A ROTARY ACTUATOR FOR SPACE MISSIONS

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Since gear reducers have been used for so many years in so many applications, any substantial advance in gear-reduction technology will find widespread application in government and in industry. Within NASA, control moment gyros for space stations are a prime application. Actuators for the Large Space Telescope and planetary missions are others. In industry, the numerical control of machine tools would be one of several logical fields of application.

Presently available rotary actuators (motor-driven gear reducers) do not meet the performance and reliability requirements for the long life space missions of the next decade. Table 1 compares the performance of state-of-the-art rotary actuators to the desired parameters. It may be noted that significant improvements are required in all areas. A new actuator is being developed which promises to meet or exceed these requirements. The design of the actuator is complete, and a breadboard has been fabricated.

The actuator is a unique integrated motor and epicyclic gear reducer. It differs from previous epicyclic reducers in that the motor is functionally integrated with the transmission. (Figure 1 shows the breadboard actuator.)

Figure 2 illustrates the operating principle of the device. The armature of the motor and the ring gear of the transmission are combined in a single element which is driven by the attractive force of a rotating magnetic vector in the stator. For each vector rotation, the ring gear completes an eccentric cycle. Because the number of teeth on the ring gear is different from that on the fixed ground gear, the ring gear rotates a fraction of a revolution. The ring gear simultaneously engages the output gear, which in one eccentric cycle is rotated a fraction of a revolution in the opposite direction. Since the pitch diameters of the two meshes are not the same, there is a resultant differential motion of the output gear.

The advantages of the design are–

Only two bearings are required, and these are on the low speed output shaft.

The fixed ground gear and the output are bridged by a single stiff member (the ring gear), resulting in extremely low windup.

The gear meshes are floating, which allows them to self-center. Since allowance for fixed shaft center distance tolerances is not required, an inherent minimum backlash configuration is achieved.

A high reduction ratio per number of meshes is obtained; for example, 818 to 1 with only 2 meshes.

The new actuator can be driven digitally for ultraprecise numerical control systems, or it may be driven as a brushless dc motor with ideal characteristics for use in linear servomechanisms. This actuator represents a significant advancement in the art of gear reduction.

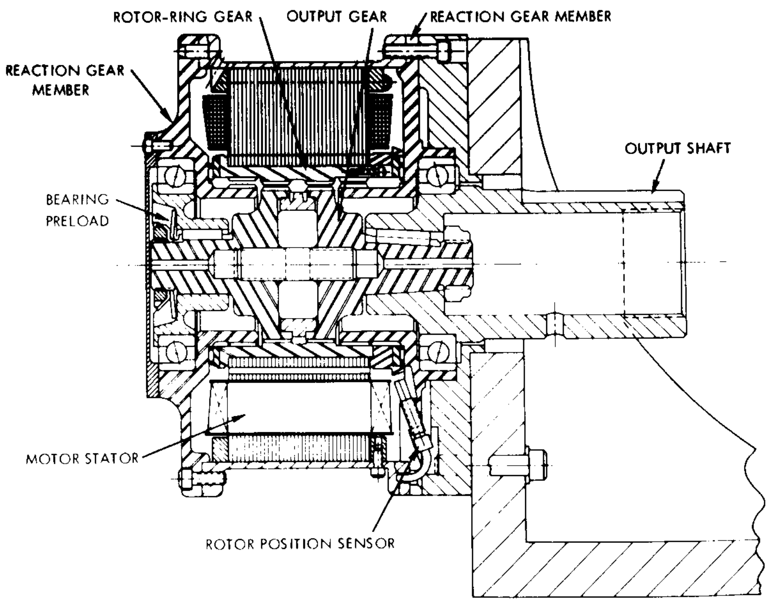

Figure 1–Breadboard actuator.

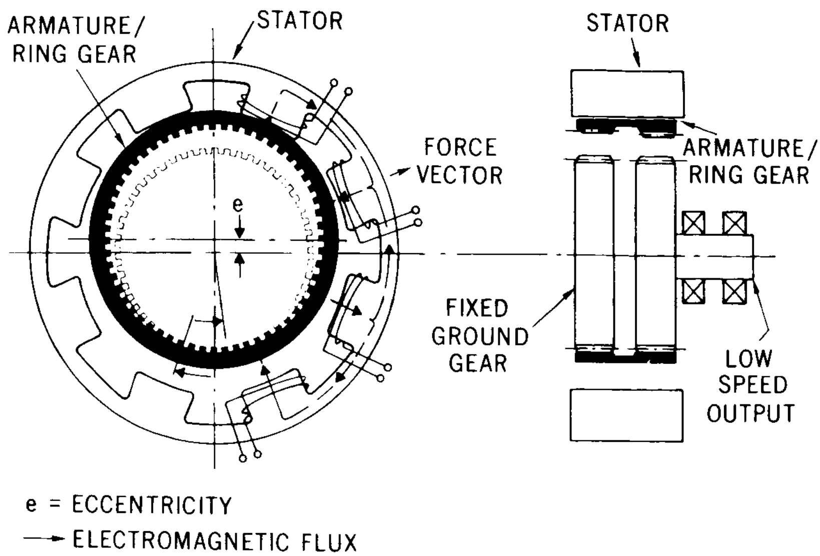

Figure 2–Operating principle of rotary actuator.

Table 1–Performance of rotary actuator compared with requirements.

Parameter	Available*	Required
Inertia (kg-m^2)	0.826	0.0826
arc-sec		
Windup	7	3
0.21 N-m		
Backlash (arc-sec)	180	5
Life (yr)	~0.2	1

*Planetary reducer.