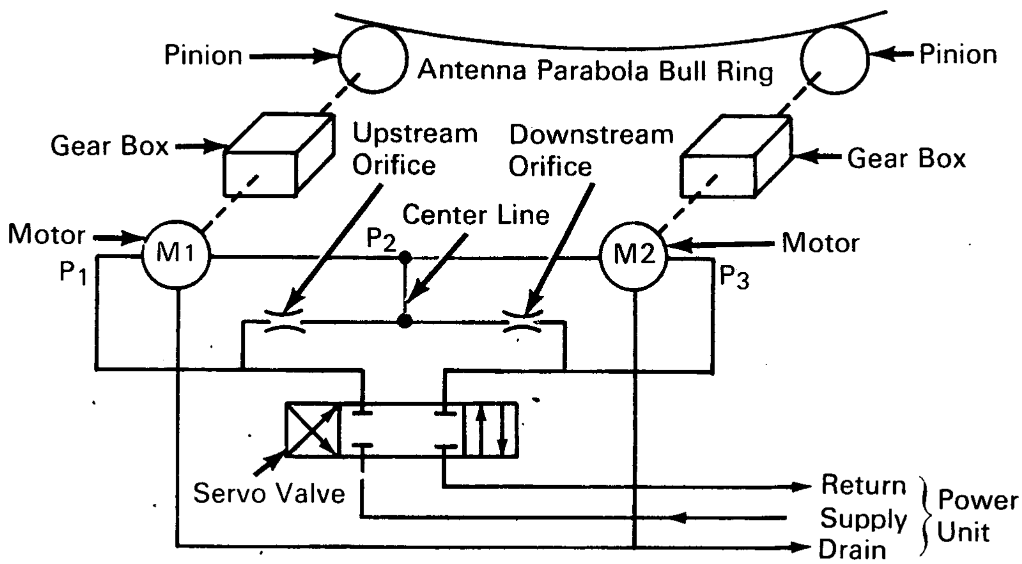
November 1967 Brief 67-10418

# NASA TECH BRIEF



## Hydraulic System Provides Smooth Control of Large Tracking and Antenna Drive Systems at Very Low Tracking Rates




### The problem:

The primary disadvantage of the conventional parallel motor control systems commonly used on the heavy structures of the DSIF and other tracking antenna drive systems is that at very low speed tracking an oscillatory condition often exists because the structure is driven cyclically by first one and then another motor. This effect is caused partly by the spring constant of the gear train and minute differences between the motors. The small servovalve opening at very low speed operation causes the pressure to the drive motors to build up relatively slowly when the motors are stalled. As the pressure increases, one motor will break away or begin to run before the other due to small differences between the units. When this happens, the pressure immediately drops due to the flow through the motor. The running motor then turns until all the backlash is removed, the gear box wound up, and the antenna moves. This motor then stalls, and the pressure increases until the other motor, now unloaded by accumulated backlash, starts and the cycle continues. Smooth control of the heavy structure at very low tracking rates, with no degradation in performance at high rates is required.

### The solution:

A concept of a simple hydraulic system configuration modification to a series connection of the drive motors with compensating orifices to offset the effects of drain line loss. Linearization of response by eliminating cogging or cyclic operation is thus obtained.

(continued overleaf)

## How it's done:

Two very small orifice elements are provided in parallel with each of the series connected motors to compensate for the drain line loss. If the servovalve is displaced to the right, the fluid driving $M_1$ is not all available to drive $M_2$ due to drain line loss, but both motors are constrained to move together by the gear train. This causes the pressure, $P_2$, between the drive motors to drop when the backlash has been removed and the differential pressure, $P_1-P_2$ increases while $P_2-P_3$ decreases. Since the flow rate through an orifice is proportional to the differential pressure, more fluid flows through the upstream than the downstream orifice. This results in a net flow into the junction between the motors which compensates for the drain line loss. To obtain the same rate and torque characteristics, it is also necessary to double the displacement of the motors by replacing the cam plates.

The relative pressures, $P_1$, $P_2$, and $P_3$, can be controlled in a linear fashion to insure gear backlash compensation by suitably sizing the two symmetrical orifices to have an appropriate flow constant.

When the system is first started, backlash will be present but since the orifices are the same size the flow in each will be equal until drain line loss causes the removal of the backlash. At this point the pressure in the center line drops until the differential flow between the orifices equals the drain line loss. In this condition, the differential pressure is automatically adjusted to a value sufficient to maintain backlash-free operation by the sizing of the orifices.

## Notes:

1. Use of this concept appears possible in servodrive systems for reversible control of heavy loads for various types of construction equipment (cranes, gantrys, etc.), where precise wide range control is required.
2. Possible advantages of this concept are:
   (a) Elimination of very low speed cogging or unstable operation of the drive motors.
   (b) Significant simplification over other series drive configurations.
3. The concept of this system configuration was implemented utilizing the low-speed skid of an 85-foot tracking antenna to prove the feasibility.
4. Inquiries concerning this invention may be directed to:

   Technology Utilization Officer
   NASA Pasadena Office
   4800 Oak Grove Drive
   Pasadena, California 91103
   Reference: B67-10418

## Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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(NPO-10316)