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MODIFICATION OF A DAMPOMETER FOR USE WITH A FREE-OSCILLATION DYNAMIC RIG

by

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MODIFICATION OF A DAMPOMETER FOR USE WITH A FREE-OSCILLATION DYNAMIC RIG

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The basic Dampometer, as supplied by the Oltronix Company, has been discussed at a previous meeting of the Supersonic Tunnel Association. The purpose of these remarks is to point out the modifications necessary to make the basic apparatus compatible with dynamic testing in the Sandia Corporation 12-inch transonic tunnel.

The Dampometer (slide 1) is based upon the idea of representing the harmonically damped oscillation by a rotating vector in such a way, that the rate of decrease of the length of the vector is a measure of the damping of the oscillating system. The curve thus described by the end of the vector is a logarithmic spiral. The oscillation to be investigated is introduced as a voltage to a cathode ray tube. The resulting deflection of the cathode ray is proportional to the envelope of the oscillation. When the oscillation is damped, the spot moves on a logarithmic spiral towards the center of the screen (one revolution corresponding to one cycle of oscillation). The screen is covered with a slotted circular disc. The number of light pulses produced by the cathode ray, while the spot moves in its spiral path from the outer to the inner radius of the slotted disc, is recorded on an electronic counter by a photocell. The logarithmic decrement is inversely proportional to this number. A second electronic counter is used to measure the time over a number of pulses, thus determining the frequency of oscillation. A complete description of the design and operation of this instrument is given in an Oltronix Company brochure "Dampometer Type DM6".

The basic Dampometer was designed for use with a forced oscillation dynamic test rig (i.e. forced vibration of constant amplitude and frequency prior to release). Sandia's dynamic rigs are of the "Z" flexure and free oscillation types wherein the model is deflected to a constant angle of attack prior to release. Use of these rigs with the basic Dampometer would have resulted in erroneous readouts of frequency and logarithmic decrement since the cathode ray tube would be energized during the deflection and initial release of the model. The apparatus was modified to cause automatic zeroing of the digital counters just after the model is released; hence, the counters record only during the period when the dot moves from the outer to the inner-radius of the screen disc.

A second source of error arises when a test model damps down to a minimum amplitude and then diverges to a larger amplitude. If the amplitude increase is sufficient to drive the rotating radius vector on the cathode ray tube out from under the inner radius of the slotted disc, the counters will record erroneous values. A manual switch is employed to open the circuit to the counters when the radius vector passes below the inner radius of the slotted disc.

The Dampometer was modified to facilitate paralleling it with a Brush recorder or Visicorder. A permanent trace is necessary to quantitatively evaluate cases of neutral stability or instability.

The deflecting mechanism and dynamic rigs used in the 12-inch tunnel are programmed to obtain three releases (damping envelopes) during a 15 to 30 second test. Two additional sets of readout counters were added to the Dampometer so that three values each of frequency and logarithmic decrement could be recorded during a test.

The Dampometer should reduce the man hours expended in data reduction for dynamic tests and increase the accuracy in the calculations of the static and dynamic stability derivatives.

Appendix I

Calculation of $T_{1/2}$ and period

The logarithmic decrement is defined as

$$\delta = \frac{S}{N_\delta} \ln \frac{R_1}{R_2} \qquad (1)$$

where S = number of slots in disc

N_δ = number of counts recorded on damping counter

R_1 = inner radius of disc

R_2 = outer radius of disc

The period is defined as

$$P = \frac{S}{(N_2 - N_1)} \quad \frac{N_f}{F} \qquad (2)$$

where (N_2-N_1) = instrument setting for impulse counting

N_f = number of counts recorded on the frequency counter

F = standard frequency set on instrument

The logarithmic decrement may also be defined as

$$= (1/n)\ \ell n \left(\frac{X_o}{X_n}\right) \qquad (3)$$

where n = number of cycles

X_o = model amplitude at release

X_n = model amplitude after n cycles

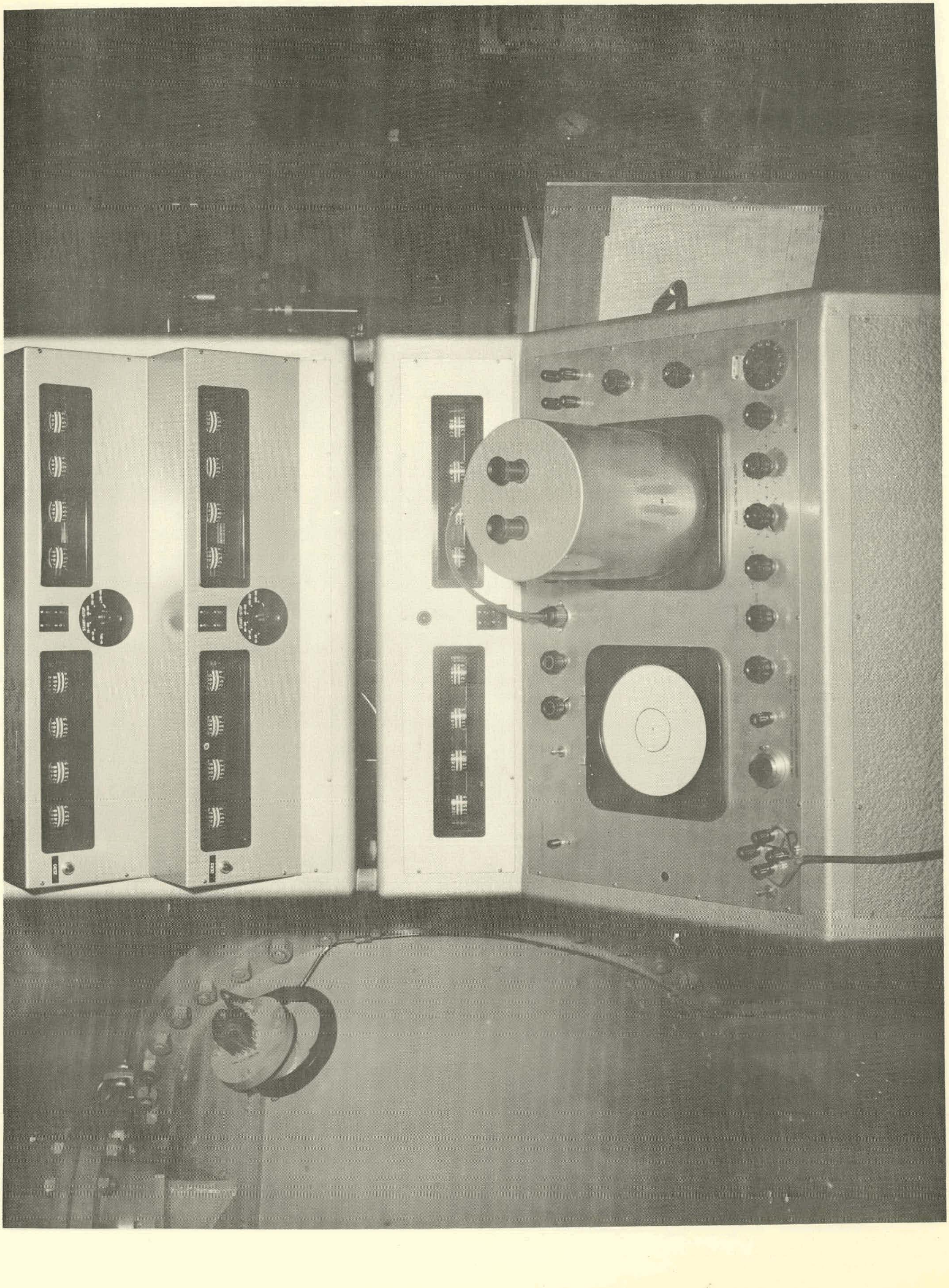
When $(X_o/X_n) = 2$, n represents the number of cycles to damp to one-half amplitude. Cover discs with a ratio of $R_1/R_2 = 2$ are used with the Dampometer. Combining these values with equations (1) and (3) results in

$$n = N_\delta / S \qquad (4)$$

The time to damp to one-half amplitude is

$$T_{1/2} = N_\delta\, N_f/F \ (N_2-N_1) \qquad (5)$$

For any given test only N_f and N_δ in equations (2) and (5) are variables.



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