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GB 789409
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(54) Measurement of the Brightness of Milled Products

(57) The surface 8 of a layer of flour is illuminated from a lamp 1, and a reflected intensity of light 5 is detected by transducer 7. In Fig. 1, the light beam from the lamp is optically split at 3 into a reference beam 4 and measurement beam 5. The measurement beam is cyclicly chopped by a rotating drum shutter in such a way that only the reference beam will strike the transducer during a first measurement phase, and during a second measurement phase both reference and measurement beams will be applied to the transducer. The output signals of the transducer are stored in memories 13, 14 so that both output signals can be taken simultaneously to an evaluating device 15, 16 for determination of the relative brightness value of the measurement beam in comparison to the reference beam. In the arrangement of Fig. 5, the chopper drum construction is such that measurement and reference beam intensity signals are obtained individually. In the arrangement of Fig. 6, both beams are chopped such that the respective signals are again obtained individually but separated by periods in which both beams are blocked and background light is sensed.

The brightness measurement can be used in a method of measuring and/or monitoring the homogeneity of a batch of flour in which a plurality of streams of product from the batch are formed and recombined, the brightness of each stream being measured and homogenization being continued until the desired brightness is obtained.

Fig. 1

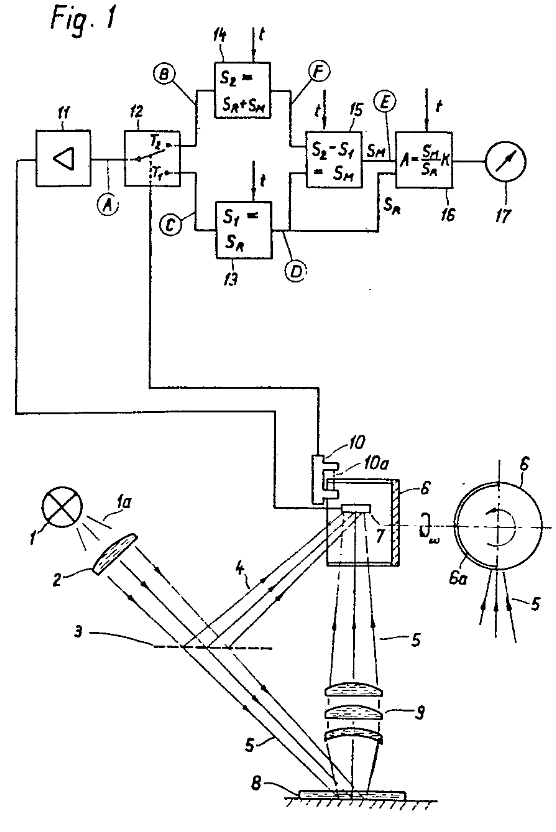

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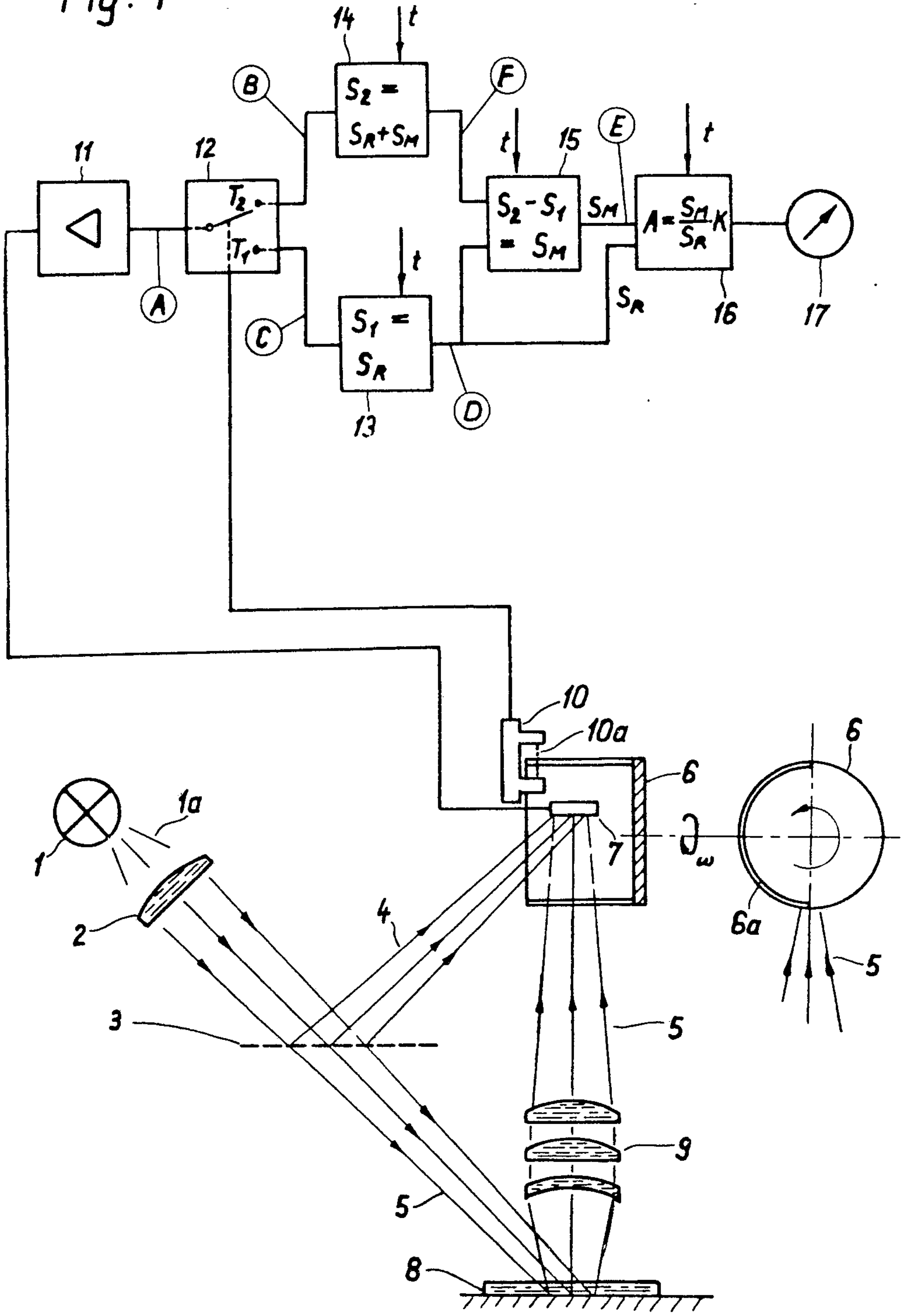
Fig. 1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t
B
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11
12
T_2
T_1
$S_2 - S_1 = S_M$
S_M
$A = \frac{S_M}{S_R} K$
A
t
S_R
C
$S_1 = S_R$
16
17
13
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10
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4
6a
5
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3
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9
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8

Fig. 2

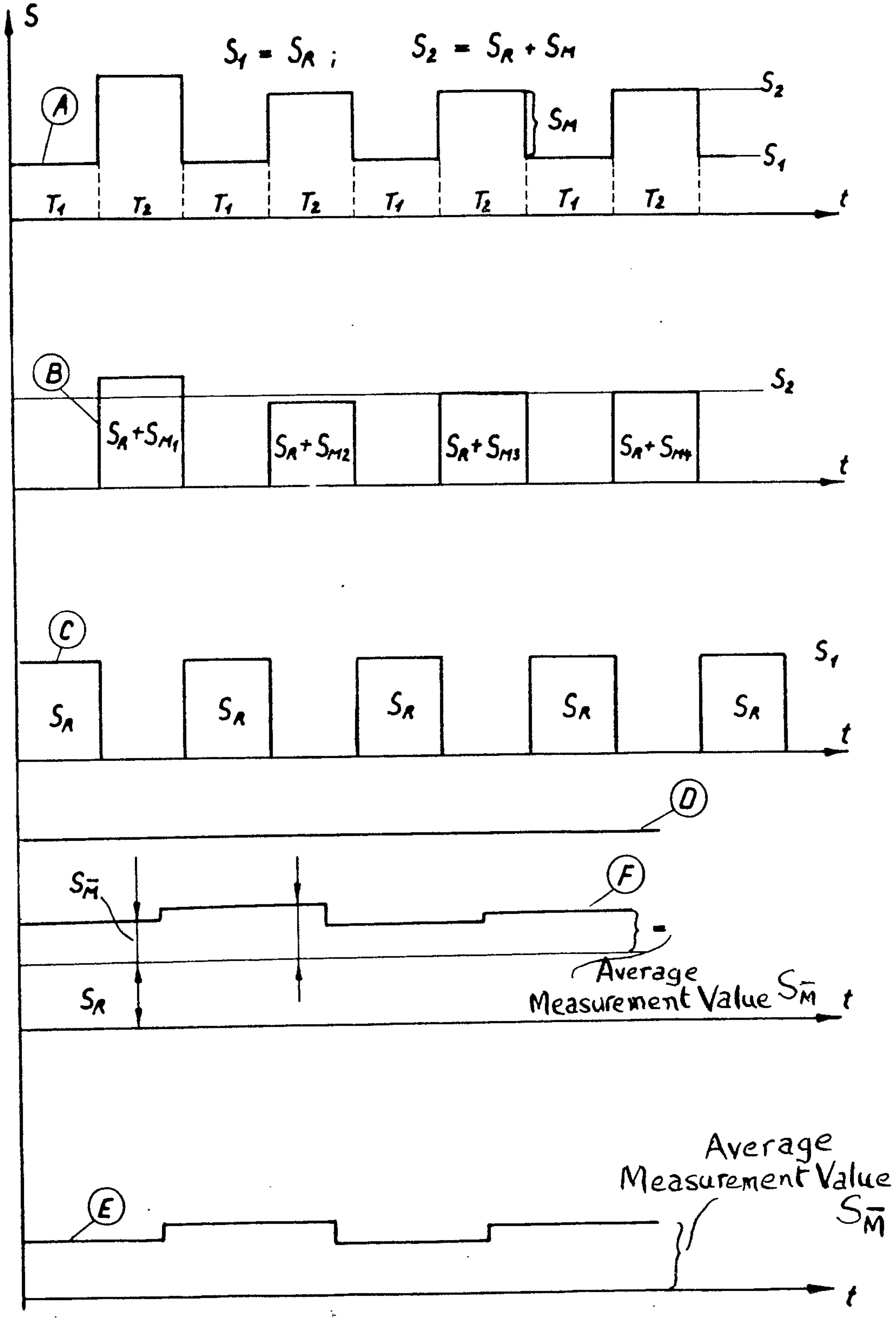
S
S1 = SR ; S2 = SR + SM
A
S2
SM
S1
T1
T2
T1
T2
T1
T2
T1
T2
t
B
S2
SR+SM1
SR+SM2
SR+SM3
SR+SM4
t
C
S1
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Fig. 3

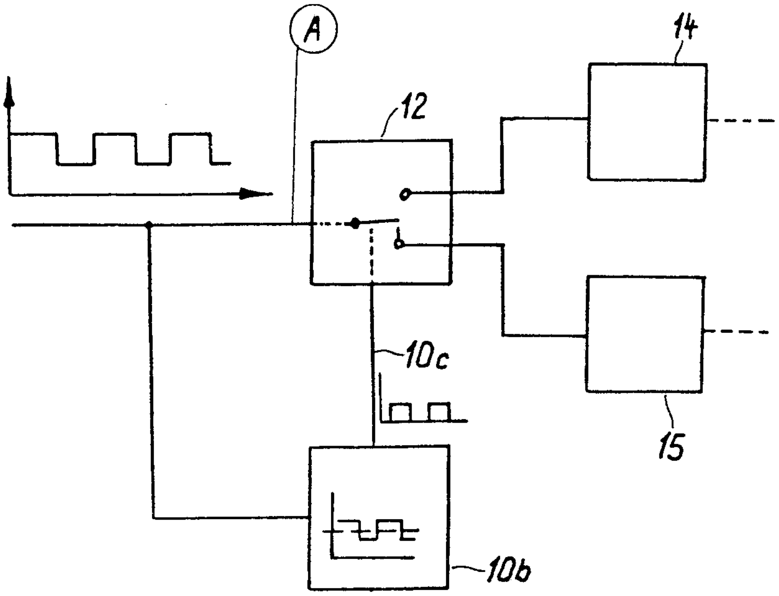


Fig. 4

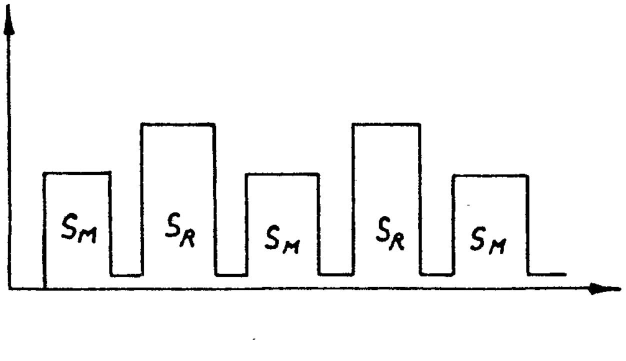


Fig. 5

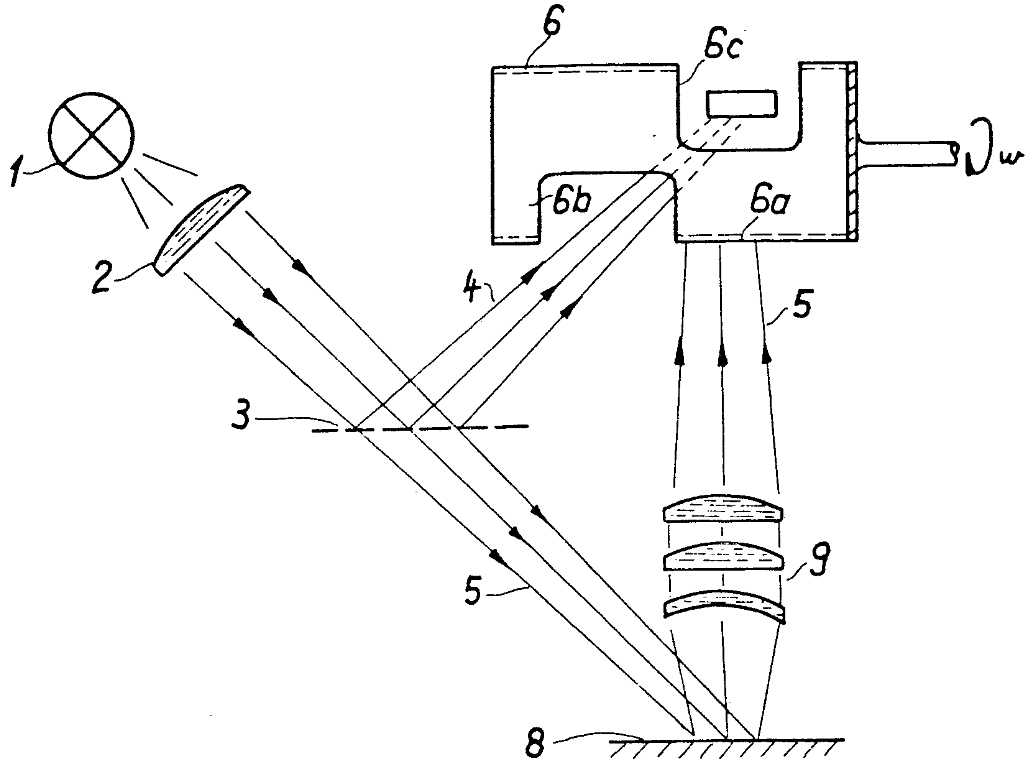
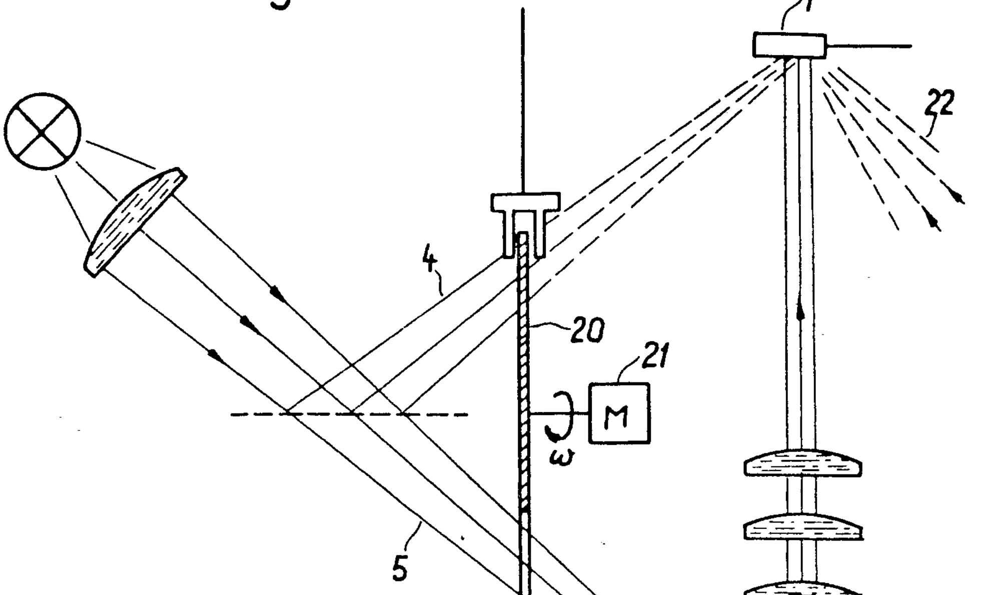


Fig. 6



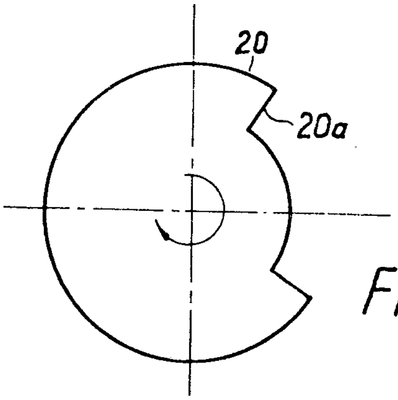
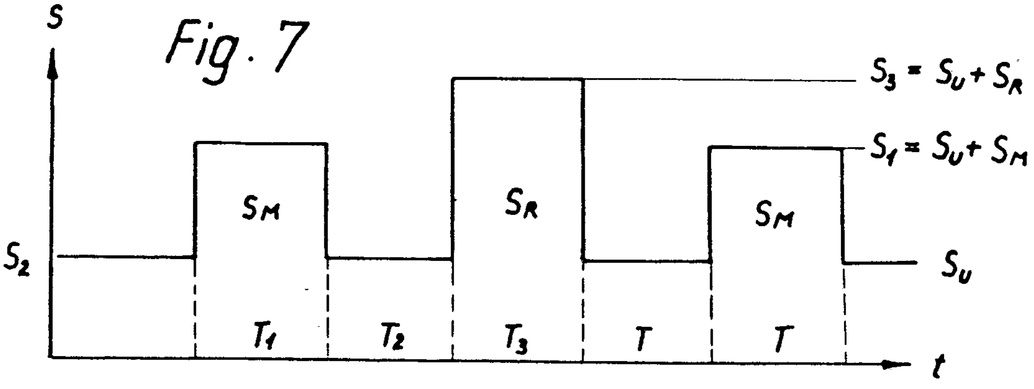
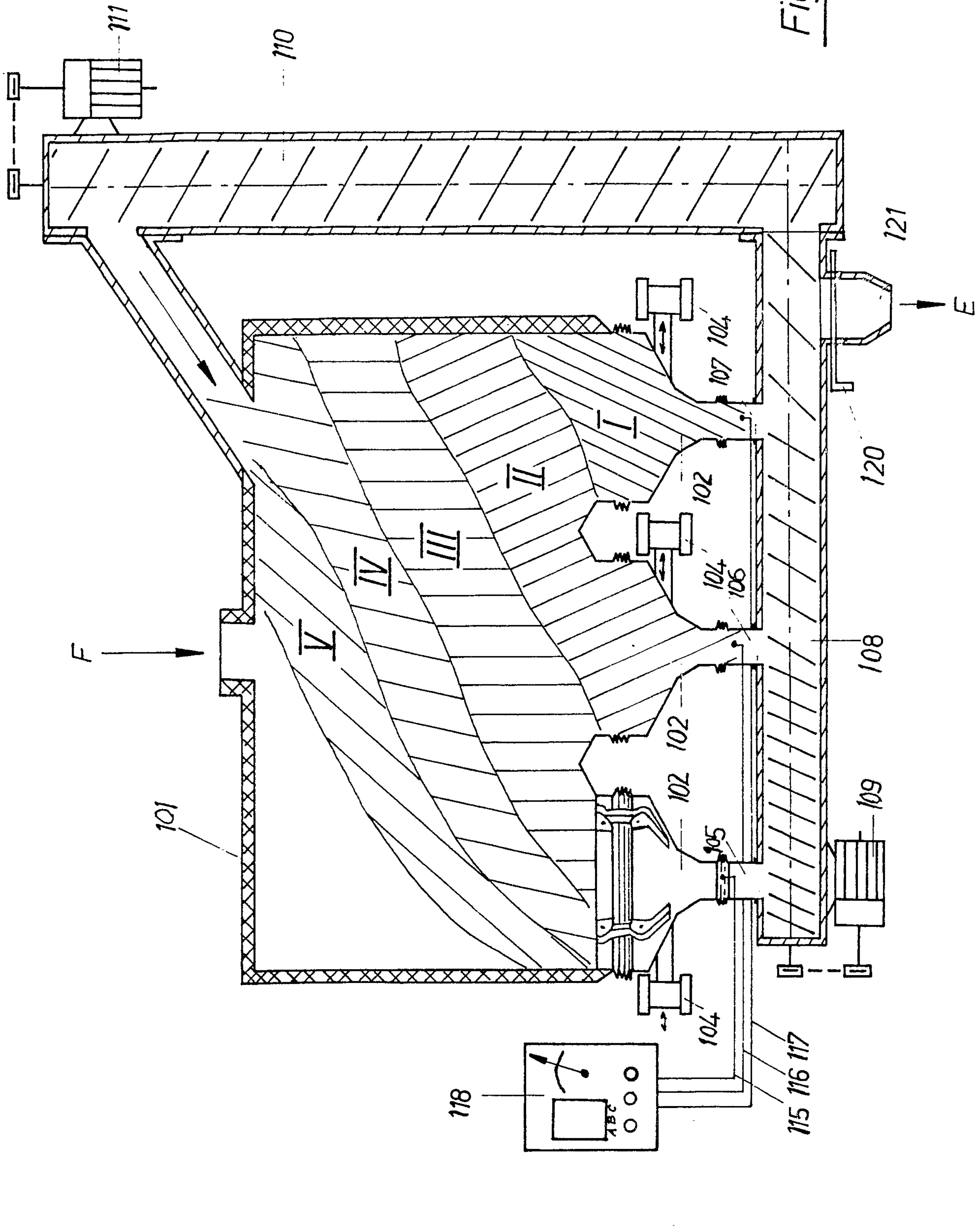


Fig. 8

Fig. 7



S_2 = S Ambient = S_U


111
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108
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104
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I
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V
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118
ABC

Fig. 9

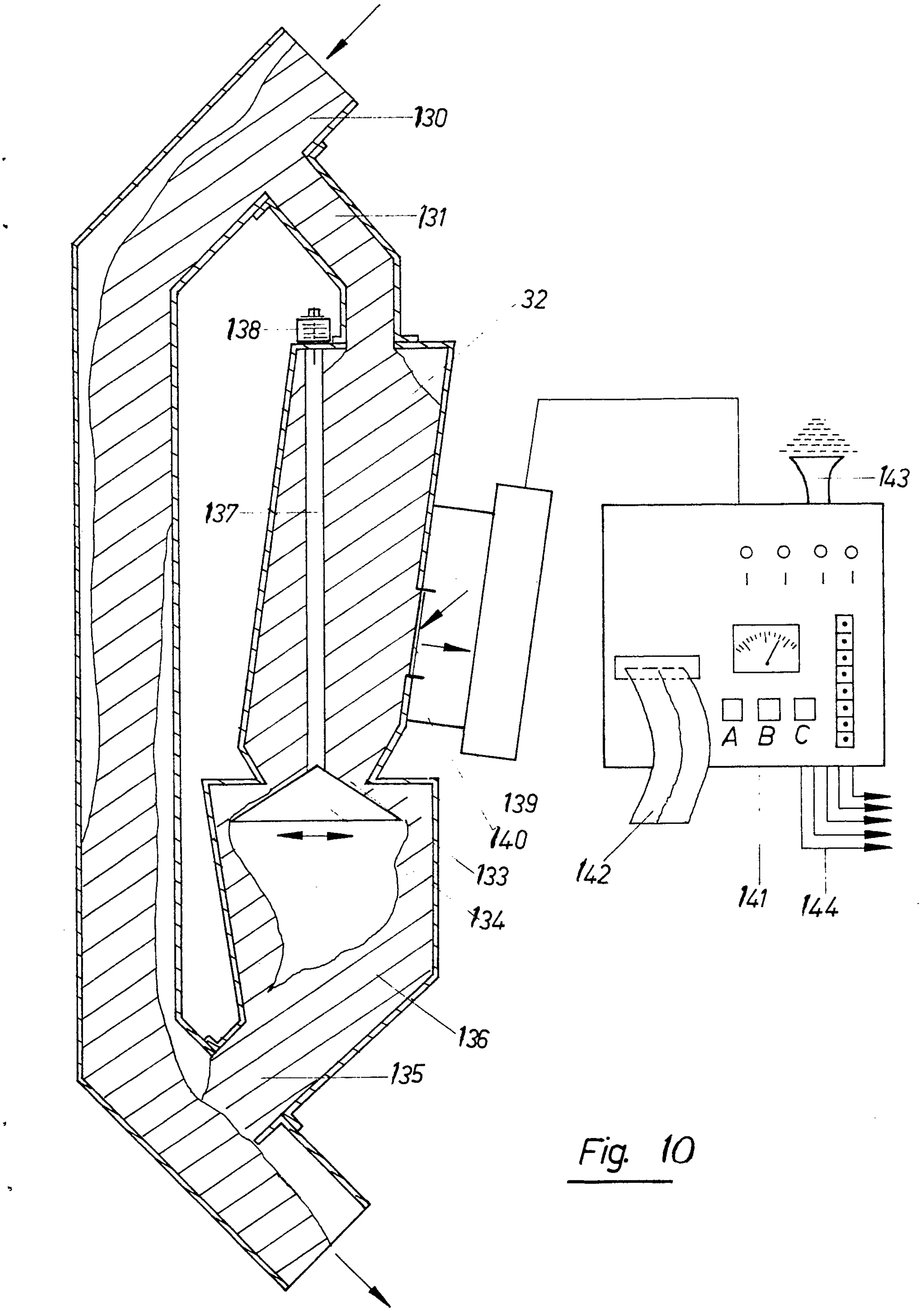

Fig. 10

SPECIFICATION

Measurement of the Brightness of Milled Products

This invention relates to the measurement of the brightness of milled products and although the invention is particularly concerned with the brightness of wheat flour it is also applicable to meal for human consumption from other grains such as semolina and to other mill-comminuted products. The invention is concerned both with methods and measuring brightness and to apparatus for this purpose.

It has already been proposed to measure the brightness of flour by means of a photosensitive element, a light beam being split into a first part-beam and a second part-beam, the first part-beam (reference beam) being directed to the photosensitive element for formation of a reference value, and the second part-beam (measurement beam) being directed to the surface of a layer of flour from which a portion is reflected to the photosensitive element as a measurement beam, whereupon electric output signals from the transducer, evoked by the reference beam and the measurement beam, are taken to an evaluating and indicating device, for determination of the brightness value of the measurement beam with respect to the reference beam.

An objective in the production of flour is to produce the greatest possible yield of bright flours, i.e. white and dark flours on the one hand, and husks or bran which are as free as possible from flour on the other hand. In practice these days, about 82% flour, whereof 60% is white flour, is sought from the milled wheat. Because of the complicated composition of grain and "mass" milling, a slight mixing of the fractions has to be accepted: particularly, dark flours contain husks, and bran contains flour.

The degree of intermixing directly affects the resulting flour brightness and is an important criterion of quality for the milled product. The price difference between bran and white flour is about 1:2, which results in the effort to get the most precise possible separation of the fractions, which can advantageously be monitored by control of flour brightness.

In the customary ash test for brightness, the husk parts give higher ash values by comparison to pure flours. The flour is bright or yellowish-white. The husk parts on the contrary are dark and impart a dark colouration to the flour. In the roundabout way of using ash, it can be determined how high the proportion of husk is in a flour sample, and from that in turn certain conclusions can be drawn as to the brightness of the flour. However, a disadvantage of the ash test is the time required, e.g. six or more hours. For this reason; determination of the degree of brightness and the setting of the mill can only be retrospectively determined in the ash test. An immediate statement as to the momentary state of the product is not attainable with the ash test, so that it is not suitable for continuous monitoring or regulation of the mill.

The "Pekar test" therefore is generally used today for determining flour brightness. In this test, a control sample and a sample of flour that is to be tested are placed side-by-side on a spatula and the surface is smoothed and then the whole is moistened. Preparation is very simple and hardly takes a minute. The "Pekar test" allows through examination with the naked eye an astonishingly fine determination of nuances of brightness between the test sample and the control.

There are brightness measuring instruments available on the market with which absolute values for brightness can be determined, within the scope of specific technical standards. Such brightness measuring instruments are an essential part of the manufacturing facility in many fields, e.g. the paper and textile industries, in the production of coating materials, and in the dye industry.

Such instruments generally cannot be used suitably to measure the brightness of flour. This is explained particularly in that the majority of known measuring instruments and methods work with comparison of measured values of an optical electric measuring cell and an optical electrical comparison cell. These instruments are too inexact for precise testing. They have to be calibrated frequently, and they are unsuitable for continuous use, e.g. as control or regulating instruments. Swiss Patent 414,205 shows such a known measurement method.

Another reflecting instrument already proposed for determination of brightness presents a light source whose radiation is optically decomposed into two part-beams which then are converted by a modulator into intermittent light beams of different frequency. One of the modulated part-beams is taken directly to a photosensitive element and the other is deflected onto a coloured surface that is to be tested, and the returned light is then also taken to the photosensitive element. This latter produces electric signals whose frequencies correspond to the frequencies of the two part-beams and whose amplitude is in proportion to the amplitude of the reference part-beam or of the reflected measurement part-beam. With use of frequency filtering devices, the measurement and reference signals are filtered out from the output signal of the photosensitive element and then, by difference formation or quotient formation, the amplitude of the measurement signal is determined in comparison to the amplitude of the reference signal, and therewith the relative brightness of the tested coloured surface is established.

By use of a single light source for the measurement beam and the reference beam, as well as use of a single photosensitive element, obviously there is elimination of inherent sources of error present in other instruments. Thus, for example, a fluctuation of the brightness of the light source acts equally on the measurement beam and the reference beam, and this in turn is compensated in the comparison or in the quotient formation of the two output signals. The same is true of fluctuations due to aging of the photosensitive element, of voltage fluctuations, and of fluctuations in amplifier circuits that may be present.

The disadvantage of this previously proposed reflecting measurement instrument resides particularly in that substantial technical problems and effort are involved in modulation of the light signals and the later separation of the two signal frequencies. This is because the precision of the result of measurement depends upon the precise separation of the two signal frequencies, with retention of the amplitudes that correspond to the light values. This involves use of expensive frequency filters. In addition, the device is subject to disturbance because of the selected modulation method: clearly, each change in the rpm of the modulator plate leads to a change of frequency of the light beam or beams, which again can lead to errors of evaluation in the band filters or the frequency filters.

According to one aspect of the present invention, in a method of measuring the brightness of a comminuted mill product, a light beam is split into a first part-beam (a reference beam) and a second part-beam (a measurement beam), the reference beam is directed onto a photosensitive element for formation of a reference value, the measurement beam is directed onto the surface of a layer of product to form a measured value and a reflected portion of the measurement beam is also directed onto the photosensitive element, the electric output signals of the photosensitive element evoked by the reference beam and the measurement beam are passed to an evaluating and indicating device for determination of the relative brightness value of the measurement beam in comparison to the reference beam reaching the photosensitive element, the beam path of at least one of the part-beams being cyclicly broken into two essentially time-shifted measurement phases such that only one of the two part-beams strikes the photosensitive element during the first measurement phase, and such that during a second measurement phase at least the other part-beam strikes the photosensitive element, and at least one output signal of the photosensitive element is intermediately stored during the first measurement phase and is compared with at least one subsequent output signal of the second measurement phase.

Clearly, in the method according to the invention there is no modulation of the light beams, but one of the part-beams is intermittently deflected or interrupted so that the other part-beam alone strikes the photosensitive element during at least one measurement phase. In this way there is no continuous "intermixing" of the two part-beams, on the photoelectric transducer which would make elaborate separation and filtering necessary. Rather, by measurement of the output signals of the photosensitive element in the different measurement phases, values can be obtained which are directly proportional to the measured value and to the reference value. The structural outlay for apparatus to carry out the method can be kept particularly low if only one of the two part-beams is deflected or interrupted while the other part-beam falls continuously on the element.

There can be especially acceptable separation of the signals if the measurement beam and the reference beam are directed alternately onto the photosensitive element. Many influences, e.g. from fluctuations of the light source or of the photosensitive element, are especially well compensated for if for evaluation of the output signals the quotient is formed from the signal that corresponds to the brightness of the measurement beam and the signal that corresponds to the brightness of the reference beam.

According to a second aspect of the invention, apparatus for measuring the brightness of a comminuted mill product comprises a light source, means for splitting a beam from the light source into a first part-beam constituting a reference beam and a second part-beam constituting a measurement beam, a photosensitive element for conversion of light beams into electric signals, means for directing the reference beam onto the photosensitive element for formation of a reference value, means for directing the measurement beam onto the surface of a layer of product and thence onto the photosensitive element to form a measurement value, a device for cyclicly breaking the beam path of at least one of the said part-beams into two time-shifted measurement phases such that only one of the two part-beams strikes the photosensitive element during a first measurement phase and such that during a second measurement phase at least the other part-beam stikes the photosensitive element, means for temporarily storing at least one output signal of the photosensitive element during the first measurement phase for comparison with at least one subsequent output signal of the second measurement phase, and means for receiving electrical output signals of the photosensitive element evoked by the reference beam and the measurement beam and determining the relative brightness value of the measurement beam in comparison to the reference beam reaching the photosensitive element. Preferably, the apparatus comprises a switch device connected at the output of the photosensitive element and having a first switch output connected to a first memory for intermediate storage of measurement value signals and a second switch output connected to a second memory for intermediate storage of reference value signals, and a monitoring device for determining respectively the first and second measurement phases and controlling the switch device. Clearly, it is thereby ensured that in the course of the process at least one of the part-beams will be applied uninfluenced by the second part-beam on the photosensitive element, and that the monitoring device will ensure an acceptable separation of the measurement phases so that the signal values in the two memories will be acceptably in proportion to the measurement value signals and the reference value signals respectively.

The monitoring device can be simply and reliably made if it is provided directly on the deflector device that effects the division of the part-beam/beams into the individual measurement phases. In practice an optical electrical monitoring device has been found to be especially useful, for monitoring the position of an aperture device, because in this way the control pulse for the monitoring device can be produced by the same aperture that effects the interruption of the measurement beam and/or the reference beam. In this way there is particularly good synchronizing of the measurement phases and the evaluation.

Insofar as control of the switching device is desired to be effected electronically, for separation of measurement value signals and reference value signals, threshold value measuring devices have proved their worth. These are connected to the output of the optical electrical transducer and control the switching device as a function of the amplitude of the signal appearing there.

The process of the invention can be effected in the presence of outside light, as well as without outside light. This can be managed with particular simplicity if the beam paths of the reference beam and the measurement beam are alternatively interrupted in such a way that during one measurement phase only one of the part-beams and the outside light beam strike the photosensitive element, and during the second measurement phase at least the other part-beam and the outside light beam strike the photosensitive element, and in that during a third measurment phase both part-beams are interrupted so that only the beam of outside light will strike the photosensitive element, and in that at least one output signal of the photosensitive element will be intermediately stored during the first and second measurement phases and the signals compared with each other as well as at least one output signal during the third measurement phase. In this way the outside light, reference light and measurement light beams are advantageously separated, and by comparison or difference formation, the outside light can be eliminated and the relationship of the reference beam and the measurement beam can be determined. This is particularly advantageous for laboratory measurements in full ambient light.

However, the same process can be applied for continuous measurement or control of continuous production, and without any drawback the ambient light can be excluded by encapsulation of the measurement point with the measuring head. Obviously the process can be used for either application, whereby not least the liability to disturbance by outside light as a consequence of damage or wrong operation is reduced.

Since, in the task to which the invention is particularly suited, namely the measurement of flour brightness, what is involved is one of the important control functions in the mill itself, and since further the brightness of the milled product is influenced by, for example, the setting of the roll frame, the cleaning, the preparation for grinding etc., there is regularly a certain range of scatter of brightness values. Preferably, therefore, even before the formation of the quotient, the averages of the signals that correspond to the brightness of the measurement beam and the reference beam are determined over one or two or more measurement cycles. The result of the quotient formation is now advantageously indicated with reference to a standard, for example in percentage terms, then recorded and examined for any exceeding or falling below specifiable limits. When the limits are exceeded, or the values go below the limits, an alarm can be tripped, or for example this variation can be incorporated in the operating process of the mill.

From the purely practical side of measured-value indication, it has proved to be advantageous that a result of quotient formation obtained in this way be indicated in percentages with respect to a standard as a line, and that the average value and the sensitivity of the drawing of the line be so selected that in normal operation of the mill there can be a straight line. A deviation of the registered quotients from a straight line can be signalled immediately as a deviation of the brightness of the product being measured. If the whole manufacturing process in the mill is precisely adjusted, the described representation of a line tracing or the straight line allows a positive assessment of the smooth running of the whole mill.

It is also advantageous to integrate the electric output signals of the photosensitive element for each individual phase during one or more periods of the mains or network frequency. In this way the brightness of flour can be successfully measured and monitored, as required in practice in milling. All influencing factors and disturbance magnitudes are taken into consideration in the simplest way, e.g. fluctuations of the light source or of the photosensitive structure, temperature and outside light disturbances (ac or dc light).

Practically, the device for breaking the beam path can be simply constructed as a rotating drum that is disposed in the beam path of at least one part-beam, whereby the drum wall presents a window for cyclic opening of the beam path, said window advantageously extending around approximately half of the drum periphery.

The invention thus allows, in the simplest way, the long-desired introduction of brightness measuring instruments in mills. Clearly, the technical advance and the inventive content of the subject of the application are ensured by the novel individual features as well particularly as by combination and sub-combination of the features that are utilized.

The method and apparatus of the invention are, as already mentioned, particularly suitable for continuous monitoring during the operation of a flour mill. Thus, the mill product may be a batch of flour whose homogeneity is to be measured and/or monitored, a stream of product being formed from the entire batch, brightness of the stream being continuously measured.

The production of flour, semolina and other milled products intended primarily for human consumption has two particularly interesting steps, i.e. the actual milling and the storage or preparation for delivery of the finished product to the customer.

In the most general terms, there are three characteristic kinds of mills:

A mill which produces only a few kinds of flour, e.g. two or three;

A mill which produces a large number of kinds of flour by suitably controlling the milling process and selection of raw material; and

A mill which produces only a small number of basic kinds of flour, which it mixes to produce a large number of grades thereof.

In each case, of course, depending on the practical situation, compromises must be made in one or the other direction to attain the object in optimum manner.

All mills, however, are subject to a common requirement, in that the finished flour must be of uniform composition. In this connection we refer to an article in "Die Mühle—Mischfuttertechnik", 2 February 1978, entitled "Homogenizsieren und Mischen von Getreide in Getreidemühlen" (Homgenizing and mixing of grain in grain mills).

Of course, a mill has to ensure that all factors, such as proteins, glutens, ash, brightness, particle size and taste, are kept within commercially required limits and must continuously monitor the entire milling process. Much of the monitoring is by sampling in the laboratory. Some, but not all, quality requirements can already be continuously monitored during the actual manufacturing process. In principle, however, one is always sceptical about sampling, since the biggest errors usually occur in sample-taking operation and cannot be eliminated even by the most accurate weighing and analysis in the laboratory.

The question of homogeniety has not yet been adequately settled, more particularly when various kinds of flour are mixed to obtain a special grade. The homogeneity of flour is such a complex matter that an unnecessarily large amount is generally used, for fear of complaints.

Flour is said to be homogenized when constituents having various specific gravities, sizes, structure or additives are made uniform within a batch of the product.

It is therefore desirable to be able to measure homogeneity and, more particularly, to be able to monitor it continuously. As explained above, the present invention makes this possible by forming a stream of product, preferably by mechanical devices, from the entire batch and the brightness of the stream is continuously measured, as representing the homogeneity.

Preferably, the stream of product is recycled to the batch of flour and the brightness is measured during a subsequent run-through until the entire batch has the desired homogeneity.

According to another preferred feature, proposed more particularly for when various basic kinds of flour are mixed, the batch of flour is stored in a vessel from which two or more streams of product are formed and are recycled to the vessel until the relative and/or absolute measured brightness is within a permitted tolerance for a given time.

Initially there were very serious doubts whether it is in fact permissible for a mainly visual quality criterion, which is not necessarily to be equated with the true value of the flour, to be used to obtain information about much more important criteria such as protein distribution. However, detailed research has shown that, on the contrary, the previous method of taking samples was a doubtful criterion, as along as individual samples were checked instead of considering all the material statistically. It is universally recognized that the homogeneity of a bulk product can be checked only by statistical methods. However, known methods cannot be applied since the mixing of flour cannot be equated with other industrial mixing processes such as the mixing of granulated plastics or various particles sizes of gravel, sand, grades of rock, etc.

In the case of flour, the initial chemical, physical and dimensional parameters (e.g. the particle size) have to be made uniform throughout an entire batch, which makes mixing more difficult than in most other industrial mixing or homogenizing processes.

Since the flour is in large masses of bulk material, static mixing is preferred, at least to some extent, in order to reduce the energy required. In the case of static mixing, however, it is known that the entire homogenizing process is cyclic. After a certain time the homogeneity reaches an optimum value which subsequently deteriorates, e.g. because of separation in the heap of bulk materials. After a certain time, the mixture becomes homogeneous again. The process may continue indefinitely or fluctuate within given limits, depending on the chosen boundary influences due to the mixer. If an examination is made of large-capacity flour mixers, which are preferably static, it is always found that the product is mixed and rotated for a given time, e.g. 9 hours. However, when the brightness is monitored, it has been found that a first optimum is reached after only 3 to 4 hours, and this is followed by a deterioration. In the present case there is an improvement after 8 hours; the result after 9 hours is not appreciably better than the first optimum after 3—4 hours.

To the amazement of the experts it has been found that the monitoring of brightness gives information about the actual mixing process. Brightness, however, has an enormous advantage in that it can be measured either in samples or continuously, thus resulting in a great advance in monitoring the production process. More particularly the mixing time can be shortened and the homogeneity can be increased.

The method can have various preferred additional features. For example, the product may be poured into the vessel so as to form heaped conical or part-conical layers of product, and the streams of product are preferably formed or withdrawn from the vessel at two or more horizontally spaced places.

Alternatively, a continuous measuring stream is formed from the stream or streams of product in a bypass and its brightness is measured and/or monitored.

In practice, however, it frequently occurs that no difference in brightness is observed within the batch. In such cases, however, the brightness can still be measured to ensure that no separation is occurring, since this will immediately be detected if the brightness is measured. In such cases, by means of suitable circuits, the homogenizing process can be controlled so that if the brightness of the entire batch of flour is constant from the beginning, the batch is recycled at least twice.

Preferably the aforementioned streams of product flow at different rates. The batch of flour is preferably stored in a vessel, e.g. a large vessel having a capacity of 20 tonnes or more, and the entire vessel constitutes a mixer. According to a simple, reliable feature, the stream of product recycled to the vessel is directly monitored for brightness, more particularly if the brightness of the stream of product is measured immediately after it leaves the vessel, thus checking the brightness of each stream of product before it is mixed with the other streams if required. In order to obtain a uniform stream of product, the flour is preferably vibrated to form a compact column. It is very simple, therefore, if the product is discharged from the vessel by a vibrating element and if the measuring position for continuously monitoring the brightness is disposed directly downstream thereof.

According to another feature which has been found advantageous, the stream of product is produced by mechanical mixing elements inside the vessel and the brightness of the product is continuously measured.

The method is particularly suitable where an actual batch-mixing installation is provided, i.e. where a large number of grades of flour are prepared from a few basic kinds of flour.

In this case the measurement of brightness has two purposes, i.e. to monitor the homogeneity and to measure the brightness of the batch after preliminary mixing. The brightness measurement can be further used as required, either for corrective action or for recording.

Although the method of measuring and/or monitoring hhe homogeneity of a batch of flour is preferably effected using a method of measuring brightness according to the first aspect and apparatus according to the second aspect, it can be effected using other means for measuring brightness and thus the present invention includes, according to a third aspect, a method of measuring and/or monitoring the homogeneity of a batch of flour, in which a stream of product is formed from the entire batch and the brightness of the stream is continuously measured. The invention also includes according to a fourth aspect, a device for measuring the brightness of flour, comprising a bulk-material measuring cylinder, an opto-electrical device for converting the light signal into an electric signal, and an evaluating device.

The invention may be carried into practice in various ways but there will now be described by way of example apparatus for measuring the brightness of flour and a method of measuring the brightness of flour in accordance with the invention together with a number of modifications of the apparatus and method and also apparatus for measuring and monitoring the homogenization of flour. The description will be with reference to the accompanying diagrammatic drawings, in which:

Figure 1 shows a schematic arrangement of a flour brightness measuring instrument;

Figure 2 shows the characteristics of signals at various points of the device shown in Figure 1;

Figure 3 illustrates a modification of the monitoring device shown in Figure 1;

Figure 4 is a curve of the output signals of the photosensitive element when the construction shown in Figure 5 is used;

Figure 5 shows a drum with a modified aperture compared with Figure 1;

Figure 6 shows schematically a modified measuring instrument with three measurement phases and impinging outside light;

Figure 7 shows the signal characteristic at the output of the photosensitive element of the embodiment of Figure 6;

Figure 8 shows the aperture arrangement of the measuring instrument according to Figure 6;

Figure 9 shows a unit comprising a vessel to contain flour, means for effecting homogenization and means for measuring the brightness of the flour to monitor the homogenization process; and

Figure 10 shows to a larger scale a detail of a unit similar to that shown in Figure 9 with a modified measuring means.

Figure 1 shows a flour brightness measuring instrument having a lamp 1 which produces a light beam 1*a* that is transmitted via a collecting lens 2 onto a semitransparent mirror 3. The mirror 3 decomposes the light beam 1*a* into two part-beams 4 and 5. Part-beam 4 falls directly onto a photocell 7 while part-beam 5 passes through the mirror 3 and falls on a measuring surface 8 formed by a layer of flour that is covered by a glass plate. The light of part-beam 5 is reflected from the surface 8 as a function of the brightness value of the flour and is focussed by lens 9 onto the photocell 7.

Photocell 7 is surrounded by a rotating drum 6 which has a cylindrical wall 6*a* on one peripheral side while the other peripheral side is left open. Depending upon the position of the drum 6, which is driven by a drive that is not illustrated, the part of part-beam 5 collected by the lens 9 is let through to the photocell 7 or it is intercepted by the wall 6*a*. Thus, the part-beam 4 (the reference beam) falls continuously on the photocell 7, the part-beam 5 (the measuring beam) is cyclicly interrupted by the drum 6. Structurally the drum 6 has proved to be especially simple, but obviously the interruption could alternatively be produced by other appropriate aperture devices or deflectors disposed in the beam path downstream of the mirror 3.

The output of the photocell 7 is connected to the input of an amplifier 11, the output of which is connected to a switching device 12. The control input of the switching device 12 is connected to a photoelectric monitoring device 10 which is located on the diametrically opposite side of the drum 6 from the lens 9. Thus, during operation, the drum wall 6*a* will always produce a switch control signal in the monitoring device 10 when the beam path for the measurement beam 5 is opened from lens 9, and as soon as the drum 6 has turned further by 180° and the beam path has again been interrupted, light path 10*a* of monitoring device 10 will again be open, and switch change control pulse will be sent to switching device 12.

The functioning of the device will now be discussed in connection with the signal diagram of Figure 2. The signal diagram is intended only to show the characteristic of the signal without reference to the type (e.g. digital or analog) of signal, and without true fidelity to the amplitudes or curve and time characteristics.

During measurement phase T_1, the measurement beam 5 is interrupted by the drum wall 6*a* so that only the reference beam 4 strikes the photocell 7. Consequently, the photocell 7 produces a signal that corresponds to the reference beam 4, this signal being amplified in the amplifier 11 and applied to the switching device. As soon as the measurement beam 5 is released after a 180° turn of drum 6, the light impingement on photocell 7 is increased by a value that corresponds to the measurement beam, and is held over the whole duration of measurement phase T_2. After a further 180° turn the output value on photocell 7 drops again because drum wall 6*a* again enters the beam path of measurement beam 5. The curve characteristic at the input of switching device 12 is designated A in Figure 2. Signal S_1 which is present during measurement phase T_1 accordingly corresponds to reference signal S_R while the signal S_2 during measurement phase T_2 corresponds to reference signal S_R plus measurement value signal S_M. The monitoring device 10 switches switching device 12 with phase T_1 to a first intermediate memory 13 and during the second measuring phase to a second intermediate memory 14. Signal D appears at the output of intermediate memory 13, said signal being maintained by memory 13 during the second measurement phase T_2, although signal S_2 has already appeared at the output of amplifier 11. During the same period, signal S_2 appears at the output of intermediate memory 14, so that in the second measurement phase T_2 signal S_1 and signal S_2 appear simultaneously at the input of computer circuit 15. In the computer circuit 15, the difference between signal S_2 and signal S_1 is formed and a corresponding signal, the measurement signal S_M, is produced and applied to the first input of an evaluating circuit 16. The second input of circuit 16 is connected to the output of the intermediate memory 13 so that reference signal S_R appears there. In evaluation circuit 16, an indicator value A is formed by dividing the measurement signal S_M by the reference signal S_R and multiplying the result by an indicator constant K. The indicator constant is selected to give an appropriate indication on an instrument 17. Indicator value A is thus always proportional to the quotient of the light value of reference beam 4 and measurement beam 5. Any brightness fluctuations of the lamp 1 or fluctuations in sensitivity of the photocell 7 are eliminated by the quotient formation. For reset, or for energizing individual elements, especially intermediate memories 13 and 14, computer circuit 15 and the evaluation circuit 16, the said elements may be connected with a synchronizing and control circuit that is not illustrated, which after completion of the individual measurement phases T_1 and T_2 respectively will energize the elements in question or set them back to zero, to introduce a new measurement phase. The selection of the structural elements from those in current use and their arrangement will present no difficulties to the specialist so they will not be described in detail.

The signals produced by each of the electronic units are averaged or integrated over at least two cycles as indicated by the input *t* to each unit shown in Figure 1 and by the resulting averaged signals D, F and E shown in the lower part of Figure 2.

Figure 3 shows an arrangement which is the same as that shown in Figure 1 except that the photosensitive monitoring device 10 is replaced by an electronic monitoring device 10*b* which is directly connected to the input of the switching device 12 so that it also receives signals S_1 and S_2 (Figure 2). The monitoring device 10*b* includes a threshold measuring device whose threshold value is so set that when an input signal is applied that exceeds value S_R, a signal is given to control lead 10*c* which in turn is connected to the control input of switching device 12. Consequently, switching device 12 is switched every time the signal value at the input of monitoring device 10*b* rises when there is a shift from measurement phase T_1 to measurement phase T_2. In this way, the photoelectric monitoring of drum 6 as in Figure 1 is eliminated but otherwise the functioning of the device is identical with that of the example of Figure 1.

Figure 4 shows the schematic signal characteristic of signals S_M and S_R in the modified arrangement of drum 6 shown in Figure 5. According to Figure 5, the drum 6 has two windows 6*b* and 6*c*, staggered by about 180° around the periphery of the drum. When the drum 6 rotates during operation, two modes will alternate; in the first the reference beam 4 will be released and the measurement beam 5 interrupted, while in the second the reference beam 4 will be interrupted and the measurement beam 5 released. Consequently there will be a signal characteristic S_M and S_R as in Figure 4, where measurement value S_M is presented directly, without difference formation. Consequently, the computer circuit 15 (Figure 1) can be omitted. Instead of the drum apertures shown in the examples, there can of course be plate devices or any other occluding devices or moving mirrors.

Figure 6 shows a measurement instrument similar to that of Figure 1, where instead of drum 6 a shutter plate 20 is provided, driven by a motor 21. As Figure 8 shows, the shutter plate 20 has a sector-shaped notch 20*a*, amounting to about 90°. The shutter plate 20 therefore cyclicly interrupts both measurement beam 5 and reference beam 4. This divides the measurement into three phases. In the setting according to Figure 6 only the measurement beam 5 strikes the photocell 7. When the plate 20 has turned a small distance, the measurement beam 5 is interrupted without immediate release of the reference beam 4. In this phase outside (ambient) light indicated schematically by numeral 22 falls on the photocell 7. In the next phase the reference beam 4 is released while the measurement beam 5 is still interrupted. The signal characteristic at the output of the photocell 7 is to be seen in Figure 7. So long as both part-beams 4 and 5 are interrupted, only signal S_U is delivered. As soon as part-beam 5 is released, measurement signal S_M is added to signal S_U. In the next measurement phase part-beam 4 is released, so that the output signal rises to the value S_U plus S_R. There are therefore three different values for the individual measurement phases, respectively proportional to the ambient light, the reference light and the measurement light. Since the ambient light is alone present when both part-beams, are cut off, the values of the reference signal S_R and the measurement signal S_M can be determined by subtraction from the measurements in phases T_1 and T_3 of the measurements in the intervening phases. The circuit is operational of course even if there is no impinging of outside light, because only the base value of curve S_2 is effected by the outside light. The circuit therefore is especially reliable and opens a further field of possible practical applications.

The brightness measuring apparatus shown in Figure 1 is used in the unit shown in Figure 9 for effectimg homogenization of a batch of flour. As shown in Figure 9, a large capacity silo 101 has inlet F for product and three horizontally spaced withdrawal places 102 in the form of vibratory dischargers 104. Three streams 105, 106, 107 of product are formed and flow into a common screw conveyor 108 having a motor 109 and varying screw pitches so as to ensure a uniform stream of product from all three withdrawal places. A vertically disposed screw conveyor 110 and motor 111 return the flour to the large silo which preferably has a capacity of 10, 20, 40 or more cubic metres.

The silo contains various kinds of flour (indicated by varying shading) which form part-conical heaps and, in conjunction with the product-removing devices, ensure substantially static mixing i.e. without mechanical mixing vanes or the like. It would be possible, however, to include such vanes which may be preferable in some cases.

In the example shown, the brightness of each stream of product is continuously measured and signals are transmitted along lines 115, 116, 117 to a common comparator 118 which compares the results and e.g. sets given limiting values, which are reached e.g. in 5 to 20 or preferably in 10 to 15 minutes, and gives a signal based thereon in order to end the homogenizing action of the mechanical conveyors, i.e. a command for final discharge through a slider 120 and a pipe 121. Of course, the homogeneity of the mixture of flour must not be disturbed during the final discharge.

It is also advantageous to monitor the brightness during the discharge period, in order to recycle any product which fails to meet the set standard, e.g. final residues, to the silo 101. For this purpose, it may be advantageous to continue to monitor the brightness at 15, 16, 17 separately, so that if, for example, special problems arise, the absolute values at each discharge place can be determined, followed by suitable intervention if necessary.

In the unit shown in Figure 9, the brightness measuring apparatus operates directly on each stream of flour. An alternative arrangement is shown in Figure 10.

The main stream of product is conveyed through a pipe 130, from which a measuring stream of product is continuously withdrawn through a bypass pipe 131. The main purpose of the subsidiary stream of product is to produce flour having a uniform bulk density so that interfering surrounding influences can be excluded when the brightness is measured. To this end, the flour is placed in a measuring cylinder having a bottom outlet 133 kept open by a suspended vibrator 134 providing a pre-set cross-section and mounted on a pendulum 137. The measuring cylinder is itself designed to eliminate any negative influence on homogeneity, and accordingly its bottom outlet cross-section is made smaller than the top inlet cross-section. The vibration ensures a flow through, and both conditions ensure that the measuring cylinder is completely filled. As a natural consequence, the density of the flour remains constant.

It has been found advantageous to incline the measuring cylinder slightly to the vertical. The flow from the measuring cylinder is directly returned to the main stream of product at 135. A widened portion 136 underneath the measuring cylinder allows the flour to flow out and can also be used for maintenance work connected with vibrator 134. The pendulum 137 is mounted on a vibration damper 138 to prevent transmission of undesirable vibrations to the remainder of the apparatus.

The lower region of the measuring cylinder wall has a window formed by a transparent glass pane 139 allowing free passage to the incoming measuring-light beam and the light reflected from the flour which passes to the measuring head 140. The head 140 contains the light source and optical system (not shown) and the light-sensitive element, which transmits the signals after they have been suitably processed in a transformation and processing centre, diagrammatically indicated by a panel 41.

Of course, the processing unit 41 can be directly juxtaposed to the head 140 or located elsewhere according to specific operating conditions.

The processing unit 141 preferably contains a means for directly indicating the measured brightness value or values. If a number of measurements are made simultaneously, e.g. as in Figure 9, there will be a number of indicating means. One of the most important items of information is the effective brightness, which is continuously recorded on a measuring strip, represented by a paper strip 142 on which traces are recorded. Alternatively, the recorded trace can show the difference in the individual values. The processing unit can also comprise a lamp or sound signal 143 for immediately indicating any impermissible deviations in brightness. The processing unit also has a plurality of output signal lines 144. These may be directed to various points, for example for the control of other pieces of equipment, for the preparation of central records or for a central control unit for uniform running of the mill.

The operation of the brightness device is described in detail above in relation to Figures 1 to 8. Thus, the path of rays is interrupted so that the light-sensitive component is illuminated by different light beams during time-shifted phases, the reference and the measuring beam preferably being of constant light, and the electric output signals of the light-sensitive component corresponding to the individual phases are stored as required during the intermediate period and sent to the evaluating device.

It can be seen that, according to the invention, the light beams are not modulated but the light-sensitive component is illuminated by, for example, one part-beam whereas the other part-beam is intermittently deflected. There is thus no "mixing" of the two part-beams in an opto-electrical transducer, which would require expensive separation and screening. Instead, the output signal of the light-sensitive component can be measured in the individual measuring phases to obtain a value which is directly proportional to the measured or the reference value.

The cost of constructing the device can be kept very low if only one of the two part-beams is deflected or broken whereas the other part-beam continuously falls on the transducer.

Particularly reliable results are obtained if the measuring beam and the reference beam are alternately caused to fall on to the light-sensitive components.

A really unexpected finding is that the invention can be embodied in a simple but reliable way; both the measurement of brightness by sampling in the laboratory and also for continuous brightness measurement or monitoring during quality control or for control of a mill.

The experts have hitherto assumed that, in order to deal with two such different problems as laboratory measurement and the monitoring of production, the expensive laboratory method must require extensive adaptation to the conditions of a production plant. In the case of the monitoring of the production of a bulk material such as flour which unavoidably produces dust, a sample freely placed in the plant, even if under glass, would need continuous dusting, since otherwise the result would be completely false. The mere use of alternating light for making the ambient light harmless is no help in solving the dust problem. The dust problem must be solved by additionally screening off the ambient air, by complete encapsulation, but this will make it unnecessary to use alternating light.

The invention can be embodied in various very sensible and advantageous ways, starting from a basic set of universally serviceable equipment, or alternatively a device adapted to the special conditions and therefore cheap can be constructed at the minimum necessary expense, in accordance with the process. With regard to the example of measurement in the laboratory in full ambient light, it is very advantageous if the reference beam and the measuring beam are interrupted during time-shifted phases and the reference beam and measuring beam are both interrupted in a third phase. In this case the measuring beam is advantageously interrupted by a flat, rotating, suitably shaped disc, before it reaches the surface of the flour, and in the third phase only the ambient light reflected from the surface of the flour is conveyed to the light-sensitive component.

In this case it is possible at relatively low expense to obtain the quotient of (a) the electric signal corresponding to the brightness of the measuring beam alone (SM) and (b) the signal corresponding to the brightness of the reference beam alone (SR) and evaluate and/or display it as a measurement of the brightness of the flour.

The same method can also be used for continuous measurement or monitoring of continuous production, and without disadvantage the ambient light, as the third phase screened by encapsulating at least the measuring unit and measuring head, i.e. also in the third phase, without using superfluous process steps in either application.

If it is decided beforehand that ambient light will be excluded, which of course can also be appropriate in the case of the measurement of samples in the laboratory, e.g. by inserting the sample in a drawer-like component in a measuring unit, the method considered optimum at present is to convey the reference beam on to the light-sensitive component during one phase and both the reference beam and the measuring beam on to the light-sensitive component during a second phase, or convey the measuring beam on to the light-sensitive component during one phase and both the measuring beam and the reference beam during a second phase.

In this case, the light beam reflected from the flour, or the measuring beam before it strikes the layer of flour, can be interrupted and, as previously explained, the quotient can be obtained from (a) the electric signal corresponding to the brightness of the measuring beam alone (SM) and (b) the signal corresponding to the brightness of the reference beam alone (SR).

Since the problem on which the invention is based, i.e., measuring the brightness of flour, relates to one of the most important objects of the mill itself, and since the brightness is influenced by milling, e.g. by the adjustment of the roller frames, etc., and the cleaning and preparation of the flour, there will naturally be a certain scatter in brightness. Another problem to be solved by the invention, therefore, was to get the scattering range "under control". To this end, before the quotient is formed, the signal corresponding to the brightness of the measuring beam is averaged over two or more measuring cycles.

The result of quotient formation is then advantageously indicated as a percentage relative to a calibration standard, recorded and tested to see whether it exceeds or falls below fixed limits. If it exceeds or falls below the limits an alarm can be triggered or, for example, if it exceeds or falls below the limits, the processing operations in the mills can be adjusted.

From the purely practical aspect, it has been found amazingly and extremely advantageously for a thus-obtained result of quotient formation as a percentage relative to a calibrated standard to be produced in the form of a line, and for the averaging and sensitivity of recording of the line to be chosen so that when the mill operates normally, the recorded line is straight.

Any deviation of the recorded quotient from a straight line can be directly displayed in the form of a deviation from the brightness of the measured product.

If the entire production process in the mill is exactly controlled, the aforementioned display of a line and/or the straight line can give itself strong and positive information about the uniform running of the entire mill.

If the chief miller, during his monitoring inspection, sees that the line is proceeding at the correct value, and if he has not found any other disturbances, e.g. of a purely mechanical kind, he has the comforting feeling that the mill is now running smoothly. More particularly, if the colour is constant, the ash is reliably shown to be constant.

It has also been found advantageous to integrate the electric output signals of the light-sensitive component of each individual phase during one or more periods of the mains frequency.

It is thus for the first time possible to measure and monitor the brightness of corn, as required in the mill.

Allowance is made for all influence factors, more particularly disturbing factors of practical importance, e.g. fluctuations in the light source or the light-sensitive component (also called the opto-electrical transducer) or, more particularly, the temperature and external disturbances in alternating or constant light.

Claims

1. A method of measuring the brightness of a comminuted mill product in which a light beam is split into a first part-beam (a reference beam) and a second part-beam (a measurement beam), the reference beam is directed onto a photosensitive element for formation of a reference value, the measurement beam is directed onto the surface of a layer of product to form a measured value, and a reflected portion of the measurement beam is also directed onto the photosensitive element, the electric output signals of the photosensitive element evoked by the reference beam and the measurement beam are passed to an evaluating and indicating device for determination of the relative brightness value of the measurement beam in comparison to the reference beam reaching the photosensitive element, the beam path of at least one of the part-beams being cyclicly broken into two essentially time-shifted measurement phases such that only one of the two part-beams strikes the photosensitive element during the first measurement phase, and such that during a second measurement phase at least the other part-beam strikes the photosensitive element, and at least one output signal of the photosensitive element is intermediately stored during the first measurement phase and is compared with at least one subsequent output signal of the second measurement phase.

2. A method as claimed in Claim 1 in which, during at least the first measurement phase, the reference beam is directed onto the photosensitive element, and during the second measurement phase, at least the measurement beam is directed onto the photosensitive element.

3. A method as claimed in Claim 2 in which the reference beam is also directed onto the photosensitive element during the second measurement phase.

4. A method as claimed in Claim 1 in which the measurement beam and the reference beam are alternately directed onto the photosensitive element during successive measurement phases.

5. A method as claimed in Claim 1 or Claim 2 or Claim 3 or Claim 4 in which a quotient is formed from a signal of the photosensitive element that corresponds to the brightness of the measurement beam and a signal of the photosensitive element that corresponds to the brightness of the reference beam.

6. A method as claimed in Claim 5 in which a determination is made of whether the quotient lies within predetermined limits.

7. A method as claimed in Claim 6 in which the ratio of the quotient to a set value is determined and is printed out as a continuous trace.

8. A method as claimed in any of the preceding claims in which light from a further source strikes the photosensitive element, the measurement is divided into at least three measurement phases, and the beam paths of the reference beam and the measurement beam are alternatingly interrupted in such a way that during one measurement phase only one of the part-beams and the outside light beam strike the photosensitive element, during the second measurement phase at least the other part-beam and the outside light beam strike the photosensitive element, output signals of the photosensitive element are intermediately stored during the respective first and second measurement phases, and the signals are compared with each other and also with at least one output signal of the third measurement phase.

9. A method as claimed in Claim 8 in which the electric output signals of the photosensitive element for the individual measurement phases are integrated to an average value that is in proportion to the light impingement of the part-beams and the outside light beams respectively.

10. A method as claimed in Claim 9 in which the comparisons are made using the average values.

11. A process as claimed in any of Claims 1 to 7 in which ambient light is shielded from the photosensitive structure.

12. A method as claimed in any of the preceding claims in which the measurement beam is cyclicly broken before it encounters the surface of the layer of product.

13. A method of measuring the brightness of a comminuted mill product substantially as described herein with reference to Figures 1 and 2 or to Figures 1 and 2 and modified substantially as described in Figure 3 or Figures 4 and 5 or Figures 6 to 8 of the accompanying drawings.

14. A method as claimed in any of the preceding claims in which the mill product is a batch of flour whose homogeneity is to be measured and/or monitored and in which a stream of the product is formed from the entire batch.

15. A method as claimed in Claim 14 in which the stream of product is recycled to the batch of flour and the brightness is measured during a subsequent run-through until the entire batch has the desired homogeneity.

16. A method as claimed in Claim 15 in which the batch of flour is stored in a vessel from which two or more streams of product are formed and are recycled to the vessel until the relative and/or absolute measured brightness is within a permitted tolerance for a given time.

17. A method as claimed in Claim 16 in which the streams of product flow through at different rates.

18. A method as claimed in Claim 16 or Claim 17 in which the product is poured into the vessel so as to form heaped part-conical layers of product, and the streams of product are withdrawn from the vessel at two or more horizontally spaced places.

19. A method as claimed in Claim 14 in which if the brightness of the entire batch of flour is constant from the beginning, the batch is recycled at least twice.

20. A method as claimed in any of Claims 14 to 19 in which a continuous measuring stream is formed from the stream or streams of product in a bypass and its brightness is measured and/or monitored.

21. A method as claimed in Claim 15 in which the batch of flour is stored in a vessel and the vessel constitutes a mixer.

22. A method as claimed in Claim 21 in which there are mechanical mixing elements inside the vessel.

23. A method as claimed in Claim 21 or Claim 22 in which the stream of product recycled to the vessel is directly monitored for brightness.

24. A method as claimed in Claim 23 in which the brightness of the stream of product is measured immediately after it leaves the vessel.

25. A method as claimed in any of claims 14 to 24 in which the or each stream of product is compacted by vibration prior to its brightness being measured.

26. Apparatus for measuring the brightness of a comminuted mill product comprising a light source, means for splitting a beam from the light source into a first part-beam constituting a reference beam and a second part-beam constituting a measurement beam, a photosensitive element for conversion of light beams into electric signals, means for directing the reference beam onto the photosensitive element for formation of a reference value, means for directing the measurement beam onto the surface of a layer of product and thence onto the photosensitive element to form a measurement value, a device for cyclicly breaking the beam path of at least one of the said part-beams into two time-shifted measurement phases such that only one of the two part-beams strikes the photosensitive element during a first measurement phase such that during a second measurement phase at least the other part-beam strikes the photosensitive element, means for

temporarily storing at least one output signal of the photosensitive element during the first measurement phase for comparison with at least one subsequent output signal of the second measurement phase, and means for receiving electrical output signals of the photosensitive element evoked by the reference beam and the measurement beam and determining the relative brightness value of the measurement beam in comparison to the reference beam reaching the photosensitive element.

27. Apparatus as claimed in Claim 26 comprising a switch device connected at the output of the photosensitive element and having a first switch output connected to a first memory for intermediate storage of measurement value signals and a second switch output connected to a second memory for intermediate storage of reference value signals, and a monitoring device for determining respectively the first and second measurement phases and controlling the switch device.

28. Apparatus as claimed in Claim 27 in which the monitoring device is provided for determination of the actual operational setting of the beam breaking device.

29. Apparatus as claimed in Claim 28 in which the beam breaking device comprises a rotating shutter element in the beam path of at least one part-beam, and the monitoring device comprises an optical-electrical monitoring device to monitor the position of the shutter element, the output of the monitoring device being connected to the control input of the switching device.

30. Apparatus as claimed in Claim 27 in which the monitoring device has a threshold measuring device connected with the output of the photosensitive element in such a way that the falling flank or the rising flank of the signal at the output of the photosensitive element can be detected upon interruption of the beam path of a part-beam.

31. Apparatus as claimed in Claim 27 in which the beam breaking device comprises a rotary drum that is disposed in the beam path of at least one part-beam, whereby the drum wall, for cyclical opening of the beam path, presents at least one window which extends around approximately half the drum periphery.

32. Apparatus for measuring the brightness of a comminuted mill product substantially as described herein with reference to Figures 1 and 2 or to Figures 1 and 2 modified substantially as described herein with reference to Figure 3 or Figures 4 and 5 or Figures 6 to 8 of the accompanying drawings.

33. Apparatus as claimed in any of Claims 26 to 32 in combination with means for forming a stream of product past the apparatus for continuous measurement of the brightness of the stream.

34. Apparatus as claimed in Claim 33 which includes a storage vessel for a batch of product and means for recycling the stream.

35. Apparatus as claimed in Claim 33 or Claim 34 in which the means for forming a stream comprises a measuring cylinder for passage of the product therethrough and vibrator for vibrating product in the cylinder.

36. Apparatus as claimed in Claim 35 in which the cylinder and vibrator are substantially as described herein with reference to Figure 8 of the accompanying drawings.

37. Apparatus as claimed in any of Claims 33 to 36 in which the stream forming means is substantially as described herein with reference to Figure 7 of the accompanying drawings.

38. A method of measuring and/or monitoring the homogeneity of a batch of flour, in which a stream of product is formed from the entire batch and the brightness of the stream is continuously measured.

39. A method as claimed in Claim 38 in which the stream of product is recycled to the batch of flour and the brightness is measured during a subsequent run-through until the entire batch has the desired homogeneity.

40. A method as claimed in Claim 39 in which the batch of flour is stored in a vessel from which two or more streams of product are formed and are recycled to the vessel until the relative and/or absolute measured brightness is within a permitted tolerance for a given time.

41. A method as claimed in Claim 40 in which the streams of product flow through at different rates.

42. A method as claimed in Claim 40 or Claim 41 in which the product is poured into the vessel so as to form heaped part-conical layers of product, and the streams of product are preferably formed or withdrawn from the vessel at two or more horizontally spaced-apart places.

43. A method as claimed in Claim 38 in which if the brightness of the entire batch of flour is constant from the beginning, the batch is recycled at least twice.

44. A method as claimed in any of Claims 38 to 43 in which a continuous measuring stream is formed from the stream or streams of product in a bypass and its brightness is measured and/or monitored.

45. A method as claimed in Claim 39 in which the batch of flour is stored in a vessel and the vessel constitutes a mixer.

46. A method as claimed in Claim 45 in which there are mechanical mixing elements inside the vessel.

47. A method as claimed in Claim 45 or Claim 46 in which the stream of product recycled to the vessel is directly monitored for brightness.

48. A method as claimed in Claim 47 in which brightness of the stream of product is measured immediately after it leaves the vessel.

49. A method as claimed in any of Claims 38 to 48 in which the or each stream of product is compacted by vibration prior to its brightness being measured.

50. A device for measuring the brightness of flour comprising a bulk-material measuring cylinder, an opto-electrical device for converting

the light signal into an electric signal, and an evaluating device.

51. A device for measuring the brightness of flour as claimed in Claim 50 in which the bulk-material measuring cylinder is associated with a vibrator for producing a uniform density in the heaped flour.

52. Apparatus for measuring and/or monitoring the homogeneity of a batch of flour substantially as described herein with reference to Figure 7 or Figure 8 of the accompanying drawings.

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