EUROPEAN PATENT SPECIFICATION

Date of publication and mention of the grant of the patent:

Application number: 9215651.9

Date of filing: 14.09.1992

Apparatus for monitoring trash in a fiber sample
Gerät zur Kontrolle der Verunreinigungen in einer Faserprobe
Appareil pour contrôler les impuretés dans un échantillon fibreux

Designated Contracting States:
BE CH DE ES FR GB IT LI PT


Date of publication of application:
24.03.1993 Bulletin 1993/12

Proprietor: ZELLWEGGER USTER, INC.
Knoxville, TN 37950-1270 (US)

Inventors:
- Shofner, Frederick M.
  Knoxville, TN 37922 (US)
- Baldwin, Joseph C.
  Knoxville, TN 37923 (US)
- Townes, Mark G.
  Knoxville, TN 37922 (US)
- Chu, Youe-Y
  Knoxville, TN 37922 (US)
- Galyon, Michael E.
  Knoxville, TN 37922 (US)

Representative: Dittrich, Horst
Zellweger Luwa AG
Patentabteilung
Wilsstrasse 11
8610 Uster (CH)

References cited:
EP-A- 0 226 430
DE-A- 3 928 279
US-A- 4 839 943

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).
Description

Summary of the Invention

The present invention relates to measurement of foreign matter in fiber samples. More specifically, methods and apparatus are provided for counting, sizing, and categorizing visible foreign matter in cotton. These measurements are according to new definitions of foreign matter or trash.

Trash and dust in cotton originate at harvesting. A major objective of any cleaning process is to remove this "visible foreign matter" (VFM) and to minimize cleaning aggressiveness. Over recent years, throughputs of cotton ginning factories have dramatically increased. For World-Class textile mills, cleaning requirements have steadily increased because modern, high-production spinning machinery is less tolerant of trash and dust. Removing trash and dust is always at the further expense of fiber loss and damage. Obviously, optimization between trash and dust, nep and short fiber content must be achieved for every ginning and spinning process.

Trash and dust represent undesirable particles in textile fiber. Not only does this VFM affect yarn evenness and tenacity, it reduces manufacturing process efficiency.

Historically, trash and dust have been measured by slow gravimetric methods. That is, the VFM is removed and its weight as a percentage of the sample is reported. Such gravimetric methods cannot provide information on the count or size or shape or type of trash and dust particles. Gravimetric precision and speed becomes unacceptable for today's cleaner sliver, when the weight percent is often less than 0.1%, and for today's information technology driven ginning, spinning and marketing environment.

More importantly, the number of trash particles, along with their size, shape and type, is increasingly a better description of fiber value or processing performance than simple weight.

Thus, it is clear that more precise, more accurate, faster and more cost-effective measurement of trash or foreign matter, according to prior art definitions, are needed. But it is equally clear that additional measurements are needed. It is no longer adequate to report percentage weight or foreign matter at various processing points; it is also important to report the sizes and types or categories of trash (leaf, bark, grass, seed coat fragments, etc.), or how difficult the foreign matter is to remove (cleanability), or whether the trash or a specific category is detrimental to a given textile manufacturing process.

GB 2 095 828 discloses a method and apparatus for the detection of defects in fibrous arrays wherein a continuous fibre array is passed successively past a transmission sensor and a reflection sensor for counting the number of defects. With this device defects can be detected in textile products, but it does not permit the testing of fibre material which is subsequently used for making yarns or other textile products. Also defects are sensed as far as they can be sensed within the fibrous array.

Also EP 226 430 shows a method for measuring the amount and type of foreign matter in a fibre assembly by scanning the assembly with a video camera. Hidden defects may also not be found by this method, which is intended for testing entire fibre assemblies but not raw material used to produce the fibre assemblies.

Accordingly, it is an object of this invention to provide new measurements of foreign matter in fiber samples. A fundamentally new physical parameter, counts of trash particles per gram of sample, is disclosed. Improved description of foreign matter and, thus, improved quality and profitability will result from widespread use of this parameter and its extensions to size, shape and type categories.

It is a further object to provide fundamentally different methods and apparatus for the measures of counts/gram, size, shape and type. These methods and apparatus ambody means for presentation of individual entities of foreign matter to optical sensing means.

And it is an important result of this invention that improved measurement of percentage weight of foreign matter in fiber samples, the prior art descriptive parameter, can be provided with improved precision, accuracy and speed for clean fiber samples.

The present invention meets the foregoing and other objectives associated with monitoring trash by providing an apparatus in which a sample of trash particles and fibers is weighed and then processed to determine trash data. A presentation system, a separator, and preferably an air transport system and nozzle, presents substantially all of the trash particles in the sample to a sensing volume in condition for being optically sensed. An optical sensor senses substantially all of the trash particles as they are presented in the sampling volume and an output signal is produced that indicates at least the presence of a trash particle in the sampling volume. This output signal is transmitted to a computer that includes analog to digital converters for the purpose of receiving analog signals. Based on the sensor output signal, the computer determines at least a count of trash particles and calculates a count of trash particles per unit weight of the original sample. Then, the computer outputs data in the form of a count of trash particles per unit weight of sample.

In the preferred embodiment, the optical sensor senses the presence, and measures a characteristic, of each trash particle, where the characteristic corresponds to the size of the trash particle. One or more outputs (V) are produced by the optical sensor that correspond to such projected area. In general, the preferred processing means receives the output (V) and output data corresponding to the count and size of the trash particles. In particular, the processing means calculates
a projected area (as hereinafter defined) of each trash particle based on the sensed characteristic (V) using a different equation for different size particles. Specifically, the processing means uses one equation for small particles and another equation for large particles, where the difference between small and large particles is defined by a predetermined threshold value of the sensed characteristic. In other words, if output (V) is smaller than the threshold, the particle is treated as a small particle. Otherwise, it is treated as a large particle.

In the preferred embodiment, the processing means also calculates a count of small particles per unit weight of sample (preferably, count/gram) and calculates a separate count of large particles per unit weight of sample. Both of the counts are also output as data.

Also, the weight of the trash particles correlates to the accumulated projected area. Thus, the preferred processing means also calculates and outputs the total predicted weight of trash in the sample and the visible foreign matter (VFM) percentage based on the accumulated projected area. In addition, the processing means calculates and outputs the mean projected effective diameter of trash particles. As used herein, "effective diameter" refers to a diameter determined experimentally using square meshes or sieves. Particles that will pass through a square mesh having X by X openings, but will not pass through the next smaller mesh having Y by Y openings, are said to have an effective diameter of (X/Y)^0.5. Projected area is the square of effective diameter and is later defined as "E-O" (Electro-optical) units.

In the preferred embodiment, a light detector is disposed to detect light produced by a source and, as a particle passes between the source and detector, the extinction of light is measured to produce an output (V). Other measurements may be made in addition to, or substitution for, extinction, such as back scattered and/or forward scattered light caused by the particle. Such measurements may be made at various angles and using different fields of view depending on the desired information. Such electro-optical techniques reveal additional characteristics of a particle including geometry or shape, fineness, composition and type. Using this information and known characteristics of trash, such as cotton trash, one may identify each particle as leaf, seed coat, grass, bark, etc. Thus, for example, one may output data indicating the number of trash particles per gram of sample (count/gram) where effective diameter is greater than 500 micrometers and that are "leaf." For another example, one may provide the count of trash particles per gram that are longer than 1,000 micrometers, thinner than 100 micrometers and whose \( V_{40}/V_0 \) ratio is less than 0.85 where \( V_{40} \) represents 40° forward light scatter and \( V_0 \) represents light extinction at 0°, both with respect to the travel direction of light. In making such measurements, it will be appreciated that presentation of the entity for measurement facilitates or makes possible the counting, sizing and typing of entities such as trash particles.

**Detailed Description of the Drawings.**

The present invention may best be understood by reference to the following Detailed Description of preferred embodiments when considered in conjunction with the Drawings in which:

FIGURE 1 is a block diagram of the trash monitoring apparatus;
FIGURE 2 illustrates a small trash particle and a sensor;
FIGURE 3 illustrates a large trash particle and a sensor;
FIGURE 4 is a side edge view of a trash particle;
FIGURE 5 is a top plan view of a trash particle;
FIGURE 6 is a front edge view of a trash particle;
FIGURE 7 is a graph showing probability on the Y axis and normalized projected area of a trash particle on the X axis;
FIGURE 8 is a graph showing the diameter of the particle on the X axis with the Y axis showing the voltage produced by the particle as it was presented to a sensor;
FIGURE 9 is a split graph showing information similar to that shown in FIGURE 8;
FIGURES 10a and 10b are a graph and chart, respectively, showing the correlation between the projected area per gram as measured by the present invention and the visible foreign matter percentage determined manually; and
FIGURE 11 is an example of typical output from the apparatus.

**Detailed Description.**

Referring now to the drawings in which like reference characters designate like or corresponding parts throughout the several views, there is shown in FIGURE 1 a trash monitoring apparatus 10 for monitoring trash in a fiber sample 12 that includes both fibers and trash. The sample 12 is first placed on a scales 14 where a pressure (or weight) sensitive transducer 16 produces a signal on line 18 that corresponds to the weight of the sample 12. The signal on line 18 is transmitted to a computer 20 which includes appropriate A to D converters for receiving the analog weight signal. The computer 20 calculates and stores the weight of the sample 12 based on the signal from line 18.

Next, the sample 12 is formed into an elongated configuration commonly referred to as a sliver by a mechanical sliver maker 21 or by hand, and the sliver is delivered through conduit 22 to an individualizer/separar 24 such as sold by Zellweger Uster, Inc. The fiber sample 12 engages separator wheels 26 and 28 and carding flats 27 and other elements known in the art within the separator 24 which separate the fibers from the trash. The trash is collected by conduits 30 and 32. As noted by the arrows within conduits 30 and 32, there
is an airflow within conduits 30 and 32 proximate to the wheels 26 and 28 that will oppose the motion of particles ejected into conduits 30 and 32. This airflow is commonly referred to as a counterflow and the conduit is referred to as a counterflow slot. The counterflow air returns fibers into the conduits 30 and 32, but the wheels impart a sufficient velocity to the trash particles that they overcome the counterflow and reach turning points 31 and 33 where the trash particles are then entrained in an airflow within conduits 30 and 32 traveling in an opposite direction from the counterflow. It is clear that turning points 31 and 33 represent small volumes of space within conduits 30 and 32 wherein the trash particles are either returned to the cylinders 26, 28 or carried out. It is also clear that the size of the trash particles which are carried out can be adjusted.

The lint (fiber) is collected by conduit 34 and delivered to a conduit 36 within which there is a vacuum driven airstream. Likewise, a vacuum driven airstream within a conduit 38 receives and entrains the trash particles from conduits 30 and 32. The separator 24 is designed to separate and individualize both the trash particles and the fibers such that substantially all of the trash particles are delivered substantially one at a time to conduit 38 and substantially all of the fibers are delivered substantially one at a time to conduit 36. While aeromechanical separation of the trash particles from the fibers with delivery to separate airflows is preferred, it will be recognized that the entities of the sample 12 could be individualized mechanically, but combined and delivered to a single airflow, and then distinguished or typed by optical means. In other words, the entities could be separated into trash and fiber categories by optical means.

The trash particles in conduit 38 are delivered to an optical sensor 40 where they are presented for measurement by a nozzle 46 as they pass through light generated by a light source 42 and detected by an optical detector 44. The particles are then collected by suction nozzle 48 and entrained in a suction driven airstream within conduit 49. As the trash particles pass through the sensor 40, they pass through a sensing volume 52 in which they are presented in a substantially random orientation. Thus, while nozzle 46 accelerates the particles and nozzle 48 decelerates the particles, the nozzles are designed to present the particle within the sensing volume 52 in a substantially random orientation. The light sensed by sensor 44 is transmitted in the form of a voltage signal on line 53 which transmits the signal to the computer 20 which has appropriate A to D converters for receiving and inputting the signal into the computer. In the preferred mode, sensor 44 and light source 42 are arranged to detect the extinction of light caused by a particle passing through the sensing volume 52. Light scattering may also be used, as can any combination. Although the preferred embodiment is described primarily with regard to detection of light extinction, sensor 44 will be understood to represent a combination detector that detects forward light scattering, backscattering of light and extinction of light caused by particles passing through sensing volume 52.

A similar electro-optical sensor 50 is provided at conduit 36 to sense the optical characteristics of the fibers as they pass through the sensor 50. In this configuration, one may feed a single sample and obtain multiple data (SS/MD) products on both fibers and trash. Sensors 50 and 40 are substantially the same except that sensor 50 includes an injection nozzle 56 and a suction nozzle 58 that are designed to orient the fiber as it passes through the sensor 50. The ability to orient the fiber is particularly useful when measuring fibers but is not absolutely necessary. Particularly, in the case of trash, it is not necessary to orient the trash in any particular angular position prior to its passing into the sensing volume 52. In fact, it is preferred to present trash in a substantially random orientation.

Sensor 40 is connected via conduit 49, and sensor 50 is connected via conduit 60 to a vacuum pump 62 that provides the suction or vacuum necessary for establishing the airstreams as described above. A filter 59 is disposed in conduit 49 upstream of pump 62 for collecting all trash particles and a filter 61 is disposed in conduit 60 for collecting all fibers. For any given sample 12, the fibers and trash may be separately recovered from the filters 59 and 61 for manual analysis, such as being weighed in scales 14. This manual analysis is primarily used to calibrate the instrument as to measurements and calculations based on outputs from sensors 40 and 50, verify such optical measurements or supplement them.

Referring now to FIGURE 2, there is shown a small particle 64 that is approaching the optical sensor 44. It will be noted that the small particle 64 has an area that is substantially smaller than the width of sensor 44. Thus, as the particle 64 passes in front of the sensor 44, it should be appreciated that the light extinguished by the particle 64 likely will be dependent upon the projected area of the particle.

Referring to FIGURE 3, a large particle 66 is shown approaching the sensor 44. When particle 66 passes before the sensor 44, it will be appreciated that the particle will span the sensor 44. Thus, the amount of light extinguished by the particle 66 that would have otherwise been sensed by sensor 64 likely will be proportional to the effective diameter of the particle 66.

Referring now to FIGURES 4, 5 and 6, a typical trash particle 68 is shown in a side edge view, a top plan view, and a front end edge view, respectively. Most trash particles have a flake shape something like that shown in the figures and, thus, it will be appreciated that the view or presentation of a trash particle 68 will vary dramatically depending upon the orientation of the flake when it passes the sensor. This might suggest that data, particularly light extinction data, produced by sensor 40 would be of limited usefulness.

In FIGURE 7, a graph is shown indicating the probability that a trash particle, such as particle 68, will
present itself in the normalized or perpendicular orientation as shown in FIGURE 5. A curve 70 shows the probability of various orientations of a trash particle when it is allowed to rotate freely on one axis, and the normal view is predicted to occur slightly more than 14% of the time. Whereas, a view of one-tenth of the normalized projected area is predicted to occur only about 3% of the time.

When the trash particle is allowed to rotate freely on two perpendicular axes, the normal view of the trash particle 68 is predicted by curve 72 to occur less than 2% of the time, while a presentation of approximately 10% of the normalized projected area is predicted to occur about 9% of the time. Likewise, a view of 15% of the normalized projected area would occur about 7.5% of the time, while a 20% view would appear about 7% of the time. Based on curve 72, in the case of a particle presented in a random orientation, one should expect to rarely see a normal view of the particle. Thus, again, one might expect that the presentation of substantially randomly oriented trash particles to an optical sensor would produce a detection signal that did not contain useful size information because one would rarely be looking at normal incidence to the particle.

However, experimental results, which are shown in FIGURE 8, show that the light extinction output of sensor 44 will correlate well with a particle’s effective diameter and, thus, will also correlate well with the particle projected area. On the Y axis of FIGURE 8, the average of peak voltages from sensor 44 is graphed against particle diameter on the X axis. The actual effective diameter of the particles were determined for the purpose of this test by manually passing the particles through screen meshes of increasingly small openings. The circular symbols graphically show data for glass beads, which are spherical, and the diamond symbols graphically show data for trash particles. It will be appreciated that the average of peak voltages is correlating well to the diameter for both trash particles and glass spheres. (The voltage signals shown in FIGURE 8 are actually two amplifiers, the higher sensitivity having gain 12.5 times the lower. The readings are normalized to the higher gain stage. Two stages are required to cover the wide dynamic range.)

In FIGURE 9, curve portions 74 and 76 are similar to the curves of FIGURE 8, but the curve portions have been broken apart for purposes of clarity. By reference to FIGURE 9, it will be appreciated that the functional relationship between the output of sensor 44 and particle size is different for small and large particles. For small particles, the sensor 44 output voltage (V) is related to particle size by an equation of the form \( V = a + bX + cX^2 \), where \( X \) is a one dimensional particle size such as an effective diameter. Specifically, for cotton trash particles smaller than about 488 microns the relationship may be defined as follows: \( V = 0.0000303X^2 + 0.00475X - 0.0403 \). For large particles, the relationship is defined by an equation having the form \( V = mX + b \). Specifically, for cotton trash particles having a diameter greater than 488 microns, the relationship is defined by the following formula: \( V = 0.313X - 5.78 \).

To quickly summarize: individual trash particles, as described in FIGURES 2-6 and the text related thereto, produce signals on lines 53 when they move through optical sensor 40 of FIGURE 1. The computer 20 at least counts these signals which of course represent trash particles, and in combination with the sample weight, produce a new, basic data product of counts per gram of sample.

But these signals on lines 53 not only represent the counts per gram of trash particles, they contain information about the size, shape, composition and orientation. See international application WO-A-91/14169. This detailed, electro-optical information could be used to determine the weight of each particle. Multiplication by the counts/gram in a specific size range and summation over all particle size ranges would give the total weight of trash particles. Division by sample weight then leads to a prediction of VFM%.

Fortunately, our investigations have revealed a simpler and more elegant method to predict VFM% using the average extinction mode signal only. FIGURES 8 and 9 represent precisely the necessary and sufficient calibration results on samples with known size, shape and composition characteristics. Orientation is also inherently included in the calibration.

The first step in measurement of an unknown sample is to calculate an effective diameter \( D \) for each trash voltage signal. Specifically, the computer 20 of FIGURE 1 uses the extinction detector output of sensor 40 to calculate a one dimensional size measure \( D \) (effective diameter) for each particle. For example, from FIGURES 8 or 9 a peak extinction voltage of 9.5 volts corresponds, in the average, to trash particles having an effective diameter of \( D = 488 \) micrometers. Importantly, this average includes all effects of size, shape, composition and orientation. This transform of voltage to effective diameter \( D \) from FIGURES 8 is handled by computer 20 via a look-up table or via quadratic and linear equations as described above.

The second step is to calculate the E-O units according to this definition:

\[
E-O = (D/1.000)^2
\]

This has the interpretation of projected area in square millimeters for each trash particle. The third step is to sum the E-O unit contributions of all particles in the sample.

As a confirmation that this method is valid for trash, consider FIGURES 10a and b. The Y axis of FIGURE 10a represents the usual gravimetric weight of visible foreign matter, VFM%. The trash material was captured with filter 59 of FIGURE 1.

E-O units on the X axis, for the wide range of trash
contents covered, are seen to be highly correlated with VFM\%s. This result supports the hypothesis that the weight per trash particle is proportional to its E-O units. This hypothesis is also plausible on physical grounds. Finally, the total E-O units per gram have an intuitively satisfying interpretation: total E-O units in square micrometers represent the projected area of the trash removed from one gram of sample.

Referring now to FIGURE 11, a typical output for five replicate samples of cotton fiber is shown. The first column entitled "Rep" shows the sample number or the repetition number. Under "Sample Size," the weight of the original cotton sample is given in grams. In the next column marked "Total," there is shown a count of trash particles per gram of original sample. In the next column, the "Mean Size," the mean effective diameter, of all trash particles for each sample, is shown in micrometers. Next, there is a column of "Dust" information shown in counts per gram. The computer 20 determines this number by counting the number of particles below a certain size (having a sensor output \( V \) smaller than a threshold) and dividing that count by the total weight in grams of the original sample. In the next column marked "Trash," there is an indication of the count per gram of particles greater than a predetermined size (having a sensor output \( V \) greater than a threshold). In cotton, particles having a mean size of less than 500 micrometers are generally considered dust and particles having a greater size are generally considered trash. Thus, in the preferred embodiment, there is an output for both dust and trash. However, it should be remembered that the term "trash," as when used in a general context herein, is referring to any nonfiber matter in the sample and thus includes dust and trash definitions above. This confusing terminology results from earlier measurement means and definitions and is, unfortunately, prevalent in the industry. In the last column, there is shown a calculated visual foreign matter percentage (VFM), the traditional unit of measure of trash in cotton fibers. The calculations are made on the basis of electro-optical units described above.

The bottom three numbers of each of the aforementioned columns show the mean of the five repetitions, the standard deviation, and the percent CV.

In the lower portion of the display shown in FIGURE 11, there are two graphs showing count per gram on the X axis and size (effective diameter) on the Y axis. The first graph in the top left-hand corner uses the scale shown on the left and upper sides of the graph. The second graph shown in the lower right-hand corner uses the scales shown on the lower and right sides of the display. These graphs show the size distribution of the trash particles in a sample of fibers, but the data have been normalized to counts per gram of sample for each particle size. In the upper right-hand corner a graphical representation, a square, is shown representing E-O units which represent the projected area of the trash in a sample.

The above-described output is exemplary of the type of output provided by apparatus 10. It is noted that the count per gram of trash was given for the entire sample and for particular categories of trash, namely, size categories. Similarly, counts of trash per gram may be provided for other categories or types of trash or sample. For example, the computer 20 also receives electro-optical data from sensor 50 on the clean fibers and electro-optically determines count and weight. Thus, apparatus 10 may output counts of trash per count of clean fiber or counts of trash per gram of clean fiber as alternative outputs.

Although the present invention has been described primarily with respect to the apparatus shown in FIGURE 1, it will be understood that the key aspects of the invention are not limited in any respect to this particular apparatus. Finally, it is useful to note, in the new data product of counts of trash particles per gram of sample, that the weight of the fiber sample may be also determined electro-optically by the fiber sensor 50 in FIGURE 1, according to provisions of international application WO-A-91/14169.

Claims

1. An apparatus for monitoring trash in a sample (12) of trash particles (66) and fibres comprising:

   - weigh means (14, 16) for determining the weight of the sample (12) and for producing weight data in weight units,
   - a separator (24) for separating the trash particles from the fibre particles and for individualising the trash particles, a sensing volume (52) for sensing individualized trash particles,
   - presentation means (46) for presenting substantially all of the trash particles in the sample individually to said sensing volume in condition to be optically sensed,
   - optical sensing means (40) for sensing substantially all of the trash particles as the trash particles are presented separated from the fibres in said sensing volume and for producing an output signal corresponding at least to the presence of trash particle in the sensing volume and
   - processing means (20) for receiving the weight data and the output signal of said optical sensing means, for determining a count of at least a portion of the trash particles, for dividing the count by the weight of the sample and for outputting data in the form of counts of trash particles per unit weight of sample.

2. The apparatus of Claim 1, wherein:
said optical sensing means further optically senses both the presence of a trash particle and a characteristic corresponding to the projected effective diameter of the trash particle, said optical sensing means further producing an output (V) that corresponds to the sensed characteristic; and said processing means further operates to output data corresponding to the count and the sensed characteristic of the trash particle.

3. The apparatus of Claim 2, wherein said processing means further calculates a projected area of each trash particle based on the sensed characteristic of each trash particle.

4. The apparatus of Claim 2, wherein said processing means further calculates the projected effective diameter of the trash particles that produce a sensor output (V) above a predetermined threshold based on a formula in the form of: \( V = nX + b \), and calculates a projected effective diameter of trash particles that produce a sensor output (V) below the predetermined threshold based on a formula of the form: \( V = ax^2 + cx + d \), where \( a, b, c, d \) and \( m \) are constants and \( X \) is the projected effective diameter of each trash particle.

5. The apparatus of Claim 4, wherein said processing means further predicts the weight of at least a portion of the trash particles based on the sensed characteristic of each particle in said portion and the count of particles in said portion.

6. The apparatus of Claim 4, wherein said processing means predicts the visible foreign matter (VFM) percentage based on the count and the sensed characteristics of substantially all of the trash particles.

7. The apparatus of Claim 2, wherein said processing means calculates a size for each trash particle based on the sensed characteristic, calculates a first count per weight of sample for trash particles in a first size range, calculates a second count per weight of sample for trash particles in a second size range, and outputs said first and second counts per weight of sample.

8. The apparatus of Claim 7, wherein said first size range comprises trash particles having a sensed characteristic smaller than a predetermined value which corresponds to the largest trash particle that may be considered dust.

9. The apparatus of Claim 2, wherein said processing means counts the trash particles that produce a sensed characteristic that falls within a predetermined range, calculates a count per weight of sample for trash particles having a sensed characteristic within a predetermined range, and outputs said count per weight of sample.

10. The apparatus of Claim 2, wherein said processing means calculates a mean size value for substantially all of the trash particles in the sample and outputs the mean size value.

11. The apparatus of Claim 1, further comprising: said processing means categorizing the trash particles into at least one separate category, counting the trash particles in the separate category to produce a categorized count and outputting data corresponding to said categorized count.

12. The apparatus of Claim 11, wherein said data comprises a categorized count per weight of sample.

13. The apparatus of Claim 1, further comprising:

means for determining a characteristic of only the fibers, producing fiber data, and inputting the fiber data into said processing means; and said processing means calculating and outputting data in the form of counts as a function of the fiber data.

14. The apparatus of Claim 13, wherein said characteristic is the count of fibers and said processing means calculates and outputs data in the form of count of trash per count of fiber.

15. The apparatus of Claim 13, wherein said characteristic is clean fiber weight and said processing means calculates and outputs data in the form of counts of trash per weight of clean fiber.

**Patentansprüche**

1. Vorrichtung zur Überwachung von Schmutz- und Schalenanteilen in einer Probe (12) mit Schalenanteilen (68) und Fasern, mit: Wägemitteln (14, 16) zum Bestimmen des Gewichtes der Probe (12) und zur Erzeugung von Gewichtsdaten in Gewichtseinheiten, einem Trennapparat (24) zum Trennen der Schalenten von den Faserteilen und zum Vereinzeln der Schalenten, einem Messraum (52) zum Erfassen vereinzelter Schalenten, einem Mittel (46) zum vereinzeln Einengebene im wesentlichen aller Schalenten der Probe in den Messraum in einem Zustand, der die optische Erfassung erlaubt, einem Mittel (40) zur optischen Erfassung im wesentlichen aller Schalenten, die von den Fasern getrennt in den Messraum eingegeben werden und zum Erzeugen eines Ausgangssignales, das mindestens
im Messraum vorhandene Schalenteile angibt und einem Mittel (20) zur Verarbeitung, das Gewichts-
4
werte und Ausgangssignale des Mittels zur opti-
5
schen Erfassung erhält, das einen Zählerwert für min-
destens einen Teil der Schalenteile ermittelt, den
6
den Zählerwert durch das Gewicht der Probe teilt und
die Werte in der Form von Zählerwerten von Schalentei-
len pro Gewichtseinheit der Probe ausgibt.

2. Vorrichtung nach Anspruch 1, wobei das genannte
7
Mittel zur optischen Erfassung, die Anwesenheit
8
von Schalenteilen und eine Eigenschaft, die dem
9
projizierten effektiven Durchmesser entspricht,
10
misst. ein Ausgangssignal (V) abgibt, das der ge-
messenen Eigenschaft entspricht und die genann-
tete Mittel zur Verarbeitung, zum Ausgeben von Da-
11
ten arbeitet, die dem Zählerwert und der erfassten Ei-
genschaft des Schalenteils entsprechen.

3. Vorrichtung nach Anspruch 2, wobei das genannte
12
Mittel zur Verarbeitung, weiter aus der erfassten Ein-
genschaft jeden Schalenteiles, für jedes Schalen-
teil eine Projektionsfläche berechnet.

4. Vorrichtung nach Anspruch 2, wobei das Mittel zur
13
Verarbeitung weiter den projizierten effektiven
14
Durchmesser derjenigen Schalenteile, die ein Sen-
sor ausgangssignal (V) oberhalb eines vorgegeben-
en Schwellwertes erzeugen, gemäß einer Formel
der Form \( V = mx + b \) und den projizierten effektiven
15
Durchmesser von Schalenteilen, die ein Sensor-
ausgangssignal (V) unterhalb eines vorgegebenen
16
Schwellwerte erzeugen, gemäß einer Formel der
17
Form \( V = ax^n + cx + d \) misst, wobei a, b, c, d und
18
m Konstanten sind und X die projizierte effektive
19
Fläche von jedem Schalenteil ist.

5. Vorrichtung nach Anspruch 4, wobei das Mittel zur
20
Verarbeitung, ausgehend von den erfassten Eigen-
schaften jeden Teilchens in mindestens einem Teil
21
der Schalenteile und vom Zählerwert der Teilchen in
22
jedem Teil, das Gewicht vorausberechnet.

6. Vorrichtung nach Anspruch 4, wobei das Mittel zur
23
Verarbeitung den Prozentsatz sichtbarer Fremd-
24
stoffe (VFM) ausgehend vom Zählerwert und den er-
25
fassten Eigenschaften im wesentlichen aller Schal-
teile vorausberechnet.

7. Vorrichtung nach Anspruch 2, wobei das Mittel zur
26
Verarbeitung für jedes Schalenteil, ausgehend von
27
der erfassten Eigenschaft, eine Größe sowie einen
28
ersten Zählerwert pro Gewicht der Probe für Schalentei-
29
te in einer ersten Größenkohle und einen zwei-
30
ten Zählerwert für pro Gewicht der Probe für Schalentei-
31
te in einer zweiten Größenkohle berechnet und
den ersten und den zweiten Zählerwert pro Proben-
gewicht ausgibt.

8. Vorrichtung nach Anspruch 7, wobei diese erste
32
Größenkohle Schalenteile mit einer erfassten Ei-
genschaft enthält, die kleiner ist als ein vorgegebe-
neter Wert, der dem grössten Schalenteil entspricht,
das noch als Saub betrachtet werden kann.

9. Vorrichtung nach Anspruch 2, wobei das Mittel zur
33
Verarbeitung Schalenteile zählt, die erfasste Eigen-
schaften aufweisen, die in einem vorgegebenen Be-
reich fallen sowie einen Zählerwert pro Gewicht der
34
Probe für Schalenteile berechnet, die eine erfasste
35
Eigenschaft in einem vorgegebenen Bereich haben
36
und diesen Zählerwert pro Gewicht der Probe aus-
37
gibt.

10. Vorrichtung nach Anspruch 2, wobei das Mittel zur
38
Verarbeitung einen mittleren Wert für die Größe für
39
im wesentlichen alle Schalenteile in der Probe be-
40
rechnet und diesen mittleren Wert für die Größe
41
ausgibt.

11. Vorrichtung nach Anspruch 1, weiter mit: dem Mittel
42
zur Verarbeitung, das die Schalenteile in minde-
stens eine eigene Kategorie einordnet, das die
43
Schalenteile in dieser Kategorie zählt um einen auf
44
die Kategorie bezogenen Zählerwert zu erhalten und
45
die Daten ausgibt, die dem auf diese Kategorie be-
46
zogenen Zählerwert entsprechen.

12. Vorrichtung nach Anspruch 11, wobei diese Daten
47
einen Zählerwert pro Gewicht der Probe aufweisen,
der der betreffenden Kategorie zugeordnet ist.

13. Vorrichtung nach Anspruch 1, weiter mit: einem Mit-
48
tel zum Erfassen einer Eigenschaft ausschließlich
49
von Fasern, die Faserdaten ergeben und zum Ein-
gen von Faserdaten in die Mittel zur Verarbeiti-
gung, und dem Mittel zur Verarbeitung, das die Da-
ten in der Form von Zählerwerten als Funktion der Fa-
serdaten berechnet und ausgibt.

14. Vorrichtung nach Anspruch 13, wobei diese Eigen-
schaft der Zählerwert für Fasern ist und dieses Mittel
zur Verarbeitung Daten in der Form eines Zählerwer-
tes von Schalenteilen pro Zählung der Fasern be-
rechnet und ausgibt.

15. Vorrichtung nach Anspruch 13, wobei diese Eigen-
schaft das Gewicht von sauberen Fasern ist und dieses Mittel zur Verarbeitung Daten in der Form
von Zählwerten von Schalenteilen pro Gewicht der
sauberen Fasern berechnet und ausgibt.

**Revendications**

1. Appareil pour surveiller les impuretés dans un échantillon (12) de particules d'impureté (68) et de
fibres comprenant :

un moyen de pesage (14, 16) pour déterminer le poids de l'échantillon (12) et pour produire des données de pesage en unités de poids, un séparateur (24) pour séparer les particules d'imputés des particules de fibres et pour individualiser les particules d'imputés, un volume de détection (52) pour capter les particules individualisées d'imputés, un moyen de présentation (46) pour présenter sensiblement toutes les particules d'imputés dans l'échantillon individuellement audit volume de détection en condition d'être optiquement détectées, un moyen de captage optique (40) pour capter sensiblement toutes les particules d'imputés tandis que les particules d'imputés sont présentées séparées des fibres dans ledit volume de détection pour produire un signal de sortie correspondant au moins à la présence d'une particule d'imputé dans le volume de détection, et un moyen de traitement (20) pour recevoir les données de poids et le signal à la sortie dudit moyen de captage optique pour déterminer un compte d'au moins une portion des particules d'imputés, pour diviser le compte par le poids de l'échantillon et pour émettre des données sous la forme de comptes de particules d'imputés par unité de poids de l'échantillon.

2. Appareil de la revendication 1, où:

ledit moyen de captage optique détecte de plus optiquement la présence d'une particule d'imputé et une caractéristique correspondant audit diamètre effectif projeté de la particule d'imputé, ledit moyen de captage optique produisant de plus une sortie (V) qui correspond à la caractéristique détectée ; et ledit moyen de traitement sert de plus à émettre des données correspondant au compte et à la caractéristique détectée de la particule d'imputé.

3. Appareil de la revendication 2, ou ledit moyen de traitement calcule de plus une aire projetée de chaque particule d'imputé en se basant sur la caractéristique détectée de chaque particule d'imputé.

4. Appareil de la revendication 2, où ledit moyen de traitement calcule de plus le diamètre effectif projeté des particules d'imputés qui produisent une sortie du capteur (V) au-dessus d'un seuil prédéterminé en se basant sur une formule sous la forme de : \( V = mX^2 + b \), et calcule un diamètre effectif projeté des particules d'imputés qui produisent une sortie de capteur (V) en dessous du seuil prédéterminé en se basant sur une formule de la forme : \( aX^2 + cX + d \), où a, b, c, d et m sont des constantes et X est le diamètre effectif projeté de chaque particule d'imputé.

5. Appareil de la revendication 4, où ledit moyen de traitement prédit de plus le poids d'au moins une portion de particules d'imputés en se basant sur la caractéristique détectée de chaque particule dans ladite portion et le compte des particules dans ladite portion.

6. Appareil de la revendication 4, où ledit moyen de traitement prédit le pourcentage de matières étrangères visibles (VFM) en se basant sur le compte et les caractéristiques détectées de sensiblement toutes les particules d'imputés.

7. Appareil de la revendication 2, où ledit moyen de traitement calcule une grandeur pour chaque particule d'imputé en se basant sur la caractéristique détectée, calcule un premier compte par poids de l'échantillon pour les particules d'imputés dans une première gamme de grandeur, calcule un second compte par poids de l'échantillon pour les particules d'imputés dans une seconde gamme de grandeur et émet les premier et second comptes par poids de l'échantillon.

8. Appareil de la revendication 7, où ladite première gamme de grandeur comprend des particules d'imputés ayant une caractéristique détectée plus petite qu'une valeur prédéterminée qui correspond à la plus grande particule d'imputé qui peut être considérée comme de la poussière.

9. Appareil de la revendication 2, où ledit moyen de traitement calcule les particules d'imputés qui produisent une caractéristique détectée qui tombe dans une gamme prédéterminée, calcule un compte par poids de l'échantillon pour les particules d'imputés ayant une caractéristique détectée dans une gamme prédéterminée et émet ledit compte par poids de l'échantillon.

10. Appareil de la revendication 2, où ledit moyen de traitement calcule une valeur de grandeur moyenne pour sensiblement toutes les particules d'imputés dans l'échantillon et émet la valeur de grandeur moyenne.

11. Appareil de la revendication 1, comprenant de plus : ledit moyen de traitement catégorisant les particules d'imputés en au moins une catégorie séparée, comptant les particules d'imputés dans la catégorie séparée pour produire un compte catégorié et émettant les données correspondant audit
compte catégorié.

12. Appareil de la revendication 11, où lesdites données comprennent un compte catégorié par poids de l'échantillon.

13. Appareil de la revendication 1, comprenant de plus :

- un moyen pour déterminer une caractéristique des fibres seulement, produire des données des fibres, et introduire les données des fibres dans ledit moyen de traitement, et
- ledit moyen de traitement calculant et émettant des données sous la forme de comptes en fonction des données des fibres.

14. Appareil de la revendication 13, où ladite caractéristique est le compte des fibres et ledit moyen de traitement calcule et émet des données sous la forme d'un compte d'impuretés par compte de fibres.

15. Appareil de la revendication 13, où ladite caractéristique est un poids de fibres propres et ledit moyen de traitement calcule et émet les données sous la forme de comptes d'impuretés par poids de la fibre propre.
Fig. 7

- 1 DEG. OF FREEDOM
- 2 DEG. OF FREEDOM

Probability vs. Normalized Projected Area
Fig. 8
Fig. 9

Cotton Trash

Volts

Size (um)

548 748 948 1148 1348
GRAVIMETRIC VFM%

\[ \text{VFM\%} = 0.0122 \times \text{EO} + 0.0124 \]
\[ R^2 = 0.994 \]
\[ n = 13 \]

TABLE:

<table>
<thead>
<tr>
<th>SAMPLE</th>
<th>EO UNITS</th>
<th>VFM%</th>
</tr>
</thead>
<tbody>
<tr>
<td>C-T</td>
<td>2.46</td>
<td>0.02</td>
</tr>
<tr>
<td>REF.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>NL-2</td>
<td>8.85</td>
<td>0.05</td>
</tr>
<tr>
<td>CARD 2</td>
<td>28.56</td>
<td>0.22</td>
</tr>
<tr>
<td>C-1</td>
<td>227.48</td>
<td>2.69</td>
</tr>
<tr>
<td>BS-1</td>
<td>16.77</td>
<td>0.12</td>
</tr>
<tr>
<td>25764</td>
<td>638.59</td>
<td>7.37</td>
</tr>
<tr>
<td>25738</td>
<td>455.75</td>
<td>5.8</td>
</tr>
<tr>
<td>25660</td>
<td>482.23</td>
<td>5.98</td>
</tr>
<tr>
<td>25605</td>
<td>126.14</td>
<td>1.74</td>
</tr>
<tr>
<td>25569</td>
<td>101.46</td>
<td>1.24</td>
</tr>
<tr>
<td>25354</td>
<td>35.12</td>
<td>0.34</td>
</tr>
<tr>
<td>25215</td>
<td>272.8</td>
<td>3.76</td>
</tr>
</tbody>
</table>

**Fig. 10a**

**Fig. 10b**