

CHAIN CODE POSITION DETECTOR

This application claims benefit of Provisional No. 60/139,447 filed Jun. 16, 1999 and also claims benefit of Ser. No. 60/138,244 filed Jun. 9, 1999.

BACKGROUND OF THE INVENTION**1. Field of the Invention**

The invention generally relates to an apparatus for measuring the position of a moving member relative to a stationary member and, in particular, a scale on a rod of a linear motion cylinder (having a rod, housing, gland and driving element such as a piston or rotor) and a detector on the cylinder housing for detecting the scale to indicate the position of the rod relative to the housing, thus detecting the length of the cylinder.

2. Description of the Prior Art

Computerized motion control of actuated cylinders requires rod position and velocity measurements. These measurements must be accurate, repeatable and have sufficient resolution for the particular application. Many applications also require the measurement to be cost effective, easily redundant, immune to mechanical noise and insensitive to debris. The problems with measuring the position of a rod of a linear motion cylinder are particularly acute. Current hydraulic cylinder measurement practice uses either string encoders with multi-turn potentiometers, linear potentiometers or magnetostrictive devices. All of these approaches can be problematic for commodity applications. Magneto-strictive devices are expensive and require either hollow rods or extensive external mountings. On the other hand, string encoders are less expensive but are frail, are subject to animal damage, and are degraded by mechanical noise. Linear potentiometers are length limited and subject to mechanical noise.

SUMMARY OF THE INVENTION

The apparatus of the invention has several advantages over the prior art including instant position detection, increased resolution, inherent redundancy, low maintenance, and vibration tolerance. The apparatus of the invention addresses many of the hydraulic cylinder position measurement problems-to provide an excellent solution in that area as well as in any area where position detection is required. Furthermore, according to the invention, the general approach can be applied to other position measuring problems where one element moves along another.

The invention measures the position of the cylinder rod by observing a scale having sequences of coded marks on the cylinder rod. The cylinder rod presents a rigid base for scales and is thus resistant to mechanical vibration. The scales are inexpensively applied to the cylinder rod through such techniques as photo engraving or laser marking. Preferably, the detector for detecting the sequences of coded marks comprises an array of detectors such as an electronic camera. The detector preferably takes multiple readings of the sequence so that the resultant information is resistant to sporadic errors. From a manufacturing standpoint, the detectors are structured to be replicated on a consistent basis to enhance system reliability.

Preferably the invention employs a stationary detector on the cylinder housing and a scale (preferably illuminated) having a code marked on the cylinder rod which code does not repeat itself within a desired range. For example, the scale may use a chain code to provide an absolute position

while viewing a minimum length of the scale. The detector uses the two-dimensional array of detector elements to detect the image of the scale. A lens or other focusing device may be used to transfer the image to the detector. The multiple detector elements provide multiple signals which, when evaluated, provide redundancy, error tolerance and improved resolution.

In one form, the invention comprises a device for sensing the position and velocity of a movable member which moves along an axis relative to a stationary member. A scale encompassing a nonrepeating code is on the movable member aligned substantially along the axis of movement. A detector is fixed to the stationary member and positioned to sense a portion of the scale. The detector generates a plurality of signals, each signal indicative of the portion of the scale sensed by the detector. A controller determines the position of the movable member relative to the stationary member as a function of the signals.

Other objects and features will be in part apparent and in part pointed out hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side perspective view of a cylinder housing having a detector thereon and a cylinder rod having a scale thereon according to the invention.

FIG. 1A is a schematic side view of one preferred embodiment of an aerial work platform machine according to the invention.

FIG. 2 is a block diagram of one preferred embodiment according to the invention of an imager and related components for processing a data signal provided by the imager.

FIG. 3 illustrates one preferred embodiment according to the invention of a scale having an 8-bit chain code.

FIG. 4 illustrates other preferred embodiments of scale codes according to the invention.

FIG. 5 is a schematic illustration of one preferred embodiment according to the invention of a zero clearance detector.

FIG. 6 is a schematic illustration of one preferred embodiment according to the invention of a detector having a pin hole lens.

FIG. 7 is a plan view of the front of the detector illustrating the pixel arrangement.

FIG. 8A is a waveform diagram of one preferred embodiment according to the invention wherein the scale marks are perpendicular to the axis of movement and the detector is read along the length of the scale marks perpendicular to the axis of movement.

FIG. 8B is a waveform diagram of one preferred embodiment according to the invention wherein the scale marks are perpendicular to the axis of movement and the detector is read along the direction of the axis of movement.

FIG. 9 illustrates various waveforms relating to the detector output of one row of detectors.

FIG. 10 is an illustration of interpolation according to one preferred embodiment of the invention.

FIG. 11 illustrates a partial side view of a cylinder position detector with self focusing lens arrays.

The Appendix describes one preferred embodiment of the invention for processing signals according to the invention of FIGS. 6 and 8A.

Corresponding reference characters indicate corresponding parts throughout the drawings.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Referring to FIG. 1, a partial schematic perspective view of one preferred embodiment of a linear motion cylinder