DEVICE FOR MONITORING A PREDETERMINED FILLING LEVEL OF A MEASURING MEDIUM IN A CONTAINER

[0001] The invention relates to an apparatus for monitoring a predetermined fill level of a medium in a container. The apparatus may also be used for determining density or viscosity of a medium in a container. The medium to be measured can be a fluid medium, a foam, or a solid medium.

[0002] The apparatus includes an oscillatable unit, a driver/receiver unit, and an evaluation unit. The oscillatable unit is, depending on application, placed at the height of the predetermined fill level, or it is positioned such that it reaches to a defined immersion depth into the medium being measured. Additionally, a feedback electronics is provided, which delivers to the driver/receiver unit the signals for exciting the oscillatable unit. The feedback electronics is preferably a fundamental wave exciter, such as is already known from the state of the art. Especially to be referenced here is the fundamental wave excitement used in LIQUIPHANT M. On the basis of a frequency and/or amplitude change of the oscillation of the oscillatable unit, the evaluation unit determines the reaching of the predetermined fill level. In the case of a density or viscosity measurement, the evaluation unit determines the density, respectively the viscosity, of the medium to be measured, as a function of a change of the oscillation of the oscillatable unit.

[0003] Apparatuses, so-called vibration detectors, are already known, which employ an oscillatable unit for detecting, respectively monitoring, the fill level of a medium in a container. As regards the oscillatable unit, such is usually at least one oscillation tine, which is secured to a membrane, or diaphragm. The membrane is excited to oscillate via an electromechanical transducer, e.g. a piezoelectric element. The oscillation of the membrane, in turn, causes the oscillatable unit secured to the membrane to oscillate. Vibration detectors of this kind are made and sold by the assignee under the mark 'LIQUIPHANT'.

[0004] Vibration detectors in the form of fill level measuring devices make use of the effect that the oscillation frequency and oscillation amplitude depend on the particular amount of covering of the oscillatable unit: While the oscillatable unit executes its (resonance) oscillations in air free and undamped, it undergoes a frequency and amplitude change, thus a detuning, as soon as it becomes immersed, partially or completely, in the medium being measured. On the basis of a predetermined frequency change (usually, for ascertaining fill level, frequency is detected), an unequivocal conclusion can be made concerning the reaching of the predetermined fill level by the medium in the container. Fill level measuring devices are used principally as protection against overfilling or as protection against pumps running empty.

[0005] Moreover, the frequency of the oscillation of the oscillatable unit is also influenced by the density of the medium. Consequently, at constant degree of covering, there is functional relationship between frequency change and the density of the medium, so that vibration detectors are well suited both for fill level and for density determination.

[0006] In practice, for the purpose of monitoring and detecting the fill level and/or the density or viscosity of the medium in the container, the oscillations of the membrane are registered and converted by means of a piezoelectric element into electrical response signals. The electrical response signals are subsequently evaluated by an evaluation unit. In the case of fill level determination, the evaluation unit monitors the oscillation frequency and/or the oscillation amplitude of the oscillatable unit and signalizes the state 'sensor covered', or the state 'sensor uncovered', as soon as the measured value subceeds, or falls below, on the one hand, or exceeds, on the other hand, a predetermined reference value. A corresponding report to the operating personnel can occur optically and/or acoustically. Alternatively, or additionally, a switching is initiated; for instance, the switching could effect the opening or closing of an inlet or outlet valve on the container.

[0007] Moreover, WO 02/31471 A2 discloses an apparatus for measuring and/or monitoring the viscosity of a medium to be measured. The apparatus, also in this case, includes an oscillatable unit secured on a membrane, an driver/receiver unit, and a control/evaluation unit. The control/evaluation unit determines on the basis of the frequency-phase curve the viscosity of the medium being measured. Especially, the control/evaluation unit adjusts to two phase values sufficiently different from one another, determines the frequencies associated with the phases, or the corresponding frequency change of the oscillations of the oscillatable unit, compares the determined frequency change with stored calibration data, and so determines the viscosity of the medium being measured.

[0008] An object of the invention is to provide an apparatus for fill level and/or density or viscosity measurement, which exhibits a constant phase-frequency characteristic over a large frequency bandwidth (working range).

[0009] The object is achieved by providing a microprocessor in the oscillation circuit formed of the oscillatable unit and the feedback electronics, with the microprocessor correcting the phase of the feedback electronics over a predetermined frequency bandwidth in such a way that the sum of the phases of the feedback electronics and of the microprocessor follows a predetermined function f(ν). The feedback electronics is e.g. an analog feedback electronics, such as that used in the LIQUIPHANT M switch available from the assignee. The invention is, however, not limited to this particular form of feedback electronics.

[0010] By the integration, in accordance with the invention, of the microprocessor into the oscillation circuit, it is possible to influence a vibration detector in an 'intelligent' manner such that it exhibits a constant phase-frequency characteristic over an extended working range. Additionally, the detector becomes adjustable for the most varied of conditions and requirements at the measurement site. Moreover, the apparatus of the invention, as a so-called multivariable sensor, can be used both for determining fill level and for measurement of viscosity or density.

[0011] In an advantageous further development of the device of the invention, the frequency bandwidth preferably extends between the limits of 300 and 1500 Hz.

[0012] The feedback electronics has, furthermore, the task—in case the driver/receiver unit fails—of producing a signalizing by means of the resonance frequency of the feedback electronics (see the amplitude behavior in **FIG. 2**). This frequency lies outside of the frequency bandwidth of the multivariable sensor.