(12) **CORRECTED EUROPEAN PATENT SPECIFICATION**

(54) **METHOD AND DEVICE FOR DETERMINING THE PRESENCE AND MASS FLOW RATE OF MILK FLOWING IN A PIPE**

VERFAHREN UND VORRICHTUNG ZUR BESTIMMUNG DES VORHANDENSEINS UND DES MASSENDURCHFLUSSES VON IN EINER ROHRLEITUNG STRÖMENDEN MILCH

PROCÉDÉ ET DISPOSITIF POUR DÉTERMINER LA PRÉSENCE ET LE DÉBIT MASSIQUE DU LAIT S'ÉCOULANT DANS UN TUYAU

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Description

[0001] The invention relates to a method and a device for determining the presence and mass flow rate of milk flowing in intermittent slugs in a pipe with air, as for example, milk flowing in a milk line in animal milking apparatus as the milk is being drawn in pulses from the animal, although the invention is not limited to such a method and a device. Further, the invention relates to a method and a device for determining the presence or absence of milk flowing in a pipeline, and the invention also relates to a method and device for detecting the commencement and ending of milking of an animal. The invention further relates to a method and a device for detecting connection and disconnection of teat cups of a milking cluster to the teats of an animal, and the invention also relates to a method and a device for detecting disconnection ("kick-off") of a milking cluster from the teats of an animal during milking thereof.

[0002] Milking apparatus for milking animals is well known, and the action of milking apparatus whereby milk is drawn under vacuum from the teats of an animal in pulsed flow whereby the milk is drawn in time spaced apart slugs of milk with air intermediate the milk slugs is known. Because two-phase flow is involved, in other words, liquid and gaseous phase flow whereby the liquid phase comprises milk and the gaseous phase comprises air, it is relatively difficult to determine the rate of milk flow flowing through a pipeline where the milk is drawn under vacuum from the teats in such a pulsed flow manner. Furthermore, it is desirable to be able to detect both the presence and absence of milk flowing in a pipeline, and it is also desirable to be able to detect the commencement and completion of milking of an animal. Further, it is desirable to detect connection and disconnection of a milking cluster from the teats of an animal, and in particular, it is desirable to be able to detect disconnection of a milking cluster from the teats of an animal during milking, as a result of kick-off.

[0003] PCT Specification No. WO 89/05974 of Hope discloses a state of the art method for acoustically determining one or more properties of a multi-phase medium flowing turbulently in a pipeline, for example, oil with sand entrained therein with the oil flowing in slugs with gas therebetween.

[0004] The invention is defined by the method of appended Claim 1 and the device of appended Claim 15.

[0005] Preferred embodiments of the invention are defined by the dependent claims.

[0006] Preferably, disconnection of the milking cluster from the teats of the animal is determined in response to the computed energy parameter value exceeding the predefined energy parameter value.

[0007] Advantageously, the absence of milk flowing in the pipeline is determined in response to the computed energy parameter value being less than the second predefined energy parameter value.

[0008] in one aspect of the invention a plurality of time spaced energy parameter values of the monitored signal within the predefined frequency bandwidth are computed, and the presence of milk flowing in the pipeline is determined in response to the time spaced computed energy parameter values being indicative of a liquid phase medium flowing with pulsed flow.

[0009] In another aspect of the invention the time spaced computed energy parameter values are consecutively computed energy parameter values.

[0010] Preferably, the commencement of milk flowing in the pipeline is determined in response to the computed energy parameter value transitioning from one of a value indicative of the teat cups of the milking cluster being attached to the teats of the animal without milk flowing in the pipeline, and a value indicative of air being drawn under vacuum into the pipeline through the teat cups to a value indicative of milk flowing in the pipeline.

[0011] Advantageously, the ceasing of milk to flow in the pipeline is determined in response to the computed energy parameter value transitioning from a value indicative of milk flowing in the pipeline to a value less than the second predefined energy parameter value.

[0012] Preferably, disconnection of the milking cluster from the teats of an animal during milking is determined in response to the computed energy parameter value transitioning from a value indicative of milk flowing in the pipeline to a value greater than the first predefined energy parameter value.

[0013] Advantageously, connection of the milking cluster to the teats of the animal is determined in response to the computed energy parameter value transitioning from a value indicative of air being drawn into the pipeline through the teat cups to a value less than the upper third predefined energy parameter value.

[0014] Preferably, connection of the milking cluster to the teats of the animal is determined in response to the computed energy parameter value transitioning from a value indicative of air being drawn into the pipeline through the teat cups to a value indicative of milk flowing in the pipeline.

[0015] Advantageously, connection of the milking cluster to the teats of the animal is determined in response to the computed energy parameter value transitioning from a value indicative of air being drawn into the pipeline through the teat cups to a value less than the second predefined energy parameter value.

[0016] In one embodiment of the invention the computed energy parameter value of the monitored signal is computed by computing the average energy of the monitored signal within the predefined bandwidth.

[0017] Preferably, the energy parameter value of the monitored signal within the predefined frequency bandwidth is computed by computing the average energy value of the energy values of the monitored signal over a predefined threshold energy value within the predefined frequency bandwidth.

[0018] Preferably, the average energy value of the monitored signal within the predefined bandwidth is com-

puted at time spaced apart intervals.

[0019] In one aspect of the invention the average energy of the monitored signal within the predefined bandwidth is computed at the end of respective predefined monitoring periods.

[0020] In another aspect of the invention the monitored signal is sampled at a predefined sampling rate, and the average energy of the sampled signal within the predefined bandwidth is computed at the end of respective predefined sampling periods.

[0021] Preferably, each predefined monitoring period comprises a plurality of predefined sampling periods.

[0022] Advantageously, the respective predefined sampling periods run consecutively one after the other.

[0023] Preferably, the respective predefined monitoring periods run consecutively one after the other.

[0024] Preferably, the first predefined energy parameter value comprises an energy value.

[0025] Advantageously, the second predefined energy parameter value comprises an energy value.

[0026] Preferably, the upper and lower third predefined energy parameter values comprise respective energy values.

[0027] Preferably, the predefined frequency bandwidth lies in the range of 6 kHz to 15 kHz. Advantageously, the predefined frequency bandwidth lies in the range of 10 kHz to 15 kHz.

[0028] Preferably, the monitored signal is derived from a microphone. Preferably, the monitored signal is derived from the electronic output signal from the microphone. Advantageously, the monitored signal comprises an analogue signal. Alternatively, the monitored signal comprises a digital signal.

[0029] Preferably, the microphone is located adjacent the pipe. Alternatively, the microphone is located within the pipe.

[0030] Preferably, the method further comprises determining the system of calibration energy values and the corresponding mass flow rates of milk turbulently flowing with a gaseous phase medium as a pulsed flow comprising a plurality of time spaced apart slugs of milk with air interspersed therebetween, wherein the milk is delivered through the pipe for predefined calibration periods at respective different mass flow rates of the milk, the mass of the milk delivered through the pipe during each predefined calibration period is recorded, and the mass flow rate of the milk for each predefined calibration period is computed and recorded from the recorded mass of the milk delivered through the pipe during the corresponding predefined calibration period, the signal indicative of a sonic signal produced by the flowing milk is monitored during each predefined calibration period, the frequency domain of the monitored signal is filtered to produce a portion of the monitored signal within the predefined bandwidth indicative of the flowing milk, the energy parameter value of the portion of the monitored signal within the predefined frequency bandwidth for each predefined calibration period is computed, the computed energy pa-

rameter values are recorded cross-referenced with the corresponding mass flow rates of the milk for the respective predefined calibration period, and the system of the calibration energy parameter values and the corresponding mass flow rates of the milk is determined from the recorded computed energy parameter values cross-referenced with the corresponding mass flow rates of the milk.

[0031] Advantageously, the computed energy parameter value of the portion of the monitored signal within the predefined frequency bandwidth which is computed for each predefined calibration period is the average energy value of the portion of the monitored signal within the predefined frequency bandwidth for that predefined calibration period.

[0032] Preferably, the system of calibration energy parameter values and the corresponding mass flow rates for the liquid phase medium is expressed as a calibration equation, whereby the mass flow rate is defined as a function of the energy parameter value of the portion of the monitored signal within the predefined frequency bandwidth.

[0033] Preferably, the calibration equation comprises one of a power law equation, a polynomial equation, and a logarithmic equation.

[0034] Advantageously, the time duration of each predefined calibration period is similar to the time duration of each predefined monitoring period.

[0035] Preferably, the monitoring means comprises a microphone.

[0036] Advantageously, the microphone comprises an analogue microphone. Alternatively, the microphone may comprise a digital microphone.

[0037] Preferably, a turbulence inducing means may be located in the pipe. Preferably, the turbulence inducing means comprises a projection extending inwardly into the pipe from a pipe wall thereof.

[0038] Advantageously, a signal processor is configured to sample the signal produced by the monitoring means indicative of the sonic signal produced by the flowing medium at a predefined sampling rate during sequential predefined monitoring periods.

[0039] Preferably, the signal processor is configured to carry out a Fast Fourier Transform on the sampled monitored signal to produce the frequency domain of the sampled signal.

[0040] Advantageously, the signal processor is configured as a filtering means to filter the frequency domain signal resulting from the Fast Fourier Transform to produce the portion of the signal within the predefined frequency bandwidth.

[0041] Preferably, the signal processor is configured to compute the energy parameter value of the monitored signal within the predefined frequency bandwidth as the average energy value of the monitored signal within the predefined frequency bandwidth.

[0042] Advantageously, the system of the calibration energy values and the corresponding calibration mass

flow rates is expressed in a calibration equation. Preferably, the calibration equation comprises one of a power law equation, a polynomial equation, and a logarithmic equation.

[0043] Preferably, the mass flow rate of the liquid phase medium is determined from the calibration equation.

[0044] Preferably, the mass flow rate of the liquid phase medium is determined from the calibration equation by substituting the computed energy parameter value in the calibration equation.

[0045] Advantageously, the signal processor is configured to determine the total mass of the liquid phase medium during each predefined monitoring period.

[0046] Preferably, the total mass of the liquid phase medium which flows during each predefined monitoring period is determined as the integral of the mass flow rate from time T1 to time T2, where time T1 is the time at the commencement of each predefined monitoring period and time T2 is the time at the end of each predefined monitoring period.

[0047] The advantages of the invention are many. A particularly important advantage of the method according to the invention is that it allows a relatively accurate determination of the mass flow rate of milk flowing with air through a pipe, for example, a milk line in pulsed flow with time spaced apart slugs of milk. Additionally, the method according to the invention allows the disengagement of a milking cluster from the teats of an animal during milking, for example, by kick-off to be detected, and the method according to the invention also allows commencement and completion of milking of an animal to be determined with a reasonable degree of accuracy. Further, the method according to the invention allows the connection of a milking cluster to the teats of an animal to be detected.

[0048] The advantages of the device according to the invention are substantially similar to those achieved from the method according to the invention.

[0049] The invention will be more clearly understood from the following description of some preferred embodiments thereof, which are given by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 is a cross-sectional side elevational view of a device according to the invention for determining the mass flow rate of a liquid flowing in the pipe,

Fig. 2 is a transverse cross-sectional view of the device of Fig. 1 on the line II-II of Fig. 1, and

Fig. 3 is a block representation of the device of Fig. 1.

[0050] Referring to the drawings, there is illustrated a device according to the invention, indicated generally by the reference numeral 1, for determining the mass flow rate of a flowing liquid phase medium, which in this embodiment of the invention is milk turbulently flowing with a gaseous phase medium, namely, air in a pipe 2 of milking apparatus (not shown) through which milk is drawn under vacuum from the teats of an animal. In this embodiment of the invention the milk is flowing in the pipe 2 as a pulsed flow comprising a plurality of time spaced apart slugs of the milk, typically in the form in which milk is drawn under vacuum in intermittent slugs from the teats of an animal being milked with air interspersed between the milk slugs. The device 1 comprises a housing 3 which is indicated diagrammatically in broken lines in Fig. 1 and a pipe element 4 extending through the housing 3 and defining a bore 5 extending therethrough for accommodating milk and air flowing through the device 1. The housing 3 is adapted for connecting into the pipe 2 of the milking apparatus (not shown) through which the milk and air is flowing with the pulsating flow under vacuum, so that the milk and air flowing through the pipe 2 flows through the bore 5 of the pipe element 4 in the direction of the arrow A.

[0051] A monitoring means comprising a microphone 8 for monitoring sonic signals produced by the milk and air flowing through the bore 5 of the pipe element 4 is located adjacent the pipe element 4, and in this embodiment of the invention is secured to an external surface 7 of a wall 9 of the pipe element 4. The microphone 8 produces an electronic analogue output signal which is indicative of the sonic signal produced by the milk and air flowing through the bore 5 of the pipe element 4.

[0052] A turbulence inducing means for inducing turbulence in the milk and air flowing in the bore 5 of the pipe element 4, in this embodiment of the invention comprises a transverse turbulence inducing bar 10 extending transversely within the bore 5 of the pipe element 4 between diametrically opposite points on the wall 9 of the pipe element 4. The microphone 8 is located downstream of the turbulence inducing bar 10 in order to detect the sound of the turbulent flow of the milk and air through the bore 5 of the pipe element 4. The electronic analogue output signal produced by the microphone 8 is indicative of the sonic signal produced by the turbulent flow of the milk and air flowing through the bore 5 of the pipe element 4.

[0053] A layer 11 of a sound insulating material is wrapped around the wall 9 of the pipe element 4 with the microphone 8 located between the layer 10 of sound insulating material and the wall 9 of the pipe element 4 in order to minimise the effect of noise generated externally of the device 1 on the microphone 8. The layer 11 of the sound insulating material extends from the turbulence inducing bar 10 to a position downstream of the microphone 8 for minimising the effect on the microphone 8 of noise generated externally of the device 1.

[0054] A signal processor, in this embodiment of the invention a microprocessor 15, which is illustrated in block representation only, is located in the housing 3 and is configured to continuously sample the analogue output signal produced by the microphone 8 during sequential predefined monitoring periods, and to determine the

mass flow rate of the milk flowing through the bore 5 of the pipe element 4, as will be described below. A visual display screen 17 is provided in the housing to display the mass flow rate of the milk determined by the microprocessor 15. Provision is also made for facilitating the determined mass flow rate to be read by an external computer from the microprocessor 15. In this embodiment of the invention the predefined monitoring periods are each of duration of approximately one second and run consecutively one after the other.

[0055] The output signal from the microphone 8 is continuously sampled at a sampling rate of 44.1 kHz, although the output signal produced by the microphone 8 may be sampled at any suitable sampling rate, and preferably, is sampled at a sampling rate at or above 32 kHz. The sampled values of the output signal of the microphone 8 are buffered by the microprocessor 15 into a buffer 16 during respective predefined sampling periods. The buffer 16 may be configured in the microprocessor 15 or may be an external memory, for example, a random access memory separate from the microprocessor 15, which would also be located in the housing 3. In this embodiment of the invention each predefined sampling period is of duration in order to allow 1,024 consecutive samples of the output signal of the microphone 8 to be read into the buffer 16. At the sampling rate of 44.1 kHz, the duration of each sampling period is approximately 23.2 milliseconds. At the end of each predefined sampling period, the buffered sampled values of the output signal of the microphone 8 are read from the buffer 16 into the microprocessor 15. The microprocessor 15 is configured to carry out a Fast Fourier transform on the buffered sampled values at the end of each predefined sampling period in order to produce the frequency domain of the sampled signal.

[0056] The microprocessor 15 is configured to filter the frequency domain of the sampled buffered signal resulting from the Fast Fourier Transform at the end of each predefined sampling period to attenuate signals of frequency below and above a predefined frequency bandwidth within which signals indicative of the flow of the milk through the bore 5 of the pipe element 4 occur. In this embodiment of the invention the predefined frequency bandwidth is 6 kHz to 15 kHz, which it has been found is the bandwidth within which signals indicative of the flow of milk through the bore 5 of the pipe element 4 occur.

[0057] The microprocessor 15 is configured to compute an energy parameter value of the sampled buffered signal within the predefined frequency bandwidth of 6 kHz and 15 kHz at the end of each predefined sampling period. In this embodiment of the invention the energy parameter value which is computed by the microprocessor 15 is the average energy of the sampled buffered signal within the predefined frequency bandwidth of 6 kHz to 15 kHz during the corresponding predefined sampling period. The average energy of the sampled buffered signal within the predefined frequency bandwidth of 6 kHz to 15 kHz is computed by the microprocessor 15 by

computing the average amplitude value of the sampled buffered signal of amplitude values above a predefined threshold value within the predefined frequency bandwidth of 6 kHz to 15 kHz. The predefined threshold value is determined in order to remove noise from the sampled monitored signal, and may be determined by the microprocessor 15 in response to a continuing analysis of the sampled monitored signal over a predefined number of the most recent predefined sampling periods. At the end of each predefined monitoring period, the microprocessor 15 computes the average energy value of the sampled monitored signal for that predefined monitoring period from the average values computed for the respective predefined sampling periods during that predefined monitoring period.

[0058] The microprocessor 15 is configured to determine the mass flow rate of the milk flowing through the bore 5 of the pipe element 4 at the end of each predefined monitoring period by substituting the computed average energy value of the sampled buffered signal within the predefined frequency bandwidth of 6 kHz to 15 kHz into a calibration equation, which is determined during calibration of the device 1 as will be described below. In this embodiment of the invention the calibration equation is a power law equation of the following form:

$$F = a.H^b$$

where

  F is the mass flow rate of milk flowing through the bore 5 of the pipe element 4 during that predefined monitoring period,
  a and b are constants determined during calibration of the device 1, and
  H is the average energy value of the sampled buffered signal within the predefined frequency bandwidth of 6 kHz to 15 kHz during that predefined monitoring period.

[0059] The microprocessor 15 is configured to compute the total mass flow of milk during each predefined monitoring period by integrating the mass flow rate of the milk for that predefined monitoring period between time T1, which is the time at the commencement of that predefined monitoring period, and T2, which is the time at the end of that predefined monitoring period.

[0060] The microprocessor 15 is configured to compute the total mass of milk flowing through the bore 5 of the pipe element 4 of the device 1 during any selected time period by summing the determined masses of the milk flowing through the bore 5 of the pipe element 4 during respective consecutive predefined monitoring periods during the selected time period. For example, the microprocessor 15 may be programmed to compute the total mass of milk which flows through the device 1 during a milking cycle of an animal from the commencement of

the milking cycle to the end of the milking cycle. In which case, the microprocessor 15 would be programmed to determine the total mass of the milk flowing through the device 1 during the milking cycle by summing the computed masses of the milk flowing through the device 1 during respective consecutive predefined monitoring periods during the milking cycle.

[0061] Turning now to the calibration of the device 1 and the derivation of the calibration equation, the device 1 is calibrated by initially delivering a flow of milk and air through the bore 5 of the pipe element 4 of the device 1 for predefined calibration periods at respective different milk flow rates. In this embodiment of the invention the predefined calibration periods are of duration similar to the duration of the predefined monitoring periods, and may be from one second to ten seconds, although the predefined calibration periods may be longer than the predefined monitoring periods. The milk is collected in a vessel at the end of each predefined calibration period, and the mass of milk in the vessel is measured and recorded for each predefined calibration period. The mass flow rate of the milk for each predefined calibration period is then computed and recorded cross-referenced with the corresponding predefined calibration period.

[0062] Signals from the microphone 8 are sampled by the microprocessor 15 during each predefined calibration period at the sampling rate of 44.1 kHz, and are buffered into the buffer 16, as already described at the end of respective predefined sampling periods during which 1,024 consecutive sampled values are read from the output signal from the microphone 8. At the end of each predefined sampling period, the microprocessor 15 carries out a Fast Fourier Transform on the buffered sampled signal, which is then filtered to produce the portion of the signal within the predefined frequency bandwidth of 6 kHz to 15 kHz. The microprocessor 15 then computes the average value of the energy of the sampled buffered signal within the predefined frequency bandwidth of 6 kHz to 15 kHz at the end of each predefined sampling period, and the computed average energy values are stored cross-referenced with the corresponding mass flow rates of the milk for the corresponding predefined calibration periods. The calibration equation is then derived from the stored average energy values and the corresponding mass flow rates of milk by curve fitting or by any other suitable mathematical process. The calibration equation may be a power law equation, a polynomial equation, a logarithmic equation or a mixed type equation, and as discussed above, in this embodiment of the invention the equation is a power law equation in the form:

$$F = a.H^b.$$

[0063] The device 1 may also be used in order to detect the commencement of milking of an animal, the end of milking of an animal, the connection of the teat cups of a milking cluster to the teats of an animal, and/or disconnection of one or more of the teat cups of a milking cluster from the teats of an animal during milking. Disconnection or disengagement of the teat cups of a milking cluster from the teats of an animal, commonly referred to as "kick-off", generally results from an animal kicking either the milking cluster or the milk line from the milking cluster, with one of its hind legs during milking, which thus results in the milking cluster being disengaged from the teats of the animal.

[0064] During periods while the milk is flowing through the bore 5 of the pipe element 4, the milk flows with the pulsed flow, and the frequency domain of the monitored signal within the predefined bandwidth of 6 kHz to 15 kHz comprises a pulsed pattern in response to the flow of the time spaced apart slugs of the milk.

[0065] Prior to commencement of milking, and prior to attaching the milking cluster of a milk line to the teats of the animal, once the vacuum is applied to the milk line or pipeline in which the device 1 is located, the application of the vacuum to the milk line or pipeline results in air being continuously drawn into the milk line through the teat cups of the milking cluster until the milking cluster has been attached to the teats of the animal. The continuous drawing of the air through the milk line, and in turn through the bore 5 of the pipe element 4, results in significant sonic noise being detected by the microphone 8. This in turn results in the frequency domain of the output signal from the microphone 8 within the predefined frequency bandwidth of 6 kHz to 15 kHz comprising a continuous relatively high energy noise signal, which is significantly higher than the average energy signal of the output signal from the microphone 8 in the frequency bandwidth of 6 kHz to 15 kHz resulting from a normal pulsed flow of milk during milking of an animal. Similarly, in the event of the milking cluster being removed or being kicked off by the animal from the teats of the animal during milking, since the vacuum is continuously applied to the milk line during milking, the frequency domain of the monitored signal from the microphone 8 within the predefined frequency bandwidth of 6 kHz to 15 kHz is a substantially continuous signal of similar high energy noise. Thus, when the frequency domain of the signal from the microphone 8 within the predefined frequency bandwidth of 6 kHz to 15 kHz comprises a substantially continuous signal of continuous relatively high energy noise, the milking cluster is determined as being detached from the teats of the animal, and thus removal or kick-off by the animal of the milking cluster from the animal teat is readily easily determined.

[0066] Additionally, in the absence of milk flowing through the bore 5 of the pipe element 4 while the milking cluster is still attached to the teats of the animal, which would occur on completion of milking of an animal, the frequency domain of the monitored signal from the microphone 8 within the predefined frequency bandwidth of 6 kHz to 15 kHz comprises a substantially continuous low energy noise signal, which is thus indicative of the completion of milking. This low energy noise signal is of

significantly lower energy value than the high energy noise signal which is indicative of the milking cluster being detached from the teats of the animal, and thus, is easily distinguishable from the high energy noise signal. Furthermore, both the substantially continuous low energy noise signal indicative of the absence of milk flowing through the bore 5 of the pipe element 4 and the substantially continuous high energy noise signal indicative of the milking cluster being detached from the teats of the animal are readily distinguishable from the pulsed signal indicative of milk flowing through the bore 5 of the pipe element 4 in pulsed milk slugs.

[0067]   Accordingly, on the microprocessor 15 determining that the frequency domain of the monitored signal within the predefined frequency bandwidth of 6 kHz to 15 kHz has transitioned from the signal indicative of pulsed flow of milk to a substantially continuous low energy noise signal, the microprocessor 15 determines that milking of the animal has been completed. On the microprocessor 15 determining that the frequency domain of the monitored signal within the predefined frequency bandwidth of 6 kHz to 15 kHz has transitioned from either a substantially continuous high energy noise signal or a substantially continuous low energy noise signal to the signal indicative of milk flowing in pulsed milk slugs, the microprocessor 15 determines that milking of the animal has commenced.

[0068]   On the microprocessor determining that the frequency domain of the monitored signal within the predefined frequency bandwidth of 6 kHz to 15 kHz has transitioned from the substantially continuous relatively high energy noise signal to either the signal indicative of milk flowing in pulsed milk slugs or the substantially continuous low energy noise signal, the microprocessor 15 determines that the milking cluster has been attached to the animal.

[0069]   On the microprocessor 15 detecting that the frequency domain of the monitored signal within the predefined frequency range of 6 kHz to 15 kHz has transitioned from the signal indicative of milk flowing in pulsed milk slugs to a substantially continuous high energy noise signal, the microprocessor 15 determines that kick-off has occurred, in other words, the milking cluster has been kicked off by the animal from the teats of the animal.

[0070]   In this embodiment of the invention the microprocessor 15 is configured to compare the computed average energy value of the monitored signal at the end of each predefined sampling period with a first predefined energy parameter value, namely, a first predefined energy value, which is indicative of air being drawn under vacuum into the milk line through the teat cups of the milking cluster. If the computed average energy value at the end of any predefined sampling period is equal to or greater than the first predefined energy value, the microprocessor 15 is configured to determine the milking clusters as being detached from the teats of the animal.

[0071]   Additionally, in this embodiment of the invention the microprocessor 15 is configured to compare the computed average energy value of the monitored signal at the end of each predefined sampling period with a second predefined energy value which is indicative of the absence of milk flowing through the pipeline while the milking cluster is attached to the teats of the animal. If the computed average energy value at the end of any predefined sampling period is equal to or less than the second predefined energy value, the microprocessor determines that no milk is flowing in the pipeline, and the milking clusters are attached to the teats of the animal.

[0072]   Also in this embodiment of the invention the microprocessor 15 is configured to compare the computed average energy value of the monitored signal at the end of each predefined sampling period with upper and lower third predefined energy values which are indicative of the upper and lower energy values of the average energy value of the signal when milk is flowing in the pipeline in pulses of milk slugs. If the computed average energy value of the monitored signal at the end of any predefined sampling period lies within the upper and lower third predefined energy values, then the microprocessor 15 determines that milk is flowing in the pipeline in pulsed milk slugs, and the microprocessor 15 proceeds to determine the mass flow rate of the milk flowing in the pipeline during that predefined sampling period.

[0073]   In use, with this embodiment of the invention, after the microprocessor 15 has computed the average energy value of the monitored signal within the predefined frequency bandwidth of 6 kHz to 15 kHz at the end of each predefined sampling period, the microprocessor 15 compares the computed average energy value with the upper and lower third predefined energy values. If the computed average energy value lies within the upper and lower third predefined energy values, the microprocessor 15 proceeds to compute the mass flow rate of the milk flowing in the milk line during that predefined sampling period from the calibration equation.

[0074]   If at the end of any predefined sampling period the computed average energy value for that predefined sampling period does not fall within the upper and lower third predefined energy values, the microprocessor 15 compares the computed average energy value with the first predefined energy value, and if the computed average energy value is equal to or greater than the first predefined energy value, and if the microprocessor 15 determines that the computed average energy value has just transitioned from being indicative of milk flowing in the pipeline to being equal to or greater than the first predefined energy value, the microprocessor 15 determines "kick-off", in other words, that the milking cluster has been kicked off from the teats of the animal during milking by the animal.

[0075]   If, on the other hand, a computed average energy value at the end of any predefined sampling period does not fall within the upper and lower third predefined energy values and is less than the first predefined energy value, the microprocessor 15 compares the computed average energy value with the second predefined energy

value. If the computed average energy value is equal to or less than the second predefined energy value, the microprocessor 15 determines that no milk is flowing in the pipeline and the milking cluster is attached to the teats of the animal. If the microprocessor 15 determines that the monitored signal has just transitioned from being indicative of milk flowing in the pipeline to being less than or equal to the second predefined energy value, the microprocessor 15 determines that milking of the animal has ceased.

[0076]   If the microprocessor 15 at the end of any predefined sampling period determines that the computed average energy value has just transitioned from being either equal to or greater than the first predefined energy value or being equal to or less than the second predefined energy value to being within the upper and lower third predefined energy values, the microprocessor 15 determines that milking of the animal has just commenced.

[0077]   If the microprocessor 15 at the end of any sampling period determines that the computed average energy value has just transitioned from being greater than or equal to the first predetermined energy value to either being indicative of milk flowing in the pipeline or being equal to or less than the second predefined energy value, the microprocessor 15 determines that the milking cluster has been attached to the teats of the animal.

[0078]   It is envisaged that as well as or instead of comparing the computed average energy values of the monitored signal within the predefined frequency bandwidth of 6 kHz to 15 kHz with the upper and lower third predefined energy values in order to detect the presence of milk flowing in the pipeline, the microprocessor 15 may be configured to detect the presence of milk flowing in the pipeline by comparing a pattern defined by a plurality of computed average energy values, and preferably a plurality of consecutive computed average energy values during a predefined time period of duration, for example, of 0.5 seconds to 20 seconds, and preferably, 1 second to 15 seconds, and advantageously, 1 second to 10 seconds, and ideally, 1 second to 5 seconds, with a predefined pattern indicative of milk flowing through a pipeline in pulsed milk slugs in order to determine the presence of milk flowing in the pipeline. Alternatively, the microprocessor may be configured to analyse such a plurality of consecutive computed average energy values over such a predefined time period to ascertain if the analysed consecutive computed average energy values are indicative of milk flowing in a pipeline in pulsed milk slugs.

[0079]   It is also envisaged that instead of or as well as comparing the computed average energy value with the second predefined energy value in order to determine the end of milking of an animal, the microprocessor 15 may be configured to determine the time spacing between consecutive slugs of milk from a plurality of the computed average energy values, and preferably, from a plurality of consecutive ones of the computed average energy values, and the end of milking of an animal would be detected in response to the time spacing between the

consecutive milk slugs being indicative of substantially no milk flowing in the pipeline.

[0080]   It will be appreciated that since the first, second and upper and lower third predefined energy values will vary depending on the type of animal being milked and on each device, and also the time spacing between the milk slugs which would be indicative of virtually no milk flowing in the pipeline will also be dependent on the type of animal being milked and the device, the first, second and upper and lower third predefined energy values, as well as the time spacing between consecutive milk slugs indicative of substantially no milk flowing in the pipeline will be determined by trial during calibration of the device. Although, it is envisaged that in general a time spacing between consecutive milk slugs of the order of ten seconds or more, in general, would be indicative of substantially no milk flowing in the pipeline, and would thus be indicative of the end of milking of an animal.

[0081]   It will be appreciated that the detection by the microprocessor 15 of the commencement of milking and the end of milking, as well as the detection of connection of the milking cluster to the teats of the animal, and kick-off may be detected by the microprocessor in cases where the microprocessor is configured to determine the mass flow rate of milk flowing in the pipe 2 by using other criteria than those described for determining the mass flow rate of the milk flowing with pulse flow through a pipe. In which case, the substantially continuous relatively high energy signal indicative of kick-off and the substantially continuous relatively low energy signal indicative of the absence of milk flowing in the pipeline while the milking cluster is still attached to the teats of the animal would still be distinguishable from the signal indicative of milk flowing through the pipeline in pulsed milk slugs, and thus, kick-off and the commencement and ending of milking of an animal as well as connection and disconnection of the milking cluster to and from the teats of the animal would still be detectable by the microprocessor 15.

[0082]   It is also envisaged that the device according to the invention may be provided to detect any one or more of the presence or absence of milk flowing in a pipeline, the commencement and ceasing of milk flowing in a pipeline, the commencement and ending of milking of an animal, the disconnection of a milking cluster from the teats of animal during milking (kick-off), the connection and disconnection of a milking cluster to and from the teats of an animal, without being provided to determine the mass flow rate and/or the total mass flow of milk through a pipeline. It is further envisaged that in cases where the device is provided to detect any one or more of the presence or absence of milk flowing in a pipeline, the commencement and ceasing of milk flowing in a pipeline, the commencement and ending of milking of an animal, the disconnection of a milking cluster from the teats of an animal during milking (kick-off), the connection and disconnection of a milking cluster to and from the teats of an animal, the device may also be provided to deter-

mine the mass flow rate and/or the total mass flow of milk through a pipeline, and in which case, it is envisaged that the means for determining the mass flow rate and/or the total mass flow of milk flowing through a pipeline may be similar to or different from that of the device described herein.

[0083] While the device has been described as comprising a microphone attached to the wall of the pipe element through which the milk and air are flowing, it is envisaged in certain cases that the microphone may be located within the pipe. For example, it is envisaged that the microphone may be located within the turbulence inducing means. It will also be appreciated that while the turbulence inducing means has been described as a turbulence inducing bar extending diametrically within the bore 5 of the pipe element, any other suitable turbulence inducing means may be provided. Indeed, in certain cases, it is envisaged that the turbulence inducing means may be provided as a relatively small projection extending inwardly into the pipe from the pipe wall, or may be provided by a number of inwardly directed projections extending into the pipe from the pipe wall or by a number of turbulence inducing bars or members spaced apart longitudinally along the pipe element.

[0084] It will also be appreciated that while the monitoring means has been described as a monitoring means for monitoring sonic signals produced by the turbulent flow of the milk and air in the pipe, the monitoring means could be such as would detect ultrasonic signals from the turbulent flow of the milk and air, or any other audible noise signals produced by the turbulent flow of the milk and air through the pipe element.

[0085] While the device according to the invention has been described as comprising a layer of sound insulating material wrapped around the wall of the pipe element in order to minimise the effect of externally generated noise on the microphone, it is envisaged that it may be preferable to omit the sound insulating layer, and in which case the monitored signal would be filtered in order to remove externally generated noise. The filtering of the monitored signal could be carried out on the analogue signal produced by the microphone or on the digital signal, after sampling of the analogue signal. The digital filtering could be carried out directly on the digital form of the signal immediately after sampling, and more preferably would be carried out on the frequency domain of the monitored signal. The filtering would remove or attenuate signals within a frequency range indicative of the externally generated noise. Alternatively, it is envisaged that in cases where the sound insulating layer is omitted, the effect of external noise on the microphone could be minimised by a noise cancellation process by using an additional externally located microphone to pick up external noise. The signals from the two microphones would then be compared in order to cancel the external noise.

[0086] It is also envisaged that the turbulence inducing means may be dispensed with, as in general the flow of milk and air in the pipe element may have sufficient natural turbulence.

[0087] Additionally, it will be appreciated that while the mass flow rate has been determined by substituting the average value of the energy of the sampled signal within the predefined frequency bandwidth of 6 kHz to 15 kHz into a calibration equation, any other suitable means for determining the mass flow rate from the computed average energy value of the signal within the predefined frequency bandwidth may be used, for example, it is envisaged that the computed average energy value of the sampled signal within the predefined frequency bandwidth may be compared with a plurality of calibration average energy values which would be cross-referenced with corresponding calibration mass flow rates, and the mass flow rate of the liquid would be determined as being the calibration mass flow rate corresponding to the calibration average energy value closest to the computed average energy value.

[0088] While the frequency domain of the monitored signals has been derived by carrying out a Fast Fourier Transform on the sampled monitored signal from the microphone at the end of each predefined sampling period, any other suitable means for producing the frequency domain of the monitored signal may be used, or a digital filter may be implemented on the microprocessor to filter the signal.

[0089] It will also be appreciated that when calibrating the device it will be calibrated in the orientation in which it is to be used, for example, if the device is to be located in a horizontally extending pipe, calibration of the device will be carried out with the pipe element 4 extending horizontally, and on the other hand, if the device is to be located in a vertically extending pipe or a pipe extending at an angle to the horizontal between horizontal and vertical, then calibration of the device will be carried out with the pipe element 4 extending vertically or at an angle to the horizontal corresponding to the use angle.

[0090] Needless to say, the device will be calibrated separately for respective liquids, for example, milk, water or other liquids the mass flow rates of which are to be determined by the device. Alternatively, it is envisaged that the device may be calibrated with one liquid, and by applying respective predetermined correction factors for respective different liquids, the device would then be automatically calibrated for such other liquids. For example, the device could be calibrated using water as the calibration liquid, and a predetermined correction factor could be used to automatically calibrate the device for monitoring mass flow of milk, and needless to say, other correction factors could be determined for other liquids, and such predetermined factors would then be applied depending on the liquid for which the device is to be used.

[0091] While the device has been described as comprising a visual display screen, it will be readily apparent to those skilled in the art that in certain cases, the visual display screen may be omitted, and the device would merely produce raw data, which could then be read by a computer or other signal processing device for display

on any suitable visual display, for example, a user interface, a personal computer, or indeed, a smart mobile phone using a near field wireless communications protocol, or any other suitable communicating means be it hard-wired or wireless.

Claims

1. A method for detecting one or more properties of milk flowing turbulently in a pipeline (2) with a gaseous phase medium as a pulsed flow comprising a plurality of time spaced apart slugs of milk with air interspersed therebetween, the one or more of the properties of the milk to be detected comprising the presence of milk flowing in the pipeline (2), the method comprising

monitoring a sonic signal produced by the turbulently flowing spaced apart milk slugs in the pipeline (2),
filtering the frequency domain of the monitored signal to produce a portion of the monitored signal within a predefined frequency bandwidth indicative of milk flowing in the pipeline (2),
computing an energy parameter value of the portion of the monitored signal within the predefined frequency bandwidth,
comparing the computed energy parameter value with a first predefined energy parameter value indicative of air being drawn under vacuum into the pipeline (2) through the teat cups,
comparing the computed energy parameter value with a second predefined energy parameter value indicative of the teat cups of the milking cluster being attached to the teats of the animal without milk flowing in the pipeline (2),
comparing the computed energy parameter value with an upper third predefined energy parameter value and a lower third predefined energy parameter value indicative of milk flowing in the pipeline (2), and
determining the presence of milk flowing in a pipeline (2) in response to the computed energy parameter value lying within the upper and lower third predefined energy parameter values, wherein the method further comprises if the presence of milk flowing in the pipeline (2) is detected, determining the mass flow rate of the milk from the computed energy parameter value, the mass flow rate of the milk being determined by
comparing the computed energy parameter value of the monitored signal within the predefined frequency bandwidth with a system of calibration energy values and corresponding calibration mass flow rates, and
determining the mass flow rate of the milk as a function of the system of the calibration energy values and the corresponding calibration mass flow rates.

2. A method as claimed in Claim 1 **characterised in that** the method further comprises determining one or more of the following:

the absence of milk flowing in the pipeline (2) in response to the computed energy parameter value being less than the second predefined energy parameter value,
disconnection of the teat cups of a milking cluster from the teats of an animal in response to the computed energy parameter value exceeding the first predefined energy parameter value,
connection of teat cups of a milking cluster to the teats of an animal in response to the computed energy parameter value transitioning from a value indicative of air being drawn into the pipeline (2) through the teat cups to a value less than the upper third predefined energy parameter value,
the commencement of milk flowing in the pipeline (2) in response to the computed energy parameter value transitioning from one of a value indicative of the teat cups of the milking cluster being attached to the teats of the animal without milk flowing in the pipeline (2), and a value indicative of air being drawn under vacuum into the pipeline (2) through the teat cups to a value indicative of milk flowing in the pipeline (2), and
the ceasing of milk to flow in the pipeline (2) in response to the computed energy parameter value transitioning from a value indicative of milk flowing in the pipeline (2) to a value less than the second predefined energy parameter value.

3. A method as claimed in Claim 2 **characterised in that** connection of the milking cluster to the teats of the animal is determined in response to the computed energy parameter value transitioning from a value exceeding the first predefined energy parameter value to a value less than the second predefined energy parameter value.

4. A method as claimed in any preceding claim **characterised in that** a plurality of time spaced energy parameter values of the monitored signal within the predefined frequency bandwidth are computed, and the presence of milk flowing in the pipeline (2) is determined in response to the time spaced computed energy parameter values being indicative of milk flowing with pulsed flow.

5. A method as claimed in Claim 4 **characterised in that** the time spaced computed energy parameter values are consecutively computed energy param-

eter values.

6. A method as claimed in any preceding claim **characterised in that** the computed energy parameter value of the monitored signal is computed by computing the average energy of the monitored signal within the predefined bandwidth.

7. A method as claimed in Claim 6 **characterised in that** the average energy value of the monitored signal within the predefined bandwidth is computed at time spaced apart intervals.

8. A method as claimed in Claim 7 **characterised in that** the average energy of the monitored signal within the predefined bandwidth is computed at the end of respective predefined monitoring periods.

9. A method as claimed in Claim 7 or 8 **characterised in that** the monitored signal is sampled at a predefined sampling rate, and the average energy of the sampled signal within the predefined bandwidth is computed at the end of respective predefined sampling periods.

10. A method as claimed in Claim 9 **characterised in that** each predefined monitoring period comprises a plurality of predefined sampling periods.

11. A method as claimed in Claim 9 or 10 **characterised in that** the respective predefined sampling periods run consecutively one after the other.

12. A method as claimed in any of Claims 8 to 11 **characterised in that** the respective predefined monitoring periods run consecutively one after the other.

13. A method as claimed in any preceding claim **characterised in that** the predefined frequency bandwidth lies in the range of 6 kHz to 15 kHz.

14. A method as claimed in any preceding claim **characterised in that** the monitored signal is derived from a microphone (8) located adjacent the pipeline (2,4).

15. A device for detecting one or more properties of milk flowing turbulently in a pipeline (2) with a gaseous phase medium as a pulsed flow comprising a plurality of time spaced apart slugs of milk with air interspersed therebetween, the one or more of the properties of the milk to be detected comprising the presence of milk flowing in the pipeline (2), the absence of milk flowing in the pipeline (2), connection of teat cups of a milking cluster to the teats of an animal, disconnection of the teat cups of a milking cluster from the teats of an animal, commencement of milk flowing in the pipeline (2), and the ceasing of milk flowing in the pipeline (2), the device comprising a monitoring means (8) for monitoring a sonic signal produced by the turbulently flowing spaced apart milk slugs in the pipeline (2,4,5), and a signal processor (15), **characterised in that** the device is configured to carry out the method as claimed in any one of the preceding claims.

Patentansprüche

1. Verfahren zum Erfassen einer oder mehrerer Eigenschaften von Milch, die turbulent in einer Rohrleitung (2) mit einem Gasphasenmedium als gepulste Strömung fließt, die eine Vielzahl von zeitlich beabstandeten Milchschwallen mit dazwischenliegender Luft umfasst, wobei die eine oder mehrere der zu erfassenden Eigenschaften der Milch das Vorhandensein von in der Rohrleitung (2) fließender Milch umfasst,

wobei das Verfahren umfasst
Überwachen eines Schallsignals, das von den turbulent fließenden, voneinander beabstandeten Milchschwallen in der Rohrleitung (2) erzeugt wird,
Filtern des Frequenzbereichs des überwachten Signals, um einen Teil des überwachten Signals innerhalb einer vordefinierten Frequenzbandbreite zu erzeugen, der auf in der Rohrleitung (2) fließende Milch hinweist,
Berechnen eines Energieparameterwerts des Teils des überwachten Signals innerhalb der vordefinierten Frequenzbandbreite,
Vergleichen des berechneten Energieparameterwerts mit einem ersten vordefinierten Energieparameterwert, der Luft anzeigt, die unter Unterdruck durch die Zitzenbecher in die Rohrleitung (2) gesaugt wird,
Vergleichen des berechneten Energieparameterwerts mit einem zweiten vordefinierten Energieparameterwert, der anzeigt, dass die Zitzenbecher des Melkgeschirrs an den Zitzen des Tieres angebracht sind, ohne dass Milch in der Rohrleitung (2) fließt,
Vergleichen des berechneten Energieparameterwertes mit einem oberen dritten vordefinierten Energieparameterwert und einem unteren dritten vordefinierten Energieparameterwert, die anzeigen, dass Milch in der Rohrleitung (2) fließt, und
Feststelen des Vorhandenseins von in einer Rohrleitung (2) fließender Milch als Reaktion darauf, dass der berechnete Energieparameterwert innerhalb des oberen und unteren dritten vordefinierten Energieparameterwertes liegt,
wobei das Verfahren ferner umfasst, wenn das Vorhandensein von in der Rohrleitung (2) fließender Milch erfasst wird, Bestimmen des Mas-

senstroms der Milch aus dem berechneten Energieparameterwert, wobei der Massenstrom der Milch bestimmt wird durch

Vergleichen des berechneten Energieparameterwerts des überwachten Signals innerhalb der vordefinierten Frequenzbandbreite mit einem System von Kalibrierungsenergiewerten und zugehörigen Kalibrierungsmassenströmen, und

Ermitteln des Massenstroms der Milch als Funktion des Systems der Kalibrierungsenergiewerte und der zugehörigen Kalibrierungsmassenströme.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Verfahren ferner ein Feststellen eines oder mehrerer des Folgenden umfasst:

die Abwesenheit von in der Rohrleitung (2) fließender Milch als Reaktion darauf, dass der berechnete Energieparameterwert kleiner als der zweite vordefinierte Energieparameterwert ist, eine Trennung der Zitzenbecher eines Melkgeschirrs von den Zitzen eines Tieres in Reaktion darauf, dass der berechnete Energieparameterwert den ersten vordefinierten Energieparameterwert überschreitet, eine Verbindung von Zitzenbechern eines Melkgeschirrs mit den Zitzen eines Tieres als Reaktion darauf, dass der berechnete Energieparameterwert von einem Wert, der anzeigt, dass Luft durch die Zitzenbecher in die Rohrleitung (2) gesaugt wird, auf einen Wert übergeht, der unter dem oberen dritten vordefinierten Energieparameterwert liegt, den Beginn des Milchflusses in der Rohrleitung (2) als Reaktion darauf, dass der berechnete Energieparameterwert von einem Wert, der anzeigt, dass die Zitzenbecher des Melkgeschirrs an die Zitzen des Tieres angeschlossen sind, ohne dass Milch in der Rohrleitung (2) fließt, oder einem Wert, der anzeigt, dass Luft unter Unterdruck durch die Zitzenbecher in die Rohrleitung (2) gesaugt wird, auf einen Wert übergeht, der anzeigt, dass Milch in der Rohrleitung (2) fließt, und das Beenden des Milchflusses in der Rohrleitung (2) als Reaktion darauf, dass der berechnete Energieparameterwert von einem Wert, der anzeigt, dass Milch in der Rohrleitung (2) fließt, auf einen Wert übergeht, der kleiner als der zweite vordefinierte Energieparameterwert ist.

3. Verfahren nach Anspruch 2, **dadurch gekennzeichnet, dass** eine Verbindung des Melkgeschirrs mit den Zitzen des Tieres in Reaktion darauf festgestellt wird, dass der berechnete Energieparameter-

wert von einem Wert, der den ersten vordefinierten Energieparameterwert überschreitet, auf einen Wert übergeht, der kleiner als der zweite vordefinierte Energieparameterwert ist.

4. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** eine Mehrzahl zeitlich beabstandeter Energieparameterwerte des überwachten Signals innerhalb der vordefinierten Frequenzbandbreite berechnet wird und das Vorhandensein von in der Rohrleitung (2) fließender Milch in Reaktion darauf festgestellt wird, dass die zeitlich beabstandeten berechneten Energieparameterwerte einen gepulsten Milchstrom anzeigen.

5. Verfahren nach Anspruch 4, **dadurch gekennzeichnet, dass** die zeitlich beabstandeten berechneten Energieparameterwerte aufeinanderfolgend berechnete Energieparameterwerte sind.

6. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der berechnete Energieparameterwert des überwachten Signals durch Berechnen der durchschnittlichen Energie des überwachten Signals innerhalb der vordefinierten Bandbreite berechnet wird.

7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet, dass** der durchschnittliche Energiewert des überwachten Signals innerhalb der vordefinierten Bandbreite in zeitlich beabstandeten Intervallen berechnet wird.

8. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, dass** die durchschnittliche Energie des überwachten Signals innerhalb der vordefinierten Bandbreite am Ende der jeweiligen vordefinierten Überwachungsperioden berechnet wird.

9. Verfahren nach Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** das überwachte Signal mit einer vordefinierten Abtastrate abgetastet wird und die durchschnittliche Energie des abgetasteten Signals innerhalb der vordefinierten Bandbreite am Ende entsprechender vordefinierter Abtastperioden berechnet wird.

10. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** jede vordefinierte Überwachungsperiode mehrere vordefinierte Abtastperioden umfasst.

11. Verfahren nach Anspruch 9 oder 10, **dadurch gekennzeichnet, dass** die jeweiligen vordefinierten Abtastperioden aufeinanderfolgend eine nach der anderen ablaufen.

12. Verfahren nach einem der Ansprüche 8 bis 11, **da-**

durch gekennzeichnet, dass die jeweiligen vorde-finierten Überwachungszeiträume aufeinanderfol-gend eine nach der anderen ablaufen.

13. Verfahren nach einem der vorhergehenden Ansprü-che, **dadurch gekennzeichnet, dass** die vordefi-nierte Frequenzbandbreite im Bereich von 6 kHz bis 15 kHz liegt.

14. Verfahren nach einem der vorhergehenden Ansprü-che, **dadurch gekennzeichnet, dass** das über-wachte Signal von einem Mikrofon (8) abgeleitet wird, das sich benachbart zur Rohrleitung (2, 4) be-findet.

15. Vorrichtung zum Erfassen einer oder mehrerer Ei-genschaften von Milch, die turbulent in einer Rohr-leitung (2) mit einem Gasphasenmedium als gepuls-te Strömung fließt, die eine Vielzahl von zeitlich be-abstandeten Milchschwallen mit dazwischen befind-licher Luft umfasst, wobei die eine oder mehrere der zu erfassenden Eigenschaften der Milch das Vor-handensein von in der Rohrleitung (2) fließender Milch, das Fehlen von in der Rohrleitung (2) fließen-der Milch, eine Verbindung von Zitzenbechern eines Melkgeschirrs mit den Zitzen eines Tieres, eine Trennung der Zitzenbecher eines Melkgeschirrs von den Zitzen eines Tieres, einen Beginn eines Milch-flusses in der Rohrleitung (2) und das Beenden des Milchflusses in der Rohrleitung (2) umfasst, wobei die Vorrichtung eine Überwachungseinrichtung (8) zum Überwachen eines Schallsignals, das von den turbulent fließenden, voneinander beabstandeten Milchschwallen in der Rohrleitung (2, 4, 5) erzeugt wird, und einen Signalprozessor (15) umfasst, **da-durch gekennzeichnet, dass** die Vorrichtung dazu konfiguriert ist, das in einem der vorhergehenden Ansprüche beanspruchte Verfahren auszuführen.

Revendications

1. Procédé pour détecter une ou plusieurs propriétés du lait s'écoulant de manière turbulente dans un pi-peline (2) avec un milieu en phase gazeuse sous la forme d'un flux pulsé comprenant une pluralité de bouchons de lait espacés dans le temps avec de l'air intercalé entre eux, l'une ou plusieurs des propriétés du lait à détecter comprenant la présence de lait s'écoulant dans le pipeline (2),

le procédé comprenant
la surveillance d'un signal sonore produit par les bouchons de lait espacés qui s'écoulent de ma-nière turbulente dans le pipeline (2),
le filtrage du domaine de fréquence du signal surveillé pour produire une partie du signal sur-veillé à l'intérieur d'une largeur de bande de fré-

quence prédéfinie indiquant que le lait s'écoule dans le pipeline (2),
le calcul d'une valeur de paramètre d'énergie de la partie du signal surveillé dans la largeur de bande de fréquence prédéfinie,
la comparaison de la valeur de paramètre d'énergie calculée avec une première valeur de paramètre d'énergie prédéfinie indiquant que de l'air est aspiré sous vide dans le pipeline (2) par les gobelets trayeurs,
la comparaison de la valeur de paramètre d'énergie calculée avec une deuxième valeur de paramètre d'énergie prédéfinie indiquant que les gobelets trayeurs de l'unité de traite sont fixés aux trayons de l'animal sans que le lait ne s'écoule dans le pipeline (2),
la comparaison de la valeur de paramètre d'énergie calculée avec une troisième valeur de paramètre d'énergie prédéfinie supérieure et une troisième valeur de paramètre d'énergie prédéfinie inférieure indiquant l'écoulement du lait dans le pipeline (2), et
la détermination de la présence de lait s'écou-lant dans un pipeline (2) en réponse à la valeur de paramètre d'énergie calculée se situant entre les troisièmes valeurs de paramètre d'énergie prédéfinies supérieure et inférieure, dans lequel le procédé comprend en outre, si la présence de lait s'écoulant dans le pipeline (2) est détec-tée, la détermination du débit massique du lait à partir de la valeur de paramètre d'énergie cal-culée, le débit massique du lait étant déterminé par
la comparaison de la valeur de paramètre d'énergie calculée du signal surveillé dans la lar-geur de bande de fréquence prédéfinie avec un système de valeurs d'énergie d'étalonnage et de débits massiques d'étalonnage correspon-dants, et
la détermination du débit massique du lait en fonction du système de valeurs d'énergie d'éta-lonnage et de débits massiques d'étalonnage correspondants.

2. Procédé selon la revendication 1, **caractérisé en ce que** le procédé comprend en outre la détermination d'un ou plusieurs des éléments suivants :

l'absence de lait s'écoulant dans le pipeline (2) en réponse à la valeur de paramètre d'énergie calculée étant inférieure à la deuxième valeur de paramètre d'énergie prédéfinie,
déconnexion des gobelets trayeurs d'une unité de traite des trayons d'un animal en réponse à la valeur de paramètre d'énergie calculée dé-passant la première valeur de paramètre d'éner-gie prédéfinie,
connexion des gobelets trayeurs d'une unité de

traite aux trayons d'un animal en réponse à la transition de la valeur de paramètre d'énergie calculée d'une valeur indiquant que de l'air est aspiré dans le pipeline (2) à travers les gobelets trayeurs à une valeur inférieure à la troisième valeur supérieure de paramètre d'énergie prédéfinie,

le début de l'écoulement du lait dans le pipeline (2) en réponse à la transition de la valeur de paramètre d'énergie calculée d'une valeur indiquant que les gobelets trayeurs de l'unité de traite sont fixés aux trayons de l'animal sans écoulement de lait dans le pipeline (2), et d'une valeur indiquant que de l'air est aspiré sous vide dans le pipeline (2) à travers les gobelets trayeurs, à une valeur indiquant que du lait s'écoule dans le pipeline (2), et

l'arrêt de l'écoulement du lait dans le pipeline (2) en réponse à la transition de la valeur de paramètre d'énergie calculée d'une valeur indiquant l'écoulement du lait dans le pipeline (2) à une valeur inférieure à la deuxième valeur de paramètre d'énergie prédéfinie.

3. Procédé selon la revendication 2, **caractérisé en ce que** la connexion de l'unité de traite aux trayons de l'animal est déterminée en réponse à la valeur de paramètre d'énergie calculée passant d'une valeur dépassant la première valeur de paramètre d'énergie prédéfinie à une valeur inférieure à la deuxième valeur de paramètre d'énergie prédéfinie.

4. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce qu'**une pluralité de valeurs de paramètres d'énergie espacées dans le temps du signal surveillé dans la largeur de bande de fréquence prédéfinie sont calculées, et la présence d'un écoulement de lait dans le pipeline (2) est déterminée en réponse aux valeurs de paramètres d'énergie calculées espacées dans le temps qui indiquent un écoulement de lait avec un flux pulsé.

5. Procédé selon la revendication 4, **caractérisé en ce que** les valeurs de paramètres d'énergie calculées espacées dans le temps sont des valeurs de paramètres d'énergie calculées consécutivement.

6. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la valeur de paramètre d'énergie calculée du signal surveillé est calculée en calculant l'énergie moyenne du signal surveillé dans la largeur de bande prédéfinie.

7. Procédé selon la revendication 6, **caractérisé en ce que** la valeur d'énergie moyenne du signal surveillé dans la largeur de bande prédéfinie est calculée à des intervalles espacés dans le temps.

8. Procédé selon la revendication 7, **caractérisé en ce que** l'énergie moyenne du signal surveillé dans la largeur de bande prédéfinie est calculée à la fin de périodes de surveillance prédéfinies respectives.

9. Procédé selon la revendication 7 ou 8, **caractérisé en ce que** le signal surveillé est échantillonné à une fréquence d'échantillonnage prédéfinie, et l'énergie moyenne du signal échantillonné dans la largeur de bande prédéfinie est calculée à la fin de périodes d'échantillonnage prédéfinies respectives.

10. Procédé selon la revendication 9, **caractérisé en ce que** chaque période de surveillance prédéfinie comprend une pluralité de périodes d'échantillonnage prédéfinies.

11. Procédé selon la revendication 9 ou 10, **caractérisé en ce que** les périodes d'échantillonnage prédéfinies respectives se déroulent consécutivement l'une après l'autre.

12. Procédé selon l'une quelconque des revendications 8 à 11, **caractérisé en ce que** les périodes de surveillance prédéfinies respectives se déroulent consécutivement l'une après l'autre.

13. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** la largeur de bande de fréquence prédéfinie se situe dans la plage de 6 kHz à 15 kHz.

14. Procédé selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le signal surveillé est dérivé d'un microphone (8) situé de manière adjacente au pipeline (2, 4).

15. Dispositif pour détecter une ou plusieurs propriétés du lait s'écoulant de manière turbulente dans un pipeline (2) avec un milieu en phase gazeuse sous la forme d'un flux pulsé comprenant une pluralité de bouchons de lait espacés dans le temps avec de l'air intercalé entre eux, l'une ou plusieurs des propriétés du lait à détecter comprenant la présence de lait s'écoulant dans le pipeline (2), l'absence de lait s'écoulant dans le pipeline (2), la connexion de gobelets trayeurs d'une unité de traite aux trayons d'un animal, la déconnexion des gobelets trayeurs d'une unité de traite des trayons d'un animal, le début de l'écoulement du lait dans le pipeline (2), et l'arrêt de l'écoulement du lait dans le pipeline (2), le dispositif comprenant un moyen de surveillance (8) pour surveiller un signal sonore produit par les bouchons de lait espacés s'écoulant de manière turbulente dans le pipeline (2, 4, 5), et un processeur de signal (15), **caractérisé en ce que** le dispositif est configuré pour mettre en oeuvre le procédé tel que revendiqué dans l'une quelconque des revendications précédentes.

Fig. 2

Fig. 1

Visual Display Screen

Microprocessor

Microphone

Buffer
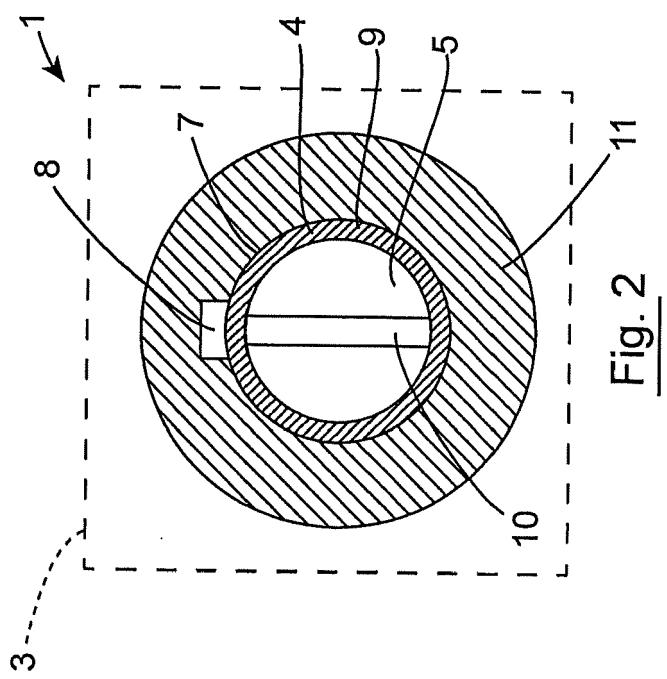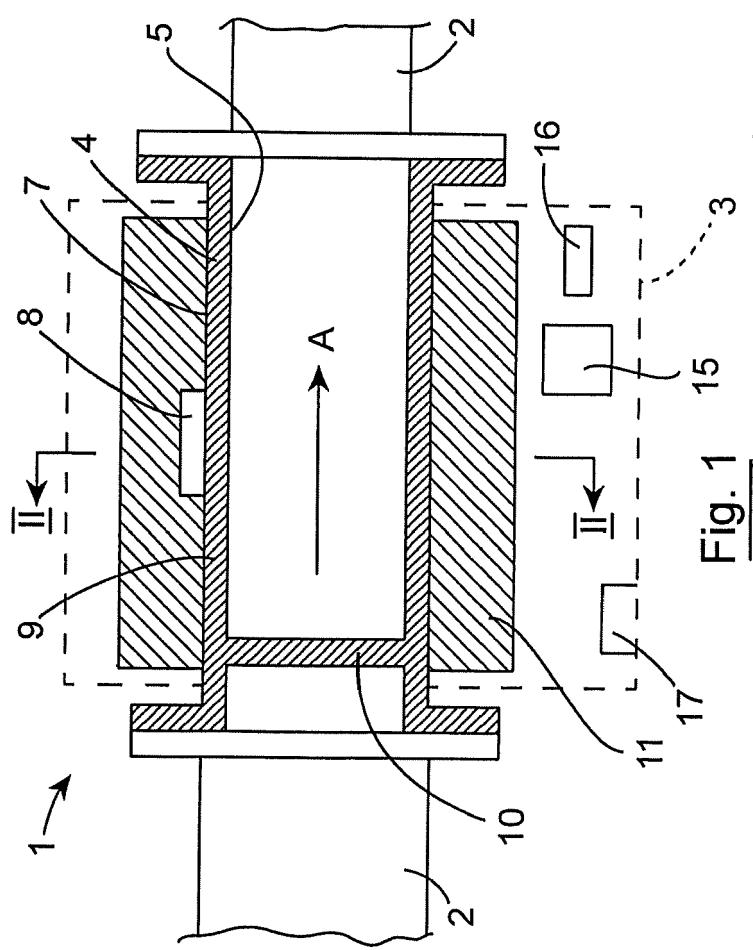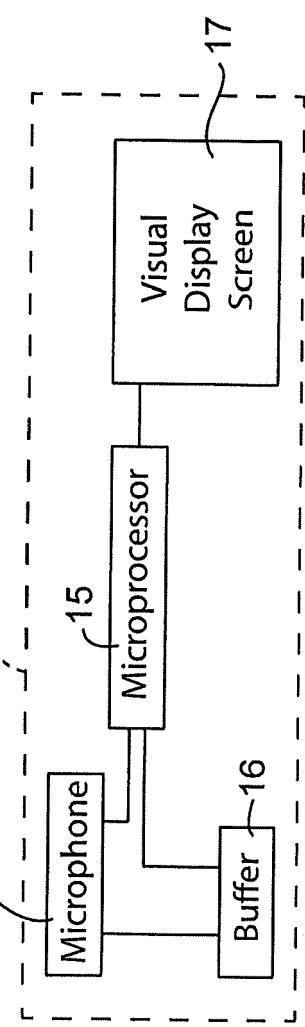
Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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