Multiple Rotor Magnetic Suspension System

J. W. Beams

Citation: Review of Scientific Instruments **36**, 95 (1965); doi: 10.1063/1.1719337
View online: https://doi.org/10.1063/1.1719337
View Table of Contents: http://aip.scitation.org/toc/rsi/36/1
Published by the American Institute of Physics

Notes

BRIEF contributions in any field of instrumentation or technique within the scope of the Journal can be accorded earlier publication if submitted for this section. Contributions should in general not exceed 500 words.

Multiple Rotor Magnetic Suspension System*

J. W. BEAMS
Department of Physics, University of Virginia, Charlottesville, Virginia

(Received 3 August 1964; and in final form, 21 September 1964)

A DOUBLE magnetic suspension has been described[1] in which the lower rotor was magnetically suspended from the upper rotor which in turn was magnetically suspended. This note describes an extension of this technique to a magnetic suspension in which more than two rotors are suspended, one above the other. Figure 1 shows a schematic diagram of triple suspension system. The upper rotor R_1 is magnetically suspended by the solenoid S_1. R_1 is vertically stabilized by the sensing coil P_1 and the servocircuit E_1. If now R_1 is made the core of the solenoid S_2, the vertical position of R_2 can be accurately maintained by the servocircuit E_2. Instead of the coil pick-up the sensing device for R_2 is usually a beam of light or of gamma rays as shown in Fig. 1. The rotor R_2 serves as the core of solenoid S_3 which supports the rotor R_3. The sensing device which regulates the height of R_3 may be either a light or gamma-ray beam or the pick-up P_3. The horizontal positions of the rotors are maintained by the three downward diverging magnetic fields. Their horizontal motions are damped by the core C which in turn is damped by plastic fibers. This damping is sufficient when the rotors are stationary or not spinning fast. Copper disks D_1 and D_2 as shown in Fig. 1 are found to be effective dampers up to rotor speeds where they flow plastically. At higher rotor speeds a small soft iron rod mounted as an inverted pendulum in an oil dashpot is found to make the system stable. For experiments at reduced air pressures such as carried out with the double suspension a stationary vacuum chamber must surround all three rotors. When it is essential to reduce the gaseous friction on the rotors a thin, nonferromagnetic, non-vacuum-tight skirt fastened to R_1 completely surrounds R_2 and R_3 while a similar skirt attached to R_2 surrounds R_3. This produces a large reduction in gaseous friction on R_2 and R_3 when the supports and chambers surrounding the rotors are spinning at approximately the same speed.[2] A gamma ray beam from a 1-Ci cobalt source serves as a sensor. The solenoid and servo systems have been previously described.[1,3] Their sizes and types depend upon the sizes and spacings of the rotors which may be varied over large ranges. The experiments indicate that the above technique can be extended to support more than three rotors.

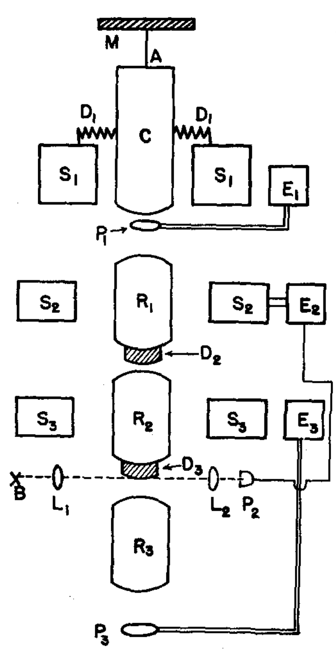

FIG. 1. Schematic diagram (not to scale) of the triple magnetic suspension.

Often it is important to measure very small torques or changes in the forces on bodies located at different vertical positions in an experimental system. In gradient problems it is important that the measurements be made in at least three positions simultaneously. This requires a triple suspension. In addition to determining small torques the magnetic suspension systems can measure minute changes in the forces on the suspended bodies.[4] Consequently very small viscous, density, and diffusion, gradients in gases, vapors, and solutions can be determined.

The writer is greatly indebted to F. Linke for help in the construction of the apparatus.

* Supported by U. S. Army Office of Research (Durham) and Navy Bureau of Weapons.

[1] J. W. Beams, Rev. Sci. Instr. **34**, 1071 (1963).

[2] The idea of eliminating air friction on a rotor by spinning the surrounding chamber at the same speed as the rotor evidently has occurred to many people independently. It was kindly suggested to the writer several years ago by Professor L. W. Alvarez and a number of others since that time.

[3] J. W. Beams, D. M. Spitzer, Jr., and J. P. Wade, Jr., Rev. Sci. Instr. **33**, 151 (1962).

[4] J. W. Beams, C. W. Hulbert, W. E. Lotz, and R. Montague, Rev. Sci. Instr. **26**, 1181 (1955); J. W. Beams and A. M. Clarke, Rev. Sci. Instr. **33**, 750 (1962); D. V. Ulrich, D. W. Kupke, and J. W. Beams, Proc. Natl. Acad. Sci. **52**, 349 (1964).