

CALIBRATION FOR ROTATIONAL ACCELEROMETER DEVICES

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I. Dual Rate of Turn TableBackground

At the Third Annual International Workshop on Human Subjects for Biomedical Research, Rolf Eppinger (NHTSA) presented a description of a method for calibrating rotational accelerometers. The two angular acceleration terms (\dot{W}) derived are

$$\begin{aligned}\dot{W}_y &= W_z W_x \cos W_x t \\ \dot{W}_z &= -W_z W_x \sin W_x t\end{aligned}\quad (1)$$

where

$$\begin{aligned}W_z &= \text{angular velocity of lower table, and} \\ W_x &= \text{ " " " upper " } .\end{aligned}$$

Genisco, Inc. (under contract to NHTSA) has developed a dual rate table to produce this described motion. The actual device and other considerations are discussed below.

Theory

A paper presented by Otis Ingebritsen at the 16th ISA Conference, 1961, discussed at great length some of the problems with a dual rate table. After careful analysis of that paper, it was determined that if the dual rate table maintained constant speed as well as perfect alignment of axes, the predicted angular accelerations would be correct. There are certain symmetry conditions of the accelerometer which must be satisfied to prevent inaccurate readings by the device. At present, it is

believed that the nine transducer accelerometers will work correctly on this dual rate table.

A contract has been initiated with the National Bureau of Standards (John Ramboz) to determine the accuracy of the dual rate table. Towards this goal, the perpendicularity of axes, existence of a common point on both axes, and vibration effects will be analyzed. A final error analysis will be presented to indicate the overall accuracy of the device.

Device Description

A standard Genisco, Inc. Model 1100-5 heavy duty rate table is the lower table (W_z in equation (1)) in the dual rate table system. It has a vertical spin axis with maximum speed of 500 revolutions per minute (RPM). Figure 1 shows a schematic of the device with the lower rotation arrow representing this base table. Accurate speed control is provided by linear feedback control from a photodiode speed detector.

The upper table motor has a horizontal spin axis (W_x). Speed control is accomplished with a silicon controlled rectifier system. The original motor vibrated in response to signals from the controller. A new motor with different type of windings minimized this effect. The maximum upper table speed is 6000 RPM; however, in producing rotational acceleration the product of W_z and W_x is limited to dial settings that produce a maximum of 720,000.

A slip ring connection device allows 15 signals to be recorded during rotation of the upper table. The motor and slip ring assemblies

are on an adjustable guide to permit various sizes of accelerometers and supporting mounts to be placed between them.

II. Calibration Test - Status Report

Background

The method of utilizing nine linear accelerometers to measure angular acceleration (Padgaonkar, et al ASME 75-APMB-3) has been utilized by Endevco, Inc. to produce a small package with accurate transducer orientation. Nine accelerometers (Endevco Model 2264) are mounted on a small or orthogonal bracket (Endevco Model 21419). Each arm of the bracket is approximately 2 inches long.

The dual rate table would provide an excellent means of calibrating this Endevco device in the rotational mode. A cooperative effort between NHTSA and Endevco has proceeded toward the development of wiring and fixtures required to check angular acceleration.

Test Fixture

The structure that is fabricated to connect the upper rate table motor and the slip ring device must be precision made. An instrument equipment shop fabricated a support fixture with highly accurate alignment of the accelerometer and set table axes. Pin registration assures known location of the accelerometer bracket to support connection as well as the orientation of the support device on the upper table. The entire test fixture will be dynamically balanced to help maintain constant motor speed.

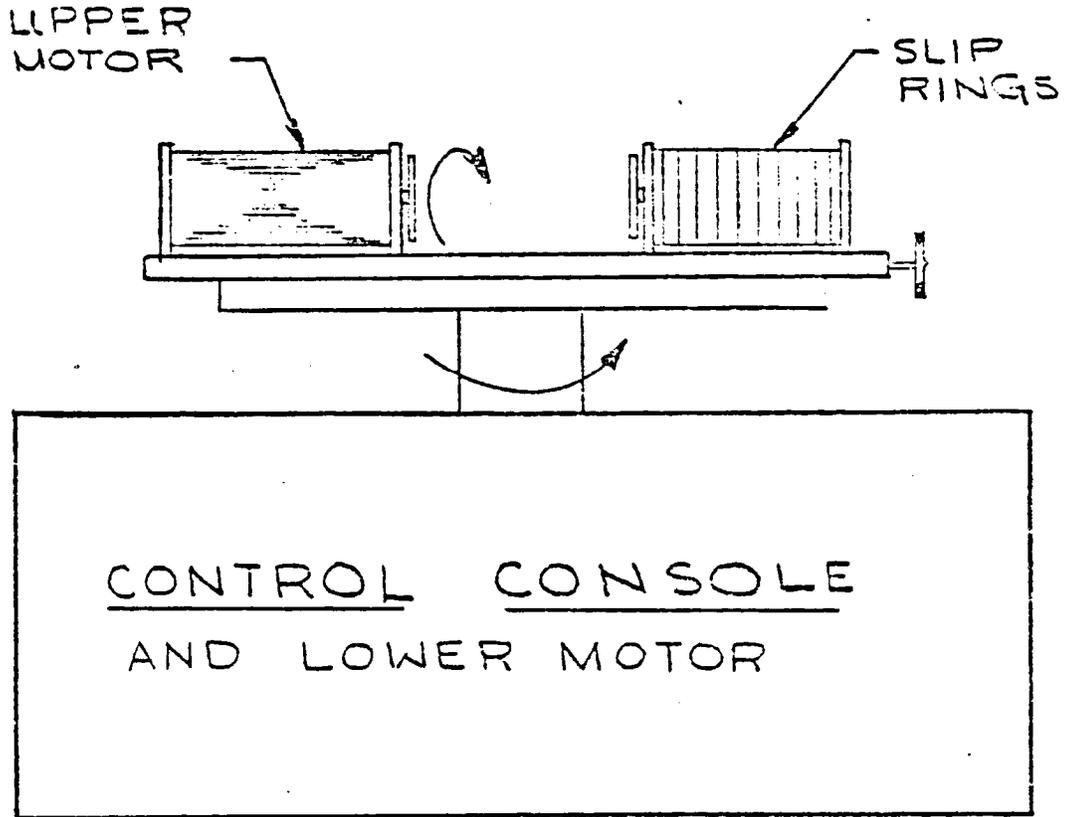


FIGURE 1 - Schematic of Dual Rate Table