secured to the insides of first member **38***b*. Magnetically-controllable medium **34***b* is retained by the elements **46***b*. Upon energizing the magnetic field generator **42***b* by providing electrical current to lead wires **53***b* which interconnect to a coil **48** wound about the first member **38**, a magnetic flux **44** is created which is carried by the first member **38***b* and traverses the elements **46***b* retaining the medium **34***b*. This energization changes the rheology of the medium and creates a resistance force that acts to prevent relative rotation between the members **38***b*, **40***b* thereby providing resistance forces to the operator **22**.

[**0078**] Referring to FIGS. **5**-**7***b*, another embodiment of the present invention comprises haptic interface unit **155** (control unit and amp not shown for clarity) utilizing a pair of magnetically-controllable devices **24** as described above with reference to **FIG. 4***a*. **FIG. 1D** illustrates the joystick located in a vehicle where monitor **30** displays operating characteristics of the vehicle. Alternatively, the brakes shown in **FIG. 4***b* may be used. For clarity, some of the components of device **155** are not shown or shown separately, such as a pair of sensors **32** one of which is shown in **FIG. 7***b*. In this embodiment, each magnetically-controllable device **24** is adapted to apply resistance forces to haptic interface device **26**, such as a Gravis Pro joystick, through drive mechanism **122**.

[**0079**] Drive mechanism **122** is in communication with haptic interface device **26** through first **124** and second **126** plates that translate in a y and x direction, respectively, responsive to the movement of the haptic interface device. Each plate **124**, **126** comprises a groove **128** and **130** (**FIG. 7**) within which post **132** at the base of haptic interface device **26** moves. The post **132** is secured to, or integral with, the interface device **26** and moves with the interface device **26** about pivot **125**. The movement of post **132** within the grooves **128**, **130** resolves the motion of haptic interface device **26** into its respective y-direction and x-direction components. Each plate **124**, **126** transfers its linear motion, corresponding to the y or x directions, through first **134** and second **136** wheels, respectively, which are fixedly attached to respective shafts **138**, **140**. As such, the linear motion of plates **124**, **126** is converted to rotational motion in shafts **138**, **140**.

[**0080**] The rotational motion of shaft **138**, **140** is then provided to each magnetically-controllable device **24** through respective engaging members **106** in contact with respective third **142** and fourth **144** wheels, fixedly attached to shafts **138**,**140**. Further, each shaft **138**, **140** has one end rotatably mounted in housing **146** and the opposite end rotatably mounted in panel **148**. Housing **146** and panel **148** may be manufactured from a variety of materials, such as plastics or metal. Legs **150**, typically provided in four places, fixedly attach housing **146** and panel **148** and provide a base upon which interface unit **155** stands. Thus, the pair of magnetically-controllable devices **24** are able to apply semi-active, variable resistance forces to oppose movement of haptic interface device **26**, such as a joystick, through drive mechanism **122**.

[**0081**] It should be recognized that the housing **146** and panel **148** are merely exemplary and any suitable housing and support means may be utilized. Further, depending upon the torque achievable in the respective devices **24**, the shafts **138** may be directly attached to devices **24**. Moreover, other types of power transmission or gearing arrangements other than spur gears may be utilized, such as bevel gears, helical gears, worm gears and hypoid gears. Springs (not shown) may be provided that connect between the haptic interface device **26** and the housing **146** to spring bias the device in all directions and provide a return spring function, i.e., center the device.

[**0082**] Signals representative of the x and y motions are provided by respective sensors **32** including arm **82** received in recesses **84** in the plates **124**, **126**. Movement of the plates **124**, **126** in the respective x and y directions rotates the respective arms **84** of sensors **32**, which are preferably rotary potentiometers. This produces a signal corresponding to x and y motion which is processed by the control system to provide force feedback signal to the respective device **24**. The one or more buttons or triggers **79***a*, **79***b* shown send additional signals to the control unit **54** (**FIG. 1**).

[**0083**] **FIG. 8** illustrates another embodiment of haptic interface unit **255** with the cover portion of housing removed for clarity. The unit **255** comprises a haptic interface device **26** pivotally moveable to cause movements in the respective x and y directions or any combination thereof. Such movements of the device **26** cause respective movements in rack and pinion assemblies **86***x*, **86***y*. interconnected to respective magnetically controllable devices **24***x*, **24***y*. Assemblies **86***x*, **86***y* include a rack **87** and pinion **106**. The rack **87** includes projections **91** which slide in slots **89** formed in the housing portion **246** thereby restricting motion to only along the z direction. A spherical ball **93** mounted on extension **83** is received in guide **95** formed in the haptic interface device **26**.

[**0084**] Movement of the device **26** in the x direction, for example, pivots the device below flange **97** about a pivot point (not shown) and causes guide **95** to engage ball **93** to move rack **87***x* in the z direction. Likewise, movement of device **26** in the y direction causes guide **95** to engage ball **93** and move rack **87***y* in the z direction. Any z movements of racks **87***x*, **87***y* cause teeth **85** on the outer surface of racks **87***x*, **87***y* to engage teeth on pinions **106***x*, **106***y*. This rotates respective shaft **104***x*, **104***y* (not shown) and fixedly secured second members **40***x*, **40***y* of magnetically controllable devices **24***x*, **24***y*.

[**0085**] Sensors **32***x*, **32***y* generate signals representative of the x and y movements through utilizing rack assemblies similar to that described in **FIG. 8***b* where a moving component of sensor **32***x*, **32***y* is interconnected to the rack (e.g. **87***s*). Coils **48***x*, **48***y* are selectively energized to produce a magnetic flux in U-shaped first members **38***x* whose legs straddle the second member **40***x*, **40***y*. A magnetically controlled medium (not shown) is included between the respective legs and the second member **40***x*, **40***y* as shown in **FIG. 4***b* and is preferably retained in an absorbent member as described therein. The control system **28** in response to position signals from leads **53***x*', **53***y*' controls the effective resistance generated by devices **24***x*, **24***y* by supplying signals to leads **53***x*, **53***y*.

[**0086**] Referring to **FIGS. 9 and 10**, another embodiment of a magnetically-controllable device **24** comprises a first member **38** having a u-shaped body that receives second member **40** at its open end **160**. An absorbent element **46** is disposed in each working space **36** between first member **38** and second member **40**. Each absorbent element **46** contains magnetically-controllable medium **34**. Magnetic-field generating device **42** is disposed about closed end **162** of second member **40**, and creates a magnetic field through magnetically-controllable medium **34**, as represented by flux lines **44**, upon energization by controller **28** (**FIG. 1**). Magnetic-field generating device **42** is connected to controller **28** by