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TECHNICAL BULLETIN

The Magic of MagiDrives

When transmitting rotary motion through some sort of environmental boundary / wall there are a variety of engineering solutions available, from simple O-ring / lip seals as might be used to contain liquids or even vacuum at the medium vacuum level, through to differentially pumped O-rings and Ferrofluidic drives for high vacuum (HV).

However, due to the much more stringent requirements in terms of leak tightness and materials outgassing properties, transmission through a wall into an Ultra High Vacuum (UHV) environment is very much more challenging.

Historically the traditional approach was to use a bellows sealed cracked arm (Fig1), a design dating back to a Charles Litton patent of 1936.

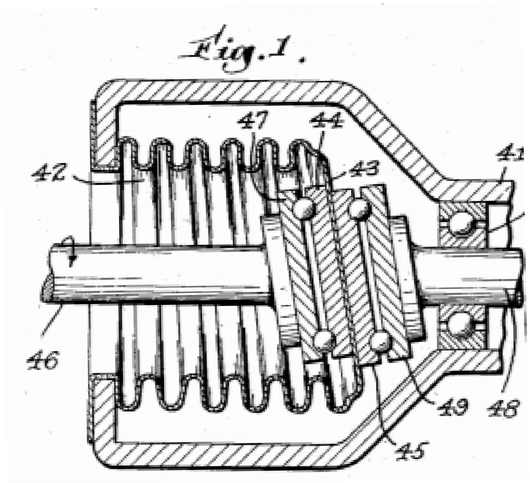

Figure 1: Charles Litton's patented design

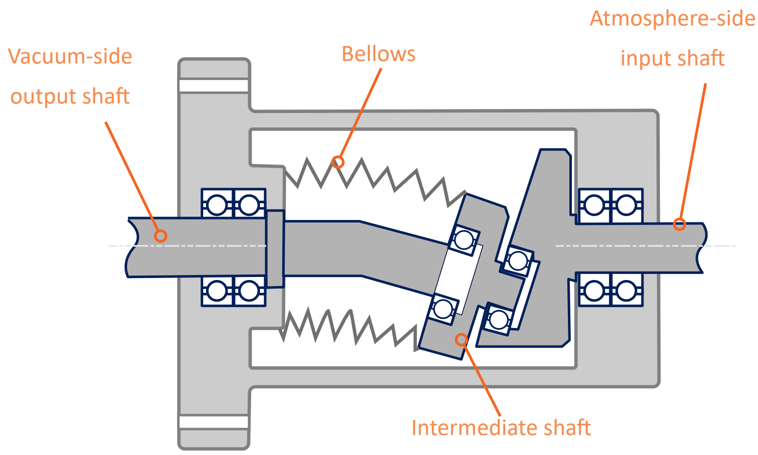

Figure 2: Contemporary design

Many products on the market today still use this approach (Fig2), and it is adequate for the less demanding applications.

The 1970s saw the adoption of magnetically coupled rotary drive mechanisms in the world of vacuum, as had been previously used in hazardous drive applications.

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UHV Design was an early adopter of this technology (Fig3), using the concepts from the company's inception in 1997 and we have been championing the technology ever since, with currently 100s of lines in the product line up, from high torque 40Nm drives on CF100 flanges, to micro drives on CF10 flanges and everything in between.

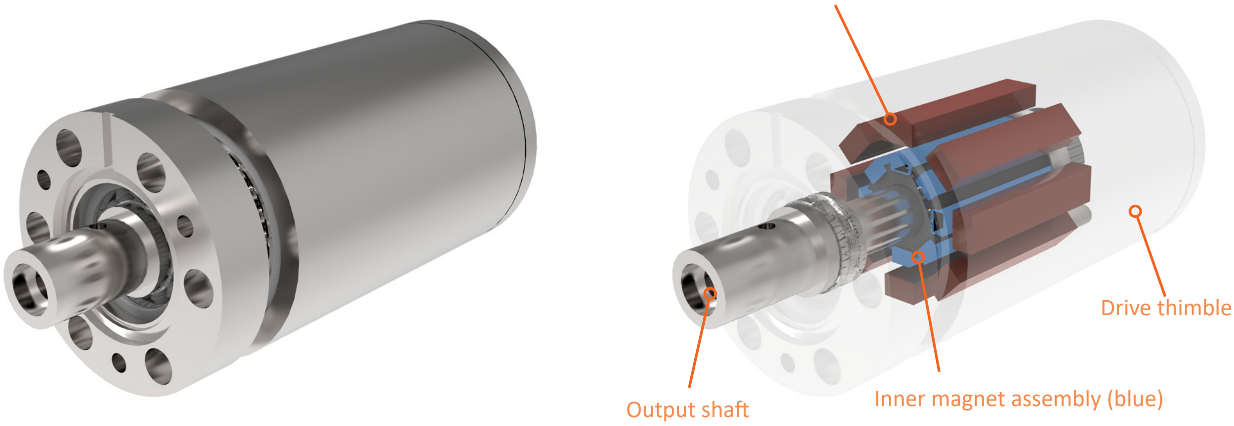

Figure 3:UHV Design's magnetically-coupled rotary drive

Even from the most cursory FMEA type considerations the reasons for our adoption of the MagiDrive concept are obvious.

- The bellows in the coupling of a traditional drive has a lifetime limited by material fatigue, and when it fails there will be a catastrophic venting of the system ….. not an appealing prospect, especially on a large storage ring for example. By contrast the vacuum envelope of MagiDrives is machined from a solid billet and there is no possibility of there ever being a catastrophic vacuum failure.
- In the event of a traditional drive being overdriven severe damage can occur to both bellows, whereas in the case of magnetic coupling, exceeding the breakaway torque will simply result in the drive jumping to the next pole position without causing any damage whatsoever.
- There are half as many bearings inside the vacuum envelope of a MagiDrive. Internal bearings being dry lubricated are the most likely elements to fail. Twice as many bearings increase the probability of failure dramatically (22x). In a MagiDrive there are only 2 internal bearings.
- The effect of the mechanical clearances in all these bearings in a traditional drive results in a mechanical backlash which renders the concept unsuitable for very precise applications. MagiDrives are in principle completely free from backlash. Although highly variable loads can result in magnetic stretch, but this is not irreproducible, as is the case with backlash.
- For motorised applications UHVD have recently produced a new product, called the Hypoid Drive to further take advantage of the intrinsically low mechanical backlash of these MagiDrive devices. Although the MagiDrives have this very desirable property of zero backlash, when they are motorised, the backlash of the gearbox becomes the limiting factor. Even expensive planetary gearboxes will have a backlash of 6-12 arc mins ~ 0.1º - 0.2º .

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To overcome this problem UHV Design have developed a large bore MD35 hollow MagiDrive (Fig4), where the motorisation and speed reduction are accomplished using a single tightly meshed hypoid gear-set.

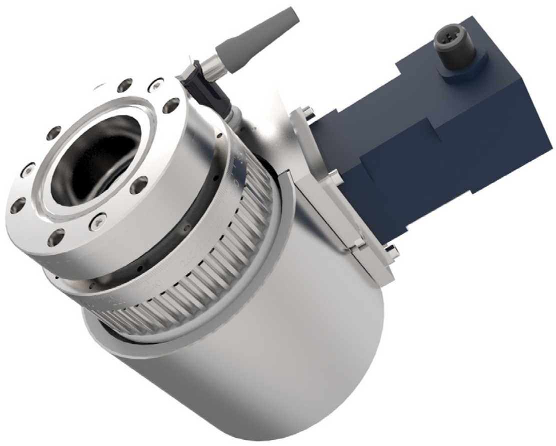
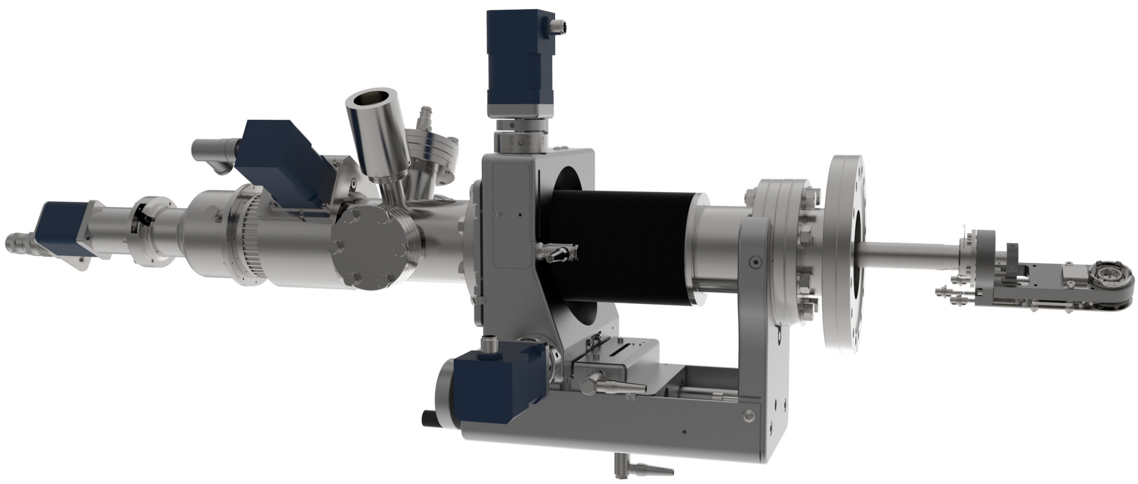


Figure 4:MD35LB with hypoid gear option

Using this concept, angular reproducibilities are typically <0.02º, 10x better.

This is an important figure of merit for users of our MultiCentre manipulators for example. These stages are used on surface analysis instruments to perform various angle resolved experiments such as X-ray Photo-electron Diffraction (XPD) where such precision is key.

Shown below is one such stage where two such drives are shown 'stacked' in order to provide both the primary rotation (sample tilt), and secondary rotation (azimuthal) in a compact format. This also demonstrates an additional beneficial aspect of hollow MagiDrives, which is the ability to stack multiple drives co-axially to provide multiple rotary motions concentrically.



XL-T | 5-axis manipulator utilising hollow and solid magnetically-coupled rotary drives to provide Polar (R1) and Azimuthal (R2) rotation

The drive assembly also has built-in adjustable limits switches and a opto home sensor, and the whole motorisation assembly is easily demountable for bakeout.

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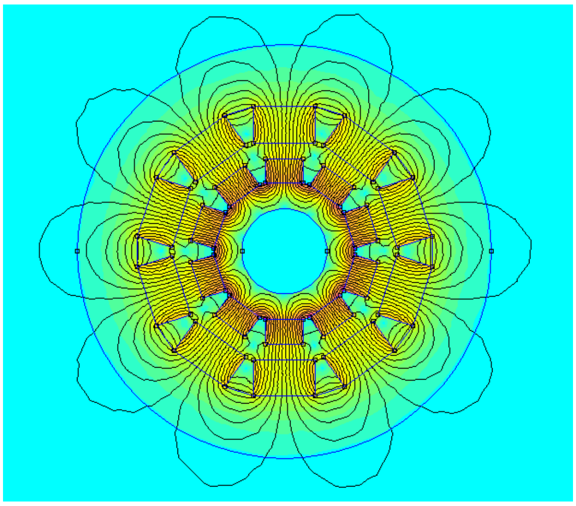
Magnetic Fields

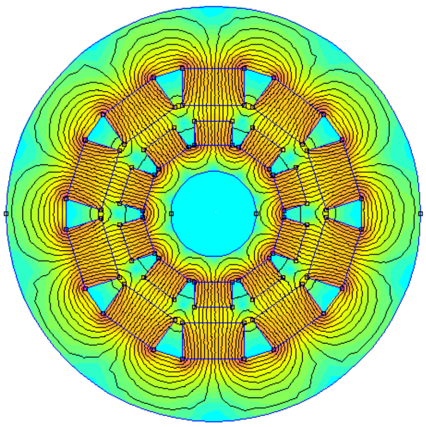
Sometimes people have expressed concerns about the magnetic field leakage from a device that contains very strong rare-earth magnets and which may therefore influence experiments, typically where measurement with low energy electrons are concerned.

This is something that we have always been conscious of and have factored into the designs of all our devices. Essentially the outer thimble is made from a martensitic stainless steel which has low coercivity, low remnant field, and high susceptibility (μ_r). The thimble therefore effectively closes the magnetic circuit thereby minimizing the field leakage.

This is illustrated below using some FEA software models. The image on the left shows the magnetic field lines when using a low μ_r thimble material and the field lines can be seen bursting out through the thimble. In the right hand image the same model is shown but using a high μ_r material which contains almost all the magnetic field.



Low μ_r thimble material



High μ_r thimble material

Obviously, any fields that do leak will have components in many directions so it is not easy to quote precise numbers, but as a general rule of thumb we design all our drive such that the total magnetic field leakage is always less than the earths ambient field (typically ~400mGauss) at distances >/= 50mm.

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FOR MORE INFORMATION

Please contact us via sales@uhvdesign.com or telephone +44(0)1323 811188 to discuss our MagiDrive range in more detail.

For more information on our complete range of UHV manipulation products please visit our website: www.uhvdesign.com which includes our unique product configuration tool that enables all of our standard products to be viewed, configured and emailed directly as a 3D CAD file.