|^2 = |S_m(k_1)|^2 \; |S_n(k_3)|^2$$

where

$$S_m(k_1) = \int_0^{\ell_1} \chi_m(x_1)e^{ik_1x_1}dx_1 \quad (7)$$

and

$$S_n(k_3) = \int_0^{\ell_3} \chi_n(x_3)e^{ik_3x_3}dx_3 \quad (8)$$

which, for a simply-supported plate (or a membrane) with $\chi_{mn}(\underline{x}) = \sin k_mx_1 \sin k_nx_3$, becomes

$$|S_{mn}(\underline{k})|^2 = \frac{4k^2_mk^2_n\,[1 - (-1)^m\cos k_1L_1]\,[1 - (-1)^n\cos k_3L_3]}{(k^2_1 - k^2_m)^2\,(k^2_3 - k^2_n)^2}. \quad (9)$$

The low wavenumber region is that region for which $k = \sqrt{k^2_1 + k^2_3}$ lies somewhat above the acoustic wavenumber k_0 and well below the hydrodynamic wavenumber $k_h = \omega/U_c$. U_c is the convection velocity $\simeq 0.6U_\infty$. The filter function $S_{mn}(\underline{k})$ samples $\phi_p(\underline{k},\omega)$ in the low wavenumber region for the case of slow flow; that is, near $k = k_{mn} = \sqrt{k^2_m + k^2_n}$. In order for the plate (or membrane) to be useful for measuring the low wavenumber component, the modes of the plate (or membrane) are selected such that they are sufficiently separated in frequency to allow determination of the response of a single mode; i.e., at its resonance frequency ω_{mn}.

$$\phi_V(\underline{x},\omega_{mn}) = \frac{\chi^2_{mn}(\underline{x})}{|Z(\omega_{mn})|^2} \iint_{-\infty}^{\infty} |S_{mn}(\underline{k})|^2 \phi_p(\underline{k},\omega_{mn})d\underline{k} \quad (10)$$

After the wavenumber-frequency spectrum is assumed to be reasonably flat in the low wavenumber region, the following approximation can be used:

$$|S_{mn}(\underline{k})|^2 = \left\{\frac{\pi L_1}{2}\,[\delta(k_1+k_m) + \delta(k_1-k_m)]\,[1-\delta_{m1}] + \pi L_1\delta(k_1)\delta_{m1}\right\} \cdot \left\{\frac{\pi L_3}{2}\,[\delta(k_3 + k_n) + \delta(k_3-k_m)]\,[1-\delta_{n1}] + \pi L_3\delta(k_3)\delta_{n1}\right\}$$

where $\delta(k_j)$ is the Dirac delta function and δ_{j1} is the Kronecker delta function.

Martin and Leehey [5] used a membrane whose dimensions were such that the modes m > 1 and n = 1 were used to obtain data. For their case

$$|S_{mn}(\underline{k})|^2 = \frac{\pi^2L_1L_3}{2}[\delta(k_1 + k_m) + \delta(k_1 - k_m)]\,\delta(k_3) \quad (11)$$

Equation (10) yields

$$\phi_v(x,\omega_{mn}) = \frac{\chi^2_{mn}(\underline{x})}{|Z_{mn}(\omega_{mn})|^2}\,\frac{\pi^2 L_1 L_3}{2}\left[\phi_p(-k_m,O,\omega_{mn}) + \phi_p(k_m,O,\omega_{mn})\right] \qquad (12)$$

The low wavenumber components at $(-k_m, O)$ and (k_m, O) are not separable. The sum of the two is, by definition, $\phi(\omega)_{kr} \equiv \phi(\omega_{mn})k_{mn}$, giving

$$\phi(\omega)_{kr} = \frac{2\phi_v(\underline{x},\omega_{mn})|Z_{mn}(\omega_{mn})|^2}{\pi^2 L_1 L_3 \chi^2_{mn}(\underline{x})} = \frac{L_1 L_3}{8\pi^2}\,\frac{(m\omega_{mn}\eta_{mn})^2}{\chi^2_{mn}(\underline{x})}\,\phi_v(\underline{x},\omega_{mn}) \qquad (13)$$

This expression is the basis for the measurements by Martin and Leehey [5]. The surface mass density m must be incremented by the fluid virtual mass, and the loss factor η_{mn} must include radiation damping. Both can be determined by analysis [7] or measured experimentally [5].

RESULTS OF MEASUREMENTS

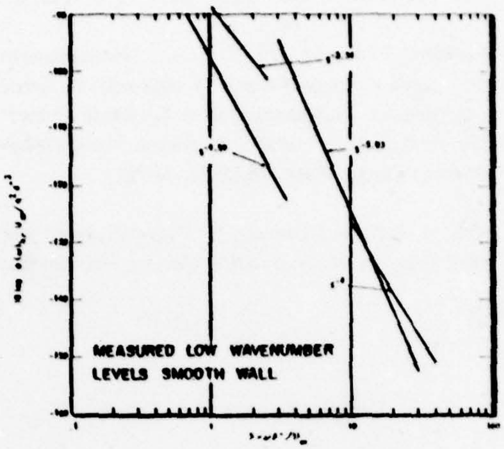
Martin and Leehey [5] used a membrane and for the range S = 1 to 2.5 found:

$$\phi(\omega)_{kr}U_\infty/q^2\delta^{*3} = 1.36 \times 10^{-9} S^{-3.34} \qquad (14)$$

Jameson [6] used a clamped plate and from S = 0.4 to 3.5 got the result

$$\phi(\omega)_{kr}U_\infty/q^2\delta^{*3} = 1.58 \times 10^{-10} S^{-4.59} \qquad (15)$$

In both experiments special care was taken to ensure that background noise levels were sufficiently suppressed to preclude significant acoustic response. As can be seen in the figure, a 10 dB difference exists between the two experiments. The nature of this discrepancy is unknown; see [5] for a discussion. Jameson's measurements have consistently been lower than those of other investigators. His data lead one to suspect that the low wavenumber component present may not be independent of the means of generation of the turbulent boundary layer.



Until all of the different measurement techniques can be shown to give the same result in a quiet (open-jet) wind tunnel, confusion will continue. And until further results are available, the data of Martin and Leehey [5] and Farabee and Geib [4] can be used as an upper bound.

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I want to thank Ellsworth Geib, Jr. and Paul Jameson for their comments and inputs. I also want to credit Nate Martin with the suggestion that there is a need to measure the low wavenumber component with all the various instrumentation available in the same wind tunnel to define better the influence of the test facility on results.

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NONSTATIONARY AND NONLINEAR VIBRATION ANALYSIS[1]

B.N. Agrawal[2] and R.M. Evan-Iwanowski[3]

***Abstract** - This paper is a review of experiments that have been used to verify analyses for combination and internal resonances. Recent work on nonstationary and nonlinear vibrations in multiple-degree-of-freedom systems is also described.*

A previous paper [1] presented a general asymptotic method with applications to nonstationary vibration analysis in spacecraft vibration testing. Evan-Iwanowski [2] has provided a comprehensive treatment of nonstationary and nonlinear vibrations in multiple-degree-of-freedom systems. Tondl [3] has summarized his work on the interaction between self-excited and forced vibration.

ANALYSIS

The equations of motion of a nonstationary and nonlinear multiple-degree-of-freedom system may be described by

$$\ddot{x}_j + \omega_j^2(\tau)x_j + C_j\dot{x}_j + \frac{\partial U_1}{\partial x_j} + \epsilon\frac{\partial U_2}{\partial x_j}\cos\theta = 0 \qquad (1)$$

where

$$U_1 = \sum_{\ell_1\ell_2\ell_3=1}^{n} A_{\ell_1\ell_2\ell_3}x_{\ell_1}x_{\ell_2}x_{\ell_3}$$

$$U_2 = \sum_{\ell_1=1}^{n} B_{\ell_1}x_{\ell_1} + \sum_{\ell_1\ell_2=1}^{n} B_{\ell_1\ell_2}x_{\ell_1}x_{\ell_2} + \ldots$$

U_1, U_2 = potential energy terms
x_j = normalized coordinates
ω_j = natural frequency of the jth mode
ϵ = positive small parameter
$\dot{\theta}$ = ν = frequency of the perturbation
τ = ϵt = slow time
C_j = damping coefficients
n = number of degrees of freedom

A general combination resonance for this system can be written as

$$\nu(\tau^*) = \sum_{r=1}^{n} h_r\omega_r(\tau^*) \qquad (2)$$

where h_r are positive or negative integers or zeros, and τ^* is the time at which the resonance relationships are satisfied exactly.

A system exhibits the above resonance when the potential energy contains a term with nonzero coefficient $B_{[\ell, h]}$, defined by

$$B_{[\ell, h]} = B_{\underbrace{1\ldots1}_{\tilde{h}_1}\ldots\underbrace{j\ldots j}_{\tilde{h}_j}\ldots\underbrace{n\ldots n}_{\tilde{h}_n}} \qquad (3)$$

where $\tilde{h}_j$ (the absolute value of h_j) indicates that the subscript j is repeated $\tilde{h}_j$ times. For example, for a combination resonance $\nu = 2\omega_1 + \omega_2$, the term $B_{112}X_1^2X_2$ must be nonzero.

In the first approximation, with higher order terms omitted, the nonstationary response becomes

$$X_j(\tau) = a_j(\tau)\cos\psi_j(\tau)$$

where

$$\dot{a}_j = \epsilon\left\{-\frac{1}{2}\bar{C}_j a_j - \frac{1}{2}\left[a_j\frac{(\partial\omega_j/\partial\tau)}{\omega_j}\right] - 2\tilde{h}_j B_{[\ell, h]} \cdot \frac{\left(\prod_{i=1}^{n} a_i^{\tilde{h}_i}\right)\sin\left(\theta - \sum_{r=1}^{n} h_r\psi_r\right)}{a_j\left(\prod_{i=1}^{n} 2^{\tilde{h}_i}\right)\left[\nu - \sum_{r=1}^{n} h_r\omega_r + 2\,\mathrm{sign}\,(h_j)\,\omega_j\right]}\right\} \qquad (4a)$$

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[1] *This paper is based upon work performed at COMSAT Laboratories under the sponsorship of the Communications Satellite Corporation*

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$$\dot{\psi}_j = \omega_j(\tau) + \epsilon \left\{ -\frac{1}{2} \frac{F_{cjj}}{a_j \omega_j} + 2h_j B_{[\ell, h]} \cdot \frac{\left(\prod_{i=1}^{n} a_i^{\tilde{h}_i} \right) \cos \left(\theta - \sum_{r=1}^{n} h_r \psi_r \right)}{a_j^2 \left(\prod_{i=1}^{n} 2^{\tilde{h}_i} \right) \left[\upsilon - \sum_{r=1}^{n} h_r \omega_r + 2 \operatorname{sign}(h_j) \omega_j \right]} \right\} \tag{4b}$$

$\bar{C}_j = C_j/\epsilon$; F_{cjj} is the coefficient of $\cos\psi_j$ in the perturbation force for the jth mode. Near resonance, the stationary response, $\dot{a}_j = \dot{\omega}_j = \dot{\upsilon} = 0$, becomes

$$a_j^2 = \frac{-2h_j B_{[\ell, h]} \left(\prod_{i=1}^{n} a_i^{\tilde{h}_i} \right) \sin \left(\theta - \sum_{r=1}^{n} h_r \psi_r \right)}{C_j \left(\prod_{i=1}^{n} 2^{\tilde{h}_i} \right) \omega_j} \tag{5}$$

Therefore, for the jth mode to be excited in a combination resonance, equation (2), three conditions must be satisfied:

- $\upsilon(\tau^*) = \Sigma_{r=1}^{n} h_r \omega_r(\tau)$ (resonance relationship)
- coefficient $h_j \neq 0$ (resonance condition)
- potential coefficients $B_{[\ell, h]} \neq 0$ (coupling condition)

A relationship

$$\sum_{r=1}^{n} h_r \omega_r(\tau) = 0 \tag{6}$$

known as internal resonance may also exist for a nonstationary system.

From the above conditions, it is clear that, at a certain perturbing frequency, several resonance conditions can be satisfied; the result is several possible stable steady-state responses. The existence of a particular resonance response depends upon the initial conditions, or the concept of domains of attraction of resonances; this concept indicates that the boundaries of a resonance are a function of the initial conditions. The domains of attraction have been determined for a two-degree-of-freedom system for a harmonic response and a combination resonance of the type $\upsilon = 2\omega_1 + \omega_2$ [4]. Tondl [5] determined the domains of attraction for parametric resonances in a nonlinear system.

In the first approximation, the linear mode shapes are retained in the solution and the natural frequencies are corrected for nonlinearity. In a technique [6] for including nonlinear normal mode shapes, not only do the natural frequencies vary with the response amplitude but also the coefficients of the mode shapes. The mode shapes of some systems are more sensitive to nonlinearity than are mode shapes of others.

EXPERIMENTS

Ibrahim and Barr [7] investigated theoretically and experimentally an elastic structure carrying a rigid circular tank containing liquid. The structure is excited in a direction perpendicular to the fluid surface. Autoparametric couplings of the first antisymmetric liquid sloshing mode with two orthogonal structural freedoms are analyzed. The autoparametric resonances occur when the conditions of internal resonance and main resonance ($\upsilon = \omega_i$) are met simultaneously. Under these conditions the modes related by internal resonance can react so that the forced excitation of one mode can result in the exponential growth of the other. The resonance relations are $\omega_3 = \upsilon$, $\omega_3 = \omega_1 \pm \omega_2$, $\omega_3 = 2\omega_1$, and $\omega_3 = 2\omega_2$. On the basis of experimental results, the theoretical analysis is satisfactory for determining the regions of instability. However, the correlation is poor for the response. The problem is representative of damping in the normal modes.

Paidoussis, Sundararajan, and Issid [8, 9] have experimentally and analytically investigated the parametric and combination resonances of a continuously flexible pipe during pulsating flow. For a cantilevered pipe, the system is nonconservative; the system is also subjected to a follower force at the free end and to gyroscopic forces. Experiments have demonstrated parametric and combination resonances involving some of the modes for certain ranges of pulsating frequency and amplitude.

Hasan and Barr [10, 11] analyzed thin-walled beams of equal angle section for parametric and combination resonances. Experimental tests indicated the existence of a primary parametric resonance $\upsilon = 2\omega_j$ and combination resonance $\upsilon = \omega_i + \omega_j$. Similar responses have been found experimentally [2] in an elastic cylindrical shell; i.e., $\upsilon = 2\omega_j$ and $\upsilon = \omega_i + \omega_j$, where ω_j are the radial natural frequencies.

In addition, several possible resonances were found in a nonlinear system consisting of three masses. Detailed analyses have been published [2, 12]. The experiments were performed for the $\upsilon = \omega_1 + \omega_2 + \omega_3$ resonance for the stationary and nonstationary regimes.

An extensive analytical and experimental study of the effects of nonlinearities and aspect ratios in thin-walled plates has been presented [2, 13]. An interesting phenomenon -- overlapping instability zones -- was described.

Evan-Iwanowski [2] determined that an internal resonance of the form $\omega_1 = 2\omega_2$ is exhibited by a double pendulum, where ω_1 is the longitudinal and ω_2 the lateral natural frequency, respectively. This can be confirmed experimentally.

Finally, analytical treatment of spherical and cylindrical shells [14, 15] subjected to an initial breathing mode with natural frequency ω_1 resulted in internal resonances of the form $\omega_1 = 2\omega_j$; ω_j are the natural frequencies of the bending modes. The value of j depends upon appropriate coupling mechanisms between ω_1 and ω_j.

CONCLUSIONS

The experimental results have generally shown good correlation with the theoretical analysis for the existence of combination and internal resonances. Initial disturbances are necessary to excite certain resonant responses. For some tests, the correlation of the response amplitudes is poor, possibly because of the difficulty of accurately representing damping in the analysis.

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BOOK REVIEWS

NOISE CONTROL, HANDBOOK OF PRINCIPLES AND PRACTICES

D.M. Lipscomb and A.C. Taylor, Editors
Van Nostrand Reinhold Comp., 1978

The Van Nostrand Reinhold Environmental Engineering Series provides information on current engineering methods for controlling the physical environment. It is in this general sense of control that the book is directed.

The editors have molded the contributions of 18 authors into a fairly homogeneous handbook covering various aspects of noise. An introduction on the nature of sound is followed by chapters on the measurement of sound, the definitions of equivalent sound levels, and the environmental assessments of noise. Basic principles of noise control -- i.e., acoustical treatment and procedures in hearing protection -- are followed by discussions of such major noise sources as industry and construction, aircraft and airport, highway and rail traffic, and home and noise from recreational activities. The managerial aspect of noise control is described in a chapter on the preparation of noise control legislation, especially in the U.S.

It is difficult to combine the experience and knowledge of so many experts without some loss of information due to transitions between chapters. However, the chapters contain general surveys on specific problems and methods for solving them that are clear and concise because they are written by experts.

The level of the book is basic: the information is conveyed in a practical manner and relies on diagrams and graphs when necessary. The book is intended for individuals who are not necessarily specialists in environmental noise and who want a general understanding of the fundamentals of noise and means of control. This handbook will be of value to such professionals.

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GEO-METRIC VIBRATION ANALYSIS

R.J. Barra
RMS Publishing Co., P.O. Box 227, Hannover, MD
1977

This book is promoted as a "different" vibrations book, and indeed it is! It is a compilation of formulas and descriptions of some limited aspects of precomputer vibration theory. Both U.S. Customary and S.I. metric units are employed. Definitions are given in both English and French.

Extensive graphs and tables provide the frequencies of uniform and tapered bars, beams, and plates. Also included are several tables of material and cross sectional properties. The tabular material is illustrated with numerous numerical examples. Exercises for the reader close the chapters.

The theory presented corresponds to that often offered in the first half of an undergraduate vibration theory course. The material is clearly written and amply illustrated. Occasional historical notes and case studies add interest to the text.

The reviewer is puzzled as to the type of course for which the book is appropriate. The structural element frequency information is certainly of interest to practicing vibration engineers, however.

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ADVANCES IN APPLIED MECHANICS VOLUME 17

C.-S. Yih, Editor
Academic Press, 1977

This volume contains five chapters on the following topics: turbulence in geophysical systems, ship hydrodynamics, elastostatics, nonlinear parametric excitation, and surface waves in anisotropic elastic materials.

The first chapter, which considers turbulence in geophysical systems, was written by Prof. Robert R. Long. The reader needs only basic knowledge of ideal and viscous fluids. Dimensional analysis of turbulent flow is emphasized. Wherever possible the author has related theoretical predictions to experimental results, especially as carried out in laboratory environments. Problems involving density variations and thermal convection are considered in detail. The final section describes a second-order closure model and its relation to the flux Richardsons number.

The second chapter by Prof. T.F. Ogilvie treats ship hydrodynamic problems. He shows that singular perturbational analysis is a useful tool for solving slender-body problems in aerodynamics and hydrodynamics. The solutions to the problems are obtained by matching far-field solutions to those near the body.

A comprehensive discussion is the slender ship in unsteady motion at zero speed. The solution procedure for the forced oscillation is divided into three regions, depending on whether the frequency ω satisfies $\omega = 0(1)$, $\omega = 0(\epsilon^{-1/2})$, or $\omega^{-1} = o(\epsilon^{1/2})$. The quantity ϵ is a small parameter that in some sense measures the slenderness of the body. The problems of a ship fixed in incoming waves are discussed. The division of the frequency range mentioned above is shown to be useful. The specific case involving head seas is considered.

The next part of chapter two discusses a ship with a steady forward motion. It is argued that the failure of the ordinary slender body theory is, to a great extent, due to end effects in the line source distribution. Another formulation of slender body theory is shown to lead to better results.

Finally, a ship with unsteady forward motion is considered, not only with the usual strip theory approach but also in an approach incorporating work on high-speed slender-body theory.

The third chapter on problems in elastostatics is by Prof. J.L. Eriksen. He concentrates on constitutive equations and the way they are interpreted from experiments. The theory of semi-inverse methods – that is, methods which reduce the number of unknowns in the basic equations subjected to some assumptions – are treated in detail. Attention is focused on the accessible domain of the energy function in static experiments. Because an accessible region requires some kind of stable behavior, the analysis is based on a stability criterion in connection with an energy method. The analytical tools are then applied to the theory of perfect crystals, with emphasis on the influence of material symmetry on the experimentally inaccessible region of the energy function.

Chapter four by Prof. C.S. Hsu is a treatment of the state of the art of the theory of nonlinear parametric excitation. An example of an asymptotic analysis of weakly nonlinear systems is a hanging string in a fluid. A general nonlinear analysis assumes periodicity of the solution. Seeking solutions at discrete times reduces the problem to a set of difference equations. Local instability of the solution is described, and the possibility of bifurcation into new periodic solutions is investigated. The special case of second order linear and nonlinear difference systems is treated using graphical aids. A discussion on global stability is followed by a description of impulsive parametric excitation. The last section is devoted to an example of a hinged bar subjected to a periodically varying impact load. The example clearly shows the usefulness of the analytical method presented.

The last chapter on the theory of surface waves in anisotropic elastic materials was written by Professors Chadwick and Smith. Special consideration is given to the existence and uniqueness of surface waves. The fundamental approach to this problem involves results from the theory of line dislocations. The eigenvalue problem for the fundamental elasticity tensor is treated in detail, as is the elastodynamic behavior of a uniformly translating line singularity in an ansiotropic elastic body, including the definition of a limiting speed. The six possible transonic states are described. The last two sections describe the uniqueness and existence of free surface waves; definite and complete criteria for such regions are given.

In conclusion it is the reviewer's opinion that this volume contains well written and interesting contributions and provides a most up-to-date treatment of various aspects of applied mechanics.

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PREVIEWS OF MEETINGS

SHOCK AND VIBRATION PROGRAM
SAE AEROSPACE MEETING
December 3-6, 1979
Los Angeles, California

These sessions were planned by the SAE Technical Committee G-5 on Aerospace Shock and Vibration.

9:00 A.M. Advances in Dynamic Analysis and Design

Chairman: B.A. Rommel, Douglas Aircraft, McDonnell Douglas Corp.
Asst. Chairman: Dr. P. Ibañez, ANCO Engineers

- ***Structural Dynamics - Future Trends - The Challenges and Opportunities***
  Dr. R. Goetz, NASA Headquarters
- ***Automated Design Using Numerical Optimization***
  Dr. G.N. Vanderplaats, NASA Ames Research Center
- ***On Solution Procedures for Nonlinear Dynamic Analysis***
  Dr. S. Ramaswamy, Dr. K.J. Bathe, MIT
- ***Finite-Element Hydroelastic Analysis Technology - A State of the Art Overview***
  Dr. R.N. Coppolino, The Aerospace Corporation
- ***Space Shuttle Dynamic Modeling and Verification***
  B.I. Bejmuk, Rockwell Space Systems Group
- ***Matrix Difference Equation Analysis of Vibrating Spatially Periodic Structures with Simply Supported Guided Ends***
  Dr. P. Denke, Douglas Aircraft, McDonnell Douglas Corporation

2:00 P.M. Advances in Dynamic and Modal Analysis/Testing

Chairman: Dr. D.A. Evensen, J.H. Wiggins Company
Asst. Chairman: Dr. M.H. Richardson, Structural Measurement Systems

- ***Shuttle Payload Random Vibration and Acoustic Environments***
  A.E. Chirby, Rockwell Space Systems Group
- ***Application of Statistical Parameter Estimation to Rail Vehicle Systems***
  D.T.K. Hasselman, J.H. Wiggins Company
- ***Experience with a Field Computerized Vibration Analysis System***
  Dr. P. Ibañez, ANCO Engineers
- ***The Application of Modal Parameter Estimation Techniques to Several Typical Structures***
  Dr. D. Brown, University of Cincinnati
- ***Extraction of Coupled Structural-Propulsion System Dynamics from Shuttle SRM and Main Propulsion Test Firing Data***
  Dr. H. Doiron, R.T. Anderson, NASA Johnson Space Center
  Dr. S.R. Ibrahim, Old Dominion University
- ***Interrelationship of Load Identification Modal Analysis and Fatigue***
  Dr. A. Klosterman, Structural Dynamics Research Corporation

SHORT COURSES

AUGUST

THE APPLICATION OF VIBRATION MEASUREMENT AND ANALYSIS IN MACHINE MAINTENANCE

Dates: August 20-22, 1979
Place: Chicago, Illinois
Dates: November 6-8, 1979
Place: New York, New York
Dates: November 13-15, 1979
Place: Dallas, Texas

Objective: These sessions are designed to give an understanding of the concept of using machinery vibration as a means of detecting wear in rotating parts, and of predicting machinery breakdowns. It will deal with the principles and methods of machine condition analysis and the economic benefits obtainable from condition monitoring. Fundamentals of vibration measurement and analysis are explained with particular reference to optimum choice of measurement parameter and techniques to avoid unnecessary errors and limitations in detection and diagnostic capability.

Contact: B&K Instruments, Inc., Bruel & Kjaer Precision Instruments, 5111 W. 164th St., Cleveland, OH 44142.

VIBRATION AND SHOCK SURVIVABILITY

Dates: August 20-24, 1979
Place: Tustin Institute of Technology

Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis, also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (815) 682-7171.

FINITE ELEMENT APPLICATIONS IN MACHINE DESIGN

Dates: August 27-31, 1979
Place: Tennessee Technological University

Objective: The course will cover basic theories of finite element techniques for force, displacement, and stress-related problems of mechanics and their applications to the solution of problems in the designs of mechanical systems, machines, and their components. Planar and three-dimensional flexural finite line elements; planar triangular, rectangular, quadrilateral and polar finite stress elements; three-dimensional tetrahedron, hexahedron, prism and polar finite stress elements; and rectangular and triangular finite plate elements will be presented.

Contact: Dr. Cemil Bagci, Dept. of Mech. Engrg., Tennessee Technological University, Cookeville, TN 38501 - (615) 528-3265/528-3254.

MACHINERY VIBRATIONS COURSE

Dates: August 28-30, 1979
Place: Anchorage, Alaska

Objective: This course on machinery vibrations will cover physical/mathematical descriptions, calculations, modeling, measuring, and analysis. Machinery vibrations control techniques, balancing, isolation, and damping, will be discussed. Techniques for machine fault diagnosis and correction will be reviewed along with examples and case histories. Torsional vibration measurement and calculation will be covered.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, Suite 206, 101 W. 55th Street, Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

SEPTEMBER

MACHINERY VIBRATION ANALYSIS

Dates: September 5-7, 1979
Place: Atlantic City, New Jersey

Dates: December 11-13, 1979
Place: New Orleans, Louisiana
Objective: The topics to be covered during this course are: fundamentals of vibration; transducer concepts; machine protection systems; analyzing vibration to predict failures; balancing; alignment; case histories; improving your analysis capability; managing vibration data by computer; and dynamic analysis.

Contact: Spectral Dynamics Corp. of San Diego, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

VIBRATION OF BEAMS, PLATES, AND SHELLS

Dates: September 10-14, 1979
Place: The Ohio State University
Objective: Understanding the natural frequencies and mode shapes of beams, plates and shells as well as their dynamic response to external excitation. A survey of the recent literature and examination of important papers will be included.

Contact: Professor A.W. Leissa, Dept. of Engineering Mechanics, The Ohio State University, 155 West Woodruff Ave., Columbus, OH 43210 - (614) 422-7271.

8TH ANNUAL INSTITUTE ON THE MODERN VIEW OF FATIGUE AND ITS RELATION TO ENGINEERING PROBLEMS

Dates: September 10-14, 1979
Place: Union College, Schenectady, New York
Objective: This course will emphasize the relationships of our current physical and phenomenological understanding of fatigue to the engineering treatment of the problem. The curriculum will be built around the several stages of the fatigue process including consideration of the plastic zone, crack nucleation and early growth, crack propagation in the plastic regime, crack propagation in the elastic regime, and failure.

Contact: Office of Graduate Studies and Continuing Education, Wells House, 1 Union Ave., Union College, Schenectady, NY 12308 - (518) 370-6288.

8TH ADVANCED NOISE AND VIBRATION COURSE

Dates: September 10-14, 1979
Place: Institute of Sound and Vibration Research, The University, Southampton, UK
Objective: The course is aimed at researchers and development engineers in industry and research establishments, and people in other spheres who are associated with noise and vibration problems. The course, which is designed to refresh and cover the latest theories and techniques, initially deals with fundamentals and common ground and then offers a choice of specialist topics. The course comprises over thirty lectures, including the basic subjects of acoustics, random processes, vibration theory, subjective response and aerodynamic noise, which form the central core of the course. In addition, several specialist applied topics are offered, including aircraft noise, road traffic noise, industrial machinery noise, diesel engine noise, process plant noise and environmental noise and planning.

Contact: Mrs. O.G. Hyde, ISVR Conference Secretary, The University, Southampton, SO9 5NH, UK - (0703) 559122, Ext. 2310 or 752, Telex 47661.

ROTATING MACHINERY VIBRATIONS SEMINAR

Dates: September 18-20, 1979
Place: Boxborough, Massachusetts
Objective: This seminar will feature lectures on fluid film bearings, torque induced lateral vibration, coupling use on rotating machinery, minicomputer use and self-excited vibrations in rotating machinery. Practical aspects of rotating machines will be emphasized.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, Suite 206, 101 West 55th St., Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

DIGITAL SIGNAL PROCESSING

Dates: September 18-20, 1979
Place: Washington, D.C.
Objective: This seminar covers theory, operation and applications -- plus additional capabilities such as transient capture, amplitude probability, cross spectrum, cross correlation, convolution coherence, coherent output power, signal averaging and demonstrations.

Contact: Spectral Dynamics Corp. of San Diego, P.O. Box 671, San Diego, CA 92112 - (714) 268-7100.

DIAGNOSING ROTATING MACHINERY VIBRATION PROBLEMS

Dates: September 18-21, 1979
Place: Santa Clara, California
Dates: October 2-5, 1979
Place: Boston, Massachusetts
Dates: October 16-19, 1979
Place: Chicago, Illinois
Dates: October 30-November 2, 1979
Place: Houston, Texas

Objective: This seminar is designed to provide both an overview of machine vibration characteristics and diagnostic techniques and an in-depth examination of several solved machine vibration problems. Topics include the fundamental causes of machine vibration, determining component and structural frequencies, considerations for setting up a preventative maintenance program (such as machine failure characteristics, diagnostic technique effectiveness, thresholds, and criteria), and monitoring equipment operation and usage. Industrial consultants and university experts will be featured at each seminar to provide a detailed discussion of illustrative case histories and to suggest advanced diagnostic techniques to solve vibration problems.

Contact: John Sramek, GenRad, Inc., 2855 Bowers Ave., Santa Clara, CA 95051 - (408)985-0700, Ext. 267.

INDUSTRIAL AND MACHINERY NOISE CONTROL PRACTICE

Dates: September 23-27, 1979
Place: Institute of Sound and Vibration Research, The University, Southampton, UK

Objective: The course is aimed at informing practical engineers on how machines make noise and how this can be controlled at both the design and installation stages. Methods of standard testing, the exact nature of national legislation and the effects of factory layout are all covered. An important aspect of the course is the inclusion of applications of noise control techniques to reciprocating engines, presses, forges, textile machines, compressors, valves, pile drivers, etc.

Contact: Mrs. O.G. Hyde, ISVR Conference Secretary, The University, Southampton, SO9 5NH, UK - (0703) 559122, Ext. 2310 or 752, Telex 47661.

UNDERWATER ACOUSTICS

Dates: September 24-28, 1979
Place: Pennsylvania State University

Objective: This short course is structured so that those attending have a choice between a basic or an advanced set of lectures during the first day and a half. Therefore it can serve as an introductory course for those who are new to the field but who have a good educational background in physics, mathematics, or some related branch of engineering; or as a refresher course for those scientists and engineers currently practicing in the underwater acoustics field. The material includes the linear and nonlinear propagation of sound in the ocean, transducers, and sources of underwater noise.

Contact: Robert E. Beam, Conference Coordinator, The Pennsylvania State University, Keller Conference Center, University Park, PA 16802 - (814) 865-5141.

OCTOBER

SONAR AND SEISMIC SIGNAL PROCESSING

Dates: October 1-5, 1979
Place: Pennsylvania State University

Objective: This course is designed to provide those scientists and engineers practicing in the fields of underwater acoustics or seismic exploration with an understanding of the principles and techniques used for the detection of underwater and underground signals. To obtain maximum benefit from the course, participants should already be familiar with the basics of Fourier transform theory and the more common probability distributions.

Contact: Robert E. Beam, Conference Coordinator, The Pennsylvania State University, Keller Conference Center, University Park, PA 16802 - (814) 865-5141.

AN INTRODUCTION TO VIBRATION AND SHOCK SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS AND CALIBRATION

Dates: October 1-5, 1979
Place: Southampton, England
Objective: Topics to be covered are resonance and fragility phenomena, and environmental vibration and shock measurement and analysis, also vibration and shock environmental testing to prove survivability. This course will concentrate upon equipments and techniques, rather than upon mathematics and theory.

Contact: James E. Frost, Plessey Assessment Services, Ltd., Titchfield, Fareham, Hampshire PO14 4QA, UK - (03294) 43031 or Wayne Tustin, 22 East Los Olivos St., Santa Barbara, CA 93105 - (805) 682-7171.

VIBRATION CONTROL

Dates: October 8-12, 1979
Place: The Pennsylvania State University
Objective: The seminar will be of interest and value to engineers and scientists in industry, government, and education. Topics include dynamic mechanical properties of viscoelastic materials; structural damping; isolation of machinery vibration from rigid and nonrigid substructures; isolation of impact transients; reduction of vibration in beams, plates, and shells; reduction of the flow-induced vibration of complex structures; case histories in vibration reduction; and characteristics of multi-resonant vibrators.

Contact: Professor John C. Snowdon, Seminar Chairman, Applied Research Lab., The Pennsylvania State University, P.O. Box 30, State College, PA 16801 - (814) 865-6364.

MACHINERY VIBRATIONS SEMINAR

Dates: October 23-25, 1979
Place: Mechanical Technology Inc., Latham, NY
Objective: To cover the basic aspects of rotor-bearing system dynamics. The course will provide a fundamental understanding of rotating machinery vibrations; an awareness of available tools and techniques for the analysis and diagnosis of rotor vibration problems; and an appreciation of how these techniques are applied to correct vibration problems. Technical personnel who will benefit most from this course are those concerned with the rotor dynamics evaluation of motors, pumps, turbines, compressors, gearing, shafting, couplings, and similar mechanical equipment. The attendee should possess an engineering degree with some understanding of mechanics of materials and vibration theory. Appropriate job functions include machinery designers; and plant, manufacturing, or service engineers.

Contact: Mr. Paul Babson, MTI, 968 Albany-Shaker Rd., Latham, NY 12110 - (518) 785-2371.

ROTATING MACHINERY VIBRATIONS COURSE

Dates: October 29-November 1, 1979
Place: Cherry Hill, New Jersey
Objective: This advanced course on rotating machinery vibrations will cover physical/mathematical modeling, mathematical computations, physical descriptions of vibration parameters, measuring, and analysis. Machinery vibrations control techniques will be discussed. Torsional vibration measurement, analysis, and control will be reviewed.

Contact: Dr. Ronald L. Eshleman, Vibration Institute, Suite 206, 101 West 55th St., Clarendon Hills, IL 60514 - (312) 654-2254/654-2053.

NOVEMBER

VIBRATION DAMPING

Dates: November 5-8, 1979
Place: University of Dayton Research Institute
Objective: Topics to be covered are: damping behavior of materials, response measurements of damped systems, surface damping treatments on vibrating members, discrete damping devices, special analytical problems, increasing linear viscoelastic material properties, damping of acoustic vibrations, selected case histories, problem solving sessions, and demonstration of digital fast fourier analyses.

Contact: Mrs. Audrey G. Sachs, University of Dayton Research Institute, Dayton, OH 45469 - (513) 229-2919.

DYNAMIC ANALYSIS WORKSHOP

Dates: November 5-9, 1979

Place: San Diego, California

Objective: This course will cover the latest techniques of analyzing noise and vibration in rotating machinery and power-driven structures. The workshop will cover both the theory and practical aspects of tracking down malfunctions and preventing failures caused by unbalance, misalignment, wear, oil whirl, etc. Included in the course will be demonstrations and practical, hands-on experience with the latest noise and vibration instrumentation; Real Time Analyzers, FFT Processors, Transfer Function Analyzers and Computer-Controlled Modal Analysis Systems. Actual case histories and specific machinery signatures will be discussed.

Contact: Spectral Dynamics Training Manager, P.O. Box 671, San Diego, CA 92112 - (714) 565-8211.

CONTROLLING THE EFFECTS OF PULSATIONS AND FLUID TRANSIENTS IN PIPING SYSTEMS

Dates: November 7-9, 1979

Place: San Antonio, Texas

Objective: The seminar will cover various means for preventing and controlling the detrimental effects of pulsations and fluid transients on piping, pumps, compressors, and other plant systems and equipment. Topics will include: pulsation generation mechanisms and their effects in plant piping and equipment; the SGA Compressor Installation Simulator (SGA Analog) and its applications; pulsation control and piping system design; mechanical response of plant components to pulsations and transient excitation; vibration control in piping systems; vibration-induced stress and meaningful stress criteria; transient fluid interaction of system components (flow instabilities, cavitation, flashing, piping effects on surge, etc.); effects and control of pulsations in flow measurement; and pulsation effects on the performance of compressor/pump installations.

Contact: Joe L. Gulinson, Southwest Research Institute, P.O. Drawer 28510, San Antonio, TX 78284 - (512) 684-5111, Ext. 2521.

THE 17TH ANNUAL RELIABILITY ENGINEERING AND MANAGEMENT INSTITUTE

Dates: November 12-16, 1979

Place: The University of Arizona

Objective: The following subjects will be covered: reliability engineering theory and practice, mechanical reliability prediction, reliability testing and demonstration, maintainability engineering, product liability, and reliability and maintainability management.

Contact: Dr. Dimitri Kececioglu, Aerospace and Mechanical Engineering Department, Aeronautical Engineering Building No. 16, University of Arizona, Tucson, AZ 85721 - (602) 626-2495/626-3901/626-3054.

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

NOISE-CON 79 FEATURES MACHINERY NOISE CONTROL

"Machinery Noise Control" was the theme of NOISE-CON 79, the 1979 National Conference on Noise Control Engineering. NOISE-CON 79 was sponsored jointly by the Institute of Noise Control Engineering and Purdue University, West Lafayette, Indiana. The three-day meeting was held on the Purdue Campus on 30 April - 2 May 1979 and covered a wide variety of subjects all related to the theme "Machinery Noise Control." Featured at the meeting were papers on agricultural and construction equipment noise, forging and impact noise, noise of engines and components, and noise generated by metal cutting. In addition, other papers on government programs, diagnostic techniques for noise control, computer noise control and noise levels in factories were presented.

The papers presented at NOISE-CON 79 have been collected into a bound volume titled "Machinery Noise Control" which is now available to those unable to attend the Conference. The book contains 404 pages and is published in soft cover. Copies of "Machinery Noise Control" are available from Noise Control Foundation, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603. The cost of the volume is $37.50; shipped postpaid except that overseas orders to be shipped by air require an additional $7.00 for air mail packing and postage.

INSTITUTE OF SOUND AND VIBRATION RESEARCH

Call for Papers

Recent Advances in Structural Dynamics

Southampton University, July 7-11, 1980

Abstracts of papers of approximately 500 words should be submitted by October 1, 1979. Accepted papers of up to fifteen pages will be required by March 1, 1980, for publication in the Conference Proceedings.

Sessions are planned for such topics as: developments in theoretical methods and testing techniques; correlation of theory with experiment; structure-fluid interaction; composite structures; wave propagation; machinery vibration; and dynamic stability.

Abstracts and requests for further information should be sent to: Dr. M. Petyt, Institute of Sound and Vibration Research, The University, Southampton SO9 5NH, England.

INSTITUTE OF ENVIRONMENTAL SCIENCES ELECTS NATIONAL OFFICERS

Robert N. Hancock, Senior Engineering Manager, Vibro Acoustics, Vought Corporation, Dallas, Texas, will assume the office of President on July 1, 1979. Mr. Hancock is currently serving as Executive Vice President of IES. He has been chairman of sessions at IES Annual Meetings and served as President of the Southwest Chapter. Mr. Hancock was Vice President of Region III, Technical Program Chairman for the 1978 Annual Technical Meeting and Chairman of the Environmental/Reliability Working Group. Mr. Hancock is a Senior Member of the Institute.

MALING NAMED INTER-NOISE 80 GENERAL CHAIRMAN

George C. Maling, Jr., Vice President-Administration of the Institute of Noise Control Engineering has been named General Chairman of INTER-NOISE 80, the 1980 International Conference on Noise Control Engineering.

James Seebold of the Standard Oil Company of California has been named Technical Program Chairman. He will be responsible for organization of the invited and contributed papers which will be presented at the three-day meeting. Clayton A. Allen, President of the Clayton A. Allen Corporation, will organize the noise clinics, a series of special sessions devoted to problems and solutions in noise control engineering.

William W. Lang of the IBM Corporation in Poughkeepsie, NY will act as Chairman of the Organizing Committee, a Committee of noise control specialists from overseas who will assist in the planning of technical participation in the meeting by overseas guests.

INTER-NOISE 80, the ninth in a series of International Conferences on Noise Control Engineering, will be held at the Hotel Inter-Continental in Miami, Florida, USA on December 8-10, 1980. The theme of the meeting, "Noise Control for the 80's" will be highlighted by a series of lectures presented by recognized specialists in the field. INTER-NOISE 80 is sponsored by the International Institute of Noise Control Engineering (INTERNATIONAL/INCE) and will be organized by the Institute of Noise Control Engineering of the United States of America, Inc. (INCE/USA).

For further information, contact INTER-NOISE 80, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 USA.

INSTITUTE OF ENVIRONMENTAL SCIENCES 1979 AWARDS PRESENTED DURING 25th ANNUAL MEETING

RELIABILITY TEST AND EVALUATION AWARD

Willis J. Willoughby, Jr., Assistant Deputy Chief of Naval Materiel for Reliability and Engineering, received the 1979 Reliability Test and Evaluation Award for outstanding contributions to the field of reliability design, test and management. This award is made by the IES for outstanding contributions to the field of Reliability Test and Evaluation. The nominations are provided to the IES Honors and Awards Chairman by the IES Environmental Reliability Project Group Chairman and approved by the IES Executive Board.

IRWIN VIGNESS AWARD

David O. Smallwood, Shock & Vibration Test Division, Sandia Laboratories, was presented the IES Vigness Award. The award was presented to Mr. Smallwood for authorship of "Multiple Shaker Random Control with Cross Coupling," a technical paper pertinent to the field of Dynamic Shock.

The IRWIN VIGNESS AWARD is given to the individual or author whose contribution to the field of acoustics, shock and vibration are considered outstanding. The Institute of Environmental Sciences established this award in 1967, in memory of Dr. Irwin Vigness, who was a consultant on specifications and standards in mechanical shock and vibration and did pioneering research in that field.

ABSTRACTS FROM THE CURRENT LITERATURE

Copies of articles abstracted in the DIGEST are not available from the SVIC or the Vibration Institute (except those generated by either organization). Inquiries should be directed to library resources. Government reports can be obtained from the National Technical Information Service, Springfield, VA 22151, by citing the AD-, PB-, or N- number. Doctoral dissertations are available from University Microfilms (UM), 313 N. Fir St., Ann Arbor, MI; U.S. Patents from the Commissioner of Patents, Washington, D.C. 20231. Addresses following the authors' names in the citation refer only to the first author. The list of periodicals scanned by this journal is printed in issues 1, 6, and 12.

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALOGS AND ANALOG COMPUTATION

79-1288

On a Technique to Obtain an Optimum Strength Shape by the Finite Element Method. Application to the Problems under Body Force

J. Oda and K. Yamazaki
Faculty of Engrg., Kanazawa Univ., Kanazawa, Japan,
Bull. JSME, 22 (164), pp 131-140 (Feb 1979) 24 figs, 2 tables, 5 refs

Key Words: Optimization, Optimum design, Finite element technique, Disks (shapes)

A technique to determine effectively an optimum shape of two-dimensional and axisymmetric bodies under body force is proposed. This technique is based on the iteration of a sequential search method consisting of the following steps: The superiority or inferiority of a given shape, which satisfies the constrained conditions of design, is judged by the deviation from the design object stress value; and the shape is modified to an optimum shape by the proportional transformation method of the finite elements, which is considered an effect of body force. By using this technique the optimum shapes of the basic problems under gravity load or centrifugal force are obtained and the results are compared with the corresponding shapes given by elementary theory.

ANALYTICAL METHODS

79-1289

Calculation of Eigenvalue and Eigenvector Derivatives for Algebraic Flutter and Divergence Eigenproblems

C. Cardani and P. Mantegazza
Aerospace Dept., Politecnico di Milano, Italy,
AIAA J., 17 (4), pp 408-412 (Apr 1979) 22 refs

Key Words: Flutter, Eigenvalue problems

A single procedure is presented for the determination of eigenvalue and eigenvector derivatives of general eigensystems, including those arising in flutter and divergence analysis. In the procedure, the eigenproblem is presented as a nonlinear algebraic system of equations with the eigenvalue and the eigenvector as unknowns and the eigenderivatives coming from the solution of a linear system of equations that is determined trivially by differentiating the nonlinear equations with respect to structural parameter. Application to flutter and divergence problems is emphasized.

STABILITY ANALYSIS

79-1290

Remarks on Vibrations of Damped Linear Systems

P.C. Muller
Lehrstuhl B f. Mechanik, Technische Universität München, Arcisstr. 21, D-8000 München 2, Germany,
Mech. Res. Comm., 6 (1), pp 7-15 (1979) 6 refs

Key Words: Linear systems, Damped structures, Stability, Transverse vibration

Marginal stability and instability are presented for the free vibrations of damped linear systems. Bounds of the frequency response in terms of eigenvalues of the stiffness, damping and mass matrices are discussed for the forced vibrations of an asymptotically stable damped linear system.

STATISTICAL METHODS

79-1291

Simulation of a Non-Stationary Stochastic Process with Respect to its Probability Density Function

J. Cacko and M. Bily
Inst. of Machine Mechanics of the Slovak Academy of Sciences, 809 31 Bratislava, Czechoslovakia,
J. Sound Vib., 62 (2), pp 293-299 (Jan 22, 1979) 1 fig, 1 ref

Key Words: Stochastic processes, Probability theory, Time dependent excitation

Various relationships are developed for simulation of a non-stationary stochastic process. They are based on modeling of its time-dependent amplitude and probability density. The main purpose of the approach is to reproduce an environmental loading process and use it as the on-line input of computer controlled loading machines.

79-1292

Output From a Non-Linear "Friction" Element with Stochastic Input

M. Apetaur and F. Opicka
Automotive Res. Institute UVMV Praha 9, Lihovarska 12, Czechoslovakia, J. Sound Vib., 62 (1), pp 141-149 (Jan 8, 1979) 8 figs, 1 table, 3 refs

Key Words: Stochastic processes, Friction, Spectral energy distribution techniques

A general theory of the stochastic properties of the output signal from a non-linear element is presented. The case of a friction element is treated in detail. A simple approximate formula for the spectral density of the output signal from a friction element under the assumption of a Gaussian input signal is derived.

79-1293

Permanent Deformations of Rigid-Plastic Structures Subject to Random Dynamic Loads

F. Casciati, L. Faravelli, and A. Gobetti
Istituto di Scienza e Tecnica delle Costruzioni Universita di Pavia, Pavia, Italy, Engrg. Struc., 1 (3), pp 139-144 (Apr 1979) 8 figs, 4 tables, 15 refs

Key Words: Probability theory, Stochastic processes, Random excitation

The probabilistic analysis of the inelastic displacement response for simple rigid-plastic structures subject to dynamic loads is considered. The paper presents a method able to approximate the probability density function of the residual displacement at any time. The procedure is based on the filtered Poisson process theory. This model aims to idealize the input stochastic process and to describe the output process. A numerical example is developed in order to show the computational aspects of the method.

79-1294

Statistical Models of Coupled Dynamical Systems and the Transition from Weak to Strong Coupling

P.W. Smith, Jr.
Bolt Beranek and Newman, Inc., Cambridge, MA 02138, J. Acoust. Soc. Amer., 65 (3), pp 695-698 (Mar 1979) 13 refs

Key Words: Coupled systems, Steady-state response, Statistical energy analysis

The statistical model for steady-state response of a coupled dynamical system that is used in both room acoustics and statistical energy analysis is taken as the hypothesis. The model is defined by the fundamental equations of linear relation between the response energies of the subsystems and the input powers. The model is used to examine the effect of varaible strength of coupling between the subsystems and the transition from weak to strong coupling.

FINITE ELEMENT MODELING

79-1295

Uncertainty Finite Element Dynamic Analysis

B.A. Dendrou and E.N. Houstis
Dept. of Civil Engrg., Purdue Univ., West Lafayette, IN 47907, Appl. Math. Modeling, 3 (2), pp 143-150 (Apr 1979) 11 figs, 7 tables, 10 refs

Key Words: Finite element technique, Dynamic structural analysis, Perturbation theory, Mathematical models

An inference-dynamic model is developed based on a model dynamic analysis using a moving boundary condition. The uncertainty of the physical parameters is implemented in the model using an inference scheme coupled with a perturbation technique. Finally, the first two statistical moments of the displacements and the stress field are estimated according to the proposed analytical scheme and are in good agreement with the initially assumed fields.

MODELING

(See No. 1474)

DIGITAL SIMULATION

(See No. 1302)

PARAMETER IDENTIFICATION

(Also see No. 1346)

79-1296

Parametric Identification of Systems Via Linear Operators

J. Nebat
Ph.D. Thesis, Syracuse Univ., 202 pp (1978)
UM 7908558

Key Words: Parameter identification technique

A general parametric identification/approximation model is developed for the black box identification of linear time invariant systems in terms of rational transfer functions. The identification procedure is shown to consist of two basic parts: the generation of a set of basis functions through a linear operation upon the input and output signals of the system; and the choice of an error criterion and its associated approximation scheme.

CRITERIA, STANDARDS, AND SPECIFICATIONS

79-1297

Aircraft/Airport Noise Control

Committee on Government Operations, U.S. House of Representatives, Rept. No. GPO-93-187, 834 pp (1977)
N79-15447

Key Words: Aircraft noise, Noise control, Standards and codes

The effectiveness of the Federal program which was established to control and lessen noise pollution is reviewed with emphasis on aircraft/airport noise control. Topics covered include: noise emission standards for consumer products, railroads, and motor carriers engaged in interstate commerce; aircraft/airport noise reduction regulations; and coordination of noise research and control programs.

79-1298

Rating of Noise Nuisance

P.P. Riley
Acoustical Investigation and Res. Organisation, Ltd., Noise Control Vib. Isolation, 10 (3), pp 87-90 (Mar 1979) 2 figs, 2 tables, 2 refs

Key Words: Noise measurement, Standards and codes

A method of rating noises based on a calculation of the extent to which they obtrude above the general background noise level is suggested. Such a method of assessment is used in both British Standard BS 4142 and in ISO R1996. The assessment, in each case, depends on a comparison of a Corrected Noise Level (the measured level of the noise with corrections for character and duration) with either the measured background noise level or a derived criterion.

SURVEYS AND BIBLIOGRAPHIES

79-1299

Aircraft Noise and the Concorde

Committee on Government Operations, U.S. House of Representatives, Rept. No. H-Rept-95-879; GPO-29-006; Rept-17, 33 pp (1978) Avail: U.S. Capitol House Document Room

Key Words: Aircraft noise, Reviews

The Concorde SST represents a serious threat to U.S. efforts to abate aircraft noise. It is extremely noisy, energy inefficient, and environmentally unsound, according to reports from FAA, EPA, and GAO. The committee believes that studies by the Department of Transportation and the FAA have failed to assess adequately the problems associated with allowing the Concorde to land at U.S. airports. The recent standards proposed by the Department and the FAA for supersonic transports would not force a reduction in noise for existing Concordes. The Concorde should not be granted permanent landing rights until it is able to meet appropriate U.S. noise standards, whether expressed in terms of decibels, size of the noise contour, or vibration frequency.

79-1300

Wind Excited Behavior of Structures. II

D.J. Johns
Dept. of Transport Tech., The Univ. of Technology, Loughborough, Leics., LE11 3TU, UK, Shock Vib. Dig., 11 (4), pp 17-29 (Apr 1979) 129 refs

Key Words: Reviews, Wind-induced excitation

This article reviews recent literature on wind-excited responses of structures. Such responses include vortex shedding, galloping oscillations, flutter, divergence and buckling, and turbulence.

79-1301

A Survey of Finite Element-Related Techniques as Applied to Acoustic Propagation in the Ocean. Part II: Transparent Boundary Simulation Techniques

A.J. Kalinowski
Naval Underwater Systems Ctr., New London, CT 06320, Shock Vib. Dig., 11 (4), pp 7-16 (Apr 1979) 6 figs

Key Words: Reviews, Finite element technique, Elastic waves, Sound propagation, Oceans, Boundary value problems

This two part article deals with finite element-related techniques applied to acoustic propagation in the ocean. Methods for modeling and simulation of boundary conditions are discussed including the related Boundary Solution Method and the Boundary Integral Method in Part 1 and transparent boundary simulation techniques in Part 2.

79-1302

Computational Techniques in Optimal State-Estimation – A Tutorial Review

W. Kortum

Inst. for Dynamics of Flight Systems, Oberpfaffenhofen, Germany, ASME Paper No. 78-WA/DSC-40

Key Words: Reviews, Digital techniques, Dynamic systems, Optimization

The objective of this tutorial presentation is to review the main computational techniques of the state-estimation problem for linearizable dynamic systems where the design is oriented toward a minimum variance (quadratic loss, gaussian) estimation error. Both the continuous and the discrete estimation problem are treated.

79-1303

Damping Properties of Turbine Blades

N.F. Rieger

Rochester Inst. of Tech., Rochester, NY 14623, Shock Vib. Dig., 11 (4), pp 3-5 (Apr 1979) 12 refs

Key Words: Reviews, Turbine blades, Damping

This article reviews damping literature pertaining to internal material damping, damping of steam turbine blade groups, and gas turbine blade damping.

TUTORIAL

79-1304

In-Plant Noise Control Programs and the Utilization of Consultants

R. Goodwin

Acoustical Systems, Inc., Vandalia, OH, S/V, Sound Vib., 13 (2), pp 6-9 (Feb 1979)

Key Words: Industrial facilities, Noise reduction

Based on plant-wide engineering studies of six large automotive manufacturers, several suggestions for developing an acoustical engineering program for noise control are offered.

79-1305

Airport Noise Exposure: The Problem of Definition

D.E. Winer

FAA, Washington, D.C., S/V, Sound Vib., 13 (2), pp 22-27 (Feb 1979) 6 figs, 2 tables, 11 refs

Key Words: Noise measurement, Airport noise

This article examines the relationships among those metrics most commonly used today in the United States in describing existing and future noise environments in the vicinity of airports.

MODAL ANALYSIS AND SYNTHESIS

79-1306

A Normal Mode Theory of Acoustic Doppler Effects in the Oceanic Waveguide

K.E. Hawker

Applied Res. Labs., The Univ. of Texas at Austin, TX 78712, J. Acoust. Soc. Amer., 65 (3), pp 675-681 (Mar 1979) 6 figs, 9 refs

Key Words: Normal modes, Acoustic excitation, Point source excitation, Moving loads

This paper considers the problem of computing the acoustic field generated by a moving point source. In particular, the acoustic field is obtained in terms of the normal modes of a horizontally stratified ocean. The source motion is assumed to be uniform (unaccelerated), but is not restricted to a path radial to the receiver. The structure of the Fourier inversion integral is analyzed and an evaluation is carried out by the method of stationary phase. The stationary phase point is explicitly computed as an expansion in powers of the ratio of the source speed to the mode group velocity. The resulting expression for the velocity potential is examined for Doppler effects for both instantaneous (modal) Doppler as well as Doppler determined by a finite bandwidth Fourier transform.

79-1307

Predict Design Behavior in the Real World

A.C. Keller

Spectral Dynamics, San Diego, CA, Indus. Res., 21 (4), pp 123-126 (Apr 1979) 5 figs

Key Words: Modal analysis, Design techniques

Application of modal analysis techniques in the design of mechanical products is described. Using the Fast Fourier Transform spectrum analyzers, a complete modal analysis is carried out 10 to 20 times faster than by the classic method. The calculated mode shapes, i.e., the resulting deformation patterns, are displayed on a high-speed graphics terminal from any viewing angle of the structure selected by the operator.

COMPUTER PROGRAMS

GENERAL

(Also see Nos. 1311, 1445)

79-1308

FRATE (Freight Car Response Analysis and Test Evaluation), Volume I: User's Manual

G. Kachadourian, N.E. Sussman, and J.R. Anderes

MITRE Corp., McLean, VA, Rept. No. MTR-7889-VOL-1, FRA/ORD-78/59, 105 pp (Sept 1978) PB-291 206/1GA

Key Words: Computer programs, Interaction: rail-wheel, Freight cars, Railroad cars

FRATE (Freight Car Response Analysis and Test Evaluation) is the name of a digital computer program which numerically solves the structural dynamic equations of motion of a single railroad freight car excited by wheel/rail interface motions. The Federal Railroad Administration (FRA) has sponsored its development for the purpose of applying it to freight car analysis and test problems. This manual is written with the objective of providing the user with all of the detailed information needed as concisely and accessibly as possible. The manual is divided into two volumes: Volume I is a User's Manual containing basic user related information, Volume II is a Technical Manual containing more detailed technical information. FRATE is written to allow the simulation of a broad range of freight cars by only simple input data changes. A Trailer-on-Flatcar (TOFC) configuration is simulated in this manual. FRATE solves the equations of motion in the time domain and includes the following features: nonlinearities which include separations, bilinear springs and no small angle assumptions; five degree-of-freedom coordinate coupling; normal mode structural flexibility; and frequency response from simulated sweep testing.

79-1309

Investigation of Tire-Pavement Interaction During Maneuvering. Volume II. Tire Analysis Program Package Computer Program Manual

J.T. Tielking

Mechanics and Materials Res. Center, Texas A&M Univ., College Station, TX, Rept. No. MM-3043-77-3, FHWA/RD-78/102, 172 pp (June 1977) PB-291 258/2GA

Key Words: Computer programs, Interaction: tire-pavement

This manual contains a complete listing of the five computer programs which make up the Tire Analysis Program Package. The listing is preceded by an introduction that includes subroutine call maps and flow charts of basic operations in the five programs.

79-1310

Investigation of Tire-Pavement Interaction During Maneuvering. Volume III. Tire Analysis Program Package User's Manual

J.T. Tielking

Mechanics and Materials Res. Center, Texas A&M Univ., College Station, TX, Rept. No. MM-3043-77-4, FHWA/RD-78/103, 149 pp (June 1977) PB-291 259/0GA

Key Words: Computer programs, Interaction: tire-pavement

The Tire Analysis Program Package consists of five computer programs (TIRESTIF, TIRELOAD, TIRETRAN, TIREFOUR, and TIREFRIC) which must be run, sequentially, to determine the boundary of the tire-road contact region and the interfacial normal and shear tractions within this region. The first three of these programs are modified versions of finite element codes (SAMMSOR and SNASOR) developed previously at Texas A&M University. The last two programs, TIREFOUR and TIREFRIC, were developed entirely under the present contract. This User's Manual lists only the example data decks and a description of their preparation. Sample output and a description of salient features is included for each program in this manual.

79-1311

Structural Area Inspection Frequency Evaluation (SAIFE). Volume 2: Description of Simulation Logic (Final Report)

C.J. Dinkeloo, E.F. Horner, and M.S. Moran

Technology, Inc., Dayton, OH, Rept. No. AD-A059-689; FAA-RD-78-29-Vol-2, 106 pp (Apr 1978) N79-15026

Key Words: Aircraft, Diagnostic techniques, Computer-aided techniques, Computerized simulation, Computer programs

To assist in the evaluation of proposed structural inspection programs for commercial jet transport aircraft, a logic is developed to simulate structural defects, failures, and inspections. This logic is incorporated in a computer program entitled Structural Area Inspection Frequency Evaluation (SAIFE). SAIFE accounts for the following factors: aircraft design analysis; fatigue testing; production, service, and corrosion defects; probability of crack or corrosion detection; and aircraft modification economics. The initial contract effort and a subsequent parametric analysis are reported. The SAIFE simulation logic, the background data for the analytical functions and decision making processes, and data for a typical simulation problem are presented.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 1301, 1304, 1305, 1343, 1349, 1352, 1371, 1470)

79-1312

Scattering of Elastic Waves by Randomly Distributed and Oriented Scatterers

V.K. Varadan

Dept. of Engrg. Mechanics, Boyd Lab., The Ohio State Univ., Columbus, OH 43210, J. Acoust. Soc. Amer., 65 (3), pp 655-657 (Mar 1979) 3 figs, 5 refs

Key Words: Elastic waves, Acoustic scattering, Statistical analysis

The two-dimensional problem of multiple scattering by randomly distributed and oriented scatterers is analyzed and the results are compared with those for the aligned scatterers. Waterman's T-matrix approach in conjunction with the statistical averaging for both position and orientation are employed to obtain the phase velocity and attenuation due to geometric dispersion for a wide range of frequencies. Analytical expressions for the dispersion relation are also derived at low frequencies for both randomly distributed and oriented inclusions and cracks.

79-1313

Vibrations of Parametrically Excited Systems

J. Zajaczkowski and J. Lipinski

Lodz Technical Univ., Lodz, Zwirki 36, Poland, J. Sound Vib., 63 (1), pp 1-7 (Mar 8, 1979) 10 refs

Key Words: Forced vibration, Parametric excitation, Time-dependent parameters

The paper is concerned with a set of linear differential equations with time-dependent parameters given by trigonometrical series. Derived formulas make it possible to examine stability, to find boundaries of the regions of instability and to estimate the steady-state response amplitude of forced vibrations.

79-1314

Forward Scattering of Underwater Sound and Its Frequency Dependence on the Medium

R.S. Andrews

Decca Radar Ltd., E.W. Div., Lyon Rd., Walton-on-Thames, Surrey, UK, J. Acoust. Soc. Amer., 65 (3), pp 672-674 (Mar 1979) 2 figs, 1 table, 12 refs

Key Words: Underwater sound

In the interference region of forward scattered sound by thermal inhomogeneities, there appears to exist a dominant thermal patch size for scattering at a given frequency. Several published results are examined.

79-1315

A Simple, Linear Count-Rate Indicator for Acoustic Emission

I.G. Scott

Aeronautical Research Labs., Melbourne, Australia, Rept. No. ARL/MAT NOTE-118, 12 pp (Sept 1977) AD-A062 152/4GA

Key Words: Acoustic emission, Nondestructive tests, Circuit boards

A simple indicator of acoustic emission activity, which can be made from readily available components, is described.

79-1316

The Absorption of Sound by Pine Trees

S.H. Burns

Electrical Engrg. Dept., U.S. Naval Academy, Annapolis, MD 21402, J. Acoust. Soc. Amer., 65 (3), pp 658-661 (Mar 1979) 1 fig, 8 refs

Key Words: Acoustic absorption, Trees

This paper describes a study of the absorption of sound by pine trees. Swept frequency measurements were made with small boughs in a reverberant box. Tests for branch and needle resonances were also made.

RANDOM

79-1317

Response of MDOF Systems to Nonstationary Random Excitation

D.A. Gasparini

Case Western Reserve Univ., Cleveland, OH, ASCE J. Engr. Mech. Div., 105 (EM1), pp 13-27 (Feb 1979) 9 figs, 2 tables, 10 refs

Key Words: Multidegree of freedom systems, Random excitation

Responses of linear, dynamic systems to nonstationary random excitation are calculated using a state formulation. Analytical expressions for evolutionary covariance matrices are derived for the case of evolutionary white noise excitation. As an example, responses of a 4-DOF system to ground acceleration are calculated. Modal decomposition is utilized and the relative importance of the cross covariance among the modes is quantified. Approximate first passage probabilities for high thresholds are calculated by using the evolutionary variances of a response and its time derivative and by making the Poisson assumption. An augmented dynamic system is proposed for the case of nonwhite excitation. The transition matrix for the augmented system is given.

79-1318

Dynamic Analysis of Variable Configuration Structures with Random Base Motion

S. Asavanich

Ph.D. Thesis, The Univ. of Wisconsin-Madison, 147 pp (1978)
UM 7822232

Key Words: Crane booms, Antennas, Random excitation, Computerized simulation

A method is developed and proposed for the dynamic analysis of variable configuration structures subjected to random excitation by computer simulation as a multivariate and multidimensional nonstationary stochastic process. The approach employs moving frames of reference or multi-global axes in conjunction with finite elements in the formulation of the stiffness matrix and governing equations of motion. A frame of reference is defined and considered for each substructure. The stiffness matrix of each substructure is formulated and transformed to a common frame of reference used as the basis in the formulation of the equations of motion. Each is superimposed to yield the stiffness matrix of the entire structure.

SEISMIC

(Also see Nos. 1373, 1417, 1444, 1448, 1449, 1450, 1483, 1484)

79-1319

Seismic Response of Hemispherical Foundation

S.M. Day and G.A. Frazier

Systems, Science and Software, La Jolla, CA, ASCE J. Engr. Mech. Div., 105 (EM1), pp 29-41 (Feb 1979) 6 figs, 1 table 19 refs

Sponsored by the National Science Foundation

Key Words: Seismic response, Interaction: soil structure, Foundations, Finite element technique

A time domain finite element method is used to investigate the response to seismic waves of rigid, three-dimensional, embedded foundations. The method eliminates the influence of artificial grid boundaries by completing the transient solution prior to the arrival of any nonphysical reflections. The accuracy of the numerical procedure is examined by comparison with analytic solutions.

79-1320

Frequency Content in Earthquake Simulation

L.D. Lutes and K. Lilhanand

Rice Univ., Houston, TX, ASCE J. Engr. Mech. Div., 105 (EM1), pp 143-158 (Feb 1979) 12 figs, 13 refs

Key Words: Earthquake response, Single degree of freedom systems, Computerized simulation, Monte Carlo method

Random processes with frequency content similar to that of recorded earthquakes are generated by using linear filters to remove the very low and very high frequency components of white noise. The mean-squared responses of single-degree-of-freedom structures to these filtered processes are compared with the corresponding mean-squared displacement and velocity response are presented.

SHOCK

(Also see No. 1487)

79-1321

Insteady Transonic Flow in Two-Dimensional Channels

T.C. Adamson, Jr. and M.S. Liou

Dept. of Aerospace Engrg., Michigan Univ., Ann Arbor, MI, Rept. No. UM-015411-F, 41 pp (Oct 1978)

AD-A062 311/6GA

Key Words: *Shock wave propagation, Nozzles*

Unsteady transonic flow with a shock wave in a two-dimensional channel is considered. Solutions valid in a thin inner region enclosing the nozzle throat are presented. A brief description of a computer movie is given; this movie shows solutions for unsteady transonic channel flow for two different cases in which the shock wave, as a result of pressure oscillations impressed downstream of the nozzle throat, moves to and upstream of the throat, disappears, and reforms at the throat. An analysis showing how results derived for the interaction between a shock wave and a turbulent boundary layer in steady flow may be used in the corresponding quasi-steady flow problem, is presented: a discussion of how these results may be used to deduce the order of the distance from the shock wave to the separation point and the time characteristic of the life of a shock induced separation bubble in unsteady flow is given.

PHENOMENOLOGY

COMPOSITE

79-1322

Dynamic Mechanical Analysis of Fiber Reinforced Composites

K.E. Reed

NASA Lewis Res. Center, Cleveland, OH, Rept. No. NASA-TM-79033; E-9831, 20 pp (1979)

N79-15157

Key Words: Composite structures, Fiber composites, *Thermal excitation, Resonant frequencies*

Dynamic mechanical and thermal properties are determined for unidirectional epoxy/glass composites at various fiber orientation angles. Resonant frequency and relative logarithmic decrement are measured as functions of temperature.

79-1323

Determination of Dynamic Characteristics of Elastic Composite Structures

K. Lang

Ph.D. Thesis, Northwestern Univ., 157 pp (1978)

UM 7907903

Key Words: Composite structures, Structural members, Variable material properties, Method of new quotient

The dynamic characteristics of the structural components, whose material properties or dimensions vary sharply or discontinuously, are analyzed by the method of the new quotient. This method is based on general variational principles which allow independent variations of various field quantities. Cases of heat conduction and harmonic waves in layered composites, vibration and buckling of composite beams and strip-plates, and vibration of non-uniform rotor blades are studied. The eigenvalues and the corresponding eigenfunctions are estimated by the method of new quotient; the results are compared with those obtained by the usual Rayleigh energy method, the exact solution (or available experimental data), and other approximate methods. In addition, the corresponding bounds on eigenvalues are constructed for certain cases with the aid of the new methodology.

DAMPING

(Also see No. 1303, 1355)

79-1324

A Feedback Vibration Controller for Circular Saws

R.W. Ellis and C.D. Mote, Jr.

Sandia Labs., Livermore, CA 94550, J. Dyn. Syst., Meas. and Control, Trans. ASME, 101 (1), pp 44-49 (Mar 1979) 7 figs, 4 refs

Key Words: Saws, Flexural vibration, Stiffness, Damping

A feedback controller which increases the transverse stiffness and damping of a circular saw in analyzed, designed and tested.

79-1325

Torsional Damper in a Second Order Fluid (Der Torsionsschwingungsdampfer in einer Flussigkeit zweiter Ordnung)

J.H. Spurk

Technische Hochschule Darmstadt, Petersenstr. 18, D-6100 Darmstadt, Federal Republic of Germany, Ing. Arch., 48 (2), pp 121-127 (1979) 3 figs, 5 refs (In German)

Key Words: Torsional vibration, Fluid-film damping

It is shown that the optimal damping of a torsional damper using a second order fluid as damper liquid may differ substantially from the optimal damping computed on the basis of a Newtonian fluid.

79-1326

Comments on Damped Response in Linear Systems

D.W. Nicholson

Explosion Effects Branch, Naval Surface Weapons Ctr., White Oak, Silver Spring, MD 20910, Mech. Res. Comm., 6 (1), pp 17-25 (1979) 7 refs

Key Words: Linear systems, Damped structures, Vibration response

Necessary and sufficient conditions for damped free motion of linear systems are discussed. In particular, these discussions have concerned systems restricted to give purely oscillatory response.

79-1327

Design and Measurement of Polymeric Materials for Vibration Absorption and Control

R.E. Wetton

Dept. of Chemistry, Loughborough Univ. of Tech., Loughborough, Leics. LE11 3TU, UK, Appl. Acoust., 11 (2), pp 77-97 (Apr 1978) 8 figs, 3 tables, 29 refs

Key Words: Vibration damping, Damping materials, Elastomers

The mechanical characteristics for vibration-damping materials are assessed for a number of important applications. A temperature-independent relaxation process in lamella-forming block copolymers is reported and its possible regions of application discussed. Recent developments are also reported for providing reasonable damping levels in soft elastomeric systems by utilizing reptation loss of non-network chains.

FLUID

(Also see No. 1300)

79-1328

Distillation Columns - A Class of Dynamic Systems with Multiplicative Inputs

M. Espana and I.D. Landau

Inst. National Polytechnique de Grenoble, Laboratoire D'Automatique, Ecole Nationale Superieure d'Electrotechnique et de Genie Physique, Grenoble, France, J. Dyn. Syst., Meas. and Control, Trans. ASME, 101 (1), pp 58-63 (Mar 1979) 5 figs, 1 table, 10 refs

Key Words: Fluid-induced excitation, Distillation equipment

The main objective of this paper is to investigate the properties of the static and dynamic behavior of the distillation columns which are consequences of the structure of the state space equations and to verify them experimentally. In addition, the use of these properties for the feedforward and feedback control of distillation columns is discussed.

79-1329

The Effect of Flow on the Piston Problem of Acoustics

F.G. Leppington and H. Levine
Dept. of Mathematics, Imperial College of Science and Tech., London SW7 2BZ, UK, J. Sound Vib., 62 (1), pp 3-17 (Jan 8, 1979) 1 fig, 8 refs

Key Words: Pistons, Fluid-induced excitation, Sound generation

A compressible fluid, bounded on one side by an infinite plane, flows with constant subsonic speed parallel to the plane, and acoustic disturbances are caused by a small amplitude vibration of a circular piston set in the plane. The effect of the mean flow on this classical radiation problem is investigated and the distant field is expressed in elementary form. The total excess energy flow is calculated for the compact piston with any subsonic mean flow (and also for the non-compact piston with low Mach number mean flow) and is compared with that for the complementary problem of a moving piston in a quiescent fluid.

79-1330

Along-Wind Gust Effect on Elevated Structures

C.B. Yun, A.M. Abdelrahman, and P.C. Wang
Polytechnic Inst. of New York, Brooklyn, NY, Engrg. Struc., 1 (3), pp 121-124 (Apr 1979) 4 figs, 2 tables, 10 refs

Key Words: Wind-induced excitation, Structural response, Random response

This paper introduces a random process approach and its application to elevated structures to wind force. As an example, a skylight structure is analyzed by random approach in regard to the gust effect. The same effects are also evaluated by using some of the current available building codes.

79-1331

Experiments on Sound Radiation Due to Non-Linear Interaction of Instability Waves in a Turbulent Jet

D. Ronneberger and U. Ackermann
Drittes Physikalisches Institut, Universität Göttingen, Bürgerstrasse 42-44, D-3400 Göttingen, Federal Republic of Germany, J. Sound Vib., 62 (1), pp 121-129 (Jan 8, 1979) 6 figs, 19 refs

Key Words: Turbulence, Sound waves, Wave guide analysis

A turbulent circular jet is excited at two frequencies and the pressure on the axis of the jet as well as in the far field is measured. A non-linear wave-guide model of the large structures of the turbulence is outlined.

79-1332

Giant Monopole Resonances in the Scattering of Waves from Gas-Filled Spherical Cavities and Bubbles

G. Gaunaurd, K.P. Scharnhorst, and H. Überall
Naval Surface Weapons Ctr., Silver Spring, MD 20910, J. Acoust. Soc. Amer., 65 (3), pp 573-594 (Mar 1979) 11 figs, 34 refs

Key Words: Cavity-containing media, Wave diffraction

The theoretical analysis needed for the complete study of the monopole mode of vibration is performed. The approach is based on the Breit-Wigner formulation of nuclear scattering theory. A complete analytical study of the fundamental resonance and its overtones in the monopole case is presented.

SOIL

79-1333

Soil-Structure Interaction Under Wind Loading

J.F. Howell
Ph.D. Thesis, The Univ. of Western Ontario (Canada) (1978)

Key Words: Interaction: soil-structure, Wind-induced excitation, Vortex shedding, Pile foundations, Footings

The role of the important parameters is demonstrated for pile foundations in torsion where closed form equations are developed to allow accurate prediction of response using the sub-structuring approach. Some common design approaches for embedded footings and pile foundations are critically examined and improvements are suggested. The excitation of a structure by vortex shedding is examined in detail in an experimental program aimed at improving the predictions of the forced vibration model.

79-1334
Vertical Vibration of Piles
R.L. Kuhlemeyer
Dept. of Civil Engrg., Univ. of Calgary, Calgary, Alberta, Canada, ASCE J. Geotech. Engr. Div., 105 (GT1), pp 273-287 (Jan 1979) 12 figs, 12 refs

Key Words: Pile structures, Foundations, Finite element technique, Interaction: soil-structure

Finite element results obtained using an established elastic half space model are presented for the vertical response of pile-soil systems. A simplified lumped mass model of the pile-soil system is described.

79-1335
Static and Dynamic Laterally Loaded Floating Piles
R.L. Kuhlemeyer
Dept. of Civil Engrg., Univ. of Calgary, Calgary, Alberta, Canada, ASCE J. Geotech. Engr. Div., 105, (GT2), pp 289-304 (Feb 1979) 7 figs, 2 tables, 14 refs

Key Words: Pile structures, Foundations, Finite element technique

Static loading results are presented in the form of flexibility coefficients for a range of two-layer soil systems. The dynamic loading fundamental solution for a pile embedded in an elastic half space is presented in terms of the statics solution multiplied by the associated complex, frequency-dependent factors.

79-1336
Shaking Table Tests and Analysis of Soil Structure Systems
T. Kagawa
Ph.D. Thesis, Univ. of California, Berkeley, 170 pp (1978)
UM 7904498

Key Words: Interaction: soil-structure, Shakers, Vibration tests, Model testing

Large-scale shaking table tests on a soil-structure system are performed. The tests provide a better understanding of the soil-structure interaction phenomena; facilitate the development of techniques for model vibration studies of soil-structure interaction; and develop techniques for predicting prototype behavior from such model studies.

EXPERIMENTATION

BALANCING

79-1337
On the Balancing Convergence of Flexible Rotors, with Special Reference to Asymmetric Rotors
Y. Matsukura, M. Kiso, T. Inoue, and M. Tomisawa
Central Research Lab., Mitsubishi Electric Corp., Amagasaki, Japan, J. Sound Vib., 63 (3), pp 419-428 (Apr 1979) 8 figs, 16 refs

Key Words: Rotors, Flexible rotors, Balancing techniques

Convergent and divergent residual unbalances are theoretically predicted and experimentally observed in a series of balancing procedures in which the conventional balancing method for symmetric rotors has been applied to that of asymmetric rotors, of which the flexural rigidities on the two principal axes at the cross-section are not the same.

DIAGNOSTICS

79-1338
Machinery Protection Through Automated Diagnostics
D.S. Wilson
Shaker Research Corp., Ballston Lake, NY, Diagnostic Machinery Health, Winter Annual Meeting of ASME, San Francisco, CA, Dec 10-15, 1978, pp 1-14, 8 figs, 1 ref

Key Words: Diagnostic techniques, Computer aided techniques, Nuclear power plants

A computer based automated system is described for determining the operating health of a plant with a large number of critical machines such as a nuclear power plant, in which the number of installed vibration sensors may range from 100 to 200. In the paper, the capabilities and limitations of such a system are discussed.

79-1339
Rotating Machinery Diagnosis Through Shock Pulse Monitoring
D. Board
SKF Industries, Inc., King of Prussia, PA, Diagnostic Machinery Health, Winter Annual Mtg. of ASME, San Francisco, CA, Dec 10-15, 1978, pp 25-40, 18 figs, 2 tables, 9 refs

Key Words: Diagnostic techniques, Rotating structures, Shock pulse method

This paper discusses shock pulse theory, illustrates its use through case histories, and describes new automated hardware that is simple to operate and maintain in the field, as well as a cost effective means of preventing catastrophic failure or unforeseen equipment downtime.

79-1340
Bearing Diagnostics: An Overview
J.S. Mitchell
Turbomachinery Consultant, San Juan Capistrano, CA, Diagnostic Machinery Health, Winter Annual Mtg. of ASME, San Francisco, CA, Dec 10-15, 1978, pp 15-24, 5 figs, 9 refs

Key Words: Diagnostic techniques, Bearings

In this paper the symptoms of problems normally associated with bearing failures are reviewed and current methods for extracting and evaluating the characteristics of rolling element bearings are described.

EQUIPMENT

79-1341
Electrohydraulic – The Most Versatile Shaker?
B.L. Huntley
Team Corp., South El Monte, CA, J. Environ. Sci., 22 (2), pp 32-35 (Mar/Apr 1979) 4 figs, 5 refs

Key Words: Electrohydraulic shakers, Test equipment, Vibration tests, Shock tests

This article discusses the less well known, but highly versatile electrohydraulic shaker and its application for vibration and shock test needs.

FACILITIES

(See No. 1420)

INSTRUMENTATION

79-1342
Experimental Study of Input Transducer Dynamics in Bearing Identification
R. Stanway and C.R. Burrows
Univ. of Sussex, Falmer, UK, ASME Paper No. 78-WA/DSC-6

Key Words: Transducers, Bearings

The authors have previously discussed the theoretical advantages of using a pseudo-random binary sequence as a test signal to estimate the eight linearized coefficients representing a journal bearing oil-film. Experiments of input transducer dynamics in bearing identification are described.

79-1343
Selection and Use of Microphones for Engine and Aircraft Noise Measurements
H.H. Taniguchi and G. Rasmussen
Boeing Commercial Airplane Co., Seattle, WA, S/V, Sound Vib., 13 (2), pp 12-20 (Feb 1979) 14 figs, 3 tables, 22 refs

Key Words: Microphones, Measuring instruments, Measurement techniques, Aircraft noise, Engine noise

This article describes a methodology and presents recommendations for the selection and use of microphones, based on situations encountered in engine and aircraft tests. The characteristics of air-condenser microphones, in a defined acoustic environment, are evaluated for their ability to meet test requirements. Microphone size, type, positioning, orientation, and calibration are considered. Specific microphone types and orientation which provide reliable measurements are recommended.

79-1344
Maximum Hold Arrangements in Precision Sound Level Meters
I. Campbell

Computer Engineering Ltd., Noise Control Vib. Isolation, 10 (3), pp 99-100 (Mar 1979) 1 fig

Key Words: Sound level meters, Measuring instruments

A sound level meter is described in which the maximum value is held digitally, thereby eliminating the decay problem.

TECHNIQUES

(Also see Nos. 1298, 1443)

79-1345

Near Field Determination of the Complex Radiation Efficiency and Acoustic Intensity Distribution for a Resonantly Vibrating Surface

C.H. Hansen and D.A. Bies

Dept. of Mech. Engrg., The Univ. of Adelaide, Adelaide, South Australia, 5000, J. Sound Vib., 62 (1), pp 93-110 (Jan 8, 1979) 11 figs, 1 table, 23 refs

Key Words: Vibrating structures, Sound waves, Elastic waves, Wave propagation, Measurement techniques, Testing techniques

An experimental procedure is described which allows both the resistive and reactive parts of the acoustic radiation efficiency of a resonantly vibrating surface to be determined from measurements in the acoustic near field. In addition, the procedure allows the precise quantitative location on the vibrating surfaces of acoustic sources which radiate energy to the far field.

79-1346

A Transient Testing Technique for the Determination of Matrix Parameters of Acoustic Systems, I: Theory and Principles

C.W.S. To and A.G. Doige

Dept. of Mech. Engrg., Univ. of Calgary, Calgary, Alberta, Canada, T2N 1N4, J. Sound Vib., 62 (2), pp 207-222 (Jan 22, 1979) 5 figs, 27 refs

Key Words: Testing techniques, Experimental data, Transient response, Matrix methods, Parameter identification technique

A transient testing technique is developed for rapid testing of components in acoustic systems. Fourier transforms of transient pressure data are utilized to provide system characteristics in the frequency domain. The approach is applicable to field testing situations where short duration testing with a minimum of portable instrumentation is desirable and no special apparatus such as anechoic terminations are available. Derivations of matrix parameters expressed in terms of the transforms of pairs of pressure data are presented for a variety of testing conditions and system types. Analytical expressions for theoretical matrix parameters for selected known systems are also included for comparison with experimental results.

79-1347

A Transient Testing Technique for the Determination of Matrix Parameters of Acoustic Systems, II: Experimental Procedures and Results

C.W.S. To and A.G. Doige

Dept. of Mech. Engrg., Univ. of Calgary, Calgary, Alberta, Canada T2N 1N4, J. Sound Vib., 62 (2), pp 223-233 (Jan 22, 1979) 16 figs, 1 table, 13 refs

Key Words: Testing techniques, Experimental data, Transient response, Matrix methods, Pipes (tubes), Parameter identification technique

This paper deals with the application of a transient testing technique for the determination of matrix parameters of acoustic systems. Experiments are conducted for six systems of various geometrical configurations such as a section of pipe; a small expansion chamber; a large expansion chamber; partition pipes; partition chambers; and an expansion chamber with insertion pipes. Two series of results were obtained for these systems, one concerned with the evaluation of matrix parameters for blockable and reciprocal cases and the other for the non-blockable and reciprocal types.

79-1348

Time-Averaged Moire Method for In-Plane Vibrational Analysis

C.Y. Liang, Y.Y. Hung, A.J. Durelli, and J.D. Hovanesian

School of Engrg., Oakland Univ., Rochester, MI 48063, J. Sound Vib., 62 (2), pp 267-275 (Jan 22, 1979) 5 figs, 12 refs

Key Words: Vibration response, Testing techniques, Movie effects

A new method is proposed for the determination of the in-plane displacement components of bodies subjected to cyclic loading. The recording on a photographic film is done statically, with exposure times longer than the period of vibration (time-average). A grating printed on the body surface is perturbed by the motion and the displacements are analyzed by photographing the grating lines.

79-1349

Underwater Imaging System Using Multi-Frequency Ultrasonic Holography

T. Sato and M. Iguchi
Electrotechnical Lab. 2-6-1 Nagata-cho, Chiyoda-ku, Tokyo, Japan, Bull. JSME, 22 (164), pp 190-197 (Feb 1979) 11 figs, 7 refs

Key Words: Acoustic holography, Underwater sound

This paper describes an acoustical holographic imaging system which has a receiving array and reconstructs the image using computer calculation.

79-1350

An Introduction to Acoustic Emission and a Practical Example

A.A. Pollock
Dunegan/Endevco, J. Environ. Sci., 22 (2), pp 39-41 (Mar/Apr 1979) 41 refs

Key Words: Acoustic emission, Nondestructive tests

In this paper the following topics are covered by way of general introduction: Fundamentals and material behavior; Scope of applications to nondestructive testing and quality control; Instrumentation principles; Typical applications; and Limitations. A specific application of AE to the testing of bucket trucks is discussed. This example illustrates the constructive use of the Kaiser effect to predict strength, the use of structural calibration as an aid to system design, and the reduction of laboratory findings to practical test procedures.

79-1351

Acoustic Imaging for Nondestructive Evaluation

G.S. Kino
Edward L. Ginzton Lab., W.W. Hansen Labs. of Physics, Stanford Univ., Stanford, CA 94305, IEEE Proc., 67 (4), pp 510-525 (Apr 1979) 21 figs, 22 refs

Key Words: Nondestructive testing, Acoustic techniques

The application of acoustic imaging techniques to nondestructive testing (NDT) of materials is discussed. After a description of the standard NDT techniques employed in the field and some examples of mechanically scanned imaging devices, most of the paper is devoted to a description of electronically scanned and focused systems.

79-1352

Acoustic Microscopy - 1979

L.W. Kessler and D.E. Yuhas
Sonoscan, Inc., Bensenville, IL 60106, IEEE Proc., 67 (4), pp 526-536 (Apr 1979) 17 figs, 36 refs

Key Words: Acoustic microscopy, Nondestructive testing, Testing techniques

Acoustic microscopy is emerging as an important analytical technique serving the needs of both biomedical and materials technology. Based upon imaging of specimens with elastic waves at VHF and UHF frequencies, acoustic microscopes reveal structural-mechanical properties with high magnification. A review of the techniques and their applications are presented.

COMPONENTS

SHAFTS

(Also see No. 1383)

79-1353

On the Subharmonic Oscillations of Unsymmetrical Shafts

T. Yamamoto, Y. Ishida, and K. Aizawa
Faculty of Engrg., Nagoya Univ., Chikusa-ku, Nagoya, Japan, Bull. JSME, 22 (164), pp 164-173 (Feb 1979) 16 figs, 20 refs

Key Words: Shafts (machine elements), Ball bearings, Subharmonic oscillations

In the analysis of an unsymmetrical shaft system with nonlinear characteristics, the method utilizing normal coordinates cannot be used. Such phenomena are explained theoretically by the method proposed in this paper.

79-1354

Vibration of a Shaft Passing Through Several Critical Speeds

S. Yanabe, K. Kikuchi, and S. Kobayashi

Tokyo Inst. of Tech., Meguro-ku, Tokyo, Japan, Bull. JSME, 22 (164), pp 156-163 (Feb 1979) 13 figs, 2 tables, 6 refs

Key Words: Shafts, Transient response, Resonance pass through, Critical speeds

The transient vibration of a shaft passing through its several critical speeds at a uniform acceleration rate is investigated. The shaft is assumed to have a uniform section and be supported at both ends by springs and dampers. The free vibration of the system is analyzed to get the relationship between the damping given at the ends of the shaft and the modal damping ratio. The maximum amplitudes of the shaft passing through the first and the second critical speeds at various acceleration rates using the approximate equations are calculated. These calculated results are compared with the experimental ones.

79-1355

Comparative Efficiency Estimation of Some Devices for Dynamic Stabilization of Shafts

A.P. Kavolėlis and L. Kulys

Lietuvos Mechanikos Rinkinys, No. 2 (18), pp 31-39 (1977) 6 figs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania

(In Russian)

Key Words: Machinery vibration, Vibration control, Shafts

The design of flexible, inertia and gyroscopic couplings is discussed. In the article devices for reducing harmful machinery component vibrations are analyzed. Operation of these devices is based on dynamic vibration damping principles. Dynamic models are represented by a rotating mass connected to the shaft.

79-1356

On Potential Instability Areas in Dynamic Equilibrium of Flexible Shafts (Apie galimas lankščių velenų dinaminės pusiausvyros nestabilumo zonas)

A.P. Kavolėlis and L. Kulys

Lietuvos Mechanikos Rinkinys, No. 1 (17), pp 19-23 (1977) 3 figs, 3 refs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania

(In Russian)

Key Words: Shafts, Critical speeds

The paper analyzes the dynamic equilibrium of flexible shafts with rotational speed exceeding a critical value. The dynamic model of the shaft is interpreted as a system with two or three degrees of freedom. The analysis is made by the *Raus-Gurvitz method.*

BEAMS, STRINGS, RODS, BARS

(Also see No. 1389)

79-1357

Instability of the Motion of a Beam of Periodically Varying Length

J. Zajaczkowski and J. Lipinski

Lodz Technical Univ., Lodz, Zwirki 36, Poland, J. Sound Vib., 63 (1), pp 9-18 (Mar 8, 1979) 5 figs, 3 refs

Key Words: Beams, Cantilever beams, Parametric vibration

The parametric instability of the motion of a cantilever beam of periodically varying length is investigated. The boundaries of the instability regions are found and plotted.

79-1358

Minimum Weight Design of Beams in Torsional Vibration with Several Frequency Constraints

M.H.S. Elwany and A.D.S. Barr

Dept. of Mech. Engrg., Univ. of Dundee, Dundee DD1 4HN, UK, J. Sound Vib., 62 (3), pp 411-425 (Feb 8, 1979) 5 figs, 5 tables, 6 refs

Key Words: Cantilever beams, Beams, Torsional vibration, Minimum weight design

The design of beams of cantilever form carrying an end inertia so as to minimize the total mass subject to the constraint that one, two or three of its torsional natural frequencies are fixed at specified values is considered. The problem is stated in variational form with the constraints introduced through Lagrange multipliers. The known solutions for less constrained problems are used as a basis from which to iterate to the required solutions. Optimum profiles and tables of numerical data computed for various examples are given.

79-1359

The Influence of Tip Mass Offset on the Stability of Beck's Column

G.L. Anderson, J.D. Vasilakis, and J.J. Wu

U.S. Army Armament Res. and Dev. Command, Benet Weapons Lab., LCWSL, Watervliet Arsenal, Watervliet, NY 12189, J. Sound Vib., 62 (4), pp 475-480 (Feb 22, 1979) 3 figs, 7 refs

Key Words: Mass-beam systems, Cantilever beams, Follower forces, Flutter

In this paper, the stability of a slender cantilever carrying a tip mass at its free end and subjected there to a follower force is investigated. The centroid of the tip mass if offset from the free end of the beam and is located along its extended axis. The associated boundary value problem is solved and the exact frequency equation is derived. The frequency equation is solved numerically for the case in which both the beam and the tip mass have circular cross-sections.

79-1360

Simple Buckling and Vibration Analyses of Beam or Spring Connected Structures

F.W. Williams

Dept. of Civil Engrg., Univ. of Wales Inst. of Science and Tech., Cardiff CF1 3NU, UK, J. Sound Vib., 62 (4), pp 481-491 (Feb 22, 1979) 6 figs, 8 refs

Key Words: Multibeam systems, Beams, Springs, Ultimate load, Natural frequencies, Mode shapes

The problem considered is the buckling or vibration of a system of columns, or general structures, which are suitably related to each other and are connected together by sets of springs, or inextensible beams, which are also suitably related to each other.

79-1361

Higher Order Tapered Beam Finite Elements for Vibration Analysis

C.W.S. To

Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 63 (1), pp 33-50 (Mar 8, 1979) 5 figs, 3 tables, 12 refs

Key Words: Beams, Variable cross section, Finite element technique

In this paper, explicit expressions for mass and stiffness matrices of two higher order tapered beam elements for vibration analysis are presented. One has three degrees of freedom per node and the other four degrees of freedom per node. The four degrees of freedom of the latter element are the displacement, slope, curvature and gradient of curvature. Thus, this element adequately represents all the physical situations involved in any combination of displacement, rotation, bending moment and shearing force. Comparisons with existing results in the literature concerning tapered cantilever beam structures with or without an end mass and its rotary inertia are made.

79-1362

Vibration and Stability of Elastically Supported Beams Carrying an Attached Mass Under Axial and Tangential Loads

H. Saito and K. Otomi

Dept. of Mech. Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 62 (2), pp 257-266 (Jan 22, 1979) 8 figs, 5 refs

Key Words: Beams, Mass-beam systems, Vibration response

The vibration and stability of an elastically supported beam carrying an attached mass and subjected to axial and tangential compressive loads are investigated. The analysis is based on the Timoshenko beam theory and the effects of the attached mass are expressed with Dirac delta functions. The influences of the support stiffness, the direction of loading, and the slenderness ratio on the natural frequency and critical load of a beam are discussed.

79-1363

Simple Models for Computing Dynamic Responses of Complex Frame Structures

C. Chen

Ph.D. Thesis, Purdue Univ., 119 pp (1978)
UM 7905708

Key Words: Complex structures, Frames, Beams, Timoshenko theory

A simple shear beam model and a Timoshenko beam model are developed for dynamic analyses of complex frame structures. Explicit formulas are derived for computing the equivalent shear and bending rigidities in terms of the member dimensions and material properties of the original frame structure. The simple models are evaluated by comparing the simple model solutions with the solutions obtained from using full scale finite elements in free vibrations of plane frames.

79-1364

Dynamic Behaviour of a Beam Subjected to a Force of Time-Dependent Frequency (Effects of Solid Viscosity and Rotatory Inertia)

S.-I. Suzuki
Dept. of Aeronautics, Nagoya Univ., Nagoya, Japan,
J. Sound Vib., 62 (2), pp 157-164 (Jan 22, 1979) 4 figs, 5 refs

Key Words: Beams, Viscoelastic media, Rotatory inertia effects, Resonance pass through, Time-dependent excitation

The dynamic behavior of a beam is investigated through the use of a Voigt-type mechanical model when the frequency of external forcing passes through the first critical frequency of the beam, increasing or decreasing.

79-1365

Coupling Effects on a Cantilever Subjected to a Follower Force

A.N. Kounadis and J.T. Katsikadelis
National Technical Univ., Athens, Greece, J. Sound Vib., 62 (1), pp 131-139 (Jan 8, 1979) 6 figs, 17 refs

Key Words: Beams, Cantilever beams, Flutter, Timoshenko theory, Transverse shear deformation effects, Rotatory inertia effects

In this investigation a solution methodology is presented for studying the stability of a uniform cantilever having a translational and rotational spring at its support, carrying two concentrated masses, one at the support and the other at its tip, and subjected to a follower compressive force at its free end. The analysis is based on Timoshenko's beam theory by considering the cantilever as a continuous elastic system. The coupling effects on the flutter load are assessed for a variety of parameters such as translational and rotational springs at the support, translational and rotational inertia of the concentrated masses, and cross-sectional shape, as well as transverse shear deformation and rotatory inertia of the mass of the column.

79-1366

The Vibrations of Generally Orthotropic Beams, A Finite Element Approach

K.K. Teh and C.C. Huang
Dept. of Mech. Engrg., Univ. of Western Australia, Nedlands, 6009, Western Australia, Australia, J. Sound Vib., 62 (2), pp 195-206 (Jan 22, 1979) 4 figs, 4 tables, 12 refs

Key Words: Beams, Natural frequencies, Finite element technique, Transverse shear deformation effects, Rotatory inertia effects

This paper presents two finite element models for the prediction of free vibrational natural frequencies of fixed-free beams of general orthotropy. The discrete models include the transverse shear deformation effect and the rotary inertia effect.

79-1367

Flexural Wave Motion in Beam-Type Disordered Periodic Systems: Coincidence Phenomenon and Sound Radiation

A.S. Bansal
Dept. of Mech. Engrg., Punjab Agricultural Univ., Ludhiana-141004, India, J. Sound Vib., 62 (1), pp 39-49 (Jan 8, 1979) 4 figs, 8 refs

Key Words: Beams, Periodic structures, Sound waves

This paper deals with flexural wave motion in uniform beam-type periodic systems whose repeating units are identical finite beams with multiple beam-length disorders. A general expression derived for the propagation constants is employed to study its variation with frequency for a beam system having 4-span disordered repeating units. Free flexural waves are studied as wave groups consisting of a large number of harmonic components of different wavelengths, phase velocities and directions. Phase velocities are computed and plotted for different frequencies in the propagation zones in which the free waves progress without attenuation.

79-1368
Free Lateral Vibration of an Axially Creeping Beam-Column Under Initial Axial Compression
F.A. Cozzarelli and G. Tittemore
State Univ. of New York at Buffalo, NY, Meccanica, 12 (3), pp 151-158 (Sept 1977) 6 tables, 13 refs

Key Words: Beam-columns, Lateral vibration

The free lateral vibration of a nonlinear viscoelastic beam-column subjected to an initial compressive axial load is considered. The constitutive law is formulated with a linear elastic term and with power functions of stress in the transient and steady creep terms, and is of the nonlinear generalized Kelvin type. The problem is analyzed for five special viscoelastic models using small deformation theory, and numerical results are discussed for a stainless steel alloy.

BEARINGS
(Also see Nos. 1340, 1342)

79-1369
Stability Characteristics of Spherical Spiral Groove Bearings (1st Report, Theoretical Analysis)
Y. Sato and A. Tamura
Tokyo Inst. of Tech., Meguro-ku, Tokyo, Japan, Bull. JSME, 22 (164), pp 174-181 (Feb 1979) 16 figs, 4 refs

Key Words: Stability, Fluid-film bearings, Bearings

The stability characteristics of spherical spiral groove bearings lubricated with incompressible liquid are investigated theoretically. Solving a differential equation for a bearing which has an infinite number of grooves, the pressure distribution induced by small vibrations of a rigid rotor about a static equilibrium position is obtained.

79-1370
Elastic Connecting-Rod Bearing with Piezoviscous Lubricant: Analysis of the Steady-State Characteristics
B. Fantino, J. Frene, and J. DuParquet
Chercheur CNRS, Laboratoire de Mecanique des Contacts BT 113, Institut National des Sciences Appliquees de Lyon, Lyon, France, J. Lubric. Tech. Trans. ASME, 101 (2), pp 190-200 (Apr 1979) 18 figs, 25 refs

Key Words: Bearings, Periodic response

The effect of the deformation of an automotive connecting-rod on the oil film characteristics is studied. The simultaneous elastic deformation and pressure distribution are obtained by iterative methods in steady-state conditions under realistic speeds and loads (5500 rpm, 25,000 N). Plane elasticity relations are used in this study. The following parameters are investigated: bearing characteristics; operating conditions; and lubricant.

79-1371
Stability Analysis and Transient Motion of Axial Groove, Multilobe, and Tilting Pad Bearings
R.G. Eierman
M.S. Thesis, The University of Virginia, 150 pp (Aug 1976) Avail: Univ. of Virginia Library

Key Words: Tilting pad bearings, Bearings, Transient response

The stability characteristics and general nonlinear transient motion of finite width lobe journal bearings assuming an incompressible lubricant with cavitation are presented. Hydrodynamic bearing forces are evaluated by an end leakage solution of the Reynolds' Equation. The quasi-analytical solution involves calculating the circumferential pressure profile for an infinitely long bearing and then applying a finite series end leakage correction function that takes into account the finite length of the bearing, fluid film squeeze and rupture. The steady-state equilibrium position is obtained by a modified 2-variable Newton-Raphson iterative scheme. Once the equilibrium position has been determined, the eight linearized dynamic coefficients are calculated for the axial groove and multilobe bearing types. Nonlinear transient orbits are presented to confirm linearized stability maps developed from the dynamic coefficients. The effects of bearing preload, offset, and oil temperature on stability are investigated for typical bearings.

BLADES
(Also see No. 1303)

79-1372
The Importance of Quadrupole Sources in Prediction of Transonic Tip Speed Propeller Noise
D.B. Hanson and M.R. Fink

Hamilton Standard Div. of United Technologies Corp., Windsor Locks, CT 06096, J. Sound Vib., 62 (1), pp 19-38 (Jan 8, 1979) 13 figs, 18 refs

Key Words: Propeller blades, Noise generation, Noise prediction

A theoretical analysis is presented for the harmonic noise of high speed, open rotors. Far field acoustic radiation equations based on the Ffowcs Williams/Hawkings theory are derived for a static rotor with thin blades and zero lift. Noise calculations are presented for two rotors, one simulating a helicopter main rotor and the other a model propeller tested at United Technologies Corporation.

COLUMNS

79-1373

Inelastic Response of Reinforced Concrete Columns Subjected to Two-Dimensional Earthquake Motions

M.I.H. Suharwardy and D.A. Pecknold

Dept. of Civil Engrg., Illinois Univ. at Urbana-Champaign, IL, Rept. No. STRUCTURAL RESEARCH SER-455, UILU-ENG-78-2022, 225 pp (Oct 1978) PB-291 207/9GA

Key Words: Columns (supports), Reinforced concrete, Earthquake resistant structures, Seismic design

The effects of two-dimensional earthquake motion on reinforced concrete (R/C) columns are determined. An analytical model to represent the shear-deflection-axial load relationship of R/C columns is developed from stress-strain relations of steel and concrete.

CONTROLS

(Also see No. 1434)

79-1374

Valve Actuators

W. O'Keefe

Power, 123 (4), pp 1-24 (Apr 1979) 99 figs

Key Words: Valve actuators, Valves

Factors to be considered in the selection of valve actuators are discussed. A number of actuators and their applications are described in detail. Among them are manual, diaphragm, piston (or cylinder) rotary vane, electric and electrohydraulic actuators.

79-1375

Resonance Equalization in Feedback Control Systems

W.J. Bigley and V. Rizzo

Lockheed Electronics Co., Inc., Plainfield, NJ, ASME Paper No. 78-WA/DSC-24

Key Words: Control equipment, Resonant response, Resonance equalization technique

This paper presents a feedback technique for eliminating the destabilizing effect or mechanical resonance in feedback control systems. The technique, called Resonance Equalization (patent pending) was developed and demonstrated in an extensive R&D project to study mechanical resonance phenomena in wide-band, high-performance servo loops.

CYLINDERS

(See No. 1396)

DUCTS

(Also see Nos. 1426, 1428)

79-1376

The Transmission of Acoustic Plane Waves at a Jet Exhaust

R.H. Schlinker

United Technologies Research Ctr., East Hartford, CT, J. Aircraft, 16 (3), pp 188-194 (Mar 1979) 11 figs, 16 refs

Key Words: Sound transmission, Ducts

An experimental study is conducted to determine the plane-wave acoustic transmission loss at the exit of an unflanged constant diameter circular duct with subsonic flow. This model geometry simulates the physical conditions at an engine exhaust in the simplest manner. The acoustic transmission coefficient is evaluated over a large range of jet Mach numbers and reduced frequencies.

79-1377
Hybrid Ray-Mode Formulation of Ducted Propagation
L.B. Felsen and T. Ishihara
Electrical Engrg. Dept., Polytechnic Inst. of New York, Farmingdale, NY 11735, J. Acoust. Soc. Amer., 65 (3), pp 595-607 (Mar 1979) 14 figs, 9 refs

Key Words: Ducts, Waveguide analysis, High frequencies

High-frequency propagation in waveguides or ducts is formulated in terms of a guided mode or a ray expansion. This paper examines the truncation problem. Other field representations involving rays, modes, a canonical integral, a continuous spectrum, and nearfield perturbation are also examined.

79-1378
Measurement of Radial and Circumferential Modes in Annular and Circular Fan Ducts
C.J. Moore
Advanced Research Lab., Rolls-Royce, Ltd., Derby DE2 8BJ, UK, J. Sound Vib., 62 (2), pp 235-256 (Jan 22, 1979) 11 figs, 11 refs

Key Words: Ducts, Acoustic linings

Methods of determining the radial mode distribution are discussed and results of such analyses on idealized distributions are presented. The use of the most suitable methods of analysis is then demonstrated in measuring the modal distribution of the distortion generated noise of an isolated fan.

79-1379
Acoustic Energy in Ducts: Further Observations
W. Eversman
Dept. of Mech. Engrg., Univ. of Canterbury, Christchurch, New Zealand, J. Sound Vib., 62 (4), pp 517-532 (Feb 22, 1979) 1 fig, 3 tables, 11 refs

Key Words: Ducts, Elastic waves, Sound waves

The transmission of acoustic energy in uniform ducts carrying uniform flow is investigated.

79-1380
Impulse Response Function for a Scalar Wave Source in a Compliant Baffle
M.W.P. Strandberg
Dept. of Physics, Massachusetts Inst. of Tech., Cambridge, MA 02139, J. Acoust. Soc. Amer., 65 (3), pp 639-646 (Mar 1979) 1 fig, 32 refs

Key Words: Baffles, Ducts, Pistons, Impact response

The velocity potential impulse response function is computed for a cylindrical piston in a compliant baffle. The solution is obtained in closed form from a baffle which matches the fluid impedance.

FRAMES, ARCHES

(Also see No. 1363)

79-1381
An Approximate Model for Static and Dynamic Analyses of Framed Structures
W. Klud-um
Ph.D. Thesis, Northwestern Univ., 201 pp (1978) UM 7907899

Key Words: Framed structures, Natural frequencies, Mode shapes, Approximation methods

An approximate method for an analysis of framed structures is proposed. The basic method is to subdivide a frame into a number of rectangular domains in the case of plane frame analysis or regular hexahedrons in the case of space frame analysis. In static analysis, the principle of minimum total potential energy is employed. The proposed model is also used in the study of dynamic characteristics of plane frames. Hamilton's principle is used to derive the equations of motion of the frame. The frequencies of the motion are obtained by solving a small matrix eigenvalue problem.

GEARS

(See No. 1382)

LINKAGES

79-1382

Extend Gear Coupling Life

M.M. Calistrat
Koppers Co., Inc., Baltimore, MD, Hydrocarbon Processing, 58 (1), pp 115-118 (Jan 1979) 8 figs, 3 refs

Key Words: Gear couplings

This paper discusses how to increase the service life of high-speed couplings by providing adequate lubrication, reducing sludge accumulation and proper maintenance techniques.

79-1383

Coupling for Misaligned Shafts

J.F. Ohlson
Dept. of the Navy, Washington, D.C., PAT-APPL-914 311/GA, 11 pp (June 15, 1978)

Key Words: Shaft couplings, Alignment

The present invention relates to torque transmission and, more particularly, to an improved shaft coupling having a spherically-formed interface and engaging teeth to accommodate misalignment of interconnected shafts during transmission.

79-1384

Vibration Stability of Unsoldered Bolted Pipe Joints (Schwingfestigkeit lötloser Rohrverschraubungen)

W.U. Zammert and H. Peeken
Institut f. Maschinenelemente und Maschinengestaltung der RWTH, Aachen, Konstruktion, 31 (4), pp 147-153 (Apr 1979) 15 figs, 10 refs

Key Words: Pipes (tubes), Joints (junctions), Fatigue life

Stability of unsoldered bolted pipe joints under mechanical and hydraulic stresses is described. The fatigue life distribution caused by various periodic internal pressures, pipe material, and ring conditions are discussed. In particular, the effect of the mounting on the vibration stability is observed. Experimental results are also described.

MECHANICAL

(See No. 1412)

MEMBRANES, FILMS, AND WEBS

79-1385

Forced Vibration Analysis of a Composite Rectangular Membrane Consisting of Strips

K. Sato
Dept. of Mechanical Engrg., Tohoku Univ., Sendai, Japan, J. Sound Vib., 63 (3), pp 411-417 (Apr 8, 1979) 4 refs

Key Words: Rectangular membranes, Composite structures, Forced vibration, Laplace transformation

The paper is concerned with the forced vibration problem of a composite rectangular membrane consisting of any number of strips of different materials. The theory is developed by the use of the Laplace transformation method. The final forms of solutions of the problem are given for the special case of a homogeneous rectangular membrane subject to two types of driving forces on the membrane surface.

79-1386

Membrane Effects Upon the Transverse Vibration of Linearly Varying Thickness Discs

D.G. Gorman and W. Kennedy
Engrg. Science School, Univ. of Dublin, Dublin 2, Eire, UK, J. Sound Vib., 62 (1), pp 51-64 (Jan 8, 1979) 9 figs, 3 tables, 9 refs

Key Words: Disks (shapes), Variable cross section, Flexural vibration, Membranes (structural members)

An analysis is presented of the changes in natural frequencies of free transverse vibration of annular discs of linearly varying thickness form, when subjected to the combined action of centrifugal loading and complex radial temperature distribution.

PIPES AND TUBES

(Also see Nos. 1384, 1396)

79-1387

Parametric Instabilities of a Periodically Supported Pipe Conveying Fluid

K. Singh and A.K. Mallik
Dept. of Mech. Engrg., Indian Inst. of Tech., Kanpur, Kanpur-208016, India, J. Sound Vib., 62 (3), pp 379-397 (Feb 8, 1979) 5 figs, 8 refs

Key Words: Pipes (tubes), Fluid-induced excitation, Mode shapes, Parametric vibration

Parametric instabilities of a periodically supported pipe conveying fluid are studied. Three different methods are used to determine the regions of instability. In the first method, Bolotin's concept is used along with the knowledge of approximate mode shapes of the pipe. In the second method Bolotin's concept is used directly without recourse to any mode shape approximation. In the third method a wave approach is used. Numerical results are presented to show the effects of various parameters on the regions of instability of a two-span pipe.

79-1388

Guide to Pipe Support Design

C.V. Char
Baton Rouge, LA, Hydrocarbon Processing, 58 (3), pp 133-139 (Mar 1979) 7 figs, 3 tables, 4 refs

Key Words: Pipes (tubes), Supports

The object of this article is to provide the civil-structural engineer with approximate methods that can be used to design almost any type of pipe support structure. Also included are some suggested methods for developing design criteria as an emergency aid for those needing information on design loads.

79-1389

On the Small Two-Dimensional Oscillations of a Sea-Line

F. Angrilli and S. Bergamaschi
Istituto di Meccanica Applicata alle Macchine, Universita di Padova, Meccanica, 12 (3), pp 144-150 (Sept 1977) 3 figs, 1 table, 11 refs

Key Words: Pipelines, Catenaries, Underwater pipelines

The aim of this work is to study the small in-plane oscillations of a submerged pipeline with a curved equilibrium configuration. Some cases of interest in practical applications are analyzed assuming that the curve of static deflection is a catenary. The limits of the method adopted to integrate the resulting differential equation are discussed and the natural frequencies computed starting from a catenary are compared with those obtained assuming static configurations with constant radii of curvature.

79-1390

Wave Forces on Cylinders Near Plane Boundaries

J.C. Wright and T. Yamamoto
Civil Engrg. Corps., USN, Chesapeake Div., Naval Facilities Engrg. Command, Washington, D.C., ASCE J. Waterway, Port, Coastal and Ocean Div., 105 (WW1), pp 1-13 (Feb 1979) 12 figs, 1 table, 14 refs

Key Words: Water waves, Cylinders, Underwater pipelines

Wave forces on a horizontal circular cylinder are experimentally measured to determine the influence of a plane boundary, water particle displacement, and water depth on these forces. The transition from potential flow conditions to real flow conditions is considered. The variation of force coefficients of inertia, lift, and drag is identified.

PLATES AND SHELLS

(Also see Nos. 1315, 1386)

79-1391

Finite Element Discretization of Open-Type Axisymmetric Elements

P.K. Basu and P.L. Gould
Dept. of Civil Engrg., Washington Univ., St. Louis, MO, Intl. J. Numer. Methods Engr., 14 (2), pp 159-178 (1979) 9 figs, 2 tables, 9 refs

Key Words: Shells of revolution, Cooling towers, Finite element technique, Computer programs

A series of open-type elements which are compatible with axisymmetric thin shell elements are derived. These elements allow the effects of intermediate openings and discrete support systems for rotational shells to be realistically modeled in the dynamic regime. Consistent load vectors for several common cases are also derived.

79-1392

Problems of the Optimization of the Elastic-Plastic Spherical Shells Under Variable-Repeated Loading (Tamprių-plastinių sferinių kevalų optimizacijos uždaviniai kartotinės-kintamos apkrovos atveju)

S. Kalanta, R. Karkauskas, and J. Atkočiūnas

Lietuvos Mechanikos Rinkinys, No. 1 (17), pp 86-93 (1977) 2 figs, 2 tables, 5 refs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania

(In Russian)

Key Words: Shells, Spherical shells, Elastic-plastic properties, Mathematical models, Periodic excitation, Extremum principles, Optimization

A discrete mathematical model for the optimization of elastic-plastic flat spherical shells is formulated. The model is based on the extreme energy principle (energy dissipation rate minimum). The finite element method is used in the discretization. Numerical examples are discussed.

79-1393

Axisymmetric Vibration of Continuous Shallow Spherical Shells

S. Mirza and A.V. Singh

Dept. of Mech. Engrg., Univ. of Ottawa, Ottawa, Canada K1N 6N5, J. Sound Vib., 62 (1), pp 65-72 (Jan 8, 1979) 3 figs, 18 refs

Key Words: Shells, Spherical shells, Shear deformation effects, Axisymmetric vibrations

The axisymmetric vibration of shallow shells supported along the outer periphery and along an intermediate circle of radius is considered. Shear deformation effects are included in the differential equations. Results are presented for three cases: fixed edge conditions, simply supported condition; and free edge condition.

79-1394

Natural Frequencies of Thin-Walled Isotropic, Circular-Cylindrical Shells

Engineering Sciences Data Unit Ltd., London, UK, Rept. No. ISBN-0-85679-226-8, 46 pp (1978) EDSU-78004

Key Words: Circular shells, Cylindrical shells, Natural frequencies, Flexural vibration, Torsional vibration

This Item provides graphical and tabulated data for the estimation of the lower natural frequencies of thin-walled unstiffened shells. Natural frequencies of initially unstressed shells for both flexural and torsional vibration are considered. Flexural vibrations are defined in terms of axial and circumferential mode numbers. Natural frequencies of shells subjected to uniform static loads are considered, and shell modal density data are given. Information on the limitations of data presented is provided and some guidance on the calculation of stiffened shell natural frequencies is given. Worked examples which illustrate the application of the Item are provided.

79-1395

On Sound Transmission into an Orthotropic Shell

L.R. Koval

Dept. of Mech. and Aerospace Engrg., Univ. of Missouri-Rolla, Rolla, MO 65401, J. Sound Vib., 63 (1), pp 51-59 (Mar 8, 1979) 9 figs, 7 refs

Key Words: Shells, Cylindrical shells, Sound transmission, Mathematical models

A mathematical model is presented for the transmission of airborne noise through the walls of an orthotropic cylindrical shell. Parameters are varied to see how orthotropicity affects noise transmission.

79-1396

Free Vibration of Circular Cylinders of Variable Thickness

R.F. Tonin and D.A. Bies

Dept. of Mech. Engrg., The Univ. of Adelaide, Adelaide, South Australia 5000, J. Sound Vib., 62 (2), pp 165-180 (Jan 22, 1979) 6 figs, 4 tables, 11 refs

Key Words: Cylinders, Cylindrical shells, Variable cross section, Pipes (tubes)

Flexural vibrations of finite length circular cylinders with shear diaphragm ends and symmetric circumferential wall thickness variations are described by using the Rayleigh-Ritz method. Both symmetric and asymmetric solutions are presented. Only circumferential variations in the wall radial dimension are considered. The cylinder wall thickness variation is described as a Fourier series and the vibration is described as a series of modes of a uniform cylinder with the same mean radius. The theory is applied to a cylinder whose inner bore is circular but is non-concentric with the circular outer surface. The mode shapes are investigated experimentally by using time-averaged holograms of the vibrating cylinder and the results compare well with the predictions of the theory.

79-1397

A Sector Finite Element for Dynamic Analysis of Thick Plates

P. Guruswamy and T.Y. Yang
School of Aeronautics and Astronautics, Purdue Univ., West Lafayette, IN 47907, J. Sound Vib., 62 (4), pp 505-516 (Feb 22, 1979) 9 figs, 2 tables, 13 refs

Key Words: Plates, Circular plates, Finite element technique, Natural frequencies

A 24 degree of freedom sector finite element is developed for the static and dynamic analysis of thick circular plates. The element formulation is based on Reissner's thick plate theory. The convergence characteristic of the elements is first studied in a static example of an unsymmetrically loaded annular plate. The elements are then used to analyze the natural frequencies of an annular plate with various ratios of inner to outer radius. The results are in good agreement with an alternative solution in which thick plate theory is used. The versatility of this finite element is demonstrated by performing free vibration analysis of an example of clamped sector plates with various thicknesses and different sectorial angles.

79-1398

Non-Linear Oscillations of Elastic Orthotropic Annular Plates of Variable Thickness

C.L. Huang and P.R. Aurora
Dept. of Mech. Engrg., Kansas State Univ., Manhattan, KS 66506, J. Sound Vib., 62 (3), pp 443-453 (Feb 8, 1979) 5 figs, 1 table, 14 refs

Key Words: Plates, Variable cross section, Nonlinear vibration

A computational analysis of the non-linear oscillations of elastic orthotropic annular plates of variable thickness is presented. The non-linear boundary value problem is converted into a corresponding eigenvalue problem by using a Kantorovich time-averaging method. Then, by a Newton-Raphson iteration scheme in conjunction with the concept of analytical continuation, the solutions to the non-linear oscillations of elastic orthotropic annular plates of variable thickness are obtained.

79-1399

Vibration of Skew Plates by Using B-Spline Functions

T. Mizusawa, T. Kajita, and M. Naruoka
Dept. of Construction Engrg., Daido Inst. of Tech., Hakusuicho-40, Nagoya, Japan, J. Sound Vib., 62 (2), pp 301-308 (Jan 22, 1979) 1 fig, 3 tables, 13 refs

Key Words: Skew plates, Rayleigh-Ritz method, Free vibration

This paper deals with the free vibration of skew plates by the Rayleigh-Ritz method with B-spline functions as coordinate functions. Convergence of the solutions is investigated in a few typical cases. The accuracy of the results is compared with the existing results based on other numerical methods and found to be in good agreement.

79-1400

Vibration of Rectangular Plates with Time-Dependent Boundary Conditions

J. Venkataramana, M. Maiti, and R.K. Srinivasan
Structural Engrg. Div., Vikram Sarabhai Space Centre, Trivandrum-695022, India, J. Sound Vib., 62 (3), pp 327-337 (Feb 8, 1979) 3 figs, 3 tables, 7 refs

Key Words: Plates, Rectangular plates, Time-dependent excitation

A general method of solution for the vibration of rectangular plates with any type of time-dependent boundary conditions is developed by an extension of the method of Mindlin and Goodman. For illustration, the problems of a plate with different time-dependent boundary conditions are solved and the closed form solutions for the transverse deflections of the plate are obtained. The non-dimensionalized transverse deflections at the middle of the plate are evaluated numerically for different dimensions of the plate and different forcing functions. These are presented graphically against the non-dimensionalized time for three cases and tabulated for other cases.

79-1401

Dynamic Response of Blast Loaded Prestressed Flat Plates

T.L. Cost and H.W. Jones
Dept. of Aerospace Engrg., The Univ. of Alabama, Tuscaloosa, University, AL 35486, J. Sound Vib., 62 (1), pp 111-120 (Jan 8, 1979) 7 figs, 4 tables, 13 refs

Key Words: Plates, Prestressed structures, Blast excitation, Modal superposition method

A finite difference method is used to study the effect of inplane loads on the dynamic response of a square flat plate subjected to a transverse blast load. The method is easily programmed for rapid evaluation on a digital computer. A modal superposition method of analysis and a shock spectrum for the load is used.

79-1402

The Natural Mode Shapes and Frequencies of Graphite Epoxy Cantilevered Plates and Shells

E.F. Crawley and S.W. Lee
Dept. of Aeronautics and Astronautics, Massachusetts Inst. of Tech., Cambridge, MA, Rept. No. AFFDL-TM-FBR-78-110, 147 pp (Aug 1978)
AD-A062 582/2GA

Key Words: Plates, Cantilever plates, Cylindrical shells, Shells, Mode shapes, Natural frequencies

The natural mode shapes and frequencies of graphite/epoxy and graphite/epoxy/aluminum cantilevered plates and cylindrical shell sections are investigated. A single assumed mode partial Ritz analysis is used to determine the frequencies of orthotropic cantilever plates. The results suggest a method for preliminary design and frequency nondimensionalization. The assumed stress hybrid shell element RS40 which includes the effects of transverse shear is used to model a set of laminated cantilevered plates and shells.

79-1403

Frequency Analysis of Thick Orthotropic Plates on Elastic Foundation Using a High Precision Triangular Plate Bending Element

P.V.T. Babu, D.V. Reddy, and D.S. Sodhi
Faculty of Engrg. and Appl. Science, Memorial Univ., of Newfoundland, St. John's, Newfoundland, Canada, Intl. J. Numer. Methods Engr., 14 (4), pp 531-544 (1979) 4 figs, 10 tables, 37 refs

Key Words: Plates, Elastic foundations, Transverse shear deformation effects, Rotatory inertia effects, Free vibration

A high precision triangular thick orthotropic plate bending element on an elastic foundation is developed for the free vibration analysis of thick plates on elastic foundation. The element has three nodes with twelve degrees-of-freedom per node, and takes into account the shear deformation and rotatory inertia. The accuracy of the element is established by comparison of the natural frequencies of certain thick and thin plates, determined from a consistent mass matrix formulation, with available results.

79-1404

On Optimal Design of Vibrating Plate (Dinamiškai apkrautos plokštelės optimalaus projektavimo klausimu)

R. Nogis
Lietuvos Mechanikos Rinkinys, No. 1 (17), pp 52-55 (1977) 3 refs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania
(In Russian)

Key Words: Plates, Vibrating structures, Optimum design

The algorithm of computing the thickness function of a plate is presented for the case in which the parameters of the plate (mass and natural frequencies) are satisfying a certain optimality condition under restrictions in the value of thickness. The condition of optimality is expressed as an extremum of one parameter or as an extremum of distance-norm of existing parameters. Two variants of algorithms are presented: conti[illegible]us and stepped thickness functions. The methods of [illegible]chnical theory of plates, perturbation theory and methods of moments are utilized.

79-1405

Numerical Analysis of the Control of Natural Frequencies of a Circular Plate with Rotational Symmetry by Changing Its Thickness Function

G.A. Abaravicius and R. Nogis
Lietuvos Mechanikos Rinkinys, No. 2 (18), pp 62-74 (1977) 6 figs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania
(In Russian)

Key Words: Circular plates, Natural frequencies, Variable cross section

The natural frequencies and mass of a rotationally symmetric plate are changed jointly by changing its thickness function. The change of thickness function is obtained by methods of perturbation and moments problem. The possibility of changing the first five frequencies and mass are evaluated numerically. The permitted size of change is estimated.

79-1406

On the Vibration of Skew Plates of Variable Thickness

M.M. Banerjee

Dept. of Mathematics, A.C. College, Jalpaiguri 735101, India, J. Sound Vib., 63 (3), pp 377-383 (Apr 8, 1979) 2 figs, 2 tables, 9 refs

Key Words: Skew plates, Plates, Variable cross section, Free vibration, Forced vibration

This paper is concerned with the determination of natural frequencies of a vibrating skew plate with variable thickness. Free and forced vibrations are treated for different ratios of the sides, skew angle and taper constant. The static deflection has also been obtained as a by product of the present solution.

79-1407

Vibrations of a Square Plate with Parabolically Varying Thickness

M.D. Olson and C.R. Hazell

Dept. of Civil Engrg., Univ. of British Columbia, Vancouver, British Columbia, Canada, J. Sound Vib., 62 (3), pp 399-410 (Feb 8, 1979) 5 figs, 3 tables, 7 refs

Key Words: Rectangular plates, Plates, Variable cross section, Natural frequency, Mode shapes, Finite element technique

Vibration results for a square plate with a parabolically varying thickness distribution and built-in edges are presented. Frequency and mode shape predictions obtained from a finite element analysis are compared with measurements made with real-time laser holography.

79-1408

A Note on Vibration of a Cantilever Plate Immersed in Water

G. Muthuveerappan, N. Ganesan, and M.A. Veluswami

Dept. of Appl. Mech., Indian Inst. of Tech., Madras 600036, India, J. Sound Vib., 63 (3), pp 385-391 (Apr 8, 1979) 5 figs, 6 tables, 7 refs

Key Words: Plates, Cantilever plates, Submerged structures, Natural frequencies, Mode shapes, Finite element technique

The added mass of the fluid surrounding it plays an important role in the dynamic behavior of a submerged structure. The first few mode shapes and the respective natural frequencies of a submerged cantilever plate are found by using a finite element procedure, eigenvalues being obtained by a simultaneous iteration technique. The influence of the water depth below the plate and also of the water's lateral extent is considered. Results on the effects of the depth of immersion on the natural frequencies and mode shapes of the cantilever plate for different aspect ratios are presented.

79-1409

Free Vibrations of a Rectangular Plate of Variable Thickness Elastically Restrained Against Rotation Along Three Edges and Free on the Fourth Edge

P.A.A. Laura, R.O. Grossi, and S.R. Soni

Inst. of Appl. Mech., Base Naval Puerto Belgrano, 8111 Argentina, J. Sound Vib., 62 (4), pp 493-503 (Feb 22, 1979) 7 figs, 4 tables, 11 refs

Key Words: Plates, Rectangular plates, Variable cross section

In this paper solutions are presented as obtained by the use of the Ritz method with deflection functions which are simple polynomials, and by the use of the extended Kantorovich method. The fundamental frequency coefficient is determined and good agreement is shown to exist between the results obtained by the two methods.

79-1410

Non-Linear Flexural Vibrations of Anisotropic Skew Plates

G. Prathap and T.K. Varadan

Fibre Reinforced Plastics Res. Centre, Indian Inst. of Tech., Madras 600036, India, J. Sound Vib., 63 (3), pp 315-323 (Apr 8, 1979) 6 figs, 14 refs

Key Words: Skew plates, Flexural vibration

The large amplitude free flexural vibrations of thin, elastic anisotropic skew plates are studied by using the von Karman field equations in which the governing non-linear dynamic equations are derived in terms of the stress function and the lateral displacement. Clamped boundary conditions are chosen and the in-plane edge conditions are either immovable or movable. Solutions are obtained by the Galerkin method on the basis of a one-term assumed vibration mode. The degree of non-linearity is obtained as a function of skew angle, aspect ratio and types of orthotropy.

79-1411

A Semi-Analytic Solution for Free Vibration of Annular Sector Plates

M. Mukhopadhyay

Dept. of Naval Architecture, Indian Inst. of Tech., Kharagpur-721 302, India, J. Sound Vib., 63 (1), pp 87-95 (Mar 8, 1979) 2 figs, 5 tables, 12 refs

Key Words: Circular plates, Curved plates, Free vibration

The paper describes a semi-analytical method in which the basic function in the circumferential direction satisfying the boundary conditions of the radial edges is substituted into the free vibration equation of the curved plate. By a suitable transformation, an ordinary differential equation is obtained. The resulting equation is solved by a finite difference technique. Tabulated results are presented for annular sector plates possessing different boundary conditions. Excellent accuracy has been obtained wherever comparisons have been possible.

79-1412

Vibration of a Viscoelastic Plate Having a Circular Outer Boundary and an Eccentric Circular Inner Boundary for Various Edge Conditions

K. Nagaya

Faculty of Engrg., Dept. of Mech. Engrg., Yamagata Univ., Yonezawa, Japan, J. Sound Vib., 63 (1), pp 73-85 (Mar 8, 1979) 4 figs, 7 tables, 9 refs

Key Words: Plates, Viscoelastic properties, Natural frequency

In this paper, vibration problems of a circular viscoelastic plate having an eccentric circular inner edge are investigated. The frequency equations in complex forms for various edge conditions are obtained. Numerical calculations are carried out for both elastic and viscoelastic plates, and the non-dimensional natural frequencies and the logarithmic decrements are given for a number of cases.

79-1413

The Control of Natural Frequencies at Circular Plate with Rotational Symmetry by Changing Its Thickness Function (Žiedines plokštelės rezonansinių dažnumų mažas keitimas keičiant plokšteles profilį)

G.A. Abaravicius and R. Nogis

Lietuvos Mechanikos Rinkinys, No. 1 (17), pp 56-61 (1977) 4 refs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania

(In Russian)

Key Words: Plates, Natural frequencies, Thickness effects

The natural frequencies and mass of a rotationally symmetric plate are controlled by changing its thickness function. This is obtained by methods of perturbation and moments problem and is expressed as a linear combination of functions. These functions are dependent on natural vibration modes and the changes of natural frequencies and mass.

79-1414

Optimization of Elasto-Plastic Round Plates Under Variable Repeated Loading by Finite Element Method (Kartotinės-kintamos apkrovos veikiamų tamprių-plastinių apvalių plokščių optimizacija, diskretizuojant baigtinių elementų metodu)

S. Kalanta and J. Atkočiūnas

Lietuvos Mechanikos Rinkinys, No. 1 (17), pp 78-85 (1977), Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania

(In Russian)

Key Words: Plates, Elastic-plastic properties, Finite element techniques, Mathematical models, Periodic excitation, Extremum principles, Optimization

The perfectly elasto-plastic plates optimization problems are considered. The equilibrium finite element method and the Mises yield criterion are applied. The discrete mathematical equivalents of the problems are formulated on the basis of extreme energy principles. Some calculation results of the yield forces and load optimization problems are presented.

79-1415

Optimization of Elastic-Plastic Plates Under Movable Loading

J. Atkočiūnas and K. Vislavičius

Lietuvos Mechanikos Rinkinys, No. 1 (17), pp 75-77 (1977) 10 refs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania

(In Russian)

Key Words: Plates, Elastic-plastic properties, Moving loads, Mathematical models, Extremum principles, Optimization

A movable load is considered as a certain type of variable-repeated loading. The mathematical equivalents used to define the parameters of the load or the structure corresponding to both cyclic plastic collapse and the linear optimality criterion are given. The extremum energy principles to solve the problem are used. Numerical examples are presented.

RINGS

(Also see No. 1421)

79-1416

Observations of the Oscillatory Behavior of a Confined Ring Vortex

M.P. Escudier and P. Merkli

Brown Boveri Research Ctr., Baden, Switzerland,
AIAA J., 17 (3), pp 253-260 (Mar 1979) 17 figs, 11 refs

Key Words: Turbomachinery, Rings, Fluid-induced excitation

Ring chambers with annular inflow and outflow through a radial exit tube find wide application in axial-flow turbomachinery as exit chambers to collect and divert the throughflow off-axis. Coriolis forces, arising as a result of the longitudinal curvature imposed on the basic swirling flow, cause the vortex to adopt a helical form within the confines of the ring. Also, an interaction between the two ends of the vortex within the exit tube gives rise to oscillations of the flow which are strongly periodic for certain values of the ratio of the annular width to the ring radius.

STRUCTURAL

79-1417

Design and Construction of a Floor-Wall Reaction System

K.A. Woodward

Structures Research Lab., Univ. of Texas at Austin, TX,
Rept. No. CESRL-77-4, NSF/RA-770698, 77 pp (Dec 1977)

PB-290 458/9GA

Key Words: Floors, Walls, Structural members, Earthquake resistant structures

A Floor-Wall Reaction System was designed and constructed by the University of Texas at Austin Civil Engineering Structures Laboratory to give researchers the ability to test large-scale models using bilateral loadings in addition to axial loads. This report documents and describes the conception, design, and construction of this system in order to enhance its use and availability. The background of the project is described and detailed information is presented on the analysis, design, construction, and floor-wall loading capabilities of the floor-wall system. The appendices present a photographic description of the system's construction, construction drawings, and a table and graph of material properties.

79-1418

Force Distortion in Resonance Testing of Structures with Electro-Dynamic Vibration Exciters

G.R. Tomlinson

Dept. of Mechanical, Production and Chemical Engrg., Manchester Polytechnic, Manchester M1 5GD, UK,
J. Sound Vib., 63 (3), pp 337-350 (Apr 8, 1979) 8 figs, 14 refs

Key Words: Structural response, Resonance tests

Harmonic input force distortion which arises when systems are excited with electrodynamic exciters is shown to be predominantly second harmonic, the major source of the harmonic distortion being due to the vibration exciter characteristics. These are examined by experimentally determining the magnetic field strength properties of a typical exciter. This information is used with the equations of motion of the exciter which are simulated on an analog computer. The amount of second harmonic force distortion generated at a system resonance is analyzed by considering a simple single degree-of-freedom model. Experimental tests on a simple system confirm the theoretical predictions.

79-1419

The Vibration of Structures Elastically Constrained at Discrete Points

H.G. Davies and R.J. Rogers

Dept. of Mech. Engrg., Univ. of New Brunswick, Fredericton, New Brunswick, Canada E3B 5A3,
J. Sound Vib., 63 (3), pp 437-447 (Apr 8, 1979) 3 figs, 1 table, 11 refs

Key Words: Forced vibration, Structural members, Constrained structures

The forced vibration of a structure with an added spring constraint acting at a point is discussed. A set of constrained vibration modes is obtained in terms of the assumed known modes of the unconstrained structure. A finite element model of a heat exchanger tube is used to investigate the importance of the restriction on the damping and the relative numbers of modes needed to provide an accurate estimate of the response over a wide range of frequencies.

SYSTEMS

ABSORBER

(Also see Nos. 1316, 1355, 1428)

79-1420

Testing of Shock Absorbers on the Testing Machine (Die Prüfung von Stossdämpfern auf der Prüfmaschine)

G. Himmler

Kranichsteiner Strasse 41, 6100 Darmstadt, Federal Republic of Germany, Automobiltech. Z., 81 (3), pp 115-118 (Mar 1979) 9 figs

(In German)

Key Words: Shock absorbers, Testing equipment

Driving dynamics require specific damping force/speed characteristics which are obtained by coordinating the functional elements of the shock absorber. By means of the specified testing machines, the characteristic data of the shock absorbers are determined in the laboratory so that the planned and obtained characteristic data can be compared. The article describes the operation of shock absorber testing machines and shows variations of the original construction in order to adapt the machine to different functions.

79-1421

The Calculation of Eccentric Annular Couplings as Systems with the Finite Number of Degrees of Freedom (Iščentriniu ziediniu sankabų kaip sistemu su baigtiniu laisvės laipsniu skaiciumi skaičiavimas)

A.P. Kavolėlis and A. Gulbinas

Lietuvos Mechanikos Rinkinys, No. 1 (17), pp 14-18 (1977) 2 figs, 4 refs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania

(In Russian)

Key Words: Rings, Springs (elastic), Couplings, Vibration control

The article presents the calculation of rotary spring rings deformed in a certain way. The rings are the principal element of antivibrational expansion couplings. The ring potential energy is expressed as a generalized square form of forces. A discrete expression form of the deformed ring axis is presented.

NOISE REDUCTION

(Also see Nos. 1297, 1433, 1457, 1462)

79-1422

Controlling Noise in Central Stations. Acoustic Structures for Equipment and Personnel

M.I. Schiff

Industrial Acoustics Co., 1979 Generation Planbook, edited by Power Magazine, pp 123-124, 2 figs, 3 tables

Key Words: Noise reduction, Enclosures

Two basic courses of action for meeting noise limits are: isolating the noise-producing equipment by means of an enclosure, or providing a work station that isolated operating personnel from existing noise levels. Typical applications of both types of action are discussed.

79-1423

Use Barriers and Enclosures to Reduce Power-Plant Noise

M.I. Schiff

Industrial Acoustics Co., Power, 123 (4), pp 103-105 (Apr 1979) 4 figs, 3 tables

Key Words: Enclosures, Noise reduction, Noise barriers

Ways to satisfy OSHA requirements in power plants are described. They are the use of sound-absorbing enclosures to isolate noisy equipment, and soundproof work stations that protect operating personnel from the existing ambient noise levels.

79-1424
User's Guide to Acoustic Enclosures
J.S. Anderson and D.G. Bull
The City Univ., London, UK, Noise Control Vib. Isolation, 10 (2), pp 51-54 (Feb 1979) 5 figs, 7 refs

Key Words: Noise reduction, Enclosures

The article discusses the concepts used in selecting an effective acoustic enclosure. They are the sound reduction index of a panel, insertion loss, and noise reduction. The need for a standard enabling the manufacturers to specify more precisely the acoustic performance of their enclosures is also suggested.

79-1425
Noise in the Commercial Environment
D.A. Waller
Power Equipment Co. Ltd., Noise Control Vib. Isolation, 10 (3), pp 93-96 (Mar 1979) 3 figs

Key Words: Noise reduction, Business equipment, Enclosures, Silencers

Reasons for reducing business equipment noise in the office are discussed and design of silencers for such machinery is described.

79-1426
The Attenuation of Lined Plenum Chambers in Ducts, II: Measurements and Comparison with Theory
A. Cummings and A.M. Wing-King
Inst. of Environmental Science and Tech., Polytechnic of the South Bank, Borough Rd., London SE1 0AA, UK, J. Sound Vib., 63 (1), pp 19-32 (Mar 8, 1979) 11 figs, 7 refs

Key Words: Sound transmission loss, Silencers, Acoustic linings, Ducts, Experimental data

Experimental measurements of the acoustic performance of single and three-pass lined plenum chambers are compared to calculations based on theoretical models described in a companion paper. Generally, quite good agreement is obtained, subject to the limitations of the theories. Comparison is made between the performance of a single plenum chamber and that of an equivalent splitter silencer. The aerodynamic pressure losses of all three silencers are compared, and observations are made concerning the relative mass, construction time, etc. of the single chamber and the splitter. A tentative design procedure for plena is suggested.

79-1427
A Note on the Interaction of Unsteady Flow with an Acoustic Liner
M.S. Howe
Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, J. Sound Vib., 63 (3), pp 429-436 (Apr 8, 1979) 2 figs, 11 refs

Key Words: Acoustic linings

The effects of a mean grazing flow on the energy exchanges involved in the interaction of a bias-flow acoustic liner with, respectively, incident sound and boundary layer turbulence are contrasted.

79-1428
The Effects of Flow on the Performance of a Reactive Acoustic Attenuator
C.R. Fuller and D.A. Bies
Dept. of Mech. Engrg., Univ. of Adelaide, Adelaide, South Australia, 5000, J. Sound Vib., 62 (1), pp 73-92 (Jan 8, 1979) 7 figs, 15 refs

Key Words: Acoustic absorption, Ducts, Acoustic linings

The effects of flow on the performance of a reactive acoustic attenuator discussed in a previous paper are investigated theoretically and experimentally. The attenuator is analyzed by using recently developed curved duct equations with flow. Theoretical predictions are obtained for the pressure reflection coefficient, the power reflection and transmission coefficient and the transmission loss of the attenuator, at varying flow Mach numbers. The two cases of sound propagating with and against the flow are discussed and good agreement is obtained with experimental measurements.

79-1429
Sonic-Boom Minimization with Nose-Bluntness Relaxation
C.M. Darden

NASA Langley Research Ctr., Hampton, VA, Rept. No. NASA-TP-1348; L-12464, 53 pp (Jan 1979) N79-15000

Key Words: Sonic boom, Noise reduction

A procedure which provides sonic-boom-minimizing equivalent area distributions for supersonic cruise conditions is described. This work extends previous analyses to permit relaxation of the extreme bluntness required by conventional low-boom shapes and includes propagation in a real atmosphere. The procedure provides area distributions which minimize either shock strength or overpressure.

79-1430

Reduction of Cabin Noise During Cruise Conditions by Stringer and Frame Damping

G. SenGupta

Boeing Commercial Airplane Co., Seattle, WA, AIAA J., 17 (3), pp 229-236 (Mar 1979) 13 figs, 15 refs

Key Words: Aircraft noise, Noise reduction, Low frequencies, Viscoelastic damping

The control of low-frequency cabin noise is analyzed in terms of the response of a pressurized fuselage structure subjected to broadband random pressure fluctuations.

79-1431

Prediction and Control of Induced Draft Cooling Tower Noise

J.S. Wang

Exxon Res. and Engrg. Co., P.O. Box 101, Florham Park, NJ 07932, Noise Control Engr., 12 (2), pp 74-81 (Mar/Apr 1979) 12 figs, 2 tables, 9 refs

Key Words: Cooling towers, Noise prediction, Noise reduction

A technique for estimating induced draft cooling tower noise in the adjacent community has been developed according to data measured at refineries and chemical plants. It is shown that fan noise dominates the falling water noise at locations distant from the cooling tower and that the noise radiated from the louvered faces dominates that radiated from the fan stacks. This information is crucial in selecting a method for cooling tower noise control.

79-1432

Some Experimental Studies on Centrifugal Blower Noise

G. Krishnappa

Engine Lab., Div. of Mech. Engrg., National Res. Council of Canada, Ottawa, Ontario, Canada K1A 0R6, Noise Control Engr., 12 (2), pp 82-90 (Mar/Apr 1979) 27 figs, 4 refs

Key Words: Fans, Noise reduction, Design techniques

Some experimental studies aimed at designing quiet fans and blowers by controlling the generated noise at the source, with a minimum sacrifice in aerodynamic performance are outlined.

79-1433

Controlling Noise in Central Stations. Fan-Noise Abatement in Power Plants

J.G. Funk

Environmental Elements Corp., 1979 Generation Planbook, Edited by Power Magazine, pp 117-119, 5 figs, 1 table

Key Words: Noise reduction, Fans, Electric power plants

The author discusses the design options a power engineer should be aware of when he selects noise suppression devices for fans in power plants.

79-1434

Controlling Noise in Central Stations. Silencers Reduce Vent, Valve Noise

J.K. Floyd

American Air Filter Co., 1979 Generation Handbook, Edited by Power Magazine, pp 119-121, 3 figs, 2 tables

Key Words: Noise reduction, Valves, Electric power plants

Pressure-relief valves and control valves are often major sources of noise in electric-utility power plants. The design of noise reduction devices for such valves is discussed.

79-1435

Controlling Noise in Central Stations. Noise-Control Equipment for Plant Prime Movers

R.F. Werkmeister

American Air Filter Co., Pulsco Div., 1979 Generation Planbook, Edited by Power Magazine, pp 121-123, 3 figs, 1 table

Key Words: Noise reduction, Gas turbine engines, Reciprocating engines

The integration of noise-control equipment with the prime-movers, e.g., gas turbines and reciprocating engines, during the design stage has been found to be the most economical method of meeting noise control requirements. Various types of silencers are discussed in the article.

79-1436

The Wake Velocity and Rudder Force on a Tanker Ship Model

N. Matheson

Aeronautical Research Labs., Melbourne, Australia, Rept. No. ARL/AERO NOTE-376, 86 pp (May 1978) AD-A062 572/3GA

Key Words: Ships, Noise reduction, Marine propellers, Ship noise

A propeller tunnel had been fitted to a 33,000 t (32,500 ton) bulk carrier to cure cavitation, vibration and noise problems occurring previously. From a series of wind tunnel tests with a model, a set of vortex generators was developed which improved the flow over the stern and increased the side force produced by the rudder.

79-1437

Construction Machinery Noise - A Project and a Package

Noise Control Vib. Isolation, 10 (2), pp 68-71 (Feb 1979) 3 figs, 1 table

Key Words: Construction equipment, Noise reduction

Measurements of the external noise levels produced by the loading shovels of construction machinery and the effectiveness of a simple control treatment in reducing these levels are described.

79-1438

Industrial Noise Control - A Systematic Approach

J. Dean

Industrial Acoustics Co., Ltd., Noise Control Vib. Isolation, 10 (2), pp 65-67 (Feb 1979) 4 figs

Key Words: Industrial facilities, Noise reduction

The article defines the most common sources of noise problems encountered in industry and describes the methods which are currently available to solve them.

ACTIVE ISOLATION

79-1439

An Elementary Explanation of the Flutter Mechanism with Active Feedback Controls

H. Horikawa and E.H. Dowell

Princeton Univ., Princeton, NJ, J. Aircraft, 16 (4), pp 225-232 (Apr 1979) 10 figs, 11 refs

Key Words: Flutter, Active control

An elementary explanation of wing flutter suppression problems with active feedback control is made using a standard root locus technique. The object of the study is to obtain insight into the control of converging frequency flutter such as the classical bending-torsion flutter of a wing. The model analyzed is a two-dimensional, typical section airfoil with pure gain feedback of the main wing motion. In this simple system, stability boundary solutions are expressed in a closed form and valuable information is obtained for various kinds of feedback signals. The results for an exploratory example are discussed. The analysis of this example using Nissim's energy method is also attempted.

79-1440

An Optimized Speed-Controlled Suspension of a 2-DOF Vehicle Travelling on a Randomly Profiled Road

T. Dahlberg

Div. of Solid Mech., Chalmers Univ. of Tech., S-412 96, Gothenburg, Sweden, J. Sound Vib., 62 (4), pp 541-546 (Feb 22, 1979) 5 figs, 3 refs

Key Words: Ground vehicles, Suspension systems (vehicles), Active isolation, Optimization, Surface roughness

The spring and damper stiffnesses of a road vehicle suspension system are optimized with respect to both ride comfort and road holding. The optimized active suspension system obtained is compared with a corresponding passive system where the constant suspension parameters coincide with those of the active system at a selected fixed speed (20 m/s).

AIRCRAFT

(Also see Nos. 1311, 1429, 1430)

79-1441

Wing Rock Due to Aerodynamic Hysteresis

L.V. Schmidt

Naval Postgraduate School, Monterey, CA, J. Aircraft, 16 (3), pp 129-133 (Mar 1979) 6 figs, 9 refs

Key Words: Aircraft, Aerodynamic loads, Hysteretic damping

An analysis is presented using control theory concepts to show that aerodynamic hysteresis of the form of relay action can lead to lateral-directional limit cycle motions. These limit cycle motions are described in a colloquial sense as airframe wing rock. The purpose of the studies described herein is to promulgate a flight mechanics analysis technique which offers the analyst an insight into potential candidate aerodynamic mechanisms.

79-1442

Unsteady Aerodynamic Modeling for Arbitrary Motions

J.W. Edwards, H. Ashley, and J.V. Breakwell

NASA Dryden Flight Research Ctr., Edwards, CA, AIAA J., 17 (4), pp 365-374 (Apr 1979) 11 figs, 2 tables, 25 refs

Sponsored by NASA and the USAF

Key Words: Aircraft, Aerodynamic loads, Mathematical models

A study is presented on the unsteady aerodynamic loads due to arbitrary motions of a thin wing and their application for the calculation of response and true stability of aeroelastic modes. The use of Laplace transform techniques and the generalized Theodorsen function for two-dimensional incompressible flow is reviewed. Numerical results are given for the two-dimensional supersonic case. Previously proposed approximate methods, starting from simple harmonic unsteady theory, are evaluated by comparison with exact results obtained by the present approach. The Laplace inversion integral is employed to separate the loads into rational and nonrational parts, of which only the former are involved in aeroelastic stability of the wing.

79-1443

Techniques for Dynamic Stability Testing in Wind Tunnels

K.J. Orlik-Rueckemann

Unsteady Aerodynamics Lab., National Aeronautical Establishment, Ottawa, Ontario, Canada, 24 pp (Nov 1978) In: AGARD Dyn. Stability Parameters, for primary document see N79-15061)

N79-15062

Key Words: Aircraft, Dynamic stability, Dynamic tests, Testing techniques, Wind tunnel tests

A systematic review is presented of the methods and techniques that are used for wind tunnel measurements of the dynamic stability parameters (derivatives) of an aircraft. The review is illustrated by numerous examples of experimental equipment available in various aerospace laboratories in Canada, France, the United Kingdom, the United States and West Germany.

79-1444

A New Method for Designing Shock-Free Transonic Configurations

H. Sobieczky, K.-Y. Fung, A.R. Seebass, and N.J. Yu

Engrg. Experiment Station, Arizona Univ., Tucson, AZ, Rept. No. NASA-CR-158063, 35 pp (July 1978)

N79-14997

Key Words: Aircraft wings, Airfoils, Design techniques, Boundary layer excitation, Shock waves

A method for the design of shock free supercritical airfoils, wings, and three dimensional configurations is described. Results illustrating the procedure in two and three dimensions are given. They include modifications to part of the upper surface of a NACA 64A410 airfoil that will maintain shock free flow over a range of Mach numbers for a fixed lift coefficient, and the modifications required on part of the upper surface of a swept wing with a NACA 64A410 root section to achieve shock free flow.

79-1445

Investigation of Torsion Free Wing Trend Flutter Models

H.T.Y. Yang and C.H. Wan

School of Aeronautics and Astronautics, Purdue Univ., Lafayette, IN, Rept. No. AFOSR-TR-78-1514, 60 pp (Sept 15, 1978)
AD-A061 942/9GA

Key Words: Aircraft wings, Flutter, Computer programs, NASTRAN (computer program), Finite element technique

Four types of aluminum plate flutter models of a torsion free wing (TFW) are studied: cantilever wing; pitch restrained wing; TFW with forward trim surface; and TFW with aft trim surface. Free vibration analyses are performed by using the finite element program NASTRAN. Generalized aerodynamic forces are computed by using the program LAT2D based on the subsonic lifting surface theory of Kussner. Flutter speeds and frequencies are predicted by using the program FLTTR based on the V-g method. The predicted flutter speeds are compared with available computed and tested results. The predicted flutter speeds for the four models are compared with each other and conclusions are made. To determine the designs that yield higher flutter speeds, parametric studies are conducted by varying each of the six parameters; thickness parameter of the wing; thickness parameter of either trim surface; location of the wing pivot; length of the boom; swept angle of the wing; and swept angle of either trim surface.

79-1446

Dynamic Response Analysis of Structural Systems Using a Direct Integration Method

J.S. Przemieniecki and R.J. Talbot

Air Force Inst. of Tech., Wright-Patterson Air Force Base, OH, J. Aircraft, 16 (3), pp 195-202 (Mar 1979) 8 figs, 17 refs

Key Words: Numerical analysis, Dynamic response, Finite element technique, Aircraft

The main categories of numerical analyses of dynamical response of structural systems represented by finite elements are discussed and a direct integration method is derived using Padé approximations to the exact exponential series solutions. The method is employed for the analysis of aircraft structures subjected to arbitrary time-dependent loading. Numerical stability, artificial attenuation, and phase shift of the approximate solutions are discussed in detail. The dynamic response solution is presented in the form of an explicit operator requiring only one inversion of the mass matrix of the system. A numerical example is included for the dynamic response of an elastic circular bar subjected to axisymmetric compressive stress at the free end. The numerical results are compared with a solution obtained by the finite difference method.

BIOENGINEERING

79-1447

Experimental Analysis of the Vibration Characteristics of the Human Skull

T.B. Khalil, D.C. Viano, and D.L. Smith

General Motors Research Labs., Warren, MI 48090, J. Sound Vib., 63 (3), pp 351-376 (Apr 8, 1979) 28 figs, 2 tables, 16 refs

Key Words: Head (anatomy), Mathematical models, Natural frequencies, Mode shapes

Analytical models of the human skull structure are constructed to characterize the gross geometric features and material properties; however, a model should also have accurate frequency response characteristics since these are essential for collision and head injury analyses. An experimental investigation is conducted to identify the dynamic characteristics of freely vibrating human skulls. Resonant frequencies and associated mode shapes in the frequency band from 20 Hz to 5000 Hz are delineated for two dry human skulls. Digital Fourier analysis techniques are used to identify the resonant frequencies and corresponding mode shapes of each skull.

BUILDING

79-1448

Optimum Design to Resist Earthquakes

E. Rosenblueth

Universidad Nacional Autonoma de Mexico, Mexico, D.F., Mexico, ASCE J. Engr. Mech. Div., 105 (EM1), pp 159-176 (Feb 1979) 6 figs, 2 tables, 10 refs

Key Words: Buildings, Seismic design, Optimum design

Optimization is taken as minimization of the sum of expected present values of initial costs (including engineering services and construction) and magnified losses due to a structure's entrance into limit states. Dead, live, and seismic loads are considered. Attention is given to optimum repair and reconstruction policies.

79-1449
Torsion in Buildings Subjected to Earthquakes
M.E. Batts
Ph.D. Thesis, The Univ. of Michigan, 162 pp (1978)
UM 7907025

Key Words: Buildings, Earthquake response, Torsional response, Seismic excitation, Eccentricity

In this dissertation, the probabilistic approach is selected for the analysis of linear response. The earthquake ground excitation is discussed and a simple expression relating torsional earthquake power spectra to translational earthquake power spectra is developed. Interaction relations are derived for systems with simultaneous X, ϕ, and Y ground excitations. The peripheral response is studied using the probabilistic approach. The state of the art of artificial accelerogram generation is discussed. Various parameters affecting ground rotational motion are discussed. Nonlinear response characteristics for a four exterior wall model are analyzed.

79-1450
Shaking Table Earthquake Response of Steel Frame
D.T. Tang and R.W. Clough
State Univ. of New York at Buffalo, Buffalo, NY, ASCE J. Struc. Div., 105 (ST1), pp 221-243 (Jan 1979) 19 figs, 5 tables, 4 refs

Key Words: Multistory buildings, Earthquake response, Shakers, Experimental data, Mathematical models

Earthquake responses of a 17-ft 4-in. (5.29-m) tall three-story steel frame structure are produced in two series of shaking table tests. The test data are used in the development and verification of analytical procedures. Mathematical models are formulated by first defining the element properties and then assembling them to obtain the system properties. Panel zone deformability, bi-linear strain-hardening plastic hinges, and foundation flexibility are considered in modeling.

79-1451
Forced Vibration Testing of a Rehabilitated Multistory Building, Volume 1
G.C. Hart, S. Huang, W.T. Thomson, M.A.M. Torkamani, and D. Rea
School of Engrg. and Appl. Science, California Univ., Los Angeles, CA, Rept. No. UCLA-ENG-7822, NSF/RA-780309, 82 pp (June 1978)
PB-289 904/5GA

Key Words: Multistory buildings, Vibration tests, Forced vibration, Earthquake response

This report describes a series of steady state harmonic forced vibration tests conducted on a multistory building before and after it was rehabilitated for seismic safety. Response is measured at 5, 25, and 45 feet from the building on the surface of ground.

FOUNDATIONS AND EARTH

79-1452
Stability of Axially Loaded Shaft and Tunnel Linings Connected to Each Other by Flexible Rings (Stabilität von Schact- und Tunnelauskleidungen aus gelenkig miteinander verbundenen Schüssen unter axialer Belastung)
H. Link
Goethestrasse 13, D-4200 Oberhausen 1, Federal Republic of Germany, Ing. Arch., 48 (1), pp 51-63 (1979) 10 figs, 2 tables, 4 refs
(In German)

Key Words: Stability, Linings, Tunnel linings

Starting with the possible loads occurring in practice in the direction of their axis, this investigation deals with the stability of these linings taken as a link chain under constant and linearly variable axial load while embedded in an elastic or fluid medium.

HELICOPTERS

79-1453
Flight Test Design for CH-47 Parameter Identification
W.E. Hall, Jr. and J. Vincent
Systems Control, Inc., Palo Alto, CA, Rept. No. NASA-CR-158948, 203 pp (Dec 1978)
N79-15025

Key Words: Helicopters, Parameter identification technique, Flight tests

The VTOL Approach and Landing Technology (VALT) program is a significant experimental research program aimed at establishing a data base for rotorcraft operation in a terminal area environment. Work was undertaken to determine helicopter math models suitable for analyzing maneuvers along a VTOL trajectory and to apply these math models to determine the flight test procedures of greatest effectiveness in establishing helicopter dynamic characteristics in this mode of operation. As the principal results of this investigation, a flight test specification is presented for the CH-47 VALT aircraft operating along the specified VTOL trajectory of the VALT program.

79-1454
Some Results of the Testing of a Full-Scale Ogee-Tip Rotor
W.R. Mantay, P.A. Shidler, and R.L. Campbell
Structures Lab., USARTL (AVRADCOM), Hampton, VA, J. Aircraft, 16 (3), pp 215-221 (Mar 1979) 15 figs, 4 tables, 8 refs

Key Words: Helicopter rotors, Helicopter noise, Noise reduction

Full-scale tests are utilized to investigate the effect of the Ogee tip on helicopter rotor acoustics, performance, and loads. Two facilities are used for this study: the Langley whirl tower and a UH-1H helicopter. The full-scale testing on the UH-1H encompasses the major portion of the flight envelope for that aircraft. Both near-field acoustic measurements as well as far-field flyover data are obtained for both the Ogee and standard rotors.

MATERIAL HANDLING

(Also see No. 1396)

79-1455
Vibratory Conveying - Analysis and Design: A Review
M.A. Parameswaran and S. Ganapathy
Mech. Engrg. Dept., Indian Inst. of Tech., Madras-600 036, India, Mech. Mach. Theory, 14 (2), pp 89-97 (1979) 11 figs, 2 tables, 23 refs

Key Words: Conveyors, Materials handling equipment, Vibrators (machinery)

One of the industrial applications of vibration is its use for conveying materials. This report is a review of the published papers in the area of vibratory jump conveying. While many have contributed to understand the phenomenon of vibratory conveying, there is still vast scope for work on the dynamics and design aspects of the vibratory conveyor.

MECHANICAL

79-1456
Out of Room? Use Minimum Movement Machinery Alignment
M.G. Murray, Jr.
Hydrocarbon Processing, 58 (1), pp 112-114 (Jan 1979) 5 figs, 1 ref

Key Words: Aligning, Machinery

A simple method for aligning machinery when space is limited is described.

79-1457
A Study on Noise Emitted from Power Hacksaw Machines
J.C. Charman and G.M. McNulty
Ardente Industrial Services, Noise Control Vib. Isolation, 10 (2), pp 58-64 (Feb 1979) 11 figs, 2 tables

Key Words: Saws, Noise reduction

This article considers noise emitted from the operation of one particular machine tool: the modern power hacksaw. Consideration is given to the variation in noise emission from a power hacksaw against varying parameters such as cutting force and wear. The feasibility of noise reduction by critical control of such parameters may also be extended to other machine tools in general. Recommendations as to the optimum blade life with respect to the parameters of noise levels and cutting times are also given.

79-1458
On the Aerodynamic Noise Source in Circular Saws
H.S. Cho and C.D. Mote, Jr.
Dept. of Mech. Engrg., Univ. of California, Berkeley,

CA 94720, J. Acoust. Soc. Amer., 65 (3), pp 662-671 (Mar 1979) 14 figs, 20 refs

Key Words: Saws, Noise source identification

A theoretical model is presented for prediction of the far-field noise. Experimental measurement of the fluctuating lift force on particular tooth models is used to identify the dipole source and a hot wire anemometer, rotating with the saw, measured the tooth wake. The theoretical predictions of dipole noise dependence upon parameter variation are generally consistent with literature noise data.

79-1459

On the Prediction of Impact Noise, I: Acceleration Noise

E.J. Richards, M.E. Westcott, and R.K. Jeyapalan
Inst. of Sound and Vibration Research, Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 62 (4), pp 547-575 (Feb 22, 1979) 20 figs, 3 tables, 7 refs

Key Words: Industrial facilities, Noise generation, Machinery noise, Impact noise

This paper, the first of a series, is concerned with the noise generated by impacting bodies due to the high surface accelerations during the contact period. An account is presented of the theoretical development and experimental validation of curves for the prediction of peak sound pressure and radiated energy for collisions of compact bodies which are incapable of flexural motions.

OFF-ROAD VEHICLES

(See Nos. 1472, 1473)

PUMPS, TURBINES, FANS, COMPRESSORS

79-1460

Mathematical Modeling of Multicylinder Compressor Discharge System Interactions

R. Singh and W. Soedel
Ray W. Herrick Labs., Purdue Univ., West Lafayette, IN 47907, J. Sound Vib., 63 (1), pp 125-143 (Mar 8, 1979) 14 figs, 25 refs

Key Words: Compressors, Fluid-induced excitation, Mathematical models

Multicylinder compressor discharge system interactions are identified and modeled here as kinematic and geometric types of coupling. The kinematic coupling effect is incorporated with the input volume velocities, at the values, which are derived from the discharge mass flow rates. To account for the geometric interactions arising because of the interconnected cavities and passages, impedance matrices are formulated. The discharge system components are described by steady state acoustic impedances, in distributed parameters format. The theory is applied to a two cylinder high speed refrigeration compressor. Unsteady flow pressures are predicted in the valve chamber (for capacity and energy consumption considerations), and at the manifold end (for muffling effectiveness consideration). Excellent agreement between theory and experiment is obtained.

RAIL

(Also see No. 1308)

79-1461

Stability Criteria for Articulated Railway Vehicles Possessing Perfect Steering

A.H. Wickens
British Rail Res. and Dev. Division, Derby, UK, Vehicle Syst. Dyn., 7 (4), pp 165-182 (Dec 1978) 8 figs, 16 refs

Key Words: Railroad trains, Articulated vehicles, Suspension systems (vehicles), Joints (junctions)

The general form of the equations of motion of multi-body articulated railway vehicles are used to establish the conditions which the elastic stiffness matrix, which describes the nature and configuration of the suspension elements connecting the various bodies, must satisfy in order to achieve both perfect steering on circular curves and dynamic stability. The resulting criteria are then used to discuss the properties of various multi-axle configurations which are either typical of current practice or possibilities for future designs.

79-1462

Noise Control of a Mine Operated Rail Personnel Carrier: Volume 1. Design and Performance of Noise Control Treatments

A.G. Galaitsis, P.J. Remington, and M.M. Myles
Bolt Beranek and Newman, Inc., Cambridge, MA, Rept. No. BBN-3690, 116 pp (Nov 1977)
PB-289 711/4GA

Key Words: Subway rails, Underground structures, Mines (excavations), Passenger transportation, Noise reduction, Interaction: rail-wheel

Diagnostic tests are performed on an FMC 2190 portal bus to determine the contribution of major noise sources to the total radiated noise. Noise control treatments, including resilient wheels, panel damping, and a motor enclosure are designed, developed, and evaluated.

79-1463
An Analog Simulation Study of the Rocking Response of a Railroad Freight Vehicle
M. Samaha and T.S. Sankar
Dept. of Mech. Engrg., Concordia Univ., Montreal, Canada, J. Sound Vib., 63 (1), pp 109-124 (Mar 8, 1979) 12 figs, 1 table, 10 refs

Key Words: Railroad cars, Freight cars, Analog simulation, Stabilization, Friction damping, Viscous damping

The steady state response of a single large capacity railroad freight vehicle is presented. The vehicle is described through an appropriate multi-degree of freedom non-linear mathematical model. The equations of motion of the system are derived by using Lagrange's procedure. The analog computer is employed for solving the non-linear differential equations of motion for obtaining the system's rocking response in the time domain. The vehicle steady state frequency response is derived from a sequence of time responses. By utilizing the frequency response plots a complete study of the system sensitivity to variation in the suspension parameters is carried out.

REACTORS

79-1464
Pump-Induced Acoustic Pressure Distribution in an Annular Cavity Bounded by Rigid Walls
M.K. Au-Yang
Nuclear Power Generation Div., Babcock & Wilcox, Lynchburg, VA 24505, J. Sound Vib., 62 (4), pp 577-591 (Feb 22, 1979) 9 figs, 2 tables, 5 refs

Key Words: Nuclear reactor components, Acoustic excitation, Cooling systems, Cavitation noise

This paper describes an analytical method for estimating the coolant pump-induced acoustic pressure distribution in the inlet annulus of a pressurized water reactor and to verify the technique by measurement on a simplified laboratory method.

79-1465
Pacemakers Abroad/Chin Shan Protecting Against Earthquakes
E. Odar
Ebasco Services, Inc., 1979 Generation Planbook, Edited by Power Magazine, pp 67-69, 5 figs

Key Words: Nuclear power plants, Seismic design

Seismic control measures undertaken in the design of nuclear plants at the Chin Shan Site in Taiwan are described.

79-1466
Linearized Transient Analysis of Nuclear Steam Generators
G.J. Van Tuyle
Ph.D. Thesis, The Univ. of Michigan, 212 pp (1978)
UM 7907191

Key Words: Nuclear power plants, Boilers, Transient response, Periodic response, Mathematical models

This paper describes the development and application of a computer model simulating the transient behavior of nuclear steam generators. The effort is directed toward development of a simplified linearized model for integral-economizer once-through steam generators. The model utilizes a movable boundary spatial discretization technique. Notable features of the model include full treatment of a time-independent momentum equation, as well as a perturbation technique used to evaluate the dependence of heat flux and pressure gradient on other system properties. A perturbation technique is developed that provides constraint equations for moving boundaries between heat transfer regions. A detailed steady-state model is developed to provide initial values for the transient calculators.

79-1467
Nonlinear Transient Analysis of Nuclear Steam Generators
M.W. Crump
Ph.D. Thesis, The Univ. of Michigan, 252 pp (1978)
UM 7907058

Key Words: Nuclear power generators, Boilers, Transient response, Mathematical models

This paper describes the development and practical application of a numerical modeling method for dynamic thermal and hydraulic analysis of nuclear steam generators. The mathematical model for fluid flows is based upon one-dimensional, nonlinear, single-fluid conservation equations for mass, momentum and energy. An empirical slip flow model is included in the fluid model to enable description of two-phase slip or homogeneous flows as well as single-phase flows.

79-1468
Static and Dynamic Properties of Sand-Cement
J. Dupas and A. Pecker
Mecasol SA, Consulting Engineers, Paris, France, ASCE J. Geotech. Engr. Div., 105 (GT3), pp 419-436 (Mar 1979)

Key Words: Nuclear power plants, Seismic design

An extensive laboratory testing program on different mixtures is undertaken to assess the design characteristics (static and dynamic) and to check the durability and cyclic strength of the backfill material. In the course of the testing program new methods for interpretation of the dynamic characteristics of the soil-cement are developed.

RECIPROCATING MACHINE

(Also see No. 1380)

79-1469
Whirling Response and Stability of Flexibly Mounted, Ring-Type Flywheel Systems
L.T. Chen
Ph.D. Thesis, The Univ. of Oklahoma, 121 pp (1978)
UM 7908816

Key Words: Whirling, Flywheels, Motor vehicle engines

In this investigation, free whirling, stability, and forced whirling are examined for ring-type flywheel systems. Practical ways to increase critical speeds are suggested. Forced whirling excited by unbalance and initial tilt of rim element is studied.

ROAD

(Also see Nos. 1309, 1310, 1440)

79-1470
A Simplified Finite Element Method for Studying Acoustic Characteristics Inside a Car Cavity
T.L. Richards and S.K. Jha
School of Automotive Studies, Cranfield Inst. of Tech., Cranfield, Bedford MK43 0AL, UK, J. Sound Vib., 63 (1), pp 61-72 (Mar 8, 1979) 10 figs, 4 tables, 9 refs

Key Words: Finite element technique, Acoustic resonance, Motor vehicle noise, Internal noise

A simplified finite element method is developed for analyzing the acoustic resonances of a prismatic car cavity. Use is made of the non-variant geometric and material properties of such a cavity in one direction (across the width of the car). Some experimental results obtained for a half-size model of a car cavity are compared with the finite element results. The accuracy of the finite element solution is assessed by analyzing a rectangular cavity and a cylindrical cavity, for which analytical solutions are already available.

79-1471
On the Theory of Dynamic Stability of Motor Vehicle Carriers
M. Singh
Ph.D. Thesis, Wayne State Univ., 162 pp (1978)
UM 7908962

Key Words: Articulated vehicles, Tractors, Mathematical models, Stability

A mathematical model of a tractor-semitrailer with three degrees of freedom -- the lateral motion of the tractor, yaw motions of the tractor and the semitrailer -- is developed. The root locus analyses are applied to determine relatively optimal vehicle parameters. The parameter thus obtained are used in a nonlinear analysis, which employs a combination of Poincaré and Liapunov stability theories. Various singular points are determined.

79-1472

Optimal Control of the Tractor-Semitrailer Truck

A. Van Zanten and A.I. Krauter
Robert Bosch GmbH, Development of Anti-Skid Systems, 7141 Schwieberdingen, Robert Bosch Strasse, West Germany, Vehicle Syst. Dyn., 7 (4), pp 203-231 (Dec 1978) 11 figs, 17 refs

Key Words: Tractors, Semitrailers, Optimum control theory, Braking effects

This paper is concerned with the braking performance and the handling behavior of the tractor-semitrailer truck under optimal braking. Optimal control theory is used in order to deal with the problem and a combination of the steepest descent method and the Davidon Fletcher Powell method is used to solve it numerically. Results for some chosen braking maneuvers are obtained for a nonlinear truck model which has 14 degrees of freedom.

79-1473

Simulation of Steering and Braking Behaviour of Tractor-Semitrailer Vehicles in Extreme Situations (Berechnung des extremen Lenk- und Bremsverhaltens von Sattelkraftfahrzeugen)

F. Uffelmann
Institut f. Fahrzeugtechnik, Technische Universitat Braunschweig, Germany, Vehicle Syst. Dyn., 7 (4), pp 183-201 (Dec 1978) 15 figs, 2 tables, 12 refs (In German)

Key Words: Tractors, Semitrailers, Braking effects, Cornering effects

This paper deals with the simulation of the behavior of tractor-semitrailer vehicles at braking on wet, slippery road surface. The nonlinear model used for the computation enables simulation of extreme situations at wheel locking and swerving. The instabilities during braking such as jackknifing and trailer swing as well as nonsteerability are investigated.

79-1474

Investigation of Tire-Pavement Interaction During Maneuvering. Volume 1. Theory and Results

R.A. Schapery and J.T. Tielking
Mechanics and Materials Research Ctr., Texas A&M Univ., College Station, TX, Rept. No. MM-3043-77-2, FHWA/RD-78/72, 254 pp (June 1977)
PB-291 257/4GA

Key Words: Interaction: tire-pavement, Finite element technique, Mathematical models

This report presents the theory and results developed during an analytical and experimental investigation of tire-pavement interaction. An analytical tire model, developed from a finite element computer program, is utilized in a new approach to tire-pavement contact analysis. An analytical model for the deformation and adhesion components of rubber friction is also described. The fast Fourier transform is utilized in calculation of the tire-pavement friction coefficient (as a function of idealized pavement surface characteristics) and in the calculation of the contact pressure distribution produced by the analytical tire model.

ROTORS

(Also see No. 1337)

79-1475

A Theoretical Technique for Analyzing Aeroelastic Stability of Bearingless Rotors

D.H. Hodges
U.S. Army R&T Labs. (AVRADCOM), Ames Res. Ctr., Moffett Field, CA, AIAA J., 17 (4), pp 400-407 (Apr 1979) 17 figs, 20 refs

Key Words: Rotors (machine elements), Stability, Helicopter rotors

A technique is introduced for aeroelastic stability analysis of certain hingeless helicopter rotors termed bearingless because of their lack of a pitch-change bearing. The rotor is modeled as three or more rigid blades each joined to the hub by means of a flexible appendage known as the flexbeam or strap. The pitch-control system twists the flexbeam to provide blade pitch change. The analysis is capable of treating effects of several different pitch-control configurations, geometric nonlinearities associated with the equilibrium deflected shape of the flexbeam, and the built-in angular offsets of the flexbeam and blade. Numerical results are presented for a variety of system parameters. The stability of the system in both hub-fixed motion and coupled rotor-body motion is considered.

79-1476

Shock Structure in Transonic Compressor Rotors

A.H. Epstein, J.L. Kerrebrock, and W.T. Thompkins, Jr.
Massachusetts Inst. of Tech., Cambridge, MA, AIAA J., 17 (4), pp 375-379 (Apr 1979) 9 figs, 4 refs

Key Words: Rotors (machine elements), Compressors, Shock response

Shock behavior consistent with the model has been quantified by gas fluroescence measurements in the MIT blowdown compressor. Three-dimensional transonic flow computations for the same rotor are described.

79-1477

Theoretical Study of the Effect of Tilt Behaviour on the Unbalance Response of a Simple Rotor

A. Mukherjee

Mech. Engrg. Dept., Indian Inst. of Tech., Kharagpur, India, Mech. Mach. Theory, 14 (2), pp 121-134 (1979) 10 figs, 12 refs

Key Words: Rotor-bearing system, Rotors (machine elements), Unbalanced mass response

The response near resonance of a simple elastic rotor as influenced by the inclination of the journal due to vibrations is studied in this paper.

79-1478

Stability and Unbalance Response of Centrally Preloaded Rotors Mounted in Journal and Squeeze Film Bearings

E.J. Hahn

The Univ. of New South Wales, Kensington, N.S.W. Australia, J. Lubric. Tech., Trans. ASME, 101 (2), pp 120-128 (Apr 1979) 15 figs, 14 refs

Key Words: Rotor-bearing systems, Squeeze-film bearings, Unbalanced mass response

The unbalance response and stability of centrally preloaded symmetric rigid rotors are investigated. Steady state solutions for unbalance transmissibilities, orbit eccentricity radii, and stability are presented for rotors running in hydrodynamic journal bearings and in rolling element bearings which are supported in squeeze film bearings. Both pressurized and unpressurized oil supply are considered. The stabilizing effect of superimposed external radial stiffness on pressurized bearings is clearly demonstrated.

79-1479

On Estimation of the Effectiveness of Vibro-Extinguishing Equipments on the Basis of "Negative Centrifugal Mass" (Apie virpesių slopinimo itaisų "Neigiamos išcentrines mases" pagrindų efektyvumo ivertinimą)

A.P. Kavolělis

Lietuvos Mechanikos Rinkinys, No. 1 (17), pp 5-13 (1977) 7 figs, 3 refs, Vilnius Civil Engrg. Inst., 232600 Vilnius, Gorkio 73, Lithuania

(In Russian)

Key Words: Vibration reduction, Rotors (machine elements)

The effectiveness of several original devices for the reduction of flexural and torsional vibrations of rotating systems is considered. Several specific characteristics of the devices are compared to those of the known devices.

79-1480

Parameter and Combination Resonances of Rotor Systems with Asymmetric Elements (Parameter- und Kombinationsresonanzen bei Rotorsystemen mit Unsymmetrien)

A.A. Muller and P.C. Muller

Wilhelmstr. 43, D-7250 Leonberg-Eltingen, Federal Republic of Germany, Ing. Arch., 48 (1), pp 65-72 (1979) 3 figs, 12 refs

(In German)

Key Words: Rotors (machine elements), Parametric resonance

The theory of parameter and combination resonances is applied to rotor systems having asymmetric elements. The number of resonances can be essentially reduced representing the rotor system by inertial as well as by rotating coordinates.

SHIP

(Also see No. 1436)

79-1481

An Investigation into the Linear Theory of Ship Response to Waves

R.E.D. Bishop and W.G. Price

Dept. of Mech. Engrg., University College, London, London WC1E 7JE, UK, J. Sound Vib., 62 (3), pp 353-363 (Feb 8, 1979) 10 refs

Key Words: Ships, Water waves, Periodic excitation

The response of an elastic ship to waves is examined in general terms by using the theory of linear non-conservative systems which suffer sinusoidal excitation. This is made possible by the conventional use of constant hydrodynamic coefficients. A more general approach is formulated which does not depend on such coefficients and is not restricted to use in sinusoidal motions. Ship responses are expressed in modal forms in which the nature of resonance is made self-evident.

79-1482

Dynamic Analysis of Fixed Offshore Structures: A Review of Some Basic Aspects of the Problem

J.H. Vugts and D.J. Hayes

Shell Internationale Petroleum Maatschappij B.V., Carel van Bylandtlaan 30, The Hague, The Netherlands, Engrg. Struc., 1 (3), pp 114-120 (Apr 1979) 8 refs

Key Words: Off-shore structures, Mathematical models, Damping, Time domain method, Frequency domain method, Modal superposition method

In this paper the following general aspects of the problem are discussed: time domain vs frequency domain description; modal superposition vs direct integration in physical coordinates (usually in conjunction with a finite element description); and damping.

79-1483

Earthquake Response of Offshore Platforms

R.G. Bea, J.M.E. Audibert, and M.R. Akky

Ocean Engrg. Group, Woodward-Clyde Consultants, Houston, TX, ASCE J. Struc. Div., 105 (ST2), pp 377-400 (Feb 1979) 13 figs, 1 table, 83 refs

Key Words: Earthquake resistant structures, Off-shore structures

The platforms discussed are steel, tubular-membered, truss-framed structures supported by tubular piles and conductors. Elastic and inelastic response, and platform system element characteristics are considered.

79-1484

Earthquake and Wave Design Criteria for Offshore Platforms

R.G. Bea

Ocean Engrg. Group, Woodward-Clyde Consultants, Houston, TX, ASCE J. Struc. Div., 105 (ST2), pp 401-419 (Feb 1979) 12 figs, 4 tables, 45 refs

Key Words: Earthquake resistant structures, Off-shore structures

A method that applies experience, projections of environmental conditions, response analyses, and reliability logic is used to develop earthquake and wave design criteria for one class of offshore platform system. The system consists of a steel, tubular-membered, template-type superstructure supported on piles and firm soils, in 300 ft of water. Three fictitious sites are considered: Eastern Gulf of Alaska, Southern California, and the Santa Barbara Channel. Ranges of design wave heights and ground motion velocities are given. Results are compared with those appropriate for a conventional building structure and with those from API RP 2A guidelines for fixed offshore platforms. Good agreement with API guidelines is indicated.

SPACECRAFT

79-1485

Effects of Vertical Tail Flexibility on the Aerodynamic Characteristics of a 0.03-Scale NASA Space Shuttle Orbiter at Mach Numbers from 0.90 to 1.55

J.A. Black

Arnold Engrg. Development Ctr., Arnold Afs, TN, Rept. No. AEDC-TSR-78-P29, 29 pp (Aug 29, 1978) AD-A062 377/7GA

Key Words: Space shuttles, Wind tunnel tests, Aerodynamic loads

A 0.03-scale model of the NASA Space Shuttle Orbiter utilizing a flexible and a rigid vertical tail is tested in the Propulsion Wind Tunnel, Transonic (16T) at free-stream Mach numbers from 0.90 to 1.55, free-stream dynamic pressures from 300 to 700 psf, angles of attack from -2 to 12 deg and angles of sideslip from -5 to 9 deg for speedbrake deflections of 25 to 55 deg, and rudder deflections of 0 and 10 deg. The objective of the test is to determine the effects of vertical tail flexibility on the static stability and control characteristics of the Orbiter vehicle.

79-1486

Dynamic Stability Parameters

AGARD, Neuilly-Sur-Seine, France, Rept. No. AGARD-CP-235; ISBN-92-0223-X, 623 pp (Nov 1978)
N79-15061

Key Words: Spacecraft, Dynamic stability, Wind tunnel tests, Flight tests, Testing techniques, Simulation, Proceedings

This symposium was organized in recognition of the strong present-day interest in dynamic stability of aerospace vehicles. The purpose of the symposium was to discuss the specific needs for dynamic stability information, the form in which it should be presented and the various means of obtaining it. The symposium was divided into the following sessions: wind tunnel techniques 1; wind tunnel techniques 2; flight testing techniques; analytical techniques; motion analysis and nonlinear formulations; sensitivity and simulator studies; and workshop session. For individual titles, see N79-15062 through N79-15097.

79-1487

A Comparison of Maximax Response Estimates

N. Popplewell and N.A.N. Youssef
Dept. of Mech. Engrg., Univ. of Manitoba, Winnipeg, Canada, J. Sound Vib., 62 (3), pp 339-352 (Feb 8, 1979) 9 figs, 19 refs

Key Words: Structural response, Shock excitation, Seismic excitation, Maximum response

Formulae for estimating the maximax response of linear, stable structures to incompletely described loads are reviewed. The accuracies of these formulae are evaluated for fairly comprehensive but ideal circumstances where the loads and, hence, the exact solutions are fully known.

AUTHOR INDEX

CALENDAR

AUGUST 1979

13-15 **Joint Automatic Control Conference,** [ASME] San Francisco, CA ***(ASME Hq.)***

28-31 **International Tire Noise Conference,** [National Swedish Board for Technical Development, STU] Stockholm, Sweden ***(International Tire Noise Conference, c/o Stockholm Convention Bureau, Strandvägen 7c, S-114 56 Stockholm, Sweden)***

SEPTEMBER 1979

21st Polish Solid Mechanics Conference [Polish Academy of Sciences, Institute of Fundamental Technological Research] Poland ***(Dr. Marek Elzanowski, Institute of Fundamental Technological Research, Świętokrzyska 21, 00-049, Warsaw, Poland)***

3-5 **Numerical Analysis of the Dynamics of Ship Structures,** Avignon, France ***(Dr. J.L. Armand, Institut de Recherches de la Construction Navale, 75008 Paris, France)***

9-14 **Petroleum Mechanical Engineering Conference** [ASME] Hyatt Regency, New Orleans, LA ***(ASME Hq.)***

10-12 **ASME Vibrations Conference,** [ASME] St. Louis, MO ***(ASME Hq.)***

10-13 **Off-Highway Meeting and Exposition** [SAE] MECCA, Milwaukee, WI ***(SAE Meeting Dept., 400 Commonwealth Dr., Warrendale, PA 15096)***

11-14 **INTER-NOISE 79,** [INCE] Warsaw, Poland ***(INTER-NOISE 79, IPPT PAN, ul. Świętokrzyska 21, 00-049 Warsaw, Poland)***

OCTOBER 1979

7-11 **Fall Meeting and Workshops,** [SESA] Mason, OH ***(SESA, 21 Bridge Square, P.O. Box 277, Saugatuck Sta., Westport, CT 06880 - Tel (203) 227-0829)***

16-18 **50th Shock and Vibration Symposium,** Colorado Springs, CO ***(H.C. Pusey, Director, The Shock and Vibration Information Center, Code 8404, Naval Research Lab., Washington, D.C. 20375 - Tel (202) 767-3306)***

16-18 **Joint Lubrication Conference,** [ASLE-ASME] Dayton, OH ***(ASME Hq.)***

17-19 **Stapp Car Crash Conference** [SAE] Hotel del Coronado, San Diego, CA ***(SAE Meeting Dept.)***

NOVEMBER 1979

4-6 **Diesel and Gas Engine Power Technical Conference,** San Antonio, TX ***(ASME Hq.)***

5-8 **Truck Meeting,** [SAE] Marriott, Ft. Wayne, IN ***(SAE Meeting Dept.)***

26-30 **Acoustical Society of America, Fall Meeting,** [ASA] Salt Lake City, UT ***(ASA Hq.)***

DECEMBER 1979

Aerospace Meeting [SAE] Los Angeles, CA ***(SAE Meeting Dept.)***

2-7 **Winter Annual Meeting** [ASME] Statler Hilton, New York, NY ***(ASME Hq.)***

FEBRUARY 1980

25-29 **Congress & Exposition** [SAE] Cobo Hall, Detroit, MI ***(SAE Meeting Dept.)***

MARCH 1980

9-13 **25th Annual International Gas Turbine Conference and Exhibit** [ASME] New Orleans, LA ***(ASME Hq.)***

APRIL 1980

21-25 **Acoustical Society of America, Spring Meeting** [ASA] Atlanta, GA ***(ASA Hq.)***

MAY 1980

25-30 **Fourth SESA International Congress on Experimental Mechanics,** [SESA] The Copley Plaza, Boston, MA ***(SESA Hq.)***

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

AHS: American Helicopter Society
30 E. 42nd St.
New York, NY 10017

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 45th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms, U.S. Council for TMM, c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers, 74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 8404
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - US National Committee c/o MIT Lincoln Lab., Lexington, MA 02173