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Ultrahigh Vacuum Linear-Rotary Transfer Mechanism Utilizing A Bakeable Self-Lubricating Bearing*

G.J. COLLET, E.L. GARWIN AND R.E. KIRBY

Stanford Linear Accelerator Center
Stanford University, Stanford, California, 94305

ABSTRACT

An in-vacuo translational-rotational motion based on a ball bearing package is described. Lubrication is accomplished by making the ball retainer from a solid dry lubricant, boron nitride (BN). This eliminates the need to separately coat the balls with lubricant prior to assembly, however, the balls are continuously coated while the bearing is in use.

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I. Introduction

Precise, controllable translational-rotational motion in ultrahigh vacuum is usually accomplished via the use of stacks of edge-welded bellows. This is particularly true when heavy loads are involved and rigid connection between load and driver is required for good control. The disadvantages of such a system are high cost, susceptibility to leaks and the additional length needed to accommodate the compressed bellows length. For long transfer distances, laboratory space can be a limiting factor as well.

Magnetically-coupled systems can be used but only light loads are possible and control, until now, has been poor. Advantages include low-cost, no additional length required and a rigid vacuum wall. Stray magnetic fringe fields can disturb some experiments, however. This paper describes a magnetically-coupled unit which has very good linear-rotational control over small linear distances, over lengths which could be that of a threaded rod screwing into a hole, and coarse linear control over longer distances which might be used in moving a sample from one region of a system to another. A feature of the system is that the bearings need not be coated prior to vacuum insertion but continuously coat themselves during use via a ball separator made from dry lubricant. It must be emphasized that this design has been used extensively for light loads (a few hundreds of grams) and has not been tested on heavier loads.

II. Description

The transfer mechanism is used to move small samples in vacuo between a set of chambers which comprise the Superconducting Materials Surface Studies System.(1) Sample transfers between rods at right angles are accomplished using rods with threaded ends and samples with mating threaded holes in their edges. The screwing-unscrewing operation takes place in vacuum valves equipped with windows. To avoid sample contamination, no thread lubricants are used and, therefore, very fine control is needed to avoid misalignment and cold-welding of the mating parts.

Figure 1 is an exploded cutaway view of the bearing unit and magnet drive. The bearing package components (1-5) are mounted on the transfer rod (6) inside the vacuum tube (7). The rod is supported internally at one end by the bearing sleeve periphery (2) and at other points by v-block units (Fig. 2). The v-block units are distributed throughout the vacuum system for support, where needed. Coupling motion to the transfer rod is provided by a type 440C stainless steel slug (8) which does not touch the vacuum wall (to reduce frictional forces) and an external C-magnet (9).

Construction of the bearing itself is as follows. WC balls (0.48 cm diameter) are constrained about the transfer rod by a boron nitride[2] ball separator (4) and a type 6061 Al alloy retainer (3). The outer bearing sleeve (2) slips over these components, all of which are loosely restrained in the axial direction by the stainless steel slug and the limit stop (1). This looseness allows decoupling of the rotary motion and the fine linear motion from the constraining end stops, and fine control is achieved because the rod is supported by the WC balls riding in the BN separator. BN is an effective dry lubricant[3] for use in UHV and the balls are continuously re-lubricated as they rotate in the separator.

Friction between the transfer rod and the v-blocks is minimized by line contact of the rod with the blocks. The blocks (Fig. 2) are machined into the ends of the rods (10) welded into vacuum flanges. The flanges (and rods) are separated from the wall by a bellows assembly (11). Three threaded rods (12) are welded in a ring which is fastened to the vacuum tube mounting flange with set screws. A heavy stainless steel cylinder (13) with three clearance holes for the threaded rods is set-screwed to the opposite end of the bellows assembly. Circumferential slots in the cylinder serve to capture three pinion gears (14) that have been screwed onto the rods. Positioning of the v-block assembly in the vacuum tube is accomplished by turning all three pinion gears simultaneously using either an internal or external drive gear (15 or 16, respectively). A small ($< 5°$) angular displacement of the v-block assembly can occur if one or two of the pinions are turned independently of the drive gear. These two modes allow movement, as desired, of the main transfer rod inside the vacuum tube in two directions transverse to the transfer rod's axis.

The transfer system has been in operation for five years without need of repair, and the system has been baked repeatedly in vacuo to 275°C. Boron nitride sorbs water rather easily so, when the system is open to the atmosphere, the bearing section is kept at 80-100°C by wrapping heating tapes around the vacuum pipe at the bearing location. No contamination of samples due to BN has been observed by the various analytical techniques (XPS, AES, SIMS, etc.) employed in the system.

ACKNOWLEDGEMENT

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References

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Figure Captions

Fig. 1 Bearing assembly and magnet drive unit. 1 - limit stop, 2 - outer bearing sleeve, 3 - ball retainer, 4 - BN ball separator, 5 - WC balls, 6 - transfer rod, 7 - vacuum wall, 8 - stainless steel slug, 9 - magnet pole piece.

Fig. 2 V-block support unit. 10 - v-block rod, 11 - bellows assembly, 12 - threaded positioning rod, 13 - positioning cylinder, 14 - pinion gear, 15 - internal gear drive, 16 - spur gear drive (optional).

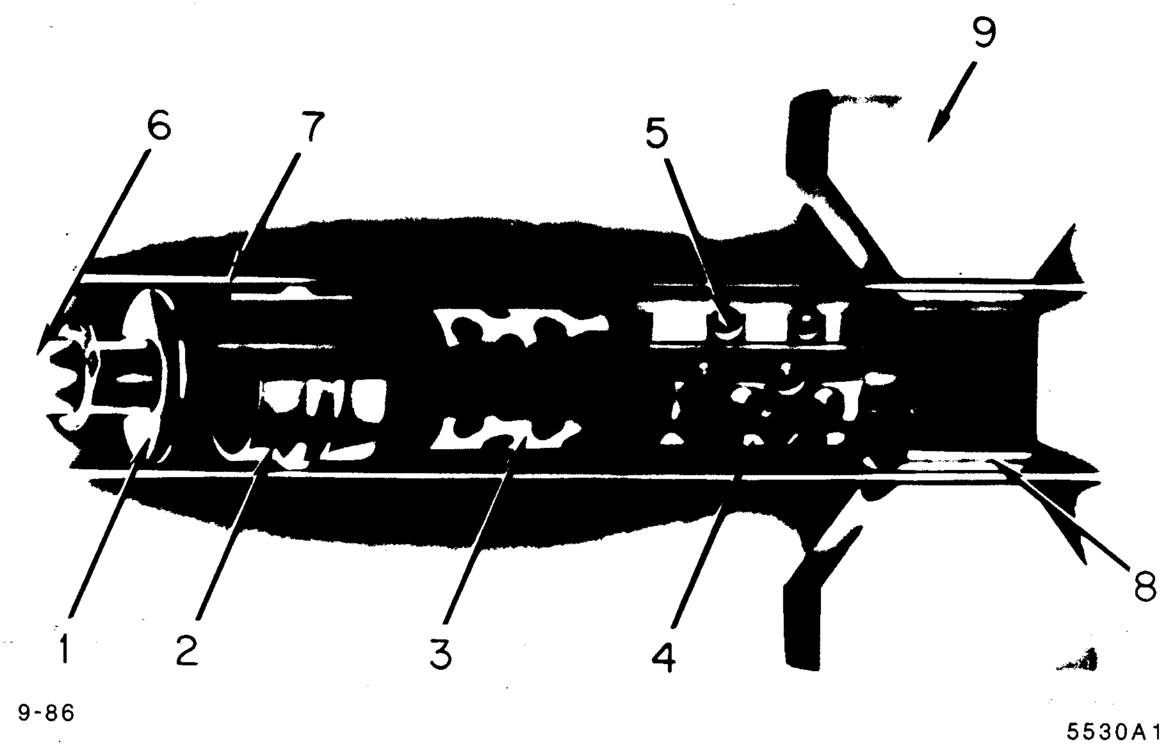

Fig. 1

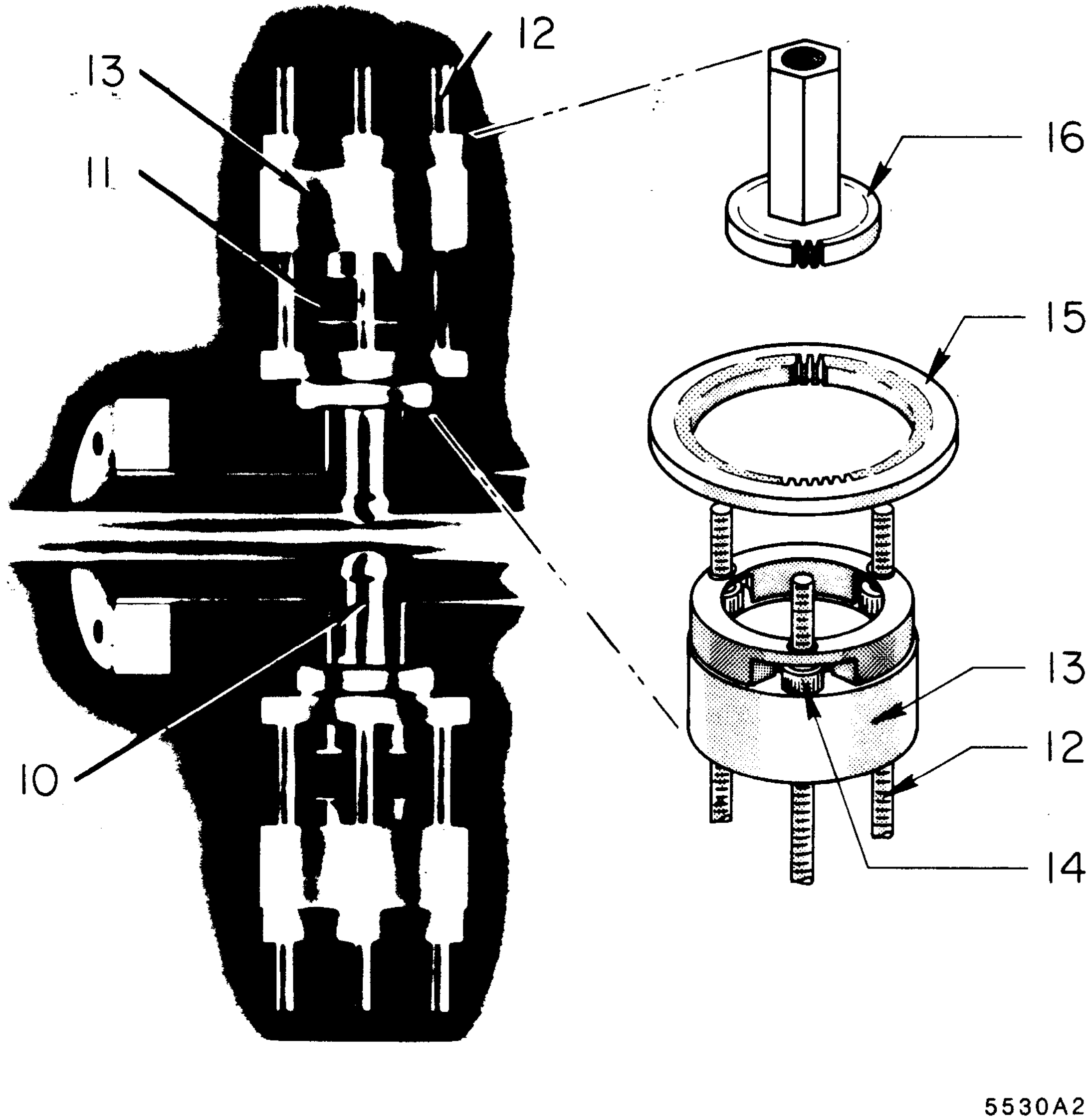

Fig. 2