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The principal achievement of the research undertaken under this grant was the development of comprehensive theories of exact controllability and stabilization of thin pkate dynamics by means of forces and moments applied on the edge of the plate, based on continuum models of plates. Two major research monographs, which lay the foundations of the design and analysis of practical strategies for active control and vibration suppression in flexible structures.

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FINAL TECHNICAL REPORT (AFOSR-86-0162)
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The principal achievement of the research undertaken under this grant was the development of comprehensive theories of exact controllability and stabilization of thin plate dynamics by means of forces and moments applied on the edge of the plate, based on continuum models of plates. Two major research monographs, which lay the foundations of the theories, were written. The motivation for this study, and its ultimate goal, is the design and analysis of practical strategies for active control and vibration suppression in flexible structures.

In research carried out jointly with J. L. Lions (College de France and CNES), a comprehensive study encompassing modelling, analysis and exact controllability of thin plates was completed. A number of different plate theories were developed, some classical but some for the first time. A systematic study of the relationship between different models as functions of various physical parameters was done. New nonlinear models and thermoelastic models were developed. For certain linear, elastic plates, a complete exact controllability theory based on physically realizable boundary control actions was carried out. (Exact controllability is concerned with the possibility of bringing the plate to a specified shape and a specified velocity in a given time.) The dependence of control variables on elastic parameters was analyzed. A very recent and significant achievement was a proof of the exact controllability of the elastic components of a thermoelastic plate through the action of controls in forces and moments at the boundary. This means that it is possible to exactly control the shape and velocity of the plate to a specified state even in the presence of thermal stresses which drive plate deformation.

A second, related, area of research was the design of feedback controls acting on the edge of the plate which uniformly stabilize plate motion, i.e., which cause all of the modes to decay at some uniform rate. Once again, such control strategies were sought for a wide variety of plate models, including nonlinear models. In fact, our results for nonlinear models (in which the nonlinearities may be both in the dynamics and in the feedback control) are probably the first of their kind. Surprising and unexpected results were found in the case of viscoelastic plates. In this situation it was noted that uniform stabilization of the "viscoelastic energy" is not possible by means of boundary feedback involving measurements of the current state of the system only (i.e., measurements which do not involve the past history of deformations), unless the viscous effects by themselves induce a uniform decay rate. This result is in stark contrast to the situation which prevails for elastic plates. On the other hand, it was also found that in the viscoelastic case it is possible to induce algebraic, nonuniform decay rates of the viscoelastic energy through such boundary feedback even when the viscous effects are quite weak.

Another line of research pursued under this grant dealt with the question of exact controllability of electromagnetic fields, which are confined to a bounded region, by means of an externally applied current density flowing tangentially

in the surface of the region. Considered was the case of fields governed by Maxwell's equations, under the assumptions that the electrical charge density and current density in the region are zero. (Continuing efforts are directed towards removing these restrictions.) Earlier results of others demonstrated that it is possible to exactly control such fields in a specified time (large enough) for fields confined to a sphere or to a right circular cylinder (together with other restrictions). However, in a recent paper we have shown that such exact control is possible in any star-shaped region, provided the control time is sufficiently large. The minimum control time was shown to depend in a specific way on the geometry of the region and on the electric permittivity and magnetic permeability. Furthermore, the precise form of the controls was established and these were shown to be optimal among a class of controls appropriate to the problem.

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[2] "Uniform boundary stabilization of von Karman plates", Proceedings IEEE Conference on Decision and Control, Austin, TX, 1988, to appear.

[3] "Uniform stabilization of a thin elastic plate by nonlinear boundary feedback", in Lecture Notes in Control and Information Sciences, Springer-Verlag, Berlin, to appear.

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[5] "Partial exact boundary controllability of thermoelastic plates", Seminar of the College de France, to appear.

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