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Drinkuth et al.

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[54] **ARTICLE INSPECTION BY SUCCESSIVELY TELEVISED IMAGES**

[75] Inventors: **William H. Drinkuth,** Hebron; **Edward J. Stephens,** Manchester, both of Conn.

[73] Assignee: **Emhart Industries, Inc.,** Farmington, Conn.

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Related U.S. Patent Documents

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[52] **U.S. Cl.** **178/6;** 178/DIG. 1; 178/DIG. 33

[51] **Int. Cl.**[2] **H04N 7/00**

[58] **Field of Search** ..... 178/6, DIG. 1, DIG. 33

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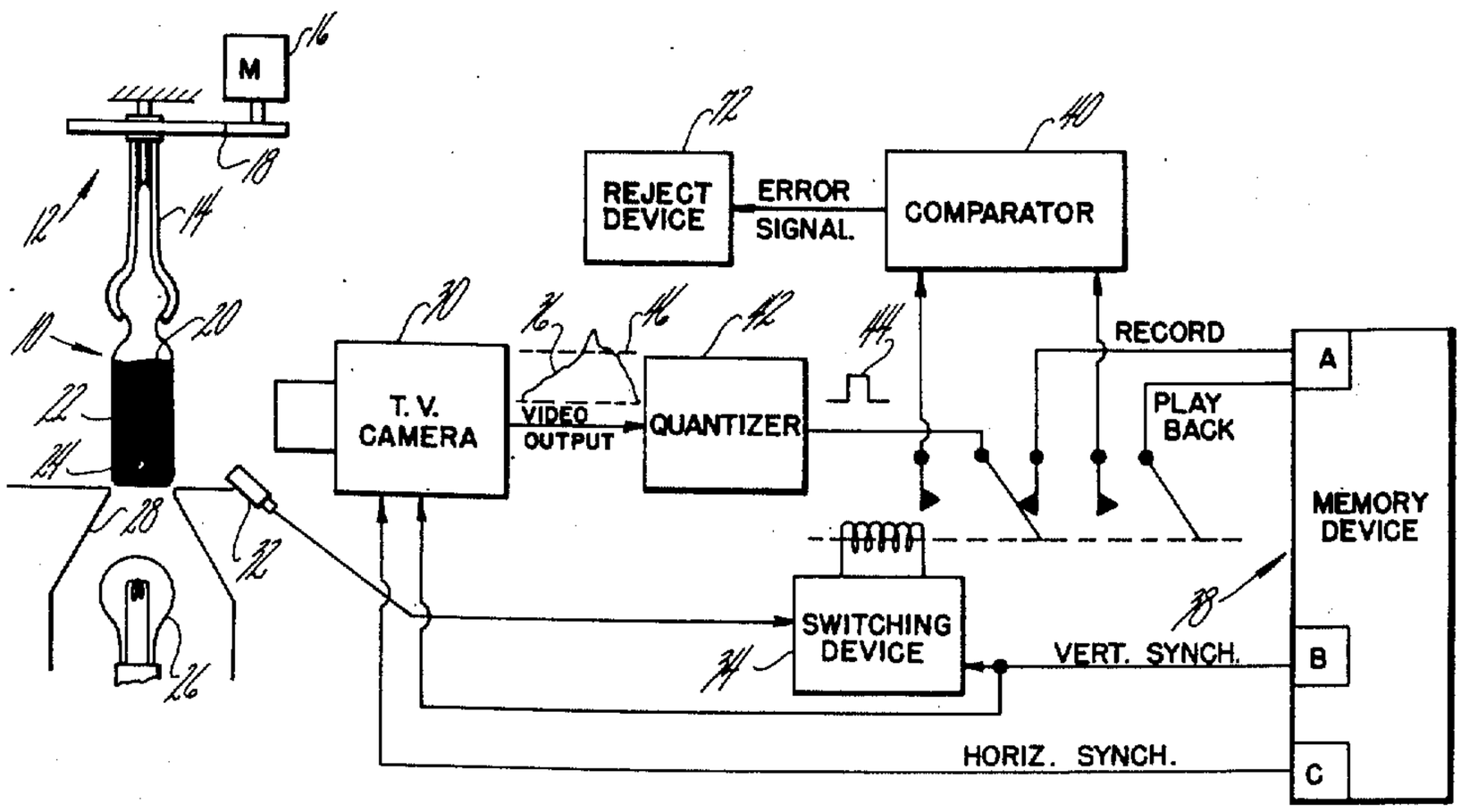
Primary Examiner—Robert L. Griffin
Assistant Examiner—Edward L. Coles
Attorney, Agent, or Firm—McCormick, Paulding & Huber

[57] **ABSTRACT**

A liquid-filled transparent container is spun momentarily to cause the liquid therein to swirl, and successive video frames provide voltage analogs through a television camera. A memory device is synchronized with the camera and stores at least one of the voltage analogs so that a comparator can subtract one successive analog signal from another to generate an error signal if foreign particles are present in the swirling liquid.

15 Claims, 4 Drawing Figures



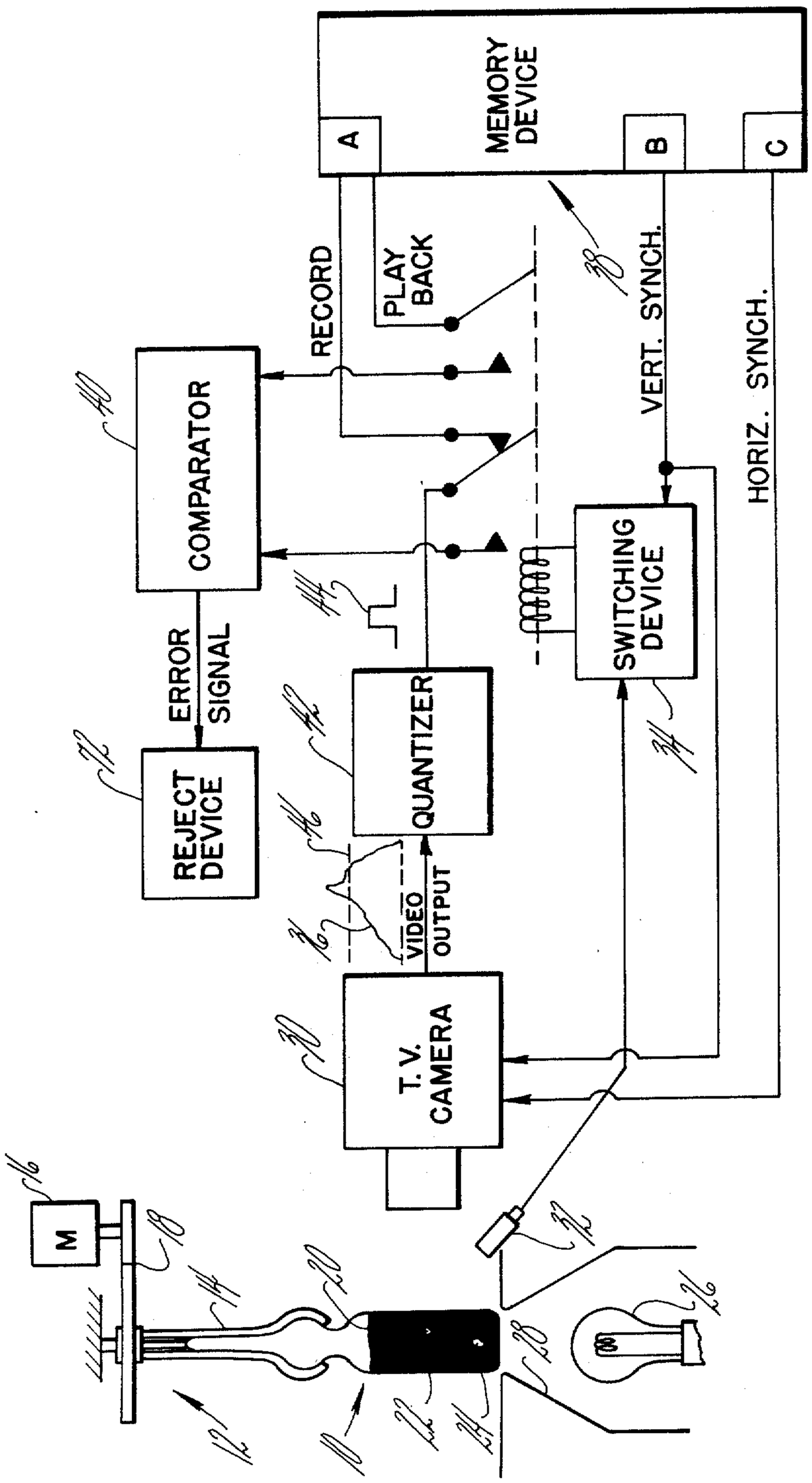


FIG. 1

INVENTORS
WILLIAM H. DRINKUTH
EDWARD J. STEPHENS

BY

McCormick, Paulding & Huber

ATTORNEYS

FIG. 2

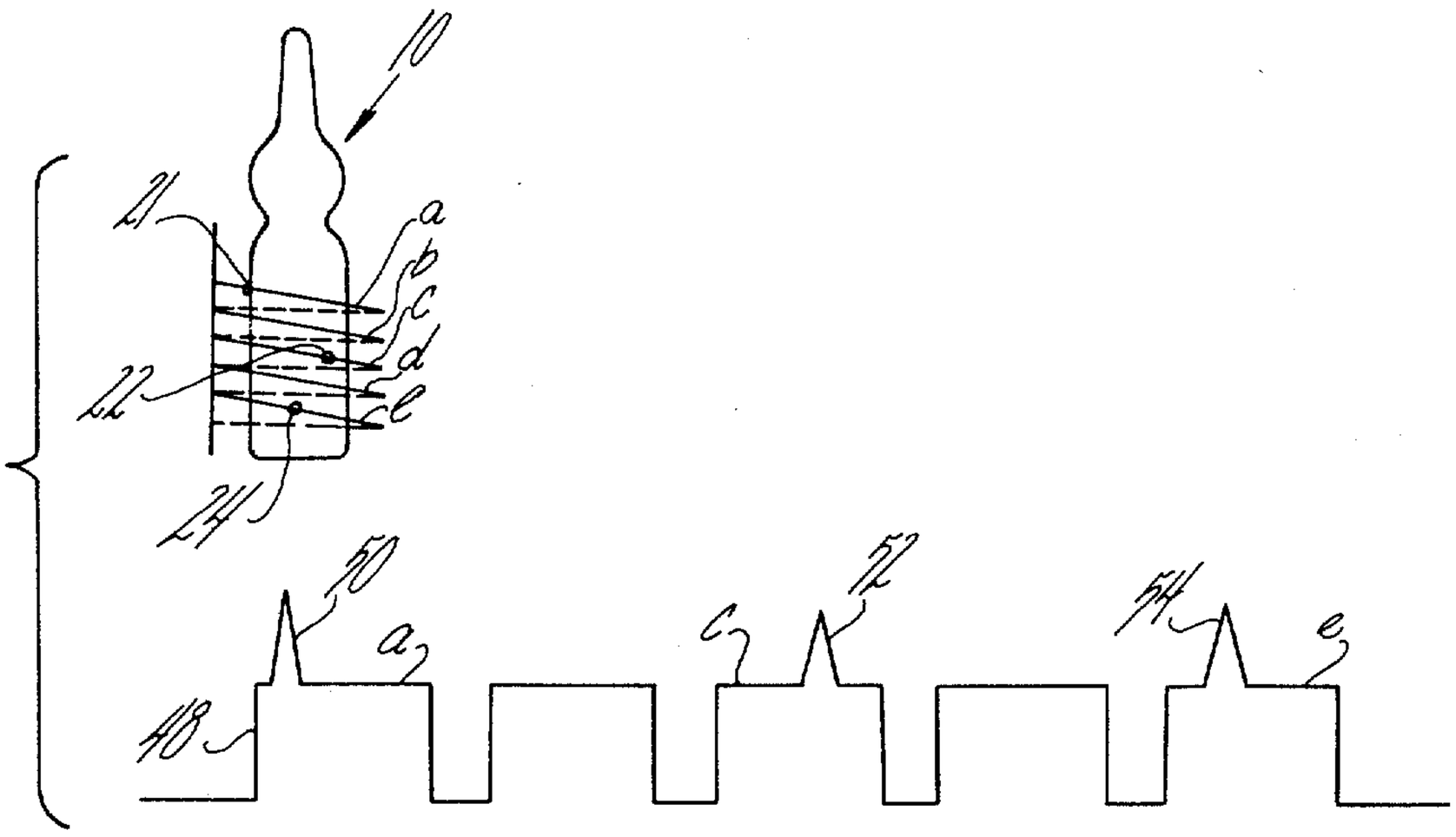


FIG. 3

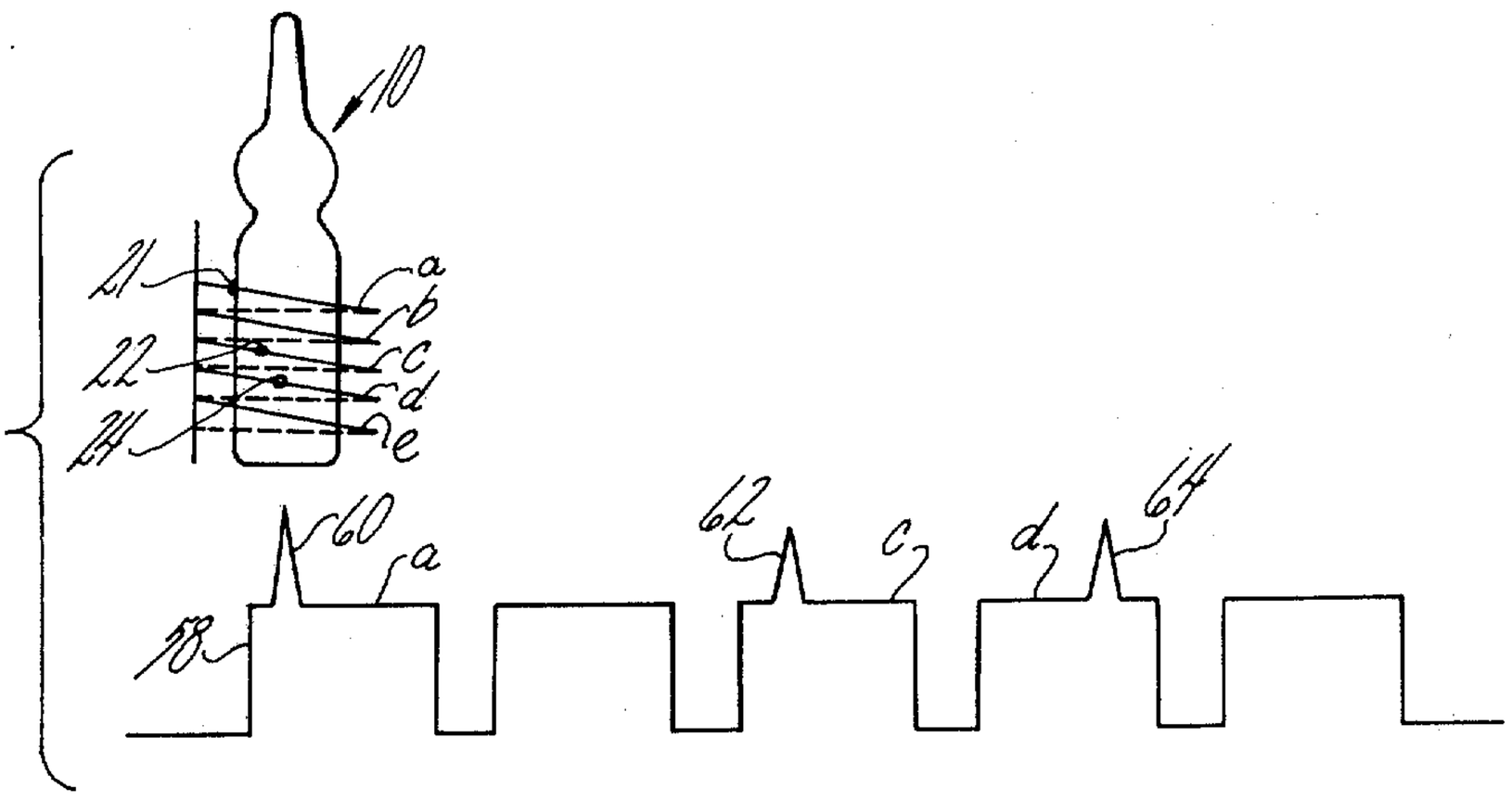
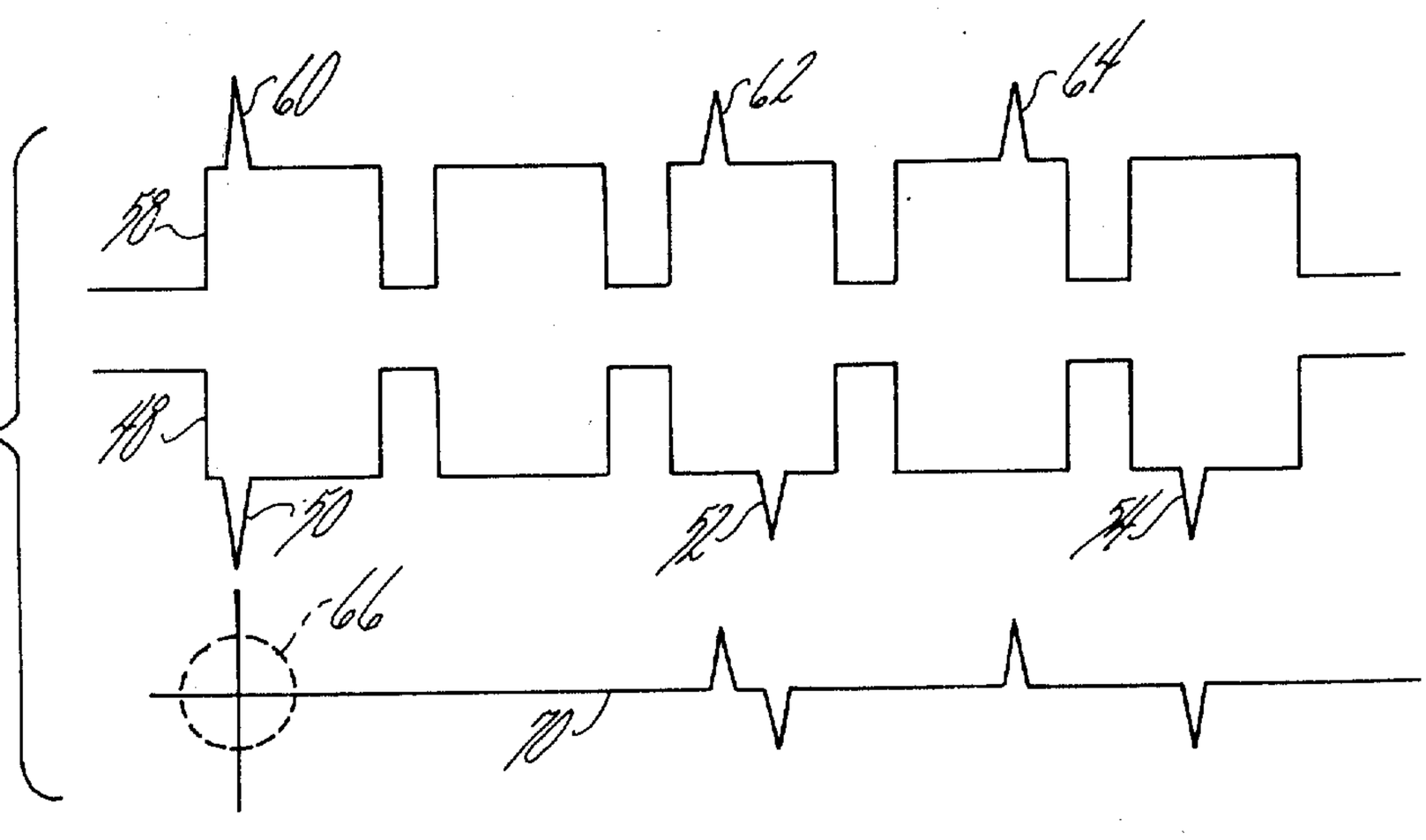


FIG. 4



ARTICLE INSPECTION BY SUCCESSIVELY TELEVISED IMAGES

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

SUMMARY OF INVENTION

This invention relates to the inspection of articles by electronic means, and deals more particularly with a method and means for comparing successively televised images of an article to distinguish between apparently stationary desirable characteristics of the article and undesirable characteristics which are moving with respect to these stationary characteristics.

A general object of the present invention is to provide an improved method and means for article inspection wherein successive images of the moving article are compared electronically to generate an error signal whenever the difference therebetween does not fall within a predetermined range.

A more specific object of the present invention is to provide a method and means of article inspection by successively televised images wherein the article being inspected is transparent and contains a liquid which is to be inspected for the presence of foreign particles, said container being rotated on its vertical axis to impart a swirling motion to the liquid so that successive images of the article can be electronically subtracted to produce an error signal only if one or more foreign particles are being moved with the swirling liquid.

In the description to follow, the successive video images of the article undergoing inspection are compared electronically to detect foreign particles inside a transparent container, but it should be understood that the invention is not so limited, and that the method and means of the present invention could be readily adapted for use in detecting dimensional differences between successively formed video images of any moving article. For example, the article being inspected might be a container symmetrical about its vertical axis, and by rotating such an article through successive angular positions for scanning as suggested in the description to follow, the outline of the container can be checked for continuity to detect flaws in its surface, or to detect a "leaner" where the container is a glass bottle or jar. Further, in the inspection of glassware articles or other transparent containers, the internal surface of the container can be readily inspected in a similar manner, and this internal surface inspection can be accomplished simultaneously with inspection of the exterior surface without departing from the scope of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of a presently preferred embodiment well adapted to carry out one method of the present invention for particulate matter detection in glass ampuls.

FIG. **2** is a schematic view showing graphically the results of a single scan of the ampul shown in FIG. **1.**

FIG. **3** is a view similar to FIG. **2** but showing graphically the same ampul shown in FIG. **2** at a slightly later instant of time.

FIG. **4** shows the video analog signal of FIG. **2** in inverted position, and the results of adding said inverted signal to the analog signal shown in FIG. **3,** with the sum of said signals being indicated graphically at the bottom of this view.

DETAILED DESCRIPTION

Turning now to the drawings in greater detail, FIG. **1** shows an article **10** which has been positioned at an inspection station by suitable article transfer means indicated generally at **12.** The transport means **12** includes a chucking device **14** which permits the article or ampul **10** to be spun on its vertical axis at least momentarily by the motor **16** through a driving connection indicated generally at **18.** In the illustrated embodiment, the article to be inspected comprises an ampul having a quantity of liquid **20** therein, and in accordance with the present invention this liquid **20** is to be inspected for the presence of foreign particles as for example the particles indicated generally at **22** and **24.** The term article as used herein is intended to represent both the container or ampul **10** and its contents, since the latter represents the portion being inspected.

Still with reference to the inspection station, means is provided for illuminating the transparent container from beneath by a lamp **26** which is shielded as indicated generally at **28** so that illumination from said lamp is directed into the container and by internal reflection remains inside the container for achieving optimum illumination of the foreign particles **22** and **24.** In this manner, the liquid itself will not be illuminated appreciably, and will thereby present a dark, or black, background for the television camera **30** in order to provide a contrast for the illuminated particles **22** and **24.** Still with reference to the inspection station, a photocell or similar device **32** is provided for indicating to the switching device **34** the presence of an article **10** at the inspection station.

The television camera **30** comprises a conventional component of the present system, being adapted to produce a video output as shown with a single horizontal scanline being indicated schematically at **36** to represent the conventional scanning signal produced by the camera **30.** In accordance with the present invention, the camera **30** is driven with vertical and horizontal synchronizing pulses from the output of channels B and C of the memory device **38** respectively. This insures that the camera **30** is operating synchronously with the memory device **38** which may comprise a conventional memory disc of the type commonly used with television cameras generally. Thus, a vertical synchronizing pulse is provided to the switching device **34** and to the television camera **30** as indicated in FIG. **1.** The channels B and C of the memory device **38** are impressed with vertical and horizontal synchronizing pulses for the camera **30** such that the memory device **38** and the camera **30** always operate in timed or synchronized relationship with one another. The memory device **38** may comprise a disc, a drum, a delay line, a tape, or other well-known electronic memory device.

In accordance with the present invention, means is provided for storing at least one voltage analog signal from the camera **30** in the memory device **38** for later recall in timed relationship with a succeeding voltage analog signal from the camera **30** for comparison in the comparator **40.** As indicated schematically in FIG. **1,** the video output or voltage analog signal from the camera is reduced by a quantizer **42** to a simple stretched

pulse form, as indicated at **44,** whenever a particular horizontal scanline, as for example that shown at **36,** is provided with a return which exceeds a predetermined voltage level as indicated generally at **46.** Thus, whenever a particle above a predetermined size is detected by the camera **30,** and more particularly is detected at a particular horizontal scanline of a particular frame thereof, the video output signal will be simplified in the manner indicated by the quantizer **42.**

The initial voltage analog signal **44** will be fed to the memory device **38** through the record line indicated as a result of the switching device **34** being initially located in the position shown. After a predetermined time delay, a second voltage analog signal from the camera **30** is fed directly to the comparator **40** when the switching device **34** is repositioned to its alternate position (not shown), with the result that channel A of the memory disc **38** plays back the recorded voltage analog signal. It will be understood by those skilled in the art that the simple switch shown schematically in reference to the device **34** is intended to represent an electronic switching device for accomplishing this switching function. As a result of the switching device **34** being moved to its alternate position, the voltage analog signal produced by the camera **30** is fed directly to the comparator **40,** and the recorded information in channel A of the memory disc **38** is played back to the comparator **40,** and both voltage analog signals are synchronized with respect to one another for permitting an electronic comparison to be made by the comparator **40.**

Turning now to a more detailed description of the function served by the comparator **40,** FIG. **2** shows an ampul **10** with the horizontal scans of the television camera **30** being indicated schematically at a, b, c, d, and e. For purposes of illustration, a glass defect is indicated generally at **21** on the external surface of the ampul **10** and foreign particles **22** and **24** are shown inside the ampul. In accordance with the present embodiment of the invention, wherein it is desired to detect the presence of foreign particles in a liquid contained in the article rather than defects existing on the surface of the article itself, the ampul **10** is first spun about its vertical axis by the mechanism described with reference to FIG. **1,** and then its rotation is stopped with the result that the liquid contained therein continues to swirl carrying with it the particles **22** and **24** contained therein. As a result of this, the initial scan of the article **10** by the television camera **14** produces a voltage analog signal as represented schematically in FIG. **2.** More particularly, the vertical synchronizing pulse **48** which initiates the frame representing this initial scan is provided to the camera through the synchronizing channel B of the memory device **38.** The stationary defect, or dirt particle **21,** on the surface of the glass will produce a pulse **50** in the horizontal scanline a as shown. The horizontal scanline c will produce a pulse **52** as a result of the presence of foreign particle **22,** and the horizontal scanline e will produce a pulse **54** as a result of the foreign particle **24.**

As described hereinabove, and as indicated schematically in FIG. **3,** the switching device **34** will operate after a predetermined time delay to take a second look at the ampul **10** producing a second voltage analog of the article at the inspection station, which second analog signal is synchronized with respect to the previous signal being fed to the comparator **40** in the manner described above. As shown in FIG. **3,** a vertical synchronizing pulse **58** will be provided to initiate this frame of the camera through the snchronizing channel B of the memory device **38** and the stationary glass defect or particle **21** will appear as a pulse **60** located in the same relationship with respect to the vertical synchronizing pulse **58** as the previous pulse **50** with respect to the previous vertical synchronizing pulse **48.** Here again, the pulse **60** occurs on the same scanline a on this frame of the camera. Quite by accident perhaps the foreign particle **22** is also detected on the same horizontal scanline c as indicated by the pulse **62.** However, the foreign particle **24** has been moved by the swirling liquid to the scanline d as indicated by the pulse **64** in the example shown.

As previously mentioned, the voltage analog signal indicated generally in FIGS. **2** and **3** are simultaneously fed to the comparator **40,** and as indicated schematically in FIG. **4,** the first of these two signals is inverted on the same time base so as to be conveniently added to the second signal with the resultant signal being indicated generally at **70** in FIG. **4.** It will be readily apparent that the pulses **50** and **60** produced by the stationary glass defect, or particle **21,** will cancel one another as indicated generally at **66** in FIG. **4.** However, the pulses **52** and **62** associated with the foreign particle **22** do not cancel one another but result in a positive and negative pulse combination which can be used to generate an error signal for operating a reject device **72** in order to remove that particular ampul **10** from other ampuls which do not contain such foreign particles. The pulses **54** and **64** created by particle **24** also produce a positive and negative pulse combination which can be used to generate an error signal. Depending upon the amplitude of the error signal so produced and also on its width, the system described herein can be used to reject ampuls containing particles which exceed some predetermined size.

We claim:

1. A method for inspecting articles wherein each of said articles comprise a transparent container containing a quantity of liquid, which liquid is to be inspected for the presence of foreign particles, said method comprising the steps of

a. placing the article at an inspection station,

b. scanning the article with a television camera to produce a voltage signal indicative of the image seen by said camera,

c. storing said voltage signal in a memory device for subsequent use,

d. moving the container so that the orientation of the liquid to be inspected is altered,

e. scanning the article a second time with said television camera to produce a second voltage signal representing the second image seen by said camera,

f. comparing said voltage signals to provide an error signal whenever said second voltage signal does not bear a predetermined relationship to said first voltage signal, and

g. synchronizing said voltage signals with respect to one another, said step of comparing said synchronized voltage signals, comprising a process of subtracting said first and second voltage signals from one another to produce said error signal when the difference exceeds a threshold value.

2. A system for inspecting a liquid filled transparent container which is to be inspected for the presence of foreign particles in the liquid, and comprising means

for rotating the article momentarily so that the liquid is allowed to swirl while the article is held at an inspection station, a television camera for viewing said article, means for causing said camera to generate successive voltage signals indicative of said article images, a memory device for storing at least one such voltage signal, switching means causing said stored voltage signal to be recalled in timed relationship with a succeeding voltage signal, a comparator for combining said recalled voltage with said succeeding voltage and for generating an error signal whenever said signals do not bear a predetermined relationship to one another and, means for synchronizing said camera with said memory device so that said voltage signals are fed to said comparator in accurately indexed relationship to one another.

3. The system according to claim **2** and further including a light source so arranged adjacent one end of the container as to illuminate the particles.

4. The system according to claim **3** wherein said comparator subtracts said voltage signals from one another to provide said error signal, and a reject device operable in response to said error signal to separate a container with foreign particles from these containers without foreign particles.

5. A method for inspecting transparent containers for the presence of foreign particles in a liquid contained therein, said method comprising the steps of

a. spinning the container so that the liquid contents are swirled therein,

b. scanning the container and its contents with a television camera to produce a voltage signal indicative of the image seen by said camera,

c. storing said voltage signal in a memory device,

d. scanning the container and its contents a second time to produce a second voltage signal representing the second image seen by said camera, and

e. recalling the stored voltage signal to compare it with said second voltage signal.

6. The method according to claim **5** and further characterized by the steps of

a. synchronizing said voltage signals with respect to one another,

b. comparing said voltage signals to provide an error signal whenever said second voltage signal does not bear a predetermined relationship to said first voltage signal.

7. The method according to claim **6** and further characterized by the additional step of stopping the rotation of said spinning container prior to the scanning steps so that only the liquid contained therein continues to move between said scanning steps, said step of comparing said synchronized voltage signals comprising a process of subtracting said first and second voltage signals from one another to produce an error signal which is not effected by stationary particles on the container and not effected by defects in said transparent containers.

8. The method according to claim **6** and further characterized by rejecting said container when the amplitude of said error signal exceeds a threshold value.

9. The method according to claim **6** and further characterized by rejecting said container when the time base width of said error signal exceeds a length corresponding to a predetermined particle size.

10. A method for inspecting *liquid filled* articles comprising the steps of

a. placing the article at an inspection station,

b. scanning the article with a television camera to produce an electric signal which varies in accordance with the image seen by said camera,

c. storing said signal in a memory device for subsequent use,

d. rotating the article so that the orientation of the inspection portion with respect to the camera is altered,

e. stopping rotation of the article to cause swirling of the liquid,

f. scanning the article a second time with said camera to produce a second electric signal,

g. synchronizing said signals with respect to one another, and

h. comparing said signals to provide an error signal whenever said first and second signals do not bear a predetermined relationship to one another.

11. The method according to claim **10** wherein said step of comparing said first and second signals comprises a process of subtracting one from the other to produce said error signal in response to moving particles in the swirling liquid, said error signal being uneffected by stationary particles on the container and uneffected by optical defects in the transparent container.

12. The method according to claim **10** and further characterized by the additional step of illuminating the container from a light source so that the liquid provides a relatively dark background against which the particles stand out for a better contrast in the field of view of the camera.

13. A system for inspecting liquid filled transparent containers for the presence of foreign particles in the liquid, said system comprising

a. means for supporting an article at an inspection station,

b. means for rotating the article on its longitudinal axis, said means for rotating the container being carried out long enough to impart a swirling motion to the liquid and to any foreign particles therein, said article being held stationary at least momentarily,

c. a television camera for generating successive video frames, each of said frames includes a pattern of electrical signals which vary in accordance with the successive images seen by said camera,

d. a memory device for storing at least one such pattern of electrical signals,

e. synchronizing means for said stored signals,

f. and a comparator for combining said stored signals with a current video frame to generate an error signal whenever said compared patterns of electrical signals do not bear a predetermined relationship to one another, said comparator being effective to subtract said pattern of electrical signals from one another to generate said error signal.

14. The system according to claim **13** further characterized by a reject device operable in response to said error signal to separate a container with foreign particles from those without foreign particles.

15. The system according to claim **13** further characterized by a light source adjacent one end of the container at said inspection station for illuminating the particles in the liquid filled container.

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