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(54) METHOD AND APPARATUS FOR IDENTIFYING A MOULD

(71) We, EMHART ZURICH S.A., a Company organised under the laws of Switzerland, of Seefeldstrasse 224, 8008 Zurich, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

The present invention relates to a method and apparatus for identifying a moulded vessel with the mould from which it is produced. It is known to use moulds having markings for imparting relief-like markings to the vessel and to identify the mould by moving the vessel relative to a reading device which illuminates the vessel, at least in the region of the moulded markings, and to evaluate the diffraction or reflection of the light caused by the markings.

In the manufacture of an article in a press mould, casting mould or blow mould, deficiencies and errors of the mould are transferred to the article. The result is, especially in manufacturing installations equipped with a number of identical moulds and possessing a high production rate, that two important problems arise: the identification of that mould in which a specific article suffering from a defect was moulded and the sorting out of all the articles which have been made in this mould, before the defective article was recognised or in the period between recognition of the defective article and replacement of the corresponding mould. The solution of these problems especially important in modern installations for the production of glass vessels. The moulds utilised in such installations are subjected to exacting thermal conditions and high mechanical loads and exhibit a correspondingly high rate of wear. Furthermore, such installations are equipped with a number of identical moulds and are operated at a high productions rate. Since it is only possible for the vessels to be examined for possible errors after they have passed through a tempering furnace, a large number of vessels have usually been moulded in a defective mould, before the defect is discovered.

In order to solve both problems, the moulds are furnished with a marking, which is transferred onto every article moulded in them. This marking may simply be an ordinal number. A known device for reading the ordinal number on a glass vessel designating the mould from which it is produced is described in French Patent Application No. 74 21259 (AB Platmanufaktur) published under No. 2234613 and corresponding to British Patent Specification No. 1458726. This device is provided for reading ordinal numbers which are represented in a digital code. The individual code elements are constituted as dash-shaped, relief-like projections, which are disposed along a peripheral circle and preferably on the bottom surface of the vessel. To read them, at least one part of the peripheral circle is illuminated. The relief-like projections of the code elements then cause both the light passing through the vessel wall and also the light reflected from the vessel wall to be diffracted more intensely than that from a plane vessel wall or a wall of uniform thickness. To read the code, the illuminated vessel is rotated about the centre of a circle in front of a stationary reading device, and the changes in illumination of the reading device caused by the code elements are converted into electrical signals. In order to distinguish the illumination changes produced by the code elements from those which, for example, are caused by other markings formed on the vessel wall by mould joints or irregularities in the vessel wall, an evaluating device connected to the reading device is controlled by a synchronising generator. For the synchronising generator, a signal generator may be used, which generates synchronising impulses which are proportional to the rotational speed of the drive apparatus for the vessel.

A preferred use of this device in the sorting line of an installation for manufacturing glass vessels is described in U.S. Patent Specification 3,923,158. In this, the output from the device and the output from at least one test device of the sorting line are connected to associated inputs of a recording device. As soon as one of the test devices detects an unacceptable fault or an inadmissable number of faults, the ordinal number moulded on the defective vessel and simultaneously or previously read by the reading device is indicated by the recording device and is stored and printed out optionally as desired.

The above-described known device possesses a number of disadvantages, which severely restrict its practical use.

The evaluating circuit can only evaluate the read signals correctly when the code elements to be read pass before the reading device synchronously with the synchronising impulses. For this to occur, at least two conditions must be satisfied. Firstly, the rotational speed of the vessel must coincide exactly with the rotational speed of the drive mechanism which triggers the signal generator, that is to say the vessel must not be subject to any slip relative to the drive device. This requirement cannot in practice be fulfilled with the high throughput speeds and rotational speeds encountered in the measuring and testing stations of a modern sorting line. Secondly, the angular interval between the code elements on the peripheral circle of the vessel must stand in an exactly defined relationship to the angular intervals between markings utilised for triggering the signal generator and situated on the drive device. This requirement can only be satisfied in new moulds. On account of the exacting thermal conditions and mechanical loading of the moulds already mentioned, these moulds are subject to unavoidable wear and small changes in shape, which adversely affect the angular interval between the code elements. Independently of the quality of the mould, changes in angle between the code elements can also be caused by uneven expansion and contraction of the vessel during tempering.

In the known device described, the relief-like moulded code elements are utilised as optical lenses, which image the light source upon the photo-element of the reading device. This necessitates a relatively high degree of accuracy in the shape of each code element, which cannot however be guaranteed on account of the wear of the moulds already referred to.

Furthermore, in this known device, the reading device is illuminated with substantially parallel light, so long as there is no code element in the light path between the source and the reading device. This basic illumination is dependent upon the colour of the glass of the vessel and the thickness of its wall, and the reading device accordingly produces a variable base signal, upon which the signal generated by a code element is superimposed. The absolute value of the two signals is therefore dependent not only upon the illumination of the reading device of a code element, but also upon fluctuations in the base signal. The absence of a constant reference signal, against which the read signals can be set in comparative relationship, renders the evaluation of the signals difficult and can indeed make this evaluation impossible.

It is an object of the present invention to provide an improved method of and apparatus for identifying a moulded vessel with the mould from which it is produced in which the disadvantages referred to above are materially reduced if not substantially obviated.

The present invention, broadly stated, provides a method of identifying a moulded vessel with the mould from which it is produced which comprises moulding into the wall of the vessel a group of identifying marks within a first predetermined area and a group of timing marks within a second predetermined area having a predetermined spatial relationship with the first area whereby the timing marks identify the spatial distribution of the identifying marks within the first predetermined area.

The invention further provides a method of identifying the mould in which a vessel made from an optically transparent material has been moulded, in which method moulds having an individual marking suitable for imprinting onto the vessel comprising relief-like elements are used, and in which the vessel for the purpose of identifying the mould is moved relative to a reading device, is illuminated at least in the region of the moulded marking and the diffraction or deflection of the light caused by the elements of the marking is evaluated, characterised in that a multi-part marking is used, two parts of which are disposed upon opposite sides of a line oriented in the direction of movement, the one part containing code elements suitable for constituting at least one symbol in a digital code, and the other part containing timing marks which are provided for the purpose of generating timing impulses suitable for the sequential reading of the code elements.

There is also provided an apparatus for carrying out the method of the immediately preceding paragraph comprising an illuminating device suitable for generating a light beam oriented to a reading location, a device for supporting the vessel and for transporting the vessel wall furnished with the marking through the reading location and parallel to the line separating the two parts of the marking and a reading device comprising at least two photo-elements, one of which is provided for reading the code elements at the reading location and the other for reading the timing marks at the reading location, the illuminating and reading devices being disposed on the same side of the supporting and transporting device.

In a preferred embodiment of the present invention the markings are read in incident light. With this new method, it is ensured that the code elements pass in front of the reading device synchronously with the synchronising impulses, independently of what rotational speed and the vessel may possess relative to the drive device, because the marking contains code elements and timing marks. This synchronising is not adversely affected by the ageing of the mould or by irregular contraction of the glass during tempering, because any possible change in the distance between successive code elements is compensated by an equal change of the distance between the associated timing marks.

Some embodiments of the invention will now be described by way of example, reference being made to the accompanying drawings in which:

Fig. 1 is a lateral view of the lower part of a glass vessel with markings according to one embodiment of the invention,

Fig. 2 is a partial section on the line I-I through the lower part of the vessel of Fig.1,

Fig.3 illustrates an alternative form of markings,

Fig.4 is a diagrammatic plan view of a device for carrying out the method of this invention together with a block diagram for reading and evaluating the markings.

Fig.5 is a perspective view of a light shielding block incorporated in front of the reading device of Fig.4.

Fig.6 is a diagrammatic representation of the intensity of illumination of a photodiode before and during the passage of a marking,

Fig.7 is a view similar to Fig.1 illustrating an alternative marking,

Fig.8 is a view similar to Fig.5 illustrating an alternative light shielding block,

Fig.9 is a schematic view illustrating the reading of the markings shown in Fig. 7 using the light shielding block shown in Fig.8,

Fig.10 is a diagrammatic plan view of an embodiment for reading markings in incident light,

Fig.11 is an enlarged diagrammatic view of the light reflected from a code element and

Fig.12 illustrates the corresponding intensity of illumination of an associated photodiode.

Fig.1 shows the lower part of a circular-section moulded glass vessel 10, the lower end of which is of reduced diameter and carries marks indicated generally at 11. The individual marks are disposed in two horizontal rows, the first row of which, comprising marks 12-15, is disposed above a plane normal to the vessel axis and referenced 17 and the second row, comprising marks 19-24, is disposed below this plane. The marks project from the wall of the glass vessel, as shown in Fig. 2, are oval in plan view and have a part-circular cross-section in a plane parallel to the plane 17. The marks being on a reduced diameter part of the vessel, are set back from the maximum vessel diameter, and safeguarded against damage when vessels contact each other. On account of their shape, the marks act as optical lenses, and diffract light passing through them.

The example of a marking shown in Fig. 1 contains, in the row below the plane 17, a group of four marks 20 to 23, which are used as timing marks and which are disposed in a predetermined area. These marks are provided for producing synchronising impulses, which regulate a reading device and an evaluating device yet to be described. The marking also comprises a group of identifying marks above the plane 17 and in another predetermined area which is in predetermined spatial relationship with respect to the area occupied by the timing marks and which, in this example, is vertically above the area of the timing marks. In this example there are only two identifying marks 13, 14, in the four possible positions. The indicated position of the two identifying marks 13, 14 used as code elements, relative to the timing marks 20 to 23 corresponds to the number 5 in the BCD-code (0, 1, 0, 1). Finally, in the marking shown, a further pair of marks 19, 12 and 24, 15 is provided to the right and left of the areas of the identifying and the timing marks, one mark of each pair being below and one above the plane 17. Each of these pairs of marks is provided for generating a starting signal, which activates a synchronising generator, reading device and evaluating device. The two pairs of marks are disposed on the two sides of the identifying and timing marks, so that the starting signal is produced before the timing marks and code elements enter the reading device, independently of the rotational direction of the vessel.

The markings illustrated as an example enables the numerals 1 to 10 to be represented in BCD-code. In order to increase the range of numerals and for example to constitute the numbers 0 to 99, it is possible simply to arrange two tetrates one after the other. This would mean in practice that, instead of the four timing marks shown, eight such marks would need to be used with one field for a code element associated with each timing mark. It will be understood that in the same way it is also possible for three or more tetrates to be utilised for representing still larger numerals. Each timing mark is used to identify a possible position of an identifying mark.

Instead of the marks shown, which are oval in plan, it is of course also possible for marks which are circular in plan to be used. Because the marks are used as optical lenses and are more effective, the larger their cross-section, the marks are preferably formed as elongate or dash-shaped marks, which act as cylindrical lenses. Fig.3 shows a marking comprising such dash-marks, the dash-marks corresponding to the marks shown in Fig.1 being referenced with the same symbol plus an apostrophe. With this marking system, timing marks in the lower group are joined to an associated identifying mark in the upper group to form a single dash-mark of double the length.

Fig.4 shows diagrammatically a plan view of an apparatus for carrying out the new method and also a block diagram for the reading device and the electronic evaluation device. The apparatus co-operates with a rotational device, not shown, which is disposed in the path of a sorting line and in which a vessel 10 is rotated at least once about its vertical axis of symmetry 26. Rotational devices of this type are known in the art and described, for example, in Swiss Patent Specification 548,599 and 570,912. An illuminating device is disposed to one side of the rotational device and comprises a light source 30 and a condenser lens 31, which generates a substantially parallel light beam. A light shielding block 33 is mounted on the other side of the rotational device. The light shielding block 33 (Fig.5) comprises six channels 34 to 39, which are disposed in two superimposed rows each of three channels 34, 35, 36 and 37, 38, 39. The cross-section of each channel is slightly larger than the cross-section of a mark, for example the mark 20' in Fig.3. The light shielding block is mounted in such a way that the longitudinal direction of the channels lies in substantially the same direction as the light beam produced by the illuminating device 30, 31 and the middle dividing wall 40 between the two rows of channels is substantially the same height as the spacing between the identifying and timing marks shown in Fig.1, as is shown for the light shielding block indicated in broken lines in Fig.2. The result of this arrangement is that light which penetrates through the vessel 10 below the plane 17 falls upon one or more channels of the lower row (37, 38, 39), while light which passes through the vessel above the plane 17 falls upon one or more channels of the upper row (34, 35, 36). With the embodiment shown in Fig.5, each of the channels also has a vertical dividing wall 70 to 75, which subdivides each channel into two narrow channels. The end of each channel nearest the light source is open. The entry end of light transmitters 42 and 47 is introduced into the opposite end of the channels. The light transmitters preferably consist of a fibre optic. The outlet end of each light transmitter 42 to 47 is connected to an associated photodiode 50 and 55 respectively. The signal outputs of the photodiodes 50 and 54, which are connected by the light transmitters 42, 46 respectively to the channels 34, 36 respectively, lead to a gate circuit 57, the output of which is connected to the input of the memory store 60. The signal outputs from the photodiodes 51 and 55, which are connected via the light transmitters 43, 47 respectively to the channels 37, 39 respectively, also lead to a gate circuit 58, which is connected to a further input of the store 60. The signal output of the photodiode 52, which is connected via the light transmitter 44 with the channel 35 and is used for reading the marks provided as identifying code elements, is connected directly with the store 60, and the signal output of the photodiode 53, which is connected via the light transmitter 45 with the channel 38 and is used for reading the timing marks is directly connected to the store 60 and in addition to the input of a counter 61. The output of this counter is also connected to the store 60. From the output of the store, a line 62 leads to one input of a comparator 63.

The rotational device, not shown here, for the vessel 10 contains a switch 65, which is actuated when a vessel enters the rotating device. This switch is connected via a line 66 with the store 60.

In addition, one or more data input devices 68 are provided. Each data input device contains a sensing field, by means of which at least one number can be sensed. The output of each data input device is connected with the input of a multiplexer 69, the output of which is connected to the other input of the comparator 63.

The illuminating device, reading device and electronic evaluating circuit are constructed of conventional components. It lies within the scope of any skilled person to find the most suitable components for a given specific purpose, so that no discussion will be given here on details of the electronic circuit and especially of the construction of the store 60 nor of the control of this store during input and retrieval.

For the following description it will be assumed that a vessel 10 has entered a rotational device and is being rotated about its vertical axis 26. When the vessel enters the rotational device, the switch 65 is actuated, and this resets the store 60, that is deletes all stored signals. It will also be assumed that the vessel is rotated in the direction of arrow 80 and that the marking 11" is situated in the position shown in Fig.4, that is not in the light path between the illuminating device 30, 31 and the reading device 32. The substantially parallel light beam produced by the illuminating device then passes through the vessel wall adjacent to the illuminating device into the vessel and through the vessel wall adjacent to the reading device out of the vessel, the diffraction of the light beam upon entering the vessel being practically compensated by the diffraction as it emerges from the vessel again. Because the channels of the light shielding block 33 are aligned to the direction of the light beam and the direction of the light is scarcely influenced by the vessel, the light-conductors disposed at the rear ends of the channels and thus the associated photodiodes are illuminated relatively uniformly. As already mentioned above, the illuminating of the photodiodes and the electrical signal emitted by these is dependent upon the colour of the glass, thickness of vessel wall and optical quality of vessel wall. It is possible for both the mean value of the illumination and also the temporary deviation from this mean value to undergo relatively large changes, as indicated in Fig.6 diagrammatically for the periods T1, T3 and T5.

When the vessel 10 has rotated into a position in which a part of the emerging light passes through the marks of the marking, this part of the light is diffracted onto a convergence point or convergence region as a consequence of the lens effect of the marks. When a mark is situated in the light path in front of one of the channels of the light stop block 33, this diffraction has the effect that the light diverging again after the convergence point or region does not fall upon the light conductor disposed at the rear end of the channel or upon the associated photo-diode, but upon the walls of the channel, where it is absorbed. When a mark passes in front of a channel, the illumination of the associated photodiode is therefore interrupted, and the output signal from the photodiode drops to zero, as indicated in Fig.6 for the time intervals T2 and T4. In order that light which is only slightly diffracted shall not reach the rearward end of the channel, but instead shall be absorbed by a wall, the width of each channel, in one preferred embodiment of the light shielding block, is sub-divided by a central partition 70 to 75. For the evaluation of the electrical signals generated by the photodiodes, it is then only necessary to set a threshold value detector to a predetermined value, for example to the value *S* indicated by a broken line in Fig.6, and only to further process those signals which fall below this threshold value. In this way, the signals produced by the marks of the marking are not influenced by the unavoidable fluctuations in the illumination of the photodiodes which occur as light passes through the unmarked parts of the vessel walls.

As already mentioned above, the pairs of marks 12, 19 and 15, 24 are provided for activating the reading device 32 and store 60. When the vessel is rotated in the direction indicated by arrow 80, the pair of marks 12, 19 appears first in front of the channel 34, 37. In accordance with the above explanations, the output signals from the two photodiodes 50 51 then fall below the threshold value, and the memory store 60 is activated. If the vessel is rotated in the direction opposite to arrow 80, then the pair of marks 15, 24 appears first in front of the channels 36, 39, which causes the store 60 to be activated by the output signals from the two photodiodes 54, 55. The store then remains activated until, when the next vessel enters the switch 65 is actuated and supplies a restoring signal. This means that all signals produced by the photodiodes 50, 51 or 54, 55 after activation of the store do not have any effect.

As the vessel rotates further in the direction of the arrow 80, the marks 12, 19 appear in the light path in front of the channels 35, 38 respectively, so that the associated photodiode 53 produces a first synchronising signal, which is conducted to the store 60 and to the counter 61. The store is so adjusted that the code signal associated with the first synchronizing signal is not stored. The counter 61 counts the first synchronising signal. When, with further rotation, the timing mark 20 appears in the light path before the channel 38, the photo-diode 53 again produces a synchronising signal, while the photodiode 52, subject to unchanged illumination due to the absence of an identifying mark, produces no signal. The synchronising signal is counted in the counter 61 and has the effect in the memory store that the code element zero is stored in the storage cell associated with this second synchronising signal. As the vessel revolves further, the timing mark 21 and the identifying mark 13 then appear in front of the channels 38, 35 respectively. The third synchronising impulse produced by the mark 21 is again counted in the store 61 and has the effect that the code element 1 produced by the mark 13 is stored in the storage cell associated with the third synchronising signal.

With the marking system selected as example, when the marks 22 and 14, 23 pass before the channels 35 and 38 of the light stop block, the same operations are initiated as described above for the marks 20 and 13, 21. Because the marking system selected as example contains four code elements, the counter 61 is so adjusted that after the fifth synchronising signal (the first synchronising signal from the "start" mark 19 and the four synchronising impulses produced by the synchronising timing marks 20 to 23) it blocks the store input and at the same time conducts the contents of the memory store via the conductor 62 to the one input of the comparator 63.

It will be understood that when marking comprising several tetrates of code elements are used, the counter can be adjusted accordingly.

When vessels having a specific ordinal number are to be sorted out, then this ordinal number is fed into the input device 68. The device converts the input ordinal number into the same code as is used for marking the vessels, so that the comparator 63 can compare the two codings. In an embodiment tested in practice, a multiplexer 69 is connected between the input device 68 and comparator 63. This arrangement enables a number of ordinal numbers to be fed into the input device 68 and to be stored there, and the ordinal number read off from the vessel to be compared with the several ordinal numbers fed into the input device. If the ordinal number read off from the vessel agrees with the ordinal number or one of the ordinal numbers fed into the input device, then a signal appears at the output 82 of the comparator. This signal can be used in known manner for rejecting the corresponding vessel out of the sorting line.

In one arrangement, already tested in practice, of the method of the invention for identifying the mould in which a glass vessel has been moulded, the marking shown in Fig. 7 is used. This marking comprises two tetrates 85, 86 for coding the mould number, and the timing marks 87, 88 used for generating the start signal and formed identically to the eight timing marks 89. With this marking system also, the eight timing marks 89 are disposed below the plane 84 and between the two marks 87,88, provided for triggering the start signal. The identifying code elements of the two tetrates 85, 86 disposed above the plane 84 are constituted as vertical extensions of the timing marks 89. As in the marking system already described, each code element shaped as a cylindrical lens corresponds to a binary "1" and the undeformed vessel wall to a binary "0". The vessel number shown as an example in Fig.7 by the two tetrates 85, 86 corresponds, when reading from the mark 87 towards the mark 88, to the number 35 in BCD code. Each of the marks used for generating the start signal and of the timing marks is constructed as a cylindrical lens and projects about 0.35 mm from the vessel wall. These marks have a height of about 3.5 mm. The width of the marks and the spacing between two adjacent marks are about 1.1 mm. The marks of the identifying code elements possess the same cross-section as the timing marks, but their height is only about 2.5 mm.

The light shielding block used for reading the marking described is shown in Fig.8. This light shielding block is shown considerably enlarged by comparison with the marking illustrated in Fig.7, for clarity of understanding. The light shielding block 91 comprises five light shielding channels 92 to 96. Channel 92 is provided for the timing marks and channel 93 for the identifying code elements. Because the marks 87, 88 provided for triggering the start signal are not higher than the timing marks, the light shielding block possesses, for each of these marks also, only one channel 94, 95, respectively, disposed at the level of channel 92. The fifth channel 96 is disposed at such a height that the light falling upon it is not influenced by the marking. The use of this fifth channel will be described below. The cross-section of the channels is substantially smaller than the cross-section of the individual marks measured in the direction of the incident light. The aim of this is to ensure that the light shielding provided by a channel lies as far as possible always in the vicinity of the optical axis of the cylindrical lens formed by the marks. In this way, the diffraction of the light aimed at by the use of the cylindrical lenses is also effectively used when individual cylindrical lenses are displaced to their theoretically determined position or possess an inadequate or defective form. A light shielding block which can be used for the marks described in the foregoing section possesses, for example, channels having a width of about 0.25 mm,a height of about 1 mm and a length of about 10 mm. These channels are preferably formed as saw-tooth slits, the upper and lower open sides of which are covered with thin plates 97, 98 and 99.

Fig.9 shows diagrammatically a lateral view of a vessel 100 in the reading position, an illuminating device 101 and the light shielding block 91 with associated photodiodes. As already described earlier, the marking is disposed in the region of the lower reduced diameter part of the vessel so that the marks do not get damaged when vessels strike one another. In order that the marks used as optical lenses shall as far as possible be perpendicular to the axis 102 of the light beam, the illuminating device 101 is appropriately inclined. The light shielding block 91 has the same inclination in order that the individual channels shall extend in the direction of the non-diffracted light. On the side of the light shielding block remote from the vessel a support plate 105 is disposed. The distance between light shielding block and support plate is about 2 mm. On the support plate small collector lenses are mounted in the direct extensions of the channels of the light shielding block; of these, only the lenses 106, 107 and 108 can be seen in Fig.9, these being associated with the channels 96, 93, 94. These lenses collect the light arriving through the corresponding channel and conduct it to an associated photodiode 110, 111 and 112, respectively. With this arrangement of the photodiodes in the direct vicinity of the channels of the light shielding block, the use of additional light conductors between channel and photodiode (as described for the embodiment of Fig.4) is not necessary.

The evaluation circuit connected after the photodiodes corresponds to the circuit shown in Fig.4 with the difference that the gate circuits 57, 58 are not required.

The method of operation of the photodiodes associated with channels 92, 93, 94 and 95 is the same as that for the photodiodes 53, 54, 50 and 54, respectively, as already explained with the help of Fig.4, so that further description will not be given here.

As already mentioned above, the channel 96 and the photodiode 110 associated with it are so arranged that the light falling upon them is not influenced by the markings. The photodiode 110 is used as an actual value emitter (reading emitter) in a control circuit not shown here which regulates the voltage to the light source in the illuminating device. The result of this arrangement is that the density of illumination upon the photodiodes remains virtually constant independently of changes in the thickness or colour of the vessel wall or of the aging of the light source over long periods of time. Suitable control circuits for this purpose are known to any skilled person, so that a description of same will not be given here.

As practical testing has demonstrated, it is possible for the markings described to be read with the reliability required for industrial purposes from a glass vessel of 60 mm diameter even at the circumferential speed of 3.5 m/sec which is usual in the stations of a sorting line.

It will be understood that the light shielding block and support plate for the photodiodes are incorporated in a light proof housing. In order to prevent excessive heating of the photodiodes and accummulation of dirt in the light shielding channels, cool pressurized air can be introduced into the housing, flowing out through the channels. It will also be understood that the illuminating device and the light shielding block together with the photodiodes are preferably mounted to be adjustable in height and for pivotal movement in order that the device can be utilized for vessels of differing dimensions.

As already described in the introduction of this application, the reliability of reading of the identifying code elements and timing marks is adversely affected by the properties of the vessel wall. For instance, steeply domed bottoms of bottles cause deflection of the entire light beam. This total deflection can be greater than the partial deflection caused by the markings, in which case the markings do not produce in the reading device a difference in illumination which can be evaluated. Furthermore, the capability for evaluation of the differences in illumination produced by the marking on the photodiodes of the reading device is dependent upon the transparency of the vessel wall. When light shines through the lateral walls of a vessel, the reliability of a reading decreases when the light beam is displaced from the maximum vessel diameter towards the vessel edge. It will also be understood that faults in the vessel wall, for example bubbles or cords, can produce fault signals in the reading device which cannot be distinguished from the signals caused by markings.

The above discussed sources of errors may be avoided by illuminating the markings in incident light and detecting changes in the reflected light. Reading in incident light enables markings to be read with high reliability, uninfluenced by the transparency of the material of the vessel, by the curvature of the vessel wall carrying the markings and by possible faults in the glass. It is also not necessary for the light beam which is used for illuminating the vessel wall carrying the markings to be directed towards the axis of the vessel. The improved apparatus for this purpose can be constructed as simply as the device previously described, but has the advantage that it requires less room than the previous device and can therefore be added more simply to already existing testing equipment.

Such an improved device is shown diagrammatically in plan in Fig.10 and includes a rotating device (not shown) for rotating a vessel 10' about its axis of symmetry 26'. Furthermore, an illuminating device 29 is provided, comprising a light source 30' and condenser lens 31'. In this embodiment, the illuminating device is so disposed that the emerging or reflected light beam is in a plane situated transversely to the axis 26' of rotation and symmetry of the vessel 10'. The illuminating device can be pivoted in this plane and displaced in the direction of the light beam in order to illuminate on the peripheral circle of the vessel on which the marking 11' is disposed a region having a diameter somewhat larger than the height of the two-part marking, in the example described about 12 mm (for a height of about 7 mm for the two-part marking shown in Fig.3). The illuminating device is also adjustable in height in order to illuminate markings disposed at different levels on the vessel wall. The device further contains a light shielding block 33' into which light conductors are introduced as shown in Fig.4. Instead of the light conductors, photodiodes may be inserted in the light shielding block. In front of the light shielding block of projection optic 41 is disposed, which images the region of the vessel wall illuminated by the light source onto the inlet ends of the light conductors or directly onto the appropriate photodiodes. The optical axes of the projection optic and of the light shielding block lie in the same plane as the illuminating device. The angle α between the optical axis is, in a preferred embodiment, about 70°, as will be described in more detail below.

As any skilled person will readily understand, it is possible without difficulty to arrange the illuminating device and projection optic and also the light shielding block in such a manner that a marking at the mouth of the vessel can be illuminated and imaged in the light shielding block. With an embodiment of this type, the optical axes of the illuminating device and projection optic lie practically on a conical surface.

It is, of course, also possible so to arrange the illuminating device and the projection optic together with the light shielding block that a marking disposed upon the bottom of the vessel is illuminated and imaged in the light shielding block. If the bottom of the vessel is flat, the corresponding optical axes then lie practically on a cylindrical surface.

Fig.11 shows a greatly enlarged, horizontal section through a part of a vessel wall and three code elements or timing marks 120, 121, 122 projecting from this wall. As can be clearly seen in this figure, the code elements or timing marks possess a circular arc shaped cross-section which is, however, definitely less than a semi-circle. (Practical experience has shown that code elements and timing marks with this type of cross-section are more simple to mould than semi-circular or semi-spherical elements.) This light from the illuminating device falling obliquely onto the vessel wall, the direction of which is, for example, along line 123, is according to known laws to a major portion refracted into the vessel wall (line 123') and to a minor portion reflected in the direction of line 124, without reaching the reading device. The light incident in the same direction, corresponding for example to line 126 and striking one side of code element 121, is also to a major portion refracted on the vessel wall (line 126') and to a minor portion reflected. Depending upon the direction of the tangent line of the reflecting area of the code element this reflected light has the direction for instance of line 127. A chord 128 can be associated with the curvature of the part of the code element towards the incident light, which chord connects together the transition between the vessel wall and code element and the furtherest projecting point of the code element. In the example shown, this chord is at an angle β of about 35° to the tangent 129 to the vessel wall in the region of the code element 121. Although the incident light is reflected and possibly diffusely reflected or scattered in a plurality of directions on the convex surface of the code element, this reflecting surface may be replaced, to a coarse approximation, by the chord 128 and if, as shown in Fig.10, the optical axis of the projection optic and of the light shielding block intersects the vessel axis, that is to say it is perpendicular to the tangent 129, then it is to be expected that an optimum quantity of light will be reflected into the reading device if the angle α between the optical axes of the illuminating and reading devices is virtually 70°.

Practical experience hitherto has confirmed this argument. The markings can be read with the necessary reliability if the angle between said optical axes lies in the range between 60 and 80°.

As shown in Fig.11 each illuminated code element not only acts as a reflector but produces a shadow region 130 in the immediate vicinity of the reflecting area. The sharp transition from the reflecting area to the shadow region improves the edge steepness of the read signal and therefore the reliability of the signal detection.

Fig.12 shows diagrammatically the illumination of the input surface of a light conductor or a photodiode of the reading device as a vessel is rotated in the direction indicated by arrow 131. During period T_a the vessel wall between code elements 120 and 121 is illuminated. As already described above, the light reflected from the vessel wall does not reach the reading device. On account of the light shielding block 33', which almost completely excludes all unintentional diffusely reflected and scattered light, the illumination of the photodiodes during this period is practically zero. During the subsequent period of time T_b the side of the code element 121 facing towards the incident light is illuminated and light is reflected into the reading device. Because the reflecting surface of the code element does not correspond to the above assumed chord 128 but is a circular arc, the direction of the reflected light lies for only a very short period in the optimum direction along line 127. A brief consideration will show that the illumination of the photodiode with reflected light at first increases slowly and then very rapidly, reaches a maximum value and again falls rapidly off before period T_b has ended. Then, during the passage of the unilluminated side of code element 121 and the vessel wall between the two code elements 121 and 122 there follows a period T_c, during which the photodiode is not illuminated. When code element 122 enters the region of the light beam from the illuminating device the same process is repeated during a period T_d, as that already described for period T_b.

When a marking is read by light transmitted through the vessel according to Figs. 4

and 6 the reading device is illuminated in the absence of markings and becomes darkened when a marking interferes with the light beam. When reading a marking in incident light the reading device which is unilluminated in the at-rest state becomes illuminated. As any skilled person will readily understand, the corresponding output signal of the reading device can be reversed by simple electronic means, so that the electronic evaluation of the signals described with reference to Fig.4 can also be used when reading with incident light.

In accordance with the above considerations and the discussion of the illuminating of the photodiodes with reference to Fig.12 it will also be understood that a substantially rectangular reading signal having a large signal amplitude is obtained if instead of the described code elements having a circular arc cross-section code elements having a practically triangular cross-section are used.

Although in the embodiment as described in connection with Fig.10 the optical axis of the reading device intersects the axis of rotation of the rotating device, it will be understood that the reading with incident light is also possible if the optical axis of the reading device is laterally offset with respect to the axis of rotation of the rotating device (and of the vessel).

It further will be understood that the described new process may be used with the same advantage if the marked vessels are not rotated but simply advanced in a rectilinear or bent conveyor path in front of the reading device, while the marking is directed towards this reading device. This embodiment of the new method is specially suitable for reading the marking on vessels with rectangular cross-section.

WHAT WE CLAIM IS:

1. A method of identifying a moulded vessel with the mould from which it is produced which comprises moulding into the wall of the vessel of a group of identifying marks within a first predetermined area and a group of timing marks within a second predetermined area having a predetermined spatial relationship with the first area whereby the timing marks identify the spatial distribution of the identifying marks within the first predetermined area.

2. A method according to Claim 1 which comprises simultaneously advancing said first and second predetermined area through a light beam at a reading location, detecting interference with the light beam by the sequential passage of each timing mark and the sequential passage of each identifying mark through said location and generating a sequence of timing signals corresponding to the timing marks and an identifying signal corresponding to each identifying mark and detecting the coincidence in time of each identifying signal with a timing signal to provide an output signal representing the spatial distribution of the identifying marks in the first predetermined area.

3. A method according to Claim 2 in which interference with the light beam is detected by detecting changes in the reflection of the light beam from said first and second areas.

4. A method according to Claim 2 in which interference with the light beam is detected by detecting changes in the transmission of the light beam through said first and second predetermined areas.

5. Method of identifying the mould in which a vessel made from an optically transparent material has been moulded, in which method moulds having an individual marking suitable for imprinting onto the vessel comprising relief-like elements are used, and in which the vessel for the purpose of identifying the mould is moved relative to a reading device, is illuminated at least in the region of the moulded marking and the diffraction or reflection of the light caused by the elements of the marking is evaluated, characterized in that a multi-part marking is used, two parts of which are disposed upon opposite sides of a line oriented in the direction of movement, the one part containing code elements suitable for constituting at least one symbol in a digital code, and the other part containing timing marks which are provided for the purpose of generating timing impulses suitable for the sequential reading of the code elements.

6. Use of the method according to Claim 5 for the purpose of identifying the mould in which a glass vessel has been moulded.

7. Method according to Claim 1, characterized in that the markings are read in incident light.

8. Method according to Claim 5 or 7, characterized in that code elements of substantially triangular cross-section are used.

9. Method according to Claim 5 characterised in that code elements and timing marks are used which are constituted as dash-shaped deformations projecting from a vessel wall disposed transversely to the direction of movement and acting like cylindrical lenses upon light passing through them.

10. Method according to Claim 9 characterised in that those code elements and timing marks which are disposed upon the same straight line extending transversely to the direction of movement are combined into a single element or a single mark.

11. Method according to any one of Claims 5 to 10 characterised in that a three-part making is used, the third part of which is constituted of at least one mark disposed ahead of the first and second parts in the direction of movement of the vessel, which mark is provided for the purpose of generat-

ing a signal activating the reading and evaluating device.

12. Method according to Claim 5 characterised in that, for the purpose of evaluating the diffraction of the light caused by the elements or marks of the marking, a reading device is used which is so arranged and constituted that it is illuminated during the absence of an element of a mark from the light path and is darkened during the passage of an element or a mark through the light path.

13. Apparatus for carrying out the method according to Claim 5 comprising an illuminating device suitable for generating a light beam oriented to a reading location, a device for supporting the vessel and for transporting the vessel wall furnished with the marking through the reading location and parallel to the line separating the two parts of a marking and a reading device comprising at least two photo-elements, one of which is provided for reading the code elements at the reading location and the other for reading the timing marks at the reading location, the illuminating and reading devices (29, 41, 33') being disposed on the same side of the supporting and transporting device.

14. Apparatus according to Claim 13 characterised in that for reading a marking on a vessel with a rectangular cross-section the supporting and transporting device is a conveyor means with rectilinear or a bent conveyor path.

15. Apparatus according to Claim 13 characterised in that the supporting and transporting device is a rotating device and that the optical axes of the illuminating and reading devices (29, 41, 33') are disposed in the same plane oriented transversely to the rotational axis (26') of the rotating device or in conical or cylindrical surfaces disposed symmetrically to the rotational axis.

16. Apparatus according to Claim 13 characterised in that the supporting and transporting device is a rotating device and that the optical axis of the reading device (41, 33') intersects the rotational axis (26') of the rotating device or extends parallel thereto and the optical axis of the illuminating device (29) intersects the optical axis of the reading device practically in the surface intended for the passage of the marking (11').

17. Apparatus according to Claim 15 characterised in that the angle between the optical axes of the reading and illuminating devices (29, 41, 33') lies in the range between 60 and 80° and preferably in 70°.

18. Apparatus according to Claim 13, characterized in that the at least two photo-elements (52, 53) provided for the purpose of reading the code elements and timing marks are disposed one above another and that at least one further photo-element (50, 51, 54, 55) provided for the purpose of reading an activating signal is disposed laterally thereof.

19. Apparatus according to Claim 13, characterized in that a tubular light shield (34-39) is associated with each photo-element (50-55) of the reading device, which light shield permits passage only of light which is incident virtually parallel to the longitudinal direction and absorbs obliquely incident light.

20. Apparatus according to Claim 13, characterized in that at least two photo-elements (50-55) of the reading device are disposed separately from the associated tubular light shield (34-39) and in that light conducting means (42-47) are provided for transmitting the light passing through the light shields to the associated photo-element.

21. A method of identifying a moulded vessel with the mould from which it is produced substantially as herein described with reference to Figs. 1 to 6, Figs. 7 to 9 or Figs. 10 to 12 of the accompanying drawings.

22. Apparatus for identifying a moulded vessel with the mould from which it is produced, constructed, arranged and adapted to operate substantially as herein described with reference to Figs. 10 to 12 of the accompanying drawings.

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1580735 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

Fig. 1

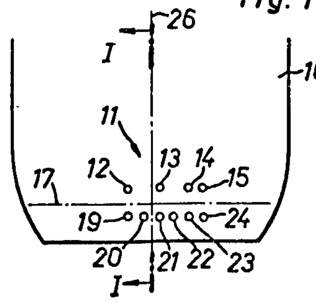


Fig. 2

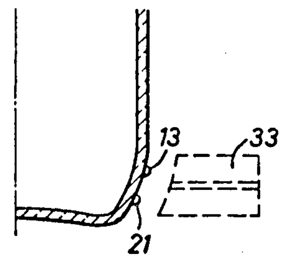


Fig. 3

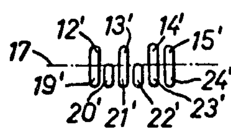


Fig. 4

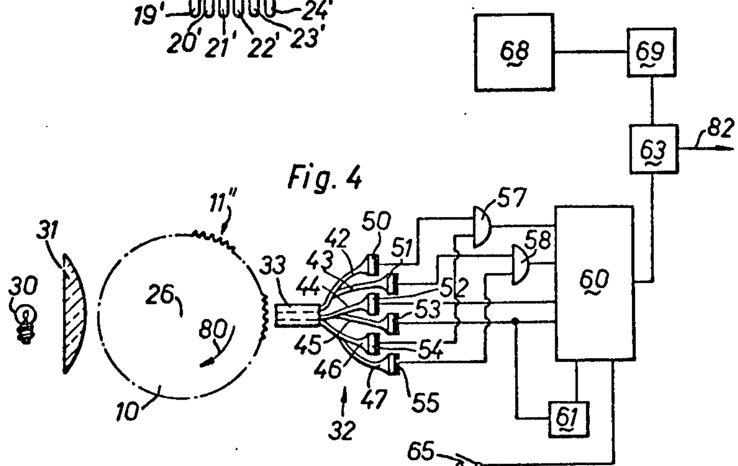


Fig. 5

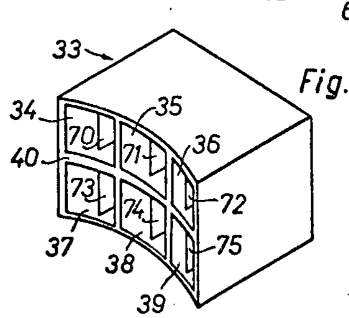


Fig. 6

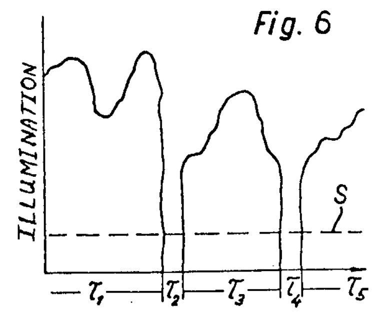


Fig. 7

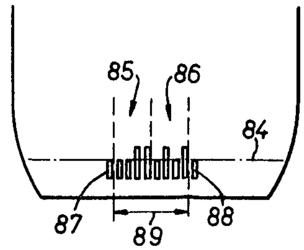


Fig. 8

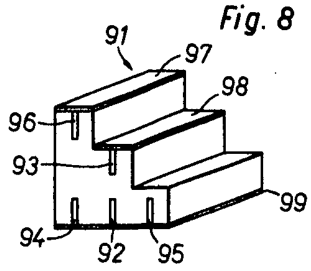
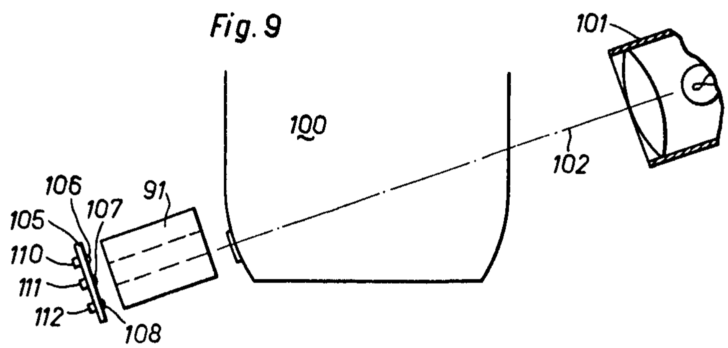


Fig. 9



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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

Fig. 10

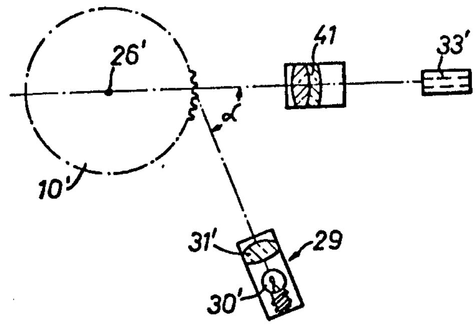

Fig. 11

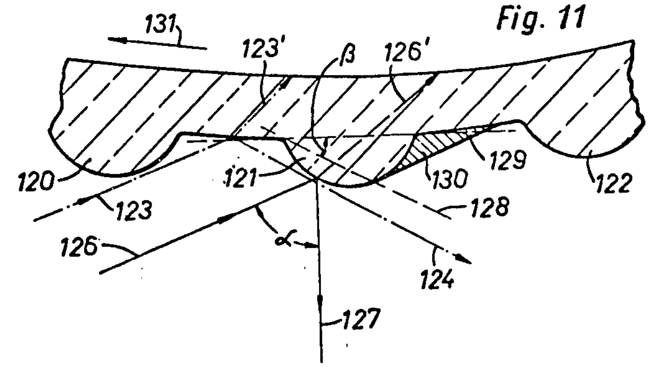

Fig. 12