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(71) Applicant(s)
W R Grace & Co.-Conn

(Incorporated in USA - Connecticut)

Grace Plaza, 1114 Avenue of the Americas, New York, New York 10036, United States of America

(72) Inventor(s)
Michel Mercusot
Ghislain Jean Declercq

(74) Agent and/or Address for Service
J A Kemp & Co
14 South Square, Gray's Inn, LONDON, WC1R 5LX, United Kingdom

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INT CL^5 **G01G 17/00 19/00 , G08B 19/02 21/00**
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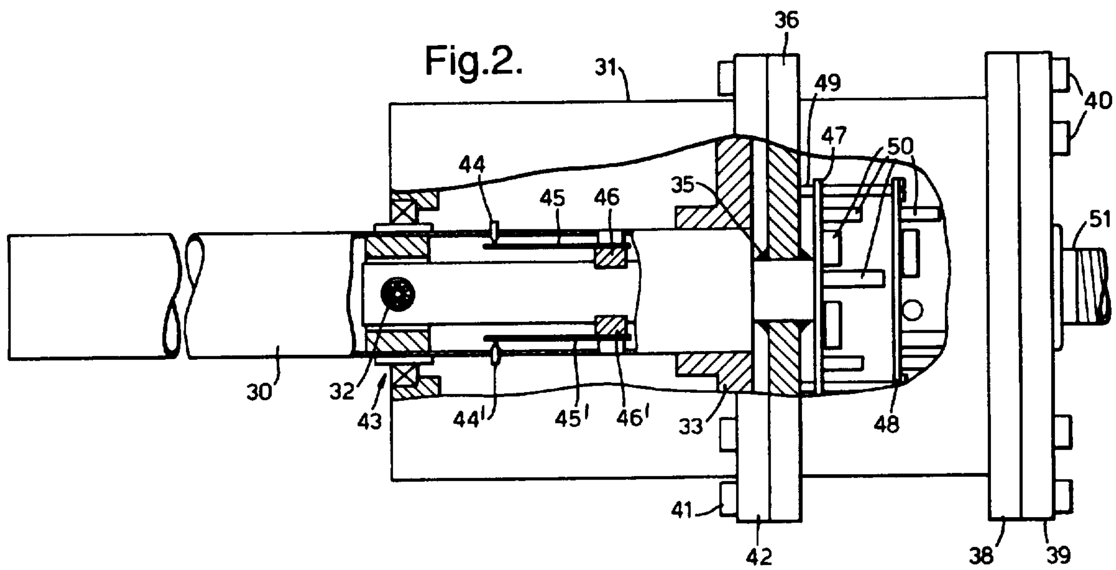
(54) Detecting the build-up of deposits in a manufacturing plant

(57) A sensor for detecting the build up of deposits in plant, for example a paper-making installation, comprises an elongate probe 30 mounted on a mounting body 31 by way of at least one strain gauge. The strain gauges may be mounted on leaf springs 45, 45' and measure the static bending moment in the probe 30 or strain gauges may be used to monitor changes in the frequency of natural vibration of the probe 30 (Fig. 4). The measured change in mass of the probe provides an indication of the amount of deposit in the part of the plant in which it is placed and this signal can be used to control the application of a deposit-controlling composition. An optional further sensor can be provided to assess the nature of the deposit.

Fig.2.



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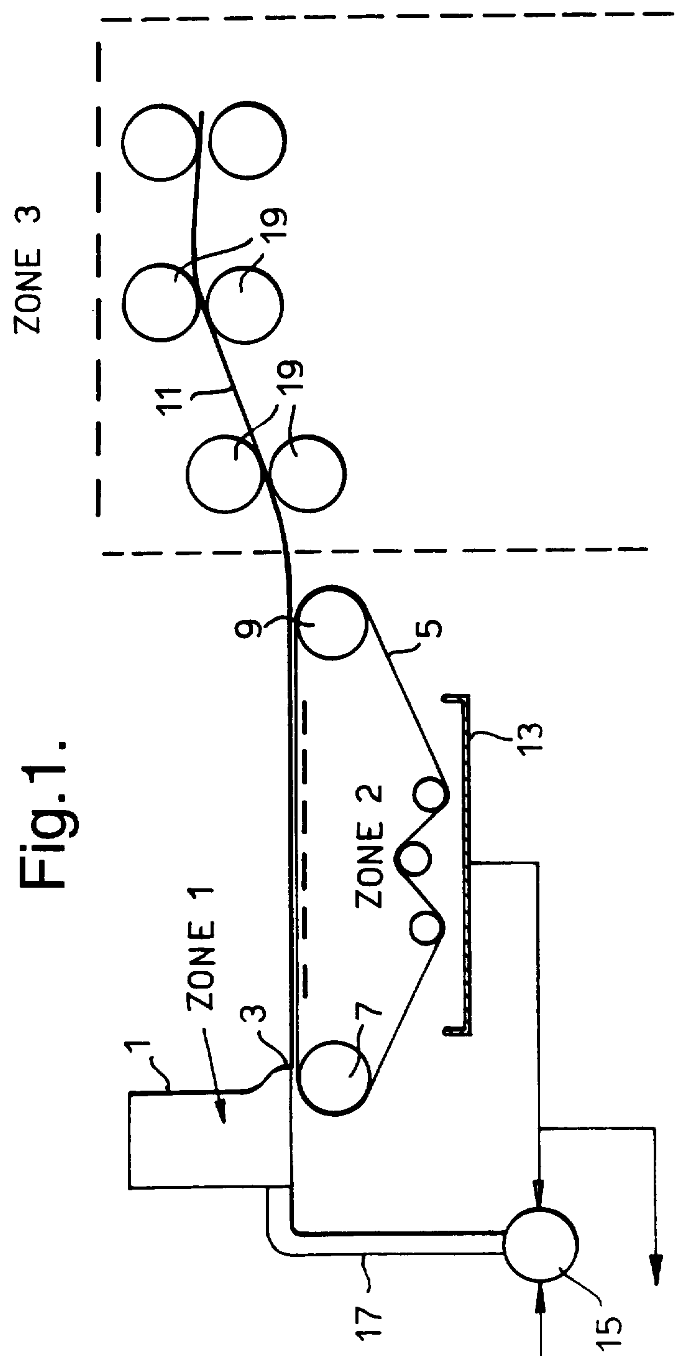
At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

Fig.1.



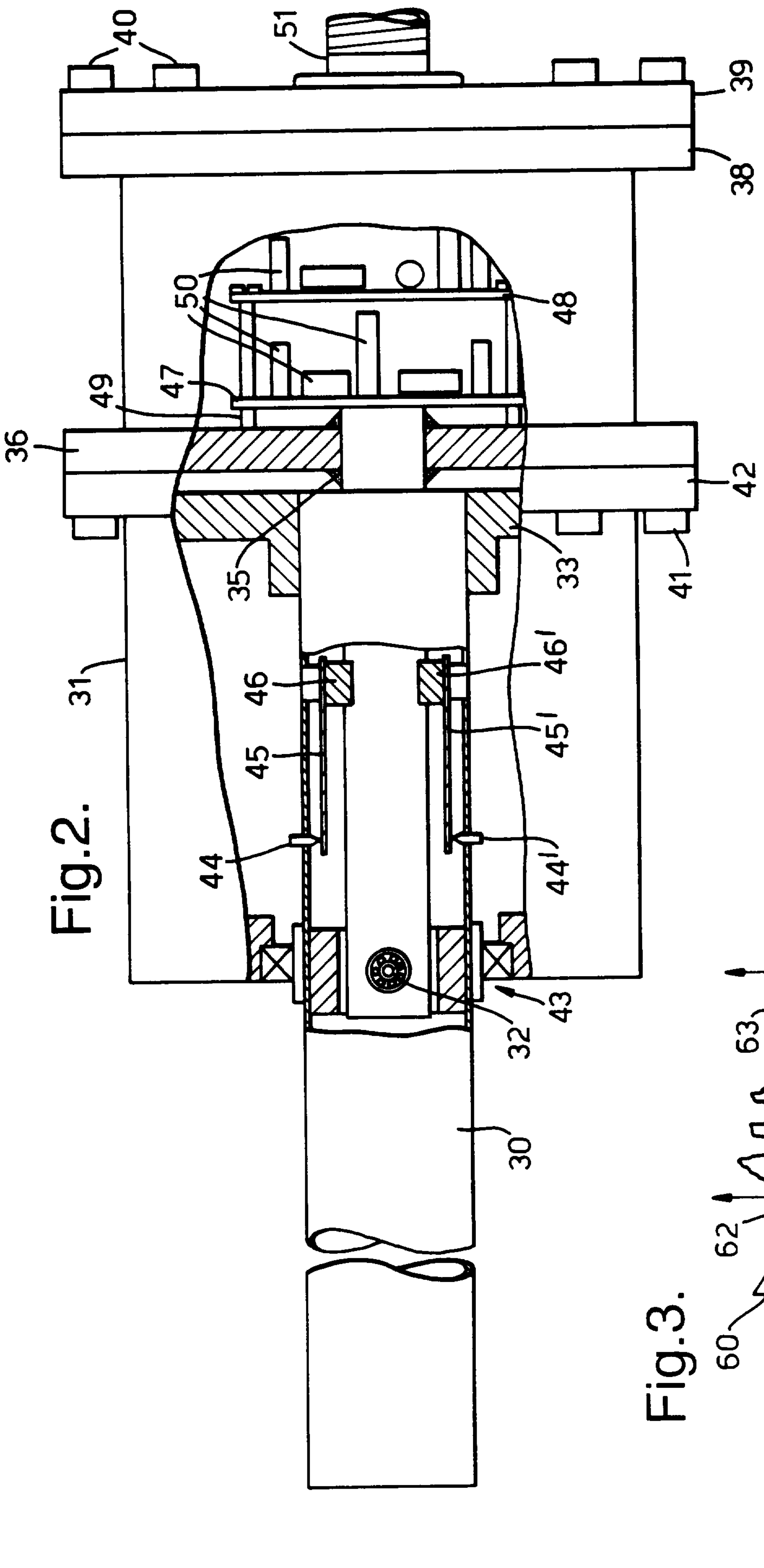

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Fig.2.

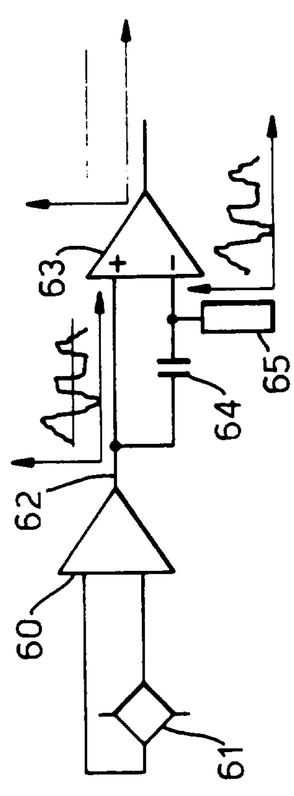
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Fig.3.

Fig.4.

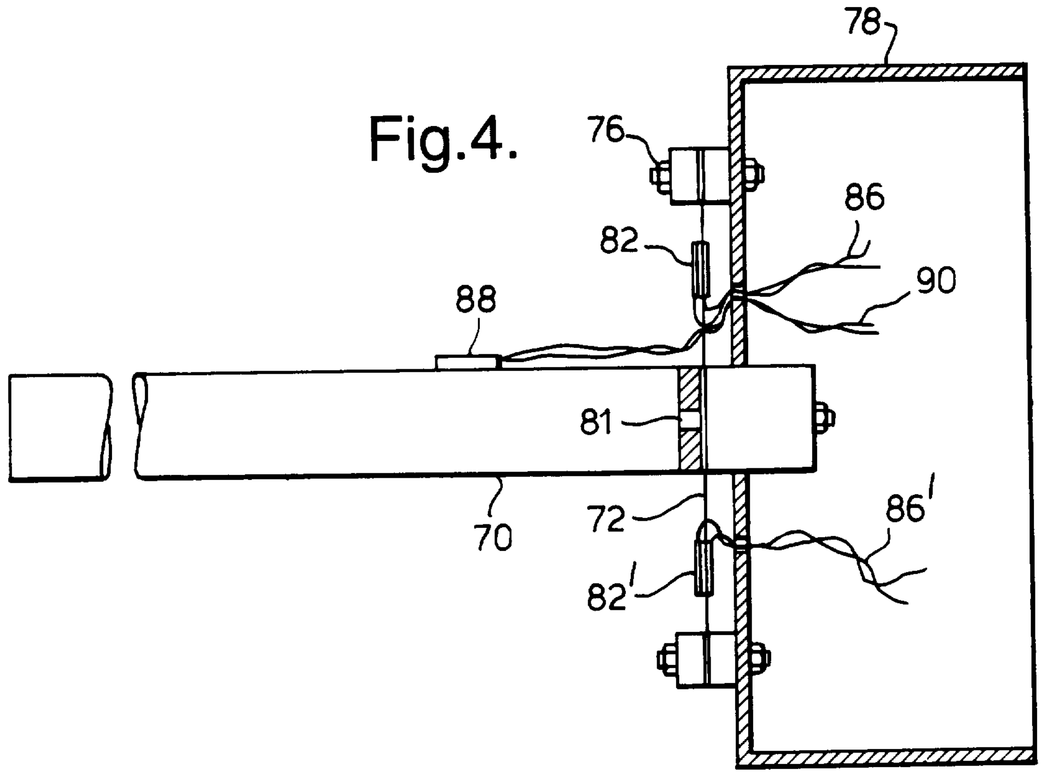
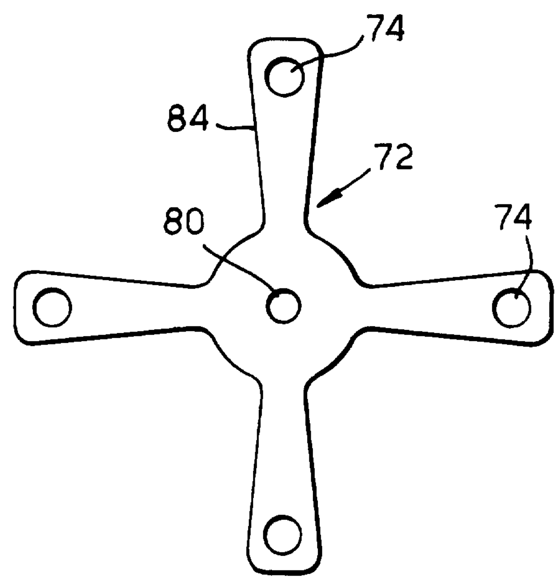


Fig.5.



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DEPOSITION SENSING METHOD AND APPARATUS

The present invention relates to a method of and apparatus for sensing the build-up of deposition, in particular in locations which are not readily accessible for manual observation.

The process is particularly useful for monitoring the build-up of deposit in contaminated industrial water, for example in cooling water circuits, boiling water enclosures, and paper pulp machinery to give but a few examples. Another application is in smoke stack soot monitoring. In each case the method and apparatus enable one or more deposition-controlling composition to be applied in an appropriate dose.

Many industrial processes suffer from formation of deposit on surfaces. This deposit could be of microbiological origin in equipment such as Evaporative Cooling Towers, water boilers, or machines in the paper making industry, but could also be formed by precipitation of inorganic materials (scaling) or deposition of adhesives, ink, etc, ... in recycled papermaking processes.

It is known to monitor the build-up of a deposit by providing a surface on which the film is allowed to build up and then periodically moving that surface to a location where it can be observed in order to evaluate the degree of build-up. Such a system is disclosed in US-A-5,155,555 (Nalco Chemical Company).

Another approach has been to monitor the acquisition of moisture by a piezoelectric crystal by observing the change in the resonant frequency when the crystal is subject to electrical excitation. Such a system is disclosed in US-A-4,562,725. The alteration of the properties of the crystal resulting from the presence of moisture is unique to the action of water in the crystal and consequently this action would be thought unsuitable for monitoring deposits containing small amounts of water.

Yet a further approach, which can be used with a solid build-up if a substantial build-up is expected, is disclosed in DD-A-2,52872 in which the accretion of ice in an evaporator is monitored, for purposes of triggering defrosting of the evaporator, by measuring the bending stress on a cantilever support for the evaporator.

It is an object of the present invention to provide a means of sensing the build-up of deposition on the surfaces of an industrial installation, without the need for visual observation of the deposit.

Accordingly, one aspect of the present invention provides a method of measuring the build-up of deposit, comprising placing an elongate probe in a region where the build-up will appear, allowing the deposit to build up, and detecting variations in the mass of said probe as being indicative of the build-up of said deposit on the probe.

A further aspect of the present invention provides a sensor for determining the build-up of a deposit comprising an elongate probe adapted to be installed in a region where monitoring is to be effected, at least one strain gauge for measuring the flexural strain in said probe in response to the weight of the probe and any accretion of deposit built up thereon, and means for monitoring the magnitude of the flexural strain continuously over a period of time.

In order that the present invention may more readily be understood, the following description is given, merely by way of example, with reference to the accompanying drawings in which:-

FIGURE 1 is a schematic side view of a paper mill in which, for example, the sensing method and apparatus of the invention can be usefully employed;

FIGURE 2 is a side elevational, partly sectional view of a first embodiment of sensor in accordance with the present invention;

FIGURE 3 is a view of part of the output circuitry to eliminate the influences of machine vibrations on the output signal from the sensor;

FIGURE 4 is a sectional view of a second embodiment of sensor in accordance with the present invention; and

FIGURE 5 is a view showing the mounting diaphragm of the sensor of Figure 4.

Referring now to the drawings, which exemplify the invention in terms of monitoring of build-up of pulp and other particles with a biological film in paper making equipment, there will be seen only one possible application for the present invention. Various other applications are possible, as indicated above.

The precise nature of the environment in which the deposition sensing method and apparatus of the present invention are capable of being applied is not crucial to the present invention and thus the illustration, in Figure 1, of a single application in the form of a paper making installation is considered adequate to illustrate the use of the invention.

Furthermore, although in the present context the sensing of the build-up of a biological film deposit in paper making machinery is taken as the downline control which can be exercised as a result of the signal resulting from the method and apparatus of the invention, it will be understood that other downline control operations may be exercised as a result of the use of the invention. For example, where the probe is sensing the build-up of scale in a boiler water circuit or an evaporative water cooling installation the downline operation to be carried out in response to the signal from the process and apparatus of the invention may be the addition of a composition for dispersing and/or preventing scale deposits in the water; and where the probe is monitoring the build-up of soot in a smoke stack the downline operation may comprise the timing of periodical soot blowing operations or the addition of soot-dispersing compositions. This concept can be extended to any other industrial application in which the probe is used to measure the deposit of build-up over a period of time.

Referring now to the papermaking equipment shown in the drawings, Figure 1 shows the headbox 1 which supplies a pulp suspension at 3 to the wire 5 which is guided through a settling zone defined between wire supporting rolls 7 and 9 over a zone 2 through which water and tiny pulp particles from the forming paper web 11 on the wire will fall, eventually to be caught by a wire pit 13 from which the recovered liquid can be recycled into the headbox by way of a pump 15 and recycle pipe 17.

The paper web 11 is then passed through press zone 3 over press rolls 19 which serve to remove the water.

It is known that there are tendencies of deposition of various components in zone 1 within the headbox, and which can tend to cause an undesirable build-up at the outlet from the headbox 1, and also in the zone 2 region below the horizontal run of the wire on which the wet pulp begins its de-watering treatment as well as in the press section zone 3.

The build-up of pulp particles and of deposit in these three zones can upset the stable operation of the paper making process and it is therefore desirable to control the build-up of deposit using a chemical treatment by adding one or more controlling composition to the wet pulp going to the headbox 1. Excessive doses of these treatment chemicals will mar the quality of the finished paper web 11, and will be unnecessarily expensive but equally insufficient dosage will allow the deposit to build up to an extent where it fragments from the inner surfaces of the headbox and of the de-watering zone and possibly appears as defects and sometimes causes holes in the finished paper web 11. It is therefore important to be able to control the build-up of deposit at all times, so that there is no excessive build-up but equally no excessive dosing of chemicals to counter that build-up.

In order to monitor the build-up of the deposit, we now propose to incorporate at a location within the paper-making machine, for example within the de-watering zone 2, at least one sensor of the type shown in Figure 2.

Figure 2 shows a first embodiment of the sensor as comprising an elongate probe 30 in the form of a stainless steel tube, mounted in a mounting body 31 by means of a pivot bearing 32 at the centre of gravity of the probe. The part of the probe to the left of the bearing 32 is shown foreshortened, whereas the portion to the right of the bearing is shown in its full length, and this comprises at its end a counterbalance mass 33 in order to ensure that when the probe 30 is free of any external deposit it will balance exactly around the bearing 32 which is nearer one end of the tube. When the exposed left hand part of the probe 30 becomes laden with a deposit, that part will be heavier and the probe will tend to settle with the left hand side low.

The bearing is carried by an inner rod 34 which is welded at 35 to a carrier disc 36 itself integral with a rear housing portion 37 enclosing the electrical connections and part of the circuitry for the sensor output.

The opposite end of the rear housing portion 37 has an integral external flange 38 to which a cover 39 is secured by bolts 40. Likewise the mounting body portion 31 is secured to the carrier disc 36 by way of mounting bolts 41 clamping an end flange 42 of the mounting body 31 to the carrier disc 36 of the rear body portion 37.

Surrounding the centre of gravity of the tubular probe 30, at the same axial station as the bearing 32, is an external seal arrangement 43 to prevent ingress of the materials borne by the atmosphere around the left hand part of the probe 30 from entering the interior of the mounting body portion 31.

Upper and lower adjusting screws 44 and 44', respectively, are threadedly engageable in the wall of the stainless steel tube defining the probe 30 and are in register with the tips of upper and lower spring blades 45, 45′ which are carried by the inner rod 34 by means of upper and lower mountings 46 and 46′, respectively.

Within the rear housing portion 37 at the right hand end of the mounting body portion are two printed circuit boards 47 and 48 which are carried by an array of mounting studs 49 threadedly engageable in the carrier disc 36. These printed circuit boards carry the necessary circuit elements, schematically illustrated at 50, to form the output circuitry of the sensor.

The output signal is conveyed to an external control unit, which may be effective to control the dosage of deposit-inhibiting or -controlling compositions by way of a conduit 51 providing a waterproof seal to the rear housing portion 37 by way of its cover 39.

The spring blades 45 and 45′ each carry strain gauges (not shown) to measure the flexural strain on the respective blades, thereby allowing the amplitude of displacement of the probe from the horizontal position to be measured (in terms of the flexural strain on one or other of the blades). For example, when the probe tilts in the anti-clockwise direction as viewed in Figure 2 the adjustment screw 44′ will rise to deflect the left hand end of the spring blade 45′ upwardly, thereby generating strain on the strain gauges associated with the blade 45′.

Assuming that the upper adjuster screw 44 has been adjusted so that it just touches the left hand tip of the upper blade 45 then the increased bending on lower spring blade 45′ may occur simultaneously with a slight relaxation of the bending on the upper spring blade 45, giving confirmation of the signal. This may be particularly relevant if the balance of the probe 30 is not precise, in which case slight residual flexure on the upper blade 45 may be necessary in order to retain the probe in the horizontal position when free of deposit.

Bearing in mind the free pivotal mounting of the probe 30 in Figure 2, it may be important to eliminate the effects of any general machine vibrations from this form of sensor and for that purpose the circuitry of Figure 3 may be useful. This comprises an amplifier 60 connected across opposite sides of a measuring bridge 61 so that imbalance in the bridge will give rise to imbalance on the inputs of the amplifier and the difference can then be amplified at the amplifier output 62. This output signal is applied directly to one input of a differential amplifier 63 and a tapping from the output is taken through a RC network comprising a capacitor 64 and a resistor 65, with the result that the transient component of the output signal from the first amplifier 60 remains on the second input of the differential amplifier 63 while the static component is reduced to zero. Thus, the output of the differential amplifier will subtract the two input signals to eliminate the transient component and to leave the static component. In practice, such a circuit has been found to give an attenuation of -80 db in the vibration-responsive (transient) component of the signal.

In the preferred form of the sensor the probe may be associated with a further transducer in the form of an analyser cell which reacts in response to the composition of the deposit. Such a further cell may, for example but not necessarily, be mounted on the exterior of the probe. In the case of such a further cell the deposit monitoring sensor can detect not only the quantity of deposit but also its nature, (biological, inorganic ...) in order that the deposit-controlling composition introduced into the headbox 1 will be appropriate for the predominant constituent of the deposit growth being controlled.

Thus, in the present sensor one of the circuit boards 47 and 48 may be connected to this analyser cell.

The analyser cell may, for example, work on the basis of a voltage differential responsive to the chemical action of the deposit thereon, or as a result of change in capacitance of the cell in response to the nature of a build-up thereon, or may work in response to biological oxygen demand.

The outlet leads from the respective printed circuit boards 41 and 43 may be connected to appropriate pins of a multi-pin connector (not shown).

The sensor shown in Figure 2 is suitable for use in many environments but, where only a small build-up of deposit is expected, it may be advantageous to use a modified monitoring head in which the cantilever probe 30 is extended outwardly (towards the right in Figure 2) so that the strain gauge 33 is positioned near the midpoint of the probe 30 to give a substantially balanced configuration when there is no deposit present on the left hand half of the sensor probe. When, in this case, deposit builds up on the left hand half of the probe, the signal sensed by the strain gauges will no longer be in equilibrium and the effect of the growth of deposit on the left hand part of the probe will be more noticeable as a departure from a zero signal.

A further possibility is for the probe to be able to vibrate by angular displacement about the datum position shown in Figure 2, in response to the general level of mechanical vibrations in the machine being monitored and for the resonant frequency of the probe to be detected so as to indicate the build-up of deposit on the probe as a function of the variation of the resonant frequency of the probe (indicative of the moment of inertia of the probe about its point of support at the bearing 32). This version of the sensor relies on the fact that a change in the mass of the probe, particularly in the form of a build-up of mass remote from the mounting (pivot) of the probe, will change the moment of inertia of the probe and this in turn will change the natural frequency of vibration (the resonant frequency) of the probe. Vibration of the probe is triggered by general machine vibrations (or possibly by a special vibrator if desired) and the probe will then vibrate most readily at its natural frequency (which will change when the mass is changed, as in the case of selecting an appropriate one of a set of metallic musical tuning forks each of which will resonate at its own natural frequency pitch, different from those of the other forks in the set.

By relying on the natural vibrations in the paper-making mill, it is possible to avoid the need for any moving parts such as a mechanical vibrator to be incorporated in the sensor, and yet at the same time information derived from the value of the natural (resonant) frequency of the probe 30 will allow determination of the mass of the beam and any accretion thereon. The signal from the strain gauges on the spring blade 45′ will then vary sinusoidally in response to the vibrations, and the signal can then be analysed both for amplitude and for frequency. In practice the beam will be most likely to vibrate at its own natural frequency in response to natural vibration in the de-watering area of the paper-making plant, for example due to the operation of the wire drive mechanism and support rolls, so that the signal only needs to be evaluated in order to ensure that the frequency determined is the first natural frequency rather than a harmonic.

As indicated above, in the case of the vibrational probe the further the build-up is from the mounting (pivot) the more noticeable will be the change in its natural frequency of oscillation.

Similarly, in the case of the static probe the turning moment causing the probe to displace from its rest position when free of deposit will be affected more greatly by build-ups of deposit remote from the pivot than by such a build-up closer to the pivot. The elongate nature of the probe allows for this possibility of accretion of build-up displaced from the probe pivot.

In some environments there may be a greater tendency for accretion of build-up than in others, and equally in some machines there may be space for a longer probe than in other machines. It is therefore envisaged that the length of the probe may be adjustable in order to allow the probe to be tailor-made for a particular machine. This adjustment may be achieved either by providing a single probe of variable length or, more preferably, by providing a range of probes of which an appropriate one can be selected in order to suit the characteristics of the machine in question.

One possible modification of the sensor shown in Figure 2, in order to work in the resonance-responsive mode, would be for the two spring blades 45 to work instead as spring contacts of a switching system so that when, during vibration of the machine to be monitored, in this case the paper-making machine, the probe oscillates about its pivot 32 (in response to an increased mass on the left hand side of the probe exposed to the likelihood of build-up of deposit in use of the machine) the upper and lower spring blades 45 and 45′ will alternately contact their respective adjuster screws 44 and 44′, provided the screws are sufficiently far apart to allow a situation where only one of the spring blades 45 and 45′ will be contacting its adjacent screw at any one time. Clearly, then, when the probe tilts slightly in the anti-clockwise direction the upper adjuster screw 44 and spring blade 45 will be out of contact while the lower adjuster screw 44′ and spring blade 45′ will be in contact, and when the probe is tilted in the clockwise direction the upper screw and blade 44 and 45′ will be in contact and the lower screw and blade 44′ and 45′ will be out of contact. The frequency of alternation between these two states can be measured and will be the resonant frequency of the combination of the probe 30, its counterbalance weight 33, and the build-up of deposit on the probe 30, with the arrangement such that because the probe 30 (minus deposit) and the balance weight 33 are accurately balanced about the axis of bearing 32 any out-of-balance will result from the deposit on the probe 30 and the magnitude can therefore be related to the resonant frequency of the assembly 30, 33.

An alternative embodiment of the probe is illustrated in simplified form in Figure 4. Here the probe 70, again in the form of a hollow stainless steel tube. In this case the mount for the probe is a cruciform diaphragm 72 which is shown in side view in Figure 4 but is shown in frontal view in Figure 5. Each of the four limbs of the diaphragm 72 includes a hole 74 to receive a mounting screw 76 which clamps the end of that limb of the diaphragm to a mounting body 78. Similarly the centre of the mounting diaphragm includes a hole 80 for receiving a mounting stud 81 at the proximal end of the probe 70 and the tension in the various limbs of the cruciform mounting diaphragm 72 result in the probe 70 being substantially horizontal in its rest condition. Strain gauges 82 and 82′ on the upper and lower vertical limbs 84 and 84′, respectively, of the mounting diaphragm 72 provide signals, by way of connecting leads 86, 86′ indicative of the loading on the probe in that when the probe tilts in the anti-clockwise direction (by drooping of the distal end of the probe 70) the limbs 84 and 84′ will tend to flex and as a result there will be a change in strain to be measured by the strain gauges 82.

The horizontal limbs of the diaphragm 72 serve simply to enhance the mounting of the probe 70 but during loading of the probe with deposit to increase the weight of the probe these horizontal limbs will not be deflected. They may, however, be subject to deflection in the event of machine vibration in a horizontal direction and it is therefore possible to use this vibration-responsive flexure to measure the resonant frequency of the combination of the probe 70 with deposit thereon if additional strain gauges are attached to the horizontal limbs.

This particular embodiment shows the optional additional cell 88 with its connector leads 90, this cell serving to detect the nature of the deposit on the probe, as described above.

A further embodiment of the method and apparatus of the invention can be incorporated as a modification of either of the two forms of the probe where the vibration is measured, in that a vibrator can be incorporated in the probe mounting so as to initiate the vibration of the probe in order to allow either the amplitude of vibration or the resonant frequency of the vibration to be monitored using the strain gauges shown in either Figure 2 or Figure 4, or the switching possibility exemplified above as a modification of the probe of Figure 2.

Although in the present case the strain gauge is shown as being part of the support for the probe 30, it is equally possible for the probe to be fixedly mounted at or near one of its ends and to project in cantilever fashion into the intended region of monitoring of deposit. The strain gauge can be positioned along the probe where it will respond to bending of the probe between the ends of the probe 30 shown in Figure 2, but the optimum position for the strain gauge in such an arrangement will be at the point of mounting in the support body 31 (where the moment created by the presence of deposit on the probe 30 will be greatest.

The circular cross-section of the probe 30 ensures that there is no problem concerning orientation of the probe when mounted on wall 40 of the plant being monitored, as the bending response will be the same in all orientations of the cylinder defining the probe.

This circular form of the probe is also particularly suitable for an omni-directional incidence of the deposit, for example in the case of a water monitoring system where the deposit will precipitate from the water around the probe. In other cases it may be desirable to vary the cross-section of the elongate probe either for adapting it to the particular geometry of the location where the probe is installed, or to adapt it to a known direction of arrival of the deposit. For example, in the case of a soot monitoring application it may be advantageous to provide the probe in the form of a plate or a paddle on the end of an arm, where the plate or paddle has a plane extending generally perpendicular to the direction of incidence of the deposit, in order to catch as much of the deposit as is possible.

Cross-sections other than circular or plate-shaped are possible depending on the requirements of the environment to be monitored.

The down-line operation which may be controlled in response to the output of the sensor can be any one of a number of different operations, as indicated above, but equally the manner in which that control is exercised can also be in one of various different forms.

As a first possibility the output of the sensor can be used to display a signal which can be interpreted by an operator who then changes the rate of execution of the down line operation (for example the rate of dosing of a paper mill with a composition which inhibits the growth of biological film therein) in order to maintain optimum conditions, in response to the information portrayed by the displayed signal indicative of deposition quantity. Such a system could be referred to as a semi-automatic control system.

A second basic form of the control may be an automatic one which relies on direct application of the output from the sensor to the speed control or displacement control of a pump in order to vary the rate of dosing, for example by changing the speed or by varying the displacement, of the pump. Such a system responds purely to the actual acquisition of build-up with time and may rely on a control regime which effectively plots total build-up of deposit against time and reacts to that build-up.

A third, more intelligent, automatic control regime may be one in which the controller assesses the general trend of the deposition signal to detect whether the rate of increase is itself increasing or reducing, in order to increase the dosing rate more noticeably in the case of a rising rate of build-up of deposit and to reduce the dosing rate when the rate of change of build-up quantity is itself reducing. Such a system allows a measure of prediction of future build-up value and is therefore to some extent predictive rather than purely reactive.

A still further version of an "intelligent" automatic control regime may be one which combines the second and the third regimes mentioned above, i.e. part of the control action is in response to the actual quantity of build-up, and part is in response to the trend of the change in build-up, for example by comparing the actual rate of change with a predicted "expected" rate of change.

The hardware for effecting the "intelligent" third and fourth control regimes just mentioned may rely on a programmable logic controller (plc) to be programmed with software to exercise the appropriate control over the downline (e.g. dosing) operation.

CLAIMS

1. A method of measuring the build-up of deposit comprising placing an elongate probe in a region where the build-up will appear, allowing the deposit to build up, and detecting variations in the mass of said probe as being indicative of the build-up of said deposit on the probe.

2. A method according to claim 1, wherein said monitoring of the probe is effected by static measurement of the bending moment in the probe.

3. A method according to claim 1, wherein the probe is mounted in cantilever fashion and the variations in the mass of the probe are detected by measuring the strain of the cantilever mounting.

4. A method according to claim 1, wherein the monitoring of the build-up is effected by vibrating the probe flexurally and monitoring the amplitude of vibration.

5. A method according to any one of the preceding claims, wherein the mass of said probe is detected by monitoring the vibration in said probe in response to natural machine vibrations in the region where the build-up will appear, and detecting the frequency of the natural vibrations to evaluate the mass of the combination of the probe and deposit thereon by detecting the resonant frequency of vibration thereof.

6. A method according to any one of claims 1 to 4, comprising vibrating said probe laterally by means of a vibrator and monitoring the vibration of the probe for detecting the frequency or amplitude of the vibrations to represent the mass of the probe.

7. A method of controlling build-up of deposit in an industrial apparatus, comprising measuring the build-up by a method according to any one of the preceding claims, and including the step of controlling the dose of the application of a deposit-inhibiting composition in response to the mass variations detected.

8. A method according to claim 7, including the

steps of selecting one of several deposit-inhibiting compositions to be added to said region, and further including providing a sensor responsive to the nature of the deposit on the probe, and selecting a said deposit-controlling composition to be most effective for the nature of the deposition identified.

9. A method according to claim 7 or 8, and including the step of displaying a signal representative of the detected mass variation of said probe, and adjusting the dose of the application of said composition in response to the signal displayed.

10. A method according to claims 7 or 8, and including determining the rate of change of build-up with time, and comparing the determined rate of change with an expected rate of change, to increase or decrease the rate of dosing in response to a rise or a fall in the rate of build-up with time.

11. A method according to any one of claims 7, 8 and 10, wherein the rate of dosing is at least partially controlled in direct response to the build-up detected by the probe.

12. A method of measuring the build-up of deposit in a plant, substantially as hereinbefore described with reference to the accompanying drawings.

13. A sensor for determining the build-up of a deposit in industrial equipment, comprising an elongate probe adapted to be installed in a region of the equipment where monitoring is to be effected, at least one strain gauge for measuring the flexural strain in response to the weight of the probe and any accretion of deposit built up thereon, and means for monitoring the magnitude of the flexural strain continuously through the life of the plant.

14. A sensor according to claim 13, wherein said probe includes at one end a support including strain gauges to measure the strain resulting from the weight of the support.

15. A sensor according to claim 14, wherein said support includes a flexible mount and wherein the strain gauges are mounted on said mount to measure the deformation of said mount in response to deflection of the probe from a datum position.

16. A sensor according to claim 15, wherein said mount is a diaphragm.

17. A sensor according to claim 16, wherein said diaphragm is cruciform in shape and has the probe mounted at the intersection of the arms of the cross and is itself supported by clamping at the ends of the arms of the cross.

18. A sensor according to any one of claims 13 to 17, wherein said probe is cylindrical in cross-section.

19. A sensor according to any one of claims 13 to 18, and including a mounting body adapted to be secured to the exterior of a wall of plant to be monitored, and bearing means supporting said probe in said mounting body, to project transverse to the extent of a said wall on which the mounting body can be mounted.

20. A sensor according to any one of claims 13 to 19, including mounting means for permitting the probe to vibrate in angular oscillation about a datum position, and means for measuring the instantaneous strain of the mounting means for measuring the vibration characteristics of the probe with any deposit thereon.

21. A sensor according to claim 20, and including a vibrator arranged to drive the probe for vibration by angular displacement about said datum position.

22. A sensor according to any one of claims 13 to 21 and further including circuitry comprising a bridge connected to several said strain gauges for providing an output signal which can be directly related to the flexural strain in the probe.

23. A sensor according to claim 22, wherein said circuitry is mounted on a printed circuit board which is attached within the mounting body, and wherein said printed

circuit board includes connectors which receive signals from said at least one strain gauge and which pass output signals to the exterior of said mounting body by way of a waterproof connector.

24. A sensor according to claim 22 or 23, wherein said circuitry includes a differential amplifier receiving on a first input an out-of-balance signal from said bridge, and on a second input a modified form of said out-of-balance signal in which the static component of said out-of-balance signal has been attenuated, whereby the output from said differential amplifier has the transient component attenuated in order to suppress the effects of vibration on the strain gauge signal.

25. A sensor according to claim 24, wherein said modified form of the out-of-balance signal is applied to the second input of the differential amplifier by way of a resistor-capacitor network for attenuating the static component of the signal.

26. A sensor according to claim 24 or 25, and including a further amplifier for amplifying the out-of-balance signal from said bridge before splitting between said first and second inputs of the differential amplifier.

27. Industrial equipment in which a deposit forms in use of the equipment, including a sensor for determining the build-up of said deposit, said sensor comprising an elongate probe installed in a region of the equipment where the deposit builds up; means mounting said probe resiliently in relation to the plant whereby the probe can oscillate by angular displacement about a datum position in response to natural vibrations of the equipment; means for monitoring the vibrations of the probe in response to said machine vibrations; and means for evaluating the frequency of said vibrations as being indicative of the resonant frequency of the combination of the probe and any deposit thereon.

28. Apparatus according to claim 27, wherein said

means for monitoring the vibration comprise switch contacts adapted to be made and broken in response to alternating movement of the probe during vibration.

29. Apparatus according to any one of claims 13 to 28, and further including means responsive to the nature of said deposit to provide a signal indicative of the particular material deposited on the probe.

30. Apparatus according to any one of claims 27 to 29, wherein said equipment is a cooling water drum system, or a boiler water system, or a paper manufacturing machinery.

31. Apparatus according to any one of claims 13 to 30, wherein the length of said elongate probe is adjustable in order to change the moment, or the change in moment of inertia, exerted on said probe by a build-up thereon.

32. A sensor for build-up of deposit in plant, substantially as hereinbefore described with reference to and as illustrated in, Figure 2, or Figures 4 and 5, of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17
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T S SUTHERLAND

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Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASES: WPI

Documents considered relevant following a search in respect of Claims :-
1-31

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X	GB 2227316 A	(GLASGOW COLLEGE) Figure 1, page 4, line 19 to page 5 line 1	1,4
X	GB 1087475	(ROSEMOUNT) page 1 lines 53 to 74	1,4
X	US 4553137	(ROSEMOUNT) Claim 1	1,4

Databases: The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).