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Flueric-Controller Pneumatic Stepping Motor System

A novel pneumatic nutating stepping motor was developed during a research effort on flueric controls for propulsion and power systems. The nutating motor, Figure 1, consists of an output gear which is free to rotate only, and a nutating gear that is free to nutate or wobble only. The nutating gear is actuated by eight bellows around its periphery. When four adjacent bellows are pressurized, the nutating gear is tilted into contact with the rotating gear. Sequencing the bellows' pressurization pattern causes the nutating gear to nutate. Since the nutating gear has 181 teeth, and the output gear 180 teeth, the output gear is forced to rotate 2° for each nutation of the input gear.

A flueric logic circuit, Figure 2, composed of 24 flueric amplifiers was developed to control the nutating motor. The purpose of the logic circuit is to store the actuator bellows' pressurization pattern and to sequence it in either a forward or backward direction, depending on the direction of the input command pulses. Forward pulses enter the circuit at eight locations marked T_f, and backward pulses enter the circuit at eight locations, T_b. The outputs labeled A $\bar{A}$ to D $\bar{D}$ actuate power amplifiers which, in turn, provide high pressure and flow to the eight bellows of the nutating motor. The heavy lines in Figure 2 indicate the signal lines which would be pressurized when bellows $\bar{A}$, B, C, and D are pressurized. The application of one forward pulse to the eight T_f ports would advance the pattern to $\bar{A}$, $\bar{B}$, C, and D.

An integrated version of the logic circuit was developed in which the entire flueric circuit was contained in a solid block 2 in. x 2 in. x 3 in. The block was composed of copper laminates fused together by diffusion bonding.

Test results indicate that the flueric circuit could drive the nutating motor at a speed of almost 300 steps (or 75° of output shaft rotation) per second. The output torque at zero speed was approximately 80 in-lb.

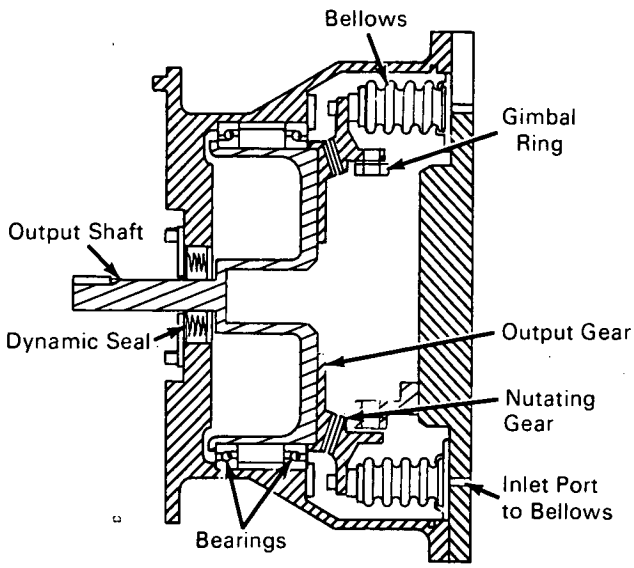

Figure 1. Pneumatic Stepping Motor Actuator

The complete system constitutes a reliable, open loop actuator system with inherently high output stiffness, reasonable slewing speeds and small step size. Although the stepping motor uses more air than an equivalent piston actuator driven by a flapper valve, this high air use might be accepted for some applications in order to gain simplicity, reliability and high output stiffness.

References:

1. NASA-TN-D-4495, "A Breadboard Flueric-Controlled Pneumatic Stepping Motor System," by William S. Griffin, 1968.

2. NASA-TN-D-5155, "Design and Performance of Two Integrated Circuits for Fluidic-Controller Pneu-

(continued overleaf)

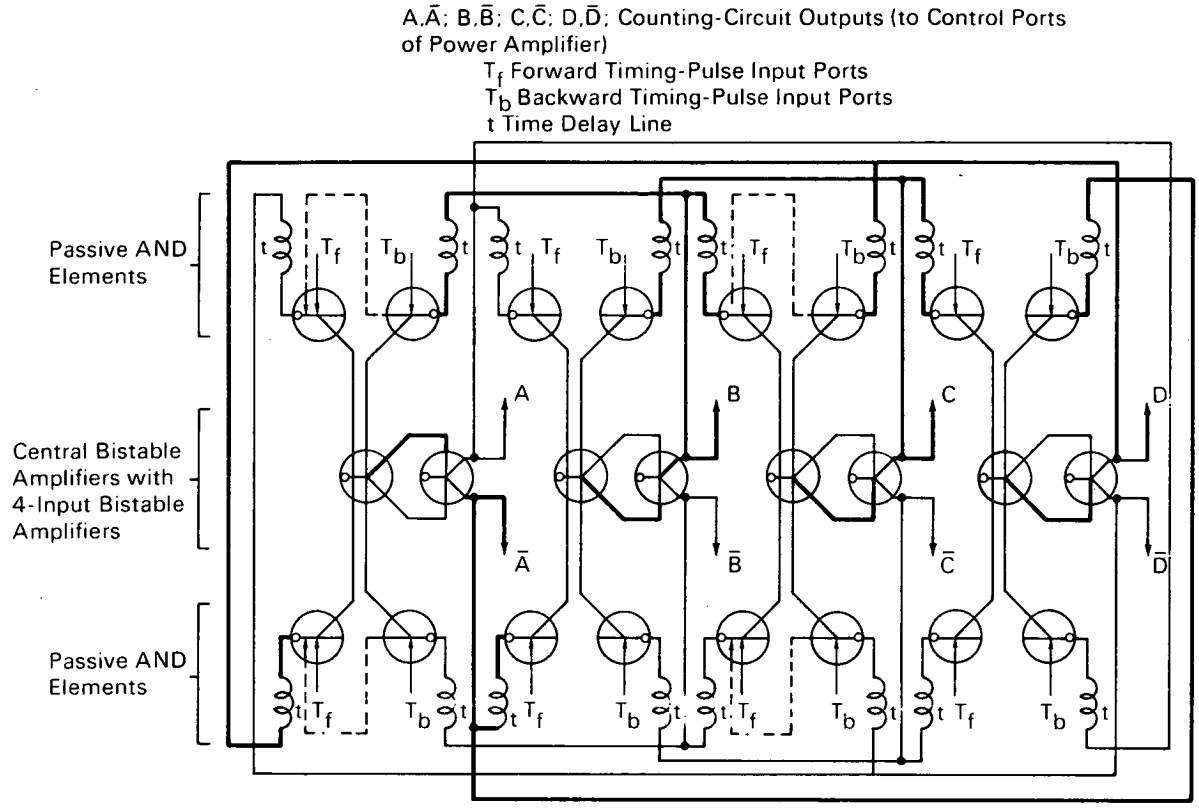

Figure 2. Flueric Logic Circuit

matic Stepping Motor System," by Miles O. Dustin and Robert E. Wallhagen, 1969.

Notes:

1. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

   Reference:
   NASA-TM-X-52250 (N67-11333), Development of High Speed Flueric Logic Circuitry for a Novel Pneumatic Stepping Motor

2. Technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B70-10332

Patent status:

No patent action is contemplated by NASA.

Source: W. S. Griffin, M. O. Dustin and R. E. Wallhagen
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