April 13, 1954 E. H. BICKLEY 2,675,488

SCANNING APPARATUS FOR COLOR SORTING

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Fig. 1.

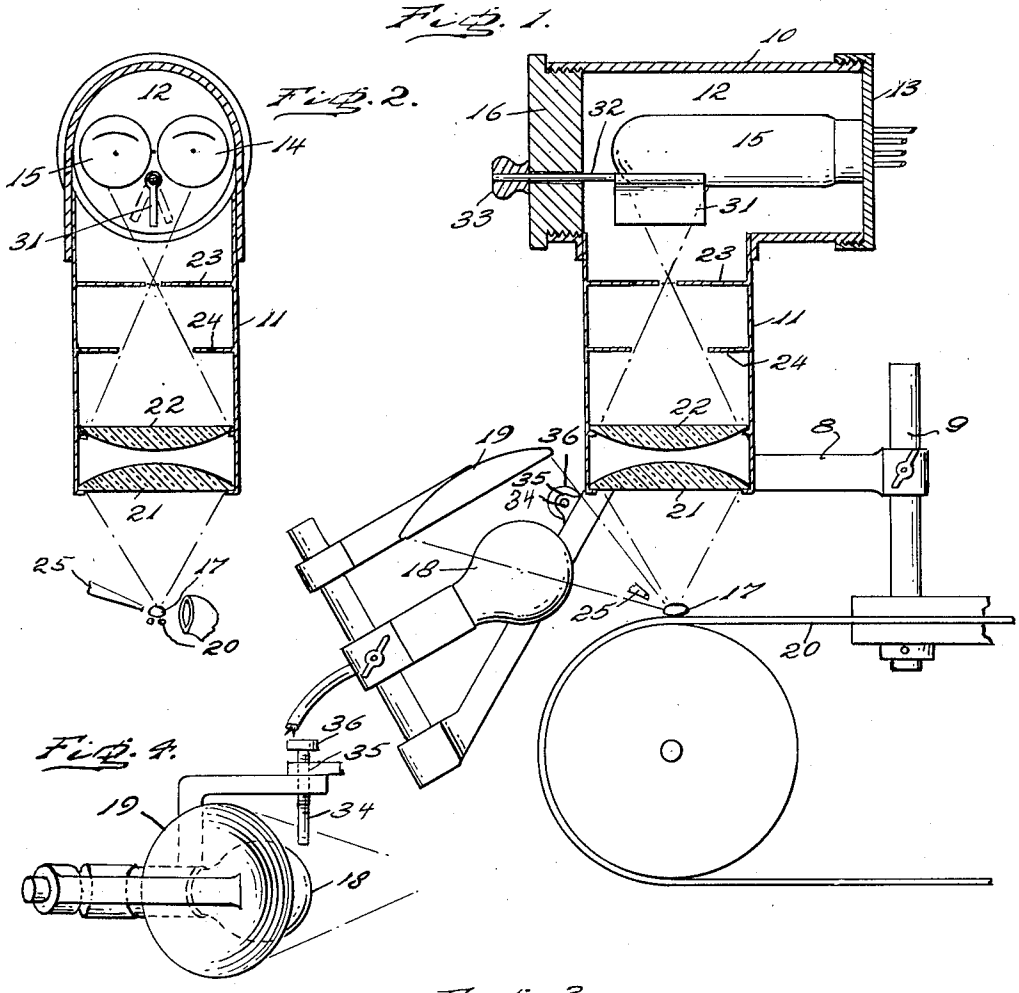
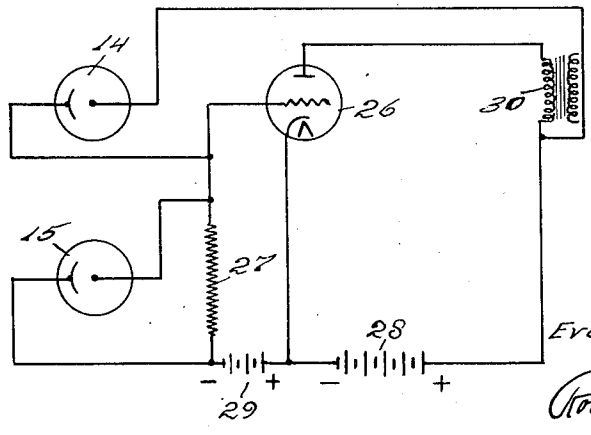


Fig. 2.

Fig. 4.

Fig. 3.



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SCANNING APPARATUS FOR COLOR SORTING

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13 Claims. (Cl. 250—209)

1

The present invention relates to machines for the color sorting of beans, peanuts, rice, and other objects of varying color, and more particularly to a novel photo-electric scanning apparatus and electrical circuit therefor.

In scanning units heretofore in use it has been the practice to utilize a single photo-electric cell as the medium for distinguishing between light colored objects and dark colored objects, and for that purpose very efficient sorting can be obtained. However, where the light distribution of an object is uneven the single cell scanning device fails to operate with the accuracy required. Such condition exists, for example, in the sorting of peanut kernels where a piece of skin adhering to the kernel will be ineffective to influence the selecting mechanism, so that the kernel is sorted along with good kernels instead of being thrown into the reject container. Thus, if the positive signal is utilized to operate the selecting mechanism, the latter will be actuated before (and in spite of) a small section of skin adhering to the kernel has had an opportunity to affect the signal with the result that improper sorting takes place.

Some of the objects of the present invention are to provide an improved color selecting apparatus for color sorting machines; to provide a scanning unit for color selecting wherein means are provided to correctly sort objects even though the color distribution is uneven; to provide a scanning unit for color selection wherein two photo electric cells of different color sensitivity operate together as a color selecting means for objects having uneven color distribution as well as objects having even color distribution; to provide a novel amplifying circuit responsive to color frequency signals as selected by a photo-electric scanning unit; to provide a scanning unit having two photo-electric cells of different color sensitivity and means for balancing and unbalancing the sensitivity at will; to provide a scanning unit having two photo-electric cells of different spectral sensitivity with provision for varying the sensitivity sum or difference to a predetermined constant state of unbalance for a selected color sorting; and to provide other objects as will hereinafter appear.

In the accompanying drawings Fig. 1 represents a sectional elevation of a photo-electric scanning head embodying one form of the present invention; Fig. 2 represents a vertical medial section of the unit shown in Fig. 1, while diagrammatically showing associated parts in side elevation; Fig. 3 is a diagram of the sorting control

2

circuit associated with the scanning head of the invention; and Fig. 4 represents a detail in plan of the light source unit.

Referring to the drawings, one form of the present invention comprises a light-proof housing forming an upper head 10 and a depending cylindrical tube 11 communicating with the head 10 said housing being supported by an arm 8 from an adjacent standard 9. The head 10 forms a compartment 12 which is sealed at one end by a closure 13 as a support for two photoelectric cells 14 and 15, the conducting wires for which lead exteriorly of the closure for connection to the sorting control circuit. The opposite end of the head 10 is closed by a removable plug 16. The two photo-electric cells 14 and 15 are arranged side by side in the compartment 12 at opposite sides of the axis of the tube 11 and both facing into the tube 11, so that normally reflected light rays from the bean or nut kernel 17, or other objects, being sorted, will be focussed upon each cell with either equal or unequal intensity according to conditions as will be later explained.

For directing and focussing reflected light rays to the aforesaid cells, the axis of the tube 11 intercepts the bean 17 at the inspection point where light from the lamp source 18 is focussed by a reflector 19 upon the object such as a bean or nut kernel on a conveyor 20. This conveyor 20 travels below and transversely with respect to the tube 11 in such direction that the motion of the image of the moving objects being sorted is lengthwise of the cells. The reflected light enters the bottom of the tube 11 to pass through a pair of superposed plano-convex lenses 21 and 22, which are so arranged as to focus the image of the bean within an opening provided by an annular mask or diffuser 23, which is located coaxially and transversely of the tube 11 between the lenses and the two photo-electric cells. A second annular mask 24 encircles the converging rays of reflected light and serves to cut off any stray light rays which otherwise might reach the cells to thereby disturb cell operation. The rays of light after passing through the opening in the mask or diffuser 23 diverge to strike the respective photo-cells 14 and 15, with a controlled intensity, corresponding to a selected sorting condition as will later appear. In the scanning of a succession of objects for sorting, both cells respond to the received color inspection and the resultant signal determines whether the sorting machine passes the bean or peanut kernel as an accept or reject. If the signal is for an accept bean, then the sorting machine opens a control valve to eject a puff of air

against the bean by way of a nozzle 25 and blow the bean into the appropriate container. Reference may be had to applicant's co-pending application Ser. No. 609,619, filed August 8, 1945 issued December 25, 1951, as Patent No. 2,580,275, for details of the sorting machine with which the present invention is used.

An important object of the present invention is to increase the sensitivity of the scanning head to sort objects having both dark and light areas or unevenly distributed color, such, for example, as the sorting of peanut kernels so that kernels having a piece of skin sticking to the kernel will be segregated with all other skin sticking kernels. In the present showing, the photo-cell 14 is more sensitive to red rays and the photo-cell 15 is more sensitive to blue rays, but the invention is not limited to the particular positioning of the cells as shown since a transposition of the cells may be made for different sorting requirements. Referring to the signal amplifying circuit of Fig. 3, the cell 14 is connected between the grid and the positive side of the plate battery 28, while the cell 15 is connected across the grid resistor 27. The grid resistor 27 is connected between the grid and the negative side of the bias battery 29. The output from the tube 26 includes the coil 30 for operating the magnetic valve of the sorting machine whereby the amplified signal controls the disposition of the bean according to color. It should be noted that the present circuit is novel in that no separate source of energy is required for the photo-cells because the potential drop across the grid resistor when there is a signal is sufficient to operate the cell which is connected across this resistor.

From the foregoing it will be seen that the light reflected from the object at the inspection point initially falls upon both cells simultaneously and with equal intensity, but since the cell 14 may be more sensitive than the cell 15, it is important that the two cells be brought into sensitivity balance, as otherwise the sorting would be influenced to a greater extent by objects matching the color sensitivity of the cell 14. For the purpose of establishing this balance, a relatively thin plate 31, having opposite sides formed as reflecting surfaces, is mounted between the cells and the mask 23 to depend edgewise with its plane in coincidence with the axis of the tube 11. An oscillatable rod 32 is attached to the upper edge portion of the plate 31 and is carried by the plug 16 to project exteriorly thereof to terminate in a hand knob 33 for adjusting purposes. When the plate 31 is so mounted the rod 32 is turned to swing the plate 31 counterclockwise, as shown in the drawings, to bring one reflecting face angularly in the path of the light rays to divert some of the reflected light rays from the cell 14 to the cell 15, and so cutting the light as to reduce the rays reaching the cell 14 until the relative sensitivity of the cells is balanced. The turning of the plate 31 may be stopped in this position, to become a reference position from which the plate 31 can be swung in either direction to increase or decrease the relative amount of light falling on the cell 14 oppositely to that falling on the cell 15 according to the required color sorting. When the plate 31 is in this reference position the sensitivity of the two cells is balanced so no signal is provided by the reflected light from an object regardless of its intensity. A signal will be produced, however, with a change in color. Assuming that it is desired to sort peanut kernels, the plate 31 can be swung to the side of the reference position which will increase the amount of light falling upon the cell 14 and as a result the signal is large from kernel skin, or a piece of skin, sticking to the kernel, while small from a clean peanut kernel. Thus, peanut kernels having even distribution of color, as long as it is not red, will be sorted into the same container, while any having red characteristics will be delivered into another container. While this illustrative setting of the plate 31 is for sorting out objects having red or dark red characteristics, a setting of the plate 31 to some other position will result in the sorting out of objects having other color characteristics.

From the foregoing it will be apparent that by reason of the balanced cell construction, color sensitivity is more active than the light sensitivity so that variations in the candle power of the light are less disturbing than in the heretofore known single cell type of scanning unit. While slight variations in voltage or illumination are practically negligible by this novel construction, it is important that an initial luminosity setting be made by which the balancing or reference adjustment for sensitivity can be made. For this purpose a light cut-off rod 34 is mounted for axial adjustment into the path of the reflected light rays to the bean 17. As shown, this rod 34 is threaded into a boss 35 for operation by a knob 36 and can thus be shifted to a selected position to either increase or decrease the projected illumination and thereby obtain a selected degree of luminosity from which the plate 31 can be set for the reference balance.

While in the foregoing description peanut meats are referred to as illustrative of the objects to be sorted, it is to be understood that the scanning unit of the invention is broadly for color sorting of many different objects, such as coffee, peas, kidney beans, Lima beans, buttons, or liquids in transparent pipes.

Having thus described my invention, I claim:

1. A scanning unit for color sorting apparatus, comprising the combination of means for conveying an object to an inspection point for color sorting, a head forming an enclosed light-proof compartment, two light-responsive photo-electric cells in said compartment, in side to side relation for simultaneous reaction to light rays of same color value, a light-proof tube forming an extension of said head, means mounting said head to locate said tube in alignment with said object inspection point, a source of light, means focussing said source at said inspection point, an annular mask forming an opening for the passage of light rays reflected toward said cells from an object, and means for focussing said rays in said opening to diverge and strike said cells respectively.

2. A scanning unit in accordance with claim 1, wherein the photo-electric cells have different light sensitivity characteristics.

3. A scanning unit in accordance with claim 2, wherein one photo-electric cell is sensitive to red color and the other cell is sensitive to blue color.

4. A scanning unit in accordance with claim 3, wherein means are provided to balance the sensitivity of the two cells and establish a reference setting.

5. A scanning unit in accordance with claim 4 wherein said balancing means is adjustable from said reference setting to produce a predetermined state of unbalanced sensitivity.

6. A scanning unit for color sorting apparatus,

comprising the combination of means for conveying an object to an inspection point for color sorting, a head forming an enclosed light-proof compartment, a light-proof tube forming an extension of said head, means mounting said head to locate said tube in alignment with said object inspection point, two light-responsive photo-electric cells in said compartment spaced equally at opposite sides of the axis of said tubes for simultaneous reaction to light rays of same color value, one of said cells being responsive to red color and the other responsive to blue color, an annular mask forming an opening for the passage of light rays reflected towards said cells from an object, a source of light, means focussing said source at said inspection point means for focussing said rays in said opening to diverge and strike said cells respectively, and a plate adjustable across the axis of said tube in the path of said diverging rays of reflected light and having a reflecting surface whereby the state of sensitivity of said cells can be varied at will.

7. A scanning unit according to claim 6 wherein means are provided exteriorly of said head for adjusting said plate.

8. A scanning unit according to claim 7 wherein the plate is formed with reflecting surfaces at opposite sides thereof respectively.

9. A signal-responsive circuit for a scanning unit for color sorting apparatus, comprising an amplifying thermionic tube, a plate circuit for said tube connecting the plate to the tube cathode and including a source of energy and a primary coil, a grid circuit including a source of energy and a grid resistor, a photo-electric cell connected across said first mentioned source of energy and said grid circuit, and a second photo-electric cell also connected to said tube grid and in shunt to said grid resistor.

10. A signal-responsive circuit in accordance with claim 9 wherein said first mentioned cell is sensitive to red color and said second mentioned cell is sensitive to blue color.

11. A signal-responsive circuit in accordance with claim 9 wherein said photo-electric cells have different color sensitivity characteristics.

12. A scanning unit for color sorting apparatus, comprising the combination of means for conveying an object to an inspection point for color sorting, a head forming an enclosed light-proof compartment, a light-proof tube forming an extension of said head, means mounting said head to locate said tube in alignment with said object inspection point, two light-responsive photo-electric cells in said compartment spaced equally at opposite sides of the axis of said tubes, for simultaneous reaction to light rays of same color value one of said cells being responsive to red color and the other responsive to blue color, an annular mask forming an opening for the passage of light rays reflected towards said cells from an object, a source of light, means focussing said source at said inspection point means for focussing said rays in said opening to diverge and strike said cells respectively, and adjustable reflecting means across the axis of said tube in the path of said diverging rays of reflected light and having a reflecting surface whereby the state of sensitivity of said cells can be varied at will.

13. A scanning unit for color sorting apparatus, comprising the combination of means for conveying an object of an inspection point for color sorting, a head forming an enclosed light-proof compartment, two light-responsive photo-electric cells in said compartment, in side to side relation for simultaneous reaction to light rays of same color value, a light-proof tube forming an extension of said head, means mounting said head to locate said tube in alignment with an object inspection point, a source of light, means focussing said source at said inspection point diffuser mask means forming said opening for the passage of light rays reflected toward said cells from an object, and means for focussing said rays in said opening to diverge and strike said cells respectively.

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