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ACOUSTIC VIBRATION OF STRUCTURES IN LIQUIDS

D. Firth *

Abstract - This article outlines the physics of the vibration of an elastic structure excited by sound waves in a liquid in contact with the structure. The historical background is summarized, and some recent literature is described. Examples include plates, ducts, and complicated engineering systems. Possible future developments are suggested.

The dynamic response of a vibrating elastic structure in contact with a fluid is changed by the fluid loading and radiation damping. Various excitation phenomena are possible. A structure will vibrate in response to boundary layer turbulence in the moving fluid or as a result of flow-dependent fluid-elastic instabilities. Another possible source of excitation is a sound field in the fluid, for example, sound due to circulating pumps in heating and ventilating systems or in nuclear reactors.

The sound field is modified by the structure, and the elastic motion of the structure is modified by the fluid. The problem has characteristics of both acoustics and elasticity. An important parameter in determining the strength of the interaction is the specific acoustic impedance of the fluid and the structural material properties. Specific acoustic impedance is defined as the product of the density and the longitudinal wave speed (speed of sound). The value for air is 4×10^2 $Kg\text{-}m^{-2}\text{-}S^{-1}$, for water 2×10^6 $Kg\text{-}m^{-2}\text{-}S^{-1}$, and for stainless steel 4×10^7 $Kg\text{-}m^{-2}\text{-}S^{-1}$. The acoustic-structure interaction is stronger as the ratio of the impedances approaches unity. If the fluid is a gas, the acoustic-structure interaction is weak in most situations, and the determination of the acoustic pressures and structural response can be solved independently. If the fluid is a liquid, the acoustic-structure interaction is strong, and the system must be solved simultaneously.

This review describes liquid-loaded systems. Either the source of excitation is an acoustic wave in the fluid or the acoustic behavior of the fluid is an important part of the problem.

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HISTORICAL BACKGROUND

The acoustic pressure field at the surface of a flexible structure can be separated into three components: the incident field (Pi) in the absence of any structure; the rigid-scattered field (Ps) due to the presence of the structural surface, assumed rigid; and the radiated field (Pr) due to the motion of the structural surface that occurs during vibration (excluding incident and rigid-scattered fields). The sum Pi + Ps is sometimes called the blocked pressure field (Pb). It satisfies the condition of zero particle velocity normal to the rigid surface.

The equation of forced motion of a structure can be written

$$L(u) = Pi + Ps + Pr$$

L, a linear operator on the normal displacement u, corresponds to the appropriate differential equation for the structural motion. Away from the structure, the pressure fields must satisfy the wave equation.

In most cases, a further requirement is that no cavitation takes place at the interface; the fluid and the structure remain in contact. Hence the normal derivative of (Pi + Ps + Pr) equals the negative of the product of the fluid density (φ), and the normal acceleration of the structure:

$$\frac{\partial}{\partial n}(Pi + Ps + Pr) = -\varphi \frac{\partial^2 u}{\partial t^2}$$

An early simplification of the problem was to approximate the elastic structure by a simple harmonic oscillator. This approach was used by Rayleigh [1], who considered a spring-loaded piston in a baffle. He was able to show that the presence of the fluid decreased the resonant frequency of the piston and increased the damping. Stokes [2] provided the explanation for the increase in damping and argued in detail that the frequency of oscillation is important in determining whether or not the fluid can be treated as incompressible.

Lamb [3] used the incompressible approximation to study the vibration of an elastic plate in contact with water. He used the Rayleigh-Ritz method to determine the frequencies and decay times for the two lowest modes of a circular plate rigidly fixed in an infinite baffle, and showed that these frequencies were lower than those for corresponding vibrations in a vacuum. Lax [4] extended this work to include all purely radial modes; he assumed a compressible fluid and found three effects:

- the plate pushes the fluid and so appears to have added inertia; this lowers the resonant frequency
- the plate radiates energy into the fluid, so that the amplitude of a freely vibrating plate decays
- the fluid provides a coupling medium: motion in one mode causes forces that act on another mode; as a result, energy is transferred from one mode to another. This transfer causes the mode shapes of a freely vibrating plate in contact with a fluid to differ from the corresponding modes in a vacuum.

These authors considered the case of a mechanically vibrating system radiating waves into an acoustic medium. The case of acoustic waves exciting a mechanical system has been studied theoretically [5] and experimentally [6]. The forced motion caused by a sound field impinging on submerged plates could give rise to the propagation of free waves in the plate, either through reflections at its boundaries or imperfections in it.

The relationship between frequency and wavelength for free waves in an infinite plate in contact with an incompressible fluid has been published [7], as has a similar relationship for a flat strip of finite width submerged in a compressible fluid [8].

Infinite homogeneous structures can vibrate only in waves equal to the incident field components. If a structure is not homogeneous -- e.g., has holes or stiffeners -- or if it is bounded, the acoustically-induced structural waves cannot be the same as the blocked field because the waves are also required to equal structural boundary conditions. The total structural wave field can be separated into two components:

- the forced wave equal to the excitation field
- the free waves scattered from the boundaries or discontinuities. These waves travel at the free, fluid-loaded wave speed, not at the forced surface wave speed.

An element of structural surface of area δs, which has a normal particle velocity u generally does not radiate sound in the same way that a simple isolated source of strength $u\delta s$ radiates sound because of the surface. However, a reciprocal relationship does exist between the acoustic pressure produced by a volume element with velocity $u\delta s$ at some point in the radiation field of a vibrating body and the pressure produced by a simple source at some point on the rigid body at the location of the element. Smith [9] has derived a relationship between the acoustic power radiated by a structure vibrating in a single resonant mode and the response of that mode to sound waves incident from remote sources. To use this approach for liquid-loaded structures, some estimate of mode shapes and frequencies is necessary.

A good summary [10] and a mathematically-oriented text [11] have been published about the development of analytical, numerical, and statistical methods for tackling the problems of acoustic liquid-loaded structural vibrations.

RECENT DEVELOPMENTS

The problem of a monopole source in a liquid in the vicinity of a flat plate has been analyzed by Krasil'nikov [12], who showed the presence of two fields: one remains close to the plate (associated with the free wave in the plate) and one radiates over all space. King [13] used the reciprocity relation to derive the far-field acoustic radiation and did not consider the complicated plate near-field. His exposition is imprecise, as pointed out by Fahy [14], and King's further remarks [15] do not entirely clarify the derivation. However, the results, which show that the propagation of real acoustic energy in the presence of a plate is dependent on the relative stiffness of the plate (hence, different radiation patterns can be obtained in air and water) seem valid.

At higher frequencies, as the wavelengths decrease, the plate can no longer be thought of as a two-dimensional surface; three-dimensional elasticity theory must therefore be used. An attempt has been made [16] to relate reflection and transmission coefficients of a material to certain physical constants of the material (including absorption). Some of these constants can be determined independently; others -- absorptions and shear wave speed -- must be adjusted to give the best fit with the experimental results.

Free waves introduced by boundaries in a liquid-loaded strip have been investigated [17]. The wavelength-frequency relationship, including rigidity and tension effects, was derived. For wavelengths less than about twice the width of the strip, the finite width can be ignored. When the exciting acoustic wave frequency is equal to a resonant frequency for the liquid-loaded strip (that is, the 'free' wave shape equals a normal mode) the free to forced wave ratio increases significantly.

Radiation from freely supported beams has been investigated and mode shapes in air and water compared by Blake [18]. He concluded that the only effect of liquid loading was due to added mass (thus reducing the resonant frequencies) and that mode shapes and radiation efficiencies were not affected (unlike Lax's circular plate [4]). An interesting paper by Yeh [19] contains some speculation on how liquid loading reduces the vibration frequencies from their air values.

The analysis of wave propagation in cylindrical geometries is mathematically complex. Berakha [20] considered axisymmetric waves in an isotropic medium containing a liquid-filled duct. He used three-dimensional elasticity theory to derive the dispersion relationship and compared the results with the hollow cylinder case. At low frequencies, only one wave can propagate; the speed is slightly higher than that for the vacuum duct. At higher frequencies, an extra wave, equivalent to the Rayleigh wave on a surface bounding a liquid half space, is possible. Berakha also derived the normal mode frequencies.

A similar problem, involving a point source excitation in a fluid column surrounded by either a fluid or an elastic solid of infinite extent, has been considered [21]. Conditions for normal mode propagation were defined, phase and group velocity dispersion curves were presented, and decay rates for these modes were considered. Arbitrary excitation of the source excites a number of normal waves and generates considerable modal interference; the problem is thus a complex one.

The flow of acoustic fluid in a cylindrical pipe involves complex equations for the fluid rather than for the structural motion. Chen and Rosenberg [22] considered velocities much lower than the critical flow velocity (where shell motion becomes unstable). Plots of frequency versus wave-number were compared for an empty shell, a fluid-filled shell, and a fluid-conveying shell. The results for the last case depended upon whether the wave propagates upstream or downstream. At the low-frequency limit the water hammer wave velocity was derived for axisymmetric waves. The results were extended to orthotropic pipes by Bert and Chen [23], who demonstrated the adequacy of a Donnell-type shell theory. The qualitative results for pipes made of either orthotropic or isotropic materials are similar, but considerable quantitative differences exist.

Finite element techniques can be used to analyze the acoustic-structure interaction problem. The finite element formulation can be restricted to a description of the structure, the acoustic medium can be represented by an impedance matrix. A numerical technique using a finite element computer program to model the structure and an acoustic radiation computer program to calculate acoustic impedance matrices at the structure surface has been published [24]. Results are within 10% of experimental measurements of resonant frequencies of piezoelectric transducers. Extension of this method to more complex structures is limited only by computer costs.

The finite element method can be used to model the acoustic medium to a surface on which the acoustic wave equation can be separated. Such a model has been employed to determine the scattering of normally incident acoustic waves from an elastic disc [25]. The differences between a perfectly hard body, a rigid body, and an elastic model of the disc were demonstrated. An incident wave could excite resonances of the fluid-loaded disc at several frequencies. Only the model that includes the elastic properties of the structure is adequate for the prediction of scattered pressures at these frequencies.

Real structures, even simple cylindrical shells, are not perfect, and imperfections can affect the interaction problem. Krajcinovic [26] has discussed the influence of out-of-roundness and eccentricity on the magnitude of the added mass for a rod vibrating in an acoustic fluid in a rigid cavity. The effects are significant for narrow cavities; the formulas given can easily be included in engineering analyses. Departures from perfect circular symmetry of a cylindrical shell have been shown [27] to account for the discrepancies between measured structural response and simple calculated response to acoustic excitation.

Nuclear reactor systems contain pumps that circulate large amounts of coolant fluid through the core and heat exchangers. Coolant fluids provide a source of energy for structural vibrations, either flow-induced [28], or acoustically induced [29]. Samarin and Nozdrin [30] have reported measurements taken on a water-moderated water-cooled reactor. They distinguished between local (flow-induced) pressure fluctuation and long range (acoustic) oscillations. The pressure fluctuation was less than 1.5 percent of the static pressure. The most dangerous combination was the coincidence of the natural frequencies of the liquid-loaded structural elements and the acoustic frequencies of the loop. A program to study the phenomena has been published [31].

Similar effects will be expected in fast breeder reactors, which use liquid sodium as a coolant fluid. One way to avoid the difficulties in making measurements in sodium is to build a model using water instead of sodium. The problem than becomes one of attempting to ensure that all the resonant frequencies scale by the same factor. Worraker and Whitton [32] have proposed that this is best done using brass to model the stainless steel; brass gives better agreement of the liquid to structure specific acoustic impedance ratio for the reactor and the model. An alternative strategy is proposed by Bentley et al [33] to show that some of the structural frequencies can be scaled equally well by reducing the wall thickness of the shells.

FUTURE DEVELOPMENTS

The basic physics of acoustic liquid structure interaction now seems to be fairly well understood. Future developments will likely have to do with the details of the phenomena, for example boundaries, imperfections. Statistical energy analysis, successful in analyzing gas-structure interactions will probably be extended to analyze strongly interacting liquid-structure systems. Because more complex structures will be analyzed, the finite element approach is likely to be developed further.

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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 fluid-structure interaction and beam vibration. Dr. Krajcinovic discusses some structural transient interaction problems involving either a constant wetted surface or an expanding or receding wetted surface.

Dr. Wagner and Professor Ramamurti discuss beam vibrations as they apply to modeling structures.

SOME TRANSIENT PROBLEMS OF STRUCTURES INTERACTING WITH FLUID

Dusan Krajcinovic*

Abstract - This paper is a general review of transient interaction problems involving either a constant wetted surface or an expanding or receding wetted surface.

Interest in problems of fluid-solid interaction is not new. In fact, the first systematic study was probably in 1850. After the publication of Rayleigh's treatise Theory of Sound in 1896, the dynamics of structures in a vacuum and conventional acoustics developed as independent disciplines. In recent years, new technologies and energy sources, developments in transportation, and the arms race have resulted in an avalanche of publications on problems of structure-fluid interactions.

Interaction problems can be classified in two large groups as steady-state or transient.

The steady-state problems of rods, plates, and shells in contact with or submerged in fluid have been studied extensively and are not discussed in this review. Transient problems are more complex and of more practical interest. It is convenient to separate transient interaction problems into the following: problems with constant wetted surface and those with an expanding or a receding wetted surface. Such problems could also be grouped according to the response of the structure or the fluid model; an example is the paper by Grigoliuk [7].

TRANSIENT INTERACTION PROBLEMS WITH CONSTANT WETTED SURFACE

The interaction between a submerged, infinitely long, thin elastic circular cylindrical shell and an axisymmetric pressure wave traveling at constant speed in the direction of the longitudinal axis x of the cylinder (Fig. 1) has been studied. It was assumed that no separation (cavitation) occurs anywhere on the surface of the shell.

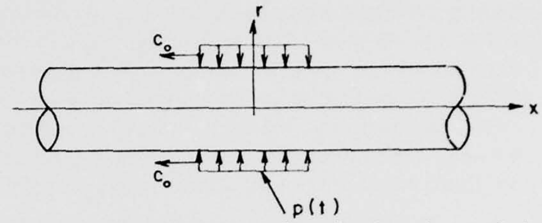

Figure 1. Thin Cylindrical Shell Subjected to an Axisymmetric Pulse Traveling in the Direction of Longitudinal Axis

The partial differential equations governing the deformation of the shell can be written in the form

$$L_{11}u + L_{13}w = -m_o \frac{\partial^2 u}{\partial t^2}$$

$$L_{31}u + L_{33}w = -m_o \frac{\partial^2 w}{\partial t^2} - \rho_f \frac{\partial \phi}{\partial t}\bigg|_{r=R} + p_o(ct-x) \tag{1}$$

L_{ij} are differential operators, $u(x, t)$ and $w(x, t)$ represent axial and radial components of the displacement of a mid-surface point of the shell; m_o and R are the surface mass density and the radius of the shell; ρ_f is the density of the fluid; c is the speed of propagation of sound in the fluid; and p_o = const represents the intensity of the pressure. The fluid velocity potential $\phi(r, x, t)$ satisfies the wave equation

$$c^2 \nabla^2 \phi = \frac{\partial^2 \phi}{\partial t^2} \tag{2}$$

The three partial differential equations shown in equations (1) and (2), together with boundary and initial conditions, define the boundary value problem. These two sets of equations are coupled by the impermeability condition

$$@\ r = R \qquad \frac{\partial \phi}{\partial r} = -\frac{\partial w}{\partial t} \tag{3}$$

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which states that the velocities of the fluid and the shell particle with which the fluid is in contact are identical.

The partial differential equations are usually reduced to differential equations by two successive integral transforms -- a Fourier with respect to x and a Laplace transform with respect to t -- to an ordinary differential equation. The main problem lies in the inversion of the Laplace transform. For a simple Dirac-delta pressure, in which a pressure ring travels along the shell, the inversion process is straightforward. The solution for radial displacement is in the form of an infinite sum of infinite integrals [17]

$$w(x,t) = \sum_{j=1}^{\infty} \int_{o}^{\infty} f_w(\Omega_j, \omega, c) \sin\Omega_j t \begin{matrix} \sin \omega x \\ \cos\omega x \end{matrix} d\omega \qquad (4)$$

where Ω_j are the frequencies of natural vibrations; i.e., simple poles used for the inversion of the Laplace transform. The integrand in equation (4) is complicated and oscillatory, so that numerical evaluation is difficult.

The process is even more complex for an arbitrary loading function $p(t)$ involving a double integral with an oscillatory integrand. The analysis can be greatly simplified without significant loss of accuracy, however, by neglecting both the inertial force $m_o \ddot{u}$ in the direction of x-axis and the compressibility of the fluid [17]. The second assumption is not always justified, especially at long wavelengths and in cases of symmetry with respect to $x = 0$. Two other approximate models have been proposed [5, 13].

Another transient problem is the interaction of a cylindrical shell with a pressure wave having a front parallel to the generatrix of the cylinder [2, 16]. Mindlin and Bleich [16] assumed plane fluid flow and ignored the axial component of fluid velocity. Somewhat later Haywood [8] computed the hydrodynamic forces on the basis of cylindrical waves.

Consider the exact formulation of the two-dimensional problem. In the case of an infinite shell and a wave infinite in the x direction (Fig. 2), the governing shell equations are written in terms of two unknown functions, usually the normal hoop force $N(\theta, t)$ and the radial displacement $w(\theta, t)$. The resulting hydrodynamic pressure consists of the known incident pressure field p_i, the pressure field scattered by the rigid cylinder p_{sr}, and the pressure field radiated by the deforming wetted contour of the shell p_{se} [9].

$$p(\vec{r}) = p_i(\vec{r}) + p_{sr}(\vec{r}) + p_{se}(\vec{r})$$

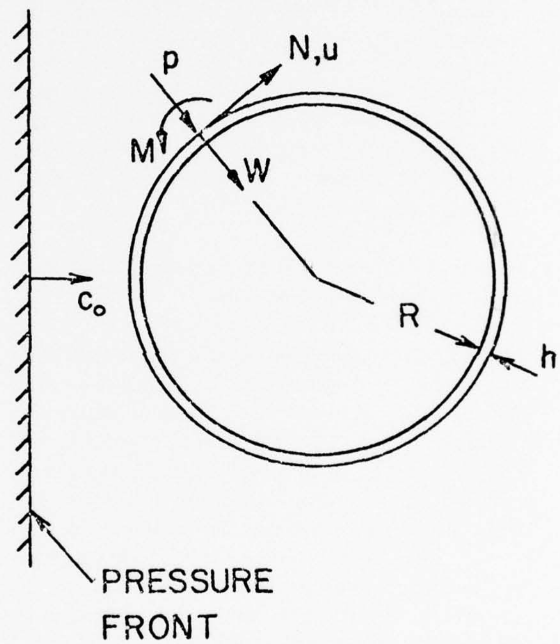

Figure 2. Thin Cylindrical Shell Subjected to a Plane Transverse Pressure Pulse

The determination of the scattered and radiated pressure fields $p_{sr}(\vec{r})$ and $p_{se}(\vec{r})$ is complex, involving integral transforms with respect to time and expansions into infinite trigonometric series with respect to angle θ. The hydrodynamic pressures are obtained as infinite sums of infinite integrals. Because the integrands, which include Bessel and Macdonald functions are difficult to compute [9, 17], and the series converges very slowly, approximate techniques are used. The zero-th and first deformation mode are used to derive approximate formulas for the hydrodynamic forces; the analysis is somewhat less cumbersome but still complex. Of course, an inherent problem with approximate methods is the uncertainty in defining the limits of their applicability.

The same problem has been solved for the case spherical shell [13]. Three-dimensional problems involving cylindrical shells of finite length are tractable only in a variational or purely numerical sense.

A significant simplification is possible if the ultimate load-carrying capacity of a structure is of primary interest. In certain practical problems a submerged structure such as shell or plate is used for containment. The structure maintains the integrity of a submerged structure during an accident, regardless of the level of damage. Stress levels in the structure during an accident would be much greater than the yield stresses of the structure. If the kinetic energy of the incident load exceeds by many times the maximum energy of elastic deformation of the structure and if the load is applied for a much shorter time than the period of the natural vibration of the structure, its structural behavior can be approximated with a rigid-ideally plastic model [25]. Such a model can usually be used when a slender structure is subjected to a blast type of loading (explosion).

A rigid-ideally plastic model and an incompressible fluid have been used to derive a closed-form solution for a blast-loaded simply-supported circular plate in contact with a fluid [10]. If the initial surface of the fluid is assumed to have a surface of zero potential (i.e., neglecting the energy of surface waves), the axisymmetric problem of a circular plate can be written as

$$\frac{\partial}{\partial r}(rM_r) - M_\theta = -\int_0^r \left(p_o - \rho_f \frac{\partial \phi_o}{\partial t} - m_o \frac{\partial^2 w}{\partial t^2}\right) r\,dr \qquad (5)$$

M_r and M_θ are the radial and circumferential bending moment in the plate, $p_o(t)$ is the external (incident) loading; m_o, the surface density of the plate; $w(r, t)$, the normal displacement of a point on the middle surface of the plate; ρ_f = const, the density of the fluid; and $\phi_o(r, t) = \phi\,|_{z=0}$, the fluid velocity potential at the fluid-plate interface. The motion of the potential fluid is governed by the Laplace equation

$$\nabla^2 \phi = 0 \qquad (6)$$

The boundary conditions at the surface $z = 0$ are

$$\phi = 0 \quad \text{for} \quad r \geqslant a,\ z = 0$$

$$\frac{\partial \phi}{\partial z} = -\frac{\partial w}{\partial t} \quad \text{for} \quad r \leqslant a,\ z = 0 \qquad (7)$$

where a is the radius of the plate. The fluid velocity potential and its derivatives become zero at infinity. Initial conditions are also taken to be zero.

The mixed boundary value problem defined by the Laplace equation (6) and the boundary conditions (7) is conveniently handled with such integral transforms as Hankel's transform. The transformed equation (6) is solved, and the boundary conditions (7) can be written after some manipulations in form of Titchmarsh-Busbridge dual integral equation allowing a closed-form solution [23].

The effective mass of the system, which consists of the actual mass of the plate m_o and the added mass m_a, is derived in the form

$$m_o + m_a = m_o \left(1 + 0.489\,\frac{a\rho_f}{h\rho_o}\right) \qquad (8)$$

where h is the plate thickness and ρ_o the plate density ($m_o = h\rho_o$). The added inertia depends on both the density ratio (ρ_f/ρ_o) and the radius to thickness ratio (a/h) of the plate. Thus, even if the ratio ρ_f/ρ_o is less than 1 (0.13 for a steel plate on the water), the $(a\rho_f/h\rho_o)$ ratio can easily be as large as unity and even larger. In other words, the presence of a fluid such as water significantly decreases the final, plastic deformation of the plate.

The dynamic plastic response of an infinitely long thin cylindrical shell immersed in an infinitely extended potential fluid and subjected to an internal axisymmetric pressure pulse of arbitrary shape and duration has been considered [11, 24]. The Neumann problem for the Laplace equation for the exterior of a circular cylinder is in the form of an infinite integral, which is subsequently integrated using asymptotic expansions near $t = 0$ and $t \to \infty$ and Fillon's quadrature in the rest of the range. The correlation technique has been used to reduce an arbitrary pulse to a step pulse of intensity P_e and duration t_e; the pulse is uniformly distributed over a portion of shell of length $2L_e$ [29]. A plot of the maximum plastic deformation of the shell U_o (after the deformation is terminated, $t \geq t_f$) and the effective pressure intensity to static yield pressure P_o ratio is shown in Figure 3. Although the density ratio $\gamma_f/\gamma = 0.1$ is modest, the final plastic deformation is decreased by a factor ot three.

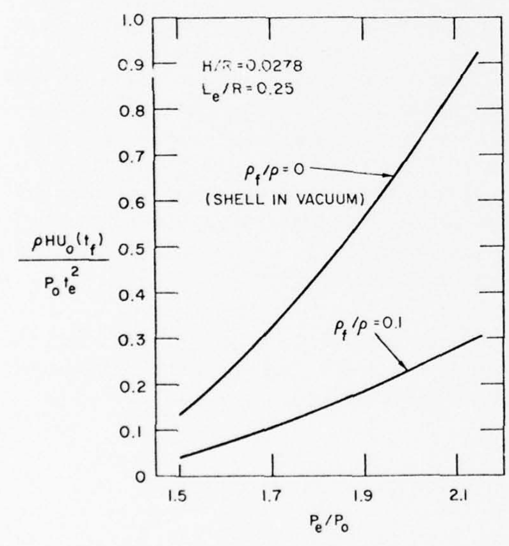

Figure 3. Maximum Plastic Deformation as a Function of Pulse Intensity and Density Ratio

TRANSIENT INTERACTION PROBLEMS WITH VARIABLE WETTED SURFACE

Interest in the second class of transient problems -- so-called hydrodynamic impact problems that arise when structures fall onto the water -- was initially motivated by landing of seaplanes and ship slamming; more recently the retrieval of spaceships has been studied. Problems encountered in the design of offshore drilling platforms and containment suppression systems at nuclear power plants also belong to this class.

The exact formulation of a hydrodynamic impact problem involves a structure responding in an elastoplastic mode with possible influence of strain rates on the magnitude of yield stress and a viscous and compressible fluid.

Turbulence and cavitation (especially with blunt bodies or in late stages of penetration) complicate the problem. The mathematical model, even if turbulence and cavitation are ignored, consists of two systems of partial differential equations (governing the motion and deformation of the structure and flow of the fluid) that are coupled by a condition on a moving boundary (expanding wetted surface); the model is very complex, and no analytical solution is yet available.

Early papers on this topic, predate present-day computers and were concerned with the impact and subsequent penetration of a rigid body through the incompressible fluid [20, 27, 28]. Most of the solutions involved the two-dimensional problem of a wedge. The first solution [27] is based on the principle of momentum conservation

$$m_o V_o = (m_a + m_o) V \tag{9}$$

where m_o is the total mass of the rigid body; V_o and V, its velocity at the incipient impact and at an arbitrary time thereafter; and $m_a(t)$, the added (apparent, virtual) mass, reflecting the resistance of the fluid particles being displaced by the penetrating fluid. Fluid resistance depends of course on the dimensions and shape of the wetted contour; this contour changes until penetration is complete.

Equation (9) can be rewritten in the form

$$\frac{d}{dt}(m_o + m_a)\, V = 0 \tag{9a}$$

and the equation of motion is

$$(m_o + m_a)\frac{dV}{dt} + \frac{dm_a}{dt}\, V = 0 \tag{10}$$

Equation (10) can be expanded to include the effects of buoyancy, weight, and lift forces [1].

$$m_o\ddot{z} - F_u - F_b - W + L = 0 \tag{11}$$

The dots denote time derivatives,

$\dot{z}$ = V is the penetration velocity

$F_u = m_a\ddot{z} + \dot{m}_a\dot{z}$ is the unsteady force resulting from the time rate of change of the momentum of fluid

F_b = Buoyancy force

$W = m_o g$ is the weight of the wedge

L = lift force

The solution of equation (11) requires determination of the added mass $m_a(t)$, a classical problem of fluid mechanics.

If the energy of surface waves is neglected, the determination of added mass can be reduced [20] to the solution of the potential flow about an obstacle bounded by the wetted surface and its reflection in plane of zero velocity potential (Fig. 4). The resulting Neumann problem can be recast into a Dirichlet problem by means of a complex velocity potential.

This exact formulation is easily applied in case of simple body shapes such as wedges. The solution involves conformal mapping in two-dimensional problems and construction of fundamental potential functions on the multi-sheeted Riemann space [21] for three-dimensional cases. If the effect of piled up water is accounted for, the line of zero potential is defined either as the initial water surface [27] or, more appropriately, as the maximum level of the piled up free surface of the water [28]; see figure 5. In case of a wedge, the difference in assumptions is reflected by a factor of $\pi/2$. The contour of the free-water surface is computed by integrating the upwash velocity over time; the result is an Abel's integral equation that, in many cases, especially when the wetted contour is given in terms of a finite power series, leads to a closed-form solution. Surprisingly, no one recognized that the governing equation was in fact an Abel's integral equation, but various authors [15, 19] approximated the actual contour of the body with an appropriate power series in order to solve the problem.

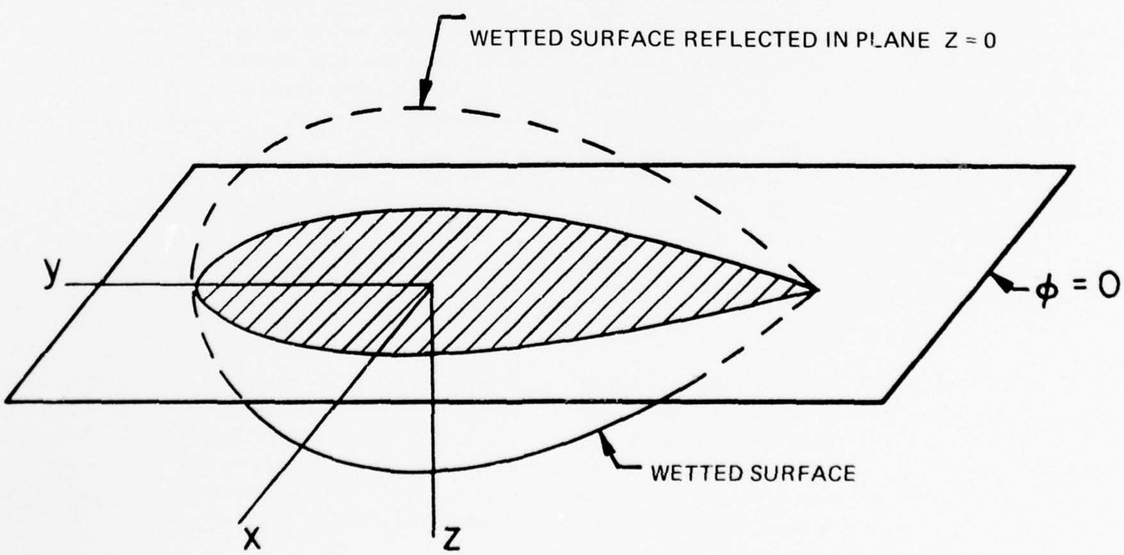

Figure 4. Body Bounded by the Wetted Contour and Its Reflection about the Surface of Zero Potential

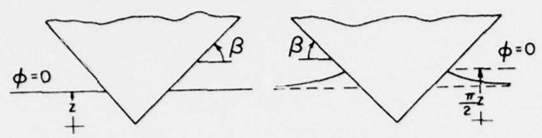

Figure 5. Impact of a Rigid Wedge on the Surface of a Liquid: von Karman's Model (left) and Wagner's Model (right)

The main contradiction of the rigid body model is the fact that the pressure at the initial moment is predicted as infinite while the structure being subjected to this infinite pressure is considered undeformable. The contradiction was resolved somewhat by considering the fluid to be compressible Instead of infinite values the initial pressure at the stagnation point was ρcV, where ρ is the initial density of the fluid; c , the speed of sound in unperturbed fluid; and V , the impact velocity. Compressibility was found to be significant in the case of moderate impact speeds ($V_0 << c$); only in case of blunt bodies during a period immediately following impact (characterized by supersonic speed of flow along the body contour) with duration measured in fractions of milliseconds [22].

The determination of mutual dependence of contact pressure and deformation was approximated with a model consisting of lumped masses interconnected with springs [18]. The problem was solved by assuming that the deformation of the structure is related to the increment in upwash velocity in the same way as penetration is related to the original upwash velocity; i.e., through an Abel's integral equation [19]. The model leads to rather simple solutions which were, unfortunately, not tested against more exact solutions.

The first attempt to solve the two-dimensional hydrodynamic impact problem of an elastic plate in its exact formulation was in 1935 [12]. Complex variables and conformal mapping were used to reduce the problem of determination of the fluid velocity potential to a Fredholm integral equation of the second kind with a complicated kernel. A closed-form solution is obtained only when the plate (i.e., beam) thickness varies according to a sine law. In addition, the solution cannot be considered complete because the author established only the formula for the interaction forces and did not concern himself with the entire process of motion (including separation indicated by the occurrence of negative pressures at the interface).

Other attempts at analytical solution of this problem have been made [14]. It is safe to say, however, that a reliable and complete solution of the problem of this kind is not possible. One of the first attempts at a numerical solution involved the finite difference method for solving the two-dimensional problem of a rigid circular cylinder falling on the surface of an incompressible fluid [3]. Mesh size and time increment proved to be important in the computation. Only results at very early times are given; it is thus possible that the severe distortion of the mesh has a detrimental effect on accuracy during the later stages of penetration. A numerical solution of the hydrodynamic impact on an elastic shell of revolution -- the landing of a re-entry vehicle on the surface of water -- has been presented. The procedure consists of numerical integration of the governing dynamic equations of shell motion. The hydrodynamic pressure is expressed as a double infinite series of integrals. It is of interest that the interaction (i.e., mutual influence of deformation and pressure) does not appreciably change the maximum value of deflection or the stress resultants (i.e., bending moments and normal forces). To the contrary, the pressures at the apex computed for two cases (with and without interaction) have absolutely nothing in common.

CONCLUSIONS

This review has presented some of the most important transient problems of solid-fluid interaction. It is aimed at readers not thoroughly familiar with interaction problems of this type. It makes no pretension of presenting an exhaustive and complete reference list. However, such lists have been published [6, 9, 17], as have review papers [4, 7, 26]. From this review, it is anticipated that the reader will become aware of the magnitude and complexity of solid-fluid interaction problems.

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BEAM VIBRATIONS - A REVIEW

Hans Wagner* and V. Ramamurti*

Abstract - Most structural elements encountered in practice can be treated as beams sacrificing little accuracy. For this reason, this review article summarizes work on the vibration of beams since 1973.

DETERMINISTIC LINEAR VIBRATIONS

Finite element methods have been used to solve flexural vibration problems of beams with various boundary conditions [1]. Attempts have been made to use quintic polynomials to solve vibration problems of tapered beams [2]. The polynomials have been applied to pretwisted blade vibrations [3] and to large amplitude blade vibrations [4]. The optimum first mode frequency of beams of specified volume resting on an elastic foundation has also been computed by the finite element method [5].

Optimization studies have been reported [6, 7], as have upper and lower frequency limits for single and multi-span beams [8]. The general nature of beam vibrations associated with shock problems has been discussed [9 - 11], as have wind- and flow-induced vibrations [12 - 14]. Beams subjected to axial force fields have been studied [15]. Three-dimensional displacements have been expanded in a double power series of transverse coordinates to find one-dimensional equations applicable to low frequency vibrations [16]. Chatter characteristics of beams have been described [17], and overhung beams have been discussed [18]. Effects of steady longitudinal motion of vibration frequencies have been studied [19]. Simple formulas for calculating frequencies of continuous beams with different boundary conditions [20] and for multi-span curved beams [21] have been devised. A rigorous mathematical analysis of continuous linear systems with specific application to the determination of eigenvalues of cantilevers has been derived [22].

The effect of support flexibility on natural frequency has been discussed [23]. Coupled torsional and flexural modes have been studied with transfer matrices [24]. A generalized theory of nonuniform thin-walled beams has been presented [25]. An exact solution has been obtained for small oscillations of a plane constant curvature prismatic bar [26]. Modi and Misra [27] have described the dynamics of three identical flexible cylindrical cantilevers joined symmetrically to a central head. Thermally-induced vibrations of Euler-Bernoulli and Timoshenko beams have been studied [28], as have transverse vibrations of nonuniform beams [29]. Free vibrations of beams with various boundary conditions -- e.g., elastically restrained ends, tip masses -- have been extensively studied [30 - 45], with emphasis on the effect on natural frequencies and mode shapes of varying system parameters.

Timoshenko beams [46 - 56], the effect of shear on natural frequencies [46 - 48], rotary inertia and shear deformation [49 - 53], thermoelastic vibrations of Timoshenko beams [54], elastically-connected Timoshenko beams [55], and mode shapes and frequencies of transversely orthotropic Timoshenko beams have been studied [56].

Orthotropic multilayered beams have been the topic of a paper involving determination of flexural and torsional resonant frequencies [57]; the governing differential equations for flexural vibrations of viscoelastic multilayered beams, as well as natural frequencies and steady-state response [58 - 70] have also been determined using various boundary conditions. The approaches include Fourier analysis of material and kinematic vibrations, Laplace transforms, and the finite element method. Timoshenko beams have also been considered [61, 63]. The influence of the number of layers and the thickness ratio of viscoelastic to elastic layers have been studied [60]. It has been shown [65] that the effect of damping increases monotonically with an increase in the sectional area of coating of a viscoelastic bar. The application of an axial compressive force to a viscoelastic beam also increases damping. The prevention of local shear at free or hinged ends by means of rigid rivets has been analyzed [64].

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STABILITY OF DETERMINISTIC VIBRATION

The stability of various beams has been examined [71 - 79], namely a turborotor by a perturbation technique [71], a cantilever subjected to a follower force at its free end and rotating at uniform angular velocity [72], a free beam [75, 76], and beams on continuous elastic foundations [77]. The cantilever study was extended to include rotary inertia and tip mass [73] and determination of critical flutter load [74]. The dynamic stability of a beam subjected to moving loads has been investigated [78, 79] using a set of approximate equations of motion (Galerkin method). The critical speeds were predicted in terms of system parameters using simple algebraic expressions.

DETERMINISTIC NONLINEAR VIBRATION

More than 20 papers [80] to [102] have dealt with the nonlinear vibration of beams. Pandalai [80] derived the equations of motion of a plate in curvilinear coordinates and showed that the large amplitude flexural vibrations of beams and plates are of the hardening type. The modal equations applicable to plates, rings, beams, and shells using Lagrange's method have been derived [81]; the large amplitude vibrations of rings and shells are of the softening type. Large deflections of beams have been studied using matched asymptotic expansions [82]. Large amplitudes of whirling motion of a simply supported beam constrained to a fixed length have been investigated [83]. Subharmonic response of the order 1/3 was revealed in a study involving transverse vibrations of a beam with ends a fixed distance apart [84]. Subharmonic response of the order of 1/9 has been described [85], and the nonlinear vibrations of beams with geometric properties varying along the length have been analyzed [86]. The perturbation method has been combined with the numerical technique to solve nonlinear dynamic problems of complicated structures [87]. Nonlinear inertia effects have been accounted for [89].

A steady-state solution for beams with nonlinear auxiliary mass dampers has been published [90]. The nonlinear response and stability of a buckled beam has been analyzed using a form function approximation [91]. Nonlinear effects of high temperatures have been discussed [92]. Results obtained with the principle of minimum strain energy were compared with those of finite element and perturbation methods [92]. The behavior of beams with time-dependent boundary conditions has been discussed [93]. Lakin [94] considered a fourth order boundary value problem associated with small vibrations of a uniform flexible rod and obtained the limiting behavior of eigenvalues. Anderson [95] formulated the nonlinear equations of motion of a slender bar rotating at constant angular velocity about a transverse axis and discussed the mathematical connection between two physically distinct nonconservative stability problems [96]. The governing differential equations for the torsional vibration of thin-walled beams of open cross section have been solved [96], and the dynamic behavior of a hinged beam carrying a concentrated mass has been analyzed [98] using harmonic balance to solve the equations. Approximate equations of motion of a three-layer unsymmetrical beam with viscoelastic cores have been developed [99], and the frequency response for clamped ends has been compared to experimental results.

Parametric vibrations of a weightless cantilever beam with concentrated masses have been considered [100]. Lateral bending torsion vibrations of a cantilever under parametric excitation have been analyzed [101]. Because the beam had nonlinear damping, instability regions settled into steady nonlinear limit cycles the amplitudes and frequencies of which can be theoretically predicted. The bending behavior of a beam under a moving load has also been studied [102].

RANDOM LINEAR VIBRATION

Randomly varying forces or material properties were subjects of 11 articles [103 - 113], the first eight of which deal with beams subjected to random excitation. The correlation method was used to compute the deflection and bending moment of a beam subjected to random force with constant mean value and moving at constant speed [103]. The modal approach was used to formulate probability parameters of the displacement field of a two-span beam in terms of loads [104]. An example is a beam excited by white noise; the displacement dispersion formulated as the sum of two series representing the corresponding undamped mode groups.

An organized approach for implementing the techniques of random process theory in recovering structural information from random vibration data has been presented [105]. Linear elastic analysis of pin-ended rods in stationary random homogeneous surface pressure fluctuations has been developed [106]. Fast Fourier transforms make the use of random process theory both feasible and economic for experimental structural analysis. Optimum configurations of vibration reducers have been found for elastic systems with random excitation [107]. Optimal estimation of response to random loads of internally damped beams has been made [108]. The space-averaged response of an infinite, elastically-supported, periodic beam has been studied using an 'approximate assumed mode' method [109]. The damping capacity of three materials subjected to narrow-band strain fluctuations has been investigated [110]; the material effectively underwent sinusoidal strain with randomly varying amplitude.

The random nature of the material properties of beams has been considered [111 - 113]. Yang and Lin [111] explored the effect of random span-length deviations of an otherwise perfect periodic beam on many supports. In another paper [112] they dealt with the random fluctuations of bending stiffness along the beam. The grouping pattern of natural frequencies was used to establish a perfect correlation among certain random natural frequencies; hence their relative positions can never be reversed. Damped lateral vibrations in an axially creeping beam with random material parameters have been investigated [113]. In a specific example of a beam made of aluminium alloy, the bending moment was sensitive to randomness in temperature and density; the circular frequency was almost deterministic.

RANDOM NONLINEAR VIBRATION

The technique of equivalent linearization was used, in conjunction with the finite element method [114], to analyze nonlinear beams subjected to white and non-white excitation. The nonlinear means square multi-mode response of beams subjected to uniform pressure uncorrelated in time was investigated by Seide [115]. Calculations were carried out for beams with both hinged and fixed ends.

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BOOK REVIEWS

"SHOCK AND VIBRATION COMPUTER PROGRAMS"

Review of Summaries

SVM-10

Edited by Walter and Barbara Pilkey

Shock and Vibration Information Center, 1975

Both specialized and general computer programs have been documented, sometimes inadequately (e.g., quirks known to the developer) but often exceptionally well, e.g., NASTRAN, SAP IV, MARC, and ANSYS.

The Pilkeys' is an update and extension of the previously reviewed **Structural Mechanics Computer Programs**. The newer book is limited to shock and vibration computer programs and exposes the user to the shortcomings and excellent compositions of popular and not-so-popular programs. Due to the large number of papers (35) restrictions are placed on the reviews of these papers. The book is divided into two main sections, each of which is considered below.

The section on computer programs is excellent. The stationary structures portion, in shock and vibration, contains information about the following: bond graph theory, transfer functions, torsional systems, crash simulation, frames, dynamics of spacecraft structures, random vibration of structures (extremely short), seismic analysis, and dynamic buckling of structures.

The machinery dynamics section includes information about kinematics and dynamic design of mechchanisms, rotating machinery, and optimum design of dynamic mechanical systems.

The section on noise includes the following: prediction of highway noise and aircraft noise prediction. Solid Mechanics topics include nonlinear transient response of solids and time dependent materials; no mention is made of fracture mechanics. The section on data processing was too short, especially amplitude probability distributions required in fatigue analysis of materials subjected to stochastic inputs. Fluid structure interaction and liquid propellant dynamic analysis are included in flow-induced structural vibration.

In summary, the section on computer programs shortchanges aeroelasticity -- compressor and turbine blade flutter, panel flutter of spacecraft and aerospace vehicles. Fracture mechanics and its relation to fatigue are not included. They have an important role in metal applications to vehicles and machinery.

The section on capabilities and routines within programs is more theoretical than the other and contains much information and references to existing programs. There are chapters on damping, eigenvalue extraction, nonlinear analysis, numerical stability (an excellent discussion), fracture and fragmentation under shock loading, and inertial matrices for finite elements. Instead of an introductory chapter about some of the more general purpose programs, the reviewer would have preferred a chapter describing more extensive modal analysis, methods of condensation, and mass and amplitude normalization.

In summary, the book is well written, considering the number of contributors. The reviewer notes that a number of outdated or passé programs discussed in **Structural Mechanics Computer Programs** were replaced by more up-to-date programs in the new book. The editors are to be congratulated for assembling the information and advising authors about locations and ways to obtain the programs, both of which are given in each chapter.

Herb Saunders
General Electric Company, LSTGD
Schenectady, New York 12345

NONLINEAR VIBRATIONS AND TRANSIENT PROCESSES IN MACHINES
(Nelineinye kolebaniya i perekhodnye protsessy v mashinakh)
Moscow, Izdatelstvo "Nauka" (1972)

Book is the collection of the reports on the topic concerned with the problem mentioned in the title. The reports describe the works of the group of scientists from the Institute of Science of Machines (Institut Mashinovedeniya) of the Soviet Union Academy of Sciences. The part of the report is continuations of the former book Kolebanija i ustoytssyvost pryborov, mashin i elementov system upravlenya, Nauka, Moskva 1968r.

The collection includes 42 reports of 48 authors. Prof. K.W. Frolov is the editor.

The reports are divided in the seven groups. The first (seven reports) concerns problems of analysis of the vibrations of machines by limited excitation, i.e., the source of energy has a limited power. It is a continuation of the ideas of N.O. Kononenko. There are investigated theoretically vibrations of the systems of the variable coefficients, the systems with the two control functions, the statistical dynamic of systems vibrator-machine, theoretic and experimental investigations of the hydraulic pulsator and vibratory transporter.

The second group (two reports) concerns the investigations of the vibrations of machines on the men operators.

The third group (nine reports) concerns the investigations of the transient vibrations of the systems with random stiffness, the transient vibrations by passing the resonance zone, the transient processes in the vibrating systems with the dry friction, the parametric and self-excited vibrations. The vibrations of fluids in the vibrating elements of hydraulic pumps, the problems of fluid flow through the fissures, the vibrations of the pendulum with variable length, and the galloping of the vehicle are investigated.

The fourth group (nine reports) concerns the problem of dynamical processes in the machines. There are problems of dynamic multimass-system, vibro-impact system, vibrations of the systems with hysteresis, stiffness of the ball bearings, dynamic of hydraulic machines, calculation of the frequencies of rotors, dynamic of flexible rotors, and dynamic of vibrators.

The fifth group (five reports) concerns the methods used to analyze vibrations of the complicated mechanical system. The problems of mechanical and mathematical models of hydraulic and pneumatic systems, and models of system with distributed masses are investigated. There are also investigated the analytical methods especially small parameter methods. There are investigated the dynamic effects of the sudden variations of systems parameters values.

The sixth group (five reports) concerns investigations of self-excited vibrations of machines. The problems of synchronization of mechanical vibrations with dry friction and the vibrations in the systems with random variable parameters are investigated.

The seventh group (five reports) concerns the methods of isolation of vibrations of the machines and devices. The investigations of dampers of mechanical and pneumatical vibrations are described. The reports concern the wide domain of the problems of nonlinear vibrations. The high scientific level of these works is connected with the applications in various types of machines.

The rich bibliography is connected. The works are useful for scientific workers in the field of nonlinear mechanical vibrations.

Z. Osinski, Poland
Courtesy of Applied Mechanics Reviews

ADVANCE PROGRAM

48TH SHOCK AND VIBRATION SYMPOSIUM

October 18-20, 1977

Huntsville, Alabama

The U.S. Army Missile Research and Development Command
Redstone Arsenal
will be your host for this Symposium

THE SHOCK AND VIBRATION
INFORMATION CENTER

GENERAL INFORMATION

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For more information on the Symposium contact:

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OPENING SESSION

(Unclassified) 9:00 A.M. Tuesday, October 18
The Playhouse

Chairman: Mr. James Daniel, U.S. Army Missile Research and Development Command, Redstone Arsenal, Alabama

Cochairman: Mr. Henry C. Pusey, Director, Shock and Vibration Information Center, Naval Research Laboratory, Washington, D.C.

Welcome: Major General Charles F. Means, Commander, U.S. Army Missile Research and Development Command, Redstone Arsenal, Alabama

Keynote Address: Dr. John L. McDaniel, Deputy/Technical Director, U.S. Army Missile Research and Development Command, Redstone Arsenal, Alabama

Invited Speakers: "Shock Response Research at the Waterways Experiment Station" Colonel John L. Cannon, Commander/Director, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

"Technical Information Resources for the Shock and Vibration Community" Mr. E.J. Kolb, Principal Technical Information Officer for the Army, Headquarters, U.S. Army Materiel Development and Readiness Command, Alexandria, Virginia

"Earthquakes: Their Causes and Effects" Dr. Robert M. Hamilton, Chief, Office of Earthquake Studies, U.S. Geological Survey, Reston, Virginia

Session 1A (Unclassified) 2:00 P.M. Tuesday, October 18
Parlor A

MODAL TEST AND ANALYSIS

Chairman: Mr. Brian Keegan, NASA Goddard Space Flight Center, Greenbelt, Maryland

Cochairman: Mr. Garland D. Johnston, NASA Marshall Space Flight Center, Huntsville, Alabama

1. Force Apportioning for Modal Vibration Testing Using Incomplete Excitation G. MOROSOW, Martin Marietta Corporation, Denver CO and R.S. AYRE, University of Colorado, Boulder, CO.

2. On the Distribution of Shaker Forces in Multiple-Shaker Modal Testing - W.L. HALLAUER, Jr. and J.F. STAFFORD, Virginia Polytechnic Institute and State University, Blacksburg, VA.

3. Modal Confidence Factor in Vibration Testing - S.R. IBRAHIM, Old Dominion University, Norfolk, VA.

4. Scaling and Response Predictions of Both Model and Prototype Protective Structures to Air Blast Loads by Impedance Techniques - F.B. SAFFORD, Agbabian Associates, El Segundo, CA., R.E. WALKER, U.S. Army Waterways Experiment Station, Vicksburg, MS, and T.E. KENNEDY, Defense Nuclear Agency, Washington, D.C.

BREAK

5. A Building Block Approach to the Dynamic Behavior of Modal Modeling Techniques - M. LALANNE, J.C. CROMER, I.N.S.A., Villeurbanne, France, and D. BONNECASE, L.L. GAUDRIOT, Metravib, Ecully, France.

6. Advanced Applications of Transfer Functions - J.R. FOWLER, Hughes Aircraft Company, El Segundo, CA., and E. DANCY, Hewlett-Packard, Los Angeles, CA.

7. Load Transformation Development Consistent with Modal Synthesis Techniques - R.F. HRUDA and P.J. JONES, Martin Marietta Corp., Denver, CO.

8. Reduced System Models Using Modal Oscillators for Subsystems (Rationally Normalized Modes) - F.H. WOLFF and A.J. MOLNAR, Westinghouse Electric Corp., Pittsburgh, PA.

SUPPLEMENTARY

Laguerre Polynomials: An Approach to Measurement Representation - G.R. SPALDING, Wright State University, Dayton, OH.

Session 1B (Unclassified) 2:00 P.M. **Tuesday, October 18**
Parlor B

TRACKED VEHICLES

Chairman: Mr. Donald W. Rees, Chief Applied Physics Section, U.S. Army Tank Automotive Research and Development Command, Warren, Michigan

Cochairman: Mr. Gorges Garinther, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, Maryland

1. Noise in Light-Weight Tracked Vehicles - An Overview - J.T. KALB, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, MD.

2. Analysis of Tracked Vehicle Dynamics - A.G. GALAITSIS, Bolt Beranek and Newman, Cambridge, MA.

3. Hull Vibratory Power Flow and Resulting Interior Noise on the M113A Armored Personnel Carrier - P.A. RENTZ, Bolt Beranek and Newman, Canoga Park, CA.

4. Reducing Tracked Vehicle Vibration and Noise - Hardware Considerations - R.B. HARE, FMC Corporation, San Jose, CA and T.R. NORRIS, Consultant, San Francisco, CA.

BREAK

5. Tracked Vehicles: Noise and Vibration Study Using a Reduced Scale Model - T.R. NORRIS, Consultant, San Francisco, CA and D.W. REES, U.S. Army Tank Automotive Research and Development Command, Warren, MI.

6. Use of an Earth Berm to Reduce the Environmental Noise Impact of the Test Track at Detroit Arsenal - N.D. LEWIS, Bioacoustics Division, Army Environmental Hygiene Agency, Aberdeen Proving Ground, MD.

7. Noise Limits for Army Material - Presentation and Discussion with Audience Participation - G. GARINTHER, U.S. Army Human Engineering Laboratory, Aberdeen Proving Ground, MD.

Session 2A (Unclassified) 9:00 A.M. Wednesday, October 19
Parlor A

INSTRUMENTATION

Chairman: Mr. Thomas Kennedy, Defense Nuclear Agency, Washington, D.C.

Cochairman: Mr. Ami Frydman, U.S. Army Harry Diamond Laboratories, Adelphi, Maryland

1. Angular Vibration Measurement Techniques - M.W. OBAL and P.W. WHALEY, Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, OH.

2. High Frequency Ground Vibration Measurement - H. NOLLE, Monash University, Clayton, Australia

3. The Reciprocity Calibration of Vibration Standards Over an Extended Frequency Range - R.R. BOUCHE, Bouche Laboratories, Tujunga, CA.

4. Hydrodynamic Ram Induced Panel Displacements Determined by a Moire Fringe Technique - S.J. BLESS, J.P. BARBER and P.F. FRY, University of Dayton Research Institute, Dayton, OH.

SUPPLEMENTARY

Data Acquisitions Systems for the Immediate Future - J.F. SCHNEIDER, Air Force Weapons Laboratory, Kirtland AFB, NM

BREAK

LOADS AND ENVIRONMENTS

Chairman: Mr. Jerome Pearson, Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio

Cochairman: Mr. Rudolph H. Volin, Shock and Vibration Information Center, Naval Research Laboratory, Washington, D.C.

5. An Investigation of Internal Acoustic Transmission of Vibration in the AIM-7E Missile - D.B. MEEKER and T.W. ELLIOTT, Pacific Missile Test Center, Point Mugu, CA.

6. The Vibration Response of the Phoenix Missile in the F-14 Aircraft Captive Flight Environment - M.E. BURKE, Pacific Missile Test Center, Point Mugu, CA.

7. Some Dynamic Response Environmental Measurements of Various Tactical Weapons - W.W. PARMENTER, Naval Weapons Center, China Lake, CA.

8. Axial Force Functions for the Water Entry of Ogive Shapes - J.L. BALDWIN, Naval Surface Weapons Center, Silver Spring, MD.

SUPPLEMENTARY

Calculation of Attach Point Loads Due to Combustion Instability in the Space Shuttle Solid Rocket Boosters - F.R. JENSEN and D. WANG, Hercules Inc., Magna, UT.

Session 2B (Unclassified) 9:00 A.M. Wednesday, October 19
Parlor B

STRUCTURAL ANALYSIS

Chairman: Dr. Nicholas Basdekas, Office of Naval Research, Arlington, Virginia

Cochairman: Dr. J.P. Balsara, U.S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi

1. A Source of Large Errors in Calculating System Frequencies - R.M. MAINS, Washington University, St. Louis, MO.

2. Optimum Element Size in Shock Load Analysis of Buried Structures - A.K. GUPTA and R.R. ROBINSON, IIT Research Institute, Chicago, IL.

3. Finite Element Analysis of a Bolted Structure in High Speed Impacts - J.K. GRAN, L.E. SCHWER, J.D. COLTON and H.E. LINDBERG, SRI International, Menlo Park, CA.

4. Wave Propagation in Cylindrical Shell with Joint Discontinuity - A. HARARI, Naval Underwater Systems Center, Newport, RI.

BREAK

5. Calculation of Natural Frequencies and Mode Shapes of Mass Loaded Aircraft Structures - P.W. WHALEY, Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, OH.

6. Rocket Motor Response to Transverse Blast Loading - N.J. HUFFINGTON, Jr. and H.L. WISNIEWSKI, U.S. Army Ballistic Research Laboratory, Aberdeen Proving Ground, MD.

7. Experimental and Theoretical Dynamic Analysis of Carbon-Graphite Composite Shells - B.E. SANDMAN and A. HARARI, Naval Underwater Systems Center, Newport, RI.

8. Use of Shock Spectra to Evaluate Jitter of a Flexible Maneuvering Spacecraft - W.J. KACENA, Martin Marietta Corp., Denver, CO.

SUPPLEMENTARY

SPAR - L. KIEFLING, Marshall Space Flight Center, AL.

Session 2C (Unclassified) 2:00 P.M. Wednesday, October 19
Parlor A

SPECIAL TOPICS

Chairman:	Dr. Robert Sierakowski, University of Florida, Gainesville, Florida
Cochairman.	Mr. Paul Hahn, Martin Marietta Corporation, Orlando, Florida

1. Environmental Vibration Data Base Management System - D.J. MALSBARY, G.E. WADLEIGH, and W.E. JENKINS, General Dynamics/Convair Division, San Diego, CA.

2. System Hardness Evaluation by Analysis - W.H. ROWAN, TRW Systems Group, Redondo Beach, CA. and CAPT. D.A. SHUPE, Ogden Air Logistics Center, Hill AFB, UT.

3. Bird Impact Loading - CAPT. J.S. WILBECK, Air Force Materials Laboratory, Wright-Patterson AFB, OH. and J.P. BARBER, University of Dayton Research Institute, Dayton, OH.

4. Prediction of Constrained Fragment Velocities - P.S. WESTINE, Southwest Research Institute, San Antonio, TX. and J.H. KINEKE, Jr., Ballistic Research Laboratories, Aberdeen Proving Ground, MD.

BREAK

5. Fracture Mechanics Applied to Step-Stress Fatigue Under Sine/Random Vibration - R.G. LAMBERT, General Electric Company, Utica, NY.

6. Acoustic Radiation from a Venturi Type Flowmeter Due to Hydrodynamic Excitation - G.H. WEIDENHAMER, Bettis Atomic Power Laboratory, West Mifflin, PA. and R. LINDNER, Garrett Air Reserach, Los Angeles, CA.

7. A Non-Contacting Beta Backscatter Gage for Explosive Quantity Measurement - P.B. HIGGINS, R.A. BENHAM and F.H. MATHEWS, Sandia Laboratories, Albuquerque, NM.

8. Testing Piping Constraint Energy Absorbers for Reactor Containment Applications - R.G. YAEGER and R.C. CHOU, Franklin Institute Research Laboratories, Philadelphia, PA.

SUPPLEMENTARY

Parameter Identification Applied to Large Flexible Structures - W.R. WELLS, Wright State University, Dayton, OH.

Session 2D (Unclassified) 2:00 P.M. Wednesday, October 19
Parlor B

PANEL SESSION: SOFTWARE EVALUATION

Moderator:	Dr. Nicholas Perrone, Office of Naval Research, Arlington, Virginia
Comoderator:	Dr. J. Gordan Showalter, Shock and Vibration Information Center, Naval Research Laboratory, Washington, D.C.
Panelists:	Mr. William Walker, Air Force Office of Scientific Research, Washington, D.C. Dr. Michael Gaus, National Science Foundation, Washington, D.C. Dr. Walter D. Pilkey, University of Virginia, Charlottesville, Virginia Mr. E.J. Kolb, Headquarters, U.S. Army Development and Readiness Command, Alexandria, Virginia

Inter Agency Software Evaluation Group

The Inter-Agency Software Evaluation Group (ISEG) was set up for the purpose of formalizing the computer program evaluation process. Criteria for computer program assessment are being carefully considered as well as prospective contractors who may carry out such assessments in detail and communicate results of the same to the public. Participating agencies within ISEG include Army, Air Force, Navy, NSF and ERDA.

Initially attention is being focused on structural mechanics related software. The panel would be receptive to audience reaction to the notion of objective software assessment.

Session 2E (Unclassified) 3:30 P.M. Wednesday, October 19
Parlor B

PANEL SESSION: DATA MANAGEMENT

Moderator:	Major David R. Spangler, Defense Nuclear Agency, Washington, D.C.
Comoderator:	Mr. Edwin J. Martin, General Electric/Tempo, Santa Barbara, California
Panelists:	Mr. James A. Malthan, Agbabian Associates, El Segundo, California
	Mr. Wilbur Rinehart, NOAA, Boulder, Colorado
	Mr. Donald J. Malsbary, General Dynamics/Convair Div., San Diego, California
	Mr. Clarence A. Davidson, Sandia Laboratories, Albuquerque, New Mexico

The purpose of this session is to provide information on existing data files of interest to the shock and vibration community and to present several approaches to the management of data so that users may derive maximum benefit. The panel is expected to answer questions on current methods of handling data and to solicit requirements from users that are not addressed in their present data management systems. Approximately thirty minutes will be provided for questions and comments from the audience.

Session 3A (Unclassified) 9:00 A.M. Thursday, October 20
Parlor A

SHORT DISCUSSION TOPICS

Chairman:	Dr. Grant Gerhart, U.S. Army Tank Automotive Research and Development Command, Warren, Michigan
Cochairman:	Mr. Tommie Dobson, 6585 Test Group, Holloman AFB, New Mexico

This session will program papers covering progress reports on current research efforts and unique ideas, hints and kinks on instrumentation, fixtures, testing, analytical short cuts and so forth. It is intended to provide a means for up-to-the-minute coverage of research programs and a forum for the discussion of useful ideas and techniques considered too short for a full-blown paper.

If you have a contribution to offer, the enclosed "Short Topic" form may still reach SVIC by the **12 September 1977** deadline. A list of speakers will be included in the final program.

Session 3B (Classified) 9:00 A.M. Thursday, October 20
Rocket Auditorium

CLASSIFIED SESSION

Chairman:	Mr. David M. Hurt, Naval Ship Engineering Center, Washington, D.C.
Cochairman:	Dr. Alan Ross, University of Florida Graduate Engineering Center, Eglin AFB, Florida

1. Three-Dimensional Soil Island Calculation of an Embedded Reinforced Concrete Structure Subjected to a Simulated Nuclear Explosion - H. S. LEVINE, J. P. WRIGHT, J. ISENBERG, and J. BAYLOR, Weidlinger Associates, Menlo Park, CA.

2. Shock Loading of Submerged Submarines from Near-Surface Air Bursts of Large Conventional Explosive Charges - M.W. OLESON, Naval Research Laboratory, Washington, D.C., Y. PARK, Naval Ship Engineering Center, Washington, D.C., and R.O. BELSHEIM, NKF Engineering Associates, Inc., Silver Spring, MD.

3. Analysis of Acoustic Coatings by the Finite Element Method - A.J. KALINOWSKI, Naval Underwater Systems Center, New London, CT.

BREAK

4. Development and Validation of Pre-Launch Shock Capability for the Navy's Tomahawk Cruise Missile - W.M. DREYER, R.E. MARTIN, and R.G. HUNTINGTON, General Dynamics/Convair Division, San Diego, CA.

5. Structural Response of Earth Penetrators in Angle-of-Attack Impacts - J.D. COLTON, SRI International, Menlo Park, CA.

6. Characterization of Torpedo Structural Modes and Resonant Frequencies - C.M. CURTIS and B.E. SANDMAN, Naval Underwater Systems Center, Newport, RI.

Session 3C (Unclassified) 2:00 P.M. Thursday, October 20
Parlor A

VIBRATION TESTING

Chairman:	Mr. Richard D. Baily, Material Test Directorate, Aberdeen Proving Ground, Maryland
Cochairman:	Mr. Fred Anderson, U.S. Army Missile Research and Development Command, Redstone Arsenal, Alabama

1. On the "Integrated" Testing of Complex Systems - R.L. WOODFIN, Naval Weapons Center, China Lake, CA.

2. A Mathematical Method for Determining a Laboratory Simulation of the Captive Flight Vibrational Environment - S. OGDEN, Pacific Missile Test Center, Point Mugu, CA.

3. Acoustics or Shakers for Simulation of Captive Flight Vibration - A.M. SPANDRIO and M.E. BURKE, Pacific Missile Test Center, Point Mugu, CA.

4. Automatic Environmental Control System for Mission Profile Testing - R. SCHILKEN, Pacific Missile Test Center, Point Mugu, CA.

BREAK

5. A Free Flight Simulation of Cruise Type Missile Environments - J.O. JONES, Pacific Missile Test Center, Point Mugu, CA.

6. Broad-Band Mechanical Vibration Amplifier - R.T. FANDRICH, Harris Corp., Melbourne, FL.

7. Stability and Frequency Response of Hydromechanical Shakers in Vibration Rigs - S. SANKAR, Concordia University, Quebec, Canada.

8. MIL-STD-781C Random Reliability Testing Performed by Using Acoustic Coupling - S.M. LANDRE, Harris Corporation, Melbourne, FL.

Session 3D (Unclassified) 2:00 P.M. Thursday, October 20
Parlor B

ISOLATION AND DAMPING

Chairman:	Professor F.C. Nelson, Department of Mechanical Engineering, Tufts University, Medford, Massachusetts
Cochairman:	Mr. Irvin P. Vatz, Teledyne Brown Engineering, Huntsville, Alabama

1. A Proposed Specification for Damping Material Performance - D.I.G. JONES and J.P. HENDERSON, Air Force Materials Laboratory, Wright-Patterson AFB, OH.

2. A Reduced-Temperature Nomogram for Characterization of Damping Material Behavior - D.I.G. JONES, Air Force Materials Laboratory, Wright-Patterson AFB, OH.

3. Computerized Processing and Empirical Representation of Viscoelastic Material Property Data and Preliminary Constrained Layer Damping Treatment Design - L. ROGERS, Air Force Flight Dynamics Laboratory, Wright-Patterson AFB, OH. and A. NASHIF, Anatrol Corporation, Cincinnati, OH.

4. New Structural Damping Technique for Vibration Control - B.M. PATEL and G.E. WARNAKA, Lord Kinematics, Erie, PA., and D.J. MEAD, University of Southampton, Southampton, UK.

BREAK

5. Vibrations of a Compressor Blade with Slip at the Root - D.I.G. JONES, Air Force Materials Laboratory, Wright-Patterson AFB, OH. and A. MUSZYNSKA, Institute of Fundamental Technological Research, Polish Academy of Sciences, Warsaw, Poland.

6. Response of a Helical Spring Considering Hysteretic and Viscous Damping - P.F. MLAKAR and R.E. WALKER, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

7. Multi-Variable Optimization for the Vibration Isolation of Road Vehicle Suspensions - E. ESHAILZADEH, Massachusetts Institute of Technology, Cambridge, MA.

8. Non-Amplifying Seismic Restraint for Vibration Isolated Equipment - P. BARATOFF and B. MUI, Korfund Dynamics Corporation, Westbury, NY.

SUPPLEMENTARY

Isolation Mounts for the MEAO-B X-ray Telescope - H. HAIN, Lord Kinematics, Erie, PA. and R. MILLER, American Science and Engineering, Cambridge, MA.

SHORT COURSES

SEPTEMBER

FINITE ELEMENT MODELING WORKSHOP

Dates: September 29 and 30, 1977
Place: O'Hare Hilton, Chicago, Illinois
Objective: The program for this Vibration Institute-sponsored workshop includes lectures, demonstrations, and problem-solving sessions on the use of finite element-oriented computer codes to solve engineering problems. Emphasis will be on modeling hardware to obtain thermal, stress, and vibration data. Existing computer codes -- NASTRAN, ANSYS, and SAP -- will be used. The purpose of this workshop is to teach general purpose computer codes to solve engineering problems. Each participant will have the opportunity to run a problem on a remote terminal situated in the classroom.

Contact: Vibration Institute, 101 W. 55th St., Clarendon Hills, IL 60514-(312)654-2254/654-2053

OCTOBER

NOISE CONTROL

Dates: October 13 - 15, 1977
Place: Hampton, Virginia
Objective: An intensive short course on noise control will be presented immediately preceeding NOISE-CON 77, the 1977 National Conference on Noise Control Engineering. The presentations will cover fundamentals of acoustics and noise control; design of facilities for noise control; noise measurements and data reduction; and acoustical standards used in noise measurements.

Contact: NOISE-CON 77 Conference Secretariat, P. O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 - (914) 462-6719

1977 ASQC/SRE RELIABILITY AND QUALITY CONTROL SEMINAR

Dates: October 22, 1977
Place: Niagara Hilton, Niagara Falls, NY
Objective: The 1977 ASQC/SRE Reliability and Quality Control seminar will be concerned with burn-in ovens, in-circuit testers, testing on I.C. boards, inspection and quality control techniques, equipment replacement, and operational influences on reliability. The keynote speaker will be Rear Admiral Robert W. Watkins, USN.

Contact: Leonard Krantz (ASQC), Bell Aerospace Textron, P.O. Box 1, Buffalo, NY 14240 - (716) 297-1000, Ext. 7032

GIFTS USERS WORKSHOP

Dates: October 31 - November 4, 1977
Place: The University of Arizona, Tucson
Objective: To introduce the users to the GIFTS System and provide them with adequate experience with an understanding of the program. The GIFTS program is a collection of program modules designed to handle finite element computations in an automated, graphically-oriented fashion. The programs run in a small core space on many mini-computers and time sharing systems. The program capabilties include automatic model and load generation, result display, static and dynamic analysis including substructuring. It is expected that additional modules will be available for solid analysis and display, as well as axisymmetric solid analysis under arbitrary loading.

Contact: The University of Arizona, Special Professional Education College of Engrg., Tucson, AZ 85721 (602) 884-3054/884-1755

NOVEMBER

MACHINERY VIBRATION

Dates: November 8 - 10, 1977
Place: Cherry Hill, New Jersey
Objective: Lectures and demonstrations on rotor dynamics and torsional vibration have been scheduled for this seminar. General sessions on the opening day are intended to serve as a review of the technology; included are the concepts of critical speeds, resonances, and stability of machines; the finite element method; and rotor dynamic measurements. Double sessions on rotor dynamics and torsional vibrations will be held on the second and third days. The following topics are included in the rotor dynamics sessions: bearing (antifriction and fluid film) dynamics, rotor dynamic calculations, dynamics of foundations, application of large computer programs for structural vibration analysis, modern balancing techniques and applications, and solutions to industrial balancing problems. The sessions on torsional vibration feature fundamentals, modeling measurement and data analysis, self-excited vibrations, isolation and damping, transient analysis, and design of machine systems. Participants will be able to attend lectures in the area commensurate with their interests.

Contact: Vibration Institute, 101 W. 55th St., Clarendon Hills, IL 60514 (312)654-2254/654-2053

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

Dates: November 7 - 11, 1977
Place: Washington, D.C.
Objective: This course is intended to provide a basic education in resonance and fragility (vulnerability) phenomena, in vibration and shock environmental measurement and analysis, also in vibration and shock testing to prove reliability. This seminar will benefit quality and reliability personnel, test laboratory managers, engineers and aides, plant engineers and maintenance supervisors, packaging and transportation engineers, men in Government and military activities and their contractors. There are no definite prerequisites for this course.

Contact: Tustin Institute of Technology, Inc., 22 E. Los Olivos St., Santa Barbara, CA 93105 (805)963-1124

THE 15TH ANNUAL RELIABILITY ENGINEERING AND MANAGEMENT INSTITUTE

Dates: November 14 - 18, 1977
Place: Tucson, Arizona
Objective: This seminar, presented by the Univ. of Arizona, College of Engineering and Honeywell Information Systems, Arizona Computer Operations, Phoenix, is designed to cover the following subjects: Reliability Engineering Theory and Practice; Component, Equipment and System Reliability Prediction; Reliability Testing and Demonstration; Maintainability Engineering Theory and Practice; Safety; Liability; and Reliability Maintainability Management.

Contact: Dr. Dimitri Kececioglu, Aero. & Mech. Engrg. Dept., Univ. of Arizona, Bldg. 16, Tucson, AZ 85721 (602) 884-2495/884-3901/884-3054

ACOUSTICAL MODELING WORKSHOP IV

Dates: November 14 - 18, 1977
Place: MIT, Cambridge, Massachusetts
Objective: Participants will build their own models, take and interpret data to solve complex acoustic propagation problems. Sessions will consider applications of data to environmental noise prediction, evaluation of noise control measures, and site selection for buildings, roadways and guideways. Some subjects covered include sound speed, frequency and geometric scaling, air absorption, surface reflectivity, impulsive and continuous signals, spatial distribution of sources, interior and exterior noise situations and their characteristics, effect of barriers and absorbers in control of noise, control of reverberation, and the use of data in design.

Contact: Ms. M. Toscano, Rm. 3-366, Acoustical Modeling Workshop IV, Massachusetts Institute of Technology, Cambridge, MA 02139

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

TRACK/TRAIN DYNAMICS CONFERENCE IN CHICAGO

A conference on Advanced Techniques in Track/Train Dynamics and Design will be held on September 27 & 28, 1977, at the O'Hare Hilton in Chicago, under the auspices of the Track/Train Dynamics program. Leading authorities will present papers and will participate in panel discussions on the topics of the current state-of-the-art in structural mechanics, dynamics and mechanics of materials as applied in the rail industry. Structural mechanics and train dynamics computer programs will be demonstrated, and terminals will be available for "hands-on" demonstrations and trials of existing programs. Some interactive graphics preprocessors and postprocessors will be exhibited.

For more information, please contact:

Gerald J. Moyar
Manager, Task IX, Advanced Analytical Techniques
Track/Train Dynamics II
AAR Technical Center
3140 South Federal Street
Chicago, IL 60616

CALL FOR PAPERS

Symposium on Future Trends in Computerized Structural Analysis and Synthesis

The purpose of this symposium, to be held at the Mariott Hotel at Twin Bridges, Washington, D.C., on October 30-November 1, 1978, is to provide multidisciplinary medium for communicating recent and projected advances in computer hardware, software, numerical analysis, applied mechanics and their application to future structural analysis and synthesis systems. Papers are invited on the impact of development in each of the aforementioned areas on structural analysis and synthesis. Authors should submit three copies of an extended abstract of about 1,000 words prior to September 30, 1977. One page abstracts are also solicited on current research in progress for short presentations at special sessions.

For further information contact the Conference Co-Chairmen:

Prof. Ahmed K. Noor
MS-246
George Washington Univ. Center
at NASA-Langley Research Center
Hampton, VA 23665

Prof. Harry Schaeffer
Dept. of Aerospace Engrg.
Univ. of Maryland
College Park, MD 20742

CALL FOR PAPERS

24th International Instrumentation Symposium

This Symposium, presented by Aerospace Industries and Test Measurement Divisions of the Instrument Society of America, at the Hilton Hotel in Albuquerque, New Mexico - May 1 - 4, 1978, has been established as the outstanding forum for presentation of original work in aerospace and test measurement instrumentation. In addition to the paper sessions, tutorials and workshops, tours of Los Alamos and Sandia Laboratories will be included.

For further information, contact:

Allen Diercks
Endevco
Rancho Viejo Road
San Juan Capistrano, CA 92675

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. Vibration and Noise Control Engineering Proceedings, published by the Institution of Engineers, Australia, 157 Gloucester Street, Sydney, 2000, Australia

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALOGS AND ANALOG COMPUTATION

(Also see No. 1540)

77-1535

Vibrational Control Theory

S.M. Meerkov
Inst. of Control Sciences, Moscow, USSR, J. Franklin Inst., 303 (2), pp 117-128 (Feb 1977) 27 refs

Key Words: Vibration control

The theory of vibrational control is developed. The necessary and sufficient conditions for vibrational stability of linear dynamic systems are found. Basic relations of the vibrational control method and the optimal shape of vibrations are determined. Unlike conventional methods, based on feedback or feedforward principles, the method of the paper does not require measurement of the deviations or disturbances.

OPTIMIZATION TECHNIQUES

77-1536

The Application of the Optimization Method to Dynamic Problems of Computer-Aided Design (Über die Anwendung von Optimierungsverfahren bei dynamischen Problemen in der rechnerunterstützten Konstruktion)

A. Kanarachos
Lehrstuhl f. Maschinenelemente u. Konstruktionslehre der Ruhr Universität, Bochum, Konstruktion, 28 (2), pp 53-58 (Feb 1976) 10 figs, 13 refs
(In German)

Key Words: Computer-aided design, Optimization, Dynamic structural analysis

The method of optimization is firmly established in several areas of technology (e.g., control theory, space flight etc.). Recently, this theory has been gaining in importance in the construction field. A discussion of all available optimization methods of interest to designers is presented.

PERTURBATION METHODS

77-1537

Multiple Time Scaling for Analysis of Third Order Non-Linear Differential Equations

R.N. Tiwari and R. Subramanian
Dept. of Electrical Engrg., Indian Inst. of Tech., Kanpur - 208016, India, J. Sound Vib., 52 (2), pp 165-169 (May 22, 1977) 2 figs, 6 refs

Key Words: Perturbation theory, Transient response, Steady state response

The two time perturbation procedure has been employed for investigating the transient and the steady state analysis of third order non-linear non-autonomous differential equations.

STABILITY ANALYSIS

77-1538

On the Stability of Systems of Coupled Partial Differential Equations with Random Excitation

G. Ahmadi
Dept. of Mech. Engrg., Pahlavi Univ., Shiraz, Iran, J. Sound Vib., 52 (1), pp 27-35 (May 8, 1977) 16 refs

Key Words: Stability analysis, Flutter, Plates, Shells, Rods

The stability of the null solution of a class of a system of coupled partial differential equations with stationary random coefficients is studied. Criteria for near asymptotic stability of the equilibrium state are established. Some examples of the application of the results to engineering problems are presented. A variational scheme for improvement of the stability criteria is also discussed.

STATISTICAL METHODS

(Also see No. 1607)

77-1539

Some Elements in Statistical Energy Analysis

G. Maidanik
David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD 20084, J. Sound Vib., 52 (2), pp 171-191 (May 22, 1977) 5 figs, 11 refs

Key Words: Statistical energy analysis, Noise control

Resonant responses of basic dynamic systems within a specified frequency band are defined and an elementary Statistical Energy Analysis (SEA) is detailed. The application of the elementary SEA to noise control engineering is exemplified by a situation involving a complex system that can be modeled by two coupled basic dynamic systems. The significance of upgrading the elementary SEA is discussed and demonstrated by an example.

FINITE ELEMENT MODELING

(See No. 1558)

MODELING

(See No. 1696)

DIGITAL SIMULATION

77-1540

Seminar on Understanding Digital Control and Analysis in Vibration Test Systems

NASA, Goddard Space Flight Center, Greenbelt, MD, Conf. Proc held at Greenbelt MD, 17-18 June 1975, and Pasadena, CA, 22-23 July 1975, Rept. No. *NASA-TM-X-74637*, 93 pp (May 1975) refs
N77-20514

Key Words: Digital techniques, Analog simulation, Random vibration, Shock testing

Methods of computer-controlled random vibration and reverberation acoustic testing, methods of computer-controlled sinewave vibration testing, and methods of computer-controlled shock testing are covered. General algorithms are described in the form of block diagrams and flow diagrams. The advantages of digital methods over analog vibration methods are demonstrated.

DESIGN INFORMATION

(Also see No. 1627)

77-1541

Vibration Reduction in Machine Systems by Means of Computer-Aided Parameter Discussion in the Design Stage (Schwingungsminderung in Maschinensystemen durch rechnergestützte Parameterdiskussion in der Konstruktionsphase)

D. Wünsch and A. Seeliger

Institut f. Fördertechnik u. Getriebetechnik der T.U. Berlin, Konstruktion, 28 (9), pp 347-352 (Sept 1976)
11 figs, 2 tables, 9 refs
(In German)

Key Words: Vibration reduction, Bearings, Engines, Design techniques

An accurate stress prediction is obtained when the reciprocal action of the torque, which excites the vibrators in the drive direction, and the mechanical vibration is taken into consideration. Machine equations and equations of motion are treated at the same time in the computer. Forces or moments introduced into the driven side by the operation must be known exactly. In the article three examples from the area of general machine design, relating to the above problem are discussed.

DESIGN TECHNIQUES

(See No. 1663)

CRITERIA, STANDARDS, AND SPECIFICATIONS

77-1542

Some Recent Developments in Noise Legislation

C.E. Mather

Public Works Dept., Western Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 30-35 (Oct 11-12, 1976)

Key Words: Noise reduction, Regulations

This paper details some of the more recent developments in environmental and occupational noise legislation in England and America, compares their similarities and differences, and makes some observations regarding their effectiveness.

77-1543

Noise Levels and Their Measurements and Interpretation in the Vicinity of Military Airfields

S. Kanagasabay

Directorate of Civilian Medical Services, Ministry of Defence, London, UK, In: AGARD Special Aspects of Aviation Occupational and Environmental Medicine, 6 pp (Feb 1977) refs (N77-20735)
N77-20742

Key Words: Aircraft noise, Traffic noise, Industrial facilities, Noise measurement, Regulations

Indexes for nuisance noise from road traffic, aircraft, and industrial premises were formulated and related to the civilian environment. The noise source from aircraft and in particular, the noise in the vicinity of airfields was studied. In view of already existing legislation providing recompense for the population affected by noise levels in excess of criteria laid down for civil airfields, The Royal Air Force was required to develop criteria for noise in the vicinity of military airfields.

77-1544

Waterfront Occupational Noises

H.J. Parry and J.K. Parry

Parry Noise Consulting, 444 NE Ravenna Blvd., Seattle, WA 98115, Noise Control Engr., 8 (2), pp 61-68 (Mar/Apr 1977) 6 figs, 5 tables, 6 refs

Key Words: Industrial facilities, Noise reduction, Regulations

A recent study of the noise exposure of various workers at the Port of Seattle, Washington, is described. An earlier study identified work areas and equipment that might constitute violations of federal and state regulations. For these possible problems, work-shift exposures were measured, and engineering and administrative controls were recommended and implemented in some situations.

77-1545

Review of Construction Noise Legislation

Task Committee on Noise and Vibration of the Committee on Social and Environmental Concerns in Construction of the Construction Div., ASCE J. Struc. Div., 103 (CO1), pp 123-137 (Mar 1977) 7 tables, 7 refs

Key Words: Construction equipment, Construction industry, Noise generation, Noise reduction, Regulations

Noise prediction schemes currently used by various communities are discussed. Three major cities in the United States, Los Angeles, Chicago, and New York, have enacted legislation dealing specifically with construction noise. These ordinances are reviewed with respect to their influence on the contractor and the construction equipment manufacturer. Noise emission standards for portable air compressors are analyzed as an example of newly proposed standards. Noise control guidelines for the construction contractor are recommended.

SURVEYS AND BIBLIOGRAPHIES

(Also see No. 1673)

77-1546

Aircraft Sonic Boom: Studies on Aircraft Flight, Aircraft Design, and Measurement (A Bibliography with Abstracts)

G.H. Adams

National Tech. Information Service, Springfield, VA., Supersedes NTIS/PS-76/0175, 148 pp (Apr 1977) NTIS/PS-77/0218/6GA

Key Words: Bibliographies, Sonic boom, Aircraft noise, Aircraft, Design techniques

Aerodynamic design of aircraft and wings, flight characteristics and maneuvers, supersonic transport characteristics, acoustic fields and noise measurement, Government policies and regulations, meteorological parameters, shock waves, and supersonic and hypersonic wind tunnel tests are discussed. Structural and biological effects are documented in separate published searches. This updated bibliography contains 143 abstracts, 24 of which are new entries to the previous edition.

77-1547

Aircraft Sonic Boom: Effects on Buildings (A Bibliography with Abstracts)

G.H. Adams

National Tech. Information Service, Springfield, VA., Supersedes NTIS/PS-76/0176, 75 pp (Apr 1977) NTIS/PS-77/0219/4GA

Key Words: Bibliographies, Sonic boom, Aircraft noise, Buildings

Research findings are cited on the effects of sonic booms on buildings, structural components, forms, windows, and walls. Test-house investigations are included, along with damage analysis and vibration response. Documentation is made on residential buildings. Other topics contained in the volume range from theory to failure analysis. Sonic boom propagation and effects on biological forms, including human responses, are cited in separate bibliographies. This updated bibliography contains 70 abstracts, 10 of which are new entries to the previous editon.

77-1548

Nonlinear Acoustics (A Bibliography with Abstracts)

D.W. Grooms

National Tech. Information Service, Springfield, VA., Supersedes NTIS/PS-76/0235, NTIS/PS-75/351 and COM-74-10868, 122 pp (Apr 1977) NTIS/PS-77/0203/8GA

Key Words: Bibliographies, Sound transmission

Studies include nonlinear acoustic theory and applications to sound transmission in the atmosphere, underwater, solids, liquids, and gases. Nonlinear relationships are also presented for shock tubes, sonar equipment, sonic booms, acoustic defectors, sound generators, acoustic delay lines, porous materials, pipes, ducts, and jet engine noise. This updated bibliography contains 118 abstracts, 31 of which are new entries to the previous edition.

COMPUTER PROGRAMS

GENERAL

(Also see Nos. 1617, 1719, 1723)

77-1549

Calculation and Optimization of Compression Springs by Means of a Desk Calculator (Druckfederberechnung und -optimierung mit dem Tischrechner)

P. Frölich
Luft- u. Raumfahrt bereich der Nord- Micro GmbH, Bergen-Enkheim, Konstruktion, 28 (6), pp 227-228 (June 1976)
(In German)

Key Words: Computer programs, Springs, Optimization

Computer operation for the calculation of compression springs on a desk calculator is described. The program calculates all types of springs and optimizes the springs (cylindrical coil springs from round wire) for a complete material utilization.

77-1550

Computer Program for the Curvatures and Accelerations of Rectangular Link-Connecting Points

K. Hain
Konstruktion, 28 (11), pp 417-422 (Nov 1976)
(In German)

Key Words: Computer programs, Graphic methods, Power transmission systems

In the application of connecting curves, often it is not sufficient to know the curve shapes. The velocity and the acceleration of the connecting points describing the curve are also of equal interest. A simple computer program indicates some relationship between curvature and acceleration, but not an exact agreement. The computer program described in the article is based on diagram series - calculation method, which connects the advantages of both graphic and calculation methods.

77-1551

Reliability Study of SINGER. Volume I. Validation of Model

S.M. Holzer, A.E. Somers, and J.C. Bradshaw, III
Dept. of Civil Engrg., Virginia Polytechnic Inst. and State Univ., Blacksburg, VA., Rept. No. AFWL-TR-76-192-Vol-1, 92 pp (Jan 1977)
AD-A037 819/0GA

Key Words: Computer programs, Dynamic structural analysis, Reinforced concrete, Hardened installations

The first volume of the report is connected with the refinement and the demonstration of the current capability of the computer code SINGER. The function of SINGER is to predict the complete response (including element failures and structural collapse) of skeletal reinforced concrete structures to static and dynamic loads.

77-1552

Application of NASTRAN to Large Deflection Supersonic Flutter of Panels

C. Mei and J.L. Rogers, Jr.
Langley Res. Center, NASA, Langley Station, VA., In: NASA, Langley Res. Center NASTRAN: User's Experiences, pp 67-98 (Oct 1976) refs (N77-20485)
N77-20490

Key Words: NASTRAN (computer program), Computer programs, Flutter, Panels

Flat panel flutter at high supersonic Mach number is analyzed using NASTRAN Level 16.0 by means of modifications to the code. Two-dimensional plate theory and quasi-steady aerodynamic theory are employed. The finite element formulation and solution procedure are presented. Modifications to the NASTRAN code are discussed. Convergence characteristics of the iteration processes are also briefly discussed. Effects of aerodynamic damping, boundary support condition and applied in-plane loading are included.

77-1553

Correlation of AH-1G Airframe Test Data with a NASTRAN Mathematical Model

J.D. Cronkhite and V.L. Berry

Bell Helicopter Co., Fort Worth, TX, Rept. No. NASA-CR-145119; Rept-699-099-016, 160 pp (Feb 1976)
N77-19488

Key Words: NASTRAN (computer program), Computer programs, Experimental data, Airframes

Test data were provided for evaluating a mathematical vibration model of the Bell AH-1G helicopter airframe. The math model was developed and analyzed using the NASTRAN structural analysis computer program. Data from static and dynamic tests were used for comparison with the math model. Static tests of the fuselage and tailboom were conducted to verify the stiffness representation of the NASTRAN model. Dynamic test data were obtained from shake tests of the airframe and were used to evaluate the NASTRAN model for representing the low frequency (below 30 Hz) vibration response of the airframe.

77-1554

Some Applications of the NASTRAN Level 16 Subsonic Flutter Analysis Capability

R.V. Doggett, Jr. and H.J. Cunningham

Langley Res. Center, NASA, Langley Station, VA., In: NASA Langley Res. Center NASTRAN: User's Experiences, pp 495-512 (Oct 1976) refs(N77-20485)
N77-20508

Key Words: NASTRAN (computer programs), Computer programs, Flutter, Aircraft wings

The Level 16 flutter analysis capability was applied to an aspect-ratio-6.8 subsonic transport type wing, an aspect-ratio-1.7 arrow wing, and an aspect-ratio-1.3 all movable horizontal tail with a geared elevator. The transport wing and arrow wing results are compared with experimental results obtained in the Langley transonic dynamic tunnel and with other calculated results obtained using subsonic lifting surface (kernel function) unsteady aerodynamic theory.

77-1555

Development, Documentation and Correlation of a NASTRAN Vibration Model of the AH-1G Helicopter Airframe

J.D. Cronkhite

Bell Helicopter Co., Fort Worth, TX, In: NASA Ames Res. Center NASTRAN: User's Experiences, pp 273-294 (Oct 1976) refs (N77-20485)
N77-20500

Key Words: NASTRAN (computer program), Computer programs, Helicopters, Vibration response

NASTRAN was evaluated for vibration analysis of the helicopter airframe. The first effort involved development of a NASTRAN model of the AH-1G helicopter airframe and comprehensive documentation of the model. The next effort was to assess the validity of the NASTRAN model by comparisons with static and vibration tests.

77-1556

Thermal and Structural Analysis of Helicopter Transmission Housings Using NASTRAN

R.W. Howells, J.J. Sciarra, and G.S. Ng

Boeing Vertol Co., Philadelphia, PA., In: NASA Ames Res. Center NASTRAN: User's Experiences, pp 353-380 (Oct 1976) refs (N77-20485)
N77-20503

Key Words: Housings, Power transmission systems, Helicopters, NASTRAN (computer program), Computer programs

The application of NASTRAN to improve the design of helicopter transmission housings is described. A finite element model of the complete forward rotor transmission housing for the Boeing Vertol CH-47C helicopter was used to study thermal distortion and stress, stress and deflection due to static and dynamic loads, load paths, and design optimization by the control of structural energy distribution. The analytical results are correlated with test data and used to reduce weight and to improve strength, service life, fail-safety, and reliability. The techniques presented, although applied herein to helicopter transmissions, are sufficiently general to be applicable to any power transmission system.

77-1557

A NASTRAN Implementation of the Doubly Asymptotic Approximation for Underwater Shock Response

G.C. Everstine

Naval Ship Res. and Dev. Center, Washington, D.C., In: NASA Ames Res. Center NASTRAN: User's Experiences, pp 207-228 (Oct 1976) refs (N77-20485)
N77-20497

Key Words: NASTRAN (computer program), Submerged structures, Underwater explosions

A detailed description is given of how the decoupling approximation known as the doubly asymptotic approximation is implemented with NASTRAN to solve shock problems for submerged structures. The general approach involves locating the nonsymmetric terms (which couple structural and fluid variables) on the right hand side of the equations. This approach results in coefficient matrices of acceptable bandwidth but degrades numerical stability, requiring a smaller time step size than would otherwise be used. It is also shown how the structure's added (virtual) mass matrix, is calculated with NASTRAN.

77-1558

A Finite Element-Analytical Method for Modeling a Structure in an Infinite Fluid

P.R. Zarda

Naval Ship Res. and Dev. Center, Washington, D.C., In: NASA Ames Res. Center NASTRAN: User's Experiences, pp 251-272 (Oct 1976) refs(N77-20485) N77-20499

Key Words: NASTRAN (computer program), Computer programs, Interaction: structure-fluid, Finite element technique

A method is described from which the interaction of an elastic structure with an infinite acoustic fluid is determined. The displacements of the structure and the pressure field of the immediate surrounding fluid are modeled by finite elements, and the remaining pressure field of the infinite fluid region is given by an analytical expression. This method yields a frequency dependent boundary condition for the outer fluid boundary when applied to the frequency response of an elastic beam in contact with an acoustic fluid.

77-1559

A Summary of NASTRAN Fluid/Structure Interaction Capabilities

A.J. Kalinowski and J.S. Patel

Naval Underwater Systems Center, Newport, RI, In: NASA Ames Res. Center NASTRAN: User's Experiences, pp 229-250 (Oct 1976) refs(N77-20485) N77-20498

Key Words: NASTRAN (computer program), Computer programs, Interaction: structure-fluid

A summary of fluid/structure interaction capabilities for the NASTRAN computer program is presented. Indirect applications of the program towards solving this class of problem were emphasized. For completeness and comparative purposes, direct usage of NASTRAN is briefly discussed.

77-1560

Modal Seismic Analysis of a Nuclear Power Plant Control Panel and Comparison with SAP 4

M.R. Pamidi and P.R. Pamidi

Sargent and Lundy, Engineers, Chicago, IL., In: NASA Ames Res. Center NASTRAN: User's Experiences, pp 515-530 (Oct 1976) refs (N77-20485) N77-20509

Key Words: NASTRAN (computer program), Computer programs, Nuclear power plants, Seismic response, Beams, Membranes

The application of NASTRAN to seismic analysis by considering the example of a nuclear power plant control panel was considered. A modal analysis of a three-dimensional model of the panel consisting of beam and quadri-lateral membrane elements, is performed. Using the results of this analysis and a typical response spectrum of an earthquake, the seismic response of the structure is obtained.

77-1561

Real Eigenvalue Analysis in NASTRAN by the Tridiagonal Reduction (FEER) Method

M. Newman, P.F. Flanagen, and J.L. Rogers, Jr.

Langley Res. Center, NASA, Langley Station, VA., In: NASA Langley Res. Center NASTRAN: User's Experiences, pp 127-148 (Oct 1976) (N77-20485) N77-20493

Key Words: NASTRAN (computer program), Computer programs, Eigenvalues

Implementation of the tridiagonal reduction method for real eigenvalue extraction in structural vibration and buckling problems is described. The basic concepts underlying the method are summarized and special features, such as the computation of error bounds and default modes of operation are discussed. In addition, the new user information and error messages and optional diagnostic output relating to the tridiagonal reduction method are presented. Some numerical results and initial experiences relating to usage in the NASTRAN environment are provided, including comparisons with other existing NASTRAN eigenvalue methods.

77-1562

A Comparison of the Two NASTRAN Differential Stiffness Techniques

J.R. McDonough

Computer Sciences Corp., Los Angeles, CA., In: NASA Ames Res. Center NASTRAN: User's Experiences, pp 149-160 (Oct 1976) refs(N77-20485) N77-20494

Key Words: NASTRAN (computer program), Computer programs, Stiffness methods

NASTRAN contains two techniques to solve the differential stiffness problems. One is incorporated in a new static analysis rigid format and the other is contained in a new normal modes analysis rigid format. The two techniques relative to computational accuracy and time of execution are compared.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 1543, 1544, 1546, 1547, 1548, 1572, 1573, 1593, 1594, 1595, 1622, 1674, 1675, 1687 1688, 1689, 1700, 1703, 1705)

77-1563

Energy Observations in Structure-Borne Noise Generation and Radiation (Energiebetrachtungen zur Körperschallentstehung und -ausbreitung)

M. Heckl

Inst. f. Techn. Akustik an d. T.U. Berlin, Konstruktion, 28 (9), pp 353-358 (Sept 1976) 5 figs, 7 refs (In German)

Key Words: Noise generation, Sound transmission

In numerous structure-borne noise problems a series of useful and far reaching conclusions may be drawn from energy observations. This is true in the generation of structure-borne noise as well as in its propagation and damping. From the knowledge of certain degrees of transmission (coupling factors) the structure-borne noise transfer from one part to another may be calculated. For low damping a simple equation for the energy distribution was obtained.

77-1564

Methods of Continuous Ambient Noise Level Monitoring

J.C. Wooding and I.A. Charity

State Electricity Commission of Victoria, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 141-142 (Oct 11-12, 1976) 3 figs

Key Words: Industrial facilities, Noise reduction

This is a discussion of the measurement and analysis of noise over periods longer than a few hours. It is based on the experience of engineers of the State Electricity Commission of Victoria (Australia) working in this area.

77-1565

Engineering Noise Control for a New Process Plant

J.C. Shearer

R. Bruce King & Associates Pty Ltd., Adelaide, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 139-140 (Oct 11-12, 1976)

Key Words: Industrial facilities, Noise control

The problems and methods of engineering noise control in relation to the design of a new process plant are described and discussed, using the new Clinker Production Plant of Adelaide Cement Company Ltd. as a specific example. It is concluded that consideration should be given to noise control engineering at the earliest stage of planning for a new process plant.

PERIODIC

77-1566

Linearization Techniques for Non-Linear Dynamical Systems

P.T. Spanos

Ph.D. Thesis, California Inst. of Technology, 164 pp (1977)

UM 77-10,473

Key Words: Multi-degree-of-freedom systems, Dynamic systems, Periodic excitation, Random excitation

This dissertation is concerned with the application of linearization techniques to the study of the response of non-linear dynamical systems subjected to periodic and random excitations. A general method for generating an approximate solution of a multi-degree-of-freedom non-linear dynamical system is presented. This method relies on solving an optimum equivalent linear substitute of the original system. The new method for transient response is applied to the random response of a Duffing Oscillator and a Hysteretic System. The solution for the Duffing Oscillator is compared with data obtained by a Monte Carlo study.

RANDOM

(See No. 1566)

SEISMIC

(See Nos. 1560, 1677, 1678, 1679, 1680)

SHOCK

(Also see Nos. 1557, 1597, 1698, 1716)

77-1567

Consideration of Ground and Air Vibration Problems Associated with Surface Blasting Operations

B.J. Kennedy and T.N. Hagan

Mount Isa Mines, Ltd., Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 71-75 (Oct 11-12, 1976) 4 figs, 9 refs

Key Words: Blast effects, Ground vibration, Shock response

This paper considers established damage and response criteria and the blasting techniques by which vibrations can be reduced to levels that cause neither damage nor complaints. Acceptable levels for structures and personnel are given.

77-1568

Control of Vibrations Due to Blasting

E.J. Polak and D.G. Bennett

Bureau of Mineral Resources, Canberra, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 76-80 (Oct 11-12, 1976) 6 figs, 13 refs

Key Words: Blast effects, Ground vibration, Vibration control

During blasting operations the energy released from an explosive charge travels in the form of body waves and air waves. The effect on objects depends on the amount of explosive and its distribution, the distance from explosion, the geological nature of the ground, and the properties of the object. Safe charge size, maximum particle velocity, and controlled delay blasting are discussed.

77-1569

Outrunning Ground Shock Models

I. Nelson and G.Y. Baladi

Weidlinger Associates, New York, NY, ASCE J. Engr. Mech. Div., 103 (EM3), pp 377-393 (June 1977)

Key Words: Ground shock, Air blast, Nuclear explosion effects

Ground shock response is calculated for a layered site under the airblast loading from a nuclear burst, using two advanced mathematical models, i.e., the variable moduli and CAP (CAP model is an elastic-nonideally plastic constitutive relation employing a yield surface that combines both ideal plasticity and strain hardening) models. The computer time histories of the motion from the two calculations are compared at several ranges, extending from the superseismic region into the outrunning region.

77-1570

A Simplified Model of Shock-on-Shock Interaction

G.F. Aiello

Martin Marietta Aerospace, Orlando, FL., Rept. No. OR-14282, DNA-4190F, 66 pp (Aug 1976) AD-A037 247/4GA

Key Words: Explosion effects, Shock waves, Reentry vehicles, Mathematical models

A simplified model is presented of the shock-on-shock problem as it pertains to the encounter between a supersonic cone and a planar blast wave. The model provides an accurate and inexpensive means of predicting the circumferential distribution of peak pressures and pulse duration for all encounter angles between nose-on and broadside with the cone at zero or small angles of attack.

77-1571

Predicting Impact Wear

P.A. Engel

IBM Corp., Endicott, NY, Mach. Des., 49 (12), pp 100-105 (May 26, 1977) 10 figs, 1 table

Key Words: Impact response, Wear, Design techniques

Until now, no analytical method has been available for predicting impact wear. With the new method given here, not only can you predict how fast impacting parts will wear, you can also adjust design parameters to minimize wear.

TRANSPORATION

(Also see Nos. 1602, 1658)

77-1572

Investigation of Vehicular Noise Levels in High Street, Maitland, New South Wales

A.J. Carmichael and E. Betz

Hunter District Water Board, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 125-126 (Oct 11-12, 1976) 2 tables, 2 refs

Key Words: Traffic noise

A noise study undertaken for a busy commercial main street revealed the need for such studies for urban planning. The study also revealed that uncontrolled vehicular use in such areas could create a community health hazard.

77-1573
Noise Characteristics of One Type of Diesel-Engined Mining Front-End Loader
V. Mason and R.J. Hooker
Sugar Research Inst., Mackay, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 133-134 (Oct 11-12, 1976) 2 figs, 1 table

Key Words: Transportation vehicles, Noise generation, Engine noise, Gear boxes

Noise sources on the low profile front-end loaders used extensively in the mining industry were investigated. Tests on seven vehicles covering a range of sizes and engines showed that in all cases the gearbox was the major noise source. Other major sources were the engine, the exhaust and the hydraulic system. Engine and gearbox noise radiated by the bodywork was significant. Measures required to reduce the noise level at the driver's position to 90 dB(A) from a maximum of about 106 dB(A) are discussed.

77-1574
CNU-XXX (Proposed Container for CBU-75/B), Rough Handling, Vibration and Mechanical Handling Tests
R.T. Gibbons
Air Force Packaging Evaluation Agency, Wright-Patterson AFB, OH, Rept. No. PTPD-77-4, 22 pp (Jan 1977)
AD-A036 867/0GA

Key Words: Shipping containers, Packaging, Ammunition, Transportation effects, Vibration tests

Developments in the area of munitions transportation and storage have eliminated the need for sealed metal containers for some weapons systems. This was the case when ADTC/SDM, Eglin AFB, Florida, proposed an open metal crate to replace the CNU-218 container for the CBU-75/B dispenser bomb. The development of open metal crates is reviewed.

PHENOMENOLOGY

DAMPING

77-1575
Transient Response of Continuous Elastic Structures
W. Pilkey and J. Strenkowski
Dept. of Mech. Engrg., Univ. of Virginia, Charlottesville, VA., Rept. No. UVA/525303/ME77/101, 72 pp (Feb 1977)
AD-A037 001/5GA

Key Words: Transient response, Structural members, Modal analysis, Elastic properties, Viscoelastic properties, Damping effects

A general theory for the dynamic response of linear damped continuous structured members is formulated with a modal analysis. The theory applies to elastic or viscoelastic solids. Proportional and non-proportional damping are included.

77-1576
Effects of Several Types of Damping on the Dynamical Behavior of Harmonically Forced Single-Degree-of-Freedom Systems
J.F. Byers
Defense Research Lab., Texas Univ. at Austin, TX, Rept. No. DRL-A-272, 153 pp (Jan 2, 1967)
AD-A036 695/5GA

Key Words: Single- degree-of-freedom systems, Damping effects, Harmonic excitation

This thesis presents an accurate solution of several types of damping on the dynamical behavior of harmonically forced single-degree-of-freedom systems. The study is based on the fundamental parameters of the system. The fundamental response is described with reference to the equivalent damping energy, the Ritz method, and dimensional analysis. Dimensional analysis is used to develop a method for predicting the general response diagram characteristics. The high accuracy of the solutions permitted the collection of some very important design data. The results are presented in both graphical and tabular form and may be useful to those engaged in calibration, design, and data analysis of work requiring an accurate solution.

77-1577
Vibration Damping by Friction in Structural Joints
R.S.H. Richardson
Dept. of Mech. Engrg., Monash Univ., Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 117-118 (Oct 11-12, 1976) 2 figs, 2 refs

Key Words: Coulomb friction, Vibration damping, Slip joints

There is a need for methods of predicting energy dissipation in common joint configurations. In this paper a simple overlapping joint between two flat metal surfaces is considered.

FATIGUE

(Also see Nos. 1657, 1704)

77-1578
Strength Calculations of the Multiaxial Phase-Shifted Vibration Loading with Principal Stress Directions Fixed-with-Respect-to-the-Body (Festigkeitsberechnung bei mehrachsiger phasenverschobener Schwingbeanspruchung mit körperfesten Hauptspannungsrichtungen)
H. Dietman and I. Issler
University of Stuttgart, Konstruktion, 28 (1), pp 23-30 (Jan 1970) 18 figs

Key Words: Fatigue life

In the article the theory for material failure under multiaxial phase shifted vibrational loading, with fixed principal axis with respect-to-the-body is developed. The theory starts with the fact that the octahedral torsional shearing stress is mainly responsible for the damage of deformable materials under vibrating loads. Then the time and direction dependent octahedral stresses caused by external loads are determined and combined into a "stress characteristic". Finally a stress capacity combination must be determined experimentally, which may be represented as "material characteristic". From a comparison of the stress characteristic and material characteristic a limit stress is obtained, which leads to damage. Experimental results confirm the theory presented.

FLUID

(Also see Nos. 1558, 1613, 1621, 1642, 1653, 1669, 1676, 1709)

77-1579
Coupled Dynamics Analysis of Wind Energy Systems. Final Report
J.A. Hoffman
Paragon Pacific, Inc., El Segundo, CA., Rept. No. NASA-CR-135152, 86 pp (Feb 1977) refs
N77-20558

Key Words: Wind-induced excitation, Rotors, Coupled response, Computer programs

A qualitative description of all key elements of a complete wind energy system computer analysis code is presented. The analysis system addresses the coupled dynamics characteristics of wind energy systems, including the interactions of the rotor, tower, nacelle, power train, control system, and electrical network. The coupled dynamics are analyzed in both the frequency and time domain to provide the basic motions and loads data required for design, performance verification and operations analysis activities. Elements of the coupled analysis code were used to design and analyze candidate rotor articulation concepts. Fundamental results and conclusions derived from these studies are presented.

77-1580
Finite State Modeling of Aeroelastic Systems
R. Vepa
Stanford Univ., CA., Rept. No. NASA-CR-2779, 189 pp (Feb 1977)
N77-19489

Key Words: Mathematical models, Aerodynamic loads, Airfoils

A general theory of finite state modeling of aerodynamic loads on thin airfoils and lifting surfaces performing completely arbitrary, small, time-dependent motions in an airstream is developed and presented. The nature of the behavior of the unsteady airloads in the frequency domain is explained, using as raw materials any of the unsteady linearized theories that have been mechanized for simple harmonic oscillations.

SOIL

(See Nos. 1569, 1597)

VISCOELASTIC

77-1581
Dynamic Stability of One-Dimensional Non-Linearly Visco-Elastic Bodies
R.C. Browne
Ph.D. Thesis, Univ. of Maryland, 95 pp (1976)
UM 77-9491

Key Words: Dynamic stability, Viscoelastic media

This dissertation treats the dynamic behavior of one-dimensional non-linearly visco-elastic bodies. The constitutive functions are of rate type, i.e., the stress depends on the strain and rate of strain but not on their past history. The dissertation begins with a description of the theory of three-dimensional non-linear visco-elastic bodies. Special attention is given to the constitutive requirements of frame-indifference, orientation-preservation, and order-preservation.

EXPERIMENTATION

DIAGNOSTICS

77-1582

Some Examples of Rotor Instabilities in Flexible Shaft Machines

J.J. Spillman

Consulting Engineer, Perth, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 119-120 (Oct 11-12, 1976) 2 figs

Key Words: Vibration monitoring, Diagnostic techniques, Rotors, Shafts

Three examples of rotor instability in flexible shaft machines are described. They are situations in which a major failure could have occurred. Instrumentation for continuous vibration monitoring with provision for an automatic shut-down when vibration levels exceed a pre-set level is discussed.

77-1583

Putting Vibration and Other Operating Variables to Work in a Monitoring System

J.S. Mitchell

Endevco, San Juan Capistrano, CA., Power, 151 (5), pp 87-89 (May 1977) 14 figs

Key Words: Diagnostic techniques, Pumps, Compressors, Fans

Monitoring concepts developed in Part I (March 1977) of this series are applied here to specific types of machinery -- including pumps, compressors, and fans.

77-1584

Avoiding Unscheduled Plant Shutdowns - Vibration Monitoring

R.S. Heggie

James A. Madden Associates Pty. Ltd., Sydney, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 109-110 (Oct 11-12, 1976) 4 tables, 4 refs

Key Words: Diagnostic techniques, Vibration signatures, Machinery vibration

A technique for machinery vibration monitoring is described. The effectiveness and practical value of the technique are examined in the light of extensive application in several continuous process plants over the past four years.

77-1585

The Applications of Cepstrum Analysis to the Dianosis of Machine Sound and Vibration Signals

R.B. Randall

Bruel & Kjaer, Naerum, Denmark, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 97-98 (Oct 11-12, 1976) 3 figs, 4 refs

Key Words: Cepstrum analysis, Diagnostic techniques, Turbine blades, Gear boxes, Machinery noise, Machinery vibration

The cepstrum is defined and its advantage in reducing the influence of signal transmission path explained. Examples are given of the application of the "power cepstrum" to the detection of periodic effects in a spectrum, viz. harmonics and sidebands. The first can be used to diagnose missing blades in a turbine, and the second for diagnosing various faults in gearboxes. The "complex cepstrum", where all phase information is retained so that the procedure is reversible, is also defined and explained, and an example given of its application to deconvolution.

77-1586

A Brief Review of the Monitoring of Vibration in Rotating Machines

A.L. Knight

Bell & Howell Ltd., Noise Control, Vib. and Insul., 8 (5), pp 168-170 (May 1977) 4 figs

Key Words: Diagnostic instrumentation, Diagnostic techniques, Rotating structures, Rotors

In the article the author reviews the range and application of such vibration sensors as piezoelectric accelerometers, velocity transducers and contactless displacement transducers, as well as vibration monitors.

77-1587
A Signal Processing System for Vibrations, Shock and Noise
S.R. Welaratna
Digital Signal Analysis Group, Hewlett-Packard Ltd., Noise Control, Vib. and Insul., 8 (5), pp 156-158 (May 1977) 7 figs

Key Words: Signal processing techniques, Diagnostic techniques

Signal processing through the use of digital signal analysis is discussed. Waveform and spectral analyses are covered.

77-1588
Dynamic Predictive Maintenance for Refinery Equipment
E. Balaam
Scientific Energy Systems-Beta Corp., Houston, TX, Hydrocarbon Processing, 56 (5), pp 131-136 (May 1977) 17 figs, 7 refs

Key Words: Vibration analyzers, Diagnostic instrumentation

Effective onstream time of refinery equipment can be achieved by applying the latest performance and vibration analysis instruments. Preventive maintenance procedures are discussed. Some typical maintenance costs are reviewed.

77-1589
Acoustic Signature Analysis for Noise Source Identification
A.C. Keller
Spectral Dynamics Corp., San Diego, CA, Noise Control, Vib. and Insul., 8 (5), pp 178-182 (May 1977) 11 figs, 6 refs

Key Words: Noise source identification, Acoustic signatures, Diagnostic techniques

A spectrum analyser is used to relate the frequency components of the noise spectrum of some specific mechanical event or pattern in the machine as it operates. Single-channel real-time spectrum analysers are used to obtain this amplitude vs. frequency, or amplitude vs. order, information.

FACILITIES

77-1590
Calibration of a Reverberant Room for the Measurement of Sound Power in Tones
D.A. Bies and C.H. Hansen
Univ. of Adelaide, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 121-122 (Oct 11-12, 1976) 1 fig, 7 refs

Key Words: Reverberation chambers, Calibrating

The assumption that the radiation impedance presented to the test apparatus under investigation in a reverberation room is the same as would be in an echo free field is tested experimentally.

77-1591
Semi-Anechoic Testing Rooms: Some Sound Advice
R.A. Dykstra and D.E. Baxa
Kohler Co., Kohler, WI, S/V, Sound and Vibration, 11 (5), pp 35-38 (May 1977) 4 figs, 20 refs

Key Words: Test facilities, Anechoic chambers

In 1973, Kohler Co. completed the construction of a semi-anechoic room to be used for the acoustical analyses of its small-engine (4-24 HP) line. This article discussed the acoustical response characteristics of Kohler Co.'s semi-anechoic room. The room is first evaluated as a system. Then, an analysis of the room's sound absorptive wedges is discussed.

77-1592
Vibration and Acoustic Testing -- The Role of NATA
A.J. Russell
National Assoc. of Testing Authorities, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 36-40 (Oct 11-12, 1976) 1 table, 3 refs

Key Words: Vibration tests, Acoustic tests, Testing facilities

An outline of the development and operation of the laboratory accreditation system of National Association of Testing Authorities, Australia is presented in this paper. Details of the acoustic and vibration measurement services which NATA registered laboratories provide for engineers and architects are given.

INSTRUMENTATION

77-1593
Measurement of Sound Intensity

G. Pavic

Electrotechnical Inst. "Rade Končar", Baštijanova bb, 41000 Zagreb, Yugoslavia, J. Sound Vib., 51 (4), pp 533-545 (Apr 22, 1977) 5 figs, 1 table, 7 refs

Key Words: Sound level meters

A method is formulated for sound intensity measurement in a non-dispersive medium. Errors associated with measurements are discussed. Comments on the applicability and limitations of the method are given and some experimental results are produced.

77-1594
Simple Techniques to Estimate Noise Levels Based on Manufacturer Equipment Data

R.S. Norman

IIT Res. Inst., Chicago, IL, ASME Paper No. 76-WA/PID-21

Key Words: Sound level meters, Sound measurement, Measurement techniques

In this paper, the standard sound power measurement techniques are briefly reviewed along with the methods normally used to estimate sound pressure levels. Simple techniques are discussed whereby manufacturers can obtain noise measurements on products in their own plants and estimate the noise levels produced by these products when in use. Problems associated with line and area sources are discussed. Methods for obtaining the acoustic characteristics of manufacturing areas are discussed.

77-1595
Considerations Relating to Instruments for the Measurement of Equivalent Continuous Noise Levels (LEQ) - Part 2

R.F. Norgan

Computer Engrg. Ltd., UK, Noise Control, Vib. and Insul., 8 (5), pp 186-187 (May 1977) 2 figs

Key Words: Sound level meters

The concept of Crest Factors and Time Concepts is explained and their unsuitability as parameters in Leq and Dose meters is described. The author concludes the article with a brief history of the Leq meter development.

77-1596
How Accurate is Your Accelerometer?

N.H. Clark

National Measurement Lab., CSIRO, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 105-106 (Oct 11-12,1976) 1 fig, 1 table, 7 refs

Key Words: Accelerometers, Calibrating

There is no general agreement on the accuracy required in vibration measurements made with accelerometers. Sometimes only the value of a fundamental frequency may be sought. Another occasion may call for measurement of small changes in the amplitude of a particular frequency component, requiring substantial accuracy. This paper is concerned mainly with the accuracy attainable with piezoelectric accelerometers.

77-1597
Grout/Soil Interaction and Velocity Gage Emplacement for Ground-Shock Measurement

M.B. Balachandra and J.A. Malthan

Agbabian Assoc., El Segundo, CA, Rept. No. AA-R-7364-7-4265, DNA-4089F, 201 pp (Aug 1976) AD-A037 098/1GA

Key Words: Ground shock, Shock measurement, Measuring instruments

Analytical work aimed at establishing velocity gage emplacement procedures for ground-shock measurement is reported. Finite element calculations were performed using nonlinear, inelastic material models, in support of experiments at WES using artificial soil specimens in the Small Blast Load Generator. The investigations covered a wide range of borehole/free-field impedances under a variety of interface conditions.

77-1598
Dynamic-Stress-Data Management for Aeromechanical Testing of Turbomachinery

W.J. Rakowski

J-Projects Branch, Engine Test Facility, ARO, Inc., Arnold Air Force Station, TN 37389, Exptl. Mech., 17 (6), pp 207-212 (June 1977) 7 figs, 4 refs

Key Words: Test instrumentation, Turbomachinery

This paper reviews the evolution of on-line data-monitoring and posttest data-processing/analysis techniques that have been utilized at theArnold Engineering Development Center to support dynamic strain-gage test programs. The transition from hardwire single-channel analog analysis equipment to the incorporation of digital computers for aiding on-line data monitoring, bulk processing of test data, and rapid editing/analysis of test results is discussed. The present on-line monitoring and posttest processing/analysis systems are presented, and refinements for improving the on-line data monitoring and posttest data-processing capabilities are discussed.

TECHNIQUES

(Also see Nos. 1593, 1594, 1704)

77-1599

A New Procedure for the Measurement of Sound Transmission Loss

D.A. Bies and J.M. Pickles

Univ. of Adelaide, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 123-124 (Oct 11-12, 1976) 1 fig, 6 refs

Key Words: Sound transmission loss, Measurement techniques

A new procedure for measuring transmission loss is presented that can be applied to any test item, including apertures. The use of an aperture is suggested as a convenient standard test item of known transmission loss for checking the accuracy of any particular test procedure and test facility. Criteria are presented that define measurement limits within which accurate estimation of transmission loss can be expected from existing or proposed test chambers.

77-1600

Aging of Adhesive Metal Joints. Part 1: Torsional Vibration Tests of Adhesive Substances after Climate Exposure (Alterung von Metallklenverbindungen. Teil 1: Torsionsschwingungsversuche an Klebstoffsubstanzen nach Klimaeinwirkungen)

W. Althof and H. Schlothauer

Deutsche Forschungs- und Versuchsanstalt fuer Luft- und Raumfahrt. Brunswick, W. Germany, Rept. No. DLR-IB-152-75/02-Pt-1, 36 pp (24 Feb 1975)

(In German)

N77-20516

Key Words: Testing techniques, Torsional vibration, Adhesives, Joints

Several adhesives were exposed to climatic conditions for a long period. The changes in the substances were determined by means of torsional vibration tests. This information will be used as a reference in tests with adhesive joints.

COMPONENTS

SHAFTS

77-1601

The Effective Flexural Stiffness of Shouldered Rods and Shafts (Zur effektiven Biegesteifigkeit von abgesetzten Stäben und Wellen)

H. Bauerhop

Kraftwerk-Union, Erlangen, W. Germany, Konstruktion, 28 (2), pp 45-51 (Feb 1976) 17 figs, 1 table, 6 refs

(In German)

Key Words: Rods, Shafts, Stiffness Coefficients

For a dynamic investigation of structures it is often sufficient to regard the continuum as one-dimensional. However, even though many calculation methods are based on this simplification, the assumption is not valid for variable cross section designs. Since for many cross sectional variations, the usual computation by means of the 45 degree rule produces only insignificant stiffness values, a new improved method is proposed.

BEAMS, STRINGS, RODS, BARS

(Also see Nos. 1538, 1560, 1601, 1664, 1647)

77-1602

Dynamics Analysis of a Flexible Vehicle -- Flexible Guideway System with Random Guideway Roughness Input

D.B. Cherchas and J.D. Jackson

Dept. of Mech. Engrg., Univ. of Toronto, Canada, High-Speed Ground Transp. J., 11 (1), pp 19-51 (Spring 1977) 13 figs, 13 refs

Key Words: Interaction: vehicle-guideway, Beams, Bernoulli-Euler method, Surface roughness

A technique is developed for analyzing the coupled dynamics of a two-dimensional high speed guided ground vehicle system consisting of a flexible vehicle propelled along a single-span, flexible guideway. Both vehicle and guideway are treated as Bernoulli-Euler beams, the former in free-free configuration and the latter with simple, rigid end supports.

A modal analysis technique is implemented to calculate their respective transverse flexural motions. The analysis provides for the incorporation of any number of transverse, flexural modes for the vehicle and guideway. Vehicle aerodynamic drag force is also included in the system model.

77-1603

Approximation Solution for the Deflection of a Beam under a Series of Moving Loads (Näherungslösung für die Durchsenkungen eines Balkens under einer Folge von wandernden Lasten)

K. Popp

Lehrstuhl B für Mechanik, T.U. München, Arcisstrasse 21, D-8000, München 2, BRD, Ing. Arch., 46 (2), pp 86-95 (1977) 6 figs, 1 table, 6 refs

(In German)

Key Words: Beams, Moving loads, Approximation methods

An analytical approximation is presented for the deflections of a beam under a sequence of equal and equally spaced moving loads. The comparison with numerical simulation results shows an excellent agreement. The efficiency of the method is demonstrated by an explicitely solved special case.

77-1604

Design Curves for Structural Response Due to Impact Loading

P.C. Chou and W.J. Flis

Drexel Univ., Philadelphia, PA, Rept. No. NADC-76380-30, 74 pp (Oct 1976)

AD-A037 011/4GA

Key Words: Beams, Impact response, Composite materials

A method is developed to produce a design curve for predicting the response of a given type of structure to impact loading. This curve gives the maximum strain in the structure, which may have various size and material properties, due to impacts involving different masses and velocities. An example of a simply supported beam under central impact is presented in detail. Both experimental results and numerical calculations were used in establishing the design curve.

77-1605

The Vibration of Beams of Fibre Reinforced Material

L.S. Teoh and C.C. Huang

Dept. of Mech. Engrg., Univ. of Western Australia, Nedlands, Western Australia 6009, Australia, J. Sound Vib., 51 (4), pp 467-473 (Apr 22, 1977) 3 figs, 10 refs

Key Words: Beams, Composite materials, Natural frequencies, Mode shapes

This paper presents a theoretical analysis of the vibrations of fibre reinforced, composite beams. In the analysis, a continuous model is used and both shear and rotatory inertia are included. An illustrative example is worked out to show the effect of shear deformation and fibre orientation.

77-1606

Pre-Twisted Beam Elements Based on Approximation of Displacements in Fixed Directions

E. Dolumaci

Dept. of Mech. Engrg., Ege Univ., Bornova, Izmir, Turkey, J. Sound Vib., 52 (2), pp 277-282 (May 22, 1977) 1 fig, 1 table, 4 refs

Key Words: Beams, Cantilever beams

A pre-twisted beam element based on approximation of displacements in fixed directions is presented. This element can represent the rigid body modes correctly and gives a considerably faster speed of convergence than the element based on approximation of displacements in the principal directions for the same order of complete polynomial displacement field.

77-1607

Probabilistic Response of Beams and Frames

F. Ellyin and P. Chandrasekhar

Structures and Solid Mechanics Section, Dept. of Civ. Engrg., Univ. de Sherbrooke, Sherbrooke, Canada, ASCE J. Engr. Mech. Div., 103 (EM3), pp 411-421 (June 1977)

Key Words: Beams, Frames, Reinforced concrete, Probability theory, Monte Carlo method

This paper presents a method for evaluating the probabilistic dynamic response (distribution of natural frequencies and amplitudes) of reinforced concrete beams and frames. It considers the statistical variation of material properties, geometric parameters, and exciting force. The basic dependent variables that are considered probabilistic are individual geometric parameters, the area of reinforcement and strengths of materials. The dependent variables that are of statistical nature are dynamic modulus of elasticity of concrete, moments of inertia, and areas. The Monte Carlo simulation is used to generate the distribution of the dependent variables from that of the independent parameters. Examples covering a wide range of geometric and load parameters are considered for both beams and frames. Distribution of natural frequencies and response amplitudes are calculated by a specially developed computer program. The results are then reviewed from the practical point of view.

77-1608
Dynamic Response of Bars Subjected to Longitudinal Impact -- An Experimental Approach

Y.E. Hassan and K.E. Machin
Dept. of Mech. Engrg., Univ. of New Brunswick, Fredericton, N.B., Canada, Intl. J. Mech. Sci., 19 (1), pp 23-28 (Jan 1977) 7 figs, 1 table, 13 refs

Key Words: Bars, Axial excitation

The response of structure to shortduration impact is studied experimentally by employing explosively induced stress pulses in long aluminum bars containing central circular holes. The amplitude of the strain is measured in all cases. The effect of the direction of loading on the existing strain is also studied.

77-1609
Elastic Waves in Heterogeneous Bars of Varying Cross-Section

P. Gordon and S.C. Sanday
Materials Engrg. Div., Frankford Arsenal, Philadelphia, PA, J. Franklin Inst., 303 (2), pp 129-145 (Feb 1977) 10 figs, 11 refs

Key Words: Bars, Variable cross-section, Elastic waves, Wave propagation, Method of characteristics, Laplace transformation

The propagation of elastic waves in a heterogeneous bar of variable cross-sectional area is investigated via use of the method of characteristics and the Laplace transform technique. The Young's modulus and density are assumed to be representable as either power law or exponential distributions in the axial coordinate. The transform method is used to establish an infinite number of multi-parameter solutions in closed form for either a stress, velocity or displacement type boundary condition.

77-1610
Simulating Piston Slap by an Analogue Computer

S.D. Haddad and P.W. Fortescue
Inst. of Sound and Vib. Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 52 (1), pp 79-93 (May 8, 1977) 14 figs, 9 refs

Key Words: Pistons, Impact response, Mathematical models

Piston slap at TDC has been simulated on an analog computer. The mathematical model is based upon elastic impact between point masses. Sliding contact is accommodated. Extrapolation by computer to other conditions shows the behavior pattern is sensibly unchanged. For the behavior pattern shown a simplified analytic model may be used based upon the side force history after TDC only.

77-1611
The Dynamic Behaviour of Stiffened Strings

M.G. Faulkner, A. Mioduchowski, and J.S. Kennedy
Dept. of Mech. Engrg., The Univ. of Alberta, Edmonton, Alberta, T6G 2E1, Canada, Ing. Arch., 46 (2), pp 97-103 (1977) 10 figs, 8 refs

Key Words: Strings, Natural frequencies

The small oscillation of a stiffened string about its static equilibrium configuration is studied. The solution requires both the static and dynamic shape of the rod to be determined and since the governing equations do not lend themselves to an analytical solution a Runge-Kutta integration technique was used. Experimental results for the natural frequencies are compared to the numerical solution for a particular stiffened string.

77-1612
Harmonically Forced, Finite Amplitude Vibration of a String

G. Tagata
Nippon Gakki Co., Ltd., 10-1, Nakazawa-Cho, Hamamatsu, Japan, J. Sound Vib., 51 (4), pp 483-492 (Apr 22, 1977) 6 figs, 5 refs

Key Words: Strings, Harmonic excitation

For the so-called parametric oscillation of a string fixed at one end and driven harmonically in its axial direction from the other end, analysis and numerical calculations are carried out to determine how the amplitude characteristic changes in the first, second and third unstable regions when the applied frequency is successively lowered, with account being taken of the non-linear term arising from the correction of the local elongation due to the tension of the string. The results are in good qualitative agreement, with experimental values.

77-1613
Experimental and Simulation Studies of Transmission Line Vibration

J.M. Simmons, R.J. Hooker, and R.H. Frith
Dept. of Mech. Engrg., Univ. of Queensland, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 11-15 (Oct 11-12, 1976) 9 figs, 14 refs

Key Words: Transmission lines, Fluid-induced excitation, Wind-induced excitation, Vortex shedding

Overhead electrical transmission lines experience serious vibration due to vortex-shedding excitation. An assessment is made of the overall dynamic situation. Experiments have been performed on an actual line and a hybrid computer study has been made. The results and implications of these studies, which represent initial stages in a long term study, are presented and discussed.

77-1614

Experimental Studies of Fatigue Failures of Down Lead Cables

C.V. Chelapati, J.M. Plecnik, and J. Cunningham
Dept. of Civil Engrg., California State Univ., Long Beach, CA, Rept. No. CEL-CR-77.010, 34 pp (Dec 1976)
AD-A037 164/1GA

Key Words: Cables, Dynamic tests, Fatigue life

Eight hard drawn copper cables were tested to failure under static lateral axial load and either dynamic lateral load or torsional couple. Due to the large number of test parameters involved and the limited number of specimens tested, firm conclusions cannot be drawn about the fatigue life of copper cables under dynamic lateral or torsional loading combined with axial tension.

BEARINGS

(Also see Nos. 1541, 1632)

77-1615

Effect of Bearings on the Running Stability of Rotors with Groove Excitation (Einfluss der Lagerung auf die Laufstabilität einfachen Rotoren mit Spalterregung)

R. Wohlrab
Konstruktion, 28 (12), pp 473-478 (Dec 1976) 14 figs, 6 refs
(In German)

Key Words: Bearings, Stability, Self-excited vibrations

From time to time, in thermal turbomachinery bearings, power dependent self-excited vibrations, caused by grooves, are observed. Equations of motion for a symmetrically engaged, elastically mounted, damped Laval shaft are set up. By solving the differential equations of vibration system damping as a characteristic quantity of stability is obtained. Starting with a set up of a practically stiff shaft the effect of bearings on the damping of the system, independently of system excitation, is investigated.

77-1616

Vibration Isolation Using Pressurized Squeeze Film Bearings

S. Simandiri and E.J. Hahn
School of Mech. & Industrial Engrg., Univ. of New South Wales, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 51-55 (Oct 11-12, 1976) 13 figs, 1 table, 6 refs

Key Words: Squeeze film bearings, Vibration isolation, Noise reduction, Rotors

Hydrodynamic squeeze film bearing mounts, sufficiently pressurized to ensure full film lubrication, are a practical means of obtaining vibration isolation and noise reduction in high speed rotating machinery, running in rolling element bearings. This paper investigates the beneficial effect of using such mounts.

77-1617

Calculation of the Dynamic Behavior of a Hydrostatic Spindle-Bearing System by Means of a Digital Computer (Berechnung des dynamischen Verhaltens hydrostatischer Spindel-Lager-Systeme auf Digitalrechneranlagen)

W. Miessen
Das Lehrstuhl f. Werkzeugmaschinen am Laboratorium f. Werkzeugmaschinen u. Betriebslehre der RWTH Aachen, Konstruktion, 28 (7), pp 275-281 (July 1976) 8 figs
(In German)

Key Words: Computer programs, Bearings, Hydrostatic bearings, Machine tools

The static and dynamic behavior of a metal cutting machine is decisively influenced by the properties of the spindle-bearing system. Besides the ball bearings and friction bearings, the importance of hydrostatic bearings for metal cutting machines has been growing. Since the characteristics of a spindle-bearing system may be controlled in the design and construction stages, a calculation method had to be developed. The method described takes bearing damping into consideration and is applicable, in principle, to any desired bearing. However, since the digital computer program is based on experiment, it was written for a spindle system with hydrostatic bearings.

77-1618

Properties of Tilt-Segment Radial Bearings (Die Eigenshaften von Kippsegment-Radiallagern)

R. Klump

Institut f. Maschinenkonstruktionslehre d. Univ. Karlsruhes (TH), Konstruktion, 28 (8), pp 320-324 (Aug 1976) 10 figs, 6 refs

(In German)

Key Words: Friction bearings, Stability, Lubrication, Damping coefficients, Springs (elastic)

Theoretical and experimental results of tilt segment-friction bearings are investigated. Besides the stationary bearing properties such as load capacity, temperature and the lubricant groove, particular emphasis is placed on vibration and damping coefficients by means of spring and damping coefficients. A clear measure for this is the system damping of a symmetric one mass rotor. The author shows that a change in the given lubricant groove shape caused by temperature fluctuations during the operation may lead to considerable changes in bearing properties. The stability of tilt segment bearings decreases with increasing relative inertia forces of the vibrating segments.

77-1619

Critical Speeds of Cylindrical Radial Friction Bearings (Die Übergangsdrehzahl von zylindrischen Radialgleitlagern)

H. Ott and E. Wenig

Institut f. Grundlagen d. Maschinenkonstru an der ETH Zürich, Konstruktion, 28 (8), pp 301-306 (Aug 1976) 7 figs, 10 refs

(In German)

Key Words: Critical speeds, Friction bearings, Lubrication

Critical speeds at various bearing clearances, oil temperatures, and loads were measured on a special test stand for radial friction bearings. From the elastomeric lubricant groove calculations, the theoretical minimum lubricant groove width was obtained. They were associated with the measured critical speeds. The elastic deformations of the contact surfaces are of the same order of magnitude as the minimum lubricant groove width. From the experimental results a simple iterative method for the prediction of critical speeds is derived which takes into consideration the geometry of the bearing, its operating data, and the elastic deformations of its contact surfaces.

77-1620

Calculation of Intermittently Loaded Friction Bearings (Beitrag zur Berechnung instationär belasteter Axial-Gleitlager)

J. Fricke

Inst. f. Reibungstechnik u. Maschinenkinetik der T.U. Clausthal, Konstruktion, 28 (3), pp 97-102 (Mar 1976) 9 figs, 7 refs

(In German)

Key Words: Friction bearings

For the calculation of load capacity and groove width of nonsteady loaded bearings the pressure development in the lubricant groove as a result of rotation, pressure generation caused by lubricant displacement should be taken into consideration. In this article load capacities of various groove shapes under pure displacement are discussed. A calculation procedure for the determination of groove width time slope for nonsteady loaded axial bearings is illustrated through two examples.

CYLINDERS

77-1621

On Vibrations Due to Vortex Shedding Induced on Two Cylinders with One in the Wake of the Other

G. Diana, M. Falco, and M. Gasparetto

Instituto di Meccanica e Costruzione di Macchine - Politecnico di Milano, Italy, Meccanica, 11 (3), pp 140-156 (Sept 1976) 35 figs, 12 refs

Key Words: Cylinders, Fluid-induced excitation, Vortex shedding

This paper reports on research concerning the vibrations induced on cylinders by the vortex shedding. The main purpose of the present paper is to describe the experimental results obtained on two cylinders, one in the wake of another, both vibrating. Many cases are considered either with equal or different frequencies. An analytical model simulating the phenomenon is developed, the analytical results obtained are reported and compared with the experimental ones.

DUCTS

77-1622
On the Singular Behavior of Linear Acoustic Theory in Near-Sonic Duct Flows
M.K. Myers and A.J. Callegari
Joint Inst. for Advancement of Flight Sciences, The George Washington Univ., NASA Langley Res. Ctr., Hampton, VA 23665, J. Sound Vib., 51 (4), pp 517-531 (Apr 22, 1977) 5 figs, 11 refs

Key Words: Ducts, Sound propagation

The propagation of sound in a converging-diverging duct containing a quasi-one-dimensional steady flow with a high subsonic throat Mach number is studied. The behavior of linearized acoustic theory at the throat of the duct is shown to be singular, and the explicit form of the singularity is determined for two special types of area variation. Numerically computed results showing the development of the singularity are presented.

77-1623
Noise Attenuation in Ducts with Flow
D.A. Bies and M. Zockel
Univ. of Adelaide, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 16-19 (Oct 11-12, 1976) 5 figs, 5 refs

Key Words: Ducts, Fluid-induced excitation, Noise reduction

Evidence is reviewed here to show that quite large attenuation rates are possible in a dissipative muffler provided that all parameters including duct width, liner impedance, and flow Mach number are properly chosen. In general, the required dimensions are not difficult to meet though it must again be admitted that the required backing cavity depth at low freqeuncies will be of the order of a quarter wavelength at the frequency of maximum attenuation.

77-1624
The Real Attenuation Performance of Air Conditioning Duct Liners
L.A. Challis and I. Lawrence
Louis A. Challis and Assoc. Pty. Ltd., Consulting Acoustical Engineers, Sydney, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 99-100 (Oct 11-12, 1976) 4 figs, 5 refs

Key Words: Air conditioning equipment, Ducts, Noise reduction, Acoustic linings

This paper presents the results of a sponsored research project aimed at determining the insertion loss achievable by various lengths of duct liner with a range of thicknesses, duct sizes, and erosion resistant surfaces conventionally used by the air conditioning industry.

FRAMES, ARCHES

(Also see No. 1607)

77-1625
Structural Stiffness, Strength and Dynamic Characteristics of Large Tetrahedral Space Truss Structures
M.M. Mikulas, Jr., H.G. Bush, and M.F. Card
NASA, Langley Res. Ctr., Langley Station, VA, Rept. No. NASA-TM-X-74001, 50 pp (Mar 1977) N77-19487

Key Words: Trusses, Stiffness, Spacecraft, Dynamic properties

Physical characteristics of large skeletal frameworks for space applications are investigated by analyzing one concept: the tetrahedral truss, which is idealized as a sandwich plate with isotropic faces. Appropriate analytical relations are presented in terms of the truss column element properties which for calculations were taken as slender graphite/epoxy tubes. Column loads, resulting from gravity gradient control and orbital transfer, are found to be small for the class structure investigated. Fundamental frequencies of large truss structures are shown to be an order of magnitude lower than large earth based structures. Permissible loads are shown to result in small lateral deflections of the truss due to low-strain at Euler buckling of the slender graphite/epoxy truss column elements. Lateral thermal deflections are found to be a fraction of the truss depth using graphite/epoxy columns.

GEARS

(Also see No. 1585)

77-1626
Noise Control in Planetary Transmissions
W.E. Palmer and R.R. Fuehrer
Detroit Diesel Allison, Div of General Motors Corp., SAE Paper No. 770561

Key Words: Power Transmission systems, Noise reduction, Gears

Noise generated by vehicles has become of increasing concern, in recent years, in its effect both inside and outside the vehicle. Although the noise contributed by heavy-duty automatic transmissions in on- and off-highway vehicles is insignificant in relation to that generated by other vehicle components, a program was initiated to investigate sources and causes of transmission noise and to develop methods of reducing or eliminating that noise.

77-1627

Meaning and Determination of Operational Factors for the Design of High Capacity Drives (Bedeutung und Ermittlung von Betriebsfaktoren fur die Auslegung von Leistungsgetrieben)

H. Gross

Fertigungstechnik Metal der Fa Degussa, Frankfurt, W. Germany, Konstruktion, 28 (3), pp 85-89 (Mar 1976) 8 figs, 16 refs

(In German)

Key Words: Gears, Couplings, Design techniques

Highly loaded drive elements such as gears and couplings very often are designed with the help of operational factors. However, there are numerous interpretations of their meaning. The VDI Standard 2151 proposes to view the operational factor as a value, which ties together nominal torque, the loading and the dynamic load capacity of the drive. For this, bearing life calculations are needed. The article explains this concept and provides with information on questions, which were left open in the standard. Finally, by means of an example, it is demonstrated that the determination of operational factors on the basis of bearing life calculations is worthwhile.

77-1628

Calculation of Natural Frequencies of Several Vibration Models of Cam Gears with a Sliding Drive Element (Berechnung der Eigenkreisfrequenzen einiger Schwingungsmodelle für Kurvengetriebe mit geradgeführtem Abriebslied)

H. Kerle

Konstruktion, 28 (11), pp 423-428 (Nov 1976) 6 figs, 3 tables, 23 refs

(In German)

Key Words: Natural frequencies, Mathematical models, Cam gears

The calculation of natural frequencies of cam gears leads to the transformation of real systems into the modeling sphere. However, there is no systematic way to determine how many degrees of freedom are required for this model. In an example, the numerical results of four qualitatively different models of cam gears with slide drive elements (rams) are investigated and by means of a calculation judgment criteria are developed for defining the so-called minimal models.

77-1629

Combined Laws for Stationary and Reverse Positions (Kombinationsgesetze für Bewegungen mit Rast- und Umkehrlagen)

E. Petersen

Lehrstuhl u. Institut f. Maschinenbauelemente B u. Getriebetechnik d.T.U. Hannover, W. Germany, Konstruktion, 28 (3), pp 90-96 (Mar 1976) 8 figs, 2 tables, 16 refs

(In German)

Key Words: Cams

There is a large body of literature describing the motions of cam drives with two or more stationary positions. The laws of motion treated in the article are useful when stationary and reverse positions have to be tied together and small accelerations and/or good running properties are required. The three combined laws -- presented as normalized motion and characteristic value equation -- contain a parameter which determines the reversing point position, through which the required reverse accelerations or other secondary conditions may be maintained. The laws are compared, evaluated and their application is described in an example.

ISOLATORS

77-1630

The Mechanism for Bending Moment Transfer in Slip Joints

N. Häusler

Konstruktion, 28 (3), pp 103-108 (Mar 1976) 16 figs, 1 table

(In German)

Key Words: Slip joints

A method of calculation based on the finite element technique is developed, which enables the calculation of the load-dependent relative displacements and contact stresses between the shaft and the hub in a press fit of a slip joint under a flexural load. From the derived stresses and deflections the author explains the mechanism of bending transfer and gives recommendations for the design of alternating and rotationally loaded slip joints. Measurements on slip joints confirm calculated relative displacements.

LINKAGES

(Also see Nos. 1577, 1627)

77-1631

An Harmonic Analysis of the Motion and Kinetic Energy of Unsymmetric Elliptic Slider Mechanisms

W. Meyer zur Capellen

Forsch. Ingenieurw, 42 (1), pp 8-22 (1976) 11 figs, 7 refs

Key Words: Slider crank mechanisms, Harmonic analysis

When studying the dynamics of a (six-link) slider crank driven by the coupler-point of a double-slider (thus an elliptically driven slider linkage) for which the ellipse was tall and narrow, the Fourier series of the kinetic energy was used. The expressions derived for the Fourier coefficients can be clearly arranged and are simple and complete.

77-1632

A Determination of Contact-Loss at a Bearing of a Linkage Mechanism

C.L.S. Wu and S.W.E. Earles

Ford Motor Co., J. Engr. Indus., Trans. ASME, 99 (2), pp 375-380 (May 1977) 9 figs, 1 table, 9 refs

Key Words: Linkages, Bearings, Dynamic response, Kinematics

A method is described for analyzing the kinematic and dynamic response of a linkage mechanism in which one bearing has a known clearance. Assuming the clearance to be represented be a massless link, the analysis predicts the occurrence of contact-loss. Part of an extensive experimental investigation is presented in which the impact accelerations resulting from contact-loss are measured. A good correlation is shown to exist between the predicted and measured time of contact-loss. Although the analysis may predict no contact-loss, it does not readily indicate, from a design poing of view, how this condition could be produced.

77-1633

A New Constant Velocity Coupling

V. Milenkovic

GATX/GARD, Inc., Niles, IL, J. Engr. Indus., Trans. ASME, 99 (2), pp 367-374 (May 1977) 8 figs, 6 refs

Key Words: Couplings

A constant velocity coupling has been developed that does not resemble any coupling built before. It was intended for a specialized application, with specifications that are outside the range of any existing designs. A kinematic model as well as a subscale prototype have been constructed, and the latter was successfully tested. The principles of the coupling are discussed in some detail, with emphasis on their kinematic aspects. The formal proof for the constancy of the velocity ratio of this coupling is presented.

77-1634

Diaphragm Couplings Challenge Disk and Gear Types for High Torque

Product Engr. (N.Y.), 48 (6), pp 33-35 (June 1977)

Key Words: Flexible couplings

In this article, the design and mechanical properties of the diaphragm couplings are described. Their application is illustrated by a practical example.

77-1635

Unconventional Thread Form Holds Nut to Bolt During Severe Vibrations

Product Engr. (N.Y.), 48 (6), pp 11-12 (June 1977)

Key Words: Bolts, Thread cutting

A new thread that resists vibrations more effectively than others, known as Spiralock, is now available. The thread is being used in a free-spinning, flanged nut, to eliminate internal self-loosening, the cause of walk-off. The thread form incorporates a wedge ramp at the root of the thread created by widening a portion of the normal thread angle at its root. This produces a metal-to-metal contact over mating thread length. The result is a firmer grip.

MECHANICAL

(Also see No. 1541)

77-1636

Calculation of Intermittent Stresses in Nonlinear and Play-Restricted Machine Units (Berechnung der instationären Beanspruchungsgrössen von nichtlinearen und spielbehafteten Maschinenanlagen)

Chr. Troeder and H. Peeken

Institut für Maschinenbauelemente und Maschinengestaltung der RWTH, Aachen, Germany, Konstruktion, 28 (4), pp 129-137 (Apr 1976) 18 figs, 1 table, 3 refs (In German)

Key Words: Machine elements, Damping

A method of calculation is described, which enables stress determination in machine units mounted arbitrarily on structural components. The case of intermittent run-up, as well as in the stationary operations are treated. By this method the effects of clearance, as well as the nonlinear elasticity and damping are determined. The numerous examples give an idea of the capability of the method. Theoretical results agree well with the experimental results.

MEMBRANES, FILMS, AND WEBS

(Also see No. 1560)

77-1637

Low Wavenumber Wall Pressure Measurements Using a Rectangular Membrane as a Spatial Filter

N.C. Martin and P. Leehey
Acoustics and Vibration Lab., Massachusetts Inst. of Tech., Cambridge, MA 02139, J. Sound Vib., 52 (1), pp 95-120 (May 8, 1977) 17 figs, 5 tables, 19 refs
Sponsored by the Sonar Tech. Div., Naval Sea Syst. Comm. and Sensor Technol. Program Office of Naval Research

Key Words: Rectangular membranes, Random excitation

The response of a rectangular membrane to a convecting random pressure field is interpreted to reveal the inherent wavenumber filtering characteristics of the device. After experimental determination of its resonant response characteristics, one such membrane is used to measure the low wavenumber components of the wall pressure fluctuations beneath a plane turbulent boundary layer.

77-1638

Relationship Between the Fundamental Frequency and the Static Response of Elastic Systems

C. Sundararajan
Foster Wheeler Energy Corp., Livingston, NJ 07039, J. Sound Vib., 51 (4), pp 493-499 (Apr 22, 1977) 6 tables, 4 refs

Key Words: Natural frequencies, Boundary value problems, Plates, Membranes

An approximate relationship between the fundamental frequency and the static response of undamped, linearly elastic systems is derived. The relationship is used to calculate the fundamental frequencies of membranes and plates of different geometries and boundary conditions.

PANELS

(Also see No. 1552)

77-1639

Nonlinear Analysis of Reinforced Concrete Panels, Slabs and Shells for Time Dependent Effects

A.F. Kabir
Div. of Structural Engrg. and Structural Mechanics, California Univ., Berkeley, CA, Rept. No. UCSESM-76-6, 250 pp (Dec 1976)
PB-264 116/5GA

Key Words: Panels, Slabs, Shells, Reinforced concrete, Dynamic response

A numerical method of analysis is developed to trace the quasistatic responses of various types of reinforced concrete structures, of practical interest, under sustained load conditions. Time-dependent environmental phenomena, such as creep and shrinkage effects, are considered to obtain the evolution of the field variables of such structures in elastic and inelastic regimes. Ultimate collapses of shear panels, slabs of arbitrary geometry and free-form shell-type structures are then predicted considering local failures in steel and concrete along with the deterioration of structure stiffness due to progressive cracking.

PIPES AND TUBES

77-1640

Effects of Internal Flow Disturbance on Acoustic Radiation from Pipes

M.K. Bull and M.P. Norton
Univ. of Adelaide, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 61-65 (Oct 11-12, 1976) 4 figs, 5 refs

Key Words: Pipes, Vibration response, Noise generation, Fluid-induced excitation

Spectral measurements of the acceleration response of and acoustic power radiated from a steel pipe with fully-developed internal turbulent air-flow, at a distance of about 50 diameters downstream of various bends, are presented. The data are for flow Mach numbers from about 0.2 to about 0.5.

77-1641
Turbo-Generator Loop Pipe Vibration Problem
R.W. McLeod and I.A. Charity
State Electricity Commission of Victoria, Australia, Vibration and Noise Control Engineering, Prodeedings, Sydney Australia, pp 113-114 (Oct 11-12, 1976) 4 figs

Key Words: Pipelines, Steam generators, Vibration damping

This case study describes the investigations into the cause of a severe vibration problem of the pipes connecting the steam chests and nozzle box of a 120 MW turbo-generator and the solution.

77-1642
Transients in Tubes Containing Liquids
N. Krause, W. Goldsmith, and J.L. Sackman
F.M.C. Associates, San Francisco, CA, Intl. J. Mech. Sci., 19 (1), pp 53-68 (Jan 1977) 14 figs, 2 tables, 10 refs

Key Words: Tubes, Fluid-filled containers, Hopkinson bar technique

An experimental investigation of the elastic and fluid pressure waves produced by the longitudinal impact of steel strikers on tubes filled with water was performed by means of a modified Hopkinson pressure bar technique. The tubes employed consisted of aluminum and acrylic plastic with three different wall thicknesses.

PLATES AND SHELLS

(Also see Nos. 1538, 1638, 1639, 1716)

77-1643
Dynamic Response of Axisymmetric Elastic-Plastic Structures
W.H. Caldwell-Johnson
Ph.D. Thesis, Wayne State Univ., 86 pp (1976)
UM 77-9377

Key Words: Cylindrical shells, Transient excitation

This thesis is concerned with the determination of the strains and displacements in axisymmetric thin cylindrical shells (or any structural element generated therefrom) subjected to transient axisymmetric loads.

77-1644
Vibrations of Stiffened Cylinders with Cutouts
Mahabaliraja, D.E. Boyd, and R.L. Brugh
School of Mech. and Aerospace Engrg., Oklahoma State Univ., Stillwater, OK 74074, J. Sound Vib., 52 (1), pp 65-78 (May 8, 1977) 9 figs, 6 tables, 11 refs
Sponsored by the Ballistics Res. Labs., U.S. Dept. of Army, Aberdeen, MD

Key Words: Beams, Cylindrical shells, Hole-containing media, Natural frequencies, Mode shapes

An approximate method of determining the free vibration characteristics of ring and/or stringer-stiffened cylindrical shells with cutouts is presented in this paper. The method is based on the Rayleigh-Ritz technique in which beam characteristics functions (axially) and trigonometric functions (circumferentially) are used in the displacement series for the shell reference surface.

77-1645
Dynamic Behaviour of a Cylindrical Shell with a Cutout
V. Ramamurti and J. Pattabiraman
Dept. of Applied Mech., Indian Inst. of Tech., Madras 600036, India, J. Sound Vib., 52 (2), pp 193-200 (May 22, 1977) 5 figs, 2 tables, 17 refs

Key Words: Cylindrical shells, Hole-containing media, Natural frequencies, Mode shapes, Iteration

This paper presents the results of analytical and experimental investigations connected with the dynamic behavior of a cylindrical shell with a rectangular cutout. The finite element method is used to predict the vibration frequencies and mode shapes. The resulting eigenvalue problems are solved by using a simultaneous iteration technique.

77-1646
Effects of Internal and External Flow on the Vibration Characteristics of Anisotropic Cylindrical Shells
A.A. Lakis
Dept. de Genie Mecanique, Ecole Polytechnique, Montreal (Quebec) Canada, Rept No. EP-77-R-11, 58 pp (Feb 1977)
N77-20515

Key Words: Cylindrical shells, Fluid-induced excitation

A general theory for the dynamic analysis of anisotropic thin cylindrical shells containing turbulent flowing fluid is presented. The shell may be uniform or non-uniform, provided it is geometrically axially symmetric. This is a finite-element theory, using cylindrical finite elements, but the displacement functions are determined by using classical shell theory.

77-1647

Forced Response of Neutrally Buoyant Inflated Viscoelastic Cantilevers to Ocean Waves

V.J. Modi and D.T. Poon
Dept. of Mech. Engrg., The Univ. of British Columbia, Vancouver, British Columbia V6T 1W5, Canada,
J. Sound Vib., 52 (1), pp 51-63 (May 8, 1977) 6 figs, 13 refs

Key Words: Shells, Cantilevers, Floating structures, Inflatable structures

The dynamics of the neutrally buoyant inflated viscoelastic cantilevers constituting a submarine detection system is investigated. Thin shell theory is used to account for the stresses arising due to the internal pressure. A significant feature of the analysis is the use of the reduced shell equation which is similar in form to that for a vibrating beam with rotary effects. The forcing function in the form of surface wave excitation consists of a fundamental frequency and its second harmonic.

77-1648

Dynamic Behaviour of Thin, Ring-Reinforced, Cylindrical Shells Subjected to Impulsive Inner Loads

S.I. Suzuki
Dept. of Aeronautics, Nagoya Univ., Chikusa-ku, Nagoya, Japan,
J. Sound Vib., 51 (4), pp 459-466 (Apr 22, 1977), 6 figs, 7 refs

Key Words: Cylindrical shells, Internal pressure, Dynamic response

Stress analysis is carried out for the case where a thin cylindrical shell reinforced with a ring at its mid-point is subjected to impulsive inner pressures. The relationships between the maximum dynamic stresses, the dimensions of the cylinder and the ring are obtained. The fundamental equation of motion of the cylinder is solved by the Laplace transformation method.

77-1649

Vibrations and Dynamic Response of Viscoelastic Plates on Nonperiodic Elastic Supports

K. Nagaya
Dept. of Mech. Engrg., Yamagata Univ., Jyonan, Yonezawa, Japan,
J. Engr. Indus., Trans. ASME, 99 (2), pp 404-409 (May 1977) 6 figs, 15 refs

Key Words: Plates, Viscoelastic properties, Elastic foundations, Mathematical models

This paper discusses the vibration and transient response problems of nonperiodically elastic supported viscoelastic continuous plate. The three-element viscoelastic model is adopted in the analysis. The solution for the plate is obtained from the correspondence principle by applying the Laplace transform to the constitutive equation and the equation of motion for the elastic plate. Expressions of displacements and bending moments for an impact load are obtained, and the results for the viscoelastic plate are compared with those for the elastic plate.

77-1650

Vibration and Acoustic Radiation of Elastically Supported Rectangular Plates

N.S. Lomas and S.I. Hayek
COMSAT Laboratories, Clarksburg, MD 20734,
J. Sound Vib., 52 (1), pp 1-25 (May 8, 1977) 11 figs, 2 tables, 7 refs

Key Words: Rectangular plates, Elastic foundations, Coupled response

A Green function solution is developed for the steady-state vibrations of an elastically supported rectangular plate coupled to a semi-infinite acoustic medium. Rotational motion at the plate boundaries is controlled by continuous distributions of rotary springs. The solution takes the form of that for a simply supported rectangular plate. The coefficients are determined from systems of simultaneous algebraic equations that include the coupling due to non-homogeneous boundary conditions and the acoustic surface impedance. The solution is also extended to cover the case of an arbitrary load distribution and an expression is derived for the power balance in the coupled plate-fluid system. Results of a numerical evaluation of the modal coupling factors due to fluid loading are compared with low frequency approximations. Effects of the support conditions on the low frequency sound radiation from a plate are illustrated by an example.

77-1651

Static and Dynamic Behavior of Circular Plates of Variable Thickness Elastically Restrained Along the Edges

P.A.A. Laura, C. Filipich, and R.D. Santos

Inst. of Applied Mechanics, Naval Base Puerto Belgrano, Argentina, J. Sound Vib., 52 (2), pp 243-251 (May 22, 1977) 8 figs, 4 tables, 7 refs

Key Words: Circular plates, Variable cross section, Forced vibration

Simple polynomial approximations and a variational approach are used to solve a rather complex elasto-mechanics problem. It is assumed that the plate is elastically restrained against rotation and translation along the edge. The approach developed in the present paper allows for a unified solution of both free and forced vibration problems, the static situation being a special situation of the dynamic state.

77-1652

Shear and Rotatory Inertia Effects on Large Amplitude Vibration of Skew Plates

M. Sathyamoorthy

Dept. of Aeron. Engrg., Indian Inst. of Tech., Madras, 600036, India, J. Sound Vib., 52 (2), pp 155-163 (May 22, 1977) 3 figs, 6 refs

Key Words: Skew plates, Transverse shear deformation effects, Rotatory inertia effects

The large amplitude free flexural vibration of elastic isotropic skew plates is investigated, the effects of transverse shear and rotatory inertia being included. By use of Galerkin's method and the extended Berger approximation, solutions are obtained on the basis of an assumed vibration mode. The non-linear period vs. amplitude behavior is of the hardening type and the non-linear period is found to increase when the effects of transverse shear and rotatory inertia are considered in the analysis. The influence of these effects on aspect ratios and skew angles of thin and moderately thick skew plates is investigated both at small and large amplitudes.

RINGS

77-1653

Dynamic Behaviour of a Ring Subjected to Time-Dependent Fluid Pressures

S.I. Suzuki

Dept. of Aeron., Nagoya Univ., Chikusa-ku, Nagoya, Japan, Intl. J. Mech. Sci., 19 (1), pp 29-36 (Jan 1977) 6 figs, 5 refs

Key Words: Rings, Fluid-induced excitation, Periodic excitation

A dynamic stress analysis is carried out for a ring filled with a fluid subjected to the transient inner pressure resulting from an explosion in the vicinity of its center. The relationships between hydraulic pressures and stresses in a ring and time are investigated due to an impulsive force which is assumed to be a step function in time.

SPRINGS

(Also see No. 1549)

77-1654

Synthesis of Spring Parameters to Satisfy Specified Energy Levels in Planar Mechanisms

G.K. Matthew and D. Tesar

Dept. of Mech. Engrg., Univ. of Maryland, College Park, MD., J. Engr. Indus., Trans. ASME, 99 (2), pp 341-346 (May 1977) 4 figs, 24 refs

Key Words: Springs, Structural synthesis

The potential energy storage capabilities of linear springs are integrated with the nonlinear motion of mechanisms to provide approximation of desired counter-loading functions. The approximating function is required to be identical to the desired function at a number of precision points. The work is directly analogous to the algebraic form of kinematic synthesis, thus enabling an immediate conceptual grasp of those already familiar with kinematics.

77-1655

Synthesis of Spring Parameters to Balance General Forcing Functions in Planar Mechanisms

G.K. Matthew and D. Tesar

Dept. of Mech. Engrg., Univ. of Maryland, College Park, MD, J. Engr. Indus, Trans. ASME, 99 (2), pp 347-352 (May 1977) 8 figs, 4 tables, 7 refs

Key Words: Springs, Structural synthesis

The analytical formulation from a companion paper is extended to allow the concept of multiply separated positions to be applied to the spring-energy problem. A major change in perspective for mechanisms is accomplished by the ability to presume that the mechanism pre-exists. Heretofore it has always been necessary to deal with mechanisms on a positional basis where higher-order motion could not be considered without also including the location of the mechanism. The set of analytics applied to springs is not affected by ignoring positional information.

77-1656

Stability Boundaries of a Swinging Spring with Oscillating Support

G. Ryland, II and L. Meirovitch

Dept. of Engrg. Science and Mechanics, Virginia Polytechnic Inst. and State Univ., Blacksburg, VA 24061, J. Sound Vib., 51 (4), pp 547-560 (Apr 22, 1977) 7 figs, 10 refs

Key Words: Springs, Pendulums, Vibrating foundations

This paper is concerned with the motion of a flexible pendulum whose support oscillates harmonically along a vertical line. A simple computational procedure is developed which permits the calculation of large symmetric tridiagonal determinants. This procedure is used to compute combinations of system parameters for which periodic solutions are possible. Then periodic solutions are used to produce stability diagrams in a three-dimensional parameter space, where the stability diagrams can be regarded as three-dimensional Strutt diagrams.

STRUCTURAL

(Also see No. 1575)

77-1657

Life Prediction of Notched, Vibrating Structural Components by Means of Interpolation Method (Eine Interpolationsmethode für die Lebensdauervorhersage gekerbter, schwingend beanspruchter Bauteile)

K. Heckel and U. Kurth

Konstruktion, 28 (11), pp 443-446 (Nov 1976) 3 figs, 5 refs

(In German)

Key Words: Fatigue life, Structural components

A method for the estimation of life of vibrating, slightly notched structural members, based on Neuber's "macroscopic support effect" theory, is described. From the experimental stress cycle diagrams (Wöhler lines) of two differently notched specimen, a nonlinear deformation law is derived. It describes the cyclic deformation behavior of the entire range of life to fracture.

TIRES

77-1658

Traffic Noise - A Study of a Tyre/Road Noise Mechanism

S.E. Samuels

Australian Road Res. Board, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 66-70 (Oct 11-12, 1976) 8 figs, 3 tables, 6 refs

Key Words: Traffic noise, Tires

This paper deals with a basic study of what is believed to be the major mechanism of tire/road noise, namely the displacement and replacement of air trapped in the cavities between the tire tread and the road surface.

SYSTEMS

ABSORBER

77-1659

Variety of Cushioning Materials Absorb Impact, Energy and Shock

Product Engr. (N.Y.), 48 (5), pp 25-27 (May 1977) 3 figs

Key Words: Energy absorption, Packaging materials, Polyurethane resins, Foams, Bumpers

An elastomeric bumper system produced by the reaction injection process, named Davisorb, is described. The system is made up of a thin separately molded skin covering a system of foam energy-absorbing blocks mounted on a rigidly attached reinforcement or load transfer bar.

77-1660

Attenuation of Hydraulic Noise in Buildings by a Simple Energy Absorption Technique

T.B. Guy

Dept. of Mech. Engrg., Faculty of Military Studies, Univ. of New South Wales, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 129-130 (Oct 11-12, 1976) 4 figs, 3 refs

Key Words: Hydraulic equipment, Buildings, Energy absorption

A new method of hydraulic noise attenuation using an energy absorption technique is described and illustrated by its application to the problem of domestic water supply noise. The method is shown to be extremely effective in the suppression of pressure pulses and hydraulic noise over a wide pressure range.

NOISE REDUCTION

(Also see Nos. 1542, 1545, 1623, 1624, 1660, 1691, 1699, 1701)

77-1661
The Noise of Three Types of Pneumatic Motor

V. Mason and R.J. Hooker

Sugar Research Inst., Mackay, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 135-136 (Oct 11-12, 1976) 1 fig, 2 tables

Key Words: Pneumatic equipment, Noise reduction

The noise output and mechanical performance characteristics of three types of pneumatic motor (piston motor, vane motor, and gear motor) have been investigated with a view to finding methods of reducing their noise output. The air exhaust produced the loudest noise source. A redesigned exhaust port arrangement reduced noise considerably. A prototype exhaust silencer was also tested.

77-1662
Pneumatic Silencers for Exhaust Valves and Parts Ejectors

H.W. Lord, H.A. Evensen, and R.J. Stein

Michigan Technological Univ., Houghton, MI, S/V, Sound and Vibration, 11 (5), pp 26-34 (May 1977) 21 figs, 2 tables, 4 refs

Key Words: Silencers, Pneumatic equipment

A common source of noise found in many industries is that of air jet noise associated with air blow-off from pneumatic valves, and jets used for parts ejectors or scale and grit blowers. In the first example, the air exhaust serves no useful purpose so the main function of a silencer is to reduce the jet noise without unduly increasing time for exhaust of discharge. However, in the second example, the jet provides a necessary thrust. Consequently, silencers for these jets must reduce the noise level but maintain adequate force produced by the jet. Nine brands of air ejector silencers and twelve brands of air exhaust silencers were tested under uniform conditions of steady and transient flow. Information useful for the selection of ejector and exhaust silencers, on the basis of sound reduction, is provided.

77-1663
Rules for Noiseless Design (Regeln für lärmarme Konstruktionen)

H.W. Müller and D. Föller

Fachgebiet Maschinenelemente u. Getriebe an d. T.U. Darmstadt, Konstruktion, 28 (9) pp 333-339 (Sept 1976) 5 figs, 19 refs

(In German)

Key Words: Machinery noise, Noise reduction, Design techniques

In the first part of this article, the causes of machine noise are discussed. In the second part, 28 rules for noiseless design are presented.

77-1664
The Development of a Noise-Reduced Dumper

P.J. Hallman

Noise Control, Vib. and Insul., 8 (5), pp 164-166 (May 1977) 1 table, 4 figs

Key Words: Machinery noise, Noise reduction

Modifications to a dumper (Diesel driven, four wheel drive vehicle) to eliminate noise are described.

77-1665
Noise Control in Building Development

K.J. Mott

Addicoat Hogarth Wilson Pty Ltd., Consulting Engineers, Sydney, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 101-102 (Oct 11-12, 1976)

Key Words: Noise reduction, Construction equipment, Industrial facilities

This paper points up the need to anticipate commonly encountered noise problems in building. Noise control procedures available at the design stage are discussed in terms of the effects of impact on the environment by noise of building construction and operation; impact on the occupants by the noise of the external environment; and impact on the occupants by the noise generated by mechanical plant within the building.

77-1666

Case Histories of Practical Noise Attenuation of Construction Plant and Equipment

J.F. Nichols

Metropolitan Water Sewerage and Drainage Board, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 137-138 (Oct 11-12, 1976)

Key Words: Construction equipment, Noise reduction

Case histories are presented of construction plant noise attenuation carried out by the Sydney Metropolitan Water Sewerage and Drainage Board over the last 15 years. Included is a brief outline of reasons for the program, priorities, methods employed, the case histories and conclusions.

77-1667

Noise Reduction of Jumbo Mounted Percussive Drills: Phase I. Noise and Usage Survey

E.K. Bender and N.M. Rubin

Bolt Beranek and Newman Inc., Cambridge, MA, Rept. No. BuMines-OFR-45-77, 82 pp (Sept 76) PB-265 083/6GA

Key Words: Drills, Tools, Noise measurement, Vibration measurement, Noise reduction

Noise from four drills -- Gardner-Denver D93LAR and DH123 and Ingersoll Rands D475 and VL120 models -- were measured at the two manufacturers' test sites. Data are given in terms of characteristic noise and vibration levels. A survey of percussive rock drill users is reported. The rationale for the choice of a demonstration drill, the Gardner-Denver DH123, is given and a desired noise reduction goal is established.

AIRCRAFT

(Also see Nos. 1546, 1553, 1554, 1704)

77-1668

The Influence of Pitch-Lag Coupling on the Predicted Aeroelastic Stability of the XV-15 Tilting Proprotor Aircraft

W. Johnson

NASA Ames Research Ctr., Moffett Field, CA, Rept. No. NASA-TM-X-73213; A6946, 22 pp (Feb 1977) N77-19989

Key Words: Aircraft, Dynamic stability

The predicted dynamic stability of the XV-15 tilting proprotor aircraft in cruise flight is updated. The major influence of the pitch-lag coupling of the XV-15 gimballed, stiff-inplane rotor on the aircraft stability is shown.

77-1669

A Practical Approach to the Prediction of Oscillatory Pressure Distributions on Wings in Supercritical Flow

H.C. Garner

Aerodynamics Dept., Royal Aircraft Establishment, Farnborough, UK, Rept. No. ARC-CP-138; RAE-TR-74181; ARC-36100, 61 pp (1976) (Supersedes RAE-TR-74181; ARC-36100) 18 figs, 7 tables N77-19017

Key Words: Aircraft wings, Fluid-induced excitation, Flutter

Brief consideration of current approaches to the prediction of unsteady wing loading in mixed subsonic and supersonic flow shows a wide variety of method and a clear need for economy in transonic aerodynamic calculations for flutter clearance in subsonic flight. In support of measurements of steady and oscillatory pressure distributions on a particular wing, an approximate theoretical treatment was devised in terms of nonlinear steady surface pressures and linear oscillatory loading. The steady data were taken either from transonic small-perturbation theory or from the static experiments. The resulting theoretical or semi-empirical calculations can take account of stream Mach number, mean incidence, mode of oscillation, frequency, and amplitude.

77-1670

An Application of Fast Frequency-Sweep Excitation to the Measurement of Sub-Critical Response of a Low Speed Wind Tunnel Model

C.W. Skingle and D.R. Gaukroger

Structures Dept., Royal Aircraft Establishment, Farnborough, UK, Rept. No. ARC-CP-1356; RAE-TR-74129; ARC-36184, 28 pp (1976) (Supersedes RAE-TR-74129; ARC-36184) 7 figs, 2 tables, refs N77-19016

Key Words: Aircraft wings, Flutter, Wind tunnel tests, Fourier analysis

An analysis method was developed to enable modal frequencies and damping ratios of a system to be obtained from excitation and response records in conditions where the system is also excited by unknown random forces. The transient input was a fast frequency-sweep, and the resulting response and force input records were processed using digital Fourier analysis techniques. The results are compared with those obtained from sustained sinusoidal excitation. Comparisons are given for the frequency and damping characteristics of the first four modes of the model.

77-1671

Wind Tunnel Flutter Tests at Subsonic Speeds on a Half-Wing with a Fan-Engine Nacelle

D.A. Drane and G.B. Hutton

Structures Dept., Royal Aircraft Establishment, Farnborough, UK, Rept. No. ARC-CP-1354; RAE-TR-74130; ARC-35955, 38 pp (1976) (Supersedes RAE-TR-74130; ARC-35955) 14 figs, refs

N77-19014

Key Words: Flutter, Nacelles, Wind tunnel tests, Aircraft wings

Flutter tests were made on a half-wing model with a fan-engine nacelle attached by a pylon at an inboard section. The model was nominally rigid, and flexibilities in pitch and roll were introduced at the root. Measurements were made of the flutter charactersitics of the model at Mach numbers of 0.6 and 0.8 over a range of dynamic pressures using three different methods of analysis.

77-1672

The Flutter of a Two-Dimensional Wing with Simple Aerodynamics

T. Niblett

Structures Dept., Royal Aircraft Establishment, Farnborough, UK, Rept. No. ARC-CP-1355; RAE-TR-75008; ARC-36164, 35 pp (1976) (Supersedes RAE-TR-75008; ARC-36164) 14 figs, refs

N77-19015

Key Words: Aircraft wings, Flutter, Damping, Stiffness

The flutter stability of a rigid wing with two degrees-of-freedom and subjected to the simplest aerodynamic forces including damping was considered. The limits of combinations of nodal axis positions which can lead to flutter were found, and a fairly simple expression from which the flutter speed can be found is given. The results are compared with those from simple frequency-coalescence theory.

77-1673

Aerodynamic Noise

AGARD, Paris, France, Rept. No. AGARD-LS-80, 307 pp (Jan 1977)

AD-A037 334/0GA

Key Words: Aircraft noise, Jet engines, Aircraft, Bibliography

The aim is to provide an up-to-date account and authoritative appraisal of aerodynamic noise concepts, theory, and experiments. Particular emphasis is given to practical methods for the prediction, measurement and reduction of external noise from jet/fan aircraft. Following a brief overview of relevant aircraft design and operational considerations, the main articles include detailed presentations on the fundamental theory of aerodynamic noise generation and propagation, basic aero-acoustic of jet efflux noise, engine exhaust noise characteristics, fan noise, airframe self-noise, airframe/engine interaction effects, aero-acoustic measurement and analysis techniques, aircraft identification and location methods, and ground-based facilities with forward-speed representation. A bibliography of 171 items is included in the publication.

77-1674

Response of a Subsonic Nozzle to Acoustic and Entropy Disturbances

M.S. Bohn

Daniel and Florence Guggenheim Jet Propulsion Ctr., California Inst. of Tech., Pasadena, CA 91109, J. Sound Vib., 52 (2), pp 283-297 (May 22, 1977) 10 figs, 7 refs

Key Words: Aircraft noise, Jet noise, Noise generation

The one-dimensional response of a subsonic nozzle flow to small pressure and entropy disturbances is calculated. The response is expressed in terms of transmitted acoustic waves (which propagate from the nozzle in the direction opposite to that of the disturbance wave) for three independent disturbances: a downstream-propagating acoustic wave impinging upon the nozzle exit, and an entropy wave convecting through the nozzle. The solution for high frequency disturbances is discussed and used with the compact (long wavelength disturbance) solution to normalize several numerical calculations.

77-1675

University Noise Research - Proceedings of the EPA-University Noise Seminar Held at Purdue University, West Lafayette, Indiana on October 18-20, 1976

J.W. Sullivan and A.F. Seybert

Ray W. Herrick Labs., Purdue Univ., Lafayette, IN, Rept. No. EPA/550/9-77/300, 193 pp (Dec 76)

PB-265 114/9GA

Key Words: Noise reduction, Aricraft noise, Proceedings

Material presented and discussed at the seminar included research, development and demonstration projects in all areas of noise control except noise generated by aircraft. Emphasis was placed on non-Federally funded programs and hardware oriented projects. An appendix to the report provides an extensive compendium of university noise research projects regardless of the nature of the source or sponsoring institution.

BRIDGES

77-1676

Motion of Suspension Bridge Subject to Wind Loads

J. Beliveau, R. Vaicaitis, and M. Shinozuka

Univ. of Sherbrooke, Sherbrooke, Quebec, Canada, ASCE J. Struc. Div., 103 (ST6), pp 1189-1205 (June 1977) 8 figs, 1 table, 19 refs

Key Words: Suspension bridges, Wind-induced excitation

Vertical and torsional motions of a suspension bridge due to wind loading are studied. Both, self-excited, due to bridge motion, and buffeting, independent of bridge motion, wind loads are included. The self-excited aerodynamic forces are modeled using aerodynamic coefficient or Duhamel integral formulations. For this purpose, experimental information on section models from wind tunnel testing is utilized. The buffeting random loads are determined from specified spectral densities or horizontal and vertical turbulent wind velocity fluctuations. Numerical results are obtained using frequency and time domain formulations. Dynamic bridge stability is also investigated.

BUILDING

(Also see Nos. 1547, 1551, 1660)

77-1677

Elastic Earthquake Analysis of a Class of Torsionally Coupled Buildings

C.L. Kan and A.K. Chopra

Univ. of California, Berkeley, CA., ASCE J. Struc. Div., 103 (ST4), pp 821-838 (Apr 1977) 4 figs, 3 tables, 13 refs

Key Words: Buildings, Multistory buildings, Seismic response

A simple procedure is developed for analysis of elastic response of a particular class of torsionally coupled multistory buildings to earthquake ground motion, characterized by smooth response spectra. In this procedure the response of a N-story torsionally coupled building - a system with 3N degrees-of-freedom (DOF) - is determined by analyzing two systems: An N-story torsionally uncoupled counterpart of the actual building -- a system with N DOF; and an associated one-story torsionally coupled system -- a system with 3 DOF. The simpler analysis procedure leads to "exact" results if the variation of earthquake spectral acceleration with vibration period is idealized as flat or hyperbolic.

77-1678

Effects of Torsional Coupling on Earthquake Forces in Buildings

C.L. Kan and A.K. Chopra

Univ. of California, Berkeley, CA., ASCE J. Struc. Div., 103 (ST4), pp 805-819 (Apr 1977) 7 figs, 31 refs

Key Words: Buildings, Seismic response

The elastic response of torsionally coupled one-story buildings to earthquake ground motion, characterized by idealized shapes for the response spectrum, is studied. Influence of the basic system parameters on the response is investigated. The relationship between the forces - base shears and torque - in a torsionally coupled system and the base shear in a corresponding torsionally uncoupled system is established, and the effects of torsional coupling on earthquake forces are identified. Useful upper and lower bounds are presented for the base shears and torque due to simultaneous action of two horizontal components of ground motion of equal intensity.

77-1679

Seismic Structural Design/Analysis Guidelines for Buildings

J.D. Prendergast and W.E. Fisher

Construction Engrg. Research Lab. (Army), Champaign, IL, Rept. No. CERL-SR-M-206, 28 pp (Feb 1977)

AD-A037 747/3GA

Key Words: Seismic design, Earthquake resistant structures, Buildings, Modal analysis

This report presents interim guidelines for the seismic structural design/analysis of the lateral-force-resisting systems of permanent military buildings. These guidelines are intended to enable critical, high-loss- and low-loss-potential buildings to withstand their respective design earthquakes without unacceptable loss of function or structural damage. Modal analysis procedures are advocated for critical buildings and high-loss-potential buildings with irregular shapes, large differences in lateral resistance, or other unusual structural features. The equivalent static lateral load method is advocated for high-loss- and low-loss-potential buildings which are regular in shape and have uniform mass and stiffness distributions. Both procedures employ a design spectrum for the seismic ground motion which is constructed based on the effective peak ground acceleration at the site.

77-1680

Earthquake-Induced In-Building Motion Criteria

S.-C. Liu, L.W. Fagel, and M.R. Dougherty
National Science Foundation, Washington, D.C., ASCE J. Struc. Div., 103 (ST1), pp 133-152 (Jan 1977) 13 figs, 2 tables, 14 refs

Key Words: Earthquake-resistant structures, Seismic response, Buildings, Multistory buildings, Mathematical models

Two 10-member ensembles of digitally generated waveforms that simulate real earthquake accelerograms are used to excite mathematical models of two-story to 20-story buildings of widths ranging from 100 ft to 300 ft and founded on soils characterized by shear-wave velocities of up to 4,000 fps. Realistic equivalent structural damping is determined and used in this analysis based on the actual building response data recorded during the San Fernando earthquake of 1971. Calculated upper bound motion responses on floors throughout the buildings are presented in terms of peak values of acceleration, velocity, and displacement. Envelopes of damped response spectra derived from the in-building accelerograms are also presented, and the use of these spectra is demonstrated with an illustrative example.

77-1681

Earthquake Related Activities of the Center for Building Technology

C. Culver
Center for Building Technology, National Bureau of Standards, Washington, D.C., Rept. No. NBSIR-76-1193, 24 pp (Mar 1977)
PB-265 103/2GA

Key Words: Earthquake resistant design, Buildings

The report describes activities related to earthquake engineering being carried out by the Center for Building Technology as part of the Center's overall Disaster Mitigation Program. Laboratory and field research, post disaster investigations and efforts to develop comprehensive earthquake resistant design provisions are included. The professional disciplines within the Center and the laboratory facilities are discussed. Recent accomplishments and mechanisms employed for facilitating implementation of the Center's research results are also discussed.

77-1682

Vibration Isolation of the Theatre Royal

D. Eden
Peter R. Knowland and Assoc., Sydney, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 107-108 (Oct 11-12, 1976) 2 tables, 2 refs

Key Words: Vibration isolation, Buildings

The new Theatre Royal in Sydney is directly over both tracks of the Eastern Suburbs Railway. This paper discusses the vibration isolation and attenuation incorporated in the design to reduce the level of objectionable noise intrusion to the Theatre from the future railway.

77-1683

Analyze Tower Vibration Quicker

K.K. Mahajan
The Litwin Corp., Wichita, KS., Hydrocarbon Processing, 56 (5), pp 217-219 (May 1977) 1 fig, 3 tables, 9 refs

Key Words: Towers, Chimneys, Wind-induced excitation

The article extends Zorrila's method for calculating vibrations in towers due to wind by establishing simplified relationships from his data. It also presents some of his graphical data in tabular form for quick vibration investigations of self-supporting vertical cylindrical, cantilevered structures such as towers and stacks. Criteria, as recommended by Zorrila, is used to establish a need for such analysis.

CONSTRUCTION

(Also see Nos. 1545, 1666)

77-1684

Vibration of Pavement Concrete

J.E. Bryden and R.W. Rider
Engineering Res. and Dev. Bureau, New York State Dept. of Transportation, Albany, NY., Rept. No. NYSDOT-ERD-77-RR-40, 53 pp (Mar 1977)
PB-265 358/2GA

Key Words: Vibrators (machinery), Vibratory techniques, Concrete construction, Pavements

The effects of spud vibrators mounted on slip-form pavers were examined on three paving projects. Slump and entrained air of the plastic concrete were measured and paver speed was deliberately varied. A total of 364 pavement cores were taken at various distances from the vibrators for determination of density, entrapped air content, aggregate distribution, and mesh embedment. Riding quality of the finished pavement was also measured.

FOUNDATIONS AND EARTH

(Also see No. 1569)

77-1685

Foundation Design for Reciprocating Compressors

S.C. Arya, R.P. Drewyer, and G. Pincus

The CE-Lummus Co., Houston, TX., Hydrocarbon Processing, 56 (5), pp 223-234 (May 1977) 7 figs, 7 tables, 10 refs

Key Words: Foundations, Machine foundations, Compressors, Natural frequencies, Resonance, Design techniques

Compressor operating frequencies are close to foundation natural frequencies which create resonant conditions. A design method to avoid operating problems is described.

HELICOPTERS

(Also see Nos. 1555, 1556)

77-1686

Research Requirements for the Reduction of Helicopter Vibration

G.S. Doman

Boeing Vertol Co., Philadelphia, PA, Rept. No. NASA-CR-145116; D210-11154-1, 37 pp (Dec 1976) N77-19058

Key Words: Helicopters, Vibration control

A search for all prospective approaches to the reduction of helicopter vibration was conducted to establish insight for the planning of a corrective research program. The state of the art as revealed in the literature is summed up and followed by a discussion of state-of-the-art solutions and of identified technological gaps. It is applicable to all helicopters without regard to size. Extending the historic trend toward lower vibration levels will require the successful application of principles which isolate the fuselage from the rotor systems. Simplicity of the necessary isolation systems should be facilitated by providing other refinements of the dynamic design of the system.

HUMAN

(Also see No. 1544)

77-1687

Low Frequency Noise and Testing for Its Effects

N. Broner, R.J. Alfredson, and T.J. Triggs

Dept. of Mech. Engrg., Monash Univ., Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 56-60 (Oct 11-12, 1976) 10 figs, 21 refs

Key Words: Noise tolerance, Human response

The general effects of noise, and in particular, low frequency and infrasonic noise on human performance, are reviewed. High levels of low frequency noise in some transportation environments are reported and an experimental design and task battery for testing of human performance effects due to noise is outlined. The design takes into account possible transfer effects and allows for time sharing among tasks.

77-1688

Sources of Industrial Impact/Impulsive Noise

C.L. Dym

Bolt Beranek and Newman, Inc., 50 Moulton St., Cambridge, MA 02138, Noise Control Engr., 8 (2), pp 81-87 (Mar/Apr 1977) 2 figs, 2 tables, 9 refs

Key Words: Machinery noise, Human response

Many machines generate, as an unwanted by-product, noise that can be classified as impact/impulsive. Such noise, if of sufficient intensity or if repeated often enough over a sufficient period of time, can produce temporary and even permanent hearing threshold shifts in exposed workers. Although widely accepted analysis and measurement techniques and damage risk criteria have been developed for continuous noise, impact/impulsive noise has not received extensive treatment. A study directed towards establishing a data base for the evaluation of research priorities in the field of impact/impulsive noise is summarized.

77-1689

Do We Measure Damaging Noise Correctly?

P.V. Bruel

Bruel & Kjaer, 23 Linde allé, DK-2850 Naerum, Denmark, Noise Control Engr., 8 (2), pp 52-60 (Mar/Apr 1977) 11 figs, 1 table, 14 refs

Key Words: Industrial facilities, Noise measurement, Measurement techniques, Human response

For steady industrial noise without excessive impulses, the risk for hearing loss is reasonably well related to the total noise dose criterion. However, the inadequacy of the criterion's assessment of the hearing loss risk for fluctuating industrial noise with relatively high peak values has led to the investigation of impulses encountered in industrial environments. The majority of industrial noise has a higher intensity in the 250 Hz to 500 Hz frequency range than at 6kHz, while short duration peaks contain a significant amount of energy in the 4 kHz to 6 kHz frequency region. Because the frequencies in the 4 kHz to 6 kHz range are also amplified in the outer and middle ear, the short duration peaks seem to play a dominant role in contributing preferential damage in this range. A simple method for setting limits for hearing loss risk; considering the crest factor of noise when weighting the noise dose criteria, is proposed.

ISOLATION

(Also see No. 1616)

77-1690

Design Criteria for Vibration Isolating Mountings for Machinery on Suspended Floors

J.A. Macinante and H. Simmons

National Measurement Lab., CSIRO, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 46-50 (Oct 11-12, 1976) 6 figs, 9 refs

Key Words: Machinery vibration, Mountings, Vibration isolation

A suspended floor is represented as a mass-spring-damper system, supporting a similar system that represents vibrating machinery on a spring mounting. The machinery is assumed to generate a vertical sinusoidal force. An expression is derived by conventional methods for the amplitude of the vertical vibratory force transmitted into the structure supporting the floor, and hence for the transmissibility ratio. The analysis considers the fundamental flexural mode of vibration of the floor, assuming vertical uncoupled vibration of the machinery on its mounting. Linear elasticity and viscous damping of both floor and mounting are assumed. From computer-drawn transmissibility ratio contours covering ranges of floor and mounting parameters of interest in practice, key (worst) cases are identified on which conservative design of the mounting can be based.

77-1691

Vibration and Noise Control on a Rotating Vane Diffuser Drive Unit

D.A. Bies and M. Zockel

Mech. Engrg. Dept., Univ. of Adelaide, Australia, Vibration and Noise Control Egnineering, Proceedings, Sydney, Australia, pp 91-92 (Oct 11-12, 1976) 3 figs, 2 refs

Key Words: *Noise reduction, Vibration isolation, Reverberation chambers*

This paper describes a vibration and noise control problem with large and efficiently radiating surfaces and the complex techniques which must be employed to achieve relatively modest sound pressure levels of 60 dB in a reverberation chamber. The techniques of vibration isolation, described in this paper, are applied to a specific problem viz. to minimize noise in a reverberation chamber due to the installation of a rotating vane diffuser.

MATERIAL HANDLING

77-1692

Theoretical and Experimental Research on Vibromachines for the Transport and Handling of Material

N. Bachschmid and A. Rovetta

Istituto di Meccanica delle Macchine - Politecnico di Milano, Italy, Meccanica, 11 (3), pp 172-179 (Sept 1976) 9 figs, 43 refs

Key Words: Materials handling equipment, Vibratory conveyors

This paper deals with the various phases into which research on vibromachines (conveyors) have been articulated over last years in many countries. A synthesis is then given of the theoretical research carried on at the Institute of Mechanics of Machines of Polytechnic of Milan, setting forth the results obtained and analyzing the approaches to the problems of different technical and scientific studies. A comparison is made between a vast series of experimental and theoretical results obtained by the same authors.

77-1693

Noise from Two, Four and Eight Ton Punch Presses

L.L. Koss

Dept. of Mech. Engrg., Monash Univ., Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 131-132 (Oct 11-12, 1976) 2 figs, 3 refs

Key Words: Materials handling equipment, Presses, Noise reduction

The peak sound pressure levels radiated by two, four and eight ton John Heine punch presses were measured as a function of load for sudden fractures.

MECHANICAL

(See Nos. 1541, 1663)

METAL WORKING AND FORMING

77-1694

Experimental Investigation of the Characteristics of Dynamic Cutting Process

M.M. Nigm and M.M. Sadek

Ein-Shams Univ., Cairo, Egypt, J. Engr. Indus., Trans. ASME, 99 (2), pp 410-418 (May 1977) 9 figs, 10 refs

Key Words: Metal working, Cutting, Experimental data

The dynamic response of the shear plane and the variations of the dynamic cutting coefficients are experimentally investigated at various values of feed, cutting speed, rake angle, clearance angle, frequency, and amplitude of chip thickness modulation. Wave generating and wave removing cutting tests, in which high-speed photography is used to investigate the geometry of chip formation, are carried out. The theoretical model of dynamic cutting developed earlier is assessed with reference to these experimental results. A comparison between this model and previous models in relation to the experimental results is also presented.

77-1695

Determination of Dynamic Cutting Coefficients from Steady State Cutting Data

M.M. Nigm, M.M. Sadek, and S.A. Tobais

Ein-Shams Univ., Cairo, Egypt, Intl. J. Mach. Tool Des. Res., 17 (1), pp 19-38 (1977) 13 figs, 2 tables, 31 refs

Key Words: Cutting, Mathematical models

A mathematical model is presented for the determination of the dynamic cutting coefficients from steady state data. This theory is based on a non-dimensional analysis of the steady state orthogonal cutting process. It takes into consideration the oscillations of the shear plane in response to dynamic variations of the cutting parameters. The model is verified, directly with dynamic cutting tests for wave cutting and wave removal, in which the variations of the shear plane angle and those of the cutting force coefficients were measured. Indirect verification was achieved by reference to the work of previous investigators concerned with dynamic cutting and the stability of the cutting process.

OFF-ROAD VEHICLES

77-1696

A Mathematical Model of the Air-Suspension Stem-Vibration Strawberry Harvester

J.H. Ruff

Ph.D. Thesis, North Carolina State Univ. at Raleigh, 143 pp (1976)

UM 77-11,164

Key Words: Agricultural machinery, Mathematical models

A mathematical model of the air-suspension, stem-vibration strawberry harvester was developed for the dual purpose of obtaining a better understanding of the operational mechanics of the harvesting concept and to aid in increasing the field performance of the harvester. The combination of a probabilistic strawberry stem failure model and a mathematical analysis of the forced vibration of the strawberry-stem system enabled fruit removal to be predicted in a digital simulation model.

77-1697

The Vibration Isolation of Equipment Installed in Off-Road Vehicles

K.P. Byrne and N.D. Olver

School of Mech. & Industrial Engrg., Univ. of New South Wales, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 41-45 (Oct 11-12, 1976) 7 figs, 1 table, 2 refs

Key Words: Off-highway vehicles, Military vehicles, Trucks, Vibration isolation, Equipment response

This paper presents the results of a survey of the shock and vibration environment produced in a number of types of military trucks when operating on surfaces typical of those encountered in operational roles. The shock and vibration environment is described in terms of statistical measures and the influence of parameters such as vehicle load, surface, position and orientation of the point of interest within the vehicle are examined. The application of the results to other off-road vehicles is discussed and the implication of the results with regard to the design of shock and vibration isolating systems is examined.

PACKAGE

(Also see No. 1659)

77-1698

Pressure and Vibration Test of the ACA/A395 Container for the BL-755 Seek Cluster Bomb Unit

R.T. Gibbons and E.P. Moravec

Air Force Packaging Evaluation Agency, Wright-Patterson AFB, OH., Rept. No. PTPD-77-13, 11 pp (Mar 1977)

AD-A037 811/7GA

Key Words: Containers, Weapons systems, Explosives, Shock tests

The Air Force Packaging Evaluation Agency has been involved in several 'compare and contrast' type situations where a series of tests are performed on multiple containers designed to protect the same item. This was the case in testing of containers for the BL-755 seek cluster bomb unit.

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see Nos. 1583, 1585, 1598, 1685)

77-1699

Noise Exposure and Control on Fixed Marine Structures

S.H. Judd

Standard Oil Company of California, San Francisco, CA., S/V, Sound and Vibration, 11 (5), pp 20-24 (May 1977) 14 figs

Key Words: Off-shore structures, Noise reduction, Machinery noise

Machinery noise sources on drilling and producing platforms include engines, turbines, gears, generators, pumps and compressors. Noise transmission is both structureborne and airborne. Exposure evaluation requires consideration of work shifts ranging up to 12 hours per day, seven days in a row, as contrasted to the typical on-shore 40-hour work week. Exposure time is not limited to the work shift for those who must live on the structure. The design problem is to avoid or eliminate excessive noise levels. If this is not feasible, noise levels are minimized both as to intensity and the physical area affected by use of quiet machinery. Enclosure and/or other acoustical treatment is then used to bring exposure within acceptable limits. Off-duty areas and crew quarters are placed in the quietest available location, and isolated from structureborne and airborne noise. Examples of noise sources and control measures are illustrated by case histories.

77-1700

Backlash in Hydraulic Control Systems

K.J. Rogers and P. Dransfield

Footscray Inst. of Tech., Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 25-29 (Oct 11-12, 1976) 4 figs, 1 ref

Key Words: Hydraulic systems, Noise generation

Hydraulic backlash is a phenomena which degrades the performance of some hydraulic control systems under some operating conditions. It is associated with cavitation, and with load oscillation and possible noise emission. The types of systems and the operating conditions under which hydraulic backlash can develop are discussed. For a particular system, tha magnitude and the decay rate of hydraulic backlash are studied via experimenta and simulation. The origins of, and remedies for, hydraulic backlash are discussed.

77-1701

Reducing Gear Pump Noise Potential by Design

K. Duke and P. Dransfield

Footscray Inst. of Tech., Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 20-24 (Oct 11-12, 1976) 6 figs, 2 refs

Key Words: Pumps, Gears, Noise reduction, Design techniques

Noise emission is a problem with hydraulic control systems. Modern trends to higher pressures and higher pump speeds increase the problem. The pump, with its pulse-like discrete pumping action is a primary source of noise generation. Any reduction in the magnitude and abruptness of pump discharge ripple, and consequently of pump pressure ripple, can be expected to reduce the noise generating potential of the pump. With gear pumps, pressure relief grooves are machined in the side plates to control pressure ripple and other pressure effects. The present paper describes development of a new groove system which minimizes pressure pulsation via use of a leakage groove plus a set of pressure relief grooves.

77-1702

The Development of a Low Noise Centrifugal Fan

L.A. Challis

Louis A. Challis and Associates Pty. Ltd., Consulting Acoustical Engineers, Sydney, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 93-94 (Oct 11-12, 1976) 2 figs, 5 refs

Key Words: Fans, Noise reduction

Since the first fans were developed, the problems of fan noise have presented engineers with a whole range of noise problems. The solution of these problems can be approached in many ways - the solutions invariably result in some new problems which are often nearly as unpalatable as the original noise problems. This paper presents the results of a research and developmental program, which is aimed at developing an acoustical fan, intended to overcome some of the most disturbing problems associated with conventional silencing techniques.

77-1703

Construction of Radial Fans with Special Regard to Noise Generation (Auslegung eines Radialventilators in bezug auf die Geräuschentwicklung)

H. Neuhäuser
Institut f. Dampf u. Gasturbinen der T.U. Wien, Vienna, Austria, Konstruktion, 28 (4), pp 145-150 (Apr 1976) 13 figs, 9 refs
(In German)

Key Words: Fans, Noise generation

The article describes measures for primary noise reduction in radial fans. The major part deals with the broad band noise, which is predominant in fans, and is composed of whirl and turbulence noise. The author derives the broad band noise level (at high speed) from theory, and demonstrates the effect of the impeller seal on the suction side, as well as the effect of a vane regulator on the turbulence noise level.

77-1704

The Measurement of Aerodynamic Forces on an Oscillating Model of a Fan-Engine Nacelle

R. Cansdale and D.R. Gaukroger
Royal Aircraft Establishment, Farnborough, UK, Rept. No. RAE-TM-Struc-889; BR53602, 29 pp (June 30, 1976)
N77-19018

Key Words: Fans, Engines, Nacelles, Measurement techniques, Aerodynamic excitation, Stiffness coefficients, Damping coefficients

A technique developed to measure the aerodynamic forces generated when a model fan-engine nacelle is oscillated in a uniform airflow enables the model to be oscillated in pitch or in yaw about one of two axis positions. A series of measurements for the four combinations of axis position and direction are analyzed to yield the aerodynamic stiffness and damping derivatives for motions of pitch, yaw, and vertical and lateral translation. A preliminary series of tests was made using a simple model of a fan-engine in a low speed wind tunnel. The rig and test technique are described and the outcome of the tests discussed.

RECIPROCATING MACHINE

77-1705

Characteristics of the Noise Sources in a Rotary 2-Stroke Lawnmower

A.D. Jones and G.L. Brown
Dept. of Mech.Engrg., Univ. of Adelaide, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 95-96 (Oct 11-12, 1976)
2 figs, 1 table, 2 refs

Key Words: Lawnmowers, Noise generation, Engine noise, Pistons

The problem of lawnmower noise is considered in terms of the four component parts: inlet, exhaust, mechanical and blade. Detailed investigations into the nature of mechanical noise and exhaust noise are described, from both theoretical and experimental considerations. For mechanical noise, piston slap is considered in detail, and the expected results of certain design modifications are shown. The exhaust noise is described as consisting of two components: flow noise and pulse noise. Recommendations for the reduction of both these exhaust noise components are given.

ROAD

77-1706

A Nonlinear Vertical-Plane Mathematical Model for Air Cushion-Supported Vehicles

D.D. Moran
Ship Performance Dept., David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD., Rept. No. SPD-615-05, 56 pp (June 1976)
AD-A037 062/7GA

Key Words: Ground effect machines, Mathematical models, Oscillation, Dynamic response

An analytical model for predicting the pitch and heave response of air-cushion-supported vehicles during overland operation is developed. The effects of air compressibility and skirt contact with the supporting surface are included in the model. The resulting analytical model is used to predict the response of an experimental model for periodically varying terrain.

77-1707

Response to Profile-Imposed Exctiation with Randomly Varying Traversal Velocity

K. Sobczyk, D.B. Macvean, and J.D. Robson
Institute of Fundamental Technological Res., Polish Academy of Sciences, Warsaw, J. Sound Vib., 52 (1), pp 37-49 (May 8, 1977) 9 figs, 9 refs

Key Words: Ground vehicles, Random excitation, Surface roughness

Stationary response of a travelling system to profile-imposed excitation is investigated. The system is treated as linear and both the profile and traversal velocity of the system are considered to be stationary and Gaussian random functions of horizontal distance. The problem is formulated by means of a differential equation with random coefficients, and detailed analysis of vertical vibrations of the system travelling with small random velocity fluctuations is performed. An analytical expression for response spectral density is obtained in a relatively simple form for a general case, and this is used in calculation of the effect of randomly-varying velocity on a system's response in particular cases relevant to vehicle dynamics.

ROTORS

(Also see No. 1582)

77-1708

Understanding Flexible Rotor Critical Speeds

P. Kirlan
Steam Turbine Div., Turbodyne Corp., Wellsville, NY, Hydrocarbon Processing, 56 (5), pp 209-212 (May 1977) 8 figs, 9 refs

Key Words: Critical speeds, Flexible rotors

An unbalance (synchronous response) calculation provides a direct indication of the speeds at which peak amplitudes and bearing forces occur. These are called unbalance critical speeds. Design considerations involving critical speeds are discussed.

77-1709

A Study of Feedback, Blade and Hub Parameters on Flap Bending Due to Non-Uniform Rotor Disk Turbulence

G.H. Gaonkar and A.K. Subramanian
Dept. of Mathematical Studies, School of Science and Tech., Southern Illinois Univ., Edwardsville, IL 62026, J. Sound Vib., 51 (4), pp 501-515 (Apr 22, 1977) 10 figs, 22 refs

Key Words: Rotors, Blades, Disks, Turbulence, Fluid-induced excitation

The effects of non-uniform (vertical) turbulence in the rotor disk are further studied with reference to comprehensive hingeless rotorcraft during "low-lift high advance ratio" operations. The analysis is based on linear quasi-steady aerodynamics including reverse flow, and on the assumption that the flow in the rotor plane is not appreciably influenced by random vortices shed from the blades.

77-1710

The Effect of Spin on the Non-Linear Resonant Motions of a Dynamical System

M.R.M.C. Da Silva
Dept. of Engrg. Science, Univ. of Cincinnati, Cincinnati, OH 45221, J. Sound Vib., 52 (2), pp 201-209 (May 22, 1977) 6 figs, 10 refs

Key Words: Perturbation theory, Resonant response, Rotors

The motions of a two degree of freedom mechanical oscillator in a state of internal resonance due to the non-linear coupling between its modes are analyzed by the method of multiple scales. The system is connected by a motor to a vertical shaft driven at a constant spin rate relative to inertial space.

77-1711

Dynamic Behaviour of Thin Cylindrical Shell Rotating with High-Speed

S.I. Suzuki
Dept. of Aeronautics, Nagoya Univ., Chikusa-ku, Nagoya, Japan, Ing. Arch., 46 (2), pp 75-84 (1977) 10 figs, 6 refs

Key Words: Rotors, Rotating structures, Cylindrical shells, Rotation, Velocity

The dynamic behavior due to abrupt changes in the angular velocity of rotating simply supported thin cylindrical shells is investigated. Donnel's equation is used and the solution is obtained by Laplace transformation. The effects of shearing forces and rotatory inertia are assumed to be negligible.

77-1712

Theoretical Discussions on Vibrations of a Rotating Shaft with Nonlinear Spring Characteristics

T. Yamamoto and Y. Ishida
Dept. of Mech. Engrg., Nagoya Univ., Chikusa-ku, Nagoya, Japan, Ing. Arch., 46 (2), pp 125-135 (1977) 4 figs, 1 table, 14 refs

Key Words: Rotors, Shafts, Springs (elastic), Forced vibrations

Various kinds of nonlinear forced oscillations may appear, when the restoring force of a rotating shaft has nonlinear spring characteristics. A rotating shaft system with gyroscopic moments acting does not experience rectilinear lateral vibrations of the shaft but a whirling type of motion. The nonlinear spring characteristics of the shaft are assumed to be distributed two-dimensionally and polar coordinates

are used for their representation. Nonlinear spring characteristics expressed in polar coordinates may be characterized by a component with a constant value and other components whose magnitudes vary 1, 2, 3, 4, ... times, during a single whirl of the shaft around its equilibrium position. This type of representation gives a clear description of the phenomena of nonlinear forced oscillations and aids in the prediction of their occurrences. The present discussion centers on the subharmonic oscillation of order 1/3 of forward precession as a representative case. Other kinds of nonlinear oscillations are discussed briefly. Experimental results of previous reports may clearly be explained in the light of the results of this paper.

SHIP

77-1713

Shipboard Noise and Vibration

A.A. McQueen

Shipbuilding Div., Dept. of Industry and Commerce, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 115-116 (Oct 11-12, 1976)

Key Words: Ships, Engine vibration, Engine mounts, Shipboard equipment response, Vibration control

The importance of noise and vibration in ship design and operation is described. The main sources of noise and vibration are presented together with methods of treatment.

77-1714

Studies Leading to Vibration and Noise Free Ships

G.C. Volcy and M. Nakayama

Research and Technical Advisory Services Div. of Bureau Veritas Maritime Depts., Paris, France, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 86-90 (Oct 11-12, 1976) 7 figs, 7 refs

Key Words: Ships, Vibration control, Noise reduction

The building of sophisticated types of ships having various operational tasks to fulfill, often imposes rational solution of phenomena of sometimes contradictory character. So it was the case with a series of speedy hybrid roll-on/roll-off (ro-ro) container ships. On such vessels the relatively complicated internal steel-work of the hull girder is exposed to the excitations of the powerful propulsive installation hence the possibility of appearance of vibrations and noise. To assure normal operational conditions of the vessel by structural and machinery reliability and to meet the requirements of human comfort for the crew, rational studies, related to the integral treatment of static and vibratory (free and forced) phenomena of the ship and her propulsive plant, have been undertaken for the concerned series of ships. The main items studied and results obtained are reported.

77-1715

Vibration Excitation Forces from a Cavitating Propeller. Model and Full Scale Tests on a High Speed Container Ship

C.A. Johnsson, O. Rutgersson, S. Olsson, and O. Bjorheden

Swedish State Shipbuilding Experimental Tank, Goteborg, Sweden, Rept. No. Pub-78, 53 pp (1976) (presented at the Symp. on Naval Hydrodynamics (11th) London, UK (Mar 28-Apr 2, 1976))
PB-264 956/4GA

Key Words: Cargo ships, Vibration measurement

In connection with the technical trials with the triple screw container ship M/S Nihon measurements of pressure fluctuations and observations of propeller cavitation were carried out. In the present report the results are compared with the corresponding results from tests in cavitation tunnel. The comparison also includes some results of theoretical calculations. The measurements of full scale vibration are analyzed and compared with criteria of comfort. The results of the investigation are summarized at the end of the report. In an Appendix the different methods used for analyzing the measurements of pressure fluctuations are described and compared.

77-1716

Spherical Acrylic Plastic Hulls Under External Explosive Loading

J.D. Stachiw

Ocean Tech. Dept., Naval Undersea Center, San Diego, CA., J. Engr. Indus., Trans. ASME, 99 (2), pp 469-479 (May 1977) 16 figs, 4 tables, 18 refs

Key Words: Spherical shells, Submerged structures, Explosion effects

NEMO-type acrylic spherical hulls have been subjected to underwater explosions in order to determine their resistance to hydrodynamic impulse loading. Six 15-in. OD and one 66-in. OD spheres have been subjected to explosions of sufficient magnitude to initiate fracture in the hull. The tests were conducted at simulated depths of 10, 100, 1000, and 2000 ft utilizing explosive charges of 1.1, 8.2, 14.6, 169.9, 387.8, and 688.6 grams. Test results are given.

SPACECRAFT

(Also see Nos. 1570, 1625)

77-1717

Near Resonant Vibration Tests of an Orbiting Flexible Spacecraft: Theory, Design and Simulation

S.C. Garg

Inst. for Aerospace Studies, Toronto Univ., Ontario, Canada, Rept. No. UTIAS-204; CN-ISSN-0082-5255, 183 pp (Nov 1976) refs

N77-20158

Key Words: Spacecraft, Vibration tests

A proposed dynamics experiment is presented on the joint U.S./Canada Communications Technology Satellite. The experiment is to excite the spacecraft in flight by means of thrusters and measure dynamic response characteristics using accelerometers, and to compare the results with an analytical model of the flexible spacecraft dynamics. A pulse-train input is designed which is intended to be as close as possible to the spacecraft natural frequency. The response to it of the spacecraft, which is actively controlled, is explored by means of simple theory as well as a detailed digital attitude control simulation, to which flexible dynamics blocks were added. Inputs slightly off resonance are also considered.

77-1718

Finite-Element Analysis of CTS-Like Flexible Spacecraft

P.K. Nguyen and P.C. Hughes

Inst. for Aerospace Studies, Toronto Univ., Ontario, Canada, Rept. No. UTIAS-205; CN-ISSN-0082-5255, 108 pp (June 1976) refs

Sponsored by the Dept. of Communications, Ottawa

N77-20157

Key Words: Spacecraft, Dynamic structural analysis, Finite element technique

The dynamics of a class of non-spinning flexible spacecraft were studied. The spacecraft consists of a relatively rigid center body to which a number of flexible appendages are rigidly attached. The center body has pitch, roll, and yaw attitude motion. Deformations of the appendages are assumed elastic, small in amplitude, and are studied via a finite element analysis. Using a transformation from distributed displacements to finite element displacements, the angular momenta and moments of inertia of the flexible appendages are expressed in terms of elemental inertia matrices.

77-1719

Space Shuttle Response to Acoustic Combustion Instability in the Solid Rocket Boosters

F.R. Jensen

Bacchus Works, Hercules, Inc., Magna, UT., Rept. No. AFRPL-TR-76-62, 84 pp (June 1976)

AD-A037 157/5GA

Key Words: Space stations, Sound pressure, Combustion excitation, Booster rockets, Computer programs

Response of the Space Shuttle vehicle to unstable acoustic pressure oscillations in the solid rocket boosters was calculated. The NASTRAN computer program was used to analyze the various finite element shuttle models. A detailed finite element model of the solid rocket motor was constructed for use with the cyclic symmetry option in NASTRAN. The models were analyzed separately and results were combined to represent the total structure by using a mechanical impedance-type approach. Some hand calculations were performed to estimate the axial connection point force and displacement. The good agreement between hand calculation and computer solution provided some confidence in the computer solution.

77-1720

Flight Experiment Demonstrating Existence of Re-Entry Vehicle Nosetip Transient Shock Waves

J.M. Cassanto, A. Monfort, and C. Fehl

General Electric Co., Philadelphia, PA., J. Spacecraft and Rockets, 14 (6), pp 365-369 (June 1977) 11 figs, 17 refs

Key Words: Re-entry vehicles, Shock response

A flight experiment to demonstrate the existence of nosetip transient shock waves (oscillating shocks) has been conducted successfully on a re-entry vehicle that contained a high-frequency-response pressure sensor. The pressure sensor was a solid-state device located 18% of the re-entry vehicle length from the nosetip. The nosetip ablated shape was mapped utilizing recession sensors. A wind-tunnel test program was conducted.

STRUCTURAL

(Also see No. 1551)

77-1721

Natural Frequencies of Stiffened Box Structures

W.J.T. Daniel and R.J. Hooker

Dept. of Mech. Engrg., Univ. of Queensland, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 1-5 (Oct 11-12, 1976) 3 figs, 3 tables, 19 refs

Key Words: Box type structures, Stiffened structures, Natural frequencies, Finite element technique

Natural frequencies of stiffened box structures are calculated by the finite element method and compared with measurements on experimental models. The finite element solution strategy is discussed.

77-1722

Measurement of the Vibration of Large Structures

B. Dorien-Brown and B.H. Meldrum

National Measurement Lab., CSIRO, Australia, Vibration and Noise Control Engineering, Proceedings, Sydney, Australia, pp 6-10 (Oct 11-12, 1976) 2 figs, 10 refs

Key Words: Dynamic structural analysis, Measurement techniques, Measuring instruments

The paper discusses the measurement and analysis of the vibration of large structures. It sets out the instrumentation requirements and describes signal conditioning equipment designed to satisfy these requirements. Measurement techniques are discussed including natural and artificial excitation of structures, the use of multi-channel measurements to determine mode shapes, and on- and off-site calibration. Methods of analysis of records, including visual and computer-aided techniques are mentioned. Reference is made to measurement methods and techniques used by the authors and colleagues on four large structures; a radio-telescope, a solar observatory, an oil refinery structure and a bulk cargo unloader.

TRANSMISSIONS

(Also see Nos. 1550, 1556)

77-1723

Calculation of the Dynamic Behavior of High Capacity Hydrostatic Drives (Rechnergestützte Berechnung des dynamischen Verhaltens hydrostatischer Antiebe grosser Leistung)

R. Schulz

Konstruktion, 28 (5), pp 179-182 (May 1976) 3 figs, 1 table

(In German)

Key Words: Hydrostatic drives, Computer programs, Dynamic response

The problems occurring in the calculation of dynamic behavior of hydrostatic drives are described. The digital computer is recommended as the suitable aid in construction and design. The requirements for the digital computer program are listed and the most important parts of the program are discussed.

TURBOMACHINERY

(Also see No. 1598)

77-1724

Investigation of the Stability of Operating Points of Self-Controlled Running Turbomachines (Untersuchung zur Stabilität von Arbeitspunkten selbstregelnd betriebener Kreiselarbeitsmaschinen)

E. Piltz

Fachbereich Versorgungstechnik, Fachhochschule Braunschweig-Wolfenbüttel, Salzdahlummer Str. 46-48, D-3340, Wolfenbüttel, Federal German Republic, Ing. Arch. 46 (2), pp 105-113 (1977) 5 figs, 6 refs (In German)

Key Words: Stability, Turbomachinery

Simple conditions are given for stability of stationary operating points of self-controlled running turbomachines. By restriction to sufficient criteria it is possible to decide on stability only from graphs of the usual characteristics of the turbomachine and the plant.

USEFUL APPLICATION

(See No. 1600)

AUTHOR INDEX

TECHNICAL NOTES

H. Troger and C.S. Hsu
Response of a Nonlinear System Under Combined Parametric and Forcing Excitation
J. Appl. Mech., Trans. ASME, 99 (1), pp 179-181 (Mar 1977) 3 figs, 7 refs

M. Perulli, L. Avezard, A. Guédel, A. Lelarge, and C. Malarmey
Application of the Conditional Sampling Technique to the Characterization of Radiating Noise Sources
J. Sound Vib., 51 (4), pp 567-569 (Apr 22, 1977) 5 figs, 1 table, 1 ref

K.W. Yeow
Decay of Sound Levels with Distance from a Steady Source Observed in a Built-Up Area
J. Sound Vib., 52 (1), pp 151-154 (May 8, 1977) 1 fig, 1 table, 2 refs

A.T. Holmes, E.J. Richards, and M.E. Westcott
Some Comments on Impact Sound
J. Sound Vib., 51 (1), pp 139-142 (Mar 8, 1977) 1 fig, 6 refs

P. Filippi
Acoustic Diffraction by a Half-Plane with Discontinuous Boundary Conditions
J. Sound Vib., 52 (1), pp 133-136 (May 8, 1977) 1 fig, 3 refs

K.K. Raju and K.S. Rao
Vibrations of Shaft Supported Plates by Finite Element Method
J. Sound Vib., 51 (4), pp 563-566 (Apr 22, 1977) 3 tables, 2 refs

C.C. Huang
Traveling Loads on a Viscoelastic Timoshenko Beam
J. Appl. Mech., Trans. ASME, 99 (1), pp 183-184 (Mar 1977) 3 figs, 8 refs

M.K. Au-Yang
Generalized Hydrodynamic Mass for Beam Mode Vibration of Cylinders Coupled by Fluid Cap
J. Appl. Mech., Trans. ASME, 99 (1), pp 172-173 (Mar 1977) 3 refs

M.A. Satter and G. Ahmadi
Mean-Square Response of a Pipe Carrying Flowing Fluid to Non-Stationary Random Excitations
J. Sound Vib., 51 (4), pp 577-581 (Apr 22, 1977) 11 refs

A. P. Bhattacharya, P. C. Upadhyaya, and K. N. Bhowmic
Large Amplitude Vibration of Sectorial Plates
J. Sound Vib., 52 (1), pp 137-142 (May 8, 1977) 1 fig, 11 refs

S.K. Goyal and P.K. Sinha
Transverse Vibrations of Sandwich Plates with Concentrated Mass, Spring and Dashpot
J. Sound Vib., 51 (4), pp 570-573 (Apr 22, 1977) 2 figs, 2 refs

G.K. Ramaiah and K. Vijaykumar
A Note on Flexural Vibrations of Annular Plates of Narrow Width
J. Sound Vib., 51 (4), pp 574-576 (Apr 22, 1977) 4 refs

D. Krajcinovic
Dynamic Response of Infinitely Extended Plastic Plates
J. Appl. Mech., Trans. ASME, 99 (1), pp 175-177 (Mar 1977) 1 fig, 11 refs

K. Nagaya
Transverse Vibration of a Plate Having an Eccentric Inner Boundary
J. Appl. Mech., Trans. ASME, 99 (1), pp 165-166 (Mar 1977) 1 fig

M.F. Spotts
Minimizing Spring Volume
Mach. Des., 49 (13), pp 111-112 (June 9, 1977)

M.S. Hundal
Optimum Damping for Impact Absorbers
J. Sound Vib., 52 (1), pp 148-150 (May 8, 1977) 2 figs, 1 ref

CALENDAR

OCTOBER 1977

3-5 **Joint Lubrication Conference,** Kansas City, MO *(ASME Hq.)*

17-19 **NOISE-CON 77,** Hampton, VA *(Conf. Secretariat, Noise Control Foundation, P.O. Box 3469, Arlington Branch, Poughkeepsie, NY 12603 Tele. (914) 462-6719*

18-20 **48th Shock and Vibration Symposium,** Huntsville, AL *(H.C. Pusey, Director, The Shock and Vibration Info. Ctr., Code 8404, Naval Res. Lab., Washington, D.C. 20375 Tele. (202)767-3306*

NOVEMBER 1977

27 - Dec 2 **Winter Annual Meeting,** [ASME] Atlanta, GA *(ASME Hq.)*

DECEMBER 1977

6-8 **Sixth Turbomachinery Symposium,** Houston, TX *(Dr. M.P. Boyce, Gas Turbine Labs., ME Dept., Texas A&M, College Station, TX 77843)*

13-16 **Acoustical Society of America, Fall Meeting,** Miami Beach, FL *(ASA Hq.)*

MARCH 1978

25-27 **Applied Mechanics Western and J.S.M.E. Conference,** Honolulu, Hawaii *(ASME Hq.)*

APRIL 1978

3-5 **Design Engineering Conference & Show** [ASME] Chicago, IL *(R.C. Rosaler, Rice Assoc., 400 Madison Ave., N.Y., NY 10017)*

9-13 **Gas Turbine Conference & Products Show,** [ASME] London *(ASME Hq.)*

MAY 1978

4-5 **IX Southeastern Conference on Theoretical and Applied Mechanics,** [SECTAM] Nashville, TN *(Dr. R.J. Bell, SECTAM, Dept. of Engrg. Sci. & Mech., Virginia Polytechnic Inst. & State Univ., Blacksburg, VA 24061)*

8-10 **Inter-NOISE 78,** San Francisco, CA *(INCE, W.W. Lang)*

8-11 **Offshore Technology Conference,** Houston, TX *(SPE, Mrs. K. Lee, Mtgs. Section, 6200 N. Central Expressway, Dallas, TX 75206)*

14-19 **Society for Experimental Stress Analysis,** Wichita, KS *(SESA, B.E. Rossi)*

JUNE 1978

Eighth U.S. Congress of Applied Mechanics, Los Angeles, CA *(ASME)*

OCTOBER 1978

1-4 **Design Engineering Technical Conference,** Minneapolis, MN *(ASME Hq.)*

8-11 **Diesel and Gas Engine Power Conference and Exhibit,** Houston, TX *(ASME Hq.)*

8-11 **Petroleum Mechanical Engineering Conference,** Houston, TX *(ASME Hq.)*

17-19 **Joint Lubrication Conference,** Minneapolis, MN *(ASME Hq.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, N.J. 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave. N.W.
Washington, D.C.

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, N.Y. 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, N.Y. 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, Ill. 60605

AHS: American Helicopter Society
30 E. 42nd St.
New York, N.Y. 10017

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, N.Y. 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, N.Y. 10017

ASME: American Society of Mechanical Engineers
345 E. 47th St.
New York, N.Y. 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, Ill. 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, Wis. 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, Pa. 19103

CCCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, N.Y. 10017

IES: Institute Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, Ill. 60056

IFToMM: International Federation for Theory of Machines and Mechanisms, US Council for TMM, c/o Univ. Mass., Dept. ME, Amherst, Mass. 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch,
Poughkeepsie, N.Y. 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, England

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, Conn. 06880

SNAME: Society of Naval Architects and Marine Engineers, 74 Trinity Pl.
New York, N.Y. 10006

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, Mass. 02173