26-m Antenna HA-dec Counter Torque Modifications

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This article describes the improvement in tracking performance of a 26-m antenna as a result of changes in the hydraulic circuit of the HA-dec servo subsystem. A discussion of previous problem areas and the results of the new modification are stated.

I. Introduction

A servo hydraulic control system is used to control the motion of the 26-m HA-dec DSIF antennas. Over the past several years improvements have been made in tracking performance; however, several persistent problems have remained. The most persistent of these has been an apparent "hitching" of the drive motor. This article describes a change which will substantially reduce this effect.

All of the improvements to date have been in the area of the control room electronics. However, modifying the electronics alone yielded only partial results. As servo loop gain was increased the gearing backlash became the limiting factor. Therefore attention was directed to the antenna-mounted components.

The drive system for the antenna consists of two separate gear reducers for each axis. This provides two-point drive on each of the bull gears. The two-point drive was utilized to reduce the bull gear load during extreme wind loading condition, in addition it affords a means for providing an anti-backlash gearing arrangement for servo drive.

When the antenna system was first designed, an attempt was made to operate with one gear box driving and one gear box restraining. This is similar to the series arrangement. However the overall system gain was reduced by a factor of two, so this arrangement was dropped for a more suitable arrangement. The current hydraulic circuit is shown in Fig. 1. The subsystem is basically a velocity control system with rate feedback used to close the velocity loop.

Anti-backlash is achieved by driving one hydraulic motor at full load line pressure and the other at a pressure which is reduced by means of a counter balance valve. The motors are geared together and therefore, in theory at least, are operating at the same speed. Because of the reduced pressure across one motor, at light to moderate loads it will be operating as a pump and provide a torque to eliminate gear backlash.

II. Problem

The problem with the present arrangement is that it does not perform well at low speed. The counter balance valves require a minimum flow to develop the reduced pressure. At low velocities the motor flow is less than the required minimum and the drive motors will begin to alternately run across the backlash region. This effect is commonly called hitching.

The minimum flow through the counter balance valve is particularly a problem at zero antenna velocity. Under these conditions the only flow is the leakage to drain through the motor cases. This case leakage tends to vary widely from site to site and causes severe hitching problems at some sites.

The hitching problem has two principal effects. The first is a visual feedback to the operator who observes an unsteady motion and under extreme conditions an increase in the servo tracking error. The second effect is that the rate loop gain is limited by the nonlinear backlash characteristics at low speed. In order to maintain stability the loop gain is so low that the tracking error is increased and the position loop bandwidth limited.

III. Solution

In order to eliminate the hitching, a means for providing a small constant flow across the counter balance valve is required. Fig. 2 shows the addition of two pressure compensated flow control valves, located between each of the driving motors and their counter balance valve and case drain. This provides a constant flow through the counter balance valve to drain. The flow required to assure proper operation of the counter balance valve was found to be approximately 0.1 gal/min.

A prototype installation was made at DSS 11 to prove the validity of the scheme. With the flow control valves blocked out of the circuit, the counter torque pressure was adjusted to 20.7 N/cm^2 ΔP. Smooth manual velocity runs were attempted at the lowest possible antenna rates. Data printouts were made of each run and the antenna rate varied from 0.0004 to 0.0020 deg/s. A visual observation on the antenna revealed that during these runs the drive motors would stop and start alternately as they ran across the backlash. This produces the hitching motion.

The flow control valves were then inserted into the hydraulic circuit and the test repeated. Under the same type of electronic control a somewhat lower rate was obtained of approximately 0.001 deg/s but the variation in rate was only ± 0.0001 deg/s as compared with the previous test of ± 0.0008 deg/s. In addition the visual observation indicated that both motors were running constantly and smoothly together.

Several operational commitments have been satisfied by DSS 11 with the prototype installation. Operational personnel have stated the antenna tracking performance to be significantly improved as a result of this modification.

A permanent installation for all DSIF sites is currently in process for this modification.

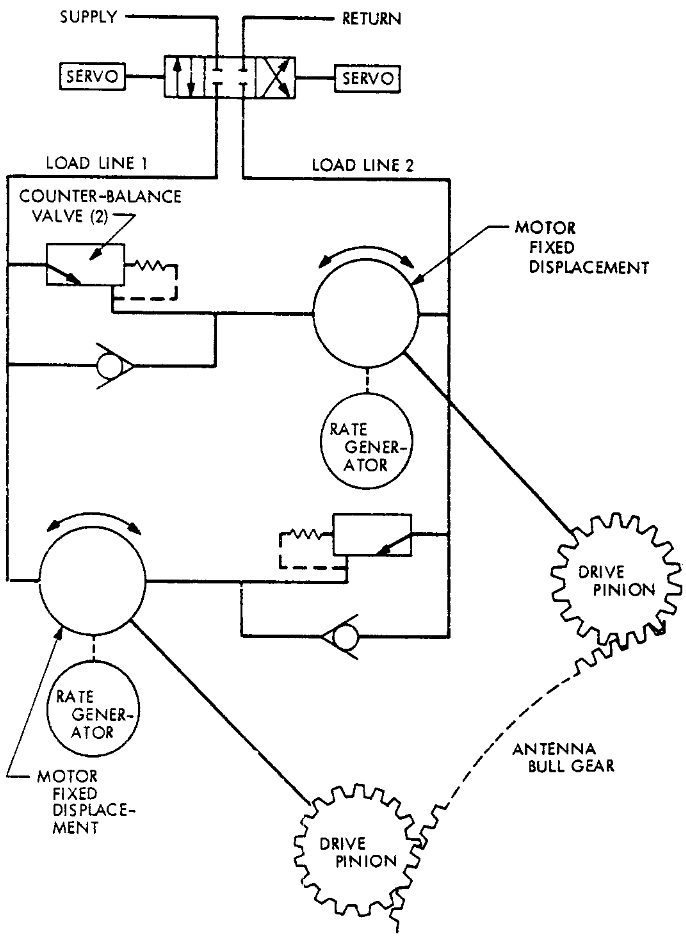

Fig. 1. Hydraulic circuit of HA-dec servo subsystem

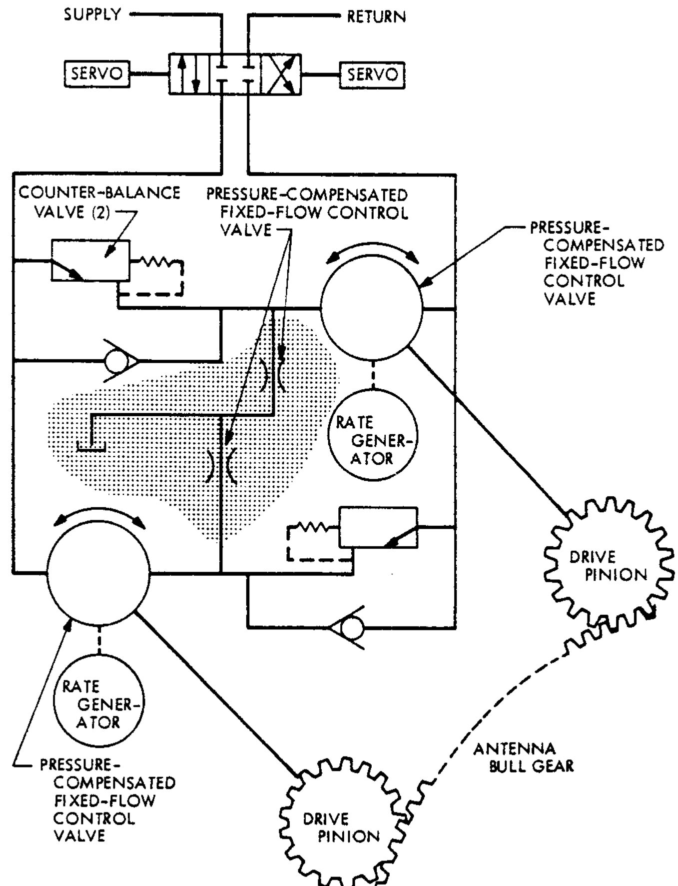

Fig. 2. Pressure-compensated flow control valve