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Ansevin et al.

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[54] **INSPECTING THE BOTTOM WALL OF HOLLOW OPEN-ENDED CONTAINERS**

[75] Inventors: **Ronald W. Ansevin**, Pittsburgh; **Edward D. Avetta**, Pittsburgh; **William P. McKay**, Irwin, all of Pa.

[73] Assignee: **Owens-Illinois, Inc.**, Toledo, Ohio

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[21] Appl. No.: **233,084**

[52] **U.S. Cl.**.... **250/223 B,** 209/111.7, 250/219 DF, 356/240

[51] **Int. Cl.** **H01j 39/12**

[58] **Field of Search** .... 250/219 DF, 219 DE, 250/223 R, 223 B, 235, 236, 237; 209/111.5, 111.7; 356/240, 209, 210

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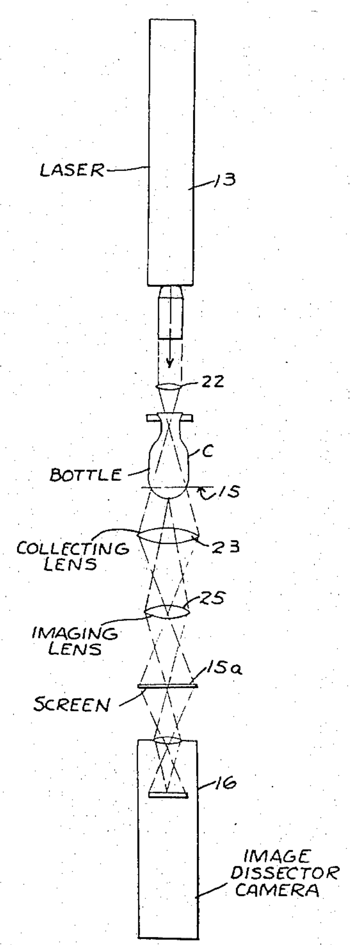
Primary Examiner—Archie R. Borchelt
Assistant Examiner—D. C. Nelms
Attorney—J. R. Nelson et al.

[57] **ABSTRACT**

A method and apparatus for inspecting the bottom wall of hollow open-ended containers wherein a beam of radiant energy to which the container is transparent is directed through the open end of the container to illuminate the bottom wall. The beam is further directed against a screen to produce a darkened image of the defect on the screen. The image of the screen is then analyzed by an image scanning device to produce a reject signal when a defect is present.

35 Claims, 10 Drawing Figures



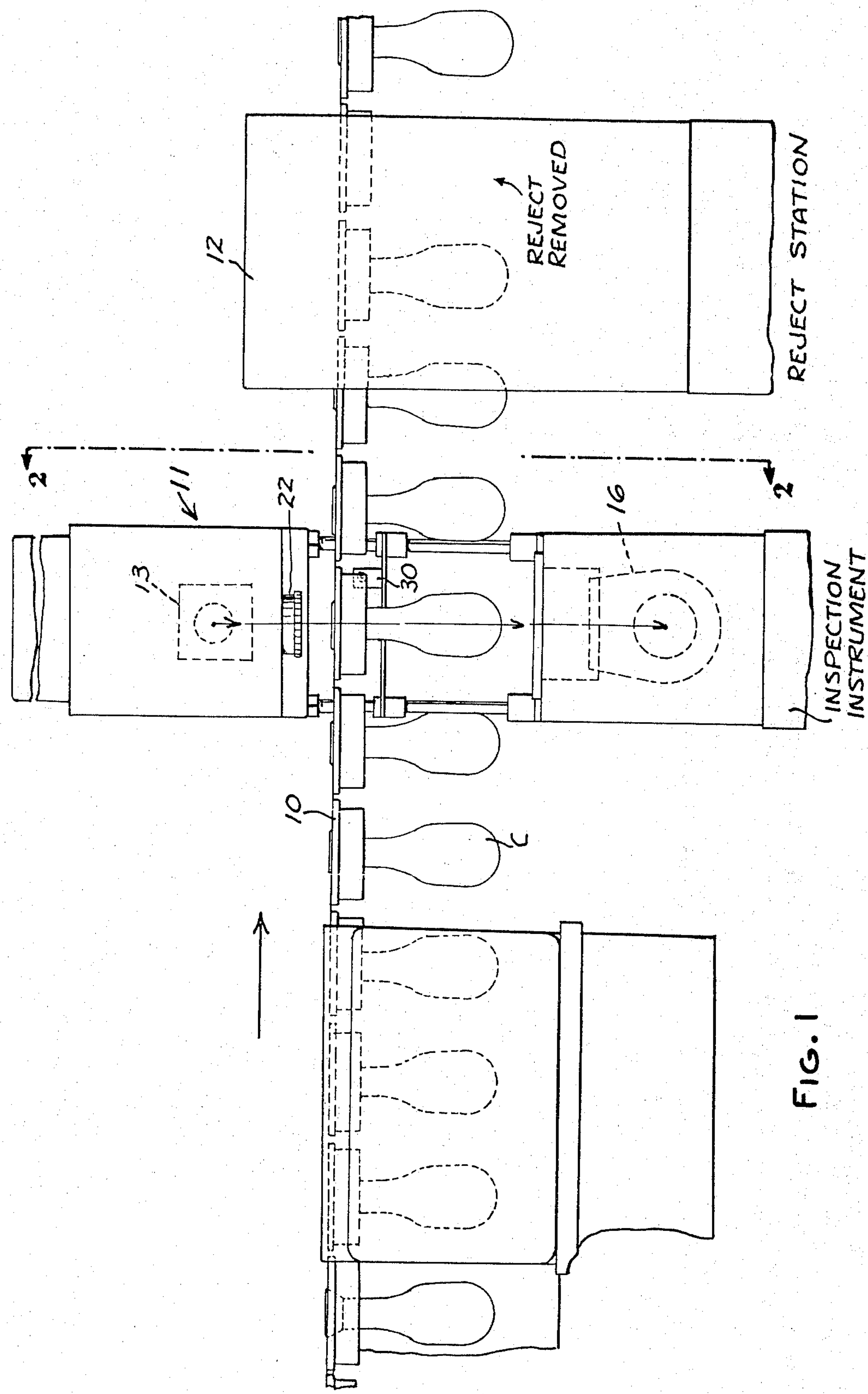

12
REJECT REMOVED
REJECT STATION
2
11
22
13
30
16
2
INSPECTION INSTRUMENT
10
C

FIG. 1

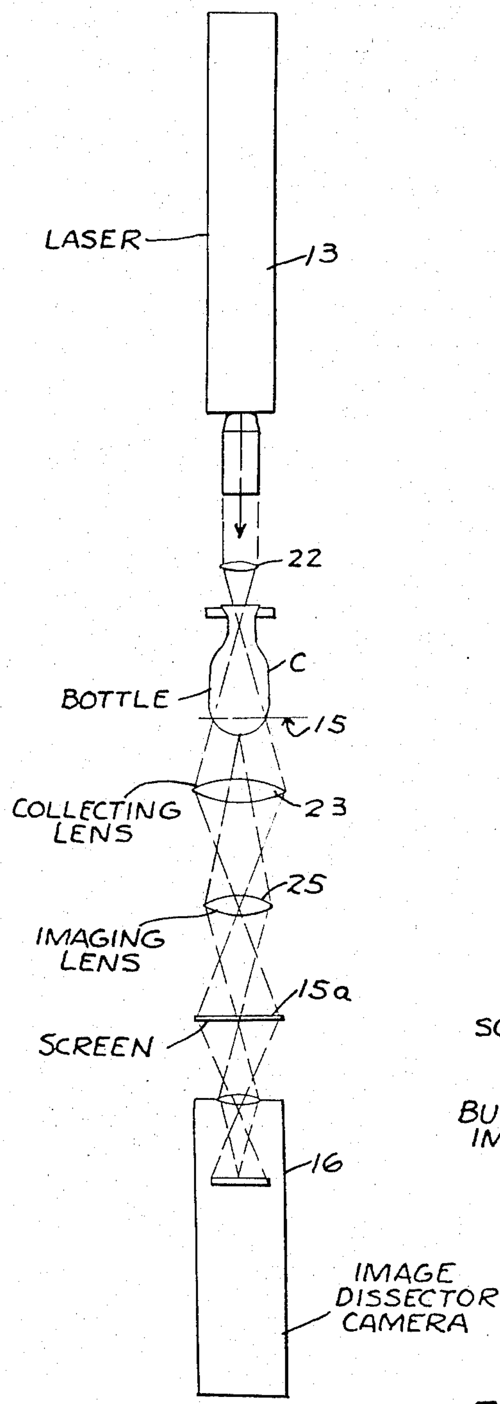
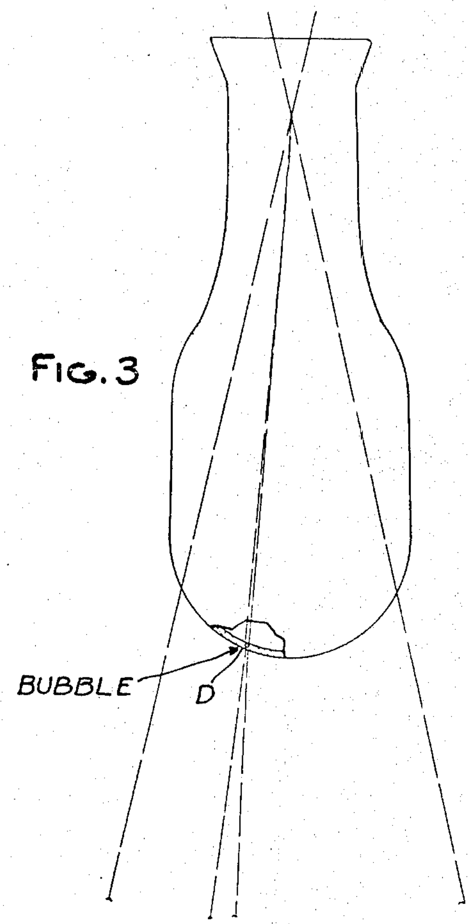


FIG. 2

FIG. 3



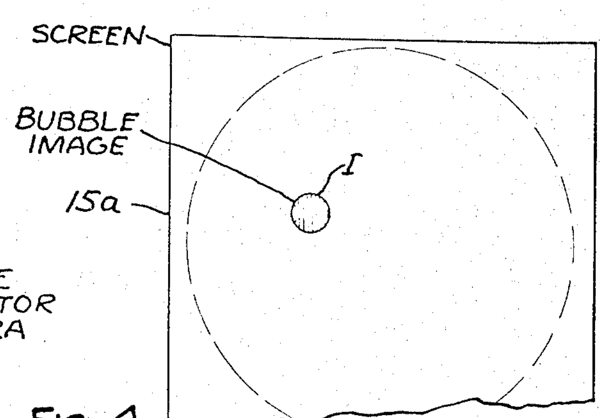


FIG. 4

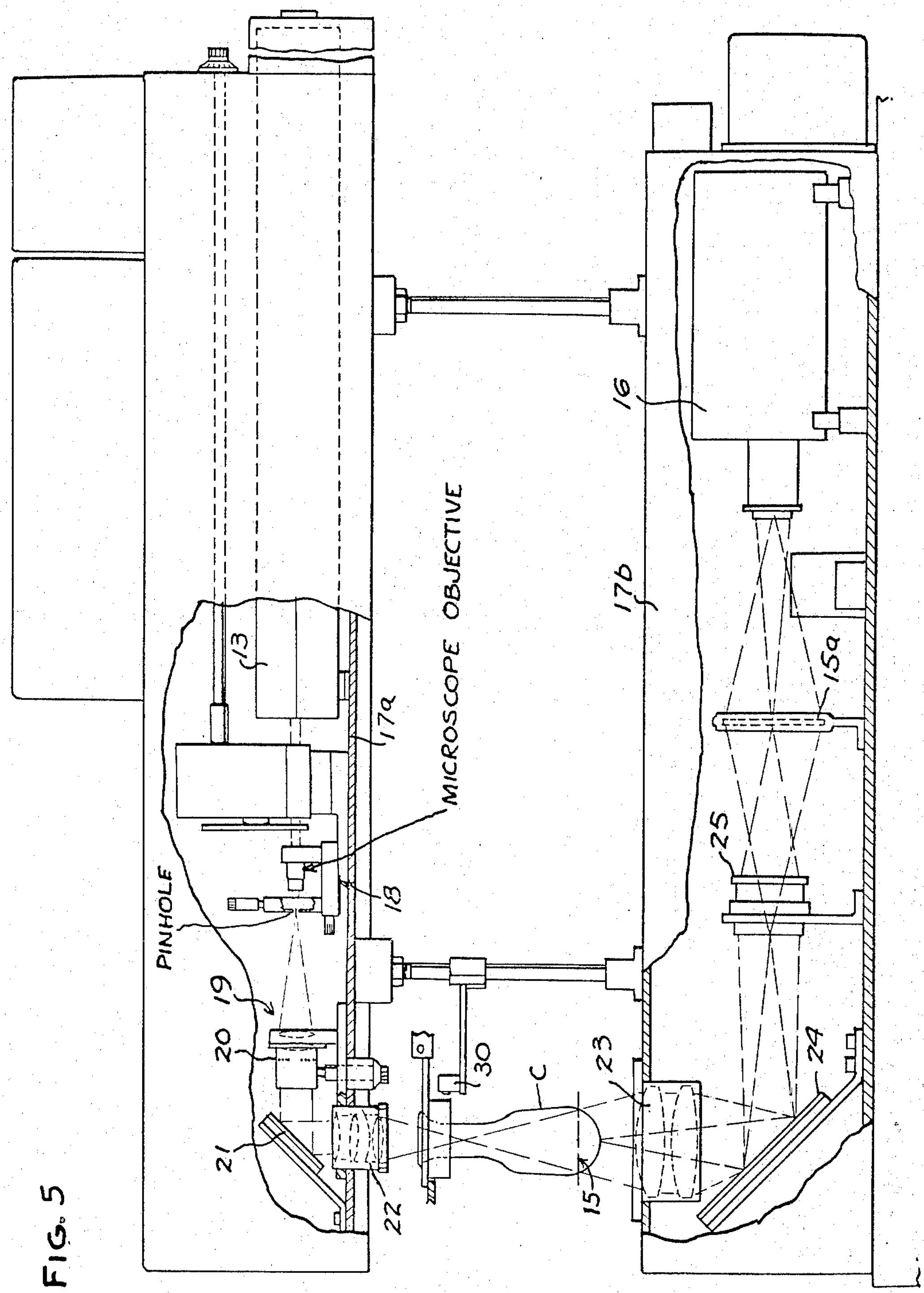

MICROSCOPE OBJECTIVE
PINHOLE
13
16
17a
17b
18
19
20
21
22
23
24
25
15
15a
30
C

FIG. 5

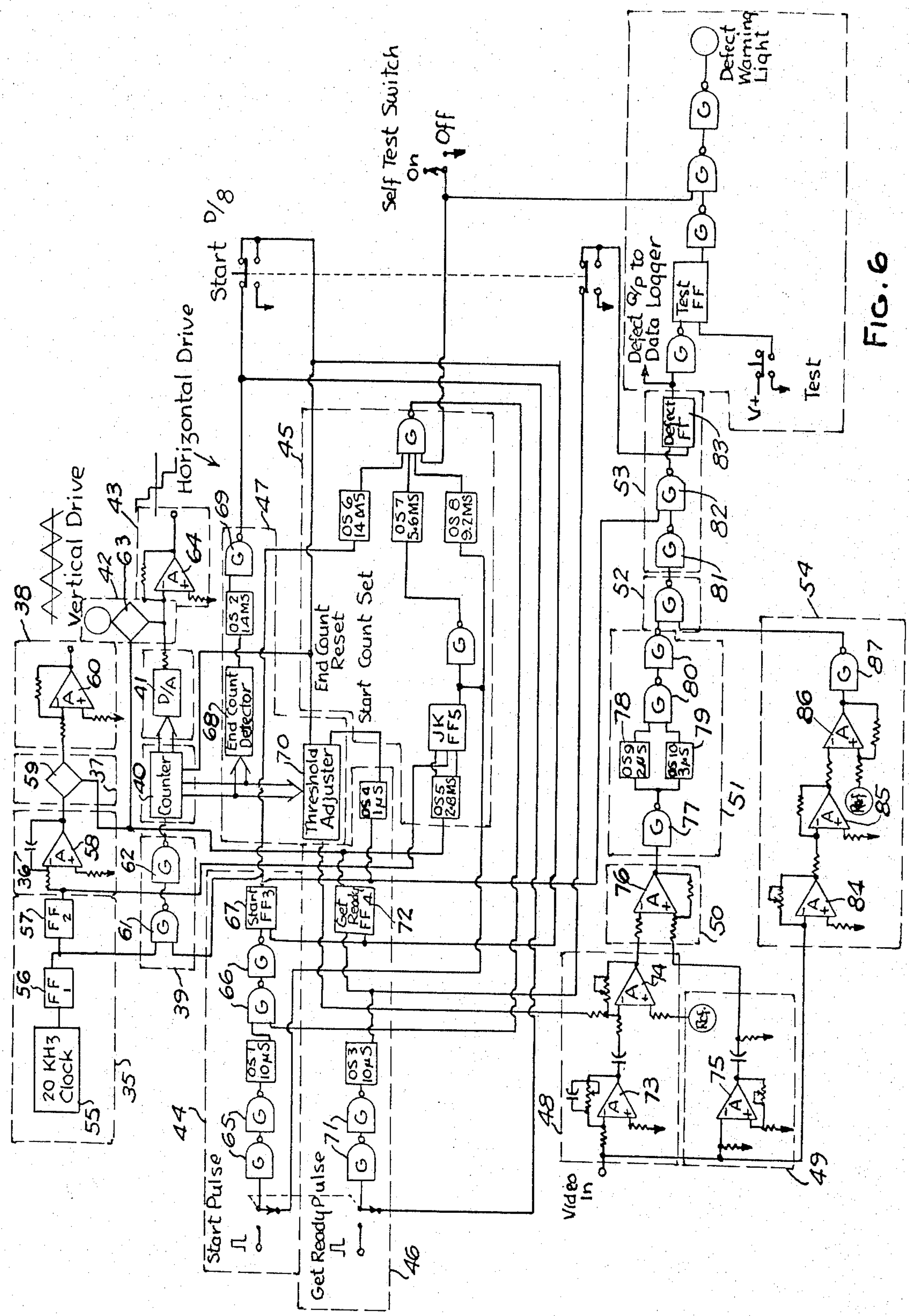

Vertical Drive
Horizontal Drive
20 KH3 Clock
FF 1
FF 2
Counter
D/A
End Count Detector
Threshold Adjuster
End Count Reset
Start Count Set
OS 1 10μS
OS 2 1.4MS
OS 3 10μS
OS 4 1μS
OS 5 2.8MS
OS 6 14MS
OS 7 5.6MS
OS 8 9.2MS
OS 9 2μS
OS 10 3μS
JK FF5
Start FF3
Get Ready FF4
Start Pulse
Get Ready Pulse
Start D/8
Self Test Switch
On
Off
Defect Warning Light
Defect O/P to Data Logger
Test FF
Defect FF
Test
V+
Video In
Ref

FIG. 6

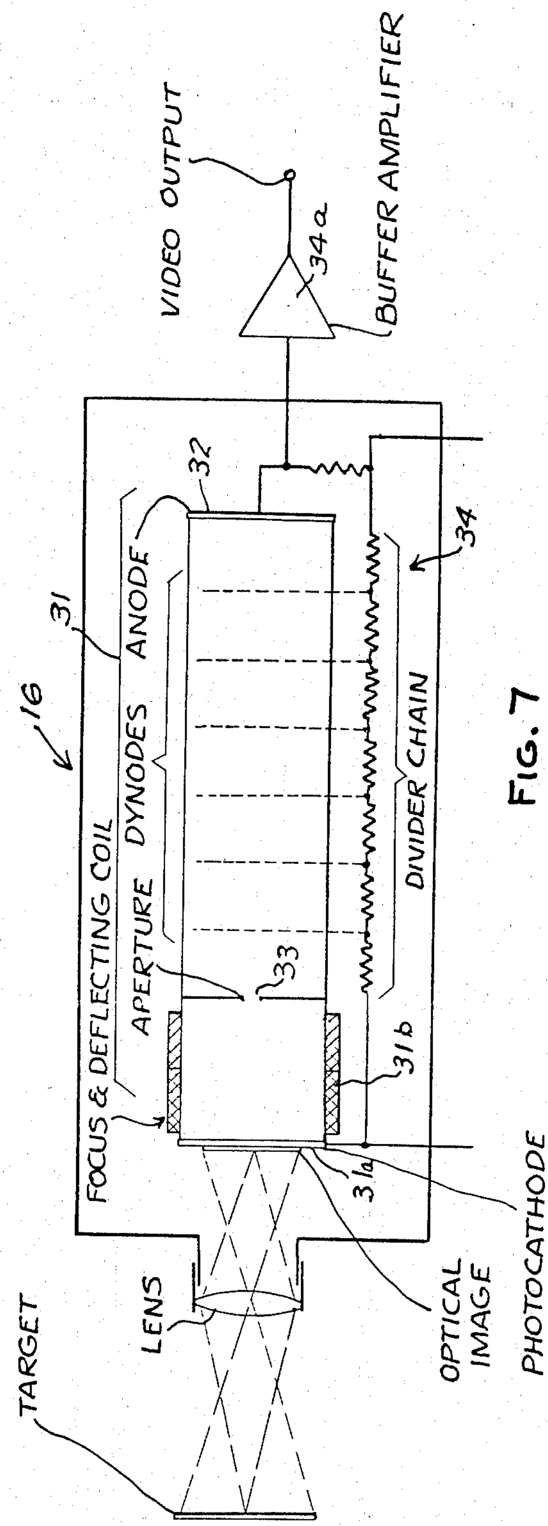

VIDEO OUTPUT
34a
BUFFER AMPLIFIER
32
34
16
31
ANODE
DYNODES
APERTURE
FOCUS & DEFLECTING COIL
33
DIVIDER CHAIN
31b
31a
PHOTOCATHODE
OPTICAL IMAGE
LENS
TARGET

FIG. 7

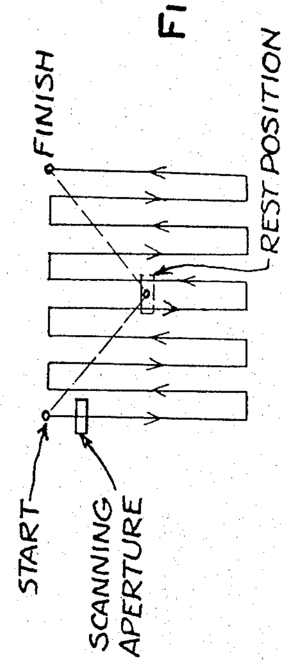

FINISH
REST POSITION
START
SCANNING APERTURE

FIG. 8

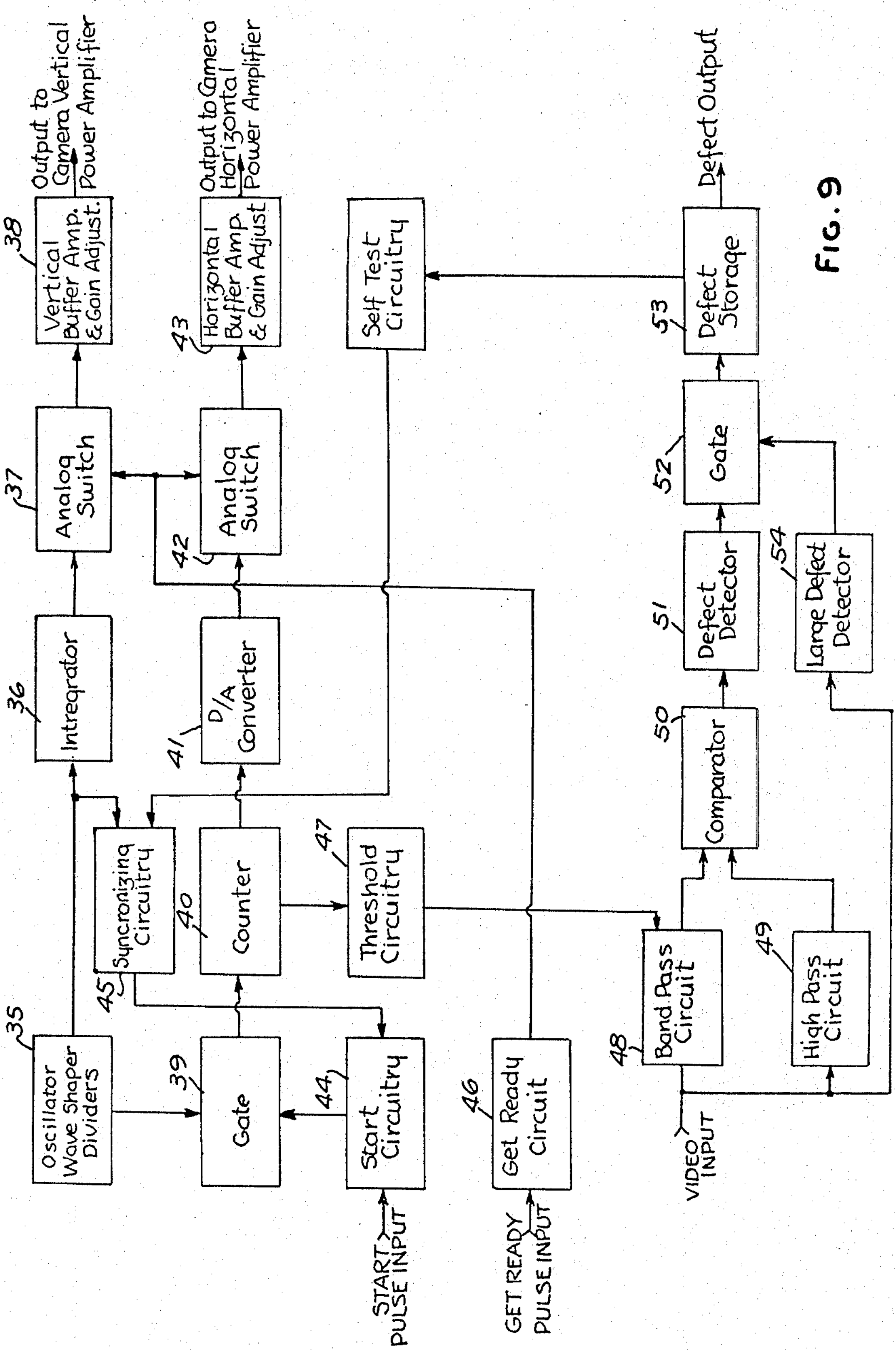

Output to Camera Vertical Power Amplifier
Output to Camera Horizontal Power Amplifier
Defect Output
38
Vertical Buffer Amp. & Gain Adjust.
43
Horizontal Buffer Amp. & Gain Adjust
Self Test Circuitry
53
Defect Storage
37
Analog Switch
42
Analog Switch
52
Gate
36
Integrator
41
D/A Converter
51
Defect Detector
54
Large Defect Detector
50
Comparator
45
Syncronizing Circuitry
40
Counter
47
Threshold Circuitry
48
Band Pass Circuit
49
High Pass Circuit
35
Oscillator Wave Shaper Dividers
39
Gate
44
Start Circuitry
46
Get Ready Circuit
START PULSE INPUT
GET READY PULSE INPUT
VIDEO INPUT

FIG. 9

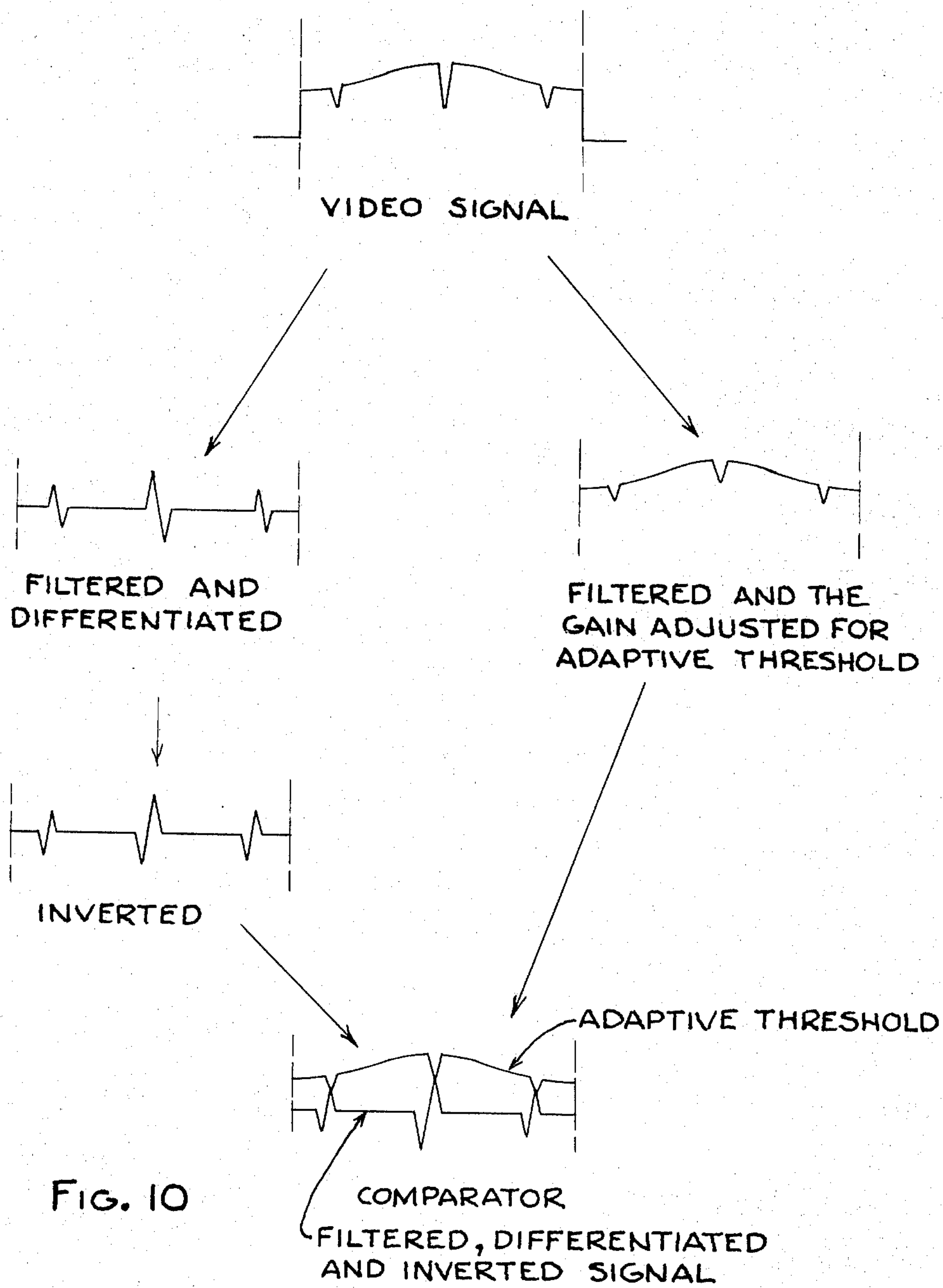

VIDEO SIGNAL
FILTERED AND DIFFERENTIATED
FILTERED AND THE GAIN ADJUSTED FOR ADAPTIVE THRESHOLD
INVERTED
ADAPTIVE THRESHOLD
COMPARATOR
FILTERED, DIFFERENTIATED AND INVERTED SIGNAL

FIG. 10

INSPECTING THE BOTTOM WALL OF HOLLOW OPEN-ENDED CONTAINERS

This invention relates to a method and apparatus for inspecting hollow containers and articles for defects.

BACKGROUND OF THE INVENTION

In the inspection of hollow articles which have open ends, such as glass containers, for defects such as chips, seeds, or bubbles, inclusions and the like, a major problem that occurs is that certain marks on the surface of the container, such as mold marks and the like, produce false signals even though they may not affect either the strength or appearance of the article and therefore should not be used as a basis for rejecting the article. A further problem in connection with such articles is that it is difficult to make an inspection when the articles are moving at high speeds on the order of 800 to 1,000 containers or articles per minute. Further, various attempts that have been made to make such inspection have necessitated the use of rapidly moving parts that are obviously difficult to align and maintain and produce possible sources of error in the inspection.

Among the objects of the invention are to provide a method and apparatus for effectively inspecting the bottom wall of hollow open-ended articles such as containers for defects such as chips, seeds, and bubbles; wherein the method and apparatus is relatively unaffected by other unobjectionable optical markings such as mold marks and the like; wherein the articles can be inspected while being moved continuously at relatively high speeds; and wherein the apparatus does not require the use of moving parts.

SUMMARY OF THE INVENTION

In accordance with the invention, a beam of radiant energy to which the article is transparent is directed through the open end of the article to illuminate the bottom wall. The beam is further directed against a screen to produce a darkened image of the defect on the screen which is enlarged for some types of defects. Successive portions of the image are then analyzed by an image scanning device to produce a reject signal when a defect is present.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a part-sectional side elevational view of an apparatus embodying the invention.

FIG. **2** is a schematic diagram of the method and apparatus utilized in the invention.

FIG. **3** is a fragmentary diagram on an enlarged scale of a portion of the diagram shown in FIG. **2**.

FIG. **4** is a bottom plan view of the schematic shown in FIG. **3** showing the image of a defect on a screen.

FIG. **5** is a fragmentary part-sectional view taken along the line **2—2** in FIG. **1**, parts being broken away.

FIG. **6** is an electrical schematic of the apparatus embodying the invention.

FIG. **7** is a schematic of the scanning portion of the apparatus.

FIG. **8** is a scanning diagram of the portion of the apparatus shown in FIG. **7**.

FIG. **9** is a block diagram of the circuitry shown in FIG. **6**.

FIG. **10** shows a series of pulse diagrams as they are modified in various portions of the circuitry.

DESCRIPTION

Referring to FIG. **1**, the method and apparatus embodying the invention is shown as particularly adapted for use in connection with the manufacture of hollow glass containers C which have an open upper end and are generally bulbous in shape. In one method of manufacture of such containers, they are made on what is commonly known as a glass ribbon machine wherein a ribbon of glass is deposited onto a conveyor made of a plurality of interconnected orifice plates **10** that are moved beneath blow heads and in synchronism with molds to blow and form the glass ribbon into the articles.

In accordance with the invention, the articles C are moved successively and continuously by orifice plates **10** through an inspection station **11** where the bottom wall of the containers is inspected and thereafter to a reject station **12** where a reject device such as a cylinder is operated to reject any containers that have defects in the bottom wall. The defects which are to be detected in the case of glass comprise chips, seeds or bubbles or the like.

The basic method and apparatus for making the inspection at the inspection station **11** is shown diagrammatically in FIG. **2** and comprises a source **13** of radiant energy to which the article is transparent, such as a helium-neon laser, which is emitted in a collimated manner and then caused to form a point image by means of lens **22**. The point image of lens **22** is located within the open end of the article or container C to be inspected. From this point image the radiant energy diverges to completely illuminate the plane **15** of the bottom wall of the container. Defects, such as a chip, seed, bubble, inclusion, or the like located in the bottom wall of the container are projected as dark shadows within this diverging beam. In this way the provision of a point source of radiant energy allows the formation of a sharp and distinct shadow of a defect within the illuminated bottom image on screen **15***a*. The image on the screen **15***a* is then analyzed for changes in illumination by an image dissector camera which analyzes successive portions of the entire illuminated image as the container moves continuously through the inspection station.

A combination of collecting lens group **23** and an imaging lens group **25** is utilized to form image **15a**. This optical arrangement allows the influence of mole marks and other non-critical optical imperfections to be minimized. Without this arrangement of lenses **23** and **25**, such non-critical imperfections would also be imaged as dark shadows and could not be distinguished from real defects. Lenses **23** and **25** tend to minimize the relatively smaller images that might be created by optical deviations from mold marks and the like which are not objectionable and are not to be detected.

Defects such as bubbles or seeds, as shown in FIGS. **3** and **4**, cause a redirection of light and an enlarged darkened image I of the defect on screen **15***a*. Such defects produce a lens effect caused by the pocket of gas in the bubble or seed that functions to focus the light and contributes to the enlarged darkened image of this defect type.

A laser source of radiant energy is preferred since it provides sharp, well-defined shadow images of defects, has high output power, long life and is relatively cool.

The specific apparatus for making the inspection is shown in FIG. **5** wherein identical reference numerals are utilized for purposes of clarity. The source of radiant energy comprising laser **13** is mounted in a housing 17a at one side of the path of the articles C and is directed horizontally through a spatial filter **18.** The spatial filter is essentially a beam diverging device and a pinhole. A standard high power microscope lens is used for the beam diverger. The pinhole serves to remove interference in the beam caused by stray light diffracted from dust, etc., that is part of any laser optical system. Diffraction interference degrades the laser beam by producing phase and amplitude variations or modulation across the uniphase output of the laser beam. Unless these are removed, Fresnel zone patterns will occur in the laser beam which will represent excessive noise to the electronic system.

The beam then passes through a collimating lens **19** and an iris **20** placed immediately after the collimating lens **19.** This provides control of the output beam diameter and directly affects the cone angle of the laser beam which examines the bottle bottom. The size of the iris is adjusted by a knob located on the underside of the top section just behind the diverging lens group **22.** This adjustment controls the area of examination of the bottle bottom within the limitations of the acceptance angle of the condensing lens group **23.** The beam is then reflected by a mirror **21** downwardly through a lens assembly **22** that produces the diverging beam.

A second housing **17b** is positioned at one side and below the path of the containers or articles C and includes a lens assembly **23** which directs the light that has passed through container C against a mirror **24** which, in turn, reflects the light through a lens **25** which images the bottom of the container onto a ground glass screen **15***a*. Screen **15***a* is preferably made of red filter glass to prevent stray light from causing unwanted noise in the electronics system. The image dissector camera **16** is mounted within the housing **17***b*.

Sensors such as magnetic sensors **30** are provided adjacent the inspection station to sense the presence of a support with a container thereon for purposes presently described to synchronize the operation of the electronics associated with the apparatus, which are shown schematically in FIG. **6.**

Referring to FIG. **7**, the image dissector camera **16** consists of an image dissector tube **31** with its high voltage power supply and a set of imaging optics. The lens forms an image of the target on the photocathode surface **31***a* of the tube, where the incident photons cause the emission of photo-electrons.

The photocathode surface **31***a* is maintained at a high negative potential with respect to the anode **32.** Therefore, as the photo-electrons are emitted, they are accelerated towards the anode through a focusing coil and deflecting coils **31***b*. The focusing coil **31***b* forms an electron image of the photocathode on a rectangular aperture plate **33.** The aperture plate **33** is located between the photocathode **31***a* and the photomultiplier section **34,** and only those photo-electrons passing through this aperture **33** are amplified by the photomultiplier.

The output current from the anode **32**, representing a highly amplified version of the photo-electron current emitted by the cathode **31***a*, is monitored by a small resistor in series with the anode lead. The voltage across this resistor, the video output, is buffered by an operational amplifier **34***a* and directed to the main system. X and Y deflection coils **31***b* allow any portion of the target image to be monitored by deflecting the photoelectrons from that section through the photomultiplier aperture.

In order for the camera to observe the complete image of the bottle bottom, a scan pattern or raster must be generated which permits each section of the image to be scanned in turn.

Generation of such a pattern (FIG. **8**) requires the simultaneous application of suitable drive voltages to the X and Y deflection coils **31***b* of the image dissector camera **16.** It is easily seen that such a pair of waveforms are; a triangular waveform for the vertical drive and a staircase waveform for the horizontal drive. The horizontal scan of the camera will be against the direction of apparent motion of the article or bottle.

A typical image dissector camera which produces satisfactory results is Model F5005 Vidissector Camera with an F4011 tube, manufactured by ITT Industrial Laboratories. The camera is equipped with an S25 photocathode with a 0.005 × 020.0 inch aperture. The photocathode has a **1.1** inch diameter active area.

Referring to the block diagram FIG. **9**, the signal from oscillator wave shaper divider **35** is fed to an integrator **36** and, in turn, to an analog switch **37** to the vertical drive **38** for the camera.

The oscillator wave shaper divider **35** also supplies a gate **39** and, in turn, a counter **40**, and successively a digital analog converter **41**, an analog switch **42**, and the horizontal drive **43** for the camera. A start pulse begins the start circuitry **44** and operates the synchronizing circuitry **45.** A gate pulse actuates "get ready" circuitry **46** controlling analog switches **37** and **42.** A three-element band pass circuit including a band pass circuit **48**, a high pass circuit **49** and a large defect circuit **54** is provided. Threshold circuitry **47**, actuated by counter **40**, operates band pass circuit **48** and together with high pass circuit **49** provides signals to a comparator **50** and, in turn, to a defect detector **51** and through a gate **52** to a defect storage **53** for subsequent rejection. The gate **52** is controlled by the large defect circuit **54.**

The corresponding elements of the block diagram (FIG. **9**) are shown in broken lines in FIG. **6.**

Referring to the schematic diagram FIG. **6**, the oscillator wave shaper divider **35** comprises a clock **55** and flip flops **56, 57.** Integrator **36** comprises an amplifier **58.** Analog switch **37** comprises switch **59** while vertical buffer amplifier and gain adjuster **38** comprise an amplifier **60** and associated circuitry. The gate circuit **39** comprises gates **61, 62.** Analog switch **42** comprises switch **63** and horizontal buffer amplifier and gain adjusting circuit **43** comprises an amplifier **64.**

The start circuitry **44** comprises gates **65, 66** and a flip flop **67.** The threshold circuitry **47** comprises count detector **68**, gate **69** and threshold adjuster **70.** The get ready circuit **46** comprises gates **71** and flip flop **72.** Band pass circuit **48** comprises amplifiers **73, 74** and high pass circuit **49** comprises an amplifier **75.** Comparator **50** comprises an amplifier **76.** Defect detector **51** comprises a gate **77**, one-shots **78, 79** and gate **80.** Defect storage **53** comprises gate **81**, gate **82** and flip flop **83.** Large defect circuit **54** comprises amplifiers **84, 85, 86** and a gate **87.**

Referring to the schematic diagram FIG. **6**, the output pulses from **20** KHz clock **55** are shaped by flip flop

56 and the frequency is halved. The frequency is halved again by flip flop **57** and the output is fed to an integrator **36** formed by amplifier **58**. The output of amplifier **58** is a 5 KHz triangular wave, symmetrical about zero volts, the result of integrating the 5 KHz square wave from flip flop **57**. Assuming that analog switch **37** is closed, the signal from amplifier **58** is amplified and buffered by amplifier **60** for application to the vertical drive input of the camera **16**.

The output of flip flop **56** is fed via gates **61** and **62** to seven bit ripple counter **40**. Digital to analog converter **41** follows the counter **40**, and its output is a positive going staircase starting at zero volts when the counter **40** is in the zero state. The output of the digital to analog converter **41** is summed by amplifier **43** with an adjustable bias and inverted, thus generating a bipolar, negative going staircase waveform for application to the horizontal drive input to the camera **16**.

In operation, an article coming down the line initiates a get ready pulse through a remote sensor **30** positioned on the line which sets flip flop **72**. The output of flip flop **72** closes switch **37** which starts the vertical scan and opens a switch **42** which removes the bias from amplifier **43**, thus driving the scan to its extreme horizontal position.

The output of the counter **40** was set to zero at the end of the previous raster and the digital to analog converter **41** output is also zero. When the article is in position at the inspection station, a "start" pulse is initiated by sensor **30** which sets flip flop **67**, opening gate **61** and allowing clock pulses from flip flop **56** into the counter **40**.

Thus, the camera scans the image vertically and steps across horizontally each time the count increases by one. When the preset number of pulses have been counted, the end of count detector **68** resets the counter and also the start and get ready flip flops **67**, **72**. As soon as flip flop **72** is reset, it opens switch **37**, removing the vertical drive signal and closing switch **42**, reapplying the bias to amplifier **43**, thus setting its output to zero which places the scanning aperture in the middle of the field.

Referring to FIG. **6**, the video signal is fed simultaneously to three channels. The first channel **48** consists of amplifier **73** which together with the network following it has a specific band pass transfer function and amplifier **74** which level shifts the conditioned video signal and applies it to one side of differential comparator **50**. The second channel **49** is formed by amplifier **75** and the network at its output which has specific high pass transfer function.

Differential comparator **50** compares the outputs of amplifiers **74** and **75** and triggers one-shots **78** and **79** via gate **77** if a difference (defect) occurs. The third channel **54** is formed by amplifiers **84** and **85** which feed the video signal to comparator **86** which provides a positive output when the input goes more negative than a preset reference level.

The output of comparator **86** provides a means of blanking the defect logic via gate **52** between scans. However, if a very large defect should occur which happened to be more positive than the reference level, it would cause false blanking to occur. One-shots **78**, **79** overcome this problem by generating a defect output in the form of a pulse 1 μs wide but delayed by 2 μs. This allows any large defect spike time in which to disappear after, which the defect signal can pass through the gate and set defect flip flop **83** which in turn signals the data logger. Gate **82** controlled by the start flip flop **67** blanks the defect logic between bottles.

Examination of a typical trace shows that the sensitivity of the system is a maximum in the center of the scan pattern and decreases or falls off toward the edges. This is due to the combined effect of a Gaussian laser output, the imaging optics, and uneven camera sensitivity. In order to compensate for these effects, two different methods are employed in the detection circuitry. One method acts to give improved uniformity of detection as the scan format steps across the bottle bottom image. The other applies to give an adaptive threshold for each scan line. Each method acts in an orthogonal direction to the other. The total result is an improved uniformity of detection sensitivity across the bottle area investigated, even for conditions of nonuniform illumination or uneven camera sensitivity.

For improved detection sensitivity in the scan step direction the electronics signal at the output of amplifier **74** is weighted, the weight being controlled by the scan count. Essentially the threshold adjustment circuit monitors the counter output and delivers a preset bias to amplifier **74** whose value depends on the actual scan count. To accomplish this, the pulses from counter **40** are fed to the threshold adjuster **70** which furnishes a changing bias voltage between selectable counts. For example, the scan pattern may be divided into five segments for weighing purposes. These may be counts 0 to 12, 12 to 24, 24 to 40, 40 to 52 and 52 to 64, but could in general be extended to include each scan increment if desired.

In the direction along each scan line, another approach is employed. The pulse representing a given defect is higher when it appears near the center of the sweep and lower near the ends. To provide more uniform detection sensitivity across the scan sweep, an adaptive threshold is utilized. The incoming video signal is processed in two separate stages, one stage represents the defect information and the other serves to provide an adaptive threshold. The defect information is processed by selective filtering and differentiation at the output of amplifier **73** and is then inverted by amplifier **74** and sent to comparator **76**. In the comparator, the processed defect signal from the band pass circuit **48** is referenced to the output of amplifier **75** of the high pass circuit **49**. The reference signal is generated by filtering the video input to decrease its high frequency content and is then adjusted in gain to represent the general signal envelope across the scan. This envelope serves as the adaptive threshold which duplicates the general contour of the video signal. In this way, the signal variation across the scan which is due to the nonuniform illumination and uneven camera photocathode sensitivity is employed to give greater detection sensitivity where the defect signal amplitude is lower at each end of the scan. This results in an overall improvement in uniformity of detection sensitivity. The manner in which the signal is modified is shown in FIG. **10**.

We claim:

1. An apparatus for inspecting the bottom wall of hollow open-ended articles for defects which comprises

means for moving the articles successively and continuously in a predetermined path past an inspection station, means at the inspection station for directing a beam of radiant energy to which the article is transparent against the bottom wall of the article,

a screen positioned adjacent the bottom wall of the article for creating an image of the bottom wall on the screen with an image of the defect present in the bottom wall,

and means for analyzing successive portions of said image to determine the presence of a defect.

2. The combination set forth in claim **1** including means for creating a reject signal when said analyzing means detects the presence of a defect.

3. The combination set forth in claim **1** wherein said image creating means comprises a lens system interposed between said articles and said screen.

4. The combination set forth in claim **3** wherein said lens system comprises collecting lens means and imaging lens means.

5. The combination set forth in claim **1** wherein said means for directing a beam of radiant energy includes a laser.

6. The combination set forth in claim **1** wherein said means for creating an image includes means for collimating said beam and thereafter creating a divergent beam.

7. The combination set forth in claim **1** wherein said means for directing a beam includes a source positioned adjacent the path of the article at one side thereof and mirror means for redirecting the beam into the open end of the article.

8. The combination set forth in claim **1** wherein said means for analyzing said image includes collecting lens means.

9. The combination set forth in claim **1** wherein said means for analyzing said containers includes an image dissecting camera.

10. The combination set forth in claim **1** including lens means interposed in the path of said image between said screen and said analyzing means for minifying the image of said screen.

11. The combination set forth in claim **1** wherein said means for analyzing said image is positioned at one side of the path of the container, and mirror means for redirecting the image from said screen toward said analyzing means.

12. The combination set forth in claim **1** wherein said means for analyzing said image comprises raster scanning means and means for compensating for the effect that the scan pattern signals are a maximum in the center of the scan pattern and decrease toward the edges by increasing the sensitivity of the scan pattern signals toward the edges of the scan.

13. The combination set forth in claim **12** wherein said compensating means functions to count the scan pattern and modify the scan pattern in accordance with the count.

14. The combination set forth in claim **12** including means for producing a threshold signal that has a greater magnitude adjacent the center of the scan pattern than at the edges and means for comparing the scan pattern signal with the threshold signal to produce a reject signal when any scan pattern signal exceeds the threshold signal.

15. The combination set forth in claim **14** wherein said comparing means comprises filtering means for filtering the scan pattern signal and means for adjusting the gain thereof.

16. An apparatus for inspecting the bottom wall of hollow open-ended articles for defects which comprises

means for directing a beam of radiant energy to which the article is transparent against the bottom wall of the article,

a screen positioned adjacent the bottom wall of the article to create an image of the bottom wall with an image of the defect present in the bottom wall,

and means for analyzing successive portions of said image to determine the presence of a defect.

17. The combination set forth in claim **16** including means for creating a reject signal when said analyzing means detects the presence of a defect.

18. The combination set forth in claim **16** wherein said image creating means comprises a lens system interposed between said article and said screen.

19. The combination set forth in claim **18** wherein said lens system comprises collecting lens means and imaging lens means.

20. The combination set forth in claim **16** wherein said means for directing a beam of radiant energy includes a laser.

21. The combination set forth in claim **16** wherein said means for creating an image includes means for collimating said beam and thereafter creating a divergent beam.

22. The combination set forth in claim **16** wherein said means for directing a beam includes a source positioned adjacent the path of the article at one side thereof and mirror means for redirecting the beam into the open end of the article.

23. The combination set forth in claim **16** wherein said means for analyzing said image includes collecting lens means.

24. The combination set forth in claim **16** wherein said means for analyzing said containers includes an image dissecting camera.

25. The combination set forth in claim **16** including lens means interposed in the path of said image between said screen and said analyzing means for minifying the image of said screen.

26. The combination set forth in claim **16** wherein said means for analyzing said image is positioned at one side of the path of the container, and mirror means for redirecting the image from said screen toward said analyzing means.

27. The combination set forth in claim **16** wherein said means for analyzing said image comprises raster scanning means and means for compensating for the effect that the scan pattern signals are a maximum in the center of the scan pattern and decrease toward the edges by increasing the sensitivity of the scan pattern signals toward the edges of the scan.

28. The combination set forth in claim **27** wherein said compensating means functions to count the scan pattern and modify the scan pattern in accordance with the count.

29. The combination set forth in claim **27** including means for producing a threshold signal that has a greater magnitude adjacent the center of the scan pattern than at the edges and means for comparing the scan pattern signals with the threshold signal to produce a reject signal when any scan pattern signal exceeds the threshold signal.

30. The combination set forth in claim **29** wherein said comparing means comprises filtering means for filtering the scan pattern signals and means for adjusting the gain thereof.

31. The method of inspecting the bottom wall of hollow open-ended articles which comprises

moving the articles successively and continuously in a predetermined path past an inspection station,

directing a beam of radiant energy to which the article is transparent through the open end of the container against the bottom wall of the container as the container moves continuously through the inspection station to illuminate the bottom wall,

causing a defect in the bottom wall to redirect a portion of the beam,

creating an image of the bottom wall whereby a defect produces a localized change in the illumination of the image,

analyzing said image,

and producing a reject signal when said analysis evidences the presence of a defect,

said step of analyzing said image comprising analyzing successive portions of said image to produce scan pattern signals,

the step of analyzing successive portions of the image is by a raster scan and including the step of compensating for the effect that the scan pattern signals are a maximum in the center of the scan pattern and decrease toward the edges by increasing the sensitivity of the scan pattern signals toward the edges of the scan,

the step of producing a threshold signal that has a greater magnitude adjacent the center of the scan pattern than at the edges and comparing the scan pattern signals with the threshold signal to produce said reject signal when any scan pattern signal exceeds the threshold signal.

32. The method set forth in claim 31 wherein said comparing step is achieved by filtering the scan pattern signals and adjusting the gain thereof.

33. The method of inspecting the bottom wall of hollow open-ended articles which comprises

moving the articles successively and continuously in a predetermined path past an inspection station,

directing a beam of radiant energy to which the article is transparent through the open end of the container against the bottom wall of the container as the container moves continuously through the inspection station to illuminate the bottom wall,

causing a defect in the bottom wall to redirect a portion of the beam,

creating an image of the bottom wall whereby a defect produces a localized change in the illumination of the image,

analyzing said image,

and producing a reject signal when said analysis evidences the presence of a defect,

said step of analyzing saidimage comprising analyzing successive portions of said image to produce scan pattern signals,

the successive portions of said image being scanned transversely to the direction of movement of the articles.

34. The method of inspecting the bottom wall of hollow open-ended articles which comprises

directing a beam of radiant energy to which the article is transparent through the open end of the container in a diverging path against the bottom wall of the container,

causing a defect in the bottom wall to redirect a portion of the beam,

creating an image of the bottom wall whereby a defect produces a localized change in the illumination,

and producing a reject signal when said localized change evidences the presence of a defect,

said step of analyzing said image comprising analyzing successive portions of said image to produce scan pattern signals,

the step of analyzing successive portions of the image is by a raster scan and including the step of compensating for the effect that the scan pattern signals are a maximum in the center of the scan pattern and decrease toward the edges by increasing the sensitivity of the scan pattern signals toward the edges of the scan,

the step of producing a threshold signal that has a greater magnitude adjacent the center of the scan than at the edges and comparing the scan pattern signals with the threshold signal to produce said reject signal when any scan pattern signal exceeds the threshold signal.

35. The method set forth in claim 34 wherein said comparing step is achieved by filtering the scan pattern signals and adjusting the gain thereof.

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