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(54) **Machine for sorting plastic bottles as a function of their plastic composition in order to recycle the same.**

(57) An apparatus and a method are disclosed, for use to sort objects such as bottles, made of different transparent or translucent plastic materials according to the kind of plastic material of which these objects are made. The method consists in producing a beam of U.V. light and subjecting each object to be sorted to this beam in a detection zone, and detecting the intensity of the beam transmitted by the object at different wavelengths selected within a range encompassing the "cut-off wavelengths" of the different plastic materials to be sorted, the cut-off wavelength being the wavelength known per se and specific to each plastic material, above which the coefficient of light transmission through the plastic material, dramatically increases. By comparing with each other the values of the intensity detected at said different wavelengths, one can determine the cut-off wavelength of the plastic material of which the object subjected to the beam is made, and thus identify this plastic material. This method makes it possible to industrially recycle reject objects made of different plastic materials, which has proved to be very difficult to do up to now.

BACKGROUND OF THE INVENTION**a) Field of the invention**

5 The present invention relates to a method for sorting objects such as bottles or containers, at least two different transparent or translucent plastic materials, according to the kind of plastic materials these objects are made of.

The invention also relates to an apparatus for use to carry out this method.

b) Brief description of the prior art

It is known that a very large number of plastic bottles or containers are sold and disposed off every day throughout the world. Because these reject plastic bottles or containers are not biodegradable, they constitute a substantial source of pollution.

15 It has already been suggested to recover the plastic materials of which they are made, which materials are usually P.V.C., P.E.T. (polyester), polystyrene, polypropylene or polyethylene, in view of recycling them. The major problem however with such a recovery is that, on the one hand, it is very difficult to distinguish most of the existing plastic materials from each other and that, on the other hand, P.V.C., P.E.T., polyethylene and polypropylene must be separated from each other to make their recycling possible and economically viable.

20 Accordingly, there is presently a great need for a method for use to sort reject plastic bottles or containers according to their plastic compositions, in order to separate, for example, P.V.C. bottles or containers from P.E.T. and other plastic bottles or containers, and thus make recycling of these rejects possible.

Different methods and apparatus are presently being known, for use to sort objects made of different transparent or translucent materials according to the kind of material of which they are each made.

25 By way of example, U.S. patent No. 4,919,534 granted to ENVIRONMENTAL PRODUCTS CORP. discloses an apparatus for sorting bottles made of transparent material, in view of separating those made of plastic material, especially P.E.T., from those made of glass. The differentiation between glass and plastic is achieved by optical means whose operation derives from the fact that glass does not affect the polarization of a beam of light passing therethrough, contrary to plastic which does affect the polarization of such a beam. The apparatus disclosed in this patent No. 4,919,534 is certainly efficient to differentiate glass from any kind plastic material. However, it is of no use to differentiate different plastic materials from each other.

30 U.S. patent No. 4,663,522 to SPANDREL ESTABLISHMENT discloses an apparatus for detecting the kind of material of which an object is made, which comprises optical means for measuring the intensity of the radiations scattered in a forward direction into one or more conceptual hollow cones of appropriate angles when the object to be sorted is subjected to a light beam.

35 U.S. patent Nos. 3,802,558 to SORTEX COMPANY OF NORTH AMERICA INC. and 4,513,868 to GUNSON'S SORTEX LTD. both disclose an apparatus for sorting particles such as glass beads, grains of rice, and the like, which comprises optical means to measure the ability of each particle to transmit, reflect or emit visible light in a predetermined part of the spectrum. In U.S. patent No. 4,513,868, sorting is carried out by detection of light coming from the object and having any undesired character. In U.S. patent No. 3,802,558, sorting is carried out according to the transparency and the color of the particles. None of these patents suggests that it is possible to use the apparatus disclosed therein to sort different kinds of plastic materials.

40 As of interest also are U.S. patent Nos. 3,067,862 to ANCHOR HOCKING GLASS CORPORATION and 4,379,636 to HAJIME INDUSTRIES LTD., which both disclose an apparatus for inspecting objects in order to detect defects therein. Both of these documents comprise optical means to measure light refraction, diffraction and/or diffusion of each object to be inspected, when this object is subjected to a beam of light. None of them however are directed to the sorting of objects made of different materials, and more particularly objects made of different plastic materials.

50 OBJECTS AND SUMMARY OF THE INVENTION

An object of the present invention is to provide method for sorting objects made of different transparent or translucent plastic material according to the kind of plastic materials these objects are made of, which method is very simple and efficient, very easy to scale up for operation in an industrial scale, and particularly well adapted for use sorting bottles or containers made of P.V.C., P.E.T. and other conventional plastic materials, in view of recycling them.

Another object of the present invention is to provide an apparatus for carrying out this method, which apparatus is essentially optical and made of readily available components, which does not contain any moving

elements and is of a low cost to manufacture, aside which, whenever desired, can be easily connected to a mechanical or pneumatical sorting device to cause automatic sorting of the objects being processed according to the kind of plastic material they are made.

The machine, method and apparatus according to the invention are essentially optical and take advantage of a "natural" property of any transparent or translucent plastic material, namely to have a specific wavelength in the U.V. band, called "cut-off wavelength", above which the coefficient of light transmission of the material dramatically increases when this material is subjected to a beam of light. The cut-off wavelength where such a "step" in light transmission may be noticed is quite different from one plastic material to another and can be said to be specific to each kind of plastic material although there can be some variations in the value of the cut-off wavelength of a given plastic material depending on some factors, such as the thickness of this material.

In the following table, typical cut-off wavelengths of different transparent or translucent plastic materials commonly used in the industry are given, together with some examples of products available on the market, which are made of such plastic materials.

15

TABLE

Plastic material	typical cut-off wavelength (nm)	examples of products made of such material
polyethylene	192	ZIPLOC bag, bottle of milk
polystyrene	280	pull box
natural P.V.C.	302	bottles of CRISCO oil or WINDEX
P.E.T.	315	bottles of COCA- COLA, PEPSI, LESTERINE or NAYA water
UV-protected P.V.C.	340	bottles of VICHY or LABRADOR water
green P.E.T.	400	bottles of CANADA DRY, SEVEN UP, SPRITE

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As aforesaid, the method and apparatus according to the invention take advantage of this cut-off wavelength property to detect the kind of plastic material from which are made objects such as reject bottles or containers, passing between a source of U.V. light and detecting means that may consist of a set of sensors each adjusted to a given wavelength and if desired, to sort the objects as a function of the transmission signal(s) detected by the sensors.

In practice, the sensors may be adjusted to give signals indicative of light transmission at different increasing wavelengths. If, for example, bottles of natural P.V.C. and polyethylene have to be sorted, use can be made of a first sensor adjusted to any value between 192 and 302 nm, say 200 nm, to differentiate between these two plastic materials provided however that there are no opaque bottles. Indeed, any signal indicative of some light transmission given by the first sensor will indicate that the bottle being sensed is made of polyethylene.

If no signal indicative of some light transmission is given by the first sensor when a bottle intersects the beam, this will indicate however that the bottle being sensed is made of natural P.V.C. Of course, other sensors may be used in combination with the first sensor to detect the presence or absence of bottles and to normalize the signals.

5 As aforesaid, a mechanical or pneumatic sorting device can be connected to the apparatus. This device may consist of blowers activable to push the object being sensed into a given bin as is known from U.S. patent Nos. 3,802,558; 4,513,868 or 4,663,522, or of flaps or baffles to mechanically direct the object into a given chute.

10 Since the differentiation between the different plastic materials is made by determination of the coefficient of transmission of these materials, it is obvious that the objects to be sorted must be transparent or translucent within the range of U.V. wavelengths where the measurement is carried out.

The apparatus and method according to the invention can be devised however to make it possible to identify as such any opaque material, such as metal or opaque plastic, and to sort it out.

15 More particularly, the present invention as broadly claimed hereinafter is directed to an apparatus for sorting objects made of at least two different transparent or translucent plastic materials according to the kind of plastic materials these objects are made of, each of these different plastic materials having a light transmission coefficient which dramatically increases above a given wavelength in the U.V., such a given wavelength known "per se" being called the "cut-off wavelength" and being a characteristic of the plastic material, the apparatus comprising:

20 – means to produce a beam of U.V. light; and
– detecting means spaced apart from the beam producing means and positioned to receive the U.V. light beam, the detecting means giving signals proportional to the intensities of the received beam at different wavelengths selected within a range encompassing the known cut-off wavelengths of the different plastic materials,

25 whereby, in use, each object to be sorted is inserted between the beam producing means and the detecting means in such a manner as to intersect said U.V. light beam and the signals given by the detecting means at said different wavelengths are compared with each other to determine the cut-off wavelength of the plastic material of which said inserted object is made, and thus to identify this plastic material.

30 The present invention as broadly claimed hereinafter is also directed to a method for sorting objects made of at least two different transparent or translucent plastic materials according to the kind of plastic materials these objects are made of, each of these different plastic materials having a light transmission coefficient which dramatically increases above a given wavelength in the U.V., such a given wavelength known per se being called the "cut-off wavelength" and being a characteristic of the plastic material, which method comprises the steps of:

35 – producing a beam of U.V. light;
– subjecting each object to be sorted to this beam in a detection zone;
– detecting the intensities of the beam transmitted by the object in the detection zone at different wavelengths selected within a range encompassing the known cut-off wavelengths of the different plastic materials, and

40 – comparing with each other the intensities detected at said different wavelengths to determine the cut-off wavelength of the plastic material of which the object subjected to the beam is being made, in order to identify this plastic material.

BRIEF DESCRIPTION OF THE DRAWINGS

45 Other objects, advantages and applications of the present invention will be better understood upon reading of the following, non restrictive general description of the invention, given with reference to the accompanying drawings in which:

50 Fig. 1 is a curve giving the coefficient of light transmission of different plastic materials as a function of wavelengths ranging from 270 to 360 nm and showing how one can determine the cut-off wavelengths of these different plastic materials in view of differentiating them; and

Fig. 2 is a block diagram of an example of apparatus according to the invention.

GENERAL DESCRIPTION OF THE INVENTION

55 The apparatus according to the invention as shown in Fig. 2 is intended to be used for sorting objects made of a number "n" of different transparent or translucent plastic materials according to the kind of plastic material of which each of the objects to be sorted is being made, such as P.V.C., UV-protected P.V.C., polystyrene,

polyethylene, polypropylene or P.E.T. As was explained hereinabove, each of these n different plastic numbered 1, 2...i... n in Fig. 1 has a light transmission coefficient which dramatically increases above a given wavelength in the U.S. This given wavelength which is called the "cut-off wavelength" and identified as $\lambda_1, \lambda_2, \dots \lambda_i \dots \lambda_n$ in Fig. 1, is a characteristic of each plastic material.

Basically, the apparatus according to the invention comprises means to produce a beam of U.V. light and detecting means spaced apart from the beam producing means and positioned to receive the U.V. light beam. The beam producing means includes a U.V. light source 11 and a beam conditioning device 13 known per se, which are both selected to generate a beam partly composed of U.V. light, made up of wavelengths ranging from, say, 150 to 1,000 nm. The detecting means whose function is to give signals proportional to the intensity of the received beam at different wavelengths selected within a range encompassing the cut-off wavelengths of the different plastic materials, may comprise:

- means 15 to split the received light beam into a plurality of sub-beams;
- means $F_0, F_1, F_2 \dots F_i \dots$, that may consist of interferential filters, gas cells or dispersion elements, to filter each of these sub-beams at one given wavelength different from the wavelengths at which the other sub-beams are filtered; and
- a light intensity sensor or detector $S_0, S_1, S_2, S_i \dots S_n$ associated to each of the filtering means to give a signal proportional to the intensity of the sub-beam filtered by the associated filtering means.

Advantageously, the splitting means 15 is adapted to produce a number of sub-beams at least equal to the number " n " of different plastic materials to be identified, plus one. One of the filtering means hereinafter called "first filtering means" which is identified as F_0 in Fig. 2, is also adapted to filter the sub-beam it receives from the splitting means 15 at a wavelength which is lower than the lowest cut-off wavelength of the different plastic materials to be identified. In operation, the signal given by the detector D_0 associated to the first filtering means F_0 is used as an indication of the presence or absence of an object to be sorted intersecting the U.V. light beam.

Another filtering means hereinafter called "second filtering means", is adapted to filter the sub-beam it receives from the splitting means 15 at another wavelength which is higher than the highest cut-off wavelength of the different plastic materials to be identified, in order to produce, via the associated detector, a normalization signal.

The wavelength at which this second filtering means is adapted to filter the sub-beam it receives from the splitting means 15 to produce the normalization signal, may in practice be a wide band of wavelengths whose upper limit is higher than the highest cut-off of the plastic material to be detected. This wide band of wavelengths may, in fact, be so wide as to encompass all the band of emission of the light source 11 therefore making it unnecessary to use a filtering element of physical structure as second filtering means, as is shown in Fig. 2 where the associated detector is identified as S_n .

The remaining filtering means $F_1, F_2 \dots F_i \dots, F_{n-1}$ are advantageously adapted to filter the sub-beams they receive from the splitting means 15 at further wavelengths which are respectively comprised between the various pairs of adjacent cut-off wavelengths to be determined.

In practice, the wavelengths at which the first and each of the remaining filtering means $F_0, F_1 \dots F_i \dots$ are adapted to filter the sub-beams they receive from the splitting means 15, consist of narrow bands of wavelengths of, typically, from 5 to 10 nm, hereinafter called $\Delta \lambda_0, \Delta \lambda_1, \Delta \lambda_2, \Delta \lambda_i$, which are respectively centered on the wavelengths of the first and other filtering means, as is shown in Fig. 1.

All the detectors $S_0, S_1, S_2 \dots S_i \dots S_n$ are connected to a hardware/software processing unit 16 comprising means 17 known per se for use, to normalize the signals received from all the detectors with the normalization signal received from the detector S_n associated to the second filtering means. The basic purpose of this normalization is to take into account any variation in the opacity of the objects to be sorted, or any lack of uniformity between these objects as will be better explained hereinafter. The processing unit 16 also comprises processing means 19 operatively associated to the normalization means 17 and acting in feedback on all of the detectors. These processing means are devised to synchronize the operation of these detectors when the signal given by the detector S_0 associated to the first filtering means F_0 intersecting the U.V. light beam. These processing means are also devised to process the normalized signals received from the normalization means as will be explained hereinafter, to give a processed signal indicative of the kind of plastic material of which is made the object intersecting the U.V. light beam.

This processed signal can be displayed in any form, i.e. visual or sonorous for us, for "use" by a human operator. However, this processed signal is preferably used to control optional discarding means in the form of a sorting device 21 that can be mechanical and make use of baffles or flaps controllably pistons or solenoids, or be pneumatic and make use of valve-controlled, air nozzles connected to a pressurized air source, to "push" the object "O" leaving the detection zone 14 into a bin, container or chute corresponding to the kind of plastic material of which this object is made.

The discarding means 21 are therefore connected to the processing means 19 and responsive to the processed signal given by this processing means 19 to selectively discard the objects "0" to which processed signals corresponds, into bins corresponding to the kinds of plastic material of which these objects are made.

In use, the apparatus can be made automatic and used to sort many objects per second, provided they are fed at sufficient speed into the detection zone 14. To do so, conveying means 23 can be provided for mechanically bringing the objects "0" to be sorted between the beam producing means and the detecting means, so that these objects successively intersect the light beam and be sorted when they leave the detection zone 14.

As was explained in the preamble of the present disclosure, the apparatus according to the invention is particularly well adapted to sort bottles made of at least two different plastic materials selected from the group consisting of polyethylene, polystyrene, PVC, PET, UV-resistant PVC and green PET.

As was also explained hereinabove, each plastic material comprises a "cut-off wavelength" which is known, easily determinable and specific to it and under which the coefficient of transmission is almost equal to 0. In Fig. 1, these cut-off wavelengths are identified as $\lambda_1, \lambda_2, \dots, \lambda_i, \dots$ and λ_n ; the wavelengths increasing with increasing values of indices.

A narrow band of wavelength $\Delta\lambda_{i-1}$ can be associated to each pair of plastic materials such as materials $i-1$ and i whose cut-off wavelengths $\Delta\lambda_{i-1}$ and λ_i are adjacent. This band $\Delta\lambda_{i-1}$ is located between the cut-off wavelengths λ_{i-1} and λ_i in such a manner that $\Delta\lambda_{i-1}$ is higher than λ_{i-1} but lower than λ_i .

As can be understood, there will always be a band of wavelengths $\Delta\lambda_i$, i being an integer ranging between 1 and n , which all of the plastic materials whose cut-off wavelengths are higher than $\Delta\lambda_i$, will remain opaque. If the object to be sorted does not transmit light as explained hereinabove based on the definition of the cut-off wavelength within the narrow range $\Delta\lambda_i$, this object will necessarily be made of one of the materials $i + 1, i + 2, \dots$ or n .

This, by way of example, if there is no transmission detected in the narrow range $\Delta\lambda_{n-1}$, the object is made of material n . If however, the object does not transmit light in the range $\Delta\lambda_{n-2}$, the object is made of either material $n - 1$ or material n . One may then determine of which one of these two materials the object to be sorted is being made, by checking whether the object transmits light in the immediately higher range $\Delta\lambda_{n-1}$.

As aforesaid, the processing means 19 receives and processes all the signals coming from the detectors $S_0, S_1 \dots S_i \dots S_n$ which signals are each associated to a range of wavelengths $\Delta\lambda_0, \Delta\lambda_1, \dots, \Delta\lambda_{n-1}$. The algorithm used in the processing means 19 is adapted to find the first range of wavelengths, say $\Delta\lambda_i$ (starting with the highest i and decreasing), where the object subjected to the U.V. light beam does not transmit light. Of course, the material which the object is made is the one whose cut-off wavelength is immediately superior to this range $\Delta\lambda_i$.

In practice, the objects subjected to the beam may have different shapes, thickness, texture, uniformity, etc., especially when these objects are rejects. To take into account these variations, a plurality of readings can be made at different locations of every object while the same is moving across the light beam, and all these readings can be correlated for validation purposes the kind of material of which the object is made, being actually determined from a statistic evaluation on all these readings.

In order to further improve the efficiency of the device, all the intensities that are detected by all the detectors within the measurement ranges $\Delta\lambda_0, \Delta\lambda_1, \dots, \Delta\lambda_i, \dots$ and $\Delta\lambda_n$ can be normalized with the signal received from the detector S_n which is preferably adapted to work on a broad range of wavelengths encompassing the cut-off wavelengths of all the plastic materials to be identified.

As can be understood, $n - 1$ of the $n + 1$ detectors are used to identify the n materials forming the objects to be sorted. The remaining detectors are those identified as S_0 and S_n in the drawings. Detector S_n gives a signal that is used for normalizing the signals from the other detectors. Detector S_0 gives a signal corresponding to the transmitted intensity in the narrow range $\Delta\lambda_0$ which is lower than the lowermost cut-off wavelengths of the different plastic material to be identified. The purpose of this detector S_0 is essentially to detect whether there is an object intersecting the light beam where the measurements of the other detectors are being made. Indeed, the detector S_0 will never give a signal if there is an object intersecting the beam, since all the materials of which these objects are made, "read" as being opaque in the $\Delta\lambda_0$ range. Of course, this particular property can also be used for synchronizing the operation of all the detectors as was explained hereinabove.

In order to provide permanent updating of the apparatus and take into account any variation in the intensity of the light source 11, correcting means (not shown) may be incorporated into the electronic of the apparatus. These correction means can use one or more detectors and be programmed to make readings and corrections whenever necessary, during the short intervals that there is no object intersecting the light beam.

Example

An apparatus according to the invention as disclosed hereinabove was devised and tested for sorting bottles made of PVC and PET, respectively. This apparatus comprised a mercury light source (ORIEL® No. 6513), a lens acting as beam conditioning device 13, a fused silica window acting as beam splitter 15, a pair of filters centered around 300 and 334 nm and three detectors consisting of U.V. enhanced, silicium photodiodes.

The U.V. light beam generated the light source had a portion of it that passed through the window 15 and the 334 nm interferential filter before reaching the first one of the three detectors. This 334 nm interferential filter had a reflecting surface oriented toward the source, so that a portion of the beam was reflected via the window towards the second detector, with no wavelength filtration.

Another portion of the original beam was reflected by the window acting as beam splitter towards the third detector that was located behind the 300 nm, interferential filter, the latter filter also having a reflecting surface facing the window so that part of the beam was reflected towards the second detector with no filter.

This particular arrangement made it possible to split the original beam in three different sub-beams without too much loss in energy.

The detector receiving the signal filtered at 300 nm was used for the detection of the presence or absence of the bottles within the detection zone. The detector associated to 334 nm filter was used to differentiate PVC from PET. Last of all, the third detector with no filter was used to correct all the signals and take into account the variations in opacity of the objects that were subjected to sorting. This last detector was also used to distinguish the bottles that were not made of PVC or PET from those that were to be actually sorted.

Tests were carried out with this apparatus at a speed of 25 readings per object to be sorted while the objects were moving down within the detection zone. Such a speed allowed full analysis the materials of which each bottle was made since all of these bottles were about 30 cm high. The results that were obtained were excellent and sorting of the bottles of UV-protected PVC from those made of PET was actually carried out in real time.

Claims

1. An apparatus for sorting objects made of at least two different transparent or translucent plastic materials according to the kind of plastic materials said objects are made of, each of said different plastic materials having a light transmission coefficient which dramatically increases above a given wavelength in the U.V., said given wavelength known per se being called the "cut-off wavelength" and being a characteristic of said plastic material, said apparatus comprising:
 - means to produce a beam of U.V. light; and
 - detecting means spaced apart from said beam producing means and positioned to receive said U.V. light beam, said detecting means giving signals proportional to the intensities of said received beam at different wavelengths selected within a range encompassing the known cut-off wavelengths of said different plastic materials,
 whereby, in use, each object to be sorted is inserted between the beam producing means and the detecting means in such a manner as to intersect said U.V. light beam and the signals given by said detecting means at said different wavelengths are compared with each other to determine the cut-off wavelength of the plastic material of which said inserted object is made, and thus to identify said plastic material.
2. An apparatus as claimed in claim 1, wherein said detecting means comprises:
 - means to split said received light beam into a plurality of sub-beams;
 - means to filter each of said sub-beams at one given wavelength different from the wavelengths at which the other sub-beams are filtered; and
 - a light intensity detector associated to each of said filtering means to give a signal proportional to the intensity of the sub-beam filtered by said associated filtering means;
 - said signal together with all the other signals received from the other detectors forming said signals given by said detecting means and used to identify the plastic material of each object to be sorted.
3. An apparatus as claimed in claim 2, wherein:
 - the splitting means are adapted to produce a number of sub-beams at least equal to the number of different plastic materials to be identified, plus one;
 - one of said filtering means hereinafter called "first filtering means", is adapted to filter the sub-beam it receives from the splitting means at a wavelength which is lower than the lowest cut-off wavelength of the different plastic materials to be identified, the signal given by the detector associated to said first

filtering means being indicative of the presence or absence of an object to be sorted intersecting the U.V. light beam;

– another one of said filtering means hereinafter called "second filtering means", is adapted to filter the sub-beam it receives from the splitting means at another wavelength which is higher than the highest cut-off wavelength of the different plastic materials to be identified, the signal given by the detector associated to said second filters means being a normalization signal; and

– each remaining filtering means is adapted to filter the sub-beam it receives from the splitting means at a further wavelength which is comprised between each pair of adjacent cut-off wavelength to be determined; and

wherein said apparatus further comprises:

– means connected to all of said detectors, to normalize the signals given by said detectors with the normalization signal given by the detector associated to the second filtering means, and thus to take into account any variation in the opacity of the objects to be sorted, or any lack of uniformity between said objects.

4. An apparatus as claimed in claim 3, further comprising:

– processing means operatively associated to said normalization means and connected to all of said detectors to synchronize the operation of said detectors when the signal given by the detector associated to the first filtering means is indicative of the presence of an object to be sorted intersecting the U.V. light beam, and then to process the normalized signals received from the normalization means to give a processed signal indicative of the kind of plastic material of which is made the object intersecting the U.V. light beam.

5. An apparatus as claimed in claim 4, further comprising:

– conveying means to bring the objects to be sorted between the beam producing means and the detecting means, so that said objects successively intersect said light beam; and

– means connected to said processing means and responsive to the processed signal given by said processing means to selectively discard the objects to which processed signals corresponds, into bins corresponding to the kinds of plastic material of which said objects are made.

6. An apparatus as claimed in claim 5, wherein said discarding means are pneumatic.

7. An apparatus as claimed in claim 3, wherein:

– the wavelength at which said second filtering means is adapted to filter the sub-beam it receives from the splitting means to produce the normalization signal, is, in fact, a wide band of wavelengths whose upper limit is higher than the highest cut-off wavelength of the plastic material to be detected; and

– the wavelength at which each of the other filtering means is adapted to filter the sub-beam it receives from the splitting means, is, in fact, a narrow band of wavelengths centered on said wavelength of said other filtering means.

8. An apparatus as claimed in claim 4, wherein:

– the wavelength at which said second filtering means is adapted to filter the sub-beam it receives from the splitting means to produce the normalization signal, is, in fact, a wide band of wavelengths whose upper limit is higher than the highest cut-off of the plastic material to be detected; and

– the wavelength at which each of the other filtering means is adapted to filter the sub-beam it receives from the splitting means is, in fact, a narrow band of wavelengths centered on said wavelength of said other filtering means.

9. An apparatus as claimed in claim 5, wherein:

– the wavelength at which said second filtering means is adapted to filter the sub-beam it receives from the splitting means to produce the normalization signal, is in fact a wide band wavelength whose upper limit is higher than the highest cut-off of the plastic material to be detected; and

– the wavelength at which each of the other filtering means is adapted to filter the sub-beam it receives from the splitting means is in fact a narrow band of wavelengths centered on said wavelength of said other filtering means.

10. An apparatus as claimed in claim 7, wherein said objects to be sorted are bottles made of at least two different plastic materials selected from the group consisting of polyethylene, polystyrene, PVC, PET, UV

protected PVC and green PET.

11. An apparatus as claimed in claim 8, wherein said objects to be sorted are bottles made of at least two different plastic materials selected from the group consisting of polyethylene, polystyrene, PVC, PET, UV protected PVC and green PET.
12. An apparatus as claimed in claim 9, wherein said objects to be sorted are bottles made of at least two different plastic materials selected from the group consisting of polyethylene, polystyrene, PVC, PET, UV protected, PVC and green PET.
13. A method for sorting objects made of at least two different transparent or translucent plastic materials according to the kind of plastic material of which each of said objects is made, each of said different plastic materials having a light transmission coefficient which dramatically increases above a given wavelength in the U.V., said given wavelength known per se being called the "cut-off wavelength" and being a characteristic of said plastic material, said method comprising the steps of:
 - producing a beam of U.V. light;
 - subjecting each object to be sorted to said beam in a detection zone;
 - detecting the intensities of the beam transmitted by said object in said detection zone at different wavelengths selected within a range encompassing the known cut-off wavelengths of said different plastic materials, and
 - comparing with each other the intensities detected at said different wavelengths to determine the cut-off wavelength of the plastic material of which said object subjected to said beam is made, in order to identify said plastic material.
14. A method as claimed in claim 13, wherein said detecting step comprises:
 - splitting the transmitted light beam into a plurality of sub-beam;
 - filtering each of said sub-beams at a given wavelength different from the wavelengths at which the other sub-beams are filtered; and
 - detecting the intensity of each of said filtered sub-beams.
15. A method as claimed in claim 14, wherein:
 - said splitting step is carried out to produce of a number of sub-beams at least equal to the number of different plastic materials to be identified, plus one; and
 - said filtering step comprises filtering one of said sub-beams hereinafter called the "first sub-beam" at a first wavelength lower than the lowermost cut-off wavelength of the different plastic materials to be identified; filtering another one of said sub-beams hereinafter called "second sub-beam" at a second wavelength which is higher than the highest cut-off wavelengths of the plastic materials to be identified; and filtering all the other sub-beams at other wavelengths each comprised between a pair of adjacent cut-off wavelengths to be determined; andwherein said method further comprises:
 - normalizing the intensities detected at all of said different wavelength with the intensity detected at said second wavelengths to take into account any variation in the opacity of the objects to be sorted or any lack of uniformity between said objects.
16. A method as claimed in claim 15, further comprising:
 - synchronizing said detecting step as a function of the intensity detected at said first wavelength; and
 - processing the normalized intensities detected at all of said different wavelengths to determine the cut-off wavelength of the plastic material of which said inserted object is made, and thus to identify said plastic material.
17. A method as claimed in claim 15, wherein:
 - use is made as said second wavelength, of a wide band of wavelengths whose upper limit is higher than the highest cut-off wavelength of the plastic material to be detected; and
 - use of made, as said first and other wavelength, of narrow bands of wavelengths centered on said first and other wavelengths, respectively.
18. A method as claimed in claim 15, wherein:
 - use is made as said second wavelength, of a wide band of wavelengths whose upper limit is higher

than the highest cut-off wavelength of the plastic materials to be detected; and
– use of made, as said first and other wavelength, of narrow bands of wavelengths centered on said first and other wavelengths, respectively.

- 5 **19.** A method as claimed in claim 16, comprising the additional steps of:
 – conveying the objects to be sorted through said detection zone; and
 – selectively discarding the objects having the detection zone into different bins corresponding to the kind of plastic material of which said object is made.
- 10 **20.** A method as claimed in claim 18, comprising the additional steps of:
 – conveying the objects to be sorted through said detection zone; and
 – selectively discarding the objects having the detection zone into different bins corresponding to the kind of plastic material of which said object is made.

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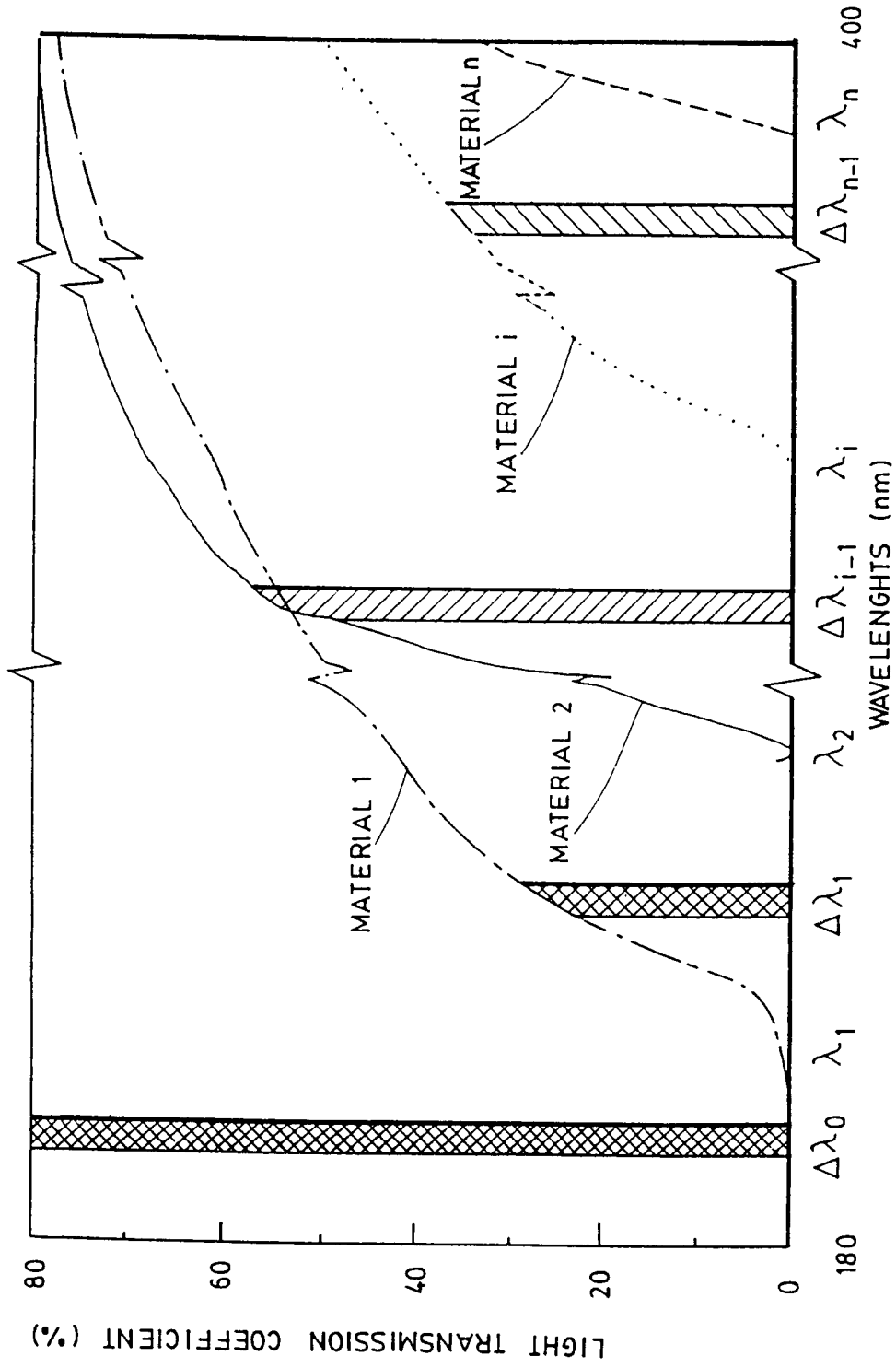
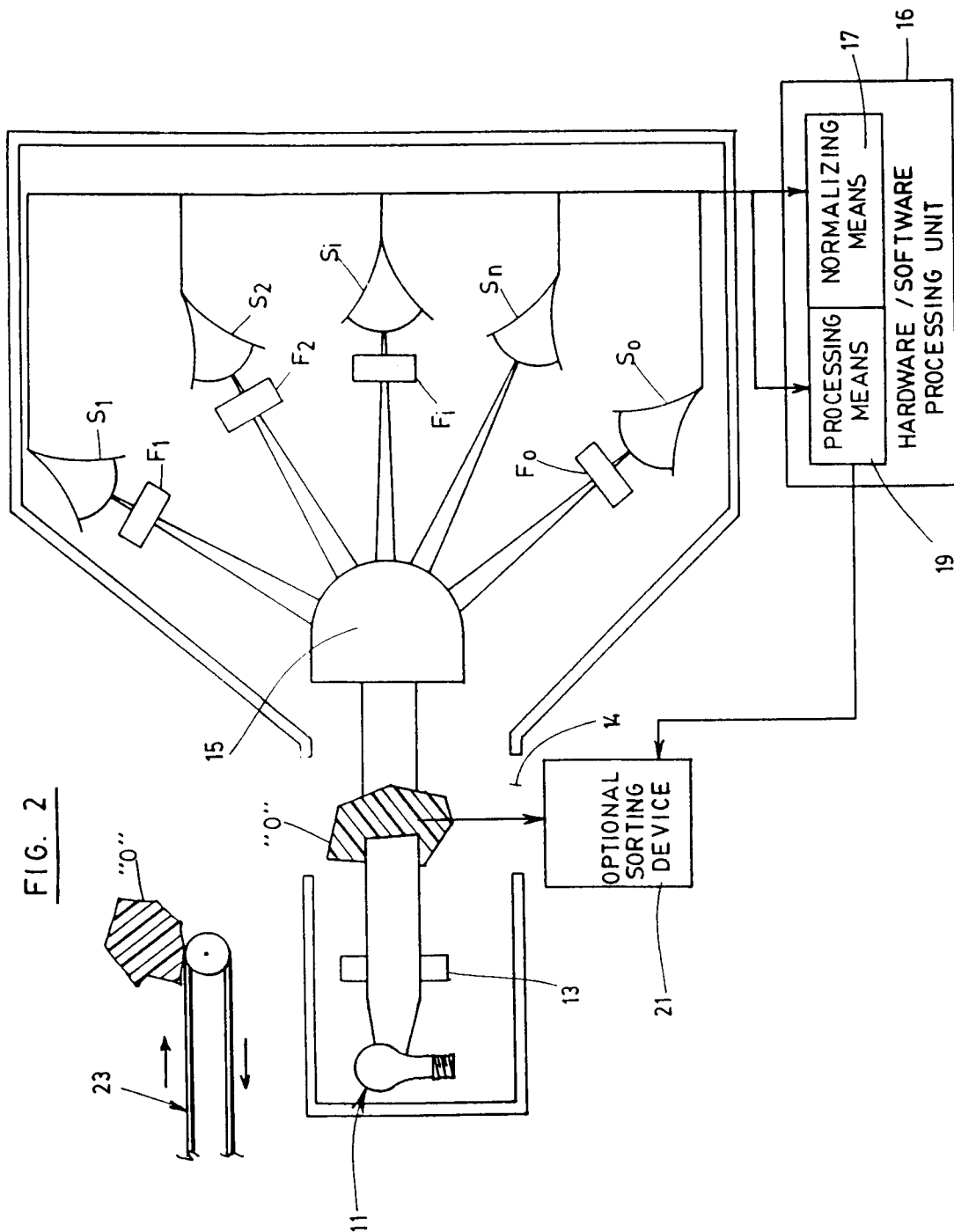


FIG. 1





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 91403513.4
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
P,X	<u>EP - A - 0 441 012</u> (HOOVER) * Claims 1,14,18 * --	1,5,13	B 07 C 5/34 B 07 C 5/342
D,A	<u>US - A - 3 802 558</u> (RHYS) * Claims 1,5-7,13-16,19 * --	1,13	
D,A	<u>US - A - 4 513 868</u> (CULLING) * Claims 1,12 * --	1,13	
D,A	<u>US - A - 4 663 522</u> (WELBOURN) * Claims 1,20,26,27,30 * --	1,8	
D,A	<u>US - A - 4 379 636</u> (YOSHIDA) * Claim 1 * --	1	
A	<u>US - A - 4 017 194</u> (CONROY) * Claims 1,5,7 * --	1	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	<u>CA - A - 963 650</u> (ANCHOR HOCKING) * Claims 2,10 * ----	1	B 07 C
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 13-03-1992	Examiner FUSSY
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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