# ACTIVE DAMPING OF A FLEXIBLE BEAM

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One objective in the flexible-beam research program is to develop an algorithm that will determine actuator and sensor locations. This is necessary because large space structures will have many locations where actuators can be placed. This research seeks to determine the "best" or optimum locations. In addition, the "best" locations are determined while certain constraints are satisfied which guarantee that mission performance requirements are achieved.

The approach adopted in this research is to consider actuators and sensors to be collocated so as to produce an equivalent viscous damper. Ultimately, the experimental results of measuring the log decrement during free decay will correlate with the analytical predictions. (See fig. 1.)

OBJECTIVE: TO DEMONSTRATE ACTIVE VISCOUS DAMPING ON A FLEXIBLE BEAM

APPROACH:

- o TO USE COLLOCATED ACTUATOR/SENSOR TO PRODUCE VISCOUS FORCE
- o MEASURE DAMPING DURING FREE-DECAY

Figure 1.- Active damping of a flexible beam.

Figures 2 and 3 show the flexible-beam facility.

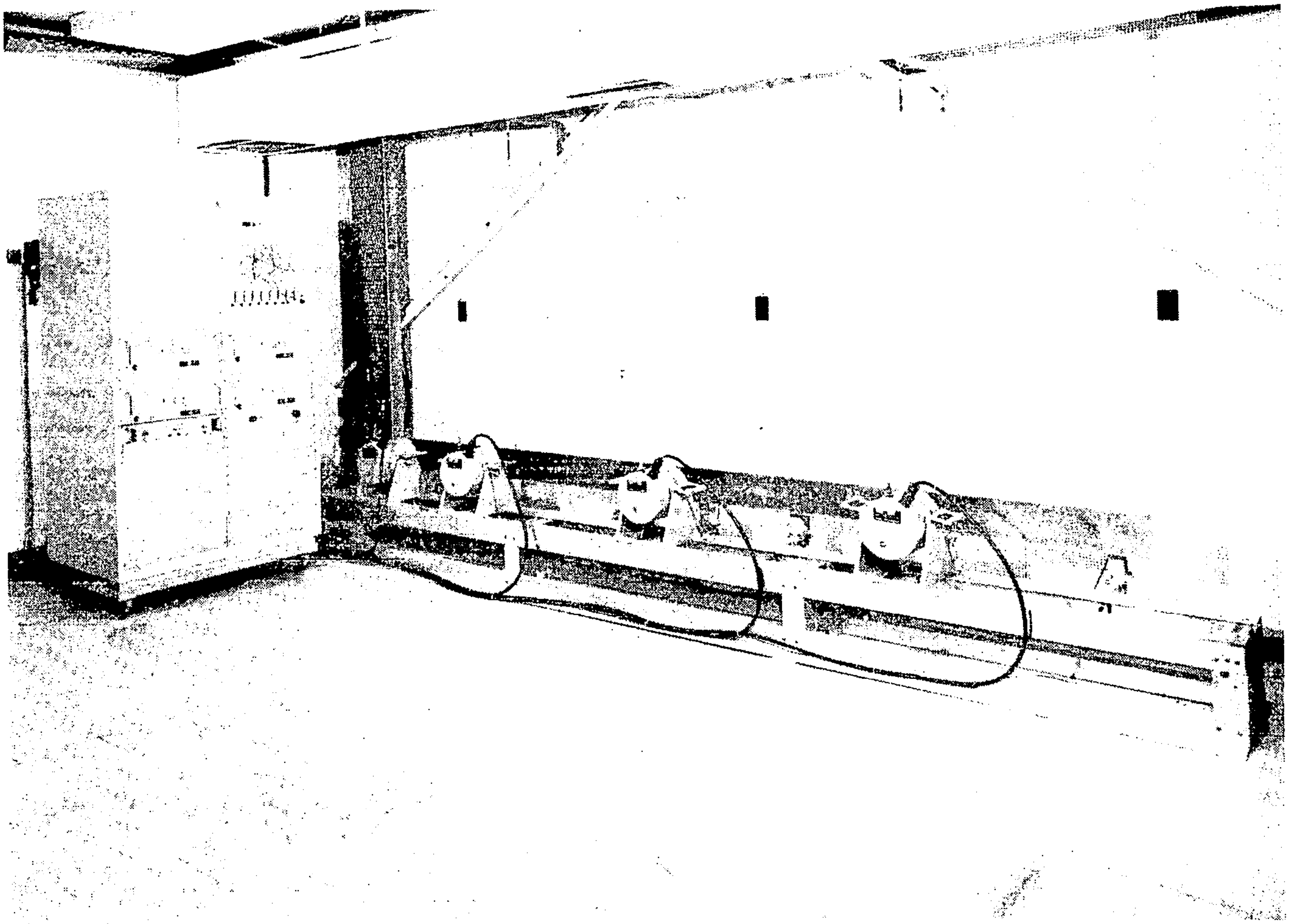


Figure 2.- Side view of flexible-beam facility.

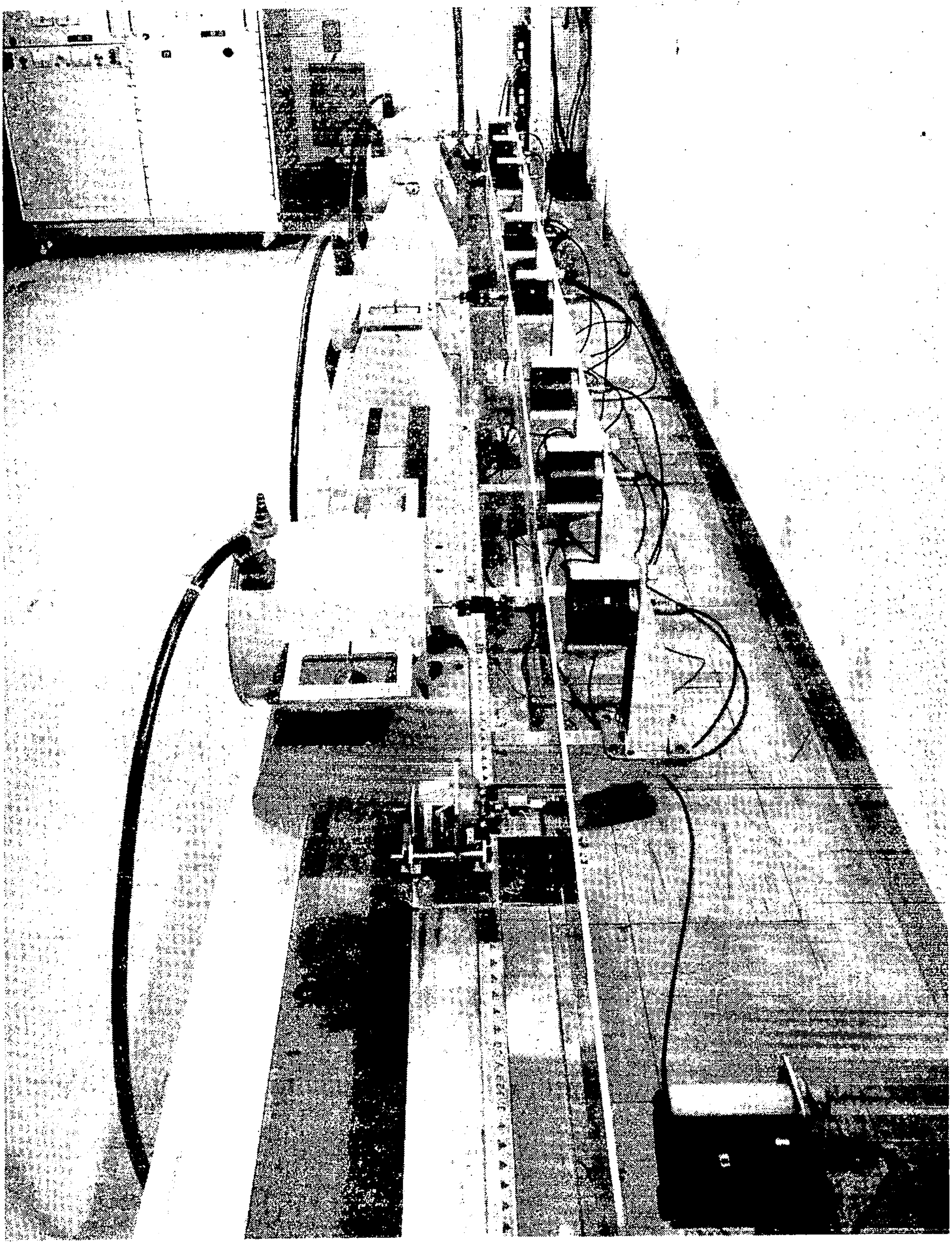


Figure 3.- Flexible-beam facility.

Figure 4 shows the locations of the actuators and sensors along the beam axis. These locations were determined by the optimization algorithm so that the first five bending modes are controlled.

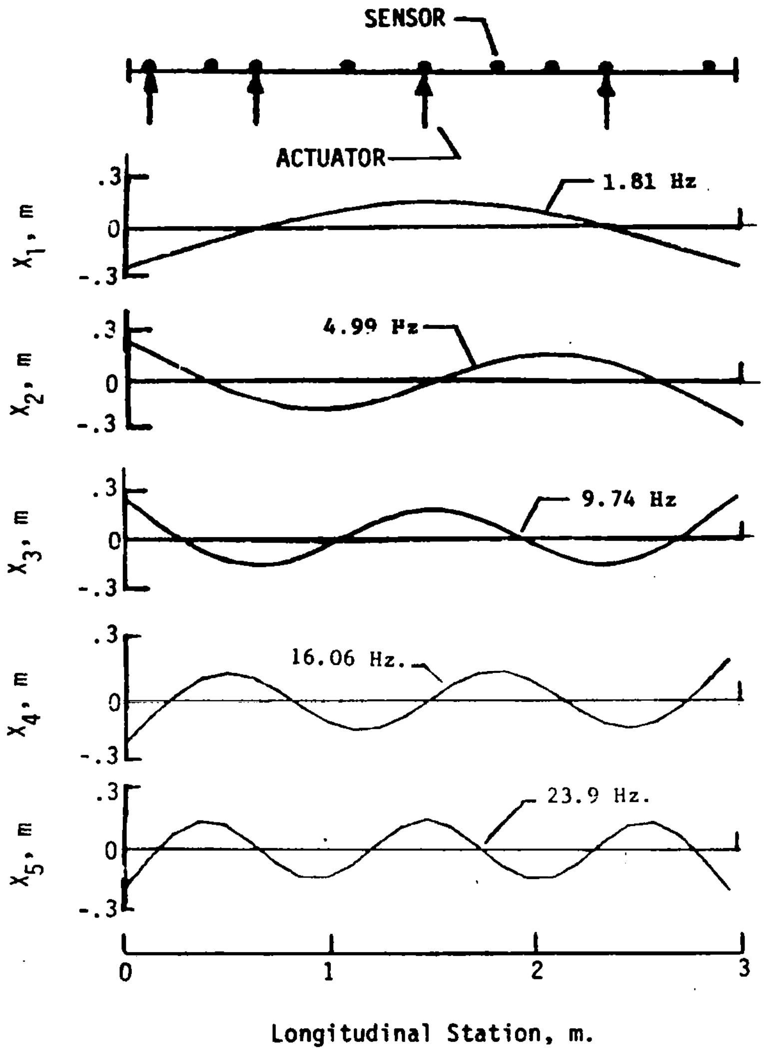
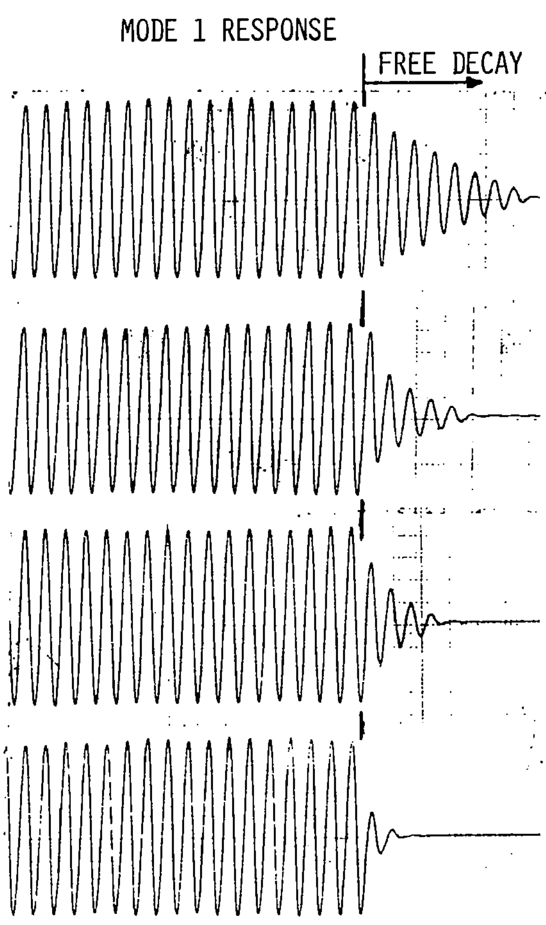



Figure 4.- Actuator and sensor locations on flexible beam.

Figure 5 shows the results of active damping as applied to the flexible beam. Four different sets of damper gains are shown in the right-hand column. The vertical bar is proportional to the damping rate of the damper at the location shown on the beam. The experimental plots at the left of the figure were obtained from the first bending mode of the beam. With the damping rate of each damper set to zero, the beam was vibrated in the first mode. At the time that free decay starts, the damping rate of each damper is set to the desired value. The comparison of the percent of modal damping is made using two experimentally based methods. These values should be compared to the analytically determined value. The column entitled "graph" used a graphical technique to measure the amplitude of adjacent peaks. This data is used to calculate the log decrement, which in turn is used to calculate percent of modal damping. The column entitled "ITD" contains the results of using the Ibrahim time domain method. There seems to be reasonable agreement between the two experimental methods until large modal damping is achieved. In this region small measurement errors can cause large modal damping errors.




PERCENT MODAL DAMPING

| EXPERIMENT | | ANALYSIS |
|---|---|---|
| GRAPH | ITD | |
| 4 | 3.5 | 5 |
| 9 | 8 | 10 |
| 15 | 9.3 | 14.8 |
| 46 (?) | 21 | 39 |

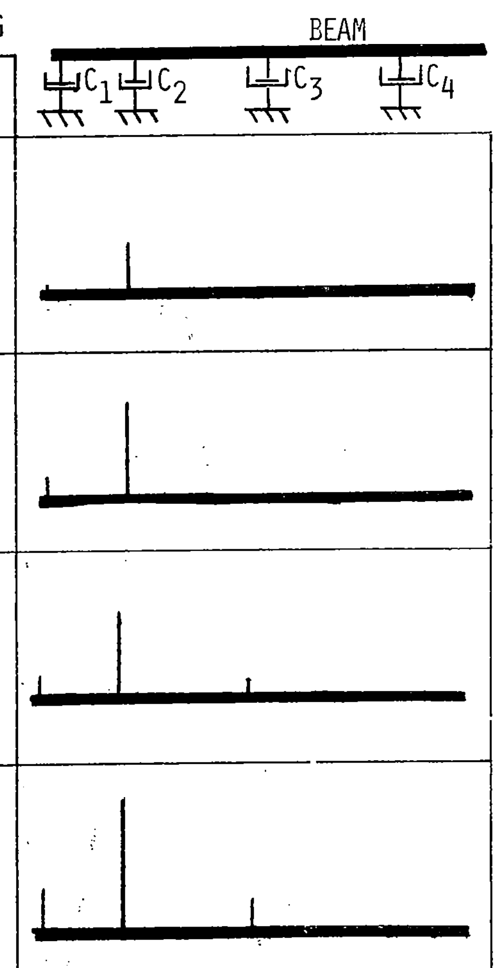



Figure 5.- Active damping results.

Figure 6 and 7 are expanded amplitude and time scale plots that show better the response detail during free decay when the dampers are turned on.

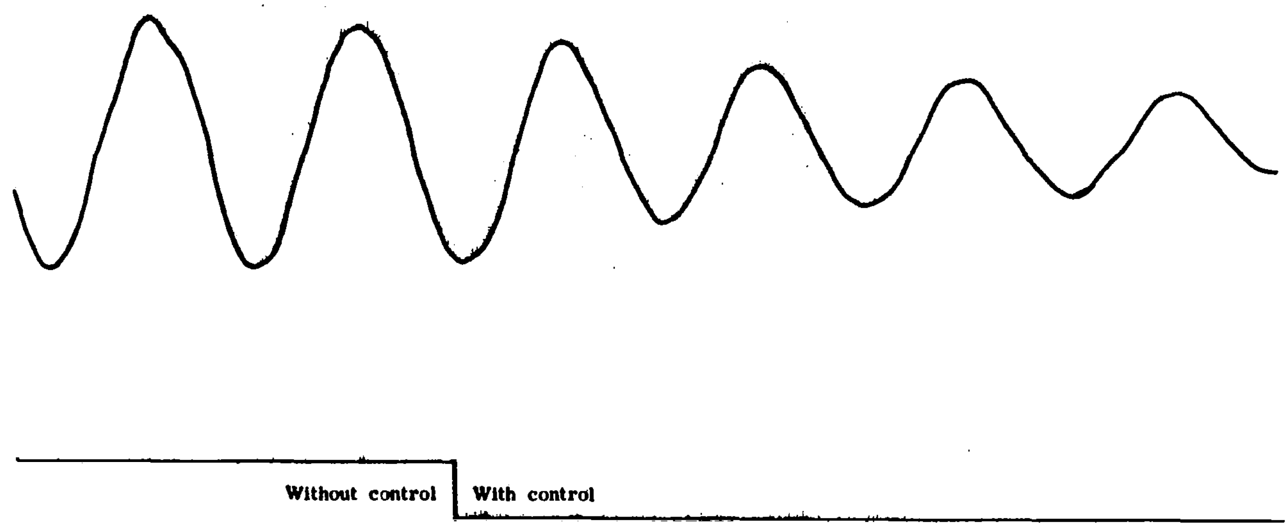



Figure 6.- Mode 1 response with a design modal damping = 0.05.

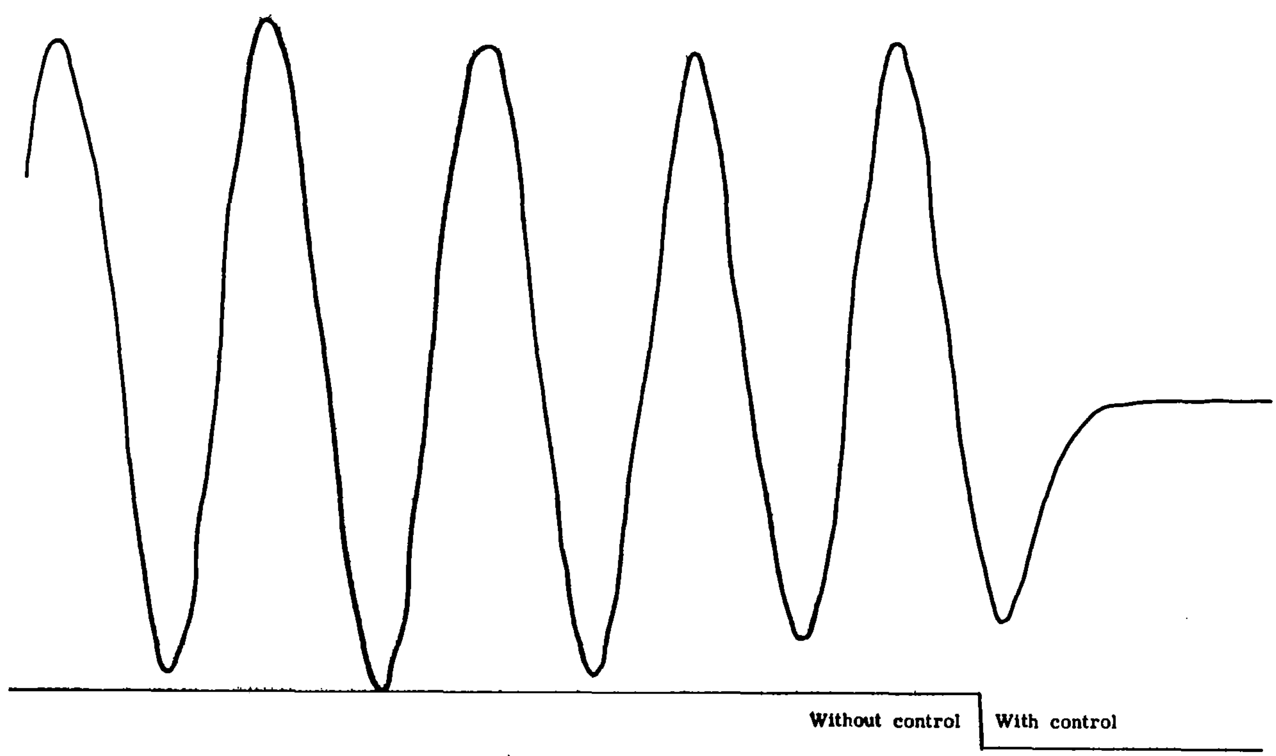



Figure 7.- Mode 1 response with a design modal damping = 0.6.

Figure 8 summarizes the accomplishments and needs of this research.

- ACTIVE VISCOUS DAMPING HAS BEEN DEMONSTRATED
- DIFFICULT TO MEASURE HIGH MODAL DAMPING
- ACTUATORS REQUIRE COMPENSATION
- DIGITAL CONTROL (VERSUS ANALOG) MAY REQUIRE MORE ANALYSIS

Figure 8.- Summary.