SHOP NOTES

These are "how to do it" papers. They should be written and illustrated so that the reader may easily follow whatever instruction or advice is being given.

Minimum profile ultrahigh vacuum gate valve based on linear/rotary motion feedthrough

Albert Stolow
Steacie Institute for Molecular Sciences, National Research Council of Canada, Ottawa, Ontario K1A OR6, Canada

(Received 22 November 1995; accepted 2 March 1996)

A simple, very low profile (<1 in.) ultrahigh vacuum gate valve for isolation of molecular beam sources is described. The radial gate drive is based upon a linear/rotary motion feedthrough. A novel coupling scheme is described where the linear motion is used to translate the gate while the rotary motion is used to independently raise and lower the gate. A molecular beam skimmer, mounted on the gate, may be accurately and reproducibly located.

It is often the case in molecular beam experiments that the source (e.g., oven, pulsed valve, etc.) requires servicing more often than other parts of the apparatus. This is particularly problematic in the case of molecular beam sources coupled to ultrahigh vacuum (UHV) chambers because venting entails a lengthy bake-out procedure. Commercially available gate valves may be used to isolate the source region; however, their significant thickness means that the source must be located farther from the interaction region, greatly reducing the flux—which falls off as $1/(\text{distance})^2$. A clever design solution to this problem was presented in terms of a low profile UHV gate valve based upon a sophisticated home-built linear motion feedthrough.[1] The manufacture of this feedthrough demands very tight machining tolerances and the precision welding of small stainless steel bellows. Unfortunately, these requirements may exceed the capabilities of many university machine shops and entail considerable shop expense. In this note, we describe a new minimum profile UHV gate valve with a novel drive mechanism based upon independent linear and rotary motion of the driveshaft. Furthermore, the driveshaft is coupled to a commercially available linear/rotary motion feedthrough, greatly simplifying the manufacture of the gate valve and reducing machining costs. In this design, the linear motion leads to accurate, reproducible (± 0.002 in.) positioning of the gate, whereas rotation of the shaft leads to a completely independent sealing action (i.e., raising and lowering) of the gate. This particular gate valve has been in continuous use in our femtosecond time-resolved photoelectron spectroscopy apparatus[2] for two years. The base pressure in this apparatus is 10^{-10} Torr and, with the gate sealed, it is completely independent of whether or not the source chamber is vented. This allows for rapid and efficient servicing of the source (e.g., about 1.5 h) without affecting the UHV chamber.

A photograph of the gate valve is shown in Fig. 1. The flange is a standard 8 in. conflat flange (thickness 0.88 in.) with a 1.33-in.-diam miniconflat port on one side. The flange is milled to contain the gate and the drive assembly. A 0.75-in.-diam axial bore provides a large clear aperture for the molecular beam. The single Viton sealing O ring may be seen underneath the gate. This O ring limits the bake-out temperature of the gate valve to 150 °C. (An improved design might consider the use of a spring-loaded Teflon gasket). The driveshaft (0.125 in. diameter) enters radially through the port and provides the linear/rotary drive for the two gate motions. The gate provides both the flat surface for sealing the valve and a key to locate a molecular beam skimmer (Beam Dynamics). It is essential that the gate can be located precisely and reproducibly in order to put the molecular beam skimmer in the correct position. The four 0.5-in.-diam holes normally contain four rods (not shown) which

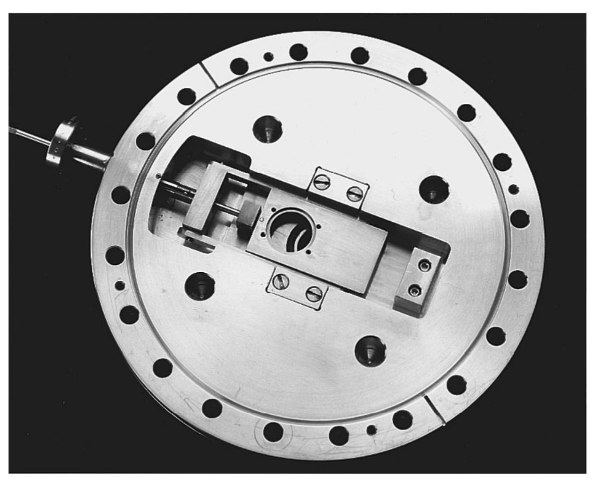

FIG. 1. Photograph of the low profile UHV gate valve on a 8 in. conflat flange. The rectangular gate is shown with the skimmer removed. The sealing O ring can be seen beneath. The linear/rotary driveshaft is seen to enter radially through a miniflange (1.33 in.) port. The gate operation is described in the text.

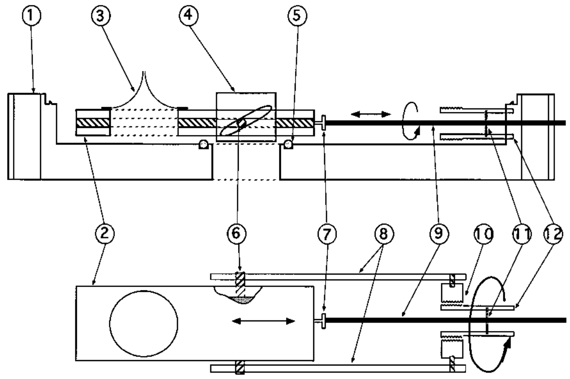

FIG. 2. A schematic illustration of the gate valve components and operation, described in the text. The linear motion of the shaft (9) leads to the positioning (i.e., translation) of the gate (2). The rotation of the shaft leads to a differential motion which lowers and raises the gate. The shaft rotation, coupled through (11), (12), (10) and (8), drives the pins (6) downwards (upwards) in a cam (4), leading to the lowering (raising) of the gate, as described in the text.

positively align the molecular beam source itself (e.g., pulsed valve) to the skimmer axis.

The general principle of the valve operation is based upon two types of motion: a translation to position the gate and a differential (up-down) motion to seal the gate. The components of the gate valve are shown schematically in Fig. 2.

A 8 in. conflat flange (1) is machined to contain the gate (2) and a bore with a dovetail O-ring groove (5), used to seal the valve. The gate also has a bored hole for beam passage when the gate is ''open'' and is machined with mounting holes and a key for a beam skimmer (3). Slots are machined along opposite edges of the gate as clearance for pins (6). These slots allow for translation, but not up-down motion, of the pins (6) relative to the gate. These pins are fixed in two stainless steel arms (8) but extend to the other side of the arms where they are further constrained by milled 30° slots in two side cams (4). A 0.125 in. shaft (9) is introduced radially through a 1.33 in. miniconflat port on the wall of the 8 in. flange (not shown). The shaft is captured in an end bearing (7) on the gate which allows for free rotation—but not translation—of the shaft with respect to the gate. A small carbide pin (11) is pressed into the shaft. This pin translates freely in two slots (not shown) in a tube (12). The tube (12) is externally threaded on one end and captured in an end bearing (also not shown) in the 8 in. flange. The tube is threaded into a stainless steel block (10) that is connected to the stainless steel arms (8) by two additional pins. The arms (8) are located by, but freely rotate on, the pins in the steel block (10). The threaded components (10) and (12) were burnished with dry molybdenum disulfide to provide lubrication. After two years of use, no visible signs of wear are evident.

The linear and rotary motions of the shaft allow for independent translation and raising/lowering of the gate. The operation is as follows, starting with the gate in the raised position. Linear motion of the shaft (9) causes translation of the gate (2) with respect to the 8 in. flange (1). The gate is guided by the pins (6) in the machined slots. The carbide pin (11) slides freely in the slots (not shown) in the threaded tube (12) as the gate is translated. Thus, linear motion of the shaft leads to positioning (opening and closing) of the gate valve.

Sealing of the gate is derived from rotary motion of the shaft, through the carbide pin (11) that turns the threaded tube (12). The tube rotates freely because it is captured in an end bearing in the wall of the 8 in. flange. Rotation of the tube (12) causes the internally threaded block (10) to translate, forcing the two arms (8) to drive the pins (6) along the 30° slots in the cams (4). The motion of the pin (6) along this 30° axis can be resolved into two vector components, one parallel (translating in the slots) and one perpendicular (up–down) to the long axis of the gate, and therefore causes the gate to move in a pure up and down motion, sealing the valve. Thus, the raising and lowering of the gate is completely independent of the position of the gate. This allows for accurate positioning of the gate using shaft translation and then lowering the gate, using the shaft rotation, without altering this position.

The shaft is coupled to a commercial linear/rotary motion feedthrough (e.g., MDC No. 672002) which provides the control over the gave valve, thus avoiding the fabrication and leak-testing of a complex feedthrough. Furthermore, a micrometer on the feedthrough linear motion allow for precise (±0.002 in.) and reproducible positioning of the gate (and, hence, skimmer). This gate valve may be easily scaled and also allows for remote drive: In our case, the gate valve is located at the centre of a large UHV chamber and is operated remotely by bringing a long shaft through the chamber in a stainless steel UHV bellows.

ACKNOWLEDGMENTS

The author thanks E. E. Chaban (Bell Laboratories) for helpful discussions in the initial phase of this project, M. Kotler of NRC Engineering Services for advice, and the NRC Mechanical Components Lab for excellent execution of the design.

[1]E. E. Chaban and J. E. Reutt-Robey, Rev. Sci. Instrum. **64**, 2391 (1993).
[2]I. Fischer, D. M. Villeneuve, M. J. J. Vrakking, and A. Stolow, J. Chem. Phys. **102**, 5566 (1995).