

- [54] **SLURRY DEFECT SORTER**
[75] Inventors: **Charles A. King, Vienna; Herbert D. Young, Haymarket; John F. Walton, McLean, all of Va.**
[73] Assignee: **General Kinetics Incorporated, Reston, Va.**
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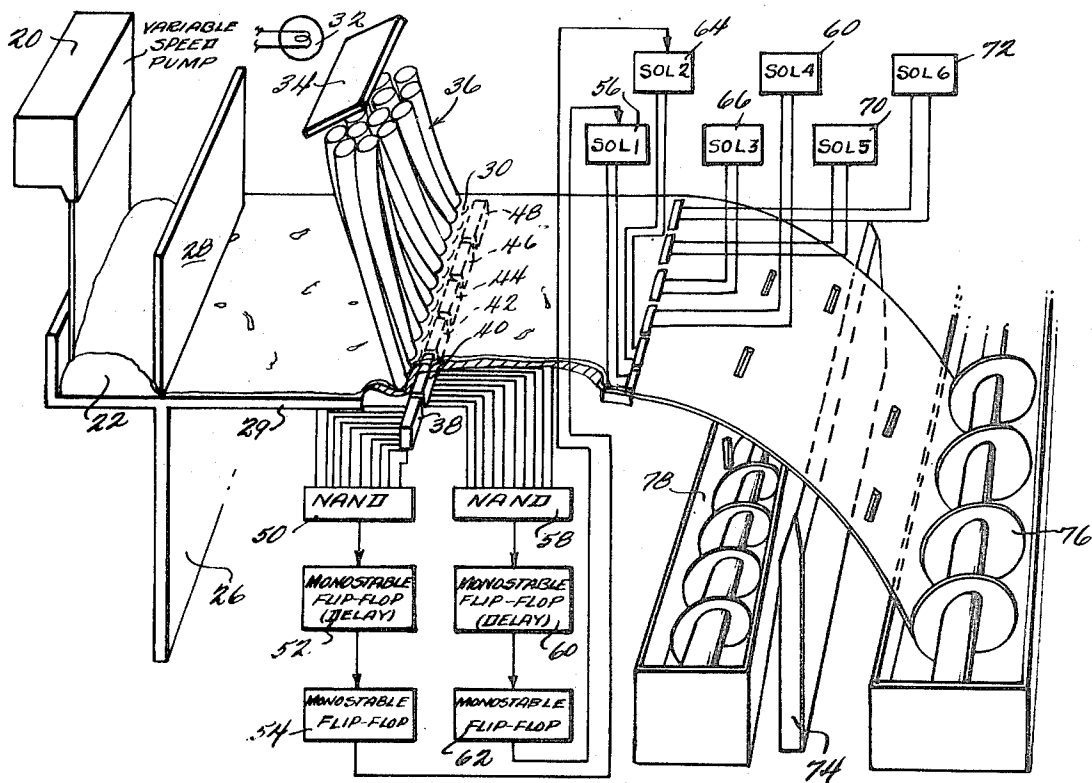
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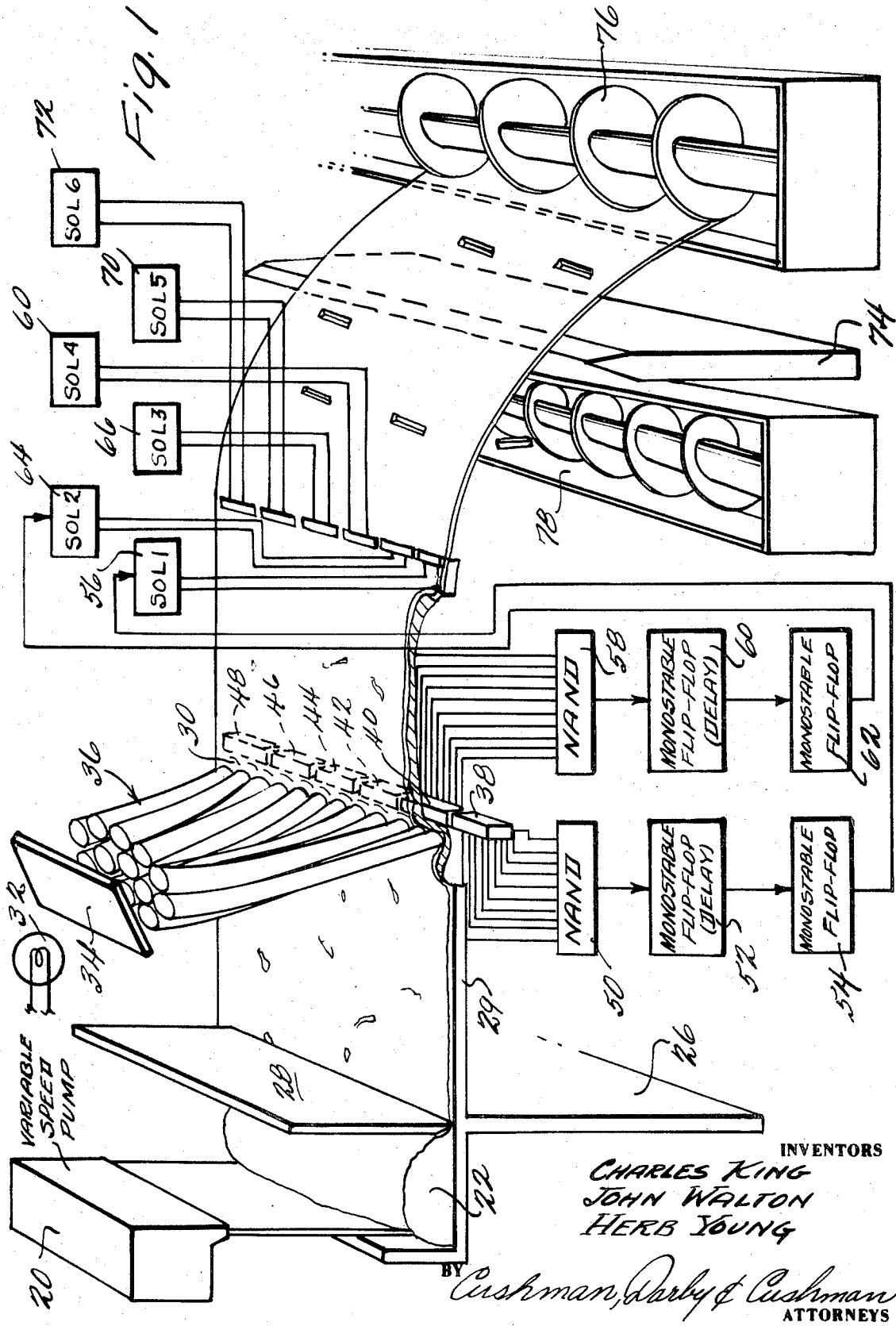
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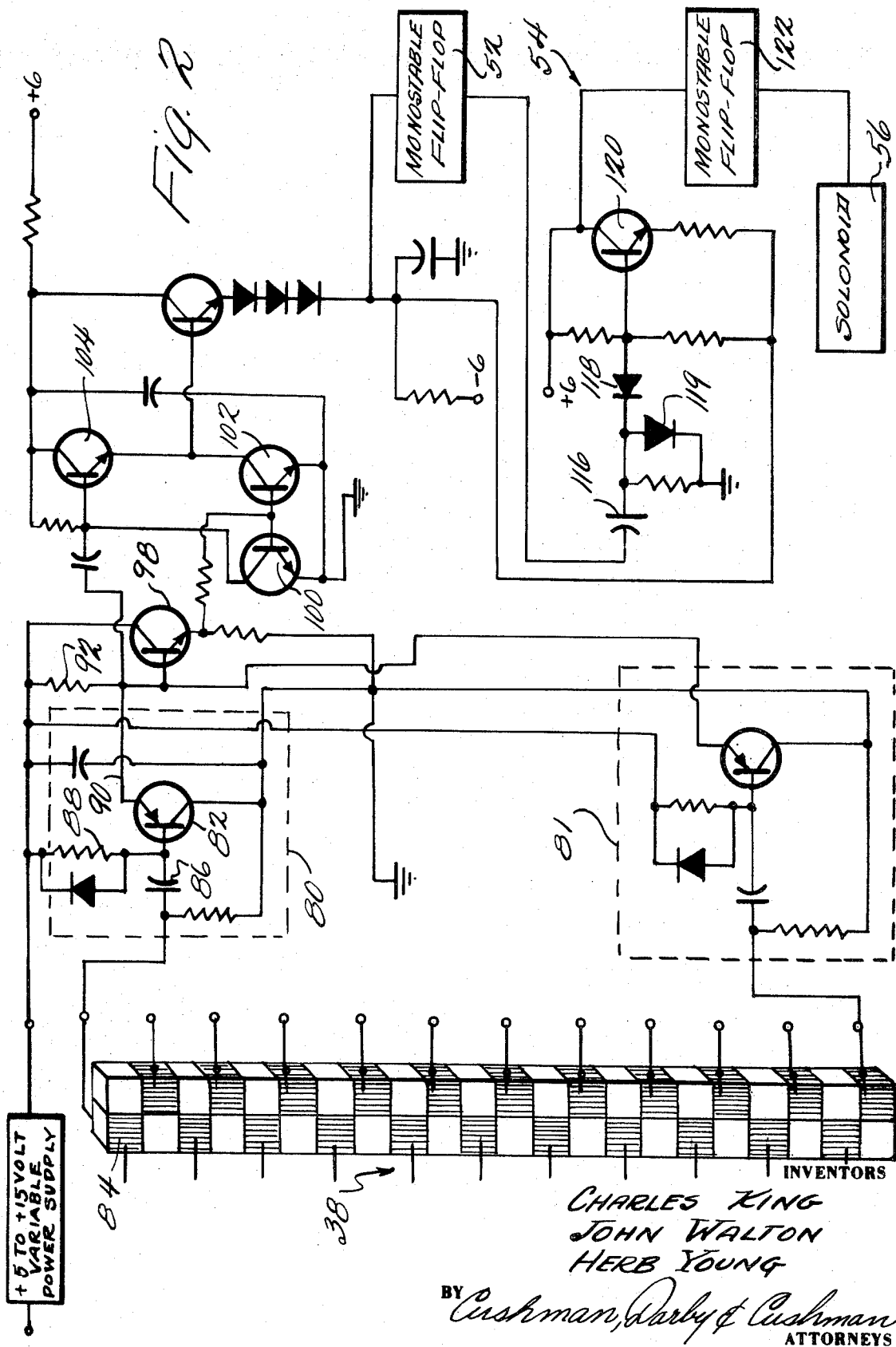
[57] **ABSTRACT**
A method and apparatus for detecting and removing

from a moving fluid, such as a slurry of applesauce or the like, defects having a different optical transmittance from other portions of the fluid whereby a region across the width of a thin sheet of the moving fluid is illuminated and a plurality of groups of photo-responsive elements are disposed for receiving the light passing through the fluid. Each element responds to the detection of a defect by producing a signal which is delayed and applied to an air solenoid which is associated with the group including that element and which produces a short blast of air for deflecting a small portion of the fluid, including the defect. The trajectory of the fluid sheet as it passes the solenoids and falls is such that undeflected portions pass to one side of a barrier and are received in and conveyed away by one screw conveyor and deflected portions pass to the other side of the barrier and are received in and conveyed away by another screw conveyor. Each element is preferably connected to a monostable or one shot multivibrator by a trigger gate which is connected to a variable voltage source for adjusting for all of the gates together the amplitude of the signal required to trigger each of the gates.

11 Claims, 2 Drawing Figures







SLURRY DEFECT SORTER

BRIEF DESCRIPTION OF THE PRIOR ART AND SUMMARY OF THE INVENTION

The invention relates to an apparatus and method for detecting and removing defects from a moving fluid stream, such as a slurry of applesauce or the like.

Many manufactured and processed fluid foods have defects in them of one type or another which have an optical transmittance which varies from the transmittance of the desired constituents of the fluid and which must be removed before the fluid can be packed and sold. Particularly in the food processing industry, wherein fluids such as slurries of applesauce and other similar foods are produced in whole or in part from fruits and vegetables, defects such as bits of skin, bruised tissue, blossoms, twigs, leaves, etc. inevitably remain in the process fluid just before it is to be packaged and must be, to the extent possible, removed in order to produce a high quality product which will be acceptable to the ultimate consumer.

The present invention relates to a unique method and unique apparatus for detecting and removing defects from a moving fluid stream, such as a slurry of applesauce. This is accomplished in the embodiment of the invention set forth below by passing the fluid stream through a device which configures the stream to a thin sheet of moving fluid, for example, 1/16th of an inch thick. A fixed area extending across the width of the moving stream and divided into a plurality of subareas is continuously illuminated by a suitable light source, and a plurality of photoresponsive devices, each associated with one subarea, are disposed beneath the slurry on the side opposite from the light source for each detecting the light passing through one of the subareas. Each such photo-responsive device is comprised of a group of photo-responsive elements, such as photodiodes, which each receive light from a small portion of a subarea.

When one of the photodiodes in one of the groups responds to a change in optical transmittance of the subarea of the fluid sheet through which it receives light, thus detecting the presence of a defect, an appropriate signal is produced and passed through a trigger gate. The output of this gate is in turn passed to a monostable flip-flop, also termed a one shot flip-flop, which responds by producing a pulse having an adjustable width which is that necessary to cause an associated solenoid to be operated at the correct time. The trailing edge of that pulse causes a second monostable or one shot flip-flop to produce a pulse also having an adjustable width which is then applied to an air solenoid which is disposed downstream from the photo-responsive devices and which produces a blast of air at the time that the defect is beneath the solenoid. The width of this second pulse is the time duration of the air blast. The blast of air deflects a portion of the moving sheet of applesauce, including the defect, from the trajectory which the rest of the sheet takes as it leaves the device, clears a barrier and falls into a screw conveyor for carrying the applesauce to apparatus for further processing or packaging. The deflected portions of the applesauce, including the defects, do not clear the barrier and fall instead into a second screw conveyor for carrying those portions, together with the defects, away from the device. Each group of photo-responsive elements is connected to a separate solenoid by similar electronic ele-

ments for each responding individually to the detection of a defect in the subarea with which that group is associated in the same fashion and for producing an air blast which removes a defect detected by an element of that group, together with a small portion of the stream in the fashion described above.

According to a further aspect of the invention each of the photo-responsive elements in each group is connected to a trigger gate with all of the gates being connected to the same variable source and forming part of a NAND gate. The outputs of each of trigger gates are connected to a common emitter resistor and form the input section of a NAND gate. The NAND gate output is connected to a conventional one shot flip-flop. The threshold voltage necessary to cause each of the gates to operate the flip-flop can be easily adjusted for all of the gates by simply varying the single variable voltage connected to the trigger gates via the common resistor so that it is not necessary to adjust the sensitivity of each trigger gate separately. Further all groups of photo-responsive elements may be adjusted with this single adjustment.

Many other objects and purposes of the invention will become clear from the following detailed description of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a perspective and partially schematic view of one embodiment of the invention.

FIG. 2 shows a schematic of the trigger gates, one shot multi-vibrators and other circuitry for producing a signal for triggering an air solenoid which directs a short blast of air onto an appropriate portion of the moving fluid.

DETAILED DESCRIPTION OF THE DRAWINGS

Reference is now made to FIG. 1 which shows a first embodiment of the invention. In this arrangement, a variable speed pump 20 supplies to the device a fluid 22 which has a number of defects which are to be removed. As mentioned above, it has been found that the device can be used particularly for removing defects from a slurry such as applesauce and the arrangement shown in FIG. 1 is designed especially for that purpose. Slurry 22 enters the device via a slot between members 26 and 28 which configure the fluid to a flat sheet having a thickness of preferably about 1/16th inch. A support member 29 runs beneath the moving slurry 22 after it passes through the slot defined between members 26 and 28 and, as is apparent, a portion of this support has been removed for clarity in illustrating the invention. In the embodiment of the invention constructed especially for detecting and removing defects from applesauce, the thin sheet of the applesauce or other slurry which passes between members 26 and 28 moves through the device at about a speed of 400 ft. per minute, but, as will be apparent from the discussion below, the slurry can be moved at any appropriate speed, and pump 20 can be easily adjusted to vary that speed as desired or required.

The slurry moving along on support 28 first passes through a fixed area 30 onto which light is impinged from a suitable conventional source 32 via a conventional filter 34 and a plurality of fiber optic tubes 36 which receive the light and illuminate a thin band across the width of the slurry which, in the embodiment constructed for detecting and removing defects from

applesauce, was roughly 4 inches wide. Filter 34 is preferably comprised of a first infra-red filter which reflects infra-red light away from the fiber optics tubes to prevent unnecessary heating thereof and a second color filter which matches the color characteristics of the slurry to enhance the defect contrast. The light impinging upon the moving sheet of fluid passes through that sheet and impinges upon photo-responsive elements which are separated into six groups 38, 40, 42, 44, 46 and 48. While only six such groups are shown in this embodiment, any number can be employed and in fact in the embodiment which has been installed eight groups of photo-responsive diodes, each comprising 22 separate diodes arranged in the manner shown in FIG. 2, were employed across the 4-inch width of the sheet so that each group covered roughly a 1/2-inch width of the illuminated area. Each group thus receives the light passing through one subarea and each element in that group receives the light passing through a portion of that subarea.

The photo-responsive elements, for example, photodiodes, which comprise each group of elements, each respond to a defect in the portion of the subarea from which light is received, which, as mentioned above, has a light transmittance which differs from that of the desirable constituents of the slurry by producing an appropriate signal which is transmitted to the gate. For example a signal produced by any of the elements in group 38 causes gate 50 to apply a signal to multivibrator 52 which responds by producing a pulse. A signal from any of the elements of a group causes the NAND gate associated with that group to produce an output signal which is applied to the associated monostable multivibrator. The trailing edge of the pulse produced by one monostable or one shot multivibrator 52 triggers the monostable multivibrator 54 whose output pulse is in turn applied to the associated air solenoid 56, which, as shown is mounted above sheet 22 to produce a short blast of air directed to the portion of the moving sheet which, because of the delay introduced by circuitry 52 and the inherent delay of the remainder of the electronic elements, includes the defect which originally caused one of photo-responsive elements in group 38 to produce a signal indicating a defect. The photo-responsive elements in group 40 are similarly connected to gate 58 which produced a signal which is applied to monostable multivibrator 60. The output of multivibrator 60 triggers the multivibrator 62 whose output pulse is applied to solenoid 64. Similar circuitry is provided for connecting groups 42, 44, 46, 48 to solenoid 66, 68, 70 and 72, respectively, but since this circuitry is preferably identical to that associated with groups 38 and 40 it has been omitted for convenience in illustration.

This short air blast deflects a small portion of the moving sheet 22, which includes the defect, along a trajectory as it moves off the end of support 28 and falls which is different from the trajectory of the remainder of the fluid which has not been so deflected. A barrier 74 is disposed so that the portions of the fluid which have not been deflected pass to one side of barrier 74 and are conveyed away by a conventional screw conveyor 76, and portions which have been deflected pass to the other side and are conveyed away by another conventional screw conveyor 78 so that the defects in the applesauce slurry or other fluid are separated and

removed from the rest of the fluid quickly, simply and effectively.

Any number of such devices, each suitable for checking, for example, a sheet of applesauce 4-inches wide and 1/16th inch thick, passing through the apparatus at 400 ft. per minute can be employed, each feeding into screw conveyors 76 and 78. In one such arrangement 13 such devices were employed for receiving and removing defects from the output of a medium sized plant for producing applesauce. In that particular plant, it was found that each air blast removed approximately 0.02 oz. of applesauce with each defect.

Reference is now made to FIG. 2 which shows a detailed schematic of the circuitry of FIG. 1 for producing signals for causing the air solenoids to produce appropriate short blasts of air at the proper times to remove detected defects. As can be seen in FIG. 2, group 38 includes a plurality of photo-responsive elements, such as photodiodes, which are staggered to assure total inspection of the food slurry and yet avoid electrical interference between diodes which result unless adjacent diodes are separated by a dead barrier.

Group 38 is comprised of 22 individual and conventional photodiodes which are each connected to and form part of a NAND gate 50 as shown in FIG. 1 which includes a plurality of individual trigger gates of which gates 80 and 81 are shown in FIG. 2. Each of the individual photodiodes comprising group 38 is connected to a separate trigger gate, such as gates 80 and 81, but only two such gates are shown for convenience in illustration. Gate 80 comprises a PNP transistor 82 the base of which is connected to photodiode 84 via DC blocking capacitance 86. The collector of transistor 82 is connected to ground and its base resistor 88 is connected to low impedance, variable voltage sources 4 such that transistor 82 is normally non-conductive. The output of trigger gate 80 on line 90 is normally essentially at the power supply 94 voltage. When the intensity of light incident upon the photodiode connected to the base of transistor 82 via DC blocking capacitor is suddenly reduced because of a defect in the subarea of fluid stream 22 through which that photodiode receives its light, the voltage output of the photodiode drops and hence the voltage at the base of transistor 82 likewise drops as the drop is AC coupled to the base of transistor 82. Because of blocking capacitor 86, gate 80, as well as the other trigger gates, is insensitive to any slow drift of the DC bias on the photodiodes in group 38. To produce trigger outputs, the voltage of photodiode 84 must change by an amount which exceeds the voltage applied to the emitter of transistor 82 by emitter resistor 92 and also to all the other emitters of the transistors in the other trigger gates attached to the photodiodes of group 38. Since the trigger gate is in effect an emitter follower, the emitter of transistor 82 likewise drops, dropping the voltage on line 90 in turn to ground.

Transistor 98 is also connected to line 90 so that when the emitter of transistor 82 drops essentially to ground, transistor 98 shifts from its conductive to its non-conductive condition. Transistor 98 thus changes its output condition each time that the transistor in a trigger gate connected to line 90 shifts from its non-conductive to conductive condition. This shift of transistor 98 in turn causes transistors 100 and 102 to shift from their conductive to non-conductive conditions which causes normally conductive transistor 104 to be-

come non-conductive. This shift of transistor 104 changes the voltage at the input to conventional one shot flip-flop 52 from a slightly negative to a slightly positive value, for example from -2 to +4 volts. The passing of the defect raises the voltage at the base of transistor 82 as capacitor 86 charges and transistor 82 then returns to its non-conductive condition, causing transistor 98 to again be conductive, transistors 100 and 102 conductive, and transistor 104 conductive so that the voltage at the input to flip-flop 52 returns to a slightly negative value. Each defect detected thus causes an electrical pulse to be applied to one shot flip-flop 52.

The emitter of transistor 82 in trigger gate 80, as well as similar transistors in the other trigger gates including gate 81, are connected to a variable voltage source 94 via the common emitter resistor 92 while transistors 100, 102 and 104 are connected to a fixed voltage source as shown. By varying the emitter voltages of the transistors in the trigger gates, e.g. by varying a single power supply 94, the drop in voltage required by a photodiode, which will cause an air solenoid to be operated, can be quickly, simply and easily varied for all of the photodiodes in a group together without the necessity to change the values of the rest of the elements in gate 50. Thus, the sensitivity of the circuit can be easily and quickly adjusted at any time. This single adjustment can be used to adjust group 38 or groups 38, 40, 42, 44, 46, 48 simultaneously.

The pulse applied to conventional flip-flop 52 causes that element to produce a pulse having an adjustable time width such as will cause the air solenoid 56 to be operated at just the right time. The width of the pulse produced by flip-flop is thus a substantial part of the time delay. The proper value for this time width of course, depends on the placement of solenoid 56 downstream with respect to group 38, the rate of flow of the stream 22, the electronic and mechanical delays of the other electronic elements and the air solenoids, etc. and can be determined easily after the device has been installed.

The trailing edge of the pulse produced by flip-flop 52 is passed by capacitor 116 and diode 118, which together with diode 119 block and ground the leading edge, to the base of transistor 120 which shifts from its normally conductive to non-conductive condition in response thereto and then returns to its conductive condition as capacitor 116 charges to its steady state value so that a pulse shifting briefly from a slightly negative, e.g. 3 volts, to a slightly positive e.g. 4 volts, is applied to the input of conventional flip-flop 122 which then also produces a pulse having an adjustable time width. The pulse produced by flip-flop 122 is applied to air solenoid 56 which produces a blast of air for a length of time which is dependent upon the width of the pulse produced by flip-flop 122. Flip-flop 122, transistor 120 and its associated elements thus, produce a delayed pulse, the delay of which is determined by the duration of the pulse produced by flip-flop 52.

Many changes and modifications in the above embodiment of the invention can of course be made without departing from the spirit of that invention. Accordingly, the scope of the invention is intended to be limited only by the scope of the appended claims.

What is detecting is:

1. Apparatus for detection and removing from a moving fluid defects having a different optical transmittance from other portions of said fluid comprising:

means for illuminating a fixed area through which said fluid with said defects move,

means for detecting the light from at least a single subarea of said area passing through said moving fluid including a plurality of groups of photoresponsive elements each group receiving light incident upon a subarea of said area and transmitted through said moving fluid,

means connected to said detecting means for producing a signal when the light detected by said detecting means indicates at least a single defect is in a given portion of said fluid in said fixed area including a plurality of circuit means each connected to one of said groups for each producing said signal when any of the photoresponsive elements in that group detects a defect,

means connected to said producing means for receiving said signal and producing and directing an air stream, in response to receipt of said signal, onto each given portion including a defect for a short time so that the paths of travel of said given portions including defects are deflected from the path of travel of fluid not defelected by said air stream including a plurality of means each connected to one of said circuit means for each receiving said signal from the circuit means connected to it and producing and directing an air stream, in response to receipt of said signal, onto said given portion including a defect for a short time so that paths of travel of said given portions including defects are deflected from the path of travel of fluid not deflected by said air stream,

means for receiving fluid not deflected by said air stream, and

means for receiving fluid deflected by said air stream, including said defects.

2. Apparatus as in claim 1 wherein said circuit means includes

plurality of further circuit means each having first and second inputs with one of said photoresponsive elements connected to each of said second inputs for each producing said signal when the voltage applied to said second input changes by a voltage level greater than the voltage applied to said first input and not producing said signal when the voltage applied to said first input changes by a voltage level greater than the voltage applied to said second input and

variable voltage source means connected to each of said first inputs.

3. Apparatus as in claim 2 further including means connected to each of said further circuit means for producing a square wave pulse when one of said signals is produced.

4. Apparatus as in claim 3 further including means for delaying said square wave pulse.

5. A circuit as in claim 4 wherein said square wave producing means is a monostable multivibrator and said delaying means includes means connected to said multivibrator for producing a pulse upon receipt of the trailing edge of said square wave pulse and a further monostable multivibrator connected to said means for producing a pulse on receipt of the trailing edge for producing a further square wave pulse when said means

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for producing a pulse on receipt of the trailing edge produces that pulse.

6. A circuit as in claim 5 wherein said multivibrators each have means for varying the width of the square wave pulse produced by the multivibrator.

7. Apparatus as in claim 1 wherein said receiving means are screw conveyors and including a barrier between said conveyors so that fluid not deflected clears said barrier and fluid deflected does not clear said barrier.

8. Apparatus as in claim 1 wherein said illuminating means includes a light source, a light filter, and a plu-

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ality of fiber optic tubes for gathering the light from said source and illuminating a fixed area across said moving fluid.

9. Apparatus as in claim 1 including means for configuring said fluid into a thin flat sheet.

10. Apparatus as in claim 1 wherein said receiving and producing and directing means includes at least a single air solenoid.

11. Apparatus as in claim 1 wherein said elements are each photodiodes.

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