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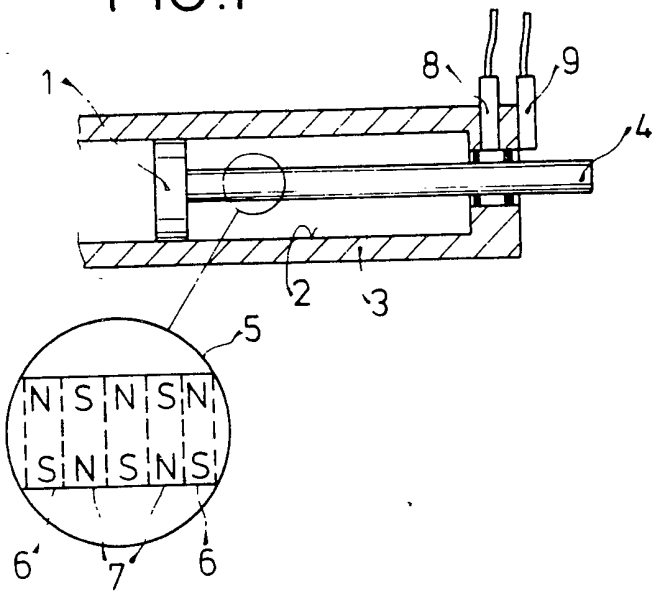
(54) **Magnetic measurement of position and/or speed of a piston**

(57) A plurality of alternately differing magnetic fields (6, 7) are provided in a piston rod 4 alternating in the direction of movement thereof, and magnetic-field dependent generators (8, 9) are disposed on a stationary part, such as the cylinder or a member which extends within a hollow piston rod Figure 4 (not shown). The magnetic field variation can be of polarity or magnitude.

FIG.1



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1/2.

FIG.1

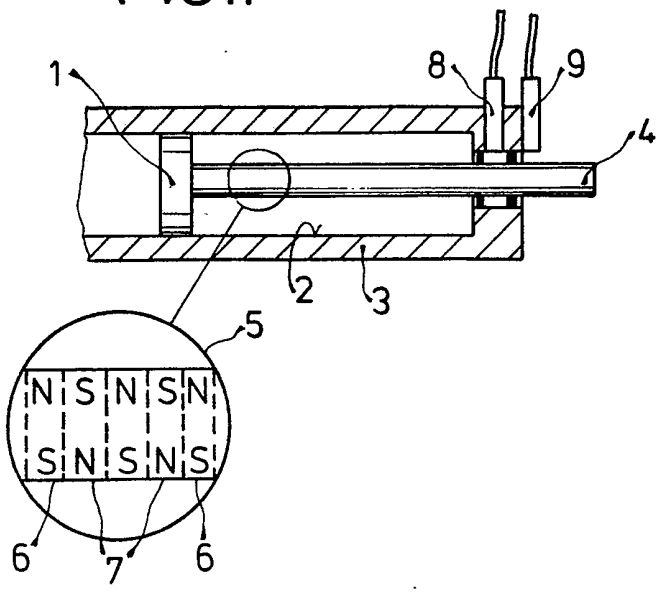


FIG.2

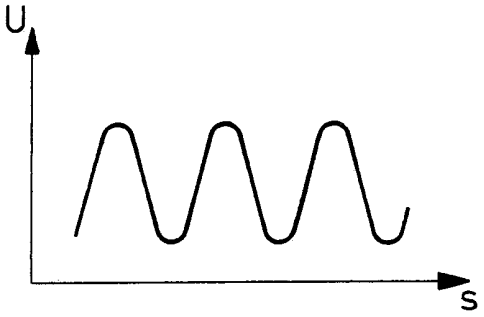


FIG.3

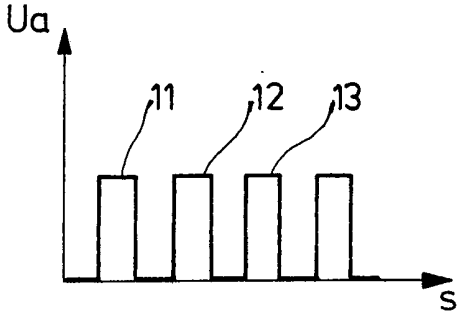


FIG.4

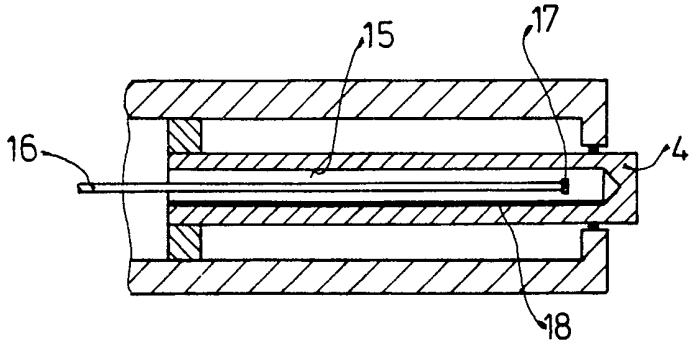


FIG.5

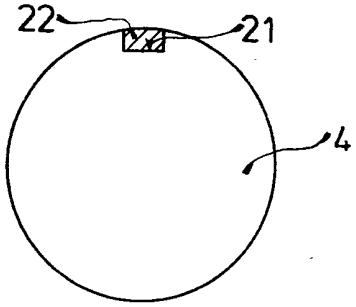


FIG.6

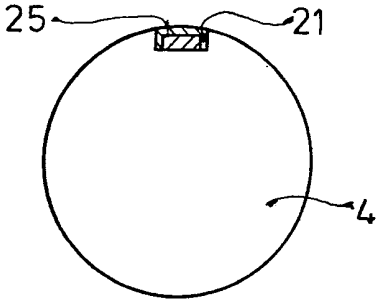


FIG.7

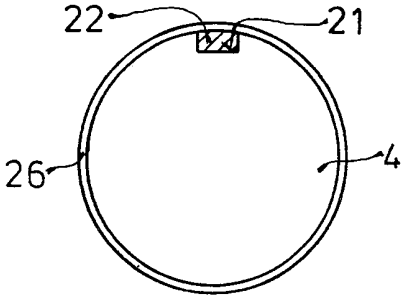
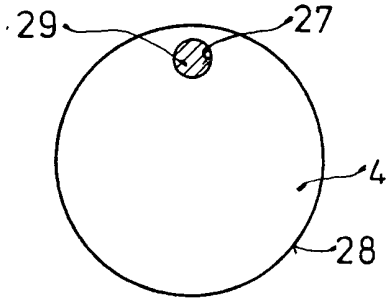


FIG.8



SPECIFICATION

Device for the contactless measurement of position and speed

The invention relates to a piston and cylinder device having means for the contactless measurement of the position and/or speed of the moving part of the device.

The control and regulation of piston and cylinder devices, particularly hydraulic and pneumatic units, requires a measuring means by which the instantaneous position and speed of the moving part can be detected. For reasons of wear, it is desirable to be able to sense the measured value in a contactless manner.

In accordance with the invention, this object is achieved in that the moving part carries a plurality of different magnetic fields which alternate in the direction of movemnt of the moving part, and that a magnetic-field-dependent generator is arranged on the stationary part. In a further development of the invention, it is particularly advantageous to dispose north and south poles in an alternating sequence on the surface of the moving part.

Further refinements are disclosed in the illustrated embodiments which will be described hereinafter with reference to the accompanying drawings.

In the drawings:

Figure 1 shows, in accordance with the invention, a hydraulic or pneumatic cylinder in an axial, longitudinal section,

Figure 2 is a graph of the characteristic of a position-dependent voltage U when using a Hall generator as a magnetic field dependent generator,

Figure 3 is a graph relating to another generator, and

Figure 4 shows another embodiment having a hollow-bored piston rod.

Figures 5 to *8* are cross sections through a piston rod having magnetic materials arranged in different ways.

In the embodiment of Figure 1, the piston 1 of a hydraulic cylinder 3 is guided in a working bore 2 of the cylinder 3 and is mounted on the end of a piston rod 4.

As is shown by the portion of the piston rod drawn to an enlarged scale and indicated at 5, the surface of the piston rod 4 has a plurality of magnetic zones 6 and 7 which are disposed one behind the other in the direction of movement of the piston rod and which are produced in the piston rod, made from magnetizable material, by polarization extending transversely of the longitudinal direction. In the illustrated embodiment, each individual zone 7 is polarized in the opposite direction to that of its adjacent zone 7.

Two magnetic-field-dependent generators 8 and 9, which in the illustrated embodiment can comprise Hall generators, are located opposite the surface of the piston rod 4 which is magnetically polarized in this manner. Each of the Hall generators generates an output voltage whose magnitude and direction are dependent upon the magnetic field prevailing at the sensing location. The sinusoidal characteristic of the output voltage U (shown in Figure 2) of the Hall generator 8 is then produced in dependence upon the distance *s* covered by the piston. The second Hall generator 9 can be disposed in the cylinder wall 3 so as to be offset in the axial direction of the cylinder, such that its distance from the first Hall generator 8 corresponds to half a pole pitch of the differing magnetic zones 6 and 7, and thus the second Hall generator likewise generates over the distance *s* a sinusoidal voltage which, however, is dephased electrically by 90° relative to that of the first Hall generator and consequently indicates whether the piston 1 is moving forwardly or backwardly.

The pulse-shaped characteristic of the indication voltage Ua illustrated in Figure 3 can be generated by using reed contacts as magnetic-field-dependent generators which close when the magnetic field acting upon them reaches a predetermined minimum intensity. The individual pulses 11, 12, 13 etc. can be fed in a simple manner to a memory or to a digital counter (not illustrated) which, in accordance with the number of pulses stored, indicates the position reached at any given time.

In the embodiment of Figure 4, the piston rod 4 of the hydraulic device (not otherwise illustrated) incorporates a central longitudinal bore 15 into which extends a stationary sensing rod 16 whose free end carries a magnetic-field-dependent generator, a Hall generator 17 in the illustrated embodiment. A seperately manufactured magnetic strip 18 is disposed on the wall 15 of bore and parallel to the axis (not designated) at the bore. In the same manner as is indicated at 5 in Figure 1, the magnetic strip incorporates north and south magnetic poles which alternate in the direction of movement and which generate in the Hall generator a positive or negative and weak or strong output voltage according to the position of the piston rod.

If it is not possible to make the piston rod from a material in which the magnetization is reliably maintained for the life-time of the device, it is also possible, as is shown by the embodiments of Figure 5 to 8, to introduce into the piston rod 4 a special magnetic material whose fields can be sensed externally by magnetic-field-dependent generators 8 and 9 in the manner shown in Figure 1.

In detail, in the embodiment of Figure 5, a groove 21 is milled along a peripheral surface line of the piston rod 4 which is of circular cross section and which is made from magnetizable or non-magnetizable material. A magnetic material 22 is placed into the groove 21 and its free outer surface is provided with an alternating magnetic field of the kind indicated at 5 in Figure 1.

In the embodiment of Figure 6, a longitudinal groove 21 is milled in the piston 4 which is also made from magnetizable or non-magnetizable material, although, in contrast to Figure 5, the outside 25 and the longitudinal sides of the magnetic material placed into the groove are additionally encased in non-magnetic material, so that the magnetic material can be better connected to the piston rod and, together therewith, can be ground to obtain a smooth surface. This is particularly advantageous when the magnetic material used is relatively soft as in the case of, for example, plastoferrites.

In the embodiment of Figure 7, a magnetic material 22 is placed into the longitudinal groove 21 in the same manner as in Figure 5, the outside of which magnetic material follows the contour of the cylindrical piston rod 4 and is retained by a shrunk-on, thin-walled tube 26 made from non-magnetic material.

In the embodiment of Figure 8, the piston rod 4 made from non-magnetizable material incorporates a bore 27 which is parallel to the longitudinal axis of the piston rod and which is close to the outer periphery 28 of the piston rod 4 and accommodates an inserted, transversely magnetized magnetic material 29.

In all the embodiments of Figures 5 to 8, the magnetic material is magnetized with alternate polarities at short distances apart and, with respect to one or several magnetic generators of the kind shown at 8 and 9 in Figure 1, results in an alternating magnetic field which, upon adjustment of the piston rod, leads to position-dependent output voltages from the generator or generators. The special advantage of the device in accordance with the invention resides in the fact that it can measure position or speed with a resolution of approximately 1mm, and that the device can be constructed in a simple manner and renders it possible to perform measuring operations in a trouble-free manner at locations to which it is difficult to gain access.

It will be understood that instead of using alternatively poled magnetic fields, magnetic fields of different strength could be used i.e. to give relatevly strong and weak fields.

CLAIMS

1. A piston and cylinder device comprising means for the contactless measurement of speed and/or position of the moving part of the device, wherein said means comprises a plurality of alternatively differing magnetic fields provided in the moving part of the device and alternating in the direction of movement thereof, and a magnetic-field dependent generator disposed on the stationary part.

2. A device as claimed in claim 1, wherein at least two generators are disposed one behind the other in the direction of movement.

3. A device as claimed in claim 1 or 2, wherein north and south magnetic poles are disposed in an alternating sequence on the surface of the moving part.

4. A device as claimed in claim 1 or 2, wherein the moving part, has a plurality of magnetically relatively weak and strong zones which alternate in the direction of movement of the part.

5. A device as claimed in any of the preceding claims wherein the moving part incorporates a recess which extends in the direction of movement and which accommodates a rod which is made from magnetizable material and which incorporates in its longitudinal direction said magnetic fields.

6. A device according to any of the preceeding claims wherein the moving part is the piston of the device.

7. A piston and cylinder device comprising means for the contactless measurement of the position and/or speed of the moving part of the device, substantially as hereinbefore described with reference to the accompanying drawings.

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