Feb. 13, 1940. W. R. HORSFIELD 2,190,563

SORTING APPARATUS

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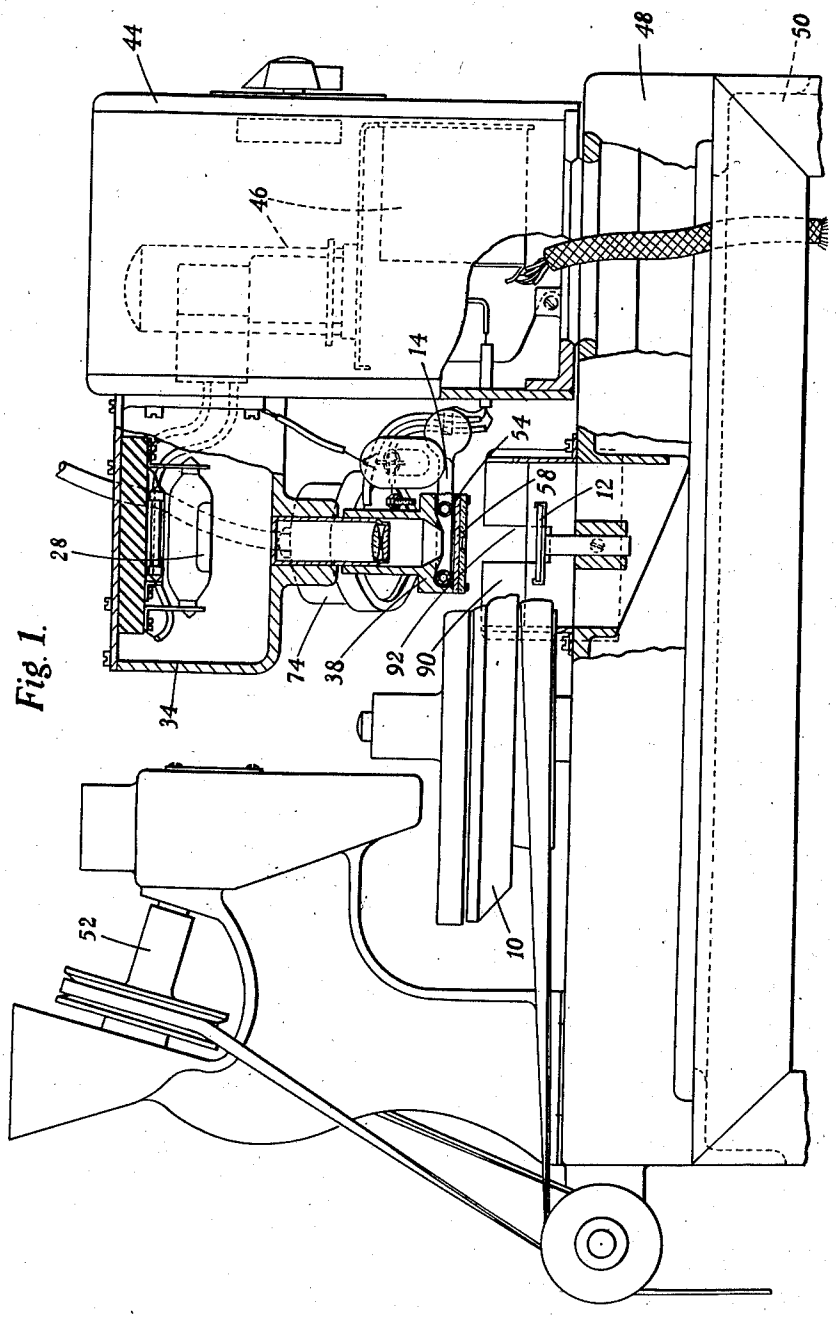


Fig. 1.

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SORTING APPARATUS

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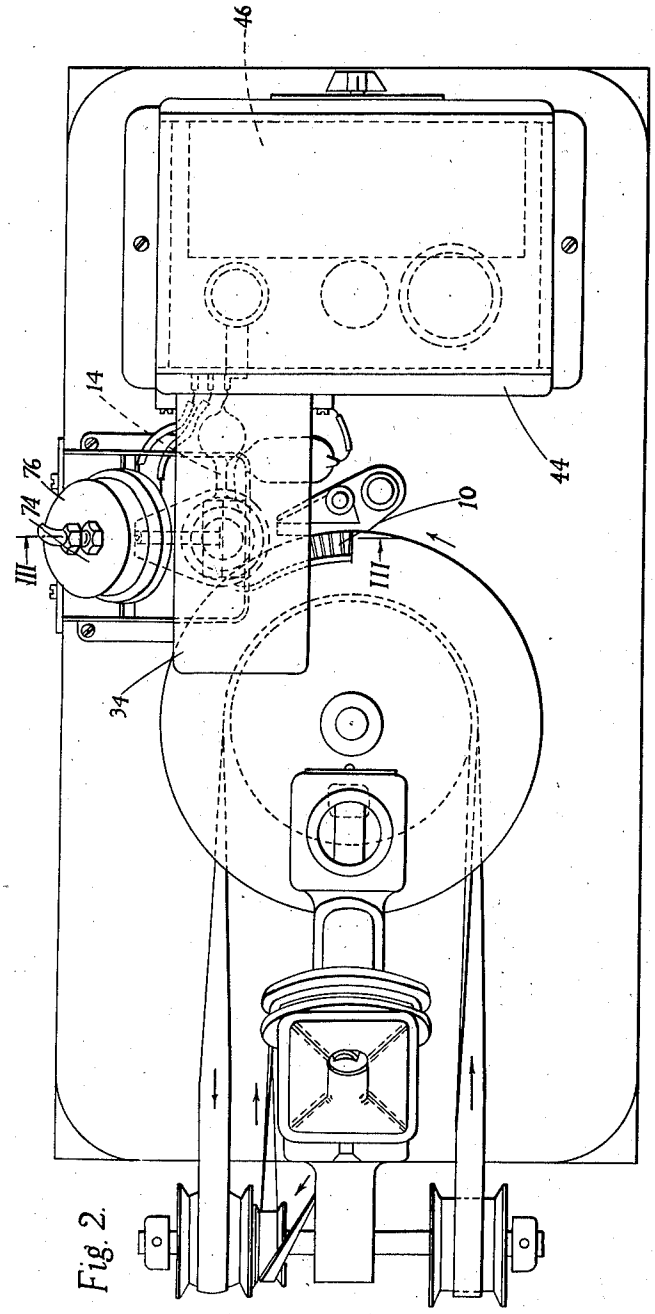


Fig. 2.

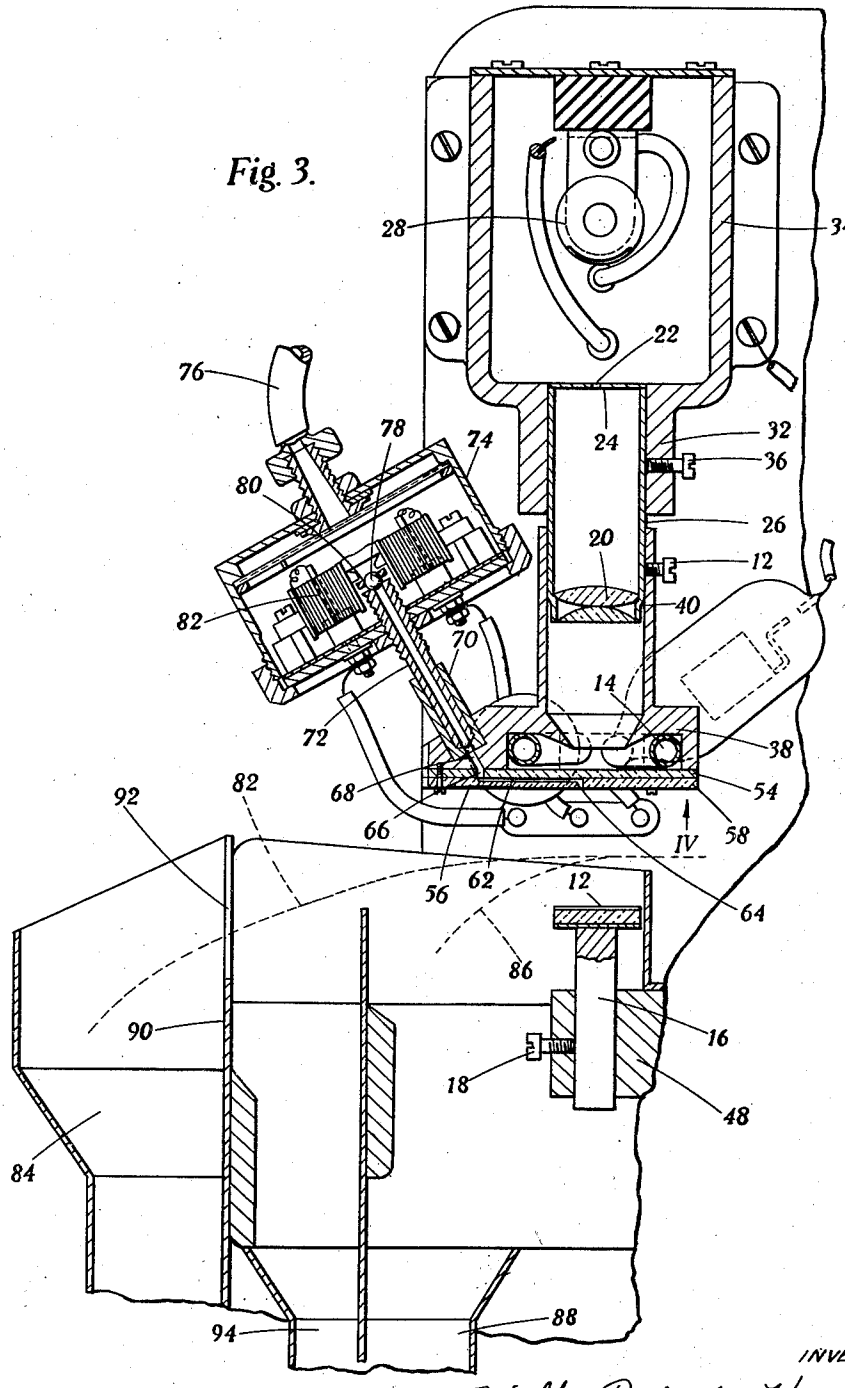
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Fig. 3.



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Fig. 4.

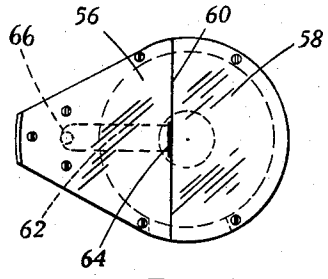


Fig. 5.

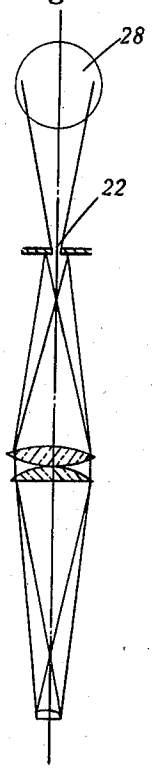
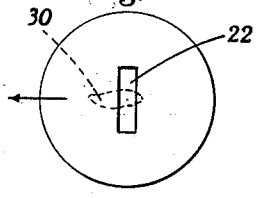


Fig. 6.



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UNITED STATES PATENT OFFICE

2,190,563

SORTING APPARATUS

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Application March 4, 1938, Serial No. 194,009
In Great Britain March 10, 1937

6 Claims. (Cl. 209—111)

This invention relates to apparatus for automatically sorting objects in accordance with their albedo, colour transparency or other optical characteristics. It is particularly applicable in sorting rice grains for the detection and rejection of discoloured or darkened grains, but it is equally applicable in other cases in which it is desired to detect or reject objects which differ optically from the standard.

It is to be understood that the term "optical characteristics" includes characteristics pertaining to the invisible regions of the spectrum as well as to the visible region.

In sorting apparatus of this kind that have been proposed, photo-electric cells are used in conjunction with amplifiers the output of which is used to operate a rejecting device. Difficulties are encountered, however, in distinguishing between signals emitted by the photo-electric cell due to the standard and non-standard objects.

According to the present invention these difficulties are avoided or minimised by providing a background for the objects which matches the objects to be sorted. In general, the background will be made to match the standard objects to be accepted, although it would be within the invention in certain cases to make this background match the non-standard objects which are to be rejected. In either case objects which match the background, when passed between the background and the photo-electric cell, will produce no change in the illumination on the cell and therefore no signal will be emitted. When an object passes the background which does not match it, a change in the illumination on the photo-electric cell will be produced and a signal will be emitted. All that is required, therefore, is to provide a rejecting device which responds to a current impulse from the amplifier, and there is no necessity to provide for discrimination between signals of unequal strength except in so far as this is required in order to set the tolerance which is to be permitted in the variation from the standard.

The apparatus according to this invention for sorting rice grains or other cereal grains is illustrated in the accompanying drawings, in which

Figure 1 is a side elevation of the apparatus with parts broken away and partly in section,

Figure 2 is a plan,

Figure 3 is an end elevation in section on the line III—III in Figure 2,

Figure 4 is a view of a part of the apparatus looking in the direction of the arrow IV in Figure 3, and

Figures 5 and 6 are diagrams illustrating the optical system of the apparatus.

The rice or other grains are thrown tangentially from the surface of a rotating plate 10 so that they traverse one at a time the space between a white background plate 12 and a mercury vapour lamp 14 the tube of which is arranged in the form of a ring. The background plate 12 is supported on a vertical rod 16 which can be adjusted vertically and secured by means of a set-screw 18. An objective 20 (see also Figures 5 and 6) forms an image of each grain on a slit 22 formed in a plate 24 closing the upper end of a tube 26 supporting the objective 20. Above the plate 24 is mounted a photo-electric cell 28.

The position of the background plate 12 is adjusted until its brightness is the same as that of standard rice or other grains. It is to be understood that the expression "brightness" means the brightness or luminosity as referred to the photo-electric cell, the colour sensitivity of which may not correspond to that of the eye. The objective 20 of course forms an image of the white surface of the plate 12 on the slit 22 and it will be understood that so long as normal grains pass across the field of the objective 20 no change will occur in the amount of light received by the photo-electric cell. If, however, a dark or discoloured grain passes, the total amount of light passing through the slit 22 will be materially decreased because, as clearly shown in Figure 6, the area of the slit is of the same order as the area of the image 30 of the grain itself. In this particular embodiment, which is adapted for sorting rice grains, which are about a quarter of an inch long the slit is one-sixteenth of an inch wide. Only one-quarter of the length of the image of each grain is therefore comprised within the width of the slit at any instant and it follows that a dark spot occupying only a fraction of the area of a grain will produce an appreciable diminution in the total amount of light passing through the slit. The length of the slit is about a quarter of an inch. This is considerably more than the width of a grain but it is advisable to provide a margin because the grains after leaving the edge of the disc 10 do not always follow exactly the same path.

The tube 26 slides in a socket-like extension 32 of a casing 34 within which the photo-electric cell 28 is mounted, and the tube can be adjusted vertically and secured in any adjusted position

by the set-screw 36. The lamp 14 is supported in a housing 38 provided with a tubular extension 40 sliding upon the lower part of the tube 26 and provided with a set-screw 42 whereby it can be held in any adjusted position. The adjustment of the tube 26 enables the images of the grains to be focussed sharply on the slit 22. The casing 34 is secured to another casing 44 within which is an amplifier indicated at 46 which receives the photo-electric current from the cell 28, the output of this amplifier being used as will hereinafter be described to operate a rejecting mechanism.

The casing 44 is carried by a base-plate 48 mounted upon a stand indicated at 50 and the base-plate also supports the rotatable disc 10, a rotating feeding device 52 and other devices described more fully in the specification of my co-pending application Serial No. 194,010, now Patent No. 2,160,101 dated May 30, 1939.

The lower side of the housing 38 is closed by a window 54 of transparent material to the lower face of which are secured two plates 56, 58 of similar transparent material having straight edges 60 which fit together closely along a line transverse to the direction of travel of the grains. The plate 56 is formed with a groove 62 in its upper surface which communicates with a shallow notch 64 formed in the edge 60, forming with the edge of the plate 58 a narrow slit or jet orifice. A hole 66 in the window 54 places the groove 62 in communication with a bore 68 in the material of the housing 38, this bore communicating with a socket 70 which receives a tube 72 communicating with the interior of a chamber 74 to which air under pressure is supplied through a tube 76. The upper end of the tube 72 within the chamber 74 is closed by a ball 78 carried by the armature 80 of an electromagnet 82. The ball 78 normally closes the upper end of the tube 72 but when the electromagnet 82 is energized, thus attracting the armature 80, the ball is lifted away from the end of the tube thereby admitting compressed air which passes down the tube 72 through the hole 66 along the groove 62 and through the slit 64.

The output of the amplifier 46 is fed to the windings of the electromagnet and the arrangement is such that the electromagnet is de-energised so long as no change takes place in the amount of light falling on the photo-electric cell 28. Thus, no air is admitted to the tube 72 so long as normal grains pass across the field of the objective 20. If, however, a dark or discoloured grain passes, the amount of light falling on the photo-electric cell is decreased momentarily and the ball 78 is momentarily lifted. A puff of air is therefore ejected from the slit 64 upon the defective grain thereby deflecting it downwards. It will be seen that the slit 64 is displaced slightly from the axis of the objective 20. This displacement corresponds to the very short time lag that occurs between the detection by the photo-electric cell of the dark or discoloured grain and the arrival of the puff or jet of air at the path of the grains. In the actual apparatus this displacement of the notch 64 is about one-eighth of an inch and the grain travels this distance during the time required for the operation of the electric and pneumatic devices constituting the rejecting mechanism.

Normal grains follow the path indicated at 82 and fall into a hopper 84 through which they are led away. Rejected grains which are deflected downwardly follow the path 86 into a hopper 88. Some of the grains may be accidentally deflected horizontally, for example by collision with other grains, so that their images do not pass across the slit 22. Such grains strike a baffle plate 90 formed with an aperture 92 for the passage of normal grains, and fall into a hopper 94 from which they are led back to the feeding device 52 for re-sorting.

It will be evident that the apparatus may be used for sorting objects in accordance with their colour instead of in accordance with their brightness or albedo. If, for example, the normal objects are blue in colour and it is desired to reject red or green objects it is only necessary to place a blue colour filter in the path of the light on the objects to the photo-electric cell. The position of the background plate 12 is adjusted until the objects match the background in blue light. Red or green objects will reflect less blue light and will thus bring about a rejection impulse as hereinbefore described. Unduly opaque objects can be sorted out from translucent objects even though their surface brightness may not differ from the normal.

I claim:

1. In photo-electric sorting apparatus in combination, a horizontal background surface supported so as to be adjustable in the vertical direction, means for projecting the objects to be sorted one at a time across the space above said background surface, a housing for a ring-shaped electric glow discharge lamp situated above the path of said objects, a transparent plate closing the lower side of said housing and formed with a passage therein constituting an air jet, said lamp illuminating from above both the objects and the background surface, a photo-electric cell receiving light from said objects and background surface and means under the control of the photo-electric cell for supplying air momentarily to said jet as a consequence of the passage of an object which does not match the background surface, said jet deflecting said object downwardly.

2. The invention according to claim 1 wherein the transparent plate is made up of two layers one of which is in two parts having straight edges fitting close together one of said parts being formed with a groove in that surface which is next to the other layer, said groove communicating at one end with a pipe leading from a source of air under pressure and at the end with a shallow notch formed in the straight edge of that part.

3. The invention according to claim 1 wherein an objective is situated above the transparent plate and a screen having an aperture therein is situated between the objective and the photo-electric cell in such a position as to receive thereon images of the objects as they pass across the space above the background surface, said screen shielding the photo-electric cell from all light except that which passes through the aperture therein.

4. The invention according to claim 1 wherein an objective is situated above the transparent plate and a screen having an aperture therein is situated between the objective and the photo-electric cell in such a position as to receive on said aperture images of the objects as they traverse the axis of the objective, the air jet aforesaid being displaced from the axis of the objective along the path traversed by the objects to be sorted by that distance through which an object passes in the interval between its scanning

by the photo-electric cell and the issue of air from the jet.

5. Apparatus for automatically sorting objects in accordance with an optical characteristic thereof comprising in combination a photo-electric cell, an amplifier associated therewith, means for throwing said objects one at a time across a free space within the field of view of said photo-electric cell, means for illuminating said objects, an illuminated background surface for said objects the illumination of which matches that of those objects which possess said optical characteristic, and a rejecting device operated by said amplifier and comprising means for directing a jet of air upon said objects while traversing said free space.

6. The invention according to claim 5 wherein the means for throwing the objects consists of a rotating plate.

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