

July 14, 1953

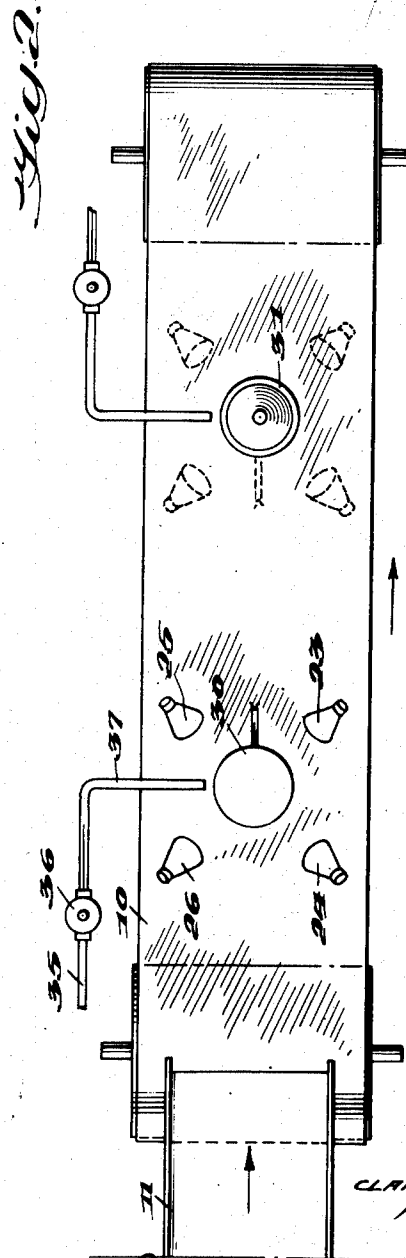
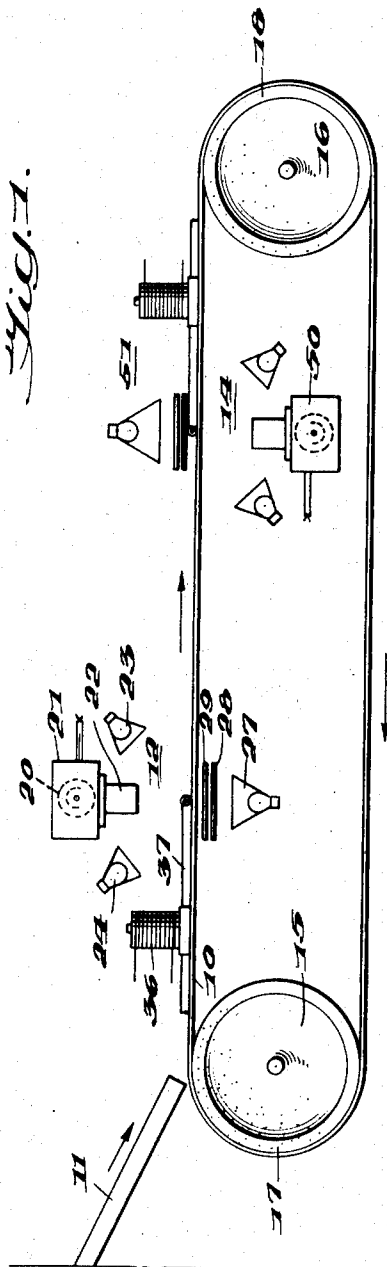
C. T. NEMIR

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PHOTOELECTRIC INSPECTING AND SORTING APPARATUS

Filed April 27, 1949

3 Sheets-Sheet 1



Inventor
CLARENCE T.
NEMIR,

334

Harvey O'Connell
ATTORNEYS

July 14, 1953

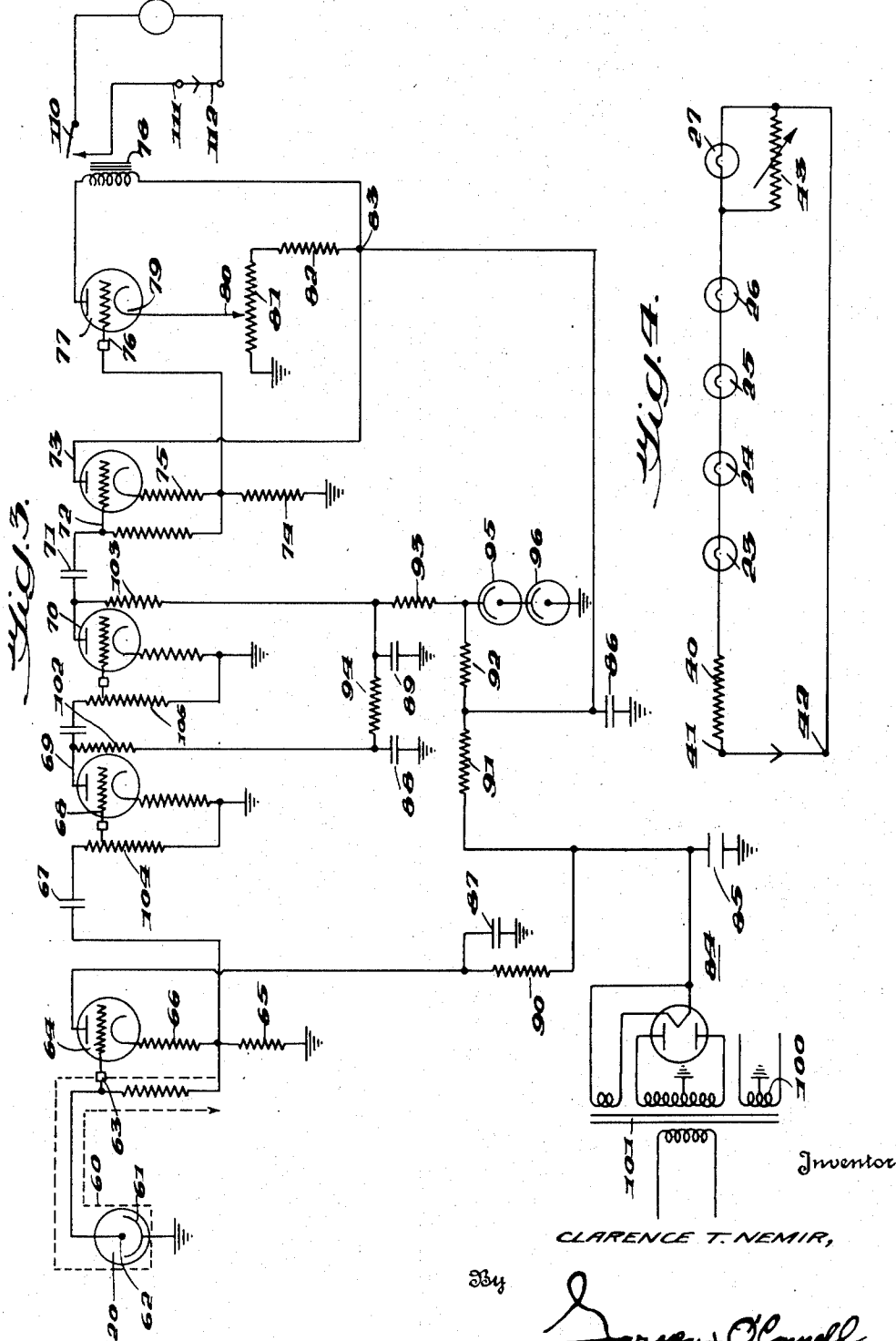
C. T. NEMIR

2,645,343

PHOTOELECTRIC INSPECTING AND SORTING APPARATUS

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CLARENCE T. NEMIR,

Barney O'Connell
ATTORNEYS

July 14, 1953

C. T. NEMIR

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Fig. 5.

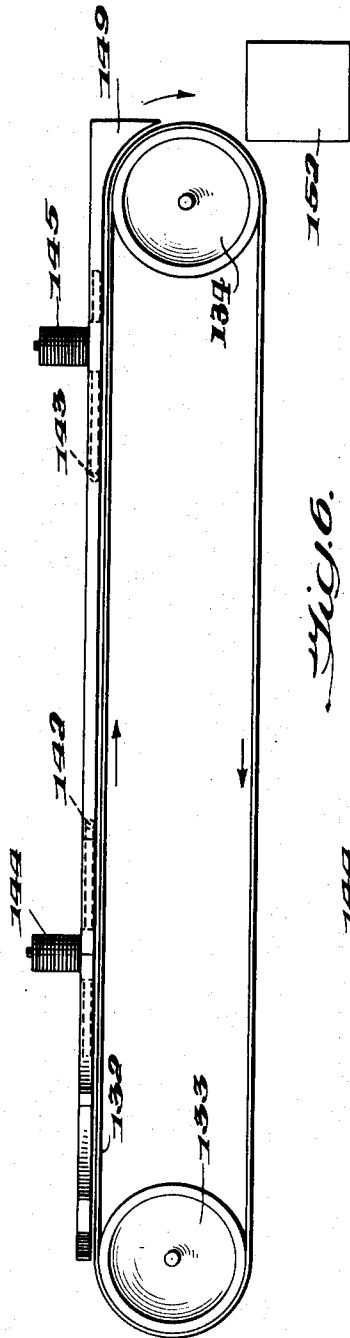
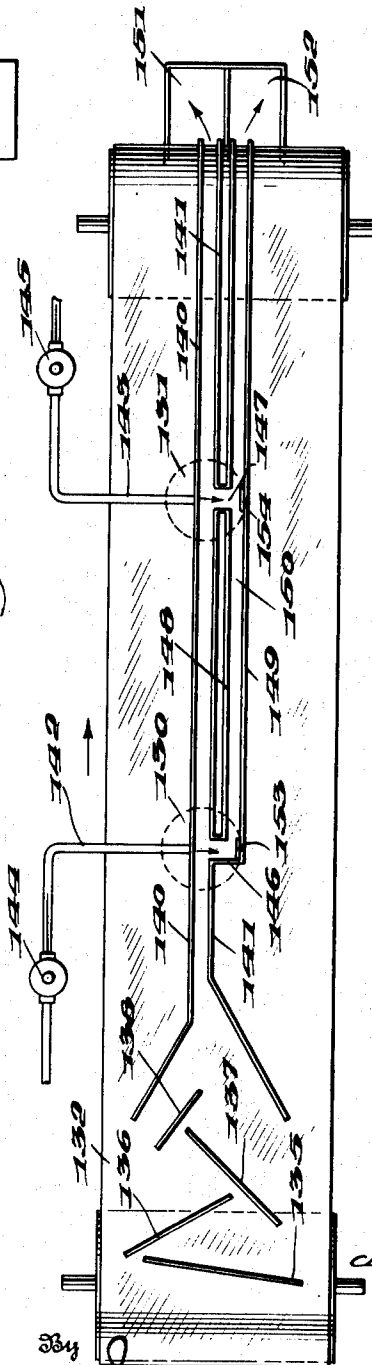


Fig. 6.



Inventor

CLARENCE T.
NEMIR,

Garvey & O'Connell
ATTORNEYS

UNITED STATES PATENT OFFICE

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PHOTOELECTRIC INSPECTING AND
SORTING APPARATUSClarence T. Nemir, Washington, D. C., assignor to
The Kelling Nut Co., Chicago, Ill., a corpora-
tion of Illinois

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This invention relates to sorting apparatus, and more particularly to photo-electric inspection and sorting machines.

It is a principal object of this invention to provide an improved form of conveyor type photo-electric sorting apparatus having means to photo-electrically inspect and sort conveyed objects as they may be seen from both above and below the conveyor surface.

The conveyor types of photo-electric inspection and sorting apparatus known prior to this invention have not provided for the photo-electric inspection of conveyed objects as seen from both above and below the conveyor belt. This is particularly disadvantageous when photo-electrically inspecting and sorting conveyed objects of a size and shape such as to present their largest surface areas in planes generally parallel to the plane of the conveyor surface. For example, blanched cashew nuts could not be adequately inspected and sorted to cull the unblanched nuts with the known types of photo-electric sorting apparatus prior to this invention since their size and shape are such as to cause them to be positioned on the conveyor with relatively large surface areas, which might be unblanched, in contact with the conveyor surface and thus unseen by the photo-electric inspection station.

The present invention proposes to overcome the above disadvantages by providing a transparent conveyor surface together with suitable photo-electric inspection stations for photo-electrically examining the conveyed objects from both above the conveyor and below the conveyor as seen through the transparent conveyor surface. The invention, in a preferred embodiment, further provides for light sources to illuminate the objects to be inspected and these light sources may be arranged in such manner as to facilitate the inspection of the objects as conveyed on the relatively shiny surface of the transparent conveyor. The apparatus of this invention also provides for an adjustment of the background lighting in the sensitive inspection area.

The present invention in yet another embodiment provides for the positioning of the objects to be inspected and sorted in a spaced single file relationship and to guide such file of objects through the sensitive inspection area of the photo-electric inspection station.

Further objects and advantages of the invention will be apparent with reference to the following specification and drawings in which,

Figure 1 is a diagrammatic side elevation of the photo-electric sorting apparatus of this inven-

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Figure 2 is a diagrammatic plan view of the apparatus of Figure 1 as seen from above;

Figure 3 is a schematic wiring diagram of a preferred form of photo-electric cell amplifier and relay for use with the invention;

Figure 4 is a wiring diagram of the voltage source to a set of lamps for illuminating the objects to be photo-electrically sorted;

Figure 5 is a diagrammatic side elevation of a modified form of photo-electric sorting apparatus of this invention, and

Figure 6 is a diagrammatic plan view of the apparatus of Figure 5 as seen from above to show the arrangement of guide members for aligning in spaced single file the objects to be sorted.

Referring to Figures 1 and 2 of the drawings, the photo-electric sorting apparatus of this invention is diagrammatically shown with the details of the machine supporting framework omitted in order to simplify the drawings and clarify the invention. It will be understood that any suitable framework and supporting members may be used to support and position the various elements of the invention in the desired relative positions as shown. The objects to be photo-electrically examined and sorted according to their light reflective properties as seen from both above and below their positions on the conveyor are fed to the transparent conveyor 10 from a suitable form of chute 11 which may be adapted to arrange the objects in spaced single file position on the conveyor for passage through the sensitive areas of the photo-electric inspection stations 12 and 14. In connection with the modified form of the invention as shown in Figures 5 and 6, the details of one form of apparatus for aligning in spaced single file positions the objects to be sorted as they pass the photo-electric inspection stations will be described.

The endless conveyor 10 is formed of any suitable transparent material which may, for example, be cellulose acetate sheeting. In order to facilitate the proper operation of the invention, the conveyor 10 must be clearly transparent and free from surface scratches and therefore any apparatus parts coming in contact with the conveyor surface should preferably be provided with felt or other soft substances on the contacting surfaces. The conveyor rollers 15 and 16 which are supported on suitable journals (not shown) are driven by any suitable mechanism (also not shown) to cause the conveyor 10 to move in the direction of the arrows, that is with the conveying run of the belt moving from left to right. The conveyor rollers 15 and 16 may be provided with soft rubber surfaces 17 and 18

for driving contact with the transparent conveyor belt 10.

Suitably positioned at spaced intervals along the conveyor run are the photo-electric inspection stations 12 and 14 for inspecting the articles to be sorted as seen from above and below the conveyor, respectively. The photo-electric inspection station 12 is comprised of the photo-electric cell 20 contained in the light tight box 21 and having an aperture and lens system 22 for determining in a known manner the active photo-electric field of inspection on the conveyor. Surrounding the box 21, and suitably supported in a manner not shown in detail are a plurality of reflective light sources, which as shown in the preferred embodiment may be four in number and each comprised of a lamp and reflector generally indicated by reference numerals 23, 24, 25 and 26. Suitably positioned beneath the transparent conveyor 10 at a point opposite the sensitive inspection field of the photo-electric cell 20 is a background light source 27, whose light is directed through the light diffusers comprised of the ground glass plates 28 and 29 to the sensitive inspection field 30 of the transparent conveyor. Although not shown on the drawing, the bottom surface of the conveying run of the conveyor belt may be supported on a felt covered board having circular cut-out positions to additionally define the inspection fields 30 and 31.

A pipe line 35 containing air under pressure is connected through a solenoid controlled air valve 36 to a nozzle pipe 37 whose nozzle end is positioned to one side of the inspection field 30 in a manner to blow an object to be sorted out of the normal line of its travel when the valve 36 is actuated to its open position. The solenoid valve 36 is actuated and controlled by the photo-electric cell 20 connected to a suitable amplifying relay apparatus such as that to be described in connection with Figure 3 of the drawings and the adjustments may be such as to cause, selectively as desired, either a dark object of a light object to be moved out of its normal line of travel as it passes the nozzle 37.

The background light source 27 is of considerable importance to the invention since it provides a diffused light background within the sensitive inspection area. It will be remembered that the conveyor 10 is formed of transparent sheet material which necessarily has a shiny surface and in view of the obvious flexible nature of the endless conveyor, such shiny surface would cause varying points of intense light reflections from the reflective light sources 23, 24, 25 and 26 to strike the photo-electric cell 20. Thus a comparatively white background of steady diffused light in the sensitive inspection area as provided by the light source 27 and ground or frosted glass light diffusing plates 28 and 29 is desirable in order to enable a more sensitive adjustment of the photo-electric cell responses and eliminate spurious responses of the photo-cell from undesired conveyor reflections.

In order that the valve of the background lighting may be adjustable a voltage source such as that shown in Figure 4 of the drawings may be employed. The reflective lights 23, 24, 25 and 26 are connected in series with a suitable voltage dropping resistor 40 and the background light 27 to the terminals 41 and 42 of the voltage source V. A variable resistor 43 is connected in parallel with the background light 27 in such manner that adjustments of the valve of resistor 43 are effective

to vary the amount of light provided by the background light 27.

Referring again to Figures 1 and 2, the photo-electric inspection station 14 is identical with the inspection station 12 as described above, except that the photo-cell unit 50 and associated reflective light sources is placed beneath the sensitive inspection area 31 of the transparent conveyor for inspection of the underside of objects on the conveyor. Similarly, the background light source 51 is placed above the conveyor 10 and opposite the sensitive inspection area 31. No further description of the inspection station 14 will be made, it being understood that all of the elements are similar to those described for the inspection station 12.

While any suitable form of photo-electric cell amplifying and relay apparatus may be employed for each of the inspection stations 12 and 14, a preferred amplifier circuit arrangement is shown in Figure 3. The photo-cell 20 is contained in an electrically grounded and light tight shield box 60. The photo-cell cathode 61 is grounded as shown and the anode 62 is connected to the control grid 63 of a cathode follower impedance matching tube 64. The output at the junction of cathode load resistance 65 and bias resistance 66 is coupled through condenser 67 to the input control grid 68 of a conventional two-stage resistance coupled voltage amplifier including the triode tubes 69 and 70. The output of the voltage amplifier is connected through a coupling condenser 71 to the control grid 72 of the cathode follower impedance matching output tube 73 whose output signal at the juncture of the cathode load resistance 74 and bias resistance 75 is directly connected to the control grid 76 of the relay tube 77. A current sensitive relay 78 is connected in the plate circuit of relay tube 77 and the bias of the relay tube is obtained by the connection of its cathode 79 to the tap 80 on the voltage divider comprised of potentiometer 81 and resistor 82 connected from ground to the positive voltage terminal 83. A conventional full wave rectifier power supply 84 including filter condensers 85, 86, 87, 88 and 89, isolating resistors 90, 91, 92, 93 and 94 and voltage regulator tubes 95 and 96 is employed to supply operating potentials to the amplifier and relay tube circuits. Filament voltages may be supplied through a conventional filament wiring circuit (not shown) from the filament winding 100 on the power transformer 101. The voltage amplifier tubes 69 and 70 are provided with plate load resistors 102 and 103 respectively and their grids are returned to ground through potentiometer type gain controls 104 and 105. By adjustment of the gain controls 104, 105 and the relay tube bias control 81, the relay 78 may be caused to close the relay switch contacts 110 upon a given condition of lighting on the photo-cell 20 so as to connect the voltage source terminals 111 and 112 to the solenoid air valve 36 and thus open the valve. Alternatively, the solenoid valve may be normally open and closed upon actuation of the plate relay 78 for certain conditions of operation.

In the modified form of the invention shown in Figures 5 and 6 a novel arrangement for guiding and sorting the objects to be sorted on the transparent conveyor belt is disclosed and in order to clarify the invention the photoelectric apparatus which is identical to that disclosed in Figures 1 and 2 has been omitted from these figures of the drawings. However, the sensitive

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areas of the inspection stations are shown as 130 and 131, respectively, for inspection of the objects from both above and below the conveyor. The transparent conveyor belt 132 is carried by the conveyor rollers 133 and 134 and moves in the direction of the arrows. Closely spaced above the upper surface of the conveying run of the conveyor are a plurality of guide members which may be formed of any suitable material such as plastic strips or the like and supported from the machine framework by any suitable means (not shown). The guide members include a plurality of strips 135, 136, 137 and 138 positioned at the entering end of the conveyor 132. It will be noted that strip 135 is positioned at an angle deviated in the direction of conveyor travel but very close to a right angle with the direction of travel of the conveyor while the strips 136, 137 and 138 are positioned at angles progressively closer to the direction of travel of the conveyor. The guide strips 135, 136, 137 and 138 are positioned successively in reversed angle or zig-zag manner with the discharge end of each strip overlapped by the entering end of each successive strip. Thus, objects deposited haphazardly on the entering end of the conveyor are caused to move against the guide strips 135, 136, 137 and 138 and are gradually accelerated in movement to the speed of movement of the conveyor while at the same time being separated from each other and aligned in single file for passage through the sensitive inspection areas 130 and 131.

To assure the correct alignment of the single file of objects with respect to the inspection stations 130 and 131, the channel guide strips 140 and 141 may be provided. At each inspection station 130 and 131, an air nozzle 142 and 143 is provided to cooperate with the solenoid operated air valves 144 and 145 to be effective to move the objects to be sorted in a direction transverse to the travel of the conveyor when the respective valve is operated. The guide wall 141 is provided with openings 146 and 147 opposite the air nozzles 142 and 143, respectively, which communicate with a reject channel 150 defined by the guide strips 148 and 149. Objects remaining in the channel defined by the guide strips 140 and 141 are deposited in the container 151 while objects which have been sorted into channel 150 are deposited in the container 152. In the event that the objects to be sorted are fragile, inserts 153 and 154 of cushion material may be applied to the inner wall of guide strip 149 at the positions opposite the air nozzle 142 and 143.

In considering the operation of the photo-electric sorting apparatus of this invention, it will be understood that the response of the photo-cells and associated relay amplifiers may be adjusted to cause the solenoid valves to be selectively operated when an object having a surface darker than a predetermined light valve passes the inspection station. Thus, when using the guide channel as shown in Figures 5 and 6 of the drawings, dark cashew nut shells which are completely free of the white nut meat may be sorted into one of the channels and deposited in the associated container. The apparatus of this invention enables a cashew nut shell to be examined from above and below its position on the transparent conveyor and thus any shells containing nut-meat on their inner underside surfaces will be sorted from those which are free of nut meats on their underside. It is particu-

larly desirable to obtain cashew nut shells that are completely free of nut meats when the shells are to be processed to produce oils.

On the other hand, the sorting apparatus of this invention may be adjusted to sort blanched nuts or the like from incompletely blanched nuts on which some dark nut skins are still adhering. The cashew nut, for example, is of such shape and size that it arranges itself on a conveyor with the maximum amount of its surface area exposed in planes generally parallel to the conveyor surface plane and, therefore, to accurately sort the completely blanched cashew nuts from partially blanched cashew nuts it is necessary to photo-electrically inspect the nuts from positions both above and below the conveyor as provided for by this invention.

While I have specifically described preferred embodiments of the invention, it will be understood that certain variations in the disposition of the photo-cells and lighting arrangements may be made without departing from the spirit and scope of the invention as defined by the appended claims. For example, the number of reflective light sources may be greater or less than that specifically described and the photo-cells may be arranged without a lens and aperture system, if so desired.

What I claim is:

1. A sorting machine for sorting out off-colored objects comprising a transparent horizontally disposed conveyor belt adapted to convey objects to be sorted in a horizontal direction, means to position objects to be sorted on said conveyor, a first photo-electric inspection station means positioned above said conveyor at a point along the conveyor run, in a manner to photo-electrically inspect said objects from above the conveyor, a first light source positioned above said conveyor in a manner to reflect light from the conveyor and objects to said first photo-electric means, a second photo-electric inspection station means positioned beneath said conveyor in a manner to photo-electrically inspect said objects from beneath the conveyor, a second light source positioned beneath said conveyor in a manner to reflect light from the conveyor and underside of said objects to said second photo-electric means, relay means for each of said inspection stations and actuated in accordance with a given condition of response of the respective photo-electric means, and object sorting means for each of said inspection stations and controlled by the respective relay means.

2. The invention as defined in claim 1 wherein each of said object sorting means is comprised of a fluid pressure nozzle positioned adjacent the conveyor run in the vicinity of the respective photo-electric means in a manner to move said objects transversely of the conveyor when supplied with fluid pressure, a source of fluid pressure for said nozzle, and a solenoid valve controlled by the respective relay means for connecting said fluid pressure to said nozzle.

3. A sorting machine for sorting out off-colored objects comprising a transparent horizontally disposed conveyor belt adapted to convey objects to be sorted, means to position objects to be sorted on said conveyor, a first photo-electric inspection station means positioned above said conveyor at a point along the conveyor run, in a manner to photo-electrically inspect said objects from above the conveyor, a first light source positioned above said conveyor in a manner to reflect light from the conveyor and objects to said first photo-electric

tric means, a first background light source positioned beneath said conveyor and opposite said first photo-electric means, a second photo-electric inspection station means positioned beneath said conveyor in a manner to photo-electrically inspect said objects from beneath the conveyor, a second light source positioned beneath said conveyor in a manner to reflect light from the conveyor and underside of said objects to said second photo-electric means, a second background light source positioned above said conveyor and opposite said second photo-electric means, relay means for each of said inspection stations and actuated in accordance with a given condition of response of the respective photo-electric means, and object sorting means for each of said inspection stations and controlled by the respective relay means.

4. A sorting machine for sorting out off-colored objects comprising a transparent horizontally disposed conveyor belt adapted to convey objects to be sorted in a horizontal direction, means to position objects to be sorted on said conveyor, a first photo-electric inspection station means positioned above said conveyor at a point along the conveyor run, in a manner to photo-electrically inspect said objects from above the conveyor, a first light source positioned above said conveyor in a manner to reflect light from the conveyor and objects to said first photo-electric means, a first background light source positioned beneath said conveyor and opposite said first photo-electric means, a second photo-electric inspection station means positioned beneath said conveyor in a manner to photo-electrically inspect said objects from beneath the conveyor, a second light source positioned beneath said conveyor in a manner to reflect light from the conveyor and underside of said objects to said second photo-electric means, a second background light source positioned above said conveyor and opposite said second photo-electric means, each of said first and second background light sources having light diffusing elements interposed before the conveyor, relay means for each of said inspection stations and actuated in accordance with a given condition of response of the respective photo-electric means, and object sorting means for each of said inspection stations and controlled by the respective relay means.

5. The invention as defined in claim 4 wherein each of said object sorting means is comprised of a fluid pressure nozzle positioned adjacent the conveyor run in the vicinity of the respective photo-electric means in a manner to move said objects transversely of the conveyor when supplied with fluid pressure, a source of fluid pressure for said nozzle, and a solenoid valve controlled by the respective relay means for connecting said fluid pressure to said nozzle.

6. A sorting machine for removing off-colored objects as claimed in claim 4 wherein the means to position objects on said conveyor includes a plurality of stationary guide strips associated with the upper side of the conveying run of said conveyor, said guide strips being closely spaced with the surface of said conveyor to form paths within which the objects to be sorted are confined in their movement with the conveyor, a first group of said guide strips being positioned at the entering run of the conveyor and extending generally transversely of the conveyor path, the guide strip of said first group that is nearest to the entering run of the conveyor being positioned at an angle deviating slightly in the direction of

conveyor travel from a right angle to the conveyor travel and the successive ones of the strips in said first group being positioned at successive angles closer to the direction of conveyor travel, the successive angles of the strips in said first group being reversed in zigzag relation with the entering end of each succeeding strip overlapping the discharge end of the preceding strip, the last guide strip of said first group that is furthest from the entering run of said conveyor being positioned to guide said objects into a first channel defined by a second group of guide strips, said first channel being positioned to pass through the sensitive areas of the photo-electric inspection stations, and a third group of guide strips being positioned in a plane parallel to said second group of guide strips to form a second channel for guiding objects without the sensitive areas of the inspection stations, and additional guide strips forming communicating channels between said first and second channels at the object sorting positions of the inspection stations.

7. A sorting machine for separating out off-colored objects comprising a horizontally disposed horizontally travelling conveyor of transparent material, a first photo-electric sensing means disposed opposite one face of said conveyor to inspect objects carried thereon from one direction, a second photo-electric sensing means positioned opposite the other face of said conveyor to inspect objects carried thereon from the opposite direction, means for positioning said objects to be inspected on said conveyor whereby said objects are carried successively through the inspection ranges of said first and second photo-electric sensing means, and sorting means responsive to actuation by said photo-electric sensing means to separate out off-colored objects.

8. A sorting machine for separating out off-colored objects comprising a horizontally disposed substantially horizontally travelling conveyor of transparent material, a first photo-electric sensing means positioned above said conveyor to inspect objects thereon from above, a second photo-electric sensing means positioned below said conveyor to inspect objects thereon from below, positioning means located at the feed end of the conveyor for aligning the objects to be inspected in a single file on the conveyor whereby they are carried successively through the inspection ranges of first and second photo-electric sensing means without substantial alteration of their position, and an air nozzle located to eject objects from their aligned position on the conveyor responsive to signal from said photo-electric sensing means.

9. A sorting machine for separating out off-colored objects comprising a substantially horizontally travelling conveyor of transparent material, a first photo-electric sensing means positioned above the conveyor to inspect objects thereon from above, light diffusing means positioned below the conveyor opposite said first photo-electric sensing means for adjustment of light intensities, a second photo-electric sensing means positioned below said conveyor at a point farther along its travel to inspect objects thereon from below, light diffusing means positioned above said conveyor opposite said second photo-electric sensing means to adjust light intensities, positioning means at the feed end of the conveyor to align the objects to be inspected substantially in single file on the conveyor whereby said objects are carried successively through the range of said first and second photo-electric sensing means, an air jet means responsive to

signals from said photo-electric sensing means for moving off-colored objects out of alignment on said conveyor.

CLARENCE T. NEMIR.

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