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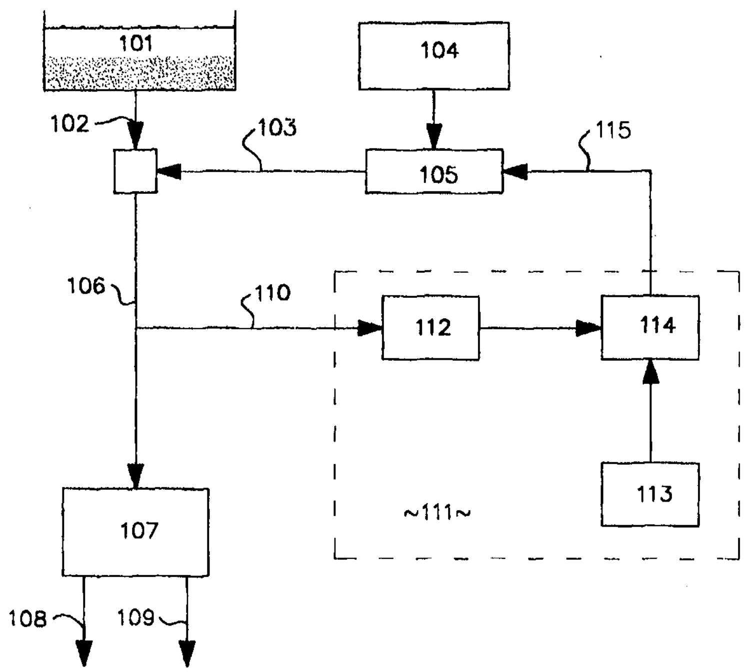

(57) Abstract

A sludge dewatering control system (10) which relies on a determination of sludge structure after addition of an additive as a predictor of dewaterability of said sludge by dewatering means. The system (10) relies on a method of control of dewatering of sludge, the method comprising obtaining a relationship (25) between particle structure and cake solids content of the sludge (15), continuously monitoring the particle structure of the sludge so as to provide a continuous determination of the cake solids content of the sludge and adding an additive to the sludge as a function of the cake solids content so as to control the dewatering characteristics of the sludge (15). Sludge structure is determined by reference to fractal dimension of the particles making up the sludge.

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SLUDGE DEWATERING CONTROL SYSTEM

The present invention relates to a sludge dewatering control system and, more particularly, to such a system adapted to assist in the control of additives to sludge for the purpose of improving the dewaterability thereof.

BACKGROUND

In many treatment processes a flocculant is used to assist in the coagulation of solids in liquid in a treatment tank. Ultimately the flocculant in combination with waste materials settles to the bottom of the liquid in the treatment tank and is removed as a sludge.

In the case of some water and waste water treatment processes naturally occurring bacteria perform the same function as the flocculant.

Chemical flocculants include ferric chlorate or organic coagulants such as polymers.

In order to facilitate transport of the sludge it is desirable to dewater the sludge and this can be done by a number of known methods including centrifuge dewatering and filtration dewatering.

After removal of the sludge from the treatment tank and prior to dewatering, an additive can be mixed with the sludge in order to improve the dewaterability characteristics of the sludge. Polymer polyelectrolytes are known to be useful additives in this regard.

Monitoring methods for determining the effectiveness of the additive and of the characteristics of the non-dewatered and dewatered sludge are labour intensive, and are slow. They do not lend themselves to use as part of an additive control system in a modern, industrial plant.

In the absence of a reliable instrumental method to control the additive concentration to achieve optimal dewatering, additive addition is usually set at a higher than optimum rate so as to provide a margin of safety.

This wastes additive, which can be expensive, for example where the additive is a polymer.

It is an object of the present invention to address or ameliorate one or more of the abovementioned disadvantages.

BRIEF DESCRIPTION OF THE INVENTION

In this specification the term "sludge" refers to substantially settled solid coagulated material derived from a treatment process. The sludge has added to it an additive for the purpose of improving the dewaterability behaviour of the sludge when processed through a dewatering device such as a centrifuge, belt press, filter press or the like.

After the sludge has had additive added to it, it may be termed "feed" for the dewatering device.

In this specification the term "sludge" is applied to the material both before and after additive addition. That is the term covers both sludge as derived from the treatment process and the sludge plus additive mix.

Typically the additive, for example where it is a polymer, alters the structure of the particles making up the sludge. The structure can be categorised by its mass fractal number and variations in the structure tracked by a corresponding variation in mass fractal number.

In the literature the sludge is also sometimes referred to as a floc. In this specification the term sludge is preferred.

The dewatering device produces two outputs, namely dewatered sludge which is termed "cake" and the residual watery sludge driven from the cake which is termed a "watery stream". In the case where the dewatering device is a centrifuge or cyclone the watery stream is also termed a "centrate".

In this specification the term "continuously monitoring the structure of the sludge" refers to a process of monitoring which is automatic and periodic in obtaining samples for processing. However the method of control and the control system implementation of the method are "continuous" in the sense that whilst the taking of samples is a necessarily sequential process the total process of obtaining samples, analysing them and acting on the analysis will be continuous. Also the sampling will be performed at a sufficient rate to match with the control time constant required of the process.

Accordingly, in one broad form of the invention there is provided a method of control of dewatering of sludge, said method comprising obtaining a relationship between particle structure and cake solids content of said sludge, continuously monitoring said particle structure of said sludge so as to provide a continuous determination of said cake solids content of said sludge and adding an additive to said sludge as a function of said cake solids content so as to control the dewatering characteristics of said sludge.

Preferably said additive is a polymer.

Preferably said sludge is water sludge.

In an alternative preferred form said sludge is sewage sludge.

Preferably said sludge is a sludge and additive mix.

Preferably said method includes the use of a structure monitor which relies on the characterisation of said particle structure of said sludge by the use of fractal geometry.

Preferably a measure of said particle structure is determined by a measurement of the mass fractor dimension of said particle structure.

Preferably said monitor utilises small angle light scattering (SALS) equipment to determine said mass fractal dimension in conjunction with data processing means so as to effect control of the dewatering characteristics of said sludge.

Preferably said control is effected by reference to a predetermined relationship of additive dose against mass fractor dimension of said sludge.

Preferably control is effected by reference to a predetermined relationship of cake solids content against fractor dimension of said sludge.

Preferably particle structure is determined by obtaining a sample of said sludge after addition of said additive and before dewatering.

Preferably said particle structure is determined by obtaining a sample of said sludge after dewatering.

In a further broad form of the invention there is provided a sludge dosing control system including the above method.

Preferably the sludge dosing control system includes a small angle light scattering monitor adapted to derive details of the particle structure of a sludge for input to a dosing control mechanism.

In a further broad form of the invention there is provided a sludge dewatering control system which relies on a determination of sludge structure after addition of an additive as a predictor of dewaterability of said sludge by dewatering means.

Preferably said structure is determined by reference to the mass fractal dimension of said sludge.

In a further broad form of the invention there is provided a method of control of dewatering of sludge, said method comprising obtaining a relationship between particle structure of said sludge and dewaterability of said sludge, monitoring said particle structure of said sludge so as to provide a determination of said dewaterability of said sludge and regulating the addition of an additive to said sludge in accordance with said relationship thereby to control the dewatering of said sludge.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be described with reference to the accompanying drawings wherein:

Fig 1. is a process diagram of a sludge dewatering control system according to a first embodiment of the invention and, Fig 2. is a graph of the relationship between sludge particle structure and cake solids content suitable for providing relationship data as an input to the control system of Fig 1,

Fig 3. is a process diagram of a sludge dewatering control system according to a second embodiment of the invention,

Fig 4. is a graph illustrating cake solids concentration against feed fractal dimension and centrate solids content against feed fractal dimension in relation to the system of Fig 3,

Fig 5. is process diagram of a sludge dewatering control system according to a third embodiment of the invention,

Fig 6. is a graph of cake solids content against centrate fractal dimension and centrate solids content against centrate fractal dimension in relation to the system of Fig 5,

Fig 7. is a process diagram of a sludge dewatering control system implementing the system of Fig 5,

Fig. 8 is a graph of the relationship between intensity of scattered light and momentum transfer from which fractal dimension can be calculated for the system of Fig 7,

Fig 9 is a diagram of a combined dilution and small angle light scattering cell for use with the system of Fig 7 and

Fig 10 is a flow diagram of a software implementation for use with the system of Fig 7, and

Fig 11A is a graph of cake solids content against polymer content of an exemplary sludge and,

Fig 11B. is a graph of fractal dimension against polymer content for an exemplary sludge with polymer combination.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Embodiments of the invention to be described rely on the combination of two key observations.

The first observation, with reference to Fig 11B is that sludge structure is affected in a measurable way, at least over a predetermined range of additive (polymer) dose as reflected by significant variation in measured fractal dimension.

The second observation to take into account is that (mass) fractal dimension can be used to characterise the dewaterability behaviour of such a sludge. As can be seen in Fig 11A there is a marked change in cake solids content (dewaterability) over a relatively narrow range of polymer concentration in the sludge.

The combination of the observations of Fig 11A and Fig 11B allow one to draw the conclusion that cake solids content (dewaterablility) can be controlled by proportion of additive (polymer) in the sludge and that the relationship between sludge structure as measured by its mass fractal dimension and its polymer content is such that fractal dimension can be used as a control variable to maximise cake solids content (dewaterability) around an optimal concentration of additive - in this instance polymer.

In practice the graphs of Fig 11A and 11B are combined and the relationship of Fig 2 is established for a particular installation and utilised as a control relationship for polymer (or other additive to which the process is sensitive) addition in a control loop as to be further described below.

In relation to the second observation and Fig 11B the scientific literature describes one particular method of characterising sludge structure by measurement of fractal dimension. A relevant paper is entitled "A new technique for floc structure characterisation" by Jung S J, Amal R and Raper JA (1993) to be found in APPCHE and CHEMECA 93 Proceedings, 2, 89-93. This paper is incorporated into this specification by cross reference.

The paper uses the term "floc structure" rather than "sludge structure" as used in this specification. The paper explains how mass and surface fractal dimension can be obtained by a small angle laser light scattering device.

The particular preferred embodiments of the invention to be described below are set in the context of water and waste water treatment plants where the dominant additive to improve dewaterability is a polymer such as, for example, zetag 92. However the process can be applied to other sludges derived from other processes, subject to a suitable additive being available which affects dewaterability and to which the control process is sensitive.

A first preferred embodiment of the invention is illustrated in Fig 1. which comprises a flowchart of a control process for application to a sludge dewatering system.

The dewatering system 10 includes a waste water treatment tank 11 wherein bacteria are present or a flocculant (not shown) is added to the waste water under treatment and which results in the formation of a sludge 12 which settles to the bottom of the tank 11 and which is removed via sludge outlet 13 for supply to a dewatering unit 14 via dewatering inlet 15.

The dewatering unit can comprise a belt unit or a centrifuge unit or other known mechanism for the removal of water from sludge. The dewatered waste 16 is discharged from dewatering unit 14 via exit pipe 17 for transport by truck or similar to another site.

The dewatering system 10 further includes a dosing device 18 which is adapted to add predetermined amounts of an additive 19 to the sludge 12 prior to dewatering by dewatering unit 14. In this example the additive is a polymer of the type known to provide assistance in the improvement of dewatering characteristics of sludge 12.

A control system 20 is applied to the dosing device 18 whereby the amount and timing of polymer dose administered by dosing device 18 is controlled by microprocessor or data processing device 21 in reliance upon input data 22 and relationship data 23.

The relationship data 23 provides a mathematical relationship between solids content of sludge 12 and its structure, more particularly its structure as relevant to determining the dewatering characteristics of the sludge.

The input data 22 is derived from a monitor which contiguously monitors the structure of the sludge 12 prior to processing by dewatering unit 14.

Ideally the monitor is a small angle light scattering (SALS) unit 24 so as to provide a substantially continuous indication of the structure of the sludge 12 to data processing device 21. The data processing device 21 utilises this input data 22 in conjunction with the structure/solids content relationship derived via relationship monitor 25 to determine an estimate of the solids content of sludge 12 and thence to apply a control signal 26 to dosing device 18 so as to adjust the dose of polymer of like additive administered by dosing device 18 with the end result of controlling the dewaterability of the sludge entering dewatering unit 14.

A typical structure vs cake solids content relationship is illustrated in Fig 2.

With reference to Figs 3 and 4 a second embodiment of the invention will be described.

With reference to Figs 5 and 6 a third embodiment of the invention will be described below.

The major distinction as between the second and third embodiments is that in the third embodiment reliance is placed on analysis of the watery stream output from the dewatering unit. The assumption underlying this approach is that the sludge structure in the watery stream is sufficiently similar to the sludge structure with polymer entering the dewatering unit that one is an analogue of the other for the purposes of control of polymer dose.

The dewatering control system of the second embodiment includes a treatment tank 101 which results in the formation of a sludge 102 which is removed for supply to a dewatering unit 107.

The dewatering unit can comprise a belt filter, or vacuum filter, or a centrifuge unit or other known mechanism for the removal of water from the sludge. the dewatered sludge cake 108 is discharged from the dewatering unit for further treatment or disposal as well as the watery stream 109 which is usually recycled.

The dewatering system further includes a dosing device 105 which is adapted to add predetermined amounts of an additive 104 to the sludge 102 prior to dewatering by dewatering unit 107. In this example the additive is a polymer of the type know to provide assistance in the improvement of dewatering characteristics of sludge 102.

A control system 111 is applied to the dosing device 105 whereby the amount and timing of polymer dose administered by dosing 105 controlled by microprocessor or data processing device 114 with reference to relationship data 113.

The relationship data 113 provides a relationship between sludge structure as relevant to determining the dewatering characteristics of the sludge.

A sample 110 is taken of the mixed sludge and polymer stream 106 for analysis by the structure monitor.

Ideally the structure monitor 112 is a small angle light scattering (SALS) device so as to provide an indication of the structure of the conditioned sludge 106 to data processing device 114. The data processing device 114 utilises this input data in conjunction with the structure/dewaterability relationship 113 to adjust the dose of polymer or like additive administered by dosing device 105 with the end result of controlling the dewaterability of the sludge entering dewatering unit 107.

A typical feed sludge structure vs. dewaterability relationship is illustrated in Figure 4.

Another third embodiment of the invention will now be described with reference to the accompanying drawings wherein: Figure 5 is a process diagram of a sludge dewatering control system according to a third embodiment of the invention and Figure 6 is a graph of the relationship between structure of the solids leaving the dewatering unit in the watery stream.

The dewatering system includes a treatment tank 201 which results in the formation of a sludge 202 which is removed for supply to a dewatering unit 207.

The dewatering unit can comprise a belt filter, or vacuum filter, or a centrifuge unit or other known mechanism for the removal of water from the sludge. The dewatered sludge cake 208 is discharged from the dewatering unit for further treatment or disposal as well as the watery stream 209 which is usually recycled.

The dewatering system further includes a dosing device 205 which is adapted to add predetermined amounts of an additive 204 to the sludge 202 prior to dewatering by dewatering unit 207. In this example the additive is a polymer of the type know to provide assistance in the improvement of dewatering characteristics of sludge 202.

A control system 211 is applied to the dosing device 205 whereby the amount and timing of polymer dose administered by dosing device 205 is controlled by microprocessor of data processing device 214 and relationship data 213.

The relationship data 213 provides a relationship between sludge structure as relevant to determining the dewatering characteristics of the sludge.

A sample 210 is taken of the watery stream 209 leaving the dewatering unit 207 for analysis by the structure monitor.

Ideally the structure monitor 212 is a small angle light scattering (SALS) device so as to provide an indication of the structure of the conditioned sludge 206 to data processing device 214. The data processing device 214 utilises this input data in conjunction with the structure/dewaterability relationship 213 so as to adjust the dose of polymer or like additive administered by dosing device 205 with the end result of controlling the dewaterability of the sludge entering dewatering unit 207. Use, the system of the second or third embodiments can be implemented in accordance with the disclosure of Figs 7 to

10 inclusive. Minor modification to be described below renders it suitable to implement the first embodiment.

Fig 7 discloses the basic arrangement of the dewatering device and its associated control system. In this instance the dewatering device is a centrifuge 301 which receives sludge feed 302 and a polymer feed 303 for combination either before entry to or within the centrifuge 301. The centrifuge outputs a dewatered sludge cake 304 and a residual watery stream in the form of centrate 305. Typically the solids content of the cake 304 can vary between 12% and 25% (electrodewatering assistance can improve this). Typical solids content of the centrate 305 is the order of 1%. Figs 4 and 6 provides typical values.

The sludge feed 302 can come from a variety of processing plants and can take the form of water sludge which is low in organic materials and high in inorganic material or alternatively it can take the form of sewage (or waste water) sludge which is high in organic materials and low in inorganic materials. Indications to date are that control parameters are more sensitive to the highly organic materials.

A centrate sample 306 is diverted from the main centrate outlet and passed to a dilution unit 307 which mixes the sample 306 with dilution water to provide a more dilute sample for the small angle light scattering detector 308. In the detector 308 a laser beam 309 is shone through the dilute sample 310 to a detector array 311 comprising, in this instance, 8 to 10 solid state light detectors arranged at increasing angles to the incident beam. The laser 309 can be a continuous 2mW helium neon laser (633nm) unit with a beam diameter of the order of 1 millimetre.

The detector 308 also includes a light source 312 which shines light through the dilute sample 310 to a photo detector 313 which detects percentage transmission of light thereby to control the dilution of water in the dilute sample 310.

With reference to Fig 9 the sequence of operation of the combined sample dilution unit 307 and detector 308 is:

1. flush cell with dilution water until transmittance equals 100%.
2. divert centrate to the cell
3. add dilution water until the transmittance is in the correct range.
4. measure small angle light scattering.
5. go back to step 1.

The information provided by this sequence of operation of the combined unit (Fig 9) allows the plotting of a graph of log of intensity against log of momentum transfer Q as shown in Fig 8. The slope of the resulting graph is a measure of mass fractal dimension (dF) of the solids in the centrate sample. As previously discussed and with reference to Figs 4 and 6 similar results will be obtained by a similar measurement at the input of the sludge and polymer mix into the centrifuge 301. Sampling the centrate at the output instead of sampling at the input to the dewatering device provides a more dilute sample thereby requiring at least further dilution prior to entry into the detector 308.

Information provided by the graph of Fig 8 is fed to a data processing unit 314 where it is analysed in accordance with the flow chart of Fig 10

The flow chart requires a comparison of the fractal dimension measurement obtained (dF) with the "inbuilt" dF v polymer dose relationship obtained from previous calibration tests. In practice this relationship can also be a relationship of cake solids content versus fractal dimension of the sample as per Figs 2, 4 and 6 (permissible as the result of superposition of Figs 11A and 11B as described earlier in the specification).

In practice as will be observed in Figs 4 and 6 (and in Fig 11A) a clearly identifiable knee 316 can be observed in these calibration curves and this is the "set point" for fractal dimension/polymer concentration to which the control system works in accordance with the flow chart of Fig 10.

The above describes only some embodiments of the present invention and modifications, obvious to those skilled in the art, can be made thereto without departing from the scope and spirit of the present invention.

INDUSTRIAL APPLICABILITY

The embodiments of the invention can be applied to processes which dewater sludge so as to optimise additive addition. Such processes are found in water and waste water treatment plants, mineral processing plants and the like.

CLAIMS

1. A method of control of dewatering of sludge, said method comprising obtaining a relationship between particle structure and cake solids content of said sludge, continuously monitoring said particle structure of said sludge so as to provide a continuous determination of said cake solids content of said sludge and adding an additive to said sludge as a function of said cake solids content so as to control the dewatering characteristics of said sludge.
2. The method of Claim 1 wherein said additive is a polymer.
3. The method of Claim 1 wherein said sludge is water sludge.
4. The method of Claim 1 wherein said sludge is sewage sludge.
5. The method of Claim 1 wherein said sludge is a sludge and additive mix.
6. The method of Claim 1 or Claim 2 wherein said method includes the use of a structure monitor which relies on the characterisation of said particle structure of said sludge by the use of fractal geometry.
7. The method of Claim 6 wherein a measure of said particle structure is determined by a measurement of the mass fractor dimension of said particle structure.
8. The method of Claim 7 wherein said monitor utilises small angle light scattering (SALS) equipment to determine said mass fractal dimension in conjunction with data processing means so as to effect control of the dewatering characteristics of said sludge.
9. The method of Claim 8 wherein said control is effected by reference to a predetermined relationship of additive dose against mass fractor dimension of said sludge.
10. The method of anyone of Claims 1 to 8 wherein control is effected by reference to a predetermined

relationship of cake solids content against fractor dimension of said sludge.

11. The method of any previous claim wherein particle structure is determined by obtaining a sample of said sludge after addition of said additive and before dewatering.

12. The method of anyone of Claims 1 to 9 wherein said particle structure is determined by obtaining a sample of said sludge after dewatering.

13. A sludge dosing control system including the method of any previous claim.

14. A sludge dosing control system including a small angle light scattering monitor adapted to derive details of the particle structure of a sludge for input to a dosing control mechanism.

15. A sludge dewatering control system which relies on a determination of sludge structure after addition of an additive as a predictor of dewaterability of said sludge by dewatering means.

16. The system of Claim 15 wherein said structure is determined by reference to the mass fractal dimension of said sludge.

17. A method of control of dewatering of sludge, said method comprising obtaining a relationship between particle structure of said sludge and dewaterability of said sludge, monitoring said particle structure of said sludge so as to provide a determination of said dewaterability of said sludge and regulating the addition of an additive to said sludge in accordance with said relationship thereby to control the dewatering of said sludge.

18. The method of Claim 17 wherein said additive is a polymer.

19. The method of Claim 17 wherein said sludge is water sludge.

20. The method of Claim 17 wherein said sludge is sewage sludge.

21. The method of Claim 17 wherein said sludge is a sludge and additive mix.
22. The method of Claim 17 wherein said method includes the use of a structure monitor which relies on the characterisation of said particle structure of said sludge by the use of fractal geometry.
23. The method of Claim 22 wherein a measure of said particle structure is determined by a measurement of the mass fractal dimension of said particle structure.
24. The method of Claim 22 wherein said monitor utilises small angle light scattering (SALS) equipment to determine said mass fractal dimension in conjunction with data processing means so as to effect control of the dewatering characteristics of said sludge.
25. The method of Claim 24 wherein said control is effected by reference to a predetermined relationship of additive dose against mass fractal dimension of said sludge.
26. The method of any one of Claim 24 wherein control is effected by reference to a predetermined relationship of cake solids content against fractal dimension of said sludge.
27. The method of any one of claims 17-26 wherein particle structure is determined from a sample of said sludge obtained after addition of said additive and before dewatering.
28. The method of any one of Claims 17-26 wherein said particle structure is determined from a sample of said sludge obtained after dewatering.

AMENDED CLAIMS

[received by the International Bureau on 6 March 1998 (06.03.98); original claims 1-28 replaced by amended claims 1-30 (4 pages)]

1. A method of control of dewatering of sludge, said method comprising obtaining a relationship between particle structure and cake solids content of said sludge, continuously monitoring said particle structure of said sludge so as to provide a continuous determination of said cake solids content of said sludge and adding an additive to said sludge as a function of said cake solids content so as to control the dewatering characteristics of said sludge.

2. The method of Claim 1 wherein said additive is a polymer.

3. The method of Claim 1 wherein said sludge is water sludge.

4. The method of Claim 1 wherein said sludge is sewage sludge.

5. The method of Claim 1 wherein said sludge is a sludge and additive mix.

6. The method of Claim 1 or Claim 2 wherein said method includes the use of a structure monitor which relies on the characterisation of said particle structure of said sludge by the use of fractal geometry.

7. The method of Claim 6 wherein a measure of said particle structure is determined by a measurement of the mass fractal dimension of said particle structure.

8. The method of Claim 7 wherein said monitor utilises small angle light scattering (SALS) equipment to determine said mass fractal dimension in conjunction with data processing means so as to effect control of the dewatering characteristics of said sludge.

9. The method of Claim 8 wherein said control is effected by reference to a predetermined relationship of additive dose against mass fractal dimension of said sludge.

10. The method of any one of Claims 1 to 8 wherein control is effected by reference to a predetermined relationship of

cake solids content against fractal dimension of said sludge.

11. The method of any previous claim wherein particle structure is determined by obtaining a sample of said sludge after addition of said additive and before dewatering.

12. The method of any one of Claims 1 to 9 wherein said particle structure is determined by obtaining a sample of said sludge after dewatering.

13. A sludge dosing control system which operates according to the method of any previous claim.

14. A sludge dosing control system including a small angle light scattering monitor adapted to derive details of the particle structure of a sludge for input to a dosing control mechanism.

15. A sludge dewatering control system which relies on a determination of structure of a sludge after addition of an additive as a predictor of dewaterability of said sludge by dewatering means.

16. The system of Claim 15 wherein said structure is determined by reference to the mass fractal dimension of said sludge.

17. The system of claim 15 or 16 wherein said determination of said structure of said sludge is made by reference to changes caused to a light beam as a result of the light beam passing through said sludge.

18. A method of control of dewatering of sludge, said method comprising obtaining a relationship between particle structure of said sludge and dewaterability of said sludge, monitoring said particle structure of said sludge so as to provide a determination of said dewaterability of said sludge and regulating the addition of an additive to said sludge in accordance with said relationship thereby to control the dewatering of said sludge.

19. The method of Claim 18 wherein said additive is a polymer.

20. The method of Claim 18 wherein said sludge is water sludge.

21. The method of Claim 18 wherein said sludge is sewage sludge.

22. The method of Claim 18 wherein said sludge is a sludge and additive mix.

23. The method of Claim 18 wherein said method includes the use of a structure monitor which relies on the characterisation of said particle structure of said sludge by the use of fractal geometry.

24. The method of Claim 23 wherein a measure of said particle structure is determined by a measurement of the mass fractal dimension of said particle structure.

25. The method of Claim 23 wherein said monitor utilises small angle light scattering (SALS) equipment to determine said mass fractal dimension in conjunction with data processing means so as to effect control of the dewatering characteristics of said sludge.

26. The method of Claim 25 wherein said control is effected by reference to a predetermined relationship of additive dose against mass fractal dimension of said sludge.

27. The method of Claim 25 wherein control is effected by reference to a predetermined relationship of cake solids content against fractal dimension of said sludge.

28. The method of any one of claims 18-27 wherein particle structure is determined from a sample of said sludge obtained after addition of said additive and before dewatering.

29. The method of any one of Claims 18-27 wherein said particle structure is determined from a sample of said sludge obtained after dewatering.

30. The method of any one of claims 18-29 including the step of passing a light beam through said sludge and providing said determination of dewaterability by reference

to changes caused to said light beam as a result of it passing through said sludge.

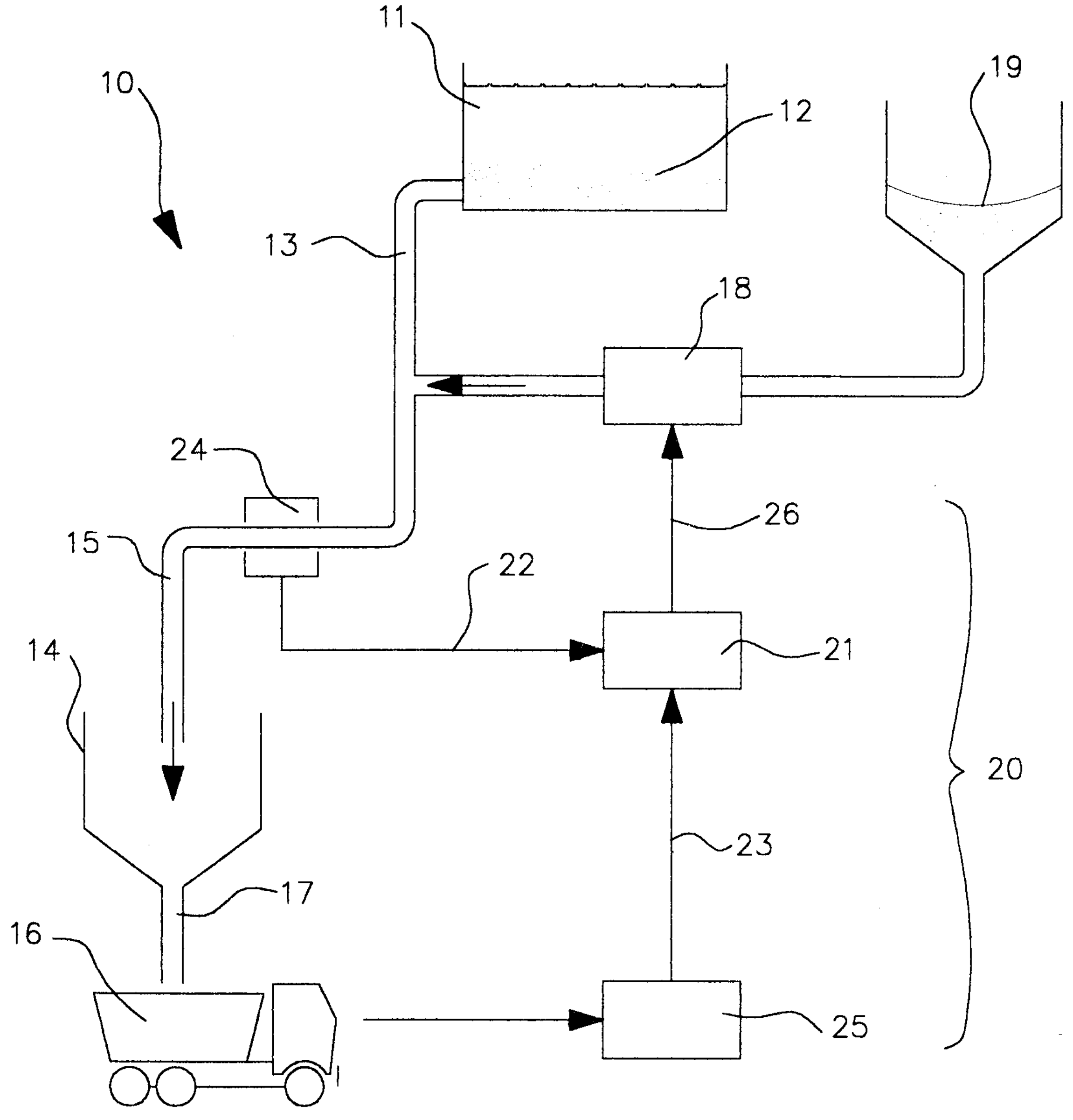

Fig. 1

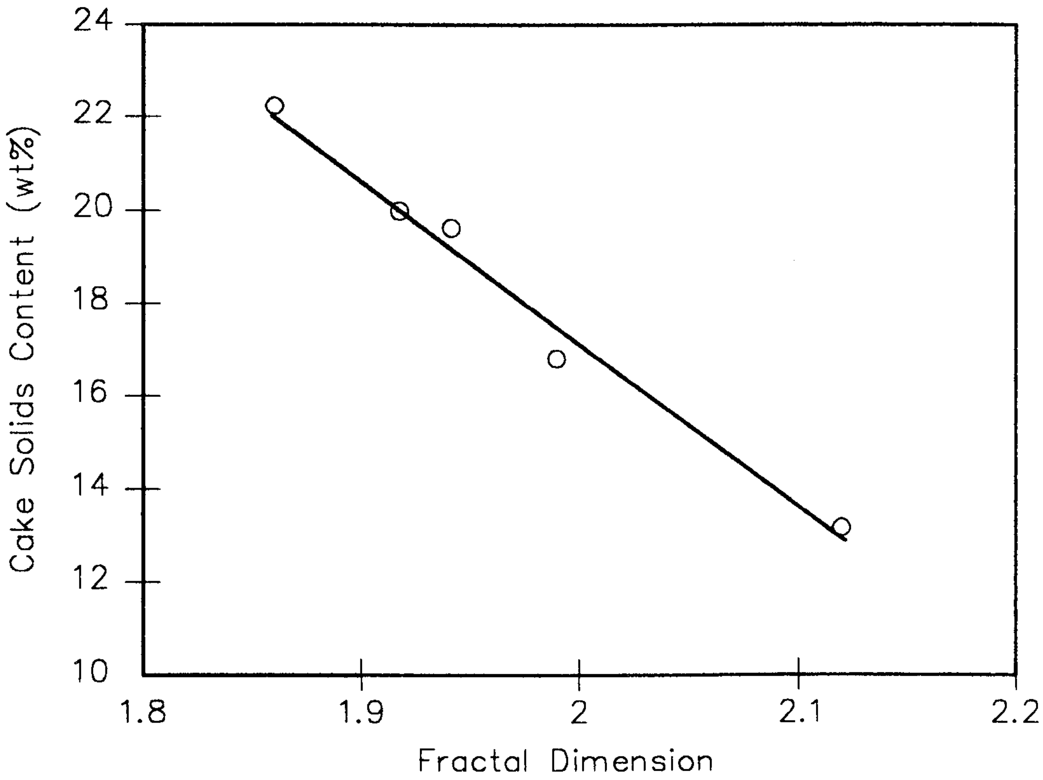
24
22
20
18
16
14
12
10
Cake Solids Content (wt%)
1.8
1.9
2
2.1
2.2
Fractal Dimension

Fig. 2

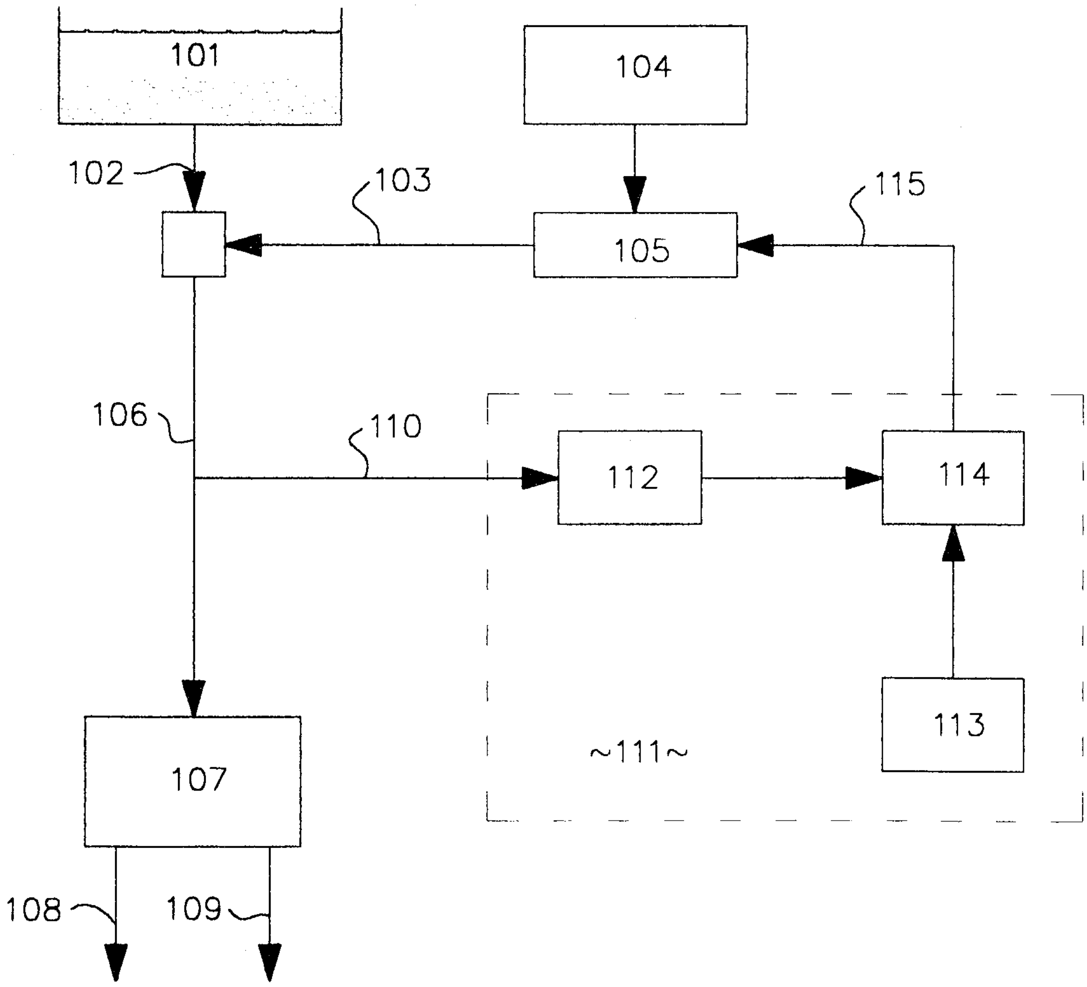

Fig. 3

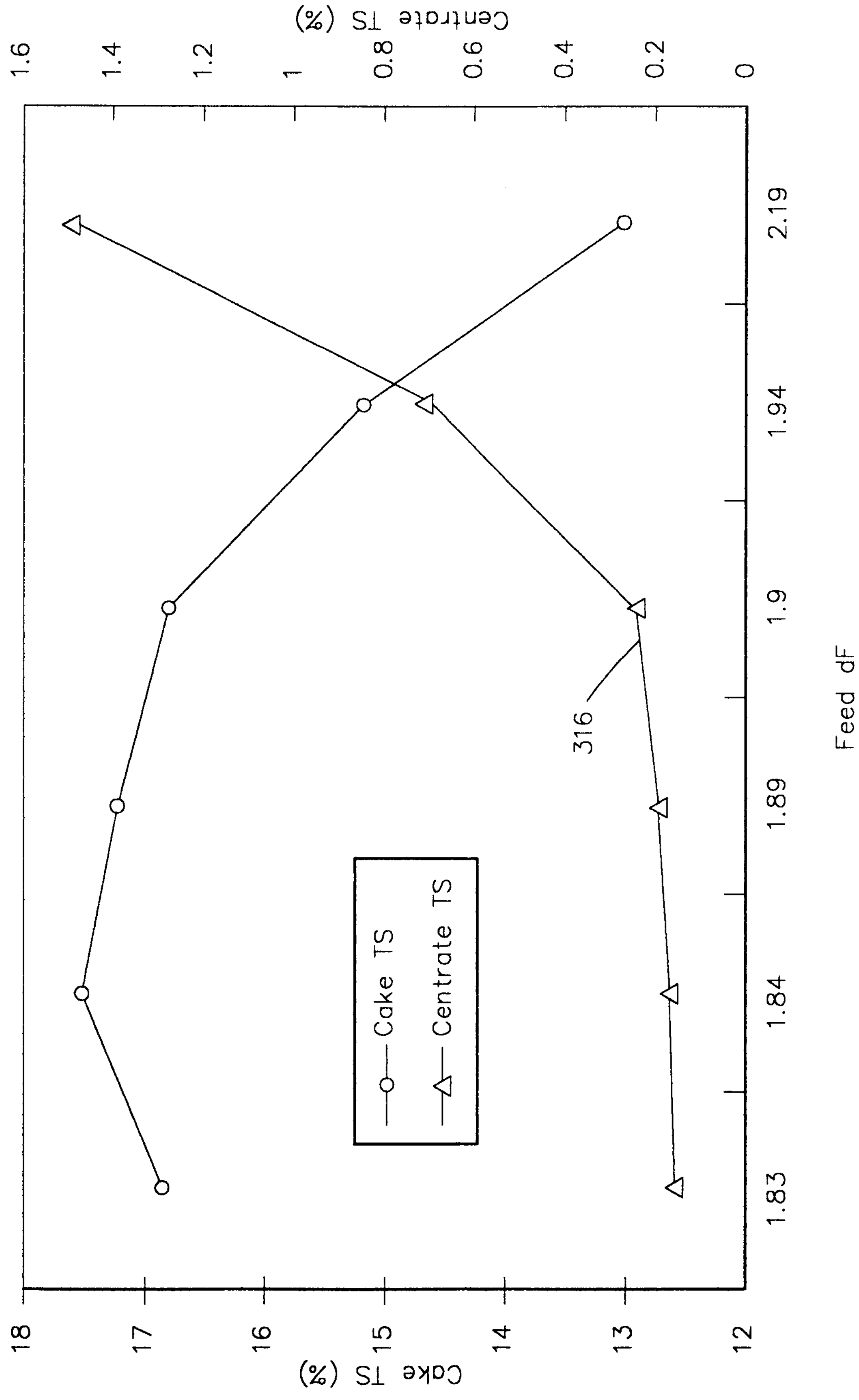
Centrate TS (%)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Cake TS (%)
18
17
16
15
14
13
12
Feed dF
1.83
1.84
1.89
1.9
1.94
2.19
Cake TS
Centrate TS
316

Fig. 4

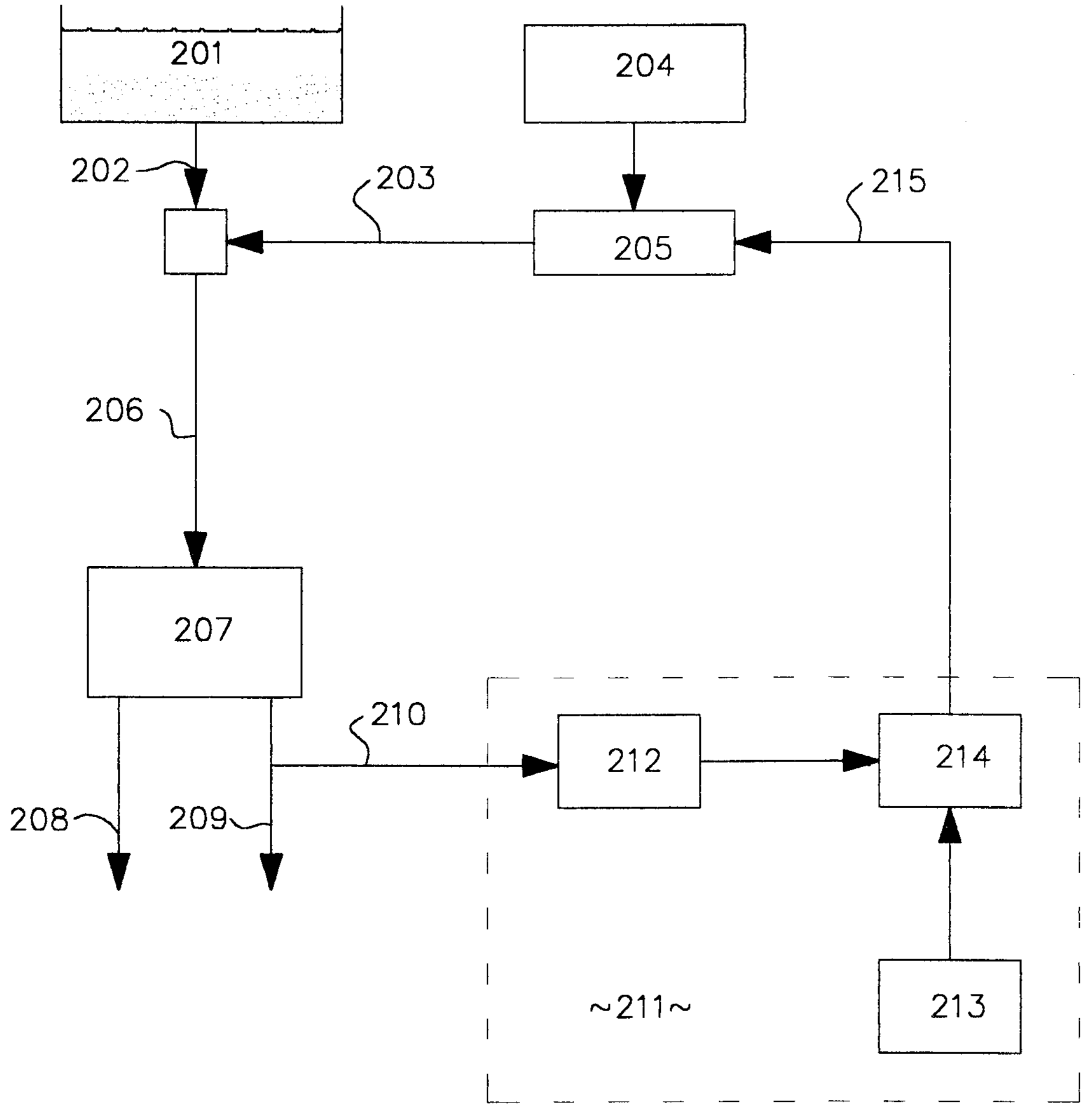

Fig. 5

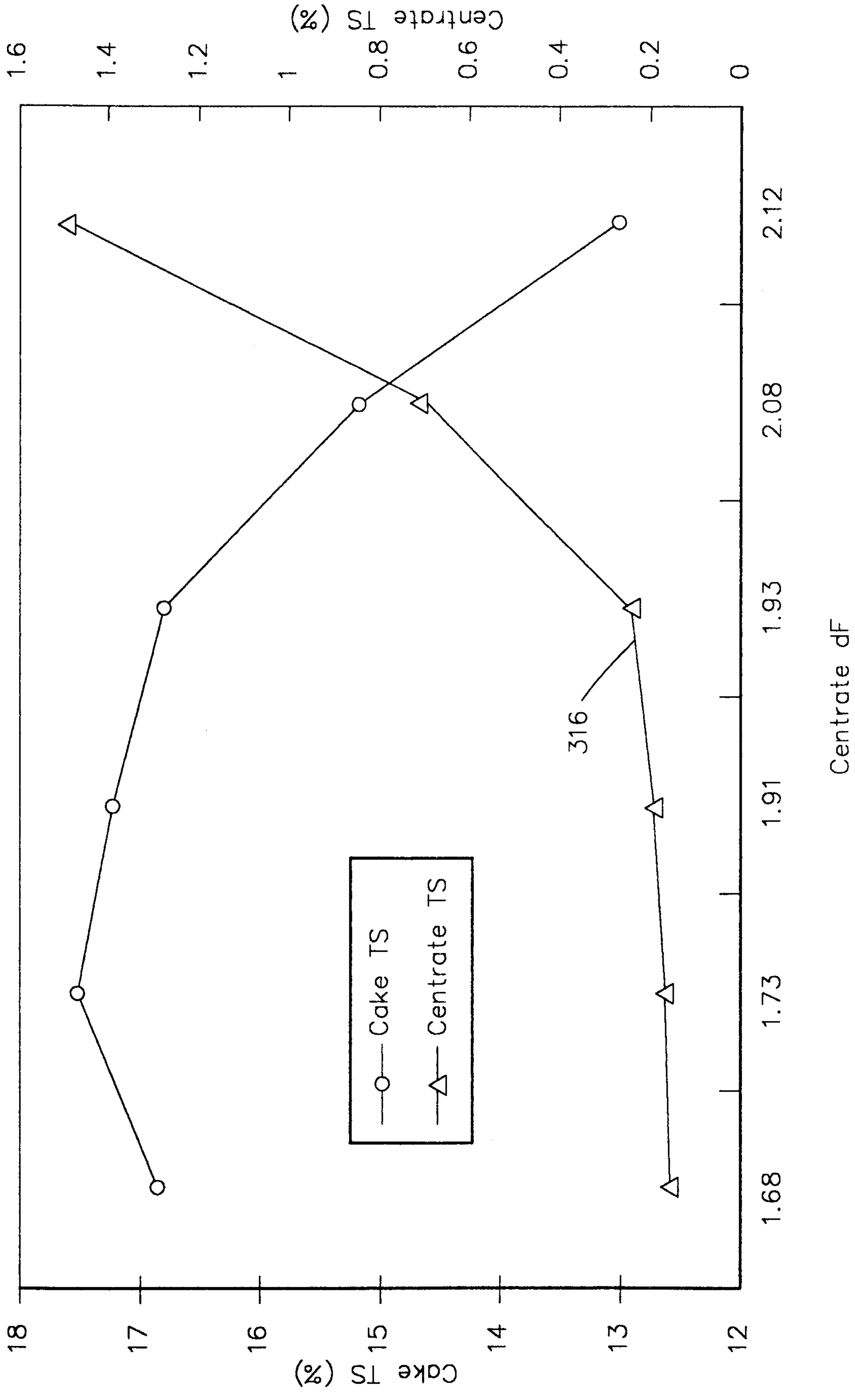
Centrate TS (%)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Cake TS (%)
18
17
16
15
14
13
12
Centrate dF
1.68
1.73
1.91
1.93
2.08
2.12
Cake TS
Centrate TS
316

Fig. 6

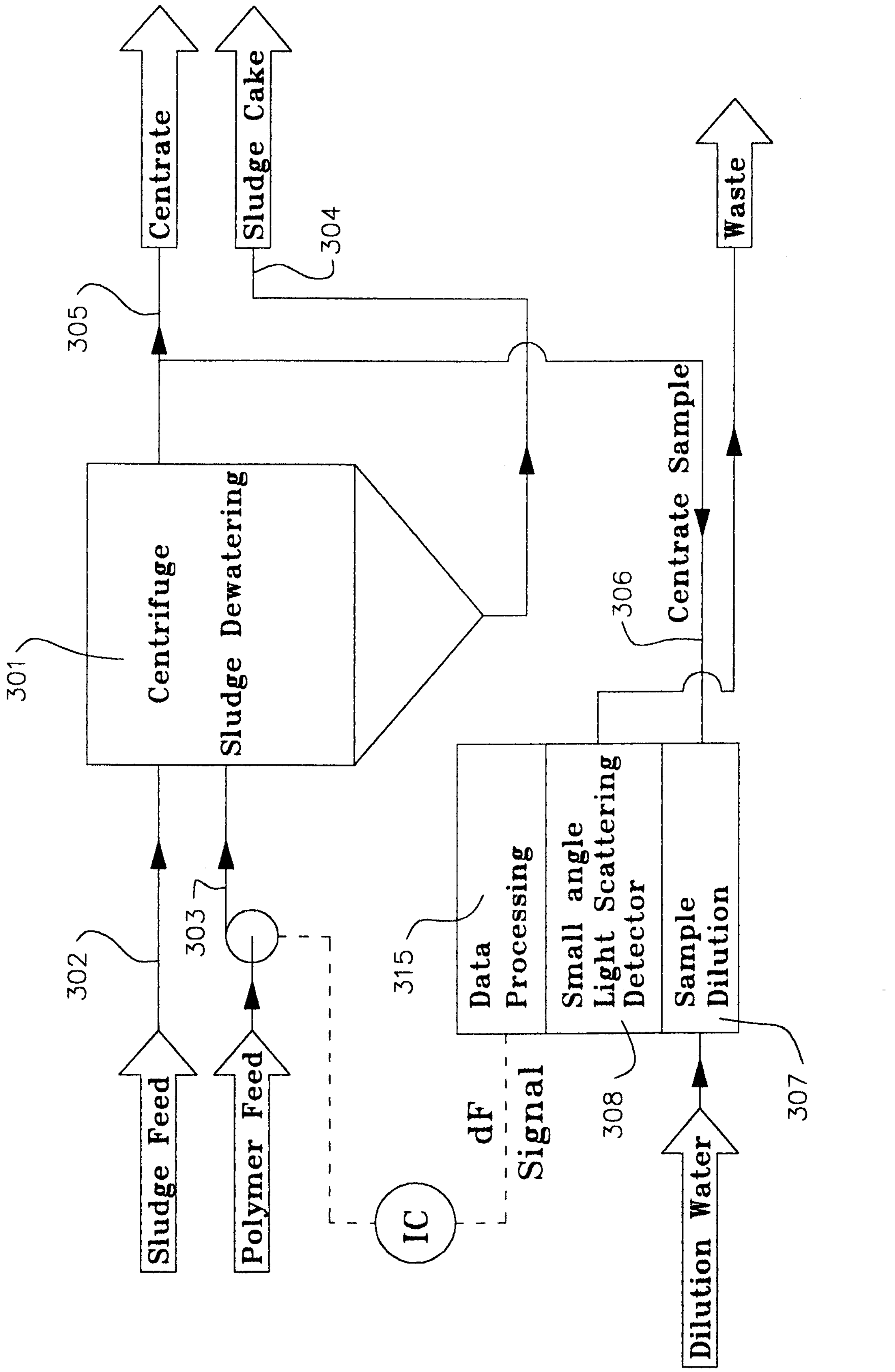
Centrate
Sludge Cake
Waste
305
304
301
Centrifuge
Sludge Dewatering
Centrate Sample
306
302
303
315
Data Processing
Small angle Light Scattering Detector
Sample Dilution
308
307
Sludge Feed
Polymer Feed
dF Signal
IC
Dilution Water

Fig. 7

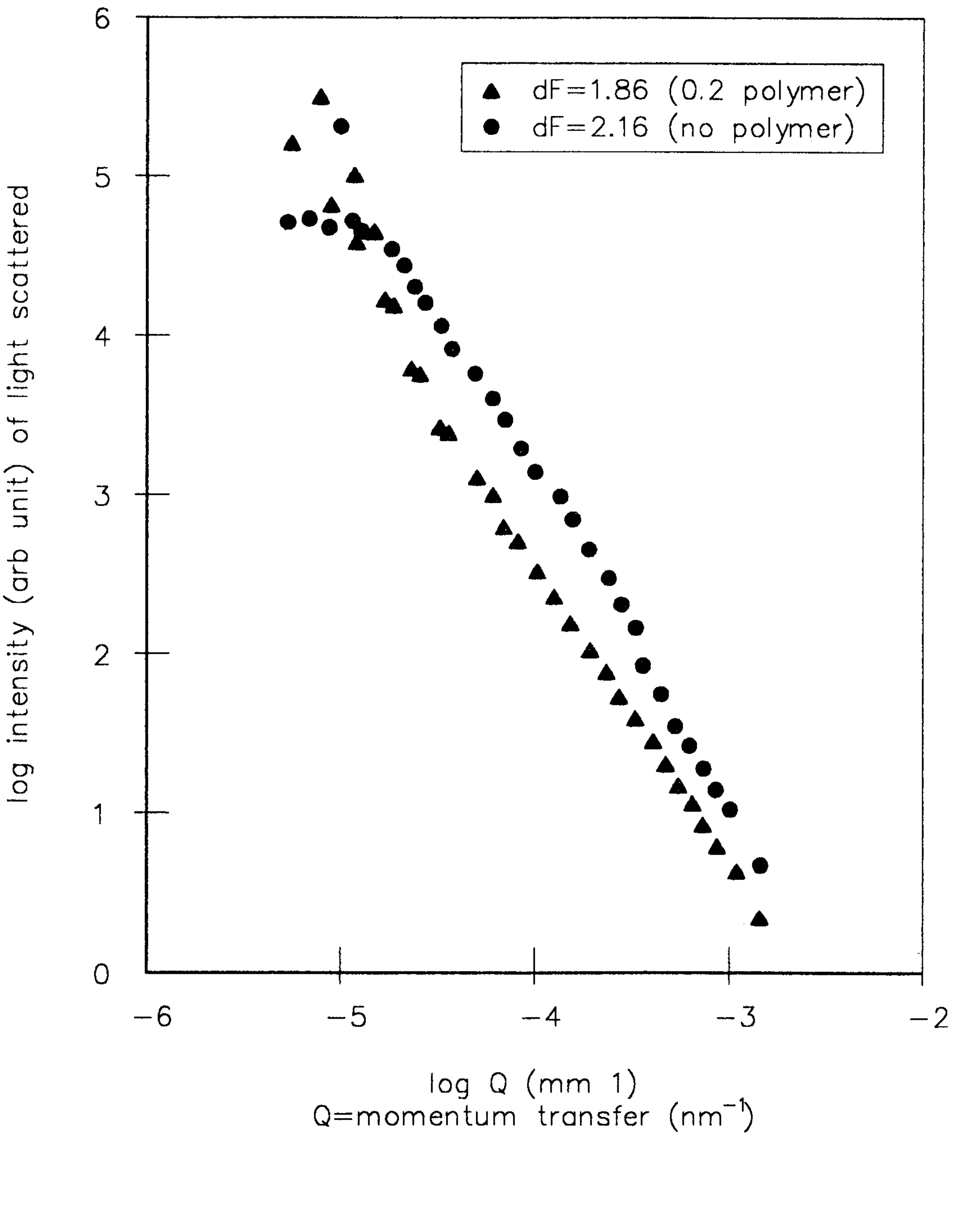
6
5
4
3
2
1
0
−6
−5
−4
−3
−2
dF=1.86 (0.2 polymer)
dF=2.16 (no polymer)
log intensity (arb unit) of light scattered
log Q (mm 1)
Q=momentum transfer (nm⁻¹)

Fig. 8

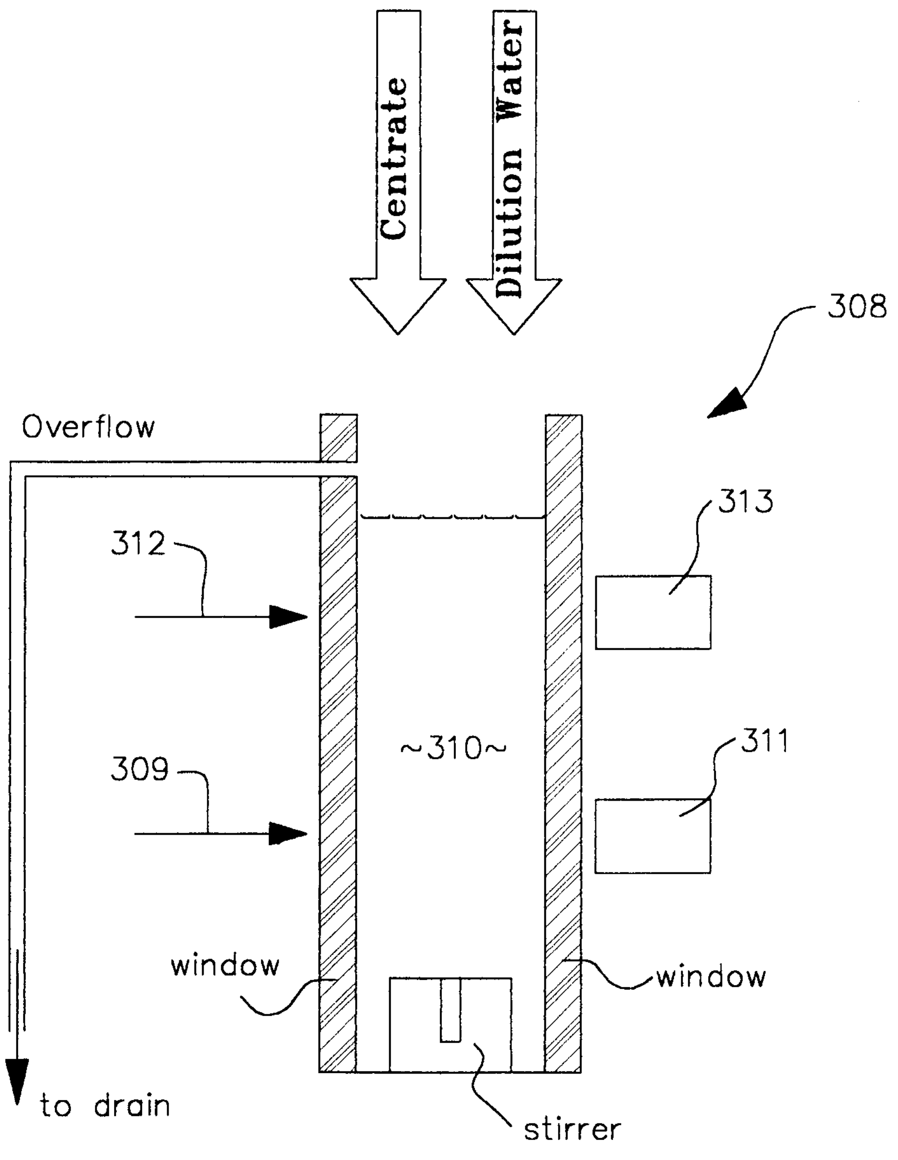
Centrate
Dilution Water
308
Overflow
313
312
~310~
311
309
window
window
to drain
stirrer

Fig. 9

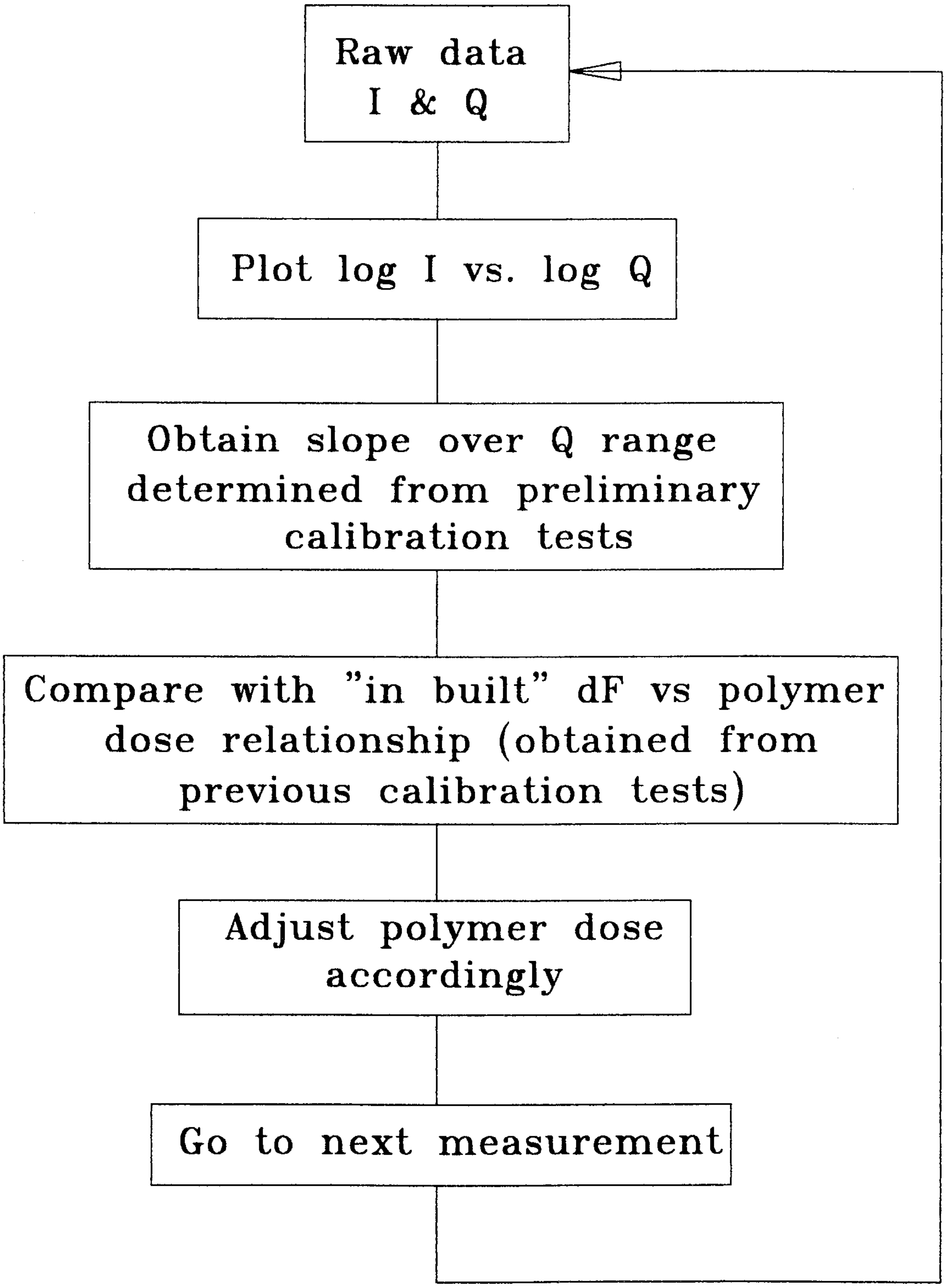
Raw data
I & Q
Plot log I vs. log Q
Obtain slope over Q range determined from preliminary calibration tests
Compare with "in built" dF vs polymer dose relationship (obtained from previous calibration tests)
Adjust polymer dose accordingly
Go to next measurement

Fig. 10

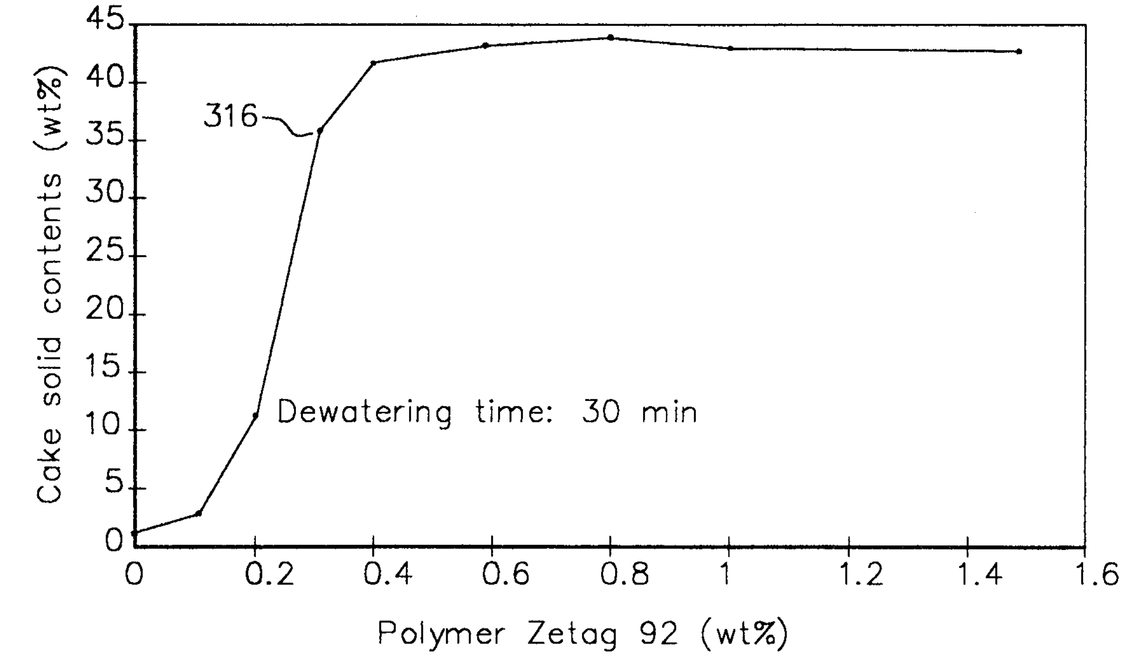

Fig. 11A

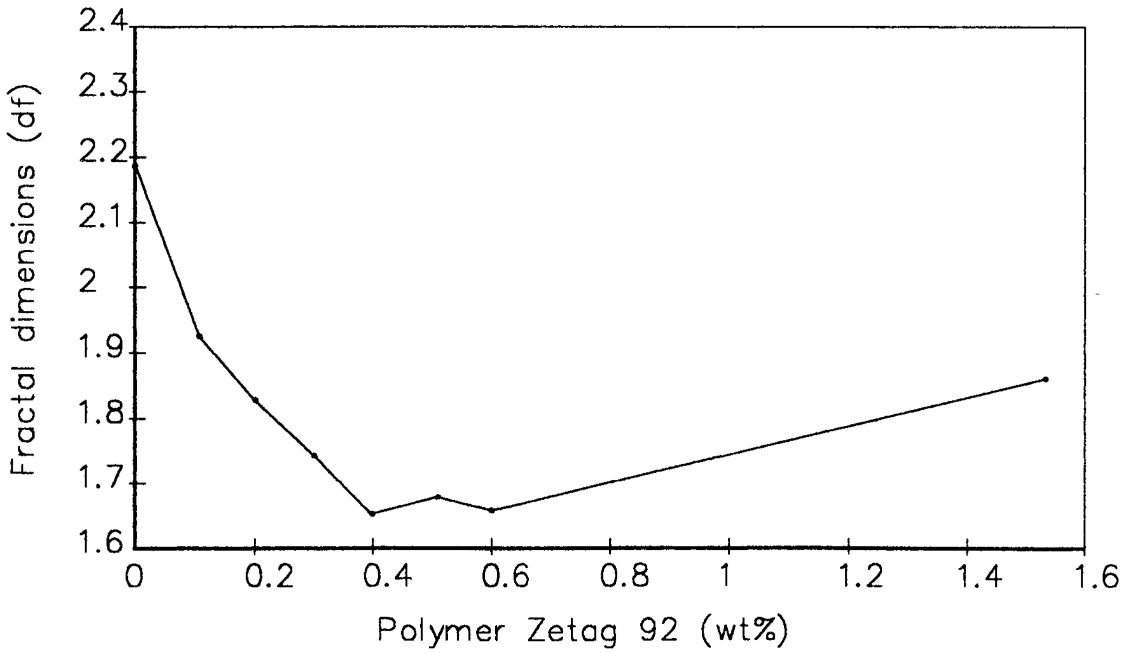

Fig. 11B

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 97/00723

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: C02F 11/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC6 : C02F 11/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU : IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT : (K.W. - CONTROL, REGULAT:)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP, A, 316997 (CALGON CORPORATION) 24 May 1989 see whole document	1-28
X	US,A, 5534139 (CADEK) 9 July 1996 see whole document	1-28
P,X	US,A, 5626766 (CADEK) 6 May 1997	1-28

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 December 1997	08 JAN 1998

Name and mailing address of the ISA/AU	Authorized officer
AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929	M. OLLEY Telephone No.: (02) 6283 2143

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 97/00723

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	AU,A, 38741/93 (658735) 16 December 1993 see whole document	(1-5), (11-13), 15, (17-21)

International Application No.
PCT/AU 97/00723

INTERNATIONAL SEARCH REPORT
Information on patent family members

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
EP	316997	AU	25719/88	CA	1334939	JP	1164408
		US	4990261	US	5240594		
US	5534139	AT	2298/93	CA	2135537	DE	4437062
		FI	945228	SE	9403615	US	5534139
		US	5626766				
US	5626766	AT	2298/93	CA	2135537	DE	4437062
		FI	945228	SE	9403615	US	5534139
		US	5626766				
AU	38741/93	US	5380440	ZA	9303872		
							END OF ANNEX