US012392422B2

(54) **VALVE HAVING A POSITION SENSING MEANS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(57) **ABSTRACT**

A valve has a position sensing mechanism including at least one Hall sensor and a signal transmitter, wherein the Hall sensor senses magnetic field components in a first measuring direction and in a second measuring direction orthogonal thereto, wherein the two measuring directions are arranged in a planar measurement zone of the Hall sensor. The signal transmitter is an axially polarized magnet which is arranged on a valve tappet linearly displaceable along an axis of movement such that the poles thereof lie in the axis, wherein the axis runs parallel to the first measuring direction and at a distance from the measurement zone along a surface normal of the measurement zone. An imaginary centerline is defined on the measurement zone through a center of the measurement zone and along the first measuring direction, wherein the axis is arranged at a distance from the imaginary centerline along the second measuring direction.

10 Claims, 3 Drawing Sheets
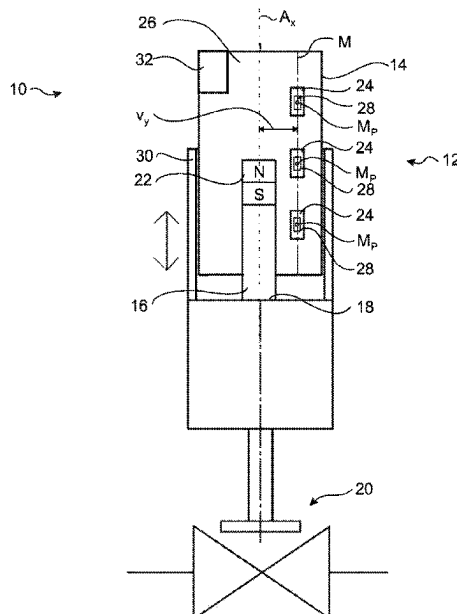
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Fig. 1
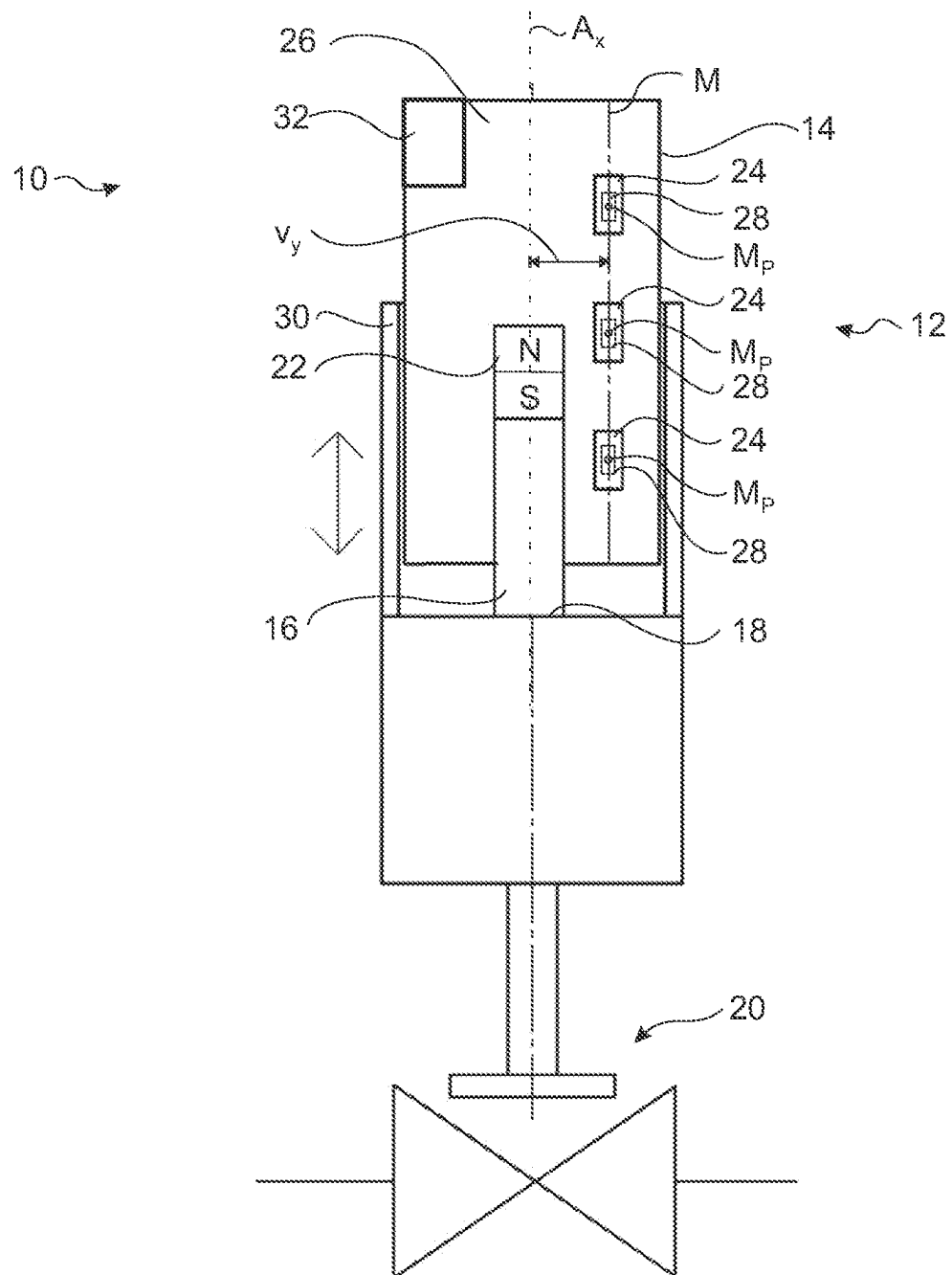
Fig. 2
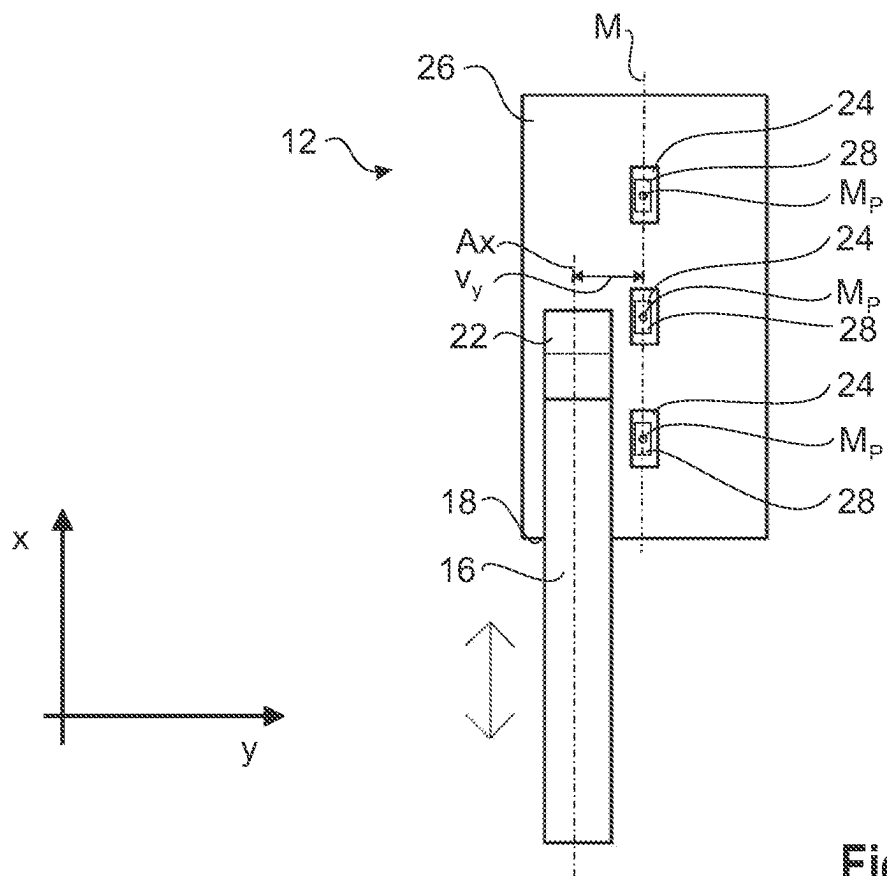
Fig. 3

Fig. 4

Fig. 5

Position (x)

VALVE HAVING A POSITION SENSING MEANS

FIELD OF THE INVENTION

The invention relates to a valve having a position sensing means.

BACKGROUND

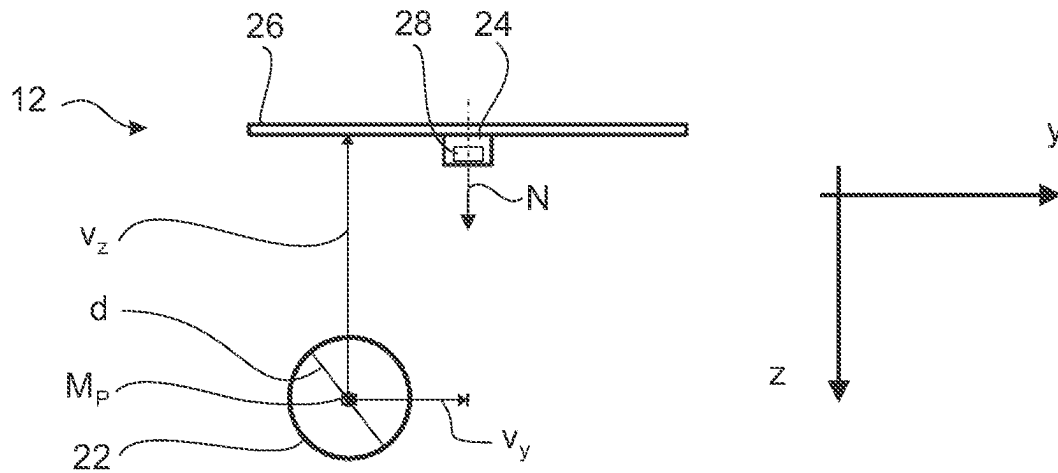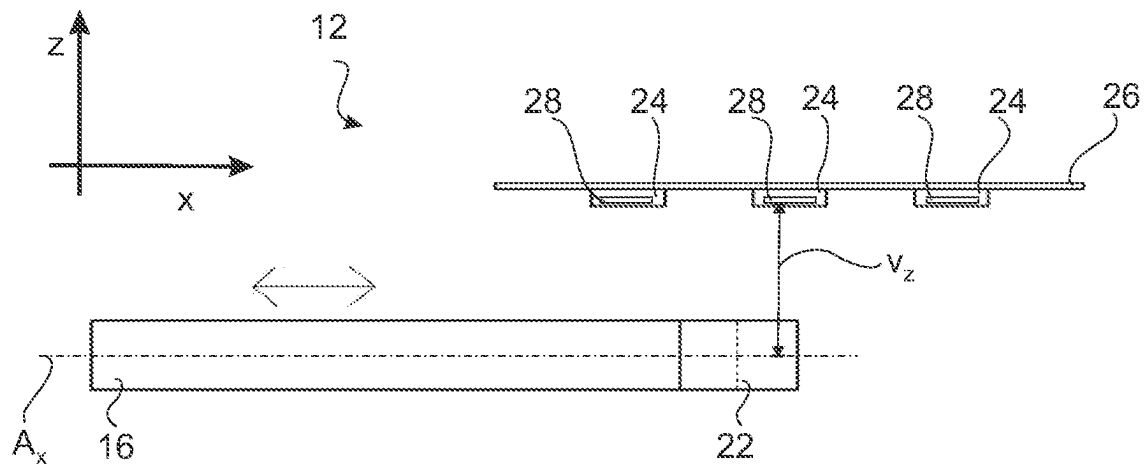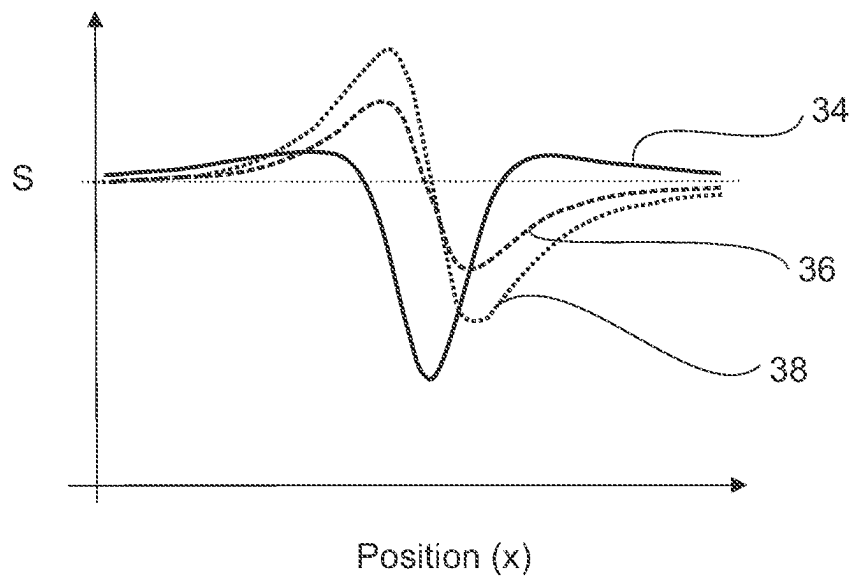To sense the position of a valve element and thus determine the state of the valve with respect to an open or closed position, it is known to arrange a magnet as a signal transmitter on a linearly movable valve tappet connected to the valve element, which moves in the sensing range of a Hall sensor. The measurement signal generated in this way in the Hall sensor is used to determine the position.

The signal strength of the measurement signal varies greatly with the distance at which the magnet passes the Hall sensor, so that the smallest possible distance is normally selected to obtain the highest possible signal amplitude. Therefore, the Hall sensor is usually positioned as close as possible to the magnet, and the measurement zone thereof is aligned centrally to the axis of movement of the magnet so that a surface normal extending from a centerline of the measurement zone intersects the axis of movement.

In the case of Hall sensors which measure a movement in three spatial directions perpendicular to each other, an axial movement of an axially polarized magnet in such an arrangement results in a measurement signal for the direction of movement (hereinafter also referred to as the x direction) and in a measurement signal for the direction from the magnet to the Hall sensor along the surface normal of the measurement zone (hereinafter also referred to as the z direction). Due to the course of the magnetic field lines, no or only a very small signal is measured for the third spatial direction, which is perpendicular to the first measuring direction in the plane of the measurement zone (also referred to as the y direction in the following).

To evaluate the measurement signals, it is known, for example, from DE 10 2018 203 884 A1 to form the quotient of the two measurement signals obtained and to apply a sigmoid function, for example an arctangent function, to this result for linearization.

Due to the manufacturing process, the properties of the partial sensors for the individual spatial directions, such as sensitivity, offset and drift, vary in the case of Hall sensors integrated in semiconductor chips. Here, the x and y partial sensors arranged on the surface of the Hall sensor have similar properties, while the properties of the z partial sensor directed into the depth of the Hall sensor differ to a greater extent.

Thus, when using the measurement signals of the x and z partial sensors, all sensor properties must be taken into account upon evaluation, which requires complex calculations or error corrections.

The object of the invention is to improve the position sensing in a valve.

SUMMARY

The improvement comprises a valve having a position sensing means comprising at least one Hall sensor and a signal transmitter, wherein the Hall sensor is structured so as to comprise at least two partial sensors which sense magnetic field components in a first measuring direction and in a second measuring direction orthogonal thereto, wherein

the two measuring directions lie in a planar measurement zone of the Hall sensor. In the plane of the measurement zone, an extension of the Hall sensor in the two measuring directions is greater than an extension of the Hall sensor perpendicular thereto. The signal transmitter is an axially polarized magnet which is arranged on a valve tappet linearly displaceable along an axis of movement such that the poles thereof lie in the axis of movement, wherein the axis of movement runs parallel to the first measuring direction and at a distance from the measurement zone along a surface normal of the measurement zone. An imaginary centerline is defined on the measurement zone through a center of the measurement zone and along the first measuring direction, wherein the axis of movement is arranged at a distance from the imaginary centerline along the second measuring direction.

Thus, as in the known arrangement, the axis of movement is placed in front of the measurement zone at a (small) distance in the z direction (i.e., perpendicular to the plane spanned by the two measuring directions), but is additionally also offset along the second measuring direction with respect to the imaginary centerline of the measurement zone, which forms the axis of symmetry of the y partial sensor. Thus, the y partial sensor also senses a component of the magnetic field of the signal transmitter and provides a sufficiently large signal. This allows to use the values of the x partial sensor and the y partial sensor for the calculation of the measurement signal, which are both arranged in the planar measurement zone and have similar sensor characteristics.

Thus, the advantage is achieved that when forming a quotient of the measurement signals, identical sensor errors are shortened out and similar sensor errors are at least reduced, which simplifies the evaluation.

In the arrangement described above, the first measuring direction corresponds to the x direction, while the second measuring direction corresponds to the y direction.

The measurement zone represents the active measuring range of the Hall sensor and is usually significantly smaller than the housing dimensions of the Hall sensor. This measurement zone is known for each sensor and is clearly apparent for a person skilled in the art on the Hall sensor itself or from a manufacturer's documentation for this Hall sensor, to enable a positionally accurate installation of the Hall sensor. For example, in known Hall sensors, a center of the measurement zone is indicated with dimensions of the measurement zone and the orientation of the measuring directions.

Suitable for implementing the invention are Hall sensors which are designed to be mounted on a circuit board and which usually have contacts arranged on both sides of the surface defined by the measurement zone, so that the measurement zone is parallel to an upper side of the Hall sensor and parallel to the circuit board.

As the axis of movement is positioned in front of the surface of the measurement zone of the Hall sensor in the z direction, the circuit board on which the Hall sensor is arranged can be mounted on a housing wall, which enables a compact arrangement.

The distance of the axis of movement from the imaginary centerline may be selected at the discretion of a person skilled in the art. It should be noted here that the distance should be chosen so large that a measurement signal of the y partial sensor assigned to the second measuring direction is obtained which can be used for practical purposes. With increasing distance, the signal strength of the y component initially increases, as the y component of the magnetic field

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of the signal transmitter is increasingly sensed, until the signal strength decreases again after exceeding a maximum due to the general distance dependence. However, the signal strength of the x component decreases as the distance increases as soon as the axis of movement and the imaginary centerline are no longer congruent. Within this usable distance, a person skilled in the art can freely select the position of the axis of movement.

It has proven to be a well-suited arrangement to select the offset of the axis of movement relative to the imaginary centerline along the second measuring direction so large that in a projection along the surface normal of the measurement zone, the axis of movement does not overlap with the imaginary centerline and optionally not with the measurement zone.

Optionally, the offset of the axis of movement with respect to the imaginary centerline along the second measuring direction is selected to be a factor of 0.3 to 0.5 of a diameter of the signal transmitter perpendicular to the axis of movement.

For example, with a diameter of the signal transmitter of 19 mm and a height of 5 mm, the offset from the imaginary centerline can be 5 mm to 8 mm. Here, a measurement zone having a diameter of 1 mm along the second measuring direction was assumed. The offset of the axis of movement in the z direction may be, for example, 10 mm.

The axis of movement can be arranged at a distance from the imaginary centerline such that the signal strengths in the first and second measuring directions are of the same order of magnitude in terms of value. For example, the ratio of the differences between the minimum and maximum values for the measurement signals resulting from the first and second measuring directions when the signal transmitter moves away over the entire range of movement thereof may be between 1.0 and 2.0.

The signal transmitter is preferably a permanent magnet which has exactly two poles and is linearly polarized, so that simple and inexpensive magnets may be used.

To extend the measuring range, a plurality of separate Hall sensors may be arranged in series along the axis of movement which sense the signal transmitter one after the other. For example, three to five, in particular identical Hall sensors may be provided one behind the other in a straight line, with the axis of movement for all Hall sensors having an identical offset with respect to the imaginary centerline of the measurement zone.

The Hall sensor is in particular received in a control head of the valve, into which the valve tappet extends with the signal transmitter attached thereto.

The control head exclusively comprises, for example, sections of the valve through which there is no fluid flow of the process medium.

The control head e.g. has a fastening structure for a circuit board on which the Hall sensor is mounted. In addition, the control head usually has a passage for the valve tappet on a side facing a valve element of the valve. The fastening structure and the passage specify the position of the axis of movement with respect to the Hall sensor by their positions, which simplifies the precise mounting of the Hall sensor.

The valve element is in contact with areas of the valve through which fluid flows and closes or releases a valve seat, for example, the valve element being connected in a clear mechanical relationship to the valve tappet and thus to the signal transmitter, so that a determination of the position of the signal transmitter provides clear information about the position of the valve element.

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The valve is, for example, a process valve, the invention can however also be implemented in all other suitable valves.

To process the signals from the Hall sensor, the position sensing means preferably comprises a control and/or evaluation unit which is connected to the Hall sensor in a signal-transmitting manner. This control and/or evaluation unit may, for example, be arranged on the same circuit board as the Hall sensor. However, it is also possible to process the signals externally and thus to arrange the control and/or evaluation unit elsewhere on the valve or outside the valve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a schematic representation of a valve according to the invention;

FIG. **2** schematically shows the positioning of a signal transmitter relative to a Hall sensor of the position sensing means of the valve from FIG. **1** in the y-z plane;

FIG. **3** schematically shows the positioning of the signal transmitter relative to the Hall sensor in the x-y plane;

FIG. **4** schematically shows the positioning of the signal transmitter relative to the Hall sensor in the x-z plane; and

FIG. **5** shows a schematic representation of the measurement signals of the partial sensors of the Hall sensor sensed in the position sensing means of the valve from FIG. **1**.

DETAILED DESCRIPTION

FIG. **1** shows a valve **10**, here a process valve, with a schematically illustrated position sensing means **12**, which is received in a control head **14** of the valve **10**.

The control head **14** comprises here exclusively components of the valve **10** through which no process medium flows.

A valve tappet **16** projects through a passage **18** at the lower end of the control head **14** and is firmly connected to a valve element **20** outside the control head **14**.

The valve element **20** interacts with process media carrying components of the valve **10**, which are only outlined herein. For example, the valve element **20** may close or release a valve seat or interact with a component which closes or releases the valve seat. In any case, the movement of the valve tappet **16** is transmitted immediately and directly to the valve element **20**, so that a position of the valve tappet **16** provides clear information about the position of the valve element **20**.

A signal transmitter **22** is arranged on the valve tappet **16** at the end opposite the valve element **20**. The signal transmitter **22** is an axially polarized magnet the poles of which are arranged along the longitudinal axis of the valve tappet **16**. The arrangement of the poles shown in FIG. **1** is selected by way of example, the signal transmitter **22** may, of course, also have the opposite polarity.

The longitudinal axis of the valve tappet **16** defines an axis of movement A_x, the valve tappet **16** reciprocating linearly along the axis of movement A_x within a predetermined range of movement to move the valve element **20**.

The signal transmitter **22** is arranged fixed in position on the valve tappet **16** and generates a magnetic field rotationally symmetrical about the axis of movement A_x. Only a single signal transmitter **22** is provided in the valve **10** here.

The signal transmitter **22** is part of the position sensing means **12**. The position sensing means **12** also includes one or more (here three) Hall sensors **24**. In this example, all Hall sensors **24** are mounted together on a circuit board **26**. All of the Hall sensors **24** are lined up along a straight line.

Each of the Hall sensors **24** includes a measurement zone **28** which is smaller than the housing dimensions of the Hall sensor **24**.

In this example, all of the Hall sensors **24** are configured so as to be adapted to sense measurement signals in three spatial directions, x, y, z which are perpendicular to each other. Here, the x and y directions are considered to be a first and a second measuring direction, which are located in the area of the measurement zone **28** and which are thus arranged on the largest face of the substantially cuboid Hall sensor **24**. The first and second measuring directions x, y are here also parallel to the surface of the circuit board **26**. The third measuring direction thus extends in the z direction into the depth of the Hall sensor **24** perpendicular to the measurement zone **28**. This measurement direction is not relevant to the method described herein, but the signal provided by this partial sensor may also be evaluated to obtain further information.

The invention can of course also be implemented with Hall sensors which include only partial sensors for the first and second measuring directions x, y, but not for the z direction.

The drawings are not to scale.

A fastening structure **30** to which the circuit board **26** is fixedly mounted is formed inside the control head **14**.

Due to the fastening structure **30** and the passage **18**, the position of the valve tappet **16** and the Hall sensors **24** inside the control head **14** are fixed, and thus also the relative positions of the signal transmitter **22** to the Hall sensors **24**.

The axis of movement A_x is aligned along the first measuring direction x and is arranged with an offset v_y and v_z relative to the Hall sensors **24**, more precisely relative to an imaginary centerline M of the measurement zone **28** of each of the Hall sensors **24** with respect to the y direction (see also FIGS. **2** to **4**).

The imaginary centerline M passes through a center M_P of each measurement zone **28** and along the first measuring direction x. The z direction coincides with a surface normal N of the measurement zone **28** (see also FIG. **2**).

As shown in FIG. **2**, the offset v_y creates a distance between the axis of movement A_x and the imaginary centerline M along the second measuring direction y, while the offset v_z creates a distance between the axis of movement A_x and the measurement zone **28** in the z direction.

Optionally, the offset v_y is selected so large that in a projection along the surface normal N, the signal transmitter **22** does not overlap with the measurement zone **28**, as shown in FIGS. **1** to **3**. In any case, however, the axis of movement A_x is positioned such that a surface normal N extending from the imaginary centerline M of the measurement zone **28** does not intersect the axis of movement A_x.

The signal transmitter **22** is an axially polarized permanent magnet having exactly one north and one south pole. The diameter d perpendicular to the axis of movement A_x is, for example, 19 mm. The height along the axis of movement A_x is chosen here to be 5 mm.

In this example, the measurement zone **28** of the Hall sensor **24** has a width of 1 mm along the y direction.

The offset v_y is 5 to 8 mm here.

In general, the offset v_y may be, for example, a factor of 0.3 to 0.5 of the diameter d of the signal transmitter **22**.

The position sensing means **12** further comprises a control and/or evaluation unit **32** (see FIG. **1**), which is connected to the Hall sensors **24** in a signal-transmitting manner and which is also arranged on the circuit board **26** here.

If the valve tappet **16** is moved along the axis of movement A_x, the signal transmitter **22** moves by the same

amount as the valve element **20**. As the signal transmitter **22** moves relative to the Hall sensors **24**, the measurement signal generated by the Hall sensors **24** changes.

The control and/or evaluation unit **32** registers, in a known manner not explained in more detail here, which of the Hall sensors **24** is currently closest to the signal transmitter **22** and is thus currently responsible for sensing.

The moving magnetic field of the signal transmitter **22** generates in the partial sensor of the Hall sensor **24** responsible for the first measuring direction x a measurement signal **34** which increases and decreases again substantially continuously in terms of magnitude, as shown in FIG. **5**.

For the second measuring direction y, magnetic field components are sensed in the y direction due to the offset v_y, which change polarity in the course of the passage of the signal transmitter **22** along the Hall sensor **24**. Accordingly, a measurement signal **36** is obtained which has both a positive and a negative peak (see FIG. **5**). The course of the measurement curves depends of course on the polarity of the signal transmitter **22**.

The measurement signal **38** of the z partial sensor is not taken into account here.

The position of the axis of movement A_x with respect to the measurement zone **28**, i.e. the magnitude of the offset v_y, v_z, is to be selected at the discretion of a person skilled in the art such that the amplitude S of the measurement signal **36** received for the second measuring direction y is of the same order of magnitude as the amplitude S of the measurement signal **34** received for the first measuring direction x.

Optionally, the maximum signal strengths (measured from zero line-to-peak or peak-to-peak) of the measurement signals **34**, **36** for the first and second measuring directions x, y have a ratio of 1.0 to 2.0.

When evaluating the measurement signals **34**, **36**, a quotient is formed from the sensed measurement signals **34**, **36** for the first measuring direction x and the second measuring direction y, and this result is fed to a sigmoid function, for example an arctangent function, to obtain the length signal, from which a curve with an approximately straight-line rising section results in a known way, which has a direct dependence on the movement of the signal transmitter **22** and thus permits a simple determination of the position of the signal transmitter **22** and the valve element **20** (not shown here).

The length of this approximately linear section between two inflection points of the curve specifies the usable measuring range. In general, the dependency applies here that a higher offset v_y leads to a larger usable measuring range, but if a value for the offset v_y specified by the current system is exceeded, the amplitude S of the signal of the second measuring direction y is reduced as the offset v_y increases. In this parameter range, a skilled person must select the suitable position of the movement axis A_x for the specific system.

The invention claimed is:

1. A valve having a position sensing means comprising at least one Hall sensor and a signal transmitter, wherein the Hall sensor is structured so as to comprise at least two partial sensors which sense magnetic field components in a first measuring direction and in a second measuring direction orthogonal thereto,

wherein the two measuring directions lie in a plane of a measurement zone of the Hall sensor, wherein the Hall sensor extends farther in the two measuring directions than the Hall sensor extends perpendicular thereto, and wherein the signal transmitter is an axially polarized magnet, generating a magnetic field rotationally sym-

metrical about an axis of movement, which is arranged on a valve tappet linearly displaceable along the axis of movement such that poles thereof lie in the axis of movement, wherein

the axis of movement runs parallel to the first measuring direction and at a distance from the measurement zone along a surface normal of the measurement zone,

wherein an imaginary centerline is defined on the measurement zone through a center of the measurement zone and along the first measuring direction,

wherein the axis of movement is arranged at a distance from the imaginary centerline along the second measuring direction,

wherein the plane of the measuring zone does not intersect the signal transmitter, and

wherein an offset of the axis of movement with respect to the imaginary centerline along the second measuring direction is a factor of 0.3 to 0.5 of a diameter of the signal transmitter perpendicular to the axis of movement.

2. The valve according to claim 1, wherein an offset of the axis of movement relative to the imaginary centerline along the second measuring direction is so large that in a projection along the surface normal of the measurement zone, the signal transmitter does not overlap with the measurement zone.

3. The valve according to claim 1, wherein the signal transmitter is a permanent magnet having exactly two poles.

4. The valve according to claim 1, wherein a plurality of separate Hall sensors is arranged along the axis of movement.

5. The valve according to claim 1, wherein the Hall sensor is received in a control head of the valve, into which the valve tappet extends with the signal transmitter attached thereto.

6. The valve according to claim 5, wherein the control head comprises a fastening structure for a circuit board on which the Hall sensor is mounted, and a passage for the valve tappet on a side facing a valve element, wherein positions of the fastening structure and the passage at least partially define the position of the axis of movement.

7. The valve according to claim 1, wherein the valve is a process valve.

8. The valve according to claim 1, wherein the position sensing means comprises a control and/or evaluation unit which is connected to the Hall sensor in a signal-transmitting manner.

9. The valve according to claim 1, wherein the offset from the imaginary centerline is between 5 mm and 8 mm.

10. A valve having a position sensing means comprising at least one Hall sensor and a signal transmitter, wherein the Hall sensor is structured so as to comprise at least two partial sensors which sense magnetic field components in a first measuring direction and in a second measuring direction orthogonal thereto,

wherein the two measuring directions lie in a plane of measurement zone of the Hall sensor, wherein the Hall sensor extends farther in the two measuring directions than the Hall sensor extends perpendicular thereto, and wherein the signal transmitter is an axially polarized magnet, generating a magnetic field rotationally symmetrical about an axis of movement, which is arranged on a valve tappet linearly displaceable along the axis of movement such that poles thereof lie in the axis of movement,

wherein the axis of movement runs parallel to the first measuring direction and at a distance from the measurement zone along a surface normal of the measurement zone,

wherein an imaginary centerline is defined on the measurement zone through a center of the measurement zone and along the first measuring direction, and

wherein the axis of movement is arranged at a distance from the imaginary centerline along the second measuring direction,

wherein the plane of the measuring zone does not intersect the signal transmitter, and

wherein a ratio of differences between minimum and maximum values for the measurement directions when the signal transmitter moves over an entire range of movement are between 1.0 and 2.0.

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