(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
01 November 2018 (01.11.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/198103 A2

(51) International Patent Classification:
A01J 5/007 (2006.01) *A01J 7/02* (2006.01)

(21) International Application Number:
PCT/IE2018/000005

(22) International Filing Date:
26 April 2018 (26.04.2018)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
S2017/0089 26 April 2017 (26.04.2017) IE

(71) Applicant: **DAIRYMASTER** [IE/IE]; Causeway, County Kerry (IE).

(72) Inventors: **HARTY, Edmond Patrick**; Dromgower, Ballyheigue, County Kerry (IE). **DALY, John Gerard**; 34 The Marina, Tralee, County Kerry (IE).

(74) Agent: **F.F. GORMAN & CO.**; 15 Clanwilliam Square, Dublin 2 (IE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(54) Title: A METHOD AND APPARATUS FOR MONITORING QUALITY OF MILK

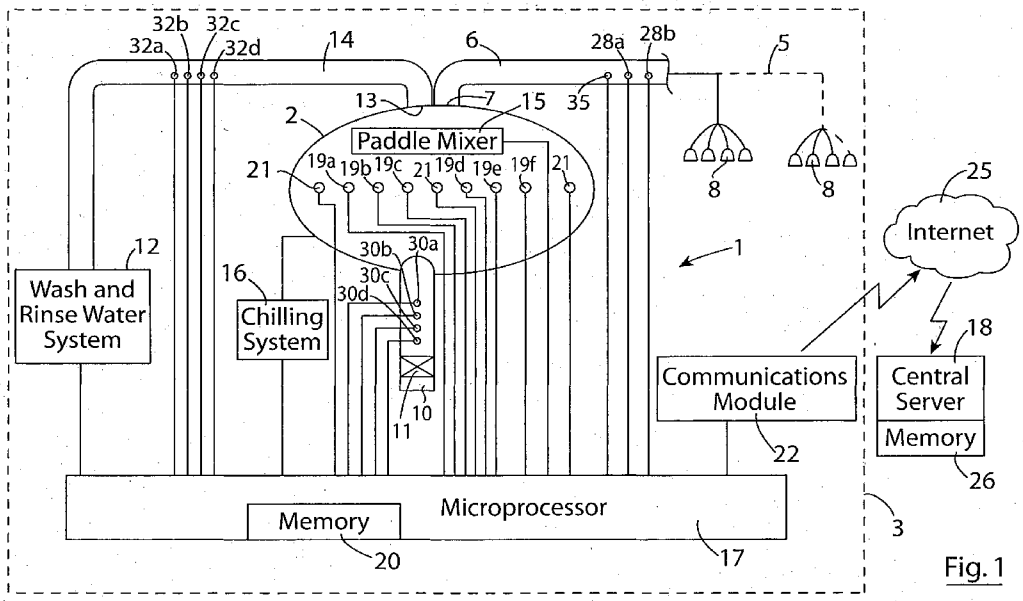


Fig. 1

(57) Abstract: Apparatus (1) for monitoring and determining the milk quality category of milk in a milk storage tank (2) comprises a plurality of milk quality sensors (19) located in the milk storage tank (2), and milk quality sensors (28) located in a milk delivery pipeline (6) for delivering milk to the milk storage tank (2) from a milking system (5). A microprocessor (17) reads signals from the milk quality sensors (19) for determining the quality of the milk in the milk storage tank (2), and determines the data indicative of the milk quality category of the milk in the milk storage tank (2), which is stored in a memory (20) of the microprocessor (17). A communications module (22) wirelessly transmits via the internet (25) the data indicative of the milk quality category of the milk in the milk storage tank (2) to a central server (18), which in turn is stored in a memory (26) of the central server (18). A creamery is permitted access to the data indicative of the milk quality category of the milk stored in memory (26) prior to collection of milk from

WO 2018/198103 A2

[Continued on next page]

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

the milk storage tank (2). By comparing signals read from the milk quality sensors (28) in the milk delivery pipeline (6) with signals read from the milk quality sensors (19), it is possible to determine if the milk storage tank (2) is harbouring bacteria. Discharge rinse water quality sensors (30) are located in an outlet port (10) from the milk storage tank (2) and in a rinse water delivery pipeline (14) to the milk storage tank (2) for determining the cleanliness of the milk storage tank (2).

"A method and apparatus for monitoring quality of milk"

The present invention relates to a method for monitoring milk quality, and the invention also relates to apparatus for monitoring milk quality.

Dairy farms which comprise a plurality of milking animals, in general, cows comprise a milking system, which typically is housed in a milking parlour. The milking system in general has the capacity to milk a plurality of animals simultaneously. Typically, the animals are milked twice per day in two milking sessions, one milking session in the morning and the other milking session in the evening. Milk from dairy farms in general, is supplied to a creamery to be further processed and sold as, for example, liquid milk, powdered milk or as other products, for example, butter, cheese and the like. Creameries collect milk from dairy farms, in some cases every day, and in other cases at three or four day intervals, while some creameries may collect milk from dairy farms at five day intervals. This, thus, requires that the milk from the milking sessions between milk collections must be stored in a milk storage tank for subsequent collection by the creamery. In order to preserve the milk in the milk storage tank, the milk is chilled to a temperature generally specified by the creamery, and typically, below 4°C. It is known that the quality of the milk may vary from dairy farm to dairy farm.

In general, the capacity of milk collection trucks of creameries is such as to facilitate collection of the milk from a number of dairy farms on a single milk collection run. It is therefore important that the milk collected on each milk collection run from the various dairy farms should be of a substantially similar quality. Otherwise, milk of a lesser quality from one of the dairy farms on the milk collection run would result in contamination of better quality milk collected from other dairy farms on that milk collection run.

In many cases, to ensure that as far as practicable the quality of milk being collected from the various dairy farms on each milk collection run is of similar quality, creameries tend to rely on historical quality data relating to the milk from the various dairy farms, and thus, the dairy farms supplying the creamery may be grouped based on the historical quality data of the milk supplied by those dairy farms to the creamery. This, thus, in general allows creameries to select the dairy farms from which milk is to be collected on the same milk collection run, so that the milk collected by each milk collection truck is of similar quality.

However, it is not unknown for milk stored in the milk storage tank of a dairy farm to deteriorate quite suddenly, this may result from an infected animal, a failure in the milking system, a failure of the power supply to the milk storage tank or through other such causes, which may go undetected until the milk has been collected and delivered to the creamery. In which case, the milk from one dairy farm which has deteriorated may result in contamination of the milk collected from all the other dairy farms on that milk collection run. This is undesirable, and there is therefore a need for a method and apparatus for monitoring milk quality which addresses this problem.

The present invention is directed towards providing such a method and apparatus for monitoring milk quality.

According to the invention there is provided a method for monitoring milk quality, the method comprising locating a milk quality sensing means for monitoring at least one characteristic of milk indicative of the quality of the milk in at least one of a milk storage tank in which the milk is stored and a delivery pipeline through which the milk is delivered to the milk storage tank, configuring a signal processor to read signals indicative of the at least one monitored characteristic of the milk from the milk quality sensing means, configuring the signal processor to determine from the signal read from the milk quality sensing means data indicative of the milk quality and to store the data indicative of the milk quality, and providing access to at least one authorised user to the signal processor to read the data indicative of the milk quality.

In one aspect of the invention the data indicative of the milk quality is stored in a storing means. Preferably, data indicative of the monitored characteristics of the milk read from the milk quality sensing means is stored in a storing means.

In another aspect of the invention the milk quality sensing means comprises one or more of the following sensors:

- a total bacteria count sensor for detecting the total count of bacteria in the milk,
- a specific bacteria sensor for determining the count of a specific bacteria in the milk,
- a somatic cell count sensor for monitoring the somatic cell count in the milk,
- an antibody sensor for detecting a specific antibody in the milk,
- a milk composition sensor for determining the quantity of at least one component of the milk, as a percentage of the milk,

- a protein sensor for monitoring the quantity of protein in the milk as a percentage of the milk,
- a fat content sensor for monitoring the fat content in the milk as percentage of the milk,
- a sensor for detecting an operational parameter of the milk storage tank, such as the temperature of the milk in the milk storage tank and/or the time taken to cool the milk to a predefined chilled temperature, and
- a sensor which would detect any other parameter or characteristic of the milk which would affect the quality of the milk.

Preferably, the signal processor is configured to determine the data indicative of the milk quality as one of a plurality of milk quality categories from the signals read from the milk quality sensing means indicative of the characteristics of the milk. Advantageously, the signal processor is configured to determine the data indicative of the milk quality as being one of a low milk quality category and a high milk quality category, the quality of the milk of the high milk quality category being of higher quality than the milk of the low milk quality category. Preferably, the signal processor is configured to determine the data indicative of the milk quality as being one of the low milk quality category, the high milk quality category, and an intermediate milk quality category, the quality of the milk of the intermediate milk quality category being less than the quality of the milk of the high milk quality category, and being greater than the quality of the low milk quality category.

In one aspect of the invention the milk is delivered to the milk storage tank directly as it is being milked from an animal.

In another aspect of the invention the milk storage tank forms a part of a milking system, whereby the milk milked from one or more animals is delivered into the milk storage tank and stored therein. Preferably, the milk storage tank is located in a milking parlour.

In one aspect of the invention the milk is cooled in the milk storage tank to a predefined chill temperature. Preferably, the milk is cooled in the milk storage tank to the predefined chill temperature on the milk being delivered into the milk storage tank. Advantageously, the milk is agitated in the milk storage tank during cooling of the milk in the milk storage tank. Ideally, the milk in the milk storage tank is agitated until the temperature of the milk in the milk storage tank has been cooled to the predefined chill temperature.

In one aspect of the invention the predefined chill temperature lies in the range of 2.5°C to 4.5°C. Preferably, the predefined chill temperature lies in the range of 3°C to 4°C. Ideally, the predefined chill temperature lies in the range of 3.2°C to 3.6°C.

In another aspect of the invention the milk stored in the milk storage tank is collected at predefined intervals. Preferably, the predefined intervals at which the milk stored in the milk storage tank is collected lie in the range of 1 day to 5 days.

In one aspect of the invention milk from at least one milking session per day is delivered to the milk storage tank. Preferably, milk from at least two milking sessions per day is delivered to the storage tank. Advantageously, one of the two milking sessions is a morning milking session and the other one of the two milking sessions is an evening milking session.

In one aspect of the invention milk from a plurality of milking sessions is delivered to the milk storage tank, and at the end of the predefined number of days the milk from the milking sessions during the predefined number of days stored in the milk storage tank is collected therefrom.

In another aspect of the invention the milk quality sensing means comprises at least one tank milk quality sensing means configured for locating in or adjacent the milk storage tank, and for monitoring at least one characteristic of the milk in the milk storage tank.

In another aspect of the invention the milk quality sensing means comprises at least one pipeline milk quality sensing means configured for locating in or adjacent the milk delivery pipeline through which milk is delivered into the milk storage tank for monitoring at least one characteristic of the milk flowing through the milk delivery pipeline.

Preferably, at least one of the pipeline milk quality sensing means is configured to monitor at least one characteristic of the milk similar to one of the characteristics of the milk which are monitored by at least one of the tank milk quality sensing means.

Advantageously, the signals indicative of the characteristics of the milk in the milk storage tank are read from the at least one tank milk quality sensing means by the signal processor when at least one predefined condition prevails in the milk in the milk storage tank.

Preferably, the signals indicative of the characteristics of the milk in the milk storage tank are read from the at least one tank milk quality sensing means by the signal processor after the temperature of the milk in the milk storage tank has been reduced to the predefined chill temperature.

In another aspect of the invention the signal processor is configured to compare signals read from at least one of the pipeline milk quality sensing means with signals read from at least one of the tank milk quality sensing means which are configured to monitor similar characteristics of the milk flowing through the milk delivery pipeline and stored in the milk storage tank to determine if there is a discrepancy between the quality of the milk in the milk storage tank and the quality of the milk flowing through the milk delivery pipeline.

In one aspect of the invention each milk quality sensing means is hardwired to the signal processor.

Alternatively, each milk quality sensing means is configured to communicate wirelessly with the signal processor. Preferably, each milk quality sensing means is configured to communicate with the signal processor through a near field communications protocol.

In another aspect of the invention a discharge rinse water quality sensing means is located adjacent a rinse water outlet from the milk storage tank for monitoring at least one characteristic of rinse water discharged from the milk storage tank indicative of the cleanliness of the milk storage tank.

Preferably, the signal processor is configured to read signals from the discharge rinse water quality sensing means to determine the cleanliness of the milk storage tank.

In another aspect of the invention a pipeline rinse water quality sensing means is located in a rinse water delivery pipeline through which wash and rinse water is delivered into the milk storage tank for monitoring at least one characteristic of the rinse water delivered into the milk storage tank indicative of the cleanliness of the rinse water.

Preferably, the signal processor is configured to read signals from the pipeline rinse water quality sensing means to determine the cleanliness of the rinse water.

In another aspect of the invention the signal processor is configured for comparing the signals read from the pipeline rinse water quality sensing means with signals read from the discharge rinse water quality sensing means for determining if there is a discrepancy between the cleanliness of the rinse water discharged from the milk storage tank and the cleanliness of the rinse water delivered into the milk storage tank through the rinse water delivery pipeline.

In another aspect of the invention the discharge rinse water quality sensing means comprises one or more of a total bacteria count sensor for detecting the total bacteria count in the rinse water, a bacteria count sensor for detecting the count of a specific bacteria in the rinse water, a detergent sensor for detecting detergent residue in the rinse water, and a sanitising solution sensor for detecting sanitising solution residue in the rinse water.

Preferably, the pipeline rinse water quality sensing means comprises one or more of a total bacteria count sensor for detecting the total bacteria count in the rinse water, a bacteria count sensor for detecting the count of a specific bacteria in the rinse water, a detergent sensor for detecting detergent residue in the rinse water, and a sanitising solution sensor for detecting sanitising solution residue in the rinse water.

In one aspect of the invention each rinse water quality sensing means is hardwired to the signal processor. Alternatively, each rinse water quality sensing means is configured to communicate wirelessly with the signal processor.

In one aspect of the invention the signal processor is configured as a first signal processor and a second signal processor, the first signal processor being configured to read signals from the milk quality sensing means, and being configured to communicate with the second signal processor for communicating to the second signal processor one of the data indicative of the milk quality and the monitored characteristic of the milk.

In another aspect of the invention access to the signal processor by the at least one authorised user is provided to the second signal processor.

In a further aspect of the invention access to the signal processor by the at least one authorised user is provided to the first signal processor.

Preferably, the first signal processor is configured to store data values of the signals indicative of the monitored characteristics. Advantageously, the first signal processor is configured to determine the data indicative of the milk quality. Ideally, the first signal processor is configured to store the data indicative of the milk quality.

In one aspect of the invention the first signal processor is configured to determine the milk quality category of the milk in the milk storage tank.

Preferably, the first signal processor is configured to store data indicative of the milk quality category of the milk in the milk storage tank.

Advantageously, the first signal processor communicates data indicative of the determined milk quality category to the second signal processor.

Preferably, the first signal processor is configured to read signals from the discharge rinse water quality sensing means and from the pipeline rinse water quality sensing means.

Advantageously, the first signal processor is configured to determine the cleanliness of the milk storage tank.

In another aspect of the invention the first signal processor is configured to determine the cleanliness of the rinse water delivered to the milk storage tank through the rinse water deliver pipeline.

Preferably, the first signal processor is configured to compare the signals read from the discharge rinse water quality sensing means with the signals read from the pipeline rinse water quality sensing means.

Advantageously, the first signal processor communicates with the second signal processor wirelessly. Advantageously, the first signal processor communicates with the second signal processor via a communications network.

In another aspect of the invention the first signal processor communicates with the second signal processor via a mobile phone network.

Preferably, the first signal processor communicates with the second signal processor via the internet.

In one aspect of the invention the second signal processor comprises a central server.

In another aspect of the invention one of the authorised users comprises a creamery to which milk in the milk storage tank is to be supplied.

The invention also provides a method for monitoring the cleanliness of a milk storage tank, the method comprising locating a discharge rinse water quality sensing means for monitoring at least one characteristic of rinse water discharged from the milk storage tank indicative of the cleanliness of the milk storage tank, configuring a signal processor to read signals from the discharge rinse water quality sensing means indicative of the at least one monitored characteristic in the rinse water, and configuring the signal processor to determine data indicative of the cleanliness of the milk storage tank from the signals read from the discharge rinse water quality sensing means, and providing access to at least one authorised user to the signal processor to read data indicative of the cleanliness of the milk storage tank.

In one aspect of the invention the signal processor stores the data indicative of the cleanliness of the milk storage tank.

In another aspect of the invention the discharge rinse water quality sensing means is located in an outlet of the milk storage tank through which rinse water is discharged from the milk storage tank.

In another aspect of the invention a pipeline rinse water quality sensing means located in a rinse water delivery pipeline through which wash and rinse water is delivered to the milk storage tank, and the signal processor is configured to read signals from the pipeline rinse water quality sensing means and to

determine data indicative of the cleanliness of the rinse water delivered to the milk storage tank through the delivery pipe line from the read signals.

Preferably, the signal processor is configured to compare signals read from the pipeline rinse water quality sensing means with signals read from the discharge rinse water quality sensing means configured for monitoring a similar one of the characteristics of the rinse water to that monitored by the pipeline rinse water quality sensing means.

Advantageously, each rinse water quality sensing means comprises one or more of a total bacteria count sensor for detecting the total bacteria count in the rinse water, a bacteria count sensor for detecting the count of a specific bacteria in the rinse water, a detergent detecting means for detecting detergent residue in the rinse water, and a sanitising solution detecting means for detecting sanitising solution residue in the rinse water.

In one aspect of the invention the signal process is configured as a first signal processor and a second signal processor, the first signal processor being configured to communicate with the second signal processor for communicating data indicative of the cleanliness of the milk storage tank. Preferably, the first signal processor is configured to read signals from the discharge rinse water quality sensing means indicative of the monitored characteristic of the rinse water. Advantageously, the first signal processor is configured to determine the data indicative of the cleanliness of the milk storage tank.

In one aspect of the invention the first signal processor is configured to determine the cleanliness of the rinse water delivered to the milk storage tank through the rinse water delivery pipeline.

In another aspect of the invention the first signal processor is configured to communicate the data indicative of the cleanliness of the rinse water delivered to the milk storage tank through the rinse water delivery pipeline.

Additionally, the invention provides apparatus for monitoring the quality of milk in a milk storage tank, the apparatus comprising a milk quality sensing means for monitoring at least one characteristic of milk indicative of the quality of the milk, the milk quality sensing means being located in or adjacent one of the milk storage tank and a milk delivery pipeline through which milk is delivered to the milk storage tank, a

signal processor configured to read signals from the milk quality sensing means indicative of the at least one monitored characteristic, the signal processor being configured to determine data indicative of the milk quality of the milk in the milk storage tank from the signals read from the milk quality sensing means.

In one aspect of the invention a storing means is provided, and data indicative of the milk quality of the milk in the milk storage tank is stored in the storing means.

In another aspect of the invention the signal processor is configured to provide access thereto by an authorised user to read the data indicative of the milk quality of the milk in the milk storage tank therefrom.

In one aspect of the invention the milk quality sensing means comprises one or more of the following sensors:

- a total bacteria count sensor for detecting the total bacteria count in the milk,
- a specific bacteria count sensor for detecting the specific bacteria count in the milk,
- a somatic cell count sensor for detecting the somatic cell count in the milk,
- an antibody sensor for detecting an antibody in the milk,
- a milk composition sensor for detecting the percentage content of at least one constituent of the milk,
- a protein sensor for detecting the percentage protein content in the milk,
- a fat content sensor for detecting the percentage fat content in the milk,
- a sensor for detecting an operational parameter of the milk storage tank, such as the temperature of the milk in the milk storage tank and/or the time taken to cool the milk to a predefined chilled temperature, and
- a sensor which would detect any other parameter or characteristic of the milk which would affect the quality of the milk.

Preferably, the signal processor is configured for determining the quality of the milk in the milk storage tank from the signals read from the milk quality sensing means as being one of a low milk quality category and a high milk quality category.

In another aspect of the invention the signal processor is configured for determining the quality of the milk in the milk storage tank from the signals read from the milk quality sensing means as being one of the low

milk quality category, the high milk quality category and an intermediate milk quality category, the quality of the milk of the intermediate milk quality category being less than the quality of the milk of the high quality milk category and being greater than the quality of the milk of the low quality milk category.

Preferably, the milk storage tank is configured for storing milk directly from a milking system.

Advantageously, the milk storage tank is located in or adjacent a milking parlour. Preferably, the milk storage tank is configured to store milk directly as it is being milked from an animal.

In one aspect of the invention a cooling means is provided for cooling the milk in the milk storage tank to a predefined chill temperature and for maintaining the temperature of the milk in the milk storage tank at the predefined chill temperature.

Preferably, the predefined chill temperature lies in the range of 2.5°C to 4.5°C. Advantageously, the predefined chilled temperature lies in the range of 3°C to 4°C. Ideally, the predefine chilled temperature lies in the range of 3.2°C to 3.6°C.

In one aspect of the invention the milk storage tank comprises an agitating means for agitating the milk in the milk storage tank during cooling of the milk in the milk storage tank. Preferably, the agitating means is configured to agitate the milk in the milk storage tank until the milk in the milk storage tank has been cooled to the predefined chill temperature.

In one aspect of the invention the signal processor is configured to read signals from the milk quality sensing means indicative of the monitored characteristics of the milk in the milk storage tank when at least one predefined condition prevails in the milk in the milk storage tank.

In another aspect of the invention the signal processor is configured to read signals from the milk quality sensing means indicative of the quality of the milk in the milk storage tank in response to the temperature of the milk in the milk storage tank having been cooled to the predefined chilled temperature.

In one aspect of the invention the milk quality sensing means comprises a tank milk quality sensing means configured for locating in or adjacent the milk storage tank.

In another aspect of the invention the milk quality sensing means comprises a pipeline milk quality sensing means configured for locating in a milk delivery pipeline through which milk is delivered to the milk storage tank.

In one aspect of the invention the signal processor is configured to compare signals read from the pipeline milk quality sensing means with signals read from the tank milk quality sensing means which is configured to monitor similar characteristics of the milk as those for which the pipeline milk quality sensing means is configured to monitor for determining if the quality of the milk in the milk storage tank is different to the quality of the milk being delivered to the milk storage tank through the milk delivery pipeline.

In another aspect of the invention the milk quality sensing means is hardwired to the signal processor. Alternatively, the milk quality sensing means is configured to communicate wirelessly with the signal processor.

In one aspect of the invention a discharge rinse water quality sensing means is located in a rinse water discharge outlet from the milk storage tank for monitoring at least one characteristic in the rinse water, and the signal processor is configured to read signals from the discharge rinse water quality sensing means indicative of the at least one monitored characteristic, and to determine from the read signals data indicative of the cleanliness of the milk storage tank.

In another aspect of the invention a pipeline rinse water quality sensing means is located in a rinse water delivery pipe through which wash and rinse water is delivered into the milk storage tank, and the signal processor is configured to read signals from the pipeline rinse water quality sensing means indicative of the monitored characteristics for determining from the read signals data indicative of the cleanliness of the rinse water delivered to the milk storage tank through the rinse water delivery pipeline.

Preferably, the signal processor is configured for comparing signals read from the tank rinse water quality sensing means and the pipeline rinse water quality sensing means for determining if there is a difference between the quality of the rinse water delivered to the milk storage tank through the rinse water delivery pipeline and the quality of the rinse water discharged from the milk storage tank.

In one aspect of the invention the rinse water quality sensing means comprises one or more of the following rinse water quality sensors:

- a total bacteria count sensor for detecting the total bacteria count in the rinse water,
- a specific bacteria count sensor for detecting the bacteria count of a specific bacteria in the rinse water,
- one of a detergent sensor for detecting the level of detergent residue in the rinse water, and
- a sanitising solution sensor for detecting the level of sanitising solution residue in the rinse water.

Preferably, the rinse water quality sensing means are hardwired to the first signal processor.

Preferably, the rinse water quality sensing means are configured to communicate wirelessly with the first signal processor.

In one aspect of the invention the signal processor is configured as a first signal processor and a second signal processor, the first signal processor being configured to read signals from the milk quality sensing means indicative of the monitored characteristic of the milk, and being configured to communicate with the second signal processor for communicating data indicative of the milk quality to the second signal processor.

Preferably, the first signal processor is configured to determine the milk quality from the signals read from milk quality sensing means, and to store data indicative of the milk quality.

Advantageously, the first signal processor is configured to communicate the data indicative of the milk quality to the second signal processor.

Preferably, the first signal processor is configured to determine the milk quality category of the milk in the milk storage tank.

In one aspect of the invention the first signal processor is configured to communicate data indicative of the determined quality milk category of the milk in the milk storage tank to the second signal processor.

Preferably, the second signal processor is configured to store the data indicative of the milk quality.

In another aspect of the invention the first signal processor is configured to read signals from the discharge rinse water quality sensing means and to determine the data indicative of the cleanliness of the rinse water discharged from the milk storage tank. Preferably, the first signal processor is configured to transmit to the second signal processor data indicative of the signals read from the discharge rinse water quality sensing means and the data indicative of the cleanliness of the water discharged from the milk storage tank.

Advantageously, the first signal processor is configured to read signals from the pipeline rinse water quality sensing means and to determine the cleanliness of the rinse water in the rinse water delivery pipeline.

In another aspect of the invention the first signal processor is configured to transmit data indicative of the signals read from the pipeline rinse water quality sensing means and the data indicative of the cleanliness of the rinse water in the rinse water delivery pipeline.

Preferably, the first signal processor is configured to communicate wirelessly with the second signal processor.

In one aspect of the invention the first signal processor is configured to communicate with the second signal processor via a mobile phone network. Preferably, the first signal processor is configured to communicate with the second signal processor via a wireless communications network. Advantageously, the first signal processor is configured to communicate with the second signal processor via the internet.

In another aspect of the invention the second signal processor is configured to provide access by the at least one authorised user to the data indicative of the quality of the milk.

In a further aspect of the invention the second signal processor comprises a central server.

The invention also provides a milking system comprising a milk storage tank and apparatus according to the invention for monitoring the quality of milk in the milk storage tank.

Further the invention provides apparatus for determining the cleanliness of a milk storage tank, the apparatus comprising a rinse water quality sensing means configured for monitoring at least one characteristic in the rinse water indicative of the cleanliness of the milk storage tank, a signal processor configured to read signals from the rinse water quality sensing means indicative of the at least one monitored characteristic, the signal processor being configured to determine data indicative of the cleanliness of the milk storage tank from the signals read from the rinse water quality sensing means.

Preferably, the data indicative of the cleanliness of the milk storage tank is stored in a storing means.

Advantageously, the rinse water quality sensing means is configured for locating in an outlet of the milk storage tank through which rinse water is discharged from the milk storage tank.

In one aspect of the invention the signal processor is configured to permit access thereto by an authorised user for reading the data indicative of the cleanliness of the milk storage tank.

The invention further provides a method for monitoring quality of milk in a milk storage tank, the method comprising locating a milk quality sensing means for monitoring at least one characteristic of milk indicative of the quality of the milk in the milk storage tank in which the milk is stored, configuring a signal processor to read signals indicative of the at least one monitored characteristic of the milk from the milk quality sensing means when at least one predefined condition prevails in the milk in the milk storage tank, configuring the signal processor to determine from the signal read from the milk quality sensing means data indicative of the milk quality and to store the data indicative of the milk quality.

Preferably, the data indicative of the milk quality is stored in a storing means.

Advantageously, data indicative of the monitored characteristics of the milk read from the milk quality sensing means is stored in a storing means.

In one aspect of the invention the milk quality sensing means comprises one or more of the following sensors:

- a total bacteria count sensor for detecting the total count of bacteria in the milk,
- a specific bacteria sensor for determining the count of a specific bacteria in the milk,

- a somatic cell count sensor for monitoring the somatic cell count in the milk,
- an antibody sensor for detecting a specific antibody in the milk,
- a milk composition sensor for determining the quantity of at least one component of the milk, as a percentage of the milk,
- a protein sensor for monitoring the quantity of protein in the milk as a percentage of the milk,
- a fat content sensor for monitoring the fat content in the milk as percentage of the milk,
- a sensor for detecting an operational parameter of the milk storage tank, such as the temperature of the milk in the milk storage tank and/or the time taken to cool the milk to a predefined chilled temperature, and
- a sensor which would detect any other parameter or characteristic of the milk which would affect the quality of the milk.

Preferably, the signal processor is configured to determine the data indicative of the milk quality as one of a plurality of milk quality categories from the signals read from the milk quality sensing means indicative of the characteristics of the milk.

Advantageously, the signal processor is configured to determine the data indicative of the milk quality as being one of a low milk quality category and a high milk quality category, the quality of the milk of the high milk quality category being of higher quality than the milk of the low milk quality category.

Preferably, the signal processor is configured to determine the data indicative of the milk quality as being one of the low milk quality category, the high milk quality category, and an intermediate milk quality category, the quality of the milk of the intermediate milk quality category being less than the quality of the milk of the high milk quality category, and being greater than the quality of the low milk quality category.

Advantageously, the milk is cooled in the milk storage tank to a predefined chill temperature.

In another aspect of the invention the milk is cooled in the milk storage tank to the predefined chill temperature on the milk being delivered into the milk storage tank.

Preferably, the milk is agitated in the milk storage tank during cooling of the milk in the milk storage tank.

Preferably, the milk in the milk storage tank is agitated until the milk in the milk storage tank is homogeneous.

In one aspect of the invention the milk in the milk storage tank is agitated until the temperature of the milk in the milk storage tank has been cooled to the predefined chill temperature. Preferably, the predefined chill temperature lies in the range of 2.5°C to 4.5°C. Advantageously, the predefined chill temperature lies in the range of 3°C to 4°C. Ideally, the predefined chill temperature lies in the range of 3.2°C to 3.6°C.

In one aspect of the invention the at least one predefined condition prevailing in the milk in the milk storage tank comprises the temperature of the milk in the milk storage tank.

In another aspect of the invention the at least one predefined condition prevailing in the milk in the milk storage tank comprises the homogeneity of the milk in the milk storage tank.

Preferably, the predefined temperature condition of the milk comprises the temperature of the milk in the milk storage tank being at the predefined chill temperature.

Advantageously, the predefined conditions of the milk in the milk storage tank prevail when the milk in the milk storage tank is homogeneous and at the predefined chill temperature.

Preferably, milk from at least one milking session per day is delivered to the milk storage tank. Advantageously, milk from at least two milking sessions per day is delivered to the storage tank. Preferably, one of the two milking sessions is a morning milking session and the other one of the two milking sessions is an evening milking session.

In one aspect of the invention milk from a plurality of milking sessions is delivered to the milk storage tank, and at the end of the predefined number of days the milk from the milking sessions during the predefined number of days stored in the milk storage tank is collected therefrom.

Preferably, the signals indicative of the characteristics of the milk in the milk storage tank are read from the milk quality sensing means by the signal processor after the temperature of the milk in the milk storage tank has been reduced to the predefined chill temperature.

In one aspect of the invention the milk quality sensing means is hardwired to the signal processor. Alternatively, the milk quality sensing means is configured to communicate wirelessly with the signal processor.

Preferably, access to the signal processor by at least one authorised user is provided.

Advantageously, one of the authorised users comprises a creamery to which milk in the milk storage tank is to be supplied.

The advantages of the invention are many. A particular important advantage of the invention is that it provides advance notice to the authorised user, for example, a creamery of the milk quality category the milk stored in a milk storage tank of a dairy farm prior to collection of the milk from the milk storage tank by the creamery. This advantage, therefore allows the creamery to assign a milk collection truck to collect the milk from the milk storage tank so that the milk collected from other dairy farms by the same milk collection truck on the milk collection run are all of substantially similar milk quality category to the milk quality category of the milk in that milk storage tank. Thus, in the event of the milk in the milk storage tank which normally would be of a relatively high milk quality category being of a lower milk quality category than normal, the creamery can ensure that the milk from that milk storage tank is collected by a milk collection truck which is collecting milk of substantially similar milk quality category. Another advantage of the invention is that by providing advance notice of the milk quality category of the milk in the milk storage tank to the creamery, the creamery can select the most appropriate production stream through which the milk of that milk storage tank is to be processed.

A further advantage of the invention is achieved when the creamery has real time access to the milk quality category data of the milk in the milk storage tank, in that if it appears that the milk quality category of the milk is deteriorating, and that any delay in the collection of the milk would result in further deterioration in the quality of the milk, and indeed deterioration of the quality of the milk to the extent that it would be unusable, the creamery may take appropriate action by bringing forward the collection date for collecting the milk from the milk storage tank.

A further advantage of the invention is achieved when the apparatus is provided with rinse water quality sensors, in that the cleanliness of the milk storage tank can be readily determined and its freedom from detergent and sanitising solution residues after the milk storage tank has been subjected to a wash and rinse water cycle or cycles, and also if the milk storage tank has been subjected to a sanitising cycle, can also be readily determined, and if necessary corrective action can be taken prior to delivery of the first batch of milk from the first of the milking sessions to the milk storage tank.

An additional advantage of the invention is that the quality of the rinse water can also be readily determined.

The invention will be more clearly understood from the following description of a preferred embodiment thereof which is given by way of example only with reference to the accompanying drawings, in which:

Fig. 1 is a block representation of apparatus for monitoring the quality of milk stored in a milk storage tank, and

Fig. 2 is a plot of the volume of milk stored in the milk storage tank and a plot of the temperature of the milk stored in the milk storage tank, both plotted against time in days.

Referring to the drawings and initially to Fig. 1 thereof, there is illustrated apparatus according to the invention indicated generally by the reference numeral 1 for monitoring the quality of milk in a milk storage tank 2 of a milking system also according to the invention and indicated generally by the reference numeral 5. The milking system 5 and the milk storage tank 2 are located in a milking parlour 3, and the milk storage tank 2 is connected directly to the milking system 5 for receiving milk directly from the milking system 5 as animals are being milked by the milking system 5 and for storing the milk therein. The apparatus 1 is illustrated in block representation in Fig. 1, while the milking system 5 is illustrated in diagrammatic form in Fig. 1.

The milking system 5 comprises a milk delivery pipeline 6 through which milk is delivered from the milking system 5 to the milk storage tank 2 through a first inlet port 7 in the milk storage tank 2. Milk is drawn from the teats of the animals through milking clusters 8 under vacuum by the milking system 5, and the milk is then delivered to the milk storage tank 2 through the milk delivery pipeline 6. Although only two

milking clusters 8 are illustrated in Fig. 1, as will be understood by those skilled in the art, the number of milking clusters 8 in the milking system 5 will be dependent on the size of the milking parlour 3 and the number of animals to be milked simultaneously. An outlet port 10 is provided from the milk storage tank 2 through which milk is discharged from the milk storage tank 2, for example, to a milk collection truck for delivery to a creamery where the milk is further processed. A manually operated or a pneumatically operated isolating valve 11 closes the outlet port 10. A wash and rinse water system (not shown), which will be well known to those skilled in the art is provided for washing and rinsing the milking system.

A wash and rinse water system 12 is connected to the milk storage tank 2 through a rinse water delivery pipeline 14 for washing and rinsing the milk storage tank 2, and for sanitising the milk storage tank 2 if desired, after the milk has been collected from the milk storage tank 2. The rinse water delivery pipeline 14 connects the wash and rinse water system 12 to a second inlet port 13 of the milk storage tank 2 for accommodating wash and rinse water from the wash and rinse water system 12 to the milk storage tank 2. Wash and rinse water is returned to the wash and rinse water system 12 from the milk storage tank 2 or to a water treatment plant through the outlet port 10 for further treatment, as will be understood by those skilled in the art. The wash and rinse water system 12 is configured to subject the milk storage tank 2 to a wash cycle by delivering wash water which typically contains a detergent and may also contain a sanitising solution to and through the milk storage tank 2 for washing thereof. After washing of the milk storage tank 2 the wash and rinse water system 12 delivers clean rinse water to and through the milk storage tank 2 for two or three rinse cycles, in order to rinse any remaining detergent residue and sanitising solution residue from the milk storage tank 2. A typical wash and rinse water cycle to which the milk storage tank 2 is subjected includes initially subjecting the milk storage tank 2 to two pre-rinse cycles during which the milk storage tank 2 is rinsed with water. On completion of the two pre-rinse cycles, the milk storage tank 2 is then subjected to a detergent wash cycle, which typically comprises delivering a hot water detergent wash to the milk storage tank 2. On completion of the wash cycle, the milk storage tank 2 is subjected to two or three post-rinse cycles, typically three post-rinse cycles in order to rinse any remaining detergent residue and sanitising solution residue from the milk storage tank 2. During the post-rinse cycles rinse water is delivered to the milk storage tank 2. The washing, sanitising and rinsing of such milk storage tanks as the milk storage tank 2 will be well known to those skilled in the art and further description should not be required.

The milk storage tank 2 comprises a chilling system 16 which will be well known to those skilled in the art for cooling the milk in the milk storage tank 2 to a predefined chill temperature, and for maintaining the milk in the milk storage tank 2 at the predefined chill temperature. The predefined chill temperature typically lies in the range of 3°C to 4°C, and in general lies between 3.2°C and 3.7°C, and in general, the predefined chill temperature is specified by a creamery to which the milk from the milk storage tank 2 is being supplied. In this embodiment of the invention the predefined chill temperature is approximately 3.5°C. Temperature sensors 21 in the milk storage tank 2 monitor the temperature of the milk in the milk storage tank 2, and the chilling system 16 is operated in response to signals read from the temperature sensors 21 for cooling the milk and maintaining the milk in the milk storage tank 2 at the predefined chill temperature, as will be described below.

The milk storage tank 2 comprises an agitating means, namely, a paddle mixer 15 mounted therein, which in this embodiment of the invention is operated continuously while the chilling system 16 is activated and actively cooling the milk in the milk storage tank 2. Additionally, periodically the paddle mixer 15 is activated, typically, for two minute periods for circulating the milk within the milk storage tank 2 to homogenise the milk prior to reading signals from the temperature sensors 21 for determining the temperature of the milk in the milk storage tank 2, so that the signals read from the temperature sensors 21 provide an accurate reading of the temperature of the milk in the milk storage tank 2.

The chilling of milk in such a milk storage tank and the agitating of milk in such a milk storage tank as the milk storage tank 2 will be well known to those skilled in the art.

Returning now to the apparatus 1 for monitoring the quality of the milk in the milk storage tank 2, the apparatus 1 comprises a signal processor, which in this embodiment of the invention is provided in the form of a first signal processor, in this embodiment of the invention a microprocessor 17, and a second signal processor, in this embodiment of the invention a central server 18, which is described below. The microprocessor 17 is configured to read signals from a milk quality sensing means comprising a tank milk quality sensing means, namely, tank milk quality sensors 19 for monitoring different characteristic of the milk relating to the quality of the milk in the milk storage tank 2.

In this embodiment of the invention six tank milk quality sensors 19a to 19f are provided for monitoring six different characteristics relating to the quality of the milk. The first tank milk quality sensor 19a is a total

bacteria count sensor for determining the total bacteria count of the milk. The second tank milk quality sensor 19b is a bacteria count sensor for determining the bacteria count of a specific bacteria in the milk. The third tank milk quality sensor 19c is a somatic cell count sensor for detecting if any of the animals being milked are suffering from mastitis. The fourth tank milk quality sensor 19d comprises a milk composition sensor for determining the composition of the milk, or for determining the percentage content of specific components in the milk. The fifth tank milk quality sensor 19e comprises a protein sensor for determining the percentage protein content of the milk. The sixth tank milk quality sensor 19f comprises a fat content sensor for determining the percentage fat content of the milk.

The tank milk quality sensors 19 may be located within the milk storage tank 2 or externally of the milk storage tank 2 and when located externally of the milk storage tank 2, would be provided with probes extending into the milk storage tank 2 to interface with the milk, or to extract samples of the milk from the milk storage tank 2 for delivery to the corresponding tank milk quality sensor 19. The tank milk quality sensors 19 may be of the type which give an instant value of the characteristic of the milk being sensed, or may be of the type which require time, for example, up to a number of hours to produce a value of the characteristic being monitored. The tank milk quality sensors 19 are configured to produce an electronic signal indicative of the value of the respective characteristic of the milk being monitored. The electronic signals may be analogue signals or digital signals. The tank milk quality sensors 19 in this embodiment of the invention are hardwired to the microprocessor 17. However, it is envisaged that in other embodiments of the invention the microprocessor 17 may communicate with the milk quality sensors 19 wirelessly, through, for example, a Bluetooth protocol or any other suitable near field communications protocol.

The microprocessor 17 is programmed to read and process the signals from the tank milk quality sensors 19 and to determine and store the values of the monitored characteristics of the milk in a memory 20. The microprocessor 17 is also programmed to determine from the values of the monitored characteristics the quality of the milk in one of three milk quality categories, namely, a high milk quality category, a low milk quality category, and an intermediate milk quality category. The quality of the milk categorised as being in the intermediate milk quality category is of quality less than that of milk in the high milk quality category, but is of quality greater than that of milk in the low milk quality category. Data indicative of the milk quality category of the milk in the milk storage tank 2 is then stored in the memory 20. All data indicative of the monitored characteristics of the milk in the milk storage tank 2 as well as data indicative of the milk quality category of the milk in the milk storage tank 2 stored in the memory 20 is time and date stamped as of the

time and date at which the signals indicative of the characteristics of the milk in the milk storage tank 2 are read by the microprocessor 17 from the milk quality sensors 19.

A communicating means for wireless communicating the data stored in the memory 20 of the microprocessor 17 indicative of the monitored characteristics of the milk in the milk storage tank 2 and the determined milk quality category of the milk in the milk storage tank 2 to the central server 18 comprises a communications module 22 operated under the control of the microprocessor 17 for transmitting the stored data indicative of the monitored characteristics and of the milk quality category of the milk in the milk storage tank 2 to the central server 18 over the internet 25. The data indicative of the monitored characteristics and of the milk quality category of the milk in the milk storage tank 2 is stored in a memory 26 of the central server 18.

The central server 18 is configured to provide access by the farmer whose animals are being milked by the milking system 5 to the data indicative of the monitored characteristics of the milk in the milk storage tank 2 and of the milk quality category of the milk in the milk storage tank 2. As well as being configured to permit access by the farmer to the data stored in the memory 26 of the central server 18, the central server 18 is also configured to permit access by an authorised user, for example, a creamery which is being supplied with the milk from the milk storage tank 2 to the stored data stored in the memory 26 indicative of the milk quality category of the milk stored in the milk storage tank 2, so that the creamery can access the data indicative of the milk quality category of the milk stored in the milk storage tank 2 prior to designating a milk collection truck to collect the milk from the milk storage tank 2. The creamery may also be permitted to access the stored data stored in the memory 26 of the central server 18 indicative of the values of the monitored characteristics of the milk stored in the milk storage tank 2.

By providing such access to this data stored in the memory 26 of the central server 18 by the creamery, the creamery can determine the production stream for which the milk stored in the milk storage tank 2 is suitable. For example, the creamery can determine whether the milk stored in the milk storage tank 2 is suitable for producing as liquid milk, or is suitable for producing high quality formula baby powdered milk, or is suitable for producing lower quality milk powder. This enables the creamery to determine the most appropriate milk collection truck to be used for collecting the milk from the milk storage tank 2. This, thus, allows the creamery to collect milk of similar quality from milk storage tanks of a number of farmers equipped with similar apparatus to that of the apparatus 1 in the same milk collection truck, thereby

avoiding the danger of milk of low milk quality category from one farmer contaminating milk of high milk quality category collected from a number of farmers on a collection run by a milk collection truck.

It is also envisaged that the apparatus similar to the apparatus 1, with which the milk storage tanks of the other farmers are equipped, will communicate with the central server 18 or other central servers of the respective farmers, so that the creamery which is collecting milk from milk storage tanks of these farmers will be able to read from the central server 18 or the other central servers of the apparatus of the respective farmers the milk quality category of the milk in the milk storage tanks of the respective farmers, as well as the other stored data indicative of the values of the monitored characteristics of the milk in the milk storage tanks of the respective farmers, so that the appropriate milk collection truck will collect milk of similar quality from the various farmers.

Additionally, in this embodiment of the invention the milk quality sensing means also comprises a pipeline milk quality sensing means, namely, a plurality of pipeline milk quality sensors 28 located in the milk delivery pipeline 6 adjacent the inlet port 7 of the milk storage tank 2 for monitoring characteristics indicative of the quality of the milk delivered to the milk storage tank 2 through the milk delivery pipeline 6. In this embodiment of the invention two pipeline milk quality sensors 28 are located in the milk delivery pipeline 6, namely, a first pipeline milk quality sensor 28a which is a total bacteria count sensor for detecting the total bacteria count in the milk being delivered through the milk delivery pipeline 6, and a second pipeline milk quality sensor 28b which is a bacteria count sensor for determining the bacteria count of a specific bacteria in the milk being delivered through the milk delivery pipeline 6. The total bacteria count sensor 28a is similar to the total bacteria count sensor 19a, and the bacteria count sensor 28b is similar to the bacteria count sensor 19b and is configured to determine the bacteria count of a bacteria similar to that for which the second tank milk quality sensor 19b is configured to determine. The pipeline milk quality sensors 28 are hardwired to the microprocessor 17, but may communicate wirelessly with the microprocessor 17 through, for example, a Bluetooth protocol or any other suitable near field communications protocol.

The microprocessor 17 is programmed to read signals which are indicative of the values of the monitored characteristics from the pipeline milk quality sensors 28, and to determine from the read signals the total bacteria count of the milk being delivered through the milk delivery pipeline 6 and the bacteria count of a specific bacteria in the milk being delivered through the milk delivery pipeline 6 from the signals read from

the pipeline milk quality sensors 28a and 28b, respectively. The determined values of the total bacteria count and the bacteria count of the specific bacteria in the milk being delivered through the milk delivery pipeline 6 are stored by the microprocessor 17 in the memory 20. The microprocessor 17 is programmed to compare the total bacteria count of the milk read from the pipeline milk quality sensor 28a in the milk delivery pipeline 6 with the total bacteria count of the milk in the milk storage tank 2 read from the tank milk quality sensor 19a. If the result of this comparison by the microprocessor 17 is indicative of a higher total bacteria count in the milk in the milk storage tank 2 than the total bacteria count in the milk being delivered through the milk delivery pipeline 6 to the milk storage tank 2, the microprocessor 17 determines that the milk storage tank 2 is harbouring bacteria, and the microprocessor 17 is programmed to subject the milk storage tank 2 to appropriate wash and rinse cycles in order to decontaminate the milk storage tank 2 after the next collection of the milk from the milk storage tank 2.

The microprocessor 17 is programmed to carry out a similar comparison between the value of the signals read from the second pipeline milk quality sensor 28b with the value of the signals read from the second tank milk quality sensor 19b for similarly determining if the milk storage tank 2 is contaminated with the specific bacteria, the count of which is detected by the second tank and pipeline milk quality sensors 19b and 28b. If the milk storage tank 2 is deemed to be harbouring the bacteria, the count of which is detected by the second tank and pipeline milk quality sensors 19b and 28b, the milk storage tank 2 will be similarly subjected to appropriate wash and rinse cycles after the next collection of milk from the milk storage tank 2.

In this embodiment of the invention rinse water quality sensing means comprising a plurality of discharge rinse water quality sensors 30 are located in the outlet port 10 from the milk storage tank 2 for monitoring respective characteristics indicative of the quality of the rinse water being discharged from the milk storage tank 2 during the final rinse of the milk storage tank 2 at the end of a wash and rinse cycle. In this embodiment of the invention four discharge rinse water quality sensors 30 are provided, namely, a first discharge rinse water quality sensor 30a which comprises a total bacteria count sensor for determining the total bacteria count in the rinse water, a second discharge rinse water quality sensor 30b which comprises a bacteria count sensor for determining the bacteria count of a specific bacteria in the rinse water, a third discharge rinse water quality sensor 30c which comprises a detergent sensor for detecting any detergent residue in the rinse water, and a fourth discharge rinse water quality sensor 30d

which comprises a sanitising solution detector for detecting any residue of sanitising solution in the rinse water.

The microprocessor 17 is hardwired to the discharge rinse water quality sensors 30 in the outlet port 10 of the milk storage tank 2, although the microprocessor 17 may communicate wirelessly through, for example, a Bluetooth protocol or other suitable near field communications protocol with the discharge rinse water quality sensors 30.

The microprocessor 17 is programmed to read the signals indicative of the values of the sensed characteristics of the rinse water from the discharge rinse water quality sensors 30 and to determine the total bacteria count in the rinse water, the bacteria count of a specific bacteria in the rinse water, the percentage residue of detergent in the rinse water, if any, and the percentage residue of any sanitising solution in the rinse water, if any. The values of these characteristics are stored in the memory 20 by the microprocessor 17.

The microprocessor 17 is programmed to determine from the signals read from the discharge rinse water quality sensors 30 data indicative of the cleanliness of the milk storage tank 2 and to store the data indicative of the cleanliness of the milk storage tank 2 in the memory 20 of the microprocessor 17. The microprocessor 17 determines from the stored data indicative of the cleanliness of the milk storage tank 2 if the milk storage tank 2 has been adequately cleaned and rinsed, and is free of detergent and sanitising solution residue. The microprocessor 17 is programmed to operate the wash and rinse water system 12 to subject the milk storage tank 2 to a second wash and rinse cycle, or a number of rinse cycles, if the milk storage tank has not been adequately cleaned by the previous wash and rinse cycle, or contains detergent residue or sanitising solution residue from the previous wash and rinse cycle, as the case may be. At the end of the second wash and rinse cycle, or the additional rinse cycles, as the case may be, the microprocessor 17 again reads signals from the discharge rinse water quality sensors 30 to determine if the milk storage tank 2 has been adequately washed and rinsed. If at this stage the microprocessor 17 determines from the signals read from the discharge rinse water quality sensors 30 that the milk storage tank 2 has not been adequately cleaned and disinfected or is not free from detergent or sanitising solution residue, the microprocessor 17 is programmed to transmit through the communications module 22 an alert signal to the central server 18. The central server 18 in turn outputs an alert signal in order to alert

the farmer to the fact that the milk storage tank 2 requires further attention before it is suitable for storing milk.

Alternatively, instead of the microprocessor 17 being programmed to activate the wash and rinse water system 12 to carry out a second wash and rinse cycle and/or additional rinsing cycles, as the case may be, the microprocessor 17 may be programmed to transmit through the communications module 22 an alert signal to the central server 18, which in turn would also alert the farmer to the fact that the milk storage tank 2 requires further attention before it is suitable for storing milk.

In this embodiment of the invention the rinse water sensing means also comprises pipeline rinse water quality sensing means, namely, pipeline rinse water quality sensors 32 located in the rinse water delivery pipeline 14 to the milk storage tank 2 adjacent the inlet port 13 thereof for monitoring the quality of the rinse water being delivered through the rinse water delivery pipeline 14 into the milk storage tank 2. In this embodiment of the invention four pipeline rinse water quality sensors 32 are provided, namely, a first pipeline rinse water quality sensor 32a comprising a total bacteria count sensor for detecting the total bacteria count in the rinse water in the rinse water delivery pipeline 14, a second pipeline rinse water quality sensor 32b comprising a bacteria count sensor for detecting the bacteria count of a specific bacteria in the rinse water, a third pipeline rinse water quality sensor 32c comprising a detergent sensor for detecting the percentage detergent residue if any in the rinse water, and a fourth pipeline rinse water quality sensor 32d comprising a sanitising solution sensor for detecting the percentage sanitising solution residue if any in the rinse water. The pipeline rinse water quality sensors 32a to 32d are similar to the discharge rinse water quality sensors 30a to 30d, respectively. The pipeline rinse water quality sensors 32 are hardwired to the microprocessor 17, although the microprocessor 17 may communicate with the pipeline rinse water quality sensors 32 wirelessly, for example, through a Bluetooth protocol or any other suitable near field communications protocol.

The microprocessor 17 is programmed to read the signals from the pipeline rinse water quality sensors 32 which are indicative of the values of the monitored characteristics of the rinse water flowing through the rinse water delivery pipeline 14. The microprocessor 17 is programmed to determine from the signals read from the pipeline rinse water quality sensors 32, the values of the monitored characteristics of the rinse water flowing through the rinse water delivery pipeline 14. The determined values of the monitored characteristics of the rinse water are time and date stamped and stored in the memory 20.

The microprocessor 17 is programmed to compare the stored values of the monitored characteristics monitored by the pipeline rinse water quality sensors 32 with the stored values of the monitored characteristics of the rinse water discharged from the milk storage tank 2 monitored by the corresponding discharge rinse water quality sensors 30. If the comparison between the monitored characteristics of the rinse water flowing through the pipeline 6 and the monitored characteristics of the rinse water discharged from the milk storage tank 2 is indicative of the total bacteria count of the rinse water monitored by the discharge rinse water quality sensor 30a being greater than the total bacteria count monitored by the pipeline rinse water quality sensor 32a, which would indicate that the milk storage tank 2 had not been adequately washed during the previous wash and rinse cycles, the microprocessor 17 is programmed to operate the wash and rinse water system 12 to subject the milk storage tank 2 to a further wash and rinse cycle and to an appropriate number of rinse cycles. Similarly, if the bacteria count of the specific bacteria in the rinse water discharged from the milk storage tank 2 monitored by the discharge rinse water quality sensor 30b is greater than the bacteria count of the specific bacteria in the rinse water flowing through the rinse water delivery pipeline 14 monitored by the pipeline rinse water quality sensor 32b, the microprocessor 17 is programmed to likewise subject the milk storage tank 2 to further wash and rinse cycles, and to a further appropriate number of rinse cycles.

In the event that detergent residue is detected by either of the discharge or pipeline rinse water quality sensors 30c or 32c, or in the event that sanitising solution residue is detected by either of the discharge and pipeline rinse water quality sensors 30d and 30e, the microprocessor 17 is programmed to operate the wash and rinse water system 12 to subject the milk storage tank 2 to a further number of rinse water cycles.

Alternatively, instead of operating the wash and rinse water system 12 in the event of the signals read from the discharge and pipeline rinse water quality sensors 30 and 32 indicating that the milk storage tank 2 is not yet ready to store milk, the microprocessor 17 may be programmed to transmit an alarm signal through the communications module 22 to the central server 18, which in turn would output an alert signal in order to alert the farmer to the problem with the milk storage tank 2.

The microprocessor 17 is programmed that at the end of each milking session when the data indicative of the milk quality category of the milk in the milk storage tank 2 has been determined and stored in the

memory 20, to operate the communications module 22 to transmit to the central server 18 the data indicative of the milk quality category and the data indicative of the monitored characteristics of the milk in the milk storage tank 2. Additionally, the microprocessor 17 is programmed at appropriate times, typically on completion of each wash and rinse cycle to which the milk storage tank 2 is subjected, to operate the communications module 22 to transmit to the central server 18 data stored in the memory 20 relating to values of the monitored characteristics read and determined from the discharge and pipeline rinse water quality sensors 30 and 32, which may be downloaded by the farmer as desired.

Additionally, in this embodiment of the invention the microprocessor 17 is programmed to operate and control the chilling system 16 and the paddle mixer 15 of the milk storage tank 2 in response to the temperature of the milk in the milk storage tank 2, which is read by the microprocessor 17 from the temperature sensors 21, and a temperature sensor 35 in the milk delivery pipeline 6, in order to cool the milk in the milk storage tank 2 to the predefined chill temperature during delivery of milk into the milk storage tank 2 during a milking session, and for maintaining the milk in the milk storage tank 2 at the predefined chill temperature. The microprocessor 17 also logs and stores the temperature values read from the temperature sensors 21 and 35 time and date stamped in the memory 20, and determines the length of the time taken to cool the milk in the milk storage tank to the predefined chilled temperature during each milking session. The data relating to the time taken to cool the milk to the predefined chilled temperature during each milking session is time and date stamped and stored in the memory 20. All the stored data relating to the temperature of the milk in the milk storage tank 2 and in the milk delivery pipeline 6 as well as the times taken to cool the milk in the milk storage tank 2 during each milking session is transmitted to the central server 18 after each milking session, when the temperature of the milk in the milk storage tank 2 has been cooled to the predefined chilled temperature. Additionally, all data stored in the memory 20 of the microprocessor 17 may be transmitted under the control of the microprocessor 17 to a smart mobile phone of a farmer.

In use, animals are typically milked twice per day by the milking system 5, once in the morning and once in the evening. On each milking session, the milk from the animals is delivered through the milk delivery pipeline 6 into the milk storage tank 2, where it is stored for subsequent collection by the creamery. In this case the milk is collected from the milk storage tank 2 by the creamery at four day intervals.

Reference is now made to Fig. 2 which illustrated two graphs, namely, graph A and graph B. Graph A is a graph of the temperature of the milk in the milk storage tank 2 which is plotted on the vertical Y-axis on the left-hand side of Fig. 2 in °C against time in days plotted on the horizontal X-axis of Fig. 2. Graph B is a graph of the total volume of milk stored in the milk storage tank 2 plotted in litres on the vertical Y-axis on the right-hand side of Fig. 2 against time which is plotted in days on the horizontal X-axis. As can be seen from Fig. 2, at the beginning of day one, the milk storage tank 2 is empty, the milk from the previous four days having been collected by the creamery after the morning milking session of day one. After collection of the milk from the milk storage tank 2, the milk storage tank 2 is subjected to one or more wash and rinse cycles as described above, and passed by the apparatus 1 as being ready to receive milk from the evening milking session on day one.

As the milk from the evening milking session on day one is delivered into the milk storage tank 2, signals from the pipeline milk quality sensors 28 in the milk delivery pipeline 6 are read by the microprocessor 17 which determines the values of the monitored characteristics of the milk flowing through the pipeline 6, and the determined values of the characteristics of the milk flowing through the milk delivery pipeline are time and date stamped and stored in the memory 20 for subsequent comparison as already described with the values of the characteristics determined by the microprocessor 17 from the signals which are read from the tank milk quality sensors 19. As the milk is being delivered into the milk storage tank 2, the temperature of the milk is relatively high, and is reduced by the chilling system 16 under the control of the microprocessor 17, so that after a time period after the evening milking session has been completed, the temperature of the milk is reduced to a steady state temperature, namely, the predefined chill temperature of approximately 3.5°C.

On activation of the chilling system 16 to cool the milk in the milk storage tank 2, the paddle mixer 15 is simultaneously activated to agitate the milk in the milk storage tank 2. The paddle mixer 15 is continuously operated while the chilling system 16 is activated for cooling the milk in the milk storage tank 2. On the milk in the milk storage tank 2 being chilled to the predefined chill temperature, the chilling system 16 and the paddle mixer 15 are deactivated. At the end of the cooling of the milk in the milk storage tank 2 when steady state conditions prevail throughout the milk in the milk storage tank 2, and the temperature of the milk has been reduced to the predefined chill temperature of 3.5°C, the microprocessor 17 commences to read the signals from the tank milk quality sensors 19a to 19f. The steady state conditions are deemed to prevail throughout the milk in the milk storage tank 2 just after the temperature

of the milk therein has been reduced to the predefined temperature of 3.5°C and when the chilling system 16 and the paddle mixer 15 have been deactivated at point a_1 of graph A of Fig. 2. When the signals indicative of the monitored characteristics have all been read by the microprocessor 17 from the tank milk quality sensor 19a to 19f, the values of the signals indicative of the monitored characteristics are stored, time and date stamped in the memory 20. The microprocessor 17 then determines the data indicative of the milk quality category of the milk in the milk storage tank 2 from the stored values of the monitored characteristics. The data indicative of the milk quality category of the milk is also stored in the memory 20 time and date stamped. On completion of the determination of the data indicative of the milk quality category of the milk, the microprocessor 17 activates the communications module 22 to transmit the data indicative of the milk quality category of the milk to the central server 18.

Additionally, the microprocessor 17 compares the values of the monitored characteristics of the milk in the milk storage tank 2 read from the tank milk quality sensors 19a and 19b with the values of the monitored characteristics of the milk when flowing in the milk delivery pipeline 6 from the pipeline milk quality sensors 28a and 28b in order to ascertain if the bacteria counts read from the tank milk quality sensors 19a and 19b are higher than the bacteria counts read from the pipeline milk quality sensors 28a and 28b, which would be an indication that the milk storage tank 2 is harbouring bacteria, and would therefore require appropriate attention when next being subjected to wash and rinse cycles after collection of the milk from the milk storage tank 2. The data indicative of the comparisons is time and date stamped and stored in the memory 20 and then transmitted to the central server 18.

On the morning of day two at points 1 and 2 on the graphs A and B respectively, the morning milking session commences, and the microprocessor 17 commences to read signals from the pipeline milk quality sensors 28 located in the milk delivery pipeline 6 from which the monitored characteristics of the milk are determined and time and date stamped and stored in the memory 20. As the milk from the morning milking session is delivered into the milk storage tank 2 the temperature of the milk in the milk storage tank 2 commences to rise due to the higher temperature of the milk being delivered into the milk storage tank. The chilling system 16 and the paddle mixer 15 are operated by the microprocessor 17 to agitate and to mix the incoming warm milk with the milk already stored in the milk storage tank 2, and to reduce the temperature of the milk in the milk storage tank to the predefined chilled temperature of approximately 3.5°C. On completion of the morning milking session when the temperature of the milk in the milk storage tank 2 has been reduced to and stabilised at the predefined chill temperature of 3.5°C, and steady state

conditions prevail in the milk in the milk storage tank 2, namely, at point a_2 on graph A, the microprocessor 17 commences to read the signals from the tank milk quality sensors 19 and determines the values of the monitored characteristics from the signals read, which are time and date stamped and stored in the memory 20. The microprocessor 17 then determines the data indicative of the milk quality category of the milk in the milk storage tank 2 from the signals read from the tank milk quality sensors 19, which is then time and date stamped and stored in the memory 20 and transmitted to the central server 18 along with the values of the monitored characteristics monitored by the tank and pipeline milk quality sensors 19 and 28 as already described.

The microprocessor 17 then also compares the values of the monitored characteristics read from the tank and pipeline milk quality sensors 19a and 19b and 28a and 28b, respectively, and transmits data indicative of the comparisons to the central server 18 as already described. And so on in day two milk from the evening session is delivered to the milk storage tank 2, and on day three milk from the morning and evening sessions are delivered to the milk storage tank 2, and on day four milk from the morning session is delivered to the milk storage tank 2.

After the morning milking session on day four the milk from the milk storage tank 2 is collected by the creamery.

On completion of each of the milking sessions on days two to four, the milk is chilled and agitated until the temperature of the milk in the milk storage tank 2 has been reduced to the predefined chill temperature of 3.5°C. At that stage, namely, at points a_3 to a_6 on graph A, the signals from the tank milk quality sensors 19 are read, and as already described the milk quality category of the milk in the milk storage tank 2 is determined. Additionally, during each milking session, the signals from the pipeline milk quality sensors 28 are also read as already described, and at the end of each milking session, the signals from the pipeline milk quality sensors 28a and 28b are compared with the signals read from the tank milk quality sensors 19a and 19b as already described, and the data relating to the milk quality category and the milk quality characteristics is transmitted by the microprocessor 17 to the central server 18 as already described.

Additionally, during the periods between each milking session, the paddle mixer 15 is activated periodically for two minute periods in order to homogenise the milk in the milk storage tank 2, and on

completion of each two minute agitation of the milk, the temperature of the milk in the milk storage tank 2 is read from the temperature sensors 21. For so long as the temperature of the milk in the milk storage tank 2 remains at the predefined chill temperature of approximately 3.5°C, no action is required. However, on the temperature of the milk in the milk storage tank 2 being determined as exceeding the predefined chill temperature of 3.5°C, the chilling system 16 and the paddle mixer 15 are activated until the temperature of the milk in the milk storage tank 2 has been reduced to the predefined chill temperature of 3.5°C. At that stage the chilling system 16 and the paddle mixer 15 are deactivated.

Additionally, during the periods between the milking sessions, it may be desired to determine the milk quality category of the milk in the milk storage tank 2, and at such intervals at which the milk quality category of the milk in the milk storage tank 2 is to be determined, the paddle mixer 15 is activated for a two minute agitating period in order to homogenise the milk. On completion of the two minute agitating period, the paddle mixer 15 is deactivated, and provided the temperature of the milk in the milk storage tank 2 is at the predefined chill temperature of 3.5°C, signals are read from the tank milk quality sensors 19a to 19f, and the milk quality category of the milk is determined from the values of the signals read from the tank milk quality sensors 19. The data indicative of the milk quality category of the milk just determined is then transmitted by the microprocessor 17 through the communications module 22 to the central server 15 along with the values of the milk quality characteristics read from the tank milk quality sensors 19.

After completion of the milking session of the morning of day four, when the temperature of the milk in the milk storage tank 2 has been reduced to approximately 3.5°C and has been stabilised at approximately 3.5°C, the microprocessor 17 commences to read signals from the tank quality sensors 19 and determines the values of the monitored characteristics from the signals read from the tank milk quality sensors 19. The microprocessor 17 then determines the data indicative of the milk quality category of the milk in the milk storage tank 2 from the values of the characteristics of the milk read from the tank milk quality sensors 19. The data indicative of the milk quality category of the milk in the milk storage tank 2 is then stored in the memory 20 and is transmitted to the central server 18, where it can be accessed by the creamery.

Once the creamery has read the data indicative of the milk quality category of the milk in the milk storage tank 2, the creamery then determines the appropriate milk collection truck for collecting milk from the milk

storage tank 2, so that the milk in the milk storage tank 2 will be of substantially similar milk quality category to that being collected by the milk collection truck of the creamery.

On collection of the milk by the creamery from the milk storage tank 2, the milk storage tank 2 is then subjected to wash and rinse cycles by the wash and rinse water system 12. The extent of the wash and rinse cycles is determined by the state of the milk storage tank 2, in other words whether or not it has been determined as harbouring bacteria. On the last rinse of the rinse cycles the microprocessor 17 reads the signals from the discharge rinse water quality sensors 30 and the pipeline rinse water quality sensors 32 and processes the signals read from the tank and pipeline milk quality sensors 30 and 32 as already described and transmits the data indicative of the cleanliness of the milk storage tank 2 or an alarm signal as the case may be to the central server 18. If further washing and rinsing of the milk storage tank 2 is required, this is carried out under the control of the microprocessor 17 as already described.

In this embodiment of the invention the signal from the tank milk quality sensors 19 are read under predefined conditions of the milk, which in this embodiment of the invention are when the milk in the milk storage tank 2 has been homogenised, and the temperature of the milk in the milk storage tank is at the predefined chill temperature.

In this embodiment of the invention the bacteria count sensors 19b, 28b, 30b and 32b for detecting the bacteria count of a specific bacteria may be configured for detecting the bacteria count of bacteria such as thermoduric, psychotropic bacteria, streptococcus, streptococcus agalactiae, staphylococcus aureus, mycoplasma species, coliform bacteria, other streptococci and/or bacillus. Although, needless to say, the specific bacteria count sensors may be configured to detect any other bacteria.

While the apparatus 1 has been described as comprising a plurality of milk quality sensors and rinse water quality sensors, in certain cases, it is envisaged that only one or two milk quality sensors and one or two rinse water quality sensors may be provided. For example, it is envisaged that in some embodiments of the invention only a total bacteria count sensor 19a and a somatic cell count sensor 19c would be provided while only a total bacteria count sensor 28a would be provided. It is also envisaged that in certain embodiments of the invention only a total bacteria count sensor 30a may be provided and only a total bacteria count sensor 32a may be provided for detecting the corresponding characteristics of the rinse water. It is also envisaged that, in general, at least the detergent sensor 30c would be provided,

although the sanitising solution sensor 30d may be omitted if the milk storage tank is not subjected to a sanitising solution. Needless to say, it will be appreciated that all the pipeline milk quality sensors 28 and the pipeline rinse water quality sensors 32 may be omitted in certain embodiments of the invention.

It is envisaged that the total bacteria count sensor 30a and the bacteria count sensor 30b may be similar to the total bacteria count 19a and the bacteria count 19b, respectively. Indeed, in certain cases, it is envisaged that the total bacteria count sensor 19a and the bacteria count 19b may also be configured for determining the total bacteria count and the specific bacteria count in the rinse water in the milk storage tank 2.

Any suitable detergent and sanitising solution sensors may be provided, and typically, the detergent and sanitising solution sensors may be conductivity sensors, although it will be readily apparent to those skilled in the art that any other suitable detergent and sanitising solution sensors may be provided.

While the signal processor of the apparatus 1 according to the invention has been described as comprising the microprocessor 17 and the central server 18, it will be readily apparent to those skilled in the art that any suitable signal processing system may be provided. Indeed, it is envisaged that a single computer may be provided, for example, it is envisaged that the central server may be configured to read the signals directly from the milk and rinse water quality sensors, either wirelessly or through a hard wiring system. It will also be appreciated that instead of providing a specific microprocessor or signal processor for reading the signals from the milk quality sensors and the rinse water quality sensors, and programming such a dedicated signal processor or microprocessor to determine the values of the sensed characteristics of the milk and rinse water and to determine the milk quality category of the milk, the signal processor or microprocessor operating the milking system could be programmed to take the place of the microprocessor 17 as well as the central server 18, and carry out the method of the invention. Furthermore, it is envisaged that a microprocessor for controlling the operation of the agitating and chilling of the milk in the milk storage tank and other aspects of the milk storage tank may be programmed to carry out the functions of the microprocessor 17, and in which case the microprocessor 17 would be dispensed with.

While the milk storage tank although illustrated in block representation has been illustrated as a horizontally oriented milk tank, it will be readily apparent to those skilled in the art that the milk storage tank may be of any suitable construction, and could also be a vertically oriented milk storage tank.

While the microprocessor 17 has been described as being configured to categorise the milk into three milk quality categories, the microprocessor 17 could be programmed to categorise the milk into only two milk quality categories, for example, a high milk quality category and a low milk quality category, or the microprocessor may be configured to categorise the milk into more than three milk quality categories.

While the first signal processor has been described as comprising a microprocessor, the signal processor may be provided as any suitable signal processor, for example, a microcontroller, a programmable logic controller or the like. It is also envisaged that the first signal processor may be configured as a data collection device which would collect data from the milk and rinse water quality sensors and would transmit the collected data to the central server, and the computations instead of being carried out in the first signal processor, would be carried out in the central server. It is also envisaged that instead of or as well as providing access by an authorised user to the central server, it is envisaged that access by an authorised user, for example, a creamery could be provided directly to the first signal processor.

Although not described, it is envisaged that one of the milk quality sensors and possibly one of the rinse water quality sensors may be a sensor configured to detect antibiotic residue in the milk and/or in the rinse water, and such an antibiotic residue sensor may be located in the milk storage tank, in the outlet port from the milk storage tank, in the rinse water delivery pipeline and/or in the milk delivery pipeline.

Additionally, the milk quality sensing means could comprise a sensor for detecting an operational parameter of the milk storage tank, such as the temperature of the milk in the milk storage tank and/or the time taken to cool the milk to the predefined chilled temperature, and/or a sensor which would detect any other parameter or characteristic of the milk which would affect the quality of the milk.

While the milk storage tank has been described as comprising a chilling unit, it is envisaged in certain cases, that the milk storage tank may be provided without such a chilling unit.

It is also envisaged that instead of the creamery having to access the central server in order to obtain the data indicative of the milk quality category of the milk, it is envisaged that the central server on receiving the data indicative of the milk quality category of the milk in the milk storage tank, the data indicative of the milk quality category of the milk in the milk storage tank could be transmitted directly to the creamery, or the data indicative of the milk quality category of the milk could be transmitted directly to the creamery from the microprocessor 17. The advantage of transmitting the data indicative of the milk quality category of the milk to the creamery is that if it appeared that the milk in the milk storage tank was in a state likely to deteriorate relatively quickly, the creamery could expedite the collection of the milk from the milk storage tank, and knowing the milk quality category of the milk would then be in a position to stream the milk to the production process appropriate to milk of the milk quality category of the milk.

It is envisaged that while specific milk quality sensing means which produce signals which are indicative of milk quality characteristics have been described, other sensors which would also produce a signal indicative of a characteristic of the milk which would give an indication of the quality of the milk may be provided, for example, sensors which would measure the impedance and/or conductivity of the milk, or which would measure the impedance and/or the conductivity of the milk at a plurality of predefined frequencies may also be provided, which could be configured to produce signals indicative of specific aspects of the milk, which would give an indication of the quality of the milk. It is also envisaged that the data regarding the temperature values of the milk at specific times, and the length of time it took to cool the milk to the predefined chilled temperature during each milking session which are stored by the microprocessor (not shown) of the milk storage tank 2 may also be transmitted to the central server, and would be accessible to the creamery in real time along with all other data transmitted to the central server. This data would allow the creamery to make a decision as to the appropriate production stream for which the milk in the milk storage tank 2 would be suitable. This data would also allow the creamery to designate a suitable milk collection truck to collect the milk from the milk storage tank 2, which would be collecting milk of similar quality from other farmers. Additionally or alternatively, this data would also allow the creamery to make a decision as to whether the milk should be collected immediately from the milk storage tank, and if so to dispatch an appropriate milk collection truck for collecting the milk from the milk storage tank 2. Needless to say, the data immediately upon being transmitted to the central server would be available in real time to the authorised user or users, be it a creamery or any other authorised user, so that the creamery or other authorised user could monitor the quality and/or other parameters of the milk in the milk storage tank as well as other operational parameters of the milk storage tank in real time, and

decisions regarding when to collect the milk could be made in real time in the event of any problem with the milk stored in the milk storage tank.

For example, in the event that the cooling period during which the milk was cooled to the predefined chilled temperature during any of the milking sessions was excessive, or during the just completed milking session was excessive, and could result in a relatively rapid deterioration of the milk, the creamery could make a decision to collect the milk immediately in order to avoid further deterioration of the milk, and thus dispatch a milk collection truck immediately to collect the milk from the milk storage tank 2. Alternatively, the creamery could continue to monitor the quality of the milk in real time, and defer collecting the milk until the monitored data indicated that the milk was beginning to deteriorate, and collection thereof would be necessary. Additionally, if at any stage a power failure occurred while milk was stored in the milk storage tank 2, data relating to such a power failure would be immediately available in real time and would be accessible to the creamery in real time, which could make a decision as to whether the milk in the milk storage tank should be collected immediately, in order to avoid further deterioration of the milk, and also to carry out further tests on the milk when received by the creamery.

While in the specific embodiment of the invention the use of the apparatus 1 according to the invention has been described for use in which the animals are milked twice per day, it will be readily apparent to those skilled in the art that the apparatus 1 may be used in milking systems in which the animals are milked less than or more than twice per day, for example, once per day, three times per day, four times per day and the like. It will also be appreciated that the apparatus may be used in conjunction with a robotic milking system, where milk could in many cases be delivered to the milk storage tank substantially continuously throughout the day. In which case, the microprocessor could be configured to read the signals from the milk quality sensors at predefined time intervals throughout the day, and/or at night, when steady state conditions would prevail in the milk in the milk storage tank. Needless to say prior to reading the signals from the milk quality sensors during the day at the predetermined time intervals, the microprocessor would be configured to ensure that steady state conditions prevailed in the milk in the milk storage tank and that the temperature of the milk in the milk storage tank would be at the predefined chill temperature before the signals were read from the milk quality sensors.

While the apparatus has been described for monitoring both the quality of the milk and the quality of the rinse water, in certain embodiments of the invention, it is envisaged that the apparatus according to the

invention may be provided for monitoring only the quality of the milk, and would not be provided for monitoring the quality of the rinse water.

While the microprocessor 17 has been described as being configured for controlling and operating the chilling system of the milk storage tank and for controlling and operating the paddle mixer of the milk storage tank, it is envisaged that the chilling system, the paddle mixer and other aspects of the milk storage tank may be operated and controlled by a dedicated signal processor dedicated to control the operation of the milk storage tank. In which case, the microprocessor 17 would only be concerned with reading signals from the milk quality sensors and the rinse water quality sensors and determining data indicative of the milk quality category and the cleanliness of the milk storage tank and the rinse water. Additionally, in this case the microprocessor 17 would be configured to communicate with the dedicated signal processor of the milk storage tank in order to determine when steady state conditions prevailed in the milk in the milk storage tank and to determine when the temperature of the milk in the milk storage tank was at the predefined chill temperature.

While the paddle mixer has been described as being activated for an agitating period of two minutes in order to homogenise the milk in the milk storage tank prior to reading signals from the temperature sensors and from the milk quality sensors in order to ensure that the predefined conditions prevail in the milk prior to reading signals from the temperature sensors and the milk quality sensors, any predefined agitating period may be set during which the paddle mixer would be operated to produce a homogenous mixture of the milk in the milk storage tank prior to reading the signals from the temperature sensors 21. Indeed, it is envisaged that the predefined agitating period may range from one minute to five minutes, and in general would be selected to optimise between providing a homogenous mixture of the milk, and avoiding over agitating of the milk, which could lead to deterioration of the milk.

Claims

1. A method for monitoring milk quality, the method comprising locating a milk quality sensing means for monitoring at least one characteristic of milk indicative of the quality of the milk in at least one of a milk storage tank in which the milk is stored and a delivery pipeline through which the milk is delivered to the milk storage tank, configuring a signal processor to read signals indicative of the at least one monitored characteristic of the milk from the milk quality sensing means, configuring the signal processor to determine from the signal read from the milk quality sensing means data indicative of the milk quality and to store the data indicative of the milk quality, and providing access to at least one authorised user to the signal processor to read the data indicative of the milk quality.

2. A method as claimed in Claim 1 in which the data indicative of the milk quality is stored in a storing means.

3. A method as claimed in Claim 1 or 2 in which data indicative of the monitored characteristics of the milk read from the milk quality sensing means is stored in a storing means.

4. A method as claimed in any preceding claim in which the milk quality sensing means comprises one or more of the following sensors:

- a total bacteria count sensor for detecting the total count of bacteria in the milk,
- a specific bacteria sensor for determining the count of a specific bacteria in the milk,
- a somatic cell count sensor for monitoring the somatic cell count in the milk,
- an antibody sensor for detecting a specific antibody in the milk,
- a milk composition sensor for determining the quantity of at least one component of the milk, as a percentage of the milk,
- a protein sensor for monitoring the quantity of protein in the milk as a percentage of the milk,
- a fat content sensor for monitoring the fat content in the milk as percentage of the milk,
- a sensor for detecting an operational parameter of the milk storage tank, such as the temperature of the milk in the milk storage tank and/or the time taken to cool the milk to a predefined chilled temperature, and
- a sensor which would detect any other parameter or characteristic of the milk which would affect the quality of the milk.

5. A method as claimed in any preceding claim in which the signal processor is configured to determine the data indicative of the milk quality as one of a plurality of milk quality categories from the signals read from the milk quality sensing means indicative of the characteristics of the milk.

6. A method as claimed in any preceding claim in which the signal processor is configured to determine the data indicative of the milk quality as being one of a low milk quality category and a high milk quality category, the quality of the milk of the high milk quality category being of higher quality than the milk of the low milk quality category.

7. A method as claimed in any preceding claim in which the signal processor is configured to determine the data indicative of the milk quality as being one of the low milk quality category, the high milk quality category, and an intermediate milk quality category, the quality of the milk of the intermediate milk quality category being less than the quality of the milk of the high milk quality category, and being greater than the quality of the low milk quality category.

8. A method as claimed in any preceding claim in which the milk is delivered to the milk storage tank directly as it is being milked from an animal.

9. A method as claimed in any preceding claim in which the milk storage tank forms a part of a milking system, whereby the milk milked from one or more animals is delivered into the milk storage tank and stored therein.

10. A method as claimed in any preceding claim in which the milk storage tank is located in a milking parlour.

11. A method as claimed in any preceding claim in which the milk is cooled in the milk storage tank to a predefined chill temperature.

12. A method as claimed in any preceding claim in which the milk is cooled in the milk storage tank to the predefined chill temperature on the milk being delivered into the milk storage tank.

13. A method as claimed in any preceding claim in which the milk is agitated in the milk storage tank

during cooling of the milk in the milk storage tank.

14. A method as claimed in any preceding claim in which the milk in the milk storage tank is agitated until the temperature of the milk in the milk storage tank has been cooled to the predefined chill temperature.

15. A method as claimed in any preceding claim in which the predefined chill temperature lies in the range of 2.5°C to 4.5°C.

16. A method as claimed in any preceding claim in which the predefined chill temperature lies in the range of 3°C to 4°C.

17. A method as claimed in any preceding claim in which the predefined chill temperature lies in the range of 3.2°C to 3.6°C.

18. A method as claimed in any preceding claim in which the milk stored in the milk storage tank is collected at predefined intervals.

19. A method as claimed in any preceding claim in which the predefined intervals at which the milk stored in the milk storage tank is collected lie in the range of 1 day to 5 days.

20. A method as claimed in any preceding claim in which milk from at least one milking session per day is delivered to the milk storage tank.

21. A method as claimed in any preceding claim in which milk from at least two milking sessions per day is delivered to the storage tank.

22. A method as claimed in any preceding claim in which one of the two milking sessions is a morning milking session and the other one of the two milking sessions is an evening milking session.

23. A method as claimed in any preceding claim in which milk from a plurality of milking sessions is delivered to the milk storage tank, and at the end of the predefined number of days the milk from the

milking sessions during the predefined number of days stored in the milk storage tank is collected therefrom.

24. A method as claimed in any preceding claim in which the milk quality sensing means comprises at least one tank milk quality sensing means configured for locating in or adjacent the milk storage tank, and for monitoring at least one characteristic of the milk in the milk storage tank.

25. A method as claimed in any preceding claim in which the milk quality sensing means comprises at least one pipeline milk quality sensing means configured for locating in or adjacent the milk delivery pipeline through which milk is delivered into the milk storage tank for monitoring at least one characteristic of the milk flowing through the milk delivery pipeline.

26. A method as claimed in any preceding claim in which at least one of the pipeline milk quality sensing means is configured to monitor at least one characteristic of the milk similar to one of the characteristics of the milk which are monitored by at least one of the tank milk quality sensing means.

27. A method as claimed in any preceding claim in which the signals indicative of the characteristics of the milk in the milk storage tank are read from the at least one tank milk quality sensing means by the signal processor when at least one predefined condition prevails in the milk in the milk storage tank.

28. A method as claimed in any preceding claim in which the signals indicative of the characteristics of the milk in the milk storage tank are read from the at least one tank milk quality sensing means by the signal processor after the temperature of the milk in the milk storage tank has been reduced to the predefined chill temperature.

29. A method as claimed in any preceding claim in which the signal processor is configured to compare signals read from at least one of the pipeline milk quality sensing means with signals read from at least one of the tank milk quality sensing means which are configured to monitor similar characteristics of the milk flowing through the milk delivery pipeline and stored in the milk storage tank to determine if there is a discrepancy between the quality of the milk in the milk storage tank and the quality of the milk flowing through the milk delivery pipeline.

30. A method as claimed in any preceding claim in which each milk quality sensing means is hardwired to the signal processor.

31. A method as claimed in any preceding claim in which each milk quality sensing means is configured to communicate wirelessly with the signal processor.

32. A method as claimed in any preceding claim in which each milk quality sensing means is configured to communicate with the signal processor through a near field communications protocol.

33. A method as claimed in any preceding claim in which a discharge rinse water quality sensing means is located adjacent a rinse water outlet from the milk storage tank for monitoring at least one characteristic of rinse water discharged from the milk storage tank indicative of the cleanliness of the milk storage tank.

34. A method as claimed in Claim 33 in which the signal processor is configured to read signals from the discharge rinse water quality sensing means to determine the cleanliness of the milk storage tank.

35. A method as claimed in any preceding claim in which a pipeline rinse water quality sensing means is located in a rinse water delivery pipeline through which wash and rinse water is delivered into the milk storage tank for monitoring at least one characteristic of the rinse water delivered into the milk storage tank indicative of the cleanliness of the rinse water.

36. A method as claimed in Claim 35 in which the signal processor is configured to read signals from the pipeline rinse water quality sensing means to determine the cleanliness of the rinse water.

37. A method as claimed in any preceding claim in which the signal processor is configured for comparing the signals read from the pipeline rinse water quality sensing means with signals read from the discharge rinse water quality sensing means for determining if there is a discrepancy between the cleanliness of the rinse water discharged from the milk storage tank and the cleanliness of the rinse water delivered into the milk storage tank through the rinse water delivery pipeline.

38. A method as claimed in any preceding claim in which the discharge rinse water quality sensing

means comprises one or more of a total bacteria count sensor for detecting the total bacteria count in the rinse water, a bacteria count sensor for detecting the count of a specific bacteria in the rinse water, a detergent sensor for detecting detergent residue in the rinse water, and a sanitising solution sensor for detecting sanitising solution residue in the rinse water.

39. A method as claimed in any preceding claim in which the pipeline rinse water quality sensing means comprises one or more of a total bacteria count sensor for detecting the total bacteria count in the rinse water, a bacteria count sensor for detecting the count of a specific bacteria in the rinse water, a detergent sensor for detecting detergent residue in the rinse water, and a sanitising solution sensor for detecting sanitising solution residue in the rinse water.

40. A method as claimed in any preceding claim in which each rinse water quality sensing means is hardwired to the signal processor.

41. A method as claimed in any preceding claim in which each rinse water quality sensing means is configured to communicate wirelessly with the signal processor.

42. A method as claimed in any preceding claim in which the signal processor is configured as a first signal processor and a second signal processor, the first signal processor being configured to read signals from the milk quality sensing means, and being configured to communicate with the second signal processor for communicating to the second signal processor one of the data indicative of the milk quality and the monitored characteristic of the milk.

43. A method as claimed in Claim 42 in which access to the signal processor by the at least one authorised user is provided to the second signal processor.

44. A method as claimed in any of Claims 42 or 43 in which access to the signal processor by the at least one authorised user is provided to the first signal processor.

45. A method as claimed in any of Claims 42 to 44 in which the first signal processor is configured to store data values of the signals indicative of the monitored characteristics.

46. A method as claimed in any of Claims 42 to 45 in which the first signal processor is configured to determine the data indicative of the milk quality.

47. A method as claimed in any of Claims 42 to 46 in which the first signal processor is configured to store the data indicative of the milk quality.

48. A method as claimed in any of Claims 42 to 47 in which the first signal processor is configured to determine the milk quality category of the milk in the milk storage tank.

49. A method as claimed in any of Claims 42 to 48 in which the first signal processor is configured to store data indicative of the milk quality category of the milk in the milk storage tank.

50. A method as claimed in any of Claims 36 to 44 in which the first signal processor communicates data indicative of the determined milk quality category to the second signal processor.

51. A method as claimed in any of Claims 42 to 48 in which the first signal processor is configured to read signals from the discharge rinse water quality sensing means and from the pipeline rinse water quality sensing means.

52. A method as claimed in any of Claims 42 to 51 in which the first signal processor is configured to determine the cleanliness of the milk storage tank.

53. A method as claimed in any of Claims 42 to 52 in which the first signal processor is configured to determine the cleanliness of the rinse water delivered to the milk storage tank through the rinse water deliver pipeline.

54. A method as claimed in any of Claims 42 to 53 in which the first signal processor is configured to compare the signals read from the discharge rinse water quality sensing means with the signals read from the pipeline rinse water quality sensing means.

55. A method as claimed in any of Claims 42 to 54 in which the first signal processor communicates with the second signal processor wirelessly.

56. A method as claimed in any of Claims 42 to 55 in which the first signal processor communicates with the second signal processor via a communications network.

57. A method as claimed in any of Claims 42 to 56 in which the first signal processor communicates with the second signal processor via a mobile phone network.

58. A method as claimed in any of Claims 42 to 57 in which the first signal processor communicates with the second signal processor via the internet.

59. A method as claimed in any preceding claim in which the second signal processor comprises a central server.

60. A method as claimed in any preceding claim in which one of the authorised users comprises a creamery to which milk in the milk storage tank is to be supplied.

61. A method for monitoring the cleanliness of a milk storage tank, the method comprising locating a discharge rinse water quality sensing means for monitoring at least one characteristic of rinse water discharged from the milk storage tank indicative of the cleanliness of the milk storage tank, configuring a signal processor to read signals from the discharge rinse water quality sensing means indicative of the at least one monitored characteristic in the rinse water, and configuring the signal processor to determine data indicative of the cleanliness of the milk storage tank from the signals read from the discharge rinse water quality sensing means, and providing access to at least one authorised user to the signal processor to read data indicative of the cleanliness of the milk storage tank.

62. A method as claimed in Claim 61 in which the signal processor stores the data indicative of the cleanliness of the milk storage tank.

63. A method as claimed in Claim 61 or 62 in which the discharge rinse water quality sensing means is located in an outlet of the milk storage tank through which rinse water is discharged from the milk storage tank.

64. A method as claimed in any of Claims 61 to 63 in which a pipeline rinse water quality sensing means located in a rinse water delivery pipeline through which wash and rinse water is delivered to the milk storage tank, and the signal processor is configured to read signals from the pipeline rinse water quality sensing means and to determine data indicative of the cleanliness of the rinse water delivered to the milk storage tank through the delivery pipe line from the read signals.

65. A method as claimed in any of Claims 61 to 64 in which the signal processor is configured to compare signals read from the pipeline rinse water quality sensing means with signals read from the discharge rinse water quality sensing means configured for monitoring a similar one of the characteristics of the rinse water to that monitored by the pipeline rinse water quality sensing means.

66. A method as claimed in any of Claims 61 to 65 in which each rinse water quality sensing means comprises one or more of a total bacteria count sensor for detecting the total bacteria count in the rinse water, a bacteria count sensor for detecting the count of a specific bacteria in the rinse water, a detergent detecting means for detecting detergent residue in the rinse water, and a sanitising solution detecting means for detecting sanitising solution residue in the rinse water.

67. A method as claimed in any of Claims 61 to 66 in which the signal process is configured as a first signal processor and a second signal processor, the first signal processor being configured to communicate with the second signal processor for communicating data indicative of the cleanliness of the milk storage tank.

68. A method as claimed in Claim 67 in which the first signal processor is configured to read signals from the discharge rinse water quality sensing means indicative of the monitored characteristic of the rinse water.

69. A method as claimed in Claim 67 or 68 in which the first signal processor is configured to determine the data indicative of the cleanliness of the milk storage tank.

70. A method as claimed in any of Claims 67 to 69 in which the first signal processor is configured to determine the cleanliness of the rinse water delivered to the milk storage tank through the rinse water delivery pipeline.

71. A method as claimed in any of Claims 67 to 70 in which the first signal processor is configured to communicate the data indicative of the cleanliness of the rinse water delivered to the milk storage tank through the rinse water delivery pipeline.

72. Apparatus for monitoring the quality of milk in a milk storage tank, the apparatus comprising a milk quality sensing means for monitoring at least one characteristic of milk indicative of the quality of the milk, the milk quality sensing means being located in or adjacent one of the milk storage tank and a milk delivery pipeline through which milk is delivered to the milk storage tank, a signal processor configured to read signals from the milk quality sensing means indicative of the at least one monitored characteristic, the signal processor being configured to determine data indicative of the milk quality of the milk in the milk storage tank from the signals read from the milk quality sensing means.

73. Apparatus as claimed in Claim 72 in which a storing means is provided, and data indicative of the milk quality of the milk in the milk storage tank is stored in the storing means.

74. Apparatus as claimed in Claim 72 or 73 in which the signal processor is configured to provide access thereto by an authorised user to read the data indicative of the milk quality of the milk in the milk storage tank therefrom.

75. Apparatus as claimed in any of Claims 72 to 74 in which the milk quality sensing means comprises one or more of the following sensors:

- a total bacteria count sensor for detecting the total bacteria count in the milk,
- a specific bacteria count sensor for detecting the specific bacteria count in the milk,
- a somatic cell count sensor for detecting the somatic cell count in the milk,
- an antibody sensor for detecting an antibody in the milk,
- a milk composition sensor for detecting the percentage content of at least one constituent of the milk,
- a protein sensor for detecting the percentage protein content in the milk,
- a fat content sensor for detecting the percentage fat content in the milk,

- a sensor for detecting an operational parameter of the milk storage tank, such as the temperature of the milk in the milk storage tank and/or the time taken to cool the milk to a predefined chilled temperature, and
- a sensor which would detect any other parameter or characteristic of the milk which would affect the quality of the milk.

76. Apparatus as claimed in any of Claims 72 to 75 in which the signal processor is configured for determining the quality of the milk in the milk storage tank from the signals read from the milk quality sensing means as being one of a low milk quality category and a high milk quality category.

77. Apparatus as claimed in any of Claims 72 to 76 in which the signal processor is configured for determining the quality of the milk in the milk storage tank from the signals read from the milk quality sensing means as being one of the low milk quality category, the high milk quality category and an intermediate milk quality category, the quality of the milk of the intermediate milk quality category being less than the quality of the milk of the high quality milk category and being greater than the quality of the milk of the low quality milk category.

78. Apparatus as claimed in any of Claims 72 to 77 in which the milk storage tank is configured for storing milk directly from a milking system.

79. Apparatus as claimed in any of Claims 72 to 78 in which the milk storage tank is located in or adjacent a milking parlour.

80. Apparatus as claimed in any of Claims 72 to 79 in which the milk storage tank is configured to store milk directly as it is being milked from an animal.

81. Apparatus as claimed in any of Claims 72 to 80 in which a cooling means is provided for cooling the milk in the milk storage tank to a predefined chill temperature and for maintaining the temperature of the milk in the milk storage tank at the predefined chill temperature.

82. Apparatus as claimed in any of Claims 72 to 81 in which the predefined chill temperature lies in the range of 2.5°C to 4.5°C.

83. Apparatus as claimed in any of Claims 72 to 82 in which the predefined chilled temperature lies in the range of 3°C to 4°C.

84. Apparatus as claimed in any of Claims 72 to 83 in which the predefine chilled temperature lies in the range of 3.2°C to 3.6°C.

85. Apparatus as claimed in any of Claims 72 to 84 in which the milk storage tank comprises an agitating means for agitating the milk in the milk storage tank during cooling of the milk in the milk storage tank.

86. Apparatus as claimed in any of Claims 72 to 85 in which the agitating means is configured to agitate the milk in the milk storage tank until the milk in the milk storage tank has been cooled to the predefined chill temperature.

87. Apparatus as claimed in any of Claims 72 to 86 in which the signal processor is configured to read signals from the milk quality sensing means indicative of the monitored characteristics of the milk in the milk storage tank when at least one predefined condition prevails in the milk in the milk storage tank.

88. Apparatus as claimed in any of Claims 72 to 87 in which the signal processor is configured to read signals from the milk quality sensing means indicative of the quality of the milk in the milk storage tank in response to the temperature of the milk in the milk storage tank having been cooled to the predefined chilled temperature.

89. Apparatus as claimed in any of Claims 72 to 88 in which the milk quality sensing means comprises a tank milk quality sensing means configured for locating in or adjacent the milk storage tank.

90. Apparatus as claimed in any of Claims 72 to 89 in which the milk quality sensing means comprises a pipeline milk quality sensing means configured for locating in a milk delivery pipeline through which milk is delivered to the milk storage tank.

91. Apparatus as claimed in any of Claims 72 to 90 in which the signal processor is configured to

compare signals read from the pipeline milk quality sensing means with signals read from the tank milk quality sensing means which is configured to monitor similar characteristics of the milk as those for which the pipeline milk quality sensing means is configured to monitor for determining if the quality of the milk in the milk storage tank is different to the quality of the milk being delivered to the milk storage tank through the milk delivery pipeline.

92. Apparatus as claimed in any of Claims 72 to 91 in which the milk quality sensing means is hardwired to the signal processor.

93. Apparatus as claimed in any of Claims 72 to 92 in which the milk quality sensing means is configured to communicate wirelessly with the signal processor.

94. Apparatus as claimed in any of Claims 72 to 93 in which a discharge rinse water quality sensing means is located in a rinse water discharge outlet from the milk storage tank for monitoring at least one characteristic in the rinse water, and the signal processor is configured to read signals from the discharge rinse water quality sensing means indicative of the at least one monitored characteristic, and to determine from the read signals data indicative of the cleanliness of the milk storage tank.

95. Apparatus as claimed in any of Claims 72 to 94 in which a pipeline rinse water quality sensing means is located in a rinse water delivery pipe through which wash and rinse water is delivered into the milk storage tank, and the signal processor is configured to read signals from the pipeline rinse water quality sensing means indicative of the monitored characteristics for determining from the read signals data indicative of the cleanliness of the rinse water delivered to the milk storage tank through the rinse water delivery pipeline.

96. Apparatus as claimed in any of Claims 72 to 95 in which the signal processor is configured for comparing signals read from the tank rinse water quality sensing means and the pipeline rinse water quality sensing means for determining if there is a difference between the quality of the rinse water delivered to the milk storage tank through the rinse water delivery pipeline and the quality of the rinse water discharged from the milk storage tank.

97. Apparatus as claimed in any of Claims 72 to 96 in which the rinse water quality sensing means

comprises one or more of the following rinse water quality sensors:

- a total bacteria count sensor for detecting the total bacteria count in the rinse water,
- a specific bacteria count sensor for detecting the bacteria count of a specific bacteria in the rinse water,
- one of a detergent sensor for detecting the level of detergent residue in the rinse water, and
- a sanitising solution sensor for detecting the level of sanitising solution residue in the rinse water.

98. Apparatus as claimed in any of Claims 72 to 97 in which the rinse water quality sensing means are hardwired to the first signal processor.

99. Apparatus as claimed in any of Claims 72 to 98 in which the rinse water quality sensing means are configured to communicate wirelessly with the first signal processor.

100. Apparatus as claimed in Claims 72 to 99 in which the signal processor is configured as a first signal processor and a second signal processor, the first signal processor being configured to read signals from the milk quality sensing means indicative of the monitored characteristic of the milk, and being configured to communicate with the second signal processor for communicating data indicative of the milk quality to the second signal processor.

101. Apparatus as claimed in Claim 100 in which the first signal processor is configured to determine the milk quality from the signals read from milk quality sensing means, and to store data indicative of the milk quality.

102. Apparatus as claimed in Claim 100 or 101 in which the first signal processor is configured to communicate the data indicative of the milk quality to the second signal processor.

103. Apparatus as claimed in any of Claims 100 to 102 in which the first signal processor is configured to determine the milk quality category of the milk in the milk storage tank.

104. Apparatus as claimed in any of Claims 100 to 103 in which the first signal processor is configured to communicate data indicative of the determined quality milk category of the milk in the milk storage tank to the second signal processor.

105. Apparatus as claimed in any of Claims 100 to 104 in which the second signal processor is configured to store the data indicative of the milk quality.

106. Apparatus as claimed in any of Claims 100 to 105 in which the first signal processor is configured to read signals from the discharge rinse water quality sensing means and to determine the data indicative of the cleanliness of the rinse water discharged from the milk storage tank.

107. Apparatus as claimed in any of Claims 100 to 106 in which the first signal processor is configured to transmit to the second signal processor data indicative of the signals read from the discharge rinse water quality sensing means and the data indicative of the cleanliness of the water discharged from the milk storage tank.

108. Apparatus as claimed in any of Claims 100 to 107 in which the first signal processor is configured to read signals from the pipeline rinse water quality sensing means and to determine the cleanliness of the rinse water in the rinse water delivery pipeline.

109. Apparatus as claimed in any of Claims 100 to 108 in which the first signal processor is configured to transmit data indicative of the signals read from the pipeline rinse water quality sensing means and the data indicative of the cleanliness of the rinse water in the rinse water delivery pipeline.

110. Apparatus as claimed in any of Claims 100 to 109 in which the first signal processor is configured to communicate wirelessly with the second signal processor.

111. Apparatus as claimed in any of Claims 100 to 110 in which the first signal processor is configured to communicate with the second signal processor via a mobile phone network.

112. Apparatus as claimed in any of Claims 100 to 111 in which the first signal processor is configured to communicate with the second signal processor via a wireless communications network.

113. Apparatus as claimed in any of Claims 100 to 112 in which the first signal processor is configured to communicate with the second signal processor via the internet.

114. Apparatus as claimed in any of Claims 100 to 113 in which the second signal processor is configured to provide access by the at least one authorised user to the data indicative of the quality of the milk.

115. Apparatus as claimed in any of Claims 100 to 114 in which the second signal processor comprises a central server.

116. A milking system comprising a milk storage tank and apparatus as claimed in any of Claims 68 to 111 for monitoring the quality of milk in the milk storage tank.

117. Apparatus for determining the cleanliness of a milk storage tank, the apparatus comprising a rinse water quality sensing means configured for monitoring at least one characteristic in the rinse water indicative of the cleanliness of the milk storage tank, a signal processor configured to read signals from the rinse water quality sensing means indicative of the at least one monitored characteristic, the signal processor being configured to determine data indicative of the cleanliness of the milk storage tank from the signals read from the rinse water quality sensing means.

118. Apparatus as claimed in Claim 117 in which the data indicative of the cleanliness of the milk storage tank is stored in a storing means.

119. Apparatus as claimed in Claim 117 or 118 in which the rinse water quality sensing means is configured for locating in an outlet of the milk storage tank through which rinse water is discharged from the milk storage tank.

120. Apparatus as claimed in any of Claims 117 to 119 in which the signal processor is configured to permit access thereto by an authorised user for reading the data indicative of the cleanliness of the milk storage tank.

121. A method for monitoring quality of milk in a milk storage tank, the method comprising locating a milk quality sensing means for monitoring at least one characteristic of milk indicative of the quality of the milk in the milk storage tank in which the milk is stored, configuring a signal processor to read signals

indicative of the at least one monitored characteristic of the milk from the milk quality sensing means when at least one predefined condition prevails in the milk in the milk storage tank, configuring the signal processor to determine from the signal read from the milk quality sensing means data indicative of the milk quality and to store the data indicative of the milk quality.

122. A method as claimed in Claim 121 in which the data indicative of the milk quality is stored in a storing means.

123. A method as claimed in Claim 121 or 122 in which data indicative of the monitored characteristics of the milk read from the milk quality sensing means is stored in a storing means.

124. A method as claimed in any of Claims 121 to 123 in which the milk quality sensing means comprises one or more of the following sensors:

- a total bacteria count sensor for detecting the total count of bacteria in the milk,
- a specific bacteria sensor for determining the count of a specific bacteria in the milk,
- a somatic cell count sensor for monitoring the somatic cell count in the milk,
- an antibody sensor for detecting a specific antibody in the milk,
- a milk composition sensor for determining the quantity of at least one component of the milk, as a percentage of the milk,
- a protein sensor for monitoring the quantity of protein in the milk as a percentage of the milk,
- a fat content sensor for monitoring the fat content in the milk as percentage of the milk,
- a sensor for detecting an operational parameter of the milk storage tank, such as the temperature of the milk in the milk storage tank and/or the time taken to cool the milk to a predefined chilled temperature, and
- a sensor which would detect any other parameter or characteristic of the milk which would affect the quality of the milk.

125. A method as claimed in any of Claims 121 to 124 in which the signal processor is configured to determine the data indicative of the milk quality as one of a plurality of milk quality categories from the signals read from the milk quality sensing means indicative of the characteristics of the milk.

126. A method as claimed in any of Claims 121 to 125 in which the signal processor is configured to

determine the data indicative of the milk quality as being one of a low milk quality category and a high milk quality category, the quality of the milk of the high milk quality category being of higher quality than the milk of the low milk quality category.

127. A method as claimed in any of Claims 121 to 126 in which the signal processor is configured to determine the data indicative of the milk quality as being one of the low milk quality category, the high milk quality category, and an intermediate milk quality category, the quality of the milk of the intermediate milk quality category being less than the quality of the milk of the high milk quality category, and being greater than the quality of the low milk quality category.

128. A method as claimed in any of Claims 121 to 127 in which the milk is cooled in the milk storage tank to a predefined chill temperature.

129. A method as claimed in any of Claims 121 to 128 in which the milk is cooled in the milk storage tank to the predefined chill temperature on the milk being delivered into the milk storage tank.

130. A method as claimed in any of Claims 121 to 129 in which the milk is agitated in the milk storage tank during cooling of the milk in the milk storage tank.

131. A method as claimed in any of Claims 121 to 130 in which the milk in the milk storage tank is agitated until the milk in the milk storage tank is homogeneous.

132. A method as claimed in any of Claims 121 to 131 in which the milk in the milk storage tank is agitated until the temperature of the milk in the milk storage tank has been cooled to the predefined chill temperature.

133. A method as claimed in any of Claims 121 to 132 in which the predefined chill temperature lies in the range of 2.5°C to 4.5°C.

134. A method as claimed in any of Claims 121 to 133 in which the predefined chill temperature lies in the range of 3°C to 4°C.

135. A method as claimed in any of Claims 121 to 134 in which the predefined chill temperature lies in the range of 3.2°C to 3.6°C.

136. A method as claimed in any of Claims 121 to 135 in which the at least one predefined condition prevailing in the milk in the milk storage tank comprises the temperature of the milk in the milk storage tank.

137. A method as claimed in any of Claims 121 to 136 in which the at least one predefined condition prevailing in the milk in the milk storage tank comprises the homogeneity of the milk in the milk storage tank.

138. A method as claimed in any of Claims 121 to 137 in which the predefined temperature condition of the milk comprises the temperature of the milk in the milk storage tank being at the predefined chill temperature.

139. A method as claimed in any of Claims 121 to 138 in which the predefined conditions of the milk in the milk storage tank prevail when the milk in the milk storage tank is homogeneous and at the predefined chill temperature.

140. A method as claimed in any of Claims 121 to 139 in which milk from at least one milking session per day is delivered to the milk storage tank.

141. A method as claimed in any of Claims 121 to 140 in which milk from at least two milking sessions per day is delivered to the storage tank.

142. A method as claimed in any of Claims 121 to 141 in which one of the two milking sessions is a morning milking session and the other one of the two milking sessions is an evening milking session.

143. A method as claimed in any of Claims 121 to 142 in which milk from a plurality of milking sessions is delivered to the milk storage tank, and at the end of the predefined number of days the milk from the milking sessions during the predefined number of days stored in the milk storage tank is collected therefrom.

144. A method as claimed in any of Claims 121 to 143 in which the signals indicative of the characteristics of the milk in the milk storage tank are read from the milk quality sensing means by the signal processor after the temperature of the milk in the milk storage tank has been reduced to the predefined chill temperature.

145. A method as claimed in any of Claims 121 to 144 in which the milk quality sensing means is hardwired to the signal processor.

146. A method as claimed in any of Claims 121 to 145 in which the milk quality sensing means is configured to communicate wirelessly with the signal processor.

147. A method as claimed in any of Claims 121 to 146 in which access to the signal processor by at least one authorised user is provided.

148. A method as claimed in any of Claims 121 to 147 in which one of the authorised users comprises a creamery to which milk in the milk storage tank is to be supplied.

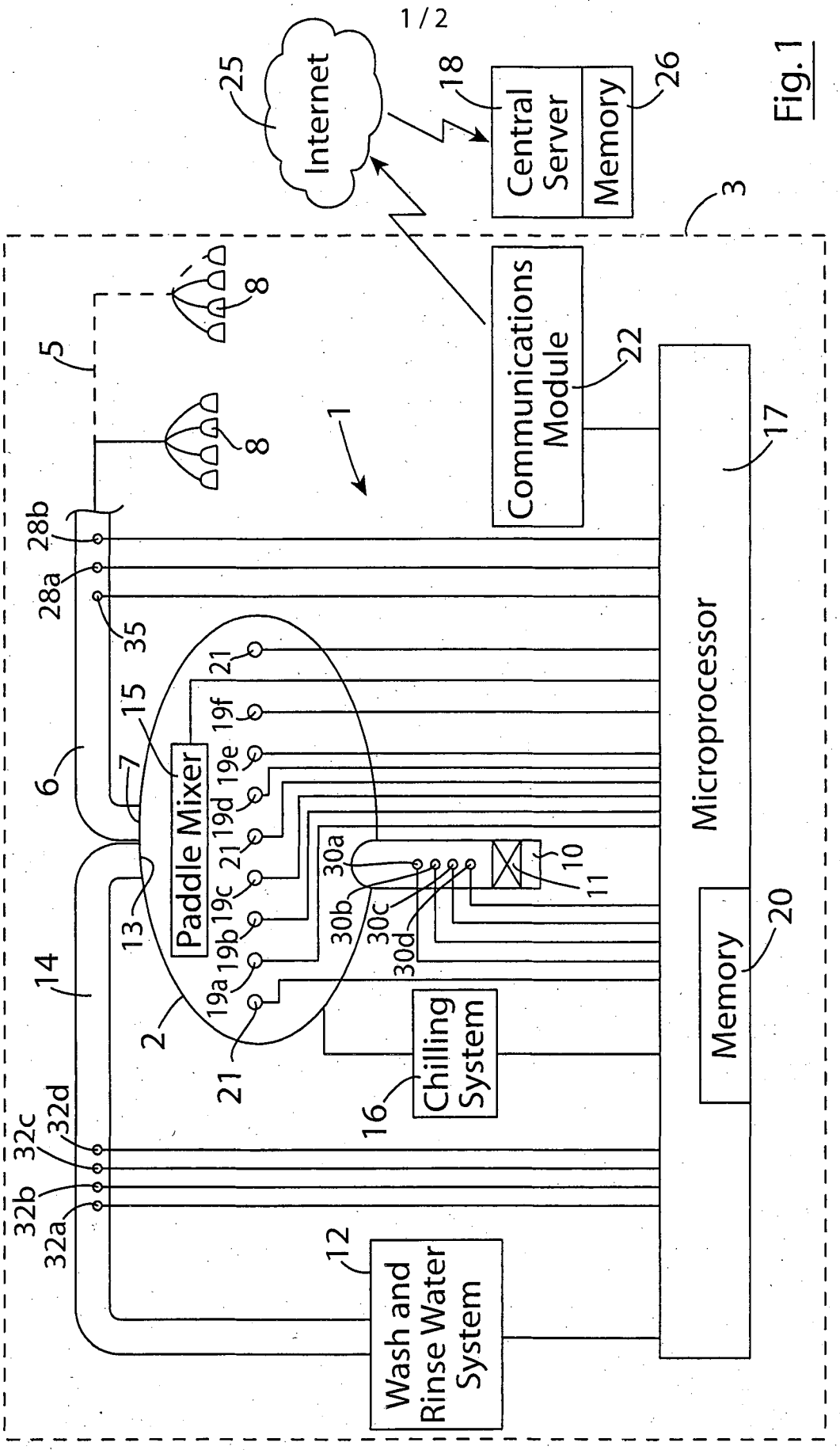
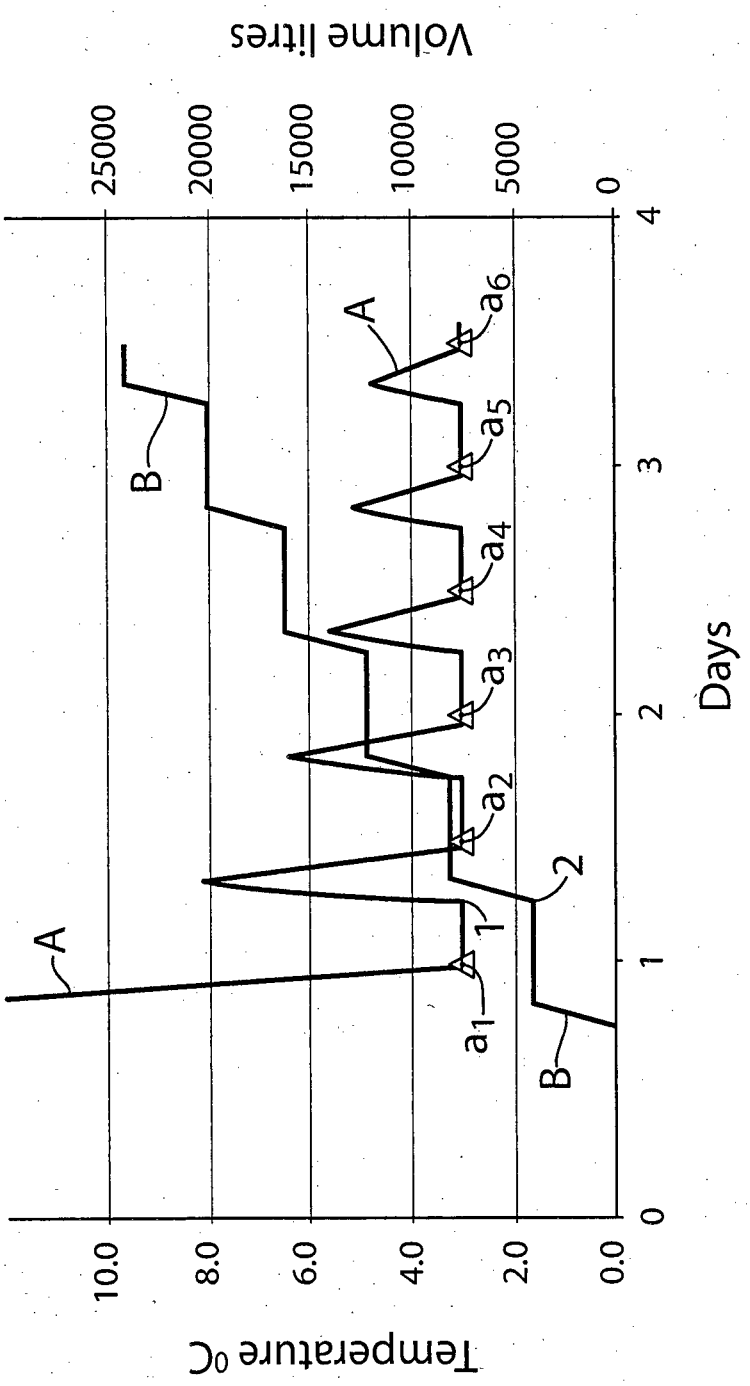

Internet
25
18
Central Server
Memory
26
3
Communications Module
22
Microprocessor
17
Memory
20
Paddle Mixer
Chilling System
16
Wash and Rinse Water System
12
1
2
5
6
7
8
8
13
14
15
21
21
21
19a
19b
19c
19d
19e
19f
28a
28b
30a
30b
30c
30d
32a
32b
32c
32d
35
10
11

Fig. 1

Fig. 2


Volume litres
25000
20000
15000
10000
5000
0
Temperature 0C
10.0
8.0
6.0
4.0
2.0
0.0
Days
0
1
2
3
4
A
B
1
2
a1
a2
a3
a4
a5
a6