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PHOTOELECTRIC CONTROL APPARATUS

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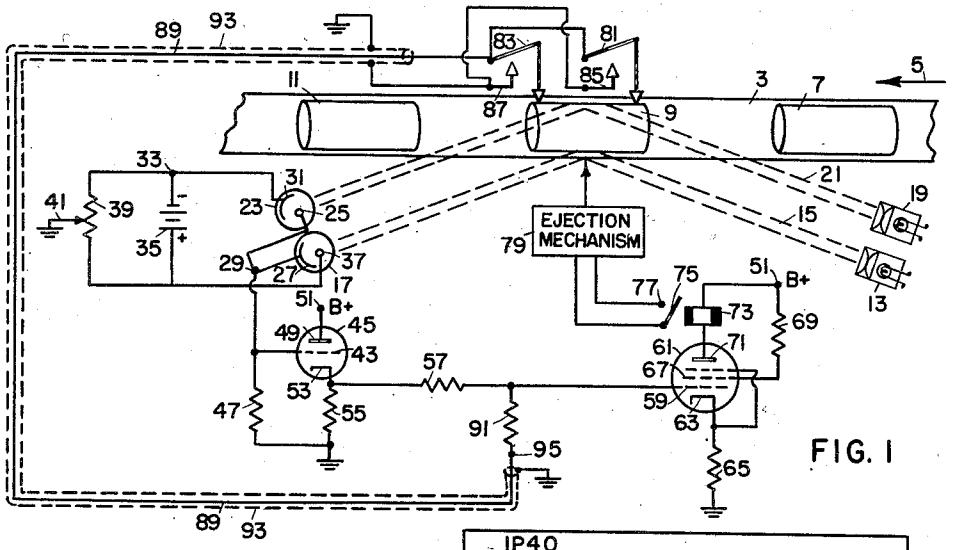


FIG. 1

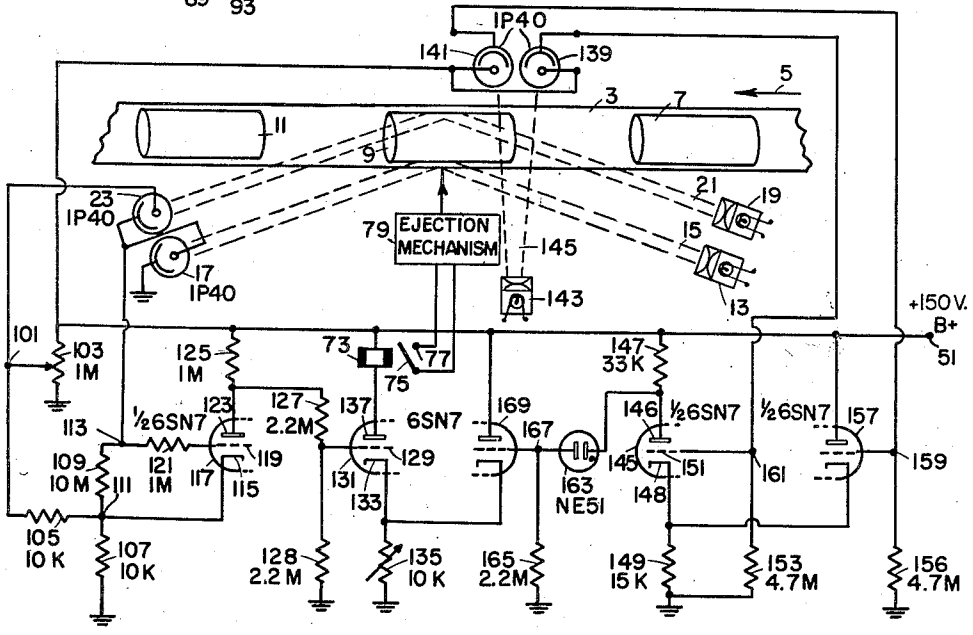


FIG. 2

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PHOTOELECTRIC CONTROL APPARATUS

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This invention relates to photoelectric apparatus for the automatic inspection of industrial products. It will be described in connection with its application to the automatic inspection of tin cans made of differentially-coated tin plate.

Tin cans are made of sheet steel having a coating of tin plate on both sides of the sheet. Thus a finished tin can has a coating of tin plate on both its inside and its outside surfaces. Broadly speaking, the purpose of both inside and outside tin coatings is to prevent corrosion of the can, but the corroding agents to which these coatings are normally subjected differ materially.

A great number of canned foods contain acids. These acids reach relatively high concentrations in the case of citric fruit juices. The inside tin coating of a can must be sufficiently thick to prevent corrosion of the steel by these acids. If the inside tin coating is inadequate, these acids react chemically with the steel; gases containing hydrogen are formed inside the can; and when the inside pressure is sufficient, the can eventually explodes.

The outside tin coating of a can is normally exposed only to air, the corroding action of which is generally much slower than that of food acids. The thickness of the tin coating on the outside of a can need therefore be only a fraction of that on the inside of a can.

In the past, it has been standard practice to manufacture tin cans from sheet steel having coatings of tin plate of the same thickness on opposite sides of the sheet. As this thickness was determined by the amount of tin plate necessary to prevent corrosion inside the can, more tin than was necessary was used on the outside of the can, and a waste of tin resulted. It has therefore been proposed to use differentially-coated tin plate, so named because of the difference in the thickness of the tin coating on opposite sides of the sheet. Differentially-coated tin plate has a thick tin coating on the side which is to become the inside of the can, and a much thinner tin coating on the side which is to become the outside of the can. In order to distinguish the thickly-coated side from the thinly-coated side, manufacturers of differentially-coated tin plate pass the plated sheet through two rollers having different surface characteristics, so that the thickly-coated side has a highly-polished surface, while the thinly-coated side has a dull granular finish.

A tin can made of differentially-coated tin plate is considered to be defective if it has become "reversed" during the manufacturing process. A reversed tin can is one in which the thick coating is outside the can, and the thin coating inside it. Corrosion of the steel usually results when the thinly-coated side of the can is exposed to food acids; the contents of the can spoil, and eventually the can explodes. As the damages consequential to such events may be extensive, it is important for tin-can manufacturers to detect and isolate such reversed tin cans.

It is therefore an object of this invention to provide apparatus for the automatic comparison of the reflectivities of different surfaces of a product.

It is a more specific object of this invention to provide apparatus for the automatic inspection of tin cans made of differentially-coated tin plate.

According to the illustrated embodiments of the present invention, there is provided a comparison device which compares the reflectivity of both sides of a sheet of differentially-coated tin plate, and a control device responsive to the comparison device and which performs a control function such as the ejection of reversed tin plate. Where the differentially-coated tin plate is inspected when it is already in the form of a can open at both ends, timing means are provided which prevent the control device from operating until the can has reached a testing position.

Other objects of this invention will become apparent to those skilled in the art from a reading of the following specification and an inspection of the accompanying drawing, in which:

Figure 1 is a schematic diagram of an embodiment of the present invention in which mechanical timing means are used; and

Figure 2 is a schematic diagram of another embodiment of the present invention in which photoelectric timing means are provided.

Referring to Figure 1, there is shown a section of a conveyor belt 3 which is assumed to be moving in the direction of the arrow 5. Conveyor belt 3 is shown carrying three cans 7, 9, and 11 which are open at both ends. Can 9 is in the testing position, as will be explained hereinafter.

With the can 9 in the testing position, a light source 13 is directed toward can 9, so that its light beam 15 strikes the outside surface of can 9 and is reflected onto a photoelectric cell 17. Another light source 19 is directed toward the can 9 so that its light beam 21 strikes the inside surface of the can 9 and is reflected onto a photo electric cell 23. The anode 25 of cell 23 and the cathode 27 of cell 17 are connected together at terminal 29. The cathode 31 of cell 23 is connected to the negative terminal 33 of voltage source shown as a battery 35, and the anode 37 of cell 17 is connected to the positive terminal 38 of battery 35. Connected across battery 35 is a potentiometer 39 having its sliding contact 41 connected to ground.

Photocells 17 and 23 thus form a potential divider connected across battery 35, with terminal 29 as the tap of the potential divider. If can 9 is a normal can, its inside surface, being highly polished, reflects more light than its outside surface which has a dull finish. Therefore, a greater amount of light is reflected upon cell 23 than upon cell 17. The impedance of cell 23 is lower than that of cell 17, the voltage drop across cell 23 is lower than that across cell 17, and the value of the potential at terminal 29 is closer to that of negative terminal 33 than to that of positive terminal 38.

On the other hand, if can 9 is "reversed," its inside surface has a dull finish and reflects less light than its outside surface which is highly polished. Therefore a lesser amount of light is reflected upon cell 23 than upon cell 17. The impedance of cell 23 is higher than that of cell 17, the voltage drop across cell 23 is higher than that across cell 17, and the value of the potential at terminal 29 is closer to that of positive terminal 38 than to that of negative terminal 33. While the potential at terminal 29 varies as explained above, its value with respect to ground may be adjusted by means of sliding contact 41 of potentiometer 39.

Thus the potential at terminal 29, which is negative when a normal can is in the testing position, changes in the positive direction when a reversed can is in the testing position. This change may be used to operate an ejection mechanism in the following manner:

Terminal 29 is connected to the control grid 43 of an electron valve or tube 45, and to ground through a resistor 47. The anode 49 of tube 45 is connected to power-

supply terminal 51, and its cathode 53 is connected to ground through a resistor 55. Tube 45 operates as a conventional cathode follower, and the potential at its cathode 53 will therefore follow that at terminal 29.

The cathode 53 is connected through an isolating resistor 57 to the control grid 59 of an electron valve or tube 61. The cathode 63 of tube 61 is connected to ground through a biasing resistor 65, its screen grid 67 is energized through a dropping resistor 69 connected to power-supply terminal 51, and its anode 71 is connected to power-supply terminal 51 through a relay 73. Relay 73 operates to open or close relay contacts 75 and 77. When relay contacts 75 and 77 are closed, an ejection mechanism 79 operates to eject or remove can 9 from the conveyor belt 3.

If can 9 is a normal can, the potential at terminal 29 which is negative is applied through the cathode-follower tube 45 to the control grid 59 of tube 61. The current flow through tube 61 and relay 73 is then sufficiently low to keep open relay contacts 75 and 77 and therefore keep the ejection mechanism 79 from operating.

If can 9 is a "reversed" and therefore defective can, the potential at terminal 29 rises in the positive direction. This potential is applied through the cathode-follower tube 45 to the control grid of tube 61. The current flow through tube 61 and relay 73 is thereby sufficiently increased to close relay contacts 75 and 77, and causes the ejection mechanism 79 to operate.

The ejection mechanism may be of several types well known in the art. For instance, it may comprise a pipe connected to a reservoir of air under pressure. The pipe is arranged to blow the defective can away from the conveyor belt when a valve controlled by relay 73 is operated.

It is necessary to provide timing means to prevent the operation of the ejection mechanism 79 until can 9 is in the testing position. If can 9 is displaced from its position shown in Figure 1 by one third of its length to the left or to the right, light beam 15 is still reflected from the outside of can 9 onto cell 17, but the position of can 9 prevents light beam 21 from impinging upon cell 23. With more light impinging on cell 17 than on cell 23, the ejection mechanism would operate every time, unless these timing means are provided.

Two movable contacts 81 and 83 and two stationary contacts 85 and 87 are positioned close to the conveyor belt 3. Movable contacts 81 and 83 are electrically connected together and to one end of a shielded cable 89, the other end of which is connected through an isolating resistor 91 to the control grid 59 of tube 61. Stationary contacts 85 and 87 are electrically connected together and to the grounded shield 93 of cable 89.

When there is no can in the testing position, movable contacts 81 and 83 are in electrical contact with stationary contacts 85 and 87. Cable 89 and the lower terminal 95 of resistor 91 are grounded.

Any positive potential at the cathode 53 of tube 45 is divided over the potential divider comprising resistors 57 and 91 before it is applied to the control grid 59 of tube 61. Thus divided, the value of this potential is not sufficient to cause relay 73 to operate the ejection mechanism 79.

When a can is in the testing position, the can disconnects movable contacts 81 and 83 from stationary contacts 85 and 87. Then and only then are the cable 89 and the lower end 95 of resistor 91 disconnected from ground and left "floating." A positive potential at the cathode 53 of tube 45, due to the presence of a "reversed" can in the testing position, is then applied directly to control grid 59 of tube 61 without being divided. Thus directly applied, the value of this potential is sufficient to cause relay 73 to operate the ejection mechanism 79.

In the embodiment of the invention shown in Figure 2, the timing means are photoelectric. The use of mechanical contacts which have to be periodically replaced is thus avoided. Three cans, 7, 9, and 11, are shown on conveyor belt 3, can 9 being in the testing position. Two light sources 13 and 19 have their beams 15 and 21 directed respectively toward the outside and inside surfaces of can 9. Beam 15 is reflected onto cell 17, and beam 21 is reflected onto cell 23.

The photocells 17 and 23 are connected in a bridge arrangement as follows: a positive potential is supplied by means of tap 101 on potentiometer 103, potentiometer 103 being connected between a power-supply terminal 51 and ground. Two resistors 105 and 107, connected between tap 101 and ground, form two arms of the bridge. The two photocells 17 and 23, connected between tap 101 and ground, form the other two arms of the bridge. Resistor 109, which is connected between junction point 111 of resistors 105 and 107 and junction point 113 of photocells 17 and 23, is the center element across which the output potential of the bridge is developed.

Junction point 111 is connected to the cathode 115 of an electron valve on tube 117, and junction point 113 is connected to the control grid 119 of tube 117 through a grid current limiting resistor 121. The anode 123 of tube 117 is connected to power-supply terminal 51 through a load resistor 125. Resistor 125 has a high value of resistance to prevent leakage current through tube 117 from changing materially the potential at junction point 111 and thus unbalance the photoelectric bridge circuit.

The conduction through tube 117 is a function of the potential difference between junction points 111 and 113. The potential at junction point 111, which is determined almost exclusively by voltage division over fixed resistors 105 and 107, which have equal resistance values, remains fixed at a value equal to half of that of the potential at tap 101. The potential at junction point 113, however, is variable, as it is determined by voltage division over photocells 17 and 23, the impedance of which is a function of the light impinging on them.

If can 9 is a normal can, its inside surface, being highly polished, reflects more light than its outside surface which has a dull finish. Therefore, a greater amount of light is reflected upon cell 23 than upon cell 17. The impedance of cell 23 is lower than that of cell 17, the voltage drop across cell 23 is lower than that across cell 17, the value of the potential at junction point 113 is closer to that of tap 101 than to ground, the control grid 119 of tube 117 is more positive than its cathode 115, and tube 117 is fully conductive.

On the other hand, if can 9 is "reversed," its inside surface has a dull finish and reflects less light than its outside surface, which is highly polished. Therefore, a lesser amount of light is reflected upon cell 23 than upon cell 17. The impedance of cell 23 is higher than that of cell 17, the voltage drop across cell 23 is higher than that across cell 17, and the value of the potential at junction point 113 is closer to ground than to that of tap 101. The control grid 119 of tube 117 is less positive than its cathode 115, and the current flow through tube 117 is either greatly reduced or completely eliminated.

The anode 123 of tube 117 is connected through a potential divider comprising resistors 127 and 128 to the control grid 129 of an electron valve or tube 131. The cathode 133 of tube 131 is connected to ground through a biasing resistor 135, and its anode 137 is connected to power-supply terminal 51 through a relay 73. Relay 73 operates to open or close relay contacts 75 and 77. When relay contacts 75 and 77 are closed, the ejection mechanism 79 operates to eject or remove can 9 from the conveyor belt 3.

If can 9 is normal, tube 117 is fully conductive. The voltage drop across its load resistor 125 is high, and the potential at anode 123 is correspondingly low. The potential at anode 123 is applied to the control grid 129 by means of the voltage divider comprising resistors 127 and 128, and the current flow through tube 133 is sufficiently low to keep open relay contacts 75 and 77 and therefore prevent the ejection mechanism 79 from operating.

If can 9 is reversed, the current flow through tube 117 is either greatly reduced or completely eliminated. The drop across its load resistor 125 is reduced, and the potential at anode 123 becomes more positive. The potential at anode 123 is applied to the control grid 129 by means of the voltage divider comprising resistors 127 and 123, and the current flow through tube 133 is sufficiently increased to close relay contacts 75 and 77, thereby causing the ejection mechanism 79 to operate.

As in Figure 1, timing means are provided to prevent the operation of the ejection mechanism 79 until can 9 is in the testing position. Two photocells 139 and 141 are positioned on one side of the conveyor belt 3, and a light source 143 is positioned on the other side of the conveyor belt 3. The light beam 145 coming from light source 143 is directed toward photocells 139 and 141 in such a way that, when can 9 is in the testing position, half of the beam 145 strikes the cell 139, while the other half of the beam 145 is prevented from striking cell 141 by the presence of can 9 between light source 143 and cell 141. A circuit is provided which prevents tube 133 from conducting and the relay 73 from operating the ejection mechanism 79 unless light from beam 143 strikes cell 139 and cell 141 is dark.

An electron valve or tube 145 has its anode 146 connected to power-supply terminal 51 through a load resistor 147, and its cathode 148 connected to ground through a biasing resistor 149. Photocell 139 has its anode connected to power-supply terminal 51 and its cathode connected to the control grid 151 of tube 145 and to ground through resistor 153. Photocell 141 has its anode connected to power-supply terminal 51 and its cathode connected to ground through resistor 155 and to the cathode 148 of tube 145 through a cathode-follower stage 157.

Cell 141 and resistor 156 form a potential divider between the power-supply terminal 51 and ground. When light beam 145 strikes cell 141, cell 141 conducts, and the potential at junction point 159 has a high positive value. When no light strikes cell 141, the impedance of cell 141 increases, and the potential at junction point 159 has a lesser positive value.

Cell 139 and resistor 153 also form a potential divider between power-supply terminal 51 and ground, and the variation of the potential at junction point 161 is similar to that of junction point 159; when light strikes cell 139, cell 139 conducts, and the potential at junction point 161 has a high positive value. When no light strikes cell 139, the impedance of cell 139 increases, and the potential at junction point 161 has a lesser positive value.

Tube 145 is fully conductive only when the potential at point 161 has a high positive value and when simultaneously the potential at junction point 159 has a low positive value. This condition occurs only when cell 139 is struck by light beam 145 and cell 141 is in the dark. At all other times, tube 145 passes very little or no current.

The anode 146 of tube 145 is connected to ground through a neon lamp 163 and a resistor 165 connected in series with it. The junction point 167 of neon lamp 163 and of resistor 165 is connected through a cathode-follower stage 169 to the cathode 133 of tube 131.

When tube 145 is not conducting fully, there is a sufficient potential drop across neon lamp 163 to render it conductive. Resistor 147, neon lamp 163, and resistor 165 form a potential divider between power-supply terminal 51 and ground, and the positive potential at junction point 167 is applied as a blocking potential through cathode-follower stage 169 to the cathode 133 of tube 131, thus preventing tube 131 from conducting and actuating the ejection mechanism 79. However, when the can 9 is in the testing position, tube 145 conducts fully and shorts neon lamp 163, which becomes deenergized. No blocking potential is then applied from junction point 167 to cathode 133 of tube 131, and tube 131 is unblocked. When it gets the proper signal from the bridge circuit comprising cells 17 and 23, it can conduct and thereby operate the ejection mechanism 79.

I claim:

1. Apparatus to inspect a differentially coated tin can when said can is in a testing position, said apparatus being designed to be connected to a source of electrical current and comprising: means to direct a first beam of radiant energy toward the outside surface of said tin can when said tin can is in testing position, means to direct a second beam of radiant energy toward the inside surface of said tin can when said tin can is in testing position, a first photoelectric cell positioned so as to receive radiant energy from said first beam after its reflection by the outside surface of said tin can, a second photoelectric cell positioned so as to receive radiant energy from said second beam after its reflection by the inside surface of said tin can, means to connect the first and second photoelectric cells across said source of electrical current so as to form a bridge network, an electron valve having an input circuit and an output circuit, means to apply the differential voltage obtained from said bridge network to the input circuit of said electron valve, relay means connected to the output circuit of said electron valve and responsive to conduction therethrough, means to apply a blocking potential to the input circuit of said electron valve to prevent conduction therethrough, and timing means operable by said tin can to remove said blocking potential when said can is in testing position.

2. Apparatus according to claim 1 wherein said timing means comprise mechanical contacts.

3. Apparatus according to claim 1 wherein said timing means comprise a third and a fourth photocell and means to direct a third beam of radiant energy toward said third and fourth photocells, said third photocell being positioned so as to receive radiant energy from said third beam when said tin can is in testing position, and said fourth photocell being positioned so that radiant energy from said third beam directed toward said fourth photocell is interrupted by said tin can when said tin can is in testing position.

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