DEMONSTRATION OF VARIOUS ROTOR INSTABILITIES (EXHIBIT OF BENTLY ROTOR DYNAMICS RESEARCH CORPORATION LABORATORY RIGS AT SYMPOSIUM ON INSTABILITY IN ROTATING MACHINERY)

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The following papers describe the operation of rotor rigs used at the symposium exhibit to demonstrate various instability phenomena occurring in rotating machines. The instability phenomena demonstrated included oil whirl/whip (fig. 1), antiswirl (fig. 2), rub (fig. 3), loose rotating parts (fig. 4), water-lubricated bearing instabilities (fig. 5), and cracked shaft (fig. 6). The rotor rigs were also used to show corrective measures for preventing instabilities. Vibrational response data from the rigs were taken with modern, computerized instrumentation.

The rotor nonsynchronous perturbation rig demonstrated modal identification techniques for rotor/bearing systems (fig. 7). Computer-aided data acquisition and presentation, using the dynamic stiffness method, makes it possible to identify rotor and bearing parameters for low modes.

The shaft mode demonstrator (fig. 8) presented the amplified modal shape line of the shaft excited by inertia forces of unbalance (synchronous perturbation). The first three bending modes of the shaft can be demonstrated.

The user-friendly software, "Orbits," presented a simulation of rotor precessional motion that is characteristic of various instability phenomena.

The data presentation demonstration used data measured on a turbine-driven compressor train as an example of how computer-aided data acquisition and presentation assists in identifying rotating machine malfunctions.

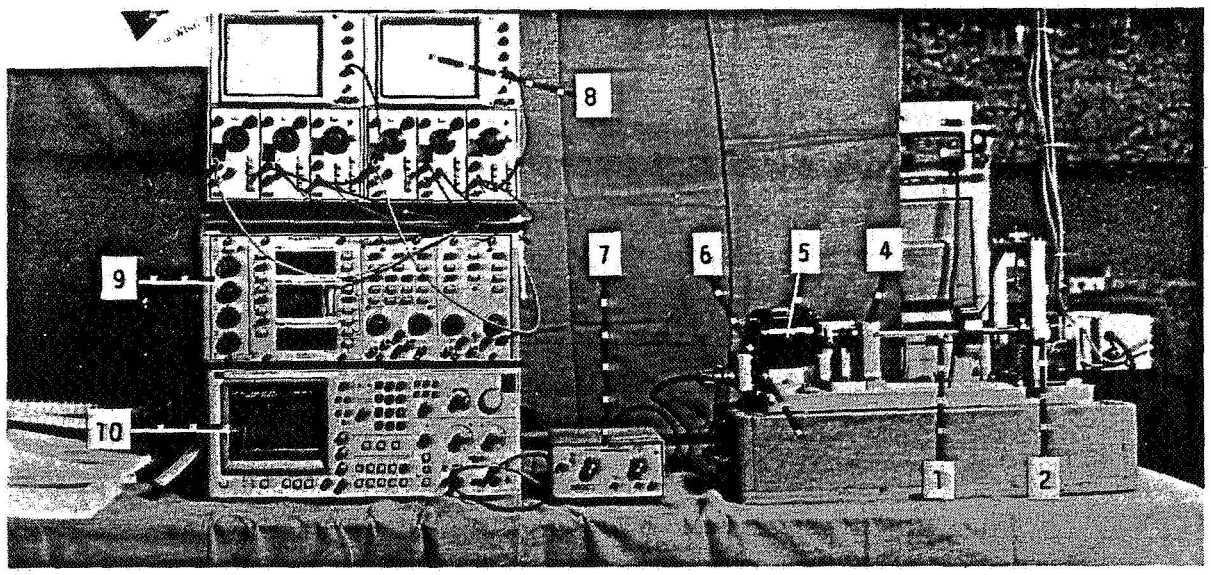

Figure 1. Oil Whirl/Whip Demonstration. 1 -- Rotor, 2 -- Oil Lubricated Cylindrical bearing, 3 -- Oil Tank, 4 -- Rigid Bearing, 5 -- Electric Motor, 6 -- Concrete Base, 7 -- Speed Controller, 8 -- Oscilloscope, 9 -- Digital Vector Filter DVF 2, 10 -- Spectrum Analyzer.

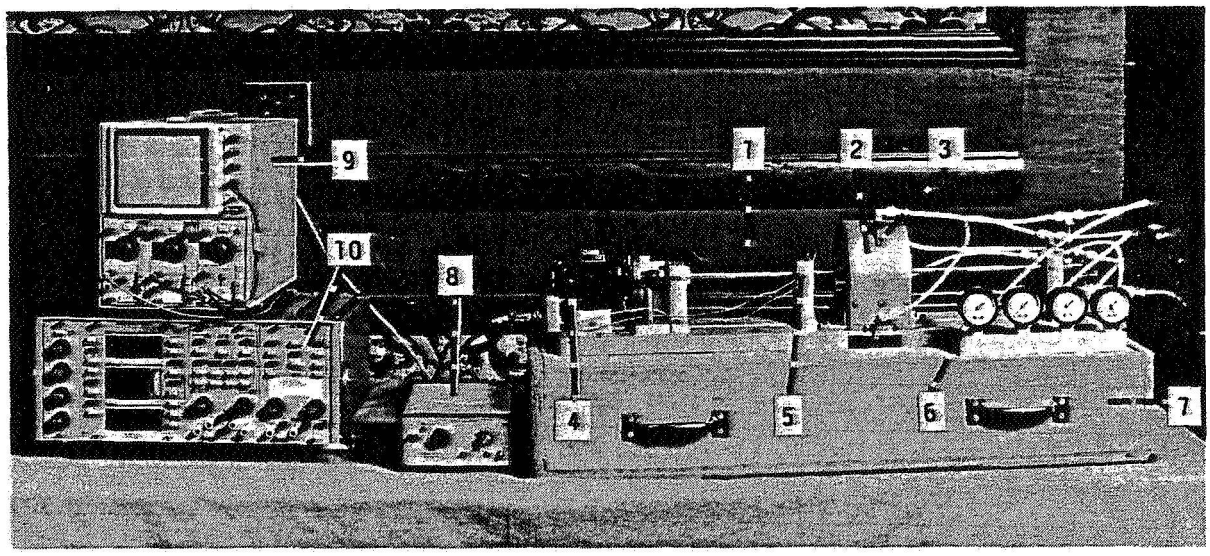

Figure 2. Anti-Swirl Demonstrator. 1 -- Rotor, 2 -- Seal, 3 -- Air Jet, 4 -- Electric Motor, 5 -- Proximity Probes, 6 -- Manometers, 7 -- Concrete Base, 8 -- Speed Controller, 9 -- Oscilloscope, 10 -- Digital Vector Filter DVF 2.

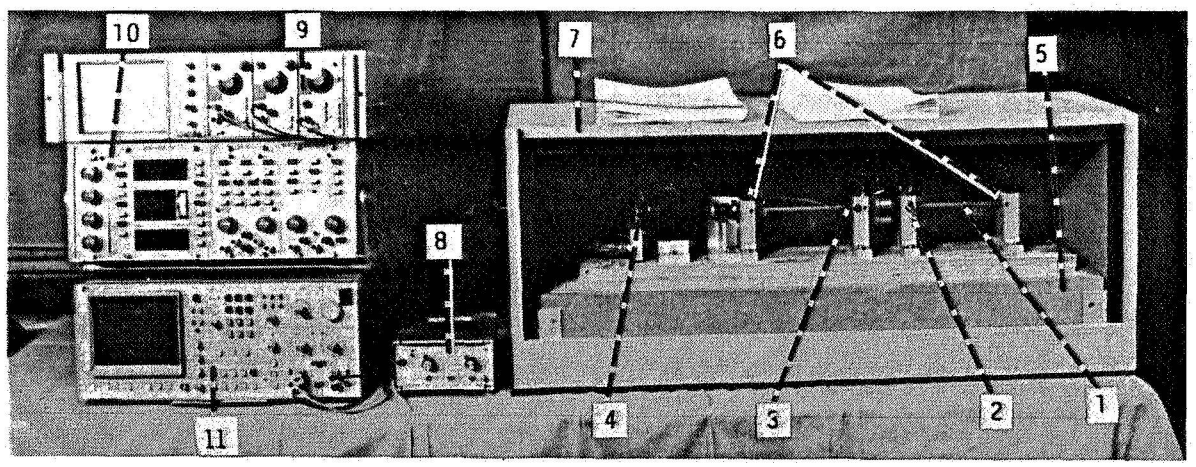

Figure 3. Partial Rotor-to-Stator Rub Demonstration. 1 -- Shaft, 2 -- Brass Screw Generating Rub, 3 -- X-Y Displacement Proximity Probes, 4 -- Electric Motor, 5 -- Concrete Base, 6 -- Rigid Bearings, 7 -- Acoustic Insulation Box, 8 -- Speed Controller, 9 -- Oscilloscope, 10 -- Digital Vector Filter DVF 2, 11 -- Spectrum Analyzer.

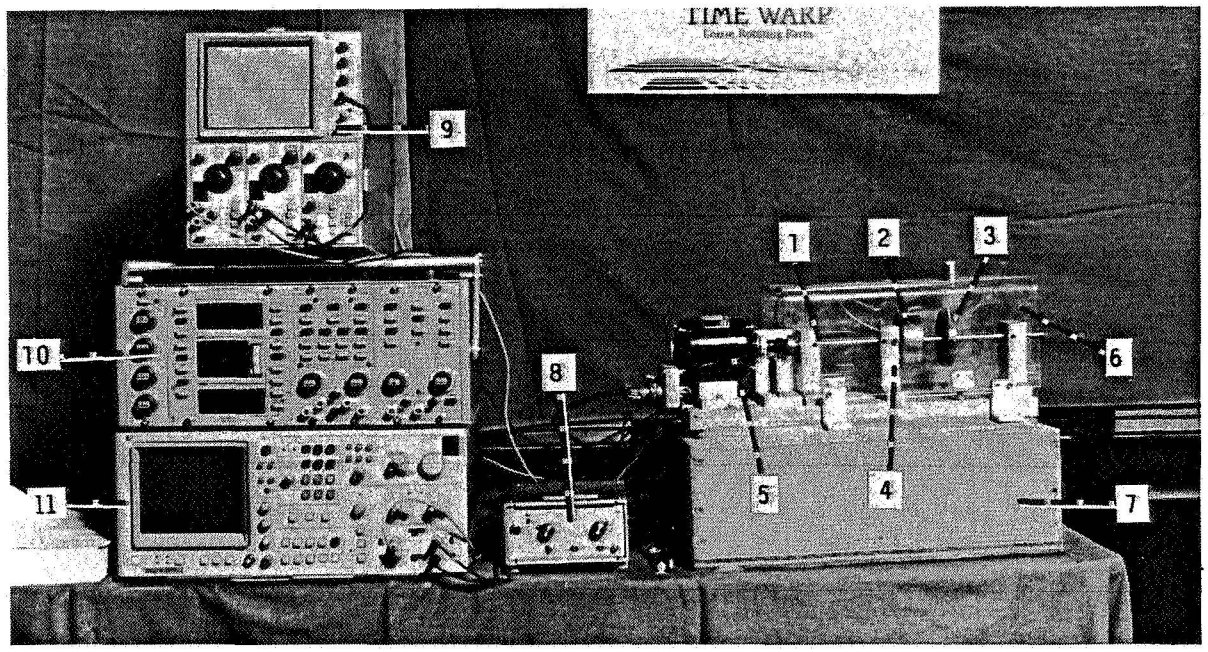

Figure 4. Loose Rotating Part Instability Demonstration. 1 -- Rotor, 2 -- Fixed Disk, 3 -- Loose Disk, 4 -- X-Y Displacement Proximity Probes, 5 -- Electric Motor, 6 -- Protection Guard, 7 -- Concrete Base, 8 -- Speed Controller, 9 -- Oscilloscope, 10 -- Digital Vector Filter DVF 2, 11 -- Spectrum Analyzer.

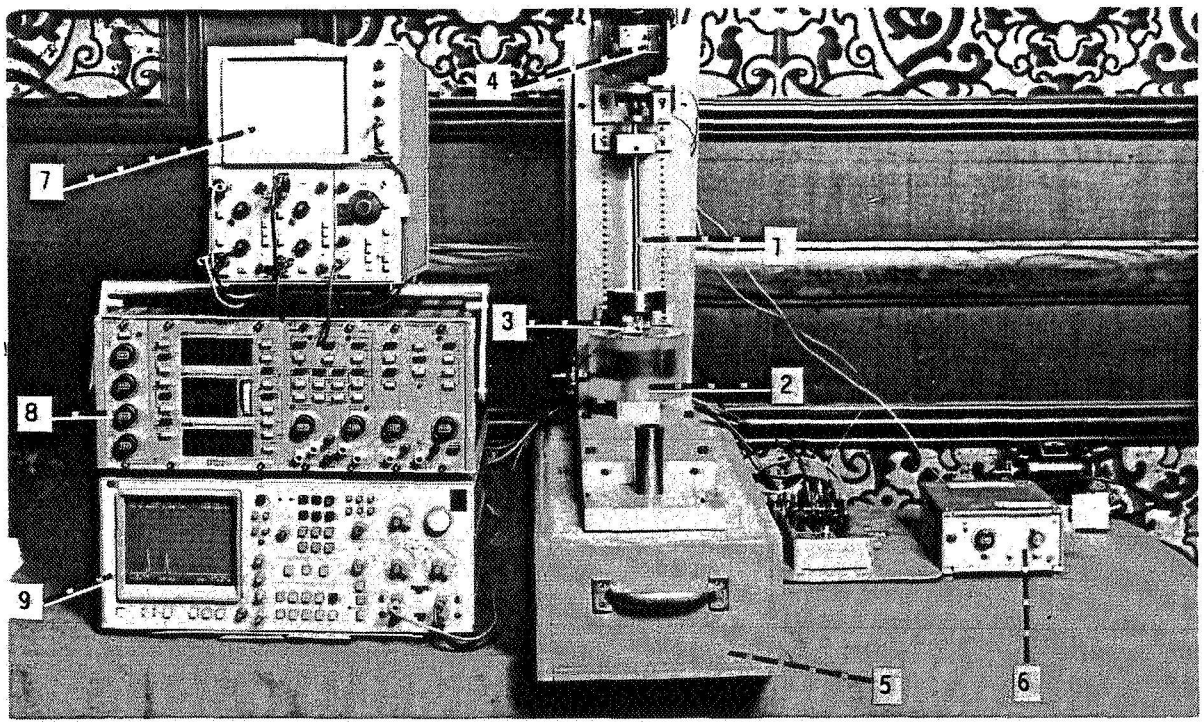

Figure 5. Rotor with Rubber-Lined Water-Lubricated Bearing Demonstrating Instabilities in Fluid Flow Machines. 1 -- Rotor, 2 -- Rubber-Lined Water-Lubricated Bearing, 3 -- X-Y Displacement Proximity Probes, 4 -- Electric Motor, 5 -- Concrete Base, 6 -- Speed Controller, 7 -- Oscilloscope, 8 -- Digital Vector Filter DVF 2, 9 -- Spectrum Analyzer.

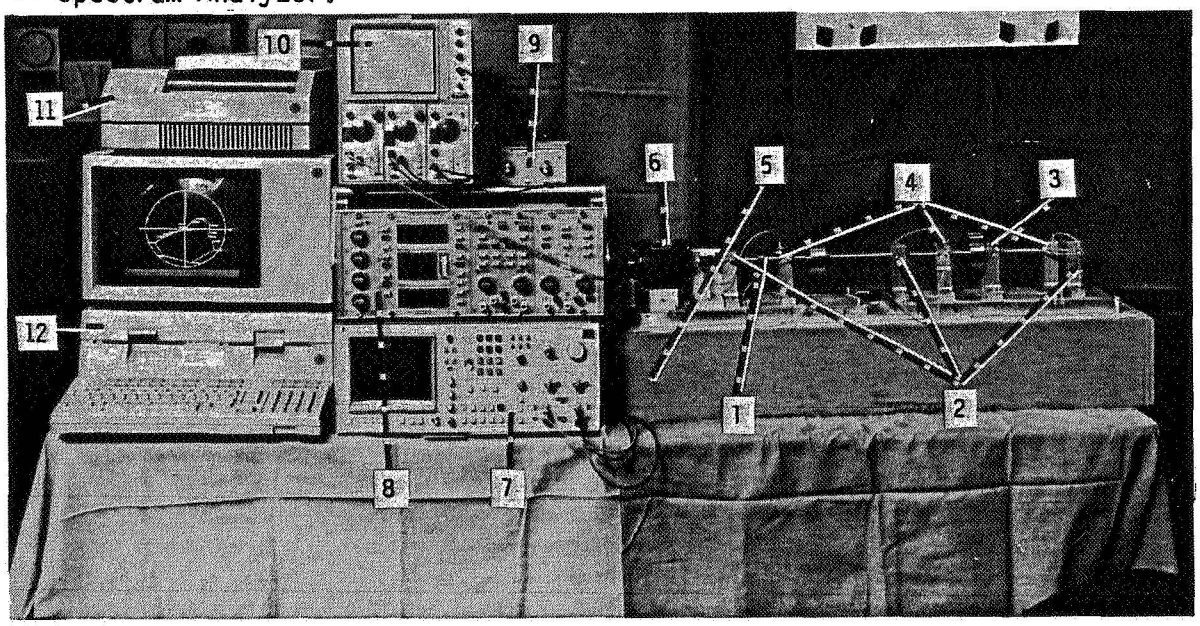

Figure 6. Cracked Shaft Demonstrator. 1 -- Rotor, 2 -- Bearings, 3 -- Safety Guard, 4 -- X-Y Displacement Non-contacting Probes, 5 -- Concrete Base, 6 -- Electric Motor, 7 -- Spectrum Analyzer, 8 -- Digital Vector Filter DVF 2, 9 -- Speed Controller, 10 -- Oscilloscope, 11 -- Printer/Plotter, 12 -- Hewlett Packard 9836C Computer.

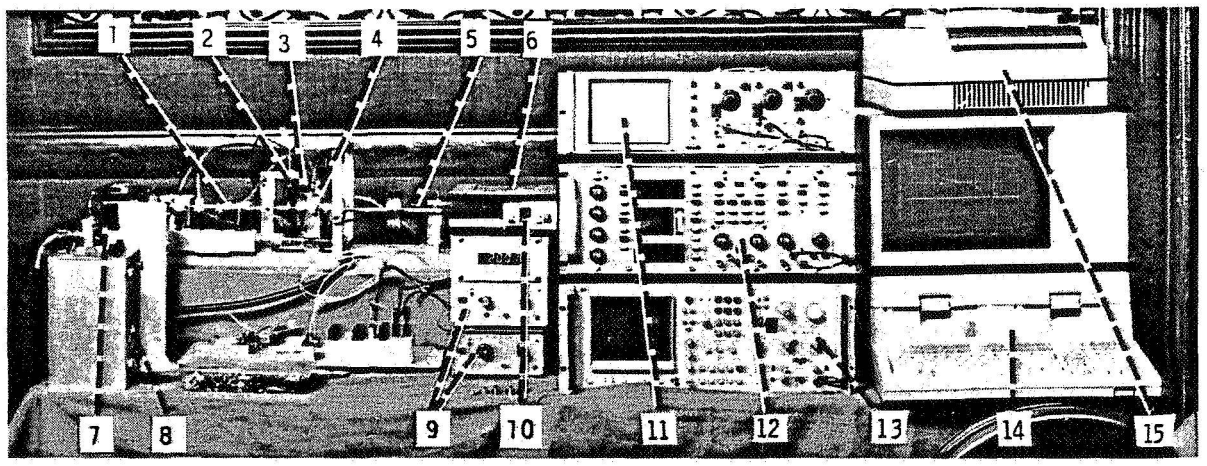

Figure 7. Laboratory Rig Demonstrating Identification of Rotor/Bearing Parameters by Perturbation Testing. 1 -- Perturbation Rotor, 2 -- Keyphasor Probe, 3 -- Oil Lubricated Bearing, 4 -- X-Y Proximity Probes, 5 -- Main Rotor, 6 -- Main Electric Motor, 7 -- Perturbation Electric Motor, 8 -- Pressure Controller, 9 -- Speed Controller, 10 -- Thermometer, 11 -- Oscilloscope, 12 -- Digital Vector Filter DVF 2, 13 -- Spectrum Analyzer, 14 -- Hewlett Packard 9836C Computer, 15 -- Printer/Plotter

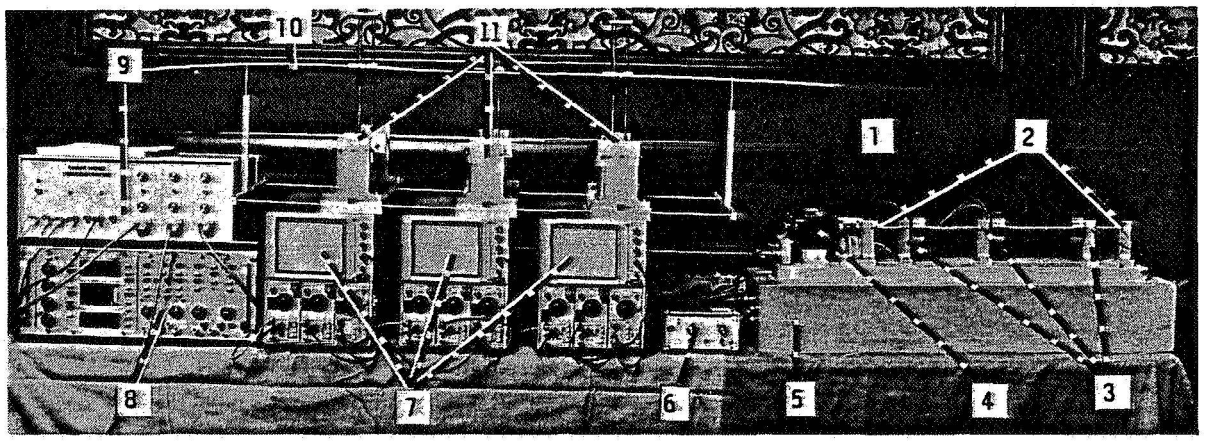

Figure 8. Shaft Bow Mode Demonstrator. 1 -- Rotor with Three Disks, 2 -- Rigid Bearings, 3 -- X-Y Proximity Probes, 4 -- Electric Motor, 5 -- Concrete Base, 6 -- Speed Controller, 7 -- Oscilloscope, 8 -- Digital Vector Filter DVF 2, 9 -- Amplifier, 10 -- Elastic Rod Demonstrating Shaft Bow, 11 -- Servomechanism Translating 1v Amplitudes and Frequencies (Polar Coordinates) of the Vertical Signals into Vertical and Horizontal Motion (Cartesian Coordinates) of the Rod Supports.

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