

PATENT SPECIFICATION

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(54) ANGULAR VELOCITY SENSORS

(71) We, ILLINOIS TOOL WORKS INC., a corporation organised under the laws of the State of Delaware, United States of America, of 8501 West Higgins Road, Chicago, Illinois 60631, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a device for sensing the angular velocity of a rotating body. The rotating body may include a permanently magnetised toothed wheel or disc, or alternatively a ferromagnetic wheel or disc which rotates in the magnetic field of a permanent magnet. As the wheel or disc rotates, a varying magnetic flux is established adjacent its periphery. The variation in the magnetic field created by the rotating wheel or disc is then detected by the sensing device.

Probably the most common type of sensing device is that which generates a voltage that is a function of the speed of rotation of the rotating wheel or disc. A disadvantage of such a device is that the output signal decreases with speed to such an extent that it places a lower speed limit on a control system using such devices. The device is therefore unsuitable for vehicle antiskid control systems.

Another type of rotational speed sensor for sensing the varying magnetic flux is the type that relies on sensing the change of inductance that occurs in a magnetic core. One such type of device is shown in U.S. Patent 3,505,595. A high frequency excitation voltage is supplied to a winding on an elongated core, and the change of inductance is caused by the varying magnetic field created by the rotating body.

In accordance with the present invention a sensing device for sensing the angular velocity of a rotatable member that includes a plurality of equally spaced peripheral

projections which are capable of producing a time-varying magnetic field when the member is rotated, comprises a pair of magnetic cores positioned, in use, in the time-varying magnetic field, each core having a winding so that a signal is induced in each winding when the member rotates, each winding being coupled to a respective AC excitation generator for producing an excitation signal in the winding, the signals provided by the two generators being 180° out of phase with respect to one another, and the two windings being connected together to form two arms of a four-arm bridge circuit which is normally balanced when the member is stationary, the other two arms consisting of a pair of impedances which are not affected by the magnetic field, and the cores being spaced such that when the centre of one of the cores is aligned with the centre of any one of the projections, the centre of the other core is approximately aligned with the centre of the space between that projection and the next projection around the periphery.

Preferably the magnetic cores are closed-loop toroidal shaped cores.

In order that the invention may be more clearly understood, one example will now be described with reference to the accompanying drawings, in which:

Figure 1 is a side view of part of a sensing device for sensing the angular velocity of a toothed wheel;

Figure 2 is an end view of the device shown in Figure 1; and

Figure 3 is a circuit diagram of the complete sensing device.

In Figures 1 to 3 a sensing device 32 is illustrated which is useful where the relative change in flux density is very small. In this sensor, two closed-loop magnetic cores 34 and 48 are employed. The rotating wheel 36 may have either magnetic teeth 38, or the entire wheel may be constructed of unmagnetised ferromagnetic material. A magnet 42 provides the necessary magnetic

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field if the teeth are unmagnetised. The magnetic flux from the magnet 42 follows the air flux paths 65 and 69 and passes through the cores 34 and 48. Each core has a flat upper surface 44 to minimise the air gap 45.

The magnetic cores 34 and 48 each have a sense winding 40 and 46 respectively, one end of each winding being connected to a common terminal 53, which is grounded. The other end of the winding 40 is connected to the terminal 52 which is in turn connected to the junction of resistors 60 and 66. The resistor 60 is coupled to the AC excitation generator 56, which supplies an excitation signal of a first phase to the winding 40. The second end of the winding 46 is connected to the terminal 54, which in turn is connected to the junction of resistors 62 and 68. The resistor 62 is coupled to the AC excitation generator 58, which supplies an excitation signal to the winding 46 that is 180° out of phase with respect to the signal supplied by the generator 56. The resistors 66 and 68 are connected together and to an output terminal 64.

In the absence of the wheel 36 or when it is stationary, a balanced output signal appears across the terminals 53 and 64. When the magnetic flux changes due to the rotation of the wheel 36, the output signal from the sensor will have a phase reversal and will go through zero volts once per tooth cycle or interval. The cores 34 and 48 are spaced apart so that when the centre of the core 34 is aligned with a tooth 38, the centre of the core 48 will be approximately aligned with the centre of the air gap between the tooth in alignment with the core 34 and the next adjacent tooth. The phase cross-over points of this signal may be detected by a phase detector.

The balance differential sensing system of Figures 1 to 3 will also function with open-loop elongated cores but there will then be a decrease in sensitivity. The sensitivity may be improved by providing low magnetic reluctance flux paths for the flux paths 65 and 69 of Figure 2. As an alternative to the direct coupling from the generators 56 and 58, which is shown in Figure 3, the excitation signal may be supplied by a transformer coupling to the windings 40 and 46. This can be accomplished by the addition of

primary windings on the cores 34 and 48 so that the windings 40 and 46 act as secondary windings of the transformer.

WHAT WE CLAIM IS:—

1. A sensing device for sensing the angular velocity of a rotatable member that includes a plurality of equally spaced peripheral projections which are capable of producing a time-varying magnetic field when the member is rotated, comprising a pair of magnetic cores positioned, in use, in the time-varying magnetic field, each core having a winding so that a signal is induced in each winding when the member rotates, each winding being coupled to a respective AC excitation generator for producing an excitation signal in the winding, the signals provided by the two generators being 180° out of phase with respect to one another, and the two windings being connected together to form two arms of a four-arm bridge circuit which is normally balanced when the member is stationary, the other two arms consisting of a pair of impedances which are not affected by the magnetic field, and the cores being spaced such that when the centre of one of the cores is aligned with the centre of any one of the projections, the centre of the other core is approximately aligned with the centre of the space between that projection and the next projection around the periphery.

2. A sensing device according to claim 1 in which the member is an unmagnetised member of magnetic material, and a permanent magnet is positioned adjacent the cores so that magnetic flux from the permanent magnet passes through the projections and the cores, the cores comprising closed-loop toroidal shaped cores.

3. A sensing device according to claim 1 or claim 2, in which each of the cores includes a flat surface for positioning adjacent the periphery of the rotating member.

4. A sensing device according to claim 1 and substantially as herein described with reference to the accompanying drawings.

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