AUSTRALIA 658745

PATENTS ACT 1990

PATENT REQUEST: STANDARD PATENT

We, OWENS-BROCKWAY GLASS CONTAINER INC., being the person identified below as the Applicant, request the grant of a patent to the person identified below as the Nominated Person, for an invention described in the accompanying standard complete specification.

Full application details follow.

Applicant: OWENS-BROCKWAY GLASS CONTAINER INC.

Address: One SeaGate, Toledo, Ohio 43666, United States of America

Nominated Person: As above

Address: As above

Invention Title: "INSPECTION OF TRANSPARENT CONTAINERS WITH OPPOSING REFLECTION MEANS"

Name of actual inventor: James A. Ringlien

BASIC CONVENTION APPLICATION DETAILS:
Application Number: 07/901,009
Country: United States of America
Country Code: US
Date of Application: 19th June, 1992

Address for service is: SHELSTON WATERS
55 Clarence Street
SYDNEY NSW 2000

Attorney Code: SW

DATED this 15th Day of June, 1993
OWENS-BROCKWAY GLASS CONTAINER INC.

S 038266 150693

by Leon R. Allen.
Fellow Institute of Patent Attorneys of Australia
of SHELSTON WATERS

To: The Commissioner of Patents
WODEN ACT 2606

File: 17000
Fee: $197.00

P/00/008
Section 29(1)
Regulation 3.1(2)

AUSTRALIA

PATENTS ACT 1990

NOTICE OF ENTITLEMENT

We, OWENS-BROCKWAY GLASS CONTAINER INC. of One SeaGate, Toledo, Ohio 43666, United States of America, being the applicant in respect of an Application for an invention entitled:

INSPECTION OF TRANSPARENT CONTAINERS WITH OPPOSING REFLECTION MEANS

state the following:-

1. The person nominated for the grant of the patent has entitlement from the actual inventor/s by assignment.

2. The person nominated for the grant of the patent has entitlement from the applicant/s of the basic application/s listed on the patent request form by assignment.

3. The basic application/s listed on the patent request form is/are the first application/s made in a Convention country in respect of the invention.

..... June 4, 1993
(Signature) (Date)

Name: H. G. BRUSS

Title: Assistant Secretary

File: 16573 AUST

SHELSTON WATERS
55 CLARENCE STREET, SYDNEY, AUSTRALIA

AU9341256

(12) PATENT ABRIDGMENT (11) Document No. AU-B-41256/93
(19) AUSTRALIAN PATENT OFFICE (10) Acceptance No. 658745

(54) Title
INSPECTION OF TRANSPARENT CONTAINERS WITH OPPOSING REFLECTION MEANS

International Patent Classification(s)
(51)[5] **G01J 001/10**

(21) Application No. : **41256/93** (22) Application Date : **15.06.93**

(30) Priority Data

(31) Number	(32) Date	(33) Country
901009	**19.06.92**	**US UNITED STATES OF AMERICA**

(43) Publication Date : **23.12.93**

(44) Publication Date of Accepted Application : **27.04.95**

(71) Applicant(s)
OWENS-BROCKWAY GLASS CONTAINER INC.

(72) Inventor(s)
JAMES A. RINGLIEN

(74) Attorney or Agent
SHELSTON WATERS , Level 21, 60 Margaret Street, SYDNEY NSW 2000

(56) Prior Art Documents
US 4959538
US 3628872
US 2429066

(57) Claim

1. Apparatus for detecting commercial variations in hollow transparent containers that comprises: means for conveying containers along a path to an inspection station, a light source for directing light energy through a container at said station, light sensing means, and means for detecting commercial variations in the container at said station as a function of variations of light intensity received at said sensing means, characterized in that said light source and said light sensing means are positioned on the same side of said path, said light sensing means comprises an array sensor, said variations-detecting means comprises means for scanning said array sensor to develop a two-dimensional image of a portion of the container illuminated by said light source, and said apparatus further includes a retroreflector positioned on the

.../2

other side of said path opposite said light source and light sensing means for reflecting light energy transmitted from said source through a container at said station back through the container onto said sensing means in such a way that light rays that encounter mild refraction due to container geometry and mild refractive variations in the container are reflected by said retroreflector along the path of incidence back through the container onto said sensing means, while light rays that encounter stronger refraction due to greater refractive variations or encounter opaque variations are not reflected by said retroreflector along the path of incidence onto said sending means thereby appearing in said two-dimensional image at said sensing means as a dark spot against a light background.

7. A method of inspecting transparent containers for commercial variations that affect optical properties of the containers, comprising the steps of:

(a) directing light energy through a container such that individual light rays travel along paths that depend on optical properties of the container,

(b) reflecting the light energy back through the container in such a way that individual light rays nominally travel in reverse direction along the same light paths, and

(c) detecting commercial variations in the container as a function of intensity of light energy reflected back through the container.

658745

AUSTRALIA

PATENTS ACT 1990

COMPLETE SPECIFICATION

FOR A STANDARD PATENT

ORIGINAL

Name of Applicant: OWENS-BROCKWAY GLASS CONTAINER INC.

Actual Inventor: James A. Ringlien

Address for Service: SHELSTON WATERS
55 Clarence Street
SYDNEY NSW 2000

Invention Title: "INSPECTION OF TRANSPARENT CONTAINERS WITH OPPOSING REFLECTION MEANS"

The following statement is a full description of this invention, including the best method of performing it known to us:-

INSPECTION OF TRANSPARENT CONTAINERS WITH OPPOSING REFLECTION MEANS

The present invention is directed to inspection of transparent containers for commercial variations or defects that affect optical properties of the containers, and more particularly to an apparatus and method for enhanced detection of sharp-edge variations such as ribbon tears.

Background and Objects of the Invention

In the manufacture of transparent containers such as glass bottles, various types of checks or defects may occur in the sidewalls, heels, bottoms, shoulders and/or necks of the containers. These checks or defects, termed "commercial variations" in the art, can affect commercial acceptability of the containers. The commercial variations may be opaque, such as stones, or may be refractive such as blisters, bubbles or tears.

It has heretofore been proposed to employ electro-optical inspection techniques for detecting commercial variations that affect optical properties of the containers. The basic principle is that a light source is positioned on one side of the container and a camera is positioned on the other. The light source may be configured to have an intensity that varies across one dimension of the source. Light rays normally

while it is rotated about its axis during the inspection process. The light source is positioned within the arcuate conveyor path - i.e., within the diameter of the starwheel - which creates space problems and necessitates use of a fairly large starwheel. Another difficulty with typical inspection systems heretofore proposed lies in the difficulty in detecting sharp-edged defects such as ribbon tears.

It is therefore a general object of the present invention to provide an inspection apparatus and method in which the major optical components - i.e., the light source and camera - are disposed on one side of the conveyor path, preferably externally of the arcuate path of a starwheel conveyor, which therefore forms a more simple and compact inspection system, and permits use of a smaller starwheel with reduced inertial and energy consumption. Another object of the present invention is to provide an apparatus and method for inspecting transparent containers of the described type that provide enhanced detection of sharp-edge commercial variations such as ribbon tears, as well as detection of other typical commercial variations such as stones, blisters, bubbles, lap marks and blowouts.

Summary of the Invention

According to one aspect of the invention there is provided an apparatus for detecting commercial variations

in hollow transparent containers that comprises: means for conveying containers along a path to an inspection station, a light source for directing light energy through a container at said station, light sensing means, and means for detecting commercial variations in the container at said station as a function of variations of light intensity received at said sensing means, characterized in that said light source and said light sensing means are positioned on the same side of said path, said light sensing means comprises an array sensor, said variations-detecting means comprises means for scanning said array sensor to develop a two-dimensional image of a portion of the container illuminated by said light source, and said apparatus further includes a retroreflector positioned on the other side of said path opposite said light source and light sensing means for reflecting light energy transmitted from said source through a container at said station back through the container onto said sensing means in such a way that light rays that encounter mild refraction due to container geometry and mild refractive variations in the container are reflected by said retroreflector along the path of incidence back through the container onto said sensing means, while light rays that encounter stronger refraction due to greater refractive variations or encounter opaque variations are not reflected by said retroreflector along the path of

incidence onto said sending means thereby appearing in said two-dimensional image at said sensing means as a dark spot against a light background.

In the preferred embodiment of the invention, the light source and sensor are respectively disposed to transmit and receive light energy along a common optical axis. A beam splitter is positioned on the optical axis for physically separating the light source and camera. The camera comprises a sensor array, either a linear array sensor or an area array sensor, that is scanned at increments of container rotation for developing a two-dimensional image of the container under inspection.

According to a second aspect of the invention there is provided a method of inspecting transparent containers for commercial variations that affect optical properties of the containers, comprising the steps of:

(a) directing light energy through a container such that individual light rays travel along paths that depend on optical properties of the container,

(b) reflecting the light energy back through the container in such a way that individual light rays nominally travel in reverse direction along the same light paths, and

(c) detecting commercial variations in the container as a function of intensity of light energy reflected back through the container.

Brief Description of the Drawing

The invention, together with additional objects, features and advantages thereof, will be best understood from the following description, the appended claims and the accompanying drawing, which is an electro-optical schematic diagram that illustrates a presently preferred embodiment of the invention.

Detailed Description of Preferred Embodiment

The drawing illustrates an apparatus 10 for inspecting transparent containers 12 for commercial variations that affect the optical properties of the container. Apparatus 10 includes a conveyor 14, such as a starwheel conveyor of the type illustrated in above-noted U.S. Patent No. 4,601,395, for conveying containers 12 along an arcuate path to and through an inspection station at which apparatus 10 is disposed. A light source 16 in the form of one or more light bulbs 18 is positioned to direct light energy onto a beam splitter 20, from which a portion of the light energy is reflected along an optical axis to and through the container 12 under inspection. A

retroreflector 22 is positioned on the opposing side of container 12 to reflect the light energy incident thereon back through container 12 and along the same optical axis onto beam splitter 20. A portion of this reflected light energy is transmitted through beam splitter 20 to a lens system 24 having an entrance pupil disposed at the conjugate image of light source 16. Light energy is directed by system 24 onto an array sensor 26, which together with lens system 24 forms a light sensing camera 28.

Container 12 at the inspection station of apparatus 10 is coupled to a suitable device 30, such as a motor and drive wheel, for rotating container 12 about its axis during the inspection process. An encoder 32 is coupled to container rotation device 30 for providing a signal to an information processor 34 indicative of increments of container rotation, either directly as a function of angular increments of container rotation, or indirectly as a function of time increments during which container 12 is rotated at nominally constant angular velocity. Information processor 34 is coupled to camera 28 for scanning array sensor 26 at increments of container rotation, and thereby obtaining a two-dimensional image of the container and of light source 16 as viewed through the container. Information processor 34 provides outputs to a suitable display, and to a suitable mechanism for rejecting a container 12 in which commercial variations exceed a desirable level.

In operation, light energy from bulb 18 is reflected by beam splitter 20 through container 12, and then reflected by retroreflector 22 back through container 12 and beam splitter 20 through lens system 24 to camera array 26. Retroreflector 22, which may comprise a micro-corner cube sheet, a glass bead screen or a glass bead reflective paint on a substrate, is characterized by the fact that light energy incident thereon is nominally reflected back on itself along the path of incidence. Each light ray that travels through container 12 is refracted or bent according to the exact path that it travels as a function of sidewall geometry, as well as a function of any refractive variations that the ray encounters. Each ray (that is not blocked by an opaque variation) strikes reflector 22, and is nominally reflected back along its incoming path. Each ray then strikes the container, is refracted by the container along its original path of incidence, and then is directed onto camera sensor 26.

It has been found that light rays that encounter mild refraction due to container geometry, such as rays 36, 38 in the drawing, as well as light rays 40 that encounter only a mild refractive variation in the container, are directed by reflector 22 back along their paths of incidence to camera 28 to create a bright image of light source 16 at the camera. However, light rays 42 that encounter stronger refraction at the container, due to the refractive characteristics of

unacceptable commercial variations, are not reflected by reflector 22 back along their paths of incidence, and thus appear as a dark spot in an otherwise bright image at camera 28. This is believed to be due to the fact that retroreflector 22 has a lower reflectivity for rays incident upon it at large angles from the normal angles of incidence. There is also a slight side shift and spreading of the returned rays so that they do not quite follow the exact path, which makes narrow edge variations such as ribbon tears appear wider at camera 28. Opaque variations, of course, appear as dark spots in an otherwise bright image since light rays cannot travel therethrough either to or from reflector 22.

It will therefore be apparent that apparatus 10 fully satisfies all of the objects and aims previously set forth. In particular, retroreflector 22 can be provided in the form of a very thin sheet, greatly increasing the amount of space available within the starwheel conveyor diameter and permitting use of smaller starwheel diameters. Furthermore, the inspection apparatus of the present invention has been found to operate well in detecting internal and external ribbon tears, stones, edges of blisters, lap marks and bad blowouts. Any location on the container where there is an abrupt thickness change appears dark at camera 28. Information processor 34 may employ any suitable technique for sensing dark spots in the camera image.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. Apparatus for detecting commercial variations in hollow transparent containers that comprises: means for conveying containers along a path to an inspection station, a light source for directing light energy through a container at said station, light sensing means, and means for detecting commercial variations in the container at said station as a function of variations of light intensity received at said sensing means, characterized in that said light source and said light sensing means are positioned on the same side of said path, said light sensing means comprises an array sensor, said variations-detecting means comprises means for scanning said array sensor to develop a two-dimensional image of a portion of the container illuminated by said light source, and said apparatus further includes a retroreflector positioned on the other side of said path opposite said light source and light sensing means for reflecting light energy transmitted from said source through a container at said station back through the container onto said sensing means in such a way that light rays that encounter mild refraction due to container geometry and mild refractive variations in the container are reflected by said retroreflector along the path of incidence back through the container onto said sensing means, while light rays that encounter stronger refraction due to greater

refractive variations or encounter opaque variations are not reflected by said retroreflector along the path of incidence onto said sending means thereby appearing in said two-dimensional image at said sensing means as a dark spot against a light background.

2. The apparatus set forth in claim 1 wherein said light source and said light sensing means are respectively disposed to transmit and receive light energy along a common optical axis.

3. The apparatus set forth in claim 2 wherein said light source comprises a beam splitter disposed on said axis.

4. The apparatus set forth in claim 3 wherein said light sensing means includes a lens system disposed at the conjugate image of the light source.

5. The apparatus set forth in any preceding claim wherein said conveying means comprises a starwheel conveyor for conveying the container along an arcuate path through said station, and wherein said reflector means is disposed within said arcuate path.

6. The apparatus set forth in claim 5 wherein said conveyor further comprises means for rotating the container about its axis at said inspection station.

7. A method of inspecting transparent containers for commercial variations that affect optical properties of the containers, comprising the steps of:

(a) directing light energy through a container

such that individual light rays travel along paths that depend on optical properties of the container,

(b) reflecting the light energy back through the container in such a way that individual light rays nominally travel in reverse direction along the same light paths, and

(c) detecting commercial variations in the container as a function of intensity of light energy reflected back through the container.

8. Apparatus for detecting commercial variations in transparent containers substantially as herein described with reference to the accompanying drawing.

9. A method of inspecting transparent containers for commercial variations that affect optical properties of the containers substantially as herein described with reference to the accompanying drawing.

DATED this 12th day of SEPTEMBER, 1994.

OWENS-BROCKWAY GLASS CONTAINER, INC

Attorney: JOHN B. REDFERN

Fellow Institute of Patent Attorneys of Australia

of SHELSTON WATERS

Abstract of the Disclosure

Apparatus (10) for detecting commercial variations in transparent containers (12) such as glass bottles that includes a conveyor (14) for directing containers along a path through an inspection station, and a light source (16) disposed on one side of the path for directing light energy through a container at the inspection station. A light sensing camera (28) is positioned on the same side of the conveyor path, and a retroreflector (22) is positioned on the opposing side of the conveyor path opposite the light source and camera for reflecting light energy transmitted from the source through a container at the station back through the container onto the camera. Commercial variations are detected as a function of variations in intensity of light energy received at the camera.