PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

EP. 0039718

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification [3]: **G01N 15/06, 21/85**	A1	**(11) International Publication Number:** **WO 81/01467** **(43) International Publication Date:** 28 May 1981 (28.05.81)

(21) International Application Number: PCT/SE80/00295

(22) International Filing Date: 21 November 1980 (21.11.80)

(31) Priority Application Number: 7909651-7

(32) Priority Date: 22 November 1979 (22.11.79)

(33) Priority Country: SE

(71) Applicant *(for all designated States except US):* SVENSKA TRÄFORSKNINGSINSTITUTET [SE/SE]; 53-69 Drottning Kristinas väg, S-114 86 Stockholm (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only):* FLADDA, Gerdt [SE/SE]; 58 Parkvägen, S-183 51 Täby (SE). KUBULNIEKS, Egils [SE/SE]; 60 Hökmossevägen, S-126 42 Hägersten (SE). PETTERSSON, Torulf [SE/SE]; 147 Marknadsvägen, S-183 34 Täby (SE).

(74) Agents: AB STOCKHOLMS PATENTBYRÅ, et al.; Box 3129, S-103 62 Stockholm (SE).

(81) Designated States: BR, DE, DE (European patent), FI, FR (European patent), GB, GB (European patent), JP, NO, US.

Published
With international search report

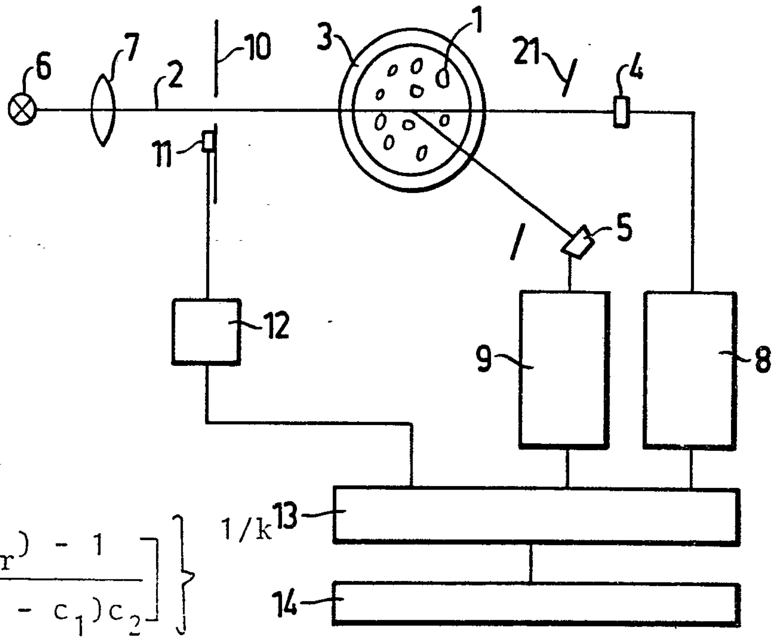
(54) Title: METHOD AND DEVICE FOR DETERMING THE CONCENTRATION OF A SUBSTANCE BOUND TO PARTICLES CARRIED BY A FLOWING MEDIUM

(57) Abstract

Method and device for determining the concentration of a substance, which is bound to particles in a flowing medium (1), which substance can prevail in varying concentration. The determination is carried out by light beams (2) so selected, that the substance is absorbent for the radiation within a certain wavelength range, while the remainder of the particle material is reflecting. By means of a detector (4) the radiation is determined which passes straight through the flowing medium, and by means of a detector (5) the radiation is determined which is scattered in a certain direction by the particles in the medium. The concentration is calculated from the equation

$$\text{konc.} = A\left\{\ln\left[\frac{c_3((I_o/I_r) - 1}{((I_s/I_r) - c_1)c_2}\right]\right\}^{1/k}$$

where I_O is the intensity of incident radiation, I_r is the intensity of radiation which has passed straight through the medium, Is is the intensity of detected scattered radiation, k is a constant between 1/2 and 1 depending on the detection angle for the scattered radiation, and A, c1, c2, c3 are constants.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	**KP**	Democratic People's Republic of Korea
AU	Australia	**LI**	Liechtenstein
BR	Brazil	**LU**	Luxembourg
CF	Central African Republic	**MC**	Monaco
CG	Congo	**MG**	Madagascar
CH	Switzerland	**MW**	Malawi
CM	Cameroon	**NL**	Netherlands
DE	Germany, Federal Republic of	**NO**	Norway
DK	Denmark	**RO**	Romania
FI	Finland	**SE**	Sweden
FR	France	**SN**	Senegal
GA	Gabon	**SU**	Soviet Union
GB	United Kingdom	**TD**	Chad
HU	Hungary	**TG**	Togo
JP	Japan	**US**	United States of America

Method and device for determining the concentration of a substance bound to particles carried by a flowing medium

This invention relates to a method of the kind referred to in the preamble of the attached claims 1 and 2, and to devices for carrying out the respective method.

The present invention is the result of efforts to find a simple and reliable method of obtaining a measured value, which has a well-defined relation to the so-called kappa number, which is a measure of the lignin content in wood fibres. When the method was well composed, however, it was found to have a much wider field of application. The method is well suited for determining the content of substances bound to particles, where the substance in question is radiation absorbing for a definite radiation wavelength interval and can be regarded as if it was placed as a thin layer in the surface of a particle, the surface of which bordering on the layer is reflecting for a radiation wavelength range, within which the radiation wavelength in question is located. The substance in question virtually may be a thin layer, but it is also possible to use the method when the substance is spread as local concentration variations in the particles. The method thereby also can be used, for example, for brightness determination of colour measurement on suspended particles, for surface structure examination of different substances on suspended particles, for studies of surface coats on suspended particles, a.s.o.

At the preparation of cellulose pulp for paper manufacture the pulp is analysed with respect to its content of residue lignin after the preparation. The lignin content of the completed pulp heretofore has been determined by taking pulp samples for chemical analysis. It then was determined how much chlorine or potassium permanganate a definite amount of pulp consumes at oxidation. These chemical analyses are relatively complicated and time-consuming. Moreover, they cannot be carried out on-line at the process.

A substantial improvement and simplification is obtained, in that the method according to the invention has been given the characterizing features defined in the attached claims. The method can be carried out on-line automatically at short intervals. It can be initiated from a control room spaced from the place where the pulp manufacture proper takes place. At experiments with the method good correlation was obtained with the values resulting from more or less direct methods being used at present, such as the kappa number method and the chlorine number method.

The wood, from which the pulp is made, is built up of different cells joined together by lignin. At the manufacture of cellulose pulp, for example according to the sulphate method where the wood chopped to chips is digested under pressure at high temperature, the wood is subjected to a treatment for exposing the individual fibres and dissolving the lignin. The lignin remaining in the pulp after this treatment can be regarded as if existing only as a thin layer about each fibre. This does not fully agree with reality, but the lignin content in each fibre is substantially higher at the periphery than at the core of the fibre. Lignin was at examinations found to be strongly absorbing for ultraviolet light, while the material, of which the core in each fibre largely consists, is reflecting for these wavelengths of the light. The present invention makes use of this circumstance.

The invention is described in greater detail in the following, with reference to the accompanying drawing, in which Fig. 1 is a basic sketch of a measuring device arranged in agreement with the principles of the invention, Fig. 2 shows the behaviour of the incident light for a cross-section of a fibre, and Fig. 3 shows a special diaphragm used.

At the invention embodiment shown in Fig. 1, fibre material 1 suspended in water is illuminated by ultraviolet light in a narrow beam 2. The suspended fibre material 1 flows at high-grade turbulence through a bulb 3. Two detectors 4, 5 are located on opposite sides of the bulb 3 toward the light source 6 with associated optical unit 7 producing the beam 2. One detector 4 is located so that it is influenced substantially only by light passing straight through the suspension. The second detector 5 is located so as to be affected only by light, which was reflected against one or more of the particles in the suspension.

The light meeting the first detector 4 can with good approximation be said to have passed through the suspension in such a manner, that the radiation has not interacted with any part of any fibre. The light meeting the second detector 5, however, always has been reflected against at least one fibre. The suspension should be so diluted that the probability is low that the light is reflected against several fibres and thereafter meets one of the detectors.

As the light source 6 delivers a substantially constant known light flow incident to the suspension, light scattering against the particles implies that an increase in intensity of the scattered, i.e. reflected, light is corresponded by a proportionally equally great decrease in intensity of the light flow passing straight through the suspension. When no light is absorbed at the particles in the suspension, but the particles are entirely reflecting, the effect on the intensity of the scattered light is equal to the effect on the intensity of the light passing straight through the suspension.

When the lignin itself, in which the particles are suspended, is absorbent to some extent, the radiation to the two detectors 4, 5 is affected equally, if the paths of the light through the suspension to the two decectors are of equal length.

When absorption does not occur at the particles themselves nor in the liquid, in which they are suspended, the total of the intensity I_s of the total scattered light and the intensity I_r of the light passing straight through is equal to the intensity I_o of the irradiated light, i.e.

$$I_s/I_r = (I_o-I_r) / I_r = (I_o/I_r)-1 \qquad (1)$$

When now the particles carry a layer of light-absorbing lignin, the term I_s is affected, but not the term I_r. The equation (1) is not valid any longer. Due to the light absorption at the reflection against fibres in the suspension, the light scattered to the second detector 5 is damped, while the light meeting the first detector 4 is not influenced by the effect of the surface layer on the fibres.

The lignin certainly is not in the form of a thin layer about every fibre, but rather has the form of local density variations in the fibres. However, for obtaining the equations on which the invention is based, the layer state of the lignin is assumed to apply with good approximation. It also is assumed that every fibre has substantially circular-cylindric or globe shape. The fibres flow with complete turbulence, in order to eliminate the influence of the shape and orientation of the fibres on the measurement result.

At illumination perpendicularly to the flow direction, the light meeting a particle passes through a portion of a circle segment with the height Δr of an annular cross-section of the particle consisting of the lignin layer, before the light meets the particle surface reflecting the light used, whereafter the light again travels through an equally long path through the lignin layer.

Fig. 2 is a cross-sectional view of a fibre 1a and shows the circle segment ABC with the thickness Δr, through which the incident light 31 and the reflected light 32 at a certain angle of incidence pass through the distance 2a. The lowest value, which the distance <u>a</u> can assume, is Δr (see Fig. 2), where the light flows radially. The highest value, which the distance <u>a</u> can assume is $s = (r+\Delta r)\sin\alpha$, where the light flows tangentially toward the surface of the fibre core. Since the angle $\beta = \alpha/2$

$$\sin\alpha = 2\,\Delta r\, s/(s^2 + \Delta r^2) = s/(r+\Delta r)$$

$$s = \sqrt{2\, r\, \Delta r} \sim \Delta r^{1/2}$$

Thereby the distance 2a, through which the light passes through the lignin layer, is obtained between the limits

$$2\,\Delta r < 2a < 2\sqrt{2\, r\, \Delta r}$$

i.e. when r is assumed constant (equal fibre size), then

$$2a \sim \Delta r^k$$

where $1/2 < k < 1$

The quotient between scattered light and light passing straight through the sample then is

$$I_s/I_r = (I_o/I_r - 1(\ \exp(-\mu\, k_i\, \Delta r^k) \qquad (2)$$

where μ is an optic constant dependent on the material (lignin), and k_i is a constant dependent on the particle size. The exponential function is obtained by applying the Lambert-Beer law. Irrespective of whether the particles are spherical or oblong, the amount of absorbing material per particle is proportional to Δr, provided that the sample, on which the measurement is carried out has a substantially constant composition of homogenous material particles. Thereby the concentration lignin, $konc_A$ is:

$$konc_A \sim \Delta r \sim \left\{ \ln \left[\frac{(I_o/I_r) - 1}{I_s/I_r} \right] \right\}^{1/k} \qquad (3)$$

This equation is not fully in agreement with practise, but certain adjustments are to be made. At comparative measurements of cellulose pulp with varying kappa number the following equation has proved to yield a good correlation between measurement results obatined with the method according to the invention and measurement results obtained in conventional manner.

$$\text{konc}_A = A \left\{ \ln \left[\frac{c_3((I_o/I_r - 1}{((I_s/I_r) - c_1)c_2} \right] \right\}^{1/k} \qquad (4)$$

where A is a proportionalization constant, c_3 is a constant selected so that $\text{konc}_A = 0$ at measurement of non--absorbing material, c_2 is a constant obtained by the measurement of two or more calibration suspensions with the same kappa number, but with different concentration of suspended material, and selected so that konc_A is independent of concentration variations of the suspended material, and c_1 is a constant dependent on the dimensions of the measuring instrument and established at the measurement of clear water.

The detector 5, however, is not arranged so that it is met by all light scattered by the particles in the suspension. The detector, instead, has a position to be met by light scattered substantially in a definite direction. Thereby, the constant k in the equation (3) is defined and entirely depending on the location of the detector 5, which indicates the scattered light, because the reflection angle for the reflection against the particles is approximately defined thereby.

For every angle, at which a particle is met by light, the light scattered to a detector 5 located in a certain angular position with some probability is a definite fraction of the entire scattered light flow. This implies, that the light intensity detected by the detector 5 can be expected to be $b \cdot I_s$, where b is a constant smaller than 1. Consequently, the light arriving at the detector 5 can be expected to be a definite fraction of all scattered light damped as if it had been scattered at an entirely definite angle by the particles in the suspension.

The constant k, of course, can be calculated, but for a definite arrangement with bulb, light source and detectors it is most simply determined by comparative examination after chemical methods of several samples, which also are fed through the bulb.

In the foregoing was assumed throughout, that all fibres in a sample have substantially the same appearance and the same size, whereby the radius r and the volume of the lignin layer are equal for all fibres and can be regarded as constant factors. In reality, however, the situation is not quite so ideal. The fibres in a sample have varying sizes. The thickness Δr of the lignin layer depends on the size of the individual fibre, i.e. on the radius r. The concentration of lignin in a sample in relation to the pulp concentration is related to the fibre size. It was found possible, however, in spite of varying size distribution of the fibre material, to measure on the basis of the above equation (4) when the optical unit is so designed that the ratio between increase of the signal from the detector 5 and decrease of the signal from the detector 4 is constant for small as well as large particles.

In Fig. 3 a diaphragm 21 is shown located between the bulb and the detectors on the output side. Said diaphragm 21 is fan-shaped, and its pointed portion 22 is located so that the straight ray path to the detector 4 passes through this portion. The wider portion 23 of the diaphragm is located so that the scattered ray path to the detector 5 passes through this portion. The angle α at the tip can be adjusted, in that the lateral pieces 24, 25 of the diaphragm 21 are hinged one to the other and rotatable about a centre 26. The lateral pieces 24, 25 at the wider portion 23 of the diaphragm are provided with end pieces 27, 28, which are angular relative to each other, and the diaphragm edges of which are arcs with the centre in 26. One end piece 27 is located above the other one 28, so that they can be moved toward and away from each other upon a change of the angle α.

At 29 and 30 the places inside the diaphragm are marked, through which the two straight lines from the centre of the bulb extend to the detectors 4 and, respectively, 5. The diaphragm shown provides by a simple structural design a funcion, which is correct in practice. Other designs, for example elliptic shape or a design having two openings or the like, however, can yield a similar result. The essential feature is that the diaphragm effects an increase of the scattering signals which proportionally is of equal size as the decrease of the signals straight ahead for different particle sizes.

The signals from the two detectors 4, 5 are fed each to a circuit 8, 9, which carry out analog-to-digital conversion and indicate the mean level of the signal during a definite period. This period preferably is longer than approx. 10 seconds. On a diaphragm 10 for the incident beam 2 a further detector 11 is provided to detect the incident light. In the ideal case, as mentioned, the sample is illuminated by a light source producing a constant light flow. This condition cannot be met when the sample is to be illuminated by ultraviolet light, and the measuring instrument is to be held within reasonable costs. The reference detector 11, therefore, is provided in order to continuously detect variations in the light intensity of the light from the light source 6 and to adjust measurement results in agreement with these variations.

The output signal from the detector 11 is fed to an analog-to-digital converter 12. The outputs from the units 8, 9 and 12 are coupled to inputs on a calculating unit 13, which carries out the calculation according to the above equation (4) and displays the calculation result on a display 14. The calculation unit may be a microprocessor. Calculation is carried out during the entire measuring period at short intervals with instantaneous values available from the detectors 4, 5 and 11. The mean value of the calculations is displayed after the end of the measuring period.

It is also possible, however, to cause the calculation unit to calculate the mean value of each one of the signals from the detectors 4, 5 and 11 during a period longer than approx. 10 seconds, whereafter the unit carries out the calculation according to equation (4) with the mean values inserted.

An alternative method with an alternative device is described in the following on the basis of equation (4).

The measured signal I_r included in the numerator in the equation (4), of course, can be measured from the same sample, but in a different, adjacent measuring instrument and in another radiation wavelength range than the measured signals included in the denominators. When for this other measuring instrument a radiation wavelength range is used where no radiation absorption occurs of such substances, which are dissolved in the carrier liquid, but have radiation absorption in the first measuring instrument, the equation (4) is not affected by such substances dissolved in the sample, because the measured signals included in the denominator in the equation (4) are affected to the same degree by the radiation absorption. This implies that this effect disappears at quote formation of these signals.

This in its turn implies that lignin dissolved in the liquid does not affect the kappa number measuring and, therefore, need not be washed off, either, when the wavelength in the adjacent measuring instrument is located in the near IR-range. The sample pretreatment, therefore, is considerably simpler.

The signal I_0 in the numerator of the equation can in this case either be the measured signal from a reference detector located in the ray path of the adjacent measuring instrument, or the measured signal I_r in the adjacent measuring instrument at clear water calibration. In the firstmentioned case the additional adjacent measuring instrument is built up in analogy with Fig. 1: light source - optics - diaphragm - bulb - detector - analog-to--digital converter. This instrument can be connected to the same calculation unit 13 as the first measuring instrument.

Finally a further alternative is described, which also is based on the equation (4).

In the equation (4) the factor $1/I_r$ included both in the numerator and denominator is a direct function of the concentration and the fraction composition of the material suspended in the sample. This implies, in the case when the fraction composition is substantially constant, that when the material concentration of the suspension flowing past the measuring instrument can be held constant, the concentration lignin will be a unique function of I_s, i.e. of the signal from the detector 5 in Fig. 1 which indicates light scattered in a definite direction. This implies that the method according to the invention can be carried out with only one detector when the material concentration and the fraction composition in the suspension are held constant. This can be brought about, for example, by positioning a concentration measuring instrument upstream of the measuring instrument according to the invention, in which case the signal from the concentration measuring instrument must control the dilution of the suspension so that the signal of the concentration measuring instrument is held constant.

The concentration lignin being a unique function of I_s, a great number of values of I_s corresponding to the lignin content can be stored in a memory in the calculation unit. The memory cell is for a received value of the input signal addressed with the value closest to the input signal, and the value in the memory cell is discharged on the display unit. The memory cells possibly may also be addressed with the two values closest to the input signal, and an interpolation between the values of the lignin content stored in these cells is carried out prior to the display on the display unit. The lignin content also can be calculated by the help of a funktion of I_s, which has been adapted to the lignin content of the sample by empiric correlation.

A great number of modifications can be imagined within the scope of the invention.

CLAIMS

1. A method for determining the concentration of a substance bound to particles carried by a flowing medium, which substance within different zones with varying concentration is located in the particles together with the remaining particle material, and where for a definite radiation wavelength range the substance is radiation absorbent and the remainder of the particle material is radiation reflecting, characterized in that the medium is radiated by a radiation source which emits radiation within the said radiation wavelength range, and that radiation passing straight through the medium is detected, and radiation which by particles in the medium has been scattered in a definite direction is detected, and that the concentration $konc_A$ of the said substance is calculated according to the formula

$$konc_A = A \left\{ \ln \left[\frac{c_3\ ((I_o/I_r) - 1)}{((I_s/I_r) - c_1)c_2} \right] \right\}^{1k}$$

where I_o is the intensity of the incident radiation, I_r is the intensity of the radiation passing straight through the medium, I_s is the intensity of the detected scattered radiation, k is a constant between 1/2 and 1 depending on the detection angle for the scattered radiation, and A, c_1, c_2, c_3 are constants.

2. A method of determining the concentration of a substance bound to particles carried by a flowing medium, where the substance in different zones with varying concentration is located in the particles together with the remaining particle material, and where for a definite radiation wavelength range the substance is radiation absorbent and the remainder of the particle material is radiation reflecting, and where also varying concentration of the substance can be dissolved in the flowing medium, but must not affect the concentration determination,

c h a r a c t e r i z e d in that the medium is radiated by two radiation sources, one of which emits radiation within said radiation wavelength range, and the second source emits radiation within a second wavelength range different from the first range, and where both radiation which within the first wavelength range has passed straight through the medium is detected, and radiation within said range which has been scattered in a definite direction by particles in the medium is detected, and radiation within said second wavelength range which has passed straight through the medium is detected, and that the concentration $konc_A$ of the first substance is calculated according to

$$konc_A = A \left\{ \ln \left[\frac{c_3 \left((I_o/I_{r2}) - 1 \right.}{((I_s/I_{r1}) - c_1)c_2} \right] \right\}^{1/k}$$

where I_o is the intensity of the incident radiation within said second wavelength range or the intensity of the radiation within said range which has passed straight through the medium without any particles therein, I_{r2} is the intensity of the radiation within said second wavelength range which has passed straight through the medium, I_{r1} is the intensity of the radiation within the first wavelength range which has passed straight through the medium, I_s is the intensity of the detected scattered radiation within the first wavelength range, k is a constant between 1/2 and 1 depending on the detection angle for the scattered radiation, and A, c_1, c_2, c_3 are constants.

3. A method of determining the concentration of a substance bound to particles carried by a flowing medium, where the substance within different zones with varying concentration is located in the particles together with the remaining particle material, and for a definite radiation wavelength range the substance is radiation absorbent and the remainder of the particle material is radiation reflecting, c h a r a c t e r i z e d in that the particle

concentration in the medium is held substantially constant at approximately constant fraction composition, and the medium is radiated by a radiation source, which emits radiation within the said radiation wavelength range, and that radiation which by particles in the medium has been scattered in a definite direction is detected, and the mean value of the detected signal is in a unique relation to the concentration of the substance carried to the particles.

4. A device for carrying out the method according to claim 1 for determining the concentration of a substance bound to particles carried by a flowing medium, where the substance within different zones with varying concentration is located in the particles together with the remaining particle material, and for a definite radiation wavelength range the substance is radiation absorbent and the remainder of the particle material is radiation reflecting, c h a r a c t e r i z e d in that a radiation source (6) with radiation substantially within the said wavelength range illuminates the medium with the particles, and two detectors (4, 5) are located so that one detects radiation received straight through the medium, and the second one detects radiation scattered by the particles in the medium in a definite direction, and a calculation unit (13) carries out a calculation of the concentration of the first substance by guidance of the signals from the detectors (4, 5) according to the formula

$$konc_A = A \left\{ \ln \left[\frac{c_3((I_o/I_r) - 1)}{((I_s/I_r) - c_1)c_2} \right] \right\}^{1/k}$$

where I_o is the intensity of the incident radiation, I_r is the intensity of the radiation which has passed straight through the medium, I_s is the intensity of the detected scattered radiation, k is a constant between 1/2 and 1 depending on the detection angle for the scattered radiation, and A, c_1, c_2, c_3 are constants.

5. A device for carrying out the method according to claim 2 for determining the concentration of a substance bound to particles carried by a flowing medium, where the substance within different zones with varying concentration is located in the particles together with the remaining particle material, and for a definite radiation wavelength range the substance is radiation absorbent and the remainder of the particle material is radiation reflecting, c h a r a c t e r i z e d in that two radiation sources are provided, one of which emits radiation within said radiation wavelength range, and the second one emits radiation within a second wavelength range different from the first range, and three detectors are so located that one detector detects radiation received straight through the medium within the first wavelength range, the second detector detects the radiation within the first wavelength range which has been scattered by the particles in a definite direction, and the third detector detects the radiation received straight through the medium within the second wavelength range, and that a calculation unit carries out a calculation of the concentration with guidance by the signals from the three detectors according to the formula

$$konc_A = A\left\{\ln \cdot \left[\frac{c_3((I_o/I_{r2}) - 1)}{((I_s/I_{r1}) - c_1)c_2}\right]\right\}^{1/k}$$

where I_o is the intensity of the incident radiation within said second wavelength range or the intensity of the radiation within said wavelength range which has passed straight through the medium without any particles therein, I_{r2} is the intensity of the radiation within said second wavelength range which has passed straight through the medium, I_{r1} is the intensity of the radiation within said first wavelength range which has passed straight through the medium, I_s is the intensity of the detected scattered radiation within said first wavelength range, k is a constant between

1/2 and 1 depending on the detection angle for the scattered radiation, and A, c_1, c_2, c_3 are constants.

6. A device for carrying out the method according to claim 3 for determining the concentration of a substance bound to particles carried by a flowing medium, where the substance within different zones with varying concentration is located in the particles together with the remaining particle material, and for a definite radiation wavelength range the substance is radiation absorbent and the remainder of the particle material is radiation reflecting, c h a r a c t e r i z e d in that the particle concentration in the medium is held on a constant level at approximately constant fraction composition, and a radiation source (6) with radiation substantially within the said wavelength range illuminates the medium with the particles, and a detector (5) detects the radiation scattered in a definite direction by the particles in the medium, and that a signal processing unit calculates the mean value of the signal and displays a value of the content of the substance bound to the particles in a definite relation to the calculated mean value.

7. A device as defined in any one of the claims 4-6 for measuring the lignin content in cellulose fibres, c h a r a c t e r i z e d in that the radiation from the radiation source lies within the ultraviolet radiation range, and the radiation source (6) preferably is a mercury lamp.

8. A device as defined in claim 5 for measuring the lignin content in cellulose fibres, c h a r a c t e r i z e d in that the radiation source emits radiation within the near infrared range and preferably is a light emitting diode.

9. A device as defined in any one of the claims 4-8, c h a r a c t e r i z e d in that a reference detector (11) is provided to detect the intensity I_0 for the light incident to the medium.

10. A device as defined in any one of the claims 4-9, c h a r a c t e r i z e d in that the calculation unit (13) carries out the calculation by guidance of mean intensities ascertained during a period exceeding approximately 10 seconds.

11. A device as defined in any one of the claims 4-10, c h a r a c t e r i z e d in that the calculation unit (13) during a period exceeding approximately 10 seconds carries out many calculations by guidance of the instantaneous value from each detector and calculates the means value of the same.

12. A device as defined in any one of the claims 4, 5, 7-11, c h a r a c t e r i z e d in that a diaphragm (21) is located on the same side of the flowing medium as the detectors (4, 5) for light radiated through the medium and before said detectors, which diaphragm (21) is designed so, that for both small and large particles the ratio between the increase of the signal from the detector (5), which detects light scattered by the particles, and the decrease of the signal from the detector (4), which detects radiation straight ahead, is constant.

13. A device as defined in claim 12, c h a r a c t e r i z e d in that the diaphragm (21) is approximately fan-shaped and located with its pointed portion so, that the radiation straight through the medium passes near the pointed portion, and the radiation scattered by the particles passes near the wider circular portion of the diaphragm.

14. A device as defined in claim 13, c h a r a c t e r i z e d in that the top angle of the diaphragm (21) is adjustable and can be adjusted to correct position by calibration.

15. A device as defined in any one of the claims 5-14, c h a r a c t e r i z e d in that a turbulence former is located so as to cause the medium to flow with high-degree turbulence past the measuring position.

FIG.1

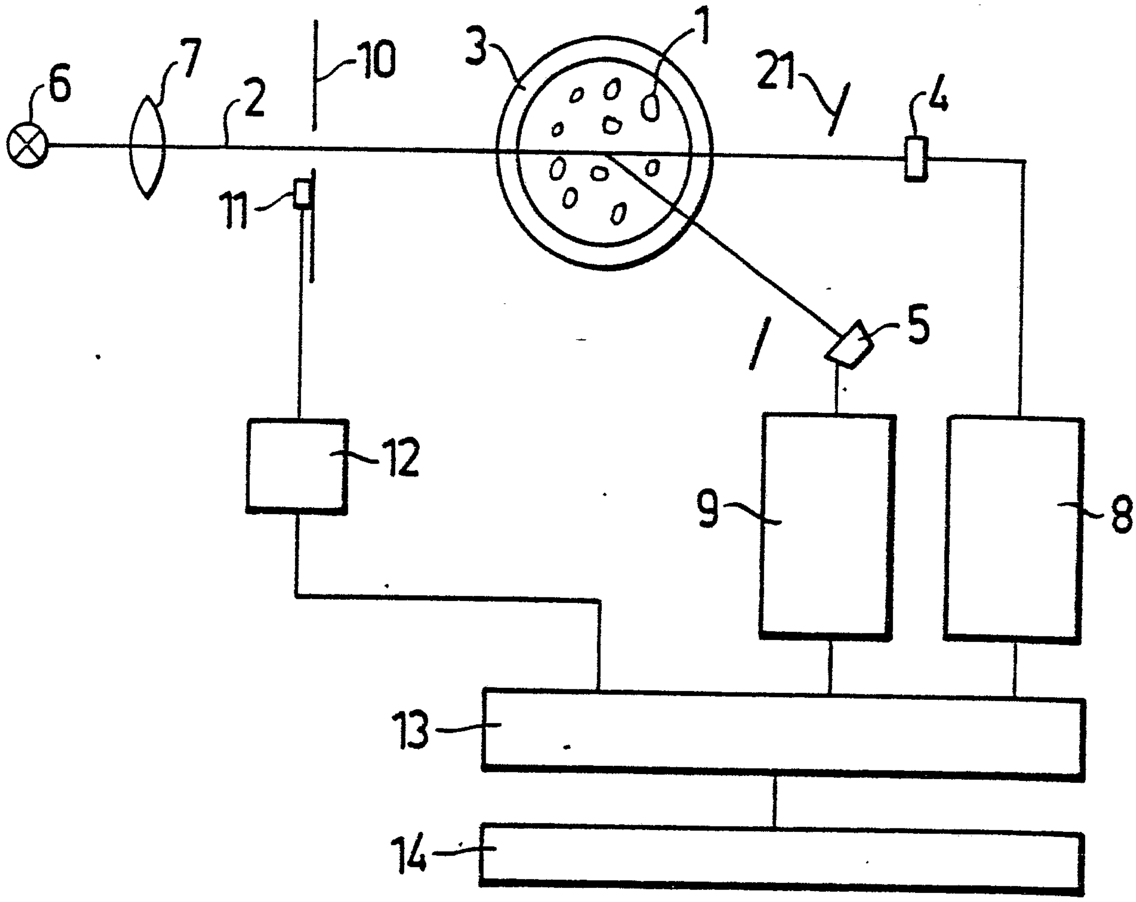


FIG.2

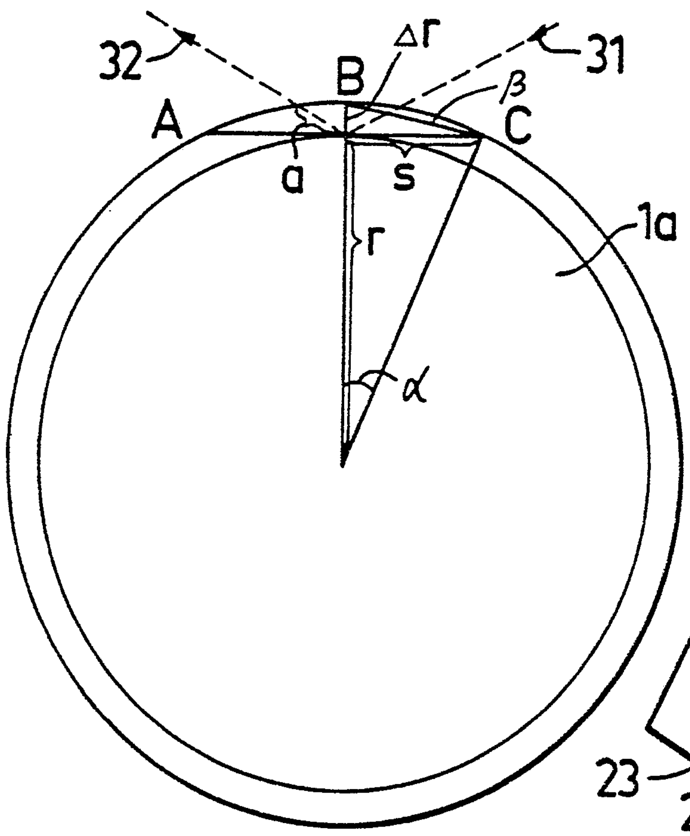
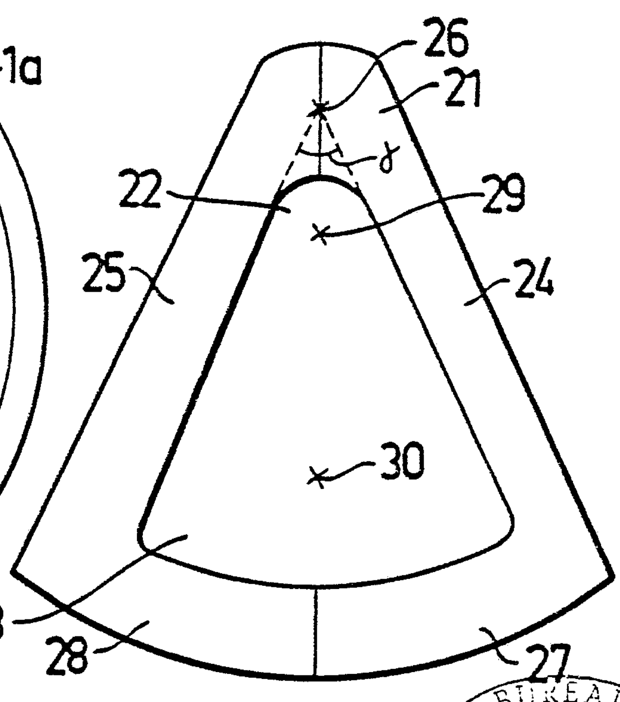


FIG.3



INTERNATIONAL SEARCH REPORT

International Application No PCT/SE80/00295

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

G 01 N 15/06 G 01 N 21/85

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
IPC2	G 01 N 21/26, 21/34
IPC3	G 01 J 3/42, 3/50, G 01 N 15/00, 15/06

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

SE, NO, DK, FI classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	DE, B2, 2 004 087 published 1970, August 27, Measurex Corp.	1-3
X	SE, B, 387 172 published 1976, August 30, Svenska Träforskningsinstitutet	5
X	SE, B, 405 171 published 1978, November 20, Svenska Träforskningsinstitutet	4,6

* Special categories of cited documents: [15]

"A" document defining the general state of the art

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

"L" document cited for special reason other than those referred to in the other categories

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

"P" document published prior to the international filing date but on or after the priority date claimed

"T" later document published on or 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

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
1981-03-04	1981 -03- 05
International Searching Authority [1]	**Signature of Authorized Officer [20]**
Swedish Patent Office	Solveig Arvidsson

International Application No. PCT/SE80/00295

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

II Continuation Fields Searched

US Cl 73:53, 61, 61.4, 63

356:102-104, 204-208, 335-336, 432-436

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE [10]

This International search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers ...., because they relate to subject matter [12] not required to be searched by this Authority, namely:

2. ☐ Claim numbers ...., because they relate to parts of the International application that do not comply with the prescribed requirements to such an extent that no meaningful International search can be carried out [13], specifically:

VI. ☐ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING [11]

This International Searching Authority found multiple inventions in this International application as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the International application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the International application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:

Remark on Protest

☐ The additional search fees were accompanied by applicant's protest.

☐ No protest accompanied the payment of additional search fees.