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Real Time Digital Control and Controlled Structures Experiments

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Controlled Structures Technology at Grumman

Grumman has a very active group in CST drawn from the Applied Mechanics Lab, Controls and Dynamics Lab and the Materials Lab of the Corporate Research Center with experimental support from the Thermal Lab, the Vibrations and Flutter Lab and the Structures and Materials Division of the Aircraft Systems Division.

Active and Passive Technology: Experiment and Modeling

- Coupon experiments of viscoelastic materials
- Modeling of viscoelastic and piezoceramic treatments
- Controlled laboratory experiments with piezoceramic and piezopolymer actuators and sensors
- Complex models of actuator and sensor dynamic effects on closed loop control

Active and Passive Synthesis

- Develop models of partial treatments using constrained viscoelastic layers

- Incorporate ANSYS models of piezo-ceramics

- Utilize the MCR code with extended FEM's of complex structures

- Refine our combined control/structure optimization to minimize added mass of passive treatment and control energy while meeting performance goals

Controlled Structures Technology Laboratory Objectives

- Validate analytical and finite-element models
- Demonstrate practical advantages and limitations of proposed schemes on real hardware
- Stimulate innovative control schemes based on experience in the laboratory
- Offer a testbed for downloading control algorithms developed on workstations using Protoblock

Issues to be Addressed in CSTL Research

- Materials issues
  - --Constrained layer viscoelastic dampers
  - --Piezoceramic actuators and sensors
  - --Bonding methods: crazy glue/epoxy
  - --Wiring scheme: overlap/grounding
  - --Constitutive relations: finite element modeling
- Passive or passive/active controls
- Time delays and filters in digital control
- Data acquisition and system identification

Applications of CSTL Findings

- Passive/active vibration control
- Precision pointing of instruments
- Optical element shape control
- Active suppression of structure borne noise
- Aircraft wing camber and twist control

Plans for the Incipient CSTL Experiment

- Cantilevered aluminum beam
  --15" x 1.25" x 0.125"

- Piezoceramic sensors and actuators
  --2.5" x 1.5" x 0.010" each

- Power voltage ampliers for each actuator
  --gain of 20, up to 200V-1A output up to 4kHz

- IBM PC/AT host computer
  --33MHz, 32bit floating point coprocessor with:
    internal bus to 34 analog inputs and 18 outputs
    and 17 Megabytes of local RAM
  --software to provide dual trace real time scope
    and spectral analyzer
  --cross c and assembler development system

Vacuum Chamber Test Experiment: Objectives

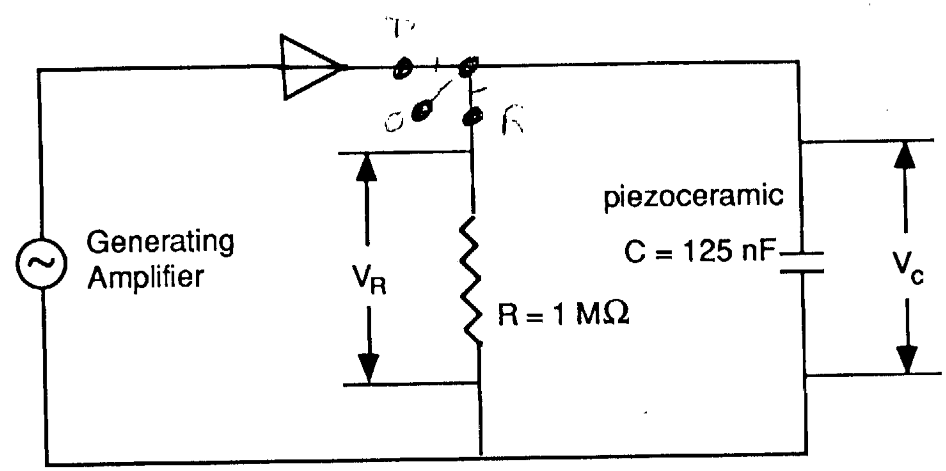
- Simulate space environment for simple CSI experiments

- Validate ground effects to enable extrapolation into more complex CSI experiments

- Estimate inherent viscoelastic damping component of piezoelectric devices

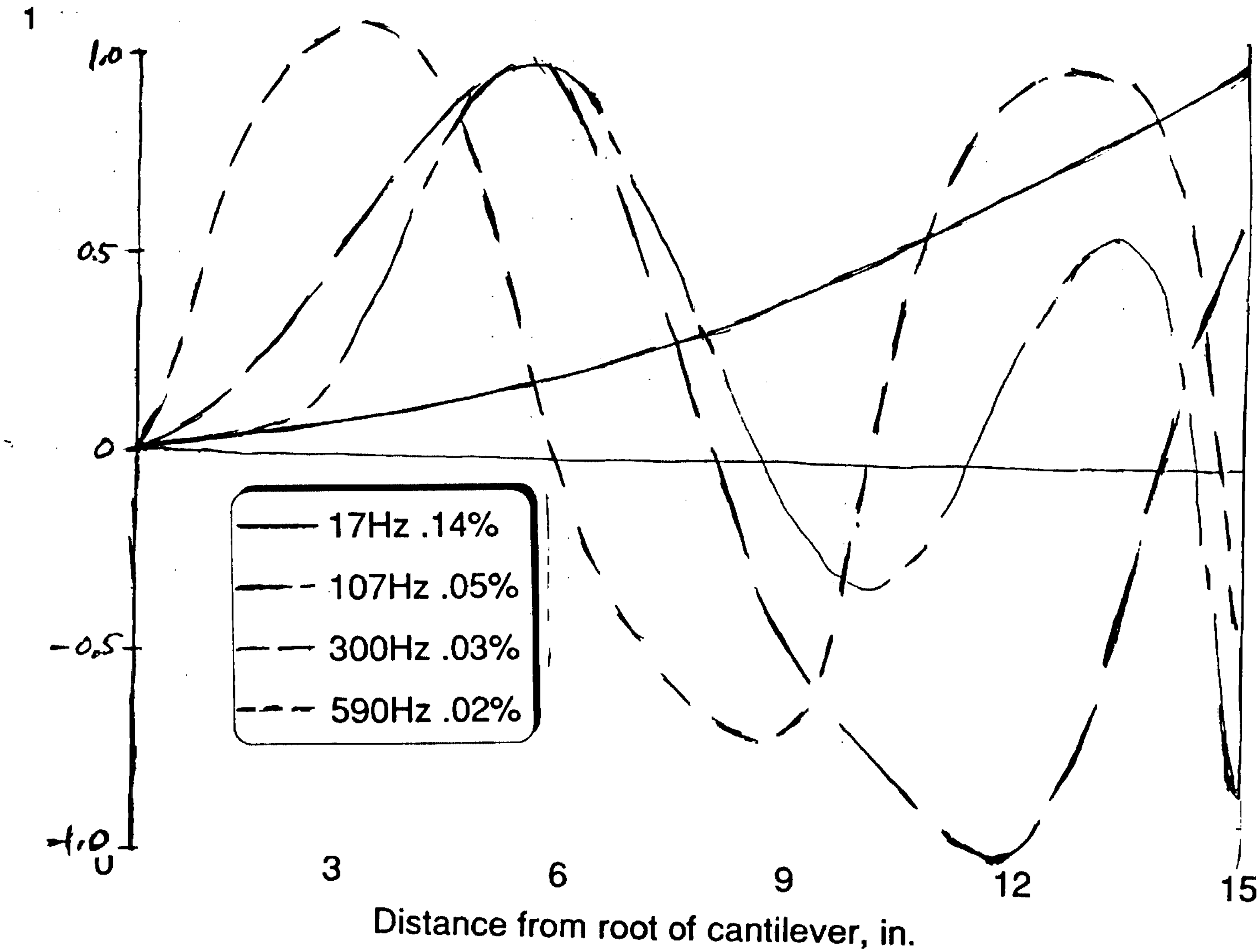
Vacuum Chamber Test Experiment: Setup

- Evacuation system & gauges
- Exciter & sensor
- 52 lb Heavy Fixture
- HP digital storage spectral analyzer
- Optional piezoceramic sensor and passive viscous damping



- Choose RC by setting RC $= \frac{1}{w_o}$ = relaxation time constant
- Fundamental frequency at 7.8 Hz, so period = 128.5 ~~MHz~~
- Measured no of cycles to ensure $\frac{x_o}{x_f} = 4$
- Open circuit (64 cycles), $\frac{x_o}{x_f} = 4$, hence $\zeta = \frac{\ln 4}{128\pi} = 0.35\%$
- Shunted circuit (53 cycles), $\frac{x_o}{x_f} = 4$, hence $\zeta = \frac{\ln 4}{106\pi} = 0.42\%$

Bare Beam Mode Shapes--Transient Raps, Noncontacting Sensor



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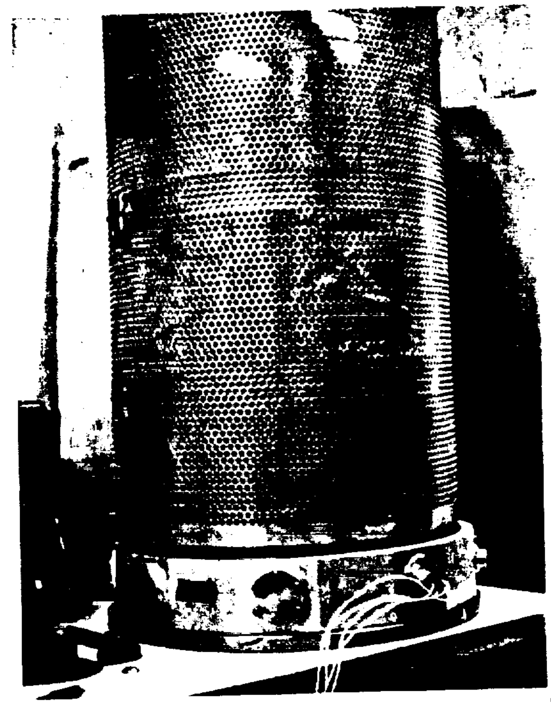

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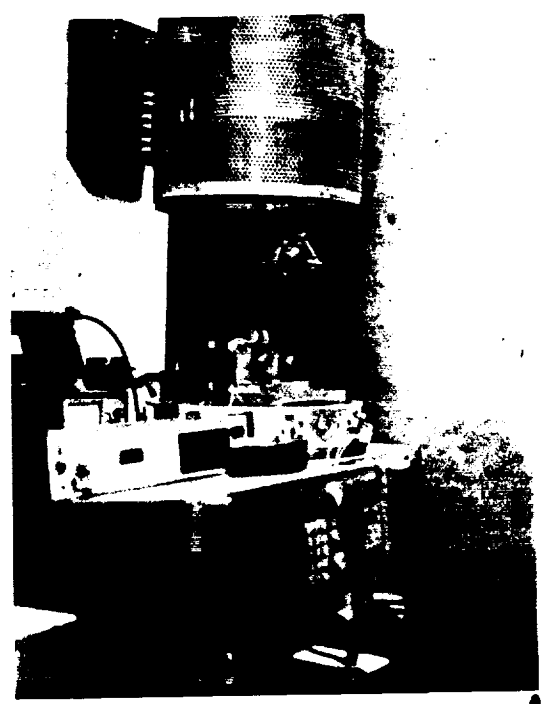

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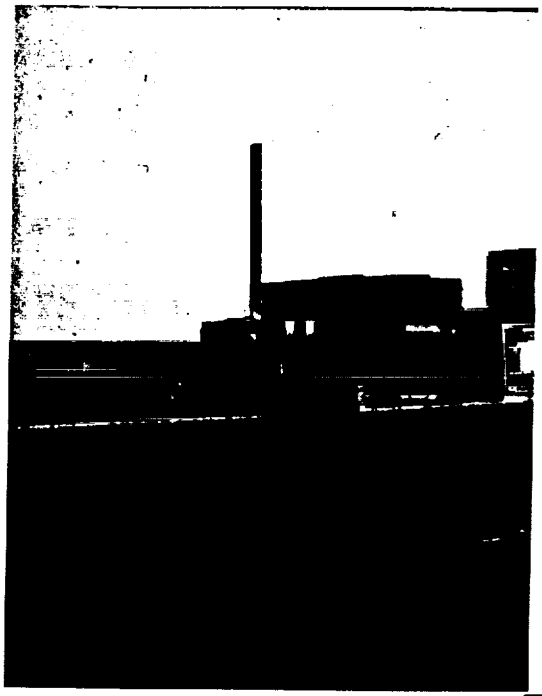

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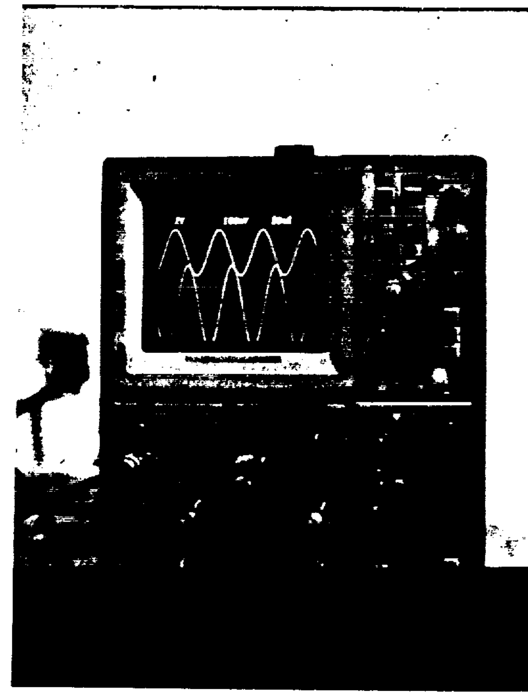

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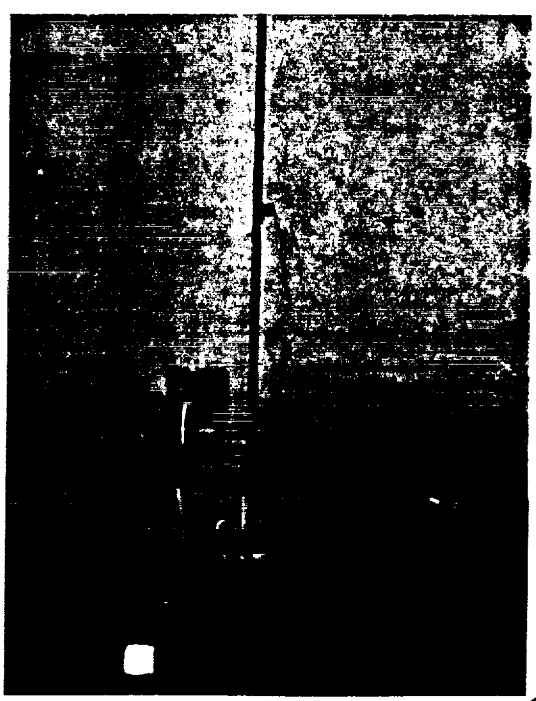

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