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DIRECTOR NOTES

Not so many years ago the operators of construction or mining equipment were on their own with respect to the noise and hazards involved in the operation of this equipment. Today they are protected by regulation laid down by the Occupational Safety and Health Administration (OSHA). Opinions vary on whether the OSHA requirements are properly written but most people agree that the safety and comfort of workers on the job is a very important consideration. Along these lines I have participated in some recent discussions on noise regulations.

It is obvious that, within certain limits, human tolerance of noise varies with the individual. It is also obvious that noise regulation cannot be imposed on an individual basis. OSHA has chosen to relate noise level to exposure time. For example, at 90 dbA or below an equipment operator may work an eight hour shift. If the level is at 95 dbA, the workshift can only be 4 hours. Under these requirements operators of some particularly noisy mining equipment may only work for an hour or two. As expected, there is a heavy demand for noise reduction specialists to lower the operating noise levels for existing equipment. For some equipment some rather significant accomplishments have been made.

What seems to be missing is a concerted effort on the part of equipment manufacturers to consider noise as a design parameter. In my opinion, this will change in the years ahead. Purchasers of heavy equipment, faced with rigid noise requirements, will make these requirements a part of their procurement specifications. Equipment manufacturers would be wise to start thinking about these requirements now.

H. C. P.

EDITORS RATTLE SPACE

WHAT DOES THE NEW COPYRIGHT LAW MEAN TO YOU?

The purpose of Copyright laws is to protect written documents, not ideas. Limitations to the use of copyrighted printed materials by engineers, researchers, writers, and publishers has been a gray area for many years. The Copyright law of 1909 was enacted to protect the investment of authors and publishers, but it has not been effective since fast copying machines became accessible to the public. To remedy this situation the U.S. Congress passed legislation that became effective January 1, 1978. The four pertinent points of this law are as follows:

1. Statutory copyright begins as soon as a document is written, rather than at the time of publication or registration. The copyright remains with the author or author's employer unless it is formally assigned to someone else.

2. Copyright of a collective work, such as a proceedings, is separate from the copyrights of the individual works it contains. If the individual copyrights are not acquired by the publisher, they remain with the author.

3. The court-developed doctrine of "fair use" -- that is, use of copyrighted material for nonprofit research and educational purposes without permission of or compensation to the copyright owner -- is given statutory recognition.

4. Methods for compensating authors and publishers for use of documents are established.

It has been recognized that continued financial motivation for generating and publishing new documents would require a new copyright law. Thus, although the new law may mean little to the average engineer in a direct sense, it will have a significant indirect effect -- continued availability of published technical material. Of course, this does not mean that the published material will be any better or worse in quality than that published before the new law became effective; it means only that such material will continue to be available.

On the other hand the engineer-author will have more direct control of his work because he can retain or reassign the copyright. The new law thus eliminates uncertainty about the copyright of a particular document. In addition, the new law provides that authors and publishers receive reasonable compensation for use of their material.

The new copyright law seems fair to users, authors, and publishers, but more bookkeeping will be required to determine who gets what compensation.

R.L.E.

RECENT DEVELOPMENTS IN STATISTICAL ENERGY ANALYSIS

R.H. Lyon*

Abstract - This is a review of recent work related to the basic theory of and developments in statistical energy analysis (SEA). Most of the cited references have appeared since 1972. Some of the more interesting new applications have been to marine systems.

This is a review of developments in statistical energy analysis (SEA) that have taken place in the past five years. Articles that appeared in 1970 [1] and 1972 [2] describe the literature before 1972. Any previous lack of confidence in the acceptance of SEA would seem to have been receding as ever increasing interest in it has made it an established concept. This review attempts to evaluate current developments in SEA.

The article begins with a brief summary of various attempts to clarify and extend the basis for SEA. The body of the paper is a review of developments in the applications of SEA -- mostly in building structures and such marine systems as ship structures, buoy systems, and offshore towers. These developments give promise that SEA will find even greater application and importance in design.

Finally, the material presented in this review tends to include all SEA-related material. Thus work that might not be considered by some to be SEA is cited; for example, work on wave transmissibilities, impedances of structures, modal densities, and other system parameters that is perhaps carried out for purposes unrelated to SEA.

DEVELOPMENTS

Lyon and Maidanik [3] used what might be called a "derivational approach" to obtain the basic relations of SEA. This approach, analogous to kinetic theory in gas dynamics, attempts to derive expressions for certain statistics of random vibration, beginning with basic mechanics. Postulates or assumptions regarding coherence of exciting forces, relative magnitude of coupling and system parameters, and distributions of system parameters are necessary. Several papers since 1970 have attempted to clarify the nature of the assumptions required to obtain SEA results and to obtain more refined estimates of the energy distribution than SEA can provide [4-11].

The most popular coupled system for study involves two mechanical structures -- plates and beams -- coupled at discrete positions by one or more mechanical impedances of known characteristics. Removal of the impedances allows two fairly simple uncoupled systems to be defined. Mode shapes and complex resonance frequencies can readily be found. Further, the dynamics of the coupled system, although complicated, can be written. Various simplifying factors can be introduced to obtain SEA results. In this sense, the "assumptions" of SEA can be made explicit, at least for a given system.

This derivational approach to SEA is appealing, but a postulational approach has also been used [13] that considers the system as part of an ensemble of systems with statistically distributed properties. Statistics of energy distributions throughout the ensemble are used to estimate the vibration of individual members. The acceptability of the SEA model, therefore, is based in part on the reasonableness of the assumed distributions and even more on the degree of correspondence between predictions based on the model and experimental data.

It should be emphasized that the derivational and postulational approaches are complimentary rather than competitive. Selection of appropriate characteristics of the ensemble can be guided by detailed analysis, particularly as certain effects, such as modal coherence, that are important in real systems are included in SEA.

*Professor, Dept. of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

Another development [13] should be mentioned. A review of past work showed that two different "coupling loss factors" had been in use. The first -- and in my opinion, proper -- coupling loss factor relates power flow to modal energies of the system in the coupled state. The second factor relates paper flow to modal energies in the uncoupled state. An uncoupled system is defined as one that results when the response variables of all but one system are set to zero, without removal of the coupling elements [8, 12]. These two coupling loss factors are given the symbols η_{ij} and a_{ij} respectively. The identification of these two quantities clarifies ambiguities in some basic papers.

In my opinion the "derivation" of new results in SEA is a cul de sac, however. What does hold promise is the inclusion of such effects as modal coherence that will allow SEA to be extended to direct or propagating fields as a result of sources or concentrated regions of absorption. Such analyses have been developed in architectural acoustics and should provide good guidance [14].

APPLICATIONS

To Building Acoustics

It is gratifying that building acoustics -- especially flanking transmission by structural paths -- which were important in the conceptual development of SEA, should now benefit from it. Several groups are examining problems in flanking transmission [15-18]. Generally, one framework of SEA is used [13], correspondence between predictions and laboratory or field data is emphasized.

The transmission of sound from one room to another involves both airborne ("through" the walls of adjoining spaces) and structure-borne paths. SEA provides both a convenient and economical way to indicate the various ways of transmitting energy and a procedure for assessing the relative importance of different paths. The energy storage elements are walls, floors, and acoustical spaces. Damping loss factors are related to reverberation times of rooms and structural segments. Coupling loss factors can be expressed in terms of transmission loss, radiation efficiencies, and transmissibility of vibration between structural elements [19].

SEA formalism can be used to predict sound and vibration transmission in a building complex on the basis of known or assumed values of such parameters as modal density, damping loss factors, and coupling loss factors. The process can also be turned around -- energy distributions and input power values can be determined experimentally, and values for the parameters calculated. The direct process appears to give good results [16, 17], but the inverse process may lead to erratic and unrealistic values of the parameters [15]. It is likely that the accuracy of parameter values is in some way dependent upon the accuracy of the measurements of energy and input power. A sensitivity analysis of the process aimed at finding an optimal strategy for determining the parameters is needed because the experimental determination of parameters is redundant [20].

To Ship Structures

An interesting development related to the flanking problem in acoustics is the use of SEA to predict noise transmission in ships. Because of its construction, a ship structure is able to transmit energy at audible frequencies to spaces quite remote from the sources of noise (pumps, valves, engines). Informal and word-of-mouth reports indicate that ship development groups in both eastern and western Europe, Japan, and the United States are using SEA to predict sound and vibration levels in commercial and naval ships. In a conference held in Delft, The Netherlands in 1976, some of the groups active in this area presented their work [21].

The literature regarding applications of SEA to ship structures is fragmentary, but some work has been published [21-24]. A major concern is whether in-plane longitudinal modes of vibration must be considered in addition to the more numerous and acoustically coupled flexural modes [22]. SEA is readily adaptable to the inclusion of longitudinal modes, but designers are naturally reluctant to increase the complexity of the SEA model unless it is demonstrated to be necessary.

The major issues seem to be practical ones of computational accuracy. Even though SEA procedures result in simplified equations as compared to finite element analysis, SEA analysis of a ship structure can result in hundreds of simultaneous equations for energy flow. Noise control treatments that involve changes in damping loss factors or coupling loss factors by the use of decoupling elements on walls or in structural joints could result in a large number of computations. The process will have to be shortened in some reasonable way.

Between the Ocean and Offshore Structures

The excitation of offshore towers and buoy systems by ocean waves has become a problem for designers as offshore drilling for oil and interest in ocean-bed mining have increased. The application of SEA to the excitation of offshore structures could result in new developments in the basic theory of SEA.

Many concepts having to do with the interaction of water waves and ocean structures are analogous to the excitation of structures by sound; for instance, the reciprocity between mean square force due to a wave on a structure and its radiation damping provided by the structure [25] and the notion of a diffuse wave field in two dimensions [26]. These concepts have been used to develop a theory for the excitation of offshore towers by random seas [27]. SEA is being considered in studies to predict sloshing responses of fluid tanks on offshore towers [28] and responses of buoy systems to random seas [29].

Prediction of the response of a structure to ocean wave excitation is largely a function of the dependence of the wave height spectrum on frequency. This dependence raises some issues regarding the proper SEA model and affects the relative importance of resonant and non-resonant response. In addition, because the shape of the spectrum is related in part to nonlinear wave conversion and excitation processes, the extent to which this nonlinearity can be ignored in the interaction process poses a question.

The applications of SEA are potentially significant for studying the responses of fixed and floating marine structures to ocean waves. The flexural and torsional modes of oil tankers, for example, or the sloshing response of liquids in the tanks of ships are problems that can be attacked immediately on the basis of work that has been done.

OTHER DEVELOPMENTS AND APPLICATIONS

Some of the work related to SEA is a continuation of earlier developments and applications. Much of the early SEA work was related to the response of aerospace structures to acoustical noise and turbulent flows. Some of this work is continuing, mostly to establish just how accurately SEA can predict response [30, 31]. A coupling loss factor of particular interest for such structures is that of two plates joined across a stiffening beam. A similar situation exists for the hull structure of ships. A complication is the transmission process across the beam due to the effects of fluid loading, which allows more energy to propagate past the obstacle and increases the coupling loss factor [32, 33].

Sound transmission through walls has been an active area of SEA application that has already been described [1, 2]. Some additional work has been done [34, 35], but much of the interest has shifted to flanking by structural paths. Another form of "flanking" -- that due to cracks or slits that sound can penetrate -- has also been attacked using SEA [36]. The transmission of sound through cylinders is another important problem with applications in aerospace, marine, and industrial noise problems [37, 38].

CONCLUSIONS

There has been no explosion of work in SEA, at least insofar as the number of papers being produced. New areas of application are being developed, however, and the work is becoming more widespread geographically. Even though the approach is new to many engineers, it is being accepted and treated as a tool; undoubtedly, the publication of a textbook [13] has helped. Some areas, such as the response of building structures to ground motions, are promising but have not as yet been explored.

ACKNOWLEDGEMENT

This review would have been much more difficult to prepare without the help of several colleagues and friends who took time from their busy schedules to send me reprints and other information. I am particularly indebted to M. Crocker, H. Davies, F. Fahy, B. Gibbs, M. Heckl, R. Josse, T. Kihlman, P. Kopff, G. Maidanik, J. Manning, A.J. Price, and E. Ungar. It is the nature of things that I will have missed someone's work -- it is not intentional, so please let me know about it.

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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.

The second part of a five part review on parametric vibration written by Dr. R.A. Ibrahim and Dr. A.D.S. Barr is contained in this issue of the DIGEST. The mechanics of nonlinear problems is included.

An annotated bibliography by Dr. R.A. Scott on linear elastic wave propagation which covers homogeneous isotropic media is published herein.

PARAMETRIC VIBRATION
PART II: MECHANICS OF NONLINEAR PROBLEMS

R.A. Ibrahim* and A.D.S. Barr**

***Abstract** - This survey of the theory of parametric vibration and its related current problems consists of five review articles. The titles are:*

I. Mechanics of Linear Problems
II. Mechanics of Nonlinear Problems
III. Current Problems (1)
IV. Current Problems (2)
V. Stochastic Problems

Because it is inconvenient to refer to all published materials, the authors have tried to review the most important literature and to emphasize recent results. Parts IV and V contain lists of unreferenced literature.

The theoretical analysis of the dynamic response of a vibrating system is usually carried out within the framework of the classical theory of small oscillations. This theory supposes that the vibration is small enough in some sense so that the kinetic and potential energies can be written as quadratic forms in the $\dot{q}_i$ and the q_i respectively (q_i being generalized coordinates), these forms having constant coefficients. The equations of motion of the system are thus constant coefficient linear equations. The corresponding harmonic solutions are adequate to describe the system so long as the motion is close to the stable static equilibrium configuration.

This theory is an approximation, however. The coefficients of the kinetic energy quadratic form are really functions of the generalized coordinates q_i (and of t in rhenomic systems). The Taylor expansion of the potential energy about the equilibrium gives cubic, quartic, and higher terms in the q_i. The inclusion of the higher order terms makes the equations of motion of the system nonlinear. If the motion is kept small, the nonlinear terms can be said to constitute a small perturbation of the linear system. This perturbation can be described by small oscillation theory. In general, such lower order nonlinearities as the quadratic and cubic terms in the coordinates, as well as their time derivatives, will be the most important. Sometimes, however, small nonlinear perturbations play an important part in determining the motion of the system, in such situations linear theory is inadequate. Nonlinearities can be important -- especially with resonance conditions that differ from those mentioned in Part I of this series (see the January, 1978, issue of the DIGEST).

The effects of various nonlinearities on the behavior of parametrically excited systems and the mechanics of systems with explicit and implicit time-dependent coefficients are reviewed in this second article of the series.

SINGLE-DEGREE-OF-FREEDOM SYSTEMS

It has been shown [1] that the linear Mathieu equation adequately predicts the stability of the zero solution. The fact that the equation does not give a unique bounded solution for the response of the system led a number of investigators [2-6] to consider nonlinear effects in the equations of motion. Bolotin [2] defined three types of nonlinearities in vibrating systems. They are expressed in equation (1).

$$\ddot{q} + 2\eta\dot{q} + \omega^2[1 - 2b\cos(\Omega t)]q + \gamma q^3 + 2\delta q^2\dot{q} + 2kq(q\ddot{q} + \dot{q}^2) = F\cos(\Omega_1 t) \quad (1)$$

where γq^3 is nonlinear stiffness, $2\delta q^2\dot{q}$ defines nonlinear damping, and $2kq(q\ddot{q}+\dot{q}^2)$ represents nonlinear inertia.

The response of the system can be calculated analytically by a perturbation scheme, the values of γ, δ, k, F, and b determine the scheme used. Various types of resonance can be obtained by setting b=0 [7-10].

Subharmonic resonance occurs when a system oscillates with a frequency equal to a fraction of the exciting frequency.

*Senior Research Specialist, Arab Organisation for Industrialisation, Sakr Factory for Developed Industries, P.O. Box 33, Heliopolis, Cairo, Egypt
**Professor of Mechanical Engineering, University of Dundee, Dundee DD1 4HN, Scotland, UK

$$\omega = \frac{m}{n}\Omega_1 \qquad \begin{array}{l} n = 2, 3,... \\ m = 1, 2,... < n \\ m/n \neq 1, 2,.. \end{array} \qquad (2)$$

For m=1 the resonance relation shown in equation (2) is called subharmonic. Otherwise it is ultrasubharmonic.

Superharmonic resonance can occur if a system oscillates at some multiple of the exciting frequency.

$$\omega = \frac{n}{m}\Omega_1 \qquad \begin{array}{l} n = 2, 3,... \\ m = 1, 2,... \end{array} \qquad (3)$$

For m=1 the resonance is superharmonic, or ultraharmonic [8]. Otherwise it is ultrasuperharmonic.

If the system described by equation (1), with b=0, is subjected to several harmonic excitations with frequencies of Ω_1, Ω_2,..., a combination tone can be induced with frequency ω such that [11, 12]

$$\omega = \frac{1}{k}|m_1\Omega_1 + m_2\Omega_2 + ... + m_n\Omega_n| , \qquad m_1, m_2,... = \pm 1, \pm 2,... \qquad (4)$$

ω is the natural frequency of the system. When k=1, the relationship shown in equation (4) is referred to as combination tone. When k = 2, 3, or more, the relationship is called a subcombination. A number of examples of this class of resonance have been published [9, 11-17].

INFLUENCE OF NONLINEARITIES ON PARAMETRIC VIBRATION

Early studies [18-22] showed that the unstable regions of the linear Mathieu equation can be reduced by including relevant nonlinear factors. The boundedness of the solution of equation (1) has been discussed [23, 24]. The limiting effects of nonlinear damping and stiffness on the growth of motion of parametrically excited systems has been studied [25]. Theorems for the boundedness, stability, and asymptotic stability of nonlinear differential equations with periodic coefficients have been established [26].

Heinrich and Schmidt [27] used the classical iteration method of conversion to integral equations to obtain the amplitude frequency response of the Mathieu equation; damping and stiffness were nonlinear of the fifth order. Schmidt [3] used integro-differential equations theory to analyze a number of nonlinear parametrically excited systems. Kononenko and Kovalchuk [28] considered equation (1) for two cases: when $\Omega = 2\omega$ and when the difference between the forced exciting frequency Ω_1 and the frequency of the free oscillation is sufficiently large or small. Ness [7] thoroughly investigated a nonhomogeneous expression for nonlinear stiffness and examined the possibility that different types of resonance could occur.

Benz [29] and Boston [30] considered the Mathieu equation when stiffness is nonlinear. The response of the one-half subharmonic increased to a certain maximum then decreased, resulting in a modulated one-half subharmonic [30]. Hsu [31] used Jacobian elliptic functions to determine the exact periodic responses of a second-order system having cubic stiffness.

Studies have shown that linear damping has two effects on parametric vibration: it modifies the stability regions and limits the peak amplitude response. Kovalenko [32] introduced external and internal damping to resolve an infinite series of unstable zones concentrated at zero parametric frequency.

The effect of internal damping on the stability of structures has been considered [33, 34]. Stevens [35] represented the material properties of a column with simple spring dashpot models. He found that the instability regions were bounded and that they shifted toward lower excitation frequencies as the material became more viscoelastic. Stevens and Evan-Iwanowski [36, 37] later used the complex modulus representation for the material; the imaginary part represents internal damping capacity. The viscoelastic effects tended to stabilize the system [36] and could destabilize the elastic structure if the range of frequencies differed from that predicted by purely elastic analysis. Asmis and Tso [38, 39] compared the effects of bilinear hysteretic damping elements, double bilinear hysteretic damping, and viscoelastic damping elements on the parametric behavior of an inverted pendulum. Large portions of the steady-state amplitude frequency response curves of a double bilinear hysteretic system were directed toward the decreasing frequency [38]. Kononenko and Kovalchuk [28, 40] investigated periodic solutions of a system with nonlinear damping using both parametric and self-parametric excitations. Kovalchuk [41] discussed the behavior of a nonlinear system having nonconservative forces dependent upon displacement and velocity. Hagedron [42] used quadratic damping forces to examine the response of parametrically excited systems.

Effects of nonlinear inertia have been studied [43, 44]. They can change an originally stable system so that it appears to be dragged into a catastrophic unstable state. Pankratov [44] introduced a nonlinear function of inertia to a system and examined its response under two simultaneously parametric excitations. The frequencies Ω_1 and Ω_2 were such that $n\Omega_1 + m\Omega_2 = 0$ (n and m are sufficiently large integers).

Tso and Caughey [45] considered a nonlinear parametrically excited system described by equation (5).

$$\ddot{q} + q + b_1 q^m + b_2 q^{n-1} - b_3 q^{n-1} \cos(\Omega t) = 0 \quad (5)$$

where b_1, b_2, and b_3 are positive constants; m and n are positive integers, m being odd, n even, and $m > n$. At m=5 and n=4, the subharmonic behavior of order one fourth was observed experimentally when the parametric excitation was large enough. Schmidt and Heinrich [46] investigated similar systems with nonlinear damping. This class of equations has been discussed in detail [3]. Meinke [47] studied a mechanical oscillator model described by a nonhomogeneous equation with time-dependent coefficients of the type shown in equation (5) and obtained the transient state of subharmonic oscillations.

MULTI-DEGREE-OF-FREEDOM SYSTEMS

Nonlinear systems with several degrees of freedom can exhibit various types of instability in addition to those already mentioned. The Hamiltonian for a conservative n-coupled degree-of-freedom system is given in the form [48] shown in equation (6).

$$H(p,q,t) = H_2(p,q,t) + H_3(p,q,t) + \ldots + H_k(p,q,t) \quad (6)$$

where $p = (p_1, p_2, \ldots, p_n)$ is the generalized momenta vector, $q = (q_1, q_2, \ldots, q_n)$ is the generalized coordinate vector, and H_k (p, q, t) is the Hamiltonian function of degree k in the variables p, q, and time t.

It has been shown that the nonlinearities contained in $H_{k>2}$, which couple different modes, can significantly influence the behavior of some dynamic systems, especially under certain nonlinear resonance conditions [49-63]. Sethna [57], Barr [49], and Tondl [63] showed that the nonlinear coupling terms appear in the equations of motion as the product of the different modes; see equation (7).

$$\ddot{\xi}_r + \omega_r^2 \xi_r = \epsilon \left\{ \left[\sum_i^n K_{ri}(t) \xi_i \right] - \Phi_r(\xi, \ddot{\xi}) - \Psi_r(\xi, \dot{\xi}) - \theta(\xi) - F_r(t) \right\} \quad (7)$$

$$r = 1, 2, \ldots, n$$

Equation (7) represents n equations in the nondimensional normal coordinates ξ_r. The first term on the right side represents the parametric excitation; Φ_r are analytic functions of the acceleration $\ddot{\xi}_i$ and displacement ξ_i and represent the nonlinear inertia; Ψ_r are functions of the velocity and displacement and represent the nonlinear damping of the system; and θ_r are analytic functions of the displacement. $F_r(t)$ are the forcing excitations, and ϵ is a small parameter.

Two conditions that can be derived from equation (7) are combination resonance and autoparametric resonance. Combination resonance, or nonlinear combination resonance, can occur when the frequency of the external excitation Ω satisfies the condition shown in equation (8).

$$\Omega = \frac{1}{k} \sum_{r=1}^{n} |m_r \omega_r| \quad (8)$$

where k and $m_r = \pm 1, \pm 2, \ldots$. This relationship can be obtained when the functions Ψ_r and θ_r are considered in the analysis of equation (7). Equation (8) was first derived by Malkin [64] and then studied by Tondl [63, 65], Szemplinska-Stupnica [58-60] and Yamamoto et al [66-68].

In autoparametric, or internal, resonance, the nonlinear function Φ_r in equation (7) can contain terms of the form $\xi_r \ddot{\xi}_i$, in which the acceleration of the ith mode ($\ddot{\xi}_i$ is an implicit function of time in rheonomic systems) acts as a parametric load to the rth mode. However, the mode $\ddot{\xi}_i$ is not an infinite source of energy independent of ξ_r but is linked to the latter by the equations of motion. The presence of these terms indicates the possibility that a certain type of instability can occur when the relationship between the normal mode frequencies is linear. This type of instability is referred to as internal, or parametric, resonance and has the general form shown below [69-75].

$$\sum_{i=1}^{n} k_i \omega_i = 0 \tag{9}$$

The k_i are integers. It is believed [75] that Korteweg [76] and Beth [73] did the earliest work on internal resonance. Minrosky [21] is credited with applying the term autoparametric coupling to problems involving nonlinearities of the type Φ_r. Tsel'man [69] called the vector $\underline{k} = (k_1, k_2, \ldots, k_n)$ the resonance vector. The number $k = |k_1| + \ldots + |k_n|$ is known as the order of internal resonance. Internal resonance can occur in a two-degree-of-freedom system with quadratic nonlinearities when the natural frequency of one mode is equal to twice the natural frequency of the other mode [49, 69]. For a system with three degrees of freedom and quadratic nonlinearities, internal resonance can occur when $\omega_r = \omega_i \pm \omega_j$; i, j, and r are different modes [49, 70]. Tomáš [77] showed that internal resonance with cubic nonlinearities can occur at either of the two relationships shown below.

$$\omega_r = \frac{2}{3}\omega_i, \text{ or } \omega_r = \frac{1}{3}\omega_i$$

Figure 1 shows some systems in which internal resonance can take place.

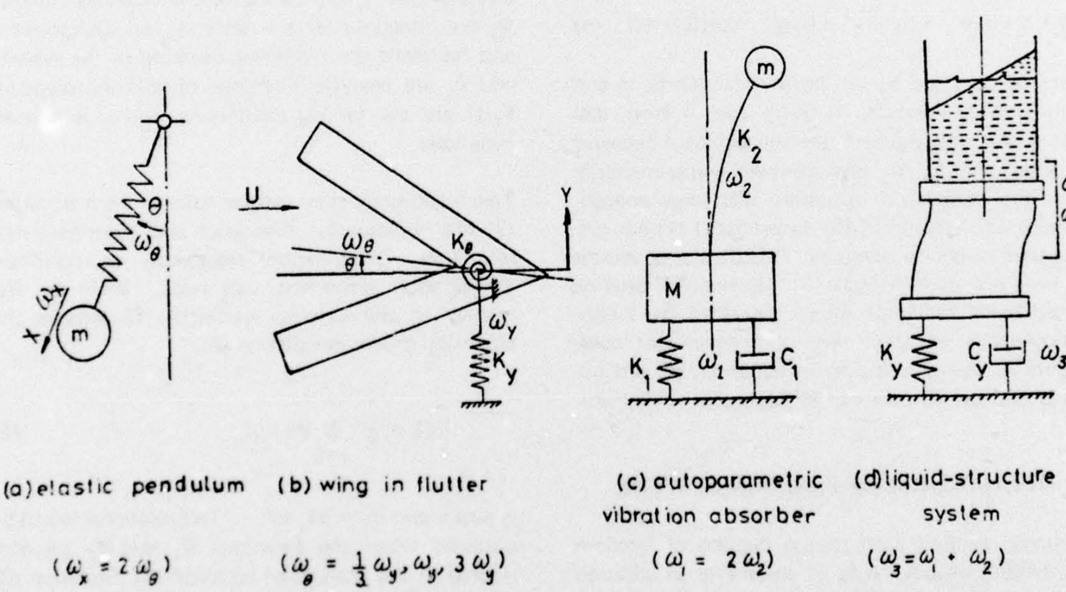

Figure 1. Systems with Autoparametric Resonance ($\sum_{i=1}^{n} k_i\omega_i = 0$) [1]

Tsel'man [69, 70] used the normal form of the Hamiltonian system to study the interaction of coupled oscillators with third order resonance ($\omega_r = 2\omega_i$ or $\omega_r = \omega_i + \omega_j$) in autonomous systems. He found that periodic "pumping transfer of energy" occurs from one mode to another for all possible initial values of one of the modes except those values associated with singular points. Khazin and Tsel'man [71] extended the analysis for n-coupled oscillators and generalized the conclusion that periodic energy transfer takes place between the oscillators at resonance.

Gilchrist [78] investigated free oscillations in quasi-linear systems with two degrees of freedom. The exchange of energy between the vibrating modes depends on their relative phase. Kronauer and Musa [79] extended Gilchrist's analysis to include more complex conservative systems.

Cheshankov [16-21] used the asymptotic method to investigate a number of conservative systems with multi-frequency resonance oscillations. Figure 2 illustrates a typical response of a two-degree-of-freedom autonomous system and the energy transfer between the x-mode and θ-mode of the elastic pendulum shown in Figure 1a when it is detuned internally at $\omega_x = 2\omega_\theta$.

The stability of the trivial solution of autonomous systems has been analyzed for different cases of internal resonance [80-85]. Dysthe and Gudmested [80] gave conditions sufficient for stability of all possible initial conditions associated with conservative Hamiltonian systems of n-degrees of freedom.

Autoparametric resonance occurs in nonautonomous systems when the conditions of internal resonance, see equation (9), and external resonance are met simultaneously. Sethna [57] classified these systems into two classes:

- Nonautonomous systems with internal and external resonances in the superharmonic class as $\Omega = \frac{1}{2}\omega_2$, $\omega_2 = 2\omega_1$. ω_1 and ω_2 are different normal mode frequencies, and Ω is the external excitation frequency. A similar case was considered by Efstathiades [86].
- Nonautonomous systems with internal and external resonances in the subharmonic case (as $\Omega = \omega_2$, $\omega_2 = 2\omega_1$). In this case it was found [51, 57] that one mode acts as a vibration absorber to the excited mode.

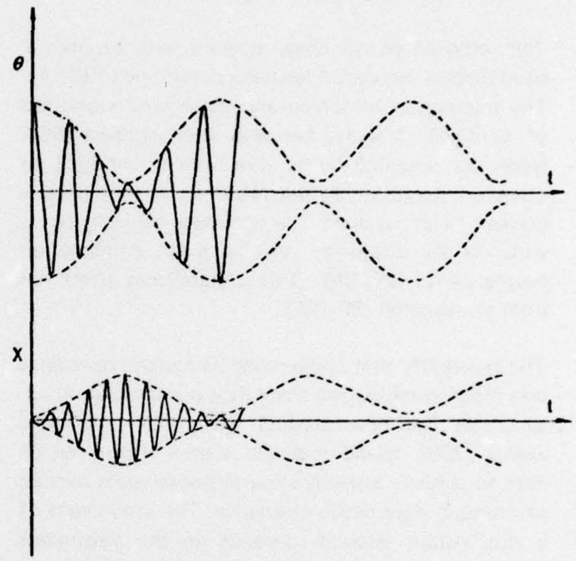

Figure 2. Energy Transfer Between θ and X Modes of the Elastic Pendulum $\omega_x = 2\omega_\theta$

The possibility that two internal resonance conditions will occur simultaneously when additional vibrating modes are considered has been studied [87]. The response of the system may show an irregular energy transfer between the coupled modes. The effect of internal resonance on the parametric combination resonance response of a nonlinear two-degree-of-freedom system has been examined [88]. Internal resonance tends to reinforce combination resonance; the result is a larger steady-state response than occurs with combination resonance alone. Internal detuning can prevent the system from reaching a steady state; beating will occur due to the continuous exchange of energy between the modes.

Equation (7) can be used to examine the effects of nonlinear functions on parametric response in the absence of internal resonance. The conditions under which periodic oscillations of large amplitude occur in a two-degree-of-freedom nonlinear system as a result of variations in inertia were obtained by Porter [89]. Both the first and second normal modes can exhibit periodic vibrations when the external excitation frequency $\Omega = \omega_1, \omega_2, \frac{1}{2}\omega_1$, or $\frac{1}{2}\omega_2$.

The response of nonlinear systems with parametric combination resonance has been determined [90-94]. The interaction of forced and parametric vibrations of nonlinear systems has also been studied [95]. Nonlinear coupling terms have been found [96] to cause an irregular beating response in the unstable domain of the system. The nonlinear damping terms widened the instability regions of the combination resonance [5, 97, 98]. This destabilizing effect has been investigated [99-102].

The possibility that single mode parametric resonance and mode combination resonance could occur simultaneously has been studied [103, 104]. Tso and Asmis [103] found that the system might not be able to achieve a steady-state response when excited in multiple parametric resonance. The attainment of a steady-state response depends on the parameters of the system and the external exciting frequency. The steady-state response amplitude when forced and parametric vibrations interact was higher than that in the absence of interaction [103].

NONSTATIONARY EXCITATION

Nonstationary processes can occur as a result of either a specific time variation in the excitation frequency or the interaction of an energy source with a vibrating system. Nonstationary processes play a significant role in many vibrating systems, especially during the transition through resonance. The most important work on this topic has been done by Mitropol'skii [105, 106] and Kononenko [107].

Mitropol'skii [106] discussed a number of nonstationary problems associated with vibrations of dynamic systems having variable mass and stiffness. He also studied variations of system parameters. Mitropol'skii considered the Mathieu equation in the case of parametric instability in which modulation frequency varies slowly with time.

$$\ddot{X} + \omega^2(1 - 2b\cos(\theta))X = 0 \qquad (10)$$

where $d\theta/dt = \Omega(t)$, $\tau = \epsilon t$

The corresponding solution to the principal parametric resonance is given in the form shown in equation (11).

$$X = a\cos(\tfrac{1}{2}\theta + \psi) \qquad (11)$$

To a first order approximation, the equations for a and Ψ are as shown below.

$$da/dt = -\frac{ab\,\omega^2}{\Omega(t)}\sin(2\psi)$$
$$d\psi/dt = \omega - \tfrac{1}{2}\Omega(t) - \frac{b\omega^2}{\Omega(t)}\cos(2\psi) \qquad (12)$$

For the simple case when $\Omega(\tau) = \Omega_0 + \alpha t$, the amplitude-frequency response curves in the neighborhood of parametric resonance were obtained by numerical integration.

If the frequency of excitation varies periodically with time, a limit cycle response is reached. It can differ from the corresponding stationary response. Asymptotic solutions have been developed for a number of nonlinear differential equations with slowly varying parameters [105-111]. Degree of damping, initial conditions, and the effect of internal resonance are accounted for. The nonstationary response depended on whether or not the excitation frequency increased or decreased with time. Beats of amplitude appeared immediately after the region of transition through resonance. The faster the transition through resonance, the more clearly distinguishable were the smaller amplitude beats that followed the first beat. The response of nonlinear systems is complex and has several peculiarities, especially when the transition is carried out slowly.

Evan-Iwanowski [112] reviewed in 1969 the results of research pertaining to the general theory of nonstationary processes.

Nonstationary responses were shown to be stabilized when the frequency sweep was in the direction away from the instability region [113-119]. For sweeps into the instability zone (increasing frequency), the response tends to approach the initial stationary value. Agrawal and Evan-Iwanowskii [120] extended the work of Mitropol'skii on the nonstationary characteristics of a gyroscopic system in the presence of different resonance conditions. They showed that the nonstationary response can shift from one stable solution to another if the rate of variation of the excitation frequency changes. This so-called drag out phenomenon was observed in some nonlinear systems that exhibit a combination resonance [112].

The theory of the interaction of a vibrating system with an excitation source was developed from studies of nonlinear systems. Kononenk [121] established the basic theory, but such nonstationary processes have been treated by various Russian scholars [121-124]. Kononenk [121] showed that the possibility of realizing parametric oscillations in parametrically excited systems is associated with the properties of the energy source. The typical effects of parametric resonances depend on the steepness of the energy source. In the presence of autoparametric resonance [125] the nonstationary process was observed experimentally as an irregular beating motion similar to the pattern of the energy source.

MATHEMATICAL TECHNIQUES

A number of analytical and numerical methods can be used to solve problems of parametric and autoparametric vibrations. Most of the analytical methods are based on the general perturbation theory [126-128] including the averaging method of Bogoliubov and Mitropol'skii [129], the asymptotic expansion scheme of Struble [130], and Hsu's method [131, 132]. It is not the purpose of this review to give an exhaustive account of these mathematical theories but to illustrate the advantages of these techniques in solving the various problems of parametric vibration.

Averaging method. The averaging method [129] requires that the differential equations of the system be written in the standard form, in which the right side is regarded as a slight perturbation proportional to a small parameter ϵ. The solution is then subjected to time variations in amplitude and phase. A number of manipulations result in 2n first-order differential equations (n is the number of original equations of the system).

In weakly nonlinear systems the changes in amplitude and phase are small and thus occur during a time interval slightly greater than the period of oscillation. According to Bogoliubov and Mitropol'skii the nonlinear terms create sources and sinks that produce or absorb very small amounts of energy during one cycle of oscillation. This method has been successfully applied to a wide range of problems.

Sethna [55-57, 133] modified the standard form to an arrangement convenient for studying the dynamics of systems in the neighborhood of resonance conditions. Van der Burgh [134] recently developed a procedure related to the averaging method for solving problems of internal resonance.

Asymptotic expansion schemes. Struble [130] combined the method of the variation of parameters and the asymptotic expansion of the perturbation method. This technique is flexible and overcomes difficulties encountered with secular terms in the standard perturbation techniques. It also provides information about nontrivial solutions in both the stable and unstable regions. These advantages attracted many investigators to this method for problems involving parametric and autoparametric resonances.

Hsu [131, 132] developed a similar scheme, combining the method of averaging and Struble's method. Hsu's theory is useful in problems of coupled parametric equations involving nonconservative forces [135, 136] and conservative systems [137].

Others. A useful account of asymptotic approximation techniques suitable for problems involving nonlinear resonance has been published [138]. Schmidt [3, 139-141] used the classical iteration method and converted the equations of motion into an integro-differential form. The Floquet theory and the Hamilton-Jacobian analysis have been used in a number of problems: nonlinear resonances [48, 71, 72, 142-147] and examinations of the stability of parametric systems with nonconservative forces [148, 149].

The direct method of Liapunov [151, 152] has been employed to study the stability of parametric systems [32, 152-155]. Hsu and Lee [156, 157] developed a method based on the use of time-dependent Liapunov functionals and the extremal properties of

Rayleigh quotients of self-adjoint operators. The method involves solving an eigenvalue problem in which time is a variable. Naveh [158] compared the stability criteria of a linear time-dependent system as obtained by Liapunov's direct method and an analytical approach.

Numerical methods are often used to determine regions of parametric instability [159-161]. The digital computer simulation for numerical integration has overcome the difficulties encountered in the analytical methods [38, 80, 162, 163]. Dysthe and Gudmestad [80] used numerical simulations to compare the results obtained by the equations of motion of nonlinear conservative systems and the averaged equations of their perturbation scheme. Another useful approach in determining the parametric stability boundaries is the analogue computer simulation [96, 121, 164-168].

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LINEAR ELASTIC WAVE PROPAGATION. AN ANNOTATED BIBLIOGRAPHY: PART I

R.A. Scott*

Abstract - This survey of the literature on linear elastic wave propagation consists of two parts. Part I covers homogeneous isotropic media. Part II covers discretely nonhomogeneous media, continuous nonhomogeneous media, anisotropic media, and diffraction.

In common with so many other fields, the recent past has seen an almost overwhelming increase in the elastodynamic literature. This increase is due in part to the fact that the topic is of interest in such diverse areas as geophysics, earthquake engineering, surface-wave technology, flaw detection, and structural mechanics [1]. Thus, no attempt has been made to include all work in languages other than English in this review. The chief goal of the survey is to provide sufficient recent references in an area so that the reader can pursue topics of interest in detail. Papers published prior to 1972 are not included.

HOMOGENEOUS ISOTROPIC MEDIA

This section covers the following aspects of homogeneous isotropic media; infinite medium; the elastic half-space; the plate; rods; circular, cylindrical, and spherical shells; the sphere; and other geometries.

Infinite Medium

Traveling loads in boreholes have been studied [2, 3]. The important spherical cavity problem has been analyzed [4-10]. Related works are [11-15]. The goals of the considerable work that has been done on earthquake modeling include determination of source dimensions and seismic moment from the Fourier spectra of seismograms. Double couple models, dislocation models, expanding cracks, effects of friction, and rupture velocity have been considered. Fundamental studies have been published [16-41]. These studies have been applied to particular earthquakes [42-48].

Crack propagation has also received considerable attention in recent surveys [49-53], reports [54-58], and a European Mechanics Colloquium [59].

*Department of Applied Mechanics and Engineering Science, University of Michigan, Ann Arbor, MI 48109

The Elastic Half-Space

Work on the elastic half-space has progressed on several fronts. Vibration, impact, and indentor studies have been done [60-74]. Work of a more geophysical nature has also been published [75-82]. Fundamental work on excitation by sources, surface forces, and stress discontinuities has been presented [83-104], as has finite difference work on a half-space with a spherical cavity [105] and on total reflection of SV-waves [106].

The Plate

The plate, the simplest elastic waveguide, continues to be studied using approximate theory and linear theory.

Approximate theories. Applications of approximate theories were reported by Adler and Reismann [107], who used Mindlin plate theory to study a transverse line load moving on a simply supported elastic strip. Fang, Hemann, and Achenbach [108], presented analytical and experimental results on dynamic stress concentration due to a circular hole. They obtained the analytic information by averaging the field quantities over the plate thickness. Hinton [109] combined Mindlin theory with a finite-element scheme to study transients. Huang [110] used Mindlin theory to examine a pressure wave impinging on a plate. Lehnhoff and George [111] also used Mindlin theory to study circular plates.

Vibrations have been studied with a higher order theory [112]. Saito and Nagaya [113] used Mindlin plate theory to examine a plate with holes, and Stephanishen [114] and Thomas [115] used Kane-Mindlin theory to study the forced motion of clamped strips. Yen and Chou [116] extended their earlier work on moving loads on a Timoshenko plate to the subsonic and intersonic regimes. Other work was also reported on finite difference schemes [117] and approximate theories [118, 119].

Linear theory. Though reasonably well known, orthogonality relations involving linear theory continue to receive attention [120-121]. Interesting results on spectra and wave reflections have been reported. Doby [122], for example, studied edge waves with orthogonality relations between longitudinal and transverse eigenfunctions. Kaul and Herrmann [123] found that the motion at grazing incidence can be obtained from the evanescent Rayleigh-Lamb solution by means of d'Alembert's limiting procedure. Kouzov and Luk'yanov [124] studied edge waves in a plate in an acoustic medium, and Vrba and Haering [125], showed that SV- and P-waves can decouple if special phase conditions are satisfied. This information is useful in establishing bounds for spectra.

Other reports involving steady-state motions have been published [126-129]. Work on transients, some of which involves Cagniard techniques, has also been done [130-136]. Sinclair and Miklowitz [137] made substantial inroads into non-mixed problems.

Rods

Work in Timoshenko theory was used for spectra for rods and related structures [138-148]. Bishop's theory received attention [149]. Brunelle [150] obtained a theory for torsional waves by averaging field quantities over the cross section, and McNiven [151] wrote on approximate theories.

Spectra of infinite, solid rods have been examined [152-154]. Hollow rods have also been studied [155-158], as have orthogonality relations [159] and reflection of a pure mode from a rod end [160].

The computer and various numerical schemes are being used to study finite rods and non-circular sections. Finite-element schemes were used to obtain frequency information for rectangular sections [161]; solid and hollow, finite, circular rods [162, 163]; and circular, square, and triangular sections [164]. Approximate satisfaction of some boundary conditions has been used to obtain dispersion information [165-168]. Various expansion procedures were used for elliptical, triangular, and rectangular sections [169], an infinite circular cylinder with an eccentric circular bore [170], and an elliptical section [171].

Approximate theories continue to be used to analyze transients. The Timoshenko model was used for various studies on steady, moving loads [172, 173] and impact [174-176]. Compressional theories were also used [177-180].

Linear elasticity theory was used in work on radial motions [181-184], torsional motions [185, 186], and longitudinal motions [187, 188]. A finite-difference scheme was used in experimental and numerical work involving longitudinal motions [189]. Dynamic fracture has also been studied [190].

Circular, Cylindrical, and Spherical Shells

In view of the thorough surveys of Engin and Engin [191] and Leissa [192] on shell vibrations, only recent papers in this area will be cited, namely: Chen and Huang [193] on hemispherical shells, and Cunningham and Leanhardt [194], Goldman [195], and Srinivasan and Sankaran [196] on cylindrical shells. Various approximate theories were used in work on harmonic forcing [197-203]. Moving load problems were examined [204-205]. Transients have been investigated with Flugge equations -- which were used to examine excitation by a side pressure pulse [206]. Characteristics and theories involving transient shear and rotatory inertia were used to study longitudinal impact [207, 208], and Timoshenko and Donnell theories were used to investigate the application of impulsive inner pressure [209, 210]. Veksler [211] included effects of transverse shear in a study on a semi-infinite shell, and Ziv and Perl [212] used Mirsky-Herrmann theory and characteristics in an investigation of a semi-infinite shell. Other numerical work has been published [213-216].

The Sphere

Vibrations of hollow and solid spheres have been studied [217-219], and transients have been investigated [220-223].

Other Geometries

No particular relevance should be attached to the sequence of citations in this section, nor is the listing unique; for example, papers on wedges could just as well be cited in the section on diffraction.

SH-transients in quarter spaces (layered) have been studied [224, 225]. Finite difference schemes were used to study plane-strain motions for welded quarter spaces [226] and for a quarter space with stress boundary conditions [227].

Wedges. Studies on wedges include: an examination of impulsive SH-waves with Laplace and Kantorovich-

Lebedev transforms [228], an examination using a finite-difference scheme of an impulsive compressional source with the boundaries stress free [229], experimental work [230], an examination of a moving SH-load [231], a treatment of scattering of a Rayleigh wave with mixed conditions specified on one boundary [232], numerical information for Rayleigh-wave scattering by integral equations and subsequent approximations [233], a study of steady vibrations using integral equations [234], a presentation of numerical results for wide-angle wedges using Kane and Spence's method -- which ignores multiple reflections [235], and an examination of diffraction by a wedge with mixed boundary conditions [236].

Curved surfaces. Circumferential surface waves on curved surfaces have been reviewed [237]. A spherical cavity was studied [238], as were a circular cylinder, a circular cavity, and a circular interface between two media [239]. Results on Stoneley, Franz, Rayleigh, and Whispering-Gallery modes were reported for a cylinder immersed in a fluid [240, 241]. Perturbation methods were used [242] and concave cylindrical surfaces examined [243]. Perturbation methods were also used by Rosenfeld and Keller [244] to study surface waves traveling parallel to the generators of a cylinder. They also gave spectral results for rods of non-circular section. Wilson and Morrsion [245] did similar studies.

Surface-acoustic-wave devices. Perhaps the most interesting development in elastic wave propagation in recent years has been the emergence of surface-acoustic-wave (SAW) devices, which employ various topographic features on half-spaces, interface waves, and clad structures. That a vast literature now exists is obvious from various review articles [246-250] and a special issue of the Proceedings of the IEEE [251]. Other results have been published [252-255].

The allied topic of scattering by various topographic features has also received considerable attention, particularly from geophysicists. Perturbation theory was used to examine scattering of P-waves from axially symmetric surface irregularities and SH-waves from a periodic curved boundary [256, 257]. Scattering was also examined by a finite surface irregularity of both P- and Rayleigh waves [258], and results were given for a triangular cut and elevation [259].

Sumner and Deresiewicz [260] studied the scattering of a Rayleigh-Lamb mode from a finite irregularity on one face of a plate; Thapar [261] reported on the effect of a Gaussian-shaped irregularity on the propagation of Stoneley waves; and Tuan and Li [262] examined scattering of a Rayleigh wave by a step discontinuity. Scattering of harmonic SH-, P-, and SV-waves by ridges and valleys was also examined using a superposition method [263]. Gjevik [264] used Whitham's variational procedure to study Love waves in a corrugated layer. Integral equation methods were used to investigate SH-wave interactions with step discontinuities [265] and SH-scattering from an irregular canyon [266]. Linear-elasticity studies of SH-scattering from a semi-elliptical valley were published [267]. Finite-difference works have appeared [268, 269], as has finite-element work on scattering by various surface irregularities [270].

Irregular geometries. Studies of harmonic motions include investigations of coupling between a rod and a half-space [271], the types of waves that can exist in thin conical shells [272], and the vibrations of strips of various thickness using Mindlin theory [273].

Reismann and Tsai [274] presented reflection and transmission coefficients for waves in dissimilar rods bonded together. Rosenfeld and Keller [275] reported WKB-type approximations for rods with slowly varying sections. Ross [276] used a finite-element technique in studies on the vibrations of cones, and Rulf and Gal Ezer [277] developed asymptotic expansions suitable for high-frequency waves in bodies of revolution.

Transients have been given attention. Sander's general first order theory was used to study the impact of a conical shell [278]. Finite differences and Morley's theory were used to investigate curved beams [279]. Koenig and Berry [280] presented a finite-element analysis using Timoshenko theory; the study involved a tapered beam consisting of two dissimilar rods bonded together. Lee and Kolsky [281] also used Timoshenko theory to study the passage of a pulse through two non-colinear rods.

Lee and Wong [282] used a Mindlin-McNiven theory and characteristics to analyze the longitudinal impact of finite and semi-infinite rods with varying sections. Moodie and Barclay [283] studied torsional transients in shells of revolution and noted that, for thin shells, such motion decouple from extensional and bending modes. Mortimer, Rose, and Blum [284] extended work involving transverse shear and rotatory inertia [208] to cylindrical shells with discontinuous sections.

Mindlin-McNiven theory and characteristics were used to study longitudinal impact of a conical bar [285]. Characteristics and a theory incorporating transverse and rotatory inertias and transverse shear deformation were combined to examine the impact of a cylinder-conical shell structure [286]. Weingarten and Fisher [287] used Nagdi shell theory and modal synthesis to investigate the response of a conical shell to lateral pressure.

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BOOK REVIEWS

STABILITY OF SHELLS MADE OF COMPOSITE MATERIALS

(Ustoichivost obolchek iz kompozitnykh materialov)

R.B. Rikards and G.A. Teters
Riga, Izdatelstvo "Zinatne", 1974

This book consists of seven chapters, the first of which is concerned with theory of surfaces as described in terms of Cartesian tensors. The second chapter develops strain-displacement and force-displacement relations within the framework of the Kirchoff-Love hypothesis. The next chapter develops equations of motion and buckling of cylindrical and spherical anisotropic shells with a consideration of nonlinear strain-displacement relations, retaining only those terms involving displacements normal to the shell middle surface.

The fourth chapter is concerned with stability of axially compressed cylindrical shells with a consideration of creep of the material. Axisymmetric initial imperfections are assumed to exist in the shell. Load-displacement relations are determined for a polymeric material with given materials parameters. Also, hydrostatic buckling loads in the presence of creep are determined. Nonlinear geometric relations are considered for each of these treatments. The axisymmetric buckling of a shallow spherical shell subject to external normal pressure is examined for creeping polymeric materials. The chapter closes with investigation of buckling of an axially compressed cylindrical shell stiffened by an elastic core.

The fifth chapter is concerned with dynamic buckling of shells. Cylindrical shells of anisotropic nature are examined for buckling due to either axial compression or uniform external radial pressure, in each case the loads being applied with such speeds that wave propagation effects may be neglected. Viscoelastic shells, as well as shells with an elastic core, are also examined. Several numerical examples are offered to illustrate geometric and loading rate effects.

The sixth chapter is concerned with experimental results on axially compressed cylindrical shells, with tests from both Soviet and Western investigators being cited. Postbuckling load carrying capacities are also investigated. Buckling loads as well as equal deflection contour lines are presented for a number of different cylindrical shells. The last chapter is concerned with optimal design of shells of composite material, as influenced by angle of wrap of the filaments and other parameters.

The book is extremely well written and presents a comprehensive summary of practically all existing information in this specialized area. It should be of value to designers of shells of composite materials.

W.A. Nash
USA
Courtesy of Applied Mechanics Reviews

DEVELOPMENT OF THE MECHANICS OF GYROSCOPIC AND INERTIAL SYSTEMS

(Razvitie mekhaniki giroskopicheskikh i inertsialnykh sistem)

Moscow, Izdatelstvo "Nauka", 1973, $9.65

The book is intended for specialists in the field of gyroscopic instruments interested in the history, the current state of the art, and the perspectives of their further development. It was written by various experts in the fields of inertial stabilization, guidance, and navigation including a tutorial chapter in English by C.S. Draper and W. Wrigley on rate gyros. Another chapter on the historical development of gyroscopes in Germany by K. Magnus is printed in German.

Most chapters in the book are tutorial in nature with many schematic diagrams and bibliographies presented for the convenience of the reader. The historical background is presented followed by chapters on the basic principles of gyroscopic instruments. A tutorial discussion on gyrostabilized platforms is also given. All kinds of gyrocompasses are described as well as some inertial navigation systems. The last part of the book is devoted to methods of deriving the differential equations for gyroscopic systems and their analysis. Systems subject to random excitation forces are also considered. It is stated that additional volumes are planned for publication which will consider other topics such as the control moment gyros, vibratory gyros, and the general theory of gyroscopic systems not treated in the current volume.

The book appears to be unique in a sense that it describes the development of the gyroscope in the West and in the Soviet Union. Theory and concepts of operation are emphasized. The book should therefore be of interest to the scientist or engineer concerned with the conceptual and theoretical aspects of gyroscopic instruments.

V. Chobotov
USA
Courtesy of Applied Mechanics Reviews

HANDBOOK OF INDUSTRIAL NOISE MANAGEMENT

R.K. Miller
The Fairmont Press, Inc., 1976

The reader may at first glance be surprised by the title and wonder about the purpose of the book. In the end, however, he will be convinced that this volume is indeed useful.

The author, referring to his own broad experience as a consultant, provides guidelines and procedures for complying with legislation in the field of noise abatement. In the United States the Occupational Safety and Health Act (OSHA) of 1970 gives the legislative framework for noise control regulations. Other industrial nations either have or plan similar standards. There is no doubt that this kind of legislation is necessary, but of course its implementation will be expensive. Rigid enforcement of noise standards is estimated to cost as much as 10 to 15 billions in the U.S. A company forced to spend money on noise reduction might want to achieve a technically optimal reduction. More often, however, the company is more interested in maximizing profits and is satisfied if noise regulations can be met at minimal cost.

Holding down costs requires systematic management of all noise abatement procedures. The book therefore is not restricted to lists of technical ways to reduce noise but clearly shows the advantages of proper administrative measures. For example, providing a worker with effective ear muffs is not sufficient. If potential hearing loss claims are to be avoided, the worker's hearing acuity must be documented by audiometric testing prior to and during employment.

The book contains chapters that deal with the following:

- OSHA compliance strategies
- feasibility of meeting regulations
- assessment of the results of abatement procedures
- reduction of the risk of worker's compensation payments
- benefits of noise abatement
- costs
- establishment of noise abatement priorities
- effective noise management through introduction of a noise control program

The book shows that the economic and legal aspects of a noise control program are just as essential as the technical ones. The book can be highly recommended to company managers, safety engineers, and union and government representatives dealing with noise management.

G. Schweitzer
Lehrstuhl und Institut f. Mechanik
Technische Universität München
8000 München 2, Germany

INTEGRATED DESIGN AND ANALYSIS OF AEROSPACE STRUCTURES

R.F. Hartung, Editor
The American Society of Mechanical Engineers, New York, 1975

This book is a series of five independent monographs on the subject of integrated design and analysis computer-program systems. The material was presented at a symposium held during the 1975 Winter Annual Meeting of the ASME. Each monograph describes the activities of an aerospace company or government agency during development and implementation of integrated design/analysis capabilities. Even though different approaches were taken by the various organizations the common objective was to provide an integrated computer-aided design system so as to reduce the calendar time and man-power needed to design a greater number of optimized aerospace vehicles. Automated data handling and flexibility(modularity) in performing computational tasks during the design process · complex interaction of many technical and management subprocesses -- are shown as necessary attributes of the integrated system.

S.A. LaFavor and A.E. Doelling describe the Computer Aided Technology Project at McDonnell Aircraft Company (MCAIR) and the various technical modules that form the nucleus of their CAD/CAM (Computer Aided Design/Manufacturing) activities. Of particular interest is their extensive use of interactive computer graphics, which range from parametric configuration sizing and performance analysis to the generation of quality assurance inspection data for automated fabrication.

G.J. Wennagel et al. described RAVES (Rapid Aerospace Vehicle Evaluation System) as developed and used by the Grumman Aerospace Corporation. This system is composed of an extensive library of stand-alone programs linked by automated data interfaces and a data directory. The current programs, operational in an interactive environment, provide capabilities for engineering analysis that range from early preliminary design to point design through detailed design/analysis.

The ATLAS integrated structural analysis and design system, as developed and used extensively by the Boeing Company, is discussed by R.E. Miller, Jr. This system provides a tool for broad aeroelastic vehicle studies of small and large configurations. Capabilities being added to ATLAS under contract with NASA Langley Research Center include design/optimization of composite structures, thermal stress, interactive job processing, and interactive graphics. Details on the impact of using ATLAS on several specific Boeing projects are presented. The data management functions performed by structures technology during product development are quantified, and the further development and application of advanced integrated software systems are discussed.

Two integrated systems of analysis used at Rockwell International are described by L. Ascani. SWEEP (Structural Weight Estimation Program), which is based on beam theory for early stages of design, contains the essential capabilities for solving aircraft problems having to do with structural analysis, optimization, and weight analysis. RRAPID (Rapid Response Analysis Program for Integrated Design) is based on finite-element theory. It provides capabilities for detailed structural-analysis; when possible, existing program modules developed by a number of different organizations are used.

J. Sobieszczanski describes how existing engineering computer programs can be linked with the auxiliary functions provided by a standard commercially-available operating system. SAVES (Sizing of Aerospace Vehicle Structures) system was developed with this approach. This program, currently being used at NASA Langley Research Center for preliminary structural design, is described; an example application and a critical evaluation are included.

The monographs in this book are evidence that aerospace companies can remain competitive only by using interdisciplinary engineering computing systems to perform computer-aided design activities. It is anticipated that the continued development of integrated systems by individual companies to establish even broader problem-solving environments, in addition to government-sponsored development of advanced software systems, will further reduce the cost of designing aerospace vehicles and will allow for more optimized configurations. As noted in several of the papers, the IPAD system (Integrated Program for Aerospace-Vehicle Design) sponsored by NASA Langley Research Center is an indication of the concern for the orderly, comprehensive, and industry-wide development of a convenient and effective computer-based engineering-information processing system. This system could serve as the key communication and calculation integrator for the air-vehicle design process including interaction with manufacturing systems.

The papers allude to the distinction between a system of linked, interfaced, computer programs (independently-developed standalone programs interfaced via data converters) and an integrated software system (a system designed as a set of program modules intimately interfaced with a common data base and with user interfaces for selected data interrogation and execution control) for performing multidisciplined computational tasks. The term "integrated system" as used in the book refers to both types of systems. An example of an integrated software system is the Boeing ATLAS system. SAVES of NASA Langley is a system of interfaced programs.

Continued system developments are mandatory. In concert with these activities, however, it is desirable to acknowledge further the following factors: management acceptance, engineering acceptance, control and management of program changes and growth, and performance/cost-analysis standards for evaluating existing systems and proposed developments.

Dr. Rodney L. Dreisbach
Boeing Commercial Airplane Company
Seattle, Washington 98124

SHORT COURSES

MARCH

MEASUREMENT SYSTEMS

Dates: March 13-17, 1978 (Engineering)
March 20 - 24, 1978 (Dynamics)

Place: Phoenix, Arizona

Objective: These courses are designed to increase productivity and cost effectiveness of data acquisition systems and groups in the field and in the laboratory. In general, the emphasis is on the electrical measurement of mechanical and thermal quantities. The lectures are prepared both from the point of view of the non-mechanical engineer, who must become familiar with electrical measuring-system criteria, and the non-mechanical engineer, who must become acquainted with material properties, flexure design, and mechanical system criteria.

Contact: Peter K. Stein, ISA, Central Arizona Section, 5602 East Monte Rosa, Pheonix, AZ 85018 (602) 945-4603/946-7333

COMPOSITE MATERIALS COMPUTATION WORKSHOP

Dates: March 27 - 31, 1978

Place: University of California, Berkeley

Objective: To provide users and producers of composites with a practical guide to solving problems in design and testing. The workshop will include lectures, practice sessions and drills demonstrating advanced methods that can be applied to everyday problem solving. Whenever possible, available methods will be condensed to an easily used formula or chart, or to a format that can be implemented readily on a programmable pocket calculator.

Contact: Continuing Education in Engineering, Univ. of Calif. Extension, 2223 Fulton St., Berkeley, CA 94720 - (415) 642-4151.

ENGINEERING SYSTEM DYNAMICS

Dates: March 28 - 31, 1978

Place: UCLA

Objective: Emphasis will be placed on a practical interdisciplinary modeling technique illustrated by examples drawn from mechanical, fluid power, electrical and aerospace engineering. Topics include fundamentals of component, subsystem and system models; state-variable representation of system dynamics; and computer-aided system analysis. Each meeting includes a workshop session devoted to problem-solving, special applications and on-line computer-aided analysis. These workshops give participants the opportunity to apply course material to systems encountered in their own areas of specialization.

Contact: Continuing Education in Engineering and Mathematics, UCLA Extension, P.O. Box 24902, Los Angeles, CA 90024 - (213) 825-1047.

APRIL

THE FOURTH ANNUAL RELIABILITY TESTING INSTITUTE

Dates: April 3 - 7, 1978

Place: Tucson, Arizona

Objective: This course is designed to provide Reliability Engineers, Product Assurance Engineers and Managers and all other engineers and teachers with a working knowledge of analyzing component, equipment, and system performance and failure data to determine the distributions of their times to failure, failure rates, and reliabilities; small sample size, short duration, low cost tests, and methods of analyzing their results; Bayesian testing; suspended items testing; sequential testing; and others.

Contact: Dr. Dimitri Kececioglu, Institute Director Aerospace and Mech. Engrg. Dept., The University of Arizona, Bldg. 16, Tucson, AZ 85721 - (602) 884-2495, 884-3901, 884-3054, 884-1755.

SURVIVABILITY, TESTING, MEASUREMENT, ANALYSIS & CALIBRATION

Dates: April 3 - 7, 1978

Place: Wright State Univ., Dayton, Ohio

Objective: Increasing an equipment's ability to survive in the dynamic environments of vibration and shock will be the main subject of this course. This course will concentrate upon techniques and equipments, rather than upon mathematics and theory.

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

NEWS BRIEFS

news on current and Future Shock and Vibration activities and events

CALL FOR PAPERS

24th International Instrumentation Symposium

This will be the fifth in a series of symposia jointly sponsored by Aerospace Industries and Test Measurement Divisions of the Instrument Society of America. The previous symposia have established this symposium as the outstanding forum for presentation of original work in aerospace and test measurement instrumentation. This symposium will be held May 1 - 4, 1978 at the Hilton Hotel in Albuquerque, New Mexico.

In addition to the paper sessions, tutorials and workshops, tours of Los Alamos and Sandia Laboratories will be included to make the experience more than worthwhile. The position of these two laboratories in the forefront of energy research will enhance the timeliness of this meeting in Albuquerque.

For more information, contact :

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

INSTITUTE OF ENVIRONMENTAL SCIENCES

24th Annual Equipment Exhibit Progress Report

April 17 - 20 are the dates for the 24th Annual Equipment Exposition and Symposium of the IES. This national organization of scientists, engineers, and managers, represents the electronics, aerospace and ecological industries.

The 1978 Exposition at Fort Worth, Texas will be the largest in the history of the IES. One hundred exhibit spaces have been allocated, and over one hundred twenty-five technical papers will be presented during the Symposium.

New features for the exhibit hall include a meeting area for formal presentations concerning products and companies. This commercial activity provides exhibitors the opportunity to specifically promote advanced state-of-the-art products or to present their company capabilities.

A planned program time will enable attendees to participate in any of the product presentation sessions. The IES Board of Directors recognizes that the quality of the exhibits are important to the engineers and scientists attending the technical symposium. This year the directors have authorized an exhibition area double that of any previous year. They have also authorized contracting exhibit space with factory representatives who can then present products of their principals. This feature will enable small new advanced state-of-the-art companies to participate in the exhibition. These exhibits will supplement those of other companies who require one or more exhibit areas for their prime products.

For additional information contact:

Charles F. Conrad
Thermotron Industries
338 W. 12th Street
Holland, MI 49423
(616) 392-1492

- or -

B. L. Peterson, Executive Director
Institute of Environmental Sciences
940 East Northwest Highway
Mount Prospect, IL 60056
(312) 255-1561

ABSTRACTS FROM THE CURRENT LITERATURE

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

ABSTRACT CONTENTS

ANALYSIS AND DESIGN

ANALYTICAL METHODS

78-195

Free Vibrations for a Semilinear Wave Equation

P.H. Rabinowitz

Mathematics Res. Center, Wisconsin Univ., Madison, WI, Rept. No. MRC-TSR-1742, 41 pp (Apr 1977)
AD-A042 331/9GA

Key Words: Wave equation, Free vibration

Existence and regularity of nontrivial time periodic solutions are proved for semilinear wave equations under mild smoothness, monotonicity, and superlinearity assumptions. The forced vibration case is also treated.

NUMERICAL ANALYSIS

(See Nos. 269, 293)

MODELING

(Also see No. 242)

78-196

Structural Modelling by the Curve Fitting of Measured Frequency Response Data

H.G.D. Goyder

Inst. of Sound and Vibration Res., Univ. of Southampton, UK, Rept. No. ISVR-TR-87, 46 pp (Oct 1976)
Sponsored by the Ministry of Defence (Admiralty Engr. Lab)
N77-29567

Key Words: Mathematical models, Curve fitting

A method for deriving the vibration characteristics of a structure from a set of measured frequency response functions is presented. A general mathematical model is formulated which makes no assumptions concerning the vibrational behavior of any particular structure. This model is employed in a curve fitting procedure which enables the parameters employed by the model to be determined from a set of measured data. Practical measurements taken from a beam are used to demonstrate the capability of the modeling technique to represent a structure.

DIGITAL SIMULATION

78-197

Computer Simulation of Large-Displacement Impact Dynamics

D.M. Norris, M. VanThiel, and B. Moran

Lawrence Livermore Lab., California Univ., Livermore, CA., Rept. No. UCRL-78734, Conf-770205-1, 34 pp (Oct 1976)
N77-29522

Key Words: Computerized simulation, Finite difference theory, Dynamic tests

A two-dimensional Lagrangian explicit finite difference (EFD) computer program was used to simulate three large-deformation dynamic tests: the Charpy V-notch impact toughness test, oblique impact of a cylindrical rod on armor plate, and driving of copper liners by a shaped high-explosive charge. The relationship of the EFD formulation to the more recently developed explicit finite element formulation is discussed.

SURVEYS AND BIBLIOGRAPHIES

78-198

Dynamic Modeling of Pressure Vessels and Piping Systems

R.H. Prause

Appl. Dynamics and Acoustics Section, Battelle Columbus Laboratories, Columbus, OH 43201, Shock Vib. Dig., 9 (11), pp 13-20 (Nov 1977) 1 table, 35 refs

Key Words: Piping systems, Pressure vessels, Mathematical models, Reviews

This paper reviews dynamic modeling of pressure vessels and piping systems. It is intended to provide a background for identifying current problems and limitations. Recommendations and expected benefits from future research are included. The bibliography provides sources pertaining to specific modeling topics.

78-199
Methods of Component Mode Synthesis
R.R. Craig, Jr.
Dept. of Aerospace Engrg. and Engrg. Mechanics, The Univ. of Texas at Austin, TX 78712, Shock Vib. Dig., 9 (11), pp 3-10 (Nov 1977) 65 refs

Key Words: *Component mode synthesis, Reviews*

A generalized substructure coupling, or component mode synthesis, procedure is described. Specific methods, applications, and such special topics as damping and experimental verification are surveyed.

78-200
Flow-Induced Vibrations of Circular Cylindrical Structures. Part I: Stationary Fluids and Parallel Flow
S.S. Chen
Argonne National Lab., Argonne, IL 60439, Shock Vib. Dig., 9 (10), pp 25-38 (Oct 1977) 1 fig, 184 refs

Key Words: Cylinders, Cylindrical shells, Fluid-induced excitation, Reviews

The objective of this paper is to review the state-of-the-art of flow-induced vibration of circular cylindrical structures and to indicate areas that need further work. Both parallel and cross flow problems are considered. Part I of the review contains a general discussion of analytical methods, classification of structural responses, and characteristics of the vibration of cylinders in stationary fluid and parallel flow. Part II considers cross-flow-induced vibration, design, and research needs.

78-201
Flow-Induced Vibrations of Circular Cylindrical Structures. Part II: Cross-Flow Considerations
S.S. Chen
Argonne National Lab., Argonne, IL 60439, Shock Vib. Dig., 9 (11), pp 21-27 (Nov 1977) 1 fig, 60 refs

Key Words: Cylinders, Flow-induced vibrations, Reviews

The objective of this paper is to review the state-of-the-art of flow-induced vibration of circular cylindrical structures and to indicate areas that need further work. Both parallel and cross flow problems are considered. Part I of the review contains a general discussion of analytical methods, classification of structural responses, and characteristics of the vibration of cylinders in stationary fluid and parallel flow. Part II considers cross-flow-induced vibration, design, and research needs.

78-202
A Comparison of Techniques and Equipment for Generating Vibration
W. Tustin
Tustin Inst. of Technology, Inc., Santa Barbara, CA 93105, Shock Vib. Dig., 9 (10), pp 3-10 (Oct 1977) 5 figs, 65 refs

Key Words: Shakers, Mechanical shakers, Electrohydraulic shakers, Electromagnetic shakers, Pneumatic shakers, Reviews

This article reviews the following shaker types: mechanical, electrohydraulic, electromagnetic, and pneumatic. Vibroacoustic facilities are also mentioned.

78-203
Recent Research in Plate Vibrations: Classical Theory
A.W. Leissa
Ohio State Univ., Columbus, OH., Shock Vib. Dig., 9 (10), pp 13-24 (Oct 1977) 7 figs, 1 table, 76 refs

Key Words: Plates, Reviews

This paper is Part I of a two-part review of literature published over the period 1973-1976 that deals with free, undamped vibrations of plates. Part I is limited to problems governed by the classical theory of plates. Complicating effects is the subject of Part II.

78-204
Airport Noise (A Bibliography with Abstracts)
G.E. Habercom, Jr.
National Technical Information Service, Springfield, VA., Rept. No. NTIS/PS-77/0704/5GA, 224 pp (Aug 1977) (Supersedes NTIS/PS-76/0625, and NTIS/PS-75/530) 219 refs

Key Words: Bibliographies, Aircraft noise, Airports

Aircraft created noise, noise intensity, noise exposure, and physiological effects, all in airport environments, are investigated in these research reports.

78-205
Automobile Impact Tests. Vol. 1. 1964-1972 (A Bibliography with Abstracts)
G.H. Adams
National Technical Information Service, Springfield, VA, Rept. No. NTIS/PS-77/0733/4GA, 126 pp

(Sept 1977) 121 refs

Key Words: Collision reserach (automotive), Bibliographies

This volume begins coverage of a two volume bibliography covering test results on the crashworthiness and safety of passenger vehicles upon impact with stationary structures, other vehicles, median berms, and curbs. Individual reports on air bag restraints and bumper tests are excluded. Anthropomorphic tests, computerized simulation, mathematical models, and scale model studies are included. Citations refer to specified makes of automobiles in a number of cases.

78-206

Automobile Impact Tests. Vol. 2. 1973-August 1977 (A Bibliography with Abstracts)

G.H. Adams

National Technical Information Service, Springfield, VA., Rept. No. NTIS/PS-77/0734/2GA, 135 pp (Sept 1977) (Supersedes NTIS/PS-76/0694, and NTIS/PS-75/651) 130 refs

Key Words: Collision research (automotive), Bibliographies

This bibliography continues test results on the crashworthiness and safety of passenger vehicles upon impact with stationary structures, other vehicles, median berms, and curbs. Individual reports are excluded on air bag restraints and bumper tests. The responses of vehicle structural components are studied in displacement and strain measurements, and in detailed examinations of permanently deformed components, following individual tests. Research involves vehicle impacts front to front, lateral, at angles, and onside, as well as collisions involving poles, bridge parapets, highway structures, and safety and test barriers. Anthropomorphic tests are described using experimental test vehicles, rocket propelled sleds, and safety harness. Computerized simulation, mathematical models, and scale model studies are also described.

78-207

Bumpers

L. Flynn

Technical Services Div., National Highway Traffic Safety Admin., Washington, D.C., Rept. No. SB-18, DOT-HS-802 482, 129 pp (July 1977)
PB-271 236/2GA

Key Words: Collision research (automotive), Bumpers, Bibliographies

The bibliography represents literature acquired since the establishment of the National Highway Traffic Safety Administration in 1967, as related to bumpers on motor vehicles. It is comprised of NHTSA contract reports, reports of other organizations concerned with highway safety, and articles from periodicals in related fields. Citations follow the format used in the monthly abstract journal Highway Safety Literature and are indexed by a key-word-out-of-context listing, author, corporate author, contract number, and report number.

MODAL ANALYSIS AND SYNTHESIS

(Also see Nos. 199, 201)

78-208

Random Decrement Technique for Modal Identification of Structures

S.R. Ibrahim

Old Dominion Univ., Norfolk, VA., J. Spacecraft and Rockets, 14 (11), pp 696-700 (Nov 1977) 5 figs, 4 tables, 7 refs

Key Words: Random excitation, Random decrement technique, Space stations

An algorithm is developed to obtain the free responses of a structure from its random responses, due to some unknown or known random input or inputs, using the random decrement technique without changing time correlation between signals. The algorithm is tested using random responses from a "generalized payload" model and from the "space shuttle" model. The resulting free responses are then used to identify the modal characteristics of the two systems. The method is limited to structures that are linear or have small nonlinearities.

COMPUTER PROGRAMS

GENERAL

(Also see Nos. 218, 301, 342, 373, 374)

78-209

Assessment of Ship Dynamics Programs for Possible Integration into the Integrated Ship Design System

R. Cross and B. Thomson

Computation Mathematics/Logistics Dept., David W.

Taylor Naval Ship Res. and Dev. Center, Bethesda, MD., Rept. No. CMD-76-22, 134 pp (Apr 1976)
AD-A043 174/2GA

Key Words: Ships, Computer programs

The Integrated Ship Design System (ISDS), is in development to permit preliminary ship design to be accomplished using interactive computing. Currently ISDS does not address ship dynamics and this report explores programs in this discipline for inclusion in ISDS. A literature search was performed to identify, classify, and tabulate computer programs involving ship dynamics. The search included programs addressing motion prediction, added resistance in waves, slamming, deck wetness, and maneuvering for displacement hulls, hydrofoils, surface effect ships, air cushion vehicles, planing hulls, and catamarans. Candidate programs were analyzed with respect to their input data requirements and the relationship of these requirements to the flow of data among existing design programs of the Integrated Ship Design System (ISDS), and two dynamics programs for displacement hulls are recommended for integration into ISDS.

78-210

A Guide to Use of the XWAVE Program. Part 1. Radiated Pressures from Vibrating Structures

F.M. Henderson
David. W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD., Rept. No. DTNSRDC-77-0041-Pt-1, 112 pp (July 1977)
AD-A042 663/5GA

Key Words: Computer programs, Submerged structures, Underwater sound

XWAVE is a computer program for calculating steady-state pressures in an infinite fluid exterior to a closed, arbitrary shaped structural surface for which a normal velocity distribution has been determined. The velocity distribution is considered to result from a vibrational motion of the surface. The program offers a variety of capabilities including: automatic generation of surface acoustic models for certain surfaces of revolution; automatic generation of several types of velocity boundary condition; an option for incorporating structure-fluid interaction effects through use of surface mobility data; and use of input data to dynamically allocate computer core storage for arrays. Three calculations illustrate XWAVE data configurations and some applications to problems involving vibrating structural surfaces.

78-211

Community Noise Exposure Resulting from Aircraft Operations. NOISEMAP Computer Program Operation Manual Addendum for Version 3.3 of NOISEMAP

N.H. Reddingius
Bolt Beranek and Newman, Inc., Canoga Park, CA., Rept. No. BBN-3409, AMRL-TR-73-108-App-Add-1, 30 pp (May 1977)
AD-A042 143/8GA

Key Words: Computer programs, Aircraft noise

This report outlines modifications to NOISEMAP 3.2 and a user oriented description of a NOISEMAP data screening program called DATASCREEN. Changes to NOISEMAP include: new identification options for the FLTTRK, DEPART, and RNPPAD cards; option to print only those pages from PRPLOT, ARPLOT, DMPGRD, or PRINT cards that contain parts of a contour; option to reduce the number of alignment pages; option to suppress the listings of SEL profiles; interface with GPCP is no longer restricted to a grid spacing of 1000 feet or less; addition of the CLEAR keyword that will expunge all entries in the library. The new program, DATASCREEN, provides an improved summary, improved error diagnostics, and additional graphic outputs. A deck prepared for DATASCREEN will be accepted by NOISEMAP. The purpose of DATASCREEN is to provide the user with an efficient screening program to use in preparing a data deck for Ldn contours.

78-212

Rotorcraft Flight Simulation with Coupled Rotor Aeroelastic Stability Analysis. Vol. 1. Engineer's Manual

T.T. McLarty
Bell Helicopter Textron, Fort Worth, TX, Rept. No. 699-099-022, USAAMRDL-TR-41A, 347 pp (May 1977)
AD-A042 462/2GA

Key Words: Computer programs, Helicopter rotors, Mathematical models

This report consists of three volumes and documents the current version in the C81 family of rotorcraft flight simulation programs developed by Bell Helicopter Textron. This version of the digital computer program is referred to as AGAJ76. The accompanying program for calculating fully-coupled rotor blade mode shapes is called DN9100. The first volume, the Engineer's Manual, presents an overview of the computer program capabilities plus discussions for the background and development of the principle mathematical models in the program. The models discussed include all those currently in the program.

78-213

DRAIN-TABS: A Computer Program for Inelastic Earthquake Response of Three-Dimensional Buildings

R. Guendelman-Israel and G.H. Powell
Earthquake Engrg. Res. Center, California Univ., Berkeley, CA., Rept. No. UCB/EERC-77/08, 147 pp (Mar 1977)
Sponsored by the Ford Foundation, New York
PB-270 693/5GA

Key Words: Computer programs, Earthquake response, Buildings

A computational procedure and computer program for the inelastic dynamic response analysis of three-dimensional buildings of essentially arbitrary configuration is described. The building is idealized as a series of independent plane substructures interconnected by horizontal rigid diaphragms. The structure idealization is explained, and the computational procedure and computer program logic are described. Instructions to be followed when adding new elements to the program are presented. A computer program user's guide and an illustrative example are included.

ENVIRONMENTS

ACOUSTIC

(Also see Nos. 210, 211, 257, 262, 295, 340, 341, 343, 344, 350, 354)

78-214

Layer Potentials and Acoustic Diffraction
P.J.T. Filippi
Laboratoire de Mecanique et d'Acoustique, Centre National de la Recherche Scientifique, 13274 Marseille Cedex 2, France, J. Sound Vib., 54 (4), pp 473-500 (Oct 22, 1977) 11 figs, 2 tables, 22 refs

Key Words: Acoustic diffraction

Various more or less classical layer potential representations of the diffracted acoustic field within an enclosure or external to an obstacle are discussed. It is shown that it is always possible to find such a representation which yields to an integral equation equivalent to the partial derivative boundary value problem: that is, the conditions of existence and uniqueness of the solution are the same in both formulations. Several numerical experiments are reported, which show that simple and reasonably inexpensive techniques provide predictions of the acoustic field, or of the eigenfrequencies, with an accuracy sufficient for acoustical engineering purposes.

78-215

The Dependence of the Changes of the Natural Vibrations of the Body of a Guitar on the Number and Distribution of the Ribs on the Fixed Resonance Board. I
J.O. Jovicic
Faculté d'Electrotechnique de l'Université de Belgrade, Acustica, 38 (3), pp 175-179 (Sept 1977) 2 figs, 10 refs
(In French)

Key Words: Musical instruments, Natural vibration, Acoustic resonance

It is known that the sound spectra of the guitar shows appreciable change if there is alteration in the number and distribution of the ribs on the resonance board. The best conditions for resonance are given by the body having a large number of natural vibrations in the frequency domain encompassing all the harmonics of the strings. In this paper the changes in the natural vibrations of the body are examined by contrast with the amplitude/frequency.

78-216

The Role of Radial Ribs on the Resonance Board of the Guitar. II. Their Effect on the Nodal Lines of the Board (Holographic Study)
J.O. Jovicic
Faculté d'Electrotechnique de l'Université de Belgrade, Acustica, 38 (3), pp 180-185 (Sept 1977) 51 figs, 11 refs
(In French)

Key Words: Musical instruments, Acoustic resonance, Resonant response, Holographic techniques

The electroacoustic method has been used to determine the resonant acoustic responses of the body of a guitar, whose upper board had small ribs, and the natural oscillations and their frequencies were found and their amplitude frequency characteristics recorded. A new method of exciting the board through sinusoidal oscillations by electromagnetic excitation was used, at frequencies corresponding to those of the natural body oscillations: the interference figures on the resonance board were recorded by the holographic interferometer method. The changes were observed in the appearance of the interference figures as a function of the exciting force, of the frequency of excitation and of the increase in the number of small ribs attached to the resonance board.

78-217

Model of Aircraft Noise Adaptation
T.K. Dempsey, G.D. Coates, and J.M. Cawthorn

Langley Res. Center, NASA, Langley Station, VA., Rept. No. NASA-TM-74052, 63 pp (July 1977) N77-30747

Key Words: Aircraft noise, Human response

Development of an aircraft noise adaptation model, which would account for much of the variability in the responses of subjects participating in human response to noise experiments, was studied. A description of the model development is presented. The principal concept of the model, was the determination of an aircraft adaptation level which represents an annoyance calibration for each individual. Results showed a direct correlation between noise level of the stimuli and annoyance reactions. Attitude-personality variables were found to account for varying annoyance judgements.

78-218

Further Sensitivity Studies of Community-Aircraft Noise Exposure (NOISEMAP) Prediction Procedures

D.E. Bishop, T.C. Dunderdale, R.D. Horonjeff, and J.F. Mills

Bolt Beranek and Newman, Inc., Canoga Park, CA., Rept. No. BBN-3295, AMRL-TR-76-116, 88 pp (Apr 1977)

AD-A041 781/6GA

Key Words: Aircraft noise, Human response, Computer programs

This report describes the results of studies of the sensitivity of the noise exposure contours to various model parameters and assumptions presently in the NOISEMAP procedure. The areas within Day/Night Level contours for ten Air Force airbases increased by 11 to 40 percent when the noise measure was adjusted for the presence of pure tones. The contour areas for typical mixed fighter, bomber/tanker, and training airbases were reduced by 3 to 11 percent by substitution of the SAE algorithms for ground-to-ground propagation and transition models, whereas adding the fuselage shielding algorithm reduced the contour areas by 13 to 22 percent. Since there is little firm evidence showing one set of algorithms more accurate than the other, the present NOISEMAP models will be retained until further technical analyses or new data show a clear basis for alteration.

78-219

Validation of Aircraft Noise Exposure Prediction Procedure

H. Seidman, R.D. Horonjeff, and D.E. Bishop

Bolt Beranek and Newman, Inc., Canoga Park, CA, Rept. No. BBN-3299, AMRL-TR-76-111, 87 pp (Apr 1977)

AD-A041 674/3GA

Key Words: Aircraft noise, Noise prediction, Human response, Computer programs

The NOISEMAP predictive procedure is used to describe the noise environment around airbases and thereby aid airbase planners to prevent community encroachment limiting the effectiveness of the installation. This report delineates the results of measurements made over one to three week periods at four Air Force airbases to acquire the data needed to validate and/or modify the noise predictive algorithms in NOISEMAP for takeoff, landing, traffic pattern, and ground runup operations. In general, the algorithms currently used in NOISEMAP provided predictions that agreed well with measured data. It was found the obtaining accurate data on aircraft operational procedures (engine power settings, airspeeds, and flight paths) was essential.

78-220

Costs and National Noise Impact of Feasible Solution Sets for Reduction of Airport Noise

H.G. Meindl, L.C. Sutherland, H. Spiro, C. Bartel, and D. Pies

Wyle Labs., El Segundo, CA., Rept. No. WR-75-9, EPA-230/3-77/017, 278 pp (Feb 1976)

PB-269 749/8GA

Key Words: Aircraft noise, Noise reduction, Airports

The purpose of this study was to determine the effectiveness and costs associated with feasible solution alternatives for the reduction of cumulative noise impact from airport and aircraft operations. Effectiveness of the various noise reduction methods was evaluated in terms of noise impact area, population, and land and housing value data determined for individual airports, three representative airport categories, and 514 air carrier airports. These data, in conjunction with cost factors associated with the various noise reduction schemes, provide the parameters by which on economic impact assessment can be conducted.

78-221

Vehicle Noise Radiation, Effective Height and Frequency Measurements

R.N. Foss

Applied Physics Lab., Washington Univ., Seattle, WA., Rept. No. APL-UW-7615, RPR-24.4, 30 pp (Aug 1976)

Sponsored by Washington State Dept. of Highways

PB-269 585/6GA

Key Words: Ground vehicles, Noise measurement, Measurement techniques

Actual vehicle measurements indicate that the best single frequency approximation for 'A' weighted noise is 650 Hz. For light vehicles, the effective source height is 0.2 m (0.7 ft) above the lane surface. For heavy vehicles, the effective source height is 0.8 m (2.6 ft) above the lane surface.

78-222

On the Role of Aerodynamically Generated Sound in Determining Wayside Noise Levels from High Speed Trains

W.F. King, III

Institut f. Turbulenzforschung, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt e.V., 1 Berlin 12, Germany, J. Sound Vib., 54 (3), pp 361-378 (Oct 8, 1977) 7 figs, 51 refs

Key Words: High speed transportation, Railroad trains, Interaction: rail-wheel, Noise generation

The relative contributions of aerodynamic and wheel/rail noise to railway wayside noise levels are not well understood. Methods for predicting these contributions discussed in this paper include (i) an equation for turbulent boundary layer noise (the minimum wayside noise), (ii) an empirical formula for total aerodynamic noise based on airframe noise studies, and (iii) the Peters equation for wheel/rail interaction noise. Comparisons are made between predicted and measured noise levels for (i) a buoyant vehicle, (ii) the Linear Induction Motor Research Vehicle (LIMRV), and (iii) a magnetically levitated vehicle.

78-223

Attenuation of Upstream-Generated Low Frequency Noise by Gas Turbines

V.L. Doyle and R.K. Matta

Aircraft Engine Group, General Electric Co., Evendale, OH., Rept. No. NASA-CR-135219; R77AEG-482, 232 pp (Aug 1977)
N77-28122

Key Words: Gas turbine engines, Aircraft noise, Engine noise, Model testing

The acoustic transfer functions of low frequency (below 3500 Hz) noise through aircraft turbines were investigated. Model test results were compared with theoretical predictions in order to assess the validity of the theory. Component tests were conducted on both high pressure and low pressure model turbines. The influence of inlet temperature and turbine speed attenuation was evaluated, while the effects of turbine pressure ratio, blade-row choking, and additional downstream stages were determined. Preliminary identification of pertinent aeroacoustic correlating parameters was made.

78-224

Progress in Shock Absorber Oil Technology

A. Dalibert

ESSOS.A.F., France, SAE Paper No. 770859, 12 pp, 12 figs, 1 table

Key Words: Shock absorbers, Lubrication, Noise generation, Damping

Shock absorber oils have to satisfy, with the mechanical device of the shock absorber, a certain number of technical targets to ensure satisfactory behavior when in service on the car. This paper details the technical requirements for the oil with respect to the following properties: damping diagram versus viscosity temperature dependence, shear stability, biphasic flow; antiwear properties to avoid lateral seizure between piston and cylinder (critical in MacPherson-type suspensions); oxidation stability; and low noise generation.

78-225

Coherence and Phase Techniques Applied to Noise Diagnosis in the NASA Ames 7 Times 10-Foot Wind Tunnel No. 1

J.F. Wilby, A.G. Piersol, P.E. Rentz, and T.D. Scharton

Bolt Beranek and Newman, Inc., Canoga Park, CA., Rept No. NASA-CR-152039; BBN-3559, 62 pp (July 1977)
N77-30905

Key Words: Noise generation, Fans, Wind tunnel tests, Experimental data

Measurements have been made of coherence and phase spectra for the acoustic field in a subsonic wind tunnel. The data are interpreted in terms of simple analytical models for propagating and diffuse noise fields, including the presence of uncorrelated noise signals. It is found that low frequency noise propagates upstream and downstream from the fan, with the noise in the test section arriving in the upstream direction. High frequency sound is generated in the test section and propagates upstream and downstream. In the low frequency range, the ratio of diffuse to propagating energy is about eight for all locations in the test section, diffuser, and settling chamber; the value of the ratio increases with frequency.

PERIODIC

78-226

Impact Vibration of a Bar

U. Bjorkenstam

Dept. of Mech. Engrg., Linkoping Univ., S-581 83, Linkoping, Sweden, Intl. J. Mech. Sci., 19 (8), pp 471-481 (1977) 8 figs, 16 refs

Key Words: Bars, Periodic excitation, Pneumatic tools

This paper treats the motion and dynamic stability of a bar having constant stiffness and mass distribution when subjected to a periodic driving force, a distributed and linear damping force and impact forces due to its motion and operation (such as would occur on, e.g. the hammer in a rock drilling machine). Comparisons have been made between the characteristics of a bar operated by either pneumatic or hydraulic means.

RANDOM

78-227

Harmonic Relationships Among Random Variables

D.A. Swick

Naval Research Lab., Washington, D.C. 20375, SIAM J. Appl. Math., 33 (3), pp 490-498 (Nov 1977) 6 figs, 1 ref

Key Words: Random vibration

The approximate probability that m random variables out of a set of n uniformly and independently distributed on (a, b) are harmonically related to within a tolerance of 100t% has been calculated. The results indicate the need for accuracy in measurement if accidental harmonic relationships are to be avoided.

78-228

On the Internal Resonance in a Nonlinear Two-Degree-of-Freedom System

T. Yamamoto, K. Yasuda, and I. Nagasaka

Nagoya Univ., Chikusa-ku, Nagoya, Japan, Bull. JSME, 20 (147), pp 1093-1100 (Sept 1977) 8 figs, 2 refs

Key Words: Forced vibration, Harmonic excitation

A two-degree-of-freedom vibrating system tuned to internal resonance with the higher natural frequency twice the lower natural frequency, having nonlinear characteristic of second and third order polynomials of the displacements, subjected to harmonic excitation, is discussed. Steady forced vibrations are investigated in the vicinity of the higher resonance point of the system. It is shown that the results of the theoretical analysis agree with those of an analog computer.

SEISMIC

(Also see Nos. 213, 339, 342)

78-229

Elastic Earthquake Analysis of Torsionally Coupled Multistorey Buildings

C.L. Kan and A.K. Chopra

Univ. of California, Berkeley, CA., Intl. J. Earthquake Engr. Struc. Dynam., 5 (4), pp 395-412 (Oct-Dec 1977) 4 figs, 9 tables, 6 refs

Key Words: Multistory buildings, Seismic response, Perturbation theory

With the aid of perturbation analysis of vibration frequencies and mode shapes it is shown that any lower vibration mode of a torsionally coupled building may be approximated as a linear combination of three vibration modes of the corresponding torsionally uncoupled system (a system with coincident centers of mass and resistance but all other properties are identical to the actual system): one translational mode along each of the two principal axes of resistance and one mode in torsional vibration. This result provides the motivation for a simpler - relative to the standard - procedure for analyzing the response of torsionally coupled multistorey buildings to earthquake ground motion. To illustrate the application and accuracy of this procedure two numerical examples are presented.

78-230

Dynamic Properties of Mass Concrete

K.L. Saucier

Army Engineer Waterways Experiment Station, Vicksburg, MS., Rept. No. WES-MP-C-77-6, CTIAC-23, 27 pp (June 1977)

AD-A043 004/1GA

Key Words: Concretes, Earthquake response, Experimental data, Earthquake resistant structures

The objective of this study was to determine the tensile strength, cyclical behavior, and stress-strain relationships for concrete under loading conditions (1-10 Hz) such as could be produced by an earthquake. Dynamic direct tensile

tests and stress-reversal tests were conducted on core samples from two concrete mixtures representative of mass concrete. Test procedures were developed for cyclical loading and loading to failure in 0.25 to 0.025 sec which represent one-fourth of a cycle having a frequency of 1 to 10 Hz. Stress-strain measurements were made on selected specimens.

78-231

Seismic Response due to Travelling Shear Wave Including Soil-Structure Interaction with Base-Mat Uplift

J.P. Wolf

Electrowatt Engineering Services, Ltd., Zurich, Switzerland, Intl. J. Earthquake Engr. Struc. Dynam., 5 (4), pp 337-363 (Oct-Dec 1977) 18 figs, 5 tables, 21 refs

Key Words: Interaction: soil-structure, Nuclear reactors, Seismic response

The seismic response due to a traveling shear wave is investigated. The resulting input consists of a translational- and a torsional-acceleration time history, which depend on the ratio of the wavelength to the dimension of the footing. A nuclear reactor building is used for illustration.

78-232

Errors in Response Calculations for Non-Classically Damped Structures

G.B. Warburton and S.R. Soni

Dept. of Mech. Engrg., Univ. of Nottingham, Nottingham, UK, Intl. J. Earthquake Engr. Struc. Dynam., 5 (4), pp 365-376 (Oct-Dec 1977) 2 figs, 4 tables, 8 refs

Key Words: Damped structures, Seismic response, Modal damping

The classical normal mode method of determining response is extremely useful for practical calculations, but depends upon the damping matrix being orthogonal with respect to the modal vectors. Approximations that allow the method to be used when this condition is not satisfied have been suggested; the simplest approach is to neglect off-diagonal terms in the triple matrix product formed from the damping and modal matrices. In this paper the errors in response caused by this approximation are determined for several simple structures for a wide range of damping parameters and different types of excitation. Based on these results a criterion, relating modal damping and natural frequencies, is formulated; if this is satisfied, the errors in response caused by this diagonalization procedure are within acceptable limits.

SHOCK

(Also see Nos. 205, 206, 219, 259, 356, 357)

78-233

Rear-End Crash Characteristics and Fuel System Safety

T. Okamoto, F. Shiba, and M. Yamada

Nissan Motor Co., Ltd., Japan, SAE Paper No. 770815, 12 pp, 14 figs, 1 table, 4 refs

Key Words: Collision research (automotive)

This paper explains the characteristics of vehicle body deformation in rear-end collisions and discusses a simplified method for controlling vehicle body crush modes, including the prevention of fuel tank crushing by lowering the stiffness of its support.

78-234

Whole Body Response of the Hybrid III Anthropomorphic Test Device

N.M. Alem, J.B. Benson, and J.W. Melvin

Highway Safety Research Inst., Michigan Univ., Ann Arbor, MI., Rept. No. UM-HSRI-77-10, 226 pp (Feb 28, 1977)

PB-268 702/8GA

Key Words: Collision research (automotive), Anthropomorphic dummies

The objectives of this project are to obtain whole body kinematic response of the GM Hybrid-III anthropomorphic test device (GM 50X-H03) under controlled test conditions which represent realistic automotive impact environments. This report presents the raw data and analysis results of 9 tests conducted at 3 impact severity levels. The test protocol and mathematical basis for the data analysis were developed for the Whole Body Response Research program.

78-235

Tolerance and Response of the Knee-Femur-Pelvis Complex to Axial Impact

J.W. Melvin and R.L. Stalnaker

Highway Safety Research Inst., Michigan Univ., Ann Arbor, MI, Rept. No. UM-HSRI-76-33, 52 pp (Oct 1976)

PB-269 059/2GA

Key Words: Collision research (automotive), Human response

The report is intended to define the tolerance and response of the human patella-femur-pelvis complex to axial impact force applied to the knee of seated vehicle occupants. The results of direct impact and driving point impedance measurements of the flexed legs of seated unembalmed human cadavers is presented. A total of 58 individual impact tests to the knees of cadavers were conducted for various impact test conditions -- rigid, lightly padded and thickly padded impact surfaces. Accident investigation data analysis is used as an aid to interpreting the test results.

78-236

On Uncoupling Structure-Fluid Interaction Problems Status Report on the IDCA

H.H. Bleich, F.L. DiMaggio, D. Ranlet, and M.L. Baron

Weidlinger Associates, NY, 23 pp (May 1977)

AD-A043 356/5GA

Key Words: Interaction: fluid-structure, Submerged structures, Explosion effects

A concerted effort has been made to analyze submerged structures under explosive loadings, by utilizing the Doubly Asymptotic Approximation (DAA), to account for the structure-fluid interaction. The DAA yields exact results for high and low frequencies and produces a smooth transition between these limits. Since a more accurate fit at intermediate frequencies may prove to be important in some problems of interest, the DAA may prove to be inadequate in some cases. The Inertial-Damping Collocation Approximation (IDCA), gives exact results for low, high, and selected intermediate frequencies, and as such represents a potential improvement over the DAA.

78-237

Studies on Shock Wave Generation, Material Stress and Technology of the Hydrospark Method

J. Hammann, G. März, D. Scheible, and H. Seiffert

Abt. Fertigungstechnische Entwicklung 2, Siemens A.G., Nüremberg, West Germany, Rept. No. BMFT-FB-T-76-78, 96 pp (Dec 1976)

(In German)

N77-29523

Key Words: Shock waves

The hydrospark method and its economical application to production were studied. Investigations of energy transfer from underwater wire explosions form the basis for the development of optimally efficient ignition devices very rapidly replaceable. The production time was reduced to economical values by means of a new type of tool, i.e., an elastic bellows enclosing the medium which transfers the shock waves. The advantages and limitations of the method are explained by examples, and details are given of materials and construction of the tools which can withstand the heavy stresses imposed by shock waves.

78-238

Shock Wave Attenuation by Perforated Plates with Various Hole Sizes

C. Kingery, R. Pearson, and G. Coulter

Ballistic Research Labs., Aberdeen Proving Ground, MD, Rept. No. BRL-MR-2757, 55 pp (June 1977)

AD-A041 854/1GA

Key Words: Plates, Perforations, Shock wave attenuation

Results are presented for a set of experiments designed to determine the attenuation of shock waves passing through perforated plates as a function of peak overpressure and hole size for a given percentage of plate area vented. The venting hole size was varied. The perforated plates were exposed to shock waves in a 4-inch (10.2 cm) shock tube over a range of peak shock overpressures from 200 psi (1379 kPa) down to 48 psi (331 kPa).

PHENOMENOLOGY

DAMPING

(Also see Nos. 224, 232, 321, 373, 374)

78-239

Load and Stability Measurements on a Soft-Inplane Rotor System Incorporating Elastomeric Lead-Lag Dampers

W.H. Weller

Langley Res. Center, NASA, Langley Station, VA., Rept. No. NASA-TN-D-8437; L-11315, 70 pp (July 1977)

Sponsored by the U.S. Army Air Mobility R&D Lab

N77-28112

Key Words: Helicopter rotors, Elastomers, Model testing, Damping

An experimental investigation was conducted of the dynamic response and inplane stability associated with a new soft-inplane helicopter rotor. The unique feature of this rotor was the use of an internal elastomeric damper to restrain the blade inplane motion about the lead-lag hinge. The properties of the elastomer were selected to provide both a nominal first inplane frequency ratio of 0.65 and sufficient damping to eliminate the need for additional external damping sources to prevent ground resonance on a typical fuselage structure. For this investigation a 1/5-scale aeroelastic model was used to represent the rotor. The four-blade model had a diameter of 3.05 m (10 ft) and a solidity of 0.103. The first out-of-plane frequency ratio was 1.06. The model was tested in hover and in forward flight up to an advance ratio of 0.45. At each forward speed the rotor lift was varied up to simulated maneuver conditions.

78-240

Energy Dissipation in Rotary Structural Joints

R.S.H. Richardson and H. Nolle

Dept. of Mech. Engrg., Monash Univ., Clayton, Victoria 3168, Australia, J. Sound Vib., 54 (4), pp 577-588 (Oct 22, 1977) 9 figs, 7 refs

Key Words: Joints (junctions), Coulomb friction, Energy dissipation

Many structures and mechanical assemblies are held together by connections containing two friction surfaces in contact under the action of a constant clamping force. When the structure is vibrating the external load acting on the joint is a time-dependent moment about an axis normal to the contact surfaces. Friction joints of this type constitute a well-defined source of damping in vibrating structures. The joint is analyzed theoretically by means of principles analogous to those used in the Panovko model of the axially loaded lap joint. Complete moment-rotation and energy loss characteristics are obtained.

ELASTIC

78-241

Normal Mode Responses of Linear Piezoelectric Materials with Hexagonal Symmetry

P.J. Chen and S.T. Montgomery

Sandia Laboratories, Albuquerque, NM 87115, Intl. J. Solids Struc., 13 (10), pp 947-955 (1977) 5 figs, 6 refs

Key Words: Normal modes, Ceramics, Piezoelectricity

The dynamic electromechanical responses of linear piezoelectric materials with hexagonal symmetry in the normal mode configuration is considered. In particular, the coupled transient problem is formulated. Numerical results are *obtained to illustrate the nature of the electrical outputs of* rectangular specimens of these materials subjected to time dependent mechanical boundary loads.

FATIGUE

78-242

Realistic Fatigue Modeling of Vibrating Mechanical Structures

J.N. Tait

Naval Air Dev. Center, Warminster, PA., J. Environ. Sci., 20 (6), pp 12-16 (Nov/Dec 1977) 2 figs, 5 tables, 4 refs

Key Words: Fatigue, Mathematical models, Coulomb friction, Viscous damping

A study program to determine the relationships between vibratory energy and fatigue involving viscous and coulomb dampers was conducted. The most difficult task has been to identify the degradation characteristics of damping and natural frequency, and to incorporate them into the mathematical models in a realistic manner. This paper presents a summary of the application of theoretical study to the laboratory test results, and the failure energy correlation resulting from computer processing of the mathematical models.

FLUID

(Also see Nos. 236, 277, 278, 287)

78-243

Structural Response Under Turbulent Flow Excitations

Y.K. Lin

Inst. of Sound and Vibration Res., Univ. of Southampton, UK, Rept. No. ISVR-TR-80, 52 pp (Aug 1976)

Sponsored by the Science Research Council

N77-29566

Key Words: Random vibration, Fluid-induced excitation, Aircraft, Panels, Buildings, Wind-induced excitation

Three problems of random vibration are discussed. In each case the external excitation is a turbulent flow. An airplane flying into atmospheric turbulence and a panel-like structure exposed to boundary-layer pressure fluctuation, are treated as linear problems.

78-244

Vehicle-Induced Gust Loads on Aluminum Overhead Sign Structures

J.B. Zell

Engrg. and Research and Development Bureau, New York State Dept. of Transportation, Albany, NY, Rept. No. NYSDOT-ERD-77-SR-55, FHWA/NYS-DOT/ERD-77-SR-55, 21 pp (Mar 1977)
Sponsored by the Federal Highway Admin.
PB-269 575/7GA

Key Words: Signs, Suspended structures, Wind-induced excitation

Vehicle-induced gust loads are not included in New York State's design of aluminum overhead sign support structures and designers have feared that these loads might lead to fatigue failures. This report summarizes the results of a project initiated to determine if current design procedures must be revised, and if existing sign structures should be inspected for possible damage. Two existing sign structures on I 787 in Albany were instrumented and tested. Test data included stress range histograms, frequencies of vibration, and damping coefficients for sign structure vibration induced by large vehicles, in this case trucks.

78-245

Influence of Cavity-Volume Damping on the Stiffness of Air Layers in Double Walls

K. Gosele and U. Gosele

Fraunhofer-Gesellschaft, Institut f. Bauphysik, Stuttgart, Federal Rep. of Germany, Acustica, 38 (3), pp 159-160 (Sept 1977) 10 figs, 4 refs
(In German)

Key Words: Panel-cavity response

A long slender cavity space which is excited by plate flexural waves will have its stiffness influenced by flow resistance on two grounds: the forced wave excited in the air cavity has a large amplitude, when there is no resistance; and, in the cavity space limited in length, longitudinal resonances appear which are less pronounced the larger the resistance.

78-246

A Study on the Vortex Oscillator (1st Report: On a Mathematical Model of a Confined Vortex Oscillator)

T. Ito, S. Takagi, Y. Suematsu, and A. Honda

Nagoya Univ., Nagoya, Japan, Bull. JSME, 20 (147), pp 1153-1160 (Sept 1977) 13 figs, 6 refs

Key Words: Vortex-induced excitation, Mathematical model

A theoretical and experimental study was carried out on a vortex oscillator which has a double input vortex chamber (i.e. a confined vortex oscillator). A mathematical model for the oscillator is proposed and examined by experiments. An oscillator with a single capacity is also examined.

SOIL

(See No. 231)

EXPERIMENTATION

DIAGNOSTICS

78-247

ASME Panel Explores Machinery, Plant-Reliability Monitoring

Oil and Gas J., 75 (50), pp 115-120 (Dec 5, 1977) 5 figs

Key Words: Diagnostic techniques

A panel session on reliability monitoring of machinery and plants at the American Society of Mechanical Engineers Energy Technology Conference held in Houston is described. The panelists discussed vibration instrumentation for commissioning turbomachinery, application of mini-computers to machinery reliability, the major goals in machinery monitoring, and needed improvements in machinery health monitoring systems.

78-248

A Pictorial Guide to the Interpretation of Frequency Spectra

H.J. Bickel

Nicolet Scientific Corp., Northvale, NJ 07647, Noise Control, Vib. and Insul., pp 240-242 (Aug/Sept 1977) 7 figs, 1 ref

Key Words: Spectrum analysis, Spectrum analyzers, Diagnostic techniques

Acoustic noise and vibration of a fan provide the illustrations for this paper. Octave and 1/3-octave acoustic spectra are examined. Fine resolution (constant bandwidth) analysis is used to show many of the discrete frequencies present in the fan's acoustic 'signature'. Turbulent airflow produces a noise-like signal whose average spectrum characteristics are illustrated.

78-249

Vibration Analyses Can Forestall Trouble

W.J. McGuckin and G. Schramm

Vibration Specialty Corp., Philadelphia, PA., Power Transm. Des., 19 (10), pp 95-98 (Oct 1977) 3 figs, 1 table

Key Words: Diagnostic techniques

An integrated program for preventive maintenance of rotating machinery is described. It is composed of two parts: Phase I is preoperational (design, fabrication, and installation) and Phase II is operational. It combines today's technology with established methods of the past, and provides the means to monitor, condition, record, playback, and interpret signals generated by operating equipment.

78-250

Vibration Watchdogs within Oil, Gas and Chemical Complexes

A. Hughes

Industrial Inertia Switch, Ltd., Noise Control, Vib. and Insul., pp 258-260 (Aug/Sept 1977)

Key Words: Diagnostic instrumentation

In many practical situations an excess vibration threshold may be all that is required to initiate some maintenance or safety procedure within the particular industry. For that purpose vibration switches are available which are designed to activate at a preset level of vibration, detecting the acceleration forces and hence the destructive forces present on the machine. Two basic designs of vibration threshold devices are described. One detects low frequency changes generally associated with unbalance forces and the other detects high frequency vibration changes associated with bearing, coupling misalignment, gear meshing, etc.

78-251

Controlling Machines by Ear With Acoustic Feedback

J.K. Krouse

Mach. Des., 49 (24), pp 146-151 (Oct 20, 1977)

Key Words: Machine diagnostics

Future acoustic feedback control systems for detecting machine malfunctions are described. Present and future applications to punch presses, monitoring spot-welds, and crack detection, are discussed in detail.

78-252

Process Machinery Vibration Data Better

V. Maddox

General Electric Co., Houston, TX, Hydrocarbon Processing, 56 (10), pp 179-184 (Oct 1977) 9 figs, 6 refs

Key Words: Diagnostic techniques, Diagnostic instrumentation

This article presents an over-all survey of data collection, reduction and reporting techniques and equipment most commonly used on rotating machinery.

78-253

Predict Problems with Acoustic Incipient Failure Detection Systems

H.P. Bloch

Exxon Chemical Co., Baytown, TX, Hydrocarbon Processing, 56 (1), pp 191-198 (Oct 1977) 10 figs, 3 tables, 8 refs

Key Words: Diagnostic techniques, High frequency resonance techniques

For early identification of failure the defects must be detected when they first develop and are quite small. Fortunately, operating noise tends to be concentrated in the low frequency range of vibration while defect-originated energy extends to much higher frequencies. These acoustic frequencies can be measured with electronic instruments incorporated in a computerized monitoring system. The cost effectiveness of the application of this technology is described and further improvements and systems additions are discussed.

78-254

Non-Intrusive Acoustical Diagnostics for Appraising Pump Contaminant Wear

G.E. Maroney and R.K. Tessmann

Fluid Power Res. Center, Oklahoma State Univ., SAE Paper No. 770770, 20 pp, 11 figs, 1 table, 20 refs

Key Words: Pumps, Diagnostic techniques, Wear

This paper discusses a non-intrusive acoustical diagnostic technique for assessing the wear and associated flow degradation of hydraulic pumps. The technique utilizes near-field airborne noise measurements to determine the acoustical energy emitted by the pump at various pumping harmonics. Ratios of the pumping harmonic noise levels are transformed into a Noise Wear Index. Data are presented which show the correlation between the Noise Wear Index and gear pump contaminant induced wear as indicated by a degradation of pump flow performance. The use of the Noise Wear Index for diagnosing system infirmities and improving system reliability is discussed.

EQUIPMENT

(Also see No. 202)

78-255

Shock Test System at Army Electronic Proving Ground

Test, 38 (3/4), p 14 (Oct/Nov 1977)

Key Words: Test facilities, Test equipment

A shock testing machine by Lansmont Corporation, combined with a SMART system by Endevco at the U.S. Army Electronic Proving Ground is described.

FACILITIES

(Also see Nos. 255, 318)

78-256

The Outlook for Simulation of Forward Flight Effects on Aircraft Noise

D.G. Crighton, J.E.F. Williams, and I.C. Cheeseman
Univ. of Leeds, UK, J. Aircraft, 14 (11), pp 1117-1125 (Nov 1977) 2 tables, 23 refs

Key Words: Test facilities, Aircraft noise

This paper offers a wide-ranging examination of the fundamental issues behind recent efforts to devise means by which forward flight effects on aircraft noise may be simulated in ground-based facilities. Theoretical predictions of flight effects for simple configurations are noted. The advantages and disadvantages of various types of simulation facility are set out, and the features of possible noise sources and propagation mechanisms are tabulated. Opinions are then given as to how these sources and mechanisms may best be simulated. The paper concludes with both general and very specific recommendations for future experimental and theoretical work.

78-257

The Evaluation of a Semi-Anechoic Chamber Used for Small-Engine Sound Analyses

R.A. Dykstra and D.E. Baxa
Kohler Co., SAE Paper No. 770764, 12 pp, 7 figs, 20 refs

Key Words: Anechoic chambers, Acoustic tests, Engine noise

This paper discusses the acoustical response characteristics of Kohler Co.'s semi-anechoic chamber. The chamber is first evaluated as a system. Then, an analysis of the room's sound absorptive wedges is discussed.

78-258

Computer-Controlled Multiple-Actuator Shaker Offers Versatile Test Capabilities

D.K. Fisher
Lawrence Livermore Lab., California Univ., Livermore, CA., Rept. No. UCID-17347, 13 pp (Jan 20, 1977)
N77-29188

Key Words: Test facilities, Computer-aided techniques, Shakers, Shock tests, Vibration tests

A multiple-actuator shaker facility is being used for such studies as shock and vibration tests of rocket motors, seismic qualification of a turbine-generator set, and performance analysis of the rock bolts used in mine-tunnel construction. Capabilities include the safe testing of hazardous materials and explosives. The computerized control system permits the shaker to be easily adapted to nonstandard shock and vibration tests.

78-259

International Symposium on Military Applications of Blast Simulation (5th)

W.G. Soper
Office of Naval Research, London, UK, Rept. No. ONRL-C-6-77, 10 pp (June 1977)
AD-A042 575/1GA

Key Words: Shock tubes, Test facilities

A review is given of papers presented at the subject Symposium, which was held in Stockholm, Sweden, 23-26 May

1977. Principal emphasis in the review is placed on advances in shock tube design, new instrumentation, and the use of scale models in blast research. Several short shock-tubes driven by sources in parallel are described, and the success of cube-root scaling of magazine explosions and blast cratering is discussed.

INSTRUMENTATION

78-260

Underwater Helmholtz-Resonator Transducers: General Design Principles

R.S. Woollett
New London Lab., Naval Underwater Systems Ctr., New London, CT., Rept. No. NUSC-TR-5633, 46 pp (July 5, 1977)
AD-A043 359/9GA

Key Words: Helmholtz resonators, Acoustic measuring instruments, Underwater sound

The object of the present study was to investigate more general configurations for Helmholtz resonators and to evolve optimum designs. Primary interest was in developing a new approach to generating sound at frequencies below 100 Hz, where existing capabilities were very limited. A design procedure for disk-driven Helmholtz resonators is outlined.

78-261

Experimental Scheme for Analyzing the Dynamic Behavior of Electroacoustic Transducers

D.P. Egolf and R.G. Leonard
Auditory and Electroacoustics Research Group, Dept. of Electrical Engrg., Univ. of Wyoming, Laramie, WY 82070, J. Acoust. Soc. Amer., 62 (4), pp 1013-1023 (Oct 1977) 12 figs, 10 refs

Key Words: Transducers

Methods for determining dynamic properties of acoustic sources have received little attention in the literature. This paper describes the development and verification of a computer-aided experimental procedure for obtaining four parameters that characterize the dynamic behavior of electroacoustic transducers. This technique, herein called the "two-load" method, is first demonstrated on a simple electrical circuit.

SIMULATORS

(See No. 339)

TECHNIQUES

(Also see Nos. 221, 338, 359, 363)

78-262

The National Measurement System for Acoustics

D.S. Pallett and M.A. Cadoff
National Bureau of Standards, Washington, D.C., S/V, Sound Vib., 11 (10), pp 20-31 (Oct 1977) 4 figs, 2 tables, 3 refs

Key Words: Measurement techniques, Acoustic measurement

The emphasis of the study of the National Measurement System for Acoustics has been to determine the adequacy of these important physical measurements and to promote improvements within the measurement system. The relevant physical quantities are indicated, and the interactions occurring between participants as well as the roles of acoustical standardization institutions are specified. Finally, the status and trends of the System and the NBS role in adapting to changing technology are discussed.

HOLOGRAPHY

(See No. 216)

COMPONENTS

BEAMS, STRINGS, RODS, BARS

78-263

Free Vibrations of Taut and Slack Marine Cables

S.E. Ramberg and O.M. Griffin
Naval Research Lab., Washington, D.C. 20375, ASCE J. Struc. Div., 103 (ST11), pp 2079-2092 (Nov 1977)

Key Words: Cables (ropes), Natural frequencies, Mode shapes

The natural frequency and damping of several typical marine cables were measured in air and in water and are reported in this paper. The changes in natural frequency and mode shape that occur in both media as the cable sags from a taut configuration are in agreement with a recently developed

linear theory. A modal "crossover" predicted by the theory was also observed as the cable tension was decreased. The onset of the catenary behavior has been identified and it coincides with at least an order of magnitude increase in the structural damping of the cables.

78-264

Free Vibrations of Curved Box Girders

M.M. Tabba and C.J. Turkstra
Dept. of Civil Engrg. and Appl. Mech., McGill Univ., Montreal, Quebec, Canada, J. Sound Vib., 54 (4), pp 501-514 (Oct 22, 1977) 6 figs, 1 table, 12 refs

Key Words: Free vibrations, Box beams, Beams, Girders, Flexural vibration, Torsional vibration

The problem of coupled free vibrations of curved thin-walled girders of non-deformable asymmetric cross-section is examined in this paper. The general governing differential equations are derived for quadruple coupling between the two flexural, tangential and torsional vibrations. An approximate solution for the case of triple coupling between the two flexural and the torsional vibrations is given for a simply supported girder, uniform specific gravity of the material of the box being assumed. Section warping is considered but axial forces, rotary inertia and structural damping are neglected. A parametric study is conducted to investigate the effect of relevant parameters on natural frequencies. The solution derived herein for the general case is also shown to cover a variety of special cases of straight and curved girders with doubly symmetric or singly symmetric cross-sections.

78-265

Finite Strip Analysis of Flat Skin-Stringer Structures

M. Petyt
Inst. of Sound and Vibration Res., Univ. of Southampton, Southampton S09 5NH, UK, J. Sound Vib., 54 (4), pp 537-547 (Oct 22, 1977) 6 figs, 4 tables, 26 refs

Key Words: Finite strip method, Skin-stringer method, Beams

A flat, rectangular finite strip element and a compatible thin-walled, open section beam element are used to predict the vibration characteristics of flat skin-stringer structures of riveted construction. Strip only idealizations and strip plus thin walled, open section beam idealizations have been used in the analyses. The effects of neglecting skin membrane action and varying the effective width of stringer-skin attachment are investigated.

78-266

Response of a Laminated Beam to a Moving Load

B. Prasad and G. Herrmann
Stanford Univ., Stanford, CA., AIAA J., 15 (10), pp 1424-1431 (Oct 1977) 9 figs, 4 tables, 20 refs

Key Words: Beams, Laminates, Moving loads, Elastic foundations, Damping effects

A study of the steady-state response of an infinite composite beam subjected to a moving concentrated load and supported by an elastic foundation with and without damping is presented. A rectangular beam, with alternating layers of two different elastic materials is considered, and the equations derived by C.T. Sun, which include microstructure, are employed. Results are also obtained on the basis of Timoshenko beam equations for an equivalent homogeneous beam, using the effective moduli suggested by Voigt and by Reuss, respectively. The influence of the damping coefficient and the load velocity on the beam response are analyzed in some detail. The limiting case for no damping and the resonance behavior of the steady-state solutions are also investigated.

78-267

Upper and Lower Bounds for Fundamental Natural Frequency of Beams

A.B. Ku
Dept. of Civil Engrg., Univ. of Detroit, MI 48221, J. Sound Vib., 54 (3), pp 311-316 (Oct 8, 1977) 1 table, 8 refs

Key Words: Beams, Natural frequency, Iteration

A better upper bound than the Rayleigh quotient is the Timoshenko quotient, the evaluation of which depends on a pair of compatible admissible moment and displacement functions. Based on both Rayleigh and Timoshenko quotients, a lower bound is readily computed. By means of an iteration procedure, both the upper and lower bound converge to the fundamental natural frequency.

78-268

Frequencies of Vibration of Beams by Schelkunoff Iteration with the HP-65 Calculator

R.D. Mindlin
Columbia Univ., New York, NY 10027, Computers and Struc., 7, pp 639-650 (1977) 2 figs, 3 tables, 3 refs

Key Words: Beams, Free vibration, Bernoulli theory, Timoshenko theory

Three programs are given for computing frequencies of free vibrations of uniform beams with the HP-65 programmable, pocket calculator: Bernoulli beams with all 10 combinations of homogeneous end-conditions, two-span Bernoulli beams on hinged supports and Timoshenko beams with 9 of the 10 combinations of homogeneous end-conditions. The programs illustrate the capacity and versatility of the calculator and various strengths and weaknesses of Schelkunoff's iterative method for solving trigonometric equations.

78-269

Numerical Analysis of Large Elastic-Plastic Deformation of Beams Due to Dynamic Loading

A. Sperling and Y. Partom

Material Mechanics Lab., Faculty of Mech. Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, Intl. J. Solids Struc., 13 (10), pp 865-876 (1977) 12 figs, 13 refs

Sponsored by the Air Force Office of Scientific Res.

Key Words: Beams, Elastic-plastic properties, Finite difference theory

Numerical calculations were performed for two examples of the response of elastic-plastic beams subjected to dynamic loads. These were a simply supported, axially restrained beam under suddenly applied uniform pressure, and an axially restrained, clamped beam with a central mass that is impacted by a projectile. Large elastic-plastic deflections were considered, and the method of finite differences was used. Experiments were carried out in which a rifle projectile hit a central mass which had been fastened to a clamped beam. Comparison between the theoretical and experimental dynamic deflections shows good agreement for relatively short response times.

BEARINGS

(Also see Nos. 368, 369)

78-270

Static and Dynamic Analysis of Capillary Compensated Hydrostatic Journal Bearings by Finite Element Method

D.V. Singh, R. Sinhasan, and R.C. Ghai

Government Engrg. College, Jabalpur, India, J. Lubric. Tech., Trans. ASME, 99 (4), pp 478-484 (Oct 1977) 12 figs, 20 refs

Key Words: Journal bearings, Periodic response, Finite element technique

Using finite element method steady state and dynamic performance of a capillary compensated hydrostatic journal bearing have been investigated. For stability studies, the critical mass of the bearing system has been determined by Routh's criterion. The locus of the journal center has been predicted by discretizing time and numerically integrating the equations of motion governing the journal bearing system.

78-271

Response of Inifinite Journal Gas Bearings to Harmonic Perturbations in the Rotational Speed

Y. Narkis and M.J. Cohen

Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Lubric. Tech., Trans. ASME, 99 (4), pp 428-433 (Oct 1977) 4 figs, 10 refs

Key Words: Gas bearings, Journal bearing, Harmonic excitation

The dynamics of a long hydrodynamic gas bearing are investigated for periodic variations of the rotational speed. The analysis is divided into two regions of interest namely: for small eccentricities the system is represented by a pair of linear differential equations with time-dependent coefficients; and for high eccentricities the nonlinear equations describing the motion of the journal center.

78-272

On the Dynamic Stability of Self-Aligning Journal Gas Bearings

M.J. Cohen

Dept. of Aeronautical Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Lubric. Tech., Trans. ASME, 99 (4), pp 434-440 (Oct 1977) 6 figs, 1 table, 14 refs

Key Words: Gas bearings, Journal bearings

The report presents an investigation of the dynamic stability behavior of self-aligning journal gas bearings when subjected to arbitrary small disturbances from an initial condition of operational equilibrium. The method is based on an approach similar to the nonlinear-ph solution of the author for the quasi-static loading case but the equations of motion of the journal are the linearized forms for small motion in the two degrees (translational) of freedom of the journal center.

78-273

A Contribution to the Problem of Designing Optimum Performance Bearings

A. Kanarachos

Lehrstuhl f. Maschinenelement und Konstruktionslehre, Ruhr-Universität Bochum, West Germany, J. Lubric. Tech., Trans. ASME, 99 (4), pp 462-468 (Oct 1977) 11 figs, 15 refs

Key Words: Bearings, Damping coefficients, Spring constants, Mathematical models

The maximum load capacity goal in hydrodynamic bearing optimization is extended to include dynamic performance characteristics, expressed by the spring and damping constants of the bearing. Investigations, based on the Maximum Principle approach and parameter optimization methods, lead to interesting conclusions, concerning the optimum film thickness geometry rsp. its convenient degrees of freedom. Emphasis is put on quasideterministic parameter optimization procedures, as they impose no restrictions on the mathematical model for the bearing pressure calculation and allow a straightforward solution of the optimization problem.

BLADES

(Also see Nos. 298, 299, 376)

78-274

Dynamic Characteristics of Rotor Blades with Pendulum Absorbers

V.R. Murthy and G.L. Goglia

School of Engrg., Old Dominion Univ. Res. Foundation, Norfolk, VA., Rept. No. NASA-CR-153929, 18 pp (July 1977) refs

N77-29138

Key Words: Rotor blades, Pendulums, Natural frequency, Computer programs

The point transmission matrix for a vertical plane pendulum on a rotating blade undergoing combined flapwise bending, and chordwise bending and torsion is derived. The equilibrium equation of the pendulum is linearized for small oscillations about the steady state. A FORTRAN program was written for the case of a vertical plane pendulum attached to a uniform blade with flapwise bending degree of freedom for cantilever boundary conditions.

78-275

Wind Tunnel Investigation of the Controllable Twist Rotor Performance and Dynamic Behavior

A.Z. Lemnios and H.E. Howes

Kaman Aerospace Corp., Bloomfield, CT., Rept. No. R-1487, USAAMRDL-TR-77-10, 175 pp (June 1977)

AD-A042 481/2GA

Key Words: Helicopter rotors, Blades, Wind tunnel tests

The Controllable Twist Rotor (CTR) principle is based on a torsionally flexible helicopter blade, utilizing inboard and outboard collective and cyclic controls to optimize the blade pitch distribution along the radius and around the azimuth. The benefits of this unique rotor system include improved performance, delayed retreating-blade stall, and reduced bending moments and vibration levels.

COLUMNS

78-276

Determination of Column-Buckling Criteria Using Vibratory Data

A.L. Sweet, J. Genin, and P.F. Mlakar

Purdue Univ., W. Lafayette, IN 47907, Exptl. Mech., 17 (10), pp 385-391 (Oct 1977) 1 fig, 1 table, 4 refs

Key Words: Vibration tests, Columns (supports), Mathematical models, Buckling

A mathematical model is presented which describes a nondestructive testing procedure for determining buckling criteria for structures. The procedure requires identification of the structure's support boundary conditions using vibration data. Column-buckling experiments are presented which validate the model.

CYLINDERS

(Also see No. 200)

78-277

The Vortex-Excited Lift and Reaction Forces on Resonantly Vibrating Cylinders

O.M. Griffin and G.H. Koopmann

Ocean Tech. Div., Naval Research Lab., Washington D.C., 20375, J. Sound Vib., 54 (3), pp 435-448 (Oct 8, 1977) 6 figs, 3 tables, 33 refs

Sponsored by the Naval Res. Lab., Civil Engrg. Lab., and the Naval Construction Battalion Center

Key Words: Cylinders, Vortex-induced vibration, Resonant response

The purpose of this paper is to present new experimental results pertaining to the vortex-excited oscillations of bluff cylinders. Measurements of the structural damping and the fluid dynamic reaction or damping in phase opposition with the cylinder's velocity were measured for three cylinders in a wind tunnel. The fluid damping measurements spanned a range of incident flow speeds which included the locking-on of the vortex shedding to the resonant cylinder vibrations. A mathematical representation is proposed wherefrom the components of the lift or excitation force transverse to the incident flow can be obtained once the structural damping and fluid reaction forces are known.

78-278

Transverse Oscillations of a Circular Cylinder in Uniform Flow. Part 1.

T. Sarpkaya

Naval Postgraduate School, Monterey, CA., Rept. No. NPS-69SL77071, 96 pp (July 20, 1977)
AD-A043 020/7GA

Key Words: Cylinders, Flexural vibration, Fluid-induced excitation

This report presents the results of an experimental and analytical investigation of the forced oscillations of a circular cylinder in uniform flow. The transverse force has been decomposed into two components and the appropriate force coefficients have been determined experimentally through the use of a Fourier-averaging technique. The results were then incorporated into the equation of motion to predict the dynamic response of elastically-mounted cylinders. The numerical predictions were found to be in good agreement with those obtained experimentally.

78-279

In-Line Flutter of Tandem Cylinders

A. Simpson

Dept. of Aeronautical Engrg., Univ. of Bristol, Bristol BS8 1TR, UK, J. Sound Vib., 54 (3), pp 379-387 (Oct 8, 1977) 5 figs, 1 table, 3 refs

Key Words: Cylinders, Couplings, Flutter, Power transmission systems

It is shown that a pair of smooth circular cylinders, mounted in tandem in an airstream and free to execute only horizontal (streamwise) small motions, can exhibit flutter and divergence instabilities. The flutter exists only when there is mechanical coupling between the cylinders and transpires to have a weak mechanism at spacings in excess of five cylinder diameters. Stability diagrams are presented to delineate the flutter and divergence phenomena. The flutter phenomenon could possibly explain "snaking" motions observed on certain multi-conductor power transmission lines.

DUCTS

78-280

Finite-Difference Theory for Sound Propagation in a Lined Duct with Uniform Flow Using the Wave Envelope Concept

K.J. Baumeister

Lewis Research Ctr., NASA, Cleveland, OH, Rept. No. NASA-TP-1001; E-9149, 64 pp (Aug 1977)
N77-30908

Key Words: Ducts, Acoustic linings, Finite difference theory

Finite difference equations are derived for sound propagation in a two dimensional, straight, soft wall duct with a uniform flow by using the wave envelope concept. The governing acoustic difference equations in complex notation are derived. An exit condition is developed that allows a duct of finite length to simulate the wave propagation in an infinitely long duct. Sample calculations presented for a plane wave incident upon the acoustic liner show the numerical theory to be in good agreement with closed form analytical theory. Complete pressure and velocity printouts are given to some sample problems and can be used to debug and check future computer programs.

78-281

Sound Transmission In and Radiation From Hard-Walled Annular Ducts Related to Fan Engine Inlets

J.N. Laan

Fluid Dynamics Div., National Aerospace Lab., Amsterdam, The Netherlands, Rept. No. NLR-TR-75144-U, 98 pp (Nov 1975)
N77-30913

Key Words: Sound propagation, Ducts, Modal analysis

The sound propagation, radiation, and field in a hard-walled annular duct of finite length was investigated. The individual modal solutions so found are described. The main properties calculated include the modal intensity and the modal far field directivity pattern. The modal intensity is determined by the rate of mode excitation and mode excitation by various sound sources is discussed.

78-282

The Origin of Self-Excited Oscillations of a Hypersonic Flow in a Duct with Sudden Enlargement of Cross Section

G. Grabitz

Max-Planck-Institut f. Stroemungsforschung, Goettingen, West Germany, Rept. No. MPIS-14/1976, 32 pp (Nov 1976)
(In German)
N77-29107

Key Words: Ducts, Self-excited vibrations, Variable cross section

The mechanism of self excitation in a hypersonic ducted flow with stepwise enlargement of the cross section was investigated. The hypersonic expansion area was idealized and described by gas dynamic equations with an integral method. Three different model equations were used to link the flow area behind the perpendicular shock with the dead water.

FRAMES, ARCHES

78-283
The Influence of the Behaviour of the Load on the Frequencies and Critical Loads of Arches with Flexibly Supported Ends
Y. Wasserman
Dept. of Mech. Engrg., Ben Gurion Univ. of the Negev, Beersheva, Israel, J. Sound Vib., 54 (4), pp 515-526 (Oct 22, 1977) 6 figs, 5 tables, 14 refs

Key Words: Arches, Natural frequencies

In this work, exact and approximate formulae for determining the lowest natural frequencies and critical loads for arches with flexibly supported ends have been obtained in three cases of load behavior during the deformation process. The influence of the manner of loading on the frequencies and on the critical load has been shown as a function of the opening angle of the arch and the rigidity of the end supports.

GEARS
(See No. 375)

ISOLATORS

78-284
Studies on Vibration Control of Beams Supporting Machine
K. Ohmata
Faculty of Engrg., Meiji Univ., Kawasaki, Japan, Bull. JSME, 20 (147), pp 1107-1114 (Sept 1977) 10 figs, 1 table, 4 refs

Key Words: Beams, Vibration control, Dynamic vibration isolators

To suppress the resonance of a simply supported beam and a clamped-clamped beam supporting a machine, the case in which the machine-suspension system is worked like a dynamic absorber and in which a dynamic absorber is attached to the machine are discussed theoretically. The adjusting conditions of the springs and the dashpots to the first or second resonances of the beams are determined and the effects of vibration isolation are discussed.

LINKAGES
(Also see No. 240)

78-285
Analysis and Synthesis of Flexural Elastic Couplings (Analyse und Synthese biegeelastischer Kupplungen)
W.I. Eberhardt
Technische Hochschule Magdeburg Otto v. Guericke, German Democratic Republic, Maschinenbautechnik, 26 (7), pp 311-316 (July 1977) 10 figs, 8 refs
(In German)

Key Words: Flexible couplings

Construction and performance of flexurally elastic one, two, and multiple double joint couplings is discussed and generally valid calculation procedures for the elastic behavior of flexurally elastic shaft connections are derived.

PANELS
(Also see No. 324)

78-286
Panel Flutter Boundary Layer Interaction. A Theoretical Study
P.W. Taylor
Dept. of Transport Tech., Loughborough Univ. of Tech., UK, Rept. No. TT-7006, 150 pp (Mar 1977)
N77-29461

Key Words: Flutter, Panels, Fluid-induced excitation

Areas in which the forces concerned with self induced flutter motion of a thin, flat panel may be affected by turbulent flow are examined. Previous theories are summarized and literature on the interaction between a fluid and a flexible panel is reviewed. A mathematical analysis of the problem of the interaction between a panel and a fluid is presented.

PIPES AND TUBES

(Also see No. 198)

78-287

Unsteady Fluid Dynamic Forces on a Simply-Supported Circular Cylinder of Finite Length Conveying a Flow, With Applications to Stability Analysis

Y. Matsuzaki and Y.C. Fung

National Aerospace Lab., Chofu, Tokyo, Japan, J. Sound Vib., 54 (3), pp 317-330 (Oct 8, 1977) 5 figs, 20 refs

Key Words: Tubes, Cylinders, Fluid-induced excitation

An exact analytic expression for the unsteady fluid pressure acting on the internal walls of a simply-supported circular cylindrical tube of finite length, carrying flow, is presented. The generalized force coefficients corresponding to specific modes of deformation are given explicitly. The results are applied to two problems: the interaction of flow and buckling of thin-walled cylindrical shells subjected to lateral pressure and/or end thrust; the aeroelastic stability of the shells. The second problem is aimed at resolving some controversy about post-divergence flutter oscillation of cylindrical shells or plates exposed to a subsonic flow.

78-288

Study of the Oscillation of a Gas-Column Caused by Heat Conduction in a Tube (Limiting Condition for the Onset of Oscillation in a Tube with No Inner Flow)

Y. Katto and K. Takano

Univ. of Tokyo, Tokyo, Japan, Bull. JSME, 20 (147), pp 1169-1173 (Sept 1977) 8 figs

Key Words: Thermal excitation, Tubes, Oscillation

An experimental study has been made on the limiting condition for the onset of oscillation in a straight tube holding a heater and a cooler in it. Under the experimental conditions of a tube of a given length, the relative location of heater and the distance between heater and cooler, the temperature difference between heater and cooler at the limiting condition of oscillation ΔT is found where n and C are constants depending on the shape and the orientation of heater and cooler.

78-289

Onset of Oscillation of a Gas-Column in a Tube Due to the Existence of Heat-Conduction Field (A Problem of Generating Mechanical Energy from Heat)

Y. Katto and A. Sajiki

Univ. of Tokyo, Tokyo, Japan, Bull. JSME, 20 (147), pp 1161-1168 (Sept 1977) 14 figs, 2 refs

Key Words: Thermal excitation, Tubes, Oscillation

The oscillation of a gas-column, which occurs when a heater is held in a tube, being open at both ends and having a steady inner flow of gas, has been studied experimentally in order to clarify the fundamental nature of the limiting condition for the onset of oscillation.

78-290

Factors Associated with Support Plate Forces Due to Heat-Exchanger Tube Vibratory Contact

R.J. Rogers and R.J. Pick

Univ. of New Brunswick, Fredericton, N.B., Canada, Nucl. Engr. Des., 44 (2), pp 247-253 (Nov 1977) 6 figs, 2 tables, 4 refs

Key Words: Tubes, Heat exchangers

Studies have been made of several of the factors associated with the forces resulting from a heat-exchanger tube vibrating against its support plate. Finite element simulation results are compared with the behavior of a cantilevered tube apparatus with two-dimensional sinusoidal excitation in air. The accuracy of the simulation technique is shown over a range of excitations. Simulations are then used to study the effects of varying the friction, damping, tube/annulus stiffness and clearance on the r.m.s. contact forces.

78-291

Detailed Studies, Strict Criteria Produce Pipeline Earthquake Design

B.E. Daniels

PetroMarine Engineering, Inc., Houston, TX, Oil and Gas J., 75 (48), pp 120, 125-126 (Nov 21, 1977) 9 refs

Key Words: Pipelines, Seismic design

The article describes the effort in designing the trans-Alaskan pipeline. It required highly diversified and specialized technology in Arctic construction methods, geotechnical surveys, applied earthquake engineering principles, and other engineering disciplines to assure maximum safety and on-stream integrity during the life of the system.

78-292
Valve Noise
Engr. Matl. Des., 21 (6), pp 42-44 (June 1977)

Key Words: Valves, Noise reduction

The Blakeborough "Flash-flow" trim, a low noise trim which can be used to reduce cavitation and aerodynamic noise of automatic control valves, is described.

PLATES AND SHELLS
(Also see Nos. 198, 200, 203, 238)

78-293
Forced Axisymmetric Motions of Viscoelastic Cylindrical Shells
S.F. Felszeghy, W. Goldsmith, and J.L. Sackman
Hughes Aircraft Co., Canoga Park, CA 91304, Intl. J. Solids Struc., 13 (10), pp 877-895 (1977) 4 figs, 10 refs

Key Words: Cylindrical shells, Viscoelastic properties, Transverse shear deformation effects, Rotatory inertia effects

The isothermal response of a viscoelastic cylindrical shell, of finite length, to arbitrary axisymmetric surface forces, initial conditions, and boundary conditions is considered within the linear theory of thin shells. The problem is formulated with the effects of shear deformation and rotatory inertia included; the viscoelastic properties are assumed to be isotropic and homogeneous.

78-294
Finite Difference Computation of the Dynamic Motion of Cylindrical Shells Including the Effect of Rotatory Inertia and Transverse Shear
A.F. Emery and F.J. Cupps
Univ. of Washington, Seattle, WA., Intl. J. Earthquake Engr. Struc. Dynam., 5 (4), pp 323-335 (Oct-Dec 1977) 8 figs, 30 refs

Key Words: Cylindrical shells, Finite difference theory, Rotatory inertia effects, Transverse shear deformation effects

The accuracy of finite difference computations for the dynamic motion of cylindrical shells, including transverse shear and rotatory inertia, has been assessed by comparison with Fourier series solutions.

78-295
Wave Propagation in Cylindrical Shells with Finite Regions of Structural Discontinuity
A. Harari
Naval Underwater Systems Center, Newport, RI 02840, J. Acoust. Soc. Amer., 62 (5), pp 1196-1205 (Nov 1977) 6 figs, 5 refs

Key Words: Cylindrical shells, Discontinuity-containing media, Sound transmission

Transmission loss in cylindrical shells due to a finite region of discontinuities is considered. The analysis considers a free traveling wave encountering finite number of stiffeners. The material and geometric properties of the stiffeners and the spacing may vary. Numerical examples are presented. The transmission efficiency and the reflection efficiency are found for two cases of interest.

78-296
Dynamics of a Cylindrical Shell System Coupled by Viscous Fluid
T.T. Yeh and S.S. Chen
Components Tech. Div., Argonne National Lab., Argonne, IL, Rept. No. CONF-761138-2, 37 pp (1976)
N77-29454

Key Words: Cylindrical shells, Fluid-induced excitation, Natural frequency, Mode shape, Modal damping

The system component is modeled as two coaxial shells separated by a viscous fluid. In the analysis, Fluegge's shell equations of motion and linearized Navier-Stokes equation for viscous fluid are employed. With the presented analysis and results, the frequency and damping characteristics can be analyzed and design parameters can be related to frequency and damping.

78-297
Taking the Shake Out of Circuit Boards
D.S. Steinberg
Singer Kearfott Div., Wayne, NJ, Mach. Des., 49 (21), pp 96-99 (Sept 22, 1977)

Key Words: Plates, Circuit boards

Typical printed-circuit boards are thin, flexible plates that vibrate easily, often resulting in loose components, cracked solder joints, and broken leads. This article shows how to select a rib configuration that will raise the board's natural frequency to a safe level.

78-298

Further Developments in the Aerodynamic Analysis of Unsteady Supersonic Cascades. Part 1: The Unsteady Pressure Field

J.M. Verdon

United Technologies Res. Center, East Hartford, CT, J. Engr. Power, Trans. ASME, 99 (4), pp 509-516 (Oct 1977) 3 figs, 18 refs

Key Words: Flutter, Plates, Blades, Fans, Aerodynamic loads

This paper presents, in two parts, a theoretical investigation of the aerodynamic response produced by an oscillating cascade placed in a supersonic stream with subsonic axial velocity component. Predictions are based on the successive solution of two linear boundary value problems which treat the velocity potential and the pressure, respectively, as basic dependent variables. Supersonic resonance phenomena and selected numerical results are discussed in Part 2 of the paper.

78-299

Further Developments in the Aerodynamic Analysis of Unsteady Supersonic Cascades. Part 2: Aerodynamic Response Predictions

J.M. Verdon

United Technologies Res. Center, East Hartford, CT, J. Engr. Power, Trans. ASME, 99 (4), pp 517-525 (Oct 1977) 8 figs, 17 refs

Key Words: Flutter, Plates, Blades, Aerodynamic loads

This paper is the second of a two-part report on a theoretical analysis of the aerodynamic response to an oscillating supersonic cascade in subsonic axial flow. Supersonic resonance criteria are discussed and lead to the distinction between *subresonant* and *superresonant* cascade motions. Numerical predictions, based on the unsteady solution reported in Part 1, are presented for two typical cascade configurations.

78-300

Unsteady Flows Through Cascades (Sinusoidal Gusts Having Different Phase for Each Blade)

S. Murata, Y. Tsujimoto, and S. Sonoda

Osaka Univ., Suita, Osaka, Japan, Bull. JSME, 20 (147), pp 1130-1135 (Sept 1977) 11 figs, 4 refs

Key Words: Plates, Airfoils, Sinusoidal excitation, Wind-induced excitation

An analytical method is given for the determination of the lift fluctuation on flat plate airfoils in cascade due to transverse and chordwise gusts. The acceleration potential method is used in combination with conformal mapping method. In order to take account of the phase difference of the gusts between adjacent blades, a new mapping function is introduced.

78-301

Symbolic Manipulation Techniques for Vibration Analysis of Laminated Elliptic Plates

C.M. Andersen and A.K. Noor

College of William and Mary, Williamsburg, VA., In: NASA. Langley Res. Ctr. Proc. of the 1977 MACSYMA Users' Conf, pp 161-175 (1977) (N77-28750) N77-28766

Key Words: Plates, Composite structures, Laminates, Stiffness coefficients, Mass coefficients, Computer programs

A computational scheme is presented for the free vibration analysis of laminated composite elliptic plates. The scheme is based on Hamilton's principle, the Rayleigh-Ritz technique and symmetry considerations.

78-302

Point Admittance of an Infinite Thin Elastic Plate Under Fluid Loading

D.G. Crighton

Dept. of Appl. Mathematical Studies, Univ. of Leeds, Leeds LS2 9JT, UK, J. Sound Vib., 54 (3), pp 389-391 (Oct 8, 1977) 7 refs

Key Words: Plates, Mechanical admittance, Fluid-induced excitation

An exact expression for the point force admittance of an infinite thin elastic plate under arbitrary static fluid loading is derived, and a simple approximation to the admittance, valid for low frequencies, is given.

78-303

Quantitative Displacement and Strain Distribution of Vibrating Plate-Like Structures Based on Time Average Holographic Interferometry

J.C. MacBain
Air Force Aero Propulsion Lab., Wright-Patterson AFB, OH 45433, Rept. No. AFAPL-TR-77-44, 94 pp (July 1977)

Key Words: Plates, Flexural vibration, Holographic techniques, Finite element technique, Computer programs

A technique for computing the bending strain resulting from the resonant modal deformation of a vibrating plate-like structure is described. Interferometric fringes obtained by time-average holography are used as the basis for generating a mathematically continuous series approximation of the structure's out-of-plane displacement. The technique is programmed for use on an interactive computer terminal. The method is tested by comparing it to the results of an eigenvalue analysis of a cantilevered plate analyzed using the finite element computer program, NASTRAN.

78-304

On Plastic Dynamic Flexure of Plates

A.A. Cannarozzi and F. Laudiero
Istituto di Scienza delle Costruzioni, Universita di Bologna, Meccanica, 11 (4), pp 208-218 (Dec 1976) 11 figs, 1 table, 31 refs

Key Words: Plates, Dynamic response

This paper discusses the rigid-plastic flexure of plates subjected to dynamic loading. A piecewise linear yield surface and small displacements are assumed. The plate is discretized by assuming the constant moment mixed triangular element of Herrmann. Some numerical examples of plates subjected to a given velocity distribution confirm the efficiency of this approach.

78-305

Dynamic Response of Composite Plates with Cut-Outs. Part 1: Simply-Supported Plates

A. Rajamani and R. Prabhakaran
Dept. of Mech. Engrg., Indian Inst. of Tech., Kanpur 208016, India, J. Sound Vib., 54 (4), pp 549-564 (Oct 22, 1977) 16 figs, 2 tables, 11 refs

Key Words: Plates, Composite structures, Hole-containing media, Natural frequencies

The effect of square cut-outs on the natural frequencies of square, simply-supported composite plates is investigated. The forced and free dynamic response of plates with cut-outs is formulated. Laminations are assumed to be symmetric about the mid-plane and the plates are considered analytically as homogeneous anisotropic plates. A comparison of results obtained from this method for isotropic plates with cut-outs with available literature is made and excellent agreement is obtained.

78-306

Dynamic Response of Composite Plates with Cut-Outs. Part II. Clamped-Clamped Plates

A. Rajamani and R. Prabhakaran
Dept. of Mech. Engrg., Indian Inst. of Tech., Kanpur 208016, India, J. Sound Vib., 54 (4), pp 565-576 (Oct 22, 1977) 13 figs, 13 refs

Key Words: Plates, Composite structures, Hole-containing media, Natural frequencies

The forced and free dynamic response of plates with cut-outs formulated earlier is used to investigate the effect of cut-outs on the natural frequencies of clamped-clamped plates. The size, shape and location of the cut-out is expressed as a displacement dependent external loading. The plates considered are homogeneous and anisotropic.

78-307

Response of Circular Bridge Decks to Moving Vehicles

R. Ramakrishnan and V.X. Kunukkasseril
Dept. of Civil Engrg., Karnataka Regional Engrg. College, Srinivasnagar, India, Intl. J. Earthquake Engr. Struc. Dynam., 5 (4), pp 377-394 (Oct-Dec 1977) 11 figs, 2 tables, 15 refs

Key Words: Plates, Stiffened plates, Bridges, Moving loads

This paper discusses the dynamic response of a curved bridge deck to a moving vehicle. The bridge deck is idealized as a set of annular sector plates and circular rings rigidly jointed together. On the basis of classical plate and ring theories a method has been developed to obtain the response to a moving vehicle idealized as a spring mass system. Numerical results have been presented to illustrate the effect of several vehicle and bridge parameters on the response.

78-308

Transverse Vibrations of Rectangular Plates with Elastically Restrained Edges and Subject to In-Plane Shear Forces

C.E. Gianetti, L. Diez, and P.A.A. Laura
Inst. of Applied Mechanics, Base Naval Puerto Belgrano, 8111 Argentina, J. Sound Vib., 54 (3), pp 409-417 (Oct 8, 1977) 5 figs, 10 refs

Key Words: Rectangular plates, Flexural vibration, Boundary condition effects

Simple polynomial expressions and the Galerkin method are used in the present study. The results are in good agreement with values previously published in the open literature for the range of shear values used in this investigation. Consideration of in-plane, normal forces does not add any complications to the procedure.

78-309

Vibrations of Thin Rectangular Plates with Arbitrarily Oriented Stiffeners

B.P. Shastry and G.V. Rao

Structural Engrg. Div., Vikram Sarabhai Space Center, Trivandrum, India, Computers and Struc., 7 (5), pp 627-629 (Oct 1977) 3 figs, 3 tables, 3 refs

Key Words: Rectangular plates, Stiffened plates, Free vibration

Free vibration of plates with arbitrarily oriented stiffeners are studied using high precision plate bending and stiffener elements. Good convergence of frequency values for coarse mesh is demonstrated. Natural frequencies of square plates with various arrangement of stiffeners are determined for both simply supported and clamped boundary conditions.

78-310

Free Vibration of a Rectangular Plate Supported on the Sides and Some Segments

T. Irie, G. Yamada, and Y. Narita

Hokkaido Univ., Sapporo, Japan, Bull. JSME, 20 (147), pp 1085-1092 (Sept 1977) 9 figs, 8 refs

Key Words: Rectangular plates, Natural frequencies, Mode shapes

A theoretical method of analysis is presented for the study of the free vibration of a rectangular plate supported on the sides and elastically supported on some segments parallel to the sides.

78-311

Non-Linear Dynamic Response of Circular Plates Subjected to Transient Loads

R.S. Alwar and Y. Nath

Dept. of Appl. Mech., Indian Inst. of Tech., Madras, India, J. Franklin Inst., pp 527-542 (1977) 7 figs, 11 refs

Key Words: Circular plates, Transient excitation

The Chebyshev polynomials have been applied to the large amplitude motions of circular plates under transient loads, with and without damping. The non-linear differential equations are linearized by using Taylor series expansion for one of the terms.

RINGS

78-312

Dynamic Behaviour of the Ring Subjected to Distributed Impulsive Load

S. Suzuki

Dept. of Aeronautics, Nagoya Univ., Chikusa-ku, Nagoya, Japan, Ing. Arch., 46 (4), pp 245-251 (1977) 7 figs, 7 refs

Key Words: Rings, Transverse shear deformation effects, Rotatory inertia effects, Impact response (mechanical)

Dynamic behavior of the ring subjected to distributed impulsive load is investigated. The ring is represented by the centroidal line and the problem is solved one-dimensionally. Impulsive load is assumed to be the step function with respect to time. The effects of shearing force and rotatory inertia to dynamic load factors with respect to axial force and bending moment are studied.

SPRINGS

(Also see No. 321)

78-313

Applying the "Pressure" to a Liquid Spring Off-Highway Truck Suspension

M.H. Naft and P.P. Seabase

Euclid, Inc., SAE Paper No. 770768, 12 pp, 11 figs

Key Words: Suspension systems (vehicles), Springs (elastic), Trucks

The compliance provided by the spring in a vehicle suspension system is vital to reduce dynamic inputs from loads and surface irregularities. A liquid compression spring device has been developed as an alternative to mechanical, oil/pneumatic and rubber types. Liquid springs exhibit a desirable combination of simplicity, safety, compact size and excellent dynamic response and ease of servicing.

TIRES

78-314

Standing Waves in Tires

J.G. McGivern and I.A. Shirk

Dept. of Mech. Engrg., Gonzaga Univ., SAE Paper No. 770873, 8 pp, 6 figs

Key Words: Tires, Spring constants

This paper is an attempt to explain the standing wave phenomena existing in tires at high speeds in terms of tire pressure, tire speed and the tire's stiffness as expressed by its spring constant.

78-315

The Potential for Improvement in Tire Response

G.R. Shearer

Tyre Technical Div., Dunlop, The Institution of Mechanical Engineers, London, UK, SAE Paper No. 770871, 12 pp, 12 figs, 2 refs

Key Words: Tires

A review of early tire development and an examination of some historical concepts with the aim of identifying areas of potential improvement in response and efficiency. Although the forces in three planes are discussed, particular reference is made to the properties of comfort, load carrying capacity and stability.

78-316

From Perceptions of Vehicle Disturbance to Corrective Adjustments of Tires

S.A. Lippmann and K.L. Oblizajek

Uniroyal Tire Co., SAE Paper No. 770868, 16 pp, 20 figs, 1 table, 2 refs

Key Words: Tires, Mathematical models

Disturbances transmitted to the occupants of vehicles often involve tires in their formation or transmission. Tire engineers attempting to reduce disturbances in specific vehicles have two courses of action; alter the tire design according to insight or whim until subjective testing indicates improvements; or analyze the chain of relationships from sensory impression through the tire-vehicle system to internal tire design. This paper describes a "chain-of-relationships" procedure using sensory comparison techniques for identifying pertinent physical stimuli, and an approach to system modeling that best identifies structural tire properties.

78-317

Tire Shear Force Generation During Combined Steering and Braking Maneuvers

J.E. Bernard, L. Segel, and R.E. Wild

Highway Safety Research Inst., The Univ. of Michigan, SAE Paper No. 770852, 20 pp, 17 figs, 4 tables, 36 refs

Key Words: Tires, Mathematical models, Shear strength

A historical overview of theory and experiment pertaining to tire shear force generation during combined slip is presented followed by a review of more recent empirical findings. The requirements for modeling the tire in combined maneuvers are summarized prior to presenting, in detail, a semi-empirical model of the tire developed to fulfill these requirements. The ability of the developed model to fit the shear force characteristics exhibited by belted, radial-ply tires and bias-ply tires is examined and demonstrated.

78-318

New Results in Vibration Testing on a Road Simulator (Neuere Ergebnisse bei Schwingungsuntersuchungen an einem Strassen-Simulator)

R. Verschoore

Automobiltech. Z., 79 (7/8), pp 311-313 (July/Aug 1977) 4 figs, 4 refs

(In German)

Key Words: Ride dynamics, Simulation, Test facilities, Tire characteristics, Stiffness coefficients, Damping coefficients

The validity of a road simulator in vibration investigations was tested in the Laboratorium voor Voertuigtechniek of the State University Gent, Belgium. The effect of the change in stiffness of a stationary wheel was investigated. Also, an effective road profile is given.

78-319

The Effect of Tire Brake-In on Force and Moment Properties

K.Z. Marshall, R.L. Phelps, M.G. Pottinger, and W. Pelz

B.F. Goodrich, SAE Paper No. 770870, 16 pp, 19 figs, 5 refs

Key Words: Tires, Interaction: vehicle-terrain

A tire break-in procedure has historically been used prior to tire force and moment testing for three reasons: to reduce variability, stabilize the data, and simulate service. For low slip angle force and moment data it is shown that the tire break-in does not achieve these objectives.

78-320

Drive Train Normal Modes Analysis for the ERDA/NASA 100-Kilowatt Wind Turbine Generator

T.L. Sullivan, D.R. Miller, and D.A. Spera

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-73718; E-9266; ERDA/NASA-1028-77/1, 34 pp (July 1977)

N77-30611

Key Words: Wind turbines, Natural frequencies, Mode shapes, Finite element technique

Natural frequencies, as a function of power were determined using a finite element model. Operating conditions investigated were operation with a resistive electrical load and operation synchronized to an electrical utility grid. The influence of certain drive train components on frequencies and mode shapes is shown. An approximate method for obtaining drive train natural frequencies is presented.

SYSTEMS

ABSORBER

(Also see Nos. 224, 313)

78-321

A Simplified Method for the Identification of Vehicle Suspension Parameters

D.M. Brueck and E.D. Ward

Iowa State Univ., Ames, IA, SAE Paper No. 770-884, 12 pp, 8 figs, 1 table, 16 refs

Key Words: Suspension systems (vehicles), Spring constants, Damping values, Error analysis

This paper presents a simplified method to identify vehicle suspension spring rates, damping characteristics, and unsprung mass inertia properties. The method presented employs a digital computer algorithm to implement an equation error identification technique. A sequence of four laboratory tests was developed to obtain suspension input and response data required in the equation error technique.

78-322

The Development of a New Bumper System for the VW Dasher

U. Seiffert and C. Hildebrandt

Volkswagenwerk AG, SAE Paper No. 770840, 8 pp, 12 figs

Key Words: Bumpers, Polyurethane resins, Energy absorption

The paper describes development and testing of a polyurethane bumper for the VW-Dasher. Requirements were established on the basis of the performance of the previous bumper design consisting of a steel profile bar and hydraulic energy absorbers.

78-323

Energy Absorbing Bumpers for Transit Buses: Transbus Program

Booz-Allen Applied Research, Bethesda, MD, Rept. No. Transbus-TR-76-003, UMTA-IT-06-0025-77-4, 49 pp (May 1976)

PB-269 405/7GA

Key Words: Bumpers, Energy absorption, Buses

The report describes the results of a program to test and evaluate the potential benefits of energy absorbing bumpers for transit buses. The objective of the program is to determine, through controlled tests, the capabilities/limitations of six new design energy absorbing bumper systems.

NOISE REDUCTION

(Also see Nos. 292, 355)

78-324

Noise Transmission by Viscoelastic Sandwich Panels

R. Vaicaitis

Langley Res. Center, NASA, Langley Station, VA., Rept. No. NASA-TN-D-8516; L-11523, 42 pp (Aug 1977)

N77-30907

Key Words: Panels, Sandwich structures, Viscoelastic properties, Noise reduction

An analytical study on low frequency noise transmission into rectangular enclosures by viscoelastic sandwich panels is presented. Soft compressible cores with dilatational modes and hard incompressible cores with dilatational modes neglected are considered as limiting cases of core stiffness.

78-325

Noise Barrier Screen Measurements, Double Barriers

R.N. Foss

Applied Physics Lab., Washington Univ., Seattle, WA, Rept. No. APL-UW-7618, 49 pp (Aug 1976) PB-269 589/8GA

Key Words: Noise barriers, Sound attenuation

This report documents the results of an investigation to determine the attenuative effect of two cascaded walls or barrier screens on the transmission of sound. The study was for point sources and involved the use of tone burst techniques for the experimental determination of the attenuation produced by a wide variety of two-wall configurations. This work was modeled at 5 and 10 kHz. The final result was the development of an algorithm for accurately predicting the attenuation of two-wall systems.

78-326

Acoustic Materials

Engr. Matl. Des., 21 (6), pp 39-41 (June 1977)

Key Words: Absorbers (materials), Noise reduction, Machinery noise

Using acoustic materials considerable noise reductions on a wide range of machinery, such as cable braiding machines, high speed multiple function printing machines, and 80 ton coin blanking presses at the Royal Mint have been achieved. A typical form of construction is illustrated where to a 16swg mild steel barrier sheet, sufficiently rigid not to require bracing, is glued to a synthetic viscoelastic damping sheet. The layer of polyurethane foam completes the design which offers three-way noise resistance - absorption, barrier and damping - in one 'sandwich'.

78-327

Noise Attenuating Coatings and Elements for Vehicles and Machines (Geräuschdampfende Beläge und Elemente f. Fahrzeuge und Maschinen)

C. Betzhold and H. Gahlau

VDI Z., 119 (15/16), pp 778-783 (Aug 1977) 17 figs (In German)

Key Words: Noise reduction, Structural components, Ground vehicles, Absorbers (materials)

Some fundamental aspects are set forth for meaningful measures to fight noise. The contribution contains hints on the correct application of attenuation systems and on some acoustical imperfections of frequently used structural elements. Furthermore, examples of the automotive and mechanical engineering show that a development of economically representable solutions is possible at a good cooperation between acoustics and construction.

78-328

Keeping the Peace

Engr. Matl. Des., 21 (6), p 49 (June 1977)

Key Words: Noise reduction, Industrial noise, Industrial facilities, Acoustic insulation

Noise insulation for a mini-mill, which produces steel billets from scrap by high performance electric arc furnace and continuous casting techniques is described. The whole structure, including the roof, is insulated within a sound reducing cocoon of plastics coated sheeting. The roof ventilator runs the length of the construction and has sound absorption panels inside the louvres to make it behave like a silencer and stop sound going straight up through the ceiling.

78-329

Industrial Noise: Reducing it at the Design Stage

Engr. Matl. Des., 21 (6), pp 35-38 (June 1977) 4 figs

Key Words: Machinery noise, Noise reduction

The article describes the nature of noise, and its effect on hearing. A brief discussion of machine noise and its reduction is also included.

78-330

Aero-Acoustic Performance Comparison of Core Engine Noise Suppressors on NASA Quiet Engine C

H.E. Bloomer and J.W. Schaefer

Lewis Res. Center, NASA, Cleveland, OH, Rept. No. NASA-TM-X-73662; E-9182, 20 pp (July 1977) Sponsored by the American Inst. of Aeronautics and the Society of Automotive Engr.

N77-28119

Key Words: Engine noise, Noise reduction

The relative aero-acoustic effectiveness of two core engine suppressors, a contractor-designed suppressor delivered with the Quiet Engine, and a NASA-designed suppressor was evaluated. The NASA suppressor was tested with and without a splitter making a total of three configurations being reported in addition to the baseline hardwall case. The aerodynamic results are presented in terms of tailpipe pressure loss, corrected net thrust, and corrected specific fuel consumption as functions of engine power setting. The acoustic results are divided into duct and far-field acoustic data.

78-331

Design Considerations in Controlling Turbine Noise

T.E. McLarty

Pulsco Div., American Air Filter Co., Diesel and Gas Turbine Progress, 43 (10), pp 34-35 (Oct 1977) 2 figs

Key Words: Turbines, Noise reduction

Design parameters and performance of a gas turbine absorptive silencer are discussed. Rectangular acoustical elements were selected. The silencer offers several features that coincide with the advantages of the gas turbine. The performance of the product has been demonstrated and further development of this design concept will lead to performance improvements.

78-332

Silencing Techniques for Gas Turbine Driven Compressor Sets for Pipe-Line Installations

W.C. Hood

Gresel BV, Noise Control, Vib. and Insul., pp 249-251 (Aug/Sept 1977)

Key Words: Noise reduction, Compressors

Gas turbine compressor noise sources are enumerated and a reduction technique for each source is discussed. The various sources are: gas turbine intake, gas turbine exhaust, gas turbine casing, driven unit (compressor), accessory package, acoustic enclosure ventilation, pipe work, oil cooler, and filter noise.

78-333

Noise Control on Offshore Installations

B.C. Postlethwaite

Acoustic Technology Ltd., Noise Control, Vib. and Insul., pp 231-234 (Aug/Sept 1977) 3 figs, 3 tables, 6 refs

Key Words: Off-shore structures, Noise reduction

The control of noise levels in offshore installations must be considered as part of the design of the structure. In the article reasons for noise control of such installations, noise regulations, general approaches to noise control and noise levels on existing operational platforms are discussed.

AIRCRAFT

(Also see Nos. 211, 218, 220)

78-334

Calculation of the Dynamic Response of CCV-Type Aircraft

B. Krag

Abt. Flugmechanik der Flächenflugzeuge, Deutsche Forschungs- und Versuchsanstalt f. Luft- und Raumfahrt, Brunswick, West Germany, Rept. No. DLR-FB-76-78, 86 pp (Dec 14, 1976)
(In German)
N77-29168

Key Words: Aircraft, Dynamic response

The lateral motion of a flexible aircraft with a T-tail was investigated. The aeroelastic oscillations of the T-tail were damped by a control system without adversely affecting the rigid body motion. Modal control theory and an extended root-locus method were used to design the control system. The developed methods were used to make an example calculation with HFB-320 aircraft.

78-335

Gust Load Alleviation Control Systems: A Feasibility Study

D. McLean

Dept. of Transport Tech., Loughborough Univ. of Technology, UK, Rept. No. TT-7606, 182 pp (1976)
N77-29169

Key Words: Aircraft, Wind-induced excitation, Mathematical models

The feasibility of determining if it is possible to produce a satisfactory method of designing an automatic flight control system, for the specific purpose of alleviating the load effects on the response of the aircraft when it encounters atmospheric turbulence is discussed. The likely benefits resulting from active control technology are considered and gust alleviation systems are reviewed. Development of mathematical models for the representation of the dynamics of a flexible aircraft and its control as well as atmospheric turbulence is discussed.

78-336

Dynamic Behavior of Stochastically Excited Aircraft Structures for Determination of Stress and Life

M.R. Bonn

Dornier-System G.m.b.H., Friedrichshafen, West Germany, Rept. No. BMVG-FBWT-76-25, 56 pp (1976)
(In German)
N77-29564

Key Words: Aircraft, Random response, Finite element technique, Modal analysis

Based on the general random response theory and considering the peculiarities valid for technical random processes, an engineering procedure was derived to calculate structural response. The assumptions refer to small damping and phase coincidence of the exciting forces. The procedure was applied to aircraft skin panels subjected to jet noise loading. This was achieved by means of the finite element method and modal analysis. The maximum rms stresses were calculated for plane and simply curved skin panels.

78-337

Identification of Stability Derivatives from Wind Tunnel Tests of Cable-Mounted Aeroelastic Models

R.L. Mohr and W.E. Hall, Jr.
Systems Control, Inc., Palo Alto, CA., Rept. No. NASA-CR-145123, 124 pp (1977)
N77-29166

Key Words: Aircraft, Space shuttles, Wind tunnel tests, Parameter identification technique

The test models were mounted within the wind tunnel on a cable support system which allowed five degrees of freedom in the model's motion. A parameter identification algorithm was computer coded to calculate the maximum likelihood estimates of the stability and control derivatives based on an assumed structure of the equations of motion. Models of the F-14 aircraft and the space shuttle orbiter were tested in the transonic dynamics tunnel to demonstrate the feasibility of identifying aerodynamic coefficients from wind tunnel test data of cable-mounted models.

78-338

Fan Inlet Disturbances and Their Effect on Static Acoustic Data

K.L. Bekofske, R.E. Sheer, and J.C.F. Wang
General Electric Co., Corporate Res. and Dev., Schenectady, NY, J. Engr. Power, Trans. ASME, 99 (4), pp 608-616 (Oct 1977) 17 figs, 1 table, 16 refs

Key Words: Aircraft noise, Testing techniques

There is evidence that measurements of fan-rotor inlet noise taken during static test situations are at variance with aircraft engine flight data. In particular, static tests generally yield a significantly higher tone at blade passing frequency than that measured during flight. An experimental program was carried out to investigate this discrepancy. Inlet ground vortices and large-scale inlet turbulence were generated intentionally in an anechoic test chamber.

BRIDGES

(Also see No. 307)

78-339

Experimental Model Studies on the Seismic Response of High Curved Overcrossings

D. Williams and W.G. Godden
Earthquake Engrg. Res. Center, California Univ., Richmond, CA., Rept. No. EERC-76-18, 167 pp (June 1976)
PB-269 548/4GA

Key Words: Bridges, Seismic response, Test models

An experimental model study relating to the seismic resistance of large multi-span curved overcrossings of the type which suffered heavy damage during the 1971 San Fernando Earthquake is reported. The feasibility of developing a model to satisfy the necessary similitude requirements of such a complex structure, and also capable of being tested on the 20 ft x 20 ft (6.1 m) Shaking Table at the University of California, is outlined. The small amplitude dynamic characteristics of the microconcrete model, a 1/30 true-scale version of a hypothetical prototype, are examined and for this elastic range the experimental results compared satisfactorily with those predicted analytically. The response of the model is described for a series of progressively more intense simulated seismic excitations applied horizontally in the asymmetric longitudinal direction, and horizontally in the symmetric direction, both alone and also with simultaneous vertical excitation. The existence of expansion joints in the bridge deck proved to have great influence on the response of the structure.

BUILDING

(Also see Nos. 213, 229)

78-340

A Seismic Risk Simulation Model for Army Facilities: Phase One, Development of Deterministic Model

R.G. Merritt
Construction Engrg. Res. Lab. (Army), Champaign,

IL, Rept. No. CERL-SR-M-223, 104 pp (Aug 1977)
AD-A043 173/4GA

Key Words: Earthquake resistant structures, Military facilities

This report describes the first phase in the development of a decision tool for assessing: the seismic hazard to Army facilities and the cost of mitigation schemes for reducing the hazard. A simulation model was developed to determine the cost of repairing damage to a facility resulting from seismic activity, as well as the cost of strengthening or replacing the facility to mitigate the effects of seismic activity.

78-341

Guidelines for Evaluating the Seismic Resistance of Existing Buildings

J.M. Lybas

Construction Engrg. Res. Lab (Army), Champaign, IL, Rept. No. CERL-TR-M-213, 134 pp (July 1977)
AD-A042 873/0GA

Key Words: Earthquake resistant structures, Buildings, Seismic response spectrum, Modal analysis

This report presents a methodology for evaluating an existing building's seismic resistance. The method uses a design response spectrum and modal analysis technqiues to compute a linearly elastic structural response. This is compared to the structure's yield capacity to obtain a factor denoting the structure's required energy dissipation capacity. Charts suitable for design office application are provided for use in estimating the levels of structural damping and ductility consistent with the required energy dissipation.

78-342

Earthquake Response and Damage Prediction of Reinforced Concrete Masonry Multistory Buildings: Modification of NONSAP for Kinematic Input

G. Krishnamoorthy, C.-H. Ho, and R. Nunn

Dept. of Appl. Mech. and Engrg. Sciences, California Univ., San Diego, La Jolla, CA., Rept. No. AMES-NSF-TR-75-3, NSF/RA/E-75/218, 33 pp (Aug 1975)
PB-270 571/3GA

Key Words: Multistory buildings, Buildings, Earthquake damage, Computer programs

A numerical procedure is developed to obtain the response of a finite element-decomposed structure subjected to a time-dependent kinematic boundary history. The procedure is incorporated into the nonlinear finite element program NONSAP.

HELICOPTERS

(Also see Nos. 212, 375)

78-343

High-Speed Helicopter Impulsive Noise

F.H. Schmitz, D.A. Boxwell, and C.R. Vause

U.S. Army Air Mobility R&D Lab (AVRADCOM), Moffett Field, CA., J. Amer. Helicopter Soc., 22 (4), pp 28-36 (Oct 1977) 13 figs, 1 table, 13 refs

Key Words: Helicopter noise, Noise generation

Forward flight impulsive noise data from a 1/7-scale UH-1H model rotor have been gathered in an acoustically treated wind tunnel and are compared with full-scale acoustic flight-test data for the same helicopter. Good agreement between model and full-scale waveforms and peak pressure amplitudes is noted when key performance parameters are matched and the data are acoustically scaled.

78-344

A Study of Helicopter Rotor Rotational Noise

A. Lee, W.L. Harris, and S.E. Widnall

Massachusetts Inst. of Tech., Cambridge, MA., J. Aircraft, 14 (11), pp 1126-1132 (Nov 1977) 10 figs, 2 tables, 13 refs

Key Words: Helicopter rotors, Noise generation

The rotational noise of model helicopter rotors in forward flight was studied in an anechoic wind tunnel. The parameters under study were the rotor thrust (blade loading), blade number, and advance ratio. The separate effects of each parameter were identified with the other parameters being held constant. The directivity of the noise was also measured. Twelve sets of data for rotational noise as a function of frequency were compared with the theory of Lowson and Ollerhead.

78-345

DSTR/501-M62B Dynamic Interface Critical Speed Problem

W.H. Parker

Detroit Diesel Allison Div., General Motors Corp., Indianapolis, IN, Rept. No. DDA-EDR-9127, USA-AMRDL-TR-77-12, 49 pp (May 1977)
AD-A042 441/6GA

Key Words: Helicopter engines, Shafts (machine elements), Couplings

A dynamic interface problem was encountered during the Dynamic System Test Rig portion of the Heavy Lift Helicopter program. This problem involved the dynamic incompatibility of the original designs of the Detroit Diesel Allison 501-M62B engine and the Boeing Vertol Dynamic System Test Rig shafting. Presented is a detailed discussion of the interface problem and the steps taken toward solution. Design modifications to both the engine and shafting were necessary to synthesize an acceptable drive train configuration. Recommendations are proposed for avoidance of engine/airframe interface problems in future programs.

HUMAN

(See Nos. 218, 219, 234, 235)

MATERIAL HANDLING

78-346

Vibration Characteristics of Loaded Vibratory Feeder

K. Sakaguchi

Nagoya Industrial Research Inst., Atsutaku, Nagoya, Japan, Bull. JSME, 20 (147), pp 1101-1106 (Sept 1977) 10 figs, 6 refs

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

This paper describes the vibration characteristics of a resonance feeder which is susceptible to the reaction force of the load. When the conveyed bodies move on the vibrating plate, the resonance frequency of the system decreases and the damping effect increases.

PRESSURE VESSELS

(See No. 351)

PUMPS, TURBINES, FANS, COMPRESSORS

(Also see Nos. 223, 254, 331, 332)

78-347

Noise Generation Mechanism in High Pressure Pumps (Zum Mechanismus der Geräuschentstehung bei Hochdruckpumpen)

R. Gösele

Forschungsinstitut Werkzeugmaschinen der Universität Stuttgart (Univ. of Stuttgart Machine Tool Res. Inst.), Konstruktion, 29 (9), pp 347-354 (Sept 1977) 16 figs, 7 refs
(In German)

Key Words: Pumps, Noise generation

According to a new investigation, pump casings vibrate. Until recently it was unknown where these forces, acting from outside the casing, originate. It is shown that they build up not in the pump casings, but in pressure lines. The calculation of these forces and the resulting vibrations are explained.

78-348

Experimental and Analytical Dynamic Flow Characteristics of an Axial-Flow Fan From an Air Cushion Landing System Model

W.C. Thompson, A.B. Boghani, and T.J.W. Leland

Langley Res. Center, NASA, Langley Station, VA., Rept. No. NASA-TN-D-8413; L-11154, 49 pp (July 1977)

N77-29172

Key Words: Fans, Air cushion landing systems, Mathematical models

An investigation was conducted to compare the steady-state and dynamic flow characteristics of an axial-flow fan which had been used previously as the air supply fan for some model air cushion landing system studies.

78-349

Fan Acoustic Signatures in an Anechoic Wind Tunnel

D.A. Dietrich, M.F. Heidmann, and J.M. Abbott

Lewis Res. Center, NASA, Cleveland, OH, J. Aircraft, 14 (11), pp 1109-1116 (Nov 1977) 12 figs, 35 refs

Key Words: Fans, Acoustic signatures, Wind tunnel tests

One-third octave band and narrowband spectra and continuous directivity patterns radiated from an inlet are presented over ranges of fan operating conditions, tunnel velocity, and angle of attack.

78-350

Acoustic Performance of Two 1.83-Meter-Diameter Fans Designed for a Wind-Tunnel Drive System

P.R. Soderman and V.R. Page

Ames Res. Center, NASA, Moffett Field, CA., Rept.

No. NASA-TP-1008; A-6888, 76 pp (Aug 1977)
Sponsored by the U.S. Army Air Mobility R&D Lab
N77-30909

Key Words: Fans, Parametric response, Noise measurement

A parametric study was made of the noise generated by two 1.83-m (6-ft) diameter fans operating up to a maximum pressure ratio of 1.03. One fan had 15 rotor blades, 23 stator blades, and a maximum rotational speed of 1200 rpm. The other fan had 9 rotor blades, 13 stator blades, and a maximum speed of 2,000 rpm. The fans were approximately 1/7-scale models of the 12.2-m (40-ft) diameter fans proposed for repowering the NASA-Ames 40- by 80 foot wind tunnel. The fans were operated individually in a 23.8-m (78-ft) long duct. Sound pressure levels in the duct were used to determine radiated acoustic power as fan speed, blade angle, and mass flow were varied.

78-351
Quiet Compressor
Engr. Matl. Des., 21 (6), pp 47-49 (June 1977)

Key Words: Compressors, Noise reduction, Design techniques

The article shows how design can be used to improve noise characteristics of compressors. In the design described, all rotating parts are housed within the main casing and the use of a one-piece casting helps to maintain rigidity and freedom from vibration. Attention to detail design excluded any out-of-balance condition which might occur. With the motor and compressor in line and attention to alignment, another source of vibration and noise is controlled. Secure mounting of motor to compressor further ensures the rigidity which keeps noise levels low.

78-352
Measurements of Quasi-Steady and Unsteady Flow Effects in a Supersonic Compressor Stage
H.E. Gallus, D. Bohn, and K.D. Broichhausen
Inst. for Jet Propulsion and Turbomachines, Technical Univ., Aachen, West Germany, J. Engr. Power, Trans. ASME, 99 (4), pp 537-544 (Oct 1977) 16 figs, 22 refs

Key Words: Compressors, Fluid-induced excitation

Results of measurements are discussed that give a survey of the flow through rotor and stator of a supersonic compressor stage. In order to analyze the flow, piezoelectric and semiconductor transducers are used for measuring the unsteady pressure distributions along the casing on the one hand and schlieren photography procedure and stroboscopic technique for flow visualization on the other.

78-353
Dynamic Blade Loading in the ERDA/NASA 100 kW and 200 kW Wind Turbines
D.A. Spera, D.C. Janetzke, and T.R. Richards
Lewis Res. Center, NASA, Cleveland, OH., Rept. No. NASA-TM-73711; ERDA/NASA-1004-77/2; E-9242, 16 pp (Aug 1977)
N77-30599

Key Words: Wind turbines, Blades

Dynamic blade loads, including aerodynamic, gravitational, and inertial effects, are presented for two large horizontal-axis wind turbines: the ERDA-NASA 100 kW Mod-0 and 200 kW Mod-0A wind power systems. Calculated and measured loads are compared for an experimental Mod-0 machine in operation. Predicted blade loads are also given for the higher power Mod-0A wind turbine now being assembled for operation as part of a municipal power plant. Two major structural modifications have been made to the Mod-0 wind turbine for the purpose of reducing blade loads.

78-354
Land Gas Turbine Exhaust Noise
R.A. Kantola
General Electric Co., Corporate Res. and Dev., Schenectady, NY, J. Engr. Power, Trans. ASME, 99 (4), pp 526-532 (Oct 1977) 14 figs, 1 table, 7 refs

Key Words: Turbines, Noise generation, Model testing

An acoustic test program on a 1/7-scale model of the exhaust configuration for a General Electric MS 5000 gas turbine has been carried out. The tests were designed to isolate the noise contributions of the individual exhaust system components and to identify the additional noise due to combinations of two or more components.

RAIL
(See No. 222)

REACTORS
(See No. 231)

RECIPROCATING MACHINE

78-355
Hushing the Diesel

Res. and Product Dev. Div., Perkins Engine Group, Engr. Matl. Des., 21 (6), pp 45-46 (June 1977)

Key Words: Diesel engines, Engine noise, Noise reduction, Design techniques

A special research engine, built for the development of noise level prediction techniques and to assess new ideas for noise reduction, is described. It incorporates the following main features: a high position camshaft, which achieves a symmetric structure and reduces the tendency for large crankcase vibrations caused by the cylinder block bowing when reacting to combustion loads from the piston. Straight load paths have been sought in the engine design concept and the crankcase sidewalls are isolated from internal bearing panels to reduce force transmission. By designing flat outer surfaces on the cylinder block 90 percent shielding with sealed acoustic shields is achieved on one side, 85 percent on the other.

ROAD

(Also see Nos. 205, 206, 234, 235, 313, 319, 322, 323)

78-356

Concrete Median Barrier Research. Vol. 1. Executive Summary

M.E. Bronstad, L.R. Calcote, and C.E. Kimball
Southwest Research Inst., San Antonio, TX, Rept. No. SwRI-03-3716-1, FHWA/RD-77-3, 94 pp (June 1976) (see also Vol 2 - PB-270 110)
PB-270 109/2GA

Key Words: Guardrails, Concretes, Collision research (automotive), Impact tests

A comprehensive research program was conducted to appraise performance of concrete median barriers. Investigations included twenty-four crash tests which evaluated performance of barrier profiles, precast designs, and end treatments. Theoretical investigations using mathematical crash simulation program identified a new barrier shape which was crash tested to compare performance with currently used profiles.

78-357

Concrete Median Barrier Research. Vol. 2. Research Report

M.E. Bronstad, L.R. Calcote, and C.E. Kimball
Southwest Research Inst., San Antonio, TX, Rept. No. SwRI-03-3716-2, FHWA/RD-77-4, 468 pp (Mar 1976) (see also Vol 1 - PB-270 109)
PB-270 110/0GA

Key Words: Guardrails, Concretes, Collision research (automotive), Mathematical models

A comprehensive research program was conducted to appraise performance of concrete median barriers. Investigations included twenty-four crash tests which evaluated performance of barrier profiles, precast designs, and end treatments. Theoretical investigations using a mathematical crash simulation program identified a new barrier shape which was crash tested to compare performance with currently used profiles. Load and stability criteria were determined from experiments and used to analyze barrier alternatives. This volume is the second of two (Portions of this document are not fully legible.)

78-358

Road Tests of Mobile Weapons

Army Test and Evaluation Command, Aberdeen Proving Ground, MD., Rept. No. TOP-2-2-511, 9 pp (July 1977)
AD-A043 540/4GA

Key Words: Ride dynamics, Towed bodies, Weapons systems

This report describes procedures for conducting standardized road and cross-country tests of mobile weapons which are moved as trailed loads behind prime movers. It covers tests performed to evaluate the capability of towed carriers, such as field cannon carriages, air defense artillery mounts, and missile launchers, to withstand tactical movement without damage to the weapon or vehicle.

78-359

Squealing of Disk Brakes - Holographic Vibration Analysis and Remedial Measures (Quietschen von Scheibenbremsen - Holografische Schwingungsanalyse und Abhilfemassnahmen)

A. Felske and A. Happe
Automobiltech. Z., 79 (7/8), pp 281-288 (July/Aug 1977) 14 figs, 50 refs
(In German)

Key Words: Brakes (motion arresters), Vibration tests, Holographic techniques

The components of a brake system (calliper frame, disk, and brake pads) which cause brake squeal are excited to vibration during the process of braking. They are vibrating like a coupled system of harmonic oscillators in which the oscillator with the highest quality determines the resonance frequency. On a brake test stand the vibration modes of the calliper frame, of the disk, and of the brake pads occurring simultaneously can be made visible during squealing in a holographically stored interference figure by means of a double pulse laser.

78-360

Suspended Driver's Cab for Off-Road Vehicles (Abgefederte Kabine f. ungefederte Geländefahrzeuge)

J.'t Hart

Automobiltech. Z., 79 (7/8), pp 317-319 (July/Aug 1977) 7 figs, 2 tables

(In German)

Key Words: Suspension systems (vehicles), Agricultural machinery

This paper describes a prototype of a driver's cab provided with a multidirectional soft suspension system. Such a cab is intended to be used on off-road vehicles in order to improve the ride comfort. The prototype has been constructed on an agricultural tractor, first in the form of a suspended driver's platform, later on as a complete suspended cab. Vibration measurements in three directions on the platform of the suspended cab and on the original sprung seat show an improvement in ride comfort and a considerable noise reduction.

78-361

Prediction of Dynamometer Power Absorption to Simulate Light Duty Truck Road Load

G.D. Thompson

U.S. Environmental Protection Agency, SAE Paper No. 770844, 36 pp, 3 figs, 3 tables, 7 refs

Key Words: Trucks, Dynamometers, Interaction: vehicle-terrain

When vehicle exhaust emission tests or vehicle fuel consumption measurements are performed on a chassis dynamometer, the dynamometer is usually adjusted to simulate the road experience of the vehicle. In this study, road load versus speed data were obtained from 15 light duty trucks. The road load of each truck was determined for different payloads, resulting in a total of approximately 50 road load measurements.

78-362

Theoretical and Experimental Results with Regard to the Transverse Dynamics of the Automatic Vehicle Control (Theoretische und experimentelle Ergebnisse zur Querdynamik bei der automatischen Fahrzeugführung)

H. Wallentowitz

Automobiltech. Z., 79 (7/8), pp 303-306 (July/Aug 1977) 6 figs, 28 refs

(In German)

Key Words: Automatic control equipment, Buses, Ground vehicles, Mathematical models

Realistic nonlinear dynamic controller behavior has been first considered in the theoretical model used in this investigation. A method to determine optimum system parameters by introducing functional relationships is shown. Further the development of a new control system is described. During this investigation numerous comparisons of theoretical and experimental results were carried out.

78-363

Applied Car Body Acoustics (Angewandte Karosserie-Akustik)

U. Sorgatz and O. Weber

Automobiltech. Z., 79 (7/8), pp 295-299 (July/Aug 1977) 9 figs, 1 table, 4 refs

(In German)

Key Words: Automobiles, Acoustic measurement, Measurement techniques

A new method for the determination of acoustic comfort inside a vehicle, developed by the Acoustic Engineering Team of VW is described. The method is called Trans-Lac-Procedure, because the transfer function for dimensional purposes is provided as well as the solution of the localization problem for sound-reducing measures.

78-364

Development of Vehicles-In-Use Sub-Limit Maneuvers. Volume II. Technical Report

D.E. Johnston, L.G. Hofmann, T.T. Myers, and H.T. Szostak

Systems Technology, Inc., Hawthorne, CA., Rept. No. STI-TR-1064-1, DOT-HS-802 353, 172 pp (May 1977)

PB-269 676/3GA

Key Words: Automobiles, Steering effects, Suspension systems (vehicles), Braking effects, Tire characteristics

Automobile sub-limit performance maneuvers and measures were developed for investigating the influence of vehicles-in-use steering, suspension, and brake system degradation and tire factors on vehicle handling. The maneuvers and performance measures are directed at vehicle static and dynamic stability characteristics, vehicle controllability, driver workload, and vehicle path stability under unbalanced force or moment disturbance inputs. The NHTSA automobile simulation was modified to incorporate various steering and suspension degradations and was employed to guide selection of maneuver and component degradation levels for full-scale vehicle testing.

ROTORS

(Also see Nos. 212, 233, 239, 275)

78-365

Flexural Vibrations of Rotating Shafts Passing Through Resonance (Biegeschwingungsverhalten rotierender Wellen beim Durchlaufen der kritischen Drehzahlen)

R. Markert, H. Pfützner, and R. Gasch

Technische Universität Berlin, Berlin, West Germany, Konstruktion, 29 (9), pp 355-365 (Sept 1977) 7 figs, 11 refs

Key Words: Rotors, Shafts, Critical speeds

Flexural vibrations of Laval shafts, which are driven by a constant torque, are investigated. In the evaluation of a piece of equipment it is important whether the drive torque is sufficient to pass through resonance, or does the rotor remain at resonance. If the resonance range is passed through, then it is of interst how large the maximum vibration deflections are. The results of this investigation are represented by a diagram where the time to pass through resonance and the maximum rotor deflections are dependent on the rotor data - the outside damping eccentricity, and drive torque.

78-366

Torsional Mobility of Rotors

J.W. van den Bosch

Naval Engrg. Test Establishment, Canada, Test, 38 (3/4), pp 6-11 (Oct/Nov 1977) 6 figs, 4 refs

Key Words: Rotors, Torsional response, Mobility method

A technique for determining the torsional characteristics of rotors has been presented, and the effects of mass cancellation were shown. The torsional mobility technique appears to be a simple and accurate method for determining not only the torsional natural frequencies and mode shapes but also the estimated values of other parameters, such as mass moment of inertia, torsional stiffness, and damping.

78-367

The Stability of a Flexible Rotor Supported by Circumferentially Fed Journal Bearings

P. Bar-Yoseph and J.J. Blech

Faculty of Mech. Engrg., Technion-Israel Inst. of Tech., Haifa, Israel, J. Lubric. Tech., Trans. ASME, 99 (4), pp 469-477 (Oct 1977) 16 figs, 3 tables, 22 refs

Key Words: Flexible rotors, Journal bearings, Rotor-bearing systems

The stability of a flexible rotor, perfectly balanced, was investigated theoretically. The rotor is symmetrically supported by circumferentially fed journal bearings. Short and finite bearings were treated. Stability was checked for small and large disturbances. Two methods were employed to treat large disturbances: Direct integration and the slowly varying technique. The nonlinear prediction was tested concurrently with the prediction of the stability charts. It was observed that in certain cases stability can be obtained in the asymptotic and in the unstable regions. Instability was obtained for regions which presumably are asymptotically stable in the entire speed range.

78-368

Stability of Squeeze-Film-Damper Supported Flexible Rotors

M.D. Rabinowitz and E.J. Hahn

The Univ. of New South Wales, Kensington, Australia, J. Engr. Power, Trans. ASME, 99 (4), pp 545-551 (Oct 1977) 11 figs, 1 table, 11 refs

Key Words: Rotor-bearing systems, Rotors, Squeeze-film dampers

Assuming the short bearing approximation and symmetric motions, the stability of the steady-state synchronous operation of centrally preloaded single-mass flexible rotors supported in squeeze-film bearing dampers is theoretically investigated. The stability regions are depicted over a wide range of system parameters and allow for easy determination of the stability of existing steady-state design data. The influence of rotor flexibility, rotor speed, bearing dimensions, lubricant viscosity, rotor mass distribution, and rotor unbalance on rotor-bearing system stability may be readily seen. In the absence of pressurization, instability regions were possible even with relatively high support damping, though no instability was indicated for speeds below the support natural frequency, or for bearing eccentricity ratio <0.4 at any speed.

78-369

Steady-State Performance of Squeeze Film Damper Supported Flexible Rotors

M.D. Rabinowitz and E.J. Hahn
The Univ. of New South Wales, Kensington, Australia, J. Engr. Power, Trans. ASME, 99 (4), pp 552-558 (Oct 1977) 10 figs, 1 table, 13 refs

Key Words: Rotor-bearing systems, Rotors, Squeeze-film dampers

The synchronous steady-state operation of a centrally preloaded single mass flexible rotor supported in squeeze film bearing dampers is examined theoretically. Assuming the short bearing approximation and symmetric motions, frequency response curves are presented exhibiting the effect of relevant system parameters on rotor excursion amplitudes and unbalance transmissibilities for both pressurized and unpressurized lubricant supply. Hence, the influence of rotor flexibility, rotor mass distribution, rotor speed, bearing dimensions, lubricant viscosity, support flexibility can be readily determined, allowing for optimal rotor bearing system design.

SHIP

(Also see No. 209)

78-370

Review of Structural Response Aspects of Slamming

T. Nagai and S. Chuang
Dept. of Ship Res., National Defense Lab., Tokyo, Japan, J. Ship Res., 21 (3), pp 182-190 (Sept 1977) 24 figs, 1 table, 13 refs

Key Words: Hulls, Girders, Slamming

This paper is intended to provide a state-of-the-art review of the structural response aspects of slamming. The emphasis is on two specific aspects: hull girder response to slamming and local structural response to slamming (for example, the forward bottom structure, forecastle deck, bow flare structure, and secondary structure at the bow). Results of drop tests and sea trials are used to illustrate the design procedure for ship bottom plating in the slamming area. The work cited here is considered to have important applications for practical design features of future ships. Several parts still require clarification, and recommendations for additional research are offered.

78-371

Wave Excitation and Vertical Plane Oscillation Experiments on a High Length-to-Beam Ratio Surface Effect Ship

J.A. Fein and L.O. Murray
Ship Performance Dept., David W. Taylor Naval Ship Res. and Dev. Center, Bethesda, MD., Rept. No. SPD-697-01, 77 pp (July 1976)
AD-A042 630/4GA

Key Words: Surface effect machines, Hydrofoil craft, Oscillation, Model testing

Captive model experiments were conducted on a high length-to-beam ratio surface effect ship testcraft design to determine vertical plane characteristics and to evaluate captive model experimental techniques. Model results for forced heave oscillation and pitch oscillations, and regular-wave exciting forces and moments and transient-waves exciting forces and moments are reported. The effects of sidewalls and cushion pressure variation on the oscillation results are identified. The correlation between the regular waves and transient waves techniques for determining the excitation is shown.

78-372

Dynamic Loading Effects on Embedment Anchor Holding Capacity

Z.M. Gouda and D.G. Ture
Civil Engrg. Lab (Navy), Port Hueneme, CA., Rept. No. CEL-TN-1489, 68 pp (July 1977)
AD-A042 906/8GA

Key Words: Ship anchors, Dynamic properties

This report provides interim guidelines for designers of dynamically loaded seafloor foundations and anchors based on available knowledge of terrestrial and seafloor soils. Investigations of the response of selected seafloor soils to dynamically induced forces are reported, and the development of standardized design procedures for propellant-actuated direct embedment anchors is presented.

SPACECRAFT

(Also see No. 208)

78-373

Effects of Damping on Mode Shapes. Vol. 1

R.M. Gates
Missile and Armament Div., Boeing Aerospace Co., Seattle, WA, Rept. No. NASA-CR-150357; D180-20572-1-Vol-1, 322 pp (June 27, 1977)
N77-29554

Key Words: Damping effects, Mode shapes, Space shuttles, Computer programs

Displacement, velocity, and acceleration admittances were calculated for a realistic NASTRAN structural model of space shuttle for three conditions: liftoff, maximum dynamic pressure and end of solid rocket booster burn. The realistic model of the orbiter, external tank, and solid rocket motors included the representation of structural joint transmissibilities by finite stiffness and damping elements. Methods developed to incorporate structural joints and their damping characteristics into a finite element model of the space shuttle, to determine the point damping parameters required to produce realistic damping in the primary modes, and to calculate the effect of distributed damping on structural resonances through the calculation of admittances.

78-374

Effects of Damping on Mode Shapes. Vol. 2

R.M. Gates, D.H. Merchant, and J.L. Arnquist
Missile and Armament Div., Boeing Aerospace Co., Seattle, WA, Rept. No. NASA-CR-150358; D180-20572-2-Vol-2, 841 pp (June 27, 1977)
N77-29555

Key Words: Damping effects, Mode shapes, Space shuttles, Computer programs

Displacement, velocity, and acceleration admittances were calculated for a realistic NASTRAN structural model of space shuttle for three conditions: liftoff, maximum dynamic pressure and end of solid rocket booster burn. The realistic model of the orbiter, external tank, and solid rocket motors included the representation of structural joint transmissibilities by finite stiffness and damping elements. Data values for the finite damping elements were assigned to duplicate overall low-frequency modal damping values taken from tests of similar vehicles. For comparison with the calculated admittances, position and rate gains were computer for a conventional shuttle model for the liftoff condition. Dynamic characteristics and admittances for the space shuttle model are presented.

TRANSMISSIONS

78-375

Helicopter Transmission Vibration and Noise Reduction Program

M.A. Bowes, N. Giansante, R.B. Bossler, Jr., and A. Berman
Kaman Aerospace Corp., Bloomfield, CT., Rept. No. R-1495, USAAMRDL-TR-77-14, 155 pp (June 1977)
AD-A042 457/2GA

Key Words: Transmission systems, Gears, Helicopters, Noise reduction, Vibration control

A combined analytical and test program has been performed to develop a method for analytically determining the vibration and noise characteristics of a helicopter transmission.

TURBOMACHINERY

78-376

The Application of a Semi-Actuator Disk Model to Sound Transmission Calculations in Turbomachinery. Part 1: The Single Blade Row

R.S. Muir
Structural Dynamics Limited, 18 Carlton Crescent, Southampton S01 2ET, UK, J. Sound Vib., 54 (3), pp 393-408 (Oct 8, 1977) 7 figs, 6 refs

Key Words: Ducts, Blades, Turbomachinery, Sound transmission, Mathematical models

The work described in this paper generalizes the semi-actuator disk model of a blade row of Kaji and Okazaki to include a three-dimensional incident sound field. The validity of the model is demonstrated in a series of comparisons with data obtained from earlier models. The model is subsequently extended to include the effects of introducing cambered blades. In a companion paper (Part II), the model is applied to multiple blade rows.

AUTHOR INDEX

TECHNICAL NOTES

W.K. Blake and R.V. Waterhouse
The Use of Cross-Spectral Density Measurements in Partially Reverberant Sound Fields
J. Sound Vib., 54 (4), pp 589-599 (Oct 22, 1977)
6 figs, 15 refs

C. Venkatesan
Optimization of an Oleo-Pneumatic Shock Absorber of an Aircraft During Landing
J. Aircraft, 14 (8), pp 830-831 (Aug 1977) 1 fig, 3 tables, 4 refs

C.H. Yew and P.N. Jogi
Longitudinal Waves in Fiber-Reinforced Composite at Low and High Frequency Ranges
J. Appl. Mech., Trans. ASME, 44 (3), pp 492-494 (Sept 1977) 4 figs, 11 refs

M. Becker, W. Hauger, and W. Winzen
Influence of Internal and External Damping on the Stability of Beck's Column on an Elastic Foundation
J. Sound Vib., 54 (3), pp 468-472 (Oct 8, 1977)
3 figs, 5 refs

H.C. Loh and J.F. Carney, III
Vibration and Stability of Spinning Annular Plates Reinforced with Edge Beams
J. Appl. Mech., Trans. ASME, 44 (3), pp 499-501 (Sept 1977) 5 figs, 12 refs

D.K. Rao and W. Stuhler
Frequency and Loss Factors of Tapered Symmetric Sandwich Beams
J. Appl. Mech., Trans. ASME, 44 (3), pp 511-513 (Sept 1977) 4 figs

B. Bhattacharya
Free Vibration of Plates on Vlasov's Foundation
J. Sound Vib., 54 (3), pp 464-467 (Oct 8, 1977)
2 figs, 3 refs

W.A. Tesch and W.G. Steenken
Dynamic Blade Row Compression Component Model for Stability Studies
J. Aircraft, 14 (8), pp 827-829 (Aug 1977) 3 figs, 5 refs

CALENDAR

MARCH 1978

25-27 **Applied Mechanics Western and J.S.M.E. Conference,** Honolulu, Hawaii *(ASME Hq.)*

APRIL 1978

3-5 **Structures, Structural Dynamics and Materials Conference,** [ASME] Bethesda, MD *(ASME Hq.)*

9-13 **Gas Turbine Conference & Products Show,** [ASME] London *(ASME Hq.)*

17-20 **Design Engineering Conference & Show** [ASME] Chicago, IL *(R.C. Rosaler, Rice Assoc., 400 Madison Ave., N.Y., NY 10017)*

17-20 **24th Annual Technical Meeting and Equipment Exposition** [IES] Fort Worth, TX *(IES Hq.)*

24-28 **Spring Convention** [ASCE] Pittsburgh, PA *(ASCE 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)*

16-19 **Acoustical Society of America, Spring Meeting,** [ASA] Miami Beach, FL *(ASA Hq.)*

JUNE 1978

30 **Eighth U.S. Congress of Applied Mechanics,** [ASME] Los Angeles, CA *(ASME)*

SEPTEMBER 1978

24-27 **Design Engineering Technical Conference,** [ASME] Minneapolis, MN *(ASME Hq.)*

OCTOBER 1978

1-4 **Design Engineering Technical Conference,** [ASME] Minneapolis, MN *(ASME Hq.)*

8-11 **Diesel and Gas Engine Power Conference and Exhibit,** [ASME] Houston, TX *(ASME Hq.)*

8-11 **Petroleum Mechanical Engineering Conference,** [ASME] Houston, TX *(ASME Hq.)*

17-19 **49th Shock and Vibration Symposium,** Washington D.C. *(H.C. Pusey, Director, The Shock and Vibration Info. Ctr., Code 8404, Naval Res. Lab., Washington, D.C. 20375 Tel. (202) 767-3306)*

17-19 **Joint Lubrication Conference,** [ASME] Minneapolis, MN *(ASME Hq.)*

NOVEMBER 1978

26-Dec 1 **Acoustical Society of America, Fall Meeting,** [ASA] Honolulu, Hawaii *(ASA Hq.)*

DECEMBER 1978

10-15 **Winter Annual Meeting,** [ASME] San Francisco, CA *(ASME Hq.)*

CALENDAR ACRONYM DEFINITIONS AND ADDRESSES OF SOCIETY HEADQUARTERS

AFIPS: American Federation of Information Processing Societies
210 Summit Ave., Montvale, NJ 07645

AGMA: American Gear Manufacturers Association
1330 Mass. Ave., N.W.
Washington, D.C.

AHS: American Helicopter Society
1325 18 St. N.W.
Washington, D.C. 20036

AIAA: American Institute of Aeronautics and Astronautics, 1290 Sixth Ave.
New York, NY 10019

AIChE: American Institute of Chemical Engineers
345 E. 47th St.
New York, NY 10017

AREA: American Railway Engineering Association
59 E. Van Buren St.
Chicago, IL 60605

AHS: American Helicopter Society
30 E. 42nd St.
New York, NY 10017

ARPA: Advanced Research Projects Agency

ASA: Acoustical Society of America
335 E. 45th St.
New York, NY 10017

ASCE: American Society of Civil Engineers
345 E. 45th St.
New York, NY 10017

ASME: American Society of Mechanical Engineers
345 E. 47th St.
New York, NY 10017

ASNT: American Society for Nondestructive Testing
914 Chicago Ave.
Evanston, IL 60202

ASQC: American Society for Quality Control
161 W. Wisconsin Ave.
Milwaukee, WI 53203

ASTM: American Society for Testing and Materials
1916 Race St.
Philadelphia, PA 19103

CCCAM: Chairman, c/o Dept. ME, Univ. Toronto, Toronto 5, Ontario, Canada

ICF: International Congress on Fracture
Tohoku Univ.
Sendai, Japan

IEEE: Institute of Electrical and Electronics Engineers
345 E. 47th St.
New York, NY 10017

IES: Institute of Environmental Sciences
940 E. Northwest Highway
Mt. Prospect, IL 60056

IFToMM: International Federation for Theory of Machines and Mechanisms, US Council for TMM, c/o Univ. Mass., Dept. ME
Amherst, MA 01002

INCE: Institute of Noise Control Engineering
P.O. Box 3206, Arlington Branch
Poughkeepsie, NY 12603

ISA: Instrument Society of America
400 Stanwix St.
Pittsburgh, PA 15222

ONR: Office of Naval Research
Code 40084, Dept. Navy
Arlington, VA 22217

SAE: Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096

SEE: Society of Environmental Engineers
6 Conduit St.
London W1R 9TG, UK

SESA: Society for Experimental Stress Analysis
21 Bridge Sq.
Westport, CT 06880

SNAME: Society of Naval Architects and Marine Engineers, 74 Trinity Pl.
New York, NY 10006

SPE: Society of Petroleum Engineers
6200 N. Central Expressway
Dallas, TX 75206

SVIC: Shock and Vibration Information Center
Naval Research Lab., Code 8404
Washington, D.C. 20375

URSI-USNC: International Union of Radio Science - US National Committee c/o MIT Lincoln Lab., Lexington, MA 02173