Dec. 24, 1963 G. FORRESTER 3,115,037

PNEUMATIC VOID DETECTOR

Filed Dec. 9, 1960 2 Sheets-Sheet 1

FIG. 1

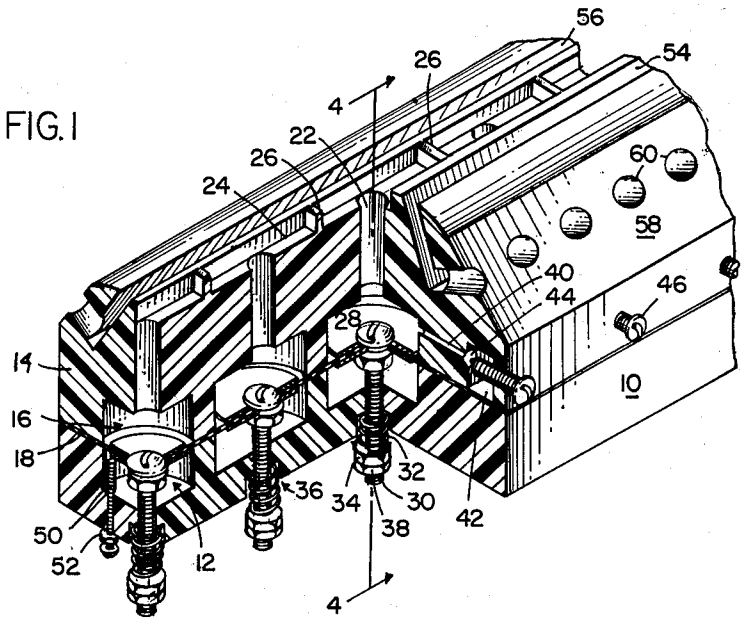
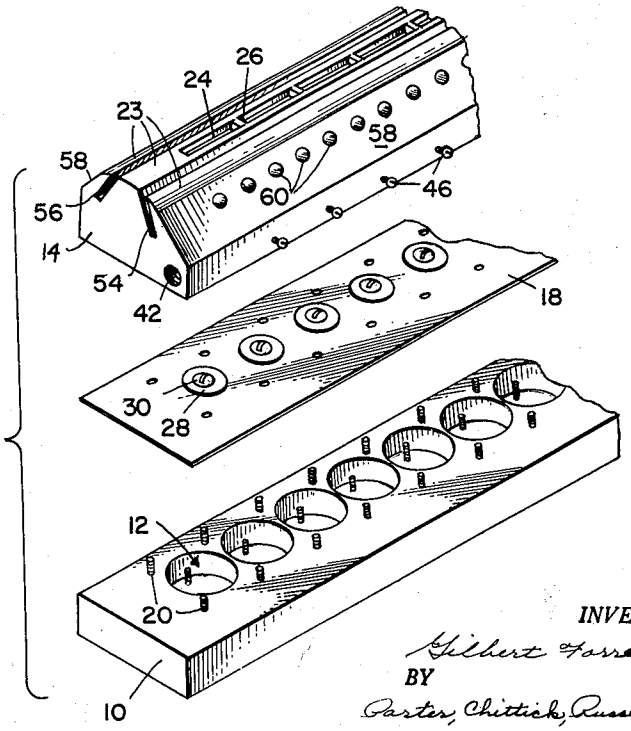


FIG. 2



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FIG. 3

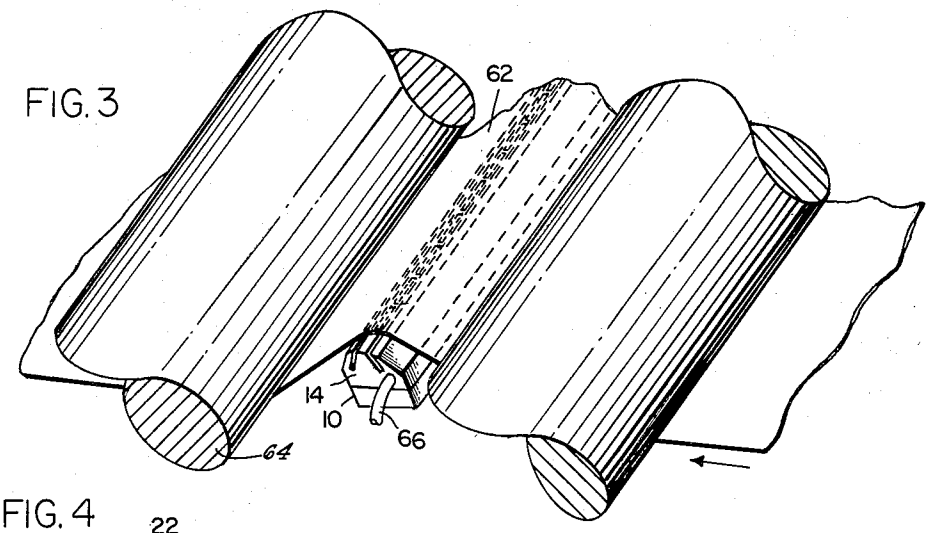


FIG. 4

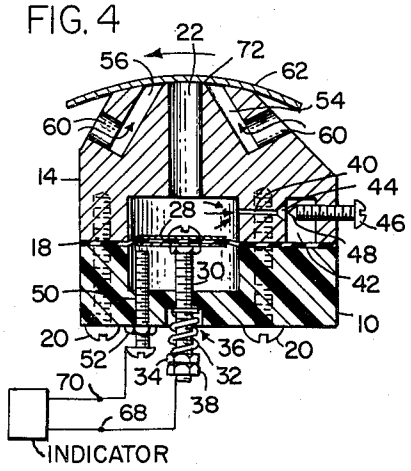


FIG. 5

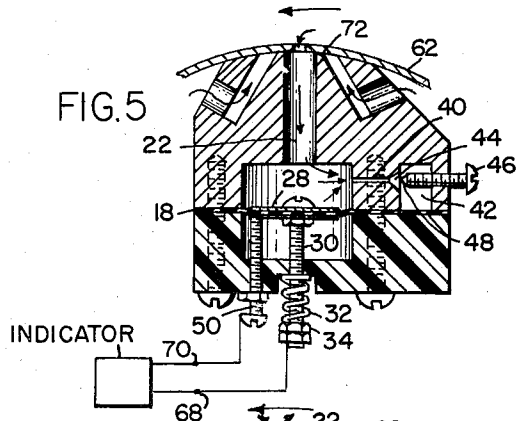


FIG. 6

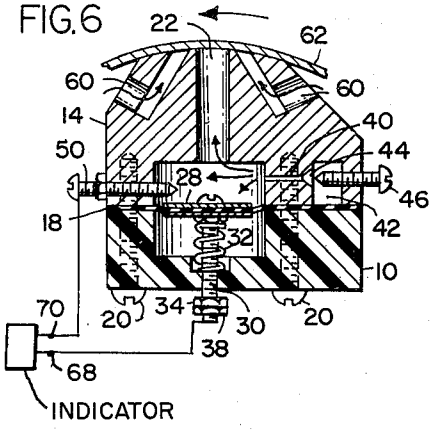
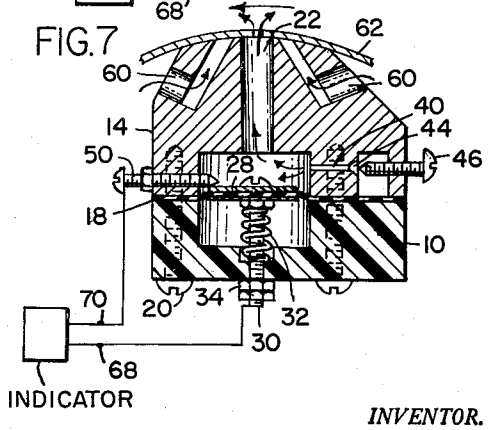


FIG. 7



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PNEUMATIC VOID DETECTOR

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This invention relates to apparatus for use in the control of quality of a moving web of flexible material, and more particularly to apparatus for detecting voids in a moving web of paper.

In the manufacture of paper it is necessary at some stage in the process to inspect the paper for voids, or holes, which may exist and which render the paper unsatisfactory in quality.

It is possible to examine each sheet of finished paper by eye, however such procedure is too slow and too costly to be economically feasible. It is also too fallible. Consequently, devices have been provided under the teachings of the prior art to accomplish such void detection by mechanical means. These devices have not proven wholly satisfactory. For example, a device may be constructed wherein a wheel or other contact element is positioned on the web of paper as it passes over a roller. When a void passes under the wheel, the wheel contacts the roller closing an electrical circuit which actuates a suitable indicator. At least two difficulties are inherent in this system. Firstly, the void may be simply in the nature of a razor-slit and hence not large enough to be detected by the wheel. Secondly, a great number of such contact making devices are required to cover the entire width of a moving web of paper.

A second method of detecting voids in a moving web of flexible material such as paper, is to position a source of light on one side of the web and means for detecting changes in the intensity of the light on the opposite side of the web. Again, such devices are unable to detect voids such as a razor-slit or a void having a flap of torn material covering a hole.

Accordingly, it is an object of my invention to provide apparatus which will detect any void in a moving web of paper, including a razor-slit and a void being covered by a flap.

It is another object of my invention to provide void detecting apparatus for use with a moving web of paper which is effective over substantially the whole width of the moving web.

In the accomplishment of these objects in a preferred embodiment of my invention I construct a void detector having a rectangular base on which is mounted an engagement head. The apparatus is positioned with the web of paper passing over the engagement head which is provided with a slightly curved top face. A longitudinal opening is formed along the top of the engagement head and is divided by walls into a series of shorter openings or slots. Each shorter slot communicates with an independent internal chamber formed by cooperating openings cut in the base and in the engagement head. A diaphragm of flexible material is sandwiched between the base and the engagement head and divides each of the chambers into an upper and lower chamber. A spring loaded electrical contact member is positioned extending up through the base and into the lower chamber and terminating in electrically conductive washers on the diaphragm. A passage communicating the upper chamber with a vacuum line is provided whereby a vacuum may be drawn through the upper chamber and the associated short slot in the top of the engagement head. The paper is then drawn across the series of slots and when a void passes over a slot, air is admitted to the associated chamber and thereby releases the vacuum therein causing the

spring loaded contact member and associated diaphragm to descend. A second contact member is positioned below the diaphragm and contact washers and the descent of the diaphragm causes an engagement of the two contact members thereby actuating appropriate registering devices. In order to detect creases in the web as well as voids, longitudinal openings positioned in a spaced relationship to the longitudinal slots are provided through which air at atmospheric pressure may communicate with the web just prior to its passing over the longitudinal slots whereby the air may flow through a crease into the longitudinal slots. Similar openings just subsequent to the slots facilitate the disengagement of the paper from the apparatus.

It is a feature of my invention to provide detector chambers in which changes in air pressure are employed to detect voids in a moving web.

It is a further feature of my invention to provide a detector for creases, wrinkles and similar surface irregularities as well as voids.

It is another feature of my invention to provide a series of longitudinal substantially contiguous detector areas disposed transversely to the moving web whereby a void signal may be registered generally if a void passes any detector area or may be registered in such fashion as to indicate the specific detector area which detected the void.

These and other objects and features of my invention will appear as the description proceeds with the aid of the accompanying drawings in which:

FIG. 1 is a view in perspective of my invention partially cut away to show the disposition of the interior elements;

FIG. 2 is an exploded view of the base, diaphragm and engagement head;

FIG. 3 is a fragmentary view in perspective showing the apparatus in position for operation;

FIG. 4 is a sectional view along the line 4—4 of FIG. 1 showing the positions of the internal elements during operation of the apparatus when no void is present;

FIG. 5 is a view similar to FIG. 4 showing the position of the interior elements when a void is detected;

FIG. 6 is a view in section similar to FIG. 4 showing the position of the interior elements in an alternative embodiment of my invention; and

FIG. 7 is a view similar to FIG. 6 showing the position of the interior elements when a void is detected.

Having reference to the above mentioned drawings for a more particular description of my invention in a preferred embodiment thereof, I construct a base **10** preferably of Lucite or a similar plastic provided with a series of downwardly extending circular openings indicated generally at **12** which are formed so as not to extend through the bottom of the base **10**. An engagement head **14** of brass or other suitable material is provided having circular openings **16** which extend upwardly from the bottom of the head **14**. A circular opening **16** is provided for each circular opening **12** in the base **10**, and is positioned to be coaxial and of equal radius therewith when the apparatus is assembled.

Sandwiched between the base **10** and head **14** is a sheet of flexible material forming a diaphragm **18**. In the preferred embodiment a rubberized fabric is employed. The base **10**, diaphragm **18**, and head **14** are secured together in an airtight relationship by a plurality of machine screws **20** extending upwardly through the base **10** into threaded holes in the head **14**. There are thus formed a series of cylindrical air chambers within the apparatus having a bottom section formed by the circular openings **12** in the base **10** and a top section formed by the circular openings **16** in the head **14**. The diaphragm **18** serves to separate the two sections with an air-tight seal.

Vertical passageways 22 are provided in the head 14 which communicate the upper portion 16 of each air chamber with the uppermost face 23 of the head 14. The vertical passage 22 terminates at its uppermost end in a longitudinal slot 24. There is a longitudinal slot 24 for each air chamber to provide a series of longitudinal slots 24 along the face 23 of the head 14. A thin wall 26 separates each pair of longitudinal slots 24.

By this arrangement of longitudinal slots 24 a longitudinal void detecting area may be formed of any desired length, it being only necessary to multiply the number of air chambers and associated longitudinal slots 24 to increase the longitudinal detection area. In operation, the apparatus is placed transversely to the moving web of paper and hence substantially the entire width of the web passes over the longitudinal detection area.

As the air chambers and associated elements are identical one to another only one such air chamber will be herein desccribed.

A first electrical contact member is positioned in the air chamber by mounting a brass washer 28 on either side of the diaphragm 18, the radius of each washer 28 being slightly less than that of the circular openings 12 and 16 which form the air chamber. A brass screw 30 is mounted through the center of the washers 28 and through the diaphragm 18 and extends slidably through the base 10. A coiled spring 32 is positioned around the screw 30 after it passes through the base 10 and is compressed against the base 10 by an adjustment nut 34. An upwardly extending cut indicated generally at 36 may be provided in the bottom of the base 10 coaxial with the screw 30 to assist the seating of the spring 32 against the base 10. A locking nut 38 is positioned on the screw 30 below the adjustment nut 34 to secure the adjustment nut 34 when it is in proper operation position.

In order to provide means for drawing a vacuum through the upper air chamber and vertical passage 22 a narrow horizontal passage 40 is provided in the head 14 communicating the upper air chamber 16 with a longitudinal passage 42 formed in the head 14 which is closed at one end and open at the other end to which a suitable vacuum line 66 may be attached. The passage 40 is sufficiently small to prevent the vacuum in line 66 from maintaining the vacuum in chamber 16 when a void occurs in the web 62. Positioned through the side wall of the head 14, and in alignment with a flared opening 44 into the longitudinal passage 42 formed at the end of the horizontal passage 40, is a screw 46 having a conical tip 48. The screw 46 thus provides valve means whereby the passage of air through the horizontal passage 40 may be controlled and individual detectors deactivated by advancing the screw 46 until the tip 48 is seated in the opening 44.

A second contact member is positioned in the lower air chamber and comprises a brass screw 50 positioned upwardly through the bottom of the base 10 which is provided with a threaded opening to receive it. The screw contact 50 extends upwardly to a position slightly below the normal operating position of the brass washer 28 which is positioned below the diaphragm 18. A locking nut 52 is provided for holding the contact screw 50 in a predetermined position.

The head 14 is constructed with a slightly curved top face 23 which is divided into three longitudinal segments by a pair of downwardly and outwardly extending longitudinal cuts 54, 56 one cut being positioned a short distance either side of the series of longitudinal slots 24. Beveled side faces 58 are also provided on the head 14 through which a plurality of openings 60 are formed into the longitudinal cuts 54, 56.

The operation of my invention is as follows:

The apparatus is positioned transversely to a moving web of paper 62 as shown in FIG. 3. A pair of rollers 64 may be employed to guide the paper over the head 14. The vacuum line 66 is attached to the open end of the

longitudinal passage 42, and a vacuum, in practice, one sufficient to sustain three inches of water, is drawn in the longitudinal passage 42. The screws 46, which serve as valve means are backed off so that the vacuum may draw through the horizontal passage 40, upper air chamber 16 and vertical passage 22 of each detector assembly. The web of paper 62 is caused to move over the head 14 and consequently over the series of longitudinal slots 24. The paper 62 is drawn down onto the longitudinal slots 24 causing the vacuum in the air chamber above the diaphragm 18 to lift the diaphragm 18, associated contact washers 28 and the brass screw 30 as shown in FIG. 4. The contact screw 50 is positioned so that it will not touch the washers 28 when the diaphragm is in raised position.

The brass screw 30 to which the washers 28 are fastened is connected by a lead wire 68 attached at its lower end to appropriate means for registering an "off-on" electrical condition. A lead wire 70 connected to the contact screw 50 is likewise connected to the registering means.

It will be apparent to one skilled in the art that the registering means above referred to may take the simple form of a source of electrical current and an alarm bell or lamp wired in series with the leads 68, 70, or the leads 68, 70 may be connected to a sorter or other device whereby the defective paper is separated from the satisfactory paper.

When a void passes over one of the longitudinal slots 24, as shown in FIG. 5, outside air passes through the hole in the paper 62 and releases the vacuum in the air chambers above the diaphragm 18. This in turn causes the diaphragm 18, washers 28 and screw 30 to descend from their raised operation position. The washer 28 below the diaphragm 18 makes electrical contact with the screw contact 50 and consequently the alarm bell or other registering device is actuated. By suitable adjustment of the contact screw 50, and of the tension in the compressed coiled spring 32 the apparatus may be caused to register any void passing over the longitudinal slots 24.

The apparatus will also detect creases and wrinkles in the paper web. This is accomplished by the operation of the longitudinal cuts 54, 56. Assuming that the paper is moving from right to left over the head 14 as shown in FIGS. 4 and 5, it will be noted that a crease in the paper would allow air to flow through the openings 60 and cut 54 over the narrow longitudinal segment 72 of the top face 23 and down into the air chamber thereby actuating the apparatus. In this regard it should be noted that the longitudinal segment 72 should be as narrow as possible in order to permit creases which are practically parallel to the apparatus to nonetheless actuate it.

The longitudinal cut 56 is provided to apply atmospheric pressure at the under surface of the paper web after it has come over the longitudinal detection slots 24 so that the paper will not bind as it is coming off the head 14.

It will also be noted that the longitudinal cut 54 located prior to the detection area serves a further important function of generally equalizing the air pressure above and below the moving web. As the web is moving at high speed small amounts of air trapped between the engagement head 14 and the web due to vibration and oscillation of the web as it approaches the apparatus may be discharged through the longitudinal cut 54 causing the web to pass smoothly over the detection area and simultaneously eliminating a possible source of false void indications.

An alternative embodiment of my invention is shown in FIGS. 6 and 7 in which instead of drawing a vacuum through the apparatus, a slight pressure is applied. The only structural changes which are required are that the compression spring 32 is mounted to urge the washers 28 and screw 30 upwardly rather than downwardly, and the contact screw 50 is positioned above the diaphragm 18 passing horizontally through the side of the head 14. A conical tip 74 may be formed at the interior end of the contact screw 50 in order to permit close adjustment of the spacing between the contact screw 50 and the

upper washer **28**. It will be noted that since the air is fed into the apparatus under pressure the normal operating position of the diaphragm **18** is depressed, as shown in FIG. 6. When a hole or crease passes over the longitudinal detection slot **24** the pressure is released and the diaphragm is pushed upwardly by the spring **32** so that the washer **28** contacts the contact screw **50** causing the apparatus to register a defect in the paper.

One advantage to the alternative embodiment using air under pressure rather than a vacuum is that any paper dust, etc., tending to accumulate in the apparatus is blown clear by the air flow.

It will also be obvious to one skilled in the art that the several detection areas are entirely independent in operation so that if it is desired, they may be wired to separate registering means whereby the location of a void may be pin-pointed on the transverse dimension of the web. It will also be noted that by providing separate valve screws **46** for each air chamber the apparatus may be adjusted to operate with webs of less width than the entire width of the apparatus.

It will be apparent from the above description that the pressure sensing chambers are in very close proximity to the paper surface, and the chambers themselves and all auxiliary chambers and air passages connecting thereto have been reduced to minimal volumes in order to render the device sufficiently sensitive to detect extremely small voids such as pinholes, passing at high speed.

It is my intention to claim all changes and modifications of the preferred embodiment of my invention herein chosen for purposes of disclosure which do not constitute departures from the spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a void detector for a moving web, said detector having a detector head having an arcuate engagement face, first walls in said detector head defining passages from surface points on said face to at least one sensing chamber located within said detector, said sensing chamber having a diaphragm member positioned in one wall thereof and having electrical contact making elements associated therewith to indicate deflection of said diaphragm from a first position, means for maintaining said diaphragm in a said first position including means for creating a differential air pressure across said diaphragm and in said sensing chamber when said web is continuous across said engagement face; means for introducing a supply of air at atmospheric pressure to the undersurface of said web in close proximity to said first walls in said detector head comprising second walls in said detector head defining at least one passage from first surface points adjacent said first walls to second surface points open to the atmosphere, said first surface points being spaced a slight distance from said first walls whereby atmospheric pressure may be supplied to the undersurface of a moving web as said web passes over said detector head to permit minor discrepancies in the structure of said web to release said pressure differential in said sensing chamber thereby actuating said electrical contact making elements.

2. Structure for supplying air at atmospheric pressure to the undersurface of a web in a void detector as defined in claim 1 further characterized by said means for supplying air at atmospheric pressure located closely adjacent said first walls and parallel thereto spaced at each side thereof transversely to the direction of travel of said web.

3. A void detector having an engagement head provided with an arcuate engagement face, a transversely elongated detector area in said face having a long narrow groove therein, a plurality of thin partitions across said groove to subdivide said groove into a plurality of adjacent segments, first walls defining a large bore passage from each of said segments to an individual internal sensing chamber in said head for each of said segments, each said internal sensing chamber having a flexible diaphragm in one wall thereof, electrical contact means actuated by motion of said flexible diaphragm, means for communicating air at non-atmospheric pressure to said sensing chamber including second walls in said detector head defining an air passage in communication with an external source for creating a differential air pressure across said flexible diaphragm when a web completely covers said groove and third walls defining a narrow bore metering passage between said sensing chamber and said air passage, and means for introducing a supply of air at atmospheric pressure to the undersurface of said web in close proximity to said first walls in said detector head, said introducing means comprising fourth walls in said detector head defining at least one passage from first surface points adjacent said first walls to second surface points open to the atmosphere, said first surface points being spaced a slight distance from said first walls, whereby atmospheric pressure may be supplied to the undersurface of a moving web as said web passes over said detector head to permit minor discrepancies in the structure of said web to release said pressure differential in said sensing chamber thereby actuating said electrical contact means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,588,831	Yokoyama	June 15, 1926
1,604,138	Vidaver	Oct. 26, 1926
1,960,281	Schweizer	May 29, 1934
2,244,864	Witham	June 10, 1941
2,390,252	Hayward	Dec. 4, 1945
2,794,444	Markey	June 4, 1957
2,884,495	Frankel	Apr. 28, 1959
2,900,468	Joy	Aug. 18, 1959